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Literature on the Revegetation of Coal-Mined Lands: An Annotated Bibliography

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ILLUSTRATION

UNIT OF MEASURE ABBREVIATIONS USED IN THIS REPORT

acre-ft/acre	acre feet per acre
BA	basal area
Btu/acre	British thermal unit per acre
Btu/cord	British thermal unit per cord
Btu/lb	British thermal unit per pound
°C	degree Celsius
cm	centimeter
cm/h	centimeter per hour
cm/yr	centimeter per year
Dbh	diameter at breast height
ft	foot
g	gram
g/cm^3	gram per cubic centimeter
g/m^2	gram per square meter
ha	hectare
in	inch
in/yr	inch per year
kg	kilogram
kg/cm^3	kilogram per cubic centimeter
kg/ha	kilogram per hectare
kl/ha	kiloliter per hectare
l	liter
l/m^2	liter per square meter
lb/acre	pound per acre
m	meter
m^2	square meter
m^2/g	square meter per gram
m^2/ha	square meter per hectare
MBtu/ha	mega British thermal unit per hectare
meq/100g	milliequivalent per 100 gram
mg/ha	milligram per hectare
min	minute
ml	milliliter
mm	millimeter
mm/d	millimeter per day
µmho	micromho
µmho/cm	micromho per centimeter
pct	percent
PLS	pure live seed
ppm	part per million
t	metric ton
t/acre	metric ton per acre
t/ha	metric ton per hectare
yd^3	cubic yard
$yd^3/acre$	cubic yard per acre

LITERATURE ON THE REVEGETATION OF COAL-MINED LANDS: AN ANNOTATED BIBLIOGRAPHY

By David L. Veith,[1] Kenneth L. Bickel,[1] Roger W. E. Hopper,[2] and Michael R. Norland[3]

ABSTRACT

This Bureau of Mines bibliography of U.S. and Canadian literature pertaining to revegetating coal-mined lands contains 805 references published from 1977 to 1984. Each reference is evaluated by keywords, providing the reader with a means of rapidly sorting through the references to locate only those dealing with the coal mining region and subject of interest. All references are annotated. Other sources of information are given, including Office of Surface Mining (OSM) and State reclamation agencies and other published bibliographies.

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[2]Soil scientist.
[3]Soil scientist (graduate student).
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INTRODUCTION

Public Law 95-87, the Surface Mining Control and Reclamation Act of 1977 (SMCRA), was signed into law on August 3, 1977. Regulations for implementing the act were prepared by the Department of the Interior's newly created Office of Surface Mining Reclamation and Enforcement (OSM). Among the regulations are performance standards for revegetating surface-coal-mined areas and surface areas of underground coal mines.

A large amount of coal mine revegetation activity and research has been reported in the technical literature, both prior to and subsequent to the act. The information is diverse and widely scattered throughout books, scientific journals, periodicals, Government reports, and other sources. While a number of bibliographies have been written relating to coal mining and reclamation, the need was identified for a method of obtaining recent literature pertaining to coal mine revegetation in a timely and efficient manner, especially since the act was passed. The Bureau of Mines, at the request of OSM, prepared this document to meet this need. This report contains bibliographic citations and annotations of 805 references published from 1977 to 1984, directly applicable to coal mine revegetation in the United States. It provides a method of rapidly screening the articles so the reader can obtain those of interest. This report is intended for use by researchers, Government personnel, mining companies, and others involved in reclaiming and revegetating coal-mined lands.

ACKNOWLEDGMENTS

The authors thank the staff of the Bureau of Mines Twin Cities Research Center who participated in this effort. The Center's librarian, Merle T. Bernstein, deserves an especially large thank you for her efforts in identifying sources and obtaining published information for the manual.

Jean Albrect and Judy Schinn, librarians at the University of Minnesota's Forestry Library, provided invaluable assistance in obtaining reference materials.

This project received strong support and encouragement from the Office of Surface Mining and was developed and closely coordinated with that organization from the outset.

FACTORS AFFECTING REVEGETATION

Every site requiring revegetation is unique. When developing a revegetation plan, many site-specific factors must be considered that influence what species to plant and how to establish and maintain the vegetation community. Regulations, land use, climate, mining and soil-handling methods, soil and overburden characteristics, and slope and aspect are important factors. Local, State, and Federal regulations must be met. The land use or uses after mining, as approved by the regulatory authority, must equal or exceed the premining land use. The vegetation established must be capable of thriving in the climate of the area. Since the soil or overburden that exists prior to mining is usually used as the plant growth medium, the characteristics of the material must be known prior to developing a revegetation plan. The mining and soil-handling methods used during mining, recontouring, and topsoiling influence the type and characteristics of the plant growing media available at the site. Finally, the slope and aspect of the site must be considered.

It is the responsibility of the individuals developing the revegatation plan to recognize these site-specific factors and obtain all information and data necessary to develop a workable plan for that particular site. A brief discussion of each of these factors follows.

Prior to 1977, there was no Federal law governing coal-mined-land reclamation, although some States did have reclamation regulations. However, since the passage of SMCRA, all coal producers must comply with regulations based on the Federal act. Those regulations were prepared by OSM, but primary responsibility for implementing and enforcing the Federal rules has been given to most coal mining States after OSM approval of their State programs. Most State programs closely parallel OSM regulations.

OSM regulations are published in the Code of Federal Regulations Title 30, Part 700 to End. Initial program regulations are in Subchapter B, Parts 710 to 725. Permanent program performance standards for land use and revegetation are given in Parts 816 (permanent program performance standards - surface mining) and 817 (permanent program performance standards - underground mining). Special performance standards are given in other parts for mining occurring in prime farmland, anthracite mining in Pennsylvania, mountaintop removal mining, and other situations. A thorough review of all applicable Federal, State, and local regulations is required before a reclamation plan can be finalized.

Reclaimed land must be capable of at least supporting the use or uses present prior to mining. Land-use classifications recognized in the permanent program are cropland, grazingland, pastureland, forestry, residential, industrial-commercial, recreation, fish and wildlife habitat, developed water resources, and undeveloped land (30 CFR 701.5). The selected postmining land use must be approved by the regulatory authority.

Many factors must be considered when selecting a land use. It must be compatible with adjacent land uses and with applicable Federal, State, and local land-use plans. Socioeconomic factors must be considered, as well as the effects on important environmental values. Soil conditions and water availability must be suitable for the proposed land use.

The climate in any area obviously affects revegetation planning. The revegetated site is affected by the length of the growing season, temperature extremes, rainfall, wind conditions, humidity, and freeze-thaw conditions. The climate affects what plant species are selected, how and when to plant, the use of soil amendments and revegetation equipment, requirements for maintaining vegetation, and other factors.

The importance of moisture is recognized in the regulations. The act requires all coal operators to assume liability for successful revegetation for 10 full years after the last year of seeding, fertilizing, irrigation, or other revegetation activities in areas that receive 26 in or less of annual precipitation. In areas where precipitation exceeds 26 in/yr, the liability period is 5 yr. The lack of moisture can often dictate the success or failure of a revegetation program, particularly in arid parts of the Western United States.

The mining method(s) employed to mine the coal, whether area mining, contour mining, open pit mining, or some combination thereof, dictates how the overburden and soil is picked up, transported, and emplaced. The material moved may be thoroughly mixed, or handled selectively, in order to create the best plant growth medium possible.

Regulations now require that topsoil be removed and replaced (unless, in some cases, substitute materials are shown to be more suitable growth media). Ideally, soil horizons would be replaced in the same sequence in which they were removed, assuming they provided a good growth medium in their natural state. However, the soil horizons are often mixed or inverted during the soil-handling process, and this can result in increased soil bulk densities nearer the surface, as natural soil bulk densities tend to increase with depth.

More importantly, equipment used to replace the soil exerts significant pressure on the surface, increasing the soil bulk density through compaction. If sufficient, compaction can reduce a soil's ability to support vigorous vegetation by adversely affecting the water content and movement, air movement, thermal conductivity, nutrient availability, root penetration, and seedling emergence.

The characteristics of the material to be used for plant growth, whether it be soil or overburden (or substitute material), must be determined prior to revegetation. Among the important characteristics are organic carbon, nitrogen, phosphorus, and potassium contents, pH, cation exchange capacity, exchangeable calcium and magnesium, and texture. The presence of toxic materials should also be determined.

Many soil-related problems can be alleviated through proper soil-handling practices and the use of soil amendments. Mulches, fertilizers, pH modifiers, sludges, and biological amendments (such as mycorrhizae-forming fungi) are available to correct soil deficiencies. Proper soil-handling methods, such as replacing topsoil immediately after removal to ensure biological viability of the soil, can aid revegetation efforts.

Sloped areas can be extremely difficult to revegetate. Vegetation must be established quickly and must hold the soil to prevent erosion. Erosion control is very important when selecting plant species, soil amendments, and a revegetation method.

The aspect, or orientation, of a sloped area is another important consideration. South-facing slopes receive the most sunlight, raising soil temperatures and drying the soil quickly, often hindering vegetative establishment and growth.

REFERENCE SELECTION

There is substantial coal mine reclamation and revegetation information available, most of which has been published in the last 15 years. To tap this reservoir of information, reference lists were generated from DIALOG SDI (Selective Dissemination of Information) Service. DIALOG[4] is a computer-based information retrieval service that accesses a number of data bases dealing with a variety of subjects. Fourteen data bases were accessed using three keyword combinations (surface mining and reclamation, strip mining and reclamation, and revegetation). This generated over 7,000 listings.

While examining each reference list from each data base, a large amount of duplication of listings within and between data bases was found. The DOE ENERGY data base listing was chosen for further examination, both for its large number of listings and for its broad coverage of the literature. This data base contains all the unclassified information that passes through the Technical Information Center of the U.S. Department of Energy. The Center abstracts and indexes reports, journal literature, conferences, patents, books, monographs, theses, and engineering materials relating to energy development for inclusion in the data base.

The DOE ENERGY reference lists were examined, and duplications were eliminated. All references that obviously did not deal with revegetation were eliminated, as were those that appeared in the foreign literature (except those dealing with developments in the United States and Canada). Because a large majority of the references listed were dated 1977 or later, and because of the availability of bibliographies containing literature citations older than 1977 (see appendix C), articles older than 1977 were also eliminated. This left more than 1,000 references to be obtained for review.

In addition to the references from the computer search, over 700 other references were obtained from project files, Bureau libraries, and the University of Minnesota's libraries, bringing the total to almost 1,800 references.

Prior to evaluation, all references were reviewed for inclusion in the bibliography. Initially, all references were included that had significant information on revegetation, whether or not the article dealt specifically with coal mine revegetation. Later, the decision was made to include only those that dealt directly with coal mine revegetation.

[4] Reference to specific trademarks does not imply endorsement by the Bureau of Mines.

A total of 805 references were evaluated within the timeframe of this project and are annotated in this bibliography. Most of them date from 1977 to 1983, but some 1984 publications are included.

AVAILABILITY OF OTHER INFORMATION

Only a portion of the available information on coal mine revegetation is included in this document; other bibliographies are listed in appendix C. New information is constantly being published in trade and scientific journals, books, theses, and Government reports (available from Government agencies and from the National Technical Information Service). Another source of published information is foreign literature, which has not been included in this document unless it deals with revegetation in Canada or the United States.

Reclamation meetings, such as the Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation presented annually at the University of Kentucky, Lexington, KY, are good sources of information. Announcements for reclamation meetings are given in trade journals, as well as in RECTEC, a U.S. Forest Service publication that can be obtained by writing to the following address:

USDA, Forest Service
Northeastern Area State and Private Forestry
Route 2, Highway 21 East
Berea, KY 40403

A great deal of information can be obtained from OSM and State reclamation agencies. Appendix D lists OSM offices and State and Indian contacts for surface-mined-land reclamation programs.

REFERENCE CATEGORIES

To evaluate the references, a list of 32 keywords based on the revegetation process was developed. This list and the coal region designations used are discussed below. The keywords and region designations are used in appendix A to evaluate and identify each article so the reader can quickly scan articles of particular interest.

The keywords were chosen to deal with all aspects of revegetation and to allow the reader to obtain information on particular aspects of revegetation of interest. Initially a revegetation plan that considers land use, regulations, cost, climate, and other factors is developed for a site.

The actual revegetation process begins when the topsoil (or plant growth medium) has been replaced and ends after bond release. Therefore, the keywords were chosen to cover information that affects the revegetation plan as well as the revegetation process, from the time the plant growth medium is replaced through bond release. Additionally, some articles are included that deal with subsoil modification before topsoil is replaced, and other articles are included that evaluate mined areas up to 50 years after mining. These articles are of particular interest in coal mine revegetation and are therefore included in the bibliography.

The following discussion defines the keywords and evaluation code and identifies the coal mining regions. For the purpose of this publication, there are six coal mining regions in the United States (fig. 1). Additionally, two designations define information that can be applied to coal mine revegetation throughout the United States or Canada, or information relating to noncoal revegetation that has application to coal revegetation. The regional designations are--

E--Eastern
I--Interior
G--Gulf Coast
R--Rocky Mountain
N--Northern Great Plains
P--Pacific (includes Alaska and Hawaii)
O--Entire United States and/or Canada
X--Noncoal

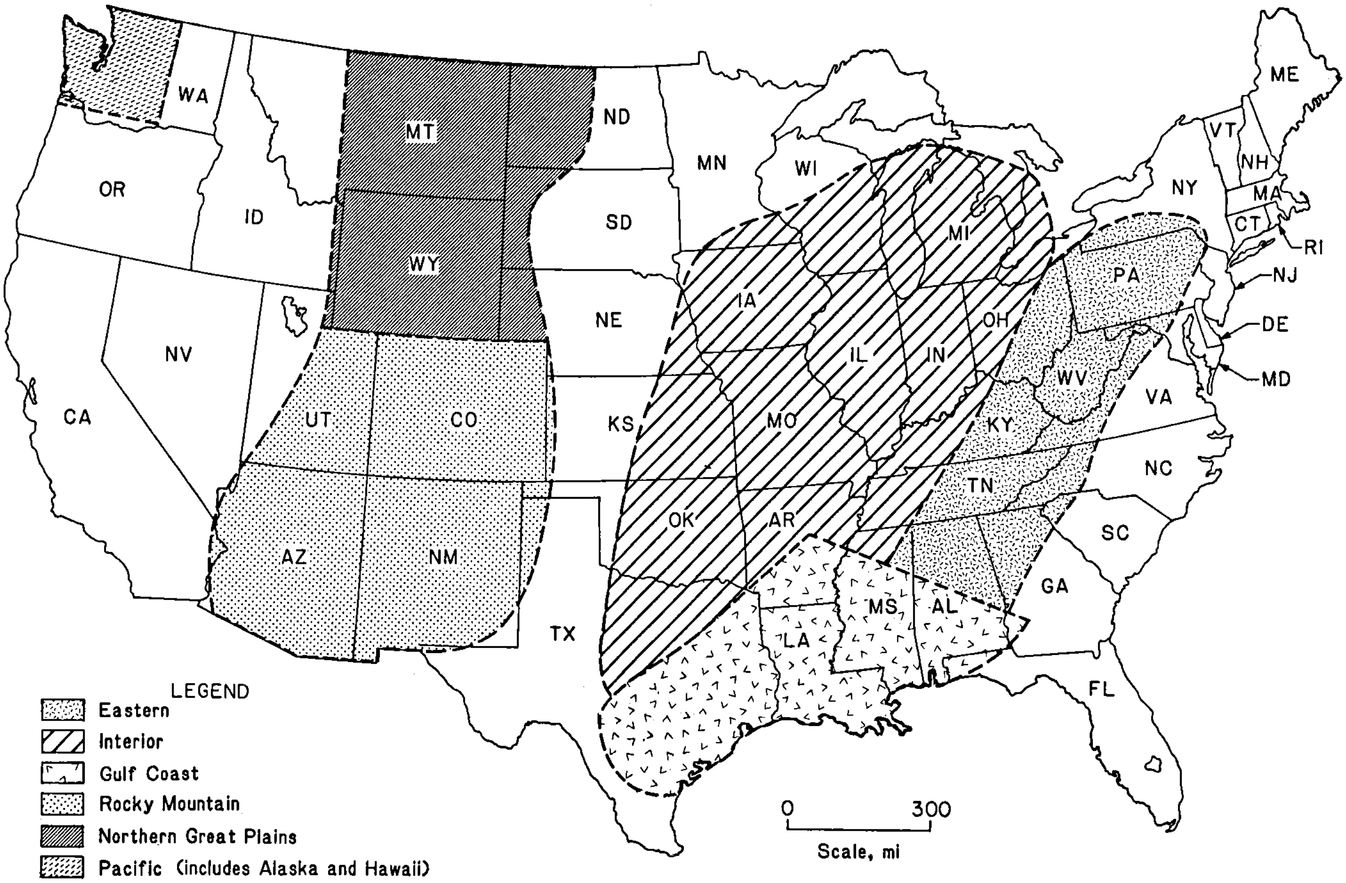

FIGURE 1. - Coal mining regions of the United States.

An evaluation code was developed to provide consistency in rating the articles. The designations E for excellent, G for good, and S for satisfactory are defined below:

E--Excellent reference for that keyword, having direct, practical application and specific information for use in the revegetation of coal-mined lands.

G--Good reference with direct application but with less specific information; or very good reference for background information.

S--Satisfactory reference with limited practical application because it is either too general for direct application or of limited scope.

The above regional coal mining designations and evaluation code were applied to the 32 keywords for each article. These keywords are defined below:

Land use--Specific uses or management-related activities, rather than the vegetation or cover of the land. Land uses may be identified in combination when joint or seasonal uses occur. There are six subcategories of land use, as follows:

Cropland--Land used for the production of adapted crops for harvest, alone or in a rotation with grasses and legumes; includes row crops, small-grain crops, hay crops, nursery crops, orchard crops, and other similar specialty crops.

Grazingland--Both grasslands and forest lands where the indigenous vegetation is actively managed for grazing, browsing, or occasional hay production.

Pastureland--Land used primarily for the long-term production of adapted domesticated forage plants to be grazed by livestock or occasionally cut and cured for livestock feed.

Forestry--Land used or managed for the long-term production of wood, wood fiber, or wood-derived products.

Wildlife--Land dedicated wholly or partly to the production, protection, or management of species of fish or wildlife.

Miscellaneous--Other land uses as defined in CFR 30, 701.5. These include residential, industrial-commercial, recreation, and undeveloped land.

Regulations--Laws and policies pertaining to reclamation and revegetation of coal-mined lands. There are three subcategories of regulations, as follows:

Local--City or county regulations and the policies of individual companies.

State--Regulations of a particular State.

Federal--Regulations of the Federal Government, such as the Office of Surface Mining's rules.

Economic considerations--Information pertaining to the costs and cost benefit of revegetating coal-mined land.

Species selection--Information pertaining to factors that need to be considered in selecting plants for revegetation, as well as plant species and variety characteristics.

Climatic conditions--Information related not only to the climate of a particular area, but also to microclimatic considerations at a particular site.

Soil characterization--Information related to testing for, and the physical and chemical characteristics of, soil(s) to be revegetated, either prior to mining, during topsoil storage, or after topsoil placement.

Erosion control--Vegetative, physical, or mechanical methods of stabilizing soil on areas to be reclaimed. Only information on soil stabilization methods whose primary purpose is erosion control is included in this category.

Soil preparation--Mechanical modification of soil prior to revegetation, using conventional agricultural equipment such as disk harrows or chisels, as well as mining equipment or other specialized equipment. Mixing of soil materials prior to soil replacement is included here. There are two subcategories of soil preparation, as follows:

Topsoil modification--Mechanical modification of the topsoil, i.e., the A soil horizon of the three major soil horizons.

Subsoil modification--Mechanical modification of soil below the topsoil, i.e., below the A horizon.

Soil amendments--Additions made to soil(s) to modify its physical, chemical, or biological character in order to facilitate revegetation. There are six subcategories of soil amendments, as follows:

pH modifiers--Soil amendments whose primary purpose is to raise or lower soil pH.

Mulch--Vegetation residues or other suitable materials applied to soil surfaces that aid in soil stabilization and soil moisture conservation, thus providing microclimatic conditions suitable for germination and growth.

Sludge--Liquid or solid wastes from municipal or industrial processes that are used to provide nutrients on revegetated sites.

Fertilizers--Information on natural and synthetic materials such as manure or nitrogen, phosphorus, and potassium compounds, spread on or worked into soil to increase its fertility.

Biological amendments--Additions of soil-dwelling organisms, such as rhizobium or mycorrhizae-forming fungi, to aid plant growth.

Other--Amendments other than those listed above, that are applied to prevent salt migration or to achieve other purposes.

Vegetation establishment--Information pertaining specifically to the planting of seed, transplants, or other plant materials, and information relating to vegetative succession on reclaimed and abandoned mine lands. There are three subcategories of vegetation establishment, as follows:

Seeding--Information relating to planting seed on minesoil, including seeding rates, techniques, and equipment.

Transplanting--The planting of plant materials other than seed, including seedlings, trees, sodding, sprigging, bare root stock, and clumps of vegetation.

Natural--Information pertaining to natural vegetative succession on mined lands.

Vegetation maintenance--Procedures required after planting to ensure successful revegetation. There are four subcategories of vegetation maintenance, as follows:

Irrigation--Techniques for water addition to planted and revegetation areas.

Soil and/or plant monitoring--Information pertaining to testing for the physical and chemical characteristics of plants and soils on revegetated areas. Information on minesoil development over time is included here.

Pesticides and herbicides--Information on the control of unwanted insects, rodents, and weeds.

Upkeep--Other procedures required to maintain revegetated areas, including mowing, harvesting, reliming, refertilizing, controlled burning, etc.

Vegetation evaluation--Methods of evaluating the success of revegetation, and criteria for allowing bond release. There are three subcategories of vegetation evaluation, as follows:

Reference area--A land unit maintained under appropriate management for the purpose of measuring vegetation ground cover, productivity, and plant species diversity that are produced either naturally or by crop production methods approved by the regulatory authority. Reference areas must be representative of geology, soil, slope, abd vegetation in the permit area.

Ground cover--The area of ground covered by the combined aerial parts of vegetation and the litter that is produced naturally on-site, expressed as a percentage of the total area of measurement.

Productivity--Information on measuring production on revegetated areas. Productivity measurements vary with land use. Three measurement methods--crop production, grazing capacity, and woody plant stocking--are normally used.

A potential problem with evaluating references using this system is personal interpretation of the keywords and the evaluation code, and applying these interpretations to the articles. Another potential problem involved the evaluators' decision to rate articles within each keyword category. In many cases there was not enough discussion or data in an article to qualify it for a "satisfactory" rating in a particular keyword; therefore, although the keyword subject was mentioned, the article did not receive a rating in that category. Using this criterion, many articles were discarded where the entire revegetation section was too general to rate in any keyword category. With four evaluators some inconsistency must be expected; however, periodic cross-checking of evaluations proved them to be very consistent.

A strong point of the keyword system is that almost every facet of coal-mined-land revegetation is included in it. It also provides a simple, rapid, and effective method of screening references so the reader can quickly determine which referencs to obtain. To illustrate by example, the reader first becomes familiar with the keyword, coal region, and evaluation criteria definitions. The next step is to select the coal region and/or keywords of interest, and move horizontally across the table in appendix A, locating references rated for the keyword; these references are identified by numbers 1 through 805 at the top of the table. The reader can then turn to the numbered annotated bibliographical listing in appendix B for more information. The referenced article can then be obtained or rejected, based on the annotation.

SUMMARY

The technical literature pertaining to revegetating coal-mined lands published in the United States and Canada from 1977 to 1984 was reviewed.

From almost 1,800 references considered for inclusion in this bibilography, 805 were chosen for detailed assessment and annotation. Each reference was evaluated for various factors (keywords), and a means was developed for rapidly sorting through the references. This report describes the rationale for selecting references, developing keywords, and evaluating the references. Other sources of information are identified in the report.

APPENDIX A.--REFERENCE EVALUATIONS

KEY TO COAL REGIONS (fig. 1)

E--Eastern
I--Interior
G--Gulf Coast
R--Rocky Mountain
N--Northern Great Plains
P--Pacific (including Alaska and Hawaii)
O--Entire United States and/or Canada
X--Noncoal

KEY TO EVALUATION CODES

E--Excellent reference for that keyword, having direct, practical application and specific information for use in the revegetation of coal-mined lands.

G--Good reference with direct application but with less specific information; or very good reference for background information.

S--Satisfactory refrence with limited practical application, because it is either too general for direct application or of limited scope.

REFERENCE EVALUATIONS

Keywords	Reference No.																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Coal region...............	O	N	O	E	O,X	N,R	I	O	E	E	R	R	R	R	R	E	E	I,E	N,R	N
Land use:																				
Cropland................	--	--	--	--	--	--	E	--	--	--	--	--	--	--	--	--	--	--	--	--
Grazingland.............	--	--	--	--	S	--	--	--	--	--	--	--	S	--	G	--	--	--	G	G
Pastureland.............	--	--	--	S	S	--	--	--	S	S	--	--	--	--	--	--	--	--	--	--
Forestry................	S	--	--	S	S	--	--	--	--	--	--	--	--	--	--	--	--	S	--	--
Wildlife................	S	--	--	--	S	--	--	--	--	--	--	--	--	--	--	G	E	E	--	--
Miscellaneous...........	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Regulations:																				
Local...................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
State...................	--	--	G	--	--	--	E	--	--	--	--	--	--	--	--	--	--	G	--	--
Federal.................	--	--	E	--	--	--	E	--	--	--	--	--	--	--	--	--	--	G	--	--
Economic considerations....	E	--	--	--	G	--	G	--	--	--	--	--	--	--	--	--	E	--	--	--
Species selection..........	G	--	--	G	--	S	--	G	G	S	S	E	S	G	G	S	G	E	E	E
Climatic conditions........	G	--	--	--	--	S	--	--	--	--	--	S	G	G	S	--	--	--	--	--
Soil characterization......	G	E	--	E	--	--	E	--	G	S	--	S	S	S	G	--	--	--	--	--
Erosion control............	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Soil preparation:																				
Topsoil modification.....	G	--	--	--	--	--	E	--	G	E	--	--	--	--	G	--	--	--	S	--
Subsoil modification.....	--	--	--	--	--	--	E	--	--	--	--	--	--	--	--	S	--	--	--	--
Soil amendments:																				
pH modifiers............	G	--	--	E	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Mulch...................	--	--	--	--	--	S	--	--	G	E	--	G	--	--	G	--	--	--	--	--
Sludge..................	--	--	--	--	--	--	--	--	G	E	--	--	--	--	--	--	--	--	--	--
Fertilizers.............	S	--	--	G	--	S	--	--	S	E	--	G	--	--	--	--	--	--	--	--
Biological amendments....	--	--	--	--	--	--	--	--	--	--	G	--	--	--	--	--	--	--	E	--
Other...................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Vegetation establishment:																				
Seeding.................	G	--	--	G	G	S	--	--	G	E	S	G	G	--	E	S	--	--	--	--
Transplanting...........	E	--	--	S	G	--	--	G	--	--	S	G	--	S	--	--	--	--	--	--
Natural.................	S	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	G	--	G
Vegetation maintenance:																				
Irrigation..............	--	--	--	--	--	--	--	--	--	--	--	G	G	--	--	--	--	--	--	--
Soil/plant monitoring....	--	--	--	E	--	S	E	--	E	--	--	--	--	--	S	--	--	--	--	G
Pesticides & herbicides..	--	--	--	--	S	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Upkeep..................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	S	--	--	--	S
Vegetation evaluation:																				
Reference area..........	--	--	--	E	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Ground cover............	G	--	--	--	--	--	--	--	G	E	--	--	--	--	--	--	--	S	--	--
Productivity............	G	--	--	--	--	--	--	--	E	--	S	--	--	--	G	--	--	--	G	G

REFERENCE EVALUATIONS--Continued

Keywords	Reference No.																			
	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Coal region................	N	G	E,I	E	P	O	I	I	I	R,N	E	O	N	G	I	N,R	N,R	I	O	I
Land use:																				
Cropland.................	--	--	G	--	--	--	S	--	--	--	--	G	--	--	S	--	--	--	S	--
Grazingland..............	G	--	--	--	G	--	--	--	--	G	--	G	G	--	--	S	S	--	--	--
Pastureland..............	--	--	G	--	S	--	--	--	--	--	--	G	--	--	--	--	--	S	S	--
Forestry.................	G	E	--	--	G	--	--	S	G	--	--	--	--	--	--	--	--	--	S	E
Wildlife.................	S	G	--	--	G	--	--	--	--	--	--	G	S	--	--	--	--	--	--	G
Miscellaneous............	--	--	--	E	--	--	--	--	--	--	E	--	--	--	--	--	--	--	--	E
Regulations:																				
Local....................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
State....................	--	--	--	--	--	S	--	--	--	--	--	--	--	--	--	--	--	--	--	E
Federal..................	--	--	--	--	--	S	S	--	G	--	--	--	--	--	--	--	--	S	--	--
Economic considerations....	--	--	G	--	--	--	G	--	--	--	--	--	--	--	--	--	--	--	--	G
Species selection..........	G	G	G	S	E	--	--	S	G	--	G	G	G	--	--	E	E	--	--	E
Climatic conditions........	G	--	--	--	--	--	--	--	--	--	--	--	--	--	--	S	S	--	--	--
Soil characterization......	--	--	G	E	--	--	S	E	E	--	--	G	S	G	--	S	S	S	--	--
Erosion control............	--	--	--	--	G	--	E	--	--	--	--	--	--	--	--	--	--	--	--	S
Soil preparation:																				
Topsoil modification.....	G	--	--	G	--	--	--	--	--	E	G	G	G	--	G	--	--	--	G	--
Subsoil modification.....	S	--	--	G	--	--	--	--	--	--	--	--	G	--	G	--	--	--	--	--
Soil amendments:																				
pH modifiers.............	--	--	--	--	--	--	--	G	--	--	--	G	--	S	--	--	--	--	--	--
Mulch....................	G	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sludge...................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Fertilizers..............	--	--	--	--	--	--	--	G	--	--	G	G	S	--	--	--	--	--	--	--
Biological amendments....	--	--	--	--	--	--	--	E	--	--	--	G	--	--	--	--	--	--	--	--
Other....................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Vegetation establishment:																				
Seeding..................	G	--	--	--	--	--	--	E	--	S	G	--	--	--	--	--	--	--	--	--
Transplanting............	G	E	--	--	E	--	--	E	G	--	G	--	G	--	--	--	--	--	--	--
Natural..................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	S
Vegetation maintenance:																				
Irrigation...............	S	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Soil/plant monitoring....	--	--	G	--	G	--	--	E	G	--	--	G	G	--	--	--	--	--	--	E
Pesticides & herbicides..	--	--	--	--	--	--	--	E	E	--	--	--	--	--	--	--	--	--	--	--
Upkeep...................	--	--	--	--	--	--	--	--	--	--	S	--	--	--	--	--	--	--	--	--
Vegetation evaluation:																				
Reference area...........	--	--	--	--	--	--	--	E	E	--	--	--	--	--	--	--	--	--	--	--
Ground cover.............	--	--	--	--	E	S	--	G	E	--	--	G	--	--	--	--	--	--	--	--
Productivity.............	G	G	--	--	E	--	--	E	E	--	--	G	--	--	--	--	--	--	G	G

REFERENCE EVALUATIONS--Continued

Keywords	Reference No.																			
	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Coal region................	I	I	E,I	G	E	O	R,G	E	E	E	I	I	O	N,R	N	N	E	N	N	E
Land use:																				
Cropland..................	--	--	--	S	S	--	--	--	--	--	--	--	--	--	--	--	--	G	--	--
Grazingland...............	--	--	--	--	--	--	--	--	--	--	--	S	--	--	--	--	--	G	S	--
Pastureland...............	--	--	--	--	--	--	--	--	--	S	S	G	--	--	--	S	--	G	--	--
Forestry..................	G	G	G	--	G	--	G	G	--	S	--	--	--	--	--	--	S	--	--	--
Wildlife..................	--	--	--	--	S	--	--	S	--	S	--	--	--	--	--	--	--	--	--	--
Miscellaneous.............	--	--	--	--	--	--	--	--	--	S	--	--	--	--	--	--	--	--	--	S
Regulations:																				
Local.....................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
State.....................	--	--	--	--	--	--	--	--	--	--	--	--	--	E	S	--	--	--	E	--
Federal...................	--	--	G	--	--	--	--	--	--	--	--	--	--	G	--	--	--	E	G	--
Economic considerations....	--	--	--	--	--	--	--	--	--	--	--	--	G	--	S	--	--	--	--	--
Species selection..........	G	E	G	--	E	--	--	--	E	--	--	G	--	--	G	--	G	--	--	--
Climatic conditions........	--	--	--	--	S	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Soil characterization......	S	--	S	S	--	G	--	--	--	G	E	G	E	--	S	E	--	--	--	E
Erosion control............	--	--	--	--	--	--	--	--	--	--	--	--	--	--	S	--	--	--	--	G
Soil preparation:																				
Topsoil modification.....	--	--	--	S	--	--	--	--	--	--	E	E	--	--	G	E	--	--	--	--
Subsoil modification.....	--	--	--	--	--	--	--	--	--	--	E	--	--	--	G	--	--	--	--	--
Soil amendments:																				
pH modifiers.............	--	--	--	--	--	--	--	--	--	E	E	E	--	--	--	--	--	--	--	--
Mulch....................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	S	G	--	--	--	--
Sludge...................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Fertilizers..............	--	--	--	S	--	--	--	--	--	G	E	E	--	--	S	G	--	--	--	--
Biological amendments....	S	--	G	--	--	--	--	E	--	--	--	--	--	--	--	--	--	--	--	--
Other....................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Vegetation establishment:																				
Seeding..................	--	S	S	--	G	--	--	--	G	--	G	G	--	--	G	E	--	--	--	--
Transplanting............	--	G	S	--	E	--	E	--	--	--	--	--	--	--	--	--	--	--	--	--
Natural..................	--	E	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Vegetation maintenance:																				
Irrigation...............	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Soil/plant monitoring....	--	--	--	S	--	E	--	--	--	--	E	--	E	--	S	E	E	--	--	E
Pesticides & herbicides..	S	--	--	--	--	--	--	--	--	--	--	--	--	--	--	G	--	--	--	--
Upkeep...................	--	--	--	--	--	--	--	--	--	--	--	G	--	--	--	--	--	--	--	--
Vegetation evaluation:																				
Reference area...........	--	--	--	--	--	--	--	--	--	--	E	--	--	--	S	E	E	--	--	--
Ground cover.............	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	E	--	--	--
Productivity.............	G	E	S	S	--	--	--	--	--	--	--	--	--	--	S	--	--	--	--	--

REFERENCE EVALUATIONS--Continued

Keywords	Reference No.																			
	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
Coal region................	E	N,R	N,R	E,X	E,X	E,X	E	E,X	E,X	X	O	G	N	N	E	N	N	N,R	N,X	N
Land use:																				
Cropland.................	S	--	S	--	--	--	--	--	--	--	--	S	--	--	--	--	--	--	--	--
Grazingland..............	S	S	S	--	--	--	--	--	--	--	--	S	G	--	G	G	G	S	--	G
Pastureland..............	S	--	S	--	--	--	--	--	--	--	--	S	--	--	--	--	--	S	--	--
Forestry.................	S	--	S	S	S	S	S	S	S	S	--	S	G	--	S	--	--	S	--	--
Wildlife.................	S	--	S	--	--	--	--	--	--	--	--	S	S	--	--	G	G	--	S	G
Miscellaneous............	--	--	S	--	--	--	--	--	--	--	--	S	--	--	S	--	--	--	--	--
Regulations:																				
Local....................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	S	--	--	--	--	--
State....................	--	--	--	--	--	--	--	--	--	--	--	S	--	--	S	--	S	--	--	--
Federal..................	G	--	--	--	--	--	--	--	--	--	--	S	--	--	--	--	--	S	--	--
Economic considerations....	--	--	--	--	--	--	--	--	--	--	--	E	--	--	G	G	--	--	--	S
Species selection..........	S	--	--	S	E	--	G	--	--	E	--	--	E	--	G	E	G	--	S	E
Climatic conditions........	--	--	--	--	--	--	--	--	--	--	--	--	G	S	S	--	--	--	--	G
Soil characterization......	S	E	G	--	E	E	--	--	E	--	--	--	G	S	G	--	--	--	--	--
Erosion control............	S	--	--	--	--	--	--	--	--	--	E	--	--	--	S	--	--	--	--	--
Soil preparation:																				
Topsoil modification.....	--	--	--	E	G	--	--	--	G	--	--	S	G	S	S	--	--	--	--	--
Subsoil modification.....	--	--	--	E	G	E	--	--	E	--	--	--	--	--	--	--	--	--	--	--
Soil amendments:																				
pH modifiers.............	S	--	--	S	--	--	--	--	E	--	--	--	--	--	--	--	--	--	--	--
Mulch....................	S	G	--	--	--	--	--	--	E	G	--	--	--	--	--	S	--	--	--	--
Sludge...................	S	--	--	E	E	E	--	E	E	--	--	--	--	--	--	--	--	--	--	--
Fertilizers..............	S	E	--	E	E	E	--	--	E	G	--	--	--	--	G	--	--	--	--	--
Biological amendments....	--	--	--	E	--	--	--	--	G	E	--	--	--	--	--	G	--	--	--	--
Other....................	S	--	--	--	--	--	--	--	--	G	--	--	--	--	--	--	--	--	G	--
Vegetation establishment:																				
Seeding..................	--	--	--	S	--	--	--	--	G	G	--	--	G	S	--	G	--	--	G	E
Transplanting............	--	--	--	G	E	E	--	G	E	--	--	--	G	--	--	G	--	--	--	--
Natural..................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Vegetation maintenance:																				
Irrigation...............	--	--	--	--	--	--	--	S	--	--	--	--	E	--	--	--	--	--	--	--
Soil/plant monitoring....	--	S	--	--	E	--	E	E	E	--	--	--	--	--	--	--	--	--	G	--
Pesticides & herbicides..	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Upkeep...................	--	S	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Vegetation evaluation:																				
Reference area...........	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	E	--	--
Ground cover.............	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	G	S	E	--	--
Productivity.............	--	--	--	E	E	E	E	E	G	E	--	--	G	--	--	G	G	E	G	E

REFERENCE EVALUATIONS--Continued

Keywords	Reference No.																			
	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
Coal region	O,X	I	O	O	E	E	E	O,X	O	I	E	E	E	E	I,E	G	R,X	O	N,X	O
Land use:																				
Cropland	--	--	S	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Grazingland	--	S	S	--	--	--	--	S	--	--	--	--	S	--	--	S	--	--	S	--
Pastureland	--	S	S	--	--	--	--	--	--	--	--	G	--	S	--	--	S	S	--	--
Forestry	--	--	S	--	--	--	--	S	G	S	G	--	S	--	G	--	--	--	--	--
Wildlife	--	--	--	--	E	G	--	S	--	--	G	--	S	--	S	--	--	--	--	--
Miscellaneous	--	--	--	--	--	--	--	S	--	--	--	--	--	--	--	--	--	--	S	--
Regulations:																				
Local	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
State	--	--	--	S	--	--	--	--	--	--	--	--	--	--	--	--	S	--	--	--
Federal	--	--	--	S	--	--	--	--	--	--	--	--	--	--	--	--	S	--	--	S
Economic considerations	--	--	S	S	--	--	--	--	--	--	--	G	--	--	--	--	E	--	--	--
Species selection	E	--	--	--	E	--	S	S	--	--	E	G	G	G	E	--	--	--	G	--
Climatic conditions	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	S	--	--	G	--
Soil characterization	E	--	--	--	--	--	--	S	--	--	S	--	--	G	S	G	--	--	--	--
Erosion control	--	--	--	--	G	--	--	--	--	--	--	S	--	--	--	--	--	--	--	--
Soil preparation:																				
Topsoil modification	G	--	E	--	--	--	--	--	--	--	--	--	--	--	--	--	G	--	--	--
Subsoil modification	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Soil amendments:																				
pH modifiers	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	G	--	--	G	--
Mulch	G	--	--	--	--	--	--	--	--	--	G	E	E	--	S	--	--	--	G	--
Sludge	--	--	--	--	--	--	E	--	--	--	--	--	--	--	--	--	--	--	--	--
Fertilizers	G	E	--	--	--	--	--	--	--	--	G	S	S	G	S	G	--	G	G	--
Biological amendments	--	--	--	--	--	--	--	--	--	--	S	--	--	--	--	--	--	E	--	--
Other	--	--	--	--	--	--	--	--	--	--	--	--	E	--	--	--	--	--	--	--
Vegetation establishment:																				
Seeding	G	--	--	--	--	--	--	S	--	--	G	S	G	S	S	--	--	S	G	--
Transplanting	--	--	--	--	--	--	--	S	--	S	--	--	--	--	--	--	--	--	S	--
Natural	--	--	--	--	--	G	--	S	--	--	--	--	--	--	--	--	--	--	S	--
Vegetation maintenance:																				
Irrigation	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Soil/plant monitoring	E	--	--	--	E	--	G	S	--	--	--	--	--	--	G	E	--	--	--	--
Pesticides & herbicides	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Upkeep	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Vegetation evaluation:																				
Reference area	--	--	--	--	G	G	--	--	--	--	--	--	--	G	--	E	--	--	--	--
Ground cover	E	--	--	--	--	--	--	--	--	--	E	E	E	--	--	--	--	--	--	E
Productivity	E	--	--	--	--	E	--	--	--	S	E	E	E	E	E	E	--	--	--	--

REFERENCE EVALUATIONS--Continued

Keywords	Reference No.																			
	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120
Coal region................	N,R	N,R	E	I	O,X	E	I	R,X	O	N,R	E	E	E,I	E	E	E	O	I	I	I
Land use:																				
Cropland.................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	S	--	G	G
Grazingland..............	S	S	--	--	--	--	--	--	--	G	--	--	--	--	--	--	S	--	--	--
Pastureland..............	S	--	--	--	--	--	--	--	--	--	S	--	--	--	--	--	S	--	G	G
Forestry.................	S	--	G	S	--	--	S	--	--	--	--	E	G	S	S	G	S	--	--	--
Wildlife.................	S	S	--	--	--	G	--	--	G	--	--	--	--	--	--	--	--	--	--	--
Miscellaneous............	--	--	--	--	--	G	--	--	--	--	--	--	--	--	--	--	S	--	--	--
Regulations:																				
Local....................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
State....................	--	--	--	--	--	--	--	--	S	--	--	--	--	--	--	--	--	--	--	--
Federal..................	--	S	--	--	--	--	--	--	S	--	--	--	--	--	--	--	--	--	--	--
Economic considerations....	--	G	--	--	--	--	--	--	--	--	E	S	S	--	--	G	--	--	--	G
Species selection..........	S	--	G	--	G	G	S	--	S	E	E	G	G	S	E	E	--	--	S	G
Climatic conditions........	--	--	--	--	--	S	--	S	--	G	--	--	--	--	--	--	--	--	G	G
Soil characterization......	--	--	G	E	E	--	G	G	--	S	--	E	--	--	S	E	--	--	S	S
Erosion control............	--	S	G	--	--	G	--	--	--	--	--	S	--	--	--	--	--	--	--	--
Soil preparation:																				
Topsoil modification.....	--	--	--	--	--	S	--	--	--	G	G	--	--	--	--	--	--	--	--	--
Subsoil modification.....	--	--	--	--	--	--	--	--	--	--	G	--	--	--	--	--	--	--	--	--
Soil amendments:																				
pH modifiers.............	--	--	--	--	E	S	G	--	--	G	E	--	--	--	--	--	--	--	--	--
Mulch....................	--	--	--	--	G	--	--	--	--	--	E	--	--	E	G	S	--	--	--	--
Sludge...................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Fertilizers..............	--	--	E	--	G	S	G	--	--	G	G	G	S	G	G	G	--	--	--	--
Biological amendments....	--	--	E	--	--	--	S	--	--	E	--	--	--	--	--	--	--	--	--	--
Other....................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Vegetation establishment:																				
Seeding..................	--	S	G	--	E	S	G	--	--	G	E	G	S	--	E	G	--	--	--	--
Transplanting............	--	E	--	--	G	G	G	--	--	--	--	G	--	G	--	G	--	--	--	--
Natural..................	--	--	--	--	E	--	--	S	--	--	--	--	--	--	--	--	--	--	--	--
Vegetation maintenance:																				
Irrigation...............	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Soil/plant monitoring....	--	--	G	--	--	--	S	E	--	--	G	G	--	E	--	E	--	--	G	G
Pesticides & herbicides..	--	--	G	--	--	--	E	--	--	--	--	--	--	--	--	--	--	--	--	--
Upkeep...................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Vegetation evaluation:																				
Reference area...........	E	--	--	E	--	--	E	G	--	--	--	--	--	--	--	--	--	--	G	G
Ground cover.............	E	--	G	--	E	--	E	--	--	--	G	--	--	--	--	--	G	E	E	E
Productivity.............	E	--	G	--	E	S	E	--	--	E	E	--	G	E	--	E	G	--	E	E

REFERENCE EVALUATIONS--Continued

Keywords	Reference No.																			
	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140
Coal region	I	0	E	E	0	0	E	I	0	I	0	0	I	P,X	E,I	0	P	I	0	R
Land use:																				
Cropland	--	G	--	E	--	--	--	--	--	--	--	--	E	--	--	--	S	S	--	--
Grazingland	G	G	--	--	--	S	--	S	--	--	--	--	--	S	--	--	S	--	--	--
Pastureland	G	G	--	--	--	S	--	S	--	--	--	--	--	--	--	--	--	S	G	--
Forestry	--	--	G	--	--	S	--	--	--	--	--	--	--	--	--	--	S	--	--	--
Wildlife	--	G	--	--	--	--	G	--	--	--	--	--	--	--	--	--	--	--	--	--
Miscellaneous	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Regulations:																				
Local	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
State	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	S	--	--
Federal	--	--	--	G	--	S	--	S	--	--	--	G	--	--	--	E	--	S	--	--
Economic considerations	--	G	--	--	--	--	--	--	--	G	E	--	--	--	--	--	--	S	--	--
Species selection	E	G	E	--	--	--	--	E	E	E	--	--	--	E	E	--	S	--	G	--
Climatic conditions	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	G
Soil characterization	--	S	S	--	--	--	--	E	S	--	--	--	--	S	--	--	--	--	E	G
Erosion control	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Soil preparation:																				
Topsoil modification	--	G	--	--	--	--	--	--	--	--	--	S	--	S	G	--	--	S	E	--
Subsoil modification	--	--	--	--	--	--	--	--	--	--	--	S	E	--	--	--	--	S	--	--
Soil amendments:																				
pH modifiers	--	G	--	--	--	--	--	E	--	--	--	--	--	--	G	--	--	--	--	--
Mulch	--	--	--	--	--	--	--	--	--	--	--	--	--	G	G	--	--	--	--	--
Sludge	--	--	--	--	--	--	--	--	--	--	--	--	--	--	S	--	--	--	--	--
Fertilizers	--	G	--	--	--	--	--	E	--	S	--	--	--	G	G	--	S	--	E	--
Biological amendments	--	G	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	G
Other	--	--	--	--	--	--	--	--	--	--	--	--	--	G	--	--	--	--	--	--
Vegetation establishment:																				
Seeding	G	--	--	--	--	--	--	--	--	--	--	S	--	G	E	--	--	--	G	--
Transplanting	--	--	G	--	--	--	--	--	--	E	--	--	--	--	E	--	--	--	--	--
Natural	G	--	--	--	--	--	S	--	--	--	--	--	--	--	--	--	--	--	--	--
Vegetation maintenance:																				
Irrigation	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Soil/plant monitoring	G	G	E	--	--	--	--	E	--	--	--	--	--	G	--	--	--	--	--	G
Pesticides & herbicides	--	--	S	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Upkeep	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Vegetation evaluation:																				
Reference area	--	--	--	--	--	E	--	--	--	--	--	--	--	--	--	--	--	S	E	G
Ground cover	E	G	--	--	--	E	G	--	--	S	--	--	--	--	--	--	--	--	--	--
Productivity	E	G	E	--	E	E	--	E	--	--	--	--	--	G	--	--	--	S	--	G

REFERENCE EVALUATIONS--Continued

Keywords	Reference No.																			
	141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160
Coal region................	N,R	N,R	N,R	G	P	N,R	E	I	N,R	N,R,X	G,E	E	O,X	N	N,R,X	N,R	E	I	I	E
Land use:																				
Cropland................	S	--	--	S	S	--	--	--	--	--	--	--	--	--	S	--	--	E	--	--
Grazingland.............	S	S	E	--	S	S	--	--	G	G	--	--	--	S	S	G	--	--	--	--
Pastureland.............	S	--	--	G	--	--	--	--	--	--	--	--	--	--	--	G	--	--	--	--
Forestry................	S	S	--	S	--	--	G	--	--	--	--	S	--	--	--	--	--	--	--	--
Wildlife................	S	S	--	S	G	--	--	--	--	G	--	--	--	S	--	S	G	--	--	--
Miscellaneous...........	S	--	--	--	--	--	--	G	--	--	--	--	--	S	--	--	--	--	--	--
Regulations:																				
Local...................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
State...................	G	--	S	--	--	--	--	--	--	--	--	--	--	S	--	--	--	--	--	--
Federal.................	G	--	S	--	S	--	--	--	--	--	--	--	--	S	--	--	--	--	--	--
Economic considerations....	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Species selection..........	--	--	S	E	S	--	S	--	S	G	--	E	S	G	G	G	G	G	--	--
Climatic conditions........	--	--	--	--	--	S	--	G	--	--	--	--	E	--	--	S	--	--	--	--
Soil characterization......	--	--	--	S	--	S	G	--	--	G	G	--	--	--	G	--	--	E	G	--
Erosion control............	S	--	--	--	--	S	--	--	--	--	--	--	--	S	--	--	--	--	--	--
Soil preparation:																				
Topsoil modification.....	--	--	--	G	S	S	S	--	--	G	--	--	--	S	--	--	--	--	--	--
Subsoil modification.....	--	--	--	G	--	S	--	--	--	G	--	S	--	--	--	--	--	--	--	--
Soil amendments:																				
pH modifiers............	--	--	--	--	--	--	--	--	--	--	S	--	S	--	--	--	--	--	G	--
Mulch...................	--	--	--	--	--	--	G	--	--	G	--	G	--	--	S	--	G	--	--	--
Sludge..................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Fertilizers.............	--	--	--	--	S	--	G	--	--	G	G	E	S	--	S	--	G	G	G	--
Biological amendments....	--	--	--	--	--	--	--	--	--	--	S	--	--	--	S	--	--	--	S	--
Other...................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Vegetation establishment:																				
Seeding.................	--	--	--	G	S	--	E	--	--	S	S	E	S	G	S	--	G	--	--	--
Transplanting...........	--	S	--	G	S	--	E	--	E	S	--	E	--	G	--	--	G	--	--	--
Natural.................	--	--	--	--	--	--	--	S	--	--	--	--	E	--	G	--	--	--	--	--
Vegetation maintenance:																				
Irrigation..............	--	--	--	--	--	--	S	--	S	G	--	--	--	--	--	--	--	--	--	--
Soil/plant monitoring....	--	--	--	--	--	--	E	S	--	G	S	--	E	--	G	--	--	E	--	E
Pesticides & herbicides..	--	--	--	--	--	--	S	--	--	--	--	--	--	--	--	--	--	--	--	--
Upkeep..................	--	--	--	G	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Vegetation evaluation:																				
Reference area...........	G	--	--	--	--	--	--	--	--	G	--	--	S	--	--	--	--	--	--	--
Ground cover............	G	--	--	--	--	--	--	--	--	G	G	--	E	--	--	--	S	--	--	--
Productivity............	G	--	E	--	--	--	E	--	--	G	G	E	--	--	--	--	--	G	G	--

REFERENCE EVALUATIONS--Continued

Keywords	Reference No.																			
	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180
Coal region...............	E	E	O	I	E	N	E	E	E	E	E	E	E	E,I	E,I	R,X	R,X	R,X	R	R
Land use:																				
Cropland.................	--	--	--	S	--	--	--	--	--	--	--	--	--	--	--	--	--	S	--	--
Grazingland..............	--	--	G	S	--	G	--	--	--	--	--	--	--	--	--	G	G	--	E	--
Pastureland..............	--	S	G	S	--	--	--	--	--	--	S	--	--	--	--	--	--	--	--	--
Forestry.................	--	--	--	S	S	--	S	G	G	S	--	S	G	G	G	--	--	--	--	--
Wildlife.................	--	--	G	S	--	--	--	--	--	--	--	--	--	--	G	S	S	--	--	--
Miscellaneous............	--	--	--	S	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Regulations:																				
Local....................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
State....................	--	--	--	--	G	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Federal..................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Economic considerations....	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Species selection..........	--	S	G	--	G	E	--	G	E	E	G	G	S	E	--	E	E	--	E	--
Climatic conditions........	--	--	--	--	--	--	--	--	G	--	--	--	--	--	--	--	--	--	S	--
Soil characterization......	E	E	--	E	S	--	S	--	G	G	--	--	--	S	--	--	--	--	G	--
Erosion control............	--	--	--	--	--	G	--	--	--	--	--	--	--	--	--	--	S	--	--	--
Soil preparation:																				
Topsoil modification.....	--	--	--	--	--	--	S	--	--	--	S	--	--	S	--	G	G	S	S	--
Subsoil modification.....	--	--	--	--	S	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Soil amendments............																				
pH modifiers.............	--	G	--	S	S	--	--	--	--	--	E	--	--	--	--	--	--	--	--	--
Mulch....................	--	--	--	--	--	E	--	--	--	--	--	--	--	--	--	S	S	G	--	G
Sludge...................	--	G	E	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Fertilizers..............	--	E	E	--	G	--	S	--	--	--	E	--	E	--	--	S	S	G	--	--
Biological amendments....	--	--	E	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Other....................	--	E	G	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Vegetation establishment:																				
Seeding..................	--	E	G	S	--	G	--	--	S	--	E	--	--	--	G	G	G	G	E	--
Transplanting............	--	--	G	--	S	--	E	--	G	S	--	G	--	--	--	--	--	--	--	--
Natural..................	--	--	--	--	--	--	--	--	--	--	--	G	--	--	--	--	--	--	--	--
Vegetation maintenance:																				
Irrigation...............	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	G	G	S	E	--
Soil/plant monitoring....	E	E	E	--	--	--	--	--	--	--	G	G	S	--	--	--	--	G	--	G
Pesticides & herbicides..	--	--	--	--	--	--	S	--	--	--	--	--	S	--	--	--	--	--	--	--
Upkeep...................	--	--	--	--	G	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Vegetation evaluation:																				
Reference area...........	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	E	--
Ground cover.............	--	--	--	E	--	E	--	--	--	--	E	E	--	--	--	E	E	--	E	--
Productivity.............	--	E	E	--	G	E	--	E	E	E	--	E	E	G	G	E	E	G	E	--

REFERENCE EVALUATIONS--Continued

Keywords	Reference No.																			
	181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200
Coal region................	R	E	N	N	N	N	N	P,R,X	N,G	X	I,G	N,R	G	O	R,X	N	N	N	N	I
Land use:																				
Cropland.................	--	--	--	--	--	S	--	--	--	--	S	--	--	--	--	G	--	--	S	--
Grazingland..............	S	--	G	G	S	S	S	--	S	--	--	G	--	S	S	--	S	--	S	--
Pastureland..............	--	S	--	S	--	S	--	--	--	--	S	--	--	--	--	--	--	--	S	G
Forestry.................	--	--	--	--	--	S	--	--	S	S	--	G	--	--	--	--	--	--	--	--
Wildlife.................	S	--	--	S	--	--	--	S	S	--	E	G	--	--	--	--	--	--	--	--
Miscellaneous............	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Regulations:																				
Local....................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
State....................	S	--	--	--	--	--	--	--	S	--	--	--	--	--	--	--	--	--	--	--
Federal..................	G	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Economic considerations....	S	--	--	--	--	--	--	E	--	--	S	--	--	--	--	--	--	G	--	--
Species selection..........	S	S	--	G	G	E	E	S	--	E	E	E	--	--	E	--	--	--	--	G
Climatic conditions........	G	--	--	--	S	S	G	G	--	S	--	--	--	--	--	--	--	--	--	S
Soil characterization......	--	--	--	--	--	--	--	--	--	G	S	--	E	--	G	G	E	G	E	S
Erosion control............	--	--	--	--	--	S	--	--	--	--	--	--	--	S	--	--	--	--	--	G
Soil preparation:																				
Topsoil modification.....	--	G	E	--	G	E	G	--	--	G	S	--	--	S	G	G	G	--	--	--
Subsoil modification.....	--	--	--	--	--	G	--	--	--	--	--	--	--	--	G	G	--	G	--	G
Soil amendments:																				
pH modifiers.............	--	E	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	E	--
Mulch....................	--	--	--	--	--	G	G	S	--	--	--	--	--	--	G	--	--	--	--	--
Sludge...................	--	E	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Fertilizers..............	--	E	--	G	G	E	G	G	--	G	S	--	G	--	E	--	--	--	--	--
Biological amendments....	--	S	--	--	--	S	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Other....................	--	E	--	--	--	--	G	--	--	--	--	--	--	--	--	--	E	--	--	--
Vegetation establishment:																				
Seeding..................	--	G	--	G	E	E	E	G	S	S	G	--	--	--	E	--	--	--	--	S
Transplanting............	--	--	--	--	--	G	--	G	--	E	G	--	--	--	--	--	--	--	--	--
Natural..................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Vegetation maintenance:																				
Irrigation...............	S	--	--	G	--	--	E	S	--	--	--	--	--	--	E	--	G	--	--	--
Soil/plant monitoring....	S	E	--	--	--	--	--	--	--	--	--	--	--	--	--	--	E	--	--	--
Pesticides & herbicides..	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Upkeep...................	--	--	--	G	--	--	--	--	--	--	S	--	--	--	--	--	--	--	--	--
Vegetation evaluation:																				
Reference area...........	G	--	--	--	--	--	--	--	--	--	--	--	--	--	--	G	--	--	--	--
Ground cover.............	--	--	--	--	E	E	E	--	--	--	--	--	--	--	G	--	--	--	--	--
Productivity.............	--	E	S	S	E	E	E	--	--	E	--	--	--	--	E	G	E	--	--	--

REFERENCE EVALUATIONS--Continued

Keywords	Reference No.																			
	201	202	203	204	205	206	207	208	209	210	211	212	213	214	215	216	217	218	219	220
Coal region...............	I	I	I,G	N	I	N	N	N	N	N	O	N	N,R	I	N,R,G	E	E,I	O	O	I,X
Land use:																				
Cropland................	E	--	--	--	--	--	--	--	--	--	--	--	--	E	--	--	--	S	--	S
Grazingland.............	--	--	--	S	--	G	--	S	E	E	--	E	E	--	S	--	--	S	--	--
Pastureland.............	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	S	S	--	--
Forestry................	--	S	S	--	--	--	--	--	--	--	--	--	--	--	--	S	S	S	--	--
Wildlife................	--	S	--	E	--	S	--	--	--	--	--	G	E	--	--	--	S	S	--	--
Miscellaneous...........	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	S	--	--
Regulations:																				
Local...................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
State...................	--	--	S	--	--	--	--	--	--	--	--	--	--	--	E	--	--	--	--	--
Federal.................	--	--	--	--	--	--	--	--	--	--	E	--	--	--	E	--	--	--	--	--
Economic considerations....	E	--	--	--	--	--	--	--	--	--	--	--	--	G	--	--	--	--	--	--
Species selection..........	--	S	--	E	G	E	E	E	E	E	--	E	G	G	S	G	E	--	--	--
Climatic conditions........	G	--	--	--	--	--	--	--	--	--	--	E	--	--	--	--	--	--	--	--
Soil characterization......	E	--	--	--	G	--	--	--	S	S	--	E	--	G	S	--	--	E	G	E
Erosion control............	G	--	--	--	--	--	--	--	--	--	--	E	--	G	S	--	S	--	--	--
Soil preparation:																				
Topsoil modification.....	E	--	--	--	--	S	--	S	--	--	--	--	S	G	S	--	--	--	--	--
Subsoil modification.....	--	--	--	--	--	--	--	--	--	--	--	--	--	G	S	--	--	--	--	--
Soil amendments:																				
pH modifiers.............	G	--	--	--	E	--	--	--	--	--	--	--	--	G	--	--	--	--	--	--
Mulch....................	--	--	--	--	--	--	--	--	--	--	--	E	S	--	--	--	--	--	--	--
Sludge...................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Fertilizers..............	G	--	--	--	E	--	--	--	--	--	--	E	--	G	--	--	--	--	--	--
Biological amendments....	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Other....................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	G
Vegetation establishment:																				
Seeding..................	--	--	--	S	--	G	--	S	G	G	--	--	G	--	--	--	E	--	--	--
Transplanting............	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Natural..................	--	--	--	--	--	--	--	S	G	G	--	--	--	--	--	--	--	--	--	--
Vegetation maintenance:																				
Irrigation...............	--	--	--	--	--	--	--	S	--	--	--	E	--	--	--	--	--	--	--	--
Soil/plant monitoring....	E	--	--	--	E	--	--	--	E	E	--	E	--	--	--	--	--	E	G	G
Pesticides & herbicides..	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Upkeep...................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Vegetation evaluation:																				
Reference area...........	E	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Ground cover.............	--	--	--	E	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Productivity.............	E	S	--	S	E	E	--	G	E	E	--	E	E	G	--	E	--	--	--	--

REFERENCE EVALUATIONS--Continued

Keywords	Reference No.																			
	221	222	223	224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240
Coal region................	E	E	E	I,E	I	E	O,X	O	O	O,X	I	R,X	R,N	O	O	R	N,R	N	E	E
Land use:																				
Cropland.................	S	--	--	--	--	--	--	--	--	--	S	--	--	--	--	--	S	--	--	--
Grazingland..............	S	--	--	E	--	--	--	--	--	--	--	S	S	--	--	--	S	G	--	--
Pastureland..............	S	--	--	E	--	--	--	--	--	--	--	--	--	--	--	--	S	--	--	--
Forestry.................	S	S	--	--	S	S	--	--	S	S	--	--	--	--	--	G	--	--	--	--
Wildlife.................	--	--	--	--	S	--	--	--	S	--	--	--	S	--	--	G	--	--	G	E
Miscellaneous............	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Regulations:																				
Local....................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
State....................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Federal..................	--	--	--	--	--	--	--	E	--	S	--	--	--	--	S	--	--	--	--	--
Economic considerations....	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	G
Species selection..........	--	--	S	E	S	--	--	--	--	G	S	E	G	--	--	G	--	G	E	E
Climatic conditions........	--	--	--	--	--	--	--	--	--	--	--	E	S	S	--	G	--	--	--	--
Soil characterization......	E	--	E	S	--	G	G	--	--	--	E	--	--	--	--	--	E	--	G	--
Erosion control............	--	--	--	--	--	--	S	--	--	--	--	--	--	G	--	--	--	E	--	--
Soil preparation:																				
Topsoil modification.....	--	--	--	--	--	G	G	--	--	E	E	G	--	--	--	--	S	--	--	--
Subsoil modification.....	--	--	--	--	--	--	--	--	--	--	E	--	--	--	--	--	--	--	--	--
Soil amendments:																				
pH modifiers.............	--	--	S	--	--	--	G	--	--	--	--	--	--	--	--	--	--	--	--	--
Mulch....................	--	--	--	G	--	S	--	--	--	--	--	G	--	--	--	G	--	--	--	S
Sludge...................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Fertilizers..............	--	--	G	S	--	G	G	--	--	G	S	--	--	--	--	--	--	--	--	S
Biological amendments....	--	--	S	--	--	--	--	--	--	--	--	--	--	--	--	E	--	--	--	--
Other....................	--	--	--	--	--	--	--	--	S	S	--	--	--	--	--	--	--	--	--	--
Vegetation establishment:																				
Seeding..................	--	--	--	E	--	--	--	--	S	E	--	--	G	--	--	--	--	--	--	G
Transplanting............	--	--	--	--	--	--	--	--	--	G	--	G	G	--	--	E	--	--	G	G
Natural..................	--	G	--	--	--	E	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Vegetation maintenance:																				
Irrigation...............	--	--	--	--	--	S	--	--	--	--	--	--	S	--	--	E	--	--	--	--
Soil/plant monitoring....	--	--	E	--	--	E	G	--	--	--	--	G	--	--	--	--	--	--	--	--
Pesticides & herbicides..	--	--	--	--	--	--	--	--	--	--	--	--	S	--	--	G	--	G	--	--
Upkeep...................	--	--	--	--	--	--	--	--	--	--	--	--	S	--	--	--	--	--	--	--
Vegetation evaluation:																				
Reference area...........	--	--	--	--	--	--	--	--	--	--	E	--	--	--	--	--	--	--	--	--
Ground cover.............	--	--	--	E	--	--	--	--	--	E	--	--	--	--	E	--	--	S	E	--
Productivity.............	--	E	S	E	--	E	--	--	--	E	G	E	--	--	--	E	--	S	E	--

REFERENCE EVALUATIONS--Continued

Keywords	Reference No.																			
	241	242	243	244	245	246	247	248	249	250	251	252	253	254	255	256	257	258	259	260
Coal region................	E	R	N,R	R	R	N,R	O	P,X	O	E	G	E,I	R,X	E	R	N	N	O	O	I
Land use:																				
Cropland.................	--	--	--	--	--	S	--	--	--	--	--	--	--	--	--	--	--	S	--	--
Grazingland..............	--	--	--	--	--	S	S	--	--	--	--	--	--	--	--	S	G	S	--	G
Pastureland..............	--	--	--	--	--	S	--	--	--	--	--	--	--	E	--	--	--	S	--	G
Forestry.................	G	--	--	--	--	S	--	--	--	--	--	S	--	--	--	--	--	S	--	--
Wildlife.................	--	--	--	--	--	S	S	--	--	--	--	--	--	--	--	--	--	S	G	--
Miscellaneous............	--	--	--	--	--	S	S	--	--	--	--	--	--	--	--	--	--	S	G	--
Regulations:																				
Local....................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
State....................	--	--	--	--	--	G	--	--	--	--	--	S	--	--	--	--	--	--	--	--
Federal..................	--	G	--	--	--	G	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Economic considerations....	--	--	--	--	--	--	G	--	--	--	--	--	--	E	--	--	--	--	G	--
Species selection..........	E	--	--	G	S	--	--	E	--	E	S	G	S	S	--	--	--	--	--	E
Climatic conditions........	G	E	--	S	--	--	--	--	--	--	--	--	--	--	G	--	--	--	--	--
Soil characterization......	--	S	G	E	E	--	--	E	G	G	G	--	G	--	G	S	S	--	--	S
Erosion control............	--	--	--	--	--	--	--	--	--	--	--	S	--	--	--	E	E	--	--	--
Soil preparation:																				
Topsoil modification.....	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	G	--	--	--	--
Subsoil modification.....	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Soil amendments:																				
pH modifiers.............	--	--	--	--	--	--	--	--	G	G	S	S	--	--	--	--	--	--	--	--
Mulch....................	G	S	--	G	--	--	--	--	--	--	--	--	--	--	--	G	G	--	--	--
Sludge...................	--	--	--	G	G	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Fertilizers..............	--	--	--	G	G	--	--	S	G	G	G	S	G	--	--	--	--	--	--	--
Biological amendments....	--	--	--	--	G	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Other....................	--	--	--	G	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Vegetation establishment:																				
Seeding..................	--	E	--	--	S	--	--	--	--	--	--	S	--	--	--	--	--	--	--	--
Transplanting............	G	--	--	--	--	--	E	--	--	--	--	G	--	--	--	--	--	--	--	--
Natural..................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Vegetation maintenance:																				
Irrigation...............	--	E	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	S	--
Soil/plant monitoring....	--	S	G	E	--	--	--	--	E	--	--	--	--	--	--	--	--	E	--	--
Pesticides & herbicides..	E	--	--	--	--	--	--	S	--	--	--	--	--	--	--	--	--	--	--	--
Upkeep...................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Vegetation evaluation:																				
Reference area...........	--	--	--	--	E	--	--	--	--	--	--	--	--	--	--	G	G	--	--	--
Ground cover.............	--	S	--	--	--	--	--	S	S	--	S	--	--	--	--	--	--	E	--	E
Productivity.............	E	S	--	G	--	--	--	--	--	E	G	--	G	--	--	--	--	E	--	G

REFERENCE EVALUATIONS--Continued

Keywords	Reference No.																			
	261	262	263	264	265	266	267	268	269	270	271	272	273	274	275	276	277	278	279	280
Coal region................	E	R,X	N	N,R	E,I	I,G	I	I	I	E,I	E	E	I	R	E,I	N,R	N	R	R,X	I
Land use:																				
Cropland.................	--	--	--	--	S	G	G	E	G	S	--	--	S	--	S	S	--	--	--	--
Grazingland..............	--	S	G	G	--	G	--	--	--	S	--	--	--	G	--	S	--	G	--	--
Pastureland..............	--	--	--	--	--	G	G	S	--	S	--	--	--	--	--	S	--	--	--	--
Forestry.................	G	--	--	--	S	G	--	--	--	S	--	G	--	--	S	--	--	--	G	--
Wildlife.................	--	--	--	--	--	G	--	--	--	S	--	--	--	--	S	--	--	--	--	--
Miscellaneous............	--	--	--	--	--	G	--	--	--	S	--	--	--	--	S	--	--	--	--	--
Regulations:																				
Local....................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
State....................	--	--	--	--	--	G	--	E	S	--	--	--	G	--	--	--	--	--	--	--
Federal..................	--	--	--	--	--	S	G	E	--	--	--	--	G	--	--	G	--	--	--	--
Economic considerations....	--	--	--	--	E	G	--	--	--	--	S	--	--	--	--	--	--	--	--	--
Species selection..........	E	--	G	E	--	G	G	G	G	E	S	G	S	G	--	--	--	G	G	--
Climatic conditions........	--	--	--	--	--	G	S	--	--	--	S	--	--	--	S	--	G	--	--	--
Soil characterization......	--	G	E	--	G	--	S	E	G	G	--	--	G	G	--	--	G	--	--	G
Erosion control............	--	--	--	--	--	--	S	--	--	G	--	G	E	--	--	--	E	--	--	--
Soil preparation:																				
Topsoil modification.....	--	S	--	--	--	--	--	G	E	G	--	--	--	--	--	--	G	--	--	--
Subsoil modification.....	--	--	--	--	--	--	--	S	--	G	--	--	--	--	--	--	--	--	--	--
Soil amendments:																				
pH modifiers.............	S	--	--	--	G	--	--	--	--	G	--	--	--	--	--	--	--	--	--	G
Mulch....................	S	G	--	--	--	--	--	--	--	G	G	G	--	--	--	--	--	G	G	--
Sludge...................	--	--	--	--	--	--	--	--	--	--	S	--	--	--	--	--	--	--	G	--
Fertilizers..............	S	--	--	--	G	--	G	G	G	G	S	G	--	--	--	--	--	--	G	--
Biological amendments....	--	--	--	--	--	--	--	G	--	--	--	--	--	--	--	--	--	--	E	--
Other....................	--	E	--	--	G	--	--	--	--	--	--	--	--	--	--	--	--	--	--	E
Vegetation establishment:																				
Seeding..................	S	G	--	--	--	--	--	S	--	G	G	G	--	--	--	--	--	G	--	--
Transplanting............	E	--	--	--	--	--	--	--	--	G	G	--	--	--	--	--	--	--	S	--
Natural..................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Vegetation maintenance:																				
Irrigation...............	--	--	--	--	--	--	--	--	--	--	--	--	--	S	--	--	--	G	--	--
Soil/plant monitoring....	--	E	E	E	--	--	--	E	--	--	G	--	S	--	--	--	E	--	--	E
Pesticides & herbicides..	--	--	--	--	--	--	--	--	--	S	--	--	--	--	--	--	--	--	--	--
Upkeep...................	--	--	--	--	--	--	--	--	--	S	--	--	--	--	--	--	--	--	--	--
Vegetation evaluation:																				
Reference area...........	--	--	--	--	--	--	S	G	G	--	--	--	--	--	--	--	--	--	--	--
Ground cover.............	--	--	--	--	--	--	--	--	--	--	G	--	S	S	--	--	--	--	--	--
Productivity.............	E	S	--	--	G	--	G	G	E	--	G	G	S	S	--	--	--	--	G	--

REFERENCE EVALUATIONS--Continued

Keywords	Reference No.																			
	281	282	283	284	285	286	287	288	289	290	291	292	293	294	295	296	297	298	299	300
Coal region................	I	I	E	I	E,G,X	I	E,I	N,R	E	I	N,R	N	E,X	O	N,R	N	O	E	N,R	R
Land use:																				
Cropland.................	--	--	G	S	--	--	--	--	S	--	--	G	--	--	--	--	--	--	--	--
Grazingland..............	--	--	S	--	--	--	--	--	S	--	G	--	--	--	S	--	S	--	G	--
Pastureland..............	--	--	G	S	--	G	--	--	S	--	--	--	--	--	S	--	--	S	--	--
Forestry.................	--	--	S	--	E	--	--	--	S	S	--	--	--	--	S	--	G	--	--	--
Wildlife.................	--	--	S	--	--	--	--	--	S	S	--	--	--	--	S	G	--	--	--	--
Miscellaneous............	--	--	S	S	--	--	--	--	S	S	--	--	--	--	--	--	--	--	--	--
Regulations:																				
Local....................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
State....................	--	--	G	G	--	S	--	--	--	--	--	--	--	--	S	--	--	--	G	--
Federal..................	--	--	--	--	--	S	--	--	--	--	--	--	--	E	S	--	--	--	G	--
Economic considerations....	--	--	G	G	S	E	--	--	--	--	--	--	--	--	--	--	--	--	--	S
Species selection..........	--	--	G	S	E	S	S	--	--	G	--	S	S	--	S	--	--	G	G	S
Climatic conditions........	--	--	G	E	--	--	S	--	--	--	--	--	--	--	--	G	--	E	G	--
Soil characterization......	--	G	G	G	--	--	S	E	E	S	--	G	E	--	--	--	G	E	--	--
Erosion control............	--	--	S	S	--	--	--	--	--	--	--	--	--	--	--	S	--	E	--	--
Soil preparation:																				
Topsoil modification.....	--	--	--	S	--	G	S	--	--	--	G	G	--	--	--	S	--	G	--	--
Subsoil modification.....	--	--	--	--	--	G	--	--	--	--	--	G	--	--	--	S	--	--	--	--
Soil amendments:																				
pH modifiers.............	G	E	S	S	--	--	S	--	--	--	--	--	S	--	--	--	--	G	--	--
Mulch....................	--	--	S	--	--	--	--	--	--	--	--	--	--	--	--	--	--	G	--	--
Sludge...................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Fertilizers..............	--	--	S	S	G	--	S	S	--	--	--	G	S	--	--	--	--	--	--	--
Biological amendments....	--	--	--	--	G	--	--	--	--	S	--	--	--	--	--	--	--	--	--	--
Other....................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	E	--	--
Vegetation establishment:																				
Seeding..................	--	--	S	S	G	--	--	--	--	--	G	--	--	--	--	--	S	G	S	--
Transplanting............	--	--	S	--	E	--	--	--	--	--	G	--	--	--	--	--	--	--	S	--
Natural..................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	S	--
Vegetation maintenance:																				
Irrigation...............	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Soil/plant monitoring....	E	E	--	--	G	--	--	E	--	S	--	--	--	--	--	--	G	E	--	--
Pesticides & herbicides..	--	--	--	--	S	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Upkeep...................	--	--	--	--	S	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Vegetation evaluation:																				
Reference area...........	--	--	--	--	--	--	--	--	--	--	--	--	--	--	E	--	--	--	--	--
Ground cover.............	--	--	--	--	--	--	--	--	--	--	--	--	--	--	E	--	--	--	--	--
Productivity.............	--	--	--	--	E	--	--	--	--	S	--	G	G	--	E	--	--	--	--	--

REFERENCE EVALUATIONS--Continued

Keywords	Reference No.																			
	301	302	303	304	305	306	307	308	309	310	311	312	313	314	315	316	317	318	319	320
Coal region................	R	E	O,X	I	O	O	O,X	O,X	P	E	E,I	R	I	E,I	E	E	I	N	N	R,X
Land use:																				
Cropland.................	--	--	--	--	--	--	--	--	--	--	--	--	E	--	--	S	--	--	--	--
Grazingland..............	G	--	S	--	--	--	--	--	--	--	--	G	--	--	--	--	--	--	--	--
Pastureland..............	--	--	S	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Forestry.................	--	--	--	S	--	--	--	S	S	G	S	--	--	--	S	--	--	--	--	--
Wildlife.................	--	--	--	S	G	G	--	--	--	G	--	--	--	--	--	--	E	--	--	--
Miscellaneous............	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Regulations:																				
Local....................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
State....................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Federal..................	--	--	--	--	G	G	--	--	--	--	--	--	--	--	--	--	E	--	--	--
Economic considerations....	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Species selection..........	S	--	S	--	--	--	--	G	G	G	S	E	S	G	G	E	E	--	--	--
Climatic conditions........	--	--	--	G	--	--	--	--	S	--	--	S	--	S	--	--	--	--	--	--
Soil characterization......	--	--	--	--	--	--	--	--	--	--	--	--	G	S	--	--	--	--	E	G
Erosion control............	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	E	--	--	--
Soil preparation:																				
Topsoil modification.....	S	--	--	--	--	--	--	--	E	--	--	E	G	--	--	--	E	--	--	S
Subsoil modification.....	S	--	--	--	--	--	--	--	--	--	--	E	G	--	--	--	--	--	--	--
Soil amendments:																				
pH modifiers.............	--	--	--	--	--	--	--	--	--	--	--	--	G	S	--	--	E	--	--	--
Mulch....................	--	--	--	--	--	--	--	--	--	--	--	--	--	S	--	--	--	--	--	--
Sludge...................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Fertilizers..............	--	--	--	--	--	--	--	--	--	--	--	--	G	S	--	G	G	--	--	--
Biological amendments....	--	--	--	--	--	--	--	--	--	--	E	--	--	--	--	--	--	--	--	--
Other....................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Vegetation establishment:																				
Seeding..................	--	--	E	--	--	--	--	--	--	--	--	--	G	G	--	--	E	--	--	--
Transplanting............	--	--	E	--	--	--	--	--	E	--	G	--	--	--	G	E	E	--	--	--
Natural..................	--	S	--	E	--	--	--	--	S	G	--	--	--	--	--	--	--	--	--	--
Vegetation maintenance:																				
Irrigation...............	G	--	--	--	--	--	--	--	--	--	--	G	--	--	--	--	--	--	--	--
Soil/plant monitoring....	--	E	--	E	--	--	E	E	E	G	--	G	G	G	--	--	G	E	S	E
Pesticides & herbicides..	--	--	--	--	--	--	--	--	S	--	--	--	--	--	E	G	--	--	--	--
Upkeep...................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	G	--	--	--
Vegetation evaluation:																				
Reference area...........	--	--	--	E	--	--	G	--	--	--	--	--	--	--	--	--	--	G	--	--
Ground cover.............	--	E	--	E	--	--	--	--	--	--	--	--	--	G	--	--	S	--	--	--
Productivity.............	--	G	G	E	--	--	--	G	E	G	G	E	G	--	G	E	S	--	--	--

REFERENCE EVALUATIONS--Continued

Keywords	Reference No.																			
	321	322	323	324	325	326	327	328	329	330	331	332	333	334	335	336	337	338	339	340
Coal region................	E	I	E	E,I,G	I	I,G	N,R,P	R	N,R	N,R	E,I	N	N	N	N	N	N	N	O	O
Land use:																				
Cropland................	--	--	G	G	G	G	G	--	--	--	--	--	--	--	--	--	--	--	E	S
Grazingland.............	--	--	G	G	G	G	G	G	G	--	--	G	S	G	S	G	S	S	G	G
Pastureland.............	G	--	G	G	G	G	G	--	--	--	--	G	--	--	--	--	S	--	G	G
Forestry................	--	--	G	G	G	G	G	--	--	--	S	--	--	--	--	--	--	--	G	G
Wildlife................	--	--	E	E	E	E	E	G	G	--	--	--	--	--	--	--	--	--	G	S
Miscellaneous...........	--	--	G	G	G	G	G	--	--	--	--	--	--	--	--	--	--	--	G	--
Regulations:																				
Local...................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
State...................	--	--	G	G	G	G	G	--	G	--	--	--	--	--	--	--	--	--	--	--
Federal.................	--	G	G	G	G	G	G	--	G	--	--	--	--	--	--	--	--	--	E	--
Economic considerations....	--	--	E	E	E	E	E	--	--	--	--	--	--	--	--	--	--	--	--	--
Species selection..........	--	G	G	G	G	G	G	G	G	G	S	G	S	G	G	G	G	G	G	S
Climatic conditions........	--	--	G	G	G	G	G	--	--	--	--	--	--	--	--	--	S	S	--	--
Soil characterization......	E	G	G	G	G	G	G	E	--	--	--	--	--	--	--	--	S	S	G	--
Erosion control............	S	--	--	--	--	--	--	--	G	--	--	G	--	--	--	--	--	--	G	--
Soil preparation:																				
Topsoil modification.....	--	--	--	--	--	--	--	S	--	S	--	--	--	--	--	--	--	--	G	--
Subsoil modification.....	--	--	--	--	--	--	--	S	--	--	--	--	--	--	--	--	--	--	G	--
Soil amendments:																				
pH modifiers............	G	E	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Mulch...................	G	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	G	--
Sludge..................	E	--	--	--	--	--	--	G	--	--	--	--	--	--	--	--	--	--	G	--
Fertilizers.............	G	G	--	--	--	--	--	S	--	--	--	--	S	--	G	S	S	S	G	--
Biological amendments....	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Other...................	--	--	--	--	--	--	--	G	--	--	--	--	--	--	--	--	--	--	S	--
Vegetation establishment:																				
Seeding.................	E	E	--	--	--	--	--	S	G	--	--	--	--	S	S	S	S	S	S	--
Transplanting...........	--	--	--	--	--	--	--	--	S	--	--	--	--	--	--	--	--	--	S	--
Natural.................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	S	--	--	S	--
Vegetation maintenance:																				
Irrigation..............	G	--	--	--	--	--	--	S	--	--	--	--	--	--	--	--	--	--	G	--
Soil/plant monitoring....	--	E	--	--	--	--	--	--	--	--	--	--	--	--	--	S	--	--	E	--
Pesticides & herbicides..	--	--	--	--	--	--	--	--	--	--	S	--	--	--	--	--	--	--	S	E
Upkeep..................	G	--	--	--	--	--	--	--	--	--	S	--	--	--	--	--	--	--	--	--
Vegetation evaluation:																				
Reference area...........	--	--	E	E	E	E	E	--	--	--	--	E	G	--	--	--	--	--	G	--
Ground cover.............	--	--	E	E	E	E	E	--	--	--	--	E	E	--	--	--	G	E	E	--
Productivity.............	G	--	E	E	E	E	E	--	--	--	--	E	E	E	G	G	G	E	E	--

REFERENCE EVALUATIONS--Continued

Keywords	Reference No.																			
	341	342	343	344	345	346	347	348	349	350	351	352	353	354	355	356	357	358	359	360
Coal region................	G	G	G	N	N	E,G	N,R	E,I	N,R	O	E	N	I	O	N,R	N	I	N	R	R,X
Land use:																				
Cropland.................	S	--	--	--	--	--	G	--	--	--	--	--	--	--	--	--	--	--	--	--
Grazingland..............	--	--	--	G	--	--	G	--	S	S	--	--	--	--	--	G	--	S	--	S
Pastureland..............	S	--	--	--	--	--	G	--	S	--	--	--	--	--	--	--	--	--	--	--
Forestry.................	--	--	--	--	--	--	G	--	S	--	G	--	--	--	--	--	--	--	--	S
Wildlife.................	--	--	--	--	--	--	G	G	S	--	S	--	--	--	E	--	--	--	--	S
Miscellaneous............	--	--	--	--	--	--	G	--	--	--	--	--	--	--	--	--	--	--	--	--
Regulations:																				
Local....................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
State....................	--	--	--	S	--	--	G	--	S	--	--	G	--	E	--	--	--	--	--	--
Federal..................	--	--	--	--	--	--	G	--	S	--	S	G	--	E	--	--	--	--	--	--
Economic considerations....	--	--	--	--	--	--	S	--	--	--	--	--	--	--	--	--	--	--	--	S
Species selection..........	G	--	E	S	G	--	--	G	--	E	E	--	--	--	E	--	E	E	E	E
Climatic conditions........	--	--	--	--	--	--	S	--	--	--	--	--	--	--	--	--	S	--	E	S
Soil characterization......	G	E	G	--	S	--	S	--	--	E	S	--	E	--	S	E	E	--	--	G
Erosion control............	--	--	--	--	--	G	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Soil preparation:																				
Topsoil modification.....	--	--	G	--	--	S	--	--	--	--	S	--	--	--	S	--	--	--	--	G
Subsoil modification.....	--	--	--	--	--	--	--	--	--	--	--	--	--	--	G	--	--	--	--	--
Soil amendments:																				
pH modifiers.............	--	--	--	--	--	--	--	--	--	--	S	--	--	--	--	--	G	--	--	--
Mulch....................	--	--	--	--	--	G	--	--	--	--	S	--	--	--	G	--	--	--	--	G
Sludge...................	--	--	--	--	G	--	--	--	--	--	--	--	--	--	--	--	G	--	--	G
Fertilizers..............	G	G	G	--	G	--	--	--	--	--	S	--	--	--	G	--	G	--	--	G
Biological amendments....	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	S
Other....................	--	--	--	--	G	--	--	--	--	--	--	--	--	--	--	--	G	--	--	--
Vegetation establishment:																				
Seeding..................	--	--	--	S	--	--	--	--	--	G	S	--	--	--	G	--	--	--	G	G
Transplanting............	--	--	--	--	--	--	--	--	--	G	S	--	--	--	G	--	--	--	--	G
Natural..................	--	--	--	--	--	--	--	--	--	--	G	--	--	--	--	E	G	G	--	--
Vegetation maintenance:																				
Irrigation...............	--	--	--	--	--	--	--	--	--	--	--	--	--	--	G	--	--	--	--	S
Soil/plant monitoring....	G	E	E	--	--	S	--	--	--	--	--	--	--	--	--	E	E	--	E	G
Pesticides & herbicides..	--	--	--	--	--	--	--	--	--	--	--	--	--	--	S	--	--	--	--	--
Upkeep...................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	E	--	--	--	--
Vegetation evaluation:																				
Reference area...........	G	E	--	--	--	--	--	--	E	--	--	--	--	--	--	G	--	--	E	--
Ground cover.............	--	--	--	G	--	--	--	--	E	--	--	--	--	--	--	G	--	--	E	S
Productivity.............	G	--	G	--	G	--	S	--	E	E	--	--	--	--	--	G	G	G	E	S

REFERENCE EVALUATIONS--Continued

Keywords	Reference No.																			
	361	362	363	364	365	366	367	368	369	370	371	372	373	374	375	376	377	378	379	380
Coal region................	O,X	G,N,R	N	O	I	I	I	O	I	O	I	N	O	N,O	E	E	R,X	E	N,R	E
Land use:																				
Cropland.................	--	S	--	G	G	--	--	--	--	--	--	G	--	--	--	S	--	--	S	--
Grazingland..............	--	S	--	--	--	--	--	--	S	G	--	G	--	--	--	--	G	--	S	--
Pastureland..............	--	--	--	--	--	--	--	--	S	--	S	--	--	--	S	S	--	--	S	--
Forestry.................	--	S	--	--	--	--	--	S	--	--	--	--	--	--	--	S	--	S	S	--
Wildlife.................	--	--	E	--	--	E	--	--	--	--	--	--	--	--	--	--	--	S	S	--
Miscellaneous............	--	--	--	--	--	E	--	--	--	--	--	--	--	--	--	S	--	--	--	--
Regulations:																				
Local....................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
State....................	--	--	G	--	--	--	--	--	--	--	--	G	--	--	--	--	--	--	--	--
Federal..................	S	--	--	G	--	--	--	G	--	--	--	G	--	--	--	--	--	--	--	--
Economic considerations....	--	E	--	--	--	G	--	--	--	--	--	E	--	--	--	--	--	--	--	--
Species selection..........	S	G	--	--	--	E	--	--	S	E	S	S	--	--	S	--	E	--	S	--
Climatic conditions........	--	E	--	--	--	G	--	--	--	--	--	S	--	--	--	--	--	--	S	--
Soil characterization......	--	G	--	G	--	E	S	--	G	--	--	S	G	E	G	G	E	--	S	S
Erosion control............	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	S	--
Soil preparation:																				
Topsoil modification.....	--	G	S	S	E	E	--	--	--	--	S	S	--	--	S	G	E	--	S	S
Subsoil modification.....	--	G	S	S	E	G	--	--	--	--	S	S	--	--	--	G	--	--	S	--
Soil amendments:																				
pH modifiers.............	--	--	--	--	--	G	S	--	E	--	E	--	G	--	--	G	G	--	--	--
Mulch....................	--	G	--	--	--	--	--	--	--	--	--	S	--	--	--	--	--	--	S	--
Sludge...................	--	--	--	--	--	--	--	--	--	--	E	--	--	--	E	--	--	--	--	E
Fertilizers..............	--	G	--	--	--	G	--	--	E	--	G	S	--	--	E	--	--	--	S	--
Biological amendments....	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Other....................	--	--	--	--	--	--	--	--	--	--	--	S	--	--	--	--	--	--	S	--
Vegetation establishment:																				
Seeding..................	--	G	--	--	--	E	--	--	S	--	G	G	--	--	S	--	S	--	S	--
Transplanting............	G	S	S	--	--	--	--	--	--	--	--	G	--	--	--	--	--	--	--	--
Natural..................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Vegetation maintenance:																				
Irrigation...............	--	G	--	--	--	--	--	--	--	--	--	S	--	--	--	--	--	--	S	--
Soil/plant monitoring....	--	--	--	--	--	--	E	--	G	--	--	--	--	--	E	--	E	--	--	S
Pesticides & herbicides..	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Upkeep...................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Vegetation evaluation:																				
Reference area...........	--	--	--	--	--	--	--	--	--	E	E	--	--	--	--	--	--	--	--	--
Ground cover.............	--	S	--	--	--	E	--	--	E	E	--	--	--	--	--	--	E	--	--	S
Productivity.............	S	S	--	--	E	E	--	--	E	E	--	--	--	--	E	--	G	--	--	--

REFERENCE EVALUATIONS--Continued

Keywords	Reference No.																			
	381	382	383	384	385	386	387	388	389	390	391	392	393	394	395	396	397	398	399	400
Coal region................	E	E	R,X	R	R,X	E	E	E,I	R,X	O	N	E	N,R	O,X	O	E,I	I	I	N	E
Land use:																				
Cropland.................	--	--	--	--	--	--	--	--	--	S	--	--	S	G	S	S	--	--	--	--
Grazingland..............	--	--	S	S	--	--	--	--	G	S	S	--	E	G	S	S	--	--	G	--
Pastureland..............	--	--	--	--	--	--	--	--	--	S	--	--	E	--	S	S	--	--	--	S
Forestry.................	S	G	--	--	--	--	--	S	--	S	--	--	E	G	S	S	G	S	--	--
Wildlife.................	--	--	--	S	--	E	G	--	S	S	--	--	E	--	--	S	--	--	--	--
Miscellaneous............	--	--	--	--	--	--	--	--	--	--	--	--	E	G	S	S	--	--	--	--
Regulations:																				
Local....................	--	--	--	--	--	--	--	--	--	--	--	--	E	--	--	--	--	--	--	--
State....................	--	--	--	--	--	--	--	E	--	S	--	--	E	--	--	E	--	S	--	--
Federal..................	--	--	--	--	--	--	--	--	--	S	--	--	E	--	--	E	G	S	--	--
Economic considerations....	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	E	--	--	--	--
Species selection..........	G	G	--	G	--	E	S	--	--	S	--	--	--	--	--	S	G	E	G	G
Climatic conditions........	--	--	--	--	S	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Soil characterization......	--	S	--	S	G	--	--	--	E	--	--	--	--	--	S	S	--	--	E	--
Erosion control............	--	--	--	--	G	--	--	--	--	--	--	--	--	--	S	G	--	--	--	--
Soil preparation:																				
Topsoil modification.....	--	--	--	--	--	--	--	--	G	--	S	--	--	--	--	G	--	G	S	G
Subsoil modification.....	--	--	--	--	--	--	--	--	G	--	--	--	--	--	--	--	--	--	S	--
Soil amendments:																				
pH modifiers............	--	G	--	--	--	--	--	--	--	--	--	--	--	--	--	S	--	--	--	--
Mulch....................	--	--	--	--	S	--	--	--	--	--	--	--	--	--	--	--	--	--	--	E
Sludge...................	E	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Fertilizers..............	--	S	--	--	S	--	--	--	--	--	S	--	--	--	--	S	--	--	E	G
Biological amendments....	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Other....................	--	--	--	--	--	--	--	--	--	--	--	E	--	--	--	--	--	--	G	--
Vegetation establishment:																				
Seeding..................	S	--	--	--	--	--	--	--	--	--	S	--	--	--	--	--	--	E	G	G
Transplanting............	S	G	--	--	--	--	S	--	--	--	--	--	--	--	--	--	--	E	--	--
Natural..................	--	--	--	--	--	--	G	--	--	--	--	--	--	--	--	--	--	--	--	--
Vegetation maintenance:																				
Irrigation...............	--	--	--	--	S	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Soil/plant monitoring....	--	--	E	--	--	--	--	--	E	S	--	G	--	--	--	S	--	--	E	--
Pesticides & herbicides..	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Upkeep...................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Vegetation evaluation:																				
Reference area...........	--	--	--	--	--	--	--	--	--	S	--	--	--	--	--	--	--	E	--	--
Ground cover.............	--	--	--	--	E	S	G	--	--	--	S	--	--	--	S	G	--	--	--	E
Productivity.............	E	G	--	G	--	S	--	--	--	S	S	--	--	--	--	G	S	--	E	--

REFERENCE EVALUATIONS--Continued

Keywords	Reference No.																			
	401	402	403	404	405	406	407	408	409	410	411	412	413	414	415	416	417	418	419	420
Coal region................	N,R	O	N,R	N,R	O	N,R,P	E	I	E	E	E,X	E,I	I	I	R	O	I	E	I	I
Land use:																				
Cropland.................	--	--	--	--	S	--	--	--	--	S	--	--	S	--	--	--	S	--	--	--
Grazingland..............	S	--	G	--	S	--	--	--	--	--	--	--	--	--	G	--	--	--	--	--
Pastureland..............	S	--	--	--	S	--	--	G	--	--	S	--	--	--	--	--	--	--	--	--
Forestry.................	S	S	--	--	S	--	G	--	S	--	S	--	--	--	--	--	--	S	--	--
Wildlife.................	S	S	G	--	S	--	--	--	--	--	S	E	--	--	--	--	--	--	S	--
Miscellaneous............	--	--	--	--	S	--	--	--	--	--	--	--	--	--	G	G	--	--	S	S
Regulations:																				
Local....................	--	--	--	--	S	--	--	--	--	--	--	--	--	--	G	--	--	--	--	--
State....................	S	--	G	--	G	--	--	--	--	--	--	--	--	--	G	--	--	--	--	--
Federal..................	--	--	G	--	G	--	--	--	--	--	--	G	--	--	--	--	--	--	S	--
Economic considerations....	--	--	--	G	--	S	--	--	--	S	--	--	--	--	--	--	--	--	--	--
Species selection..........	--	G	S	--	--	E	E	E	G	--	E	S	--	--	G	G	--	--	--	--
Climatic conditions........	--	--	--	--	--	--	G	--	--	--	--	--	--	--	S	--	--	G	--	--
Soil characterization......	--	S	--	--	--	--	--	--	--	--	G	--	E	S	G	--	S	S	G	--
Erosion control............	--	--	--	--	--	S	--	--	--	--	S	--	--	--	--	--	--	--	--	--
Soil preparation:																				
Topsoil modification.....	--	--	--	--	--	E	--	--	--	S	E	--	--	--	--	--	S	--	--	--
Subsoil modification.....	--	--	--	--	--	--	--	--	--	--	E	--	--	--	--	--	--	--	--	--
Soil amendments:																				
pH modifiers.............	--	--	--	--	--	--	--	G	--	--	E	--	E	G	--	G	--	--	--	--
Mulch....................	--	--	--	--	--	G	--	--	--	G	G	--	--	--	--	--	--	--	--	--
Sludge...................	--	S	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Fertilizers..............	--	S	--	--	--	--	S	G	--	S	E	--	--	G	--	G	--	--	--	--
Biological amendments....	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	E	--	--	--
Other....................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Vegetation establishment:																				
Seeding..................	--	S	--	--	--	G	G	E	--	S	G	--	--	--	--	G	--	--	--	--
Transplanting............	--	S	--	--	--	G	G	--	S	--	G	--	--	--	--	--	--	--	--	--
Natural..................	--	S	--	--	--	--	--	--	S	--	--	--	--	--	--	--	--	--	--	E
Vegetation maintenance:																				
Irrigation...............	--	--	--	--	--	G	--	--	--	--	--	--	G	--	--	--	--	--	--	--
Soil/plant monitoring....	--	--	--	--	--	--	S	E	E	--	G	--	E	E	--	--	--	--	G	E
Pesticides & herbicides..	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Upkeep...................	--	--	--	--	--	--	--	G	--	--	--	--	--	--	--	--	--	--	--	--
Vegetation evaluation:																				
Reference area...........	G	--	E	--	--	--	--	--	E	--	--	S	--	--	--	--	--	--	--	G
Ground cover.............	G	--	E	--	--	--	G	E	--	--	--	S	--	--	--	--	--	--	G	--
Productivity.............	G	--	E	--	--	--	E	E	--	S	E	S	G	--	--	--	--	--	G	--

REFERENCE EVALUATIONS--Continued

Keywords	Reference No.																			
	421	422	423	424	425	426	427	428	429	430	431	432	433	434	435	436	437	438	439	440
Coal region...............	E	O,X	R	E	E	E,G	N	O	E,I	O	P	E	N	O,X	I,E,G	O	E	E	I	N,R
Land use:																				
Cropland................	--	--	--	--	--	--	S	--	--	S	S	--	--	S	--	--	--	S	--	--
Grazingland.............	--	--	S	--	--	S	S	S	G	S	S	--	--	S	--	--	--	--	--	E
Pastureland.............	S	--	--	--	S	S	--	S	G	S	--	--	--	S	--	--	--	S	S	--
Forestry................	S	S	--	G	--	--	--	--	--	S	S	E	--	S	E	S	E	S	--	--
Wildlife................	--	--	--	--	--	--	--	S	--	S	S	--	E	S	G	--	G	S	S	E
Miscellaneous...........	--	--	--	--	--	--	--	--	--	S	S	G	--	S	--	--	--	--	--	--
Regulations:																				
Local...................	--	--	--	--	--	--	--	--	--	--	--	E	--	--	--	--	--	--	--	--
State...................	--	--	--	--	--	--	S	--	--	--	--	S	G	--	--	--	--	--	--	G
Federal.................	--	--	--	S	--	--	S	--	--	--	G	S	G	--	--	--	--	--	--	G
Economic considerations....	--	--	--	--	--	--	S	--	--	--	--	--	--	--	--	--	--	--	--	S
Species selection..........	--	G	S	G	E	G	--	G	--	--	S	E	--	S	--	G	--	S	G	E
Climatic conditions........	G	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Soil characterization......	--	--	E	--	G	E	--	--	S	--	--	E	--	S	--	--	--	--	G	--
Erosion control............	--	--	--	S	--	E	--	S	--	--	--	E	--	S	--	--	--	--	--	--
Soil preparation:																				
Topsoil modification.....	--	G	--	G	G	G	--	--	--	S	--	--	--	S	--	--	--	--	--	--
Subsoil modification.....	--	--	--	--	--	--	--	--	--	S	--	--	--	S	--	--	--	--	--	--
Soil amendments:																				
pH modifiers............	--	--	--	--	G	G	--	--	--	--	--	G	--	S	--	--	--	--	S	--
Mulch...................	--	--	--	G	G	--	--	--	--	--	--	G	--	S	--	--	--	--	S	--
Sludge..................	--	E	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	S	--
Fertilizers.............	--	--	--	--	G	G	--	--	G	--	--	G	--	S	--	--	G	--	S	--
Biological amendments....	--	--	--	--	S	--	--	--	--	--	--	G	--	--	E	G	E	--	--	--
Other...................	--	E	--	--	--	--	--	--	--	--	--	S	--	S	--	--	--	--	--	--
Vegetation establishment:																				
Seeding.................	--	E	--	E	G	--	--	--	S	--	--	E	--	S	--	--	--	--	G	G
Transplanting...........	--	E	--	E	--	--	--	--	--	--	--	E	--	S	--	--	E	--	--	G
Natural.................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Vegetation maintenance:																				
Irrigation..............	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Soil/plant monitoring....	E	E	--	--	G	G	--	--	--	--	--	--	--	S	--	--	--	--	E	--
Pesticides & herbicides..	--	--	--	G	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Upkeep..................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Vegetation evaluation:																				
Reference area...........	G	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	S
Ground cover............	--	E	S	--	--	G	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Productivity............	--	E	G	E	E	G	--	--	G	--	--	--	--	--	G	G	G	--	G	G

REFERENCE EVALUATIONS--Continued

Keywords	441	442	443	444	445	446	447	448	449	450	451	452	453	454	455	456	457	458	459	460
Coal region	N	N	E	E	O	E	I	R	I	O	R	R	R,X	R	N,R	E,X	E	I	I	X
Land use:																				
Cropland	--	--	--	--	--	--	G	--	--	--	--	--	--	--	S	--	--	G	--	--
Grazingland	S	S	--	--	--	--	--	S	--	--	E	S	S	S	G	--	--	--	--	--
Pastureland	--	--	--	--	--	--	G	--	--	--	--	--	--	--	--	--	--	--	--	--
Forestry	--	--	G	--	G	S	G	--	--	--	--	--	--	--	--	S	S	--	S	--
Wildlife	S	--	S	G	--	--	--	--	--	--	G	S	--	--	--	--	S	--	--	--
Miscellaneous	--	--	--	--	--	--	--	--	--	--	G	--	--	--	--	--	--	--	--	--
Regulations:																				
Local	--	--	--	--	--	--	--	--	--	--	G	--	--	--	--	--	--	--	--	--
State	--	--	--	--	--	--	--	--	--	--	G	--	--	--	--	--	--	--	S	--
Federal	--	--	--	--	--	--	--	--	--	--	G	--	--	--	--	--	--	--	--	--
Economic considerations	--	--	--	--	--	S	--	--	--	--	--	--	--	--	G	--	--	--	--	--
Species selection	G	--	--	E	G	G	S	G	--	--	E	E	E	S	--	G	G	S	S	--
Climatic conditions	--	--	--	--	--	--	--	--	--	--	--	--	G	G	--	--	--	--	S	--
Soil characterization	--	E	--	S	S	--	E	E	--	--	E	--	--	G	--	--	--	G	--	--
Erosion control	--	--	--	--	--	--	--	--	--	--	G	--	E	--	--	--	--	--	--	--
Soil preparation:																				
Topsoil modification	--	--	--	--	--	--	--	E	--	--	S	--	E	--	--	--	S	G	--	--
Subsoil modification	--	--	--	--	--	--	--	--	--	--	S	--	--	--	--	--	S	G	--	--
Soil amendments:																				
pH modifiers	--	--	S	--	--	--	G	--	--	S	--	--	--	--	--	--	S	--	--	--
Mulch	--	--	--	E	--	--	--	--	--	S	G	--	--	--	--	--	--	--	--	--
Sludge	--	--	--	--	--	--	G	--	G	S	--	--	--	--	--	--	--	--	--	--
Fertilizers	--	G	--	E	S	--	G	G	--	S	G	G	G	--	--	--	S	--	--	--
Biological amendments	--	--	--	--	--	--	--	--	--	S	--	--	--	--	--	--	--	--	--	E
Other	--	--	--	--	--	--	--	--	--	S	S	--	--	--	--	--	--	--	--	--
Vegetation establishment:																				
Seeding	--	--	--	E	S	--	--	E	--	--	G	G	G	--	--	--	--	--	--	--
Transplanting	--	--	--	--	S	S	--	--	--	--	G	G	E	S	--	G	--	--	G	--
Natural	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Vegetation maintenance:																				
Irrigation	--	--	--	--	--	--	--	--	--	--	G	G	G	--	--	--	--	--	--	--
Soil/plant monitoring	--	E	--	--	--	--	E	--	E	--	--	--	G	--	--	E	--	--	--	--
Pesticides & herbicides	--	--	--	--	--	--	--	--	--	--	S	--	--	--	--	--	--	--	--	--
Upkeep	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Vegetation evaluation:																				
Reference area	--	--	--	S	--	--	--	--	--	--	--	--	--	--	--	G	--	--	--	G
Ground cover	--	--	--	--	--	--	--	E	--	--	E	--	--	--	--	--	--	--	--	--
Productivity	--	--	G	E	--	--	--	E	--	--	E	G	E	G	--	E	G	G	--	--

REFERENCE EVALUATIONS--Continued

Keywords	Reference No.																			
	461	462	463	464	465	466	467	468	469	470	471	472	473	474	475	476	477	478	479	480
Coal region................	O,X	N	I	I,P	O	P	P	I	R	E	R,N	E,G	N,R	N,R,X	I	I	I	O	E	E
Land use:																				
Cropland.................	--	S	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	E	G
Grazingland..............	--	S	--	--	--	S	G	--	--	--	S	--	E	--	--	--	--	--	--	--
Pastureland..............	--	--	G	--	--	S	--	--	--	--	S	--	--	--	--	--	--	--	--	--
Forestry.................	--	--	--	--	--	--	--	--	--	S	S	S	--	--	--	S	G	E	--	--
Wildlife.................	--	--	--	--	--	--	G	E	--	--	S	--	--	E	--	--	--	E	--	--
Miscellaneous............	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Regulations:																				
Local....................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
State....................	--	--	--	--	--	--	--	--	--	--	--	--	S	--	--	--	S	--	--	--
Federal..................	--	--	--	--	--	--	--	--	--	--	--	--	S	S	--	--	S	--	--	--
Economic considerations....	--	--	--	--	G	--	--	--	--	--	--	--	--	--	--	--	S	--	--	--
Species selection..........	--	--	--	E	--	G	E	E	--	--	E	S	E	--	--	G	--	--	E	G
Climatic conditions........	--	--	--	--	--	S	--	--	--	--	--	--	--	G	--	--	--	--	--	--
Soil characterization......	G	G	E	--	--	--	G	--	G	--	S	--	--	G	--	--	--	--	S	G
Erosion control............	--	--	--	--	--	--	--	--	--	--	--	--	--	G	--	--	--	--	--	--
Soil preparation:																				
Topsoil modification.....	--	G	--	--	--	--	S	--	--	G	--	--	G	G	--	--	--	--	--	--
Subsoil modification.....	--	--	--	--	--	--	--	--	--	--	--	--	--	G	--	--	--	--	--	--
Soil amendments:																				
pH modifiers............	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	S	S
Mulch...................	S	--	--	--	--	--	G	--	--	--	--	--	--	S	--	--	--	--	E	--
Sludge..................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	E	S	--	--	--	--
Fertilizers.............	S	--	--	--	--	--	G	--	--	--	--	--	--	S	--	--	--	--	S	E
Biological amendments....	--	--	--	--	--	--	--	--	--	E	--	--	--	--	--	--	--	--	--	--
Other...................	--	--	--	--	--	--	--	--	G	--	--	--	--	--	--	--	--	--	E	--
Vegetation establishment:																				
Seeding.................	--	--	--	--	--	--	S	--	--	--	G	--	S	G	--	--	--	--	--	--
Transplanting...........	--	--	--	--	--	--	--	--	--	E	G	--	--	S	--	G	--	--	--	--
Natural.................	--	--	--	--	--	--	--	--	--	--	--	--	G	--	--	S	--	--	--	--
Vegetation maintenance:																				
Irrigation..............	--	--	--	--	--	--	G	--	--	--	--	--	--	S	--	--	--	--	--	--
Soil/plant monitoring....	--	E	E	--	--	--	G	--	--	--	--	--	--	--	E	E	--	G	--	E
Pesticides & herbicides..	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Upkeep..................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Vegetation evaluation:																				
Reference area..........	--	--	--	--	--	--	--	--	--	--	--	--	--	S	--	--	--	--	--	--
Ground cover............	--	--	--	--	--	--	G	--	--	--	--	--	--	S	--	--	--	--	--	--
Productivity............	S	--	--	--	--	--	G	--	--	E	--	S	--	S	--	--	--	E	E	E

REFERENCE EVALUATIONS--Continued

Keywords	Reference No.																			
	481	482	483	484	485	486	487	488	489	490	491	492	493	494	495	496	497	498	499	500
Coal region................	E	I	N	N	O,X	O	O,X	N	O	P	O	P	O	I	I	I	I	I	I	E,I,G
Land use:																				
Cropland.................	--	--	--	--	--	S	--	--	--	--	--	S	G	--	--	--	--	--	--	--
Grazingland..............	--	--	S	--	--	S	--	G	--	--	S	S	G	--	--	--	--	--	--	--
Pastureland..............	--	--	--	--	--	S	--	--	--	--	S	S	G	--	--	--	--	--	--	--
Forestry.................	S	--	--	--	G	S	--	--	G	--	--	S	G	E	--	--	--	S	G	--
Wildlife.................	S	--	--	--	--	S	--	S	--	--	S	G	G	--	--	S	--	--	--	G
Miscellaneous............	--	--	--	--	--	S	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Regulations:																				
Local....................	--	--	--	--	--	--	--	--	--	--	--	S	S	--	--	--	--	--	--	--
State....................	--	--	--	--	--	--	--	--	--	--	--	E	S	--	--	--	--	--	--	--
Federal..................	--	--	--	--	--	--	--	--	--	G	G	E	S	--	--	--	--	--	--	G
Economic considerations....	--	--	--	--	--	S	--	--	--	--	--	--	S	E	--	--	--	--	--	S
Species selection..........	E	--	S	--	--	--	S	G	S	--	--	G	--	G	E	E	--	--	G	S
Climatic conditions........	--	--	--	--	--	S	--	--	--	--	--	E	G	--	--	--	--	--	--	--
Soil characterization......	--	E	S	E	G	E	E	--	--	G	--	S	G	G	--	G	--	S	E	--
Erosion control............	G	--	--	--	--	S	--	S	--	--	E	--	S	--	--	G	--	--	--	--
Soil preparation:																				
Topsoil modification.....	G	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Subsoil modification.....	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Soil amendments:																				
pH modifiers.............	G	--	--	--	--	G	G	--	--	--	--	--	--	--	--	--	--	--	G	--
Mulch....................	--	--	--	--	--	S	G	--	--	--	--	--	--	--	--	--	--	--	--	--
Sludge...................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Fertilizers..............	--	--	--	--	G	S	G	--	--	--	--	S	--	--	--	--	--	--	G	--
Biological amendments....	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Other....................	--	--	--	--	--	G	G	--	--	--	--	--	--	--	--	--	--	--	--	--
Vegetation establishment:																				
Seeding..................	--	--	S	--	--	G	G	--	--	--	--	S	--	--	--	--	--	--	--	--
Transplanting............	--	--	--	--	G	--	--	--	G	--	--	S	--	G	--	E	--	--	G	--
Natural..................	--	--	S	--	--	--	--	--	--	--	--	S	--	--	--	--	G	--	G	--
Vegetation maintenance:																				
Irrigation...............	--	--	--	--	--	S	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Soil/plant monitoring....	--	E	E	--	E	--	E	--	G	--	--	S	S	--	E	--	E	E	S	--
Pesticides & herbicides..	--	--	--	--	--	--	--	--	G	--	--	--	--	--	--	--	--	--	--	--
Upkeep...................	--	--	--	--	--	--	--	--	--	--	--	--	S	--	--	--	--	--	--	--
Vegetation evaluation:																				
Reference area...........	--	--	E	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Ground cover.............	--	--	--	--	--	--	--	--	--	--	--	S	--	--	--	S	--	--	--	--
Productivity.............	--	--	--	--	E	--	--	--	--	--	--	S	G	E	E	S	--	--	S	--

REFERENCE EVALUATIONS--Continued

Keywords	Reference No.																			
	501	502	503	504	505	506	507	508	509	510	511	512	513	514	515	516	517	518	519	520
Coal region................	I,E	E	R	O	R	R,X	O	O	I	E	I	N	N	E	N	N,R	N,R	O	I	I
Land use:																				
Cropland.................	--	--	--	G	S	--	--	--	--	--	S	--	--	E	--	--	--	S	--	--
Grazingland..............	--	--	S	--	S	--	--	S	G	--	--	G	G	--	E	G	--	S	--	--
Pastureland..............	--	--	--	--	--	--	--	--	--	--	--	--	--	E	--	--	--	S	--	--
Forestry.................	--	--	--	--	--	S	--	--	--	--	--	--	--	--	--	--	--	S	G	G
Wildlife.................	E	--	--	--	--	--	--	--	--	E	--	G	E	--	E	--	--	--	S	G
Miscellaneous............	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Regulations:																				
Local....................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
State....................	--	--	--	--	--	--	--	--	--	S	--	--	--	--	--	--	--	--	--	--
Federal..................	--	S	--	--	--	--	--	--	S	--	--	--	--	--	--	--	--	--	--	--
Economic considerations....	E	--	--	--	G	--	--	S	E	--	--	--	--	--	--	--	--	--	E	G
Species selection..........	E	S	E	--	S	--	G	G	--	E	G	E	G	G	E	G	--	--	G	G
Climatic conditions........	--	--	--	--	--	--	--	--	--	--	--	--	--	--	E	E	G	--	--	--
Soil characterization......	--	--	S	S	--	G	--	--	--	G	--	E	G	E	S	E	G	--	--	--
Erosion control............	G	G	--	--	S	--	--	--	--	--	--	--	--	--	S	--	--	--	S	--
Soil preparation:																				
Topsoil modification.....	G	--	S	S	S	--	--	--	--	G	E	--	--	E	--	G	--	--	G	--
Subsoil modification.....	G	--	--	--	S	--	--	--	--	G	S	--	--	--	--	--	--	--	--	--
Soil amendments:																				
pH modifiers.............	--	--	--	S	--	--	--	--	--	S	--	--	--	G	--	--	S	--	--	--
Mulch....................	S	--	--	--	S	S	--	--	--	G	--	--	--	--	G	G	S	--	--	--
Sludge...................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Fertilizers..............	S	--	--	S	S	G	--	--	--	S	E	--	--	E	G	G	S	--	--	--
Biological amendments....	--	--	--	--	--	--	--	--	--	S	--	--	--	--	--	--	--	E	--	--
Other....................	S	--	--	--	S	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Vegetation establishment:																				
Seeding..................	G	S	--	--	S	S	--	G	--	G	--	--	--	--	S	G	--	--	--	--
Transplanting............	G	--	--	--	--	G	--	--	--	E	--	--	--	--	E	--	--	--	E	E
Natural..................	G	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Vegetation maintenance:																				
Irrigation...............	--	--	--	--	--	S	--	--	--	--	--	--	--	--	E	G	S	--	--	--
Soil/plant monitoring....	--	--	G	--	--	--	--	--	--	--	G	G	--	--	--	--	--	--	--	--
Pesticides & herbicides..	--	--	--	--	--	--	--	--	--	--	E	--	--	--	S	--	--	--	E	E
Upkeep...................	--	--	--	--	--	--	--	--	--	G	--	--	--	--	--	--	--	--	--	--
Vegetation evaluation:																				
Reference area...........	--	--	--	G	--	--	--	--	--	--	--	--	--	--	--	--	G	--	--	--
Ground cover.............	--	--	--	--	--	--	--	--	--	--	--	E	--	--	--	--	G	--	--	--
Productivity.............	--	--	G	G	--	E	--	--	--	--	E	E	--	E	E	--	G	--	G	G

REFERENCE EVALUATIONS--Continued

Keywords	Reference No.																			
	521	522	523	524	525	526	527	528	529	530	531	532	533	534	535	536	537	538	539	540
Coal region................	N	E	E	E	R,N	I	E,I	G,X	I	I	I	E	E	N	E	E	E	N,R	O,X	O,X
Land use:																				
Cropland.................	--	S	--	--	--	--	--	--	--	--	--	--	--	--	S	--	S	--	--	--
Grazingland..............	G	--	S	--	S	--	--	--	--	--	--	--	--	G	S	--	--	--	--	--
Pastureland..............	--	--	S	--	--	--	--	S	--	--	--	--	--	--	S	S	S	--	--	--
Forestry.................	--	--	S	--	--	--	--	--	E	S	S	--	S	--	S	--	S	--	G	--
Wildlife.................	G	--	--	--	--	G	S	--	G	--	--	--	--	--	S	--	S	--	--	--
Miscellaneous............	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Regulations:																				
Local....................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
State....................	--	--	--	--	--	--	--	--	--	--	--	--	S	--	--	--	--	E	--	--
Federal..................	--	--	--	--	--	--	--	--	--	S	--	--	S	--	--	--	--	E	--	--
Economic considerations....	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	G	--
Species selection..........	G	--	--	--	S	S	--	E	G	S	--	--	S	E	S	G	E	--	--	G
Climatic conditions........	G	--	E	--	G	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Soil characterization......	G	E	E	E	--	--	E	G	--	S	--	G	--	S	--	G	S	--	--	S
Erosion control............	G	--	--	--	--	--	--	--	--	--	--	--	--	--	S	--	--	--	--	--
Soil preparation:																				
Topsoil modification.....	--	--	--	--	S	--	--	G	--	--	--	--	--	--	S	--	G	--	--	--
Subsoil modification.....	--	--	--	--	--	--	--	--	--	E	--	--	--	--	S	--	--	--	--	--
Soil amendments:																				
pH modifiers.............	--	--	--	--	--	G	--	G	--	--	--	--	--	--	S	G	G	--	--	--
Mulch....................	G	--	--	--	--	--	--	--	--	--	--	--	--	--	S	G	G	--	--	S
Sludge...................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	G	S	--	--	--
Fertilizers..............	G	--	--	--	S	G	--	G	--	--	--	--	--	--	--	G	G	--	S	G
Biological amendments....	--	--	--	--	S	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Other....................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	S	G	--	--	--	--
Vegetation establishment:																				
Seeding..................	--	--	--	--	G	G	--	E	E	E	G	--	S	--	S	--	G	--	--	--
Transplanting............	--	--	--	--	G	--	--	--	E	--	--	--	--	--	--	--	--	--	S	S
Natural..................	--	--	--	--	--	--	--	--	--	--	--	--	--	E	--	--	--	--	--	--
Vegetation maintenance:																				
Irrigation...............	G	--	--	--	G	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Soil/plant monitoring....	G	E	E	--	S	--	--	G	--	E	--	E	--	G	--	G	--	--	--	--
Pesticides & herbicides..	--	--	--	--	--	--	--	--	--	G	E	--	--	--	--	--	--	--	--	--
Upkeep...................	--	--	--	--	S	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Vegetation evaluation:																				
Reference area...........	--	E	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Ground cover.............	--	--	--	--	--	--	--	E	--	--	G	--	--	E	--	S	--	--	--	--
Productivity.............	G	--	--	--	--	--	--	E	--	E	E	--	--	E	--	G	--	--	--	--

REFERENCE EVALUATIONS--Continued

Keywords	Reference No.																			
	541	542	543	544	545	546	547	548	549	550	551	552	553	554	555	556	557	558	559	560
Coal region................	I,E	X	X	I	I	I	I	I	N	N	N	O	E	O,X	O	E	E	E	I	O
Land use:																				
Cropland.................	--	--	--	S	E	G	--	--	S	S	S	--	S	--	--	--	--	--	--	G
Grazingland..............	--	--	--	--	S	G	--	--	S	S	S	S	S	--	--	--	--	S	--	--
Pastureland..............	--	--	--	S	E	G	S	G	--	--	S	S	S	--	--	--	--	S	--	--
Forestry.................	G	--	--	--	S	S	--	--	--	--	--	S	E	S	--	G	--	--	E	--
Wildlife.................	--	--	G	S	E	S	--	--	--	S	--	--	E	S	--	--	E	S	E	--
Miscellaneous............	--	--	--	--	S	S	--	--	--	S	--	--	S	--	--	--	--	--	--	--
Regulations:																				
Local....................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
State....................	--	--	--	--	--	--	--	--	--	--	--	--	E	--	--	--	--	--	--	--
Federal..................	--	--	--	--	--	--	--	--	--	--	--	--	E	--	--	--	--	--	--	E
Economic considerations....	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	S
Species selection..........	E	S	--	E	E	E	E	E	G	G	--	--	--	G	--	E	E	E	G	--
Climatic conditions........	--	--	--	G	G	S	E	E	S	G	--	--	--	--	--	--	--	--	--	--
Soil characterization......	--	--	--	G	--	E	E	G	G	G	G	--	--	--	--	--	S	--	--	G
Erosion control............	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	S	S	--	--
Soil preparation:																				
Topsoil modification.....	--	--	--	G	E	E	G	G	--	--	--	--	--	--	--	--	G	G	--	S
Subsoil modification.....	--	--	--	--	--	G	--	--	--	--	--	--	--	--	--	--	--	--	S	S
Soil amendments:																				
pH modifiers.............	--	--	--	E	E	E	E	E	--	--	--	--	--	--	--	--	G	G	--	--
Mulch....................	--	G	--	E	G	--	--	--	--	--	--	--	--	--	--	--	G	G	--	--
Sludge...................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	S	--	--	--
Fertilizers..............	--	--	--	E	E	E	E	E	S	S	--	--	--	--	--	--	G	G	G	--
Biological amendments....	G	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Other....................	--	--	--	--	--	--	--	--	G	G	--	--	--	--	--	--	--	--	--	--
Vegetation establishment:																				
Seeding..................	S	--	--	E	E	G	E	--	--	--	--	--	--	--	--	S	G	G	--	--
Transplanting............	S	G	--	--	--	--	--	--	--	--	--	--	--	--	--	S	G	G	G	--
Natural..................	--	E	S	--	--	--	--	--	--	--	--	--	--	--	--	G	--	--	--	--
Vegetation maintenance:																				
Irrigation...............	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Soil/plant monitoring....	S	G	--	--	G	--	E	S	--	--	G	--	--	--	--	--	--	--	--	--
Pesticides & herbicides..	S	--	--	--	--	--	--	--	--	--	--	--	--	E	--	--	--	--	E	--
Upkeep...................	S	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Vegetation evaluation:																				
Reference area...........	--	--	--	--	--	--	--	--	--	--	--	G	--	--	--	--	--	--	--	--
Ground cover.............	--	--	--	--	--	--	E	--	--	--	--	G	--	--	E	--	--	--	--	--
Productivity.............	G	E	--	S	E	S	E	E	S	S	G	G	--	--	--	G	--	--	G	--

REFERENCE EVALUATIONS--Continued

Keywords	Reference No.																			
	561	562	563	564	565	566	567	568	569	570	571	572	573	574	575	576	577	578	579	580
Coal region................	E	E	I	N,R,X	R,X	R	R,X	N,R	R	R	R,X	I	I	I	R	R,X	E,I	E	E	E
Land use:																				
Cropland................	S	--	--	--	--	E	--	S	S	S	--	--	S	S	--	--	--	--	--	--
Grazingland.............	S	--	--	--	G	E	S	S	S	S	G	--	--	--	--	S	--	--	--	--
Pastureland.............	S	--	--	--	--	G	--	S	S	S	--	--	S	--	--	--	--	--	--	--
Forestry................	S	--	--	--	--	--	--	S	--	--	--	G	--	--	--	--	S	G	--	--
Wildlife................	S	G	--	--	S	--	--	S	--	--	S	--	--	--	--	--	--	--	S	--
Miscellaneous...........	S	G	S	--	--	--	--	S	--	--	--	--	--	--	--	--	--	--	--	--
Regulations:																				
Local...................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
State...................	--	--	--	--	--	--	--	G	--	--	--	G	--	--	--	--	--	--	--	--
Federal.................	E	--	--	--	--	--	--	G	--	--	--	E	--	--	--	--	--	--	--	--
Economic considerations....	E	E	--	--	--	--	--	--	--	--	--	--	--	--	--	S	--	--	--	--
Species selection..........	--	--	G	--	E	E	E	S	--	S	G	--	--	--	--	E	G	E	--	G
Climatic conditions........	S	--	--	S	--	G	G	--	--	--	--	--	--	--	E	--	--	--	--	--
Soil characterization......	S	--	--	S	--	E	--	--	S	S	--	--	--	--	--	E	G	--	--	--
Erosion control............	S	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Soil preparation:																				
Topsoil modification.....	S	--	--	S	E	E	E	--	--	--	E	--	--	--	--	E	--	--	--	--
Subsoil modification.....	--	--	--	--	G	E	--	--	--	--	E	--	--	--	--	--	--	--	--	--
Soil amendments:																				
pH modifiers............	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	G	--	--	--
Mulch...................	--	--	--	S	E	--	--	--	--	--	--	--	--	--	--	G	G	E	--	G
Sludge..................	S	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Fertilizers.............	--	--	--	S	E	G	G	--	S	G	E	--	--	--	--	--	G	G	--	G
Biological amendments....	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	E	--	--	--
Other...................	S	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Vegetation establishment:																				
Seeding.................	--	--	--	--	E	G	E	S	--	--	--	--	--	--	--	E	--	E	S	E
Transplanting...........	--	--	--	--	--	--	--	S	--	--	--	--	--	--	--	--	G	--	S	--
Natural.................	--	--	E	--	--	--	--	--	--	--	--	--	--	--	--	G	--	--	--	--
Vegetation maintenance:																				
Irrigation..............	--	--	--	S	--	--	--	--	--	--	--	--	--	--	S	--	--	--	--	--
Soil/plant monitoring....	--	--	--	--	--	E	G	--	E	G	E	--	--	--	E	G	E	G	--	--
Pesticides & herbicides..	--	--	--	--	--	G	--	--	--	--	--	--	--	--	--	--	--	--	S	--
Upkeep..................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Vegetation evaluation:																				
Reference area..........	--	--	S	--	E	--	--	G	--	--	--	--	--	--	--	G	--	--	--	--
Ground cover............	--	--	--	--	E	E	E	G	--	--	--	--	--	--	E	E	--	--	--	--
Productivity............	--	--	--	S	E	E	E	G	--	G	G	--	--	S	E	--	E	E	S	G

REFERENCE EVALUATIONS--Continued

Keywords	Reference No.																			
	581	582	583	584	585	586	587	588	589	590	591	592	593	594	595	596	597	598	599	600
Coal region................	E,I	N	N,R	P	N,R	R	P	P	N	N	N	E	O	I	E	P	O	I	E,I	E,I
Land use:																				
Cropland.................	--	--	--	S	--	--	S	--	--	--	G	--	--	S	--	--	--	--	--	--
Grazingland..............	--	S	S	--	G	S	G	--	S	G	G	--	--	S	--	S	--	--	G	--
Pastureland..............	--	--	--	--	--	--	G	--	--	G	--	--	--	S	--	S	--	S	G	--
Forestry.................	S	--	--	S	--	--	--	--	--	--	--	S	S	S	S	--	--	--	--	--
Wildlife.................	--	--	--	S	--	S	--	--	--	--	--	S	--	S	--	G	--	--	E	--
Miscellaneous............	--	--	--	--	--	--	--	--	--	--	--	--	--	S	--	--	--	--	--	--
Regulations:																				
Local....................	--	--	--	--	--	--	--	--	--	--	--	--	--	G	--	--	--	--	--	--
State....................	--	--	--	--	--	--	--	--	--	--	--	--	--	G	--	--	--	--	--	--
Federal..................	--	--	--	G	--	--	--	--	--	--	--	--	--	G	--	--	--	--	--	--
Economic considerations....	--	--	--	S	--	--	--	--	--	--	--	--	--	E	--	--	--	--	--	--
Species selection..........	S	G	G	S	S	G	G	--	G	E	G	--	--	--	--	G	--	S	G	--
Climatic conditions........	--	--	--	--	--	--	G	G	S	S	S	--	--	--	--	G	G	--	--	--
Soil characterization......	--	S	--	--	--	G	G	--	S	--	G	--	--	S	--	--	G	G	--	--
Erosion control............	--	--	--	--	--	--	--	--	--	E	G	--	--	G	--	--	G	--	--	--
Soil preparation:																				
Topsoil modification.....	--	--	S	--	--	--	G	--	--	--	G	--	--	--	--	--	--	--	S	--
Subsoil modification.....	--	--	--	--	--	--	G	--	--	--	--	--	--	--	--	--	--	--	--	--
Soil amendments:																				
pH modifiers.............	--	--	S	--	--	--	--	--	--	--	--	--	--	--	--	--	--	G	--	--
Mulch....................	S	S	G	--	--	--	--	--	--	--	--	--	G	--	--	--	--	--	--	--
Sludge...................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Fertilizers..............	S	S	G	S	--	S	--	--	--	S	S	--	--	--	E	--	--	G	S	--
Biological amendments....	--	--	--	--	--	--	--	--	--	--	--	G	--	--	--	--	--	--	--	--
Other....................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Vegetation establishment:																				
Seeding..................	E	S	G	S	--	--	--	--	G	S	S	--	E	--	--	--	--	G	S	--
Transplanting............	S	--	--	S	--	S	--	--	--	--	--	--	--	--	G	--	--	--	S	--
Natural..................	--	--	--	--	--	--	G	--	--	--	--	G	--	--	--	G	--	--	--	--
Vegetation maintenance:																				
Irrigation...............	--	S	--	--	--	--	--	--	E	--	S	--	--	--	--	--	--	E	--	--
Soil/plant monitoring....	--	G	--	--	--	--	--	G	S	--	G	--	--	--	--	S	G	E	--	E
Pesticides & herbicides..	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Upkeep...................	--	--	--	--	--	--	S	--	--	--	--	--	--	--	--	--	--	--	--	--
Vegetation evaluation:																				
Reference area...........	--	--	--	--	G	--	G	--	--	E	--	--	--	--	--	G	--	--	--	--
Ground cover.............	--	--	G	--	G	--	G	G	G	E	--	--	--	--	--	G	--	E	--	G
Productivity.............	G	G	G	--	G	G	G	--	G	E	G	--	E	--	E	G	--	E	S	--

REFERENCE EVALUATIONS--Continued

Keywords	Reference No.																			
	601	602	603	604	605	606	607	608	609	610	611	612	613	614	615	616	617	618	619	620
Coal region................	E	E	E	O,X	O,X	O,X	E,X	N	X	R,X	N	O	N	N,R,P	E	I	P	R,P	R,P	R,P
Land use:																				
Cropland.................	--	--	--	--	--	--	--	--	--	--	--	S	--	--	--	--	E	G	G	G
Grazingland..............	--	--	--	--	--	--	--	--	--	G	S	S	S	--	--	--	--	G	G	G
Pastureland..............	--	--	--	G	G	G	--	--	--	--	S	S	S	--	--	--	--	G	--	G
Forestry.................	--	G	G	--	--	--	S	S	--	--	--	S	--	--	--	S	--	--	--	--
Wildlife.................	--	--	--	--	--	--	--	--	--	S	--	--	--	--	G	S	--	--	--	--
Miscellaneous............	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Regulations:																				
Local....................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
State....................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	G	--	--	--	--
Federal..................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Economic considerations....	--	--	S	--	--	--	--	G	--	--	--	--	--	--	--	--	--	S	S	E
Species selection..........	E	--	G	G	G	G	G	--	--	E	S	G	G	--	G	E	G	G	S	G
Climatic conditions........	--	--	G	--	--	--	--	E	--	--	--	--	--	--	--	--	G	G	--	G
Soil characterization......	--	--	--	E	E	E	--	--	E	S	G	G	--	E	--	--	S	--	--	G
Erosion control............	--	--	--	G	G	G	S	--	--	--	--	--	--	--	--	--	--	--	--	G
Soil preparation:																				
Topsoil modification.....	--	--	--	G	G	G	G	--	--	--	--	G	--	--	S	--	G	G	S	G
Subsoil modification.....	--	--	--	G	G	G	G	--	--	--	--	--	--	--	--	--	--	G	S	E
Soil amendments:																				
pH modifiers.............	--	--	--	G	G	G	G	--	S	--	--	--	E	--	--	S	--	--	--	--
Mulch....................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sludge...................	--	--	--	--	--	--	G	--	--	E	--	--	--	--	--	--	--	--	--	--
Fertilizers..............	--	--	--	E	E	E	G	--	S	E	--	G	G	--	--	S	--	S	--	S
Biological amendments....	E	--	--	--	--	--	E	--	--	--	--	--	--	--	--	--	--	--	--	--
Other....................	--	--	--	E	E	E	--	--	--	E	G	--	E	--	--	--	E	G	S	--
Vegetation establishment:																				
Seeding..................	--	--	--	G	G	G	G	--	--	G	--	--	--	--	G	G	--	S	--	--
Transplanting............	--	--	--	--	--	--	G	G	--	--	--	--	--	--	--	G	--	--	--	--
Natural..................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	S	--	--	--	--	--
Vegetation maintenance:																				
Irrigation...............	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	S	--
Soil/plant monitoring....	--	--	E	E	E	E	E	--	--	E	G	G	--	--	--	--	E	S	--	G
Pesticides & herbicides..	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Upkeep...................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Vegetation evaluation:																				
Reference area...........	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Ground cover.............	--	--	--	E	E	E	G	--	--	E	--	--	--	--	--	--	--	--	--	--
Productivity.............	--	E	E	E	E	E	E	S	--	E	G	--	--	--	--	S	E	S	--	E

REFERENCE EVALUATIONS--Continued

Keywords	Reference No.																			
	621	622	623	624	625	626	627	628	629	630	631	632	633	634	635	636	637	638	639	640
Coal region................	O	E	E,X	N,R	O	N	N	N	N	N	N	N	N	O,X	E,I	E	E	R	I	N
Land use:																				
Cropland.................	--	--	--	G	S	--	S	S	--	--	--	--	--	--	S	--	--	--	--	G
Grazingland..............	--	--	--	G	S	--	--	--	S	--	S	S	S	--	S	--	--	--	--	--
Pastureland..............	--	--	--	G	S	--	--	--	--	--	--	--	--	--	S	--	--	--	--	--
Forestry.................	--	--	S	G	S	--	--	--	--	--	--	--	--	--	S	S	G	--	E	--
Wildlife.................	--	G	S	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Miscellaneous............	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Regulations:																				
Local....................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
State....................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Federal..................	G	--	--	--	--	--	--	--	--	--	--	--	--	--	S	--	S	--	S	--
Economic considerations....	S	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	G	--
Species selection..........	--	G	E	--	S	--	--	--	--	--	--	--	--	E	--	E	E	G	E	S
Climatic conditions........	--	--	--	--	--	--	--	--	--	--	--	E	S	--	--	--	--	--	--	--
Soil characterization......	--	--	--	E	G	G	E	G	E	E	E	--	E	--	--	G	G	G	--	G
Erosion control............	--	--	--	--	--	--	--	S	--	E	--	G	--	--	--	--	--	--	--	--
Soil preparation:																				
Topsoil modification.....	--	--	--	--	G	G	--	--	--	E	--	--	S	G	S	--	--	--	--	E
Subsoil modification.....	--	--	--	--	G	G	--	--	--	E	--	--	--	G	S	--	--	--	--	--
Soil amendments:																				
pH modifiers.............	--	--	--	--	--	--	--	--	--	--	--	--	--	G	--	--	--	G	--	--
Mulch....................	--	--	S	--	--	--	--	--	--	--	--	--	--	G	S	--	G	G	--	--
Sludge...................	--	--	--	--	--	--	--	--	--	--	--	--	--	G	S	E	--	--	--	--
Fertilizers..............	--	--	S	--	--	S	--	--	--	--	--	S	--	G	--	E	E	G	--	G
Biological amendments....	--	--	--	--	S	--	--	--	--	--	--	--	--	--	--	--	E	--	--	--
Other....................	--	--	E	--	--	--	--	--	--	--	--	--	--	G	--	--	--	G	--	--
Vegetation establishment:																				
Seeding..................	--	E	--	--	--	--	--	--	--	--	--	G	--	G	S	G	G	--	S	--
Transplanting............	--	--	S	--	--	--	--	--	--	--	--	--	--	--	--	G	E	--	S	--
Natural..................	--	--	--	--	--	--	--	--	--	--	E	G	--	--	--	--	--	--	--	--
Vegetation maintenance:																				
Irrigation...............	--	--	--	--	--	--	--	--	--	E	--	--	--	--	--	--	--	--	--	--
Soil/plant monitoring....	--	--	E	--	E	--	--	--	--	E	E	E	--	--	--	E	E	G	--	--
Pesticides & herbicides..	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	E	--	E	--
Upkeep...................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Vegetation evaluation:																				
Reference area...........	--	--	--	--	--	--	--	S	--	--	G	E	E	--	--	--	--	--	--	--
Ground cover.............	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Productivity.............	--	S	G	--	--	--	G	S	--	--	E	E	--	--	--	E	E	G	--	E

REFERENCE EVALUATIONS--Continued

Keywords	Reference No.																			
	641	642	643	644	645	646	647	648	649	650	651	652	653	654	655	656	657	658	659	660
Coal region................	N	N,X	E	N	N	N	E	R	O	N,R	N,R	N,R	X	N,R	N	N	N	N	N	N
Land use:																				
Cropland.................	G	--	--	--	S	G	S	--	S	--	--	--	--	--	--	--	--	--	--	--
Grazingland..............	G	S	--	--	S	G	--	--	S	--	S	S	--	S	G	G	--	G	S	G
Pastureland..............	--	--	--	--	S	--	--	--	S	--	--	--	--	S	--	--	--	--	--	--
Forestry.................	--	--	E	--	S	--	--	--	S	--	--	--	--	--	--	--	--	--	--	--
Wildlife.................	--	--	--	S	S	G	--	--	--	--	--	S	--	S	--	--	--	--	--	--
Miscellaneous............	--	--	--	--	S	G	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Regulations:																				
Local....................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
State....................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	E	--	--	S	--	--
Federal..................	--	--	--	S	--	--	--	--	--	--	--	--	--	--	G	--	G	S	--	--
Economic considerations....	--	E	--	G	G	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Species selection..........	S	G	E	--	G	--	S	--	--	S	--	G	--	G	S	S	G	E	E	E
Climatic conditions........	--	S	--	--	G	--	--	--	--	--	--	--	--	G	--	--	--	--	--	--
Soil characterization......	G	S	E	--	G	--	--	E	E	--	--	--	E	G	--	S	--	--	G	G
Erosion control............	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Soil preparation:																				
Topsoil modification.....	G	G	--	--	--	G	S	--	--	--	--	--	--	--	--	S	--	--	--	--
Subsoil modification.....	--	--	--	--	--	G	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Soil amendments:																				
pH modifiers.............	--	--	--	--	--	--	G	--	--	--	--	--	S	--	--	--	--	--	--	--
Mulch....................	--	E	--	--	--	G	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sludge...................	--	--	--	--	--	--	E	--	--	--	--	--	--	--	--	--	--	--	--	--
Fertilizers..............	--	--	--	--	--	G	--	--	--	--	--	--	S	S	--	S	--	--	--	--
Biological amendments....	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Other....................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Vegetation establishment:																				
Seeding..................	--	E	--	--	--	G	S	--	--	--	--	G	--	--	S	--	--	G	--	G
Transplanting............	--	--	--	--	--	G	--	--	--	--	--	E	--	--	--	--	--	--	--	--
Natural..................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	S	--	--	G	E	E
Vegetation maintenance:																				
Irrigation...............	--	--	--	--	--	S	--	--	--	--	--	--	--	E	--	--	--	--	--	--
Soil/plant monitoring....	--	G	E	--	--	--	E	--	--	E	E	--	E	--	--	--	--	--	--	E
Pesticides & herbicides..	--	--	--	--	--	S	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Upkeep...................	--	--	--	--	--	S	--	--	--	--	--	--	--	--	--	S	--	--	--	G
Vegetation evaluation:																				
Reference area...........	--	--	--	--	--	--	S	--	--	--	E	--	--	--	G	G	--	E	--	--
Ground cover.............	--	G	--	--	--	--	--	--	--	--	--	--	--	--	E	G	--	E	E	G
Productivity.............	G	--	E	--	--	--	E	--	--	--	--	--	--	--	E	G	--	E	E	G

REFERENCE EVALUATIONS--Continued

Keywords	Reference No.																			
	661	662	663	664	665	666	667	668	669	670	671	672	673	674	675	676	677	678	679	680
Coal region................	N	N	O	E,X	R,X	O	O	N	O	E	I	O	I	O	O	O	E	E	E	E
Land use:																				
Cropland.................	--	--	S	--	--	--	G	--	--	--	S	--	--	--	--	--	--	--	--	--
Grazingland..............	S	S	S	--	--	--	--	S	--	--	--	--	--	--	--	--	--	--	--	--
Pastureland..............	--	--	S	--	--	--	--	--	--	--	--	--	--	--	--	--	S	S	--	--
Forestry.................	--	--	S	--	--	--	--	--	--	S	--	--	--	--	--	--	S	--	--	--
Wildlife.................	S	--	S	--	--	--	--	S	--	--	--	G	--	--	--	--	--	--	--	--
Miscellaneous............	--	--	S	--	--	--	--	--	--	--	--	--	--	--	--	--	S	S	--	--
Regulations:																				
Local....................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
State....................	--	--	--	--	--	--	--	--	--	G	--	--	--	--	--	--	--	--	--	G
Federal..................	--	--	E	--	--	--	E	--	--	--	--	--	--	--	--	--	--	--	--	G
Economic considerations....	--	--	--	--	--	--	--	--	G	S	--	--	--	--	--	--	--	--	--	--
Species selection..........	E	--	E	G	E	G	--	--	--	G	--	--	--	--	--	--	E	G	--	--
Climatic conditions........	G	--	--	--	S	--	--	G	--	--	--	--	--	--	--	--	--	--	--	--
Soil characterization......	--	E	G	--	--	--	--	S	E	--	G	--	G	G	--	--	--	S	S	--
Erosion control............	--	--	--	E	--	--	--	--	--	S	--	--	--	--	--	--	--	--	--	--
Soil preparation:																				
Topsoil modification.....	S	--	--	--	--	--	--	G	--	--	S	--	G	--	--	--	--	--	G	--
Subsoil modification.....	--	--	--	--	--	--	--	--	--	--	S	--	--	--	--	--	--	--	--	--
Soil amendments:																				
pH modifiers.............	--	--	S	S	--	--	--	--	--	--	--	--	S	--	--	--	--	S	G	--
Mulch....................	S	--	S	--	--	--	--	G	--	--	--	--	--	--	--	--	--	--	G	--
Sludge...................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	E	G	E	E
Fertilizers..............	G	--	S	S	--	--	--	G	--	--	--	--	--	--	--	--	--	G	--	--
Biological amendments....	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Other....................	--	--	--	--	--	--	--	--	--	--	--	--	S	--	--	--	--	--	--	--
Vegetation establishment:																				
Seeding..................	G	--	G	--	--	--	--	G	--	--	--	--	--	--	--	S	G	--	G	--
Transplanting............	--	--	--	--	S	--	--	--	--	--	--	--	--	--	--	--	G	--	--	--
Natural..................	E	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Vegetation maintenance:																				
Irrigation...............	S	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	E	--	--	--
Soil/plant monitoring....	G	G	--	--	--	--	--	--	--	--	G	--	G	--	--	--	--	S	G	G
Pesticides & herbicides..	--	--	S	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Upkeep...................	--	--	--	--	--	--	--	--	--	S	--	--	--	--	--	--	--	--	--	--
Vegetation evaluation:																				
Reference area...........	G	--	G	--	G	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Ground cover.............	E	--	G	--	--	S	--	G	--	--	--	--	--	--	--	--	E	--	--	--
Productivity.............	E	--	G	G	--	S	--	G	--	--	--	--	--	--	--	--	E	--	G	S

REFERENCE EVALUATIONS--Continued

Keywords	Reference No.																			
	681	682	683	684	685	686	687	688	689	690	691	692	693	694	695	696	697	698	699	700
Coal region................	E	R,X	O,X	N,R	I	I	I	N	N	N	N	N	E	R	R,N	N	N,R	N,P,R	E	N,R
Land use:																				
Cropland................	G	--	--	--	--	E	S	--	--	--	--	--	--	--	--	--	--	--	--	--
Grazingland.............	G	G	--	G	--	--	--	S	--	--	--	S	--	--	S	--	S	--	--	--
Pastureland.............	G	--	--	--	--	--	S	--	--	--	--	--	--	--	--	--	S	--	S	--
Forestry................	G	--	--	--	G	--	S	--	--	S	--	--	--	--	--	--	S	--	--	--
Wildlife................	S	--	--	G	--	--	--	--	--	--	--	--	G	G	S	--	S	--	--	G
Miscellaneous...........	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Regulations:																				
Local...................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
State...................	G	--	--	S	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	G
Federal.................	G	--	--	S	--	--	--	--	--	--	--	--	--	--	--	--	--	S	--	G
Economic considerations....	--	--	--	--	--	--	S	--	--	--	--	--	--	--	--	--	--	--	--	--
Species selection..........	E	S	--	--	G	--	--	S	G	E	S	--	G	S	G	S	S	--	S	--
Climatic conditions........	--	--	--	--	--	--	--	S	G	S	--	--	--	S	--	--	--	--	--	--
Soil characterization......	G	G	E	--	--	--	--	--	S	G	--	E	--	--	--	G	--	--	G	--
Erosion control............	S	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	G	--	--
Soil preparation:																				
Topsoil modification.....	--	G	--	--	--	--	S	--	--	--	--	--	--	--	--	--	--	--	--	--
Subsoil modification.....	--	E	--	--	--	--	S	--	--	--	--	--	--	--	--	--	--	--	--	--
Soil amendments:																				
pH modifiers............	S	--	--	--	--	--	--	--	--	--	--	--	E	--	--	--	--	--	E	--
Mulch...................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	S	E	--
Sludge..................	E	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Fertilizers.............	--	G	--	--	--	--	--	S	--	--	--	S	E	--	--	G	--	--	G	--
Biological amendments....	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Other...................	--	--	--	--	--	--	--	--	--	--	--	S	--	--	--	--	--	--	--	--
Vegetation establishment:																				
Seeding.................	S	S	--	--	--	--	--	--	G	--	--	--	G	--	G	--	--	--	E	--
Transplanting...........	S	--	--	--	E	--	--	--	--	--	--	--	G	--	G	--	--	--	--	--
Natural.................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Vegetation maintenance:																				
Irrigation..............	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Soil/plant monitoring....	G	E	--	--	--	--	--	E	E	G	G	E	--	--	--	G	--	--	E	--
Pesticides & herbicides..	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Upkeep..................	--	--	--	--	--	--	--	--	--	--	--	--	E	--	--	--	--	--	--	--
Vegetation evaluation:																				
Reference area..........	--	--	--	S	G	--	--	E	E	--	--	--	--	--	--	--	E	--	--	--
Ground cover............	S	--	--	S	--	--	--	--	--	--	--	--	G	--	--	--	E	--	S	--
Productivity............	S	--	--	E	E	G	--	S	--	--	--	--	G	--	--	G	E	--	E	--

REFERENCE EVALUATIONS--Continued

Keywords	Reference No.																			
	701	702	703	704	705	706	707	708	709	710	711	712	713	714	715	716	717	718	719	720
Coal region................	O	E	E	I	I	I	N	E	E,I	O	E	O,X	O,X	R	O,X	N,R	O	P,X	E	E
Land use:																				
Cropland................	S	--	--	--	S	--	--	S	--	--	--	--	--	--	--	--	--	--	G	G
Grazingland.............	S	--	--	--	--	--	S	--	--	--	--	--	--	--	--	S	--	--	G	--
Pastureland.............	S	--	--	S	--	S	--	--	--	--	--	G	--	--	--	S	--	--	G	G
Forestry................	S	G	S	--	--	--	--	--	S	--	G	--	--	--	G	S	--	S	G	G
Wildlife................	E	--	S	--	--	--	--	--	--	--	--	--	--	--	--	--	--	S	G	G
Miscellaneous...........	S	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	G	G
Regulations:																				
Local...................	S	--	--	--	--	--	--	--	--	S	--	--	--	--	--	--	--	--	--	--
State...................	S	--	S	--	--	--	G	--	--	S	--	--	--	--	--	--	--	--	--	G
Federal.................	E	--	--	--	--	--	--	--	--	G	--	--	--	--	--	--	S	--	G	G
Economic considerations....	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	G
Species selection..........	--	E	E	E	--	S	--	--	G	--	E	E	--	--	--	E	--	E	G	--
Climatic conditions........	--	--	--	--	--	--	--	--	--	--	E	G	--	G	S	G	--	--	--	--
Soil characterization......	--	S	--	G	G	G	--	G	--	--	--	E	G	--	--	--	--	--	S	--
Erosion control............	--	--	S	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	G	--
Soil preparation:																				
Topsoil modification.....	--	--	--	--	--	--	--	--	--	--	--	G	--	S	S	S	--	--	G	--
Subsoil modification.....	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	S	--	--	G	--
Soil amendments:																				
pH modifiers............	--	--	--	--	S	--	--	--	--	--	--	E	--	--	--	--	--	--	G	--
Mulch...................	--	--	--	--	--	--	--	--	--	--	E	--	--	--	--	G	--	--	G	--
Sludge..................	--	--	--	E	--	G	--	--	--	--	G	--	E	--	--	--	--	--	G	--
Fertilizers.............	--	--	--	--	S	--	--	G	--	--	G	E	--	--	--	S	--	E	G	--
Biological amendments....	--	--	--	--	S	--	--	G	--	--	--	--	--	--	--	--	--	--	--	--
Other...................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	G	--
Vegetation establishment:																				
Seeding.................	--	--	S	G	S	S	--	--	--	--	G	--	--	--	--	G	--	G	G	--
Transplanting...........	--	--	G	--	--	--	--	--	G	--	--	--	G	--	S	G	--	--	G	--
Natural.................	--	--	--	--	--	--	--	--	--	--	--	--	G	--	S	--	--	--	--	--
Vegetation maintenance:																				
Irrigation..............	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	S	--	--	--	--
Soil/plant monitoring....	--	E	--	E	--	G	--	E	--	--	--	E	--	--	--	--	--	--	--	--
Pesticides & herbicides..	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	S	--	--	--	--
Upkeep..................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	S	--	--	--	--
Vegetation evaluation:																				
Reference area..........	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Ground cover............	--	--	--	E	--	--	--	--	--	--	--	G	G	--	--	--	S	E	--	--
Productivity............	--	E	--	E	G	G	--	E	--	--	E	E	--	--	--	--	--	--	--	--

REFERENCE EVALUATIONS--Continued

Keywords	Reference No.																			
	721	722	723	724	725	726	727	728	729	730	731	732	733	734	735	736	737	738	739	740
Coal region................	N	N	N	N	O	O	G,I	E	G	N	N,R	N,R	N,R,P	O	N	N	N	N	N	R
Land use:																				
Cropland................	--	--	S	--	--	--	--	--	S	--	--	--	--	--	--	--	--	--	--	--
Grazingland.............	--	G	G	S	--	--	S	S	--	--	G	S	--	--	G	G	G	S	G	G
Pastureland.............	--	--	--	--	--	--	--	S	S	--	--	--	--	--	--	--	--	--	--	--
Forestry................	--	--	--	--	--	--	S	S	S	--	--	--	--	--	--	--	--	--	--	--
Wildlife................	G	G	S	S	--	--	--	--	--	--	--	S	--	E	G	G	G	--	G	S
Miscellaneous...........	--	--	--	--	--	--	--	--	--	--	--	S	--	--	--	--	--	--	--	G
Regulations:																				
Local...................	--	--	--	--	--	--	--	--	--	G	--	--	--	--	--	--	--	--	--	--
State...................	--	S	--	--	--	--	--	S	--	G	--	--	--	S	--	S	S	--	--	--
Federal.................	G	S	--	--	E	E	--	S	--	G	--	S	--	G	--	S	S	--	--	G
Economic considerations....	--	S	--	--	--	--	--	G	--	S	--	--	S	--	S	S	S	--	S	--
Species selection..........	--	G	G	G	--	--	S	G	S	--	--	E	E	--	G	G	G	G	G	S
Climatic conditions........	--	--	E	S	--	--	S	--	--	--	--	S	--	--	G	--	--	--	G	S
Soil characterization......	--	S	E	S	--	--	S	G	S	--	--	S	--	S	G	S	G	S	G	G
Erosion control............	--	--	G	S	--	--	S	G	--	--	--	--	S	--	--	--	--	S	--	--
Soil preparation:																				
Topsoil modification.....	--	S	--	S	--	--	--	--	--	--	S	E	E	S	S	S	S	S	S	S
Subsoil modification.....	--	S	--	--	--	--	--	--	--	--	S	E	--	S	S	S	S	S	S	S
Soil amendments:																				
pH modifiers............	--	--	--	--	--	--	--	S	--	--	--	--	--	--	--	--	--	--	--	--
Mulch...................	--	S	--	--	--	--	--	--	--	--	S	G	G	--	--	--	S	--	S	--
Sludge..................	--	--	--	--	--	--	--	S	--	--	--	G	--	--	--	--	--	--	--	--
Fertilizers.............	--	S	--	--	--	--	S	S	--	--	--	E	--	--	--	S	S	--	S	--
Biological amendments....	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	S	--	S	--
Other...................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Vegetation establishment:																				
Seeding.................	--	S	G	S	--	--	--	G	--	--	S	E	G	S	S	S	S	S	S	--
Transplanting...........	--	S	--	--	--	--	--	G	--	--	S	E	G	S	S	S	--	--	S	--
Natural.................	--	--	--	--	--	--	--	--	--	--	--	G	--	--	--	--	--	--	--	--
Vegetation maintenance:																				
Irrigation..............	--	--	S	--	--	--	--	--	--	--	--	G	G	--	--	S	--	--	--	S
Soil/plant monitoring....	--	--	--	--	--	--	--	G	--	--	--	E	--	--	--	--	--	--	--	--
Pesticides & herbicides..	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Upkeep..................	--	--	--	--	--	--	--	--	--	--	S	G	--	S	S	S	S	--	S	--
Vegetation evaluation:																				
Reference area...........	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Ground cover.............	--	--	--	--	--	--	--	G	--	--	--	G	--	--	--	--	--	--	--	S
Productivity.............	--	--	--	--	--	--	--	G	--	--	--	G	--	--	--	--	--	--	--	--

REFERENCE EVALUATIONS--Continued

Keywords	Reference No.																			
	741	742	743	744	745	746	747	748	749	750	751	752	753	754	755	756	757	758	759	760
Coal region................	N	E	E	R	I	O	O	E,G,I	E	E,I	O,X	O,X	O	R,X	R	E	E	E	R	X
Land use:																				
Cropland................	E	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Grazingland.............	E	--	--	S	--	--	--	S	--	--	E	--	--	--	--	--	--	--	S	--
Pastureland.............	G	--	S	--	--	--	--	S	S	--	--	--	--	--	--	--	--	--	--	--
Forestry................	--	G	--	--	--	E	G	G	S	G	--	--	--	--	--	E	G	G	--	--
Wildlife................	G	--	--	S	--	--	--	G	--	--	--	--	--	--	--	--	--	--	S	--
Miscellaneous...........	--	--	--	--	G	--	--	G	--	--	--	--	--	--	--	--	--	--	--	--
Regulations:																				
Local...................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
State...................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Federal.................	G	--	--	--	--	--	--	--	--	--	G	--	E	--	--	--	--	--	--	--
Economic considerations....	--	--	--	--	G	--	--	--	--	--	S	--	--	--	--	--	--	--	--	--
Species selection..........	E	E	G	G	--	--	--	E	E	E	E	S	--	--	G	G	S	G	--	--
Climatic conditions........	E	--	--	--	--	--	--	S	--	G	E	--	--	--	G	--	--	--	--	--
Soil characterization......	E	--	--	S	E	--	E	E	G	--	G	--	--	--	--	--	--	S	G	G
Erosion control............	--	--	--	--	--	--	--	G	S	G	E	G	--	E	--	--	--	--	--	--
Soil preparation:																				
Topsoil modification.....	--	--	--	--	--	--	--	G	S	S	--	--	--	--	--	--	--	--	--	--
Subsoil modification.....	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Soil amendments:																				
pH modifiers............	--	--	E	--	--	--	--	G	S	G	--	--	--	--	--	--	S	--	--	--
Mulch...................	--	--	G	--	--	--	S	G	E	S	S	--	--	--	--	--	S	--	--	--
Sludge..................	--	--	--	--	--	--	G	S	--	--	--	--	--	--	--	--	--	--	--	--
Fertilizers.............	E	G	E	S	--	--	G	G	G	G	S	--	--	--	--	G	G	G	--	--
Biological amendments....	--	--	--	--	--	--	--	S	S	--	--	--	--	--	--	E	G	E	--	--
Other...................	E	--	--	--	--	--	--	S	--	--	--	--	--	--	--	--	--	--	--	--
Vegetation establishment:																				
Seeding.................	G	G	E	--	--	--	S	G	S	E	G	--	--	--	--	--	S	--	--	--
Transplanting...........	--	G	--	G	--	--	--	E	--	E	--	--	--	--	--	G	--	S	S	--
Natural.................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	E	S	--	--	G	E
Vegetation maintenance:																				
Irrigation..............	--	--	--	S	--	--	--	--	--	--	--	--	--	G	--	--	--	--	--	--
Soil/plant monitoring....	E	E	E	--	--	--	--	--	--	--	--	--	--	E	--	--	--	E	--	E
Pesticides & herbicides..	G	--	--	--	--	--	--	--	--	G	S	--	--	--	--	--	--	--	--	--
Upkeep..................	G	--	--	S	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Vegetation evaluation:																				
Reference area..........	G	--	--	--	--	--	--	--	--	--	--	--	--	--	E	--	--	--	--	--
Ground cover............	E	E	E	--	--	--	--	--	G	E	S	G	--	--	E	--	--	G	--	G
Productivity............	E	E	--	G	--	--	--	--	G	E	--	--	--	--	--	E	G	G	S	E

REFERENCE EVALUATIONS--Continued

Keywords	Reference No.																			
	761	762	763	764	765	766	767	768	769	770	771	772	773	774	775	776	777	778	779	780
Coal region................	R	I	R,X	G,I,N	R	E	O	E,I	O	E	G	N,R	E	N,R	N,R	I	E	E	E	E
Land use:																				
Cropland.................	--	--	--	S	--	--	--	--	S	--	--	S	--	--	G	--	--	--	--	--
Grazingland..............	S	--	G	S	S	--	--	--	S	--	--	S	S	--	G	--	--	--	--	--
Pastureland..............	--	--	--	S	--	--	--	--	S	--	S	S	--	--	--	--	--	--	S	--
Forestry.................	--	--	--	S	--	--	--	--	S	S	--	S	--	--	--	--	G	G	--	G
Wildlife.................	S	--	S	S	--	--	--	--	S	--	S	S	E	--	G	S	--	--	--	S
Miscellaneous............	--	--	--	S	--	--	--	--	S	--	--	S	--	--	--	G	--	--	--	--
Regulations:																				
Local....................	--	--	--	--	--	--	--	--	--	--	--	S	--	--	G	--	--	--	--	--
State....................	--	--	--	--	--	--	--	--	--	S	--	E	--	--	G	--	--	--	--	--
Federal..................	--	--	--	--	--	--	E	--	E	S	--	E	--	S	G	--	--	--	--	--
Economic considerations....	--	--	--	--	--	--	--	--	G	--	--	--	--	G	G	E	E	S	--	--
Species selection..........	--	--	E	E	S	S	--	--	G	S	G	--	G	--	G	G	--	--	S	S
Climatic conditions........	--	--	--	--	--	--	--	--	--	--	G	--	--	--	S	--	--	--	--	--
Soil characterization......	--	E	--	--	G	E	--	--	E	--	S	--	--	--	S	G	--	--	G	--
Erosion control............	--	--	--	E	--	--	--	--	--	--	--	--	--	--	G	S	--	--	--	--
Soil preparation:																				
Topsoil modification.....	S	--	G	--	--	--	--	--	--	--	S	--	--	--	G	--	--	--	--	--
Subsoil modification.....	--	--	--	--	--	--	--	--	--	--	--	--	--	--	G	--	--	--	--	--
Soil amendments:																				
pH modifiers.............	--	--	--	--	--	--	--	--	G	--	--	--	--	--	--	G	--	--	--	--
Mulch....................	--	--	--	--	--	--	--	--	S	--	--	--	--	--	G	--	--	--	G	S
Sludge...................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Fertilizers..............	--	--	G	--	--	G	--	--	G	--	S	--	--	--	S	G	--	--	G	S
Biological amendments....	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Other....................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Vegetation establishment:																				
Seeding..................	--	--	--	E	S	--	--	--	S	G	S	--	S	--	G	G	--	G	E	G
Transplanting............	--	--	--	E	--	--	--	--	--	G	--	--	S	--	G	--	--	--	--	--
Natural..................	--	--	--	--	--	--	--	--	--	--	--	--	S	--	--	--	--	--	--	--
Vegetation maintenance:																				
Irrigation...............	--	--	--	--	G	--	--	--	--	--	--	--	--	--	S	--	--	--	--	--
Soil/plant monitoring....	--	E	E	--	G	--	--	E	S	--	--	--	--	--	--	G	--	--	E	--
Pesticides & herbicides..	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Upkeep...................	S	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Vegetation evaluation:																				
Reference area...........	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Ground cover.............	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	G	--	--	--	--
Productivity.............	--	--	E	--	G	G	--	--	--	--	--	--	--	--	--	--	E	--	G	S

REFERENCE EVALUATIONS--Continued

Keywords	Reference No.																			
	781	782	783	784	785	786	787	788	789	790	791	792	793	794	795	796	797	798	799	800
Coal region................	O	E	O	E,I	N,R	E	E	O	N	N	X	O	O	E	N	E	E,I	O	I	I
Land use:																				
Cropland.................	--	--	S	--	--	--	--	--	--	--	--	--	--	--	--	--	--	G	--	--
Grazingland..............	--	--	S	--	G	--	--	--	S	S	--	--	--	--	S	--	--	G	--	--
Pastureland..............	--	G	S	--	--	--	--	--	--	--	--	--	--	--	--	--	--	G	--	--
Forestry.................	--	G	G	G	--	--	S	--	--	--	--	--	--	S	--	--	S	G	--	--
Wildlife.................	--	--	S	--	G	--	--	--	--	S		E	--	--	--	--	G	G	G	G
Miscellaneous............	--	--	S	--	--	--	--	--	--	--	--	--	--	--	--	--	--	G	G	G
Regulations:																				
Local....................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
State....................	--	--	S	--	--	--	--	--	--	--	--	--	S	--	--	--	--	S	--	--
Federal..................	--	G	E	--	--	--	--	--	--	--	G	--	G	--	--	--	S	G	--	--
Economic considerations....	--	E	--	G	--	--	--	--	--	--	--	--	E	--	--	--	--	--	G	--
Species selection..........	G	E	S	S	S	--	G	--	G	--	G	G	--	--	S	--	G	G	G	G
Climatic conditions........	--	--	--	--	--	--	--	--	--	S	G	--	--	--	--	--	--	--	--	--
Soil characterization......	--	G	--	--	--	E	--	--	S	E	E	--	--	--	S	--	--	S	--	G
Erosion control............	--	--	--	--	--	E	--	--	--	--	S	--	--	--	--	--	--	G	--	G
Soil preparation:																				
Topsoil modification.....	--	--	G	--	--	--	--	--	--	E	--	--	S	--	--	--	--	G	G	S
Subsoil modification.....	--	--	G	--	--	--	--	--	--	E	--	--	S	--	--	--	--	G	G	--
Soil amendments:																				
pH modifiers.............	--	--	--	--	--	--	S	--	--	--	S	--	S	--	--	--	--	S	G	S
Mulch....................	--	--	--	--	--	--	S	--	--	--	--	--	--	--	--	--	--	S	--	--
Sludge...................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	G	--	S	--	--
Fertilizers..............	--	S	--	--	--	--	S	--	--	--	S	--	S	--	G	--	--	G	G	--
Biological amendments....	--	--	--	G	--	--	S	--	--	--	--	--	--	--	--	--	--	S	--	--
Other....................	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Vegetation establishment:																				
Seeding..................	--	--	--	G	--	--	S	--	--	S	--	G	S	S	G	--	--	S	--	S
Transplanting............	S	--	--	G	--	--	S	--	--	S	--	--	--	G	--	--	--	--	--	--
Natural..................	--	--	--	--	--	--	--	--	--	--	--	--	--	S	--	--	--	--	--	--
Vegetation maintenance:																				
Irrigation...............	--	--	--	--	--	--	S	--	--	--	G	--	S	--	E	--	--	--	--	--
Soil/plant monitoring....	S	--	--	--	--	--	--	--	G	--	G	--	--	G	--	--	--	S	G	--
Pesticides & herbicides..	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Upkeep...................	--	--	--	--	--	--	--	--	--	--	--	--	S	--	--	--	--	--	--	--
Vegetation evaluation:																				
Reference area...........	--	--	G	--	S	--	--	--	G	G	--	--	--	--	--	--	--	--	--	--
Ground cover.............	--	--	G	--	G	--	--	--	--	--	--	--	--	E	E	--	--	S	G	G
Productivity.............	--	G	G	--	G	--	G	--	G	--	--	--	--	E	E	--	--	S	--	G

REFERENCE EVALUATIONS--Continued

Keywords	Reference No.				
	801	802	803	804	805
Coal region................	I	O	O	E	E
Land use:					
Cropland.................	--	--	--	--	--
Grazingland..............	--	S	S	--	--
Pastureland..............	--	--	--	--	--
Forestry.................	--	--	--	S	G
Wildlife.................	E	--	--	--	--
Miscellaneous............	E	--	--	--	--
Regulations:					
Local....................	--	--	--	--	--
State....................	--	--	--	--	S
Federal..................	--	--	--	--	S
Economic considerations....	E	--	--	--	E
Species selection..........	E	--	E	S	--
Climatic conditions........	--	--	--	--	--
Soil characterization......	--	S	--	--	--
Erosion control............	E	--	--	--	--
Soil preparation:					
Topsoil modification.....	G	--	--	--	--
Subsoil modification.....	G	--	--	--	--
Soil amendments:					
pH modifiers.............	G	--	--	--	--
Mulch....................	--	--	--	--	--
Sludge...................	--	--	--	--	--
Fertilizers..............	G	G	S	E	S
Biological amendments....	--	--	--	--	--
Other....................	S	--	--	--	--
Vegetation establishment:					
Seeding..................	G	--	--	--	--
Transplanting............	--	--	--	G	S
Natural..................	--	--	--	--	--
Vegetation maintenance:					
Irrigation...............	--	--	--	--	--
Soil/plant monitoring....	E	S	G	G	--
Pesticides & herbicides..	--	--	--	--	--
Upkeep...................	--	S	--	--	S
Vegetation evaluation:					
Reference area...........	--	--	--	--	--
Ground cover.............	E	--	--	--	--
Productivity.............	E	--	E	G	G

APPENDIX B.--ANNOTATED BIBLIOGRAPHY

1. Abbott, D., and G. B. Bacon. Reclamation of Coal Mine Wastes in New Brunswick. CIM Bull., v. 70, No. 781, 1977, pp. 112-119.

The authors' purpose was to describe the previous reclamation program and the reclamation plan that is being developed for the future for the Minto Coalfield in New Brunswick, Canada. A good description of the spoil physical and chemical properties is presented. The initial reclamation program involved planting 3.84 million trees on 4,600 acres. Most of the plantings took place on ungraded spoil banks. These initial plantings provided the following information (1) The afforestation program did not allow for ultimate land use; (2) the growth-limiting factors were high exchangeable acidity, low pH, high levels of salts, active aluminum, and heavy metals; (3) bare-root stock tree seedlings had better survival when planted in the spring and the local stock had the best survival; and (4) tree planting provides a relatively inexpensive cover. Future reclamation of the Minto Coalfield will aim at restoring the land to an aesthetically pleasing state while allowing for maximum productivity. The authors conclude that an important key to the successful afforestation of the Minto Coalfield is soil improvement.

2. Abbott, R. D., D. J. Dollhopf, and A. M. Janney. Evaluation of Overburden Sampling Intensity in Mined Land Reclamation. Reclam. Reveg. Res., v. 1, No. 3, 1982, pp. 255-269.

This paper examines drilling intensities in order to provide a better understanding of what accuracy can be expected when characterizing overburden material from a strip-mined area located near Colstrip, MT. Three physiochemical parameters--soluble salts, clay, and nickel--were used to assess the ability of a sample drill site to characterize the overburden at different distances. Assessments were based on a logistic model which represented the probability of an accurate inhibitory characterization of overburden as a function of distance between a predicting sample and the region to be characterized. This relationship was qualified by an additional analysis which was used to help select a threshold distance within which the accuracy of characterizing the overburden is significantly improved by decreasing the distance between the overburden and the drill site. Beyond this distance accurate characterization of overburden material occurs by chance alone and is not influenced by the location of the overburden. The chance of an accurate prediction of inhibitory status can exceed 0.70 for regions of overburden that are close to a sample drill site or be as low as 0.25 with increasing distance from the drill site. The probabilities found for the strip-mined area near Colstrip reflected a degree of homogeneity in the physiochemical parameters of the overburden. The probabilities found help to indicate what handling procedures are needed to properly redistribute overburden material found to be toxic in some physiochemical parameter. The threshold distance indicates how far away use of the special handling procedures should be considered. The information presented in this paper offers insight into what can be expected from predicting inhibitory characteristics of overburden based on the material sampled from a drill site.

3. Abdnor, J. S. The Study of Reclamation Standards for Surface Mining of Minerals Other than Coal (COSMAR). Paper in Western Land Use Regulation and Mined Land Reclamation Institute. Rocky Mount. Min. Law Found., Boulder, CO, 1979, pp. 9.1-9.19.

This article provides an excellent historical review of the evolution of Federal surface mining and reclamation regulations between 1965 and 1979. The author stresses the participation of the American Mining Congress in this process through the Committee on Surface Mining and Reclamation (COSMAR) organized by the Board of Mineral and Energy Resources of the Commission on Natural Resources of the National Research

Council. The issue of states' rights is discussed. The author approaches the subject from a broad nationwide perspective, but points out the need for regional considerations.

4. Adams, L. M., J. P. Capp, and E. Eisentrout. Reclamation Of Acidic Coal-Mine Spoil With Fly Ash. BuMines RI 7504, 1971, 29 pp.

Plots were established at two sites on acidic mine spoil in northern West Virginia. Varying tonnages of fly ash were applied to the plots at both sites. Several woody and herbaceous species were evaluated in order to determine growth potential in spoil with adverse chemical and physical properties. Fly ash additions improved soil texture, increased soil pH to tolerable levels for some herbaceous species, and increased available soil water. However, tree and shrub survival was poor even with the addition of fly ash to the mine spoil.

5. Adolphson, R. V., P. R. Schulz, and K. K. Dykeman. New Equipment Developments for Steep Slope/High Altitude Revegetation. Paper in Proceedings: High-Altitude Revegetation Workshop No. 5, Colorado State University, Fort Collins, CO, Mar. 8-9, 1982. CO Water Resources Res. Inst., CO State Univ., Fort Collins, CO, Information Series No. 48, Dec. 1982, pp. 50-57.

The authors describe several pieces of revegetation equipment under development at the USDA-Forest Service Equipment Development Center, San Dimas, CA. The systems include (1) a steep slope containerized tree and/or shrub planter, (2) a steep slope seeder, (3) a liquid fertilizer spray system for use with pickup trucks, and (4) a hill-climbing machine capable of working on rugged, steep, rocky, and inaccessible work sites. Operational test results and cost comparison analyses for the first three equipment systems are included. The first three equipment systems have application in surface coal mine revegetation operations nationwide.

6. Agricultural Research. Strip Mining Without Harming the Environment. V. 27, No. 6, 1978, pp. 10-14.

Several factors that affect the reclamation of western coal mines are discussed. General descriptions are given of research currently being conducted in Colorado, Wyoming, and North Dakota. Of particular interest to researchers in the West are topsoil replacement, water quality, water utilization, plant species selection, planting methods, soil nutrient relations, irrigation, fertilization, and the effects of animal grazing on revegetated areas. The goal of these research projects is not only to restore lands to a productive site but to improve them whenever possible.

7. Albrecht, C. S., and E. R. Thompson. Impact of Surface Mining on Soil Compaction in the Midwestern U.S.A. (contract J0208016, Hittman Associates, Inc.). BuMines OFR 174-82, Feb. 1982, 303 pp.; NTIS PB 83-120 170.

The objective of this study was to evaluate the soil compaction that occurs during surface mining and reclamation activities in the midwestern area of the United States. The areas used in the study had been designated prime farmland. The study site locations included the Brazil Mine in Indiana, the Captain Mine in Illinois, the Delta Mine in Illinois, and the Power Mine in Missouri. Moist bulk densities of natural and replaced soils were measured and compared for the top 48 in of the soil profiles. Fertility of the topsoil was also assessed for natural and replaced soils. A case study for each mine site based on field sampling and observations is provided. The report assesses the regulations in the prime farmland reclamation efforts throughout the Interior Coal Mining Region recognized in this evaluation process.

8. Alder, G. M., and Z. S. Wochok. Cloning: A Prescription Approach to Revegetation. Paper in Surface Coal Mining and Reclamation Symposium, Coal Conference and Expo V (sponsored by Coal Age, Louisville, KY, Oct. 23-25, 1979). McGraw-Hill, 1979, pp. 160-164.

This paper provides general comments on the applicability of plant tissue culture technology as a tool for revegetation of disturbed lands. The application of new technologies and planting are stressed.

9. Alderdice, L., and D. H. Graves. Vegetative Response to Topsoil Versus Alternative Growth Materials in a Four-Year Old Study in Kentucky. Paper in 1983 Symposium Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Nov. 28-Dec. 2, 1983). Univ. KY, Lexington, KY, 1983, pp. 497-501.

This study investigated the response of a diverse vegetative cover to various types and rates of mulch treatments and topsoil replacement levels on mine spoil located in Breathitt County, KY. The effect of these treatments on the availability of various plant nutrients was also studied. The study showed no significant differences between treatments and total biomass produced after four growing seasons. Percent cover was not significantly affected by treatment after three growing seasons. The pH values of the amendment-spoil interface also had no significant effect on vegetative cover or biomass production. Bark treatments resulted in higher nitrogen and phosphorus values with the nitrogen levels being highly correlated to cover and biomass yield. Potassium levels were greater in the wood fiber mulch, pelletized leaves, bark-chicken manure, and bark-sewage sludge treatments. With proper site preparation and spoil amendments, a more suitable medium for successful plant establishment is created, which results in greater percent ground cover and plant productivity.

10. Alderdice, L., R. L. Howard, and D. H. Graves. Possible Treatments as Alternatives to Topsoil Replacement on Surface Mine Sites. Paper in 1981 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Dec. 7-11, 1981). Univ. KY, Lexington, KY, 1981, pp. 251-255.

This paper reports the results of 13 topsoil modifications, amendments, and substitutes tested in eastern Kentucky. The results suggest some of the methods could support significantly faster establishment and maintenance of permanent ground cover.

11. Aldon, E. F. Endomycorrhizae Enhance Shrub Growth and Survival on Mine Spoils. Ch. in Reclamation of Disturbed Arid Lands, Univ. NM Press, 1978, pp. 174-179.

The author discusses the importance of vesicular-arbuscular endomycorrhizae on the growth and yield of 14 shrub species common to the arid regions of the Southwest. Fourwing saltbush (*Atriplex canescens* (Pursch.) Nutt.) and rubberrabbit brush (*Chrysothamnus nauseosus* (Pall.) Britt.) were established in the greenhouse, and endomycorrhizae enhance shrubs showed significant increases in growth and yield when inoculated with *Glomus mosseae* and *Glomus fusciculatus*, respectively. A field trial using fourwing saltbush inoculated with *Glomus mosseae*, on coal mine spoil in western New Mexico, showed that after 2 years growth and survival were significantly better on plants grown in the spoil inoculated with *Glomus mosseae* than in spoil not infected. These studies show the importance that endomycorrhizal fungi have on the growth and survival of shrub species planted on surface mine spoil in New Mexico.

12. Aldon, E. F. Reclamation of Coal-Mined Land in the Southwest. J. Soil Water Conserv., v. 33, No. 2, 1978, pp. 75-79.

This general article describes the revegetation techniques that were utilized to reclaim the major coal mines of New Mexico and Arizona. Information is presented on the soils, climate, and natural vegetation of the area. The species that had the most promise for future use in reclamation in the Southwest were alkali sacaton (*Sporobolus airoides*, (Torr.) Torr.), western wheatgrass (*Agropyron smithii* Rydb.), fourwing saltbush (*Atriplex canescens*, (Pursch.) Nutt), and Indian ricegrass (*Oryzopsis hymenoides* (Roem. & Schult.) Ricker). Planting methods (direct seeding and transplanting), amendments (organics, topsoiling, mulches, and fertilizers), and irrigation are other revegetation techniques that were discussed. The author concludes with a list of eight items that are directly concerned with the physical success of surface rehabilitation and revegetation.

13. Aldon, E. F. Techniques for Establishing Native Plants on Coal Mine Spoils in New Mexico. Paper in Third Symposium on Surface Mining and Reclamation, Volume 1 (Louisville, KY, Oct. 21-23, 1975). Natl. Coal Assoc., Washington, DC, 1975, pp. 21-28.

Seed application, sprinkler irrigation, drip irrigation and water harvesting methods are highlighted in establishing selected native species.

14. Aldon, E. F. and C. P. Pase. Plant Species Adaptability on Mine Spoils in the Southwest: A Case Study. U.S. For. Ser. Rocky Mount. For. and Range Exper. Sta. Res. Note RM-398, Apr. 1981, 3 pp.

This research note briefly presents the results of a study initiated in 1973 to evaluate the adaptability of several native grass and shrub species at the McKinley Mine in New Mexico. Fourteen species of native and introduced 3-month-old perennials were transplanted and watered-in at the minesite. Initial survival was checked in 1973, and then survival rates were checked in 1974, 1978, and 1979. Of the 14 species tested, five native and one introduced species showed high survival rates (67 to 100 pct), good vigor, and propagation by seed or rhizomes into adjacent areas. Survival rates and climatic data are detailed in the research note.

15. Aldon, E. F., D. G. Scholl, and C. P. Pase. Establishing Cool Season Grasses on Mine Spoils. Paper in Symposium on Watershed Management 1980 (Boise, ID, July 21-23, 1980). Am. Soc. Civil Eng., 1980, pp. 91-97.

Several surface reclamation treatments were tested on experimental plots and on large demonstration areas at a coal strip mining operation about 40 miles west of Raton in northeastern New Mexico. The best combination of treatments for the establishment of western wheatgrass (Agropyron smithii Rydb.) and Russian wildrye (Elymus junceus Fisch.) utilized contour furrowing, seed drilling, and straw mulching. Plant density for this combination of treatments was 43 grass plants per square meter on the clay-loam topsoiled material. The results and discussion contained in this paper are directly pertinent to the southern portion of the Rocky Mountain Coal Mining Region and may find application over a broader geographical area.

16. Allaire, P. N. Coal Mining Reclamation in Appalachia: Low Cost Recommendations to Improve Bird/Wildlife Habitat. Paper in The Mitigation Symposium: A National Workshop on Mitigating Losses of Fish and Wildlife Habitats (CO State Univ., Fort Collins, CO, July 16-20, 1979). U.S. For. Ser. Rocky Mount. For. and Range Exp. Sta., GTR RM-65, 1979, pp. 245-251.

This paper reviews studies dealing with the wildlife management potential of reclaimed surface mineland with particular reference to mountaintop removal mining techniques. Bird species utilization data collected from reclaimed surface coal mines in eastern Kentucky over a 4-year period are discussed. Based on these data the author suggests five low-cost recommendations for improvement of bird and/or wildlife habitat on reclaimed surface mines. The information and discussion are general in nature but have specific application to the reclamation area mined by the mountaintop removal methods in the Eastern Coal Mining Region recognized in this evaluation process.

17. Allaire, P. N. Comparisons of Game and Nongame Management Models: Cost Analysis of Post-Mining Land Use Options for Wildlife. Paper in 1980 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Dec. 1-5, 1980). Univ. KY, Lexington, KY, 1980, pp. 315-323.

This paper relates the results of a survey conducted to establish costs for coal mine reclamation in eastern Kentucky for wildlife. A comparative cost analysis of six wildlife models (three for game animals and three for nongame animals) was based on cost estimates provided by the coal industry through a survey questionnaire.

18. Allaire, P. N. Short Courses Presented Nov. 17, 1983 in Lexington, KY, Off. for Inform. Serv. and Tech. Liaison, Iron Works Pike, Box 13015, Lexington, KY 40512.

These wildlife-oriented short course materials consisted of two handouts: Post-Mining Land Use: The Wildlife Option, and Vegetation Analysis Survey. Both handouts consist of a combination of course notes and printed information dealing with the subjects. The Wildlife Option course presents information on the methods and procedures to plan and establish wildlife habitat areas on reclaimed surface coal mines, primarily in Kentucky. It reviews state and Federal regulations, the principles of ecology, various guides and case studies on revegetation, and exercises to implement all the principles discussed in the course. The Vegetation Analysis Survey course deals with methods and procedures to meet the vegetation analysis requirements for wildlife under Kentucky primacy. Although specific to Kentucky, the principles discussed in these short courses have much wider geographic application for the establishment and enhancement of wildlife habitat. Extensive reference lists are also provided.

19. Allen, E. B. The Role of Mycorrhizae in Mined Land Diversity. Paper in the Third Biennial Symposium on Surface Coal Mining and Reclamation on the Great Plains (cochaired by the Rec. Res. Unit, MT State Univ. and U.S. OSM, Billings, MT, Mar. 19-21, 1984). MT State Univ. and U.S. OSM, 1984, pp. 273-295.

This paper is an excellent review of pertinent literature focusing on the importance of mycorrhizae to the physiology and ecology of reclamation plants and how these relationships may affect diversity on mined lands. The problems and solutions of maintaining and introducing vesicular-arbuscular mycorrhizae are discussed. The author states that mycorrhizae may improve the ability of desirable species to compete with weeds and increase the rate of succession from a weed stage to a stable, diverse community. This paper is an excellent reference on this topic and is pertinent to revegetation of reclaimed minelands on much of the North Great Plains and Rocky Mountain Coal Mining Regions.

20. Allen, E. B. The Competitive Effects of Introduced Annual Weeds on Some Native and Reclamation Species in the Powder River Basin, WY. Ph.D. Thesis, Univ. WY, Laramie, WY, Dec. 1979, 189 pp.

The results of four different experiments are discussed in four separate chapters of this thesis. The experiments were designed to examine the effects of introduced weeds on certain native species, several species used for mined land reclamation, and the early stages of succession following disturbance. In the first experiment three native prairie sites were disced at three distances from introduced weed seed sources to examine the effect of distance on weed colonization and competition between weeds and native species. The second experiment looked at competition between saltwort (Salsola kali L.) and the native grasses western wheatgrass (Agropyron simithii Rydb.) and blue grama (Bouteloua gracilis (H.B.K.) Lag.) under two water regimes in the greenhouse. Another greenhouse study looked at germination and competition of Salsola kali and native grasses Agropyron smithii and Bouteloua gracilis under two water regimes in the greenhouse. Another greenhouse study looked at germination and competition of Salsola kali and the same two grasses and the native annuals peppergrass (Lepidium densiflorum Schrad.) and narrow-leaved goosefoot (Chenopodium practericola Rydb.) at three temperature regimes. Finally, the fourth experiment examined weed colonization and plant water relations during the first 2 years of stripmine reclamation.

21. Amendola, F. A., M. D. Mitchell, and D. W. Simpson. Reclamation of Tree and Shrub Species at the Absaloka Mine. Paper in the Third Biennial Symposium on Surface Coal Mining and Reclamation on the Great Plains (cochaired by the Rec. Res. Unit, MT State Univ. and U.S. OSM, Billings, MT, Mar. 19-21, 1984). MT State Univ. and U.S. OSM, 1984, pp. 237-250.

This paper describes a number of techniques developed by Westmoreland Resources, Inc., for the establishment of ponderosa pine and deciduous tree-shrub thicket communities on reclaimed mined land. These studies were conducted at the Absaloka Mine, approximately 75 miles east of Billings, MT. Recent plantings of ponderosa pine (Pinus ponderosa Laws.) employing standardized procedures that consider north aspect, steep slopes, coarse soil texture, furrowing and delayed seeding of herbaceous species exhibited high survival rates. Containerized seedlings are reported to perform better than bare-root seedlings. The program for establishing deciduous tree and shrub thicket communities is in its initial stages and is continuing. The information conveyed by this paper is pertinent to major portions of the Northern Great Plains and Rocky Mountain Coal Mining Regions.

22. Amidon, T. E., J. P. Barnett, H. P. Gallagher, and J. M. McGilvray. A Field Test of Containerized Seedlings Under Drought Conditions. Paper in Proceedings of the Southern Containerized Forest Tree Seedling Conference (Savannah, GA, Aug. 25-27, 1981). U.S. For. Ser. Gen. Tech. Rep. SO-37, June 1982, pp. 139-144.

The results of a field test planting of containerized longleaf (Pinus palustris Mill.) and loblolly (Pinus taeda L.) pine seedlings in Louisiana and Texas are detailed in this paper. The survival and early performance of the seedlings produced in four different types of containers on two soils during two planting seasons were monitored. Survival, height, and root collar diameter data were taken. A severe drought caused serious losses of seedlings planted during that growing season but showed the advantages the seedlings planted the previous growing season had over the younger seedlings. Results showed that containerized seedlings survive better than bare-root stock, and that there were significant differences between types of containers used. Also, longleaf pine was more sensitive to container type than loblolly pine.

23. Ammons, J. T. Minesoil-Properties, Root Growth and Land Use Implications. Ph.D. Thesis, WV Univ., Morgantown, WV, 1979, 221 pp.

Minesoil profiles from the Interior and Eastern Coal Mining Regions were characterized morphologically, chemically, and physically and related to root patterns. Field water conditions are related to properties of minesoil classes. Variability of mappable polypedons was examined. Root behavior of several plant species in response to soil morphology, as well as to physical and chemical properties is illustrated with scaled root sketches and photographs. Classification of minesoils is stressed and supported by an economic analysis comparing classified minesoils to natural soils for alternative cropping systems. A review of pertinent literature is included.

24. Ammons, J. T., and E. F. Perry. The Relationship of Overburden Analysis to Minesoil Properties in Post Mining Land Use. Paper in Surface Coal Mining and Reclamation Symposium, Coal Conference and Expo V (sponsored by Coal Age, Louisville, KY, Oct. 23-25, 1979). McGraw-Hill, 1979, pp. 170-176.

The paper discusses the role of material characterization in premining planning to allow the selection and placement of the chemically and physically superior materials as topsoil in postmining reclamation activities.

25. Amundsen, C. C. Dynamics of the Recovery of Damaged Tundra Vegetation: Preliminary Results of Revegetation Experiments of Martina Tundra With Elymus Mollis on Adak Island, Alaska (U.S. DOE contract DE-A505-04180). U.S. DOE, Prog. Rep., DOE/EV/04180-9, Aug. 1982, 38 pp.

This report discusses the interim results of a study designed to examine the potential of dunegrass (Elymus mollis Trin.) for revegetating natural and man-caused disturbed areas on Adak Island, part of the Aleutian Islands Chain of Alaska. The study also considered a number of propagation methods and planting situations. Transplanted plants exhibited a survival rate of greater than 90 pct for 3 years on a variety of soil types. Sprigs consisting of shoots, rhizomes, and roots may be transplanted either by burial of rhizome and roots in the soil or by attachment of these portions to the surface of the soil. Estimates of short-term reclamation success could be made from the survival rates observed 2 to 3 months following transplanting. The section 3 cm above and below the leaf sheath of the plant is critical for vegetative propagation. Time of transplanting was not significantly different during July, August, and early September. Plant vigor was observed to be higher on higher density plots, with a spacing of 15 cm being optimal. These higher plant densities enhanced soil stabilization and retention. Rhizome lengths of 6 cm were adequate for sprigs used in revegetation. The results and discussions contained in this report are relevant to revegetation efforts in coastal northern (maritime) portions of Alaska.

26. Anderson, A. T. Evaluating the Environmental Effects of Past and Present Surface Mining: A Remote Sensing Applied Research Review. Paper in 14th International Symposium on Remote Sensing of the Environment, v. 1, Environ Res. Inst. MI, 1980, pp. 275-278.

The author reviews the use of remote sensing in the regulation of surface coal mining operations and the reclamation of previously abandoned mined lands. Four current remote sensing projects, that are monitoring reclamation practices are given. These projects include (1) development of a monitoring system that utilizes Landsat satellite technology, (2) aerial photographic monitoring, (3) national high-altitude aerial photography, and (4) western surface mine aerial coverage. The author states that remote sensing has a definite role in ensuring that surface mine reclamation regulations are met.

27. Anderson, C. E., and J. M. Briggs. Planning Erosion Control for Coal Mining and Reclamation. J. Soil Water Conserv., v. 34, No. 5, 1979, pp. 234-236.

This article describes the methods used to reduce off-site sediment losses and erosion of terraces that were constructed at the Iowa Coal Project Demonstration Mine in southeastern Iowa. One year after the completion of the restoration work, sediment discharge had no effect on water quality and there was no apparent erosion on the terraces. However, soil compaction and drainage were problems that needed to be resolved if row-crop farming was to be successful on the site. The cost of erosion and drainage control during mining was less than 1 pct of the total cost of mining and the cost of reclamation was about 16 pct of the total.

28. Anderson, C. P. Concurrent Establishment of Hardwood Tree Seedlings and Low Ground Cover on Reclaimed Mineland. M.S. Thesis, Purdue Univ., West Lafayette, IN, 1983, 109 pp.

This study compared site productivity of surface-mined land and an unmined reference area in Sullivan County, IN. Comparisons were made on the establishment of a herbaceous ground cover and hardwood tree seedlings planted concurrently using the same levels of management on both sites. Tree and herbaceous species used were black walnut (Juglans nigra L.), northern red oak (Quercus rubra L.), K-31 fescue (Festuca arundinacea Shreb.), and red clover (Trifoliun pratense L.) Different seedling production methods were evaluated, and chemical plant control was utilized as a means of reducing competition and improving seedling survival and growth. Soil physical and chemical properties were also analyzed, and comparisons were made between the two sites. The results indicate that herbaceous ground cover was adequate on the minesite, meeting the reclamation requirements of Public Law 95-87. However, aboveground biomass production was significantly higher on the reference site (6,152.8 kg/ha) than on the mine site (2,785.6 kg/ha) after two growing seasons. Tree survival was also significantly higher on the reference area. However, with herbicide treatment tree survival increased significantly on the mine site.

29. Anderson, C. P., P. E. Pope, W. R. Byrenes, W. R. Chaney, and B. H. Bussler. Hardwood Tree Establishment in Low Plant Cover on Reclaimed Mineland. Paper in Third Annual Conference on Better Reclamation With Trees (cosponsored by AMAX Coal Co., Purdue Univ., South. IL Univ., and Madisonville Comm. Coll., Terre Haute, IN, June 2-3, 1983). Purdue Univ., West Lafayette, IN, 1983, pp. 158-170.

A reclaimed surface-mined site was compared to an unmined reference site to evaluate the effectiveness of reclaiming land in accordance with Public Law 95-87, the Surface Mining Control and Reclamation Act of 1977. Both sites were located in Sullivan County, IN. Establishment success of grass and/or herbaceous ground cover and hardwood seedlings planted concurrently and maintained under the same level of management was used to compare site productivity of the reclaimed and the unmined areas. Bareroot and containerized seedlings of black walnut (Juglans nigra L.) and northern red oak (Quercus rubra L.) were planted on each site along with a cover crop of K-31 fescue (Festuca arundinacea Schreb.) and red clover (Trifolium pratense L.). One-half of each treatment combination was treated with herbicide (mixture of amizine and dalapon) to control low ground cover plants and to assess the competitive effects of ground cover on hardwood seedling establishment and growth. The topsoil of the reclaimed mineland had higher bulk density and lower organic matter content than the topsoil of the reference area. The topsoil of both sites exhibited similar pH. Mean ground cover percent and overall hardwood seedling survival after two growing seasons was sufficient to meet requirements specified by Public Law 95-87 for forest land. After 2 years of growth on the reclaimed minesite, individual container-grown seedings exhibited higher survival rates than bare-root seedlings. Black walnut seedling survival and growth were improved by herbicide application to control competing grass and herbaceous ground cover. Similar treatments had no significant effect on red oak survival or growth. Red oak seedings generally exhibited lower survival and net growth than black walnut seedlings. The results reported in this study are pertinent to the Interior Coal Mining Region recognized in this evaluation process. However, with prudent consideration they could find application in planning reclamation activities over a slightly broader geographical area.

30. Anderson, R. Land Imprinting; A Revegetation Concept With Reclamation Potential. Landmarc, Sept. 1981, pp. 8-11.

The concept of land imprinting, a technique developed for reclaiming overgrazed grasslands in arid or semiarid regions, is presented as a possible mineland reclamation tool. The object of land imprinting is to create impressions in the soil where sparse rainfall will be collected, making maximum use of rainfall and allowing seeds to germinate and survive during drought periods. Land imprinting equipment developed by the Department of Agriculture in Arizona is described. Because grazing has a very low economic return per unit of land, no more than $30 or $40 per acre can be invested in revegetating grassland. The equipment described damages or destroys existing vegetation, creates impressions in the soil, and also broadcasts seed. Revegetation can then be accomplished very inexpensively. The author suggests developing a self-propelled imprinter for mineland reclamation purposes.

31. Andreuzzi, F. C. Reclaiming Strip Mined Land for Recreational Use in Lackawanna County, PA. BuMines IC 8718, 1976, 21 pp.

This paper covers a demonstration of a 125-acre reclamation project on abandoned anthracite coal spoil in Lackawanna County, PA. The land use plan developed by the Bureau of Mines consisted of utilizing the area for public recreation, historical purposes and educational facilities. As a park the project serves as a prototype for reclaiming existing and future surface-mined lands.

32. Argonne National Laboratory. Land Reclamation Program, Annual Report, 1978. ANL/LRP-5, July 1979, 110 pp.

This annual report describes the Argonne Land Reclamation Program and reviews several ongoing or recently completed field and laboratory studies. Preliminary results, accomplishments, and planned future activities are presented for the Jim Bridger Mine Project in southwest Wyoming; the Bighorn Mine-Tongue River Project near Sheridan, WY; the Navajo Mine Project - Breeding and Selection of Plant Materials for Mined Land Reclamation conducted at Brigham Young University; the Macaoupin County Refuse Reclamation Project near Staunton, IL; the evaluation of selected overburden materials and management techniques for returning surface-mined land to row crop production (Burning Star Mine #3 in Randolph County, IL); the Eastern Project considering impacts of surface coal mining throughout that region; and the Alaska Project considering coal mining impacts throughout that State. The information presented in these discussions is primarily relevant to the coal mining regions in which the projects are located. The report was evaluated as a whole. Reference to a particular keyword used in the evaluation process may not be found in each research project description.

33. Argonne National Laboratory and Ford, Bacon Davis and Utah. Characterization of Uranium Tailings Cover Materials for Radon Flux Reduction (Appendix B, Characteristics of Plant Species Selected, Plant Growth as a Factor in Radon Gas Leakage From Uranium Mill Tailings, by Native Plants, Inc.). U.S. Nuclear Reg. Comm., NUREG/CR-1081, Mar. 1980, 153 pp.

This addendum describes a study conducted by Native Plants, Inc., that was designed to help determine whether or not soil-covered uranium tailings would leak radon gas via root channels of deep-rooted plants. The paper was reviewed and included in this bibliography for its unique experimental design. Test plants were grown in large containers. The growth medium was put into the containers to simulate actual reclaimed field conditions. These containers were then placed in a greenhouse where climatic conditions could be controlled. The results of this study are specific for the project. However, the methods and experimental design used should be applicable nationwide.

34. Arora, H. S., C. E. Pugh, J. B. Dixon, and L. R. Hossner. Pyrite and Acidity Formation. Ch. in Reclamation of Surface Mined Lignite Spoil in Texas. TX Agric. Exp. Sta., College Station, TX, 1980, pp. 22-35.

This article contains a review on pyrite morphology and reactivity and the results of a field study conducted to determine the concentration and location of pyrite samples collected from Milan and Freestone Counties, TX. Each sample was examined to determine the location, concentration, morphology, and reactivity of the pyritic materials present. Total sulfur content was between 0.30 and 16.79 pct on a freeze-dried-weight basis. Iron sulfides and organic sulfur were the major sulfur components. Up to 60 pct of the total sulfur content may be in the pyritic form (iron sulfides). Fluctuations in sulfur content were due to fluctuations in the pyrite content. The establishment of vegetative cover is difficult when oxidation of pyritic materials occurs.

35. Arthur, J. D. Novel Spreaders Aid Reclamation. Coal Age, v. 85, No. 7, 1980, pp. 92-94.

The author describes two devices that were designed by mine personnel to spread mine soil at two Illinois surface mines. The first device, used at the Rapatee Mine near Farmington, IL, consists of a 33-foot-long by 16-inch-wide steel H-beam with four 30- by 11-in rectangular holes cut out of the web. Inverted V-shaped cutouts along the bottom of the front and rear flanges provide teeth for breaking up and furrowing the soil. Soil penetration is about 2 to 3 in. This spreader-sacrifier is used to spread topsoil and cut furrows for subsequent seeding. The second device, used at Amax's Sunspot Mine near Ipava, IL, is constructed of I-beams welded to form an open rectangular unit measuring 25.5 by 7.5 ft. The front of this piece of equipment can penetrate the soil to a depth of 10 in. This spreader is used to distribute topsoil, subsoil, and cast overburden. Both pieces of equipment created uniform drainage surfaces that eliminated low areas and pockets of water.

36. Asay, K. H. Breeding Grasses for Revegetation of Surface Mining Spoils in Western U.S.A. Paper in Ecology and Coal Resource Development, Volume 2 (Based on the Int. Congress for Energy and the Ecosystem, Univ. ND, Grand Forks, ND, June 12-16, 1978). Pergamon, 1978, pp. 1007-1011.

This paper reviews grass breeding programs being conducted by State and Federal agencies in the Western United States and specifically discusses species and interspecific hybrids included in growth trials at the Decker, MT mine site.

37. Asay, K. H. Grasses for Revegetation of Surface Mining Areas in Western U.S. Paper in Surface Coal Mining and Reclamation Symposium, Coal Conference and Expo V (sponsored by Coal Age, Louisville, KY, Oct. 21-23, 1975). McGraw-Hill, 1979, pp. 155-159.

This paper provides an excellent review of breeding programs for native, introduced, and interspecific hybridized grasses and includes numerous successful examples of these types of plant materials.

38. Ashby, W. C. Is Good for Corn Good for Trees? Paper in 1982 Seminar on Post-Mining Productivity With Trees (Carbondale, IL, Mar. 31-Apr. 2, 1982). South. IL Univ., Carbondale, IL, 1982, pp. 15-18.

While reclaiming areas with trees is supported by regulations, it often loses out to other land uses. This article examines why areas in Illinois that could be reclaimed for forestry purposes are instead reclaimed for farmland. The author advocates a new regulatory reclamation formula that includes minesoils truly "capable of tree production."

39. Ashby, W. C., and C. A. Kolar. Productivity With Trees and Crops on Surface-Mined Lands. Pres. at SME-AIME Fall Meeting, Denver, CO, Nov. 1981. SME-AIME preprint 81-342, 5 pp.

Productivity of reclaimed land is discussed with respect to cropland, pastureland, and forestry uses. Productivity of mined land is compared with that of nonmined land using various site preparation techniques. Current Federal and State regulations are thought to be the cause of decreased productivity on mined land.

40. Ashby, W. C., C. A. Kolar, M. L. Guerke, C. F. Pursell, and J. Ashby. Our Reclamation Future With Trees. Coal Extraction and Utilization Res. Cent., South. IL Univ., Carbondale, IL, Aug. 1978, 99 pp.

This document examines the history of forest reclamation in five Illinois coal districts from the first voluntary work through the authors' survey of 30-year-old strip mine plantations. This survey confirmed the sustained and enhanced timber production over a 30-year period. The results were incorporated into a discussion on what is

known about growing trees on strip-mined lands in Illinois. Several hardwood and softwood species are recommended for Illinois surface-mined lands based on cumulative tree growth performance. Impacts of forestation as a reclamation alternative are also considered from environmental quality, recreational, educational, social, and economic viewpoints. A discussion on the effects of Illinois reclamation legislation, through the 1975 amendments to the Surface-Mined Land Conservation and Reclamation Act, on forestation efforts is presented. Evidence is given that the reclamation of coal mined lands with trees has benefited recreation, housing, education, wildlife, and timber production in Illinois. The authors conclude that tree planting is an integral part of a multipurpose land use plan.

41. Ashby, W. C., C. A. Kolar, and G. R. Philo. Reclamation With Trees. Paper in Annual Progress Report: July 1, 1980-June 30, 1981, Volume II, Research Development Summaries, Final Draft. Coal Extraction and Utilization Res. Cen., South. IL Univ., Carbondale, IL, Mar. 1982, pp. 94-98.

This report summarizes investigations conducted at the Sahara Coal Company's minesite in Saline County, IL. The studies were designed to evaluate revegetation performance for several kinds of trees on unmined lands, lands mined and ungraded, lands mined and graded, and lands mined and graded with the topsoil replaced. Fall and spring planting of seed and seedlings were tested. Additional studies on herbicides, super slurper, mycorrhizae, and containerized seedlings are described. The report also describes studies conducted at the Freeman United Coal Mining Co. in Perry County, IL, designed to evaluate the reclamation potential of several kinds of trees and shrubs planted along with a herbaceous ground cover to control soil erosion. These studies included both field and greenhouse work emphasizing root system development. Few hard data are reported, and results are discussed in a general way. However, this summary does indicate a source of potentially useful information for revegetation planning.

42. Ashby, W. C., N. F. Rogers, and C. A. Kolar. Forest Tree Invasion and Diversity on Strip Mines. Paper in Proceedings of Central Hardwood Forest Conference III (Columbia, MO, Sept. 16-17, 1980). Univ. MO, Columbia, MO, 1980, pp. 273-281.

This study was conducted to inventory planted and volunteer trees on plots established 30 years earlier by the USDA Forest Service in Indiana, Illinois, Missouri, Kansas, and Oklahoma. Only in Indiana and southern Illinois did planted trees outnumber volunteers. Volunteer trees greatly outnumbered planted trees in northern Illinois, Missouri, Kansas, and Oklahoma. The number of invading trees ranged from 17 in Oklahoma to 48 in Indiana. The six leading volunteer species were black locust (Robina pseudoacacia L.), elm (Ulmus spp.), hackberry (Celtis occidentalis L.), ash (Fraxinus spp.), black cherry (Prunus serotina Ehrh.), and boxelder (Acer negundo L.). The major pioneer invaders on open sites after mining were cottonwood (Populus deltoides Marsh.) and sycamore (Platanus occidentalis L.). The characteristics of some of the common volunteer species are given. The factors that are important for tree invasion and forest diversity on surface-mined land are spoil physical and chemical characteristcs, type of forest cover, and the availability of seed or root suckers.

43. Ashby, W. C., W. G. Vogel, and C. A. Kolar. Use of Nitrogen-Fixing Trees and Shrubs in Reclamation. Paper in Third Annual Conference on Better Reclamation with Trees (cosponsored by AMAX Coal Co., Purdue Univ., South. IL Univ., and Madisonville Comm. Coll., Terre Haute, IN, June 2-3, 1983). Purdue Univ., West Lafayette, IN, 1983, pp. 110-118.

This article provides a relatively brief literature review on the use of nitrogen-fixing woody plants in reclamation. It is a good article for individuals charged with planning reclamation or reviewing reclamation plans. Included is a section on the effects of present legal requirements on the use of nitrogen-fixing woody plants for reclamation. No specific coal region is identified by the authors. Based on the plant species mentioned and articles reviewed, this article is considered pertinent to the Interior and Eastern Coal Mining Regions in this evaluation process.

44. Askenasy, P. E., L. R. Hossner, and E. L. Whiteley. Row Crop Production on Leveled Lignite Mine Spoil Banks. Ch. in Reclamation of Surface Mined Lignite Spoil in Texas. TX Agr. Exp. Sta., College Station, TX, Rep. RM-10, 1980, pp. 48-56.

This study was conducted to test the feasibility of using leveled mine spoil for row crop production on lignite spoils near Fairfield, TX. The species tested were "Texas 28 A" corn (Zea mays L.), "Top Hand" sorghum (Sorghum bicolor (L.) Moench), "Hill" soybean (Glycine max (L.) Merr.), and "Lee" soybean (Glycine max (L.) Merr.). Nine different nitrogen-phosphorus fertilizer treatments were used in cell combinations of 0, 84, and 168 kg/ha N and 0, 56, and 112 kg/ha P_2O_5. All row crops were grown successfully on the leveled mine spoil if proper fertilization and cultural practices were used. Grain sorghum was the most promising of the species tested and produced yields comparable to those for central Texas. For all species tested, P and N additions significantly increased yields during the first year. However, only N additions had an effect during the second and third years. The influence of the row crops on mine spoil nutrient content and pH was also evaluated during the 3-year study.

45. Bagley, F. L. Tree Planting-Strip-Mined Area in Maryland. Paper in Trees for Reclamation (Lexington, KY, Oct. 27-29, 1980). U.S. For. Ser., Gen. Tech. Rep. NE-61, 1980, pp. 27-33.

This paper is divided into four sections which deal with the use of tree species for reclaiming surface mined lands in western Maryland. Part I contains the requirements that must be met to ensure successful tree plantings on surface-mined areas. Part II deals with the mechanics of planting trees on mined land. Part III lists the herbaceous species to be used in a seed mixture, along with seeding rates, when mined lands are reclaimed to (1) hayland and cropland, (2) forestry when tree seedlings are used to establish forest lands, (3) forestry when leguminous tree species are direct seeded, (4) forestry when nonleguminous tree species are direct seeded, and (5) wildlife plantings. Part IV of the paper lists the species that have been used successfully on Maryland surface-mined lands.

46. Banaszak, K. J. Predicted Changes in the Mineralogy of Spoil as a Function of Net Neutralization Potential and Rate of Flushing. Paper in 1981 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Dec. 7-11, 1981). Univ. KY, Lexington, KY, 1981, pp. 459-462.

This research was conducted to assess the changes in the mineralogy of spoil material resulting from pyrite oxidation. In general the mineralogy of fresh spoil is a mixture of silicates, carbonates, and sulfides. The changes caused by pyrite oxidation are dependent upon the flushing time of acid water and the net neutralization potential (NNP) of the spoil material. Slow flushing and low NNP favor a change in the silicates and the formation of sulfates. Fast flushing and high NNP results in little change in the silicates, but there is a loss of carbonates and hydroxides are produced from sulfides. Fast flushing and low NNP will create incomplete silicate alteration and a loss of metals from sulfides. Slow flushing and high NNP create a partial alteration of the silicates, and hydroxides are produced from sulfides. A computer simulation resulted in differing ratios of phases created or destroyed by reacting various waters with overburden mineralogies. When calcite continually reacted with the solution, a final pH of 6.5 was achieved, and for every gram of pyrite oxidized 2.23 g of calcite and 0.003 g of 2:1 +-o-+ clay were destroyed and 0.7 g and 0.001 g of goethite and gibbsite were formed, respectively. When calcite was absent, the final solution pH was 4.0, and for every gram of pyrite oxidized 0.03 g of 2:1 +-o-+ clay was destroyed and 0.7 g and 0.01 g of goethite and gibbsite were produced. The greatest destruction of soil is not the loss of 2:1 +-o-+ clays but the loss of cation exchange capacity by the precipitation of iron-aluminum flocs.

47. Barnett, J. P. Containerized Plants Regenerate Difficult Reclamation Sites. Coal Min. Process., July 1983, p. 26.

This article provides a brief review of some aspects of using containerized plants for regeneration. It specifically refers to revegetation in the South and Southwestern United States, but the techniques discussed would apply nationwide.

48. Barnhill, M. A. Endomycorrhizae in Some Nursery-Produced Trees and Shrubs on a Surface Mined Area. Tree Planters Notes, v. 32, No. 1, 1981, pp. 20-22.

This study was designed to determine whether woody plants propagated under nursery practices (high nitrogen and phosphorus fertilization and frequent fumigation) were colonized with indigenous vasicular-arbuscular mycorrhizae (VAM), and, if so, whether the associations survived after outplanting on mine spoil. Root systems of seven 1-year-old plants from each of 11 species were collected from a nursery. The nursery used summer cover cropping methods, fertilizer, and soil fumigation prior to fall seeding. In addition, seven plants each of seven species produced in the nursery and outplanted at the Ollis Creek Mine in Campbell County, TN, were collected. All plants were examined for degree of VAM infection. Results showed significant differences in degree of infection between species, and infection was less extensive on plants collected at the minesite than on those grown in the nursery only.

49. Barnhill, M. A., M. Cunningham, and R. E. Farmer, Jr. Germination Strategies in Aster Pilosus, Eupatorium Serotinum, and Solidago Altissima and Their Relation to Revegetation Systems. Reclam. Rev. Res., v. 2, No. 1, 1983, pp. 25-30.

Requirements of light, temperature, and chilling for oldfield aster (Aster pilosus Willd.), white snakeroot (Eupatorium serotinum Michx.), and tall goldenrod (Solidago altissima L.) were studied to provide the basis for direct-seeding strategies on mined land and to compare the germination strategies of these species. Seeds of the three species were collected from natural populations growing on mined land in Campbell County, TN. A study on the stratification requirements of the three species was conducted at 3° C using moist and dry conditions and storage in the dark for 0, 2, 4, or 8 weeks. At the end of each storage period a controlled-environmental growth chamber germination study was conducted in the light or dark, using the following temperature regimes: 5 to 15° C, 10 to 20° C, or 20 to 30° C. Germinated seeds were considered those that had radials at least 1 mm long. The results indicate that all three species have similar germination strategies. All three species required light and moderate to high temperatures for germination. Oldfield aster and white snakeroot failed to germinate at low temperatures without stratification. The authors concluded that these three species could be directly seeded on mine soil after a minimum stratification period of 8 weeks. This suggests that all three species could become established in southern Appalachia in the spring following a period of winter chilling.

50. Barnhisel, R. I. Lime and Fertilizer Recommendations for Reclamation of Surface-Mined Spoils. Univ. KY, Dep. of Agronomy, Lexington, KY, AGR-40, (rev.), Oct. 1976, 4 pp.

Recommendations are made for lime and fertilizer rates when a grass legume cover is established for erosion control when land use is projected as (1) timber, wildlife, or recreation, or (2) pasture or hay production. Three methods of determining lime requirements are discussed.

51. Barnhisel, R. I. Reclamation of Surface Mined Coal Spoils. U.S. EPA, EPA-600/7-77-093, Aug. 1977, 57 pp.

Field experiments were established on four types of surface-mined spoil that are commonly found in western Kentucky. The specific objectives of the study were to (1) determine the spoil chemical and physical properties and how these properties affect the establishment and survival of herbaceous cover, (2) develop a method of site preparation that will produce a stable microrelief with no adverse effects on spoil physical properties, and (3) evaluate different rates of lime incorporation into the spoil. The results show that when proper fertility levels are restored in combination with site preparation, mine spoils may be successfully reclaimed.

52. Barnhisel, R. I., J. L. Powell, and G. W. Akin. Keys to Successful Reclamation in Western Kentucky. Paper in Third Symposium on Surface Mining and Reclamation, Volume 2 (Louisville, KY, Oct. 21-23, 1975). Nat. Coal Assoc., Washington, D.C., 1975, pp. 140-151.

This paper reports the results of four related studies investigating the effects of tillage methods used in site preparation, P fertilization, types of P fertilizers, vegetation renovation methods, and lime applications on establishing and maintaining acceptable vegetative cover. Five key factors for reclamation in western Kentucky are identified.

53. Barrett, J., P. C. Deutsch, F. G. Ethridge, W. T. Franklin, R. D. Heil, D. B. McWhorter, and A. D. Youngberg. Procedures Recommended for Overburden and Hydrologic Studies of Surface Mines. U.S. For. Ser. Gen. Tech. Rep. INT-71, 1980, 106 pp.

There were two objectives for this study. The first was to determine the required information to evaluate the soils, overburden, and hydrology of a site in order to make appropriate management decisions for the selection of lease sites, development of lease stipulations, and formulation of mining and reclamation plans. The second objective was to recommend cost-effective procedures for data acquisition and analysis associated with soils, overburden, and hydrologic studies. These objectives were achieved by defining soils, overburden, and hydrologic information requirements and by evaluating alternative approaches when available. Not all of the technology and information available for the study of soils, overburden, and hydrology were identified. Only proven methods and procedures known to give good results are recommended for use.

54. Barry, H. J., III. State-Federal Agreements, Programs, and Issues Under the Surface Mining Control and Reclamation Act. Paper in Western Land Use Regulation and Mine Land Reclamation Institute. Rocky Mount. Min. Law Found., Boulder, CO, 1979, pp. 5.1-5.29.

The author examines the status of selected Western State laws, regulations, agreements, and programs under the Surface Mining Control and Reclamation Act of 1977 (SMCRA) as of 1979. He also provides a discussion of the past, present, and future issues between these Western States and the Federal Government, concerning the implementation of SMCRA. The States considered are Colorado, Montana, New Mexico, North Dakota, Utah, and Wyoming. The article is included in this bibliography for the historical perspective it provides.

55. Barth, R. C. Reclamation Practices in the Northern Great Plains Coal Province. Min. Congr. J., v. 63, No. 5, 1977, pp. 60-64.

This article discusses the reclamation practices that are used in the Northern Great Plains Coal Province. Various components of reclamation are discussed, and information is included on site preparation, species selection and planting, and soil amendments. Plant productivity was found to be higher on mined land than on unmined

reference areas in the Northern Great Plains. This article contains little technical information, but it could serve as a reference to what reclamation practices have been used successfully in the Northern Great Plains Coal Province.

56. Barth, R. C., and B. K. Martin. Soil-Depth Requirements To Reclaim Surface-Mined Areas in the Northern Great Plains (contract J0265025, CO Sch. Mines Res. Inst.). BuMines OFR 202-82, 1982, 19 pp.; NTIS PB 83-148221.

Fourteen wedge-type field plots were established in North Dakota, Montana, and Wyoming to quantify soil depth requirements for reclamation of surface-mined land with perennial grasses. Plots were grouped into four types based on spoil chemical and physical properties and plant biomass. Results showed that precipitation and plant species determined soil depth requirements.

57. Bartuska, A. M., and G. E. Lang. Detrital Processes Controlling the Accumulation of Forest Floor Litter on Black Locust Revegetated Surface Mines in North Central West Virginia. Paper in 1981 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Dec. 7-11, 1981). Univ. KY, Lexington, KY, 1981, pp. 359-365.

Detrital processes were compared between a stand of black locust (Robinia pseudoacacia L.) established on a reclaimed surface mine and a nearby mixed hardwood forest not disturbed by mining. Mean annual leaf litter deposition in the black locust stand was significantly less than in the mixed hardwood stand. However, forest litter mass was greater in the black locust stand than in the mixed hardwood stand. Substrate chemistry, specifically the high concentration of liquid in black locust leaves as compared with sugar maple leaves, was believed to be responsible for lower microbial activity and consequent slower decomposition rates in the black locust stand, resulting in thicker accumulations of leaf litter.

58. Beach, G. G. Do I Have an Alluvial Valley Floor? Paper in 1980 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Dec. 1-5, 1980). Univ. KY, Lexington, KY, 1980, pp. 97-101.

This paper presents a method for identifying an alluvial valley floor within the context of the statutory language of the Surface Mining Control and Reclamation Act of 1977 and provides a list of pertinent information that should be collected in order to allow a test for the "developed land" classification within an alluvial valley floor. The methods were devised for use in Wyoming; however, the author suggests that they may be applicable to other western areas.

59. Beach, G. G. Regulatory Reform in Wyoming. Paper in the Third Biennial Symposium on Surface Coal Mining and Reclamation on the Great Plains (cochaired by the Reclam. Res. Unit, MT State Univ. and U.S. OSM, Billings, MT, Mar. 19-21, 1984). MT State Univ. and U.S. OSM, 1984, pp. 1-7.

This paper provides a brief description of the regulatory reform efforts underway in Wyoming to improve that State's rules regulating surface mining and mineland reclamation. Comparisons are made to OSM's new Federal regulations.

60. Bell, J. C., D. F. Amos, and J. C. Parker. Evaluation of Slope Stability and Foundation Suitability for Four Southwestern VA Mine Spoils. Paper in 1983 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Nov. 27-Dec. 2, 1983). Univ. KY, Lexington, KY, 1983, pp. 549-554.

This study was conducted to evaluate the stability of spoil banks and the suitability of reclaimed benches for shallow foundations in spoils located near Norton, VA. Mine spoils were analyzed for particle size distribution, particle density, shear strength parameters, compaction characteristics, and bulk density. The relative quantities of

sandstone and siltstone had a direct effect on the particle size distribution and shear strength of the spoil material. However, these quantities had little effect on the coarse fragment content and dry bulk density. Blasting, handling, and placement of spoil material during mining and reclamation were the most likely causes for the variations in coarse fragment content and dry bulk density. As soil compaction increased so did the shear strength of the <2-mm fraction of the spoil material. Of the spoil banks observed, several had inadequate safety factors against slope failure. The authors feel that increased soil compaction, which will increase shear strength, or slope reduction will increase slope stability if drainage is adequate. Of the spoils observed, slope stability is largely dependent on the slope angle and the angle of internal friction. Due to the high variablility observed in bulk density, differential settlement of conventional strip footings would occur, creating unsuitable foundation conditions.

61. Bennett, O. L. Potential for Reclamation and Revegetation of Eastern Strip Mine Spoils. Paper in $C{=}Me^2$, Conservation, Materials, Environment, Energy (Proc. Third Int. Conf. on Environ. Problems of the Extractive Industries, Dayton, OH). The Wright Co., 1977, pp. 10.5.1-10.5.9.

This paper provides a review of the anticipated impacts of the Surface Mining Control and Reclamation Act of 1977 on mineland reclamation and reclamation research. The author reviews the results of the major research efforts in mineland reclamation in the Eastern Coal Mining Region. This paper offers a good overview of reclamation research in this region conducted prior to 1977.

62. Berg, W. A. Nitrogen and Phosphorus Fertilization of Mined Lands. Paper in Symposium on Adequate Reclamation of Mined Lands? (Billings, MT, Mar 26-27, 1980). Soil Conserv. Soc. America. and WRCC-21, 1980, pp. 20-1 to 20-8.

This paper provides a concise discussion of the use of N fertilizer to establish optimum vegetative cover and achieve species diversity. Straw mulching is assumed to increase the need for N fertilizer. The author suggests the use of test plots to establish N requirements rather than depending on standard soil tests. He also states that the sodium bicarbonate extraction soil test for plant-available P seems to be a dependable guide for determining P status.

63. Berg, W. A. Use of Soil Laboratory Analyses in Revegetation of Mined Lands. Min. Congr. J., Apr. 1975, pp. 32-35.

This paper provides a concise discussion of the role soil tests can play as a management tool for evaluating revegetation potential of disturbed lands.

64. Berry, C. R. Dried Sewage Sludge Improves Growth of Pines in the Tennessee Copper Basin. Reclam. Reveg. Res., v. 1, No. 2, 1982, pp. 195-201.

This study was conducted to determine whether dried sewage sludge, interacting with *Pisolithus tinctorius* (Pt) ectomycorrhizae, would improve survival and accelerate the early growth of loblolly pine (*Pinus taeda* L.), Virginia pine (*Pinus virginiana* Mill.), and shortleaf pine (*Pinus echinata* Mill.) on severely eroded sites in the Tennessee Copper Basin. Four different treatments were used in this study, noninoculated (naturally inoculated by *Thelephora terrestris*) or Pt mycorrhizal treatments combined factorially with sludge (34,000 kg/ha) or fertilizer (10-10-10, applied at a rate of 896 kg/ha). All three tree species grew significantly better on plots amended with sludge than on those with fertilizer. Pt ectomycorrhizae failed to stimulate the growth of the pine species. This response is apparently due to the high application rates of fertilizer and sludge. The results of the study demonstrate that the growth responses of the pine species used in this study are improved on sites amended with sewage sludge.

65. Berry, C. R. Growth Response of Four Hardwood Tree Species to Spot Fertilization by Nutrient Tablets in the Tennessee Copper Basin. Reclam. Reveg. Res., v. 2, No. 3, 1983, pp. 167-175.

The feasibility of using sewage sludge tablets and fertilizer tablets in order to achieve stand establishment of sweetgum (*Liquidambar styraciflua* L.), sawtooth oak (*Quercus acutissima* Carruth.), black alder (*Alnus glutinosa* (L.) Gaert.), and black locust (*Robinia pseudoacacia* L.) was tested in the Tennessee Copper Basin. Six fertility treatments were used on each species and consisted of a control; sludge tablets of 30, 60, and 90 g; and fertilizer tablets of 9 g (22.0 pct N, 3.5 pct P, and 1.7 pct K) and 21 g (20.0 pct N, 4.5 pct P, and 4.3 pct K). For all species, the 21-g fertilizer tablet produced significantly faster growth than did any of the other treatments. The 90-g sludge tablet and the 9-g fertilizer tablet produced similar growth responses for all species. The two nitrogen fixers, black locust and black alder, had average growth rates greater than either sweetgum or sawtooth oak, but not significantly greater. Fertility treatments did not affect the concentration of the foliar elements, particularly N, P, or K, in the tree species. However, high concentrations of foliar manganese, copper, zinc, and iron were found in all species. The author concluded that because of their high growth rates black locust and black alder could be used as alternatives to pine in the Tennessee Copper Basin.

66. Berry, C. R. Slit Application of Fertilizer Tablets and Sewage Sludge Improve Initial Growth of Loblolly Pine Seedlings in the Tennessee Copper Basin. Reclam. Rev., v. 2, No. 1, 1979, pp. 33-38.

This study evaluated the potential use of dried sewage sludge and starter forest fertilizer tablets placed in slits to stimulate the growth of loblolly pine (*Pinus taeda* L.) seedlings in the copper basin of southeastern Tennessee. The treatments used were control (no treatment), 30 g of sludge, 60 g of sludge, 90 g of sludge, 9 g of Agriform forest starter tablets, and 21 g of Agriform forest starter tablets. The sludge or fertilizer tablets were placed in the closing hole created by planting the loblolly pine with a planting bar. After 3 years the seedlings on the control plots grew poorly, while the seedlings on the five treatment plots grew significantly better. The fertilizer tablets were the most convenient to use and stimulated seedling growth. By the end of the third year the 21-g and 9-g fertilizer tablets increased seedling volume by 20 and 9 fold respectively over the control treatment. The results of this study indicate that slit application of nutrients is an alternative to broadcast application. Although broadcast application of fertilizer and sludge results in more production, slit applications are less expensive, easier to apply on rugged terrains, and less stimulating to growth of competing vegetation.

67. Berry, C. R. Survival and Growth of Pitch, Loblolly, and Pitch × Loblolly Pine Seedlings With *Pisolithus* Ectomycorrhizae After One Year on Coal Spoils in Alabama and Tennessee. Abstract of paper presented at the Meeting of the Am. Coun. for Reclam. Res. (Univ. AL, University AL, Sept. 19-22, 1979). Reclam. Rev., v. 3, 1980, pp. 61-64.

This field study consisted of planting containerized seedlings of loblolly (*Pinus taeda* L.), pitch (Pinus rigida Mill.) and pitch × loblolly pine (*Pinus rigida* × *Pinus taeda* (*Pinus xrigitaeda*)) hybrids on coal spoils near Caryville, TN, and Birmingham, AL. Half of each outplanted group had been inoculated with *Pisolithus tinctorius* (Pt) ectomycorrhizae, the other half of each group were not inoculated (NI) but soon became infected with *Thelephora terrestris* ectomycorrhizae. Although the seedlings were not in the field plots only 2 years at the time of writing, survival in all cases was about 90 pct, with the Pt seedlings outperforming the NI seedlings. Root collar diameter was the best parameter to evaluate treatment within pine lines, and in some cases the crosses did better than the parent lines.

68. Berry, C. R. , and D. H. Marx. Growth of Loblolly Pine Seedlings in Strip-Mined Kaolin Spoil as Influenced by Sewage Sludge. J. Environ. Qual., v. 6, No. 4, 1977, pp. 379-381.

This study was conducted to determine whether additions of sewage sludge would improve the growth of loblolly pine seedlings (Pinus taeda L.) on kaolin spoil obtained from surface mined sites near Macon, GA. If growth improved, a second objective was to determine the minimum quantity of sewage sludge needed to significantly increase growth. Twenty-five microplots were constructed, and kaolin spoil was added. Anaerobically digested dried sewage sludge was added to the kaolin spoil at the following equivalent rates: 0, 34, 69, 138, and 275 t/ha. Height, stem collar diameter, and fresh weight were significantly improved by sludge amendments. The mean values for each of the growth factors were highest in plots containing 69 t/ha sludge. However, these parameters were not significantly different from those in plots containing 34 t/ha sludge. When 275 t/ha were applied, all growth factors were significantly lower than with any other treatment. The survival of all planted seedlings decreased as sludge application rates increased. The degree of ectomycorrhizal development was proportional to the amount of seedling growth. The 34- and 69-t/ha sludge treatments resulted in short roots with the highest proportion of ectomycorrhizae development. The lowest amount of ectomycorrhizae development occurred in the 0- and 275-t/ha treatments. Sludge application also increased the concentration of organic matter and essential plant nutrients in the soil. The authors concluded that sewage sludge is an excellent organic amendment for kaolin spoil, with small amounts significantly stimulating growth and mycorrhizal development of loblolly pine seedlings. The lower rates of application are also economically attractive owing to transportation costs and the amount of kaolin spoil acreage that needs reclamation.

69. Berry, C. H., and D. H. Marx. Significance of Various Soil Amendments to Borrow Pit Reclamation With Loblolly Pine and Fescue. Reclam. Rev., v. 3, No. 2, 1980, pp. 87-94.

The purpose of this study was to determine whether borrow pits located in South Carolina could be reclaimed by deep subsoiling application of various inorganic and organic amendments and by planting loblolly pine (Pinus taeda L.) seedlings colonized with a specific ectomycorrhizal fungus. The site was prepared by removing all trees, subsoiling, and ripping furrows 0.9 m deep. Following subsoiling the area was disked and seeded with Ky-31 fescue (Festuca arundinacea Schreb.) prior to tree planting. Two ectomycorrhizal treatments were utilized and combined with nine different fertility treatments: (1) control, (2) fertilizer and lime, (3) fertilizer and lime + treebark, (4) fertilizer and lime + ash, (5) fertilizer and lime + bark + ash, (6) sewage sludge, (7) sewage sludge + bark, (8) sewage sludge + ash, and (9) sewage sludge + bark + ash. The sewage sludge treatments (6-9) improved pine seedling growth and fescue biomass when compared to the other soil treatments. Mean seedling volume was 28 times greater and fescue biomass five times greater on sludge plots than on nonsludge plots. There was also more soil nitrogen, phosphorus, and organic matter along with a higher cation exchange capacity on the sludge amended plots than on nonsludge plots. Foliar analysis of loblolly pine indicated that with sludge amendments the nitrogen and calcium concentrations were higher than on other treatment plots. The authors conclude that amelioration of a borrow pit considered unsuitable for plant growth can be accomplished by deep subsoiling and application of dried sewage sludge.

70. Best, G. R., P. M. Wallace, W. J. Dunn, and J. A. Feiertag. Enhancing Ecological Succession: 4. Growth, Density, and Species Richness of Forest Communities Established From Seed on Amended Overburden Soils. Paper in 1983 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Nov. 27-Dec. 2, 1983). Univ. KY, Lexington, KY, 1983, pp. 377-383.

This study assessed the germination, survival, growth, density, and species richness of 25 tree species, ranging from early to late successional species, directly seeded on amended phosphate mine overburden from north central Florida. The amendments used were (1) vesicular arbuscular fungi inoculum (VA mycorrhizae), (2) ectomycorrhizal fungi inoculum (Pt mycorrhizae), (3) fertilizer (15-0-15 applied at a rate of 320 kg/ha), (4) soil surface organic matter (straw mulch applied at a rate of 4,500 kg/ha), (5) soil amendment (phosphogypsum applied at a rate of 1,750 kg/ha), and (6) topsoil. First year growth of the tree seedlings was significantly increased with the mulch, topsoil, and VA mycorrhizae, while Pt mycorrhizae, gypsum, and fertilizer significantly decreased growth. A Community Development Index (CDI) was developed and was comprised of relative values for growth, density, and species richness of tree seedlings. The CDI was used to assess the effectiveness of the soil amendments on community establishment. During the first year mulch, topsoil, and mycorrhizal inoculum had a positive effect on the CDI, Pt mycorrhizae inoculum had a positive effect on the CDI, Pt mycorrhizae had no effect, and gypsum and fertilizer had a negative effect.

During the second growing season there were no treatment effects on the CDI. The authors feel this is due to the dominance of the pioneer successional species mimosa (*Albizzia julibrissins* Duraz.) and trumpet creeper (*Catalpa bignonioides* Walt.)

71. Bhowmik, N. G. Stream Bank Stabilization Techniques. Paper in 1983 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Nov. 27-Dec. 2, 1983). Univ. KY, Lexington, KY, 1983, pp. 343-348.

This paper presents various bank stabilization techniques that are widely used to halt the erosion of streambanks. Some of the techniques that are discussed include rip rap, various rock revetments, fencing, hardpoints, various dikes, sheet piling, concrete piling, timber, tree sausage, vegetation, and other materials such as used rubber tires. A combination of these techniques or any one of them alone can be used to prevent further erosion of a streambank.

72. Bird, R., and W. Misiolek. Report of Effects of Land Reclamation Policies on the Economic Feasibility of Lignite Surface Mine Development. Univ. AL Sch. of Mines and Energy Devel., Res. Rep., 1979, 72 pp.

This report examines potential economic impact of regulatory policy for mineland reclamation on the development of lignite mining in Alabama. It was estimated that topsoil reclamation to a depth of 4 ft could add as much as $1/t to the cost of mining the lignite, accounting for approximately 14 pct of the total cost of production. This economic analysis is specific to the potential development of lignite mining in southern Alabama.

73. Bjugstad, A. J. Shrub and Tree Establishment on Coal Spoils in Northern High Plains--USA. Paper in the Third Biennial Symposium on Surface Coal Mining and Reclamation on the Great Plains (cochaired by the Reclam. Res. Unit, MT State Univ. and U.S. OSM, Billings, MT, Mar. 19-21, 1984). MT State Univ. and U.S. OSM, 1984, pp. 223-236.

Trickle irrigation during establishment was shown to increase survival twofold for seven species of shrubs and trees planted on coal mine spoil in the semiarid area of northeastern Wyoming. The species used in this study included green ash (*Fraxinus pennsylvanica* Marsh.), Russian olive (*Elaeagnus angustifolia* L.), silver buffaloberry (*Sheperdia argentea* (Pursh.) Nutt.), Siberian peashrub (*Caragana arborescens* Lam.) American plum (*Prunus americana* Marsh.), ponderosa pine (*Pinus ponderosa* Laws.), and Rocky Mountain juniper (*Juniperus scopulorum* Sarg.). The increased survival persisted for 5 years following the initiation of the study. This period included two growing and two winter seasons after cessation of irrigation. The results of this study are pertinent to mineland reclamation activities in the Northern Great Plains and Rocky Mountain Coal Mining Regions recognized in this evaluation process.

74. Blake, G. Exotics vs. Natives. Western Wildlands, v. 7, No. 3, 1981, pp. 26-27.

The author discusses the use of exotic and native vegetation for reclaiming surface-mined land in eastern Montana. The use of exotic or introduced species may create new environmental problems since they are not adapted to the environmental conditions of eastern Montana. The regeneration of natural vegetation on surface-mined land involves three factors: (1) seed that is adapted to the local environment, (2) site preparation of the seedbed, and (3) climatic conditions. When all three are considered correctly, natural regeneration occurs.

75. Bogner, J. E., and A. O. Perry. A Case Study of Surface Mining and Reclamation Planning: Cannelton Mine No. 9-S, Cannelton, West Virginia. V. 3F in Integrated Mine-Area Reclamation and Land Use Planning. Argonne Nat. Lab. ANL/EMR-1, v. 3F, Feb. 1977, 54 pp.

This report is one in a 10-volume series prepared by the Energy and Environmental Systems Division of Argonne National Laboratory and the Resource and Land Investigations (RALI) Program of the U.S. Department of the Interior under the sponsorship of the U.S. Geological Survey. In this case study a mountaintop-removal coal mining operation in south-central West Virginia is examined. Steep-sided hills characterize the area surrounding the mining area. The area generally lacks extensive tracts of level land suitable for agricultural or residential-commercial development. The Cannelton operation already has several ridges and through innovative reclamation planning is creating areas that may have a higher land use potential than before mining. While the end use identified by a planning team, a new town site, may not have been realistic, it is a good example of integrated mine and reclamation planning. The study provides a very complete report of the mining operation and the reclamation techniques. Specific details of the report are probably unique to this part of the Eastern Coal Mining Region. However, many of the general principles and criteria are applicable to land use and reclamation planning nationwide.

76. Boles, P. H. Reclamation of Surface Mined Lands in Wyoming for Livestock Grazing and Wildlife Habitat. Paper in the Third Biennial Symposium on Surface Coal Mining and Reclamation on the Great Plains (cochaired by the Reclam. Res. Unit, MT State Univ. and U.S. OSM, Billings, MT, Mar. 19-21, 1984). Mt State Univ. and U.S. OSM, 1984, pp. 342-371.

The author presents information on revegetation results and on species of plants that have been successful on reclaimed lands, as well as those that have failed. The article contains discussions on a number of topics including restoring wildlife habitat; methods of evaluating reclamation; the use of adapted species, varieties, and subspecies; the role of hybridization in developing plants for reclamation; the use of shrub tubelings; the advantages of different seeding techniques; and the role of mycorrhizal fungi in revegetation of minelands. The discussions are extensively referenced to available literature. This paper is a very good reference for planning reclamation activities in the Northern Great Plains and Rocky Mountain Coal Mining Regions.

77. Boles, P. H. Shrub Cover and Density on Western Rangelands in Relation to Reclamation Standards for Surface Mined Lands in Wyoming. Paper in 1983 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Nov. 27-Dec. 2, 1983). Univ. KY, Lexington, KY, 1983, pp. 467-476.

A literature review dealing with shrub cover and density on western rangeland and wildlife habitat studies, along with an analysis of vegetation baseline data collected on Wyoming coal mines, was done to establish reasonable and ecologically sound reclamation goals for shrub density. Four elements (historical record, vegetation baseline data, wildlife habitat studies, and regulations) were brought together to formulate a sound reclamation standard for shrub density and cover on reclaimed lands in Wyoming. Based on the review of the literature, a general shrub density goal of 1 shrub per 9 m^2 is recommended on land used for both livestock grazing and wildlife browsing. If a portion of the reclaimed land is for the creation of wildlife habitat only, a shrub density of $1/m^2$ is recommended.

78. Bonham, C. D., L. L. Larson, and A. Morrison. A Survey of Techniques for Measurement of Herbaceous and Shrub Production, Cover and Diversity on Coal Lands in the West. U.S. OSM, Reg. V Draft Rep., Uniscale Corp., Loveland, TX, Jan. 31, 1980, 79 pp.

The article provides information on premining and postmining vegetation inventory techniques. Applicable techniques to measure vegetative cover, productivity, and species diversity are surveyed for herbaceous and shrub vegetation. Also given for each technique are possible sampling options and procedural problems. Reference areas are also discussed in relation to their purpose, an area representing inventory units present before mining and used to evaluate postmining revegetation success.

79. Booth, D. T. Emergence of Bitterbrush Seedlings on Land Disturbance by Phosphate Mining. J. Range Manage., v. 33, No. 6, Nov. 1980, pp. 439-441.

This article reports the results of a study designed to evaluate the effects of planting depth, number of seeds per seed spot, and the application of fungicide and/or vermiculite on the emergence of full-seeded bitterbrush in medium-fine-textured phosphate mine spoil in southeastern Idaho. A planting depth of 1.3 to 2.5 cm resulted in optimum emergence. Less emergence was obtained on plot of 20 seeds per seed spot than from plots with 1, 5, or 10 seeds per seed spot. Mixing the seed with a volume of vermiculite 10 to 40 times the volume of the seed and dusting the seed with Captan fungicide improve emergence. While the information contained in this article relates specifically to revegetation of land disturbed by phosphate mining, it may also be found applicable to establishing bitterbrush on surface-coal-mined land as well.

80. Booth, D. T. Innovation in Wildland Shrub Establishment. Paper in the Third Biennial Symposium on Surface Coal Mining and Reclamation on the Great Plains (co-chaired by the Reclam. Res. Unit, MT State Univ. and U.S. OSM, Billings, MT, Mar. 19-21, 1984). MT State Univ. and U.S. OSM, 1984, pp. 251-257.

This paper reviews some fluid seed drilling equipment and reports two studies addressing the problems of shrub fluid drilling. The author feels that fluid drilling provides a means for increasing control and manipulation of the seed and its environment, while retaining the capability for extensive low-cost dispersal. Study 1 demonstrated the potential for establishing shrubs that require cold-moist treatment to break dormancy through the use of fluid drilling methods. This study also provided evidence of water-soluble substances that inhibit the dormancy breaking process in some species. Study 2 indicated that land imprinting significantly improved seedling establishment of fluid-drilled surface-germinating seeds, such as those of Eurotia spp. The results and methods presented in this paper could find application throughout the arid and semiarid area of the Northern Great Plains, Rocky Mountain, and Pacific Coal Mining Regions recognized in this evaluation process.

81. Borovsky, J. P., D. F. Grigal, and R. L. Strassman. Reclamation of Tailing Basins Resulting From Copper-Nickel Milling (contract J0205050, Barr Engineering Co.). BuMines OFR 214-83, Aug. 1983, 147 pp.; NTIS PB 84-142 587.

This publication reports the results of a 3-year study that evaluated the potential for using vegetation to stabilize tailings from a potential Minnesota copper-nickel milling operation. The investigation consisted of (1) a waste characterization study, (2) a greenhouse study, and (3) a field study. Most physical and chemical characteristics of the tailings were within the range of properties exhibited by Minnesota soils. However, the tailings were found to lack organic matter, be deficient in nitrogen, phosphorus, and potassium, and contain elevated levels of soluble salts and heavy metals. Numerous grass, forbs, and woody plants tolerant of the tailings material as a rooting medium are reported. Incorporation of peat or a topsoil dressing was found not to be necessary for adequate revegetation of the copper-nickel tailings since they provided few benefits to the revegetation process that were not provided by a fertilizer application. Grass legume production with a fertilizer treatment was comparable to local agricultural yields. Heavy metals concentrated in grasses grown on the tailing remained within acceptable tolerance limits. Legumes concentrated more copper and nickel. The results and discussion contained in this report may, in part, be applicable to revegetation of surface-coal-mined land, particularly in the Interior and Eastern Coal Mining Regions.

82. Boyle, P. L., J. L. Powell, R. I. Barnhisel, and J. H. Grove. Sulphur Coated Phosphorus as a Source of P for Topsoiled Mine Land in Western Kentucky. Paper in 1982 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Dec. 5-10, 1982). Univ. KY, Lexington, KY, 1982, pp. 123-128.

This paper reports the results of a study comparing the effectiveness of sulfur-coated ammonium polyphosphate, 7-34-0-305 (SCP), to that of triple superphosphate fertilizer, 0-46-0 (TSP), and triple superphosphate plus elemental S (PS), as measured by yields of alfalfa (Medicage sativa L.). Plant response to the more conventional TSP fertilizer was greater than response to the slow-release SCP fertilizer. Both types of fertilizers raised the Bray-P soil phosphorus to the same level. The observed response differences were attributed to poorer seedling establishment on the SCP-treated plots due to slow P release and low residual soil P. The authors suggest either applying the SCP fertilizer type sufficiently in advance of seeding or including a small application of a much more soluble P fertilizer to improve plant establishment.

83. Brady, T. M., W. W. Kaufman, and D. N. Reynolds. Topsoil Rock Removal. Paper in Surface Coal Mining Reclamation Equipment and Techniques. Proceedings: Bureau of Mines Technology Transfer Seminars, Evansville, IN, June 3, 1980, and Denver, CO, June 5, 1980. BuMines IC 8823, 1980, pp. 30-47.

This article outlines the extent of the rock problem in reclamation throughout the United States, discusses in detail the legal requirements that affect the reclamation process, analyzes the state of the art of current rock pickers including their physical limitations, presents an analysis of rock pickers applied to mine reclamation, surveys environmental effects that may take place, and details the benefits that can result from introducing rock pickers into the mining industry. This article will be applicable to planning reclamation activities where removal of rocks from topsoil is necessary.

84. Branson, B. A. Strip Mining and the Environment. Natl. Parks Conserv. Mag., v. 51, No. 4, 1977, pp. 10-12.

This general article discusses the need for Federal and state regulation of surface mining. This article was written prior to the passage of Public Law 95-87. The article also contains a discussion of the economic considerations and technical problems that are associated with surface mining. The main theme of the article is that the coal industry must be more stringently regulated in order to preserve land and water resources.

85. Brenner, F. J. Food and Cover Evaluation of Strip Mine Plants as Related to Wildlife Management. Paper in Symposium on Surface Mining and Fish/Wildlife Needs in

the Eastern United States (West Virginia Univ., Dec. 1978). U.S. Fish and Wildlife Ser. FWS/OBS-78/81, 1978, pp. 294-305.

Surveys were conducted on the vegetative associations on 82 reclaimed sites in Mercer County, PA. The various species that were utilized during the reclamation process were evaluated on the basis of their success in providing sediment erosion control and food and cover for wildlife. On 12 of these areas, differing in age and reclamation types, specific studies were conducted involving mammalian populations, nutrient analysis, and digestibility of herbaceous species. Mammalian populations correlated with the amount, density, and type of vegetation on each site.

86. Brenner, F. J., R. B. Kelly, and J. Kelly. Mammalian Community Characteristics on Surface Mine Lands in Pennsylvania. Environ. Manage., v. 6, No. 3, 1982, pp. 241-249.

This study was done to determine the types of and changes in small mammal populations using mines of varying ages, the relationship between small mammal communities, and the amount, structure, and type of plant community on surface-mined lands in Mercer County, PA. Small mammal populations and biomass were determined on 10 different surface mines of varying ages and types of restoration. Studies were also conducted on an unmined (reference area) deciduous forest and grassland that had been abandoned for 20 years. The mammalian populations showed considerable variation among the different mines. Woodland deer-mice (Peromyscus Leucopus) and short-tailed shrews (Blarina brevicauda) were the most numerous species and occurred in most of the habitats studied. It was found that the plant species that were used during the initial reclamation were not as important as the volunteer species in establishing favorable habitats for the invasion of small mammals. The authors conclude that surface mines will support a variety of mammalian species and that the composition of the community is dependent upon the amount and type of vegetation. It was found that the volunteer plant species had a higher correlation with the type and size of mammalian communities than did the exotic species normally used in reclamation.

87. Briggs, R. W., and R. C. Greas. Sludge to Fertile Soil--Research Results. J. Test. Eval., JTEVA, v. 8, No. 5, 1980, pp. 265-269.

This article describes research conducted by the Dravo Lime Co., Pittsburgh, PA on the development of fertile soil from combining flue gas desulfurization sludges with municipal waste sludges. A second objective was to stabilize and combine coal fine refuse with municipal waste in order to identify potential stabilization and revegetation techniques. Testing of the various mixtures involved both greenhouse and field trials using a variety of agronomic species. Both the physical and chemical properties of the synthetic soils (sludge combinations) have been monitored and compared to desired soil parameters. The results of this study demonstrate that both flue gas desulfurization sludges and coal fine refuse can be combined with municipal waste sludge to produce a fertile soil.

88. Brisbin, I. L., Jr. The Principles of Ecology as a Framework for a Total Ecosystem Approach to High Altitude Revegetation Research. Paper in Proceedings: High-Altitude Revegetation Workshop No. 5 (CO State Univ., Fort Collins, CO, Mar. 8-9, 1982). CO Water Resour. Res. Inst., CO State Univ., Fort Collins, CO, Inf. Ser. No. 48, Dec. 1982, pp. 1-11.

This paper contains a concise, but general overview of the basic principles of modern ecology as they relate to planning projects and subsequent revegetation programs in high altitude areas. It provides a good synopsis of these principles and would be of value to individuals with little or no background in the biological sciences. Although the major emphasis is on high-altitude ecosystems, the principles presented are applicable to most surface mining situations as well. This article has been rated somewhat differently in this evaluation process since it presents basic concepts rather than the results of a research project.

89. Brissette, J. C. Pine Seedling Availability for Reforestation on Non-industrial Private Forest Lands in the South. So. J. Appl. For., v. 6, No. 1, 1982, pp. 41-44.

The author discusses the need to increase pine seedling production at southern state nurseries for the reforestation of nonindustrial private forest lands. This need could include pine seedlings for the reforestation of surface-mined lands in the south. Production was expected to increase from 602 million seedlings in 1980-81 to 702 million seedlings for the 1982-83 planting season. This projection exceeds the southern state nurseries' estimated maximum potential of 694 million. It was felt that any increase above this level will be at the cost of crop rotation and good soil management and will result in a lower quality seedling. However, there are methods available to supplement bare-root nursery seedling production, such as containerized seedlings which offer the potential for rapid production and an extended planting season. Another important method that could be used to meet future demands for pine seedlings is the use of genetically improved stock. It has been shown that this stock can produce up to 20 pct more wood than unimproved stock. Even with these methods of increasing and improving pine seedling production, predictions still indicate that demands for timber will exceed available resources.

90. Brown, D. R., and D. L. Branson. An Evaluation of Reclamation Tree Planting in Southwest Virginia. Paper in Trees for Reclamation (Lexington, KY, Oct. 27-29, 1980). U.S. For. Ser., Gen. Tech. Rep. NE-61, 1980, pp. 37-38.

The author discusses the historic use of tree plantings as a reclamation technique in southwest Virginia. Documentation is given from 1966 through June 1980 on the operating permits issued, acres disturbed, acres reclaimed, and number of tree seedlings used. A high of 4 million seedlings were planted in 1975. However, from 1975 to 1980 a decrease in the number of seedlings planted occurred. This decrease corresponds to a decrease in acreage disturbed due to reduced mining activity because of a depressed coal market and/or increased regulation. However, there have been over 3.5 million seedlings planted on abandoned mine lands since 1975.

91. Brown, J. E., R. E. Farmer, Jr., and W. E. Splittstoesser. The Establishment of Mixed Plant Communities on Surface Mined Land for Timber Production, Timber and Wildlife, Wildlife Only, and a Native Mixed Forest. Paper in 1983 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Nov. 27-Dec. 2, 1983). Univ. KY, Lexington, KY, 1983, pp. 431-435.

This study evaluated the direct seeding of tree, shrub, forage, and forb species planted in different combinations on surface-mined lands in Campbell and Morgan Counties, TN. Experimental treatments consisted of species mixtures designed for different management objectives: (1) timber production (two combinations), (2) wildlife food and cover (two combinations), (3) timber production and wildlife food and cover, (4) mixed forest with wildlife cover, and (5) a control of Kobe lespedeza (Lespedeza striata Var. Kobe) and various volunteer species. Of the species planted, the following survived and grew well: (1) trees--Virginia pine (Pinus virginiana Mill.) and black locust (Robinia pseudoacacia L.); (2) shrubs,--Indigobush (Amorpha fruticosa L.), autumn olive (Elaeagnus umbellata Thunb.), Bicolor lespedeza (Lespedeza bicolor Turcz.), and bush grape (Vitis rupestris Scheele.); and (3) forbs--aster (Aster pilosus Willd.), Bur-marigold (Bidens frondosa L.), lambs quarters (Chenopodium album L.), fireweed (Erechtites hieracifolia (L.) Raf.), small wood sunflower (Helianthus microcephalus Torr. & Gray.), and pokeweed (Phytolacca americana L.). Depending on the plant community designation, sourwood (Oxydendrum arboreum L.), Joe-Pye-weed (Eupatorium serotinum Michx.), and goldenrod (Solidago altissima L.) had varying survival rates. All sown forage plants became established and grew well with vegetative ground cover ranging from 21 to 63 pct after the first growing season. Except for the community designed as a native mixed forest, all treatment areas had at least 70 pct ground cover by the end of the second growing season.

92. Brown, J. E., and J. B. Maddox. Mixed Woodchips and Paper as a Mulch for Strip-Mined Land Revegetation. Div. Land and For. Res., Tennessee Valley Authority, Norris, TN, Tech. Note B42, Nov. 1980, 9 pp.

The study reported in this publication tested the effectiveness of combined hammermilled woodchips and paper mulch in aiding vegetation establishment. The woodchip-paper mulch mix was also compared to a standard mulch (Turfiber). The study was conducted at a surface minesite in Campbell County in east Tennessee. Three rates of application were tested: 1,120, 1,680, and 2,241 kg/ha. These rates were compared with the standard recommended rate of Turfiber (91,680 kg/ha). First-season vegetative cover produced with the lowest rate of the woodchip-paper mulch mix was comparable to that obtained with the standard rate of Turfiber at a significant cost savings. Aspects of this study are specific to the Eastern Coal Mining Region. However, the results may find application in the other domestic coal mining regions recognized in this evaluation process.

93. Brown, J. E., J. B. Maddox, and G. N. Bartley, Jr. Acrylic Emulsion as a Straw Binder in Reclaiming Coal Surface-Mined Land. Tennessee Valley Authority, Norris, TN, Tech. Note B 43, TVA/ONR/LFR-81/2, Jan. 1981, 15 pp.

The effectiveness of acrylic emulsion (AE) as a straw binder was tested and treatment cost comparisons were made between AE and emulsified asphalt. The study was conducted at a strip mine site in Campbell County, TN. Treatments consisted of (1) 0.56 kl/ha AE plus 2.2 t/ha straw, and (2) 1.68 kl/ha asphalt plus 4.5 t/ha straw. No significant difference was found in vegetative cover between the two treatments. Half the recommended rate of straw used in conjunction with AE was as effective as the recommended rates of asphalt and straw. Application costs were slightly higher for the AE treatments. The results and discussion contained in this report are directly applicable to reclamation planning in the Eastern Coal Mining Region and may be applicable in other parts of the United States as well.

94. Brown, J. E., J. B. Maddox, and W. E. Splittstoesser. The Effect of Fertilizer and Strip Mine Spoil on Germination and Growth of Legumes. Paper in 1983 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Nov. 27-Dec. 2, 1983). Univ. KY, Lexington, KY, 1983, pp. 419-422.

This greenhouse study simulated seeding conditions with a hydroseeder using fertilizer slurries and mine spoil. Seeds of alfalfa (Medicago sativa L.), hairy vetch (Vicia villosa Roth.), Kobe lespedeza (Lespedeza striata var. Kobe), Korean lespedeza (Lespedeza stipulacea Maxim.), red clover (Trifolium pratense L.), sericea lespedeza (Lespedeza cuneata (Dum.-Cours.) G. Don.), yellow sweetclover (Melilotus officinalis (L.) Lam.), and white clover (Trifolium repens L.) were soaked for 20 min in 0, 57 + 54, or 114 + 118 kg/ha N (ammonium nitrate) and P (triple superphosphate), respectively, in 8 kl/ha water. Seeds and fertilizer were then sown in three different soils: (1) a loamy sand from an area along the Clinch River near Norris, TN (river bottom soil), pH 6.1, and used as a control (unmined); (2) a silt-clay loam shaley material, pH 6.4, mine soil 1; and (3) a mixture of shale and sandstone, pH 4.1, mine soil 2. The mine soils were obtained from two separate mines located in Campbell County, TN. Fertilizer did not affect germination on river bottom soil or, at low rates, on mine soils. However, at higher fertilization rates germination was generally lower on the mine soils. The higher concentration of ammonium nitrate in the fertilizer along with the high levels of toxic ions (Mn, S, Fe, and Al) in the mine soils apparently reduced the germination of legume seeds. The shoot-root ratios of planted legumes were also affected by the type of soil material they were grown in. Shoot-root ratios were generally higher on river bottom soil and mine soil 1, which supported the best plant growth. Mine soil 2 generally had low shoot-root ratios, reflecting poor overall legume growth when compared to the other two spoil materials.

95. Brown, J. E., J. B. Maddox, and W. E. Splittstoesser. The Use of Trees, Shrubs, and Forbs for Reclamation of Mine Spoils. Paper in Third Symposium Conference on Better Reclamation With Trees (cosponsored by AMAX Coal Co., Purdue Univ., South. IL Univ. and Madisonville Comm. Coll., Terre Haute, IN, June 2-3, 1983). Purdue Univ., West Lafayette, IN, 1983, pp. 129-134.

The authors report a study conducted on mine spoils in outdoor microplots. Tests were conducted on gray shale (pH 5.5) and brownish sandstone (pH 4.0) from Campbell County, TN, in addition to a silt-loam soil (pH 6.5) from Norris, TN. The objective of the study was to determine which species of trees, shrubs, and forbs could be established via direct seeding procedures. An extensive list of species was tested including 12 trees, 14 shrubs and 14 forbs. Stratification or acid treatment was applied to some species prior to planting. The seeds and fertilizer were applied to the plots in a slurry to simulate a hydroseeder operation. Most species had a survival rate greater than 50 pct. Species that performed well with respect to plant height, root penetration, dry weight, and plant survival included black locust (Robinia pseudoacacia L.), European black alder (Alnus glutinosa (L.) Gaertn.), Virginia pine (Pinus Virginiana Mill.), wild goose plum (Prunus hortulana Bailey), autumn olive (Elaeagnus umbellata Thunb.), bristly locust (Robinia fertilis Ashe.), bush grape (Vitis rupestris Scheele.), indigobush (Amorpha fruticosa L.), staghorn sumac (Rhus typhina L.), fireweed ((Erechtites hieracifolia Raf.), flatpea (Lathyrus sylvestris L.), partridge pea (Cassia fasciculata Michx.), Pennsylvania smartweed (Polygonum pensyevanicum L.), pokeweed (Phyolacca americana L.), tick trefoil (Desmodium spp.),and sheep sorrel (Rumex acetosella L.). This paper provides a good reference of potential species for direct-seeding operations in reclaiming mineland. It provides useful information for planning reclamation activities. No specific coal region is identified by the authors other than the source of the soil material used in the study. The information offered would probably be applicable to a large portion of the Interior and Eastern Coal Mining Regions recognized in this evaluation process.

96. Brown, K. W., J. C. Thomas, and K. W. Lawnius. Distribution of Bermudagrass Roots in Native Soils and Reclaimed Lignite Spoil. Reclam. Reveg. Res., v. 2, No. 2, 1983, pp. 139-153.

This study compared the soil pH, electrical conductivity, texture, bulk density, and root growth of bermudagrass (Cynodon dactoylon (L.) Pers.) on surface-mined areas to native soils of unmined areas in eastern Texas. The surface-mined areas had been revegetated 2 years earlier. The results indicated that in all of the overburdens sampled, root biomass and distribution in the 120-cm profile were as great as, and in some cases greater than, those of native soils. The root mass was concentrated in the upper 0.25 m in both soil types. The spoil materials were generally more acidic than the native soils, but that caused no significant effect on root biomass or distribution. The bulk densities of the native soils were lower than those of the reclaimed spoil material. However, at greater depths in the soil profile, bulk densities were similar in both spoil and native soil. The spoil material also had more contained salt than the native soils, but the salt content was not high enough to have a detrimental effect on plant growth. The authors conclude that the salt content and bulk density of the spoil material did not have an apparent adverse effect on bermudagrass root growth. However, they feel that a continued decrease in spoil pH may have a future impact on root growth.

97. Brown, L. F. Reclamation and Topsoil Use. Min. Congr. J., June 1982, pp. 48-52.

The author defines land reclamation and discusses the cost effectiveness of topsoiling reclaimed molybdenum mines in Colorado. Six examples are given representing a spectrum of reclamation situations, including costs, ranging from no topsoil to long-term stockpiling of topsoil prior to use. Cost estimates are given as realistic approximations.

98. Brown, M. B. Survival of Rhizobium Innoculum in Hydroseeding Slurries. Paper in 1982 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Dec. 5-10, 1982). Univ. KY, Lexington, KY, 1982, 681 pp.

The viability of _Rhizobium_ was studied in fertilizer slurries with differing pH values. Since phosphate was the only fertilizer component to influence the pH of a hydroseeding solution, different concentrations of diammonium phosphate (DAP) and triple superphosphate (TSP) were used to prepare hydromixtures with pH values ranging from 2.9 to 7.7. With slurry pH levels of less than 6.0, innoculum viability was significantly reduced. However, with enough DAP present in the slurry to increase pH levels above 6.0, normal nodulation of sericea lespedeza (_Lespedeza cuneata_ (Dum.-cours.)G. Don) occurred. The ratio of DAP to TSP should be maintained at 4 to 6 for nodulation to occur. Hydrated lime can also be used.

99. Brown, R. W., and R. S. Johnston. Reclaimining Disturbed Alpine Lands. Western Wildlands, v. 7, No. 3, 1981, pp. 38-42.

This article contains general information on revegetation treatments that should be used when reclaiming alpine mining disturbances. Examples of treatments used successfully on the Beartooth Plateau in southeastern Montana are given. General revegetation principles such as shaping and contouring, species selection, timing of seeding, soil treatments (amendments), seeding and planting methods, and post-revegetation management are all applicable to disturbed alpine lands. By using these revegetation principles, site stability can be achieved much faster than if natural succession was allowed to proceed alone. The main challenge to reclaiming alpine sites is to link climatic variations, physiological adaptations of plants, and limiting factors of the disturbed site.

100. Brumbaugh, F. R. Get the Big Picture - To Comply With Reclamation Laws. Coal Min. and Process., Feb. 1979, pp. 57-60, 76-77.

The author describes the concept of remote-sensing aerial photography to measure ground cover in compliance with PL 95-87. Data from color infared photography were used as an example of how revegetation can be measured and verified, and a rationale was established on how this technique complies with the performance standards.

101. Buckner, D. L. Combining Measures of Spatial and Temporal Variation: A Historical Record Approach to Obtaining Baseline Data. Paper in Symposium on Western Coal Mining Regulatory Issues: Land Use, Revegetation, & Management (West. Reclam. Group, Denver, CO, Apr. 1982). CO State Univ., Range Sci. Dept., Fort Collins, CO, Sci. Ser. No. 35, Aug. 1983, pp. 84-86.

Because of ecological realities and mapping practicality, a substantial amount of spatial and temporal variability exists in the vegetation units recognized and subsequently subjected to quantitative sampling in establishing a baseline standard for revegetation success. A method consisting of random samples stratified by year over the period of baseline data collection is suggested that combines measures of spatial and temporal variation into revegetation standards. The method avoids using static measures derived from a relatively small part of a very large vegetational mosaic to predict average year-to-year values of cover and production. This article provides an excellent reference for designing reclamation monitoring programs. It was written with special reference to the Western United States. However, the methods described are applicable nationwide.

102. Bunin, J. E. Transplanting Offers Reclamation Solutions. Coal Min. Process., July 1983, pp. 24-28.

This article offers an excellent overview of the roles of containerized and bare-root nursery stock and transplanting natural vegetation in reclaiming mined lands. The article particularly refers to revegetation of mined lands in the Western United States. However, the techniques and rationales for decision making would apply nationwide.

103. Burger, J. A., S. H. Schoenholtz, R. E. Preve, and J. L. Torbert. Research Progress on the Use of Forest Regeneration Techniques for Surface-Mine Reclamation in Southwestern Virginia. Paper in Third Annual Conference on Better Reclamation With Trees (cosponsored by AMAX Coal Co., Purdue Univ., South. IL Univ. and Madisonville Comm. Coll., Terre Haute, IN, June 2-3, 1983). Purdue Univ., West Lafayette, IN, 1983, pp. 171-179.

Four separate but related southwestern Virginia studies are reported in this paper. The objective of the first study was to identify tree species capable of competing with herbaceous vegetation. Fifteen tree species were planted on a recontoured strip mine in Wise County, VA. Greater than 60 pct of the black locust (Robinia pseudoacacia L.), oak (Quercus spp.), sycamore (Platanus occidentalis L.), and white ash (Fraxinus americana L.) survived. The more shade-tolerant white pine (Pinus strobus L.) fared the best of the pines tested, with a 62-pct survival rate. A second study was conducted to evaluate the effects of ectomycorrhizal inoculation with Pisolithus tinctorius (Pt), chemical weed control, and slow-release fertilization on first-year survival and growth of white pine, Virginia pine (Pinus virginiana Mill.), and loblolly pine (Pinus taeda L.) on two surface-mined sites. The fertilizer used was Agriform tablets. Glyphosate was used for weed control. First-year survival was excellent for all three pine species with loblolly pine showing the best growth. Pt colonization increased seedling growth for all three species. Again, loblolly pine exhibited the most substantial increase in seedling volume when inoculated. Fertilization enhanced seedling growth of all three pine seedlings. Chemical weed control did not significantly increase seedling growth except when it was used in combination with fertilization. The three cultural treatments were compatible in providing increased first-year growth for all three pine species. A third study examined the effects of hydroseeding pine-grass-legume mixtures for erosion control and reforestation of mine soils. Nurse crops consisting of perennial ryegrass (Lolium perenne L.) and red fescue (Festuca rubra L.), as well as birdsfoot trefoil (Lotus corniculatus L.), crownvetch (Coronilla varia L.), or white clover (Trifolium repens L.), were applied in combination with a mixture of white, Virginia, and loblolly pine seeds. Fertilizer treatments were also applied. Ground cover was increased for all nurse crops by nitrogen application. This had an adverse effect on pine establishment. Nitrogen increased the number of pine seedlings where no nurse crops were included. Early data suggest that at least four times as much spoil erosion may be expected where nurse crops are not used in reforestation of strip mines. A fourth study compared regeneration success on siltstone and sandstone overburden types. This study was conducted in a greenhouse combining surface-seeded white, Virginia and loblolly pine seeds, sandstone or siltstone spoil, mycorrhizal application, and fertilizer treatment. Spoil type strongly influenced mycorrhizal colonization with seedlings grown on sandstone spoil exhibiting a higher degree of colonization. A spoil-type X fertilizer interaction was significant for loblolly pine biomass. The results of these studies are directly applicable to planning activities in this specific area, and perhaps over a broader geographical area within the Eastern and Interior Coal Mining Regions recognized in this evaluation process.

104. Bussler, B. H., W. R. Byrnes, P. E. Pope, and W. R. Chaney. Properties of Minesoil Reclaimed for Forest Land Use. Soil Sci. Soc. Am. J., v. 48, No. 1, 1984, pp. 178-184.

This study evaluated the physical and chemical properties of reclaimed mineland and unmined reference soil (reference area) in Sullivan County, IN. A second ojective was to determine the suitability of minesoils for reforestation with hardwood tree species established concurrently with ground cover. The topography, soils (Typic Fragiudalf and Typic Hapludalf), vegetation (mixed upland hardwood tree and shrub), and geologic formation were similar on both sites prior to mining. The results indicate that the chemical properties of the minesoil were similar to or more favorable for plant growth than those of the unmined reference soils. Plant nutrient availability for the establishment and growth of cover crop and tree species should not be limiting, especially after liming and fertilizing. However, the physical properties of the minesoil were less favorable than those of the reference soils. Minesoils had higher bulk densities, lower porosity, lower permeability, more coarse fragments, higher clay content, and lower available water-holding capacity than the reference soils at comparable depths. These physical properties could limit plant growth and survival on reclaimed minesoils.

105. Butterfield, R. I., and P. T. Tueller. Revegetation Potential of Acid Mine Wastes in Northeastern California. Reclam. Reveg., v. 3, No. 1, 1980, pp. 21-31.

This research was conducted to evaluate the potential for establishing vegetation on the Leviathan Mine sulphur spoils in Alpine County, CA. Four approaches were used to determine revegetation success on these 14-year-old spoils: a volunteer vegetation study, field trials, greenhouse trials, and soil analysis. The main factors limiting plant growth on sulfur soil materials are acidity and low nitrogen availability. Volunteer plant distribution on the spoils was apparently controlled by seedbed characteristics, soil pH, geologic origin of the spoil material, and seed dispersal methods. No spoil modifications were apparently needed for the survival of planted bareroot tree and shrub species. No consistent relationships were found between liming and geologic origin and the survival rates of planted trees and shrubs. Liming and straw mulch treatments increased both the emergence and survival of seeded grasses and legumes. Fertilization decreased emergence and survival of herbaceous species and is probably not necessary or beneficial on these spoils. The most important factor influencing vegetation establishment on these spoils is the low pH of the soil material.

106. Byerly, D. W., J. B. Maddox, C. S. Fletcher, and D. T. Eagle. Reclamation of Mined Land in the Piney Creek Watershed--An Interim Report. Paper in Symposium on Surface Mining and Fish/Wildlife Needs in the Eastern United States (WV Univ., Dec. 1978). U.S. Fish and Wildlife Serv., FWS/OBS-78/81, 1978, pp. 267-275.

This report presents general information on how reclamation of mined land will improve vegetation and the stream water quality of a 8,900-ha watershed in Van Buren County, TN. Baseline studies on the water quality and aquatic life of Piney Creek indicated that 174 ha of surface-mined land and two underground mines contributed to the adverse effects on stream water quality. Reclamation treatments to improve cover and water quality included planting trees and shrubs, seeding grasses and legumes, fertilizing, liming, construction of silt-seeding grasses and legumes, fertilizing, liming, construction of silt-retaining structures, and sealing the two underground mines.

107. Byrnes, W. R., W. R. Chaney, and P. E. Pope. Concurrent Establishment of Ground Cover and Hardwood Trees on Reclaimed Mineland and Unmined Reference Sites. Final Report, BuMines OFR 10-84, 1983, 13 pp.

This research was done to assess reforestation success and productivity for reclaimed mine land and reference sites in Sullivan County, IN. The specific objectives of the study were to (1) compare the establishment success and productivity of ground cover and commercial hardwood trees planted concurrently and maintained under the same level of management on reclaimed and unmined reference sites, (2) evaluate the survival and growth of bare-root, containerized, and mycorrhizae inoculated hardwood seedlings on both sites, and (3) evaluate chemical plant control (herbicides) as a technique for concurrent establishment of tree species and ground cover vegetation. The woody and herbaceous species used in this study were black walnut (Juglans nigra L.), northern red oak (Quercus rubra L.), tall fescue (Festuca arundinacea Schreb), and red clover (Trifolium pratense L.). The results indicated that ground cover vegetation was readily established on the minesite and exceeded the required 70 percent of the cover present on unmined reference areas. The ground productivity was similar on the mine site and reference area. With herbicide application the survival of both black walnut and red oak was adequate to meet the stocking requirements of PL 95-87. However, without chemical control, stocking results were one-half of the required level. Containerized black walnut and red oak seedlings showed higher survival and height growth than bare-root seedlings on the mine site; no significant differences were found on the reference site. Finally, mycorrhizal inoculation did not increase seedling survival or growth response.

108. Call, C. A., and C. M. McKell. Vesicular-Arbuscular Mycorrhizae--A Natural Revegetation Strategy for Disposed Processed Oil Shale. Reclam. Reveg. Res., v. 1, No. 4, 1982, pp. 337-347.

This study compared the incidence of vesicular-arbuscular mycorrhizae (VAM) associations in disturbed and undisturbed (reference area) salt desert shrub communities located in Utah and Anvil Points, CO. The authors also determined the effects of soil disturbances and surface disposal of processed oil shale on the infection potential of VAM fungi in Paraho, CO shale. The majority of plant species examined in the Utah shrub community possessed VAM. In the undisturbed shadscale and sagebrush-greasewood communities, all 17 species were mycorrhizal, while in the disturbed sagebrush-greasewood community 4 of the 5 species present were nonmycorrhizal. Disturbances at the Utah and Anvil Points sites reduced VAM potential of the soils. The mean infection percentages of bioassay plants grown in disturbed soils were about one-half those of bioassay plants grown in undisturbed soils. The bioassay plants grown on the Paraho processed shale showed no signs of VAM infection. The infection percentages were 0, 19 to 26, and 40 to 45 for the processed oil shale, disturbed native soil, and undisturbed native soil, respectively. The authors discuss VAM in terms of their roles in disturbed and undisturbed communities and their potential use in the revegetation of disposed processed oil shale.

109. Camenzind, F. J. Wildlife and Coal Development: An Overview. Paper in the Third Biennial Symposium on Surface Coal Mining and Reclamation on the Great Plains (cochaired by the Reclam. Res. Unit, MT State Univ. and U.S. OSM, Billings, MT, Mar. 19-21, 1984). MT State Univ. and U.S. OSM, 1984, pp. 111-124.

The changes that have occurred in the past 300 years in the public's attitudes toward our Nation's natural resources are briefly reviewed, with particular reference to the wildlife resource. These changes in attitude are discussed in light of current surface coal mine reclamation regulations. The need to manage each reclamation site on an ecosystem basis is emphasized. Management considerations are briefly discussed for three unique reclamation habitat types: riparian, agriculture, and forest. The concepts discussed are applicable nationwide.

110. Campbell, W. F., J. F. Walsh, J. J. Skujins, T. M. Schreeg, and D. Ianson. Utilization of Legumes in the Revegetation of Environmentally Stressed Arid Mine Spoils. Paper in Surface Coal Mining and Reclamation Symposium, Coal Conference and

Expo V (sponsored by Coal Age, Louisville, KY, Oct. 23-25, 1979). McGraw-Hill, 1979, pp. 227-239.

This article reports the results of laboratory, greenhouse, and field experiments conducted with legumes and their appropriate Rhizobia spp. to examine their potential in revegetation of arid western surface-mined soils. Soil pH, moisture content, salinity, available P and Ca were found to affect germination, emergence, survival, and N-fixation. The authors concluded that under adequate management legumes can be successfully grown on mine soils. The results indicate that legumes inoculated with the appropriate Rhizobia spp. can supply nitrogen for other non-nitrogen-fixing plants. Beyond the results reported, this article incorporates a good review of pertinent literature.

111. Campion, P., and D. K. Benner. Establishing Permanent Vegetation on Coal Refuse Without a Four-Foot Layer of Topsoil. Paper in 1981 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Dec. 7-11, 1981). Univ. KY, Lexington, KY, 1981, pp 71-78.

The purpose of this study in Wise County, VA was to demonstrate a cost-effective method of producing a vegetative cover on coal refuse without the addition of a 4-ft layer of topsoil. Six substrate treatments were ultilized and seeded with two different seed mixtures, a standard reclamation mix or a stress-tolerant mix, by two different methods, broadcast seeding or hydroseeding. Two different aspects were tested, a north-facing slope and a south-facing slope. Plant production on a dry weight basis and percent plant cover were determined. Yield was found to be the highest on the 150-mm replaced mine soil treatment. Fly-ash application decreased yield, and the yield was lower than for that on the bare refuse alone for the first year. Yield for the stress-tolerant mixture was significantly higher than for the standard reclamation mix. By increasing the depth of applied mulch, the percent vegetative cover also increased. The high yield and dense cover on the refuse material with 150 mm of replaced topsoil indicate that it is possible to establish vegetation on coal refuse without a 4-ft layer of replaced topsoil. The cost effectiveness of using this method is discussed.

112. Carpenter, S. B., and R. A. Eigel. Reclaiming Surface Mines With Black Locust Fuel Plantations. Paper in Surface Coal Mining and Reclamation Symposium, Coal Conference and Expo V (sponsored by Coal Age, Louisville, KY, Oct. 23-25, 1979). McGraw-Hill, 1979, pp. 301-307.

This article reports results obtained from a study conducted in eastern Kentucky that examined biomass production in black locust (Robinia pseudoacacia L.) plantations established for fuel production on reclaimed surface-mined sites. Plantations were established by both seeding and transplanting. Yields were also determined on coppice production following initial harvest. The study included estimates of the heat content of the wood produced, permitting expression of production in terms of heat content per unit land area (Btu/ha). The authors concluded that fuel plantation systems such as the one studied are economically favorable where costs of site preparation and plantation establishment are part of the reclamation process.

113. Carpenter, S. B., D. H. Graves, and R. A. Eigel. Producing Black Locust Biomass for Fuel on Southern Surface Mines. Energy Commun., v. 5, No. 2, 1979, pp. 101-108.

The potential use of black locust (Robinia pseudoacacia L.) in establishing fuel plantations on reclaimed mined lands is discussed. Results from field studies indicated that in unmanaged stands from 2 to 13 years old in harsh surface-mine sites, black locust dry weight yields ranged from 2 to 28 t per acre. The authors feel that with the establishment of fuel plantations and the application of appropriate silvicultural methods, these yields could be increased and the fuel plantation concept become economically feasible. Black locust biomass yield data for 72 sample sites on surface-mined lands are provided, together with an outline of future research directions. This article is applicable to reclamation planning in the Interior and Eastern Coal Mining Regions recognized in this evaluation process.

114. Carpenter, S. B., D. H. Graves, and R. R. Kruspe. Individual Tree Mulching as an Aid to the Establishment of Trees on Surface Mine Spoil. Reclam. Reveg., v. 1, No. 3/4, 1978, pp. 139-142.

This study investigated the amount of soil surface area that needs to be covered by mulch in order to significantly raise the survival of tree seedlings. A second objective was to test a variety of mulching materials. American sycamore (Platanus occidentalis L.) 1-0 seedlings, European black alder (Alnus glutinosa (L.) Gaertn.), loblolly pine (Pinus taeda L.), and Virginia pine (Pinus virginiana Mill.) were planted on surface mine spoil near Colmar, KY. The mulch treatments consisted of control (no mulch), 0.9- by 0.9-m of clear polyethylene plastic, 0.9- by 0.9-m fiberglass mat, 15.2-cm fiberglass disc, 30.5-cm fiberglass disc, latex rubber spray (1:5 rubbery polymer emulsion-water mixture sprayed in a 0.3-m-diameter circle), and bark (0.012 m^3 applied in a circular fashion). Parameters of interest were spoil moisture and temperature and the growth and survival of the tree seedlings after one season. The fiberglass mat and polyethylene plastic raised the level of soil moisture above that of the control, while the bark mulch significantly lowered soil moisture. The highest surface temperatures occurred under the polyethylene plastic and the lowest under the fiberglass mat. Effects of other treatments did not significantly differ from those with the control. The polyethylene plastic and fiberglass mat treatments resulted in a significant increase in seedling survival over that with the control. Survival with latex spray and fiberglass disc treatments did not differ significantly from that with the unmulched control. The bark mulch resulted in a significantly lower survival rate than the unmulched control. The authors conclude that survival, vigor, and growth are increased under conditions that provide more surface area under mulch, such as the polyethylene plastic or fiberglass mats.

115. Carpenter, S. B., R. F. Wittwer, D. H. Graves, and R. E. Daniels. A Comparison of Broadcast Seeding and Spot Seeding of Black Locust on Eastern Kentucky Mine Soil. Paper in 1981 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Dec. 7-11, 1981). Univ. KY, Lexington, KY, 1981, pp. 257-260.

This article compares two methods of establishing black locust on surface mine spoils in Kentucky, broadcast seeding versus spot seeding. Black locust (Robinia pseudoacacia L.) was chosen as the trial species because of its potential use as a biomass fuel. The experimental design consisted of testing two aspects (north and south) and 10 treatments-broadcast seeding at 5 seeding rates and spot seeding at 5 seeding rates. Spot seeding of black locust resulted in better survival, greater growth, and stands with more evenly distributed trees.

116. Carpenter, S. B., R. F. Wittwer, D. H. Graves, and R. A. Eigel. Production of Black Locust Biomass on Appalachian Surface Mines. Sec. in Woodpower: New Perspectives on Forest Usage. Pergamon, 1981, pp. 161-176.

This study was done to determine the biomass production and fuel potential of black locust (Robinia pseudoacacia L.) grown on reclaimed surface-mined sites in eastern Kentucky. The study was divided into three phases: (1) sampling the biomass produced on previously established black locust stands, (2) establishing two black locust fuel plantations using direct seeding and containerized seedlings, and (3) harvesting a 5-year-old stand and measuring coppice (sprout) growth. The biomass produced ranged from an average of 4.7 t/ha for 2-year-old stands to 62.1 t/ha for

13-year-old stands. These results are comparable to other yields obtained for black locust on surface-mined land. The site factors that influenced black locust growth the most were clay content of the spoil material and slope of the terrain. Biomass was directly related to clay content and inversely related to slope. The heat content of black locust grown on surface-mined land was found to be 33.1 million Btu/cord (45.3 million Btu/acre). The authors conclude that the concept of establishing fuel plantations of black locust by direct seeding on reclaimed surface-mined sites appears to be a promising solution to both reclamation problems and the development of an additional renewable energy resource in the Eastern United States.

117. Carrel, J. E., J. E. DeMott, and D. M. Zwight. Surface Mine Revegetation: Area Metering of Ground Cover. Paper in Fifth Symposium on Surface Mining and Reclamation (NCA/BCR Coal Conf. and Expo IV, Louisville, KY, Oct. 18-20, 1977). Natl. Coal Assoc. and Bituminous Coal Res., Inc., 1977, pp. 8-11.

A simple technique for remote determination of vegetative ground cover is described. A transfer of plant cover visible in a large-scale, vertical aerial photograph of the mineland area is prepared by delineating the area on a clear plastic sheet. A silhouette of the area is then made. The area occupied by vegetation is then measured by passing the silhouette through a leaf area meter. The authors report that the method is rapid, accurate, and inexpensive. The method should be applicable nationwide.

118. Carrel, J. E., C. J. Johannsen, T. W. Barney, and W. McFarland. Remote Measurements of Vegetative Cover in Surface Mines. Paper in Twelfth International Symposium on Remote Sensing of Environment, Volume III (Manila, Philippines, Apr. 20-26, 1978). Environ. Res. Inst. of MI, Ann Arbor, MI, 1978, pp. 1653-1664.

This study evaluated vegetative ground cover in Missouri by two semi-automatic techniques. The first technique used a leaf area meter to measure the extent of vegetation as represented by darkened spots on clear plastic overlays made from aerial photographs of mined lands. The second technique utilized an image-analyzing computer to scan, digitize, and classify ground cover detected in the same aerial photographs. The objectives of the study were to develop characterizations of specific revegetation patterns that resulted from the reclamation methods used, to extend the developed surface characterization to large mined areas using remote-sensing methods, and to provide detailed information to reclamation planners and monitors. Both techniques proved to be fast, accurate (85 to 95 pct), and relatively inexpensive methods to determine the extent of revegetation in surface mines. The computer system was found to be more versatile. However, these techniques cannot replace ground surveys for cover verification or more sophisticated monitoring systems. They do offer a time and money savings to those who must make policy decisions based on the degree of revegetation of a single surface mine. The authors conclude that the subjectivity in many decision processes regarding surface mine reclamation could be reduced or eliminated by using these techniques.

119. Carrel, J. E., C. L. Kucera, A. P. Harrison, Jr., C. J. Johannsen, and R. W. Blauchar. Strip-Mine Reclamation: Criteria and Methods for Measurement of Revegetation Success (U.S. DOE contract, Univ. of MO-Columbia). U.S. DOE, DOE/EV/02758-8, Sept. 1982, 17 pp.

The purpose of this study was to evaluate and identify suitable methods and criteria for determining revegetation success on reclaimed minelands in the Midwestern United States. Both direct and remote-sensing techniques for measuring plant growth cover, production, and species composition were tested. Fieldwork was conducted on old abandoned mines in Missouri and newly reclaimed mines in Missouri, Illinois, and Kansas. The authors concluded that direct, ground level measurements are necessary to obtain statistically valid data on plant performance such as crop and forage yield.

Remote-sensing methods were used to study the process of natural plant succession on abandoned coal mines. A three-step model is presented for describing patch dynamics of vegetation based on six case histories. The authors feel that this model could be used to project the rate and extent of secondary succession in other areas. A third study was conducted to examine decomposition of fescue and cellulose litter on surface mines and on a tallgrass prairie in Missouri. The rates of litter decompostion for grasslands were faster than reported in the literature. The authors concluded that rapid mineralization of plant tissues has serious implications for soil organic matter turnover and long-term fertility of reclaimed mine soils. This article is a good reference for planning and designing reclamation monitoring programs. While the study was conducted in the Interior Coal Mining Region, some of the methodology would be applicable in other regions.

120. Carrel, J. E., C. L. Kucera, C. J. Johannsen, and R. W. Blanchar. Strip-Mine Reclamation: Criteria and Methods for Measurement of Revegetation Success, Progress Report for Period Apr. 1, 1980-Mar. 31, 1981 (U.S. DOE Contract DE-AC02-76EV02758.A006). Univ. MO, Prog. Rep. COO-2758-7, Dec. 1980, 71 pp.

The purpose of this study was to find suitable methods and criteria for determining the success of revegetation in midwestern prime agricultural lands strip-mined for coal. Direct and remote-sensing techniques are described for measuring plant ground cover, production, and species composition. Digital computer image analysis of color infrared aerial photographs, when compared to ground level measurements, provided a fast, accurate, and inexpensive way to determine plant ground cover and area. However, the remote-sensing approach was inferior to standard surface methods for detailing plant species composition and abundance. This reference is an interim progress report and has been included here because it contains extensive data collected during the study that could be of use in comparative studies. In addition, the authors provide a more clear description of their methods in this report. The final report, published in 1982, has also been reviewed in this evaluation process and appears in this bibliography under the same principal author and main title.

121. Carrel, J. E., K. Wieder, V. Leftwich, S. Weems, C. L. Kucera, L. Bouchard, and M. Game. Strip Mine Reclamation: Production and Decomposition of Plant Litter. Paper in Ecology and Coal Resource Development, v. 2 (based on the Int. Congr. for Energy and the Ecosystem, Univ. ND, Grand Forks, ND, June 12-16, 1978). Pergamon, 1979, pp. 676.

Preliminary results are reported of plant production and decomposition studies from strip-mined areas in central and western Missouri. Plant species composition and abundance were measured by quadrant sampling along transects. The standing plant crop at the end of the growing season ranged from 670 to 810 g/m^2 in strip-mined areas undergoing natural recolonization. Standing crop yield on strip-mined areas planted less than a decade ago with a mixture of legumes and grasses was 200 g/m^2. Litter decomposition on revegetated minelands was found to be highly variable. Low decay rates were reported for litter samples placed on bare soil in surface-mined areas. Rapid decomposition rates were found for litter samples placed in vegetated areas. A major determinant of the decay rate appeared to be the initial carbon-nitrogen ratio. This article is a good reference for those interested in ecological aspects of surface mineland revegetation in the Interior Coal Mining Region.

122. Carter, R. P., R. R. Hinchman, and S. D. Zellmer. Land Reclamation Program. Annual Report, 1980. Argonne Natl. Lab. ANL/LRP-12, May 1981, 107 pp.

This annual report describes the Argonne Land Reclamation Program and reviews several ongoing or recently completed field and laboratory studies. Preliminary results, accomplishments, and planned future activities are presented for the Jim Bridger Mine Project in southwest Wyoming; the Kellerman Mine Project in Tuscaloosa

County, AL; the Bighorn Mine-Tongue River Project, near Sheridan, WY; the Alaska Project considering coal mining impacts throughout that State; the Maconpin County Refuse Reclamation Demonstration Project near Staunton, IL; and the Navajo Mine Project--Plant Breeding and Selection of Plant Materials for Reclamation of Arid Sites (New Mexico) conducted by Brigham Young University. The information presented in these discussions is primarily relevant to the coal mining regions in which the projects are located. The report was evaluated as a whole. Reference to a particular keyword used in the evaluation process may not be found in each research project description.

123. Cech, F. C., and R. N. Keys. Establishment and Early Growth of Sweetgum Planted on Disturbed Land. Paper in Third Annual Conference on Better Reclamation With Trees (cosponsored by AMAX Coal Co., Purdue Univ., South. IL Univ. and Madisonville Comm. Coll., Terre Haute, IN, June 2-3, 1983). Purdue Univ., West Lafayette, IN, 1983, pp. 217-228.

Sweetgum (Liquidambar styraciflua L.) seedlings from 34 seed sources that represent the natural range of this species were planted on a forest site, a reclaimed deep-mine refuse pile, and a reclaimed surface mine. These sites are in northeastern West Virginia and western Maryland. Height growth and survival differed among sources and sites. Fastest growth was exhibited by seedlings from northern sources; however, these seedlings were the shortest due to susceptibility to winter dieback. The forest site showed the best growth and survival. Low pH contributed to poor growth and survival on the reclaimed refuse pile. Competition and possible allelopathic effects by grasses and other herbaceous cover contributed to poor growth on the reclaimed mine site. This article provides a good reference on source selection for planning the use of sweetgum in reclamation projects throughout the Eastern and Interior Coal Mining Regions recognized in this evaluation process.

124. Chalfant, F. R., H. Cunningham, and J. A. Holbrook, II. Agriculture as a Post-Mining Land Use Following Mountaintop Removal Mining. Paper in 1980 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Dec. 1-5, 1980). Univ. KY, Lexington, KY, 1980, pp. 10-22.

This article discusses the feasibility of agriculture as a postmining land use alternative following mountaintop removal by mining. Office of Surface Mining regulations are discussed regarding mountaintop reclamation requirements. A set of criteria is presented by the authors that could serve as a basis for predicting potential success of farming on reclaimed mountaintop sites; i.e., planning, water needs, plant selection, etc. Soil conditions are the most important criteria for determining agricultural feasibility. A table is given listing soil physical and chemical criteria for developing agriculture as a land use.

125. Chambers, J. C. Measuring Species Diversity on Revegetated Surface Mines: An Evaluation of Techniques. U.S. For. Ser. Res. Paper INT-322, 1983, 15 pp.

The three most commonly used techniques for measuring species diversity in plant communities are reviewed in this report. The three techniques are (1) diversity indices, (2) rank correlation tests, and (3) similarity indices. The suitability of each technique for assessing species diversity on mined land is discussed, along with an evaluation of the most often used indices, test statistics, or coefficients of each technique.

126. Chambers, J. C., and R. W. Brown. Methods for Vegetation Sampling and Analyses on Revegetated Mined Lands. U.S. For. Ser. Gen. Tech. Rep. IT-151, 1983, 57 pp.

Methods of sampling vegetation for the comparison of revegetated mined lands and reference areas are outlined in this handbook. Various components of vegetation sampling are discussed in detail, with emphasis on the selection of reference areas and the methodologies involved in cover, production, density, and species diversity estimates. A method of comparing species diversity of revegetated and reference areas is also presented. The vegetation sampling techniques are discussed in relation to the revegetation of improved pastures, grazing lands, and woodlands.

127. Chapman, D. L., B. S. McGinnes, and R. L. Downing. Breeding Bird Populations in Response to the Natural Revegetation of Abandoned Contour Mines. Paper in Surface Mining and Fish/Wildlife Needs in the Eastern United States, (WV Univ., Dec. 1978). U.S. Fish and Wildlife Ser. FWS/OBS-78/81, 1978, pp. 328-332.

This study was conducted in southwestern Virginia to investigate the relationship between breeding bird populations and the structural aspects of natural revegetation. Twelve study areas on abandoned contour mine land were surveyed. Units of similar vegetation were identified within each disturbed area. To evaluate habitat heterogeneity, a series of indices, based on the Raw Index of Diversity, were developed to express the variability of the vegetation within each area. Several positive relationships were found between breeding bird populations and habitat heterogeneity. The strongest association was between the number of breeding species and the percent ground cover in the 0-1 layer. This relationship was found through all successional stages. The results of this study suggest that during early successional stages a quick vegetative cover should be developed, followed by tree plantings. The authors conclude that tree seedlings planted among herbaceous species would achieve these objectives.

128. Chichester, F. W. Premining Evaluation of Forage Grass Growth on Mine Soil Materials From an East-Central Texas Lignite Site. Soil Sci., Apr. 1983, pp. 236-244.

This paper reports the results of a greenhouse study designed to examine the growth of several warm season forage grasses and a cool season pasture mix of oats (Avena sativa L.) and clover (Trifolium spp.) on mixtures of soil profile horizon materials. The author concluded that, if an adequate supply of water and nutrients were provided, the mixtures of soil profile horizon materials evaluated had the same potential for forage grass production as the genetic topsoil at the mine site. The results reported could be applicable to study or planning of reclamation on sites with thin topsoil.

129. Chironis, N. P. Guide to Plants for Mine Spoils. Coal Age, v. 82, No. 7, 1977, pp. 122-130.

This article provides information on 21 species of shrubs, trees, legumes, and grasses that have been grown successfully on different spoil material across the United States. Included is a short discussion on a few soil factors that affect the success of plantings. For the species described information is given on growth habit, tolerances (acid and drought), varieties available, and the benefit a particular species may provide to the site. The cover provided for wildlife and the ability to fix nitrogen are examples of benefits that a particular species can provide to a site.

130. Chironis, N. P. Reedgrass Greens Slurry Ponds. Coal Age, v. 87, No. 4, 1982, pp. 86-91.

The author discusses the use of reedgrass (Phragmites australis Trin.) in revegetating slurry areas at a site in southern Illinois. A new method of establishing vegetation on slurry areas without the use of topsoil is needed because of the high cost of covering the area with 4 ft of borrow material. A good discussion is included on the morphological characteristics and adaptability of reedgrass to differing environmental conditions. The establishment of reedgrass on slurry areas was accomplished by sectioned rhizomes, which are similar to root cuttings, hand planted using techniques similar to those used for tree seedlings. Results indicate that within 8 days of initial planting lateral root and vertical shoot development had occurred. By the end of the third growing season, shoot height was over 6 ft with stand densities over 130 stems per square yard on favorable sites. These results indicate that it may be possible to establish vegetative cover on refuse areas without an initial topsoil cover.

131. Chugh, Y. P., and S. L. Barua. Planning Integrated Mining and Reclamation Operations in Area Strip Coal Mines. Paper in 1981 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Dec. 7-11, 1981). Univ. KY, Lexington, KY, 1981, pp. 5-11.

The authors present a methodology for planning integrated mining and reclamation operations for area strip coal mines. Reclamation is done concurrently with mining and lags behind the mining by a few spoils. This integrated operation implies (1) none or very little topsoil or subsoil is stockpiled and (2) operations of rock spoil grading, and subsoil and topsoil removal and replacement are conducted to minimize the adverse interactions among these operations. By utilizing this method there is a potential of reducing reclamation costs by 20 to 30 pct.

132. Chugh, Y. P., and R. Kharkar. Environmental Assessment of Surface Coal Mining in the United States. J. Mines Met. & Fuels, June 1982, pp. 326-336, 340.

This article provides a good, relatively up-to-date overview of the Federal legislation and agencies presently regulating surface coal mining in the United States. In addition, primary mining and reclamation techniques as well as regional environmental concerns and their mitigation are reviewed. This article could provide good background information to individuals with little or no knowledge of surface coal mining and mineland reclamation in the United States. The paper is national in scope.

133. Chugh, Y. P., and K. V. K. Prasad. Appraisal of Deeper Soil Loosening Equipment for Use in Reclaiming Illinois Prime Farmland After Surface Coal Mining (contract J0225015, South. IL Univ.). BuMines OFR 33-84, 1983, 112 pp.; NTIS PB84-166644.

This study appraises the deeper soil loosening equipment available in the United States and abroad that has potential for Illinois prime farmland reclamation. The types of equipment evaluated operate in the 1- to 4-ft depth range. The evaluations were based on written and/or oral contacts with equipment manufacturers and reclamation experts. The results indicated that several manufacturers in the United States, West Germany, and England market static and vibratory deeper soil loosening equipment which may have potential for application in Illinois. The information conveyed should be pertinent to prime farmland reclamation to reduce soil bulk density throughout the Interior Coal Mining Region.

134. Cline, J. F., and V. A. Uresk. Revegetation of Disturbed Grounds in the Semi-Arid Climate of South Central Washington. Health Phys., v. 36, 1979, pp. 289-294.

The purpose of this study was to evaluate the effectiveness of various soil treatments in establishing a self-sustaining vegetative cover on soil fill overlying a portion of a former radioactive waste pond. The soil was stabilized sufficiently to resist wind erosion using treatments that incorporated straw, Wyoming bentonite clay, or a straw-clay mixture. Successful revegetation was achieved in 1 year. Cheatgrass (Bromus tectorum L.), a shallow-rooted species, was planted to retard the growth of deep-rooted radionuclide carriers. The cheatgrass maintained itself through three growing seasons. The authors felt that the cheatgrass will probably persist in the study area for several decades. This study was conducted at the U.S. DOE's Hanford site in south-central Washington, and the results are specific for that area.

However, they could find application to specific reclamation problems in the Northern Great Plains and Rocky Mountain Coal Mining Regions as well.

135. Coal Age. Guide For Revegetation in Eastern U.S. V. 86, No. 7, 1981, pp. 76-79, 82-86.

This article is a good general reference to the revegetation of surface-mined land in the Eastern United States. The information provided deals with vegetation establishment, from the time of seedbed preparation through mulching. Included in the discussion are sections on the various seeding techniques available for herbaceous species, recommended varieties and mixtures, and seeding times and rates. There is also a short discussion on tree and shrub plantings. Various soil amendments that aid in vegetation establishment are discussed. The information presented in this article is based on material compiled by B. L. Rafaill, W. G. Vogel, and R. R. Hinchman.

136. Coal Age. Update on Reclamation Regulations. V. 86, No. 7, 1981, pp. 68-73.

The Surface Mining Control and Reclamation Act (Public Law 95-87) created a new Federal agency, the Office of Surface Mining (OSM). OSM regulations contain two types of regulatory guidelines: (1) those dealing with performance standards or goals, and (2) those concerning the design criteria for all construction in the mine plan area. This report summarizes the important points of each regulatory section that affects the reclamation phase of a surface mining operation.

137. The Coal Miner. Alaska's Usibelli Coal Mine Expands Info Export Markets. V. 7, No. 5, pp. 36, 38.

This is a general article that deals with the reclamation efforts at the Usibelli Coal Mine in Alaska. The article contains very little specific information on revegetation and reclamation other than to mention the various research projects that have occurred at the site since 1971.

138. Coal Mining and Processing. Indiana'a Small Mines Showcase Scraper-Dozer System. V. 20, No. 6, July, 1983, pp. 30-31.

This article briefly describes a scraper dozer system being used by small operators in Indiana for surface coal mining and reclamation. Treatment of reclamation is general.

139. Coaldrake, J. E., and M. J. Russell. Rehabilitation With Pasture After Open-Cut Coal Mining at Three Sites in the Bowen Coal Basin of Queensland. Reclam. Reveg., v. 1, 1978, pp. 1-8.

Field trials were conducted to develop a method for establishing permanent vegetative cover on three reclaimed areas of the Bowen Coal Basin located in Queensland, Australia. Species trials were made with grasses and tropical legumes. The key to rapid and successful rehabilitation of these areas is the application of superphosphate at a rate of 400 kg/ha. Large increases in cover and yield resulted for each species at each site due to the application of superphosphate. Response to nitrogen fertilizer application was variable.

140. Coe, C. A., and J. M. Klopatek. Mycorrhizae in Reclaimed Soils. Paper in 1983 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Nov. 17-Dec. 2, 1983). Univ. KY, Lexington, KY, 1983, pp. 399-405.

Two greenhouse studies were conducted to determine the presence of vesicular-abruscular mycorrhizae (VAM) in soils of undisturbed (reference area) and disturbed (reclaimed) plant communities in the Black Mesa coal region in northeastern Arizona. Soils were taken from four undisturbed plant communities; three reclaimed soils, one prelaw and two postlaw (Public Law 95-87), and three topsoil storage piles ranging from 1 to 3 years in age. All soils were analyzed for pH, electrical conductivity, saturation percent, and textural class. The first study was done to reveal the interaction of VAM with plant roots of sudan grass (Sorghum sudanense (Piper) Stapf.). The results of this study showed that mycorrhizal infection was directly related to the different soil types. Plants grown in natural soils had greater mycorrhizal infection and total biomass than plants grown in disturbed soils. The second study consisted of four treatments which were used to determine if different soil substrates had varying capacities to support mycorrhizal fungi and how VAM affects the growth of four-wing saltbush (Atriplex canescens (Pursh) Nutt.). The treatments consisted of four-wing saltbush grown in sterile and unsterile soil inoculated and noninoculated with mycorrhizal fungi. Four-wing saltbush grown in disturbed and undisturbed soils inoculated with the mycorrhizal fungi Glomus mosseae and Glomus fusiculatus had higher percent infection and greater biomass than noninoculated soils. The authors conclude that disturbance has several detrimental effects on the native mycorrhizal populations.

141. Colbert, T. A. Non-Quantitative and Non-Vegetative Reclamation Success Criteria and the Requirements of the U.S. Surface Mining Control and Reclamation Act. Paper in Symposium on Western Coal Mining Regulatory Issues: Land Use, Revegetation, & Management (West. Reclam. Group, Denver, CO., Apr. 1982). CO State Univ., Range Sci. Dept., Fort Collins, CO, Sci. Ser. No. 35, Aug. 1983, pp. 56-59.

The limitations and shortcomings associated with the existing regulatory requirements for premining and postmining vegetation inventories and reclamation success criteria are discussed. It is stressed that accepted inventory methods do not provide a means of considering land use, successional trend, or conditions. The author feels that the present regulations put too much emphasis on quantitative methods to make objective evaluations of revegetation success based on systematic statistical comparisons of premining and postmining conditions. He suggests instead that the requirements could be made more flexible by allowing consideration of professional judgment in determining reclamation success. Various alternative criteria for determining reclamation success are proposed, including livestock-carrying capacity, wildlife-carrying capacity or evidence of inhabitation by wildlife species, crop or timber production or economic appraisal of potential productivity, soil loss or sediment yield, landscape design criteria, and conversion to other developed uses. This article is primarily applicable to the Northern Great Plains and Rocky Mountain Coal Mining Regions.

142. Colling, G. SEAM--Technology Takes on Surface Mining Problems. Paper in Forestry Research: What's New in the West. U.S. For. Ser., Apr. 1977, pp. 1-4.

This article describes the Surface Environment and Mining Program (SEAM), established by the Forest Service in 1973. SEAM was designed to supply the most current reclamation and planning technology to help land managers cope with problems of mineral management. The article provides brief, nontechnical descriptions of SEAM-sponsored research, planning, and application efforts that were conducted throughout the West.

143. Collyer, L. Carrying Capacity as an Alternate Revegetation Standard. Paper in Symposium on Western Coal Mining Regulatory Issues: Land Use, Revegetation, & Management (West. Reclam. Group, Denver, CO, Apr. 1982). CO State Univ., Range Sci. Dept., Fort Collins, CO, Sci. Ser. No. 35, Aug. 1983, pp. 50-52.

The author presents an alternative approach to the reference area and historical data methods of evaluating revegetation success. The method uses carrying capacity as the revegetation standard against which revegetation success would be judged. In the opinion of the author, the carrying capacity approach increases the flexibility for measuring revegetation success on lands where the potential exists to improve the vegetative type. The author supports the use of this method with stock weight gain data from literature published by other authors. Wildlife considerations are not addressed. The method is compared with the other standard for evaluating revegetation success. This method could find application throughout the Northern Great Plains and Rocky Mountain Coal Mining Regions.

144. Conservation Consultants, Inc., and Zellars-Williams, Inc. Estech General Chemicals Corporation, Duette Mine, Manatee County, Florida. Res. Doc: Reclamation Methodology. Draft EIS. U.S. EPA, EPA 904/9-79-044 F, Oct. 1979, 57 pp.

This document provides an excellent description of proposed reclamation and revegetation methods for a phosphate mine in Florida. All parts of the minesite are treated. Revegetation methodology includes separate procedures for improved pasture establishment, reforestation, enhancement of unmined palmetto rangeland, and marsh revegetation. Special reclamation methods are described for wetland restoration, lake creation, and natural revegetation. Although the document was written specifically for a phosphate mine, many of the procedures are applicable to reclamation of surface coal mines. This publication is an excellent reference applicable to reclamation planning in this portion of the Gulf Coast Coal Mining Region.

145. Conwell, C. N., and S. Weston. Reclaiming Mining Lands in Alaska. Paper in Stability in Coal Mining (Proceedings of the First International Symposium on Stability in Coal Mining, Vancouver, B.C., 1978). Miller Freeman Pub., Inc., San Francisco, CA, 1979, pp. 459-462.

The authors provide a brief general statement of surface coal mine reclamation in Alaska. The discussion is centered around experience gained from reclamation efforts at the Usibelli coal mine near Healy, AK. Although few hard data are provided for the topics considered, the discussion will be of interest to individuals with limited knowledge of surface coal mine reclamation efforts in Alaska.

146. Cook, F. Evaluation of the Environmental Effects of Western Surface Coal Mining, Volume I (Mathematica, Inc., Princeton, NJ). EPA Ind. Environ. Res. Lab., EPA-600/7-79-110, May 1979, 136 pp.

The author presents a general review of methods used for surface mining of coal in the Western United States, the environmental effects of those mining methods, and recommendations to alter or reduce both short- and long-term environmental damage. The overall evaluation of revegetation and erosion control practices is good. Mine spoils in the West can be successfully revegetated to produce at least as good a cover as the premining cover, particularly where topsoil is replaced and proper seedbed preparation, seeding, and amendment procedures are used. Long-term survival, however, is still uncertain. Although general in nature, the article provides a comprehensive total picture of the mining and reclamation procedures applicable to western surface coal mines.

147. Creighton, J. L., R. N. Muller, and R. F. Wittwer. Biomass and Nutrient Assimilation of Intensively-Cultured Black Locust on Eastern Kentucky Mine Spoil. Paper in 1983 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Nov. 27-Dec. 2, 1983). Univ. KY, Lexington, KY, 1983, pp. 503-508.

This study evaluated the effects of several cultural treatments (fertilization, irrigation, bark mulch, and competition control) and establishment methods (direct-seeding and planting seedlings) on the biomass accumulation by black locust (Robinia pseudoacacia L.) planted on surface mine spoil near Middlesboro, KY. A second objective was to examine the patterns of nutrient assimilation in the aboveground portions of the stand. Black locust that was direct-seeded at a rate of 12.0 kg/ha resulted in greater total biomass and was more productive than planted seedlings. However, if seedlings are planted at a closer spacing (0.9 by 0.9 m), they will outproduce direct-seeded black locust planted at a rate of 6.0 kg/ha. Bark mulching was found to be the minimum cultural treatment needed to insure successful establishment and increase yields on direct-seeded plots. The other cultural treatments failed to show any significant effects. The concentration of nutrients in a tree was not affected by either cultural treatment or establishment method. The nutrient content of the various components of a tree had the following order: leaves > branch > stem > bark for N, P, K, and Mg. For calcium the order was leaves > branch > bark > stem. Approximately 40 pct of these elements in a stand were found in the foliage and could be saved, from a nutrient cycling standpoint, by dormant season harvesting. Based on soil analyses, the N, P, and K assimilated in the aboveground portion of these stands amounted to 12.2, 63.3, and 35.7 pct of the sites' nutrient reserves, respectively. The authors conclude that the black locust-surface mine-fuel plantation trio can be successfully merged only through awareness of the interaction of site, treatments, and establishment methods on the productivity and nutrient dynamics of a given site.

148. Crockett, B. R., and C. J. Beimers. The Reclamation of a Strip Mine To Provide a Recreation Area. Paper in 1981 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Dec. 7-11, 1981). Univ. KY, Lexington, KY, 1981, pp. 511-516.

This article does not discuss revegetation techniques used to reclaim strip-mined areas. However, it describes the study, design, and construction techniques used in reclaiming water-filled strip mine trenches for recreational uses in Missouri. The main emphasis of the paper was to describe the design used to create 1 large lake from 14 smaller ones to develop a multiple-use recreational area. Hydrologic and water quality studies were done to determine the impact of construction on surrounding areas. It was determined that the project had no adverse affects on water quality, land use, or conservation practices in the area.

149. Crofts, K. A., and K. E. Carlson. Transplanting Techniques Used in the Establishment of Native Vegetation. Paper in Proceedings: High-Altitude Revegetation Workshop No. 5, Colorado State University, Fort Collins, CO, Mar. 8-9, 1982. CO Water Resour. Res. Inst., CO State Univ., Fort Collins, CO, Inform. Ser. No. 48, Dec. 1982, pp. 58-78.

The authors present a comparison of various accepted surface mineland revegetation techniques in terms of their economic and operational feasibility. The discussions of various methods are based both on data obtained by the authors and on data reported in the literature by other researchers. Based on a cost analysis drawing on data from 17 studies, the authors found no instance where planting containerized stock rather than bareroot stock was justified. Three mechanized seedling transplanters were compared: (1) the Modified Whitefield Transplanter, (2) the Forestland Transplanter, and (3) the Dryland Plug Planter. Several methods of plant transplanting equipment and methods are compared. The authors contend that transplanting mature vegetation onto disturbed areas will not replace other revegetation methods. However, with time, cost and specific environmental conditions could prove this method to be the most effective. The analyses and discussions contained in this report are primarily pertinent to the Northern Great Plains and Rocky Mountain Coal Mining Regions.

150. Crookston, R. B., and J. H. Merino. Reclamation of Spent Oil Shale. Paper in American Mining Congress, Mining Convention Session Papers, Set No. 3, Environmental Controls I & II (San Francisco, CA, Sept. 11-14, 1977). Am. Min. Congr., Washington, DC, 1977, 31 pp.

This paper reviews the methods that the TOSCO Corp. has developed for the reclamation of processed oil shale. The physical and chemical properties of the spent shale are discussed. The major interest in these studies was to establish the material's engineering properties in relation to embankment stability and water movement through the embankments. Health hazards involved in shale oil production and processed shale exposure are examined. A number of revegetation studies are reviewed. The major problems encountered in establishing vegetation on spent oil shale are low fertility, poor infiltration rate, and high soluble salt content. These problems have been overcome through the application of fertilizer, the addition of topsoil, talus cover, or mulch, and supplemental irrigation to leach soluble salts lower in the profile. The research reviewed in this paper is also pertinent to some aspects of surface coal mine reclamation in the Northern Great Plains and Rocky Mountain Coal Mining Regions.

151. Cross, E. A., and F. C. Gabrielson. Reclamation of Surface Mine Spoil. Univ. AL, School of Mines and Energy Dev., Res. Rep., Sept 1981, 50 pp.

This publication reports ongoing and completed research on revegetation studies on alkaline shale spoil from the Corona Mine in southern Walker County, Al. Results of completed studies are included in this annotation. Greenhouse and field studies to evaluate the effect of Pisolitus tinctorius ectomycorrhizal fungi on the growth and survival of southern red oak (Quercus falcata Michx.) showed that after one growing season the fungi enhanced neither survival or growth. Another experiment evaluated the effects of vegetative cover and fertilization on growth, survival and tip moth damage of loblolly pine (Pinus taeda L.) planted in fields of weeping lovegrass (Eragrostis curvula (Schrad.) Nees)-Kobe lespedeza (Lespedeza striata var. Kobe), common bermudagrass (Cynodon dactylon (L.)Pers.)-Kobe lesedeza-sericea lespedeza (Lespedeza cuneata (Dum.-Cours.)G. Don.), and in unseeded areas containing sparse native vegetation. Fertilization improved all aspects of tree development, but the presence of vegetation retarded development, although tip moth damage was less. Several greenhouse experiments were designed to evaluate the effects of soil materials and amendments on the germination and growth of weeping lovegrass and perennial ryegrass (Lolium perenne L.). NH_4NO_3 treatment inhibited germination and growth of weeping lovegrass, as did acidification of the spoil (pH 7.2) and the addition of coal washings, but superphosphate fertilization yielded the greatest biomass of any treatment. Weeping lovegrass grows best on acid soils whereas perennial ryegrass prefers more basic conditions. However, in combination the grasses grew best and were compatable in a mix of 25 pct spoil and 75 pct topsoil at a combined pH of 4.6. Under this condition the ryegrass did not overpower the lovegrass, as is normally the case.

152. Cross, E. A., F. C. Gabrielson, and D. K. Bradshaw. Some Effects of Vegetative Competition and Fertilizer on Growth, Survival, and Tip Moth Damage in Loblolly Pine Planted on Alkaline Shale Surface Mine Spoil. Paper in 1981 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Dec. 7-11, 1981). Univ. KY, Lexington, KY, 1981, pp. 59-63.

Growth, survival, and tip moth damage of 1/0 loblolly pine seedlings (Pinus taeda L.) were monitored on untopsoiled alkaline shale in Alabama. Different combinations of herbaceous species and fertilizers were used to assess their effects on loblolly pine growth and survival. Tree survival and diameter growth after 2 years were highest on bare spoil compared to those areas with vegetative cover, but tip moth damage to the main leaders of loblolly pine was greatest on bare spoil. It is suggested that when erosion is not a major concern, herbaceous seeding should be delayed for 1 year on areas planted with loblolly pine seedlings in order to increase tree survival and growth.

153. Crowder, A. A., B. E. McLaughlin, G. K. Rutherford, and G. W. van Loon. Site Factors Affecting Semi-Natural Herbaceous Vegetation on Tailings at Copper Cliff, Ontario. Reclam. Reveg. Res., v. 1, No. 2, 1982, pp. 177-193.

This study was conducted to relate the chemical and physical properties of a tailings disposal site to the distribution and elemental content of the herbaceous species growing on the tailings. The location of this study is Copper Cliff, Ontario, Canada. The area had been intermittently seeded from 1958 to 1962 and was maintained by liming and fertilization. Frequency of occurrence and percentage cover values of herbaceous species were obtained from random locations along three transects. Plant and tailings materials were also collected for elemental analysis. Of the species originally seeded, redtop (Agrostis alba L.) and Kentucky bluegrass (Poa pratensis L.) have become dominant on the site, while the remaining original seeded species have become rare. Important colonizing species were ticklegrass (Agrostis scabra Willd.), quackgrass (Agropyron repens (L.) Beauv.) reed canary grass (Phalaris arundinacea L.), and alkali grass (Puccinellia distans (L.) Parl.). Microclimatic data indicated that the tailings area is comparable to old fields of the area. Concentrations of Ca, Mg, K, Mn, and Zn in the tailings were also comparable to values obtained from agricultural soils. However, Cu, Fe, and Ni values were very high in both the tailings and plants. Except for these high contents, the tailings provide a satisfactory growth medium with respect to plant nutrients and microclimate.

154. Cull, C. A., and E. J. DePuit. The Rosebud Mine: A Case Study in Western Reclamation Efforts Through Research. Paper in Surface Coal Mining and Reclamation Symposium, Coal Conference and Expo V (sponsored by Coal Age, Louisville, KY, Oct. 23-25, 1979). McGraw-Hill, 1979, pp. 241-254.

This article discusses past and ongoing research at a surface coal mine site in southeastern Montana. This research and future research needs are discussed in the general context of State and Federal law, national energy policy, and projected future energy demands. The author stresses three main points: (1) Nationwide demand for coal will increase, (2) in many cases current regulations and minimum performance standards for mining and reclamation are not cost effective, and thus are inflationary and in need of modification in order to reach an equitable compromise between economic concerns and environmental considerations, and (3) there is a continued need for problem-solving-oriented research. This article provides a good historical review of coal production and reclamation research activities in this particular area and offers a view of reclamation and reclamation research activities from the industrial perspective.

155. Cundell, A. M. The Role of Microorganisms in the Revegetation of Strip-Mined Land in the Western United States. J. Range Manage., v. 30, No. 4, 1977, pp. 299-305.

This review discusses the role of microorganisms in the reclamation of spent oil shale wastes in the Piceance Basin of northwestern Colorado and overburden from lignite strip mining in western North Dakota. The revegetation of these areas is limited by low organic matter content, salinity, fine soil texture, lack of nitrogen and phosphorus, and the slow rate of soil formation. Some of these limitations can be alleviated by microbial processes. These processes are responsible for the accretion of soil organic matter, nitrogen fixation, and the modification of adverse soil properties. Strategies to take advantage of microbial activities to encourage plant growth are discussed. These strategies include fertilization, seeding, mulching, inoculating the rhizosphere of perennial grasses with free-living heterotrophic nitrogen-fixing bacteria, and the production of sulfuric acid by sulfur-oxidizing bacteria to lower the pH of the spoil. The author concludes that soil microorganisms have an important role in the reclamation of spoil material, especially in the creation of soil organic matter and the accumulation of sufficient nitrogen for plant growth.

156. Currie, P. O. Revegetation for Flexibility in Future Use and Planned Management of Reclaimed Land. Paper in Symposium on Adequate Reclamation of Mined Land? (Billings, MT, Mar. 26-27, 1980). Soil Conserv. Soc. America and WRCC-21, 1980, pp. 16-1 to 16-12.

The author presents concepts that would take maximum advantage of complementary range by selecting plant species in combinations that could insure forage or hay production throughout the year. The author contends that selection of plant species to be used in reclamation should include introduced species and newly developed hybrids, in addition to native plants. This article is basically a literature review. The concepts presented are useful for choosing species for reestabishing rangeland on surface mined land in the Northern Great Plains and portions of the Rocky Mountain Coal Mining Regions.

157. Curtis, R. L., D. K. Fowler, C. H. Nicholson, and L. F. Adkisson. Breeding Bird Populations on Three Contour Surface Mines Reclaimed Under Differing Intensities and Types of Treatment. Paper in Symposium on Surface Mining and Fish/Wildlife Needs in the Eastern United States (WV Univ., Dec. 1978). U.S. Fish and Wildlife Ser. FWS/OBS-78/81, 1978, pp. 369-375.

The author evaluated the effects of three reclamation techniques on species composition, diversity, and abundance of avifauna found on three contour surface mines located on the eastern edge of the Cumberland Plateau. As the amount of vegetation increased, breeding bird density, diversity, and number of species also increased. The authors suggested that there was a higher degree of habitat diversity on the sites where the vegetation had been present the longest, i.e., the older narrow bench contour mines. This resulted in the recovery of avian species diversity and composition. The authors conclude that biological productivity can be restored to surface-mined areas more rapidly through intensive wildlife oriented reclamation techniques. With a multilayered vegetative structure, avian successional patterns can be increased beyond that which would occur using standard reclamation techniques.

158. Dancer, W. S. Prime Agricultural Land Restoration After Surface Coal Mining in Midwestern USA, Chemical and Nutritional Considerations. Paper in Reclamation: A Multifaced Activity. Proceedings of the Seventh Annual Meeting, Sydney, Nova Scotia, Canada, Aug. 19-Sep. 1, 1982. Can. Land Rec. Assoc., Guelph, Ontario, 1982, pp. 207-222.

Nutritional imbalances in field corn (Zea mays L.) and soybeans (Glycine max (L.) Merr.) grown on newly reclaimed land were indicated by the results of plant leaf analyses and soil tests used in greenhouse and field experiments. This nutrient imbalance is characterized by low concentrations of potassium in plant leaves and by high metal concentrations that can become toxic. Ephemeral phosphorus deficiency symptoms were observed, probably induced by temporarily high levels of soluble aluminum from rapid initial weathering of overburden. Potassium deficiences were eliminated in 3 or 4 years with good fertilizer management. This article is extremely useful for prime farmland reclamation efforts in the Interior Coal Mining Region.

159. Dancer, W. S., and I. J. Jansen. Greenhouse Evaluation of Solum and Substratum Materials in the Southern Illinois Coal Field: I. Forage Crops. J. Environ. Qual., v. 10, No. 3, 1981, pp. 396-400.

The objective of this study was to identify overburden materials that could be used in construction of postmining soils. Four bulk soil samples (one each from the topsoil Ap, claypan B_2, lower B_3, and upper C_1, and IIIC Illinoian glacial till) were taken from an abandoned highwall located on the Captain Mine in southwestern Perry County, IL. The B_3 and C_1 were combined into one sample because both layers were relatively thin. Four different greenhouse experiments were conducted in order to compare the growth of three forage crops (perennial ryegrass (Lolium perenne L.), red clover (Trifolium pratense L.), and sudangrass (Sorghum sundanense (Piper) Stapf)) on the four different materials. Mixtures of subsoil and overburden were also evaluated along with different fertility treatments. The results show that all overburden material responded to lime and fertilizer treatments. Topsoil produced the highest yields, but with additions of nitrogen, phosphorus, potassium, and lime to the other materials, yield differences were not that great. It was also shown that the C_1 materials were superior to the native subsoil and should be considered when constructing postmining soils. The authors conclude that there is evidence that replacement or alteration of the claypan subsoil of southern Illinois would increase crop growth by enhancing the chemical and physical properties. However, field experiments are necessary to support their findings.

160. Daniels, W. L., and D. F. Amos. Chemical Characteristics of Some Southwest Virginia Minesoils. Paper in 1982 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Dec. 5-10, 1982). Univ. KY, Lexington, KY, 1982, pp. 377-380.

This study was conducted to determine the chemical characteristics, using a number of standard techniques, of minesoils located near Norton, VA. The minesoils studied ranged in age from 4 to 20 years and were composed of bedded sandstone, siltstone, and coalbeds of the Wise Formation. The chemical characteristics of interest were organic matter, pH, calcium, magnesium, potassium, phosphorus, sulfur, free iron oxides, exchangeable acidity, total acidity, base saturation, and cation exchange capacity. The effects of coal particle size (1.0-2.0, 0.25-0.5, 0.05-0.10, and <0.05 mm) on the organic matter content, pH, Ca, Mg, K, exchangeable acidity, total acidity, and CEC were also determined. The results indicated that the size of the coal fragments had little effect on the apparent organic matter content. The fine (<0.05 mm) particles were reactive, but only to a limited extent. Since the exchangeable Al was low in the minesoils studied, the acidity in the soil was controlled by such sources as fine coal, organic matter, oxidation of Fe^{++}, and decomposing pyrites. Because of this, soils with low pH's coupled with high base saturation were common. The techniques used to determine total acidity (pH 8.2 $BaCl_2$-TEA) overestimated the acidity in naturally acidic minesoils. This resulted in an overestimate of the effective CEC of these soils when the acidity value was used to determine the CEC. There were also discrepancies between the two methods used to determine extractable P (dilute double-acid and bicarbonate methods). The authors state that great care must be taken in the application of standard soil testing techniques to minesoils and in the interpretation of the results.

161. Daniels, W. L., and D. F. Amos. Mapping, Characterization and Genesis of Mine Soils on a Reclamation Research Area in Wise County, Virginia. Paper in 1981 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Dec. 7-11, 1981). Univ. KY, Lexington, KY, 1981, pp. 261-266.

The objectives of this research were to accurately map and characterize the soil, identify soil-related factors influencing reclamation success, and evaluate rates and processes of soil genesis on spoil materials. Soil characterization was placed in category VII even though characterization was done on areas with vegetation already present. Information on methodologies used to characterize the minesoil is given. It was found that the soil chemical properties are variable from sampling point to sampling point. The mapping legend that was used is based on the Virginia USDA Soil Conservation Service legend. Due to the extreme variability of the soil material, 22 different mapping units were delineated. By the time the soil was 20 years old, deep A horizons and weak cambic B horizons had developed. Approximately half of the soils described had a compacted layer (1.8 g/cm^3) within 70 cm of the surface. These layers limit vegetative growth and soil genesis. The authors conclude that pedogenic horizons do develop on minesoils and should be described by conventional soil taxonomic methods.

162. Daniels, W. L., J. C. Bell, D. F. Amos, and G. D. McCart. First Year Effects of Rock Type and Surface Treatments on Mine Soil Properties and Plant Growth. Paper

in 1983 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Nov. 27-Dec. 2, 1983). Univ. KY, Lexington, KY, 1983, pp. 275-282.

This study evaluated the effects of rock type and surface treatments of topsoil, sawdust, and sewage sludge on the revegetation of southwestern Virginia coal mines. The rock mixes evaluated were pure sandstone (SS), pure siltstone (SiS), 2:1 SS:SiS, 1:1 SS:SiS, and 1:2 SS:SiS. For the establishment and production of Ky-31 tall fescue (Festuca arundinacea Schreb.) a mixture that is >1:1 SS:SiS appears to be superior. Fescue establishment and growth were inhibited by high-siltstone spoils. Inhibition was due to rockiness, low water holding capacity, high pH, and the soluble salts present in the siltstone strata. The surface treatment experiments were constructed using a 2:1 SS:SiS mix, and the following treatments were used: (1) a fertilized control (120 kg/ha 15-30-15), (2) a topsoil plus lime (7.8 mg/ha) plus fertilizer (1,120 kg/ha 15-30-15), (3) sawdust (112 mg/ha) plus fertilizer (1,120 kg/ha 15-30-15 and 336 kg/ha slow release N), (4) sewage sludge (22.4 mg/ha), (5) sewage sludge (56 mg/ha), (6) sewage sluge (112 mg/ha), and (7) sewage sludge (224 mg/ha). Fescue yield was found to be the same on control, topsoiled, and limed plots. Plots receiving 56 mg/ha sewage sludge or greater outyielded all other surface treatments and were the only plots with sufficient phosphorus. Sewage sludge was also superior to sawdust as an organic amendment because the plots receiving sawdust were deficient in nitrogen due to nitrogen immobilization. The authors conclude that careful overburden selection and placement, along with the proper surface treatment, can create a hard-rock-derived mine soil that is superior to locally occurring natural soils.

163. Danielson, R. M., J. Zak, and D. Parkinson. Plant Growth and Mycorrhizal Development in Amended Coal Spoil Material. Paper in Ecology and Coal Resource Development, Volume 2 (based on the Int. Congr. for Energy and the Ecosystem, Univ. ND, Grand Forks, ND, June 12-16, 1978). Pergamon, 1979, pp. 912-919.

The purpose of this study was to evaluate the effects of inorganic and organic amendments of coal mine spoil on the growth of a variety of plants and the development of endomycorrhizae and ectomycorrhizae on these plants. Plant species used in this study included white spruce (Picea glauca (Moench) Voss), willow (Salx glauca L.), slender wheatgrass (Agropyron trachycaulum (Link) Malte.) and alsike clover (Trifolium hybridum L.). The treatments tested included none; a 14-cm layer of fibrous peat; mineral fertilizer equivalent to 113 kg/ha N, 113 kg/ha P_2O_5, and 91 kg/ha K_2O; and anaerobically digested liquid sewage sludge applied at a rate of 243 l/m^2. Application of mineral fertilizer or sewage sludge resulted in substantial first-year growth response for willow, slender wheatgrass, and alsike clover. Ectomycorrhizae were absent on spruce in the sewage-treated spoil. Sewage sludge adversely affected the rate of endomycorrhizal infection in both slender wheatgrass and alsike clover. For both plant species fertilizer produced the largest lengths of roots containing vesicles of endomycorrhizae. This article is a good reference for individuals interested in ecological aspects of surface mineland revegetation. This research was conducted in Canada; however, the results and/or the methods described could find application throughout the United States.

164. D'Antuono, J. R. Some Aspects of Natural Vegetation Establishment on Abandoned Underground Coal Mine Refuse Areas in Illinois. IL Inst. Nat. Res. Doc. 79/18, June 1979, 84 pp.

The author reports the results of a study designed to characterize abandoned underground coal mine refuse disposal sites in Illinois. These sites were categorized as (1) well vegetated or (2) sparsely vegetated and/or barren. The revegetation occurring at both types of sites was the result of natural processes. The sites were characterized, and selected physical and chemical parameters of the spoil material were related to the occurrence of vegetation. Feasible reclamation procedures or alternatives to classical reclamation practices were evaluated. This publication offers an excellent review of the pertinent literature and extensive vegetation, soil characterization, and statistical data that could be of use for comparisons and in planning revegetation programs.

165. Darby, S. P. A Look at Trees and Reclamation in Georgia. Paper in Trees for Reclamation (Lexington, KY, Oct. 27-29, 1980). U.S. For. Ser., Gen. Tech. Rep. NE-61, 1980, pp. 11-14.

Two loblolly pine (Pinus taeda L.) plantations, established by two different companies were compared in order to assess the silvicultural techniques used to establish the plantations and the reclamation requirements when rehabilitating mine lands in Georgia. The techniques used to establish the plantations were different. For example, vegetative ground cover was established prior to planting by company B, but not A; subsoiling was used by company B, but not A; fertilization was used by company B at planting, but not A. After 11 years the average diameter at breast height (Dbh) and height for plantation A were 6 in and 31 ft, respectively. After 8 years the average Dbh and height for plantation B were 5 in and 28 ft, respectively. These comparisons raised several important issues that, if resolved, could result in increased tree planting and lower land reclamation costs.

166. Darling, A. P., and S. A. Young. The Effects of Native Hay Mulch on Soil Stabilization and Introduction of Native Species on Strip Mined Lands in Southeastern Montana. Paper in the Third Biennial Symposium on Surface Coal Mining and Reclamation on the Great Plains (cochaired by the Rec. Res. Unit, MT State Univ. and U.S. OSM, Billings, MT, Mar. 19-21, 1984). MT State Univ. and U.S. OSM, 1984, pp. 296-306.

This paper describes a study conducted on direct haul topsoiled mine spoils near Colstrip, MT, to evaluate the use of native hay mulch for soil stabilization and establishment of native species on coal strip-mined lands. A factorial combination of two variables was tested: mulching using native hay and wheat straw, and seeding with a native seed mix. Soil erosion and vegetation density, cover, and biomass were evaluated. Native hay was found to be at least as effective as wheat straw in reducing erosion, and, depending upon its seed content, perhaps more effective. Native hay mulch may be used to successfully introduce needle grass (Stipa comata Trin. & Rupr.) It was shown that, compared to nonmulched sites, both straw and native hay mulch can improve plant community diversity, evenness, and floristic richness by introducing additional species. Undesirable species introduced by native hay may limit the growth of seeded species. Consequently, it is recommended that hay free from seeds of aggressive weedy species should be used to optimize the establishment of desirable species. The results of this study are applicable to revegetation efforts on reclaimed mineland throughout the Northern Great Plains and the Rocky Mountain Coal Mining Regions.

167. Davidson, W. H. Hybrid Poplar Cutting Production and Plantation Establishment. U.S. For. Ser. State and Private Forestry, NE Area, NA-FB/M-6, Rectec, No. 3, 1981, 2 pp.

The author discusses the establishment of hybrid poplar (Populus spp.) on surface mined land in the Eastern United States. Information is presented on site preparation, soil amendments, establishment procedures and spacing of hybrid poplar plantings, and maintenance of the stand. The author states that after 8 to 10 years the entire plantation shall be ready for firewood or pulpwood cuttings with trees having a Dbh ranging from 6 to 8 in. An alternative to complete harvesting would be to leave approximately 100 trees per acre for saw log production.

168. Davidson, W. H. Hybrid Poplar Pulpwood and Lumber From a Reclaimed Strip-Mine. U.S. For. Ser. Res. Note NE-282, 1979, 2 pp.

The author presents the yields obtained from a 2-acre hybrid poplar (Populus spp.) plantation harvested at the age of 16 years. Initially the site had been planted with a mixture of hybrid poplar, white spruce (Picea glauca (Moench) Voss), and Scotch pine (Pinus sylvestris L.). However, the hybrid poplar overtopped the slower growing conifers, resulting in a hybrid poplar plantation with a conifer understory. The commercial clearcut of the 2-acre hybrid poplar plantation resulted in a yield of 90 tons of pulpwood and 9,400 board feet of lumber. Cord volume was not determined but was estimated to be 33 cords per acre. This equals a growth rate of approximately 2 cords per acre per year. A table is presented which compares selected physical properties of hybrid poplar with those of other commercial eastern species. The author states that the harvest of commercial ical size pulp and saw logs from a reclaimed strip-mine site indicates that previously mined lands can be returned to a productive use.

169. Davidson, W. H. Performance of Ponderosa Pine on Bituminous Mine Spoils in Pennsylvania. U.S. For. Ser. Res. Paper NE-358, 1977, 6 pp.

The author discusses the results of a 6 year field trial for the feasibility of establishing ponderosa pine (Pinus ponderosa Dougl ex P. & C. Laws) on bituminous mine spoils in Pennsylvania. Seedlings from numerous ponderosa pine provinces were used. The author concludes that selected sources of ponderosa pine can be planted on bituminous strip-mine spoils in Pennsylvania.

170. Davidson, W. H. Results of Tree and Shrub Plantings on Low pH Strip-Mine Banks. U.S. For. Ser. Res. Note NE-285, 1979, 5 pp.

The author presents the 11-year results of a study conducted to evaluate the survival and growth of 16 species of trees and shrubs established on 10 acid strip mines in the bituminous region of Pennsylvania. Species used in the evaluation included five species of European alder (Alnus spp.), four birch species (Betula spp.), black locust (Robinia pseudoacacia L.), sycamore (Platanus occidentalis L.), Scotch pine (Pinus sylvestris L.), autumn olive (Elaeagnus umbellata Thunb.), sawtooth oak (Quercus acutissima Carruth.), and Japanese fleeceflower (Polygonum cuspidatum Sieb. & Zucc.). First-year results indicated that mortality was very high; mortality by species ranged from 48 to 94 pct. After 11 years two birches, gray birch (Betula populifolia Marsh.) and European white birch (Betula pendula Roth.), had the highest survival rates and best growth of all the species tested. These species had survival rates of 50 pct or better at 8 of the 10 sites. Other species that performed well on a few of the sites were European alder from a German seed source and Scotch pine. The author recommends that the birch species be used for reforestation of Pennsylvania bituminous spoils when the pH is 3.5 or higher.

171. Davidson, W. H. Rooting Characteristics of Topsoiled Surface Mines. Paper in 1981 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Dec. 7-11, 1981). Univ. KY, Lexington, KY, 1981, pp. 267-270.

Evaluations of five reclaimed surface mines in the bituminous region of Pennsylvania were made to determine the effectiveness of replacing topsoil as a technique to enhance the establishment of herbaceous plants. A total of 390 random sampling points were chosen, and percent ground cover, root penetration, and topsoil depth were examined at each point. Soil samples were also collected in order to determine selected soil chemical properties for each site. The results indicate that herbaceous species can be successfully established on topsoiled surface mines. However, root growth is primarily dependent on topsoil depth. Soil chemical analysis of the sites indicates that there is large variation in soil chemical properties between the five sites.

172. Davidson, W. H. Timber Volumes of Old Pennsylvania Surface Mine Reclamation Plantations. U.S. For. Ser. Res. Note NE-303, 1981, 5 pp.

This study was conducted to evaluate 19 tree plantations established by the Morris Run Coal Mining Co. from 1919 to 1938 in Tioga County, PA. A point-sampling system was used to inventory the planting sites. Measurements and observations were made at each site in order to determine (1) the volume per acre of planted species, (2) volunteer vegetation present, (3) volume per acre of volunteer species, and (4) soil development with each plantation. Of the planted species, jack pine, (Pinus banksiana Lamb.) had the highest volume, 10,567 board feet per acre. Total volume of all planted conifers was 744,000 board feet on the 19 plantations studied. Black cherry (Prunus serotina Ehrh.) was the most common of the volunteer hardwood species. Total volume of hardwood species on the area was 356,000 board feet, with black cherry averaging 1,606 board feet per acre. Examinations of the soil profile in each plantation revealed the development of a litter layer and A and B horizons. This evaluation clearly demonstrates the potential of surface mine spoil as a forest site.

173. Davidson, W. H., and E. A. Sowa. Conifers Growing on Anthracite Minesoils Respond to Fertilization. Paper in 1982 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Dec. 5-10, 1982). Univ. KY, Lexington, KY, 1982, pp. 115-118.

Two separate studies were conducted on Pennsylvania anthracite minesoils to evaluate the growth response of established conifers to slow-release and granular fertilization. In the first study 6 plantations ranging in age from 3 to 8 year were used. At each site, every other tree in a row received one fertilizer tablet per 30 cm of average height. Agriform planting tablets (21 g) were used and had an analysis of 20-15-5. The tablets were placed in a hole 10 to 15 cm deep. Over the 4 years of the study, all fertilized trees showed a positive response to fertilizer tablets except for white spruce (Picea glauca (Moench) Voss). Japanese larch (Larix leptolepis (Sieb. & Zucc.) Gord.) responded the first year while red pine (Pinus resinosa Ait), white pine (Pinus strobus L.), and Austrian pine (Pinus nigra Arnold) did not respond until the second year after treatment. These responses lasted for a 2-year period. By the end of the fourth year there were no significant differences between fertilized and nonfertilized trees except for one site on coal breaker refuse where Austrian pine had a significant growth response to fertilization over the 4 years of the study. In the second study a plantation of Scotch pine (Pinus sylvestris L.) and red pine were treated as follows: (1) 100 kg/ha N and 90 kg/ha P, (2) 100 kg/ha N and 180 kg/ha P, and (3) a control. There were no growth responses to granular fertilization until the third year, and even then the response was short lived. Only red pine responded to both P fertility rates. The authors conclude that the growth rates of most conifers on anthracite minesoils can be increased by fertilization. The fertilizer tablets produced a growth response more quickly than granular fertilizers and the response was longer lasting.

174. Davidson, W. H., and W. G. Vogel. Hybrid Poplar for Reclamation. Paper in Third Annual Conference on Better Reclamation With Trees (cosponsored by AMAX Coal Co., Purdue Univ., South. IL Univ., and Madisonville Comm. Coll., Terre Haute, IN, June 2-3, 1983). Purdue Univ., Lafayette, IN, 1983, pp. 99-109.

This article provides a brief literature review of the use of hybrid poplar (Populus spp.) for minesoil reclamation. Much of the literature and results reviewed in this article are from research conducted by the U.S. Forest Service in the Eastern Coal Mining Region. Included in the article is a list of hybrid poplar clones that have been reported as performing well, their lineage, and the area where research on the clones was conducted. This article provides a good reference for this subject and is pertinent to potential land use considerations and to planning reclamation. The portion of the research reviewed is specific to the Eastern Coal Mining Region. However, with prudent consideration the information may be applicable to much of the Interior Region as well.

175. Dawson, J. O., T. W. Christensen, and R. G. Timmons. Nodulation of Alnus Glutinosa Seeded in Soil From Different Topographic Positions on a Spoil Bank: A Preliminary Report. Paper in 1982 Seminar on Post-Mining Productivity With Trees (Carbondale, IL, Mar. 31-Apr. 2, 1982). South. IL Univ., Carbondale, IL, 1982, pp. 133-137.

European black alder (Alnus glutinosa (L.) Gaertn.) tolerates a wide range of spoil pH's and it fixes nitrogen symbiotically with actinomycetes of the genus Frankia. For these reasons, it is widely planted on minespoils in the Eastern United States. This article summarizes the results of a greenhouse study conducted to determine if minesoils taken from different topographic positions on a spoil pile differed in their capacity to infect European black alder. Samples of minesoil were taken from six positions on a south-facing spoil bank in Vermillion County, IL, that had been mined 16 years before sampling. Each sample was put in a separate pot with 175 seeds. After 10 weeks in the greenhouse, counts of live seedlings and nodules on their roots were made. Results showed that mine soils from level terrace positions were much more infective than minesoils from the slope of the spoil bank.

176. Day, A. D., and K. L. Ludeke. Reclamation of Copper Mine Wastes With Shrubs in the Southwestern U.S.A. J. Arid Environ., v. 3, 1980, pp. 107-112.

This article reports the results of a study that examined the effects of desert soil, copper overburden, overburden plus copper mine tailings, and tailings on the germination, seedling establishment and growth of five shrub species. The study was conducted at the Cyprus Pima Mining Company copper mine near Tucson, AZ. A "sidewinder" and a "sheepfoot roller" were used to prepare the seedbed on each soil material. The five shrub species included fourwing saltbush (Atriplex canescens (Pursh.) Nutt.), quailbush (Atriplex lentiformis (Torr.) Wats.), Australian saltbush (Atriplex semibaccata R. Br.), creosotebush (Larrea tridentata (DC.) Cov.), and desertbroom (Baccharis saraothroides Gray). The desert soil was more productive, followed by overburden, overburden plus tailings, and tailings in decreasing order of productivity. Second-year growth produced taller plants, more vegetation, and more ground cover for all species tested. This article specifically addresses revegetation of copper mines in Arizona. However, much of the results and discussion are applicable to surface mineland revegetation throughout a large portion of the Rocky Mountain Coal Mining Region.

177. Day, A. D., and K. L. Ludeke. Stabilization of Copper Mine Wastes in a Semi-Arid Environment With Perennial Grasses. J. Arid Environ., v. 5, No. 7, 1982, pp. 285-290.

This study examines the effects of desert soil, copper mine overburden, overburden plus copper mine tailings, and tailings on the germination, seedling establishment, and growth of six perennial grass species. The study was conducted at the Cyprus Pima Mining Co. mine in Arizona. The six grass species included perennial ryegrass (Lolium perenne L.), crested wheatgrass (Agropyron cristatum (L.) Gaertn.), Lehmann lovegrass (Eragrostis lehmanniana Nees), weeping lovegrass (Eragrostis curvula (Schrad.) Nees), Wilman lovegrass (Eragrostis superba Peyr.), and blue panicgrass (Paniculum antidotale Retz). The desert soil was found to be more productive, followed by overburden, overburden plus tailings, and tailings in decreasing order of productivity. Second-year growth produced taller plants, more vegetation, and more ground cover for all of the species tested. This article specifically addresses revegetation of copper mines in Arizona. However, the results are applicable to surface mineland revegetation through a large portion of the Rocky Mountain Coal Mining Region.

178. Day, A. D., K. L. Ludeke, G. O. Amaugo, and T. C. Tucker. Copper Mine Wastes: Good Potential as Medium for Growing Livestock Forage. Ch. in Engineering

and Mining Journal Operating Handbook of Mineral Surface Mining and Exploration, ed. by R. Hoppe. McGraw-Hill, v. 2, 1978, pp. 128-129.

The purpose of this study was to compare the growth and the fiber, protein, and amino acid contents of barley forage (Hordeum vuglare L.) grown on soil materials in copper mine wastes in Arizona. The four soil materials used were tailings, tailings-overburden, overburden, and desert soil. The results presented in this paper are qualitative; no quantitative data are given. The greatest height growth and largest amount of tillers permit area for barley forage was obtained on the desert soil, followed by overburden, overburden-tailings, and pure tailings. The fiber content and protein content of barley forage was similar for the desert, overburden, and tailings material. However, a mixture of tailings and overburden had less fiber and more protein. This indicates a higher nutritional value for livestock feed on a mixture of tailings and overburden than on the other three soil materials. There are also differences in the amounts of certain amino acids present in the plant material grown on the four soil materials. These differences in amino acid concentration may be explained by the differences in the availability of nutrients to barley plants from the soil materials studied. The authors conclude that with improved cultural practices barley forage grown on copper mine wastes may produce high yields of quality forage for livestock feed.

179. Day, A. D., T. C. Tucker , and J. L. Thames. Response of Plant Species to Coal-Mine Soils Materials. Miner. Environ., Mar. 1983, pp. 10-14.

The growth and establishment of seven plant species in undisturbed soil and coal mine soil (spoil) was investigated in this 2-yr study conducted on the Black Mesa coal mine near Kayenta, AZ. Natural rainfall (20 cm/yr) and rainfall plus sprinkler irrigation (50 cm/yr) were the irrigation treatments applied to each soil material. Better plant growth was obtained on undisturbed soil. Supplemental irrigation resulted in improved plant growth on both soil materials. When supplemental irrigation was applied, effective ground cover was produced on both soil materials with Alfalfa (Medicago sativa L.) and all of the native grasses used, except Indian ricegrass (Oryzopsis hymenoides (Roem & Schult.) Ricker). During the first year of growth, fourwing saltbush (Atriplex canescens (Pursh.) Nutt.) had low germination, seedling establishment, and stem production. During the second year of growth this species produced a dense ground cover on coal mine soil when supplemental irrigation water was applied. Harlan II barley (Hordeum vulgare L.) and Super X wheat (Triticum aestivum L.) were used to provide initial protective cover until the perennial species could be permanently established. The results of this study indicate that supplemental irrigation is essential during seedling establishment for effective revegetation of coalmine soils in a semiarid environment. The results of this study may also be applicable to portions of the Northern Great Plains and Pacific Coal Mining Regions.

180. Day, A. D., T. C. Tucker, and J. L. Thames. Russian Thistle for Soil Mulch in Coal Mine Reclamation. Reclam. Rev., v. 2, No. 1, 1979, pp. 39-42.

Two greenhouse experiments were conducted to compare Russian thistle mulch (Salsola kali L. var. tenuifolia Tausch.) with barley (Hordeum vulgare L.) straw mulch in reducing soil-moisture loss from a coal mine spoil and two unmined soils. The coal mine spoil material was collected from the Black Mesa coal mine near Kayenta, AZ. Each of the soils was observed using the Russian thistle mulch, barley straw mulch, or no mulch. Mulches were mixed with the soil at a ratio of two parts soil to one part mulch. The two greenhouse environments utilized in this study were (1) 27° C and 5 pct relative humidity, and (2) 21° C and 75 pct relative humidity. Soil moisture loss was calculated as a percentage of the initial 50 ml of water added to the soil. Barley straw and Russian thistle mulches significantly reduced soil moisture loss from soil materials studied in both environments. Soil moisture loss was lower in environment 2 than environment 1 for all soils, but the moisture loss patterns were similar in both environments. The authors concluded that Russian thistle is as effective as barley straw as a soil mulch, in reducing soil moisture loss from the three soils studied.

181. DeBuys, W. E. Jr., and R. W. Doughty. Future Landscapes of the Colorado Plateau: Impacts of Energy Development. Univ. TX Center for Energy Studies (Austin, TX), Policy Study No. 19, July 1982, 122 pp.

This publication is a good general treatment of the changes taking place in the "Four Corners" area of the Colorado Plateau, comprised of the adjoining areas of Arizona, Utah, Colorado and New Mexico. Included are discussions of energy future, reclamation, wildlife, water, air quality, human environment and landscaping. The two chapters on reclamation and wildlife are covered here. Although no details are given, chapter 3 is a good general treatment of reclamation regulations and problems associated with revegetation of the "Four Corners" area. The site-specific nature of each mine is discussed as well as reference areas, climatic conditions, species success, and establishment procedures. Reclamation is described as "the return of the biotic community to a stable, productive state that does not require continued maintenance by human beings." The Surface Mining Control and Reclamation Act further specifies that reclaimed lands should be compatible aesthetically with surrounding lands while posing no threat to the stability and productivity of the environment. In chapter 4 the authors point out that, in some cases, revegetation of some areas may increase the ability of the land to support native wildlife, although the return of wildlife to its former level is likely to take many decades.

182. Demchak, K., R. D. Morse, D. D. Wolf, and J. L. Neal. Phosphorus Availability of Minesoils as Influenced by Phosphorus and Lime Rates and Organic Residues. Paper in 1983 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Nov. 27-Dec. 2, 1983). Univ. KY, Lexington, KY, 1983, pp. 423-429.

Red clover (Trifolium pratense L.) and tall fescue (Festuca arundinacea Schreb.) were established on a surface mine site in Wise County, VA, to evaluate the long-term effects of different rates of applied fertilizer and lime and various sources of incorporated organic residues on plant growth, tissue P content, and extractable soil P. Phosphorus fertilization rates were determined by the isotherm method, and the amounts needed to establish the mine soil solution P levels at 0, 0.025, 0.05, 0.1, and 0.2 ppm were applied. The organic amendments used were high lime and wood fines (passed through a 0.6-cm mesh), lime and papermill sludge, and lime and composted sewage sludge. Based on 1 year of data, improvements in P availability can be acheived by adding lime with either sewage sludge or phosphate fertilizer. However, lime alone did not significantly increase yields. Adding P without lime also failed to maximize yields even though yields increased as the soil solution P content was increased. The optimum initial soil solution P level for red clover and tall fescue was between 0 and 0.025 ppm. Sewage sludge produced excellent first-year yields, even without supplemental P. Sewage sludge could be an excellent amendment for improving the long-term availability of P on minesoils if mineralization keeps pace with P demands. The potential for papermill sludge and wood fines to directly supply P is not sufficient to maintain adequate growth on minesoils. Across all treatments, the total yield obtained was highly correlated with tissue P concentrations. Of the soil tests that were compared (Bray I, sodium bicarbonate, and dilute double acid) for extractable P, the sodium bicarbonate test had the highest correlation with yield and tissue P concentration across all treatments.

183. DePuit, E. J. Potential Topsoiling Strategies for Enhancement of Vegetation Diversity on Mined Lands. Paper in the Third Biennial Symposium on Surface Coal Mining and Reclamation on the Great Plains (cochaired by the Reclam. Res. Unit, MT

State Univ. and U.S. OSM, Billings, MT, Mar. 19-21, 1984). MT State Univ. and U.S. OSM, 1984, pp. 258-272.

The author discusses topsoiling strategies that have either proven or have potential utility for enhancement of vegetation diversity on mined lands. Both intraplant and interplant community diversity is addressed. The discussion is based on a review of available literature and conjecture by the author. Specific practices and principles discussed include direct place topsoiling, supplemental top-dressing, multiple lift topsoiling, topsoil management, topsoil depth, and selective soil handling. This paper is an excellent reference on this topic. The discussion tends to be specific for the Northern Great Plains Coal Mining region; however, the concepts should be applicable throughout much of the Western United States.

184. DePuit, E. J. Recent Progress in Mined Land Revegetation Research in Montana. Paper in Symposium on Adequate Reclamation of Mined Land? (Billings, MT, Mar. 26-27, 1980). Soil Con. Soc. America and WRCC-21, 1980, pp. 19-1 to 19-23.

The author presents a brief description of the history and scope of past mined land revegetation research in Montana, summarizes recent and current revegetation research being conducted in Montana, and presents a bibliography of coal mined land revegetation studies produced by Montana-based research. Results and/or conclusions from recent or current research specific to native species establishment, irrigation, fertilization, and grazing managment are presented and discussed.

185. DePuit, E. J., and J. G. Coenenberg. Methods for Establishment of Native Plant Communities on Topsoiled Coal Stripmine Spoils in the Northern Great Plains. Reclam. Rev., v. 2, No. 2, 1979, pp. 75-87.

This study evaluated seeding method (drill versus broadcast), number of species in a seeded mix, and rate of seeding on a topsoiled coal stripmine near Colstrip in southeastern Montana. Broadcast seeding was found to be superior in terms of productivity, stand composition, and diversity if the seeding rates were twice that of drill seeding. If equal seeding rates were used, drill seeding was superior to broadcast seeding in terms of perennial grass productivity. However, broadcast seeding at equal rates with drill seeding still resulted in a higher stand diversity and development of smaller seeded species. By increasing the numbers of species in a seed mix, community diversity increased without having a detrimental effect on productivity. This indicates the value that a broad seeding mixture has on both diversity and productivity. Heavy seeding rates (42, 56, and 84 kg/ha, PLS) were evaluated and generally yielded good stands of vegetation in terms of productivity, native species dominance, and diversity. However, above 56 kg/ha there was a reduction in perennial grass productivity. Stand diversity also declined when seeding rates were increased. It may be necessary, however, to use the higher seeding rates to ensure rapid vegetative stabilization on semiarid mined lands.

186. DePuit, E. J., J. G. Coenenberg, and W. H. Willmuth. Research on Revegetation of Surface Mined Lands at Colstrip, Montana: Progress Report, 1975-1977. MT Agr. Exp. Sta. MT State Univ., Bozeman, MT, Res. Rep. 127, Aug. 1978, 165 pp.

This report describes progress on a number of revegetation research projects conducted by the Montana Agricultural Experiment Station at the Western Energy Co. Rosebud Mine at Colstrip, MT, from 1975 to 1977. The major phase of reclamation addressed by this report is the revegetation of mine spoils. The results of each study are presented, with particular emphasis on the amounts of fertilizer applied, the species and seeding rates used, and the resulting cover and biomass produced.

187. DePuit, E. J., C. L. Skilbred, and J. G. Coenenberg. Effects of Two Years of Irrigation on Revegetation of Coal Surface-Mined Land in Southeastern Montana. J. Range Manag., v. 35, No. 1, 1982, pp. 67-74.

This report summarizes the data obtained on the responses of seeded vegetation to 2 years of summer irrigation on a topsoiled sodic site at the West Decker coal mine in southeastern Montana. A sprinkler irrigation system was used for the application of supplemental water. The objectives of this study were (1) to evaluate the effects of supplemental irrigation on vegetation establishment, structure, composition, diversity, and productivity, and (2) to define the effects of irrigation on root biomass and distribution. One year of supplemental irrigation significantly stimulated the productivity of seeded perennial grasses, increased warm-season perennial grass development, and increased stand diversity. Species that were significantly stimulated by 1 year of irrigation were thickspike wheatgrass (Agropyron dasystachyum (Hook.) Scribn.), slender wheatgrass (Agropyron trachycaulum (Link) Malte.), smooth bromegrass (Bromus inermis Leyss.), and blue grama (Bouteloua gracilis (H.B.K.) Lag.). Total stand productivity after 1 year was similar for irrigated and nonirrigated plots; the first year was characterized by above-average precipitation. First-year irrigation also decreased the productivity of annual weed species. The second year of irrigation, a drier year, resulted in a total irrigated stand productivity that was three times higher than that of nonirrigated plots. Plant species stimulated by 2 years of irrigation were all cool season species and included slender wheatgrass, western wheatgrass (Agropyron smithii Rydb.), smooth bromegrass, and yellow sweetclover (Melilotus officinalis (L.) Lam.). The growth of warm season species was retarded by 2 years of irrigation, with more shallow root systems and lower belowground to aboveground biomass ratios than for nonirrigated areas. Total root biomass was significantly higher in nonirrigated plots than in irrigated plots.

188. Derby, G. K., and R. D. Perry. Economic Considerations of Reclaiming Abandoned Tailings Ponds and Dams. Paper in Conference on the Economics of Mined-Land Reclamation (Chicago, IL, Sept. 1, 1981). NTIS, PC A12/MF A01, 1981, pp. 243-257.

The authors discuss methodologies that can be used to develop reclamation plans specific to an abandoned or inactive mine tailings deposit. Two representative case studies, one from the Southwestern United States and the other from the Northwestern United States, are included as examples. For each example, semidetailed reclamation plans were developed and contain information on methods, procedures, and cost estimates to reclaim each site. The authors feel that a basic reclamation plan cannot be developed to cover all the circumstances involved in reclamation costs and that reclamation requirements are site specific and engineering studies and comprehensive plans should be developed on an individual basis.

189. Deuth, M. J. Comparative Reclamation Practices of Surface Coal Mines in Wyoming and Texas. Bull. Assoc. Eng. Geol., v. 15, No. 2, Spring 1978, pp. 231-251.

The reclamation schemes of three mines are described in this article. The Big Brown-Fairfield lignite mine in eastern Texas and the Dave Johnston and Big Horn Mines in Wyoming's Powder River Basin are compared, and differences in reclaiming them are noted. Brief descriptions of State reclamation laws and methods of revegetating mined areas are given.

190. Dewar, S. W., and E. R. Berglund. First-Year Survival and Growth of Willow and Poplar Cuttings on Taconite Tailings in Minnesota. Paper in 1983 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Nov. 27-Dec. 2, 1983). Univ. KY, Lexington, KY, 1983, pp. 141-147.

This study evaluated the effectiveness of crack willow (Salix fragilis L.) and balsam poplar (Populus balsamifera L.) cuttings for afforestation of a taconite tailings basin near Keewatin, MN. Survival and growth responses were measured according to tailing texture and fertilization treatments. The fertilizer treatments used were (1) a control--no fertilizer, (2) surface application of 150 lb/acre of 46-0-0 and 150 lb/acre of 0-46-0, and (3) a roto-tilled-fertilizer treatment using the same fertilizer application rate as in (2). The overall survival of crack willow (94 pct) was not significantly affected by either texture or fertilization treatments. However, average growth of crack willow was significantly greater on roto-tilled fertilized and surface fertilized plots than on control plots. The overall survival of balsam poplar (30 pct) was significantly lower than that of crack willow. Growth of balsam poplar was significantly affected by texture; as the tailings material became coarser, the average growth decreased. Fertilization was found to have no effect on the growth of balsam poplar. The results of this study indicate that crack willow cuttings have a higher survival and higher growth response to fertilization and are more promising than balsam poplar for establishing woody vegetation on taconite tailings.

191. Dickson, K. L., and D. Vance. Revegetating Surface Mined Lands for Wildlife in Texas and Oklahoma (U.S. FWS contract FWS 14-16-009-80-045, Inst. Appl. Sci. and Dep. of Biol. Sci., N. TX State Univ.). U.S. Fish and Wildlife Ser., FWS/OBS081/25, Aug. 1981, 120 pp.

This publication is designed as a guide for reclaiming surface-coal-mined lands in Texas and Oklahoma. Guidance is provided for the development and implementation of revegetation plans that will create a diversity of habitats capable of attracting and supporting wildlife. Possible considerations of wildlife habitat where agricultural production is the primary goal in postmining land use are also presented. Excellent vegetation information, including planting spacing, planting dates, adaptability, wildlife value, and seed or plant stock sources, is provided for numerous species. The publication is primarily aimed at surface mineland reclamation in the southwestern portion of the Interior and the western portion of the Gulf Coast Coal Mining Regions.

192. Dittberner, P. L., and G. Bryant. The Use of the Plant Information Network (PIN) In High Altitude Revegetation. Paper in Ecology and Coal Resource Development, v. 2 (based on the Int. Congr. for Energy and the Ecosystem, Univ. ND, Grand Forks, ND, June 12-16, 1978). Pergamon, 1979, pp. 1022-1034.

This paper describes the Plant Information Network (PIN), which is a computer-based data bank for rapid retrieval and organization of information on the native and naturalized vascular plants in Colorado, Montana, and Wyoming. The paper provides some historical background for the development of PIN, describes specific features of the program, and explains, through example, how to access vegetation information through the program. This paper will be of interest to those working in planning revegetation activities in portions of the Northern Great Plains and Rocky Mountain Coal Mining Regions.

193. Dixon, J. B., H. S. Arora, F. M. Hons, P. E. Askenasy, and L. R. Hossner. Chemical, Physical, and Mineralogical Properties of Soils, Mine Spoil, and Overburden Associated with Lignite Mining. Ch. 2 in Reclamation of Surface-Mined Lignite Spoil in Texas, ed. by L. R. Hossner. TX A & M Univ. Syst., Rep. RM-10, 1980, pp. 12-21.

The authors briefly summarize the physical and chemical properties of unmined soils, mine spoil, and selected overburden strata from Freestone and Milam Counties, TX. Mine spoil has a more favorable texture than unmined soils, although it does form crusts which can reduce seedling emergence and oxygen diffusion. The spoil is deficient in nitrogen, phosphorus, and organic matter, all of which can be corrected with proper fertilization. This is a good article on soils properties of the Texas lignite mining areas.

194. Dixon, R. M. Land Imprinting Activities. Paper in Vegetative Rehabilitation and Equipment Workshop, 36th Annual Report (Denver, CO, Feb. 4-5, 1982). U.S. For. Serv. Equipment Devel. Cent., Missoula, MT, 1982, 20 pp.

This general article discusses the positive effects that land imprinting has on rainwater infiltration and funneling. For example, rainwater infiltration can be controlled by manipulating surface macroporosity and microroughness. The standard design of the new box-type land imprinter is also given.

195. Doerr, T. B., and E. F. Redente. Seeded Plant Community Changes on Intensively Disturbed Soils as Affected by Cultural Practices. Reclam. Reveg. Res., v. 2, No. 1, 1983, pp. 13-24.

This study examined the effects of irrigation, fertilization, seed mixture, seeding method, and interactions on successional trends of seeded grass and forb species on intensively disturbed sites near Rifle, CO. The site was disturbed by removing, mixing, and replacing the A, B, and C soil horizons. Initially, fertilization and irrigation increased grass production, but after 4 years there was no increase in aboveground production due to either treatment. Irrigation favored forb production during the first 2 years, but fertilization reduced forb biomass during the entire time the study was conducted. The aboveground biomass of native and introduced species were significantly different for only 1 year. After that time little difference in biomass production was found. However, forb production was found to be greatest when introduced species were used. Alfalfa (*Medicago sativa* L.) was the species that contributed the most to the difference found between introduced and native forbs. Aboveground biomass of the grass species was not significantly affected by seeding method (drill versus broadcast). Forb biomass was generally greater on broadcast-seeded plots when compared to drill-seeded plots. The conclusions drawn by the authors were (1) depending on land use and importance of soil stabilization, irrigation and fertilization may or may not be useful methods for vegetation establishment, (2) there are no apparent reasons for not using adapted introduced species for revegetation at appropriate rates, and (3) broadcastseeding was as effective in establishing diverse and productive stands as drill seeding.

196. Doll, E. C., N. C. Wollenhaupt, G. A. Halvorson, and S. A. Schroeder. Planning and Evaluating Cropland Reclamation After Stripmining in North Dakota. Paper in the Third Biennial Symposium on Surface Coal Mining and Reclamation on the Great Plains (cochaired by the Reclam. Res. Unit, MT State Univ. and U.S. OSM, Billings, MT, Mar. 19-21, 1984). MT State Univ. and U.S. OSM, 1984, pp. 88-101.

The authors offer an excellent review of pertinent literature and personal experience related to planning and evaluating cropland reclamation following stripmining in North Dakota. The authors stress that reclamation planning based upon duplication of premine conditions is not always the most efficient and cost-effective way to utilize the available soil and overburden materials. The topics discussed in the paper include the importance of topography, soil and overburden characterization, premine land use, soil replacement, and prime soil reclamation and its evaluation. While it was written with specific reference to North Dakota, many of the concepts conveyed may be relevant to reclamation of prime farmland in other coal mining areas as well.

197. Dollhopf, D. J., and E. J. DePuit. Chemical Amendment and Irrigation Effects on Sodium Migration and Vegetation Characteristics in Sodic Mine Soils in the Northern Great Plains. Paper in 1981 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Dec. 7-11, 1981). Univ. KY, Lexington, KY, 1981, pp. 481-485.

The purpose of this article was to determine the causes of topsoil sodication in Montana and to develop methods that would reduce sodication in order to establish diverse vegetation for grazing purposes. Spoil physical properties such as particle size distribution, clay mineralogy, and soil water movement will govern whether or not sodium will migrate from the spoil to the topsoil. In this study chemical amendments had no effect on plant growth or soil chemistry. Irrigation increased the aboveground biomass of planted grasses and legumes and reduced the annual weed production. Root biomass was decreased in irrigated plots. The key to grazingland productivity in the Northern Great Plains is the construction of minesoils so that they have suitable physical characteristics.

198. Dollhopf, D. J., C. J. Levine, and B. J. Bauman. Reclamation Advances in Selective Placement of Overburden. Paper in Symposium on Adequate Reclamation of Mined Land? (Billings, MT , Mar. 26-27, 1980). Soil Cons. Soc. America and WRCC-21, 1980, pp. 15-1 to 15-16.

This paper reports the results of a study conducted near Colstrip, MT, to examine the extent and effects of overburden material mining during the spoiling process and to evaluate the feasibility of two methods of selective placement of toxic overburden material. Selective handling of a saline overburden zone followed either of two treatments: (1) segregation and burial or (2) segregation, burial, and covering with a relatively water-impermeable clay cap. The tests found that these treatments were technically feasible with a minimum of operational delays. However, costs of these methods were about 1.1 to 1.5 times the normal operational costs. Of particular significance was that a borehole sampling pattern approaching a 30- to 60-m grid was necessary to allow sufficiently accurate delineation of inhibitory overburden materials in order to implement selective overburden handling. The study is specifically pertinent to reclamation efforts in the Northern Great Plains Coal Mining Region. However, it is felt that the concepts presented in this article are applicable to other coal mining regions as well.

199. Dollhopf, D. J., and L. J. Russell. Assessment of Acid Producing Materials in the Northern Plains. Paper in the Third Biennial Symposium on Surface Coal Mining and Reclamation on the Great Plains (cochaired by the Reclam. Res. Unit, MT State Univ. and U.S. OSM, Billings, MT, Mar. 19-21, 1984). MT State Univ. and U.S. OSM, 1984, pp. 201-210.

This paper contains a review of the sources of minesoil acid production and evaluates the use of laboratory weathering methods as an alternative for lime requirement determination. The authors primarily examine minesoil acid production in the Northern Great Plains, where the coal overburden and hard rock mine waste material tend to contain mostly unoxidized sulfur in the organic form, rather than as sulfides. Stoichiometrical analysis of these complex sulfur-containing compounds is discussed. This paper is relevant to planning reclamation activities on these materials throughout the Northern Great Plains and portions of the Rocky Mountain Coal Mining Region.

200. Drake, L. D. Recommendations for Rural Abandoned Mine Program in Iowa, USA. Miner. Environ., Mar. 1983, pp. 15-19.

Observations made on a 10-year-old test plot designed with a wedge of loess over acid spoils are related to orphan coal surface mines in Iowa that have been reclaimed under the Federal Rural Abandoned Mine Program (RAMP) by smoothing highly acid spoils, covering with a thin topsoil layer, and planting a cover crop. These observations suggest that acidified throughflow and discharge of shallow soil moisture and groundwater will eventually kill the vegetation in the lower valleys, and erosion will proceed up the valley as a migrating knickpoint on the new RAMP sites. Elimination of this problem is suggested by redirection of the acidified throughflow below the cover material in sand underdrains or tile lines in the main drainages. If adequate flow is available, the discharge could be diluted in a nearby creek or it could be neutralized in a basin paved with limestone riprap. Native prairie grasses, crown-vetch (Coronilla varia L.), and cattails (Typha spp.) were found to be especially well adapted to thin-cover sites. This article was written with specific reference to Iowa but the methods described may have application to other coal mining areas as well.

201. Drake, L. D., and G. T. Ririe. A Low-Cost Method of Reclaiming Strip-Mined Land in Iowa to Agriculture. Environ. Geol., v. 3, 1981, pp. 267-279.

A loess terrace method for reclaiming Mahaska County, IA, strip-mined cropland as mining progresses was designed and tested by the authors. This article provides an excellent analysis of this method of reclaiming strongly acidic spoils. Methodology and yields are clearly presented, as is a logical cost analysis. The article is recommended for review and planning of methods for reclaiming mine spoils that have toxic levels of acidity.

202. Dulle, R. Tree Planting Program of Southwestern Illinois Coal Corporation. Paper in 1982 Seminar on Post-Mining Productivity With Trees (Carbondale, IL, Mar. 31-Apr. 1, 1982). South. IL Univ., Carbondale, IL, 1982, pp. 103-107.

This paper outlines the tree plantings conducted by Southern Illinois Coal Corp. for the years 1978-82. A brief description of each site planted, what species were planted, how the trees were planted, and some survival data are given. Problems encountered in establishing trees are also mentioned.

203. Durham, F., and J. G. Barnum. Mine Reclamation in Arkansas. Paper in Trees for Reclamation (Lexington, KY, Oct. 27-29, 1980). U.S. For. Ser., Gen. Tech. Rep. NE-61, 1980, pp. 9-10.

This article contains general information on surface mine reclamation in Arkansas. The author discusses Arkansas' reclamation law, the extent of mining, and the direction of reclamation research. Currently, there is a need to determine which species are adapted to Arkansas conditions and then produce nursery-grown hardwoods and softwoods for use on Arkansas surface-mined land.

204. Dusek, G. L. Bull Mountains Coal Field Study. Final Report (sponsored by Consolidation Coal Co.). MT Dep. of Fish and Game, July 1978, 128 pp.

This report examines the impact or potential impact of surface mining on wildlife resources in the Bull Mountain area of Montana. Possible innovations or modifications in reclamation processes to avoid unnecessary loss of wildlife habitat are discussed. The report is based on range use, food habits, population trends, hunter harvest trends, vegetational development, and non-game-mammal inventory data collected as part of the study. This report is an excellent reference for reclamation planning. However, the data and discussions contained in the report are specific to the study area.

205. Ebelhar, M. W., R. I. Barnhisel, G. W. Akin, and J. L. Powell. Effect of Lime, N, P, and K Amendments to Surface-Mined Coal Spoils on Yield and Chemical Composition of Common Bermudagrass. Reclam. Reveg. Res., v. 1, No. 4, 1982, pp. 327-336.

This study evaluated common bermudagrass (Cynodon dactylon (L.) Pers.) as an alternative to planting cool-season grasses on acid sandstone surface-mine spoils in Muhlenburg County, KY. The objectives of the study were to evaluate the effects of lime, nitrogen, potassium, and phosphorus amendments on the growth and development of common bermudagrass, and to evaluate the effects of the amendments on the chemistry of acid surface-mine spoils. Lime applications were effective in raising the pH from 3.4 to 4.6, 5.7, and 6.3 for the 18, 36, and 72 t/ha applied, respectively. However, the lime applications may have reduced the availability of soil potassium. Nitrogen additions had the most influence on bermudagrass production. Significant increases in dry matter production were observed with each additional increment of nitrogen (0, 50, and 100 kg/ha). Deficiency symptoms were observed where nitrogen was not applied. Applications of phosphorus and potassium increased the elemental concentration in the bermudagrass but did not cause a significant increase in total dry matter production. However, phosphorus and potassium increased the winter hardiness and survivability of bermudagrass. The authors conclude that bermudagrass offers an alternative to the cool-season grasses now used on reclaimed coal spoils in the humid regions of the Eastern United States. It may serve as a nurse crop to allow the establishment of longer-lived grasses and legumes.

206. Eddleman, L. E. Coal Mine Reclamation With Native Plants. Paper in Symposium on Watershed Management 1980 (Boise, ID, July 21-23, 1980). Am. Soc. Civil Eng., 1980, pp. 80-90.

This paper reports the results of a study to examine the effect of planting season on seedling emergence and establishment. The study was conducted at Western Energy Co.'s Rosebud coal strip mine near Colstrip, MT. Forty-four native plant species were examined including 17 grasses, 16 forbs, and 11 shrubs. Planting dates were early spring, midspring, and fall of 1978 and early spring and midspring of 1979. Eleven species established significant seedling numbers in the dry year of 1979. Five additional species established significant seedling numbers in the dry year when planted the previous fall. The author interpreted the results as indicating that these 16 species possess good potential for establishment in drought years and consequently could be used to stabilize the reclaimed soil under adverse environmental conditions. The results and discussion contained in this paper are pertinent to major portions of the Northern Great Plains and the Rocky Mountain Coal Mining Regions.

207. Eddleman, L. E. Indigenous Plants of Southeastern Montana. I. Viability and Suitability for Reclamation in the Fort Union Basin. MT For. and Conserv. Exp. Sta., Sch. Forestry, Univ. MT, Missoula, MT, Spec. Publ. 4, Nov. 1977, 122 pp.

The major emphasis of this project was to obtain information on seed production, collection, handling, and germination, and on seedling establishment of indigenous plant species of the Fort Union Basin. The overall objective of this research was to acquire information that would improve the probability of success in establishing indigenous species on disturbed sites. The specific objectives of the project were to (1) examine and inventory natural seed maturation and production characteristics of indigenous plant species, (2) determine the best seed collection, handling, and storage methods, (3) determine the physical and chemical requirements that are necessary for breaking seed dormancy, (4) determine seed germination characteristics under controlled environmental conditions, and (5) examine vegetative propagation characteristics. A summary of each of the above characteristics is included in this report on 16 grass, 20 forb, and 7 shrub species. The author states that inclusion of a species in the evaluation does not constitute a recommendation for inclusion in a seed mixture for reclamation purposes. Economic and ecologic criteria must be used to determine whether a species will be useful for reclamation purposes.

208. Eddleman, L. E. Survey of Viability of Indigenous Grasses, Forbs, and Shrubs: Techniques for Initial Acquisition and Treatment for Propagation in Preparation for Future Land Reclamation in the Fort Union Basin (Annual Progress Report, U.S. Ener. and Devel. Admin. contract EY-76-S-06-2232, Task Agreement #2). RLO-2232-T2-3, Feb. 1978, 232 pp.

This report contains information on the collection, cleaning, and germination requirements of 51 species of grasses, forbs, shrubs, trees, and cacti indigenous to the Northern Great Plains. Also included is a summary of species for reclamation and seedling vigor under extreme environmental stresses. A key to the majority of grasses found in southeastern Montana, except introduced agronomic varieties, is given. A bibliography to assist in the location of germination information on plant species indigenous to the Fort Union Basin is included. This information is valuable for determining seed mixtures to use in reclamation, time of year to plant, and if preplanting seed treatments are needed.

209. Eddleman, L. E. Survey of Viability of Indigenous Grasses, Forbs, and Shrubs: Techniques of Initial Acquisition and Treatment for Propagation in Preparation for Future Land Reclamation in the Fort Union Basin. (U.S. DOE contract EY-76-S-06-2232). U.S. DOE, RLO-2232-T2-18, DE 82-018880, Prog. Rep., Feb. 1980, 87 pp.

This publication reports interim results of a study examining the dispersal phenology and germination requirements of numerous species of grasses, forbs, and shrubs indigenous to southeastern Montana. The final report for this study is also listed in this bibliography under the same author. This report has been reviewed and included because it contains extensive germination and seed treatment data for many of the species considered in the study. These data were not specifically presented in the final report. However, they may be of interest and useful in land reclamation activities or research. Since much of the information improves basic knowlege of the species considered, the information will be applicable in other areas of the Western United States as well.

210. Eddleman, L. E. Survey of Viability of Indigenous Grasses, Forbs, and Shrubs: Techniques of Initial Acquisition and Treatment for Propagation in Preparation for Future Land Reclamation in the Fort Union Basin. Final Report (U.S. DOE contract DE-AT06-76EV77002). U.S. DOE, RLO-2232-T2-18, DE 82-018880, June 1982, 29 pp.

This report contains information on the dispersal, phenology, and germination requirements of 151 species of grasses, forbs, and shrubs indigenous to southeastern Montana. A classification scheme based on the germination requirements of these species was devised and subsequently applied to rating each species for inclusion in revegetation procedures. Based on the results of this study, the author reports that less than 50 pct of the common indigenous species will easily and rapidly reestablish on mine spoils. It is reported that the probability of establishment success will be enhanced significantly by selection of those species that rapidly germinate a large percentage of their seed and that produce seedings capable of maintaining growth through short drought periods. Dormancy-breaking requirements are reported for numerous species. This report builds on previous progress reports to provide extremely useful information pertinent to determining seed mixtures for use in reclaiming surface coal mine land in major portions of the Northern Great Plains Coal Mining Region.

211. Eichbaum, W. M., and D. T. Buente. The Land Restoration Provisions of the Surface Mining Control and Reclamation Act: Constitutional Considerations. The Har. Environ. Law Rev., v. 4, No. 2, 1980, pp. 227-259.

This article examines the possible 5th and 10th amendment challenges to the land-capability provisions of the Surface Mining Control and Reclamation Act of 1977 (SMCRA). The analysis presented concludes that the land-capability requirements contained in SMCRA are within the Federal Government's constitutional authority. The authors conclude that lacking effective state regulations and enforcement, protective action taken by the Federal Government to manage natural resources is "necessary and consistent with constitutional principles."

212. Ellis, J. E., and W. J. Parton. Impact of Strip-Mine Reclamation Practices: A Simulation Study (U.S. FWS contract 14-16-0008-2107 and Interagency Agreement EPA-IAG-D6-E685, Natl. Res. Ecol. Lab., CO State Univ.) U.S. Fish and Wildlife Ser. W/Coal-78/W5, Mar. 1977, 329 pp.

A computer simulation model is described that replicates, in a reasonable fashion, the response of a strip-mined site to a variety of reclamation procedures and changes in the environment. The model was developed and tested using soil abiotic and biotic data from undisturbed plant communities around Colstrip, MT. The major components of the model include abiotic, producer, ruminant, decomposer, and sediment production submodels. The flow of water in the system, the temperature profile in the plant canopy and soil, and loss of soil due to wind and water erosion are simulated in the abiotic submodel. The producer submodel simulates the flow of carbon in the plant shoot-root system for a variety of plant species. The biomass dynamics of the microbes, nitrogen cycling in the soil-plant system, and decomposition of litter and dead roots are simulated by the decomposer submodel. The ruminant model simulates the flow of carbon and nitrogen through the grazing animals. The sediment production model is concerned with sediment load in the runoff water. The model was used in computer simulation runs, which showed that the ecosystem studied is extremely responsive to nitrogen. The simulations indicate that nitrogen may be the major factor limiting the rate at which ecosystem processes occur. Topsoil is critical to all other aspects of reclamation as a source of nitrogen and organic matter. The authors stress that the reclamation simulation model presented in their report should be considered preliminary and not directly applicable to regions with climate and soil characteristics different from the Colstrip, MT area for which it was developed. In addition it should also be pointed out that, at the time of their report, the authors had not tested the model with data other than those used to initially develop the model. The program may be exceptionally applicable to reclamation efforts in the Colstrip area and could provide an excellent starting point for reclamation studies and planning in the Northern Great Plains and Rocky Mountain Coal Mining Regions. This report has been rated "excellent" or "good" for numerous keywords used in the evaluation process. This rating system has been applied somewhat differently for this report. Since this report deals with a computer model and not actual field studies, the ratings represent the apparent treatment of these subject areas by the simulation model and the conceptual basis for the model.

213. Emrich, S. L. Methods for Evaluating Diversity. Paper in Symposium on Western Coal Mining Regulatory Issues: Land Use, Revegetation, & Management (West. Reclam. Group, Denver, CO, Apr., 1982). CO State Univ., Range Sci. Dep., Fort Collins, CO, Sci. Ser. No. 35, Aug. 1983, pp. 43-46.

The author examines the concept of establishing a diverse, effective, and permanent vegetative cover and discusses general methods of establishing species diversity. A method for evaluation species diversity that has been proposed by the Colorado Mined Land Division is described. This method is a species composition approach utilizing premine, baseline data. Consequently, it circumvents some of the problems sometimes encountered using the reference area approach. This article could be applied to designing monitoring programs for evaluating reclamation success for much of the Northern Great Plains and Rocky Mountain Coal Mining Regions recognized in this evaluation process.

214. Energy and Mineral Resources Research Institute, Iowa State University. Iowa Coal Project, Report to the Legislature. IA St. Univ., Ames, IA, Rep. IS-ICP-57, July 1977. 18 pp.

This publication provides a brief synopsis of the numerous research studies conducted under a program called the Iowa Coal Project. The major objectives of the project were to demonstrate state-of-the-art economic coal mining, coal processing, and mineland reclamation methods. To that end, a full-scale demonstration mine, beneficiation plant, and reclamation project were instituted. Agricultural row crop production was the targeted postmining land use. The agronomic studies examined the growth of corn (Zea mays L.), soybeans, (Glycime max (L.) Merr.) and tomatoes (Lycopersicum esculentum Mill.) under different tillage systems. The results of these studies indicated that deep tillage of replaced soil is necessary to obtain the greatest possible yields. Tomatoes were used as an indicator crop. No nutrient deficiencies or toxicities were observed. However, compaction increased moisture deficiency during drought periods and restricted rooting. This report, together with earlier and later progress reports, is an excellent reference for reclamation of surface-mined land for agricultural row crop production. Water quality, crop production, and overburden characterization data are contained in the progress reports. The ratings assigned to the keywords in this evaluation reflect the information and discussion contained in the associated progress reports in addition to the publication cited above.

215. Energy Resources Co. Inc. Low-Rank Coal Study, National Needs for Resource Development, Volume 4 - Regulatory, Environmental, and Market Analysis. U.S. DOE contract DOE/FC/10066-TI (v. 4), Nov. 1980, 224 pp.

This document is volume 4 of a six-volume study. The purpose of this portion of the study was to formulate scenarios for low-rank coal development, characterize the resource, evaluate the existing and required technology, review the regulatory requirements and constraints, analyze environmental impacts, and provide a market analysis. The document provides a good review of Federal and state regulations affecting coal mining and mineland reclamation. Factors affecting mineland reclamation are treated in a relatively general manner. The scope of the document is designed for nationwide applications. However, because of the distribution of lignite and subbituminous coal in the United States, the information is primarily relevant to the Northern Great Plains, Rocky Mountain, and Gulf Coast Coal Mining Regions recognized in this evaluation process.

216. Engle, J. A. Reforestation Species Study on a Reclaimed Surface Mine in Western Maryland. Paper in Trees for Reclamation (Lexington, KY, Oct. 27-29, 1980). U.S. For. Ser., Gen. Tech. Rep. NE-61, 1980, pp. 35-36.

This study was conducted to evaluate the survival and height growth of 18 species of trees planted on a reclaimed surface mine in Garrett County, MD. After 2 years height growth ranged from 0.4 to 2.3 ft. American sycamore (Platanus occidentalis L.) had the lowest height growth, while black locust (Robina pseudoacacia L.) had the best height growth. Seven species had survival rates of 75 pct or better, with pitch pine (Pinus rigida Mill.) having the highest survival rate (94 pct). Seven other species had survival rates between 50 and 75 pct. The remaining nine species were classified as having poor survival, less than 50 pct. Some of the poor survival can be attributed to poor seedling stock quality. Most of the survival and height growth problems were caused by the harsh site conditions and competition from herbaceous vegetation.

217. Evangelou, V. P., and R. I. Barnhisel. Revegetation Guide for Surface Mined Land in Kentucky. Univ. KY, (Lexington, KY), Dept. Agronomy AGR-95, 1982, 7 pp.

This guide contains information on selected grasses and legumes used to revegetate surface-mined land in Kentucky. Information is presented on species selection, seed quality, species proportions in a seed mixture, seeding rates, and the time to seed. The species listed in this guide can also be utilized in other locations of the Eastern and Interior Coal Regions.

218. Evangelou, V. P., and R. I. Barnhisel. Sampling Surface Mine Lands Before and After Mining. Univ. KY, (Lexington, KY), Dept. Agronomy AGR-41, Rev. July 1981, 7 pp.

This extension service publication provides an excellent outline for the procedures to be followed in collecting representative soil samples for fertility analysis of natural soil and surface-mined lands. While the specific instructions for submitting a sample for analysis pertain only to the State of Kentucky, the rationale and procedures for collecting samples are considered universal. Consequently the publication is not regionally specific.

219. Evangelou, V. P., and J. H. Grove. Evaluation of Changes in the Chemical Equilibria of Soils/Spoils During Wetting-Drying Cycles Using a Computer Model (REC-1). Paper in 1982 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Dec. 5-10, 1982). Univ. KY, Lexington, KY, 1982, pp. 381-386.

This research was conducted to explain why the solution composition is needed in planning the reclamation of gypsiferous soils and to show how a computer model might be used to answer questions pertinent to the mechanics of reclamation. The solution composition of gypsiferous soils is needed because plant growth will be depressed if soluble salts are too high. The computer model developed (REC-1) used three major factors that control spoil solution composition and concentration. These factors were (1) the thermodynamic solubility product constant of gypsum, (2) selectivity coefficient for Ca-Mg exchange on colloid surfaces, and (3) ion pair stability constants for $CaSO_4$ and $MgSO_4$ monomers. Data from the literature was used to test the model. The model can be used for soils and spoils that have a pH greater than 5, or if the pH is below 5 and the iron and aluminum concentrations in their solution are negligible. This model can be used to (1) predict the actual Ca:Mg ratio of limed coal spoils, (2) predict the sulfate concentration of limed coal spoils, and (3) predict solution compositions at low soil-water ratios between field capacity and permanent wilting point.

220. Evangelou, V. P., L. W. Murdock, and F. J. Coale. Oil Well Salt Brine Contaminated Soils: Their Chemistry and Reclamation. Paper in 1983 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Nov. 27-Dec. 2, 1983). Univ. KY, Lexington, KY, 1983, pp. 443-446.

This study was conducted to determine the sodium threshold contamination points of soil contaminated by brine discharge from oil wells located in McLean County, KY. Soil samples were taken from an agricultural field across a salt gradient and analyzed for extractable Ca, Mg, Na, and K, pH, and electrical conductivity (EC). A greenhouse pot experiment was conducted with the most contaminated sample and amended with four rates of gypsum: 0, 5,114, 12,000, and 25,520 lb/acre. The pots were then continuously leached until the EC of the leachate was below 3 mmho/cm. Three types of problems are generally recognized when soils are contaminated by oil well salt brines: (1) the sodium buildup in the soil solution is toxic to plants, (2) the salt buildup causes high osmotic pressures, and (3) an unbalanced solution is produced which causes soil dispersion due to sodium dominance. This study demonstrates how the degree of sodium contamination can be predicted. If the sodium concentration in a saturation extract exceeds 4 meq/l then a sodium absorption ratio (SAR) should be calculated. If the SAR approaches 10, then the amount of sodium present should be determined in an ammonium acetate extract, and the amount of gypsum needed can be estimated. The greenhouse pot experiments demonstrated that gypsum application and leaching are effective treatments for reclaiming sodium-contaminated soils. Soybeans (Glycine max (L.) Merr.) seeded in the pots grew normally only if gypsum was applied. When no gypsum was applied, high EC's and pH's resulted, when compared to the other treatments, and water did not move through the soil.

221. Evangelou, V. P., and W. O. Thom. Coal Spoil Chemistry Interpretations and the Effect of Spoil Chemical Changes in the Continuity of Nutrient Availability. Paper in Third Annual Conference on Better Reclamation With Trees (cosponsored by AMAX Coal Co., Purdue Univ., South. IL Univ., and Madisonville Comm. Coll., Terre Haute, IN, June 2-3, 1983). Purdue Univ., West Lafayette, IN, 1983, pp. 55-67.

This paper provides a discussion of the physical and chemical factors limiting tree establishment and growth on surface-mined lands and how they may be expected to shift with respect to time. The authors stress that establishment of trees or any other type of vegetation is subject to solution phase chemistry. Problems with vegetation establishment may be due to high salinity levels and/or magnesium dominance of the spoil water system. The results used in the discussion originate from research conducted in southern Ohio and eastern Kentucky. The paper provides a good reference for understanding nutrient availability based on soil solution phase chemistry in the soils of this area. This paper is probably most pertinent to the central portion of the Eastern Coal Mining Region and the east-central portion of the Interior Coal Mining Region.

222. Evans, T. F. Reforestation of Surface Mines on Lands of VICC Land Company. Paper in Trees for Reclamation (Lexington, KY, Oct. 27-29, 1980). U.S. For. Ser., Gen. Tech. Rep. NE-61, 1980, pp. 41-43.

The author discusses the use of a permanent plot inventory to determine the timber resource on VICC Land Co. lands in southeastern Virginia. The purpose of this inventory is to set the limits on yearly timber harvests and define the areas on which timber management activities should take place. By periodically remeasuring the permanent plots, it will be possible to gain information on timber growth and forest stand changes. The results of the initial inventory show an average of 1,750 trees per acre. Appoximately 60 pct of the trees were less than 1 in Dbh and 80 pct were 10 ft tall or less. Only 29 pct of the total number of seedlings inventoried were the result of planting or direct-seeding black locust (Robinia pseudoacacia L.) and Pinus spp. Pioneer tree species comprise most of the trees in the seedling inventory. This shows how important natural reseeding is to the present seedling stock. The author concludes that future tree plantings on surface-mined land should be aimed at increasing the growing stock of the more valuable hardwood species or pure stands of the more easily managed pines.

223. Everett, C. J. Effects of Biological Weathering on Mine Soil Genesis and Fertility. Ph. D. Thesis, VA Poly. and State Univ., Blacksburg, VA, 1981, 125 pp.

This study was conducted to understand the role of biological weathering in mine soils derived from overburden rock from Buchanan County, VA. The objectives of the study were to (1) evaluate plant-available phosphorus and potassium in fractured overburden rock, (2) identify the effects of biological weathering on fractured overburden rock and describe the processes involved, and (3) assess the impact of biological weathering on the availability of phosphorus and potassium to plants. Two separate greenhouse experiments were conducted to determine plant-available phosphorus and potassium and to identify the effects of biological weathering on soil properties. The results of these experiments indicate that plant-available phosphorus and potassium are influenced by biological weathering. By removing bases and producing acids, the plants caused acidification of the soil material. This process solubilized the phosphorus and increased the amount available for plant uptake. However, as the apatite dissolves, the amount of phosphorus available will decline and become limiting. Potassium was described as adequate for plant growth. Since there were considerable amounts of mica present in the soil material, the author feels that the biological weathering process will constantly replenish the soil solution with potassium from mica.

224. Everett, H. W., D. S. Henry, and S. A. Sanders. Establishment of Some Forage Species on Mine Spoil in Kentucky. Paper in Fifth Symposium on Surface Mining and Reclamation (NCA/BCR Coal Conf. and Expo IV, Louisville, KY, Oct. 18-20, 1977). Nat. Coal Assoc. and Bitum. Coal Res., Inc., 1977, pp. 12-15.

This paper provides a brief description of two studies conducted on mine spoil in both eastern and western Kentucky. The purpose of these studies was to evaluate methods of establishing several potentially useful forage species on mine spoil. Eight different grasses and legumes were planted alone or in mixtures with five different methods of establishment. The preliminary results reported indicate that when fresh mine spoil has the proper pH and nutrients available, several species can be established for erosion control and for forage production without the use of straw mulch. However, rating for ground cover 6 months after seeding showed that woodbark and straw mulch produced more cover. Percent ground cover due to seeded species only (biomass) was less with straw mulch treatments. The results of these studies are applicable to reclamation planning in major portions of the Eastern and Interior Coal Mining Regions recognized in this evaluation process.

225. Evilsizer, B. Reclamation with Trees in Illinois. Paper in Trees for Reclamation (Lexington, KY, Oct. 27-29, 1980). U.S. For. Ser., Gen. Tech. Rep. NE-61, 1980, pp. 15-16.

The author discusses the historic record of large-scale tree planting programs in Illinois, from hedgerows planted by the early pioneers to farmstead windbreaks to surface-mine reclamation. Since the 1930's approximately 50 million tree seedlings have been planted on surface-mined land. It is hoped that tree planting programs on mined land can be expanded in the future.

226. Farmer, R. E. Jr., M. Cunningham, and M. A. Barnhill. First-Year Development of Plant Communities Originating From Forest Topsoil Placed on Southern Appalachian Minesoils. J. Appl. Ecol., v. 19, No. 1, 1982, pp. 283-294.

The authors evaluated the revegetation potential of forest topsoil from mixed deciduous stands spread over minesoil in the Cumberland Mountains of eastern Tennessee. Forest topsoil from three sites near the mining operation were collected and spread over minesoils to a depth of 2 to 3 cm. Ammonium nitrate (168 kg/ha) and triple superphosphate (280 kg/ha) were broadcast on the site after the topsoil had been spread. An average of 286 plants per square meter, representing 134 taxa, had emerged by late May, and over 90 pct of these plants survived the entire growing season. The number of plants did not significantly change with either topsoil or minesoil as substrate. At the end of the growing season shoot and root weight was approximately 8.4 t/ha. The authors conclude that forest topsoils found in the areas being mined in the Cumberland Mountains can provide diverse plant communities capable of quick, effective cover which has the potential for developing into forests.

227. Farmer, E. E., and B. Z. Richardson. Acid Mine Waste Revegetation: Influence on Soil-Water Quality. U.S. For. Ser. Intermountain For. and Range Exp. Sta., FSRP/INT-266, Jan. 1981, 12 pp.

This publication summarizes the results of a 5-year study of soil-water ionic concentrations of copper, iron, and sulfate at the Blackbird copper-cobalt mine near Salmon, ID. Soil-water samples were collected using ceramic cup samplers installed in an acid-producing overburden waste dump. Part of the waste dump was treated with lime, topsoil, and fertilizer and then reseeded to establish a heavy stand of grass. Another portion of the waste material remained untreated. Both areas exhibited decreasing soil-water ionic concentrations of copper, iron, and sulfate. The revegetation procedures used in this study did not affect the concentrations compared to the untreated portion of the waste material. The authors stress that the major purpose and importance of revegetating spoils and waste dumps is to control surface erosion. They suggest that in the case of this mine, the vegetation also controls dust. The results of this study are also relevant to surface coal mine reclamation efforts and with prudent consideration could be applied in a variety of areas throughout the United States.

228. Federal Register. U.S. Office of Surface Mining and Enforcement (Dep. Interior). Surface Coal Mining and Reclamation Operations, Permanent Regulatory Program; Revegetation. V. 48, No. 172, Sept. 2, 1983, pp. 40140-40162.

This publication contains the final rules adopted by the Office of Surface Mining for the revegetation of regraded areas and all other areas disturbed by surface and underground coal mining operations. It amends 30 CFR Parts 816 and 817, and adds a definition for "ground cover" in 30 CFR Part 701. The effective date for these final rules is October 3, 1983.

229. Fedkenheuer, A. W., and J. Browne. Reclamation Research for the Future at Syncrude Canada Ltd.: Soil Simulation Revegetation Studies on Tailings Sand. Syncrude Canada Ltd., Edmonton, Alberta, Dec. 1979, 8 pp.

This is a very general article concerning Syncrude's efforts to return vast acreages of spent oil sands to a vegetative cover having a productivity at least equal to premine conditions. The location is northeastern Alberta, near Fort McMurray, and the material is the Athabasca tar sands. Syncrude's objective was to return its disturbed areas to forest and wildlife areas, and the field studies include soil building simulations, fertilization, seeding with grasses and legumes, and planting woody seedlings. No results are given; however, more details can be obtained from the sources listed in the paper.

230. Fedkenheuer, A. W., H. M. Heacock, and D. L. Lewis. Early Performance of Native Shrubs and Trees Planted on Amended Athabasca Oil Sand Tailings. Reclam. Rev., v. 3, No. 1, 1980, pp. 47-55.

The early results are reported of an attempt to establish woody plants on Athabasca oil sand tailings located in northeastern Alberta, Canada. The tailings sand was treated with 10 cm of native sand, 10 cm of lean tar sand, 10 cm of mineral fines, or 20 cm of mineral fines applied over tailings sand. Fifty kilograms per hectare of nitrogen, phosphorus, and potassium fertilizer along with 15 cm of peat were applied to each plot and rotovated to a depth of 30 cm. All plots were seeded with a grass-legume mixure at a rate of 11 kg/ha followed by tree and shrub plantings. The tree and shrub species utilized in this study were propagated and container grown. The plot treatment that resulted in the highest tree and shurb survival rates was the lean tar sand amendment. The authors feel that the reduced grass-legume cover on this treatment resulted in more moisture being available to the woody species, hence in higher survival rates. Preliminary results indicate that the following tree and shrub species had the highest survival rates over the range of treatments used: saskatoon (*Amelanchier alnifolia* Nutt.), Jack pine (*Pinus banksiana* Lamb.), lodgepole pine (*Pinus contorta* Loudon. var. *latifolia* Engelm.), shrubby cinquefoil (*Potentilla fruticosa* L.), Canadian buffaloberry (*Shepherdia canadensis* (L.) Nutt.), and snowberry (*Symphoricarpos albus* (L.) Blake).

231. Fehrenbacher, D. J., I. J. Jansen, and J. B. Febrenbacher. Corn Root Development in Constructed Soils on Surface Mined Land in Western Illinois. Soil Sci. Soc. Am. J., v. 46, 1982, pp. 353-359.

This study compares corn root development in soils constructed after mining and in an undisturbed soil (reference area) on experimental plots constructed at the Sunspot Mine in Fulton County, IL. The objectives of the study were to (1) compare corn root systems in four different constructed soils and one undisturbed soil, and (2) relate differences in root system development to measurable differences in the physical and chemical properties of the soils. The soil treatments were (1) topsoil (A horizon) over replaced B horizon (A/B), (2) topsoil over graded dragline spoil only CA/ spoil, and (3) an undisturbed soil (reference area) as a control. Root penetration and length were recorded for all samples. Based on first-year corn root data, the undisturbed site was more favorable, the A/B intermediate, and the A/spoil least desirable as rooting material. This relationship is consistent with observed differences in pH, bulk density, and soil structure. This suggests that when B horizon soil materials are replaced with minimal compaction, it is a more favorable rooting material than dragline spoil.

232. Ferguson, R. B., and N. C. Frischknecht. Revegetating Processed Oil Shale in the Upper Mountainbrush Zone of Colorado. U.S. For. Ser. Res. Paper INT-321, 1983, 9 pp.

This study was conducted to provide information on methods used to establish vegetation on processed shale disposal areas, located in Garfield County, CO, without using large volumes of water to leach salts from the processed shale. A second objective was to evaluate 14 species on their adaptablility to the soil material and climatic conditions of the site. Three amendments were used on the unleached TOSCO II processed oil shale: (1) 15 to 25 cm of topsoil covering, (2) 5 to 10 cm covering of rock fragments, and (3) barley straw (applied at a rate of 0.73 t/ha incorporated to a depth of 15 to 20 cm. All of the species used in this study (13 shrubs and 1 forb) were container grown and then transplanted onto the site. After 6 years the overall survival was four times greater on topsoiled shale than on the straw-mulched shale, and 1.5 times greater on the topsoiled shale than on the rock-mulched shale. Plots on north-facing slopes were the most favorable for plant growth. Fourwing saltbush (Atriplex canescens (Pursh) Nutt.) and prostrate summercypress (Kochia prostrata (L.) Schrad.) grew well on all amended plots. Rubber rabbitbrush (Chrysothamnus nauseosus (Pall.) Britt.), mountain big sagebrush (Artemisia tridentata subsp. vaseyana Rydb.), green ephedra (Ephedra viridis Coville), fourwing saltbrush, and prostrate summercypress were the only species that showed adaptability to topsoil-covered processed oil shale. The authors recommend that processed oil shale should be covered with a minimum of 20 cm or preferably 30 cm of topsoil before attempting revegetation.

233. Ferguson, R. B., and N. C. Frischnuecht. Shrub Establishment on Reconstructed Soils. Paper in Shrub Establishment on Disturbed Arid and Semi-Arid Lands (Proc. Symp., Laramie, WY, Dec. 2-3, 1980). WY Game and Fish Dep., 1981, pp. 57-63.

The authors discuss direct seeding of grass-shrub mixtures, direct seeding of shrubs alone, and the planting of shrub nursery stock (bare-root and containerized) on reclaimed land. Important factors to be considered for each situation are presented. Lists of shrub species showing promise for revegetation of disturbed areas in the semiarid salt desert shrub zone and the semiarid pinyon-juniper shrub zone of Utah are included. The information presented is valuable to planning revegetation efforts in portions of the Rocky Mountain and Northern Great Plains Coal Mining Regions.

234. Ferrandino, J. Preliminary Regional Characterization of Sediment Yield for Surface Coal Mines. Paper in 1981 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Dec. 7-11, 1981). Univ. KY, Lexington, KY, 1981, pp. 395-400.

The results of a preliminary regional characterization of sediment yield (CP) for surface coal mines in the United States are presented. Representative mine models were developed for six regions. Two models, a contour haulback and a mountaintop operation, were developed for the Southern Appalachian region. The SEDMOT computer model (a simple distributed parameter approach to watershed sedimentology) was used to compute hydrographs and sediment graphs for each disturbed watershed studied. The CP value, calculated by considering a minimum reclamation practice of backfilling, grading, seeding, and mulching, gives an indication of the relative erosion potential of a mine. The western mine site had the smallest overall sediment yield value of

0.002 acre-ft/acre while the Southern Appalachian contour haulback had the highest, 0.256 acre-ft/acre.

235. Fischer, N. T. An Evaluation of Sample Adequacy for Pre- and Post-Mine Vegetation Surveys Using Computer-Generated Artificial Communities. Paper in 1982 Symposium on Surface Mining, Hydrology, Sedimentology and Reclamation (Lexington, KY, Dec. 5-10, 1982). Univ. KY, Lexington, KY, 1982, pp. 103-110.

This study uses an empirical approach to the problems of sample adequacy for line intercept data. Model plant communities were developed through a computer program that allows for programmer-controlled coverage specification. An adequacy test can then be used to test against the actual number of transects required to satisfy the accuracy criteria. The two criteria used in this study were (1) the accuracy limit is equal to 1/10th of the community coverage, and (2) the accuracy limit is held constant at 5 percentage points above and below the true coverage for all coverages. The highest calculated sample size was 1,440 at 1-pct cover using the 1/10th accuracy constraint. The large sample sizes associated with low community coverage were found to be an artifact of the 1/10th accuracy constraint. There is no justification for using a mean dependent accuracy limit on vegetation coverage data. The author proposes that a constant accuracy level of 5 percentage points be used. If adopted, both time and money spent in the field collecting data may be saved without changing the quality of the data collected.

236. Fisher, J. T., J. B. McRar, and E. F. Aldon. Methods for Establishing Containerized Native Juniper on Surface Disturbed Sites in the Southwest. Paper in Third Annual Conference on Better Reclamation With Trees (cosponsored by AMAX Coal Co., Purdue Univ., South. IL Univ., and Madisonville Comm. Coll., Terre Haute, IN, June 2-3, 1983). Purdue Univ., West Lafayette, IN, 1983, pp. 76-88.

A review of methods for woody plant establishment in the Southwest is provided in addition to a discussion of current research. Containerized native juniper (Juniperus monosperma (Engelm.) Sarg.) were planted on three northern New Mexico mine spoils. Depending on the treatments applied, good to excellent success was obtained. Preliminary results indicate that irrigation and the application of triple superphosphate (0-46-0) are beneficial to seedling survival, whereas slow-release fertilizer (Osmocote 18-6-9) caused mortality. On some sites rodent protection is absolutely necessary. The importance of time of planting is also discussed. Information very useful to reclamation planning is provided. This information is pertinent to the Rocky Mountain Coal Mining Region recognized in this evaluation process.

237. Fisher, S. E., Jr., and F. F. Munshower. Extremely Acid Soils, Overburden and Minesoils in the Great Plains. Paper in the Third Biennial Symposium on Surface Coal Mining and Reclamation on the Great Plains (cochaired by the Reclam. Res. Unit, MT State Univ. and U.S. OSM, Billings, MT, Mar. 19-21, 1984). MT State Univ. and U.S. OSM, 1984, pp. 186-200.

Extremely acid soils (pH less than 4.5) developing from parent materials high in pyrite and marcasite were recently identified in the Western United States. Minesoils containing significant quantities of acid-forming materials have also been identified in this region. Analytical data are presented on overburden materials from several Western States, containing high concentrations of acid-forming materials. The authors discuss the impact of spoil materials derived from these overburden strata on the formation and characteristics of minesoils and on the establishment of a permanent, effective, and diverse vegetative cover. This paper is relevant to planning reclamation activities on these materials throughout the Northern Great Plains and Rocky Mountain Coal Mining Regions.

238. Fisser, H. G. Soil Surface Movement and Relation to Vegetation Structure. Paper in Ecology and Coal Resource Development, Volume 2 (based on the Int. Congr.

for Energy and the Ecosystem, Univ. ND, Grand Forks, ND, June 12-16, 1978). Pergamon, 1979, pp. 706-711.

The purpose of this study was to evaluate the influence of livestock grazing and chemical shrub control upon the soil surface characteristics of a low sagebrush (Artemisia arbuscula Nutt.) community in western Wyoming near Kemmerer. No significant soil movement response was found for the grazing treatment. Significant soil movement was reported for the chemical shrub control treatment. Chemical shrub control in combination with grazing resulted in extremely significant soil movement, which had a very important influence on the ability of the native vegetation to express production potential modification. The author suggests that the methods used in this study are applicable to monitoring soil surface dynamics on reclaimed mineland. This article is a good reference for designing reclamation monitoring programs. While the study was conducted in Wyoming and the results reported are specific to that area, the methods used may be applicable nationwide.

239. Fowler, D. K., and L. F. Adkisson. Survival and Growth of Wildlife Shrubs and Trees on Acid Mine Spoil. Tennessee Valley Authority, Div. Land and For. Res., Tech. Note B37, 1980, 49 pp.

This study assessed the survival and growth of selected wildlife plants over a range of acid mine spoil conditions in Campbell and Scott Counties, TN. A second objective was to identify species suitable for surface mine reclamation. Seventeen tree and shrub species were evaluated. To assess the effects of spoil pH on plant establishment and growth, plots were grouped into seven pH categories ranging from 2.50-2.99 to 5.50-5.99. Tree and shrub performances were determined by assigning minimum acceptable growth and survival criteria in each pH category. Once the species were judged to be acceptable for reclamation use, they were rated as to their short- and long-term suitability for wildlife habitat improvement. Autum olive (Elaeagnus umbellata Thunb.), elaeagnus cherry (Elaeagnus multiflora Thunb.), "arnot" bristly locust (Robinia fertilis Ashe), sawtooth oak (Quercus acutissima Carruth.), red maple (Acer rubrum L.), and "Toringo" crabapple (Malcus sieboldii (Reg.) Rehd.) were found to be species most useful for quick improvement of surface mine habitat over the range of spoil pH in Appalachia coalfields. Even though this study was conducted before Public Law 95-87 was enacted, the results are useful for selecting species that can be used in a postmining land-use design for wildlife habitat.

240. Fowler, D. K. L. J. Turner, and L. J. Slaski. Surface Mine Reclamation for Wildlife: A Model Reclamation Plan for Southern Appalachia (U.S. FWS contract 14-16-0009-78-908, Off. of Nat. Res.). U.S. Fish and Wildlife Serv. FWS/OBS-80/09, June 1981, 30 pp.

This publication presents a reclamation plan for use on surface coal mines in southern Appalachia. Suggestions for the establishment of ground cover and trees, as well as the retention of surface water on the mine site, are included. The plan presented has been implemented cooperatively by TVA and the Fish and Wildlife Service on a mine site in Campbell County, TN. The reclamation techniques discussed in the plan benefit wildlife and can aid a mine operator in achieving bond release. The costs of reclamation at the study site are compared to the costs of a more traditional forestry (monoculture) option. The economic analysis indicated that the costs of reclamation for wildlife were less than the cost associated with the forestry option. The discussions and methods contained in this document are pertinent to portions of the Interior and the Eastern Coal Mining Regions recognized in this evaluation process.

241. Frame, R. C., and R. R. Hicks, Jr. Propagation of Aspen and Woody Shrubs on Reclaimed West Virgina Surface Mines. Paper in Third Annual Conference on Better Reclamation With Trees (cosponsored by AMAX Coal Co., Purdue Univ., South. IL Univ.

and Madisonville Comm. Coll., Terre Haute, IN, June 2-3, 1983). Purdue Univ., West Lafayette, IN, 1983, pp. 37-47.

The effects of three site preparation treatments on the survival and growth of several woody species were studied on two reclaimed surface mines in north-central West Virginia. These treatments included the use of Dalapon and Atrazine herbicides or black plastic mulch to control competition from herbaceous cover. Root suckers from bigtooth aspen (Populus grandidentata Michx.) and trembling aspen (Populus tremuloides Michx.) as well as seedlings of Washington hawthorne (Crataegus phaenopyrum (L.) Medic.), gray dogwood (Cornus racemosa Lam.), European black alder (Alnus glutinosa (L.) Gaertn.), and pink spiraea (Spiraea billiardi Herincq.) were used in the study. The best overall results were obtained using Dalapon to control herbaceous competition. Washington hawthorne and gray dogwood had significantly better survival than the other species tested. The results reported are pertinent to reclamation planning in the Eastern and portions of the Interior Coal Mining Regions recognized in this evaluation process.

242. Franklin, J. W. Simulation of the Revegetation Potential of Coal Mines in Semi-Arid Climates. M.S. Thesis, Univ. AZ, Tucson, AZ, 1981, 87 pp.

The author presents a computer model that predicts the success or failure of revegetation of coal mine spoils in the semiarid Southwest, as typified by the Black Mesa Mine in northeastern Arizona. The model consists of a stochastic rainfall model coupled to a soil moisture model. For a 1-year period only, the most limiting factor is the amount of soil moisture available for the germination process. An irrigation model was also run to evaluate the addition of moisture during the first year of establishment. Very little additional moisture (via irrigation) would be necessary to greatly improve establishment; however, evaluation of a 10-year period after the year of establishment showed that without first-year irrigation there was very little chance of successful revegetation. The author concludes that Federal law governing revegetation of arid mined lands can be met if proper species are selected, the soil moisture holding capacity is increased through mulch addition, and irrigation is applied the first year of establishment. Since plant death will generally occur early in the cycle, Federal law need only require a 5-year waiting period to determine if revegetation is successful, rather than the 10-year period now established.

243. Fransway, D. F., and R. J. Wagenet. Salt Release and Movement in Processed Oil Shale. J. Environ. Qual., v. 10, No. 1, 1981, pp. 107-113.

This paper deals with the reduction of saline minerals, such as dawsonite, nahcolite and halite, contained in Paraho processed oil shale from Colorado, Utah, and Wyoming. These salts are not removed in the normal processing of oil shales, and if excessive, could cause adverse effects on plant establishment and growth if concentrated in the root zone. Properly managed, the addition of excess water could leach the salts below the root zone without affecting ground water.

244. Fresquez, P. R., and W. C. Lindemann. Greenhouse and Laboratory Evaluations of Amended Coal-Mine Spoils. Reclam. Reveg. Res., v. 2, No. 3, 1983, pp. 205-215.

The authors describe the effects of spoil treatment on the growth potential and nutrient content of blue gamma (Bouteloua gracilis (H.B.K. Lag.) and fourwing saltbush (Atriplex canescens (Pursh) Nutt.). The spoil material and stockpiled topsoil used in this greenhouse study were taken from the San Juan coal mine in northwestern New Mexico. The chemical and physical properties of the spoil and topsoil materials were then determined. In the greenhouse studies only the spoil material was amended using one or a combination of the following materials: alfalfa, gamma-irrigated sewage sludge, stockpiled topsoil, fertilizer (N and P), and gypsum. It was found that alfalfa mulch plus fertilizer increased the yields and P and K contents of blue grama more than any other treatment. Organic amendments were found to increase the yields of fourwing saltbush more than any other treatment including fertilizer. Incorporating topsoil into the spoil, as opposed to topsoiling, did not stimulate plant growth. The increased yields found for both species can be attributed to the addition of organic matter and essential plant nutrients, along with an improved biological environment. There was an increase in microbial activity, due to the spoil amendments, which resulted in the mineralization and solubilization of calcium, magnesium, potassium, and phosphorus; increased nitrification; and the lowering of the sodium absorption ratio (SAR). Gypsum applications also increased the yields of both species under optimum moisture conditions over most nongypsum treatments, whether organic matter was present or not. Gypsum application stimulated plant growth by lowering the SAR. The authors concluded that increased plant yields were due to the addition of plant-available nutrients contained in the amendments and increased microbial activity.

245. Fresquez, P. R., and W. C. Lindemann. Soil and Rhizosphere Microorganisms in Amended Coal Mine Spoils. Soil Sci. Soc. Am. J., v. 46, No. 4, 1982, pp. 751-755.

This research compared soil microbial numbers, dehydrogenase activity, and fungal genera distribution of spoil to that of the original and stockpiled soil. When evaluating this article the original undisturbed soil was considered as a reference area. A greenhouse study was also conducted, using spoil and stockpiled topsoil material, to determine the effect of spoil amendments on the microbial parameters given above. The treatments used were (1) spoil, (2) spoil and topsoil + inoculant, (3) spoil + alfalfa (Medicage sativa L.) + fertilizer, (4) spoil + alfalfa + fertilizer + topsoil, (5) spoil + sewage sludge, and (6) spoil + sewage sludge + topsoil. The soil and spoil material used in this study were collected at the San Juan coal mine near Farmington, NM. The results show that microbial numbers, dehydrogenase activity, and fungal general distribution were greater in the undisturbed soil and reclaimed area than in the stockpiled topsoil or nonvegetated spoil. This indicates that if sites are reclaimed without topsoiling or if topsoil is stored before use, steps should be taken to insure that the material remains biologically active. The use of alfalfa or sewage sludge as organic amendments generally increases microbial numbers, dehydrogenase activity, and fungal distribution over the nonamended and topsoil-inoculant treatments. The authors conclude that organic amendments are more critical to the stimulation of spoil microfora than the addition of topsoil inoculants. However, it is necessary to remember that the results were obtained under greenhouse conditions.

246. Friedlander, J. D. Liability Period and Management of Reclaimed Lands. Paper in Symposium on Western Coal Mining Regulatory Issues: Land Use, Revegetation, & Management (West. Reclam. Group, Denver, CO, Apr. 1982). CO State Univ., Range Sci. Dep., Fort Collins, CO, Sci. Ser. No. 35, Aug. 1983, pp. 103-104.

The liability period imposed by the 1977 Surface Mining Control and Reclamation Act and subsequent State regulations is reviewed and evaluated with reference to the conditions and land uses encountered in the Western United States. The author states that a universal 10-year liability period does not meet site-specific needs for assessing reclamation success in Western States owing to extreme variability in climate and land use. The author advocates making adjustments in the liability period where possible and allowing certain types of management during that time without reinitiating the liability period. The concepts related in this article could be applied to the planning of reclamation activities and the design of revegetation monitoring programs specific to the Northern Great Plains and Rocky Mountain Coal Mining Regions recognized in this evaluation process.

247. Frizzell, E. M., J. L. Smith, and K. A. Crofts. Transplanting Native Vegetation. Paper in Surface Coal Mining Reclamation Equipment and Techniques.

Proceedings: Bureau of Mines Technology Transfer Seminars, Evansville, IN, June 3, 1980, and Denver, CO, June 5, 1980. BuMines IC 8823, 1980, pp. 48-53.

A transplanting system is described that consists of a front-end loader with a transplant bucket and a transporter. Several advantages of this system are noted. Native revegetation can be moved efficiently and economically over longer distances. The system would utilize a conventional piece of mine production equipment, but only on a limited basis so as not to impede production activities. Native vegetation could be removed from an unmined area, placed in a holding area by the front-end loader, and moved by the transporter to the transplant area when convenient. This will allow maximum productivity with the front-end loader when it is available, thus providing increased flexibility in scheduling the front-end loader. The lower initial and operational costs of the transporter compared to the front-end loader would reduce transplanting costs. All power for the transporter operation other than mobility is self-contained, so a truck, large farm tractor, scraper tractor, or other piece of reclamation equipment not directly required for mine production could be used to pull the transporter. This transplanting system is also described in other publications. However, this article provides a good analysis of the operation of the equipment. No illustrations are included. The article is pertinent to revegetation planning where use of natural vegetation is being considered.

248. Fuchs, M. R., and G. R. Cox. Factors Affecting Choice of Plant Species for Revegetation on the Hanford Site (U.S. DOE contract DE-AC06-77RL01030, Rockwell Int., Richland, WA). Informal Rep. RHO-LD-155P, Apr. 1983, 29 pp.

The principal objectives of this study were to determine whether soil conditions influenced the establishment of selected native perennial grass species, the extent of these species as members of the vegetation community on the Hanford site prior to major human influences, and whether these perennial grasses could be established on other sites to be reclaimed. Three sites were evaluated. The dominant perennial grass species in the vegetative communities at each of these sites were Siberian wheatgrass (Agropyron sibiricum (Wild.) Beauv.) thickspike wheatgrass (Agropyron dasystachyum (Hook.) Scribn.), Indian ricegrass (Oryzopsis hymenoides (Roem. & Schult.) Ricker), and Sandberg bluegrass (Poa secunda Presl.), respectively. The authors conclude that these species, along with needle grass (Stipa comata) Trin. & Rupr.) and sand dropseed (Sporobulus cryptandrus (Torr.) Gray), may be successfully established for revegetation purposes on the Hanford site. Addition of nitrogen is necessary to increase the fertility of the soil. Faster stand establishment may be achieved on disturbed sites by reducing competition for moisture and nutrients through the control of invading weed species such as Russian thistle (Salsola kali L. var. tenufolia Tausch.) and tumble mustard (Sisymbrium altissimum L.). The use of selective herbicides has been shown to help reduce this competition. Factors reported to influence the choice of revegetation species include (1) the level of exchangeable magnesium in the soil; (2) soil textural class, gravel percentage, and depth to coarse sediments; (3) the presence of an indicator plant species that defines a habitat; and (4) the soil fertility level. While the results and conclusions offered are specific for reclamation of radioactive waste sites at Hanford, WA, they are applicable to surface coal mine reclamation in portions of the Northern Great Plains and Rocky Mountain Coal Mining Regions as well.

249. Gabrielson, F. C., E. A. Cross, and D. K. Bradshaw. The Effects of Fertilizer and Acid Treatment on Plant Growth in Alkaline Spoil. Abstract of paper presented at the Meeting of the American Council for Reclamation Research (Univ. AL, University, AL, Sept. 18-22, 1979). Reclam. Rev., v. 3, 1980, pp. 61-64.

The experiments described by the authors were designed to determine the response of lovegrass (Eragrostis spp.) and Kobe lespedeza (Lespedeza striata (Thunb.) H & A var.

Kobe) to acid and fertilizer treatments in alkaline mine spoil. Although parts of the abstract were difficult to follow, it was clear that lovegrass responded well to 13-13-13 fertilizer and to NH_4NO_3 treatment.

250. Gabrielson, F. C., E. A. Cross, D. K. Bradshaw, and O. L. Carter, Jr. Seed Size Influence on Germination and Plant Growth of Kobe Lespedeza and Other Species Used for Surface Mine Revegetation. Reclam. Reveg. Res., v. 1, No. 3, 1982, pp. 271-281.

This article describes a series of pilot and expanded greenhouse experiments that used various spoil-soil substrates and plant species commonly used to revegetate coal surface mines in Alabama. In the pilot experiments seeds of soybean (Glycine max (L.) Merr.), Kentucky-31 fescue grass (Festuca arundinacea Screb.), Kobe lespedeza (Lespedeza striata (Thunb.) H. & A. var. Kobe), and crimson clover (Trifolium incarnatum L.) were divided into three weight classes (small, medium, and large) and grown on greenhouse soil, acid mine spoil (pH 4.8), pine stand topsoil, and calcareous shale mine spoil (pH 7.8). No soil amendments were used in the pilot study. The results of the pilot study showed that survival and aboveground biomass were always greater when produced by large seeds as compared to small seeds. Biomass and survival of medium-sized seeds were also greater than for small seeds, but not significantly greater. The authors suggest that some of the differences found may have been due to seed size-substrate interactions. A germination experiment was conducted with different sized seeds of Kobe lespedeza, weeping lovegrass (Eragrostis curvula (Schrad.) Nees), and crimson clover. The seeds were divided into two groups per plant species based on lovegrass larger and smaller than 42 mm, Kobe lespedeza larger and smaller than 1.3 mm, and crimson clover larger and smaller than 1.5 mm. For the species tested, the larger seed class always had significantly higher germination percentages. Because Kobe lespedeza is an important legume component of reclamation seed mixtures, three experiments using Kobe lespedeza were conducted on various mine substrates (ranging from acid sand with a pH of 4.4 to calcareous shale with a pH of 7.5) in order to evaluate the advantages of using large seeds relative to spoil-soil characteristics and fertilizer and lime treatments. Seed size effects were found to differ with substrate and amendment treatment, but overall the larger seeds increased plant density and biomass. On spoil material with low cation exchange capacities (CEC) the 13-13-13 fertilizer treatment was excessive and caused a significant reduction in plant density. Lime plus fertilizer on low-CEC spoils was found to modify the effect of fertilizer alone. This article contains a great deal of useful information; however, field results may be different from the results obtained in the greenhouse experiments owing to the nonlimiting temperature and moisture regimes used in these experiments.

251. Gavande, S. A. Selecting Cover-Soil for Use in Surface Mine Reclamation in East Texas. Paper in 1982 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Dec. 5-10, 1982). Univ. KY, Lexington, KY, 1982, pp. 541-545.

This greenhouse study was conducted to compare the revegetation potential of surface soil and underlying overburden materials sampled from a proposed lignite surface-mined area in east Texas. Four composite surface soil samples and 16 mixed overburden samples representing 4 depth intervals were taken. All soil samples were analyzed for major chemical and physical parameters. Common bermudagrass (Cynodon dactylon (L.) Pers.) was selected as the test plant. All soil and overburden samples were limed to obtain a pH level of 6.5. Three fertilizer treatments were used: (1) a control, (2) 90-60-60 lb/acre of N, P, and K, and (3) 180-60-60 lb/acre of N, P, and K. The results of the soil analysis indicate that the overburden mixtures had a more favorable texture, which resulted in a greater water and nutrient holding capacity, than unmined surface soils. Plant growth on unamended overburden material indicated that the mixed overburden was equal to or a little less fertile than the surface soil material. When amended, the overburden material from all depths produced greater forage yields than surface soil under the same conditions. The author concludes that the establishment of vegetation on disturbed land in east Texas, with or without topsoil, should present no major problems.

252. Gebhart, E. J. Trees for Ohio. Paper in Trees for Reclamation (Lexington, KY, Oct. 27-29, 1980). U.S. For. Ser., Gen. Tech. Rep. NE-61, 1980, pp. 51-52.

The author discusses the use of trees for reclaiming Ohio surface-mined land. Three areas of revegetation that could utilize tree plantings are (1) planting trees on replaced topsoil with erosion control grass cover, (2) revegetation of unreclaimed mined lands mined prior to 1972 (pre-Ohio strip mine law), and (3) reforestation of barren lands that once had a grass cover. The following recommendations were given: (1) the grass species and seeding rates that should be used when grasses are planted in combination with trees, (2) the spacing and number of trees planted per acre, (3) type of stock, season of planting, and method of planting trees, and (4) tree mixtures for acid and alkaline spoils.

253. George, M. R., C. M. McKell, and S. G. Richardson. The Establishment of Cheatgrass (Bromus Tectorum L.) on Spent Oil Shale from the Paraho Process. J. Environ. Qual., v. 10, No. 2, 1981, pp. 166-169.

Establishment and growth of cheatgrass (Bromus tectorum L.) was evaluated in a greenhouse study on oil shale from northwestern Colorado that had been treated by the Paraho retorting process. The objectives of the study were to (1) study the emergence and growth of cheatgrass in soil, in soil mixed with untreated Paraho spent oil shale, and in spent shale that was either leached, treated with 10 pct H_2SO_4, covered with soil, or mixed with soil, and (2) study the emergence and seedling growth of cheatgrass on Paraho spent oil shale that was fertilized with ammonium nitrate and triple superphosphate. Fertilizer rates were 0, 28, and 56 kg/ha N and 0, 24.4, and 48.8 kg/ha P. Cheatgrass emerged sooner, had greater height, produced more biomass, and survived to produce seed when the treatment was soil alone or if the spent shale had been covered with soil material. When compared to spent shale alone, cheatgrass establishment was more successful when soil and spent shale were mixed. The authors conclude that, by covering spent shale with a soil layer or by mixing soil and shale together, successful cheatgrass establishment is possible. However, field studies are needed to verify these results.

254. Gerken, H. J., Jr., and A. L. Eller, Jr. Beef Production From Forage Produced on Reclaimed Surface Mined Land. Paper in 1982 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Dec. 5-10, 1982). Univ. KY, Lexington, KY, 1982, pp. 203-206.

This study was conducted to determine the productivity of beef cows that grazed on sericea lespedeza (Lespedeza cuneata (Dum.-Cours) G. Don) and KY-31 tall fescue (Festuca arundinacea Schreb.), establish optimum management practices, and identify potential problems affecting cow productivity on reclaimed mine land. This study was conducted near Norton, VA. Twenty-five mature Angus X Hereford cows with calves were placed on 20 hectares of sericea lespedeza - KY-31 fescue pasture where the cows and calves grazed from June through November. After weaning the cows were moved to a 32-hectare area and wintered on accumulated fescue from December through April. At weaning it was determined that all cows were pregnant, and all cows calved between early March and early April. The cows and calves were returned to the initial 20-hectare grazing area, and a Polled Hereford bull was placed with the herd to initiate a new breeding season. By October all cows were again pregnant. The results of the study indicate that cows can effectively use sericea lespedeza and other forages grown on reclaimed mine land to maintain weight, reproduce satisfactorily, and wean calves with acceptable weaning weights. No health or nutritional problems were encountered. Grazing also proved to be an effective way of managing sericea lespedeza in order to enhance the growth of other forages. Accumulated forages on surface-mined land also provided much of the winter feed required by pregnant cows. The authors conclude that the forages are available on revegetated surface-mined lands for beef production, and if properly managed for beef production these acreages could provide an acceptable economic return to the owner.

255. Gifford, G. F., and G. E. Hart. A Classification of Utah Mine Wastes. Edge: Natural Resouces/People, v. 3, No. 1, 1980, pp. 8-14.

The article presents a preliminary system of classification for Utah mine wastes based on surface hydrologic characteristics. The principal types of mining considered in the study included gold, silver, lead, zinc, fire clay, brick clay, limestone, fluorspar, phosphate, coal, copper, tungsten, uranium, vanadium, and beryllium. The classification system developed is intended for use in rating mine spoils for potential surface hydrologic limitations to revegetation. While this classification may be specific for Utah, the approach is valid for development of similar classification systems in other geographic areas.

256. Gilley, J. E. Runoff and Erosion Characteristics of a Revegetated Surface Mined Site in Western North Dakota. ND Farm Res., v. 37, No. 6, May 1980, pp. 17-20.

This article reports the results of a study in which a rainfall simulator was used to measure runoff and soil loss from undisturbed, harvested, and bare and surface-mulched treatments on a revegetated surface mined site near Zap, ND. The greatest soil losses were measured on the bare soil treatment. The least soil loss was experienced on the undisturbed plots. Application of 0.5 ton/acre surface straw mulch reduced erosion by 66 pct over the bare soil condition. The results and discussion contained in this article could apply to major portions of the Northern Great Plains and Rocky Mountain Coal Mining Regions.

257. Gilley, J. E., G. W. Gee, A. Bauer, W. O. Willis, and R. A. Young. Runoff and Erosion Characteristics of Surface-Mined Sites in Western North Dakota. Trans. ASAE, v. 20, No. 4, 1977, pp. 697-700, 704.

This study was conducted to measure runoff and erosion from native rangeland (reference area), spoil, and topsoil sites in North Dakota. The rangeland served as a premined condition and was compared to cultivated and noncultivated spoil and topsoiled mine sites. Rainfall events were simulated by a rainulator. Sediment production averaged 74,000 kg/ha for the bare topsoil sites, 18,000 kg/ha for the bare spoil sites, and 200 kg/ha for the rangeland. By applying wheat straw mulch at a rate of 4,500 kg/ha, soil losses were reduced by 84 pct on the spoil and 93 pct on the topsoil sites. For the simulated rainfall, runoff averaged 60 and 70 pct of the rainfall applied on the bare topsoil and spoil treatments, respectively. Runoff only averaged 12 pct on the rangeland site. These results indicate the need for suitable management practices on bare topsoil and spoil material to keep erosion and runoff levels within acceptable limits.

258. Gist, C. S., E. Clebsch, R. McCord, D. Wilkin, and D. Dietz. A Handbook for the Development of Terrestrial Monitoring Programs for Coal Mine Reclamation. Oak Ridge Assoc. Univ., Oak Ridge, TN, Tech. Rep. ORAU-144, July 1978, 207 pp.

This is a handbook for the design of terrestrial environmental monitoring programs for surface coal mining. It provides an excellent example for the application of decision-making theory in developing environmental monitoring programs. The Newman-Kuels multiple range test is applied to determine the most critical and cost effective parameters to be monitored. These parameters are considered in formulating alternatives for the design of a monitoring program. The alternatives thus developed are ranked by the Decision Alternative Rational Evaluation (DARE) method. In this way the responses from individuals involved in the decision-making process are evaluated.

259. Glazier, R. C., R. W. Nelson, and W. J. Logan. Planning for Mine Cut Lakes. Paper in 1981 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Dec. 7-11, 1981). Univ. KY, Lexington, KY, 1981, pp. 533-540.

The authors discuss the development of mine cuts into permanent water impoundments. When compared to backfilling costs necessary to restore premining topography and land use, mine cut lakes are a feasible alternative postmining land use. Mine cut lakes can be planned as a valuable resource for fish and wildlife habitat, recreation, and water supply (for example, irrigation). The key to the use of these water impoundments is careful planning and development of lake and watershed features aimed at producing physical, chemical, and biological characteristics suitable for the intended or potential uses.

260. Glenn-Lewin, D. C. Natural Revegetation of Acid Coal Spoils in Southeast Iowa. Paper in Ecology and Coal Resource Development, Volume 2 (based on the Int. Congr. for Energy and the Ecosystem, Univ. ND, Grand Forks, ND, June 12-16, 1978). Pergamon, 1979, pp. 568-575.

Descriptions and quantitative analyses are given for natural revegetation of abandoned coal strip mine spoils in southeastern Iowa. Vegetation reestablishment by natural means resulted in a complex of vegetation characteristics rather than a uniform successional sequence. Substrate acidity was an important factor controlling initial colonization. Approximately 40 to 50 pct of the oldest spoils studied remain unvegetated due to low substrate acidity. The results reported from this study are applicable to reclamation planning in the Interior Coal Mining Region.

261. Goodman, S. D., T. F. Koppe, and R. J. Hutnik. Revegetation of Strip-Mine Spoils With Containerized Tree Seedlings. Paper in Fifth Symposium on Surface Mining and Reclamation (NCA/BCR Coal Conf. and Expo IV, Louisville, KY, Oct. 18-20, 1977). Nat. Coal Assoc. and Bit. Coal Res., Inc., 1977, pp. 16-19.

The study reported in this paper evaluated the survival of eight species of 1-year-old conifer seedlings grown in various types of containers. Noncontainerized 2-year-old nursery stock were planted in a bare-root condition as a control. Three types of mineland sites were used in the study: Pennsylvania toxic sites, Pennsylvania current reclamation sites, and Appalachia current reclamation sites (West Virginia, Ohio, Kentucky, and Tennessee). Based on the results obtained from the first growing season, the 2-year-old commercial bare-root stock was superior to one-year-old containerized conifer seedlings on a variety of surface-mined sites. Severe weather conditions hampered the study and complicated evaluation of the results. Continued superiority of the 2-year-old bare-root stock was uncertain. This study may be of interest to individuals involved in planning reclamation activities in the Eastern Coal Mining Region. However, because of the short time period of the study and the admitted weather problems, care should be exercised in directly applying these results.

262. Gosz, J. R., L. Barton, and L. D. Potter. An Evaluation of New Mexico Humate Deposits for Restoration of Mine Spoils. Ch. in The Reclamation of Disturbed Arid Lands. Univ. NM Press, 1978, pp. 180-188.

The effects of humate and mulch applications were evaluated at the Jackpile uranium mine near Laguna, NM. The specific objectives were to evaluate the microbial and mineral nutrient qualities of humates and their effects on mine spoils, and to evaluate the effects of humates on plant growth and quality of forage of both native and introduced plants. Four humate application rates were used: 0, 714, 3,569, and 7,138 kg/ha. On a second set of plots barley mulch (1,695 kg/ha) was added along with humate. Chemical analyses showed that organic matter, nitrogen, zinc, and phosphorus contents were higher in the humate than in the native soil (Tres Hermanos Sandstone), which had a higher calcium concentration than the humate. Humate had both a stimulatory and an inhibitory effect on soil microbes. Soil fungi were stimulated by humate application rates of 714 to 3,569 kg/ha. Soil bacteria and fungi had their highest counts when humate was applied at 714 kg/ha. Application rates higher than this reduced microbe counts. The application of mulch on humate did not have a statistically significant effect on plant growth. Potassium was the only element affected by humate application; barley tissue analysis showed a marked decrease in potassium concentration. The authors concluded that there is a need to continue to evaluate the effects of humate on plant growth, particularly for the potential accumulation of metals by plants.

263. Gough, L. P. Regional Investigations of Soil and Overburden Analysis and Plant Uptake of Metals. Paper in the Third Biennial Symposium on Surface Coal Mining and Reclamation on the Great Plains (cochaired by the Reclam. Res. Unit, MT State Univ. and U.S. OSM, Billings, MT, Mar. 19-21, 1984). MT State Univ. and U.S. OSM, 1984, pp. 156-171.

This paper reports the results of regional studies on the bioavailability of metals at native and disturbed sites in the Fort Union, Powder River, and Green River coal regions. Correlations between Cu, Fe, and Zn in plants and extractable and total levels in native A- and C-horizons of soil were occasionally significant. A simple linear model generally did not provide an adequate representation of element uptake by plants. Stepwise linear multiple regression analysis incorporating several soil chemical and physical parameters improved predictive capabilities of the models but accounted for more than 54 pct of the variability in the data. Soil pH was the most important variable relating soil chemistry to plant chemistry. This paper is pertinent to reclamation planning throughout the Northern Great Plains and Rocky Mountain Coal Mining Regions.

264. Gough, L. P., and R. C. Severson. Rehabilitation Materials From Surface Coal Mines in Western U.S.A. II. Biogeochemistry of Wheatgrass, Alfalfa, and Fourwing Saltbush. Reclam. Reveg. Res., v. 2, No. 2, 1983, pp. 103-122.

This research was conducted to obtain element concentration data on species commonly used for reclamation on 11 coal mines in Wyoming, Colorado, North Dakota, and Montana. The following species were sampled at least once at each mine: crested wheatgrass (Agropyron cristatum (L.) Gaertn.), slender wheatgrass (Agropyron trachycaulum (Link) Malte), intermediate wheatgrass (Agropyron intermedium (Host) Beauv.), alfalfa (Medicago sativa L.), and fourwing saltbush (Atriplex canescens (Pursh) Nutt.). Concentrations of up to 32 to 34 elements were determined for each species. The data collected were to provide a basis for the assessment of the variability in the concentration of elements in similar species among the mines; an assessment of the variability in element concentration of a species within a mine; and an evaluation of the potential phytotoxicity, animal forage deficiency, or forage toxicity hazard. The differences in element concentrations among mines using the same species reflected the variability of the mine environment. The concentrations of elements in the wheatgrass species from all the mines tested were below that considered toxic to plants or animals. Phosphorus and magnesium concentrations in the wheatgrasses were consistently below the critical dietary levels for cattle. Alfalfa from six mines in three States had uniform concentrations of elements. However, variability among the mines was large for aluminum, calcium, lithium, and sodium. At one North Dakota mine the boron concentration may have been phytotoxic in alfalfa. Molybdenum concentrations in alfalfa were potentially toxic to grazing cattle at a Montana and a North

Dakota mine. The boron concentration of fourwing saltbush was potentially phytotoxic at a Wyoming site.

265. Gozon, J. S., C. J. Konya, S. S. LuKovie, R. G. Lundquist, and J. Olah. Mined Land Reclamation by Biological Reactivation. Paper in 1982 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Dec. 5-10, 1982. Univ. KY, Lexington, KY, 1982, pp. 19-26.

The author describes a new method of reclamation developed in Europe that restores land to full productivity within 2 years without topsoil replacement. The technique is called biological reactivation (BR) and it reestablishes within 1 year following mining the required biological balance between microbes, enzymes, and trace elements. The feasibilty of using the BR process in the United States was evaluated. The physical and chemical parameters of 140 spoil samples from 10 surface mining operations were characterized. Results indicate that the BR technology could be effectively applied to the areas tested in Ohio, Indiana, and Kentucky. There are several advantages to the BR system; for instance, there is no need to use conventional reclamation techniques such as selective stripping, storage of material, replacement of topsoil, or the use of pioneer plant species. Another advantage is that the BR technique reduces reclamation costs on prime farmland by 90 to 95 pct when compared to conventional U.S. reclamation techniques. The authors state that the second year after the BR technique has been used, a grain or vegetable yield identical with the original agricultural lands can be expected.

266. Grandt, A. F. Mined-Land Reclamation in the Interior Coal Province. J. Soil Water Conserv., Mar.-Apr. 1978, pp. 62-68.

This article characterizes surface mining rules and regulations, mining techniques, land-use capabilities, and plant species used to achieve a particular land use in the Interior Coal Province prior to the passage of the Surface Mining Control and Reclamation Act of 1977 (Public Law 95-87). The author provides a good general description of what mining and reclamation involve, including cost and planning, for those who have not had exposure to the industry. A section is included on postmining land use. All the examples given are beneficial and productive uses of the reclaimed land prior to 1977. The author concludes that with the passage of Public Law 95-87, "reclamation is a new ball game."

267. Grandt, A. F. Prime Farmland--Is Restoration a Reality? Min. Congr. J., Sept. 1982, pp. 25-30.

The author provides the results of several studies that reveal some row crop yields comparable to those from relevant reference areas on "prime farmland." While the article seems to speak to prime farmland reclamation in a national sense, the studies reported were conducted in the Midwest (Interior) coal region. The results reported would be of value for comparative studies and planning.

268. Grandt, A. F. Problems in Reclaiming Farmland in Illinois. Min. Eng. (NY), Sept. 1981, pp. 1348-1350.

This article offers excellent reviews of the salient points of the Surface Mining Control and Reclamation Act of 1977 and the 1971 Illinois Surface Mined Land Conservation and Reclamation Act, as well as the definition of "prime farmland" by the U.S. Soil Conservation Service in 7 CFR 657 (Federal Register, V. 4 No. 21). In addition, the author relates the results of a study designed to measure the effects of topsoil on graded surface-mined land and to compare corn (Zea mays L.) and soybean (Glycine max (L.) Merr) yields on original soil and graded surface-mined lands through the incorporation of a "reference area" that meets the criteria developed by the Rules and Regulations of Public Law 95-87. An inital settling period for newly reclaimed land is recommended, during which legume-grass mixtures are used to facilitate the stabilization of the chemical, physical, and biological factors of the soil prior to more traditional rotational cropping systems.

269. Grandt, A. F. Reclaiming Mined Land In Illinois for Row Crop Production. J. Soil Water Conserv., v. 33, No. 5, 1978, pp. 242-244.

The author discusses the feasibility of reclaiming Illinois surface-mined lands for row crop production. Data are presented from studies conducted on nontopsoiled sites during the late 1940's to early 1960's. The yields obtained from these studies equalled or exceeded the county averages at the time the experiments were conducted. A study was then described where a topsoiled and a graded spoil were continuously cropped with corn (Zea mays L.) and the yields obtained were compared to the yields of an unmined Muscatine silt loam (prime farmland) in Knox County, IL. The results of this study suggested that continuous row crops should not be grown on recently reconstructed mine land. Corn yields on the topsoiled area remained constant for 3 years and exceeded the yields for the Muscatine silt loam under basic levels of management. However, under high levels of management the topsoiled corn yields were 15 to 20 pct short of the yields obtained on unmined land. On the graded spoil, corn yields dropped substantially over the 3 years and never equalled the yields obtained on the topsoiled or unmined areas. An ongoing study in Randolph County, IL was also described by the author. Again, the corn yields obtained were above that predicted for a basic level of management but below that predicted for a high level of management. The author concludes that newly mined lands should not be immediately planted to corn. A legume-grass mixture should be seeded the first few years to allow the chemical, physical, and biological aspects of the replaced topsoil to stabilize. Following this period, row crops, such as corn and soybeans, can be grown successfully on land that has been stripmined for coal.

270. Grandt, A. F. Selection, Establishment, and Utilization of Plant Materials for Multiple Postmining Land Use. A Study Guide for a Mini-Course Taught at the 1983 National Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Nov. 27-Dec. 2, 1983) Univ. KY, Lexington, KY, 1983, 85 pp.

This manual contains information on the reestablishment of vegetative cover on mined land in the Eastern United States for multiple post-mining land use. Information is given on vegetation types (grasses, forbs, and woody plants), selection of plant materials, establishment of vegetation (soil testing and the soil amendments needed), planting, and maintenance. The majority of the manual contains useful information on grass, forb, and, shrub species characteristics.

271. Graves, D. H., and S. B. Carpenter. Use of Hardwood Bark in Stripmine Reclamation. Paper in Organic and Fuel Uses for Bark and Wood Residues (Bark and Residue Tech. Sess., For. Product Res. Soc., Annual Meeting, San Francisco, CA, 1979, and Boston, MA, 1980). For. Prod. Res. Soc., Madison, WI, Proc. No. P-80-27, 1980, pp. 6-12.

The authors review a number of studies being conducted by the University of Kentucky that compare various mulching systems with the use of bark mulch to evaluate vegetative responses and microclimate modification. Bark mulching resulted in higher soil moisture content compared with straw or water-borne fiber mulches. Bark mulch was the warmest mulch during the winter and was only slightly warmer than straw during the hot portion of the growing season. Mixtures of bark and organic material were superior mulches for the development of total ground cover. Bark-based mulches resulted in rapid establishment of legumes. Alternatively, water-based mulches resulted in greater establishment of grass. Direct seeding of heavy seed species such as oaks (Quercus spp.), yellow buckeye (Aesculus octandra Marsh.), and Chinese chestnut (Castanea mollissima BT.) respond favorably to bark and bark-mixture mulches. Interim results indicate that bark mulch improves the initial survival of both bare-root and containerized seedlings. A brief discussion of recent economic analyses indicate that bark mulching compares favorably with hydro mulching or with hay or straw mulching and is less expensive than mulching with composted municipal waste. The intent of the presentation was to relate current research trends. However, the information presented will be helpful in planning revegetation efforts in major portions of the Eastern Coal Mining Region, as well as the eastern portion of the Interior Coal Mining Region.

272. Graves, D. H., S. B. Carpenter, and R. F. Wittwer. Direct-Seeding of Commercial Trees on Surface Mine Spoil. U.S. EPA, EPA-600/7-80-073, Apr. 1980, 14 pp.

The potential for direct seeding of small-seeded and large-seeded tree species on minespoils in eastern Kentucky was evaluated. The study combined three directional aspects, four types of mulch applications, two levels of fertilizer application, and two herbaceous vegetation seeding rates as treatments. The small-seeded species used were Paulownia (Paulownia tomentosa (Thunb.) Steud.) and European black alder (Alnus glutinosa (L.) Gaertn.). The three large-seeded species used in the study were northern red oak (Quercus rubra L.), pin oak (Quercus palustris Muenchh.), and bur oak (Quercus macrocarpa Michx.). Survival of the large-seeded species was better than that of the small-seeded species. Initial germination for all five species was significantly higher on the warmer, south-facing aspect of the spoil. Mulching increased the survival rate and growth for all species. The best survival rates were obtained with composted municipal sewage sludge. The most height increase was obtained with bark-manure mulch. Fertilizer decreased survival and increased height growth. Competition from herbaceous ground cover reduced germination more than any other variable. Ground cover also reduced height growth. The results and discussion presented in this publication are relevant to the establishment of deciduous tree species as part of revegetation efforts on surface-mined land in the Eastern Coal Mining Region.

273. Greater Egypt Regional Planning and Development Commission. Erosion Potential of Reclaimed Agricultural Lands in Perry County (Rep. GERPDC-82-617, Carbondale, IL). U.S. EPA Grant POO 5623-01, NTIS PC A04/MF A01, July 1982, 66 pp.

The commission assigned soil loss estimates via the Universal Soil Loss Equation to 1,300 acres of land reclaimed by four mining companies using row crops. Tables were prepared indicating the level of compliance obtained with nine hypothetical crop rotation and tillage method combinations, based on the Perry County, IL erosion central standards for 1995. State-of-the-art soil management methods applied to reclaimed soils were shown to be adequate for acceptable sediment and erosion control.

274. Green, B. B. Biological Aspects of Surface Coal Mine Reclamation, Black Mesa and San Juan Basin. Argonne Natl. Lab. ANL/AA-10, Aug. 1977, 56 pp.

This report discusses case study reclamation data from the Black Mesa Mine in Arizona and the Navajo Mine in the San Juan Basin in New Mexico. Edaphic factors, such as soil characteristics, soil amendments, and topsoil storage and handling, are discussed, along with data on the soils and their characteristics. The vegetative communities at the minesites are described, along with cover and production data. Previous reclamation practices at the mines are briefly outlined, as is ongoing research. This is a good introduction to reclamation problems and practices in the southwestern coal mining areas.

275. Green, J. E., and D. H. Graves. Planning for Postmining Land Use. Paper in 1981 Symposium on Surface Mining Hydrology, Sedimentology, and Reclamation (Lexington, KY, Dec. 7-11, 1981). Univ. KY, Lexington, KY, 1981, pp. 171-173.

This is a general article which presents successful reclamation projects that the authors believe could be used as models for reclamation specialists. Coal regions are characterized by their natural environmental qualities, and the postmining land uses are listed by type. Pastureland and grazingland were not included in this presentation.

276. Greenslade, W. M. Protecting Alluvial Valley Floors. Dames & Moore Eng. Bull., No. 52, Aug. 1980, pp. 27-32.

This article provides a good review of the portions of the Surface Mining Control and Reclamation Act of 1977 that pertain to alluvial valley floors in the Western United States. The author discusses potential impacts and general mitigative approaches of mining near alluvial valley floors.

277. Groenewold, G. H., and B. W. Rehm. Instability of Contoured Surface Mined Landscapes in the Northern Great Plains: Causes and Implications. Reclam. Reveg. Res., v. 1, No. 2, 1982, pp. 162-176.

The focus of this research was on the stability characteristics of postmining landscapes at the Indian Head Mine in western North Dakota. Three types of instability have been observed in reclaimed postmining landscapes: (1) areawide settling, (2) localized subsidence or collapse, and (3) piping. The instrumentation in this study was designed to monitor the movement of surface materials and the hydrologic conditions at the site. Concrete survey markers were utilized to monitor both horizontal and vertical displacements. Water levels in piezometers were monitored to determine the hydraulic conductivity of the spoils. Gamma-gamma and gamma-density logs were obtained for each piezometer to delineate blocky and poorly consolidated zones in the spoils. Monitoring of the markers indicated that very little spoil movement had occurred; maximum vertical displacement did not exceed 5 in and no significant horizontal displacement was found. The authors state that areawide settlement occurred prior to instrumentation. Piezometer data indicated that the base of the spoils are saturated over 70 pct of the site. The results of this study indicate that the design of stable postmining landscapes require the integration of the following factors: (1) detailed knowledge of the distribution of overburden materials with emphasis on the delineation of highly sodic sediments, (2) proper equipment selection, and (3) consideration of climatic factors.

278. Grogan, S., C. L. Caldwell, O. J. Estrada, and W. Skeet. Conventional Wisdom in 1975 and the Real World in 1978 in Surface Mine Reclamation at the Navajo Mine. Paper in Ecology and Coal Resource Developent, Volume 1 (based on the Int. Congr. for Energy and the Ecosystem, Univ. ND, Grand Forks, ND, June 12-16, 1978). Pergamon, 1979, pp. 427-430.

The authors describe the evolution of the reclamation program at the Navajo Mine operated by Utah International, Inc., in northwestern New Mexico on the Navajo Indian Reservation. The "conventional wisdom" of 1975, under which the original mine plan including the reclamation program was devised, is compared to the reclamation process as it existed in 1977. Revegetation problems and their potential solutions are discussed. Much of the information is covered in a cursory manner. However, the paper may be of interest to individuals concerned with reclamation planning in the southern portions of the Rocky Mountain Coal Mining Region.

279. Grossnickle, S. C., and C. P. Reid. The Use of Ectomycorrhizal Conifer Seedlings in the Revegetation of a High Elevation Mine Site. Can. J. For. Res., v. 12, 1982, pp. 354-361.

This article reports the results of a combined greenhouse and field study that evaluated the potential use of ectomycorrhizal fungi inoculated conifers in high-elevation mine site revegetation. Lodgepole pine (Pinus contorta Dougl.), limber pine (Pinus flexlis James), and Engelmann spruce (Picea engelmannii Parry), were inoculated with the ectomycorrhizal fungi Pisolithus tinctorius (Pers.) Coker & Couch., Suillus granulatus (L. exfr.) Kuntze, and Cenococcum geophilum Fr. These, along with uninoculated control seedlings, were grown in a greenhouse for 8 months. Top height, diameter, and seedling total dry weight were greater for those conifers inoculated with S. granulatus and the control. These were then outplanted on a high-elevation molybdenum tailing pond covered with deep-mine waste rock at a site near Empire, CO. Four fertilizer treatments together with sewage sludge and wood chips were incorporated into the study. After 4 years in the field, S. granulatus-inoculated seedlings showed greater height growth. Greater height growth was obtained with the sewage sludge and wood-chip treatment than with the three treatments of combined inorganic N and P, P alone, and no fertilization. While this article is not directly related to revegetation of surface coal mines, the general paucity of mycorrhizal studies in the literature at this time necessitates inclusion of articles such as this that provide results that may find application in surface coal mine reclamation. For the evaluation process the article has been listed under the Rocky Mounain Coal Mining Region. However, the article adds to the basic knowlege of mycorrhizal associations and techniques for assessing them. As such, the article is nonregional.

280. Grove, J. H., and V. P. Evangelou. Colloid Exchange Phase Dynamics and Saline Spoil Management. Paper in 1982 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Dec. 5-10, 1982). Univ. KY, Lexington, KY, 1982, pp. 387-390.

The value of added colloid exchangers in reducing soluble salt levels in limed, formerly acid, pyritic coal spoil from western Kentucky was evaluated. Two different experiments were conducted using the limed spoil. In the first experiment 1 g each of sand, topsoil, subsoil, aluminum-saturated soil clay, calcium-saturated soil clay, and hydrogen-saturated cation exchange resin (AG 50W-X10), and 0.5 g each of wheat straw, corn stalks, aluminum-saturated peat, and calcium-saturated peat were added to 10 g of limed spoil material. In the second experiment 5 g of each of the above exchangers (except for wheat straw and corn stalks) were mixed with 5 g of the limed spoil material. In each experiment (amendment to spoil ratios of 1:20, 1:10, and 1:1) the mixtures were suspended in water and changes in solution chemistry (pH, Ca, Mg) were determined relative to an inert sand control mixture. In experiment 1 the corn stalks and wheat straw caused solution Ca and Mg to rise above control levels. This is probably due to a chelating action of soluble organic anions released from these materials. All other amendments reduced soluble Mg levels, with aluminum-saturated exchangers being more effective than the calcium-saturated materials. The ion-exchange resin was the most effective at controlling soluble salts. By increasing the ratio of amendment to spoil from 1:10 to 1:1, the average solution Ca and Mg removed increased from 5.6 pct to 34.9 pct. Even though the exchanger materials may not reclaim the entire soil profile, they do bring about a better seed zone chemical environment, which should accelerate vegetation establishment.

281. Grove, J. H., and V. P. Evangelou. Modeling Water Quality During Salty Spoil Suspension Events. Paper in 1983 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Nov. 27-Dec. 2, 1983). Univ. KY, Lexington, KY, 1983, pp. 349-353.

The authors describe a model used to predict the solution phase chemistry of sulfate-dominated colloid systems; it had been tested on pyritic spoil from western Kentucky that had been amended with calcitic and magnesitic liming materials. Liming produced spoils with a wide range of sulfate chemistry. Lime and unlimed spoil response to wetting was determined using water-to-spoil ratios of 1:1, 2:1, 5:1, and 20:1. Soluble cations (calcium and magnesium) in the solution phase were then determined. The suspensions ranged widely in their solution phase composition and properties. An evaluation was made of the ability of the model to predict solution composition upon dilution (wetting) or concentration (drying) of the solution. It was found that predicting the magnesium concentration was dependent on an estimate of the expansion of the exchange phase on clay colloid surfaces or changes in the selectivity of adsorption between calcium and magnesium with increasing salt strength. The authors conclude that the modeling of the three-phase system (solution, adsorbed, and solid) with salts of different solubilities is dependent on the interaction of the colloid-exchange phase with the surroundings.

282. Grove, J. H., and V. P. Evangelou. The Role of Lime in Salty Spoil Genesis. Paper in 1982 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Dec. 5-10, 1982). Univ. KY, Lexington, KY, 1982, pp. 1-4.

This incubation study was conducted to determine the quantity, type, and rate of sulfate salt release from acid pyritic spoil from western Kentucky as affected by lime rate and source. The study was conducted with 500-g portions of spoil and both calcitic and dolomitic limes. The lime rates used were 0, 14.4 meq/100 g (one-half the lime requirement for potential acidity control), and 28.8 meq/100 g (full lime requirement for potential acidity control. Amended spoils were maintained at 30° C and 100-cm moisture tension. Spoils were sampled 1, 9, and 16 weeks after liming, and air-dried; soluble-salt formation was determined by suspending a sample in water at a soil solution ratio of 1:20 for 2 h. The pH of unamended spoils dropped quickly, from 4.8 to 3.2 after 9 weeks of incubation. Of the other treatments only dolomite, applied at half the lime requirement, failed to maintain the initial pH level. Soluble magnesium sulfate doubled in the unlimed spoils between weeks 1 and 16. However, all lime-amended spoils, except for the highest rate of calcitic lime, released larger quantities of soluble salts than unamended spoil material. Dolomite-amended spoils generated twice as much magnesium salt as calcite-amended spoils. Calcite lime, therefore, was the most effective at reducing the soluble magnesium release. When used at the recommended rate, calcite lime reduced salt genesis. The authors recommended that dolomite not be used on sandy spoils with high pyrite content.

283. Guernsey, J. L., L. A. Brown, and A. O. Perry. Integrated Mined-Area Reclamation and Land Use Planning. A Case Study of Surface Mining and Reclamation Planning: Georgia Kaolin Company Clay Mines, Washington County, Georgia. Volume 3C in Integrated Mined-Area Reclamation and Land Use Planning. Argonne Natl. Lab. ANL/EMR-1, v. 3C, Feb. 1978, 122 pp.

This report is one in a 10-volume series prepared by the Energy and Environmental Systems Division of Argonne National Laboratory and the Resource and Land Investigations (RALI) Program of the U.S. Department of Interior under the sponsorship of the U.S. Geological Survey. The reclamation practices of Georgia Kaolin's American Industrial Clay Co. division, a kaolin producer centered in Twiggs, Washington, and Wilkinson Counties, are examined in this case study. The mining of kaolin in Georgia illustrates the effects of mining and reclamation of lands disturbed by surface mining typical of this area. Reclamation of these mined lands is regulated in accordance with the Georgia Surface Mining Act of 1968. The environmental disturbances and procedures used in reclaiming the mined lands are reviewed, and implications for planners are noted. Several aspects of the reclamation work are reviewed, including spoil characterization, vegetative species performance, operational cost, and the development of a reclamation plan. This document specifically addresses reclamation of kaolin-mined lands in Georgia. However, with judicious consideration the information relayed by this document might be applied to the planning of reclamation activities over a broader geographical area, including portions of the Eastern and Gulf Coast Coal Mining Regions recognized in this evaluation process.

284. Guernsey, J. L., M. E. Tiller, and J. R. LaFevers. Integrated Mined-Area Reclamation and Land Use Planning. A Case Study of Surface Mining and Reclamation Planning: Area Strip Coal Mining, Peabody Universal Mine, Universal, Indiana. Argonne Natl. Lab., ANL/EMR-1, v. 3D, Feb. 1977, 54 pp.

This study is concerned with land reclamation at Peabody Coal Co.'s Universal Mine near Terre Haute, IN. This site was chosen because it posseses many of the characteristics common to both midwestern and western coal mines. Included in the paper are sections on the physiographic setting, climate, hydrology, soil, and land use of west-central Indiana. There is also a section on the history of mining and reclamation along with operation procedures used at Universal Mine. The objectives of the reclamation operation at Universal Mine are grading the topsoil, providing water impoundments and access roads, and reestablishing a vegetative cover. Restoring the land to row crop prodūction is the most common form of interim and future land use in the area. Grasses and legumes are the plant species most often used; no tree plantings have been included in the reclamation efforts at Universal Mine. Estimated reclamation costs are included in this paper. Long-range "higher uses" for the area include the possible development of the area for housing and recreation sites due to the demand for these types of land use in the Terre Haute area. The authors feel that a well-designed reclamation plan should include both an interim and long-range plan. By linking the two in an orderly manner, disturbed land would be out of production for a minimum period before it is brought to its highest possible long-term use.

285. Guldin, R. W., and J. P. Barnett (eds.). Proceedings of the Southern Containerized Forest Tree Seedling Conference (Savannah, GA, Aug. 25-27, 1981). U.S. For. Ser. South. For. Exp. Sta., New Orleans, LA, GTR-SO-37, June 1982, 160 pp.

This publication contains numerous research papers specifically dealing with the use of containerized tree seedlings for reestablishment of trees in the Southeastern United States. Major topics covered by these papers include (1) the selection of appropriate containers, (2) nursery production practices, (3) planting methods and stand establishment techniques, and (4) field performance of container-grown seedlings. Individuals concerned with reestablishmennt of tree species on land disturbed by surface coal mining will find this publication a valuable reference. Information presented is primarily relevant to the southern half of the Eastern and the western portion of the Gulf Coast Coal Mining Regions.

286. Gulliford, J. B. Incorporating Orphaned Mine Spoil Reclamation Into the Mining Plan. Paper in Ecology and Coal Resource Development, Volume 1 (based on the Int. Congr. for Energy and the Ecosystem, Univ. ND, Grand Forks, ND, June 12-16, 1978). Pergamon, 1979, pp. 353-357.

This paper discusses the results of a study to incorporate orphaned mined land into current surface coal mine reclamation adjacent to these abandoned spoils. The author reports that such efforts are economically feasible but contingent on the ability to handle toxic material at the site, on the availability of nontoxic overburden to topsoil leveled mine spoils, and on common ownership of the land to be mined and reclaimed. The study was conducted in south-central Iowa. However, the approach could probably find application in other coal mining areas of the United States as well.

287. Hale, A. M. Reclamation in the Eastern U.S. Dames & Moore Eng. Bull., No. 52, Aug. 1980, pp. 33-40.

The author provides a general and relatively nontechnical review of reclamation and revegetation efforts on surface-coal-mined lands in the Eastern and Interior Coal Mining Regions. Postmining land use defines the direction that all other factors in the reclamation program must take. Topics considered in the article include (1) the importance and use of overburden analyses, (2) surface and ground water analyses, (3) soil analyses and vegetation inventories, (4) topsoil stockpiling and treatment, (5) consideration of localized climatic conditions, and (6) the establishment and maintenance of vegetation. The article provides good background information that could be helpful to individuals with little or no experience in mineland reclamation.

288. Hall, A., and W. A. Berg. Prediction of the Sodium Hazard in Coal Mine Overburden. Reclam. Reveg. Res., v. 2, No. 3, 1983, pp. 191-204.

This research was conducted to determine the sodium absorption ratio (SAR)-exchangeable sodium percentage (ESP) relationship in samples of fresh and weathered overburden collected from North Dakota and Colorado. These relationships were then compared to the SAR-ESP relationship commonly used to predict possible sodium problems in soils. The overburden samples collected were subjected to four different weathering treatments for 16, 64, or 224 days. The weather treatments used consisted of (1) air-dry, (2) field capacity, (3) wet-dry, and (4) cropped. With weathering there were statistically significant decreases in the ESP and SAR with corresponding increases in soluble calcium. The most effective treatment in reducing sodicity was the wet-dry weathering treatment. It was found that the ESP in most of the samples taken was overestimated from measured SAR values when the SAR-ESP relationship (developed by the U.S. Salinity Laboratory) was used. The authors recommend that ESP should be determined on overburden samples that have SAR values approaching problem levels.

289. Hall, G. F. Classification of Five Types of Strip Mine Spoil and Implications for Reclamation. Paper in Fifth Symposium on Surface Mining and Reclamation (NCA/BCR Coal Conf. and Expo IV, Louisville, KY, Oct. 18-20, 1977). Nat. Coal Assoc. and Bit. Coal Res., Inc., 1977, pp. 1-3.

This paper describes five soil series proposed during soil mapping in Belmont and Noble Counties, OH, that are made up of strip mine spoil material with lithology ranging from limestone to acid sandstone and shale. Recognition of distinct soil series representing spoil materials through the application of mapping and descriptive methods employed in the National Cooperative Soil Survey Program will allow for the identification, classification, delineation, and interpretation of distinctly different types of spoil material. Once identified and delineated, information gained from reclamation research and experience can be transferred to other areas with similar soils. While the soils and associated data described in this report are specific for southern and eastern Ohio, the approach is relevant nationwide.

290. Hall, R. B. Land Reclamation With Trees in Iowa. Paper in Trees for Reclamation (Lexington, KY, Oct. 27-29, 1980). U.S. For. Ser., Gen. Tech. Rep. NE-61, 1980, pp. 45-47.

The author reviews the findings of studies done on old spoil areas and the current research being conducted on surface mine spoils in Iowa. Several potential determinants of what tree species could be planted were identified and included soil, pH, soil moisture availability, soil compaction, nutrient cycling, and mycorrhizal establishment. The tree species found to be adapted to a variety of site conditions were green ash (Fraxinus pennsylvanica Marsh.) and cottonwood (Populus deltoids Marsh.). When soil moisture and pH were not the limiting factors to tree establishment, nitrogen and phosphorus were. The following tree species were recommended under nitrogen-deficient conditions: European black alder (Alnus glutinosa (L.) Gaertn), black locust (Robinia pseudoacacia L.) and 'Arnot' bristly locust (Robina fertilis Ashe). Phosphorus deficiency problems could be reduced if trees were inoculated with the appropriate mycorrhizal associator. A current study is being conducted using European alder and hybrid poplar (Populus alba × Populus grandidentata.). The establishment of tree plantations on surface-mined land is an alternative to the reclamation of sites for row-crop production.

291. Hallman, R. G. Six Equipment Items for Revegetating Surface-Mined Lands. Paper in Proceedings: High Altitude Revegetation Workshop No. 5 (CO Water Resourc.

Res. Inst., Fort Collins, CO, Mar. 8-9, 1982). CO State Univ., Fort Collins, CO. Infor. Ser. No. 48, Dec. 1982, pp. 41-49.

The author describes six equipment systems developed by the U.S. Forest Service Missoula Equipment Development Center for use in revegetating surface-mined land in the arid and semiarid west. The systems described include (1) the dryland plug planter, designed to automatically plant containerized trees and shrub stock, (2) the tree transplanter, designed to transplant small trees and large shrubs that grow naturally in the vicinity of the minesite to the revegetation area, (3) the dryland sodder, which transfers large plugs of native topsoil from the mine area to the reclamation area with minimal disturbance to the soil profile and structure or to the vegetation, (4) the sprigger, designed to undercut and gather sprigs and/or portions of rhizomatous stem that can then be planted on reclamation areas, (5) the basin blade, which can be used to scoop out large depressions along slopes, where moisture can accumulate to provide microsites favorable for plant growth, and (6) the Hodder gouger designed to create numerous depressions in the soil surface to accumulate moisture, reduce wind and water erosion, and thus promote plant establishment. The equipment described was being field-tested when this article was written.

292. Halvorson, G. A., S. W. Melsted, S. A. Schroeder, M. W. Pole, C. M. Smith, and E. Deibert. Root Zone Soil Management in North Dakota. Coal Mine Reclamation. Paper in Symposium on Adequate Reclamation of Mined Lands? (Billings, MT, Mar. 26-27, 1980). Soil Conserv. Soc. America and WRCC-21, 1980, pp. 26-1 to 26-13.

First-year results of a field study conducted at the Fairkirk Mine near Underwood, ND, are reported. The study is designed to examine variations in wheat yields (Triticum aestivum L.) with varying depths of topsoil, addition of a lift composed of low salt material, and compaction. Subsidence was also measured. Wheat yields were improved by greater depth of topsoil and addition of a low-salt second-lift material. Compaction of the overburden by scrapers reduced wheat yields. After 1 year, subsidence was almost equal on compacted and noncompacted plots. The initial data presented indicate that land reclaimed with sandy overburden may require deeper topsoil or the addition of low-salt second-lift material to achieve maximum yields in western North Dakota. Since this article is somewhat of a status report, conclusions were withheld pending incorporation of data from subsequent years. Wheat yield and characterization data are presented that could be of use in comparison studies and in reclamation planning.

293. Hamon, W. R., and R. R. Kraspe. Preliminary Research on Potential Reclamation of Oil Shale Mined Lands in Kentucky. Paper in 1981 Eastern Oil Shale Symposium Proceedings (Lexington, KY, Nov. 15, 1981). Inst. for Min. and Miner. Res., Lexington, KY, 1982, pp. 55-81.

This study investigated the reclamation potential of oil-shale-mined land in Kentucky. Assessments were made on the potential for establishing vegetation using the available soil and overburden, the use of processed oil shales to improve the physical properties of soil high in clay materials, and the treatments and species needed to establish an adequate vegetative cover. The physical and chemical properties were determined for the materials studied, soil, overburden, and oil shale. Macronutrients and micronutrients found in the raw shales were generally within the limits of those found in soils. A growth chamber study was used to test vegetative response on soils, overburden, oil shale, and admixtures (1/2 soil + 1/2 oil shale and 1/2 overburden + 1/2 oil shale). Perennial ryegrass (Lolium perenne L.) was the species chosen for this part of the study. The vegetative responses (biomass) to the two admixtures were not significantly different. However, the yields obtained from the admixture treatments were generally larger than yields from either the overburden or the soil alone. Admixtures apparently improve infiltration and water retention properties of the soil and overburden while retaining nutrients, pH, and soluble salts at desirable levels.

294. Hardaway, J. Bond Release Criteria. Paper in Symposium on Adequate Reclamation of Mined Land? (Billings, MT, Mar. 26-27, 1980). Soil Conserv. Soc. America and WRCC-21, 1980, pp. 34-1 to 34-4.

The author presents a concise discussion of the three-phase approach to the release of performance bonds practiced by the U.S. Office of Surface Mining, regulating coal mining operations on Federal land. Release of bonds occurs in varying percentages when (1) backfilling, grading, and topsoil replacement are complete, (2) establishment requirements for revegetation are met, and (3) all surface coal mining and reclamation operations are completed, including achievement of an approved alternative land use. The discussion is extensively referenced to the Surface Mining Control and Reclamation Act of 1977.

295. Hargis, N. E., E. F. Redente, W. E. Sowards, and D. G. Steward. Eliminating Biomass Sampling as a Requirement for Evaluating Revegetation Success By Predicting Biomass From Cover. Paper in Symposium on Western Coal Mining Regulatory Issues: Land Use, Revegetation, & Management (West. Reclam. Group, Denver, CO, Apr. 1982). CO State Univ., Range Sci. Dep., Fort Collins, CO, Sci. Ser. No. 35, Aug. 1983, pp. 93-96.

The authors examine the possibility of eliminating biomass as a requirement for evaluating revegetation success in instances where cover and biomass production are significantly correlated. A brief review of pertinent literature revealed that cover can be a fair to good predictor of biomass but that predictions vary in reliability. This variability is due to differences in vegetation growth form, species composition, stage of maturity, range site, and method of sampling. The authors feel that when comparing vegetation of similar growth form and utility between a reclaimed area and a reference area, such differences can be held relatively constant. Consequently, given the specifications set forth in regulations for references areas and revegetated areas, biomass on a revegetated area should not significantly differ from that on a corresponding reference area; thus collecting both cover and biomass data would lead to redundant conclusions and needless added expense. Field testing of this hypothesis was not conducted. The discussion offered in this article merits consideration when designing revegetation monitoring programs. While the article was written with special reference to the Western United States, it could find applications nationwide.

296. Harju, H. J. Reclamation for Wildlife - The Wyoming Viewpoint. Paper in Symposium on Adequate Reclamation of Mined Land? (Billings, MT, Mar. 26-27, 1980). Soil Conserv. Soc. America and WRCC-21, 1980, pp. 25-1 to 25-7.

This article contains a general discussion of principles and methods applicable to reclaiming surface-mined land to meet the needs of wildlife. Diversity of habitat, topography, and vegetation are stressed. The author suggests that the postmining topography reflect pre-mining contours by incorporating rock piles, snags, brush piles, nesting boxes, nesting platforms, and sections of highwall to introduce irregularities into the reclaimed terrain. Plant species selection should stress a variety of native plant species keyed to particular site conditions. The article is useful to provide background information for individuals with little or no experience in wildlife biology, wildlife habitat management, and reclaiming surface-mined land to meet these needs. The article focuses on conditions primarily encountered in the Northern Great Plains Coal Mining Region.

297. Harrison, J. E. Summer Soil Temperature as a Factor in Revegetation of Coal Mine Waste. Paper in Report of Activities, Part A. Geol. Sur. of Canada, Ottawa, Canada, Paper 77-IA, 1977, pp. 329-332.

This article reports the results of field studies conducted in the Crowsnest Pass area of Alberta and British Columbia, Canada. Cursory observation seemed to indicate that high summer soil temperatures were an important factor in revegetation. The investigations examined the composition of the coal waste to be revegetated; the variation of surface temperature with time, aspect, slope elevation, and depth; moisture conditions in the coal waste; thermal properties; and the implications of these data to revegetation efforts. The author recommends establishment of grasses prior to the planting of trees and shrubs to reduce thermal injury. The results and discussion contained in this report may be applicable through the United States, particularly to the Northern Great Plains Coal Mining Region.

298. Harrison, W., and A. Van Luik. Suitability of Dredged Material for Reclamation of Surface-Mined Land. Argonne Natl. Lab. AUL/ES-73, Dec. 1979. 138 pp.

The main objective of this study was to demonstrate the feasibility of using dredged material to reduce acid surface runoff and drainage from coal mine spoils near Ottawa, IL. A second objective was to promote the use of dredged material in enhancing land degraded by surface mining. Four test plots were constructed and consisted of a control and three treatment plots that received a 0.9-m covering of dredged material. Two of the treated plots received lime. All plots were seeded to grass species. The migration of chemical compounds and metals, present in the dredged material, and their effects on water quality were monitored. Appendices contain detailed information on climatic conditions, spoil characterization, and spoil monitoring. This detailed study found that the dredged material did not adversely affect the water quality of the area. The dredged material supported plant growth, decreased ground water contamination, and controlled acid runoff. One problem with the study was that no measurement of the vegetation was made, only visual evaluations.

299. Harthill, M., and C. M. McKell. Ecological Stability--Is This a Realistic Goal for Arid Land Rehabilitation? Paper in Ecology and Coal Resource Development, Volume 2 (based on the Internat. Congr. for Energy and the Ecosystem, Univ. ND, Grand Forks, ND, June 12-16, 1978). Pergamon, 1979, pp. 557-567.

The paper provides an excellent review of the underlying ecological principles inherent in reclamation and revegetation activities. The authors examine portions of Public Law 95-87 in light of these ecological principles. This article is general in content. However, it provides an excellent overview and perspective of revegetation aims and regulations as they apply to the environmental conditions unique to the arid and semiarid regions of the Western United States. This article is relevant to reclamation planning in the Northern Great Plains and Rocky Mountain Coal Mining Regions recognized in this evaluation process.

300. Harwood, G. D., and J. Anderson. Recent Advances in the Selection and Enhancement of Plant Materials: Applications for Native Plants to Revegetate Arid Mined Lands. Paper in 1981 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Dec. 7-11, 1981). Univ. KY, Lexington, KY, 1981, pp. 39-43.

This article discusses the potential for solving revegetation problems in the arid regions through the modification of plants rather than the more traditional approach to mined-land revegetation, surface modification of the site. By using tissue cultures of certain native plant species and selecting for, at the cellular level, natural or induced genetic resistances to toxic conditions, native plants are developed which express selected characteristics. Some of the desirable characteristics would be increased tolerance to drought, salinity, and toxicity. The potential benefits from the development of resistant native strains would be lower revegetation and site maintenance costs.

301. Harwood, G. D., T. R. Verma, and J. L. Thames. Coal Mine Reclamation Problems and Practices in the Southwestern United States. Paper in Stability in Coal Mining (Proc. of the First Int. Symp. on Stability in Coal Mining, Vancouver, B.C., 1978). Miller Freman Pub., Inc., San Francisco, CA, 1979, pp. 430-437.

The authors provide a general discussion of the problems and practices of surface coal mine reclamation in Southwestern United States. Their discussion is centered around experiences gained from reclamation efforts at the Black Mesa Mine in northeastern Arizona. While few or no data are provided for the individual topics covered, the discussions will be useful to individuals with limited knowledge of the problems specific to reclamation of surface-coal-mined lands in this region of the United States.

302. Haufler, J. B., R. L. Downing, and B. S. McGinnes. Factors Influencing the Revegetation Success of Orphan Mines in Southwest Virginia. Paper in Symposium on Surface Mining and Fish/Wildlife Needs in the Eastern United States. (WV Univ., Dec. 1978). U.S. Fish and Wildlife Serv. FWS/OBS-78/81, 1978, pp. 287-293.

This article discusses selected site factors that influence natural revegetation on orphan mines in southwestern Virginia. Only mined areas without any type of reclamation were considered for this study. Percent cover was determined for 712 quadrats (1 m^2) and the vegetation less than 1 cm in diameter rooted within the quadrat was clipped. Two soil samples were also taken from the center of each quadrat for analysis. One sample was taken from the surface (top 2 cm) and the other from a depth of 20 cm. The soil analysis indicated that the surface soil nutrient and pH levels correlated with the nutrient and pH levels of the deep samples. The authors feel that pH levels could possibly be used as a quick indication of nutrient levels in the soil. Soil potassium was found to be the best indication of total percent cover; as surface potassium (ppm) increased, percent cover increased. Soil pH levels were found to be the best indicator of percent bare ground. As the pH decreased below 5.0, soil pH became more influential on percent bare ground. The authors concluded that potassium levels should be examined carefully if the long-term goal of reclamation is to return the mine to a natural state.

303. Hauser, V. L. Grass Establishment: New Directions. Paper in Vegetative Rehabilitation and Equipment Workshop 36th Annual Report (Denver, CO, Feb 4-5, 1982). U.S. For. Ser. Equip. Dev. Cent., Missoula, MT, 1982, pp. 54-59.

This research was conducted to find new, more effective rangeland or pastureland seeding methods, more likely to achieve success than the present systems. Three different grass establishment methods were tested: (1) punch planting-seeds placed in the bottom of a hole that is deeper than normal, (2) transplanting, and (3) planting germinated seeds. The results indicate that planting germinated seeds was the easiest and most rapid method that could be developed for commercial use. However, transplanting has the greatest probability for successful grass establishment. Transplants are big enough and vigorous enough to overcome dry surface soil, high temperature, wind, insects, rodents, and weed competition. There is, however, a need to develop efficient mechanization if transplants are to be used in large-scale grass establishment. Even though this research was conducted on noncoal lands, it has direct application to the establishment of range or pasture species on surface-mined land.

304. Haynes, R. J. Natural Vegetation Development on a 43 Year Old Surface Mined Site in Perry County, Illinois. Paper in 1983 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Nov 27-Dec. 2, 1983). Univ. KY, Lexington, KY, 1983, pp. 437-466.

An evaluation of the natural revegetation development on a 43-year-old ungraded surface mined site in Perry County, IL, was made, and the vegetation was compared to that of an adjacent unmined oak-hickory forest. Herbaceous, shrubby vegetation and tree seedlings less than 6.6 cm Dbh were sampled on the mine site along transects. Of interest were (1) species composition, (2) number of stems per species, (3) frequency of occurrence, and (4) species distribution relative to position on the spoil banks. Trees greater than 6.6 cm Dbh on mined and unmined land were sampled for (1) relative frequency, (2) relative density, (3) relative dominance, and (4) importance value. Sixty-one species of ground cover, comprising 19 families, were recorded and included 5 annuals, 4 biennials, and 52 perennials. The most common families were Gramineae, Poaceae, Compositae, Leguminosae, and Rosaceae. When compared to the data collected 22 years after mining there had been a decline in the number of annuals and an increase in the number of perennials. Sixteen species of trees were recorded on the mined land, with 73 pct occurring in valleys and on lower slopes. When compared with the adjacent oak-hickory forest, the mined site had little similarity in species composition. Density and basal area were 61 and 59 pct, respectively, of those found on the natural forested site. The mined site resembled a southern floodplain or mesic forest type. The author concluded that the rate of succession on the mined site is suppressed. It is hypothesized that the primary factors limiting succession are the dense shrub and herbaceous vegetation, which may restrict the establishment of tree species, and the lack of an available seed source for the heavy seeded species, oak (Quercus spp.) and hickory (Carya spp.), at an appropriate time for establishment. The author concludes that the most reasonable management alternative available for this site is to allow succession to continue on its own.

305. Haynes, R. J. The Surface Mining Control and Reclamation Act of 1977 and Potential Impacts on Fish and Wildlife. Paper in Proceedings of the Thirty-Second Annual Conference, Southeastern Association of Fish and Wildlife Agencies (Hot Springs, VA, Nov. 5-8, 1978). S.E. Assoc. Fish and Wildlife Agenc., 1978, pp. 790-796.

This paper provides an interpretaion of the Surface Mining Control and Reclamation Act of 1977 with special reference to fish and wildlife. The author states that fish and wildlife will continue to be adversely affected by surface mining. These impacts will be due mainly to losses of specific habitat types and changes in land use following mining and reclamation which result in post-mining changes in habitat type. The discussion also includes the abandoned mine program that was at the proposal stage at the time of the writing of this article. This article takes a broad, nationwide view. It has been included in the current bibliography for its historical value.

306. Haynes, R. J., and J. M. Klopastek. Reclamation of Abandoned Mine Lands and Fish and Wildlife Mitigation Needs. Paper in The Mitigation Symposium: A National Workshop on Mitigating Losses of Fish and Wildlife Habitats (CO State Univ., Fort Collins, CO, July 16-20, 1979). U.S. For. Ser. Rocky Mount. For. and Range Exp. Sta., GTR RM-65, 1979, pp. 256-263.

This paper reviews methods for taking inventory of abandoned coal-mined lands. Habitat evaluation methods are briefly discussed. Criteria and planning strategies are discussed to ensure that fish and wildlife values are considered in the development and implementation of reclamation plans. This paper specifically deals with the abandoned coal mine portions of the Surface Mining Control and Reclamation Act of 1977 and the Rural Abandoned Mine Program (RAMP). While the article was written from a nationwide perspective, the experience of the authors was primarily gained through involvement with RAMP in Tennessee.

307. Haynes, R. J., G. K. Rutherford, and G. W. Van Loon. Metal Contaminants in Surface Soils and Vegetation as a Result of Nickel/Copper Smelting at

Coniston, Ontario, Canada. Reclam. Reveg. Res., v. 2, No. 2, 1983, pp. 123-137.

Soil and vegetation present near a nickel-copper smelter in Coniston, Ontario were sampled along a 12-km transect to determine the metal concentrations present. Two sites not influenced by the smelting operation (reference areas) were also sampled. The results of the study show that the smelting operations have contaminated the surface soils with nickel, copper, and iron at levels higher than are normally found in uncontaminated soils. Maximum levels found in the surface soils for nickel, copper, and iron were 1.2, 0.97, and 23.0 pct, respectively. Distance from the smelter, soil organic carbon content, and amount of erosion were the major factors in determining nickel, copper, and iron concentrations along the transect. Erosional processes have transported a large amount of contaminated surface materials to new locations. The only heavy metal that was above the normal range for plant tissue concentration was nickel found in foliar samples of tickle grass (Agrostis scabra Willd.) and paper birch (Betula papyrifera Marsh). A regression analysis indicated that tissue concentrations for tickle grass correlated with soil metal concentrations. This was not the case for paper birch. The authors conclude that the major problems associated with successful establishment of vegetation in the Coniston area are the surface soil physical and chemical properties.

308. Heale, E. L., and D. P. Ormrod. Effects of Nickel and Copper on Seed Germination and Growth and Development of Seedlings of Acer Ginnala, Betula Papyrifera, Picea Abies, and Pinus Banksiana. Reclam. Reveg. Res., v. 2, No. 2, 1983, pp. 41-54.

Nickel and copper are the predominant components of particulate fallout from a smelter located in the Sudbury Basin, Ontario, Canada. A controlled environment experiment was conducted to determine some of the effects of toxic levels of nickel and copper on the germination, growth, and development of amur maple (Acer ginnala Maxim.), paper birch (Betula papyrifera Marsh.), Norway spruce (Picea abies (L.) Karst), and jack pine (Pinus banksiana Lamb). Seeds of each species were planted in pots containing silica sand, and seven treatments were established using full-strength Hoagland's nutrient solution with $NiSO_4$ added as the Ni^{2+} source and $CuSO_4$ as the Cu^{2+} source. As the seeds germinated, visual observations were recorded every day for the first 2 weeks and every 2 or 3 days thereafter. Each seedling, if it survived, was harvested after 40 days. Cotyledon, leaf, and needle development of the species tested were affected by increasing the metal levels in the solution. There were also alterations in the pigmentation and distortions in the orientation and morphology of the cotyledons, leaves, and needles. The roots were stunted and thicker in diameter with increased metal concentrations. There were also fewer secondary lateral roots present. The germination of pine seeds was not significantly affected by the Ni^{2+} and Cu^{2+} treatments, but seedling survival was directly related. Jack pine survival was least affected by the treatments. Growth and development responses to toxic metal levels also differed among species. As the concentration of nickel and copper increased, there was a corresponding reduction in the surface areas of plant parts and seedling dry weights. The authors conclude that in order for the reclamation of metal-contaminated areas to be successful, the seeds of native species must be collected to determine if insensitive strains exist and if they are able to survive the elevated metal loadings.

309. Heilman, P. Effects of Surface Treatment and Interplanting of Shrub Alder on Growth of Douglas-fir on Coal Spoils. J. Environ. Qual., v. 12, No. 1, 1983, pp. 109-113.

This study investigated the effects that surface bedding and interplanting of Sitka alder (Alnus sinuata (Reg.) Rydb.) had on the growth of Douglas fir (Pseudotsuga menziesii (Mirb.) Franco var. Menziesii) planted on the Centralia coal mine in southwestern Washington. Bedding was used as an alternative to grass cover and consisted of alternate ridges and furrows placed across the slope. The treatments consisted of (1) contour bedding with planted Douglas fir, (2) interplanting Douglas fir with Sitka alder on bedded spoil, (3) a control planting of Douglas fir with Sitka alder on bedded spoil, and (4) a control planting of Douglas fir that was unbedded and not interplanted with Sitka alder. The results indicate that topsoil that had been contour bedded significantly increased the growth, foliar nitrogen content, and resistance to wind for 5-year-old Douglas fir. Poor growth due to nitrogen deficiency was reported for trees grown on unbedded sites. By interplanting with Sitka alder on bedded spoil, an increase in Douglas fir growth occurred, but the growth increase was not statistically significant. The author concludes that based on the low nitrogen status of trees on control plots, interplanting with Sitka alder is expected to benefit the growth of Douglas fir planted on surface mine spoil.

310. Hemler, D. A., and D. E. Samuel. Aspen Propagation on Abandoned Surface Mines and Use by White-Tailed Deer. Paper in Third Annual Conference on Better Reclamation With Trees (cosponsored by AMAX Coal Co., Purdue Univ., South. IL Univ., and Madisonville Comm. Coll ., Terre Haute, IN, June 2-3, 1983). Purdue Univ., West Lafayette, IN, 1983, pp. 48-55.

Mature bigtooth aspen (Populus grandidentata Michx.) on 29 plots established on an unreclaimed surface mine in northern West Virginia were cut during late winter to stimulate ramet propagation. Root suckers grew on 26 plots with an average of 64 ramets per plot (0.8 suckers/m^2). An average of 18.3 stump suckers were recorded on these plots. At the end of the growing season the mean height of the root suckers was 25 cm, and the radius of clone expansion averaged 4.3 m. Track counts, pellet group counts, and browse survey were conducted to determine utilization by white-tailed deer. From the track data, it appeared that deer do not frequent surface mines during the winter months. The use of the mine during the winter months appeared to remain constant before and after cuts. Ninety-two pct of the total 2,140 suckers were browsed during the summer months by deer. This summer browse data suggests that deer will use aspen suckers heavily in West Virginia when available. This paper provides silvicultural and deer browse information pertinent to reclamation planning in the Eastern Coal Mining Region. The information might find application over a slightly broader geographical area with prudent consideration of site, climate, and species characteristics.

311. Hendrix, J. W. Nursery Techniques for Production of Tree Seedlings Infected With Specific Mycorrhizal Fungi for Surface Mine Reclamation. (Contract G 1115212, Dept. of Plant Path., Univ. KY, Dec. 20, 1982). BuMines, OFR 39-83, 1983, 45 pp.

This publication reports the results of a study conducted in western and eastern Kentucky. A survey of orphan coal mine lands in these areas found a great diversity of endomycorrhizal fungi species present. Endomycorrhizal fungi isolated from orphan mines stimulated growth of sweetgum seedlings (Liquidambar styraciflua L.) on minesoil at low fertilization, but inhibited growth at high fertilization. To produce mycorrhizal sweetgum seedlings, incorporation of the fungal inoculum throughout the growth medium was superior to sidebanding. A procedure for isolation of single-spore cultures of endomycorrhizal fungi was developed. The study included a demonstration of a method for producing large numbers of bareroot pine seedlings infected with Pisolithus tinctorius for use in mine land reclamation. The information contained in this report will be useful to individuals planning surface mine reclamation projects and research in portions of the Eastern and Interior Coal Mining Regions.

312. Hennessy, G. G. Response of a Grass and Shrub Seeding Mixture on Various Soil Treatments on Strip-Mined Land in the Southwest. Ph. D. Thesis, NM State Univ., Las Cruces, NM, 1981, 230 pp.

This study evaluated the establishment and productivity of a grass and shrub mixture using different soil treatments at Utah International's San Juan Mine near Farmington, NM. The effects of ripping and furrowing on plant growth was also evaluated. Additional information on the effects of various soil treatments on aboveground and belowground growth of fourwing saltbush (Atriplex canescens (Pursh) Nutt.) was obtained from both the field study and a greenhouse study. The field test was conducted on a shale spoil material using four different topsoil treatments. The plots were seeded with a mixture of six grasses and one shrub, fourwing saltbush. Grass production, frequency, density, and cover measurements were taken on the grass species. Fourwing saltbush height and weight measurements were taken over a 2-year period. The test site was irrigated the first 2 years, and soil water content, available water, infiltration, bulk density, and soil water retention were measured. In a greenhouse, soil columns and root boxes were used to collect root and top growth data. Field and greenhouse results indicated that topsoiling was beneficial to plant growth. Water content at various depths was greater on nonripped treatments than ripped treatments. Ripping showed no beneficial effects on plant growth. This report presents an excellent background discussion on revegetation of coal mined lands in the arid portions of the Western United States. The discussion of test results is thorough and extensive. Data are given on all measured parameters.

313. Henning, S. J., and T. S. Colvin. Management of Reclaimed Surface-Mined Lands for Row Crop Production. Paper in Fifth Symposium on Surface Mining and Reclamation (NCA/BCR Coal Conf. and Expo IV, Louisville, KY, Oct. 18-20, 1977). Nat. Coal Assoc. and Bit. Coal Res., Inc., 1977, pp. 298-305.

The authors discuss the criteria used to develop a restoration plan suitable for row crop farming as part of the Iowa Coal Project Demonstration Mine situated approximately 9 miles south and west of Oskaloosa, IA. Results are presented for the first-year studies, where corn (Zea mays L.) and soybeans (Glycine max (L.) Merr.) were grown on a restored portion of the Demonstration Mine. It was concluded that row crops can be grown with moderate success the first year after restoration. To accomplish this, good seedbed preparation is required that may require heavier than normal farm tillage implements and seed planters. Minimum-tillage or zero-tillage row cropping machinery may be suitable. An agricultural subsoiler proved to be superior to a bulldozer ripper because the latter increased the difficulty of preparing a good seedbed. The authors feel that the difficulty will eventually diminish, but the need for deep tillage will continue until large, well-developed root systems are obtained consistently. This article is pertinent to reclamation planning in the Interior Coal Mining Region.

314. Henry, D. S., W. F. Kuenstler, and S. A. Sanders. Establishment of Forage Species on Surface Mined Land in Kentucky. J. Soil Water Conserv., v. 36, No. 2, Mar.-Apr. 1981, pp. 111-113.

Eight forage species were seeded on the surface mine spoil of two eastern and western Kentucky mine sites. Tall fescue (Festuca arundinacea Schreb.), caucasian bluestem (Andropogon caucasicus Trin.), big bluestem (Andropogon gererdii Vitman), indiangrass (Sorghastrum nutans (L.) Nash), switchgrass (Panicum virgatum L.), crownvetch (Coro- nilla varia L.), and two different lespedezas (Lespedeza spp.) were seeded by various methods. After 3 years there was no difference in plant response due to establishment method at either site. The most consistent stands at both sites resulted from caucasian bluestem, seeded alone. In western Kentucky switchgrass performed as well as the caucasian bluestem, and all warm-season grasses outperformed their counterparts in eastern Kentucky. Legume response was better in the eastern site than in the west. Rainfall and soil pH were primarily responsible for the regional differences.

315. Hensley, D., D. McLaren, and R. Daniels. Establishment of Christmas Trees on Mined Land Using Herbicides. Reclam. Reveg. Res., v. 1, No. 4, 1982, pp. 383-385.

This study determined the feasibility of using preplanting and postplanting herbicides for establishing pine as a crop on vegetated mined land. Four herbicide treatments were used: (1) control, (2) 1.6 pct solution of glyphosate (preplanting), (3) glyphosate + 8.96 kg/ha oryzalin (postplanting), and (4) glyphosate + 1.70 kg/ha simazine (postplanting). The 2-0 Scotch pine (Pinus sylvestris L.) were planted after the glyphosate had been applied. Scotch pine survival was significantly greater in the herbicide treatments than in the control. All three herbicide treatments resulted in comparable survival percentages: 83.3 for the glyphosate alone, 80.0 for glyphosate + oryzalin, and 80.0 for glyphosate + simazine. The best weed control was found for the glyphosate + oryzalin treatment; however, it was not statistically different from other herbicide treatments. The authors conclude that the use of preplanting non-selective herbicides will reduce competition from existing vegetation and that the application of preemergent herbicides will aid in maintaining control. This system provides a feasible and economical method for the establishment of pines for Christmas tree production on reclaimed mine land.

316. Hensley, D. L., H. Sparks, and G. R. Brown. Survival of Blackberries on Mined Land. Reclam. Reveg. Res., v. 2, No. 3, 1983, pp. 237-240.

This study evaluated the survival and growth of commercial blackberry (Rubus spp.) cultivars planted as root sections on mined land in eastern Kentucky. The blackberries were planted during 1979 and 1980, and the following cultivars were used: Comanche, Cheyenne, Cherokee, and Darrow thorny blackberries. For the 1979 planting no statistically significant differences in survival or cane growth were found. However, in the 1980 plantings the survival of the Comanche cultivar was significantly greater than that of either the Darrow or Cherokee cultivars. No statistically significant differences were found in cultivar cane growth for the 1980 plantings. For the two plantings cane growth was generally good regardless of cultivar. Growth generally improved with increased management.

317. Herricks, E. E., A. J. Krzysik, R. E. Szatoni, and D. J. Tazik. Best Current Practices for Fish and Wildlife on Surface Mined Lands in the Eastern Interior Coal Region (U.S. FWS contract 14-16-0009-79, Dep. Civil Eng., Univ. of IL). U.S. Fish and Wildlife Serv. FWS/OBS-80/68 May, 1982, 212 pp.

This document identifies and reviews some best current practices (BCP) which are available for the reclamation of fish and wildlife resources on lands mined for coal in the Eastern Interior Coal Region (EICR). A BCP is defined as a technique or method that reflects the best technology or state-of-the-art currently available for surface mine reclamation for the fish and wildlife component. Two general types of BCP's are identified. The first includes reclamation procedures based on ecological principles or fish and wildlife management practices. The second type includes reclamation practices regularly used by mine operators in the EICR developed through operational experience and demonstration. This review of BCP's includes sections on site preparation activities and methods for fish and wildlife restoration, maintenance, or enhancement. Information on surface preparation includes sections dealing with topographic development, preparation of the land surface for vegetation development, and protection of the surface from erosion. Procedures that affect water chemistry and physical configuration (including stream channel characteristics) have received particular attention owing to their role in development and maintenance of water quality. This document was developed to help surface coal mine operators identify and implement the BCP's for protecting and improving fish and wildlife resources on their minesites during both the active coal extraction and post-mining phases of their operations. It will also be useful to agencies for fish and wildlife management, technical assistance agencies, and land owners. BCP information is presented in a form that will facilitate direct incorporation of the procedures into mining and reclamation activities. This document is designed to be a user-oriented handbook. Consequently, much of the theory supporting the BCP's have been omitted, concentrating instead on providing information on applying the BCP's to particular situations. Technical references are listed at the end of each practice that provide background and theoretical basis for the development of the techniques. This handbook provides an excellent source of information for planning reclamation in the eastern portion of the Interior Coal Region.

318. Hersman, L. E., and K. L. Temple. ATP as a Parameter for Characterizing Coal Strip Mine Spoils. Soil Sci., v. 126, No. 6, 1978, pp. 350-352.

Adenosine triphosphate (ATP) concentrations were used in this study as a means of assessing microbial activity of strip mine spoils and native soils (reference area) near Colstrip, MT. A modification of Bancroft, Wieke, and Paul's procedure was used to extract ATP from the soil samples. ATP concentrations were highest in the surface samples (0-4 in), middepth samples (5-8 in) had intermediate values, and the bottom samples (9-12 in) had the lowest concentration. The average ATP concentration was higher for the native range soil than for the spoil material. With increasing depth, the difference in ATP concentration between spoils and native soils became more significant. The ATP concentration in spoil decreased faster than in the native soil. The authors concluded that it was possible to differentiate the two soil systems by comparing ATP measurements.

319. Hersman, L. E., and K. L. Temple. Comparison of ATP, Phosphatase, Pectinolyase, and Respiration as Indicators of Microbial Activity in Reclaimed Coal Strip Mine Spoils. Soil Sci., v. 127, No. 2, 1979, pp. 70-73.

The authors collected soil samples from reclaimed coal strip mine spoils in Montana in 1975 and 1977 and analyzed them for Andenosine Triphosphate (ATP), respiration, phosphatase and pectinolyase. Although soil microbial activity correlated to some extent with each parameter measured, ATP was the most satisfactory measurement. ATP is more expensive to measure due to reagent cost, but the authors recommended this method over the others because it correlates better and is a fast procedure not requiring long incubation periods.

320. Hersman, L. E., and D. A. Klein. Retorted Oil Shale Effects on Soil Microbiological Characteristics. J. Environ. Qual., v. 8, No. 4, 1979, pp. 520-524.

This laboratory study was conducted to investigate the effects of retorted oil shale additions on the microbiological characteristics of surface soils. Paraho retorted oil shale from Rifle, CO, was mixed with native northwestern Colorado soils. Five soil-shale treatments were used: (1) 100 pct soil (control), (2) 95 pct soil-5 pct shale, (3) 9 pct soil-10 pct shale, (4) 75 pct soil-25 pct shale, and (5) 100 pct shale (control). The microbiological parameters of interest were nitrogen fixation, dehydrogenase activity, oxygen utilization rates, glucose mineralization, ATP concentrations, and microbial counts for the bacteria, actinomycetes, and fungi present. Of the microbial parameters tested, nitrogen fixation was most affected by the retorted oil shale. This suggests that nonsymbiotic nitrogen fixation in surface soils may be sensitive to the presence of oil shale. Dehydrogenase activity, ATP concentrations, C-glycose mineralization activity, oxygen utilization, and fungal populations were also significantly decreased by retorted oil shale. Bacterial and actinomycete populations were not significantly affected by the presence of up to 25 pct by weight of retorted oil shale. The authors concluded that it would be necessary to assure sufficient surface soil is used to cover retorted oil shales for development and functioning of a diverse vegetative microbiological community.

321. Hill, R. D., K. R. Hinkle, and M. C. Apel. Reclamation of Pyritic Waste. U.S. EPA Municipal Environ. Res. Lab., EPA-600/D-82-340, 1982, 22 pp.

Laboratory and greenhouse studies and a full-scale demonstration project were conducted to examine the reclamation of land used for the disposal of pyritic waste with sewage sludge. Some of the mining waste had a pH as low as 1.8, and copper and zinc contents as high as 10 mg/g and 2 mg/g, respectively. Good grass growth was supported, and the quality of the leachate generated improved when mine waste was treated with sewage sludge, agricultural limestone, and fertilizer in column studies. In 1976, reclamation was initiated on 8 ha of disturbed mine land. By 1982, fair to good vegetative cover had been established on over 90 pct of the area. Yearly maintenance has been required on the more toxic areas to assure success of the vegetation. Maintenance includes addition of fertilizer and limestone, and in the worst area irrigation during drought periods. Weeping lovegrass (Eragrostis curgula (Schrad.) Nees) and Ky-31 fescue (Festuca elatior (L.) var. arundinacea (Schreb.) have been the most successful vegetation. The field studies reported were conducted at the Sulphur and Boyd Smith deep shaft pyrite mines along Contrary Creek in Louisa County, VA. The procedures and results may be applicable to reclamation efforts on other material having similar physical and chemical characteristics throughout the Eastern and in portions of the Interior and Gulf Coast Coal Mining Regions.

322. Hiller, R. M., and D. H. Graves. Relative Effectiveness of Some Coal Mine Refuse Revegetation Techniques: Leachate Quality. Paper in 1981 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Dec. 7-11, 1981). Univ. KY, Lexington, KY, 1981, pp. 377-383.

The paper evaluates direct liming and seeding of herbaceous species as an alternative for reclaiming coarse refuse areas in central Illinois. The effectiveness of these methods is based on comparisons between direct-limed and seeded areas, soil-covered and seeded areas, and untreated areas. Tension lysimeters were installed, and the leachate samples were analyzed for the presence of plant nutrients, phytotoxic elements, conductivity, and pH. It is recommended that direct liming and seeding not be used as a sole treatment on unweathered refuse due to oxidation and acid production. Direct liming and seeding would best be used on prelaw refuse areas that have undergone seasonal cycles of weathering, oxidation, acidification, and leaching. This environment can maintain an effective equilibrium between limestone neutralization and acid production.

323. Hinckle, C. R., R. E. Ambrose, and C. R. Wenzel. A Handbook for Meeting Fish and Wildlife Information Needs to Surface Mine Coal - OSM Region I. (U.S. FWS contract 14-16-0009-79-092, Sci. Applic., Inc.) U.S. Fish and Wildlife Serv. FWS/OBS-79/48.3.1, Feb. 1981, 381 pp.

This handbook is one volume in a five-volume set. Each provides information pertaining to consideration of fish and wildlife resources in the premining, mining, reclamation and compliance phases of surface mining. Methods and sources for obtaining the information necessary to satisfy State and Federal regulations are suggested. Specifically this handbook contains suggestions for: locating sources of fish and wildlife information, describing fish and wildlife on a mine site and permit area, analyzing mining impacts on fish and wildlife, establishing postmining land uses and reclamation objectives, mitigating negative impacts on fish and wildlife, identifying ways to enhance fish and wildlife on the permit area, and monitoring and complying to obtain bond release. Emphasis is placed on providing assistance to operators in enhancing fish and wildlife resources during the postmining use of the land. Suggestions concerning selected species and habitat management are given, with fish and wildlife as either the primary or the secondary land use. Several appendices are included to provide information on agency contacts, technical references, and sources of plant materials for revegetation specific for this region. This document provides an excellent framework for developing reclamation plans. It was designed to provide assistance to coal mine operators, landowners, and other parties involved in planning for the protection and/or enhancement of fish and wildlife resources during the surface mining process. This report has been rated "excellent" or "good" for numerous keywords used in the evaluation process. This rating system has been applied somewhat differently for this report. Since this document is a handbook suggesting general procedures for identifying information needs and obtaining that information rather than reporting an actual field study, the rating represents the treatment of these subject areas within the framework of the handbook. All land use designations considered in this evaluation process are considered with particular reference to fish and wildlife needs. The information provided is largely specific to OSM Region I, which correlates to the northern portions of the Eastern Coal Mining Region.

324. Hinckle, C. R., R. E. Ambrose, and C. R. Wenzel. A Handbook for Meeting Fish and Wildlife Information Needs to Surface Mine Coal--OSM Region II (U.S. FWS contract 14-16-0009-79-092, Sci. Applic., Inc.). U.S. Fish and Wildlife Serv. FWS/OBS-79/48.3.2, Feb. 1981, 368 pp.

The comments and evaluation contained in the annotation for a similar handbook in this series (Sec item 323) also apply here. However, the information provided in this volume is largely specific for OSM Region II, which correlates to the southern portion of the Eastern, the extreme southwestern portion of the Interior and the eastern portion of the Gulf Coast Coal Mining Regions.

325. Hinckle, C. R., R. E. Ambrose, and C. R. Wenzel. A Handbook for Meeting Fish and Wildlife Information Needs to Surface Mine Coal--OSM Region III. (US FWS contract 14-16-0009-79-092, Sci. Applic., Inc.). U.S. Fish and Wildlife Serv. FWS/OBS-79/48.3.3, Feb. 1981, 367 pp.

The comments and evaluation contained in the annotation for a similar handbook in this series (Sec item 323) also apply here. However, the information provided in this volume is largely specific for OSM Region III, which correlates to the central portion of the Interior Coal Mining Region.

326. Hinckle, C. R., R. E. Ambrose, and C. R. Wenzel. A Handbook for Meeting Fish and Wildlife Information Needs to Surface Mine Coal--OSM Region IV (US FWS contract 14-16-0009-79-092, Sci. Applic., Inc.). U.S. Fish and Wildlife Serv. FWS/OBS-79/48.3.4, Feb. 1981, 363 pp.

The comments and evaluation contained in the annotation for a similar handbook in this series (see item 323) also apply here. However, the information provided in this volume is largely specific for OSM Region IV, which correlates to the western portions of the Interior and the Gulf Coast Coal Mining Regions.

327. Hinckle, C. R., R. E. Ambrose, and C. R. Wenzel. A Handbook for Meeting Fish and Wildlife Information Needs to Surface Mine Coal--OSM Region V (US FWS contract 14-16-0009-79-092, Sci. Applic., Inc.). U.S. Fish and Wildlife Serv. FWS/OBS-79/48.3.5, Feb. 1981, 405 pp.

The comments and evaluation contained in the annotation for a similar handbook in this series (sec item 323) also apply here. However, the information provided in this volume is largely specific for OSM Region III, which correlates to the Northern Great Plains, Rocky Mountain, and Pacific Mining Regions.

328. Hodder, D. T., and R. C. Jewell (eds.). Reclaimability Analysis of the Emery Coal Field, Emery County, Utah. EMRIA Rep. No. 16 (U.S. BLM contract YA-512-CT9-32, Geoscientific Systems and Consulting). U.S. Bureau Land Manag., Final Report BLM/YA/EM-77/16, Aug. 1979, 413 pp.

This report examines the reclaimability of coal-strip-mined land in the Emery, UT coal field. Data collected in the study covered the geology, overburden, hydrology, climate, and vegetation of the area. Site specific problems relevent to revegetation that were identified included a lack of available topsoil, a potential excess of boron, and a general nutrient deficiency in the overburden. The use of fly ash and/or bottom ash from local powerplants was recommended as both a geochemical soil supplement and a mulch. The report provides data obtained from both pertinent literature and site-specific investigations. Much of the data and discussions are specific for the study area. However, prudent consideration may allow application over a broader geographic area.

329. Hodder, R. L. Alternatives to Established Systems for Meeting Post-Mining Land Use Goals. Paper in Symposium on Western Coal Mining Regulatory Issues: Land Use, Revegetation, & Management (West. Reclam. Group, Denver, CO, Apr. 1982). CO State Univ., Range Sci. Dep., Fort Collins, CO, Sci. Ser. No. 35, Aug. 1983, pp. 23-25.

The author provides an excellent overview of some recognized problems in the current rules and regulations governing revegetation and control of erosion on reclaimed coal mined lands in the Western United States. Directions for potential changes in guidelines and regulations are offered based on contemporary research results. The author recommends increased use of proven naturalized species that might better satisfy postmining reclamation in less time at less expense. This article was written with specific reference to reclamation activities in the Western United States. However, some of the concepts presented could have nationwide applications.

330. Hodder, R. L. Potentials and Predictions Concerning Reclamation of Semiarid Mined Lands. Ch. in The Reclamation of Disturbed Arid Lands. Univ. NM Press, 1978, pp. 149-154.

The author discusses several aspects of revegetation that must be considered if reclamation is to be successful in the semiarid West. One of the most important aspects of reclamation is preplanning, which is one of the best guarantees for a successful revegetation program. Also discussed is the need for a stable and productive surface. This can be achieved through surface manipulations and the planting of indigenous species. Effective management is the key to long-term reclamation success; without it achievement of satisfactory revegetation will be temporary. The author concludes that long-term reclamation success will be possible only if the designs and purposes of reclamation are ecologically sound and fulfill a real economic need, in addition to meeting the obligations and requirements of the governing regulations.

331. Hoffard, W. H., and R. L. Anderson. A Guide to Common Insects, Diseases and Other Problems of Black Locust. U.S. For. Serv., Forestry Rep. SA-FR 19, Oct. 1982, 9 pp.

This publication gives information about the common insect pests and diseases that infect black locust (Robinia pseudoacacia L.). The information will be helpful to individuals attempting to propagate black locust on surface-mined land in portions of the Eastern and Interior Coal Mining Regions.

332. Hofmann, L. and R. E. Ries. Comparison of Vegetative Composition, Cover, and Production on Reclaimed and Nonmined Grazed Lands. Paper in Symposium on Adequate Reclamation of Mined Land? (Billings, MT, Mar. 26-27, 1980). Soil Conserv. Soc. of Amer. and WRCC-21, 1980, pp. 27-1 to 27-10.

This paper reports the results of a grazing study conducted near Center, ND, comparing vegetative production, composition, and cover, as well as animal performance on reclaimed strip-mined land to that obtained on nonmined grazing land. Equal or higher dry matter yields were obtained on moderately, lightly, and ungrazed pastures on reclaimed mined land. Spring and early summer performance of yearling steers grazing on reclaimed pastures at moderate or light intensities was equal to that obtained on unmined pastures. Live plant cover was less on reclaimed land than on native range. However, live vegetation plus litter on reclaimed sites was equal to or better than on native range, and cover on both areas was sufficient to prevent soil loss as calculated by the Universal Soil Loss Equation. When cover was estimated using only live-plant basal hits in point frame sampling, neither the reclaimed nor the native sites had sufficient cover to prevent unacceptable soil loss. This paper is an excellent reference for planning revegetation monitoring programs in the Northern Great Plains Coal Mining Region.

333. Hofmann, L., R. E. Ries, and R. J. Loren. Livestock and Vegetative Performance on Reclaimed and Nonmined Rangeland in North Dakota. J. Soil Water Conserv., v. 36, No. 1, 1981, pp. 41-44.

This study compared the effects of heavy, moderate, and light grazing intensity on vegetation and steer performance on a revegetated area and an adjacent nonmined area (reference area). The study site was located near Center, ND. The criteria used to make the comparison were animal performance, vegetative production, vegetative composition and diversity, and plant and canopy cover. The comparisons between the reclaimed and unmined sites showed that the productivity of the reclaimed site was comparable to that on unmined land, indicating a successful reclamation program.

334. Hofmann, L., R. E. Ries, J. F. Power, and R. J. Lorenz. Effects of Grazing Intensity on Vegetation and Animal Performance on Reclaimed Strip-Mined Land. Paper in Fifth Symposium on Surface Mining and Reclamation (NCA/BCR Coal Conf. and Expo IV, Louisville, KY, Oct. 18-20, 1977). Nat. Coal Assoc. and Bit. Coal Res., Inc., 1977, pp. 306-310.

This study examined the effects of grazing on reclaimed strip-mined land near Center, ND. A mixture of cool season grasses and legumes was seeded on the study site 3 years before the study began and it was not harvested prior to the study. Three intensities of grazing were tested (heavy, moderate, and light) by stocking duplicate sets of pastures at 0, 0.24, 0.48, and 0.72 ha/yearling steer. During 1976, 3,734 kg/ha dry matter was produced on the ungrazed control. The 1976 grazing season was 55 days long, and 80, 44, and 32 pct of the forage was grazed at the heavy, moderate and light grazing intensities, respectively. In 1977 the grazing season was 30 days, and the heavily grazed pasture was left with significantly less dry matter than the other treatments. When grazing stopped, no harvestable forage remained on the heavily grazed pastures. Daily weight gains on heavily grazed pastures averaged 0.4 kg/head as compared with 0.9 kg/head on the moderately and lightly grazed pastures. In 1977 beef production was 55, 58, and 41 kg/ha for the heavily, moderately, and lightly grazed pastures, respectively. The article is pertinent to reclamation planning where grazing land is the designated land use and is primarily relevant to conditions encountered in the Northern Great Plains Coal Mining Region.

335. Holechek, J. L. Initial Establishment of Four Species on a Mine Spoils. J. Range Manage., v. 34, No. 1, Jan. 1981, pp. 76-77.

Greenhouse and field studies are reported. The objective of these studies was to evaluate initial establishment of 'Fairway' crested wheatgrass (*Agropyron cristatum* (L.) Gaertn.), 'Critana' thickspike wheatgrass (*Agropyron dasystachzum* (Hook) Scribn.), 'Ranger' alfalfa (*Medicago sativa* L.), and fourwing saltbush (*Atriplex canescens* (Pursh) Nutt.). All four species exhibited good initial establishment in both studies. Postemergence fertilization with nitrogen and phosphorus had no effect on the survival of any of the species tested. The information presented in this paper is relevant to revegetation planning in portions of the Northern Great Plains Coal Mining Region.

336. Holechek, J. L. Root Biomass on Native Range and Mine Spoils in Southeastern Montana. J. Range Manage., v. 35, No. 2, Mar. 1982, pp. 185-187.

An examination of root biomass was conducted at five locations in the vicinity of Colstrip, MT. Study sites included native range in excellent, good, and poor conditon; a naturally revegetated 40-year-old leveled, ungrazed strip mine spoil; a 5-year-old leveled, ungrazed strip mine spoil; and a 5-year-old seeded and fertilized mine spoil. The 5-year-old seeded and fertilized mine spoil exhibited the highest total root biomass. Native range in good condition had higher root biomass than either the excellent or poor condition native range. The root biomass of the 40-year-old mine spoil and the native range in excellent condition were not significantly different. Root biomass distribution did not differ between the sites, with over 55 pct of the biomass in the upper 15 cm of the soil profile. The results of this study will be applicable to assessing grazing options on revegetated surface-mined land in the Northern Great Plains Coal Mining Region.

337. Holecheck, J. L., E. J. DePuit, J. G. Coenenberg, and R. Valdez. Legume Establishment on Strip Mined Lands in Southeastern Montana. J. Range Manage., v. 35, No. 3, May 1982, pp. 298-300.

This article reports the results of a 6-year study conducted on strip-mined land at Colstrip, MT, in which the germination, survival, productivity, and cover characteristics of five species and/or varieties of legumes were evaluated. These included 'Eski' sainfoin (Onobrychis viciaefolia Scop.), 'Lutana' cicer milkvetch (Astragalus cicerl.), birdsfoot trefoil (Lotus corniculatus L.), and 'Ranger' and 'Spreader' alfalfa (Medicago sativa L.). Low rates of nitrogen and phosphorus fertilizer were applied during the first year of the study. 'Lutana' cicer milkvetch and both varieties of alfalfa exhibited good characteristics for the parameters evaluated. 'Spreader' alfalfa was superior to the 'Ranger' variety. Based on the observed site stabilization, persistence, palatability, nitrogen fixation, and productivity characteristics the authors felt that 'Latana' cicer milkvetch has high potential for use in revegetating surface-mined land in this geographic region. The information presented in this paper is useful for selecting species for revegetating surface-mined land throughout portions of the Northern Great Plain Coal Mining Region.

338. Holechek, J. L., E. J. DePuit, J. Coenenberg, and R. Valdez. Long-Term Plant Establishment on Mined Lands in Southeastern Montana. J. Range. Manage., v. 35, No. 4, July 1982, pp. 522-525.

This article reports the results of a 6-year study conducted on strip-mined land at Colstrip, MT in which the germination, survival, and cover characteristics of 'Fairway' crested wheatgrass (Agropyron cristatum (L.) Gaertn.), 'Critana' thickspike wheatgrass (Agropyron dasystachyum (Hook) Scribn.), 'Ranger' alfalfa (Medicago sativa L.), and fourwing saltbush (Atriplex canescens (Pursh) Nutt.) were evaluated. Good initial establishment and long-term survival and growth were exhibited by all species. Initial and long-term survival were unaffected by postemergence fertilization with nitrogen and phosphorus. These fertilizer applications did account for increases in plant canopy and litter cover of the grass and legume species. Invasion by native species into the study area was insignificant. 'Critana' thickspike wheatgrass appears to be well suited for inclusion in seeding mixtures in this area. 'Fairway' crested wheatgrass was too aggressive to be recommended for inclusion in seeding mixtures where the revegetation goal is to achieve species diversity for native species. The results and discussion contained in this article will be helpful in deciding composition of seeding mixtures for revegetating surface mined-lands in portions of the Northern Great Plains Coal Mining Region.

339. Holmberg, G. V., and S. J. Henning. Reclamation. Ch. in Surface Mining Environmental Monitoring and Reclamation Handbook. Elsevier, 1983, pp. 279-369.

This chapter consists of two sections, one by Homlberg and one by Henning. The section by Holmberg entitled, "Land Use, Soils, and Revegetation" provides an excellent treatment of the Surface Mining Control and Reclamation Act of 1977 (Public Law 95-87) and the procedures for adherence to and monitoring under the law. The subjects discussed include the legal requirements for land use, premining land-use planning, postmining land-use monitoring, the legal requirements for soil (other than prime farmland), steps in monitoring topsoil, mine soil interpretation, mine soil evaluation, monitoring and inventory of baseline data for the mining plan, minesoil management, topsoil storage, topsoil redistribution, monitoring the handling of soils and overburden, mine soil analysis after reconstruction, postmining mine soil development, site conditions and animal habitat, factors involved in overcompetition and measurement of compaction, the legal requirements for revegetation, plant species selection, use of introduced species, timing the revegetation process, soil stabilization, livestock grazing on revegetated mined lands, assessment of revegetation success, and soil erosion. As the title of the book implies, its purpose is to act as a handbook for environmental monitoring and reclamation. The chapter reviewed here follows this format. It includes literature reviews for the topics discussed and provides an excellent source for planning monitoring activities and for establishing criteria for assessing proposed reclamation plans. This reference has been rated "good" for numerous keywords used and is designed specifically for broad national application. It suggests approaches to answering questions about some of these subjects; however, it stops short of providing clearcut solutions. It does provide potential sources of pertinent information that could aid in treating specific problems. The section by Henning more specifically discusses prime farmland and factors that must be considered in returning surface-mined areas to crop production. It outlines methods for assessing crop production. A method using available soil survey information of soils present before mining to determine the success of production is presented. Since this section is designed for broad national application, its treatment of most key subject areas is general in nature. However, it provides potential sources of pertinent information that could aid in treating specific problems. The two sections comprising the chapter discussed here provide an excellent source of background information for individuals concerned with compliance to state and Federal regulations controlling reclamation of surface-mined lands.

340. Holt, H. A., and W. D. Schrand. Herbicide Characteristics Adaptable to Reclaimed Mine Land. Paper in Third Annual Conference on Better Reclamation With Trees (cosponsored by AMAX Coal Co., Purdue Univ., South. IL Univ., and Madisonville Comm. Coll., Terre Haute, IN, June 2-3, 1983). Purdue Univ., West Lafayette, IN, 1983, pp. 140-145.

The authors discuss important plant and herbicide factors that must be considered in developing a successful vegetation control program. They present an excellent summary of herbicide characteristics useful for weed control on reclaimed land. Numerous herbicides are reviewed, and their mode of action, mode of application, toxicity range, and persistence are considered. This paper is a good reference for herbicide use in mineland reclamation. It provides useful information for planning reclamation activities. No specific coal region is identified by the authors. The information offered would be applicable in all the coal mining regions considered in this evaluation process and for most lands uses considered.

341. Hons, F. M., P. E. Askenasy, L. R. Hossner, and E. L. Whitelly. Physical and Chemical Properties of Lignite Spoil Material as It Influences Successful Revegetation. Paper in Proceedings Gulf Coast Lignite Conference: Geology, Utilization, and Environmental Aspects (Austin, TX, June 2-4, 1976). Bur. Econ. Geol., Univ. TX, Austin, TX, 1978, pp. 209-217.

This research was done to determine the feasibility of producing agricultural crops on lignite spoil in Freestone County, TX. Of particular interest were the spoil physical and chemical properties which affect revegetation. The spoil material was found to contain adequate amounts of calcium, magnesium, and potassium for sustained plant growth (6,000, 500, and 300 kg/ha, respectively). However, nitrogen and phosphorus must be added to achieve revegetation. The biological oxidation of ammonium to nitrate by nitrification is restricted in these mine soils. This indicates that the use and efficiency of added forms of ammonium fertilizers is restricted. Up to 50 pct of applied nitrogen is unavailable to plants because of the low use efficiency. Of the forage grasses and legumes tested, Coastal bermudagrass (Cynodon dactylon (L.) Pers.), bahiagrass (Paspalum notatum Flugge), kleingrass (Panicum coloratum L.), NK-37 (a nonrhizomatous variety of common bermudagrass), 'Yuchi' arrowleaf clover (Trifolium vesiculosum Savi.), crimson clover (Trifolium incarnatum L.), and alfalfa (Medicago sativa L.) were established successfully in fertility trials. Corn (Zea mays L.), grain sorghum (Sorghum bicolor (L.) Moench.), and soybeans (Glycine max (L.) Merr.) were also established, with grain sorghum being the most promising of the row crops from an economic viewpoint. With proper fertilization and management, the yield potential of forage grasses, legumes, and grain sorghum on mined soil appears to be excellent.

342. Hons, F. M., and L. R. Hossner. Soil Nitrogen Relationships in Spoil Material Generated by the Surface Mining of Lignite Coal. Soil Sci., v. 129, No. 4, 1980, pp. 222-228.

This study was done to quantify the nitrogen relationship of surface-mined soils near Fairfield, TX. Soil samples were taken from spoil materials to a depth of 15 cm from four sites: an area mined in 1972, one mined in 1973, one mined in 1975, and an adjacent unmined site (reference area). Soils were evaluated for nitrification potentials and retention of nonexchangeable ammonium nitrogen. Of the 100 ppm NH_4^+ nitrogen applied, the minesoils nitrified only 7 pct while the unmined site nitrified 93 pct. The low nitrification potentials of the mined sites were attributed to the lack of soil microorganisms and an acidic pH. Mine soils exhibited a large nonexchangeable NH_4^+ nitrogen. Based on this nonexchangeable retention capacity of the soils, the 1972, 1973, and 1975 spoils have a theoretical capacity to convert 2,430, 1,282, and 1,326 kg of NH_4^+ nitrogen, respectively, into a nonexchangeable form. The authors concluded that the conversion of applied NH_4^+ nitrogen to nonexchangeable forms in mine soils, along with their low nitrification potentials, may result in an inefficient use of applied NH_4^+ nitrogen fertilizers and a decreased reclamation potential of planted crop species.

343. Hons, F. M., L. R. Hossner, and E. L. Whiteley. Reclamation and Yield Potential of Various Forages on Surface Mined Soil. Ch. 4 in Reclamation of Surface Mined Lignite Spoil in Texas, ed. by L. R. Hossner. TX A & M Univ. System, Rep. RM-10, 1978, pp. 36-47.

A 3-year study was conducted in Freestone County, TX, to determine the yield potential and fertilizer requirements of grass and legume forages planted on surface coal mine spoils. Grass species included 'NK-37' bermudagrass (Cynodon dactylon (L.) Pers.). bahiagrass (Paspalum notatum Flugge), 'coastal' bermudagrass and kleingrass (Panicum coloratum L.); legumes included 'Yuchi' arrowleaf clover (Trifolium vesiculosum Savi.), crimson clover (Trifolium incarnatum L.), and alfalfa (Medicago sativa L.). Generally, the soil required only N and P fertilization to provide proper nutrients for all test species. Besides moisture, which was found to be a major yield determining factor, N fertilizer had the greatest affect on grass production and P fertilizer affected the legume production more than the N treatment. Kleingrass and Coastal bermudagrass were the highest yielding grasses, and Yuchi arrowleaf clover was the most productive legume in the study. The NO_3^- form of N fertilizer was more effective with grasses than the NH_4^+ form because of higher NO_3^- mobility. It was also more effective in dry years. This article is particularly applicable to Texas, but the procedures used have application nationwide.

344. Howard, C., and S. Regele. Reclamation Monitoring--Its Purpose and Scope. Paper in the Third Biennial Symposium on Surface Coal Mining and Reclamation on the Great Plains (cochaired by the Reclam. Res. Unit, MT State Univ. and U.S. OSM, Billings, MT, Mar. 19-21, 1984). MT State Univ. and U.S. OSM, 1984, pp. 330-334.

The authors discuss the reclamation monitoring program implemented by the Montana Department of State Lands at four of the larger coal mines in eastern Montana. An analysis of the data gathered through this program indicates that the majority of areas reclaimed during the mid-1970's tend to have a vegetative cover dominated by introduced plant species and limited diversity. More recently reclaimed areas appeared to be developing vegetative covers dominated by native species.

345. Howard, G. S., G. E. Schuman, and F. Rauzi. Growth of Selected Plants on Wyoming Surface-Mined Soils and Flyash. J. Range Manage., v. 30, No. 4, July 1977, pp. 306-310.

This greenhouse study was initiated to determine potential plant growth on three surface-mined soils and their overburden materials, and on flyash, under controlled soil moisture and temperature conditions. Topsoil and overburden were collected at three mine sites near Gillete, Hanna, and Shirley Basin, WY, and the flyash was collected from the Dave Johnson power-generating plant at Glenrock, WY. Various combinations of topsoil, overburden, fertilizer, sludge, manure, and flyash were used. Neither the topsoil nor the overburden materials had detrimental effects on plant growth under nonlimiting conditions. Forage plants and range shrubs benefited from the addition of 67 kg/ha nitrogen and/or phosphorus. Additions of sewage sludge or manure also increased the growth of the plant species. This study also indicated that certain mixtures of flyash in soil and sludge can be successfully revegetated.

346. Hughes, T. H., E. A. Cross, F. C. Gabrielson, and D. K. Bradshaw. Some Effects of Spoil Composition and Mulch Types on Erosion in Walker County, AL. Abstract of paper presented at the Meeting of the American Council for Reclamation Research (Univ. AL, Sept. 19-20, 1979). Reclam. Rev., v. 3, 1980, pp. 61-64.

The authors developed this experiment to test the Universal Soil Loss Equation (USLE) on coal strip mine soil. The USLE was developed for common agricultural conditions and was found to greatly underestimate erosion on topsoil and topsoil-shale mixes, but it did predict erosion on shale plots. Mulch treatments (followed by revegetation) included wood fiber, paper-slag, hardwood bark, pine bark, organic compost, and no treatment. The barks provided the best erosion control, but the other mulches provided the best plant growth.

347. Humphries, H. B., and D. O. Meeker. Alternative Systems for Determining Post-Mining Land Use. Paper in Symposium on Western Coal Mining Regulatory Issues: Land Use, Revegetation, & Management (West. Reclam. Group, Denver, CO, Apr. 1982). CO State Univ., Range Sci. Dep., Fort Collins, CO, Sci. Ser. No. 35, Aug. 1983, pp. 6-13.

The problem of determining postmine land use is addressed and some general recommendations on land use and classification are provided. The authors present an analysis of various land classification systems and discuss the relationship of land classification to land use capabilities and the concepts of land use and potential land use. These discussions are presented within the framework of present Federal and state regulations. This paper provides a good reference on land classification and land use that is pertinent to mineland reclamation not only in the North Great Plains and Rocky Mountain Coal Mining Regions, but nationwide as well.

348. Hunt, C. M., and S. P. Shaw. Superior Wildlife Plants for Disturbed Sites. Paper in Addendum to Proceedings of a Symposium on Surface Mining and Fish/Wildlife Needs in the Eastern United States (WV Univ., Apr. 1979). U.S. Fish and Wildlife Serv. FWS/OBS-78/81A, 1978, pp. 119-122.

This paper discusses the need for developing genetically superior plants for wildlife on disturbed sites. The discussion is applicable to both the Eastern and Interior Coal Regions because the species that are used in the genetic screenings are found in both regions. Thirty-four woody plants are rated in terms of importance as food producers for wildlife. Additional advantages to wildlife could be gained through genetic selection and breeding programs of species that are to be used for disturbed site plantings.

349. Hunter, D. H., W. J. Ruzzo, and J. L. Balzer. Reference Areas Versus Historic Record--A Comparative Analysis. Paper in Symposium on Western Coal Mining Regulatory Issues: Land Use, Revegetation, & Management (West. Reclam. Group, Denver, CO, Apr. 1982). CO State Univ., Range Sci. Dep., Fort Collins, CO, Sci. Ser. No. 35, Aug. 1983, pp. 87-92.

This article provides an excellent comparison of two currently available methods for comparing premining and postmining vegetation to determine revegetation success. The reference area and historical record methods were compared by ecological, managerial, and economic criteria. Based on ecological and managerial criteria, the historical record approach was more advantageous. In addition, the extended historical record programs were less costly than all reference area programs. The authors note that the historical records method is constrained by limited sampling flexibility since it requires all vegetation data to be collected using the same sampling methods. This article provides an excellent reference for designing reclamation monitoring programs. It was written with special reference to the Western United States. However, the evaluation presented is applicable nationwide.

350. Hutchinson, T., and A. Kuja. The Use of Acid Tolerant Native Grasses for Reclamation of Mine Tailings. Paper in Ecology and Coal Resource Development, Volume 2 (based on the Int. Congr. for Energy and the Ecosystem, Univ. ND, Grand Forks, ND, June 12-16, 1978). Pergamon, 1979, pp. 1012-1016.

This article describes a greenhouse study to select plant species naturally occurring on extremely acid areas and testing their survivability on tailings from mines in the Yukon and in Sudbury, Ontario. The plants tested were collected from the Smoking Hills area on Cape Bathurst in the Canadian western arctic. These species included tufted hairgrass (Deschampsia caespitosa (L.) Beauv.), alpine sweetgrass (Hierochloe aplina (Sw.) R. & S.), polargrass (Arctagrostis latifolia (R. Br.) Griseb.), Bigelow's carex (Carex bigelowii Torr.), and Aluetian mugwort (Artemisia tilesii Ledeb.). Tailings material had pH values ranging from 1.4 to 9.1. The species were tested for their ability to grow without amendment. Since this is an interim report, no firm conclusions were offered. The results reported indicate that, even on the most unfavorable tailings sites having both high acidity and metal toxicity problems, native species, if carefully selected and tested, could probably be used for revegetation. The species discussed and the results obtained may be specific for Canada and perhaps Alaska. However, the approach would appear valid for application to revegetating problem areas regardless of their location.

351. Hutnik, R. J. Hardwood Regeneration on Disturbed Sites. Paper in 1983 Penn State Forestry Issues Conference Proceedings of "Regenerating Hardwood Stands" (University Park, PA, Mar. 15-16, 1983). PA State Univ., University Park, PA, 1983, pp. 182-189.

This article summarizes recent data on hardwood tree species establishment on strip-mined land in Pennsylvania. The article is divided into three sections and contains information on the invasion of mined land by hardwood species, plantings made on orphan spoil banks, and current reclamation practices in Pennsylvania which utilize hardwood species. The author emphasizes the important role that hardwoods play in revegetating disturbed land in Pennsylvania.

352. Imes, A. C., and M. K. Wali. Governmental Regulation of Reclamation in the Western United States: An Ecological Perspective. Reclam. Rev., v. 1, 1978, pp. 75-88.

This paper provides an interpretation of the Surface Mining Control and Reclamation Act of 1977 in the context of western coal development. The authors focus on the administrative structure and the perfomance standards established by this law. The development of State mining and reclamation regulatory programs and their roles are examined. This article has been included in the bibliography for its value as a historical perspective.

353. Indorante, S. J., and I. J. Jansen. Soil Variability on Surface Mined and Undisturbed Land in Southern Illinois. Soil Sci. Soc. Am. J., v. 45, 1981, pp. 564-568.

Five different reclaimed surface-mined soil units were defined to determine if such lands could be subdivided into relatively homogeneous segments of soil to allow more effective management. These units were compared to three undisturbed soil units. Analysis of variance of selected properties showed more significant differences among the five disturbed sites than among the three undisturbed sites. Variability within the disturbed sites was similar to that within the undisturbed sites. The authors examine the spatial variability of selected minesoil characteristics as applicable to soil mapping. The techniques used and the results discussed would be applicable to similiar studies and in planning reclamation procedures. While the article specifically refers to the study area in southern Illinois, the methods used could be applied nationwide.

354. Industrial Seminars Limited. Reclamation 83, Proceedings of the International Land Reclamation Conference and Exhibition, (Grays, Essex, England, Apr. 26-29, 1983). Industrial Seminars Ltd., Kent, England, 1983, 655 pp.

This publication primarily deals with foreign (non-U.S.) reclamation efforts and policy. It has been included in this bibliography because it provides an excellent overview of reclamation in an international setting. Diverse reclamation problems are included. Two articles are included dealing with reclamation in the United States. In an article by W. B. Schmidt entitled "Experience in the U.S.A. in Identifying and Assessing the Reclamation of Abandoned Mine Lands," aspects of the Surface Mining Control and Reclamation Act of 1977 are discussed including Primacy and the Abandoned Mine Lands Fund. In addition, the current status of the Environmental Impact Statement for the Office of Surface Mining's Abandoned Mine Lands Program and the inventory that supports this EIS are described. In an article by J. S. Griles entitled "Environmental Assessment Process for Mining Coal on Federal Lands in the United States," the requirements and procedures for conducting environmental assessments are discussed. These assessments relate to the selection of tracts of land that are to be offered as coal mining leases, prior to the lease sale and issuance of permits under the SMCRA. The ratings assigned to this publication in the evaluation process refer to the two U.S. articles described above. Ratings were not assigned to the symposium as a whole due to its diverse subject coverage.

355. Institute of Land Rehabilitation, Utah State University. Rehabilitation of Western Wildlife Habitat: A Review (U.S. FWS contract 14-16-0008-2110). U.S. Fish and Wildlife Serv. FWS/OBS 78/86, Dec. 1978, 252 pp.

This publication provides a review of information available from previous research on habitat requirements of key wildlife species and on major, successful land rehabilitation techniques. An attempt has been made to bring this information together in a single source. Synecological and autoecological information about plant species important to the rehabilitation of wildlife habitat is presented in a systems planning format to encourage the incorporation of wildlife habitat and values into the total rehabilitation planning process. This rehabilitation planning process includes predisturbance inventory, identifying goals or objectives, preparing the plan, implementing the plan, postrehabilitation management, and followup assessment. The geographical area considered in this review includes portions of North Dakota, South Dakota, Montana, Idaho, Wyoming, Colorado, Utah, Nevada, Arizona, and New Mexico. Consequently the information and discussions contained in this document are primarily pertinent to the Northern Great Plains and Rocky Mountain Coal Mining Regions considered in this evaluation process.

356. Iverson, L. R. The Role of Pioneering Species on the Reclamation of North Dakota Surface Mined Lands. Ph.D. Thesis, Univ. ND, Grand Forks, ND, 1981, 202 pp.

This study analyzes the initial vegetative succession and associated changes in the minesoil on reclaimed strip-mined sites in western North Dakota. Four reclaimed areas, ranging in age from 1 to 4 years since mining, were studied to quantify the early successional changes in vegetative composition, soil chemistry, and plant chemical composition. The sites all had been contoured, topsoiled, fertilized, and seeded after mining. The sites were compared to a native, mixed grass prairie site in the immediate area. Of the 95 species encountered, summer cyprus Kochia scoparia (L.) Roth.) was the most dominant in the first 2 years after mining. During the third and fourth years, the density of Kochia declined, while planted grass densities increased. Field studies showed that Kochia acted as a nurse crop, while field and growth chamber studies showed that autotoxicity in Kochia appeared to be the main reason for its decline. A bioassay experiment showed that alleochemics were also important in other colonizing species. Experiments with mowing and burning had both beneficial and detrimental effects, depending on when the site was mowed or burned. Analyses of seeds present in topsoils on a grazed site, an ungrazed site, and two stockpiled topsoils showed that most colonizers were not present in the topsoil but came from nearby areas. Seed densities in stockpiled topsoil were very low. This study presents an excellent analysis of what happens to vegetative communities and minesoils during the first 4 years after seeding in western North Dakota.

357. Iverson, L. R., D. Szafoni, and C. Grunnwald. Factors Affecting Revegetation of Northern Illinois Gob Piles: A Case Study at Standard, Illinois. Paper in 1983 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Nov. 27-Dec. 2, 1983). Univ. KY, Lexington, KY, 1983, pp. 255-264.

The authors describe two research studies conducted on barren gob piles near Standard, IL. These studies were conducted in order to better understand the conditions to which plants must accommodate for establishment and survival. A field study was conducted to inventory the plant species present, and to determine gob temperature, moisture characteristics, and chemical characteristics. A greenhouse study was also conducted to characterize and identify plant soil relations. The germination and growth of little bluestem (Andropogon scoparius Michx.), side-oats grama (Bouteloua curtipendula (Michx.) Torr.), 'Ky-31' tall fescue (Festuca arundinacea Schreb.), crownvetch (Coronilla varia L.), and black locust (Robinia pseudoacacia L.), treated in six different ways, were evaluated. The treatments used were (1) gob alone, (2) gob and sand at a 1:1 ratio by volume, (3) gob and sewage sludge at a 1:1 ratio by volume, (4) gob and lime at a lime rate of 1 g/100 g of gob, (5) gob and fertilizer (Miracle-Grow), and (6) gob, fertilizer, and lime. Most of the species present on the gob represent early successional species. Measurements of water potential and temperature of the gob revealed excessively harsh conditions, especially on southern slopes. The chemical analysis of the gob revealed nitrogen, phosphorus, and potassium deficiencies, along with possible iron and aluminum toxicities. However, with proper liming and fertilizer treatments these conditions could be corrected for the species tested in the greenhouse experiment. Black locust responded best to fertilization; for the other species sewage sludge application resulted in the greatest production of biomass. The response of the plant species to treatment can be ranked as follows, from greatest biomass response to least: sewage sludge, fertilizer, lime and fertilizer, lime, and sand.

358. Iverson, L. R., and M. K. Wali. Buried, Viable Seeds and Their Relation to Revegetation After Surface Mining. J. Range. Manage., v. 35, No. 5, Sept. 1982, pp. 648-652.

This article reports the results of a study conducted near Beulah, ND, designed to evaluate the quantity and quality of seeds present in prairie soils prior to surface mining. Four types of sites were used in the study: (1) grazed, (2) ungrazed, (3) 1-year-old stockpiled topsoil, and (4) fresh stockpiled topsoil. Samples were collected from three depths at each site and allowed to germinate in a growth chamber for 16 months. The stockpiled topsoils had very low seed densities. The seed densities on the grazed sites were nearly twice those found on the ungrazed sites. Weed species accounted for 43 pct of the seeds from the grazed sites, compared with 7 pct for the ungrazed sites. Comparisons of seeds in the topsoil (seed banks) and the aboveground vegetation at unmined and mined sites indicated that the seeds of the most prevalent colonizers following reclamation were not present in the topsoil but immigrated into the site. Several species present in the soil bank were not expressed in the aboveground vegetation until 3 or 4 years following reclamation. The results of these studies indicate that both seed dormancy and seed immigration are important in determining vegetation composition on reclaimed minelands following replacement of topsoil. The results and discussion contained in this report are pertinent to revegetation planning and research throughout major portions of the Northern Great Plains Coal Mining Region.

359. Iverson, L. R., and M. K. Wali. Reclamation of Coal Mined Lands. The Role of Kochia Scoparia and Other Pioneers in Early Succession. Reclam. Reveg. Res., v. 1, No. 2, 1982, pp. 123-160.

This study documents the patterns of colonization by pioneering species and their allelopathic and competitive relations on four reclaimed areas, ranging in age from 1-4 years after mining, in western North Dakota. A native mixed grass prairie was used for comparison (reference area). During the first 4 years following reclamation, 30 species had invaded the areas. Despite the seeding of agronomic species, initial colonization was dominated by pioneer species. Summer cypress (Kochia scoparia (L.) Roth.) was the dominant colonizer during the first and second years, followed by green foxtail (Setaria virdis (L.) Beauv.). Russian thistle (Salsola collina Pall.), and black birdweed (Polygonum convolvulus). During the third and fourth years, the density of Kochia aided in the establishment of later successional perennial vegetation by stabilizing the surface material and protecting it from erosion. During the same time period chemical analyses of the soil showed a decrease in EC, and in the concentration of Ca, Mg, Na, Li, Sr, and SO_4. These declines are probably due to leaching. However, total N and organic matter increased over the same time frame. Competition field studies were conducted using Kochia scoparia (L.) Roth. and wheatgrass (Agropyron spp.) Kochia acted as a nurse crop during the first few months of Agropyron spp. establishment. However, by mid summer Kochia began to shade the Agropyron spp. which reduced grass tillering. Autotoxicity studies indicate that the decline in Kochia dominance may be due to the toxicity of decaying Kochia leaves and roots to Kochia. Results of a field study indicated that thinning dense second-year *Kochia* stands to the density of first-year stands did not alter the growth of *Kochia*. Another possible explanation is that nutritional imbalances (P-Mn and P-Zn ratios) may be responsible for the autotoxicity. The results of this study indicate that alleopathy may be partially responsible for determining the fate of early successional species. The authors speculate that the later successional species may be aided by alleopathy since alleochemics inhibited the germination and growth of the initial colonizers.

360. Jackson, C. L. An Update of URAD Mine Reclamation. Paper in Proceedings: High-Altitude Revegetation Workshop No. 5 (CO State Univ., Fort Collins, CO, Mar. 8-9, 1982). CO Water Resour. Res. Inst., CO State Univ., Fort Collins, CO, Inf. Ser. No. 48, Dec. 1982, pp. 79-104.

The author provides an excellent description of the reclamation practices used by AMAX, Inc., at the URAD Mine in the Woods Creek Valley, approximately 50 miles west of Denver, CO. The sequence of revegètating the tailing areas was (1) cover with development rock to the tailing material as a growth medium, (2) landscape with rock to break the uniform flat contour, (3) spread inorganic phosphate fertilizer and wood chips, (4) rip the woodchips and phosphate fertilizer in the surface, (5) spread municipal sewage sludge to act as a source of nitrogen and organic matter, (6) seed with grass, (7) scatter dead timber onto the reclaimed surface, (8) irrigate during the first growing season, (9) plant transplants and seedlings of trees and shrubs during the second season following the establishment of grass, and (10) periodically apply maintenance inorganic fertilizers. Each of these steps is discussed in some detail. Supportive revegetation research is summarized, and heavy metal and toxic chemical uptake by vegetation is discussed. Although the reclamation procedures described were specifically developed for the unique problems present at this mine, some of the procedures could find application in other areas of the country in surface coal mine reclamation, particularly where toxic material presents a particular problem.

361. Jackson, D. Getting the Jump on Mother Nature. Eng. Min. J., Apr. 1979, pp. 128-130.

The author describes the speeded-up propagation of native or indigenous plants by Native Plants Inc., in their custom nursery in Salt Lake City, UT. The company claims 97 pct survival of transplanted woody plants produced from their tissue culture cloning technique. The advantage of this technique in mined land reclamation is best illustrated by a western mining company's order for 100,000 seedlings native to an area of high elevation and extreme cold, for delivery in 6 months. Native Plants delivered, on schedule, in a stage of development equivalent to 3 to 5 years of field growth.

362. Jackson, D. Western Coal Is the Big Challenge to Reclamation Experts Today. Coal Age, v. 82, No. 7, 1977, pp. 90-108.

This article discusses reclamation efforts in the Northern Great Plains, Rocky Mountain, and Gulf Coast Coal Regions. For each region the climate, native soil, native vegetation, reclamation methods, and reclamation costs are given. Also included are specific examples of land reclamation programs within each region. These examples contain information on site preparation techniqes and the equipment used to prepare a site, the plant species and seeding techniques used, and the soil amendments applied to the spoil. The estimated reclamation cost per acre for a particular example is also given. The article provides a good characterization of what reclamation in the Western United States involves and the conditions under which reclamation is accomplished.

363. Jackson, M. R. Wyoming Reclamation and Wildlife Impact Mitigation. Paper in the Third Biennial Symposium on Surface Coal Mining and Reclamation on the Great

Plains (cochaired by the Reclam. Res. Unit, MT State Univ. and U.S. OSM, Billings, MT, Mar. 19-21, 1984). MT State Univ. and U.S. OSM, 1984, pp. 143-147.

The author provides a brief overview of the reclamation laws and wildlife guidelines of Wyoming and how they evolved. Some of the newer techniques showing promising results for the reclamation of wildlife habitat are reviewed. These techniques include rock pile placement and the creation of surface undulations on permanently reclaimed sites, creation of impoundments managed as sport fisheries with guaranteed public access, projects utilizing an off-site location to replace golden eagle nests, the actual moving of trees with intact nests, and the issuance of a research variance to allow a mining company to leave a highwall and develop it as wildlife habitat. While revegetation is treated in only a cursory manner, this paper does provide a good general reference for wildlife-oriented reclamation in Wyoming.

364. Jansen, I. J. Reconstructing Soils After Surface Mining of Prime Agricultural Land. Min. Eng. (N.Y.), v. 33, No. 3, 1981, pp. 312-314.

The author discusses the concept of "prime farmland" referred to in the Surface Mining Control and Reclamation Act (Pubic Law 95-87). Principal site and soil parameters and material handling techniques are reviewed in the context of reconstructing postmine soils that will be acceptable under the "equivalent or higher levels of yield" provision of Public Law 95-87.

365. Jansen, I. J., and W. S. Dancer. Row Crop Yield Response to Soil Horizon Replacement After Surface Mining. Paper in 1981 Symposium on Surface Mining Hydrology, Sedimentology, and Reclamation (Lexington, KY, Dec. 7-11, 1981). Univ. KY, Lexington, KY, 1982, pp. 463-467.

Soil horizon replacement was evaluated at five different locations in Illinois. Corn (Zea mays L.) and soybean (Glycine max (L.) Merr.) response to soil horizon replacement varied with the character of the natural soil and the material available from the overburden. Yield responses to the A horizon replacement at all five sites was inconsistent, varying from a strong positive response to a significant negative response. Replacement of the B horizon was evaluated at only one site. In 1979 no yield response to replacement was found. However, in 1980, corn yields were significantly higher when both the A and B soil materials were replaced. These experiments need to be continued before the long-term effects of soil horizon replacement can be evaluated.

366. Jastrow, J. D., A. J. Dvorak, M. J. Knight, and B. K. Mueller. Revegetation of Acid Coal Refuse: Effects of Soil Cover Material Depth and Limiting Rate on Initial Establishment (U.S. DOE contract W-31-109-Eng 38; Abandoned Mined Land Reclamation Council, State of IL, Capital Development Board Project 555-090-004; IL Inst. Nat. Resour., Project 80.043). Argonne Natl. Lab., Argonne, IL, ANL/LRP-17, Sept. 1981, 79 pp.

This article reports the first-year results of a study conducted on a recontoured coal refuse disposal site near the town of Staunton in southwestern Illinois. The study was part of a larger project that is demonstrating and evaluating new, cost effective methods for reclaiming abandoned coal refuse sites. Comparisons were made of the effects of four soil cover material depths and two limestone application rates on vegetation establishment and growth. Plant survival and growth on plots without soil cover material were very poor. Excellent plant cover developed over the first growing season on all plots with soil cover material. Plant cover and production were dominated during the initial growing season by invading annuals characteristic of old field succession. Plant density data indicated that the perennials planted were becoming established in relatively large numbers on the plots with soil cover material, although they were not yet contributing to plant cover or production. The article provides extensive soil characterization data as well as plant cover, productivity, and density data. These data could be applicable to planning reclamation efforts in similar spoil material in this geographic area, as well as assessing the results of reclamation at this stage. An extensive appendix includes associated laboratory pot culture experiments that were conducted prior to the field-plot study reported in the main body of the paper. These experiments indicated that placement of soil cover over unamended spoil material would allow plant establishment. These studies were also used to establish seeding and liming rates to be used in the field study.

367. Jastrow, J. D., C. A. Zimmerman, A. J. Dvorak, and R. R. Hinchman. Plant Growth and Trace-Element Uptake on Acidic Coal Refuse Amended With Lime or Fly Ash. J. Environ. Qual., v. 10, No. 2, 1981, pp. 154-160.

This study was conducted to compare fly ash and lime as amendments for acidic gob typical of abandoned mine sites of southern Illinois. Using statistically designed growth chamber pot studies, the authors evaluated growth response of 'Kentucky-31' tall fescue (Festuca arundinacea Schreb.) and 'Lincoln' smooth brome (Bromus inermis Leyss.) on gob amended with either lime or fly ash. The majority of the article is an excellent discussion on trace element uptake of the plants as amended and grown on typical topsoil. Lime-amended gob produced more vigorous plant growth than did the fly ash treatment; in most cases trace element uptake was greater on the amended gob subtrates, with the fly ash treatment producing the greatest uptake. This article is excellent where trace element uptake is a major concern.

368. Johnson, E. A. Trees for Tomorrow. Paper in Trees for Reclamation (Lexington, KY, Oct. 27-29, 1980). U.S. For. Serv., Gen. Tech. Rep. NE-61, 1980, pp. 1-6.

The author discusses the role of forestry related areas in which research must be conducted. These studies are needed in order to determine the long-term effect of mining on forested areas and to maximize wood production on reclaimed areas. The majority of the paper is devoted to a discussion on the rules and regulations of Public Law 95-87 as they relate to forestry.

369. Jones, J. H., F. J. Olsen, and R. E. Joost. Grass Establishment on Coal Refuse Amended With Sewage Sludge and/or Limestone. Paper in Annual Progress Report: July 1, 1980-June 30, 1981, Volume II, Research Development Summaries, Final Draft. Coal Extraction and Utilization Res. Center, South. IL Univ., Carbondale, IL, Mar. 1982, pp. 86-93.

This report summarizes the results of investigations conducted at Peabody Coal Co.'s Will Scarlet Mine in Williamson County, IL. The study examined the effects of varying rates of sewage sludge and/or limestone application on grass establishment. Eleven treatments were tested. Each amendment treatment was seeded to tall fescue (Festuca arundinacea Schreb.), redtop (Agrostis alba L.), and reed canarygrass (Phalaris arundinacea L.). Stand counts, dry matter production, and plant cover measurements were used for comparison. Best yields for all three grasses were obtained on the sewage-sludge-amended treatments. Redtop and tall fescue had the highest yields. Plant toxic levels of heavy metals were present in the soils but did not accumulate in plant tissues to levels potentially toxic to livestock. The highest rates of either sewage sludge or limestone increased the pH of the coal refuse material from 2.4 to 4.8. The results of this study are pertinent to revegetation planning throughout the Interior Coal Mining Region.

370. Jonescu, M. E. Natural Revegetation of Strip-Mined Land in the Lignite Coalfields of Southeastern Saskatchewan. Paper in Ecology and Coal Resource Development, Volume 2, (based on the Int. Congr. for Energy and the Ecosystem, Univ. ND, Grand Forks, ND, June 12-16, 1978). Pergamon, 1979, pp. 592-608.

The objectives of this study were to identify the plant species present on overburden ridges and interridge areas of different ages; to determine the effects of age, ridge aspect, and variations in soil moisture of interrridge areas upon plant density; and to determine whether the disturbed area, or parts of it, provides a suitable environment for native prairie vegetation. The result of this study indicate that ridge slopes in the strip-mined areas were 50 pct or less covered with vegetation. Vegetation on these ridge areas was dominated by weedy, pioneer species including field sow thistle (Sonchus arvensis L.), squirrel-tail grass (Hordeum jubatum L.), sand goat's-beard (Tragopogon dubius Scop.), and gumweed (Grindelia perennis Nels.). Cover per species was very low. North and east aspects contained significantly more vegetation cover than did south and west aspects. No significant differences according to ages were found. Greater variety of vegetation and greater change in dominant species with time was found on interridge areas. In wet, dry, and mesic sites on younger areas, the vegetation was dominated by Hordeum jubatum and Kochia scoparia. Older areas supported species groupings similar to those found on adjacent undisturbed sites. Increasing species diversity on the older areas was interpreted as evidence of succession toward increasingly stable vegetation communities. This article contains excellent vegetation data and analyses that are applicable not only to the area of Saskatchewan where the study was conducted, but also in the Northern Great Plains Coal Mining Region recognized in this evaluation process.

371. Joost, R. E., J. H. Jones, and F. J. Olsen. Physical and Chemical Properties of Coal Refuse as Affected by Deep Incorporation of Sewage Sludge and/or Limestone. Paper in 1981 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Dec. 7-11, 1981). Univ. KY, Lexington, KY, 1982, pp. 307-312.

The purpose of the study was to determine the effect of sewage sludge and limestone incorporation on the chemical and physical properties of coarse coal refuse material and on vegetation establishment. Sewage sludge incorporation increased the organic matter and pH of refuse material and reduced the bulk density. The use of limestone also increased the pH of the material. There appear to be no adverse affects on vegetation establishment using either treatment.

372. Julian, E. L. Big Sky Coal Mine--A Mine-Site Study of Benefits and Costs of Reclaiming Surface-Mined Land in the West, Part III (U.S. NSF contract APR 76 18486). PA State Univ., The College of Earth and Miner. Sci., Dep. of Miner. Econ., University Park, PA, NSF/RA-790385, 1979, 202 pp.

This report presents several analyses of benefits and costs of reclamation using a case study of the Big Sky Mine in southeast Montana. Discussions of the environment at the mine site, the Federal and State laws and regulations affecting the mine, and the procedures and costs of reclamation are included and used as a basis for the economic analyses. Methods of assigning values to outdoor recreation and recreational benefits are examined, and values are estimated. Benefits and costs are compared with respect to both priority and social benefits. Based on the results of this study, the author concluded that with the "best" estimates of hydrologic, agricultural, and recreational benefits, with and without overvalued aesthetic benefits, and with the "best" estimate of cost, these costs exceed benefits by large margins. This article presents one of the few benefit-cost analyses for reclamation of surface coal mine land in the Western United States. In addition, the approach and methods used may be applicable to other areas of the Nation.

373. Jurinak, J. J. Overview of Soils Considerations in High Altitude Revegetation. Paper in Proceedings: High-Altitude Revegetation Workshop No. 5 (CO State Univ., Fort Collins, CO, Mar. 8-9, 1982). CO Water Resour. Res. Inst., CO State Univ., Fort Collins, CO, Inf. Ser. No. 48, Dec. 1982, pp. 128-135.

This article provides an excellent review of some of the fundamental concepts of soil, clay mineralogy, soil chemistry, and soil fertility as they apply to mineland reclamation. As such, the article is applicable nationwide.

374. Jurinak, J. J., C. Amrheim, and R. J. Wagenet. Effect of Salinity and SAR on the Sodic Hazard of Overburden Materials. Paper in 1981 Symposium on Surface Mining Hydrology, Sedimentology, and Reclamation (Lexington, KY, Dec. 7-11, 1981). Univ. KY, Lexington, KY, 1982, pp. 31-38.

Using the sodium adsorption ratio (SAR), the sodic hazard of overburden materials can be diagnosed by the equation ESR = K_g SAR, where ESR = exchangeable sodium ratio, and K_g = modified Gapon's selectivity coefficient. Two bulk overburden samples were obtained from two locations in Montana and a Yolo loam soil from California. To study the effects of salinity and SAR on the ESR of K_g, the soils were equilibrated with known concentrations of electrolyte solutions. The results show that the overburden material and the Yolo loam soil had a linear relationship between the ESR-SAR over the electrolyte and SAR ranges studied.

375. Keefer, R. F., R. N. Singh, O. L. Bennett, and D. J. Horvath. Chemical Composition of Plants and Soils From Revegetated Mine Soils. Paper in 1983 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Nov. 27-Dec. 2, 1983). Univ. KY, Lexington, KY, 1983, pp. 155-161.

This study was conducted to determine how mine soils and plants growing in the soil are affected by the application of sewage sludge, fly ash, and chicken manure. The effects were measured by yield and chemical analyses for nutrients and heavy metals. Three abandoned mine sites located in Preston and Monongalia Counties, WV, were used for this study. Each site was treated as follows: (1) 0, 22.4, or 44.8 t/ha chicken manure, (2) 0, 13.4, or 27 t/ha fly ash, and (3) 0, 45, or 90 t/ha sewage sludge. Following the application of these amendments, alfalfa (Medicago sativa L.) and sericea lespedeza (Lespedeza cuneata (Dum.-Cours.) G. Don) were seeded onto the sites. Sewage sludge and chicken manure applications did not affect plant growth. Sludge applications increased the P, Ca, Zn, Cu, Cr, Ni, Pb, and Cd concentrations in the mine soils. In general, soil P and exchangeable Ca concentrations were increased by applying any of the three byproducts onto the mine soil used in this study. Legume P and K concentrations were increased by chicken manure applications. The differences that were found in legume growth among the three sites were related to the properties of the mine soils. The authors conclude that plant growth is limited whenever soils contain high total S (>0.3 pct), exchangeable Al (>2 meg/100 g), and extractable Mn (>30 ppm) along with low pH (<4.0).

376. Keeney, T. A., and D. Coyer. Valuation of Surface Mining Design To Improve Post-Mining Land Resources. Paper in Conference on the Economics of Mined-Land Reclamation (cosponsored by the Land Reclam. Prog., Argonne Natl. Lab. and U.S. Dept. of Energy, Chicago, IL, Sept. 1-2, 1981). Argonne Natl. Lab., Argonne, IL, ANL/LRP-TM-20, Sept. 1981, pp. 123-146.

This paper presents an economic analysis of montaintop removal mining. The authors incorporate the concept of selective placement of spoil material to improve the agricultural potential of the site. They stress that the implementation of these reclamation techniques could result in land more adaptable to a use with higher economic returns, thus enhancing the postmining land value and increasing total returns. The concepts and discussions contained in this article are specific for the Eastern Coal Mining Region. Since this report deals with a computer model and not an actual field study, the ratings for the keywords used in the evaluation process represent the apparent treatment of these subject areas in the analysis.

377. Kelley, N. A. Vegetational Stabilization of Uranium Spoil Areas, Grants, New Mexico. Ph.D. Thesis, Univ. NM, Albuquerque, NM, 1978, 89 pp.

This study examined physical and chemical factors of uranium mine and mill tailings affecting vegetative stabilization. Analyses were done for selected trace elements in mill tailing material and associated vegetation from piles in New Mexico, Colorado, and Utah. Uptake and concentration of toxic elements by plants growing on specific spoil material were reported. Specific geologic material was identified for segregation and placement on the surface of dumps to reduce problems of revegetation. This was verified by a pilot revegetation project examining reestablishment of native vegetation on mine waste material. While this study specifically deals with revegetation of uranium spoils, much of the information is applicable to surface coal mine reclamation activities.

378. Kelly, A. W., Jr. The Role of West Virginia's Division of Forestry. Paper in Trees for Reclamation (Lexington, KY, Oct. 27-29, 1980). U.S. For. Serv., Gen. Tech. Rep. NE-61, 1980, pp. 63-64.

The author discusses the use of trees for reclaiming mined land in West Virginia. A general discussion is presented on the establishment of a quick herbaceous cover followed by tree plantings. The author feels that this is the most reasonable and equitable procedure for West Virginia. However, there is a need to accelerate the conversion from cover crops to a productive forest.

379. Kelly, W. Evaluation of the Environmental Effects of Western Surface Coal Mining Volume II: Mine Inventory. U.S. EPA, EPA-600/7-79-034, Feb. 1979, 197 pp.

This report contains a general summary of information for 37 surface coal mines that were active during 1975 in the Western United States, and for 7 additional mines that were under development. For each of the mines the following information was given: (1) general production information, mine life, employment, and disturbed acreage; (2) coal seam characteristics, average thickness, heating value, sulfur content, and ash content; (3) reclamation practices; (4) types of mining and reclamation research studies in progress; (5) overburden characteristics, pit geometry, and mining methods; and (6) equipment types and capacities for major stripping equipment only.

380. Kerr, S. N., and W. E. Sopper. Gaining Public Support for Spreading Sludge (Proceedings: 1979 Conference on Composting and Waste Recycling--Part II). Compost Science/Land Utilization, v. 20, No. 5, Sept.-Oct. 1979, pp. 14-16.

The authors discuss the problems of public opinion in utilizing sludge as a minesoil amendment and how, after one proposed project failed in Pennsylvania because of local opposition, several projects were successful both in gaining public approval and in reclaiming the mine spoils. The successful projects in Venango and Lackawanna Counties incorporated both liquid and dewatered sludge into prepared bituminous and anthracite spoils and seeded a mixture of 'Kentucky-31' tall fescue, (Festuca arundinacea Schreb.), 'Pennlate' orchardgrass (Dactylis glomerata L.), 'Penngift' crownvetch (Coronilla varia L.), and 'Empire' birdsfoot trefoil (Lotus corniculatus L.). In all cases the revegetation was successful through three growing seasons and no indication of decreasing productivity was observed, reportedly due to the slow nutrient release of the sludge.

381. Kerr, S. N., and W. E. Sopper. Utilization of Municipal Sludge for Woody Biomass Production on Mined Land. Paper in 1981 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Dec. 7-11, 1981). Univ. KY, Lexington, KY, 1982, pp. 313-317.

Field demonstration plots were established on anthracite refuse and bituminous spoil in Pennsylvania to study the feasibility of using treated municipal sludge for the reclamation and reforestation of mined land. The studies indicate that the use of municipal sludge to help correct adverse site conditions increases the survival of hybrid poplar (Populus spp.) cuttings and the biomass of woody species.

382. Keys, R. N, F. C. Cech, and W. H. Davidson. The Performance of Austrian Pine Seed Sources on Various Sites in West Virginia and Pennsylvania. Paper in Proceedings of the 27th Northeastern Forest Tree Improvement Conference (Burlington, VT, July 29-31, 1980). Sch. of Natl. Resour., Univ. VT, 1981, pp. 103-114.

This article reports the results of a study testing 12 sources of Austrian pine (Pinus nigra Arnold) on six sites. These sites included five mine spoil sites where the growth mediums were acid to extremely acid and one agricultural site where the soil had a pH of 6.1. Pines from a Yugoslavian source and an Austrian source are recommended for planting in Pennsylvania and West Virginia. Best survival of Austrian pine in West Virginia was found at elevations of about 2,500 ft above sea level. Lime and fly ash were found to improve survival of plantings on extremely acid sites. The information presented will be helpful for choosing species and planting stock sources for use in revegetating acid mine spoils in the Eastern Coal Mining Region.

383. Kilkelly, M. K., and W. L. Linsay. Selected Trace Elements in Plants Grown on Retorted Oil Shales. J. Environ. Qual., v. 11, No. 3, 1982, pp. 422-427.

The objective of this study was to determine the concentrations of boron, molybdenum, arsenic, selenium, and fluorine in 'Arriba' western wheatgrass (Agropyron smithii Rydb.) and fourwing saltbush (Atriplex canescens (Pursh) Nutt.) grown on oil shale revegetation plots in northwestern Colorado. The study was established at two sites: a low elevation site and a high elevation site. Each site contained an identical set of seven 3.3- by 6.6-m plots using two types of retorted shales. Various treatments were used and included leaching and different depths of soil covering over retorted shales. Boron content was found to be significantly higher in western wheatgrass grown on retorted oil shale when compared to the boron content of plants grown in a control soil. High molybdenum and copper levels were found in fourwing saltbush. Only small amounts of arsenic, selenium, and fluorine were found and appear to be of little environmental significance. The authors conclude that the high levels of boron found in plants grown on retorted shales could affect the reclamation efforts of these sites.

384. Kilkelly, M. K., H. P. Harbert III, and W. A. Berg. Field Studies on Paraho Retorted Oil Shale Lysimeters: Leachate, Vegetation, Moisture, Salinity, and Runoff, 1977-1980. U.S. EPA-600/7-81-131, Aug. 1981, 98 pp.

This report gives the results of a study that analyzed leachate, runoff, moisture, and salt movement from vegetated and unvegetated retorted oil shale. Compacted, retorted oil shale was placed in lysimeter sets, facing north on a 2-pct slope. Six replicated treatments, four with varying depths of topsoil, the other two being a retorted shale control and a soil control, were seeded with a mixture of grasses, shrubs, and forbes. The lysimeters were monitored over three growing seasons. Data on percent cover are reported. Recommendations for establishing vegetation on retorted oil shale are made.

385. Kilkelly, M. K., H. P. Harbert III, and W. A. Berg. Revegetation Studies on Tosco II and USBM Retorted Oil Shales. Paper in Fourteenth Oil Shale Symposium Proceedings (Golden, CO, Apr. 22-24, 1981). CO Sch. Mines, Golden, CO, 1981, pp. 410-421.

This study was done to evaluate a variety of intensive management techniques and practices used to reclaim processed oil shales in northwestern Colorado. Two locations were chosen to simulate disposal sites, a low-elevation and a high-elevation site. The objectives were to investigate surface stabilization through the establishment of vegetation and to monitor moisture and soluble salts in treatment profiles. Each site contained a set of several treatments using various leaching and soil coverings on two types of processed shales (Tosco II and USBM). After plot construction, all plots were fertilized with nitrogen and phosphorus; seeded with a mixture of native grasses, forbs, and shrubs; mulched with a grass hay; and irrigated until vegetation was established. After seven growing seasons all plots maintained a good vegetative cover. There were no significant differences in cover between plots except for the TOSCO retorted shale, which supported less perennial vegetation. During the experiment the most notable change was that in species composition, from a population dominated by perennial grasses to one dominated by shrubs. With the development of a satisfactory cover, surface runoff and sediment yield remained low. After an initial accumulation on the plots, surface salts were leached downward by seasonal precipitation and did not cause a serious problem.

386. Kimmel, R. O. Ruffed Grouse Brood Habitat on Reclaimed Surface Mines in West Virginia. Ph.D. Thesis, WV Univ., Morgantown, WV, 1982, 119 pp.

Surface mining in large blocks of mature forest can, when properly reclaimed, provide openings beneficial to ruffed grouse (Bonasa umbellus). In this study, human-imprinted ruffed grouse were used to evaluate food and cover on reclaimed surface mines. Of the six sites studied, a 25-year-old reclaimed mine planted with autumn olive (Elaeagnus umbellata Thunb.) had the best food and cover, while grass-legume reclamation had the poorest food and cover. The food and cover requirements of ruffed grouse are closely examined in this thesis, and the data and information given will be very useful to anyone wishing to reclaim a mined area to ruffed grouse habitat.

387. Kimmel, R. O., and D. E. Samuel. Ruffed Grouse Use of a Twenty Year Old Surface Mine. Paper in Symposium on Surface Mining and Fish/Wildlife Needs in the Eastern United States (WV Univ., Dec. 1978). U.S. Fish and Wildlife Ser. FWS/OBS-78/81, 1978, pp. 345-351.

Flushes of ruffed grouse (Bonasa umbellus) were recorded for a 2-year period on a surface mine in West Virginia. The area had originally been mined in the early 1950's, leaving an east and west highwall averaging 10 m in height with benches 40 m wide. The benches were originally planted with black locust (Robinia pseudoacacia L.) and autumn olive (Elaeagnus umbellata Thunb.). Five transect lines were established on each bench, and the vegetation present was recorded. The results indicate that a variety of volunteer species had invaded the bench area and that the grouse were equally distributed between mined and unmined land. Recommendations concerning reclaiming abandoned mine lands were made. The authors feel that before old surface mines are recontoured, thought should be given to the wildlife habitats that old mines provide. These areas are valuable habitat for species associated with old field succession.

388. Kizer, G. G. Tree Planting in Reclamation. Paper in Trees for Reclamation (Lexington, KY, Oct. 27-29, 1980). U.S. For. Ser., Gen. Tech. Rep. NE-61, 1980, pp. 49-50.

The author describes the regulation incentives that are used to increase tree planting on surface-mined land in Ohio. The first step used to encourage tree planting was to adapt a new standard for revegetation when trees were planted. When trees are planted into an established herbaceous cover, the standard requirement for success of the cover is reduced from 75 to 65 pct. This reduction in cover requirement improves seedling survival rates due to reduced competition from the vegetative cover. A second step is to require a 5-year period to determine revegetation success. Most grass and legume species will not last for the necessary period owing to the conditions of the spoil. Finally, reclaim only those mined forest lands that have been determined to be valuable. If trees are not of commercial value it is easier not to replace them. This requirement has proven to be successful. Since 1977, when only 1 pct of postmining land was used as forest land. The amount now stands at 10 pct.

389. Klein, D. A., D. L. Sorenson, and W. Metzger. Soil Microorganisms and Management of Retorted Shale Reclamation. Ch. in Revegetation Studies on Oil Shale Related Disturbances in Colorado (U.S. DOE contract DE-H502-76EV04018, Range Sci. Dep., CO State Univ.) U.S. DOE, DOE/EV/04018-6, June 1982, pp. 27-44.

This study is part of a larger project evaluating the impact and potential for reclamation following oil shale mining and retorting processes. This paper reports the sixth year results. The objectives of this study were to (1) evaluate microbial responses during reestablishment of plant communities on disturbed sites, (2) examine the effect of soil storage and disturbance on microbiological populations and on microorganism-related nutrient cycling processes, and (3) determine the effects of retorted shale on the microbiological characteristics and activities in surface soils placed over the retorted matter as they relate to revegetation potential. A single fertilizer treatment at the beginning of reclamation of a disturbed site appeared to have a long-lasting effect. Monitoring of nitrification and ammonia volatilization suggested that only a minor part of the added nitrogen will be lost due to volatilization. A major shift in biogeochemical cycling with nitrogen and phosphorus entering less available pools seemed to occur as reestablished plant communities matured. This paper is an excellent reference for planning revegetation activities and for understanding the microbial ecology of revegetated areas. Although it specifically addresses vegetation establishment on spent oil shale in Colorado, the results are probably applicable to surface mineland reclamation in general throughout much of the Northern Great Plains, Rocky Mountain, and western portions of the Pacific Coal Mining Regions recognized in this evaluation process.

390. Kleinman, L. H. Industry's View of Reclamation/Revegetation Success. Paper in Third Biennial Symposium on Surface Coal Mining and Reclamation on the Great Plains (cochaired by the Reclam. Res. Unit, MT State Univ. and U.S. OSM, Billings, MT, Mar. 19-21, 1984). MT State Univ. and U.S. OSM, 1984, pp. 335-341.

The author states that premining conditions should not be the criteria for evaluating the success of revegetation efforts because they do not relate to the functional role that vegetation must have in the postmining land use. "Landscape stability" rather than "ecological" or "vegetal stability" should be stressed. The author argues that parameters such as nutrient cycling capabilities, nitrogen fixation, plant and animal diversity, presence of uneven-aged stands of vegetation, range condition and trend analysis, forage utilization comparison, animal performance, and the achievement of land use goals should be considered as measures of reclamation success. Many of the comments offered by the author could apply nationwide.

391. Kleinman, L. H., and D. E. Layton. Reclamation Techniques and Vegetation Response at Decker Coal. Paper in Surface Coal Mining and Reclamation Symposium, Coal Conference and Expo V (sponsored by Coal Age, Louisville, KY, Oct. 23-25, 1979). McGraw-Hill, 1979, pp. 255-259.

This paper describes the revegetation program at Decker Coal Co's mine near Decker, MT. After briefly reviewing the method of site preparation, seeding, and fertilizing a reclaimed area, the results of the program are detailed. Data are given for vegetative canopy cover and annual herbage production for shrubs, perennial grass, annual grass, forbs, and total vegetation.

392. Kleinman, R. P., and P. M. Erickson. Field Evaluation of a Bactericidal Treatment To Control Acid Drainage. Paper in 1981 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Dec. 7-11, 1981). Univ. KY, Lexington, KY, 1981, pp. 325-329.

Inhibition of Thiobacillus ferrooxidan, an iron-oxidizing bacterium, has been shown to slow the rate of pyrite oxidation on surface-mined land. This has been accomplished by using sodium lauryl sulfate (SLS), an anionic surfactant, from rubber pellets. Field tests were conducted at inactive, acid-producing surface mines and coal refuse piles at sites in Ohio, Pennsylvania, and West Virginia. The effectiveness of this technique requires good infiltration of rainfall. On highly compacted sites, the overburden may be too impermeable for the surfactant to infiltrate to the pyritic material. On more permeable sites 50- to 95-pct reductions in acidity have been observed. The controlled release of anionic surfactants should be useful in augmenting revegetation and in reducing or suppressing acid drainage from refuse piles and surface-mined land.

393. Kline, L. G. Land Use Definitions: An Exercise in Semantics and Regionalism. Paper in Symposium on Western Coal Mining Regulatory Issues: Land Use, Revegetation, & Management (West. Reclam. Group, Denver, CO, Apr. 1982). CO State Univ., Range Sci. Dep., Fort Collins, CO, Sci. Ser. No. 35, Aug. 1983, pp. 26-28.

A comparison of land use definitions used in Federal surface mining regulations and those of six Western States (Colorado, Wyoming, Montana, North Dakota, Utah, and New Mexico) revealed the land uses are typically separated on the basis of vegetative cover rather than the actual land use as presently required by the regulations. Also, several State definitions reflect State interests by exclusion of uses or vegetation types referred to in the Federal definitions. The author evaluates the differences that exist and provides recommendations that could alleviate definitional problems by injecting the flexibility necessary to allow for unique circumstances while standardizing these definitions. This article is particularly pertinent to reclamation activities in the Northern Great Plains and Rocky Mountain Coal Mining Regions recognized in this evaluation process.

394. Klopatek, J. M., R. J. Olson, C. J. Emerson, and J. L. Jones. Land-Use Conflicts With Natural Vegetation in the United States. Environ. Conserv., v. 6, No. 3, 1979, pp. 191-199.

This study was done to determine the amounts and types of natural vegetation existing in the 48 conterminous States. This was accomplished by using a computer algorithm that was developed to subtract existing land-use data from the potential natural vegetation. This was done on a county-by-county basis. Using the Kuchler Potential Natural Vegetation type to identify natural vegetation, 23 of the predominant 106 types occurring in the United States have been reduced by over 50 pct by man-induced land uses. Tule marshes have lost the greatest amount of their original area, 89 pct, while bluestem prairie and its transition zone (oak-hickory forest) have declined by 85 and 77 pct, respectively. Agricultural land use is the primary reason for the large loss of these areas. In contrast to these large losses of natural vegetation, 26 types have lost only 5 pct or less of their potential area. Iowa (8 pct), Illinois (11 pct), and Indiana (18 pct) have the least amount of land covered by natural vegetation. New Mexico, Arizona, Utah, and Nevada have the greatest amount of land still covered by natural vegetation, 93 to 96 pct. The authors conclude that the areas actually occupied by natural vegetation need preservation action.

395. Knuth, W. M., and E. L. Fritz. Utilization of Color and Color Infrared Aerial Photography in the Surface Coal Mining Process. Paper in Fifth Symposium on Surface Mining and Reclamation (NCA/BCR Coal Conf. and Expo IV, Louisville, KY, Oct. 18-20, 1977). Natl. Coal Assoc. and Bit. Coal Res., Inc., 1977, pp. 4-7.

The authors provide a general discussion of the potential for applying aerial photography interpretation techniques to surface coal mine planning and reclamation. No data or examples are provided. However, the article would be very good for individuals working in reclamation who have little or no background in aerial photo interpretation. The information relayed is applicable nationwide.

396. Knuth, W. M., E. L. Fritz, J. A. Schad, and W. F. Nagle. Development of New Bond Release Criteria for Surface Coal Mines in the Eastern and Interior Coal Provinces (contract J0177024, Energy and Natural Resources Dept., HRB-Singer, Inc.). BuMines OFR 35-79, Sept. 1978, 255 pp., NTIS PB 294 708.

The bonding and bond release practices in the States of the Eastern and Interior (midwestern) Coal Provinces are reviewed. Bonding and release procedures in these States related to achieving successful reclamation were documented by collecting data from regulatory authorities and site visits. The regulations related to Public Law 95-87 are reviewed. The analysis that is included suggests new bond release criteria and modifications to existing criteria, reviews the applicable inspection techniques for bond release, and provides a conceptual graduated bonding system and incentive procedures for reclamation of surface mine sites to alternative or higher land uses. Numerous conclusions and recommendations for further research are included. A detailed bibliography and a glossary are included. This report provides an excellent reference for planning reclamation activities and monitoring revegetation for bond release. The report is specifically designed for application in the Eastern and Interior Coal Mining Regions recognized in this evaluation process.

397. Kolar, C. A., and W. C. Ashby. Reclamation: What About Trees? Coal Min. Process., v. 19, No. 7, 1982, pp. 68-69, 72.

The authors discuss reforestation efforts, past and present, in Illinois and Indiana. Results of a survey conducted on over 100 different tree plantings made during the 1930's and 1940's documented the establishment and growth of tree species on mined land. Those tree species that performed well on mined land are listed. There is also a discussion on present reforestation efforts and research in southern Illinois. Research is needed to determine if the same tree species that were used successfully in older plantings can be used in reforestation efforts under current regulations. Results indicate that survival and growth continue to be best on ungraded sites, particularly for oak species (Quercus spp.).

398. Kolar, C. A., W. C. Ashby, and G. R. Philo. Differential Performance of Trees Planted on Reclaimed Surface Mined Land. Paper in 1981 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Dec. 7-11, 1981). Univ. KY, Lexington, KY, 1982, pp. 271-278.

The purpose of this study was to assess differences in the growth and survival of tree species planted on mined land in southern Illinois that has been reclaimed by various practices. Comparisons are also made with plantings on unmined reference areas. Results vary between species, sites, planting season, and year, but indicate that extensive soil handling and site preparation adversely affect tree growth.

399. Kollman, A. L. Field Evaluation of Some Amendments in Terms of Soil Properties and Plant Productivity. Paper in Ecology and Coal Resource Development, Volume 2, (based on the Int. Congr. for Energy and the Ecosystem, Univ. ND, Grand Forks, ND, June 12-16, 1978). Pergamon, 1979, pp. 934-950.

This paper reports the results of a study designed to evaluate the effects of some amendments on the physical and chemical characteristics of the spoils and the growth of plants at field test sites in Mercer and Oliver Counties in western North Dakota. This study was part of a 5-year project entitled "A Systems Approach to the Reclamation of Strip-Mined Areas in North Dakota," funded by the Bureau of Mines. It was found that fertilizers were required at most sites. The addition of leonardite, a naturally oxidized lignite material, reduced grass growth but increased legume production. The leonardite decreased the upward movement of salts from sodic spoils to topsoils. Plant establishment and productivity were also improved by the addition of as little as 1 ft of topsoil. This article provides a good reference for reclamation planning. The bulk of the results are specific to the Northern Great Plains Coal Mining Region.

400. Koon, D. L., and D. H. Graves. Five-year Vegetative Responses of Grasses and Legumes Planted Under Differing Rates of Soil Amending Mulches on Eastern Kentucky Surface Mines. Paper in 1983 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Nov. 27-Dec. 2, 1983). Univ. KY, Lexington, KY, 1983, pp. 509-513.

This study was conducted to determine the long-term effects of various soil-amending mulches on the establishment, growth, and composition of a pastureland species seed mixture on Falcon Coal Co. land in eastern Kentucky. The species in the seeding mixture included 'Ky-31' tall fescue (Festuca arundinacea Shreb.), tetraploidal ryegrass (Lolium spp.), yellow sweetclover (Melilotus officinalis (L.) Lam.), and birdsfoot trefoil (Lotus corniculatus L.). The mulching materials used were (1) hardwood bark applied at rates of 35 and 70 yd^3/acre, (2) wood fiber mulch applied at rates of 250, 500, 750, and 1,500 lb/acre composted municipal waste at 10 and 20 t/acre, (3) bark at 35 and 70 yd^3/acre plus chicken manure (2.5 and 5.0 t/acre), and (4) 72 yd^3 composted municipal waste and bark mixture at equal volumes. Plots treated with organic mulches resulted in higher percentage of vegetative cover than plots treated with wood fiber mulch alone. The results of this study indicate that the use of organic mulches can enhance the reclamation and stabilization of drastically disturbed sites through rapid establishment and long-term maintenance of grasses and legumes.

401. Kreammerer, W. R. Measures of Sample Adequacy. Paper in Symposium on Western Coal Mining Regulatory Issues: Land Use, Revegetation, & Management (West. Reclam. Group, Denver, CO, Apr. 1982). CO State Univ., Range Sci. Dep., Fort Collins, CO, Sci. Ser. No. 35, Aug. 1983, pp. 72-74.

This article provides a brief review of seven methods of evaluating sample adequacy as applied to collected data. The seven methods include coefficient of variation, species area curve, graphic approaches, standard error of the mean expressed as a percent of the mean, Cochran's formula, WDEQ formula, and maximum numbers. The reasons high levels of sample adequacy requirements have been established for cover and productivity sampling on areas to be mined and the effects of using these high levels are discussed relative to testing hypotheses related to bond release on reclaimed land. The author suggests that realistic bond release decisions could be made based on reduced sample adequacy levels and on higher alpha levels for tests of significance. This article provides an excellent reference for designing reclamation monitoring programs. It was written with special reference to the Western United States. However, the information relayed in this article is applicable nationwide.

402. Kumar, P., and K. Sharma. Coal Mining and Reclamation in the Alberta Foothills. Coal Miner, June 1977, pp. 20-24.

This article provides a general review of the present status of coal mining and reclamation in the foothill physiographic province of Alberta, Canada. The Alberta government's overall policy for coal mining is discussed. Short descriptions are given of the ecological components of the Alberta Foothills region, including climate, topography, geology, soils, and vegetation. Current revegetation research for this region is surveyed with reference to properties of the growth media, soil improvements, seeds, and seedlings. Special reference is made to introduced species and exotics recommended for this area. The article provides an adequate survey of the topics covered and is a good introduction to individuals interested in Canandian reclamation research.

403. Kunkel, G. P., and E. J. Hinzel. Considerations in the Application of Standards for Revegetation Success. Paper in Symposium on Western Coal Mining Regulatory Issues: Land Use, Revegetation, & Management (West. Reclam. Group, Denver, CO, Apr. 1982). CO State Univ., Range Sci. Dep., Fort Collins, CO, Sci. Ser. No. 35, Aug. 1983, pp. 31-35.

The authors present and discuss the standard vegetation characteristics typically used to judge reclamation and provide for the defensible release of posted reclamation bonds. Cover, production, and species composition are reported to provide the best measures of revegetation success. Species diversity and shrub density are not consistent appropriate measures of success. Common and persistent difficulties arising from the application of various reference area concepts are presented. Some alternative approaches to the establishment of revegetation standards are discussed. This article is pertinent to planning and conducting monitoring programs associated with reclamation activities. The article is primarily relevant to the Northern Great Plains and Rocky Mountain Coal Mining Regions recognized in this evaluation process.

404. LaFevers, J. R. Economics of Mined Land Reclamation and Land-Use Planning in Western States. Ch. in the Reclamation of Disturbed Arid Lands. Univ. NM Press, 1978, pp. 68-71.

The reclamation costs of a number of mine sites in the arid and semiarid States in the Western United States were surveyed. Reclamation costs varied from 0 in States with no reclamation laws to 20 pct of the value of the coal mined. The need to develop a land-use plan is discussed as are extraction processes and reclamation techniques which are designed to create a landscape that will be of benefit to the local community or region.

405. LaFevers, J. R., and E. A. Imhoff. Land Use Planning in Surface Mine Areas. Paper in Fifth Symposium on Surface Mining and Reclamation (NCA/BCR Coal Conf. and Expo IV, Louisville, KY, Oct. 18-20, 1977). Natl. Coal Assoc. and Bit. Coal Res., Inc., 1977, pp. 311-317.

This article examines the effects of State and Federal guidelines and regulations pertinent to surface-mined lands that were in existence or that were soon to be in existence at the time of writing (1977). While some of the discussion of specific points of the regulations is no longer applicable, the article provides an excellent evaluation of the role of land use planning in the reclamation effort. The discussion contained in the article is applicable nationwide.

406. Larson, J. E. Revegetation Equipment Catalog. U.S. For. Serv. Equip. Dev. Center, Missoula, MT, Rep. 8042 2501, Feb. 1980, 198 pp.

This publication is an excellent compendium of available revegetation equipment. Helpful comments on equipment function, capabilities, and limitations are provided. Also included are comparative specifications for rubber-tired tractors and crawler tractors, as well as a list of forage plants commonly seeded on range and other perennial pasture. The geographical focus of the document is the Western United States. However, some of the equipment discussions are relevant to other regions as well. This is an excellent reference that could aid in planning revegetation activities. The ratings assigned to the keywords used in the evaluation process indicate major areas of equipment function considered in this document that are directly applicable to surface-mined lands.

407. Larson, M. M., and J. P. Vinmerstedt. Evaluation of 30-Year-Old Plantations on Stripmined Land in East Central Ohio. OH Agric. Res. and Dev. Cent., Res. Bull. 1149, 1983, 20 pp.

This study remeasured 13 experimental plantations that had been established in 1946-47 by the U.S. Forest Service in eastern and southeastern Ohio. All of the surviving trees on each area were counted, and mean diameter and height of each species were estimated. The survival of all planted trees averaged 36.6 pct on calcareous spoil and 23.3 pct on noncalcareous spoil after 30 years. Of the tree species planted, white ash (Fraxinus americana L.) and green ash (Fraxinus pennsylvanica Marsh.) had the highest survival, averaging 65 pct on calcareous spoil and 34 pct on noncalcareous spoil. White pine (Pinus strobus L.) had the greatest diameter growth of all species planted. Of the tree species direct-seeded on the spoil banks, bur oak (Quercus macrocarpa Michx.) had the best survival after 30 years, 37.2 pct survival of all seed-spots, especially when seeded on the south slopes of spoil banks. After 30 years, the study initiated by the U.S. Forest Service has demonstrated the potential of forest plantings as productive, permanent, and protective cover on coal spoils.

408. Lave, S. K., R. I. Barnhisel, and J. L. Powell. Yield, Forage Quality of Grass Species and Varieties Established on Topsoiled Mine Spoils in Western Kentucky. Paper in 1982 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Dec. 5-10, 1982). Univ. KY, Lexington, KY, 1982, pp. 535-540.

This study was conducted to compare yield and productivity of 16 cool season, perennial grass species and varieties growing on topsoiled mine spoils in Muhlerburg County, KY. The effects of harvesting grasses on ground cover were evaluated for grasses harvested in the May and November. In addition, nutrient levels, neutral detergent fiber (NDF), and acid detergent fiber (ADF) were analyzed in the harvested grasses. Tall fescue (Festuca arundinacea Schreb.) had the highest production for both harvests, good nutrient content, and low fiber. Reed canarygrass (Phalaris arundinacea L.), Kentucky bluegrass (Poa pratensis L.), creeping red fescue (Festuca rubra L.), and perennial ryegrass (Lolium perenne L.) also had low fiber and high fall yields, but had moderate nutrient content and low spring yields. Orchardgrass (Dactylis glomerata L.) and redtop (Agrostis alba L.) had intermediate nutrient content and production, but high fiber. Pubescent wheatgrass (Agropyron tricophorum (Link) Richt.), intermediate wheatgrass (Agropyron intermedium (Host) Beauv.), crested wheatgrass (Agropyron desertorum (Fisch.) Schult.), and timothy (Phleum pratense L.) had a high spring yield, but low fall yields, low nutrient content, and high fiber. Grasses in the vegetative stage had lower fiber than grasses in the seed stage. By cutting the grasses in the early spring, at the boot or early seed heading stage, it may be possible to increase the digestibility and lower the fiber content of many species. Of the varieties tested, 'Manhattan' perennial ryegrass and 'Kenhy' tall fescue outproduced 'Omega' and 'KY-31' varieties in yield, protein, nutient and fiber content, and ground cover for at least one harvest. The results presented in this paper are the first of a 5-year study.

409. Lawrey, J. D. Soil Fungal Populations and Soil Respiration in Habitats Variously Influenced by Coal Strip-Mining. Environ. Pollut., v. 14, No. 3, 1977, pp. 195-205.

Soil respiration and fungal isolation studies were done in various habitats that had been affected by strip-mining in Perry County, OH. The relationships between edaphic factors and soil activity relative to strip mining were also studied. The five habitats studied were (1) a nonvegetated strip mined habitat, (2) vegetated strip-mined habitat dominated by red pine (Pinus resinosa Ait.), (3) vegetated strip-mined habitat dominated by black locust (Robinia pseudoacacia L.), (4) vegetated strip-mined habitat dominated by big-toothed aspen (Populus grandidentata Michx.), and (5) a control habitat dominated by beech (Fagus grandifolia Ehrh.) and unaffected by strip mining (reference area). Soil elemental analyses indicated that Perry County strip-mined soils generally had a lower pH and higher levels of trace metals than did soils from nonmined lands. There were also fewer fungal genera isolated from the soils of strip-mined habitats than from soils of nonmined habitats. Microbial activity, measured as soil respiration, was decreased due to strip mining, while nonmined lands had the highest rates of soil respiration. The results of this study indicate that strip-mining activities reduce the soil fungal diversity and activity below levels that are expected for nonmined habitats.

410. League, L. Turning Mined Land Back Into Farmland. Am. Min. Congr. J., v. 69, No. 16, 1983, pp. 8-9.

This is a general article which describes R & F Coal's techniques to reclaim farmland in southeastern Ohio. Very little technical information is presented other than the amount of straw mulch that is used in the reclamation process.

411. Lee, C. R., J. G. Skogerboe, D. L. Brandon, J. W. Linkinhoker, and S. P. Faulkner. Vegetative Restoration of Pyritic Soils. Paper in 1983 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Nov. 27-Dec. 2, 1983). Univ. KY, Lexington, KY, 1983, pp. 271-274.

Results are presented on a vegetative restoration project of pyritic soil created at a U.S. Army Corp of Engineers construction site in northeastern Mississippi. The area is characterized as being extremely acid (pH 2.9), droughty, and severely compacted. To ameliorate these conditions, four soil amendments were used: (1) lime, 100 t/ha fine agricultural limestone and 100 t/ha of coarse limestone, (2) lime plus 79.6 t/ha chicken manure, (3) lime plus 6.5 t/ha rock phosphate, and (4) lime plus manure plus phosphate. The amendments were incorporated to a depth of either 15 or 45 cm, with and without subsoiling. All plots were seeded to weeping lovegrass (*Eragrostis curvala* (Schrad.) Nees), 'Pensacola' bahiagrass (*Paspalum notatum*) Flugge), and sericea lespedeza (*Lespedeza cuneata* (Dum.-Cours.) G. Don). Soil samples were collected and analyzed before and after the soil amendments were incorporated. Lime amendments allowed vegetation establishment on all plots. However, the largest biomass production was found on plots receiving the chicken manure amendment. Weeping lovegrass was the only species which responded to the 45 cm incorporation depth. After 1 year of growth, 10 woody species were planted in each plot in order to evaluate long-term restoration, erosion control, and wildlife habitat. After one growing season autumn olive (*Elaeagnus umbellata* Thunb.), white ash (*Fraxinus americana* L.), bristly locust (*Robinia fertilis* Ashe), and indigobush (*Amorpha fruticosa* L.) had the best survival. However, no significant differences in woody species survival were found during the first year between plots with amendments incorporated to depths of either 15 or 45 cm. With continued monitoring, deep incorporation of soil amendments to a depth of 45 cm should show a pronounced effect on plant growth and survival.

412. Leedy, D. L., and T. M. Franklin. Coal Surface Mining Reclamation and Fish and Wildlife Relationships in the Eastern United States. U.S. Fish and Wildlife Ser. FWS/OBS-80/24 (v. 1, Leedy) and FWS/OBS-80/25 (v. 2, Leedy and Franklin), Jan. 1981, 75 pp. (v. 1) and 109 pp. (v. 2).

Volume 1 is subtitled "Past Findings, the Surface Mining Law of 1977 (P.L. 95-87), Planning and Management Considerations, and Information Sources." Volume 2 is subtitled "Opportunities and Approaches for Fish and Wildlife Planning and Management in Coal Surface Mining Reclamation and Postmining Land Uses." Both volumes are excellent treatments of fish and wildlife needs in the Eastern United States coal areas. Of importance to revegetation are the identification of vegetative types present before disturbance as a guide for revegetation and the characteristics and sources of this vegetation. This is an excellent reference manual for wildlife revegetation planning.

413. Lekhakul, S. The Effect of Lime on Chemical Composition of Surface-Mined Coal Spoils, The Growth of Plants on Spoils, and the Leachate From Spoils. Ph.D. Thesis, Univ. KY, Lexington, KY, 1981, 154 pp.

This thesis reports the results of a greenhouse study designed to examine the effects of three liming rates and two leaching rates on the chemical composition of spoil and spoil leachate and the response of grain sorghum (Sorghum bicolor (L.) Moench). Freshly exposed spoil material collected from the western Kentucky coal district was used. Crop yields were low for all treatments. Tissue analysis indicated nitrogen and phosphorus deficiencies. The results indicated that liming plus heavy leaching can reduce the potentially toxic iron, manganese, and aluminum in spoils.

414. Lewis, B. G. Extractable Trace Elements and Sodium in Illinois Coal-Cleaning Wastes: Correlation With Concentrations in Tall Fescue. Reclam. Reveg. Res., v. 2, No. 2, 1983, pp. 55-68.

The purpose of this greenhouse study was to correlate the uptake of trace elements by tall fescue (Festuca arundinacea Schreb.) with the extractable element concentrations of five different southern Illinois coal-cleaning wastes (gob and slurry). The results indicate that there was little or no correlation between shoot concentrations of iron and the iron extracted from the wastes by dilute acid (r=0.60), Diethylenetriamine pentaacetic acid (DTPA) at pH 6.4 (r=0.47), or DTPA at pH 8.4 (r=0.17). Much better "r" values were obtained for manganese (0.94, 0.97, and 0.96), for zinc (0.96, 0.96, and 0.88), and for copper (0.67, 0.90, and 0.88), respectively. Shoot boron correlated well with hot-water-soluble boron (r=0.96) and acid-soluble boron (r=0.91). Shoot sodium also correlated well with water-soluble sodium and acid-soluble sodium (r=0.96 for both). The concentrations of aluminum, arsenic, cadmium, lead, nickel, and selenium in the shoots were below reported upper critical levels and were similar to concentrations found in tall fescue grown on a silt loam under the same greenhouse conditions.

415. Lewis, L. R., A. O. Perry, and J. R. LaFevers. A Case Study of Surface Mining and Reclamation Planning: South Boulder Creek Park Project, Sand and Gravel Operations, Boulder, Colorado. V. 3A in Integrated Mined-Area Reclamation and Land Use Planning. Argonne Natl. Lab. ANL/EMR-1, v. 3A, Feb. 1977, 95 pp.

This report is one of a 10-volume series prepared by the Energy and Environmental Systems Division of Argonne National Laboratory and the Resource and Land Investigations (RALI) Program of the U.S. Department of the Interior under the sponsorship of the U.S. Geological Survey. The reclamation practices of Flatiron Companies on their South Boulder Creek Project in Boulder, CO, are examined in this case study. The purpose of this case study is to allow the planner to gain insight into the procedures, possibilities, and constraints involved in premining planning in a cooperative situation. The site of this study contains a deposit of high-quality sand and gravel in a highly visable area, adjacent to a residential portion of the city. To maximize use of premining planning for resolution of conflicts over the company's proposed operation, an extensive cooperative effort was initiated. The article discusses salient points of cooperative and contractual agreements that were worked out. This document specifically addresses an aggregate mining operation and subsequent reclamation. However, some of the information and discussions may be applicable to coal mineland reclamation in this and other regions of the United States.

416. Leydon, J. J. Coal Mine Reclamation in Cape Breton. Paper in Proceedings of the Seventh Annual Meeting, Sydney, Nova Scotia, Canada, Aug. 29-Sept. 1, 1982. Can. Land Reclam. Assoc., Guelph, Ontario, Canada, 1982, pp. 223-239.

This paper presents the methods and materials used in reclaiming three mine sites in the New Waterford area of Nova Scotia. Complete seeding, moisture, fertilizer, and lime application information is related. This is a descriptive account of the reclamation processes used and could be applicable in the northern portions of the Eastern Coal Mining Region.

417. Liberta, A. E. Effects of Topsoil-Storage Duration on Inoculum Potential of Vesicular-Arbuscular Mycorrhizae. Paper in 1981 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Dec. 7-11, 1981). Univ. KY, Lexington, KY, 1982, pp. 45-48.

The objective of the study was to assess the effect of topsoil storage durations of 1, 2, and 3 years and undisturbed topsoil on the mycorrhizal inoculum potential of the soil. The results indicate that as storage time increases, mycorrhizal inoculum potential decreases.

418. Lilly, C. K., S. J. Tajchman, P. S. Frank, Jr., and D. A. Eckhardt. On the Microclimates of Light and Dark Strip Mine Surfaces. WV Univ., Coll. of Agric. and For., Div. of For., WV For. Notes, No. 8, 1980, pp. 13-16.

Surface temperatures exceeded air temperatures on dark spoils (coal covered) by a maximum of 34.4° C. On light colored spoils (sandstone and weathered sandstone materials) surface temperatures exceeded air temperatures by a maximum of 12.2° C. Surface temperatures on both spoils reached magnitudes reported in the literature as sufficient to restrict plant growth. The magnitude of these temperatures appeared to be related to allwave net radiation and net shortwave radiation. However, the authors note that subsurface conditions may also significantly affect surface temperatures. This research note discusses an often-overlooked, yet very important, consideration for the revegetation of surface mined lands. The study reported was conducted near Morgantown, WV. The methods used are applicable to all geographical regions.

419. Lindsay, R. E. Evaluation of Natural Revegetation of Problem Spoilbanks. Paper in Annual Progress Report: July 1, 1980-June 30, 1981, Volume II, Research Development Summary, Final Draft. Coal Extraction and Utilization Res. Cent., South. IL Univ., Carbondale, IL, Mar. 1982, pp. 81-85.

This report summarizes an investigation that determined the effects that natural weathering processes and time had on phytotoxin levels in surface mine spoilbanks and the consequent influence on natural revegetation. Sites in Jackson, Perry, Saline, and Williamson Counties in Illinois were used in the study. Selected physical and chemical spoil parameters were compared with measures of vegetation quantity and quality to identify factors influencing natural revegetation. Significant regional differences were found in overburden and revegetation characteristics. These differences are primarily due to the greater concentration of pyritic materials in the overburden in Saline and Williamson Counties, resulting in substantially higher acidity and lower macronutrient levels. The author reports that a classification system was set up for the spoilbanks occurring in Illinois, based on successional stage, inhibiting factors precluding vegetation establishment, time needed for natural recovery, and reclamation needs. Few hard data are presented in this research summary. This classification is not described in detail; however it is a source of potentially useful information for revegetation planning.

420. Lindsey, R. E., and J. R. Nawrot. Evaluation of Natural Revegetation of Problem Spoil Banks. Paper in 1981 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Dec. 7-11, 1981). Univ. KY, Lexington, KY, 1982, pp. 367-375.

The authors' purpose is to identify the degree and type of natural vegetation establishment at four study sites. The total number of vascular plant species found at all sites was 96, representing 40 families. The herbaceous species had an average ground cover of 33.7 pct. The density of vegetation was found to be related to the chemical characteristics of the spoil. A spoil classification system was established that will permit the reclamation of abandoned mined land to focus on high-priority problem sites, while those sites advancing successionally would be allowed to revegetate naturally.

421. Lindsay, S. F., T. A. Bookhaut, and G. C. White. Nutritive Levels in Plants From Stripmined Areas in Eastern Ohio. Ohio J. Sci., v. 78, No. 2, 1978, pp. 70-79.

The nutritive quality of vegetation growing on stripmined lands was obtained from Harrison and Perry Counties in east-central Ohio. The Harrison County site was characterized by calcareous spoils (pH's of 6.7 to 7.6), while the Perry County site was characterized by acidic spoils (pH's of 3.7 to 4.0). Undisturbed (reference area) plots were also established in each county. Proximate analysis of water, ash, crude protein, ether extract, cell wall constituents, and nitrogen-free extract revealed few significant differences between plants growing on the stripped and undisturbed plots. Phosphorus, calcium, potassium, magnesium, manganese, iron, copper, zinc, boron, and molybdenum were also analyzed using emission spectrography. Potassium levels were found to be significantly higher in plants growing on alkaline spoils, while manganese levels were higher in plants growing on acidic spoils. In some plants growing on acidic spoils managanese levels exceeded 600 ppm. In general, no nutrient deficiencies were found in the plants growing on either alkaline or acidic spoil material. However, plants appeared to be deficient in digestible carbohydrates on both stripped and undisturbed land.

422. Loebel, K. J., E. G. Beauchamp, and S. Lowe. Soil Modification and Plant Growth on a Calcareous Subsoil Material Treated With a Partially Composted "Sludge-Leaf" Mixture. Reclam. Reveg. Res., v. 1, No 3, 1982, pp. 283-293.

This study assessed the ameliorative effects of a mixture of sewage sludge and leaves on a road construction waste subsoil pile and the establishment of woody and herbaceous species at a site located in Geulph, Ontario, Canada. Three partially composted sewage sludge-leaf mixture treatments were applied to the waste area and incorporated. The treatments used were (1) none, a control, (2) 125 t/ha, and (3) 250 t/ha. Root cuttings of 1-1 Carolina poplar (<u>Populus canadensis eugeni</u> (Schelle) Rehd.), and seedlings of 2-2 eastern white cedar (<u>Thuja occidentalis</u> L.) and 2-0 autumn olive (<u>Elaeagnus umbellata</u> Thunb.) were planted in the experimental area. The entire area was broadcast-seeded with 30 kg/ha creeping red fescue (<u>Festuca rubra</u> L.) and 20 kg/ha birdsfoot trefoil (<u>Lotus corniculatus</u> L.). Selected soil and foliar analyses were done along with measurements of plant growth characteristics. Addition of the composted sludge-leaf mixture significantly increased the organic matter content of the soil. The 125- and 250-t/ha treatments increased the organic matter content from 0.8 pct to 2.3 and 5 pct, respectively. By adding the sludge-leaf mixture the CEC of the 125 t/ha treatment was double that of control plots and the 250 t/ha treatment resulted in a fourfold increase in the CEC of the soil. The composted mixture also increased the concentrations of ammonium, nitrate, phosphorus, and potassium when compared to control plots. Treatment with the mixture resulted in a decrease in bulk density and increased available water capacity. Dry matter production of the herbaceous species increased 5 to 8 times plant cover increased 65 to 100 pct on plots treated with the composted sludge-leaf mixture. Only Carolina poplar showed significant improvement in growth due to treatment; shoot growth was increased along with larger sized leaves. Autumn olive growth was not improved by treatment, and eastern white cedar tended to have increased plant mortality (survival decreased by 30 pct) when plots were amended with the sludge-leaf mixture. Nitrogen and phosphorus concentrations in trefoil shoots and poplar leaves increased with increasing sludge-leaf mixture application rates. However, the effects of sludge-leaf treatments were inconsistent with respect to the concentrations of other elements.

423. Louderbough, E. T., and L. D. Potter. Mancos Shale: Physical and Chemical Properties Which Affect Vegetative Communities on Shale Outcrops. Paper in 1982

Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Dec. 5-10, 1982). Univ. KY, Lexington, KY, 1982, pp. 547-550.

The purpose of this research was to describe the chemical and physical properties of Mancos shale that inhibit the establishment of vegetation on natural outcrops in the Four Corners area. Bedrock samples were collected from 78 Mancos outcrops in New Mexico, Arizona, Colorado, and Utah and analyzed for clay mineral compostion, organic carbon, pH, Electrical Conductivity, texture, sodium, sulfate, and gypsum saturation index. A hydroponic growth experiment was also conducted in order to observe the effect of chemical parameters on the growth of western wheatgrass (Agropyron smithii Rydb.) and alkali sacaton (Sporobolus airoides (Torr.) Torr.). The results indicate that ion concentration alone does not explain why Mancos outcrops remain barren or sparsely vegetated. Other factors such as soil texture, water penetration, and aeration may provide insight into the complex interactions of the chemical and physical environment of Mancos shale.

424. Lyle, E. S., Jr. Establishing Pine Seedlings in a Forage Sod. Paper in Third Annual Conference on Better Reclamation With Trees (cosponsored by AMAX Coal Co., Purdue Univ., South. IL Univ., and Madisonville Comm. Coll., Terre Haute, IN, June 2-3, 1983). Purdue Univ., West Lafayette, IN, 1983, pp. 68-75.

The purpose of this study was to develop an inexpensive method of successfully planting loblolly pine (Pinus taeda L.) and longleaf pine (Pinus palustris Mill.) seeds and seedlings in an established forage sod. Establishment of seedlings from direct-seeding and the survival of transplanted seedlings were increased by removing the sod by scalping with a plow. However, undesirable soil erosion and sedimentation resulted from the scalping treatment. Present animal repellent seed coatings (Endrin, Arasan, and aluminum flakes) were not effective when the seeds were placed on the soil surface. Pine seeds planted in mineral soil at a depth of approximately 0.5 in produced an acceptable stand of seedlings with or without a repellent coating. Seed placed on the soil surface did not produce acceptable stands unless covered with a straw mulch. The research reported in this article was carried out in Alabama. The results are pertinent to portions of the Gulf Coast, Eastern, and Interior Coal Mining Regions recognized in this evaluation process.

425. Lyle, E. S., Jr., and E. M. Evans. Revegetation of Alabama Coal Surface Mines for Soil Cover and Forage Production. Reclam. Rev., v. 2, No. 2, 1979, pp. 55-61.

This study evaluated the reclamation potential of several grasses and legumes, planted either singly or in combinations, on four mine sites in Alabama. The four sites had varying mine soil characteristics. Single species were planted and evaluated in Cullman, Jefferson, and Bibb Counties, while combinations were evaluated in Winston County. Lime and fertilizer was applied to all four sites, and mulch was added to the Winston County site. In the single-species tests, none of the species were found to be consistently better than another on all mine sites. However, common bermudagrass (cynodon dactylon (L.) Pers.), 'Pensacola' bahiagrass (Paspalum notatum Flugge.), and weeping lovegrass (Eragrostis curvula (Schrad.) Nees) became established on all three mines. The species that gave the best soil cover when all mines and treatments were considered was common bermudagrass. The authors feel that the ideal vegetation sequence for erosion control and forage production on mined land in Alabama would be a cereal that establishes quickly, followed by a grass and legume combination. Based on the combination test work, the species recommended for fall combination plantings were 'Abruzzi' rye (Secale cereale L.), crimson clover (Trifolium incarnatum L.), Serala sericea, and redtop grass (Agrostis alba L.). Species recommended for spring combination plantings included browntop millet (Panicum ramosum L.) Serala sericea, Kobe lespedeza (Lespedeza striata (Thunb.) H & A.), and 'Pensacola' bahiagrass.

426. Lyle, E. S., Jr., P. A. Wood, and B. F. Hajek, Jr. Classification of Coal Surface Mine Soil Material for Vegetation Management and Soil Water Quality (AL Agr. Exp. Sta., Auburn, AL). U.S. EPA-600/7-79-123, May 1979, 41 pp.

The authors developed a mine soil classification system for five soil classes found in Alabama minesoils, based on texture, color, and pH. Recommendations for limestone and fertilizer additions are made for the five soil types to maintain soil quality suitable for plant growth and surface water quality for at least 1 year. By modifying the Wischmeier universal soil loss equation, the authors developed a relative erodability index (REI) to predict the erosion characteristics of Alabama minesoils and determine the required timeframe for erosion control techniques. Both the mine soil classification system and the REI have application to Alabama soil types outside the five evaluated in this report, and perhaps could be expanded to soils outside Alabama as well.

427. MacDonald, M. Another Viewpoint. Western Wildlands, v. 7, No. 3, 1981, pp. 12-14.

The author discusses some of the controversy and uncertainties of surface mining in the Northern Great Plains. Several questions are brought forth concerning how far surface mining should be allowed to proceed in this region. The keys to answering the questions posed are regulation, the quality of reclamation technology for this region, and time.

428. MacLauchlan, R. S. The Search for "Workhorse" Plants. Soil Conservation, v. 42, No. 12, 1977, pp. 5-9.

This general article discusses some of the plant strains, discovered at plant materials centers of the Soil Conservation Service, to be used for erosion control plantings. A variety of disturbed areas (including surface mines) and the plant species used for erosion control on these areas are described. 'Arnot' bristly locust (Robinia fertilis Ashe), 'Cardinal' autumn olive (Elaeagnus umbellata Thunb.), and 'Tioga' deertongue (Panicum clandestinum L.) are the plant species recommended for use on eastern coal mine spoils that are acid and low in fertility. No specific species are given for use in the revegetation of western coal mines.

429. Maddox, J. B., J. E. Brown, and G. N. Bartley, Jr. The Effects of Fertilizer and Acid Strip Mine Spoil on Germination of Grass Seeds. Paper in Fifth Symposium on Surface Mining and Reclamation (NCA/BCR Coal Conf. and Expo IV, Louisville, KY, Oct. 18-20, 1977). Natl. Coal Assoc. and Bit. Coal Res., Inc., 1977, pp. 245-254.

The purpose of this study was to examine the effects of ammonium nitrate (AN) and triple superphosphate (TSP) fertilizer slurries and acid spoil on grass seed germination. The study was designed to simulate hydraulic seeding conditions and was conductd in a greenhouse. Six grass species were included in the study: annual ryegrass (Lolium multiflorum Lam.), 'Kentucky-31' fescue (Festuca arundinacea Schreb.), orchardgrass (Dactylis glomerata L.), perennial ryegrass (Lolium perenne L.), redtop grass (Agrostis alba L.), and weeping lovegrass (Eragrostis curvula (Schrad.) Nees). Spoil from a Campbell County, TN, coal strip mine was used as the germination medium for the fertilizer treatments. Soil from an area along the Clinch River near Norris, Tennessee was used as a control. Germination percentage for all species tested was highest with the river bottom soil. Germination of orchardgrass and redtop was significantly increased by TSP. AN suppressed germination of all species except redtop. Germination percentages of TSP-treated seeds were significantly higher than those for AN-treated seeds. Seed treated with TSP alone and sown on the mine spoil resulted in healthier looking seedlings than any other fertilizer treatment used in this study. The authors suggest that when hydraulically seeding grasses on acid spoil, ammonium nitrate at the rate of 112 kg/ha or greater should be applied with some other fertilizer amendment such as triple superphosphate. Triple superphosphate can be used alone at rates up to at least 336 kg/ha with no detrimental effects. In some cases it appeared to enhance germination. The authors suggest that triple superphosphate or some other phosphate carrier should always be used when hydraulically seeding grasses on acid strip mine spoil. The results of this study would be most applicable to the Interior and Eastern Coal Mining Regions.

430. Mallary, R. ECOLSITE: An Application of Computer Graphics to the Design of Landforms for Surface-Mine Reclamation. Paper in Fifth Symposium on Surface Mining and Reclamation (NCA/BCR Coal Conf. and Expo IV, Louisville, KY, Oct. 18-20, 1977). Natl. Coal Assoc. and Bit. Coal Res., Inc., 1977, pp. 32-36.

This paper provides a brief summary of the essentials of ECOLSITE, an interactive program for computer-aided landform design. The structure, operation, current capabilities, imminent improvements, and eventual performance objectives of the program are discussed. This article will be of interest to reclamation planners nationwide.

431. Maneval, D. R. Update-Reclaiming Minelands in Alaska. Min. Eng., Oct. 1983, pp. 1419-1423.

This article presents a brief synopsis of the status of mines operating and planned in Alaska and the current work in establishing baseline data of existing flora, fauna, air quality, and water quality. A brief description of current reclamation practices and a summary of current research dealing with revegetation on surface mined lands, reestablishment of animal populations, and necessary water treatment processes are included. This article is a very general status report and does not present research results. The author does discuss future research and land-use direction.

432. Manula, C. B., F. A. Camilli, and J. Kiusalaas. Site Selection and Financial Analysis of Deep Surface Mining of Anthracite Coal, Volume II, Wabash Valley Site (U.S. DOE contract ET-76-G-01-9006, Dept. of Miner. Eng. PA St. Univ.). U.S. DOE, FE-9006-TI, v. 2, Sept. 1979, 351 pp.

The economic feasibility of developing a large-scale deep open pit mine in the Wabash Valley west of Tamaqua, PA, in the Southern Anthracite Field is evaluated. The assumed production is 3 million tons of clean coal per year for a 40-year life. Based on data provided by the U.S. Geological Survey, average mining locations, strip ratios, and reserves were estimated using a computer model. This information was combined with equipment performance characteristics in a computer simulation model to determine sizes for truck fleets, shovels, and front-end loaders. A discounted cash flow model was applied using calculated capital investment and costs to obtain a selling price. Problems of drainage, pit slope stability, overburden characteristics, and revegetation are addressed, as are details of the social and economic background of the area and local land-use regulations. The aim of the study was to design an operation that would achieve maximum anthracite recovery and provide permanent reclamation. A convential shovel-truck system was used. No serious attempt was made to minimize costs, but rather to determine the cost of a feasible mine system that would fulfill basic objectives. This report provides an excellent sample of an analysis of this type and would be pertinent not only to activities in this specific area but also to planning in other areas.

433. Martin, P. R. Wildlife Mitigation in Montana. Paper in the Third Biennial Symposium on Surface Coal Mining and Reclamation on the Great Plains (cochaired by the Reclam. Res. Unit, MT State Univ. and U.S. OSM, Billings, MT, Mar. 19-21, 1984). MT State Univ. and U.S. OSM, 1984, pp. 125-142.

The terms "reclamation", "compensation", and "mitigation" are defined from the viewpoint of the Montana Fish, Wildlife and Parks Department. The mitigation guidelines developed by that department in 1983 are presented. The Department's involvement in the Federal coal leasing program and "unsuitability" determination is discussed. The author also reviews the habitat recovery and replacement guidelines developed in cooperation with the Bureau of Land Management. Two examples of specific mitigation agreements are examined.

434. Marshall, I. B. Sec. from Ch. in Mining, Land Use and the Environment, I. A Canadian Overview. Land Use in Canada Series, No. 22, Land Directorate Environment Canada, Ottawa, Canada, 1982, pp. 60-68.

A general overview of postmining reclamation efforts in Canada is provided as a section of a chapter discussing the nature of mining both metallic and nonmetallic minerals. Technical descriptions of reclamation procedures or data are not provided. The purpose of this section is to provide the reader with a relatively brief orientation statement for factors considered and affecting reclamation efforts in Canada.

435. Marx, D. H. Manipulation of Selected Mycorrhizal Fungi To Increase Forest Biomass. Paper in 1977 TAPPI Forest Biology Wood Chemistry Conference (Madison, WI, June 20-22, 1977). Tech. Assoc. Pulp and Paper Ind., Atlanta, GA, 1977, pp. 139-149.

The article outlines the use and benefit of both ectomycorrhizal and endomycorrhizal fungi for reclamation and reforestration purposes. Results are given of studies on coal mine soils in Kentucky and Virginia, clay spoils in Georgia, and undisturbed sites in North Carolina and Florida. The studies show how certain species of mycorrhizal fungi can greatly increase tree seedling survival, height, stem diameter, and seedling volume when the trees are inoculated prior to outplanting. When the article was written, one fungus, Pisolithus tinctorius, was nearly at a point where it was to be commercially produced. The studies on coal mine spoils mentioned above used Pisolithus tinctorius to form mycorrhizae with Virginia (Pinus virginiana Mill.), loblolly (Pinus taeda L.), and shortleaf (Pinus echinata Mill.) pine, with very good success.

436. Marx, D. H. Role of Mycorrhizae in Forestation of Surface Mines. Paper in Trees for Reclamation (Lexington, KY, Oct. 27-29, 1980). U.S. For. Ser., Gen. Tech. Rep. NE-61, 1980, pp. 109-116.

The author reviews the role of mycorrhizae in the forestation of surface-mined lands. A brief introduction is given on ectomycorrhizae and endomycorrhizae, their association with plant species, and the importance of these fungi to plant growth. The studies presented illustrate the importance of ectomycorrhizae, particularly those formed by Pisolithus tinctorius, to the survival and growth of Pinus spp. seedlings on surface-mined lands. Endomycorrhizal fungi have been shown to affect the growth of grass species and certain hardwood species on surface-mined land. The author states that there is a need to develop a commercial inoculation of Pisolithus tinctorius for seedling tailoring in the nursery prior to outplanting. Several of the studies presented have been reviewed and are contained in the bibliographic listing (See Berry, Marx, and Ruehle).

437. Marx, D. H., and J. D. Artman. Pisolithus tinctorius Ectomycorrhizae Improve Survival and Growth of Pine Seedlings on Acid Coal Spoils in Kentucky and Virginia. Reclam. Rev., v. 2, 1979, pp. 23-31.

The results of a study comparing the growth and survival of nursery-grown loblolly (Pinus taeda L.) and shortleaf (Pinus Echinata Mill) pine seedlings infected with Pisolithus tinctorius and Thelephora terrestris ectomycorrhizae on coal spoil are given in this article. Following fumigation of nursery soils, seedlings often become ectomycorrhizal with Thelephora, a fungus that is well adapted to greenhouse conditions but that does not survive well when outplanted onto coal mine spoils. Pisolithus, on the other hand, is frequently found on coal mine spoils. Plots were established and monitored for three years on an acid coal spoil in Kentucky, and for four years on an acid coal spoil in Virginia. Treatments at the Kentucky site were loblolly and shortleaf pine seedlings with either Pisolithus or Telephora with or without a fertilizer tablet. At the Virginia site, loblolly pine seedlings with Pisolithus or Telephora were planted. Survival and growth data were taken after each growing season. The ability of Pisolithus to persist and spread to new roots stimulated seedling growth on these acid spoils, while Telephora-inoculated seedlings showed poor survival and growth.

438. Mason, R. H. Falcon Coal Shines Brightly in Experimental Reclamation. Coal Min. Process., v. 14, No. 6, 1977, pp. 66-70.

This is a general article which discusses reclamation experiments conducted by Falcon Coal Co. near Jackson, KY. A wide variety of land use categories have been experimented with, including cropland, pastureland, forestry, and wildlife. A unique feature of Falcon Coal Co.'s reclamation experiments has been the development of a grape vineyard. This effort, using French hybrid grapevines, has proven to be successful for making commercial wine.

439. Master, W. A., and J. D. Taylor. Grundy County Reclamation Demonstration Project, Phase II, Progress Report for 1977-1978. Argonne Natl. Lab. ANL/LRP-TM-16, Sept. 1979, 46 pp.

Forty research plots were established at an abandoned strip coal mine in Illinois. The plots were treated with topsoil, digested sewage sludge, chemical stabilizer, scrubber slag, straw mulch, or lime. The plots were evaluated for vegetative cover after the 1976 and 1977 growing seasons. Plots treated with straw mulch, topsoil, and scrubber slag, as well as the control plots, were monitored for temperature in 1978. The data from these studies are given. In addition, seven native Illinois prairies species were grown in the greenhouse on spoil with pH ranging from 3.2 to 5.2. Eight native prairie species were planted on a spoil plot at the strip mine site. The only plant species showing significant productivity in either of these studies was switchgrass (Panicum virgatum L.), which dominated the field test plot 12 weeks after seeding.

440. Mathews, D. Post-Mining Utility: A Basis for Woody Plant Density Standards in Northwestern Colorado. Paper in Symposium on Western Coal Mining Regulatory Issues: Land Use, Revegetation, & Management (West. Reclam. Group, Denver, CO, Apr. 1982). CO State Univ., Range Sci. Dep., Fort Collins, CO, Sci. Ser. No. 35, Aug. 1983, pp. 36-42.

This article provides an excellent discussion of the woody plant density requirements of existing Federal and State regulations controlling reclamation activities in northwestern Colorado. These criteria have generated much concern among mine operators, ranchers, and range and wildlife management professionals of this area. The author reviews the techniques and problems of woody plant establishment, the perspective of the ranchers, and the woody plants and principal wildlife (game animals) of the area. The author states, and shows by example, that by evaluating site-specific vegetation conditions and land-use needs, it should be possible to set feasible woody plant density standards that meet specific wildlife habitat requirements while maintaining or improving the utility of the postmining vegetation for livestock grazing. The greatest potential for conflict between wildlife requirements and wildlife use rests in establishing standards for sage brush density on important sage grouse winter range or breeding-nesting complexes. This article was written with specific reference to northwestern Colorado, but the concepts conveyed could probably find application over a broader geographical area covering major portions of the Northern Great Plains and Rocky Mountain Coal Mining Regions.

441. McArthur, E. D. Shrub Selection and Adaptation for Rehabilitation Plantings. Paper in Shrub Establishment on Disturbed Arid and Semi-Arid Land (Proc. Symp., Laramie, WY, Dec. 2-3, 1980). WY Game and Fish Dep., 1981, pp. 1-8.

This article contains a concise review of some of the literature pertinent to reestablishment of shrubs on surface mined land in the arid and semiarid regions of the United States. Selection and breeding programs for fourwing saltbush (Atriplex canescens (Pursh) Nutt.) and big sagebrush (Artemisia tridentata Nutt.) are reviewed. The importance of shrublands and their postmining rehabilitation in Wyoming are the primary focus of the article. The information contained in the report is general in nature.

442. McCarthy, M. M. Alteration of Microbial Populations in Surface Mine Revegetation and Their Effects on Nitrogen Cycling. Ph.D. Thesis, UT State Univ., Logan, UT, 1980, 149 pp.

This thesis details the results of a study of microbial activity and soil chemistry of revegetated and undisturbed sites at the Decker Mine in southeastern Montana. The research was divided into two phases. Phase 1 was a field study looking at the effects of revegetation on soil chemisty and microbial activity. Soil samples from an undisturbed site and three revegetated sites of differing ages were used. Phase 2 was a laboratory study to analyze those variables found during the field study to have the most influence on the microbial community. The effects of microbial activity on the availability of nitrogen and other nutrients is evaluated, and changes in the nitrogen cycle on disturbed sites versus undisturbed sites are delineated.

443. McClenahen, J. R., and R. J. Hutnik. Effects of Cutting Intensity, Deer Browsing, and Liming on Allegheny Hardwood Tree Regeneration. Can. J. For. Res. (Canada), v. 9, 1979, pp. 362-368.

A study was conducted in Elk County, PA, to determine the influence of liming, cutting intensity, and deer browsing on survival and growth of tree seedlings and on development of understory vegetation. The study site was occupied by a 70-year-old second-growth hardwood stand. Percentages of total basal area for the major overstory species were 34 pct black cherry (Prunus serotina Ehrh.), 28 pct sugar maple (Acer saccharum Marsh.), 24 pct red maple (Acer rubrum L.), 6 pct beech (Fagus grandifolia Ehrh.), and 4 pct eastern hemlock (Tsuga canadensis (L.) Carr.). Treatments consisted of two levels of dolomitic limestone (0 and 0.91 t/ha), two deer browsing intensities (browsed and nonbrowsed), and cutting to residual basal areas of 0, 16, and 28 m^2/ha (clear cut, partial cut, and no cutting, respectively). Mortality rates and seedling height data for each treatment are detailed. Results showed that deer browsing did not statistically impact height after 6 years, liming was not effective, and partial cutting was superior to clear cutting and no cutting as a means of increasing the abundance of desirable tree species, especially black cherry.

444. McComb, W. C., S. B. Carpenter, and R. S. Caldwell. Direct Seeding of Sawtooth Oak on Surface Mine Spoil. Paper in 1981 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Dec. 7-11, 1981). Univ. KY, Lexington, KY, 1982, pp. 497-500.

This article discusses the potential use of direct-seeded sawtooth oak (Quercus acutissima Carruth.) for wildlife plantings on surface-mined lands in southeastern Kentucky. Sawtooth oak acorns were direct-seeded in the field and laboratory. The laboratory situation was used to determine seed germination without environmental stress. The field study was conducted to determine the effects of fertilization, mulching, and competing vegetation on the stocking, survival, and height growth of direct-seeded sawtooth oak. The results indicate that direct seeding of sawtooth oak on mine spoil is a feasible alternative. However, a mulch or mulch fertilizer treatment increased the germination and survival of sawtooth oak.

445. McDonald, J. D., and J. C. Errington. Reclamation of Lands Disturbed by Coal Mining in British Columbia. Paper in Stability in Coal Mining (Proceedings of the First International Symposium on Stability in Coal Mining, Vancouver, British Columbia, 1978). Miller Freeman Pub., Inc., San Francisco, CA, 1979, pp. 481-490.

This paper presents a concise overview of reclamation on lands disturbed by coal mining and coal exploration in British Columbia. Legislation regulating coal mine reclamation in British Columbia is reviewed. Revegetation problems and procedures for two of the major coalfields in British Columbia, the Crowsnest coalfield and the Pease River coalfield, are discussed. These discussions contain limited specific, but good, general information concerning the revegetation techniques employed. Some of the areas considered are in alpine environments and may be of use in limited, specific areas of the Rocky Mountains and Alaska.

446. McEwan, B. Greening Up After Mining. Environ., v. 24, No. 3, 1982, pp. 40-42.

Growing trees on mined land in the Northeast has proven to be a difficult task. Hybrid poplar (Populus spp.) may provide a solution to the problem of tree establishment on mined land. A history of hybrid poplar development is provided along with selected growth characteristics and economic benefits of planting hybrid poplar on mined areas. Hybrid poplar may prove to be an effective way to revegetate mined land in the Northeast.

447. McFee, W. W., W. R. Byrnes, and J. G. Stockton. Characteristics of Coal Mine Overburden Important to Plant Growth. J. Environ. Qual., v. 10, No. 3, 1981, pp. 300-308.

This article reports the results of a study conducted in the Illinois Coal Basin of southwestern Indiana and designed to evaluate the physical and chemical properties of mineland overburden, to evaluate plant growth in these materials, and to determine if any properties of the overburden materials might serve as predictors of potential plant growth. No chemical or physical properties examined during the study could be consistently used in a formula for predicting potential plant growth. Selected soil amendments were tested. Sewage sludge was more effective than fertilization with N-P-K in improving growth of wheat (Triticum aestivum L.) and alfalfa (Medicago sativa L.). This article provides excellent tables of data that could be applied in comparisons to other studies or in planning reclamation work on the materials treated in the study.

448. McGinnies, W. J., and P. J. Nicholas. Effects of Topsoil Thickness and Nitrogen Fertilizer on the Revegetation of Coal Mine Spoil. J. Environ. Qual., v. 9, No. 4, 1980, pp. 681-685.

Two studies were conducted to evaluate the benefits of topsoil on reshaped mine spoils in northwestern Colorado. A greenhouse study was utilized to (1) determine the effects of topsoil thickness on the herbage and root growth of winter wheat (Triticum aestivum L.) and intermediate wheatgrass (Agropyron intermedium (Host) Beauv.), (2) evaluate the effects of mixing equal parts of topsoil and spoil on the growth of both species, and (3) evaluate the effects of nitrogen fertilization (112 kg/ha nitrogen fertilizer applied in the form of ammonium nitrate) on the aboveground and root growth of intermediate wheatgrass. A second field study was used to determine the effect of topsoil thickness on the establishment and growth of a mixture of grass, forb, and shrub species. The topsoil thickness treatments were 0, 10, 20, 30, and 46 cm of topsoil placed over spoil in both the greenhouse and field studies. The thickness of the topsoil placed over the mine spoil directly influenced plant growth and production in both studies. As the depth of topsoil increased, there was a linear increase in the growth, productivity, and coverage of the plants used. The greenhouse study indicated that there was no apparent advantage to mixing topsoil and subsoil. The herbage and root production of intermediate wheatgrass was the same as when grown in 15 cm of topsoil alone. (The mixture was a combination of 15 cm of topsoil with 15 cm of spoil). The nitrogen fertilization study showed increased aboveground and belowground growth of intermediate wheatgrass. This enhanced growth caused by nitrogen fertilization could be an additional aid in soil development and stabilization on reclaimed mine sites, particularly on slopes where topsoil is shallow.

449. McGuire, P. E., M. R. Spivey, and R. H. Mason. The Palzo Project Water Quality Trends Within A Sludge-Amended Strip Mine Site. Paper in 1983 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Nov. 17-Dec. 2, 1983). Univ. KY, Lexington, KY, 1983, pp. 57-66.

This study was conducted to determine the effects of a large-scale sludge application and reclamation project on the ground and surface water quality of the Palzo tract in Williamson County, IL. Sludge application had a positive effect on the ground water quality by decreasing the spoil surface temperature, decreasing oxygen availability, minimizing exposure of reactive spoil material through erosion control, and decreasing infiltration of leachate due to water loss from evapotranspiration. Even though there has been a favorable change in the Palzo water quality, the ground and surface water discharge remains poor. This condition can be attributed to the untreated portions of the tract. The authors conclude that one of the primary factors contributing to the improved water quality of the Palzo tract is that sludge treatment and establishment of a vegetative cover have reduced the potential for the production of acid mine drainage.

450. McKell, C. M. New Developments in Soil Amendments--A Biologist's Point of View. Paper in Proceedings: High-Altitude Revegetation Workshop No. 5 (CO State Univ., Fort Collins, CO, Mar. 8-9, 1982). CO Water Res. Institute, CO State Univ., Fort Collins, CO, Inf. Ser. No. 48, Dec. 1982, pp. 151-163.

This paper contains a general discussion of several different types of soil amendments available for ameliorating unfavorable soil characteristics. A brief review of pertinent literature is offered for each type of soil problem discussed, together with potential methods of mitigating the problem. This article presents an excellent overview of this information that could be helpful to individuals planning reclamation activities, and who have little experience or knowlege of soil amendments.

451. McKell, C. M., J. Fuhrinman, G. F. Gifford, S. G. Richardson, A. G. Southard, G. Van Epps, J. S. Williams, and G. Workman. Energy Mineral Rehabilitation Inventory and Analysis. Henry Mountain Coal Field. EMRIA Report 15 (U.S. BLM contract YA-512-CT6-258, Utah State Univ.). U.S. Bureau of Land Manag., Rep. BLM/YA/TR-78/15, May 1978, 289 pp.

This publication summarizes baseline data specific to the area of coal deposits in the Henry Mountain Resource Area in south-central Utah. Chemical and biological analyses of eight geologic cores obtained from the overburden were corelated with field plantings on geologic outcrops and representative soils identified by a Soil Conservation Service soil survey. An excellent review and discussion of the reclamation potential of the area and recommendations for reclamation are provided. This publication is an excellent example of a premining feasibility study. The data and discussion are specific for this geographical area. However, this report is also valuable as a model for premining feasibility studies conducted anywhere in the Nation.

452. McKell, C. M., and G. A. Van Epps. Comparative Results of Shrub Establishment in Arid Sites. Paper in Shrub Establishment on Disturbed Arid and Semi-Arid Land (Proc. Symp., Laramie, WY, Dec. 2-3, 1980). WY Game and Fish Dep., 1981, pp. 138-154.

The authors review various aspects of reestablishing shrub species on disturbed land in arid environments. Their studies on the control of weedy plant competition in the oil shale region of northeastern Utah are used as a basis for the discussion. Control of weedy plant competition from Russian thistle (Salsola kali L. var. tenuifolia Tausch) and downy chess (Bromus tectorum L.) for 2 years allowed survival of 88 and 71 pct of transplanted shrub species in two separate studies. In the latter study natural conditions resulted in a 41-pct shrub survival. Native shrub species exhibiting the best establishment and survival included fourwing saltbush (Atriplex canescens (Pursh) Nutt.), big sagebrush (Artemisia tridentata Nutt.), rubber rabbitbrush Chrysothamnus nauseosus (Pall.) Britt.), black sagebrush (Artemisia arbuscula nova (A. Nels.) Cronq.), and black greasewood (Sarcobactus vermiculatus (Hook.) Torr.). The best adapted species for revegetation of very harsh sites include mat saltbush (Atriplex corrugata Wats.), shadscale (Atriplex confertifolia (Torr. & Frem.) S. Wats), and prostrate summercypress (Kochia prostrata (L.) Schrad.). The proper handling of transplant material and optimum planting conditions are discussed. The information contained in this article is applicable to revegetation of surface coal mines in major portions of the Rocky Mountain and Northern Great Plains Coal Mining Regions.

453. McKell, C. M., and G. Van Epps. Vegetative Rehabilitation of Arid Land Disturbed in the Development of Oil Shale and Coal. U.S. Environmental Protection Agency, EPA-600/7-80-071, Apr. 1980, 38 pp.

Two representative arid locations in Utah were utilized to study new approaches that could be used to rehabilitate disturbed arid lands. Field experiments were established in northeastern Utah on a site disturbed by exploratory drilling for oil shale and on disturbed sites on a potential coal mine in south-central Utah. The specific objectives of this study were to (1) develop propagation and transplanting techniques for selected native species in harsh sites with varying soil properties, (2) determine the suitability of a number of materials for soil surface stability that would also promote water harvesting, (3) study the ecology of selected native species in relation to germination, seedling vigor, and field survival, and (4) study soil moisture patterns in relation to plant survival. Greenhouse studies were used to gain a better understanding of the biology of selected native plants. The results of field experiments indicated that the establishment of containerized transplants was more successful than were plantings that utilized bare-root stock or were direct-seeded. Planting the native species in the spring gave better results than those planted in the fall. Using plant species that were tolerant of the adverse soil conditions gave higher survival percentages than using other native species that were not as tolerant to harsh soil conditions. By shaping the soil surface to collect water, plant survival was increased. Water harvesting could be improved by applying a soil surface stabilization material. Recommendations are given that are applicable to the oil shale regions of Utah, Wyoming, and Colorado or the Four Corners of Utah, Arizona, New Mexico, and Colorado.

454. McKell, C. M., G. Van Epps, and S. G. Richardson. Plant Establishment Research on Disturbed Arid Sites in the West. Paper in Surface Coal Mining and Reclamation Symposium, Coal Conference and Expo V (sponsored by Coal Age, Louisville, KY, Oct. 23-25, 1979). McGraw-Hill, 1979, pp. 260-277.

This article discusses a revegetation study in the arid Henry Mountains Coalfield of south-central Utah. The climate, soils, and vegetation of the study area are briefly described. Geologic cores and soil samples were taken, and their chemical and physical characteristics were measured. Six field test plots were set up on representative soils and outcrop materials. After ripping, scraping, and dozing the plots, they were planted using five different plant species. The sites were monitored over 2 years. Results of the chemical analyses of the soils and geologic materials are given, as well as percent survival and yields of the five species planted. The correlations between shoot biomass and pH, salinity, and boron concentration were calculated. Finally, the difficulty of and recommendations for revegetating disturbed sites in the Henry Mountains Coalfield are discussed.

455. McMartin, W. Western Coal: Energy vs. Agriculture. ND Farm Res., v. 35, No. 4, Jan. 1978, pp. 12-17.

This article contains a benefit-cost analysis of surface coal mining and subsequent reclamation compared to the current agricultural land use. The analysis considered eight States that comprise the major portion of the Northern Great Plains and the Rocky Mountain Coal Mining Regions. The author offers two major conclusions based on this economic analysis. First, he states the surface coal mining in the Western United States poses no threat to our national food supply since the amount of land needed for mining is small in relation to the total available. His second conclusion is that the cost of reclaiming mined land is many times higher than the agricultural benefits and thus, environmental values must be used to justify mineland reclamation in this region.

456. McMinn, J. W., C. R. Berry, and J. H. Horton. Ash Basin Reclamation With Commercial Forest Species. Reclam. Reveg. Res., v. 1, No. 4, 1982, pp. 359-365.

The performance of loblolly pine (Pinus taeda L.), longleaf pine (Pinus palustris Mill.), sweetgum (Liquidambar styraciflua L.), and American sycamore (Platanus occidentalis L.) seedlings planted on a 12-year-old abandoned ash basin was evaluated. The ash basin, located near Aiken, SC, was constructed specifically for storage and filled to a depth of 3 m with bottom ash sliced from a pulverized coal boiler. A similar planting was done on a forest site that was representative of the native forest soils of the area (reference area). Species survival was recorded over a 4-year period. Foliar analyses were conducted the first and fourth year, while soil analyses were conducted the first year only. After the fourth year, longleaf pine had failed on both sites. For the remaining species, survival was found to be better on the ash substrate than on the native soil during the 4 years of this study. The elemental concentration of ash apparently had no effect on the survival of sweetgum or American sycamore. Loblolly pine exhibited nutrient deficiency symptoms which were apparently caused by the high pH of the ash. For loblolly pine, a pH of 7.0 or above is considered to be too high. The most striking pattern found was that there were higher foliar concentrations of certain elements in the seedlings planted in native soil even though those elements occurred in higher total concentration in the ash. The authors concluded that sweetgum and American sycamore survived and grew acceptably well on a storage basin of coal bottom ash.

457. McMinn, J. W., R. R. Roth, C. R. Berry, and W. H. McNab. Comparison of Five Woody Species for Reclamation of an Upper Coastal Plain Spoil Bank. U.S. For. Ser., SE For. Exp. Sta., Asheville, NC, Res. Note SE-300, Sept. 1980, 2 pp.

The results of a 3-year revegetation study are reported. European black alder (Alnus glutinosa (L.) Gaertn.), autumn olive (Elaeagnus umbellata Thunb.), flowering crabapple (Malus floribunda Neubert), sawtooth oak (Quercus acutissima Carruth.), and Virginia pine (Pinus Virginiana Mill.) were compared for their potential use in revegetating a spoil bank formed during the excavation of a large water retention basin in Barnwell County, SC. The best height growth was exhibited by autumn olive and European black alder. Flowering crabapple and sawtooth oak exhibited the best survival.

European black alder did not become adequately established during the study. The most successful species used in the study were autumn olive and sawtooth oak. The results of this study may be applicable to revegetation of surface coal mine land in the Eastern Coal Mining Region under similar climatic, site, and soil conditions.

458. McSweeney, K., I. J. Jansen, and W. S. Dancer. Subsurface Horizon Blending: An Alternative Strategy to B Horizon Replacement for the Construction of Post-Mine Soils. Soil Sci. Soc. Am. J., v. 45, 1981, pp. 794-799.

The study reported was designed to evaluate combinations of substratum and B-horizon material. The study was conducted in a greenhouse using materials collected from solum and substratum horizons to depths of about 6 m at two surface mine sites in southern and west-central Illinois. A-horizon material or a blend containing A-horizon material was placed over the various combinations of surface rooting medium in order to simulate field conditions where seeds germinate in topsoil and root in the underlying material. The test crop was soybeans (Glycine max (L.) Merr.). In tests with the Darmstedt soil series (Albic Natraqualf) from southern Illinois, the best performance of the test crop was found on segregated A-horizon material replaced over a blend of the next 3 m of B-horizon and substratum material. Performance was poorest where A-horizon material was replaced directly over the B_2-horizon material (matric horizon) of the Darmstedt. Similar results were obtained for tests with the Sable soil series (Typic Haplaquoll) from west central Illinois. However, the difference in performance between the best and poorest treatment was not as marked. The information presented in this article is particularly relevant to topsoil and rooting medium handling and placement for reclamation of agricultural land in the Interior Coal Mining Region.

459. Mecluick, C. Tree Planting Experiences in the Eastern Interior Coal Province. Paper in Trees for Reclamation (Lexington, KY, Oct. 27-29, 1980). U.S. For. Ser., Gen. Tech. Rep. NE-61, 1980, pp. 85-91.

The author discusses tree planting experiences in Illinois, Indiana, and western Kentucky. A brief history on reclamation and the reclamation technology used in the area is presented. General information is given for tree plantings on topsoiled areas, nontopsoiled areas, and coal waste slurry. Suggestions are given on how to improve tree seedling survival on surface-mined lands.

460. Melanson, M. A., and S. M. Carter, Rehabilitation of Disturbed Arid Lands: Long Range Planning and the Role of Mycorrhizae in Rehabilitation. Paper in 1981 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Dec. 7-11, 1981). Univ. KY, Lexington, KY, 1982, pp. 79-87.

This article discusses the need to develop practical solutions to rehabilitation problems through experimentation and research. Any rehabilitation plan should be considered early in the project development in order to ensure proper rehabilitation after the project is completed. An example of original research which could lead to a practical solution of a rehabilitation problem is presented. A study was conducted on a disturbed site (a power transmission line corridor) and an undisturbed site in the northern Mojave Desert to determine whether or not mycorrhizal fungi aid in plant growth and development. Two desert species bursage (Ambrosia dumosa (Gray) Payne.) and creosote bush (Larrea tridentata (DC) Cov.) were found to have greater growth rates, shoot dry weights, survival rates, and plant vigor when mycorrhizal inoculum was added to the soil.

461. Merino, J. M., and R. B. Crookston. Reclamation of Spent Oil Shale. Min. Congr. J., v. 63, No. 10, 1977, p. 31-36.

This article discusses the techniques and practices used by Tosco Corp. in the reclamation of spent oil shale. A good portion of the article is devoted to the physical and chemical characteristics of the processed shale. These properties affect the revegetation of an area. The major problems that have been encountered when establishing vegetation on processed shale are low fertility, poor infiltration rates, and high soluble salt content. Fertilization and mulching are amendments that may help to ameliorate these problems. The article also contains a general reclamation plan for TOSCO II processed shale.

462. Merrill, S. D., E. J. Doering, and J. F. Power. Changes of Sodicity and Salinity in Soils Reconstructed on Strip-Mined Land. ND Farm Res., v. 37, No. 6, May 1980, pp. 13-16.

This article reports the results of a project involving both laboratory and field studies designed to examine upward salt migration in reconstructed soil profiles on reclaimed mineland. The four field sites used in the study were located in Oliver and Mercer Counties, ND. A mathematical model considering water flow, salt flow by convection (salt carried by water), salt flow by diffusion (movement of each kind of salt in proportion to differences in concentration), and cation exchange was applied to laboratory column experiments. Calculations using this model indicated that chemical diffusion accounted for most of the upward movement of sodium in the columns. The calculated diffusion accounted for about 50 pct of the upward migration of sodium observed at two of the field sites. The authors feel that clay mineralogy is an important factor affecting hydraulic conductivity at a given sodium adsorption ratio. The results and discussions contained in this article are pertinent to reclamation efforts in major portions of the Northern Great Plains and Rocky Mountain Coal Mining Regions recognized in this evaluation process.

463. Miller, R. M., and S. W. May. Staunton 1 Reclamation Demonstration Project, Soil Microbial Structure and Function: Final Report. Argonne Natl. Lab. ANL/LRP-11, Feb. 1981, 32 pp.

This publication reports the results of a study conducted at the Staunton 1 reclamation demonstration project near Staunton in southwestern Illinois. Microbial decompositon rates, respiration, and microbial numbers were compared for several coal refuse reclamation treatments. After 1.5 years, decomposition rates, microbial species diversity, and microbial respiration remained lower than that found on the old-field control plot. Microbial numbers in the reclamation plots approached those of the old-field plot. The information contained in this article is pertinent to similar studies conducted throughout the Interior Coal Mining Region.

464. Mining Congress Journal. New Grass Showing Promise in Reclamation Work. V. 64, No. 5, 1978, pp. 28-28.

This paper contains general information on tests conducted using 'Reubens' Canada bluegrass (Poa compressa L.) to reclaim lead-zinc mines in the Northwest and coal surface mines in the Midwest. This species is an ecotype that resembles the native grass which once dominated and stabilized prairie soils in the Northwest. 'Reubens' Canada bluegrass has a tolerance factor that allows it to germinate faster and establish a better density under low soil fertility due to its aggressive rhizome growth and tiller development. After establishment this species is able to survive the extremes of cold and dry conditions. Results of the tests have shown that 'Reubens' Canada bluegrass was able to germinate and establish over a wide range of field conditions. These tests indicate that 'Reubens' Canada bluegrass could be included in most of the seed mixtures that are used for reclamation.

465. Misiolek, N. S., and T. C. Noser. Coal Surface Mine Land Reclamation Costs. Land Econ., v. 58, No. 1, Feb. 1982, pp. 67-85.

The authors developed a computer model to estimate land reclamation costs at 11 locations across the country. Costs totaled $6,500 to $8,000 per acre (in 1980 dollars), with mine land revegetation accounting for $690 to $1,330 per acre. These results are higher than previous studies as (the authors contend) those studies did not include nondirect costs such as opportunity costs and indirect effects of taxes, secondary equipment requirements, and royalties as they affect land reclamation activity effects on the minimum acceptable selling price of coal. Estimates are based on current surface mining techniques utilizing standard construction equipment for land reclamation. The rationale developed by the authors appears sound and the approach much more realistic to estimating the costs of all phases of land reclamation.

466. Mitchell, W. F. Revegetation Progress in Alaska. Paper in Proceedings: High-Altitude Revegetation Workshop No. 5 (CO State Univ., Fort Collins, CO, Mar. 8-9, 1982). CO Water Resour. Res. Inst., CO State Univ., Fort Collins, CO, Inf. Ser. No. 48, Dec. 1982, pp. 122-127.

This paper presents a general discussion of the revegetation needs in Alaska. The author offers a nontechnical discussion of some of his experiences in breeding native and adapted introduced species for use in arctic and subarctic regions of Alaska. Specific species and varieties are discussed. The information contained in this paper may be of interest to those planning revegetation work in arctic, subarctic, and/or high-elevation areas.

467. Mitchell, W. W., G. A. Mitchell, and J. D. McKendrick. Revegetation of Alaskan Coal Mine Spoils, Progress Report for Research (U.S. DOE contract AM06-76RL02229). AK Agr. Exp. Stn., Univ. AK, Palmer, AK, DOE/EV/10256-2, Oct. 1981, 60 pp.

This document contains interim results of a research project being conducted at three locations in Alaska, designed to establish options for surface coal mine reclamation and revegetation in this area. The report contains soil characterization data, soil fertility trial data, irrigation and mulching trial data, water quality data, plant nutrient uptake data, and the results of vegetation planting trials. The preliminary results of a plant colonization and faunal habitat study are also included. Analysis of reclamation plantings conducted over a 9-year period at the Usibelli Mine indicate a significant decline in productivity without continued soil amendments. No definitive conclusions are offered; however, the interim results and the discussions will be useful to individuals planning surface mine reclamation activities or research in this region.

468. Mitsch, W. J., J. R. Tayler, K. B. Benson, and P. L. Hill, Jr. Atlas of Wetlands in the Principal Coal Surface Mining Region of Western Kentucky. Univ. Louisville, Louisville, KY, FWS/OBS-82/72, June 1983, 135 pp.

This publication provides detailed vegetative maps for most of the western Kentucky counties containing abandoned, existing, or potential coal mining operations. Additionally, details are given on the geology and coal mining, hydrology, water quality, wetland vegetation, and fish and wildlife for each mapped area. The information provided will be very useful to those interested in revegetating all environments in western Kentucky for fish and wildlife purposes.

469. Miyamoto, S. Effects of Wetting Agents on Water Infiltration Into Water Repellent Coal Mine Spoils. Soil Sci., v. 125, No. 3, 1978, pp. 184-187.

Commercially available wetting agents were studied for their effects on increasing infiltration. These included linear sulfonate (anionic), alkyl polyethylene glycol ether (nonionic), and ethoxolated alcohol (nonionic) compounds. These tests were conducted under greenhouse conditions. Soil and water application methods were used. Coal mine spoils from the Fruitland Formation on the Navajo Indian Reservation in New Mexico were used in the tests. The results of this study as reported are specific for the material used. However, they may find application over a broader geographical area.

470. Moditz, P., and E. Buckner. Container-Grown Pine Seedlings Enable Extended Planting Season on Surface Mines in East Tennessee. Paper in Proceedings of the Second Biennial Southern Silvicultural Research Conference (Atlanta, GA, Nov. 4-5, 1982). U.S. For. Ser. Gen. Tech. Rep. SE-24, 1983, pp. 141-143.

This study evaluated the use of containerized loblolly pine (Pinus taeda L.) and Virginia pine (Pinus virginiana Mill.) for extending the planting season and improving the survival of these species over that achieved with bare-root seedlings, on surface mined land in Morgan County, TN. Seedlings were grown in the greenhouse for outplanting at 3- to 4-week intervals. Treatments used to test for improved survival and growth were (1) control plantings, (2) inoculation of container rooting medium with spores and mycelia of Pisolithus tinctorius, and (3) disking to reduce herbaceous competition. Seedling survival rates for all planting dates and treatment combinations were found to be over 90 pct. Neither disking nor mycorrhizal inoculation affected survival of planted species over control treatments. The results of this study indicate that containerized pine seedlings can be successfully planted throughout the growing season on surface-mined land in east Tennessee.

471. Monsen, S. B., and A. P. Plummer. Plants and Treatment for Revegetation of Disturbed Sites in the Intermountain Area. Paper in The Reclamation of Disturbed Arid Lands (symposium sponsored by the Committee on Desert and Arid Zones Research of the Southwestern and Rocky Mountain Division of the American Association for the Advancement of Science, Denver, CO, Feb. 23-24, 1977). Univ. NM Press, 1978, pp. 155-173.

The authors provide an excellent discussion of the major factors that must be considered in revegetating disturbed arid lands. The authors focus on plant selection and establishment techniques. A list of grass and herbaceous species together with their areas of adaption is included. Numerous shrub and tree species are also listed, together with ratings for establishment by seed, seedling growth rate, competitive ability, and seedling drought tolerance. The information contained in this article is useful to revegetation planning in portions of the Northern Great Plains and Rocky Mountain Coal Mining Regions.

472. Moody, C. W., and D. T. Kimbrell. Trees for Reclamation in the Eastern United States. Paper in Trees for Reclamation (Lexington, KY, Oct. 27-29, 1980). U.S. For. Ser., Gen. Tech. Rep. NE-61, 1980, pp. 7-8.

The authors discuss the reforestation of surface-mined land in Alabama. Of the 28,528 acres that were permitted for surface mining in 1979, approximately 85 pct was planted to tree species. Species that have been utilized in the Alabama reforestation program include paulownia (Paulownia tomentosa (Thunb.) Stead.), loblolly pine (Pinus taeda L.), longleaf pine (Pinus palustris Mill.), and Virginia pine (Pinus virginiana Mill.). An improved seedling program has resulted in a 15- to 20-pct increase in volume production from first-generation seedlings. The authors feel that with good forest management on reclaimed mine land, Alabama will be able to meet its future demands for forest products.

473. Moore, R. T., S. L. Ellis, and D. R. Duba. Advantages of Natural Successional Processes on Western Reclaimed Lands. Paper in Fifth Symposium on Surface Mining and Reclamation (NCA/BCR Coal Conf. and Expo IV, Louisville, KY, Oct. 18-20, 1977). Nat. Coal Assoc. and Bit. Coal Res., Inc., 1977, pp. 274-282.

The authors review reclamation guidelines and regulations from Montana, Wyoming, and Colorado pertinent to revegetation. They contend that these regulations attempt to immediately restore a near-climax plant community on mined land, thus ignoring ecological principles. They feel that annual species that invade a reclaimed area or are present in topsoil used for reclamation and certain introduced species should be considered as an integral part of early successional development of the revegetation community. An excellent review of pertinent literature is used to defend this opinion. While this article specifically addresses reclamation in the above-mentioned States and is primarily pertinent to the Northern Great Plains and Rocky Mountain Coal Mining Regions, the ecological principles evoked are applicable nationwide.

474. Moore, R., and T. Mills. An Environmental Guide to Western Surface Mining. Part Two: Impacts, Mitigation, and Monitoring (Coal Project, FWS contract 14-16-0009-77-008). U.S. Fish and Wildlife Ser. FWS/OBS-78/04, Dec. 1977, 345 pp.

The impacts of surface mining for coal, copper, bentonite, oil shale, phosphate, gypsum, and uranium are addressed by this manual for the Northern Great Plains and Rocky Mountain Coal Mining Regions. The purpose of this manual is to assist U.S. Federal regulatory agency biologists and others in making decisions when drafting lease and permit stipulations for surface mine development projects. The manual is designed primarily for use by biologists; however, it includes introductory information on regional ecology, minerals, and mining methods, making it useful to managers, industry planners, and other decisionmakers of diverse backgrounds. The manual is organized in four substantive sections: (1) Regional Ecology and Mining Descriptions, (2) Effects of Surface Mining, (3) Recommendations for Mitigation and Enhancement, and (4) Recommendations for Monitoring. It is assumed that users of this manual will have fairly specific information about the type of surface mining operation planned for a given site and more site-specific ecological information available to them than is contained in this document. As a consequence the manual provides a starting point for determining the impacts and their effects, and for developing mitigation and monitoring recommendations for a mine in a particular area. It identifies the types of information a biologist should have when evaluating surface mining impacts. In addition it provides criteria for evaluating mitigation and monitoring procedures. Chapter 4, "Recommendations for Mitigation and Enhancement," and chapter 5, "Recommendations for Monitoring," will be of particular interest to those dealing directly with rehabilitation of mine sites and associated monitoring. In chapter 4 recommendations concerning site specific mitigation and associated stipulations are considered in relation to three possible levels of mitigatory action (high, medium, and low). These levels are separated based on (1) the degree to which the adverse impact would be eliminated or minimized, (2) the availability and practicability of the technology, (3) the relative cost of achieving each level of protection, and (4) the demonstrated or anticipated success of each procedure in protecting, reclaiming, rehabilitating, or enhancing the wildlife resources. The high level of mitigation implies application of "best available technologies" with respect to a given activity. Chapter 5 is divided into several sections. The first section outlines a conceptual approach to designing a monitoring program. The sections that follow utilize information presented in the first section to evaluate existing monitoring stipulations and provide guidelines for site-specific monitoring. Ratings for keywords used in the evaluation process have been applied somewhat differently for assessing this manual, since it primarily presents guidelines for land management decisionmaking rather than reporting an actual field study. Consequently, the ratings represent the treatment of these subject areas in the guidelines presented and the conceptual basis for these guidelines.

475. Morin, M. D. Heavy Metal Concentrations in Sludge-Amended Acid Spoil Medium Three Years After Application. Paper in 1982 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Dec. 5-10, 1982). Univ. KY, Lexington, KY, 1982, pp. 705-713.

Anaerobically digested sewage sludge was applied to an abandoned surface-mined area in southeast Williamson County, IL (Palzo tract). Three years after application, adjusted pH conditions in order to simulate the average pH of the Palzo soils. When the 0.1N HCl extraction technique was used, higher levels of metals were extracted. The higher concentrations may be due to the low pHw's of the Palzo tract and the acidic nature of the extraction method. This method also extracts total amounts of the metals present rather than available amounts. Using the DTPA chelate method resulted in lower extractable amounts, which indicate the soluble chelated forms available for plant uptake. Beside the other differences, the extractions were a function of the metals encountered.

476. Morin, M. D. Heavy Metal Concentrations in Three-Year-Old Trees Grown on Sewage-Amended Surface Mine Spoil. Paper in 1981 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Dec. 7-11, 1981). Univ. KY, Lexibgton, KY, 1982, pp. 297-306.

This article discusses the concentration of cadmium, copper, iron, manganese, nickel, and zinc in 3-year-old leaf, stem, and root tissue of silver maple (Acer saccharinum L.), green ash (Fraxinus pennsylvania Marsh.), Virginia pine (Pinus virginiana Mill.), river birch (Betula nigra L.), and eastern cottonwood (Populus deltoides Bartr. var. deltoides). Comparisons were made between trees that had survived for 3 years on abandoned surface-mined land treated with varying amounts of sewage sludge and nursery grown stock. All trees had been planted as seedlings 3 years prior to sampling except for eastern cottonwood, which had invaded the area as a volunteer species. Roots and foliage of 3-year-old trees were found to have higher heavy metal contents than stems. However, the heavy metal concentration in tissues were lower than those found in first-year tissues. This work was conducted on the Palzo tract in southern Illinois.

477. Morin, M. D. Opportunities for Commercial Forests on Surface Mined Lands. Paper in 1982 Seminar on Post-Mining Productivity With Trees (Carbondale, IL, Mar. 31-Apr. 2, 1982). South. IL Univ., Carbondale, IL, 1982, pp. 19-23.

This article reviews the history and regulations pertaining to planting trees on strip-mined areas in Illinois. To properly develop a production environment for trees, premine characteristics of the forest need to be investigated. The postmining reclamation plan should then reflect the good qualities of the site. These site characteristics are briefly reviewed.

478. Morin, M. D. Vegetation Sampling--A Tool To Measure Woody Plant Survival on Mined Land. Paper in Third Annual Conference on Better Reclamation with Trees (cosponsored by AMAX Coal Co., Purdue Univ., South. IL Univ., and Madisonville Comm. Coll., Terre Haute, IN, June 2-3, 1983). Purdue Univ., West Lafayette, IN, 1983, pp. 19-36.

A systematic sampling procedure is outlined that was designed to monitor woody revegetation efforts on mined lands in an efficient and economical manner, regardless of the spatial arrangement of the planted trees or shrubs. The sampling and statistical analysis procedures are presented in a clear step-by-step description that facilitates its application. Fixed-radius circular plots systematically arranged throughout the sampling site along equally spaced transect lines are utilized. The procedure was designed to optimize recordkeeping, maximize data collection, control sampling costs, and maximize its utility to a wide array of user groups. The procedure outlined in this paper is applicable to monitoring the progress of woody vegetation establishment on reclaimed minelands and to the planning of these monitoring programs. While the procedures were developed in central and southern Illinois, no specific coal mining region is further identified for the application of the procedure. Based on the general nature of the article and the apparent universal application of the sampling and statistical methods described, they are applicable to all of the coal mining regions recognized in this evaluation process.

479. Morse, R. D. Increasing Vegetable Productivity of Strip Mine Spoil Through the Use of Organic Soil Amendments. Paper in Ecology and Coal Resource Development, Volume 2 (based on the Int. Congr. for Energy and the Ecosystem, Univ. ND, Grand Forks, ND, June 12-16, 1978). Pergamon, 1979, pp. 926-933.

Selected vegetatble crops were grown on reclaimed strip-mined land in Wise and Buchanan Counties in southwest Virginia. They were evaluated for their ability to adapt and produce under different soil amendment regimes. The vegetables used in the study included 'JetStar' and 'Redpak' tomato (Lycopersicun esculentum Mill.); 'Calwonder' and 'Banana' pepper (Capsicum arruum L.), 'Market Prize' and 'Defender' cabbage (Brassica oleracea L. var. capitata), 'Green Duke' broccoli (Brassica oleracea L. var. italica), 'Bush Blue Lake 274' greenbeans, Cherokee Wax waxbean and French Horticultural shell bean (Phaseolus vulgaris L.), 'Bridgeton' lima bean (Phaseolus coccincus L.) 'Poinsett' cucumber (Cucumis sativus L.), 'Seneca Prolific' and 'Zucchini Elite' summer squash (Curcubita pepo L.), and 'Waltham Butternut' winter squash (Curcubita moschata Duch. ex Poir.). Sawdust added as a surface mulch or incorporated enhanced the yield of all vegetables. Yields were further increased when black plastic was used as a surface mulch on warm season vegetables. Yields of snapbeans and summer squash, grown after 1 year's cover of yellow sweet clover and fescue sod, were more than double those of the controls. The results are primarily applicable to reclamation planning in the Eastern Coal Mining Region.

480. Morse, R., and C. O'Dell. Utilization of Minesoils for Production of Vegetable Crops. Paper in 1983 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Nov. 27-Dec. 2, 1983). Univ. KY, Lexington, KY, 1983, pp. 163-168.

This study assessed the effects of incorporating green-manure crops on soil properties and yield of snapbean (Phaseolus vulgaris L.) and yellow summer squash (Cucurbita pepo L.) in mountaintop-removal minesoils of Appalachia. The green-manure regimes used were (1) control, (2) sod of yellow sweetclover (Melilotus officinalis Lam.) and 'KY-31' tall fescue, (Festuca arundinacea Schreb.), (3) sod of sericea lespedeza (Lespedeza cuneata (Dum.-Cours.) G. Don) and 'KY-31' tall fescue, and (4) a rotation of sorghum sudangrass (Sorghum sudanense (Piper) Stapf), followed by 'Abruzzi' cereal rye (Secale cereale L.) and crimson clover (Trifolium incarnatum L.), followed by 'York' soybeans (Glycine max (L.) Merr.), followed by 'Abruzzi' cereal rye. One or 2 years (2 years being better) growth of green-manure crops resulted in the improvement of soil bulk density, aggregate stability, moisture content, and the subsequent yield of snapbean and squash when compared to unamended control plots. The yields obtained in the green-manure plots were equal to or greater than national and State averages. In general, nutrient concentrations in the vegetable crops fell within the normal ranges found for the same crops in agricultural soils. However, boron and calcium leaf concentrations were below normal, while magnesium, iron, and aluminum levels were above normal. Even under these conditions no deficiency or toxicity symptoms occurred. The results of this study show that properly reclaimed and amended minesoils can produce commercial yields of horticultural crops. The production of these crops offers a viable alternative for the use of selected minesoils.

481. Moss, R. G. Abandoned Mined Land Reclamation on the Wayne National Forest--An Interdisciplinary Approach. Paper in 1982 Symposium on Surface Mining, Hydrology,

Sedimentology, and Reclamation (Lexington, KY, Dec. 5-10, 1982). Univ. KY, Lexington, KY, 1982, pp. 181-185.

A case study is presented for which a systematic and interdisciplinary approach to planning and implementing abandoned mined land reclamation was utilized. The abandoned mined land was within the Wayne National Forest in southeastern Ohio. Before the project was designed, an environmental assessment report was prepared which provided the information needed to select reclamation alternatives. The author presents the reclamation design concept used in the Yost II Abandoned Mine Land Reclamation Project case study. The techniques used include burial of toxic spoil, pond underdrain, topsoiling, liming, and rapid reestablishment of herbaceous cover for erosion control and wildlife enhancement.

482. Mueller, B. K., and P. A. Vance. Soil Moisture Retention Curves for Evaluating Plant Moisture Availability of Cover Materials and Coal Refuse From the Staunton 1 Reclamation Demonstration Project. Argonne Natl. Lab., Argonne IL, ANL/LRP-TM-21, Sept. 1981, 26 pp.

The publication reports the results of a study conducted near Staunton, IL. Moisture retention curves were characterized for the three soil materials present at the site and used in this reclamation. Based on these curves, gravimetric moisture contents of field soil samples were converted to tension values and used as indications of the importance of type and depth of soil cover material in situations where soil moisture is a growth-limiting parameter. The results and discussion contained in this document are pertinent to revegetation of surface-mined land in the Interior Coal Mining Region.

483. Munshower, F. F., and D. R. Neuman. Elemental Concentrations in Native Plant Species Growing on Minesoils and Native Range. Reclam. Rev., v. 3, No. 1, 1980, pp. 41-46.

This study was done to determine if changes in elemental concentration of indigenous range plants grown on minesoils in southeastern Montana were the result of disruption of the native soils by mining. If changes were found, a second objective was to determine if the changes could be mitigated with time and/or spoil treatment during the initial reclamation process. Four different sites were chosen for this study: (1) an unmined grassland reference area, (2 a 2-year-old topsoiled mine soil, (3) a 6-year-old poorly topsoiled mine soil, and (4) a 50-year-old nontopsoiled area. Sites 2 and 3 were seeded to native plants, while site 4 was revegetated by natural seed dispersal. Macronutrient levels (N, P, K, Mg, Ca) were found to be reduced in plants grown on the nontopsoiled areas, while plants grown on topsoiled sites had elemental concentrations similar to thoses grown on native unmined soil. Micronutrient levels (Zn, Cu, Mn, Fe, and Mo) were higher in plants grown on the topsoiled sites, while vegetation on the nontopsoiled sites had concentrations similar to those found for the unmined site. The authors conclude that the higher micronutrient levels found in vegetation growing on the recently revegetated sites may be beneficial for meeting the nutritional needs of cattle.

484. Munshower, F. F., D. R. Numan, and S. E. Fisher, Jr. Variation in Physical Properties of Overburden Produced by Preparation of the Materials. Paper in 1981 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Dec. 7-11, 1981). Univ. KY, Lexington, KY, 1981, pp. 279-282.

This study was conducted to evaluate the performance of two types of overburden preparation equipment (grinders) and two overburden particle size fractions on the soil chemical and physical properties of three different overburden samples collected from southeastern Montana. The two grinders used were a flailer and a plate grinder, while the two particle size fractions analyzed were 2 mm and 0.25 mm. No significant differences were found in the chemical analyses of soils processed by the flailer and the grinder. The 2-mm or 0.25-mm size fractions, whether prepared by the flailer or grinder, were not significantly different. Analyses of the two size fractions (2 mm and 0.25 mm) resulted in only two parameters with significant differences. The DTPA extraction of both copper and zinc yielded significantly greater quantities of these elements from the smaller 0.25-mm particle size. When particle size distributions were compared (2 mm vs. 0.25 mm), little difference was found between the two treatments. The authors recommend that regulatory agencies should clarify soil and overburden handling techniques and analytical procedures to insure uniformity and consistency of reported analyses.

485. Murray, D. R. Influence of Uranium Mill Tailings on Tree Growth at Elliot Lake. CIM Bull., Dec. 1978, pp. 79-81.

This article reports the results of a 4-year study to determine the ability of conifers to aid in reclamation of uranium tailings at Elliot Lake, Ontario, Canada. Two-year-old, bare-root seedlings of white cedar (Thuja occidentalis L.), white spruce (Picea glauca (Moench) Voss), jack pine (Pinus banksiana Lamb.), scotch pine (Pinus sylvestris L.), and red pine (Pinus resinosa Ait.) were planted in areas of established grasses and on bare tailings. The tailings were categorized as coarse or fine. The survival and growth of these conifers were related to species, environmental conditions, and tailings properties. Percent survival and annual growth, measured as plant height, were used as criteria for assessment. Overall survival and growth were below those anticipated. The best survival rates were exhibited by pine with 68 pct when planted in bare coarse tailings, 45 pct in revegetated coarse tailings, and 34 pct in vegetated fine tailings. The worst survival rates were exhibited by white cedar with 49, 14, and 7 pct in the same materials, respectively. The results reported specifically refer to revegetation of uranium mill tailings; however, they may also be applicable to surface coal mine reclamation where similar materials and/or climate are involved. Based on the species discussed, this article may be found most pertinent to the northern portions of the Eastern and Interior Coal Mining Regions recognized in this evaluation process.

486. Murray, D. R. Mine Waste Description and Case Histories. Suppl. 10-1 of Pit Scope Manual. Can. Cent. Miner. Energy Technol., Ottawa, Ontario, CANMET Rep. 77-31, Dec. 1977, 120 pp.

This document supplements Chapter 10, Environmental Planning, in a multichapter manual. Each chapter, as well as the supplements to these chapters, has been published separately. The purpose of this supplement is to outline the general principles of reclamation by vegetation. It summarizes and reviews numerous case histories in Canada. Types of mine wastes, their characteristics, and problems commonly encountered in attempting revegetation are discussed. This document offers a good reference for planning reclamation activities. It was written specifically for application in Canada; however, much of the material presented is pertinent to reclamation activities in the northern portions of the United States as well.

487. Murray, D. R., and D. Okuhara. Effect of Surface Treatment of Tailings on Effluent Quality. Reclam. Rev., v. 3, No. 3, 1980, pp. 167-177.

This paper describes the quality and quantity of effluent generated from uranium tailings containing sulfide at Elliot Lake, Ontario, Canada, on which various surface treatments have been used. Four lysimeter pits were constructed, each including 9 m square by 1.5 m deep. Approximately 125 t of uranium tailings were added to each pit. The surface treatments used follow: pit 1, covered with 15 cm of gravel; pit 2, covered with 15 cm of sawdust; pit 3, no treatment; and pit 4, treated with limestone and, fertilizer and was seeded to redtop (Agrostis alba L.) and 'creeping' red fescue (Festuca rubra L.). Pit 4 received monthly fertilization during the first growing season and the four subsequent years of this study. Chemical analyses were done on the tailings (five samples per pit) and the effluent (every 2 weeks from the first spring flow until flow stopped the following fall or winter). During the 5-year period of this study, the surface treatments were compared with bare tailings where no surface additions were made. The results indicate that the surface treatments did not alter the effluent quality to an acceptable level. The surface treatments did not affect the leaching of radium 226, ammonium, or nitrate. The acidity of the tailings also changed over the course of the study, from an initial pH of 9.5 to a pH of 2 to 3. As the acidity rose, the concentration of iron, sulfate, copper, lead, and aluminuim in the effluent increased. However, the rate and extent of these chemical changes varied with surface treatment. The authors conclude that the surface treatments used in this study did not prevent the deterioration of effluent water passing through the nonsaturated portion of uranium mill tailings.

488. Murray, E. Introducing...Reclamation. Western. Wildlands, v. 7, No. 3, 1981, pp. 8-11.

This article contains general information on reclaimining Montana surface-mined lands to rangeland. Information is presented on planning and implementing a reclamation program and on some of the successfully used plant species for reestablishing rangeland and wildlife habitat.

489. Napieralski, D. Tree Planting Methods on Surface Mined Lands. Paper in Third Annual Conference on Better Reclamation With Trees (cosponsored by AMAX Coal Co., Purdue Univ., South. IL Univ., and Madisonville Comm. Coll., Terre Haute, IN, June 2-3, 1983). Purdue Univ., West Lafayette, IN, 1983, pp. 229-230.

This article presents a succinct review of hand planting operations for tree seedlings. Topics covered include tree pickup, root pruning, planting, weed control, and inspection. This article provides a practical approach to and includes helpful tips for achieving success with hand tree planting operations. The article is applicable to all the coal mining regions considered in this evaluation process.

490. National Research Council. Disposal of Excess Spoil From Coal Mining and the Surface Mining Control and Reclamation Act of 1977: A Study of Regulatory Requirements, Engineering Practices, and Environmental Protection Objections. Nat. Acad. Press, Washington, DC, 1981, 207 pp.

Although the report deals extensively with the disposal of excess spoil to contrtol erosion and the regulatory impacts, Section 8.4, Revegetation of Excess Spoil is a general discussion of the planning and potential impacts of revegetation of coal spoils. Other sections mention revegetation as appropriate, but Section 8.3 discusses the benefits, practices, and crteria for successful revegetation for the industry as a whole.

491. National Academy of Sciences. Environments, Industry, and People: Strip-Mining for Coal in Alaska. NAS News Rep., v. 31, No. 1, Jan. 1981, pp. 14-19.

This is a general article dealing with the unique feature of permafrost in much of Alaska's coal-bearing area, and the probable modifications necessary to Public Law 95-87 to accommodate reclamation in these areas. Where permafrost exists, the area cannot be revegetated because the mean annual temperature is below 0° C. Additionally, mining in these areas will disturb present landforms such that thawing will occur and subsidence may result. The article concludes that permafrost terrain requires mining and reclamation techniques somewhat different from those discussed in the act.

492. National Academy of Sciences--National Research Council. Surface Coal Mining in Alaska: An Investigation of the Surface Mining Control and Reclamation Act

of 1977 in Relation to Alaskan Conditions. Nat. Acad. Press, Washington, DC, 1980, 379 pp.

This is an extremely comprehensive publication on coal mining in Alaska as related to Public Law 95-87. Although general in their treatment of any particular subject, the committees responsible for this report cover every aspect of coal mining from concerns over permafrost and earthquakes, which are not covered in Public Law 95-87, to social impacts of industrial development. Although the report does nor deal in detail with coal mine land revegetation, it was included in this bibliography because of the vast amount of information pertaining to all areas of concern for mining development in Alaska.

493. National Academy of Sciences--National Research Council. Surface Mining: Soil, Coal, and Society. Nat. Acad. Press, Washington, DC, 1981, 246 pp.

This report was prepared by the Committee on Soil as a Resource in Relation to Surface Mining for Coal, under the National Research Council. It describes major aspects of the impact of mining on soils and depicts soil as a mineral resource. The study was multidisciplinary in nature, drawing upon expertise in the fields of mining, soils, civil engineering, geology, and resource management. A methodology was developed to evaluate soil and land as an economic and environmental resource. As stated, an appropriate goal for reclamation is to ensure that society does not lose important land-use opportunities that were available before soil disturbance, or that could be generated in the reclamation process. The development of productive capacity in soils is governed by climate, parent material, topography, and biota. These factors produce important variations among major coal producing regions and local variations within each region. Thus reclamation goals and techniques must be adapted to these variations and public and private concerns and scientific and technical information must be considered when determining the most appropriate reclamation practice for a given site. Although the report generalizes a great deal, it provides guidance and direction for meeting the challenges of effective reclamation and includes an excellent bibliography of related literature.

494. Naughton, G. G. Spoil Bank Energy Forest Systems. Final Report to the Ozarks Regional Commission. KS Energy Off., Topeka, KS, and Dep. of Forestry, KS State Univ., Manhatten, KS, Apr. 1981, 66 pp.

This publication reports the results of a study conducted on lands in Crawford and Cherokee Counties, KS, that had been strip-mined for bituminous coal between 1877 and 1969. A classification system was designed and applied to categorize current land use and vegetation types in the area. The areas were analyzed for their potential fuel wood and saw timber production. The author concludes that the total costs of reclamation of these lands can never be recovered solely on the basis of their subsequent economic production and must, therefore, depend, in part on the amenity values associated with reclamation. This publication is an excellent reference for determining reclamation options on these types of lands in the Interior Coal Mining Region.

495. Nawrot, J. R. Stabilization of Slurry Impoundments Without Soil Cover: Factors Affecting Vegetation Establishment. Paper in 1981 Symposium of Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Dec. 7-11, 1981). Univ. KY, Lexington, KY, 1982, pp. 469-476.

This article evaluates reedgrass (Phragmites australis Trin) establishment on 12 slurry impoundments and 4 natural areas in southern Illinois. Soil cover was not used. A brief review is also given on the history, distribution, ecological adaptations, and practical applications of reedgrass. A tolerance and adaptation to the physical and chemical conditions associated with inactive slurry impoundments was

identified for reedgrass through investigations on the slurry physical and chemical properties, plant tissue analysis, plant density, and biomass production. The most significant physiological factor that has contributed to reedgrass colonizing slurry sites is the dependence of the plant on the subsurface zone for its nutrient and moisture requirements, while avoiding the more toxic surface.

496. Nawrot, J. R., M. L. Fuson, and D. M. Downing. Reedgrass and Slurry Pond Reclamation. Min. Cong. J., v. 67, No. 9, 1981, pp. 23-28.

This study was conducted at the Monterery Coal Co. No. 1 Mine in Macoupin County, IL, to determine if reedgrass (Phragmites australis Trin) could grow directly on slurry refuse and prevent embankment erosion. The objectives of the study were to (1) demonstrate the practicality of revegetating refuse and slurry areas without the use of topsoil, (2) provide protection for slurry dikes against wave erosion, and (3) enhance the wildlife habitat potential of the slurry pond. Reedgrass not only stabilized the coal slurry area without topsoil replacement, but also provided erosion control and wildlife enhancement. Reedgrass has the potential for stabilizing and covering both inactive and abandoned coal slurry areas.

497. Nawrot, J. R., W. D. Klimstra, and K. Sather. Reclamation and Revegetation Potential of Illinois Historic Longwall Mining Refuse. Paper in 1982 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Dec. 5-10, 1982). Univ. KY, Lexington, KY, 1982, pp. 129-138.

This paper provides a brief summary of the chemical characteristics of abandoned burned and unburned coarse coal refuse (gob) and slurry located in Illinois. Refuse samples were analyzed for pH, conductivity, titratable acidity, potential acidity, soluble iron, manganese, aluminum, and sulfate. These samples showed significant differences in the major phytotoxic characteristics related to the seam mined, region, and extent of combustion. The chemical, physical, and vegetation data were recently updated for seam 2, located in the historic longwall mining district of northern Illinois. In addition to the analyses listed above, macronutrient and micronutrient analyses were conducted. Unburned refuse from seam 2 is characterized by a high clay-shale ratio and low potential acidity (31 meq H^+/100 g) when compared to the acid potential of seams 6 or 7 (>120 meq H^+/100 g). These sites are also characterized by low nutrient availability, harsh physical conditions, and chronic acidity, which prevent natural revegetation. A possible reclamation alternative would be to lime and plant these areas. By doing this the rate of natural succession can be accelerated on these aged and weathered refuse areas.

498. Nawrot, J. R., and C. A. Kolar. Problem Spoilbanks: Enhancing Succession Through Reforestation. Paper in 1982 Seminar on Post-Mining Productivity With Trees (Carbondale, IL, Mar. 31-Apr. 2, 1982). South. IL Univ., Carbondale, IL, 1982, pp. 151-156.

This article discusses natural revegetation and changes in minesoil properties on Illinois coal spoilbanks. In the late 1960's and early 1970's the Cooperative Wildlife Research Laboratory at Southern Illinois University evaluated over 11,000 acres of spoilbanks with acid conditions (pH <5) and/or a vegetative cover less than 25 pct. Many of these areas were also evaluated approximately 10 years later. While the rate of natural succession varied widely, some had increased plant cover from less than 25 pct to greater than 75 pct. Using the latest data, a spoilbank classification system was developed based on the current successional rate and trend, primary inhibiting factors (such as pH), speculated time required for natural recovery, and level of reclamation effort for enhancement of current successional trends. The use of tree plantings to enhance reclamation is discussed in the context of the study findings.

499. Nawrot, J. R., and S. C. Taich. Slurry Pond Forestation: Potential and Problems. Paper in Third Annual Conference on Better Reclamation with Trees (sponsored by AMAX Coal Co., Purdue Univ., South. IL Univ. and Madisonville Comm. Coll., Terre Haute, IN, June 2-3, 1983). Purdue Univ., West Lafayette, IN, 1983, pp. 180-194.

The potential for habitat development and diversification on slurry impoundments through forestation is discussed. A study was conducted examining tree growth on a number of inactive surry impoundments in Illinois and Indiana. This investigation revealed that plantings during 1965-75 were most successful in moist soil zones near impoundment decant areas. In these areas, survival was greatest for hydrophytic species such as baldcypress (Taxodium distichum (L.) Rich.) and river birch (Betula nigra L.). Growth rates for these species in these areas were comparable to those of individuals growing in natural soil. More limited and localized success was obtained with plantings of red (Pinus resinosa Ait.) and Virginia pine (Pinus virginiana Mill.) discharge areas. Horizontal and vertical zonation of hydrogeochemical slurry characteristics relating to the separation and distribution of slurry constituents were identified. Coarse-textured pyritic materials are deposited near the discharge point, while fine silt and clay materials migrate farther toward the decant portion of the pond. Material characteristics pertinent to forestation efforts are discussed in conjunction with techniques for ameliorating problems related to acid-base balance and surface stability, and taking advantage of slurry zones which have inherently favorable physicochemical qualities for tree growth. The results of this study would be most pertinent to the reclamation of these types of sites within the Interior Coal Mining Region. They may be applicable in portions of the Eastern and Gulf Coast Coal Mining Regions as well.

500. Nawrot, J. R., A. Woolf, and W. D. Klimster. A Guide for Enhancement of Fish and Wildlife on Abandoned Mine Lands in the Eastern United States. U.S. Fish and Wildlife Ser., FWS/OBS 80/67, 1982, 101 pp.

This guide promotes fish and wildlife enhancement on abandoned mined lands in the Eastern, Interior and Gulf Coast Coal Regions. Subjects covered include characteristics of abandoned mined lands, the basis for fish and wildlife enhancement, and planning for fish and wildlife habitat. Case histories include describing problem sites, what needs to be considered when reclaiming them, and cost considerations. Information on plant species established is also given.

501. Nelson, R. W., J. F. Orsborn, and W. J. Logan. Planning and Management of Mine-Cut Lakes at Surface Coal Mines. U.S. Office of Surface Min., OSM/TR-82/1, May, 1982, 248 pp.

This manual was designed as a guide for the coal industry and regulatory agencies in the planning, design, and management of surface coal mine lakes created by mining cuts when left as permanent water impoundments. The guidelines presented in the manual are not legally binding. They are meant to be used by land reclamation planners and managers to help determine the feasibility and utility of planned new lakes. The manual covers many aspects of the planning and construction of these lakes. Two sections of the document deal with revegetation. For the most part this information is fairly general. However, it does point out several important considerations for reclamation planning. A good review of some of the herbaceous and woody species that have been used in surface mine reclamation is provided. Special techniques for establishing aquatic and shoreline plant species are discussed. Based on the material and examples described in the manual, it appears to be most applicable to the Interior and Eastern Coal Mining Regions recognized in this evaluation process.

502. Nesbitt, P. D., E. L. Richie, and J. L. McGraner. Abandoned Mine Land Reclamation in Eastern Kentucky-Case Studies. Paper in 1981 Symposium on Surface Mining,

Hydrology, Sedimentology, and Reclamation (Lexington, KY, Dec. 7-11, 1981). Univ. KY, Lexington, KY, 1981, pp. 211-225.

The authors discuss the abandoned mine land projects that their company has been involved with in eastern Kentucky. The projects include both emergency reclamation projects and investigative studies. The projects cover several postmining problems common to abandoned mine land prior to current regulations. They include coal refuse fires, hazardous impoundments and sediment structures, and landslides. For each project presented a general site description is given along with the engineering design and site reclamation techniques utilized.

503. Nicholas, P. J., and W. J. McGinnes. An Evaluation of 17 Grasses and 2 Legumes for Revegetation of Soil and Spoil on a Coal Strip Mine. J. Range Manage., v. 35, No. 3, May 1982, pp. 288-293.

This paper reports the results of a greenhouse study that evaluated the potential of 17 grass species and 2 legume species for revegetation of surface-coal-mined areas. Growth medium treatments included 53 cm of spoil material without topsoil and 25 cm of topsoil placed over 28 cm of minespoil. Grasses grown in topsoil exhibited herbage yields 7 times greater and root yields 6 times greater than grasses grown in spoil without topsoil. Native and introduced grass species exhibited similar average herbage yields. Introduced species averaged greater root production, particularly in spoil material. Two legumes, alfalfa (Medicago sativa L.) and "cicer" milkvetch (Astragalus cicer L.), produced much higher yields and higher crude protein than any of the grasses studied, regardless of the growth medium treatment. The study was conducted using spoil and soil material collected from a minesite near Steamboat Springs, CO. The results of this study are primarily relevant to that specific area. With careful consideration they might be applied to species selection for revegetation efforts over a slightly broader geographical area.

504. Nielsen, G. A., and E. V. Miller. Crop Yields on Native Soils and Strip Mine Soils: A Comparison. J. Soil Water Conserv., v. 35, No. 1, 1980, pp. 44-46.

This article summarizes parts of a national survey on mineland productivity which sought comparisons of crop yields before and after mining operations. The objectives of the survey were to (1) identify the major sources of information about mined land productivity in the United States, (2) find comparable yield figures for corn (Zea mays L.) production on native soils (reference area) and stripmine soils, and (3) suggest a means of obtaining soil performance data for crop production. The survey was sent to an organization that actively investigated strip mine spoil reclamation in order to obtain information on yields and associated yield parameters (i.e., fertilization, weed control, crop varieties used, soil conditions, and climate). The survey indicated that corn yields on mine soils were 4 to 90 pct less than on adjacent native soils. This reduction in yield was dependent upon topsoil application, age, and the special treatments used. The authors concluded that yield reductions from strip mining can be large or small depending upon the reclamation procedures and spoil qualities. The data illustrated the importance of soil replacement, supplemental additions of lime and manure, and the initial planting of legume and grass forage species.

505. Nieves, L. A., and M. H. Marti. Economic Feasibility Analysis of Water-Harvesting Techniques for Mined-Land Reclamation (U.S. DOE contract DE-AC06-76RLO 1830). Pacific NW Lab., Richland, WA, PNL-3737, July 1981, 47 pp.

This publication provides a preliminary economic feasibility study evaluating the net private benefits of water harvesting reclamation techniques as compared to conventional reclamation systems. Peabody Coal Co.'s Kayenta Mine on the Black Mesa in Arizona was used in the case analysis. The present value of direct net benefits (income minus production and reclamation costs) is calculated for grazing (representing conventional reclamation) and for cropping (representing water harvesting techniques). Three of the slope treatments tested in the water harvesting study were found to have lower estimated total costs than conventional reclamation. The water harvesting method also has advantages based on the higher estimated value of agricultural production capacity. The water harvesting system appears to be potentially viable on sites receiving only 25 to 30 pct of the precipitation normally required for crop production. The results and discussion contained in this report are pertinent to reclamation planning in the arid portions of the Rocky Mountain and Northern Great Plains Coal Mining Regions.

506. Norem, M. A., A. D. Day, and K. L. Ludeke. An Evaluation of Shrub and Tree Species Used for Revegetating Copper Mine Wastes in the SW United States. J. Arid Environ., v. 5, No. 4, 1982, pp. 299-304.

The purpose of this study was to evaluate tree and shrub species survival, growth, and reproductive potential on copper tailings and overburden material and on northern and eastern slope aspects at the Cyprus Pima Mine near Tucson, AZ. Ten tree species and seven shrub species were evaluated. The planting rates for the trees and shrubs were 20 tree seedlings per 900 m^2 and 15 shrub species per 900 m^2. Two of the 7 shrub species had 100 pct mortality and 3 of the 10 tree species had 100 pct mortality. Hopseedbush (Dodanea viscosa (L) Jacq.) was the only shrub which survived on the north aspect. For the trees, paloverde (Cereidium microphyllum (Torr.) Rose & Johnst.) survived best on the east slope and tree tobacco (Nicotiana glauca Grah.) survived only on the north slope. The remaining tree species were not affected by aspect. The authors conclude that in the arid areas of the Southwestern United States plant survival depends on the chemical composition of the mine waste material, slope exposure, and the suitability of a species to an arid environment.

507. Oaks, W. R. Plant Materials. Paper in Vegetative Rehabilitation and Equipment Workshop, 36th Annual Report (Denver, CO, Feb. 4-5, 1982). U.S. For. Serv., Equip. Dev. Cen., Missoula, MT, 1982, pp. 23-24.

The author lists the plant materials that have been released for general use by the Soil Conservation Service in 1981. Sources of information on these released plant materials are also provided.

508. Oaks, W. R. Seed Coating "Hard To Drill" Seeds. Paper in Vegetative Rehabilitation and Equipment Workshop, 36th Annual Report (Denver, CO, Feb. 4-5, 1982). U.S. For. Serv. Equip. Dev. Cen., Missoula, MT, 1982, pp. 21-22.

This article contains information on preliminary work done on the feasibility of coating trashy seeds. Since fluffy or trashy seeds are difficult to plant accurately, seed coating offers several advantages: (1) economic, (2) more accurate seed placement, (3) better seed mixing, (4) use of conventional equipment, (5) inclusion of nutrients, fungicides, or herbicides in the coatings, and (6) reduced seeding rates. A list of species is given where the seeds have been successfully treated. Further studies on seed coating are currently being conducted.

509. Obiechina, C. O., and D. D. Badger. Economic and Environmental Impacts of Coal Mining and Reclamation in Eastern Oklahoma. Agric. Exp. Sta., Div. of Agric., OK State Univ., Bull. B-763, Aug. 1982, 34 pp.

The study reported in this publication was designed to estimate agricultural productivity before and after strip mining and reclamation. Pasture and livestock budgets for reclaimed land were developed and compared to net cash returns of existing premining budgets. Static linear programming (2P) models were formulated based on the developed and existing budgets to evaluate the profitability of cattle ranching before and after strip mining and reclamation. The economic, social, and environmental impacts of strip mining on the economy of eastern Oklahoma under alternative reclamation strategies are estimated. The results of the study indicate that increased net cash income could be realized by the cattle rancher. However, this income is contingent on the success of the reclamation efforts and the solvency of the coal company mining the land. Alternative mineral rights transfer strategies aimed at reducing agricultural productivity (monetary) losses are discussed. Reclamation concurrent with mining appeared to provide the most positive impacts on the region.

510. Ohlsson, K. E., A. E. Robb, Jr., A. E. Guindon, Jr., D. E. Samuel, and R. L. Smith. Best Current Practices for Fish and Wildlife on Surface Mined Land in the Northern Appalachian Coal Region. U.S. Fish and Wildlife Ser. FWS/OBS-81/45, 1982, 305 pp.

This handbook was designed to provide ideas for simple, cost-effective methods of improving fish and wildlife resources on reclaimed surface coal mines in the northern Appalachian coal regions. It covers wildlife enhancement methods for both aquatic and terrestrial environments. It provides an extensive review of methods of revegetating land for wildlife purposes. Subjects covered include species selection, methods of soil modification to create vegetated areas suitable for wildlife, soil amendments necessary to establish vegetation, and methods of obtaining and planting seed, cuttings, and transplants for wildlife purposes. The discussion includes methods of planting areas with trees, shrubs, and herbaceous vegetation to create "edge" habitat necessary for wildlife diversity. Selecting and planting aquatic vegetation is also reviewed. This is an excellent document for anyone interested in enhancing fish and wildlife in the northern Appalachian coal region.

511. Olsen, S. H., and S. J. Henning. Nitrogen Fertilization of Corn on a Reconstructed Soil at a Surface Coal Mine. Paper in 1980 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Dec. 1-5, 1980). Univ. KY, Lexington, KY, 1980, pp. 23-25.

This article presents data from a 2-year study on the effects of nitrogen fertilizer application and deep tillage treatments on corn (Zea mays L.) yields in Mahaska County, IA. The 'Lester Pfister 75' hybrid was planted at a rate of 47,000 seeds per hectare. Maximum yields were obtained with nitrogen application rates of 250 to 300 kg/ha. This rate is approximately 25 pct higher than the rate recommended for undisturbed land in the area but is justified due to the lower fertility status and poor soil physical conditions of mined land. However, when deep tillage treatments are used, less nitrogen fertilizer may be needed to obtain maximum corn yields. Information on herbicide and pesticide application rates and the nutrient status (N, P and K) of corn leaves is also presented.

512. Olson, R. A. Ecology of Wetland Vegetation on Selected Strip Mine Ponds and Stockdams in the Northern Great Plains. Ph. D. Thesis, ND State Univ., June 1979, 493 pp.

This thesis reports the results of an extensive examination of the wetland plant communities of strip mine ponds and stockdams in five geographical locations in the Northern Great Plains Region. Density, frequency, relative frequency, relative density, relative canopy coverage, and an importance value were calculated for plant species encountered in randomly located 0.25-m^2 quadrats to characterize each major wetland community. Stockdams were found to be floristically richer than strip mine ponds. Plant communities were distributed in narrow concentric bands around strip mine ponds compared with wider, complex mosaic patterns of vegetation associated with stockdams. The magnitude of summer drawdown and basin slope were found to be major factors determining wetland community attributes. The author recommends contouring existing rangeland strip mine ponds to reclaim wetland community ecosystems. Extensive species composition, production, and plant cover data are presented. The publication is an excellent reference for revegetation planning in the Northern Great Plains Coal Mining Region and with prudent consideration could find application over a broader geographical region.

513. Olson, R. A. Wetland Vegetation, Environmental Factors, and Their Interaction in Strip Mine Ponds, Stockdams, and Natural Wetlands. U.S. For. Ser., GTR-RM-85, July 1981, 19 pp.

This publication offers a concise review of the water regime, chemical features, temperature factors, light penetration, substrate properties, and physical characteristics for strip mine ponds and stockdams in the Northern Great Plains Region. The author discusses how these parameters interact to determine wetland plant community composition and the consequent wildlife habitat quality for consumptive and nonconsumptive resource utilization. This publication is a good general reference for revegetation planning in the Northern Great Plains Coal Mining Region and with prudent consideration could find application over a broader geographical region.

514. Opeka, T., and R. Morse. Use of Green-Manure Amendments and Tillage To Improve Minesoil Productivity (U.S. EPA-IAG contract DG-E762 and U.S. SEA-CR contract 684-15-26, VA Poly. Inst. and State Univ.). EPA-600/7-29-257, Dec. 1979, 85 pp.

This report relates the results of a 2-year study conducted in Buchanan and Wise Counties, VA. The purpose of the study was to examine the effects of green manure crops and tillage treatments on vegetable crop growth and yield. Normal and deep tillage treatments produced the best yields on calcareous soils, whereas minimum and normal tillage treatments produced the best results on acid soils. The differences appeared to be moisture related. The normal and deep tillage treatments on calcareous soils tended to have higher moisture levels and the highest infiltration rates. On the acid minesoils, minimum tillage plots tended to have higher moisture content throughout their profiles than did the other treatments. Increased depth of tillage and incorporation of lime plus green manure crops tended to improve the mine soil productivity by improving some of the physical and chemical characteristics. This report is of particular importance to reclamation planning in the Appalachian area. It indicates that, with favorable economic and climatic conditions, the production of certain horticultural and agronomic crops is a potential alternative.

515. Orr, H. K. Reestablishment of Wooded Waterways and Associated Upland Shrub Communities in Surface Coal Mining Areas of the Northwestern Great Plains. Paper in Fifth Symposium on Surface Mining and Reclamation (NCA/BCR Coal Conf. and Expo IV, Louisville, KY, Oct. 18-20, 1977). Natl. Coal Assoc. and Bit. Coal Res., Inc., 1977, pp. 235-244.

This study examined suitable methods and species for reestablishment of woody vegetation along waterways and associated upland sites. Variable combinations of cultural treatments and plant species can be used for planting in waterways depending on slope, aspect, and spoil characteristics. Low shrubs such as big sagebrush (*Artemisia tridentata* Nutt.), rubber rabbitbrush (*Chrysothamnus nauseosus* (Pall.) Britt.), fourwing saltbush (*Atriplex canescens* (Pursh) Nutt.), and winterfat (*Eurotia lanata* (Pursh) Moq.) can be established on south-facing slopes and adjacent uplands. On these sites erosion can be minimized and moisture conserved by contour furrowing. On north-facing slopes, taller species such as green ash (*Fraxinus pennsylvanica* Marsh.), cottonwood (*Populus sargentii* Dode), Russian olive (*Elaeagnus angustifolia* L.), Siberian peashrub (*Caragana arborescens* Lam.), and silver buffaloberry (*Shepherdia argentea* (Pursh) Nutt.) are adaptable. On these aspects and selected locations on other aspects, Rocky Mountain juniper (*Junipercus scopulorum* Sarg.) and ponderosa pine (*Pinus ponderosa* Dougl. ex P. & C. Laws.) can also be established. Establishment and survival of these latter species may be enhanced if supplemental water and moisture conservation measures such as contour furrowing and/or mulching are applied.

No given species was consistently successful in terms of initial establishment. Container grown stock was reported superior for the conifer species. Initial survival rates were higher for bare-root stock for the deciduous species. This paper is a good reference for stock for the deciduous species. This paper is a good reference for planning revegetation in the Northern Great Plains Coal Mining Region and may find application in the Rocky Mountain Coal Mining Region as well.

516. Packer, P. E., C. E. Jensen, E. L. Noble, and J. A. Marshall. Estimating Revegetation Potentials of Land Surface Mined for Coal in the West. Paper in Ecology and Coal Resource Development, Volume 1 (based on the Int. Congr. for Energy and the Ecosystem, Univ. ND, Grand Forks, ND, June 12-16, 1978). Pergamon, 1979, pp. 396-411.

The primary objectives of this investigation were to develop capabilities for predicting the degree of revegetation success to be expected under a wide variety of climatic conditions, soil and spoil properties, and revegetation treatments, utilizing site-specific revegetation data and information from many of the major coal surface mines in North Dakota, Montana, Wyoming, Colorado, Utah, New Mexico, and Arizona. It was assumed that, unless some other revegetation objective is defined, the primary goal of revegetation on surface-mined coal in the interior West is to establish a productive and protective cover of durable plants consisting predominantly of needed species adapted to and characteristic of these areas or other similar areas before mining. It was further assumed that differences in the degree of success of revegetation efforts to date on surface-mined coal lands of the West should be related to variations in natural climatic components, changes in site-specific physical and biological characteristics, and differences in the revegetation methods. Multiple regression models were developed for estimating forage production and plant cover densities as functions of climatic environment components, growth medium characteristics, and revegetation treatment alternatives. The results of the study indicate that the amount of forage produced and the density of plant cover developed are significantly affected by at least two major climatic factors that are not readily susceptible to alteration: annual precipitation and length of growing season. Three properties of spoil materials were found to be significantly related to production and cover. These were potassium and sodium content and pH. Seven revegetation treatments including tilling, seeding methods, topsoiling, fertilizing, supplemental irrigation, mulching, and time of seeding were also found to be related to forage production and ground cover. Finally, the age of the vegetation also significantly affected forage cover and production. All of these factors together accounted for about one-half to three-forths of the variations experienced in forage production and plant cover density. The relationships and models developed in the investigation reported are relevant to reclamation planning in major portions of the Northern Great Plains and Rocky Mountain Coal Mining Regions. Ratings for keywords used in the evaluation process have been applied somewhat differently for this report. Since this report deals primarily with statistical computer models, the ratings represent the apparent treatment of these subject areas in the process of developing the model and the conceptual basis for the model.

517. Packer, P. E, C. E. Jensen, E. L. Nable, and J. A. Marshall. Models To Estimate Revegetation Potentials of Land Surface Mined for Coal in the West. U.S. For. Ser. Gen. Tech. Rep. INT-123, Aug. 1982, 25 pp.

The objectives of this research were to develop methods to estimate the degree of revegetation success obtainable under a wide variety of climatic conditions, soil and spoil properties, and revegetation treatments, using site-specific data and information from most of the surface coal mines rehabilitated through 1976 in the interior West. A strong conceptual framework was developed in the form of FORTRAN IV regression models to estimate forage production and vegetative cover for native and introduced species. Maps were also developed depicting precipitation and growing season; spoil material properties were K, Na, and pH. Seven revegetation treatments and the age of vegetation completed the list of major controlling factors accounting for 50 to 75 pct of the total variance in forage production and plant cover density. This is a good article to use as a guide to successful revegetation techniques.

518. Parkinson, D. Microbes, Mycorrhizae and Mine Spoil. Paper in Ecology and Coal Resource Development, Volume 2 (based on the Int. Congr. for Energy and the Ecosystem, Univ. ND, Grand Forks, ND, June 12-16, 1978). Pergamon, 1979, pp. 634-642.

This paper provides a succinct literature review of the state of the art in the subjects of soil microbiology and mycorrhizae as they pertain to mineland reclamation. The paper provides good background reading that would be especially useful to the individual with little or no experience in the subject. The subject matter covered has potential application nationwide.

519. Parr, D. E. Reforestation as a Post Mining Land Use in the Midwest. Paper in 1982 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Dec. 5-10, 1982). Univ. KY, Lexington, KY, 1982, pp. 249-255.

A synopsis is presented of the reforestation program being developed by AMAX Coal Co. for its Illinois and Indiana surface mines. The amount of acreage that AMAX plants to forest is determined by the amount of premining forest disturbed by mining; an equivalent amount of forest is replaced. The program emphasizes obtaining good-quality stock, proper care and handling of stock, proper planting techniques, and an effective weed control program. The author feels that the additional cost of weed control is justified because of improved seedling survival and enhanced growth. However, owing to compaction, grading to approximate original contour does not promote the long-term growth and survival of tree and shrub species. The author believes that areas designated as forest for a postmining land use can be effectively reclaimed with minimal grading without having a negative impact on surrounding land uses. Minimal grading will reduce compaction, which will in turn promote the development of a more productive forest resource.

520. Parr, D. E. Reforestation of Surface Mined Lands of AMAX Coal Co. Paper in 1982 Seminar on Post-Mining Productivity With Trees (Carbondale, IL, Mar. 31-Apr. 2, 1982). South. IL Univ., Carbondale, IL, 1982, pp.

A description is given of AMAX Coal Co.'s reforestation program in Illinois and Indiana. The discussion includes selection of herbaceous species for ground cover, planting, and weed control to allow survival and growth of trees and shrubs, and long-term management. After describing preplanting considerations and comparing mechanical and hand planting methods, the costs, methods, and advantages of chemical weed control are described. Data on tree species survival and cost per seedling using different weed control application methods are given. Long-term management involves weed control and interplanting of tree species different than those already established. This is an excellent summary of one coal company's program in forestation of mined lands.

521. Parton, W. J., J. E. Ellis, and D. M. Swift. The Impacts of Strip Mine Reclamation Practices: A Simulation Study. Paper in Ecology and Coal Resource Development, Volume 2 (based on the Int. Congr. for Energy and the Ecosystem, Univ. ND, Grand Forks, ND, June 12-16, 1978). Pergamon, 1979, pp. 584-591.

The material conveyed in this paper is reviewed elsewhere in this bibliography; see reference 212. The rating system has been applied somewhat differently for this report. Since it deals with a computer model and not actual field studies, the ratings represent the apparent treatment of these subject areas by the simulation model and the conceptual basis for the model. The model could provide an excellent starting point for reclamation studies and planning in the Northern Great Plains and Rocky Mountain Coal Mining Regions.

522. Pederson, T. A., A. S. Rogowski, and R. Pennock, Jr. Comparison of Some Properties of Minesoils and Contiguous Natural Soils (U.S. EPA contract EPA-IAGD5-E763). U.S. EPA, EPA-600/7-8-162, Aug. 1978, 141 pp.

This document reports the results of investigations to evaluate soil changes due to surface coal mining and reclamation operations in Clearfield County, PA. Four minesoil pits located within the disturbed area and four natural soil pits located in adjacent undisturbed areas were sampled and described. Minesoils exhibited a high degree of coarseness and high rock fragment content. Roots were generally found to concentrate along soil-coarse fragment interfaces. Few roots penetrated the massive minesoil material in the C horizons. Significantly more extractable aluminum was found in the natural soils than in minesoils. The clay minerals present in the minesoils were less weathered than those in natural soils. Bulk densities of surface minesoils averaged 1.70 g/cm^3 compared with 1.26 g/cm^3 for adjacent soils. This report is an excellent reference applicable to mineland reclamation planning and research in the Eastern Coal Mining Region.

523. Pederson, T. A., A. S. Rogowski, and R. Pennock, Jr. Comparison of Morphological and Chemical Characteristics of Some Soils and Minesoils. Reclam. Rev., v. 1, No. 3/4, 1978, pp. 143-156.

This publication is a summary of the completed EPA-600/7-8-162 contract report by the same authors, reference 522. This study was conducted to determine the effects of surface mining and reclamation on minesoil properties in Clearfield County, PA. Four minesoil pits within a disturbed area and four natural soil pits located in an adjacent undisturbed area were sampled, described and compared. Pedogenetic development in minesoils was minimal, and their most prominent feature was a high degree of coarseness and rock fragment content. Plant roots tended to concentrate along the coarse fragment interfaces. The concentration of chemical constituents in minesoils was similar to that found in natural soils. Significantly higher extractable aluminum content was found in the natural soils owing to prolonged weathering of the material. The C:N ratios of minesoils indicate that nitrogen is a limiting factor for microbial activity. The clay mineralogy of the native and mine soils indicates that the minesoils were derived from the same material as the native soil. The authors concluded that the high coarse fragment content and low cation exchange capacity of the minesoils suggest that agronomic use of these soils is questionable without fertilization and special cultivation equipment.

524. Pederson, T. A., A. S. Rogowski, and R. Pennock. Physical Characteristics of Some Minesoils. Soil Sci. Soc. Am. J., v. 44, No. 2, 1980, pp. 321-328.

The physical properties of spoils resulting from coal surface mining and reclamation were studied at a mine in Clearfield County, PA. The objectives of the study were to determine minesoil characteristics such as specific surface area, bulk density, moisture, water retention, hydraulic conductivity, infiltration rates, and evapotranspiration at 10 sites located within the 4-ha experimental area. The results show that the surface mining and reclamation operations at this mine have produced minesoils with an average specific area of 31 m^2/g and an average bulk density of 1,763 kg/m^3. The bulk density of the area first decreased and then increased with depth. Evapotranspiration, determined using microlysimeters, could be approximated by either class A pan evaporation (1.8 mm/d) or by model results (1.3 mm/d). There were large spatial variations in the infiltration rates, water retention, and hydraulic conductivity. The hydrologic implications of these physical properties are also discussed.

525. Penrose, K. D., and D. J. Hansen. Planting Techniques for Establishment of Container-Grown or Bareroot Plants. Paper in Shrub Establishment on Disturbed Arid

and Semi-Arid Land (Proc. Symp., Laramie, WY, Dec. 2-3, 1980). WY Game and Fish Dep., 1981, pp. 37-46.

The authors discuss the use of container-grown and bareroot plants for rapid establishment of plant cover, productivity, and species diversity. Careful planning of all aspects of the revegetation effort is stressed. Topics discussed include (1) species and plant materials selection, (2) scheduling considerations, (3) holding facilities for planting material, (4) methods of planting and avoiding poor planting, and (5) monitoring programs for the asssessment of revegetation efforts. The article is focused on revegetation of disturbed areas of the arid and semiarid regions of the Western United States. However, some of the information is applicable to other regions as well.

526. Pentecost, E. D., and R. C. Stupka. Wildlife Investigations at a Coal Refuse Reclamation Site in Southern Illinois. Paper in Addendum to Proceedings of a Symposium on Surface Mining and Fish/Wildlife Needs in the Eastern United States (WV Univ., Apr. 1979). U.S. Fish and Wildlife Ser., FWS/OBS-78/81 A, 1979, pp. 107-118.

This article discusses the revegetation of a coal refuse pile near Staunton, IL, with respect to wildlife. Attempts were made to determine if wildlife colonized the site during secondary succession. Surveys were made to determine the population of mammals, birds, amphibians, and reptiles at the site. The mammalian and avian species observed were typical of old-field communities in southern Illinois. Revegetation was completed prior to the study, and little information is given on the methods used to establish vegetative cover.

527. Perry, E. F. Minesoil Properties That Influence Fish and Wildlife Habitats. Paper in Symposium on Surface Mining and Fish/Wildlife Needs in the Eastern United States (WV Univ., Dec. 1978). U.S. Fish and Wildlife Ser., FWS/OBS-78/81, 1978, pp. 223-231.

This article presents data on minesoil classification in the Appalchian and Midwestern Coal Regions. A variety of minesoils are analyzed for chemical and physical properties. Data are given on how these properties influence post-mining land use. The author has attempted to identify key minesoil properties that influence fish and wildlife habitats.

528. Phillips, J. M., and A. E. Spooner. Dry Matter Production and Percent Ground Cover During Establishment of Selected Forage Species on Bauxite Minesoils. Paper in 1983 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Nov. 27-Dec. 2, 1983). Univ. KY, Lexington, KY, 1983, pp. 447-481.

This study was conducted to determine the adaptability of certain grass and legume species to bauxite minesoil in Saline County, AR. Brown lime was applied to the plots at a rate of 102.7 t/ha to neutralize the acidic (pH 3.0) minesoil. The acidity problem was corrected 2 months after lime application. All cool season species were planted in September 1980; the warm season species were planted the following April. The forage yields obtained on the bauxite minesoil were very low when compared to those observed in normal agricultural situations. The authors speculate that the low yields can be attributed to a restricted root zone, high soluble salts, and low macronutrient availability. Of the species planted, pearl millet (Pennisetum typhoides Burm. Stapf. and C. E. Hubb) (1,826 kg/ha) and hairy vetch (Vicia villosa Roth.) (1,406 kg/ha) had the highest yields for the forage grasses and legumes, respectively. The species having the best ground cover for the cool season species were orchard grass (Dactylis glomerata L.) and crimson clover (Trifolium incarnatum L.). The highest percent ground cover for warm season species was found for pearl millet and common bermudagrass (Cynodon dactylon (L.) Pers.).

529. Philo, G. R. Planting Stock Options for Forestation of Surface-Mined Lands. Paper in 1982 Seminar on Post-Mining Productivity With Trees (Carbondale, IL, Mar. 31-Apr. 2, 1982). South. IL Univ., Carbondale, IL, 1982, pp. 165-174.

This article presents an excellent discussion of planting trees using bare-root stock and containerized seedlings, and by direct seeding. The advantages and disadvantages of using each method in relation to planting season, species selection, special requirements of individual projects, planting success, and cost are discussed. In addition, the effects of the different tree planting methods on root form of the tree are examined. This includes the results of a greenhouse study where black walnut (Juglans nigra L.) stock was planted in minesoil using five different treatments. The results show the effect the planting stock has on initial root form and shoot growth of the trees.

530. Philo, G. R., C. A. Kolar, and W. C. Ashby. Effects of Ripping on Minesoil Compaction and Black Walnut Establishment. Paper in 1982 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Dec. 5-10, 1982). Univ. KY, Lexington, KY, 1982, pp. 551-557.

This study was conducted to evaluate the effects of ripping (subsoiling) graded minesoil on the survival and growth of direct-seeded black walnut (Juglans nigra L.) in Saline County, IL. The soil was ripped to a depth of 85 cm by a subsoiler attached to a D-8 caterpillar. Black walnut seeds were then planted in both the ripped and nonripped plots. Seedling survival in the ripped and nonripped plots during the first year was 88 and 66 pct, respectively; in July of the second season it was 85 and 64 pct, respectively. Ripping also resulted in greater stem diameter and height growth during the second growing season. Root excavations showed that root growth (length, depth, and radial spread) was significantly greater in the ripped plots than in the nonripped plots. Black walnut planted on nonripped plots had stunted taproot and lateral root development. Bulk density determinations during the second growing season indicated that ripping resulted in significant reductions in the bulk density at the 0-to-15-cm depth and 45-to-30-cm depth when compared to nonripped spoil. This study showed that favorable establishment and enhanced tree growth can be achieved by ripping (subsoiling) graded surface mine spoil. It also illustrated the extent of soil compaction problems on reclaimed mine sites. The authors conclude that grading standards should be altered to provide more favorable conditions for plant growth and eliminate the need for ripping.

531. Philo, G. R., J. A. Spaniol, C. A. Kolar, and W. C. Ashby. Weed Control for Better Black Walnut on Strip Mines. Tree Planters Notes, v. 34, No. 1, 1983, pp. 13-15.

This study was conducted to evaluate the effects of chemical and mechanical weed control on the establishment and growth of direct-seeded black walnut (Juglans nigra L.) on surface-mined land in Saline County, IL. Six experimental treatments were used: (1) a control where existing vegetation was left intact, (2) hand cultivation, (3) Roundup applied following planting, (4) Roundup and Princep applied following planting, (5) Roundup applied after planting and again the following spring, and (6) Roundup and Princep applied after planting and again the following spring. Black walnut establishment was significantly improved when cultivation or herbicides were used. The greatest seedling establishment rates were obtained when Roundup was applied alone for either 1 or 2 years. The authors speculate that the germination and survival of untreated controls were inhibited by competition or allelopathic interference from the established vegetation. The authors conclude that with weed control good early growth of direct-seeded black walnut can be achieved on mined land.

532. Pionke, H. B., and A. S. Rogowski. Placement of Acid Spoil Materials. Reclam. and Reveg. Res., v. 1, No. 1, 1982, pp. 3-17.

This study evaluated how spoil placement may potentially affect the quality and quantity of drainage and ground water on reclaimed spoil located near Kylertown, PA. Two caissons were subjected to leaching by simulating field rainwater conditions. Water content was monitored for pH, total acidity, total salts, SO_4, Ca, Mg, Mn, and Fe. Results indicate that the placement of acid- and salt-containing spoils should be based on the chemical and physical spoil properties that may affect water percolation and O_2 diffusion rates. The deeper placement of acid spoil and coarser particle size can substantially reduce the amount of acid drainage.

533. Pitsenbarger, J. E. Trees for Reclamation in the Eastern United States. A West Virginia Perspective. Paper in Trees for Reclamation (Lexington, KY, Oct. 27-29, 1980). U.S. For. Ser., Gen. Tech. Rep. NE-61, 1980, pp. 61-62.

The author reviews the impact that State and Federal reclamation laws and regulations have on tree plantings on surface-mined lands in West Virginia. A discussion is presented on what the author foresees as the direction research should take for establishing trees on mined land. One area of interest is to define tree species that would be economical and adaptable for reclamation use in West Virginia. Additional research is needed to determine which species can be direct-seeded and what are the most economical and efficient methods for obtaining a viable tree stand through direct seeding methodology. Research has shown that the establishment of forest land on mountaintop removal operations is a viable postmining land use.

534. Plantenberg, P. Factors Affecting Plant Succession on Mine Spoil at Colstrip, Montana. Pres. at 34th Annual Meeting of the Society for Range Management (Tulsa, OK, Feb. 9-13, 1981). MT State Univ., DOE/EV/70003-15, 1981, 16 pp.

This paper reports the results of a study designed to explain why major differences occur in dominance and succession on six naturally revegetated overburden sites originally formed in 1928 and 1930 near Colstrip, MT. The major factors affecting plant succession on overburden are reported to be overburden texture, the condition of adjacent rangeland, postmining management, and environmental modifications created by early successional plant species. This article provides an excellent reference for plant succession on naturally revegetated surface coal mine land and is pertinent to reclamation planning and research in the Northern Great Plains Coal Mining Region.

535. Plass, W. T. The Establishment and Maintenance of Vegetation on Minesoils in the Eastern United States. Paper in Ecology and Coal Resource Development, Volume 1 (based on the Int. Congr. for Energy and the Ecosystem, Univ. ND, Grand Forks, ND, June 12-16, 1978). Pergamon, 1979, pp. 431-437.

The author provides a discussion of reclamation practices in the eastern United States summarizing technology at the time this article was written. Historical references are used to illustrate the development of specific technology. Future trends in reclamation technology are also discussed. The paper provides a concise literature review that could provide orientation and background for individuals with little or no prior knowledge of the subject of reclamation. The information conveyed is primarily pertinent to the Eastern Coal Mining Region.

536. Plass, W. T. Organic and Inorganic Amendments Affect Vegetation Growth on an Acidic Minesoil. U.S. For. Serv., Northeast For. Exp. Sta., Res. Paper NE-502, 1982, 7 pp.

This publication reports the results of a study that examined the potential of organic amendments in minesoil revegetation treatments to produce high-density groundcovers or increase the yield of pasture and forage crops. Shredded hardwood bark, composted municipal waste, and a tannery waste were applied to an acidic minesoil. Inorganic fertilizer, agricultural lime, and an alkaline waste from an SO_2 scrubber system were applied alone and in combination with the organic amendments. Minesoil pH and specific conductance were significantly influenced by the organic amendments but not by the inorganic amendments. Both organic and inorganic amendments reduced exchangeable acidity and exchangeable aluminum. Effective ground cover (more than 1,000 lb of green forage) was established within two growing seasons when composted municipal or tannery wastes were applied without fertilizer, lime, or scrubber waste. Where lime and fertilizers were used with the various organic amendments, an effective vegetative cover was achieved in one growing season. The results and discussion contained in this report are useful to revegetation efforts in portions of the Eastern Coal Mining Region.

537. Plass, W. T. Reclamation of Coal Mined Land in Appalachia. J. Soil Water Conserv., v. 33, No. 2, 1978, pp. 56-61.

This article reviews the sequence of reclamation operations, from mining to establishment of vegetative cover, in Appalachia. Information is presented on overburden placement, topsoiling, soil amendments, species selection, site preparation, application of seed and fertilizer, and land management options. The goal of these operations is to return productivity to the land disturbed by surface mining.

538. Plummer, J. L. The Federal Role in Rocky Mountain Energy Development. Nat. Resour. J., v. 17, No. 2, Apr. 1977, pp. 241-260.

This article provides an excellent historical review of the strategic points of energy policy development and interaction between the Federal Government and the State governments in the Rocky Mountain and Northern Great Plains Coal Mining Regions. Coal leasing, mine development, and mineland reclamation are central topics for discussion. The discussion considers the evolution of State and Federal regulations through the 1960's up to 1977. This paper has been included in this bibliography primarily for the historical perspective it provides.

539. Pommerening, E. Methods Used To Revegetate the Coeur d'Alene Mine District of Idaho. Paper in Proceedings: High-Altitude Revegetation Workshop No. 5 (CO State Univ., Fort Collins, CO, Mar. 8-9, 1982). CO Water Resour. Res. Inst., CO State Univ., Fort Collins, CO, Inf. Ser. No. 48, Dec. 1982, pp. 106-109.

This article describes the revegetation program of the Bunker Hill Co., operating in the Coeur d'Alene Mining District in northern Idaho. Elevation and aspect are critical factors affecting revegetation efforts in this area. An underground nursery was established in a ventilation drift where the temperature was a constant 74° F, and the CO_2 content in the air was 0.3 pct. Lighting was provided by 1,000-watt, mercury-vapor discharge lamps. No insect or fungus problems were encountered. The company has found that a major advantage in having their own greenhouse operation is that trees and native shrubs can be grown and transplanted at the proper time of outplanting rather than when commercial nurseries are able to make seedlings available. The author reports that the greenhouse operation has helped reduce costs of reforestation efforts on the company's mined land. While this article specifically discusses a revegetation program for a heavy metal mining operation, the description of the in-house, underground greenhouse operation provides an example of one company's unique method of meeting their specific needs. Consequently, the paper has been included in this bibliography as an example of a type of revegetation-related operation that could be applied practically anywhere in the United States.

540. Pommerening, E. Revegetation of the Coeur d'Alene Mining District. Min. Congr. J., v. 63, No. 3, 1977, pp. 20-23.

This article discusses the revegetation program initiated by the Bunker Hill Co. in the lead and zinc mining area of the Coeur d'Alene mining district in northern Idaho. Two types of disturbances are common within the district: (1) tailings deposits from the concentrators, and (2) denuded mountain slopes. Research conducted on these areas has focused on vegetation establishment using herbaceous and woody species and the development of a greenhouse program to produce containerized seedlings underground. With the underground greenhouse the Bunker Hill Co. can now collect the seeds and grow its own conifers and native shrubs. This program has the advantages of being relatively inexpensive and that trees and shrubs can be grown and transplanted at the proper time rather than when they become available from commercial nurseries.

541. Ponder, F., Jr. Improving Tree Establishment and Growth With Nurse Vegetation. Paper in Third Annual Conference on Better Reclamation With Trees (cosponsored by AMAX Coal Co., Purdue Univ., South. IL Univ., and Madisonville Comm. Coll., Terre Haute, IN, June 2-3, 1983). Purdue Univ., West Lafayette, IN, 1983, pp. 90-98.

This article provides a relatively brief literature review of the use of nitrogen-fixing plant species as a nurse crop, interplanted with preferred tree species. Several herbaceous and woody species are discussed. The article provides a good reference for this subject and is pertinent to potential land-use considerations and to reclamation planning. No specific coal region is identified by the author. Based on plant species mentioned and the literature reviewed, this article is considered pertinent to the Interior and Eastern Coal Mining Regions recognized in this evaluation process.

542. Poppleton, J. E., A. F. Clewell, and A. G. Shuey. Sand Pine Scrub Restoration at a Reclaimed Phosphate Mine in Florida. Paper in 1983 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Nov. 27-Dec. 2, 1983). Univ. KY, Lexington, KY, 1983, pp. 395-398.

This paper contains information on the methods that can be used to restore scrub vegetation on reclaimed phosphate mines in Polk County, FL. Bare-root seedlings of sand pine (Pinus clausa (Chapm.) Vasey) were planted on one set of plots, and height growth and survival were monitored. On two other plots a topsoil mulch, obtained from a natural sand pine scrub community, was applied and species composition and abundance were monitored. The results indicate that the planting of bare-root seedlings of sand pine is not worth the expense, considered their 68 pct mortality, as long as pine seeds are present in the mulch and establish naturally. The mulched plots had the important tree and shrub species present in large numbers, and the growth of these species was substantial. The authors conclude that sand pine scrub communities can be restored on reclaimed lands using the mulching technique.

543. Potter, J. L. Reclaiming Sand and Gravel Pits for Wildlife. Paper in 1983 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Nov. 28-Dec. 2, 1983). Univ. KY, Lexington, KY, 1983, pp. 315-319.

The author discusses reclaiming sand and gravel pits for wildlife habitat in the Southeastern United States. Ecological factors that influence stable wetlands are given. Four topics are discussed regarding reclaiming sand and gravel pits for wildlife: (1) water regulation, (2) slope and bank alteration, (3) creating islands, and (4) establishing vegetation.

544. Powell, J. L., and R. I. Barnhisel. Reclaiming Surface-Mined Land in West Kentucky. Min. Congr. J., v. 63, No. 12, 1977, pp. 29-35.

This article discusses the factors that should be considered when planning an effective reclamation program in western Kentucky, included climate, spoil testing, plant species selection, final grading, adequate fertility and lime amendments, seedbed preparation, mechanics of seeding, and the management of seeded areas. Examples are given on plant response to the various treatments along with recommendations on nitrogen, phosphorus, and potassium fertilization rates, lime application rates, seeding rates, and grass-legume mixtures that have been used successfully in western Kentucky. The authors state that poor planning, incorrect choices, or failure to consider the factors listed above may result in total or partial failure of a reclamation project.

545. Powell, J., and R. I. Barnhisel. Reclaiming Surface Mined Land in West Kentucky. Paper in American Mining Congress, Mining Convention Session Papers, Set No. 3, Coal Mining I & II (San Francisco, CA, Sept. 11-14, 1977). Am. Min. Congr., Washington, DC, 1977, 28 pp.

This paper reviews contemporary methods for reclaiming surface-mined lands in western Kentucky. It provides an excellent summary of experimentation and observations made over the preceding 5 years. The major topics considered include the reclamation plan, grading, seedbed preparation, spoil testing, fertility amendments, climate and species selection, seed mixtures, the mechanics of seeding and postseeding management, and the potential uses of reclaimed surface-mined land. The authors review results and comment on a broad spectrum of research findings. The paper was written specifically for application in western Kentucky. However, with prudent cosideration this information could probably be applicable to a broader geographical area.

546. Powell, J. L., R. I. Barnhisel, G. W. Aikin, and M. W. Ebelhar. The State of the Art of Reclaiming Land Surface-Mined for Coal in the Western Kentucky Coal Field. Paper in Fifth Symposium on Surface Mining and Reclamation (NCA/BCR Coal Conf. and Expo IV, Louisville, KY, Oct. 18-20, 1977). Natl. Coal Assoc. and Bit. Coal Res., Inc., 1977, pp. 251-273.

This paper presents a summary of 5 years of research and observations conducted in Western Kentucky coalfields. It was the intent of the authors to present this information so that it could be used as a guide in planning, implementing, and maintaining a sound reclamation program. Topics covered in their discussion include preplanning, grading, spoil sampling and testing, plant species selection, adaption characteristics of species, fertilizer and lime amendments, seedbed preparation, and the mechanics of seeding. Possible alternative postmining land uses are presented. This is an excellent reference for reclamation planning in the Interior and portions of the Eastern Coal Mining Regions recognized in this evaluation process.

547. Powell, J. L., M. L. Ellis, R. I. Barnhisel, and J. R. Armstrong. Suitability of Various Cool Season Grass Species for Reclamation of Acid Surface-Mined Coal Spoils of Western Kentucky. Paper in 1982 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Dec. 5-10, 1982). Univ. KY, Lexington, KY, 1982, pp. 503-526.

This study was conducted to determine the relative suitability of grasses for reclamation of surface-mined coal spoil in Ohio County, KY. Thirty-three selected cool season grass species and/or varieties were evaluated in comparisons where growth media, climate, and management techniques were similar. Each of the 33 species and/or varieties was established in a pure stand, with a legume mixture, or with 'Ky 31' tall fescue (<u>Festuca arundinacea</u> Schreb.). The grasses seeded consisted of (1) four varieties of perennial ryegrass (<u>Lolium perenne</u> L.), (2) four combination mixtures of 'Ky 31' tall fescue and common perennial ryegrass, (3) three varieties each of Kentucky bluegrass (<u>Poa pratensis</u> L.), tall fescue, and annual winter wheat (<u>Triticum aestivum</u> L.), (4) two varieties each of western wheatgrass (<u>Agropyron smithii</u> Rydb.) and hard fescue (<u>Festuca ovina</u> var. <u>duriuscula</u> (L.) Koch), and (5) single-species entries of meadow fescue (<u>Festuca rubra</u> L.), timothy (<u>Phleum pratense</u> L.), orchardgrass (<u>Dactylis glomerata</u> L.), redtop (<u>Agrostis alba</u> L.), reed canarygrass (Phalaris arundinacea L.), tall wheatgrass (Agropyron elongatum (Host) Beauv.), crested wheatgrass (Agropyron desertorum (Fisch.) Schult.), intermediate wheatgrass (Agropyron intermedium (Host) Beauv.), and smooth bromegrass (Bromus inermis Leyss.). The establishment methods used were (1) liming at a rate of 17 t/ha agricultural limestone and (2) fertilizing with 135, 450, and 225 kg/ha of ammonium nitrate, triple superphosphate, and muriate potash, respectively. All amendments were incorporated with a disc harrow. Data collection included yield determinations, ground cover evaluations, spoil chemistry, and plant tissue analyses. No "best" or "worse" choices of cool-season grasses were made based on ground cover or yield. The data does indicate that a broad selection of cool-season grasses exists which can be successfully utilized to achieve various goals in land reclamation programs.

548. Powell, J. L., M. L. Ellis, R. I. Barnhisel, and J. R. Armstrong. Suitability of Various Legume Species and Varieties for Revegetation of Acid Surface Mined Coal Spoils of Western Kentucky. Paper in 1983 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Nov. 27-Dec. 2, 1983). Univ. KY, Lexington, KY, 1983, pp. 121-129.

This study evaluated the yield of 25 selected legume species and varieties grown on the same spoil material, with identical fertility treatments, located in Ohio County, KY. The legumes evaluated were (1) three varieties of birdsfoot trefoil (Lotus corniculatus L.), (2) even varieties of alfalfa (Medicago sativa L.), (3) four varieties of red clover (Trifolium pratense L.), four varieties of sericea lespedeza (Lespedeza cuneata (Dum.-Cours.) G. Don), (4) two varieties of annual lespedeza (Lespedeza spp.), and (5) single species of alsike clover (Trifolium hybridum L.), yellow sweetclover (Melilotus officinalis Lam.), white clover (Trifolium repens L.), hairy vetch (Vicia villosa Roth), and crownvetch (Coronilla varia L.). The listing given above is, in general, the order of their ranking with respect to yield. It was also found that spring seeding of legumes outyielded fall seeding. The authors recommend that birdsfoot trefoil and alfalfa be seeded if high yields are desired. The recommended varieties to use of these species are 'Dawn' or 'Fergus' birdsfoot trefoil and 'Williamsburg' alfalfa. If established in the spring, red clover has the potential to produce very high yields. No particular variety of red clover was superior for either planting season. None of the other legumes tested are recommended for seeding if the success standard of reclamation is to be judged by predetermined target level yields.

549. Power, J. F., R. E. Ries, and F. M. Sandoval. Reclamation of Coal Mined Land in the Northern Great Plains. J. Soil Water Conserv., v. 33, No. 2, Mar.-Apr. 1978, pp. 69-74.

The authors discuss the reclamation of coal-mined land in the Northern Great Plains. A short discussion is presented on the natural resources available in the region. Insufficient water is often the limiting factor for plant growth in the region. Reclamation technology must use the available natural resources to provide for efficient conservation of water by enhancing its infiltration and storage in the soil and the efficient use of stored water for plant growth. Through sound water conservation practices the productive potential of the land can be achieved.

550. Power, J. F., F. M. Sandoval, and R. E. Ries. Restoration of Productivity To Disturbed Land in the Northern Great Plains. Ch. in The Reclamation of Disturbed Arid Lands. Univ. NM Press, Albuquerque, NM, 1978, pp. 33-49.

Information is presented on the potential for restoring agricultural productivity to land disturbed by strip mining in the Northern Great Plains. The authors discuss the basic resources involved in the reclamation of mined land. These resources include the climate, adapted vegetation, soil, and overburden. The successful revegetation of land disturbed by mining in the arid and semiarid regions in the Western United

States depends primarily on the conservation and efficient utilization of the limited precipitation received and on storage and use of the water. The authors then discuss how this natural resource can be recombined to return the land to a productive use. Successful revegetation can be achieved by creating a plant-rooting medium that will effectively store precipitation, conserving the water in the plant root zone in a way that would enable plant species to use it in the most efficient way.

551. Power, J. F., F. M. Sandoval, R. E. Ries, and S. D. Merrill. Effects of Topsoil and Subsoil Thickness on Soil Water Content and Crop Production on a Disturbed Soil. Soil Sci. Soc. Am. J., v. 45, 1981, pp. 124-129.

This study was conducted to obtain quantitative data on how the thickness of subsoil (B and upper C horizons) and the A horizon (topsoil) affect the water extraction, growth, and yield of several crops in the semiarid agriculture of North Dakota. The site was the Glen Harold Mine, near Stanton. Wedge tests were used, incorporating the subsoil and topsoil in various thicknesses over the sodic mine spoils. Tested vegetation consisted of hard red spring wheat (Triticum aestivum L.), alfalfa (Medicago sativa L.), crested wheatgrass (Agropyron desertorum (Fisch.) Schult.), and a mixture of warm-season blue grama (Bouteloua gracilis (H.B.K.) Lag.) and sideoats grama (Bouteloua curtipendula (Michx.) Torr.) grasses. Generally, all crops responded to increased soil thickness with the greatest yields when total soil thickness was about 90 cm (75 to 120 cm range), including 20 cm of topsoil. Thicker or thinner soil layers decreased productivity. The crops extracted water from the upper 30 to 90 cm of spoils when the soil-spoil interface was within 90 cm of the soil surface. Depth of water extraction by crops generally was in the following relative order: Alfalfa > crested wheatgrass > native grasses > spring wheat.

552. Prodgers, R. A. Collection and Analysis of Baseline Vegetation Data. Paper in the Third Biennial Symposium on Surface Coal Mining and Reclamation on the Great Plains (cochaired by the Reclam. Res. Unit, MT State Univ. and U.S. OSM, Billings, MT, Mar. 19-21, 1984). MT State Univ. and U.S. OSM, 1984, pp. 45-57.

The author discusses several aspects of designing a baseline vegetation study. These topics include the treatment of bias classification of vegetation, measurements, vegetation mapping, and data analysis. This article is a very good nontechnical treatment of these topics. The information conveyed is applicable nationwide.

553. Pursell, P. L. Problems With Determining Trends in Land Use Changes Following Coal Mining in Illinois. Paper in Third Annual Conference on Better Reclamation With Trees (cosponsored by AMAX Coal Co., Purdue Univ., South. IL Univ. and Madisonville Comm. Coll., Terre Haute, IN, June 2-3, 1983). Purdue Univ., West Lafayette, IN, 1983, pp. 1-10.

Changes in land use due to coal mining in Illinois and the problems in obtaining reliable data from which trends of land-use changes may be determined are discussed. The importance of accurate data collection concerning premining and postmining land use to determine trends in land-use change following mining is stressed. In addition, problems are noted with lack of precision in land-use category definitions. Use of present definitions tends to indicate an apparent increase in forest and wildlife habitat, which may not have occurred. Interpretation of existing land-use categories may, in fact, mask net losses of specific forest and wildlife habitat types. The author suggests rectification of part of this problem by modification of approved land-use categories to increase the amount of premining acreage designated as specific forest or wildlife habitat types. It is suggested that loss of these uses after bond release might best be resolved by the State Regulatory Authorities' acceptance of reclamation practices designed to enhance the desirability of leaving land as forest on wildlife habitat and development and implementation of tax incentives for landowners designed to encourage perpetuation of a diverse postmining landscape.

While this paper was written with specific reference to Illinois, similar problems probably exist in many other States. Consequently this paper provides a good reference to anyone concerned with land-use determination and changes in land use following mining activities and is recommended without regional limitations.

554. Radvany, A. Control of Small Mammal Damage in the Alberta Oil Sands Reclamation and Afforestation Program. For. Sci., v. 26, No. 4, 1980, pp. 687-702.

This article describes research which was conducted on an open pit mining area in the oil sands area of northeastern Alberta, Canada, that had been reclaimed and afforested. Due to a large population of meadow voles (Microtus pennsylvanicus) and deer mice (Peromyscus maniculatus), which had become established in the dense grass habitat, a large percentage of the trees planted on the tailing pond dyke were girdled. The major objective of this research was to monitor small mammal populations through a high, a low, and a second high level which corresponded to the 3- to 4-year population cycle of small mammals. To control girdling, a technique utilizing grain treated with an anticoagulant rodenticide was placed in bait feeder stations (10 per acre). Small mammal populations were effectively reduced from 59.7 animals per acre prior to treatment to 1.0 animal per acre 4 months later. By using the rodenticide, girdling damage was reduced from an average of 50 pct to 1 to 2 pct. The author concludes that the use of poisoned bait feeder stations can be effective in keeping rodent populations and rodent damage at very low and acceptable levels. The success of a reclamation and afforestation program is possible only if the role and impact of harmful small mammal populations are recognized as a vital component of the whole reclamation picture.

555. Raelson, J. V., and G. W. MeKee. Measurement of Plant Cover To Evaluate Revegetation Success. Dep. Agron., PA State Univ., University Park, PA, Agron. Ser. 67, Jan. 1982, 45 pp.

The authors provide a clear and concise discussion of the methods of measuring plant cover, with particular reference to evaluating revegetation success on reclaimed surface-mined sites. The methods for measuring vegetative cover include visual estimation, quadrant sampling, crown diameter, line intercept, and point frequency. Also included are discussions on the statistical basis of point frequency cover, nonrandom sampling, restricted randomization, and systematic samplings. This publication is an excellent reference for individuals concerned with designing revegetation monitoring programs. The information presented is applicable nationwide.

556. Rafaill, B. L. Establishment of Trees on Artificially Revegetated and Abandoned Surface Mines. Abstract in Third Annual Conference on Better Reclamation With Trees (cosponsored by AMAX Coal Co., Purdue Univ., South. IL Univ., and Madisonville Comm. Coll., Terre Haute, IN, June 2-3, 1983). Purdue Univ., West Lafayette, IN, 1983, p. 89.

This abstract briefly relates tree and sapling data obtained from four 17- to 20-year-old contour coal surface mines. Two of these sites were abandoned contour surface mines in Campbell County, TN. The other two sites, located in Bell County, were contour mines that had been successfully reclaimed after mining by seeding with grasses and legumes and hand planted to black locust (Robinia pseudoacacia L.). The diameter at breast height (Dbh) of all trees (≥10 cm Dbh) and saplings (2.5 to 10 cm Dbh) within six 5- by 20-m macroplots at each site was measured, and the basal area (BA) was determined. The abandoned mines had a greater BA than either of the two artificially reclaimed mines. Tree density was also greater for the abandoned mines. No trend was apparent for sapling density. Virginia pine (Pinus virginiana Mill.) was the most important tree and sapling species for one of the abandoned mines. Tulip tree (Liriodendron tulipifera L.) dominated both the tree and sapling stages on the second abandoned mine. Black locust (Robinia pseudoacacia L.) was the major tree species established on the two artificially revegetated mines, and red maple (Acer rubrum L.) dominated the sapling stage on both of these sites. This annotation is based on an abstract. The information provided appears to be pertinent to reclamation planning in the Eastern Coal Mining Region.

557. Rafaill, B. L., and W. G. Vogel. A Guide for Vegetating Surface-Mined Lands for Wildlife in Eastern Kentucky and West Virginia (U.S. FWS contract FWS 14-16-0009-77-923, U.S. For. Ser., NE For. Exp. Sta.). U.S. Fish and Wildlife Service, FWS/OBS-78/84, July 1978, 99 pp.

This guidebook presents an extensive listing of plant species, with proven establishment potential on surface-mined sites that are valuable for wildlife food and cover. Information is given on the requirements of specific species for pH tolerance limits, shade tolerance, time of establishment, and growing season. General wildlife requirements and basic ideas on reclamation for wildlife on recent surface-mine sites are discussed. Specific wildlife species are considered with respect to plant species and planting patterns that have proven successful in West Virginia and eastern Kentucky. The purpose of this publication is to guide land managers, landowners, and mine operators in revegetating surface-mined land for wildlife in this area. Much of the information presented is applicable throughout a major portion of the Eastern and Interior Coal Mining Regions.

558. Rafaill, B. L., W. G. Vogel, and R. R. Hinchman. Guide for Revegetation in Eastern U.S. Coal Age, July 1981, pp. 76-86.

The authors present a concise discussion of revegetation methods applicable to reclaiming surface mined lands in the Eastern United States. Topics discussed include seedbed preparation, seeding techniques, planting of tree and shrub seedlings, recommended plant varieties and seed mixtures, seeding times and rates, fertilizer rates, liming rates, and mulches. Excellent lists of plant materials suggested for surface mine reclamation are included.

559. Raisanen, D. L. Survival of Selected Tree Species on Sites Reclaimed to Various Reclamation Standards. Paper in 1982 Seminar on Post-Mining Productivity With Trees (Carbondale, IL, Mar. 31-Apr. 2, 1982). South. IL Univ., Carbondale, IL, 1982, pp. 93-102.

This article details the results of a study to evaluate different methods of planting trees for forestry and wildlife purposes. Twenty-six plots were established at five mined sites in southern Illinois. Nineteen forest tree species and eight species planted for wildlife were planted with four treatments. The treatments consisted of fertilizer, herbicide, planting seedlings into four different herbaceous cover mixtures, and ripping to a depth of 24 in. Data on survival after one growing season are given, showing that the use of herbicides increased survival by 80 pct, while a difference of only 10 pct separates the survival rates of trees on various herbaceous cover mixtures. The results of fertilization and ripping were inconclusive.

560. Ralston, D. S. Planning Prime Farmland Reclamation. Paper in Symposium on Surface Coal Mining and Reclamation in the Northern Great Plains (Billings, MT, Mar. 1982). MT State Univ., Bozeman, MT, 1982, pp. C-6-1 through C-6-16.

This general article deals with the planning that is involved when prime farmland is to be reclaimed. It discusses the elements of implementing a permanent program for prime farmland reclamation as required by Federal regulations. Equipment options available for moving overburden materials are presented. Two categories of equipment are discussed: direct-cast equipment, which is used for excavating and placement of overburden materials; and haul-back equipment, which transports overburden materials over longer distances. The general cost effectiveness and limiting factors of each piece of equipment are also discussed. The importance of overburden characterization is mentioned as a way of determining the suitability of the various soil materials for restoring crop productivity.

561. Ramani, R. V., C. J. Bise, C. Murray, and L. W. Saperstein. User's Manual for Premining Planning of Eastern Surface Coal Mining, Volume 2, Surface Mine Engineering (EPA Grant R803882, PA St. Univ.). U.S. EPA, EPA-600/7-80-175, Oct. 1980, 349 pp.

The purpose of the research reported in this document was to study the surface mining of coal in the Eastern United States and to establish guidelines for developing, evaluating, and selecting the most environmentally sound mining and reclamation practices. A comprehensive summary of the analyses required to lay out a surface mine is provided while accounting for limitations imposed by geology, equipment, reclamation, economics, and environmental control requirements. Methods, techniques, and alternatives are recommended for selecting and designing mining systems that include soil handling and storage, overburden removal, and minimization of environmental effects of drilling, blasting, off-highway transportation, coal loading, and steep slopes. Reclamation procedures and planning constitute a relatively small portion of the material presented in this manual. However, this information is usefully presented in the context of the overall planning of surface mining operations. This manual was written specifically for application in the Eastern Coal Mining Region as recognized in this evaluation process.

562. Randall, A., O. Grunewald, S. Johnson, R. Ausness, and A. Pagoulatos. Reclaiming Coal Surface Mines in Central Appalachia: A Case Study of the Benefits and Costs. Land Econ., v. 54, No. 4, 1978, pp. 472-489.

This paper reports the results of a study that specifically addresses the estimation of benefits from surface mine reclamation in a case study conducted in the watershed of the North Fork of the Kentucky River in Kentucky. Estimates of the benefits of reclamation were then compared with reclamation costs from pertinent literature. The results of the analysis indicate that, for the study region involved, the benefits of reclamation occurring under Kentucky regulation as of 1976 exceed reclamation costs. The authors report that the incremental benefits of reclamation under the Federal bill as introduced in the 1977 Congress, under certain assumptions, exceed the costs. The authors note that even assuming the universal application of the best available reclamation technologies in their study region, surface mining for coal would generate some residual external costs unaccounted for in their anaylsis.

563. Rastorfer, J. R. Composition and Distribution Patterns of Bryophytes at a Reclaimed Surface Mine in Grundy County, IL. Argonne Natl. Lab. ANL/LRP-16, Dec. 1981, 81 pp.

This study assessed the natural colonization of bryophyte species on reclamation demonstration sites in northeastern Illinois. Mosses and liverworts are invaders during primary and secondary succession, and their presence on mine soil may indicate the suitability of the site for successful growth of other native plants. Three of the areas surveyed were previously mined; two had been reclaimed, while the third area consisted of spoil. A fourth area, an abandoned field, was used as a reference area. A list of the vascular plant species used to reclaim the previously mined sites is given. Thirty-two moss taxa and one liverwort species were found on the four sites. Based on distribution patterns and relative abundance, Barbula unguiculata, Ceratodon purpureus, Ditrichum pallidum, and Funari hygrometrica were recognized as primary invaders. Rhynchostegium serrulatum, Bryum caespiticium, and Weissa controversa appear to be secondary invaders. The numbers of bryophyte taxa differed from one area to another, reflecting the differences in microhabitats. The presence of vascular plants may be necessary to change several abiotic factors (pH, nutrients, moisture, and temperature regimes) in order to provide favorable microhabitats for bryophytes.

The distribution pattern indicates that, in general, mosses were unable to colonize unshaded bare mine soil. Three hypotheses are given for the role of bryophytes in plant community development.

564. Redente, E. F. Reclaiming Oil-Shale Disturbances. Western Wildlands, v. 7, No. 3, 1981, pp. 35-37.

The author discusses the problems encountered when reclaiming spent oil shale in Colorado, Utah, and Wyoming. The four basic methods that can be used to mine and retort oil-shale are (1) underground mining, (2) surface mining, (3) true in situ, and (4) modified in situ mining. Each method poses major reclamation problems. The most difficult disposal and revegetation problems are encountered on spent oil shale after retorting. Reclamation techniques that have proven to be successful are given. Native plant species have been shown to produce better stands over time than do introduced species. A mixture of native and introduced species may control the invasion of annual species during early stand development, but in the long run a seeded native mixture may be more effective. Treatments that help to stimulate grass, forb, and shrub establishment are given; these include fertilization, mulching, and irrigation.

565. Redente, E. F., T. B. Doerr, C. E. Grygiel, E. Allerdings, J. M. Stark, and E. Biondini. Effects of Plant Species, Soil Material, and Cultural Practices Upon Plant Establishment and Succession. Ch. in Revegetation Studies on Oil Shale Related Disturbances in Colorado (U.S. DOE contract DE-A502-76EV04018, Dep. of Range Sci., CO State Univ.). U.S. DOE, DOE/EV/04018-6, June 1982, pp. 1-25.

This study is part of a larger project evaluating the impact and potential for reclamation following oil shale mining and retorted processes. This paper reports the sixth year results of this study. The principal objectives of the research reported in this paper included (1) determining the proper seeding practices of potentially usable mixtures of plant species and their relationship to cultural practices such as fertilization, irrigation, and mulching, (2) determining the rate and direction of plant succession on disturbed topsoil, subsoil, overburden, retorted shale, and retorted shale overlain by soil as influenced by natural invasion, species mixtures, and cultural practices, and (3) determining proper management procedures for long-term stabilization and reclamation of retorted shale materials. The rate of natural plant succession was substantially influenced by the degree of soil disturbance. Mixing soil horizons increased the probability that annual weeds would be the prominent invaders of a site and decreased the probability of perennial species significantly contributing to the established vegetation communities. Introduced species were slightly more resistant to invasion by volunteer species. Fertilizer was found to be effective in increasing seeded grass and shrub production. Manipulation of topsoil depth and the use of a capillary barrier were shown to be the best treatments for supporting plant species over Paraho retorted shale. This paper is an excellent reference for planning revegetation establishment on spent oil shale in Colorado. The results are probably applicable to surface mineland reclamation throughout much of the Northern Great Plains, Rocky Mountain, and eastern portions of the Pacific Coal Mining Regions recognized in this evaluation process.

566. Redente, E. F., N. E. Hargis, and M. Biondini. Revegetating Disturbed Areas To Protect the Environment, Final Report (OSM-BuMines contracts G1115082 and G1105017, CO Sch. Mines and subgrant with CO State Univ.). Dep. Range Sci., CO State Univ., Fort Collins, CO, Jan. 1984, 104 pp.

The results and conclusions of a 3-year study at the Trapper Mine in northwestern Colorado are reported. The study examined vegetation response to four different topsoil thickness (15, 30, 45, and 60 cm) and five manipulations that included combinations of disking, ripping, and fertilizing. Wheat (Triticum aestivum L.) grain yields were highest when soil thickness was 45 cm and the soil and overburden were ripped. Alfalfa (Medicago sativa L.) yields appeared to be highest when overburden was disked and fertilized and the topsoil was replaced to a thickness of 60 cm. Standing crop biomass for range vegetation was highest when overburden was ripped and soil was replaced to 60 cm. However, maximum species diversity was obtained by disking overburden and replacing 15 cm of topsoil. Performance of most range plants improved over the 3 years of the study. The results and discussions contained in this report should be applicable to major portions of the Northern Great Plains and Rocky Mountain Coal Mining Regions.

567. Redente, E. F., C. B. Mount, and W. J. Ruzzo. Vegetation Compostion and Production as Affected by Soil Thickness Over Retorted Oil Shale. Reclam. Reveg. Res., v. 1, No. 2, pp. 109-122.

This study was done to provide guidelines for topsoil thickness requirements for the reclamation of oil shale lands in the Piceance Creek Basin of northwestern Colorado. The study evaluated the effects of retorted shale properties, topsoil thickness, a capillary barrier, seed mixtures, and nitrogen and phosphorus fertilization. Six top soil-shale profiles were constructed and consisted of (1) 60 cm retorted shale without topsoil covering, (2) 30 cm topsoil over 60 cm retorted shale, (3) 60 cm topsoil over 60 cm retorted shale, (4) 90 cm topsoil over 60 cm retorted shale, (5) 60 cm topsoil over 30 cm rock capillary barrier (barrier to salt migration) over 60 cm retorted shale, and (6) disturbed soil control with no retorted shale. Following profile construction, three mixtures of native and/or introduced species were drill-seeded and fertilized with nitrogen and phosphorus at three different levels. Vegetation did not establish on the nontopsoiled treatment owing to the adverse chemical and physical properties of the Paraho retorted shale. As topsoil thickness increased over the retorted shale, mean canopy cover of seeded species increased. The greatest canopy cover values were observed on the capillary barrier treatment. The 90-cm topsoil treatment had the second highest canopy cover values. Mean aboveground dry matter production was significantly greater on the 90 cm topsoil treatment than all other treatments except the capillary barrier. Plants growing on the shallower topsoil treatments were subject to the detrimental effects of retorted oil shale. Aboveground biomass for the three seed mixtures were about equal; however, the native mixture had significantly greater canopy cover than the introduced or combination native and introduced seed mixtures. Grass production was significantly increased by N and P fertilizer application, while forb production decreased significantly with fertilization. The results of this study indicate that topsoiling must be an integral part of the reclamation plan for retorted shale. Without soil coverings wind and water erosion could result in serious air and water contamination.

568. Redente, E. F., W. E. Sowards, D. G. Steward, T. L. Ruiter (eds.). Symposium on Western Coal Mining Regulatory Issues: Land Use, Revegetation, & Management (Western Reclamation Group, Denver, CO, Apr. 1982). CO St. Univ., Range Sci. Dep., Fort Collins, CO, Sci. Ser. No. 35, Aug. 1983, 110 pp.

The Western Reclamation Group was formed in 1981 by representatives of the coal mining industry, environmental consultants, State regulatory agencies, and universities. The group reviewed the regulations, policies, and guidelines for revegetation success standards of six Western States (Colorado, Montana, New Mexico, North Dakota, Utah, and Wyoming) and the U.S. Office of Surface Mining in Denver. Subgroups were formed and made evaluations on four major topics: (1) land use determinations and classification, (2) concepts of reclamation standards, (3) quantitative evaluation procedures, and (4) management of reclaimed lands. The symposium is organized according to these major topics. The individual articles are preceded by a statement summarizing the conclusions and recommendations of that particular subgroup. The symposium is evaluated here as a whole because it provides an excellent reference for the major topics listed above. Individual articles were reviewed seperately and are listed in this document by the authors' names. Evaluation of the symposium is based on the summaries provided by the subgroups for each of the major topics. The information provided in this symposium is applicable to the Northern Great Plains and Rocky Mountain Coal Mining Regions recognized in this evaluation process.

569. Reeder, J. D., and W. A. Berg. Nitrogen Mineralization and Nitrification in a Cretaceous Shale and Coal Mine Spoils. Soil Sci. Soc. Am. J., v. 41, No. 5, 1977, pp. 922-927.

This article reports the results of a study utilizing laboratory incubation techniques to examine the rates and amounts of N mineralization in geologic strata. Laboratory incubations were conducted to determine ammonification and nitrification rates in Cretaceous shale, two strip-mine spoils, and an undisturbed soil collected from the Seneca Mine site near Hayden, CO. Net mineralization of N was significantly higher for the vegetated spoil material and the natural soil when compared with the shale and fresh spoil material. Nitrification of added NH_4-N resulted in significantly higher NO_3-N levels in the vegetated spoil and soil material. Rates and total amounts of CO_2 evolution from the geologic material resembled those from the natural soil. The results and discussion contained in this article are relevant to mineland reclamation research and planning throughout much of the Rocky Mountain and Northern Great Plains Coal Mining Regions.

570. Reeder, J. D., and W. A. Berg. Plant Uptake of Indigenous and Fertilizer Nitrogen From a Cretaceous Shale and Coal Mine Spoils. Soil Sci. Soc. Am. J., v. 41, No. 5, 1977, pp. 919-921.

The significance to plant growth of indigenous N mineralization and utilization of added NH_4^+ was examined in a greenhouse study. Barley (Hordeum vulgare L.) was grown on incubated and nonincubated samples of a Cretaceous shale, two strip-mine spoils, and a natural soil (Cryoboroll) collected from the Seneca Mine Site near Hayden, CO. Plants grown on shale or fresh spoil took up less indigenous N than plants grown on vegetated spoil or on the natural soil. The results indicated that initial plant recovery of fertilizer N from the geologic materials equaled that recovered from the soil. However, fertilizer N added to the geologic material may be less available to plants over time compared to the same amount of fertilizer N added to soil. The results also suggested that laboratory incubation tests could be used to estimate the plant-available N potentials of certain drastically disturbed lands prior to extensive revegetation programs. The results and discussion contained in this article are relavent to mineland reclamation research and planning throughout major portions of the Rocky Mountain and Northern Great Plains Coal Mining Regions.

571. Reeves, F. B., Jr., R. Reinsvold, J. Saboloni, and A. Park. Importance of Mycorrhizal Fungi in Revegetating Disturbed Soils and Retorted Shale. Ch. in Revegetation Studies on Oil Shale Related Disturbances in Colorado (U.S. DOE contract DE-H502-76EV04018, Dep. Range Sci., CO State Univ.). U.S. DOE, DOE/EV/04018-6, June 1982, pp. 45-56.

This study is part of a larger project evaluating the impact of, and potential for, reclamation following oil shale mining and retorting processes. This paper reports the sixth-year results of this study. The main goal was to examine the ecology of the mycorrhizal association and to develop an understanding of how these fungi can be maintained or reestablished in disturbed, stored, or processed soil material. Topsoil storage for 3 years decreased the mycorrhizal inoculum potential of the topsoil when the soil was left unplanted. However, this potential was maintained in the upper 90 cm of the storage pile when the topsoil was planted with mycorrhizal-related plant species. Functional mycorrhizae did not form in decarbonized Paraho or Union shales after several growing seasons. No adverse effects on the mycorrhizal inoculum potential of the topsoil placed over these shales were reported. TOSCO II spent shale, when leached and fertilized, allowed the formation of mycorrhizae in the upper 30 cm of the profile but inhibited mycorrhizal formation at greater depths. This paper is an excellent reference for planning revegetation activities and for understanding the microbial plant ecology of revegetation of disturbed areas. Although it specifically addressess revegetation establishment on spent oil shale in Colorado, some of the results may be applicable to surface mineland reclamation in general throughout much of the Northern Great Plains, Rocky Mountain, and eastern portions of the Pacific Coal Mining Regions recognized in this evaluation process.

572. Reising, J. W. Post-Mining Reforestation Requirements of the Surface Coal Mining Land Conservation and Reclamation Act; Illinois Program Rules and Regulations. Paper in 1982 Seminar on Post-Mining Productivity With Trees (Carbondale, IL, Mar. 31-Apr. 2, 1982). South. IL Univ., Carbondale, IL, 1982, pp. 25-30.

This article reviews portions of Public Law 95-87, the Surface Mining and Reclamation Act of 1977, that relate to reforestation of mined lands. The effects of this and other reclamation laws in Illinois on reclamation trends are examined. Data presented for 1976-81 show that reclamation plans are showing a trend of more land being returned to forest and less to agricultural land.

573. Reiss, I. H. Crops on Reclaimed Land. Paper in 1977 Coal Convention Session Papers (Am. Min. Congr. Coal Conv., Pittsburgh, PA, May 1-4, 1977). Am. Min. Congr., Washington, DC, 1979, SCT No. 3, 22 pp.

This article reviews AMAX Coal Co.'s Meadowlark Farms reclamation procedures and policies. Arguments are presented for reclaiming former corn production areas to pastureland for beef production, instead of back to corn production as the law requires.

574. Reiss, I. H. Total Utilization of a Land Resource. Min. Congr. J., v. 63, No. 10, 1977, pp. 55-59.

This article contains a response by Mr. Reiss to the questions raised by a previous article entitled "We Are Farmers, Not Miners." In this article he elaborates on the concept that coal is a legitimate crop in terms of a long-term land-use program. He also discusses grassland farming as a viable alternative to cornland. Also included in this article is an insert that discusses the crop yields obtained on various reclaimed areas in Illinois. The author concludes that corn, coal, and cattle are still compatible.

575. Reith, C. C. Factors Related to Reclamation Success on Graded Spoil and on Topdressed Surfaces at Two Coal Mines in New Mexico. Paper in 1982 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Dec. 5-10, 1982). Univ. of KY, Lexington, KY, 1982, pp. 153-162.

The author compares the success of revegetation on 5- to 7-year-old surface mines in the San Juan Basin of New Mexico that have similar reclamation histories except for the presence of topdressing or type of soil. Differences in reclamation success were then related to the properties of the topdressing and spoil. Seventeen soil and physical properties were measured at each site and correlated with reclamation success. None of the 17 factors were positively correlated with reclamation success at either mine. At one mine, sand content was positively correlated with reclamation success, while magnesium concentration and sodicity were negatively correlated with success. At the other mine, aspect and sodium absorption ratio (SAR) were correlated with reclamation success. The only parameter that was the same at both mines was the exchangeable sodium percentage, which was negatively correlated with success.

576. Reynolds, J. F., M. J. Cwik, and N. E. Kelley. Reclamation at Anaconda's Open Pit Uranium Mine, New Mexico. Reclam. Rev., v. 1, No. 1, 1978, pp. 9-17.

This paper presents the reclamation activities used at Anaconda's uranium mine that show promise in revegetating critical areas in the semiarid climate of the Southwest.

A three-step process is involved in the rehabilitation of critical areas for use as rangeland: Step 1, overburden analysis to select against phytotoxic properties of the various materials on the waste dump; step 2, document important phytosociological traits on overburden and compare the traits with those of surrounding plant communities on unmined land; and step 3, a revegetation project that included intensive soil analysis and innovative seedbed preparation techniques. These steps indicated that the Tres Hermanos materials can support native vegetation that is comparable to that of surrounding grasslands. Long-term monitoring is needed to establish trends and determine the overall success of stabilization efforts.

577. Rice, C. W., R. J. Barnhisel, and J. L. Powell. The Establishment of Loblolly Pine (Pinas taeda L.) Seedlings on Mined Land With Pisolithus Tinctorius Ectomycorrhizae. Paper in 1982 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Dec. 5-10, 1982). Univ. KY, Lexington, KY, 1982, pp. 527-534.

This study was conducted to assess the role of mycorrhizae in the establishment of loblolly pine (Pinus taeda L.) on surface mine spoil near Central City, KY. A second objective was to compare the growth and survival of loblolly pine between nursery and field inoculations of mycorrhizae fungi. Four treatments were used in this study: (1) Pisolithus inoculant added to uninoculated seedlings, (2) seedlings inoculated in the nursery with Pisolithus tinctorius, (3) control-uninoculated seedlings, and (4) control-uninoculated seedlings with vermiculite added. With the seedlings left over from this study, a demonstration study was established in eastern Kentucky on mined land near Quicksand. In the western Kentucky study, survival of loblolly pine was significantly greater when Pisolithus inoculant was added in the field (treatment 1). The survival of nursery-inoculated seedlings decreased significantly over the course of this study. By the end of the second growing season, the survival of these seedlings was only 10 pct. After four growing seasons there were no significant differences in height and root collar diameter among the surviving seedlings. Mycorrhizal infection was highly variable, with no apparent differences among treatments. After 4 years only one fruiting body of Pisolithus tinctorius had appeared on a plot; this plot had been field-inoculated. However, the fruiting bodies of a native mycorrhizal fungus, Thelephora terrestris, appeared on several plots. The survival and growth of loblolly pine planted at the demonstration site in eastern Kentucky were better than those of pine planted in western Kentucky. Mycorrhizal infection was also greater at the eastern Kentucky site. The authors conclude that the poor survival of nursery-inoculated seedlings suggests that the "tailoring" of loblolly pine with Pisolithus tinctorius may not always be the best approach on limed and fertilized surface-mined soils since field inoculation enhanced pine survival.

578. Richards, T. W., and D. H. Graves. Direct Seeding Study With Mulch Treatments After 5 Years. Paper in Third Annual Conference on Better Reclamation With Trees cosponsored by AMAX Coal Co., Pudue Univ., South. IL Univ. and Madisonville Comm. Coll., Terre Haute, IN, June 2-3, 1983). Purdue Univ., West Lafayette, IN, 1983, pp. 145-201.

Results reported are from a study of direct seeding of 15 tree species in barren mine spoils mulched with hardwood bark, water-borne fiber mulch, and a composted municipal garbage-sewage sludge product with the trade name of Real Earth. Germination rates averaged greater than 30 pct for northern red oak (Quercus rubra L.), bur oak (Quercus macrocarpa) Michx.), Ohio buckeye (Aesculus glabra Willd.), Chinese chestnut (Castanea mollissima) Blume), Virginia pine (Pinus virginiana Mill.), and loblolly pine (Pinus taeda L.). After 5 years Virginia pine had decreased substantially, and most loblolly pine seedlings had died. Survival for the four hardwood species, which had highest germination rates ranged from 64 to 100 pct for the 5 years. The effects of the mulching treatments were not conclusive. By the end of five growing seasons, the control plot had the highest average stocking for all species tested. This report provides germination and survival data pertinent to revegetation activities involving the direct-seeding method. The study was conducted in Breathitt County, KY, but the results would probably be applicable to revegetation activities throughout the Eastern and Interior Coal Mining Regions recognized in this evaluation process.

579. Richards, T. W., W. C. McComb, and D. H. Graves. Small Mammal Damage in Surface Mine Tree Plantings. Paper in 1983 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Nov. 27-Dec. 2, 1983). Univ. KY, Lexington, KY, 1983, pp. 407-411.

This general article contains information on the impact that small mammals have on tree plantings in eastern Kentucky. The predation of direct-seeded tree species by mice of the genus Peromsycus may be a cause of low germination and in some cases complete failure of direct-seeding trials in existing cover. When tree seedlings are used, voles (Microtus spp.) and cottontail rabbits (Sylvilagus floridanus) may impact seedling survival on mined land by basal gnawing or girdling of the tree species. The authors state that successful tree plantings and direct seeding in existing cover, where small mammal populations exist, depend on recognizing and dealing with the predation problem.

580. Richards, T. W., R. F. Wittwer, and D. H. Graves. Direct Seeding Oaks for Surface Mine Reclamation. Paper in 1982 Seminar on Post Mining Productivity With Trees (Carbondale, IL, Mar. 31-Apr. 2, 1982). South. IL Univ., Carbondale, IL, 1982, pp. 57-62.

The results of four separate studies are summarized in this article. All four studies looked at the feasibility of direct-seeding oak tree species on mined land in Kentucky. Treatments included fertilization, mulches, and herbaceous cover, each considered separately and in combination. The oak species studied included northern red oak (Quercus rubra L.), pin oak (Quercus palustris Muenchh.), chestnut oak (Quercus prinus L.), bur oak (Quercus macrocarpa Michx.), and sawtooth oak (Quercus acutissima Carruth.). Data summarizing the stocking percentage and height growth for each treatment are given. Results show that mulching and fertilizing gave the best results, but herbaceous cover seriously impairs survival and growth.

581. Richards, T. W., R. F. Wittwer, and D. H Graves. Feasibility of Direct Seeding Trees on Surface Mines in Kentucky. Paper in Vegetative Rehabilitation and Equipment Workshop 36th Annual Report (Denver, CO, Feb. 4-5, 1982). U.S. For. Ser. Equip. Dev. Cen., Missoula, MT, 1982, pp. 39-44.

The authors discuss the development of a planting machine that is capable of planting (direct-seeding) large-seeded tree species on surface-mined land in Kentucky. Adaptations were made on a Cole multiflex unit planter. It was found that the planter was capable of planting large-seeded tree species in loose mine spoil but had limited ability on steep slopes. Further experimentation is needed to develop a planting machine suited to the variable site characteristics encountered on surface-mined land.

582. Richardson, B. Z., and E. E. Farmer. Changes in Sodium Adsorption Ratios Following Revegetation of Coal Mine Spoils in Southeastern Montana. U.S. For. Ser., Intermountain For. and Range Exp. Sta. Ogden, UT, Res. Pap. INT-287, May 1982, 4 pp.

The results of a 7-year study of the change in sodium adsorption ratios (SAR) following revegetation of coal mine spoils in southeastern Montana are presented. SAR values decreased from greater than 12 to less than 3 within 5 to 7 years. Biomass production increased, further decreasing the relative proportion of sodium ions in sodic spoils. This study was conducted at the Decker coal mine. The results and discussion contained in the report are useful to planning reclamation activities in portions of the Northern Great Plains and Rocky Mountain Coal Mining Regions.

583. Richardson, B. Z., and T. P. Trussell. Species Diversity for Wildlife as a Consideration in Revegetating Mined Area. Paper in Shrub Establishment on Distrubed Arid and Semi-Arid Land (Proc. Symp., Laramie, WY, Dec. 2-3, 1980). WY Game and Fish Dep., 1981, pp. 70-80.

The methods used to promote vegetative diversity on reclaimed portions of five minesites are discussed. The mines used in the study were located in Idaho, Nevada, and Wyoming. The spoils at all of the test sites were amended with fertilizer. Mulch was applied to three of the sites. Rapid ground cover establishment was the initial objective at all five sites. Once established, increasing species diversity and reestablishment of native shrubs became important. A constant ratio of shrubs to grasses over time was obtained by interseeding shrubs with grasses during direct-seeding operations. The authors feel that adding organic matter and ameliorating specific growth-limiting characteristics encourage natural succession and species diversity on reclaimed mined lands. The methods and discussions contained in this article are applicable to revegetation efforts on surface coal mine lands throughout major portions of the Northern Great Plains and the Rocky Mountain Coal Mining Regions.

584. Richardson, P. Federal Mining Law Endangers Usibelli's Reclamation Efforts. Alaska Constr. Oil, v. 20, No. 5, 1977, pp. 20-26.

The author discusses several problems that exist with the Surface Mining Control and Reclamation Act of 1977 and the reclamation of Alaska's surface-mined land. Several of the regulations do not seem to apply to Usibelli Coal Mining Co.'s operations, which had field-proven reclamation success prior to the passage of Public Law 95-87. For example, the requirement that topsoil must be stockpiled and replaced does not apply in certain situations in Alaska. In Usibelli's case topsoil was either very thin or nonexistent. Yet using the extracted overburden or innerburden, successful vegetation establishment was achieved. The author then discusses several of the strategies that have been used to successfully reclaim mined land in Alaska and reclamation projects that are planned for in the future.

585. Richardson, S. G. Quantitative Revegetation Standards for Situations Where Woody Vegetation Communities Are Converted to Herbaceous Communities. Paper in Symposium on Western Coal Mining Regulatory Issues: Land Use, Revegetation, & Management (Western Reclam. Group, Denver, CO, Apr. 1982). CO St. Univ., Range Sci. Dep., Fort Collins, CO, Sci. Ser. No. 35, Aug. 1983, pp. 53-55.

The author provides a brief discussion of two possible methods for evaluating revegetation success on areas where woody vegetation is converted to predominantly herbaceous vegetation after mining. The first method uses burned or chained areas in close proximity to the reclaimed site for reference areas. In the second method regression equations relating such parameters as percent total vegetative cover or percent herbaceous cover to percent tree cover are determined. The postmining revegetation standard is then adjusted accordingly. The methods described in this paper are applicable to the Northern Great Plains and Rocky Mountain Coal Mining Regions recognized in this evaluation process.

586. Richardson, S. G., and C. M. McKell. Salt Tolerance of Two Saltbush Species Grown in Processed Oil Shale. J. Range Manage., v. 33, No. 6, Nov. 1980, pp. 460-462.

This paper reports the results of a greenhouse study that evaluated the tolerance of fourwing saltbush (Atriplex canescens (Pursh) Nutt.) and cuneate saltbush (Atriplex cuneata A.Nels.) to salt in processed oil shale over an EC range of 4 to 38 mmho/cm. Both species survived and grew at salinities as high as 38 mmho/cm. However, cuneate saltbush was more salt tolerant than fourwing saltbush. The species exhibited differing growth responses dependent on the particular salt or salts in the soil solution. The results and discussion are applicable to surface coal mine revegetation efforts in major portions of the Rocky Mountain and Northern Great Plains Coal Mining Regions.

587. Rickard, W. H., and R. H. Sauer. Land Rehabilitation Research at Pacific Northwest Laboratories: A Brief Summarization for Presentation at Argonne National Laboratory. Battelle Pac. NW Lab., Richland, WA, Jan. 1977, 21 pp.

This publication provides brief descriptions of reclamation research conducted by the Pacific Northwest Laboratories. The four research projects included in the report are listed and briefly described. (1) Primary Productivity and Grazing Potential of Undisturbed Sagebrush-Bluebunch Wheatgrass Communities - This study collected productivity data from an area in the sagebrush (Artemisia spp.)-bluebunch wheatgrass (Agropyron spicatum (Pursh) Scribn. & Smith) region of the United States that has a long history of no grazing. These data are viewed in conjunction with data from a controlled cattle grazing study to determine the capacity of this ecosystem to sustain moderate grazing pressure, to measure weight gains of cattle while on sagebrush-bluebunch wheatgrass pastures, and to study dietary preferences of the cattle. Reproductive capacity of the important cattle forage grasses was decreased by grazing. Gross changes in plant communities are anticipated under moderate grazing intensities. The study was conducted on the U.S. ERDA Hanford Reservation in south-central Washington. (2) Response of Sagebrush-Bluebunch Wheatgrass Communities to Severe Soil Disturbances - This study examined secondary succession on abandoned dry land wheat fields on the U.S. ERDA Hanford Reservation. After 30 years native plants were still poorly represented. The fields were dominated by introduced weed species, especially cheatgrass (Bromus tectorum L.). (3) Plant Cover on Stressful Habitats of Natural Origin - This study examined species composition and canopy cover on steep slopes having either north or south aspect. The study was conducted in south-central Washington. Cheatgrass provided a significant portion of the vegetation on south-facing slopes. Native vegetation is more significant on north-facing slopes. It was concluded that south-facing slopes in this region are not conducive to establishment of native perennial grasses. (4) Rehabilitation of Surface Mine Lands by Water Harvest - This study involved radical modification of the topography of a minesite to accumulate precipitation and placement of topsoil in sufficient depth to store adequate amounts of this water to enable growth of plants that exhibit higher productivity and higher economic value than those typically used under conventional land restoration practices. This project is reported in more detail in other entries in this bibliography. The ratings assigned to keywords in the evaluation process refer to this publication as a whole and not to each individual research project. The information presented and the research discussed are useful to revegetation planning in portions of the Northern Great Plains, Pacific, and Rocky Mountain Coal Mining Regions.

588. Rickard, W. H., and J. L. Warren. Canopy Cover and Phytomass Comparisons of Steep Slopes Planted to Cheatgrass. Northwest Sci., v. 55, No. 1, 1981, pp. 40-43.

An earth mound was formed in the State of Washington with steep north- and south-facing slopes. The mound was planted with cheatgrass (Bromus tectorum L.) in 1971 and monitored in 1978 to evaluate plant cover on the two slopes. The north-facing slope greatly outproduced the south-facing slope, with live, aboveground phytomass of 830 g/cm^2 compared with 163 g/cm^2 for the south-facing slope. This greater production was attributed to more favorable temperature and water conditions on the north slopes rather than to soil nutrient differences.

589. Ries, R. E. Supplemental Water for the Establishment of Perennial Vegetation on Strip-Mined Lands. ND Farm Res., v. 37, No. 6, 1980, pp. 21-23.

This research was conducted to determine the density and dry matter production of perennial vegetation established on mined land in North Dakota which had natural precipitation supplemented by irrigation. Two separate studies are detailed in this paper. The first study utilized treatments consisting of two water levels (natural precipitation and natural precipitation + irrigation), two planting dates (end of May and end of July), and two species mixtures (an introduced forage mixture and a native forage mixture). The second study utilized four water treatments and a single forage mixture. The water used for irrigation in the second study was of poor quality (EC of 3.0 to 4.0 mmho/cm^2). The results of the first study indicated that supplemental irrigation water can help insure a fast and successful establishment of perennial vegetation, especially when natural precipitation is low. Supplemental irrigation will also permit planting later in the growing season, which may help to control weedy species. Supplemental water applied at different levels may also provide some control over the final species composition in newly established stands. The preliminary results from the second study indicated that the use of poor-quality water in the establishment of vegetation had no detrimental effects on the vegetation. The author concludes that supplementing natural precipitation may provide protection against plant establishment failures and warrants consideration as a reclamation technique when water is available and the cost of failure is high.

590. Ries, R. E., and L. Hofmann. Pasture and Hayland: Measures of Reclamation Success. Paper in the Third Biennial Symposium on Surface Coal Mining and Reclamation on the Great Plains (cochaired by the Reclam. Res. Unit, MT State Univ. and U.S. OSM, Billings, MT, Mar. 19-21, 1984). MT State Univ. and U.S. OSM, 1984, pp. 307-317.

This paper reviews information gained from 8 years of research on a reclaimed grassland in North Dakota. Several characteristics of a reclaimed and two unmined grasslands used for tame pastureland were quantified and evaluated as measures for determining reclamation success. These characteristics included vegetation and animal productivity, ground cover, soil loss, species composition and numbers, and seasonality. The authors express the view that vegetative productivity and ground cover provide appropriate measures for documenting reclamation success for the postmine use of pasture and occasional hay production. The information conveyed is applicable to designing revegetation monitoring programs in major portions of the Northern Great Plains and Rocky Mountain Coal Mining Regions.

591. Ries, R. E., F. M. Sandoval, and J. F. Power. Reclamation of Disturbed Lands in the Lignite Area of the Northern Plains. Paper in Technology and Use of Lignite (Proc. symp. cosponsored by U.S. ERDA and Univ. ND, Grand Forks, ND, May 18-19, 1977). U.S. DOE, GFERC/IC--77/1, 1977, pp. 309-327.

This article provides a good overview of the status of reclamation techniques and research in the Northern Great Plains Coal Mining Regions. A review of some of the current reclamation research is provided, together with pertinent soil characterization and yield data. Trends of data and tentative conclusions are discussed.

592. Riley, R. K., and M. L. Brown. The Natural Invasion of Wildlife Food and Cover Species Onto Bitiminous Coal Spoil. Paper in Symposium on Surface Mining and Fish/Wildlife Needs in the Eastern United States (WV Univ., Dec. 1978). U.S. Fish and Wildlife Ser., FWS/OBS-78/81, 1978, pp. 376-379.

This study reports on the natural invasion of mycorrhizae-deciduous tree species associations onto four different bituminous coal spoils in Allegheny County, MD. A brief review of mycorrhizae-tree associations is given. Two fungi were identified that associated with several wildlife food and cover deciduous tree species, *Pisolithus tinctorius* and *Scleroderma aurantium*. The naturally occurring mycorrhizae were evaluated under soil amendments even though they were not added to the soil.

This study suggests that deciduous tree species can be used for reforestation of bituminous spoil if P. tinctorius and S. aurantium are used as inoculum to form mycorrhizae associations. Recommendations on mycorrhizal use in revegetation of bituminous coal spoils are given.

593. Roberts, D. R., and S. B. Carpenter. The Influence of Seed Scarification and Site Preparation on Establishment of Black Locust on Surface-Mined Sites. Tree Planters Notes, v. 34, No. 3, 1983, pp. 28-30.

The effects of scarifying black locust (Robinia pseudoacacia L.) seeds and what scarification method is best for seeds to be sown on Eastern or Interior surface-mined land was studied. A field experiment was also conducted in order to determine what field procedures influence the germination potential of black locust. Black locust seeds were placed in concentrated sulfuric acid for 10, 30, 60, and 90 min. After the seeds were rinsed, four different treatments were imposed on them in a controlled environment germination tests. For each acid treatment one-half of the seeds were planted; 50 pct of the seeds were watered immediately, and 50 pct had a 72-h water delay. The other half of the acid-treated seeds were dried at 34° C for 24 h and then either watered (50 pct) or were subjected to a water delay (50 pct). The only significant effect found for increasing seed germination were the 60- and 90-min acid treatments. Germination was increased from 16 pct for nonscarified seeds to 56 and 46 pct for the 60- and 90-min treatments, respectively. The field trial utilized seeds that were scarified for 60 min, rinsed, and oven dried at 34° C overnight. The field treatments consisted of 2.4 cm of bark mulch and bare spoil. None of the scarified seeds survived when seeded on the bare mine spoil. Seedling survival was significantly increased by using bark mulch. If the environment is unfavorable for the establishment of black locust, the authors recommend decreasing the seed scarification treatment. This results in greater innate protection of the seed by the seed coat.

594. Roberts, H. A. (ed). Decision Analysis for Abandoned Mine Reclamation Site Selection and Planning. Decision Analysis Task Force of the Illinois Institute of Natural Resources. Project No. 90.012, Doc. No. 79/29, Aug. 1979, 256 pp.

The focus of this report is the application of decision analysis to the selection of abandoned mine sites throughout Illinois for reclamation. The report consists of six independently written chapters treating various aspects of the problem. An overall unified methodology incorporating all categories of pertinent factors is not presented. The chapters discuss overall modeling framework, and handling social, political, economic, environmental, and regional water quality considerations within that decision analysis framework. The purpose of this report was to provide a framework within which to apply pertinent state-of-the-art theory and methods of decision analysis to making environmental management decisions at the State level. While this report was written specifically for reclamation efforts of the abandoned mined lands of Illinois, the methods discussed could have significantly beneficial application in other States and surface coal mining regions.

595. Robertson, S. D., and R. F. Wittwer. The Effects of Slit-Applied Fertilizer Treatments on Growth and Survival of Sycamore and Cottonwood Planted on Minespoil. Paper in 1983 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Nov. 27-Dec. 2, 1983). Univ. KY, Lexington, KY, 1983, pp. 483-488.

This study examined the effects of slit-applied fertilizers on the growth and survival of eastern cottonwood (Populus deltoides Bartr. ex Marsh.) and American sycamore (Platanus occidentalis L.) planted on mountain-top removal spoil in Bell County, KY. Two separate studies were conducted to evaluate both bulk and slow-release tablets. The first study compared four levels of slow-release fertilizer in tablet form to a surface-applied bulk fertilizer and an unfertilized control. Fertilization had no effect on the survival of cottonwood or sycamore during the second or third growing season. However, there were significant treatment differences for height and root collar diameter. For cottonwood, control plots had lower heights and root collar diameters than the fertilized plots. Broadcast fertilizer was less effective in stimulating growth than the tablet form fertilizers. Broadcast fertilizer treatments resulted in lower sycamore root collar diameters than the other fertilizer treatments. The second study utilized slit-applied slow-release fertilizer tablets. An untreated control was compared to low and high levels of N only, P only, and N plus P treatments. Survival of both species was significantly higher on control plots than on fertilized plots. The high P and the high P plus high N treatments resulted in the lowest survival rates for both species. The authors conclude that slit-applied, slow-release fertilizer tablets did not affect seedling survival; however, slit-applied bulk fertilizers decreased survival and should be avoided except with extremely acid-tolerant species such as black locust (Robinia pseudoacacia L.).

596. Rogers, L. E., and W. H. Rickard. Terrestrial Ecology. Paper in Pacific Northwest Laboratory Annual Report for 1979 to the DOE Assistant Secretary for Environment. Part 2. Econological Sciences. Pac. NW Lab., Battelle, Richland, WA, PNL-3300 PTZ, Feb. 1980, pp. 3-11.

This paper presents summaries of two studies conducted as part of the Terrestrial Ecology program of the Pacific Northwest Laboratory. The research reported was conducted on the Arid Lands Ecology Reserve, part of the Hanford National Environmental Research Park in south-central Washington. The first study examined wildlife utilization of disturbed plant communities. The study compares the vegetation, ground-dwelling beetles, small mammals, birds, and large mammals on adjacent replicated plots of native bunchgrass and cheatgrass (Bromus tectorum L.) community types. Early season vegetative production was similar on both types of plots. Vegetative production was greater in the cheatgrass community types as the season progressed. Canopy cover and species diversity was greater for the native bunchgrass communities. The cheatgrass communities were more productive than the native bunchgrass communities. The second study presented an examination of the response of shrubs to severe drought as measured by litterfall collection. Growth of shrubs, as measured by the amount of collected litterfall, was limited during the drought year of 1977. Greasewood (Sarcobatus vermiculatus (Hook.) Torr.) produced more litterfall than did the other shrub species studied. Hopsage (Grayia spinosa (Hook.) Moq.) failed to produce leaves during the drought year. While the research reported in this paper was not directly related to reclamation of surface coal mines, the information presented will be useful in considering options for revegetation of such land in portions of the Pacific, Northern Great Plains, and Rocky Mountain Coal Mining Regions.

597. Rogowski, A. S., H. B. Pionke, and J. G. Broyan. Modeling the Impact of Strip Mining and Reclamation Processes on Quality and Quantity of Water in Mined Areas: A Review. J. Environ. Qual., v. 6, No. 3, 1977, pp. 237-244.

The authors provide a concise literature review of the parameters affecting the hydrology of the spoil system. Studies of acid generation, neutralization, and transformation in strip-mine spoil materials, spoil water flow, oxygen diffusion, surface runoff, erosion, evapotranspiration, and temperature distributions within spoil banks are reviewed. The authors discuss the potential for modeling the hydrology and the acid-producing areas of a spoil system. While the article is written with a nationwide perspective, much of the literature reviewed is based on studies conducted in the Eastern and Interior Coal Mining Regions.

598. Rosso, W. A. Revegetation Augmented by Reuse of Treated Acid Mine Drainage. Paper in 1980 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Dec. 1-5, 1980) Univ. KY, Lexington, KY, 1980, pp. 1-8.

The author evaluates the use of treated acid mine drainage (AMD) as irrigation water. The AMD was treated with limestone prior to irrigation. Four test programs were utilized: (1) irrigation with treated AMD containing sludge, (2) irrigation with treated AMD with sludge removed, (3) irrigation with untreated AMD, and (4) no irrigation. Prior to irrigation spoil materials were characterized, and all plots were limed, fertilized, and seeded. Monitoring of the spoil material was conducted to document any changes in soil chemistry during irrigation. Runoff was also monitored, and it was determined that irrigation with untreated AMD had no detrimental effects on water quality. The effects of the various irrigation treatments on vegetative cover and production were evaluated. When compared to the control, all three irrigation treatments enhanced the vegetation in terms of production and cover. There appears to be an advantage to both the vegetation and water quality when irrigating with acidic water on the types of spoils used.

599. Rosso, W. A., and B. H. Wolcott, Jr. Wildlife Option in Kentucky. Paper in Fifth Symposium on Surface Mining and Reclamation (NCA/BCR Coal Conference and Expo IV, Louisville, KY, Oct. 18-20, 1977). Natl. Coal Assoc. and Bit. Coal Res., Inc., 1977, pp. 20-23.

This paper presents a new wildlife option for Kentucky State reclamation regulations. Specific regulatory guidelines are presented. The plans and their initial implementation for the first reclamation project approved under these new regulations are evaluated. This project was located at the Ken Mine in Ohio County, KY. Few results are included. However, the approach described and the guidelines presented for the new regulation may be of interest to individuals planning reclamation projects in the Eastern and Interior Coal Mining Region.

600. Rothwell, F. M. Mycorrhizal Associates of Plant Species Found on Planted and Orphan Mine Sites. Abstract of paper presented at the Meeting of the American Council for Reclamation Research (Univ. AL, Sept. 19-22, 1979). Reclam. Rev., v. 3, 1980, pp. 61-64.

The author describes the occurence of mycorrhizal fungi associations on (1) planned revegetation sites mined in the early to mid-sixties in Kentucky, (2) orphan sites mined in the late forties or early fifties in Kentucky, and (3) orphan sites mined in the early to mid-sixties in Tennessee. The planned sites were graded and planted to woody and herbaceous species without mulch. Lime and fertilizer were added as needed. Vegetation at the time of the study varied between sites; however, the occurrence of mycorrhizal fungi was basically equivalent among sites, with 80 pct of the plant samples from the planned sites and 75 pct of the samples from orphan sites infected. In all cases, about 90 pct of the fungi occurrences were endomycorrhizal.

601. Rothwell, F. M., and W. G. Vogel. Mycorrhizae of Planted and Volunteer Vegetation on Surface-Mined Sites. U.S. For. Ser. NE For. Exp. Sta., Gen. Tech. Rep. NE-66, 1982, 12 pp.

This publication reports the results of a study that examined the presence and type of mycorrhizae associated with planted and volunteer herbaceous and wood species on surface-mined sites in north-central Tennessee and southwestern Kentucky. An extensive list of host vegetation species is presented. The information contained in this report will be useful to individuals planning revegetation efforts and/or research on surface-mined lands in major portions of the Eastern and Interior Coal Mining Regions.

602. Rowell, C. E., and S. B. Carpenter. Black Locust Biomass Prediction on Eastern Kentucky Strip Mines. South. J. Appl. For., v. 7, 1983, pp. 27-30.

Regression equations to predict the dry weight of aboveground biomass of black locust (Robinia pseudoacacia L.) were developed from a sample of 1,420 trees collected in

130 direct-seeded stands located on 10 reclaimed strip mines in the eastern Kentucky Cumberland Plateau. Initially, 10 regression equations using the log 10 transformation of diameter squared times height were developed for each of the 1- to 10-year-old age classes within the sample. By consolidating the 1- to 4-year and 5- to 10-year age classes, two equations were selected that best estimated woody biomass. These two equations provided a better estimation of individual tree woody biomass, in each age class, than did a single equation, which can either overestimate or underestimate the total woody biomass in a stand.

603. Rowell, C. E., and S. B. Carpenter. Site Quality and Prediction of Black Locust Biomass Production on Surface Mine Sites in Eastern Kentucky. Paper in 1982 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Dec. 5-10, 1982). Univ. KY, Lexington, KY, 1982, pp. 231-236.

Site quality and biomass production evaluations were made on 127 existing black locust (Robinia pseudoacacia L.) stands, ranging in age from 2 to 10 years, located on 10 surface mine sites in the eastern Kentucky Cumberland Plateau Region. The objectives of this study were to (1) present individual tree and site biomass equations which predict aboveground woody biomass, (2) evaluate site and stand variables to determine their accuracy in predicting site biomass production, (3) assess existing productivity and establish site classes ("good" or "poor") for new mine spoils, and (4) derive procedures and statistics to assess the potential or existing growth of black locust stands on mine spoil. Procedures included harvesting all aboveground portions of each tree located within a 10-m^2 plot and conducting soil analyses at each site. Tables and equations are given for individual tree weight predictions to aid in determining actual standing biomass or annual biomass production on a site. Productivity classes were established using site-stand characteristics of existing black locust stands. A site classification equation is also given to assign an annual black locust growth value to new unreclaimed mine soils.

604. Rowell, M. J. Continued Studies of Soil Improvement and Revegetation of Tailings Sand Slopes (Syncrude Canada, Ltd. contract 98-0051-R, Northwest Soil Research, Ltd.). Syncrude Canada, Ltd., Edmonton, Alberta, Environ. Res. Monog. 1977-4, 1977, 156 pp.

The second year (1976) of a study is reported, dealing with the improvement of a 5-year-old revegetated area on a tailings sand dike by implementation of different fertilizer treatments. Levels of available N, P, K, and S significantly decreased during the period between June and September. Good growth continued throughout the summer only when extra N, P, K, and S fertilizers were added in June. The most efficient use of fertilizer occurred when nitrogren was added at a rate of about 80 kg/ha or less. At higher fertilizer application rates there was a tendency for brome grass (Bromus inermis Leyss.) to replace creeping red fescue (Festuca rubra L.) the dominant grass in the sward. Root-shoot ratios ranging from 4:1 to 7:1 are reported, indicating an accumulation of root tissue over 5 years. Erosion on steep tailings sand slopes was minimized by rapid establishment of a plant cover. This was most effective where the surface was amended with peat, mine overburden, and N, P, K, and S fertilizers. Between 13 and 34 pct of the intercepted rainfall was estimated to leach beyond the 30-cm depth while plants were being established during the first year of growth. Rapid infiltration rates of 24.0 to 30.5 cm/h were reported. The seed mix used contained oats as a nurse crop and nine grass and four legume species. Dry weight production of oats was significantly greater than for either the grasses or the legumes. Dry weight production of root tissues approximately equaled that of shoot tissues. Root growth was largely restricted to the surface 15 cm. Greater proportions of the roots in the 15-to-30-cm depth resulted from deeper tillage of peat and overburden. Total soil respiration as well as total numbers of bacteria, fungi, and actinomycetes were greater from the revegetation experiments in comparison to samples of fresh or weathered tailings sand. The results reported in this publication are, to some extent, specific for reclamation of oil sand mining waste materials. However, they could find application in planning reclamation efforts for other materials possessing similar properties. The research reported was conducted at the Great Canadian Oil Sand, Ltd. (now Suncor) plant at Fort McMurray, Alberta. However, with proper consideration, a major portion of the conclusions may be applicable to a broader geographical area.

605. Rowell, M. J. Revegetation and Management of Tailings Sand Slopes: 1977 Results (Syncrude Canada Ltd. contract 98-0145-EA, Northwest Soil Research Ltd.). Syncrude Canada Ltd., Edmonton, Alberta, Environ. Res. Monog. 1978-5, 1978, 141 pp.

This publication is the third annual report of an ongoing project investigating revegetation on a steeply sloping dike composed of tailings sand from tar sand extraction at the Great Canadian Oil Sand, Ltd. (now Suncor) plant, Fort McMurray, Alberta. The objectives of this research were to investigate methods for the establishment of vegetation for erosion control and to determine cost-effective methods for long-term management of these areas. Fourteen plant species were tested. Fertilizer rate was found to affect species composition of the reestablished vegetation. Seed washoff during snowmelt resulted in poor seed distribution for fall seeding trials. Aboveground vegetation production was related to the amount of fertilizer applied. The yield of plant roots was less affected by fertilization. Incorporation of peat or peat and overburden to deeper depths in the profile resulted in deeper penetration and yield of roots. Initial results of decomposition and microbial population and activity studies are presented and discussed. The results reported in this publication are, to some extent, specific for reclamation of oil sand mining waste materials in this area. However, with prudent consideration they could find application over a broader geographical area in planning reclamation efforts for other materials possessing similar properties.

606. Rowell, M. J. Revegetation and Management of Tailings Sand Slopes From Tar Sand Extraction: 1978 Results (Syncrude Canada Ltd. contract 98-8021-CD, Northwest Soil Research Ltd.). Syncrude Canada Ltd., Edmonton, Alberta, Environ. Res. Monog. 1979-5, 1979, 131 pp.

Research results are reported for revegetation of two areas on a steeply sloping dike composed of tailings sand from tar sand extraction at the Great Canadian Oil Sand, Ltd. (now Suncor) plant at Ft. McMurray, Alberta. The research objectives were to investigate methods for the establishment of a stable vegetative cover that would prevent erosion of the slope and possibly become self-maintaining. A comparison of two tillage depths was conducted for incorporation of soil amendments to depths of 15 and 30 cm, to promote deeper rooting. Fertilizer additions significantly increased the uptake of N and K and to a lesser extent P and S into the shoot tissues. Root mass production was not affected by fertilizer. Deeper incorporation of peat and overburden promoted deeper rooting. However, there appeared to be no advantage for the deeper tillage treatment over the 15-cm tillage treatment in promoting stable soil surface conditions. Soluble salt concentrations were reduced over the course of the study. Soil pH showed no significant change. The effectiveness of different fertilizer treatments was assessed in terms of biomass production, nutrient uptake, and the efficiency of use of the fertilizer nutrients. On older established areas where no additional fertilizers had been added, erosion-free surfaces still existed. However, an annual fertilizer application of about 90 kg N, 25 kg P and 40 kg K per hectare is recommended to maintain vigorous cover while efficiently using fertilizers. Where peat or peat and overburden are used on the tailings sand surface, it is recommended that fertilizer be added at a rate of 60 to 80 kg N; 40 kg P, and 60 to 80 kg K per hectare in the first year to obtain the most efficient use of the fertilizers. Older revegetated sites exhibited more rapid rates of decomposition than areas revegetated later in the study. Decomposition rates were correlated with total soil respiration and to a lesser extent with numbers of aerobic microorganisms. Analysis of decomposing litter residues indicated different patterns in the release of the major plant nutrients. The results reported in this publication are specific for reclamation of oil sand mining waste materials in this area. However, with prudent consideration they could find application over a broader geographical area in planning reclamation efforts for other materials possessing similar properties.

607. Ruehle, J. L. Growth of Containerized Loblolly Pine With Specific Ectomycorrhizae After 2-Years on an Amended Borrow Pit. Reclam. Rev., v. 3, No. 2, 1980, pp. 95-101.

The purpose of this study was to use a combination of soil amelioration techniques and ectomycorrhizae to determine their effects on the establishment of loblolly pine (*Pinus taeda* L.) on a borrow pit located near Aiken, SC. Plots were amended with either processed sewage sludge or fertilizer and limestone. All plots were double-disked 10 to 15 cm deep to incorporate the amendments. 'Ky-31' tall fescue (*Festuca arundinacea* Schreb.) was then sown over the entire area to prevent erosion and retard nutrient loss. One year after site preparation, containerized loblolly pine seedlings inoculated with *Pisolithus tinctorius* (Pt), *Thelephora terrestris* (Tt), or no ectomycorrhizae were planted on the site. The results indicate that on fertilized plots, loblolly seedlings colonized with Pt ectomycorrhizae at planting had significantly better survival (96.0 pct) after two years than did seedlings colonized with Tt (88.0 pct) or nonmycorrhizal seedlings (89.6 pct). There were no differences in height, root-collar diameter, or seedling volume between Pt and Tt colonized seedlings, but Pt was greater than the control. Survival of seedlings on sludge-amended plots was not affected by ectomycorrhizal treatment. However, the height, root-collar diameter, and seedlings volume of loblolly pine on sludge-amended plots was greater with Pt ectomycorrhizae than with Tt or control seedlings. Foliar nutrient contents were also affected by mycorrhizal and soil amendment treatments. The author concludes that loblolly pine seedlings tailored with *Pisolithus* ectomycorrhizae can be successfully established on borrow pits amended with either sewage sludge or fertilizer.

608. Running, S. W. Plant Stress Physiology in Reclamation. Western Wildlands, v. 7, No. 3, 1981, pp. 15-17.

The author discusses the climatic variables that are important in determining tree seedling survival on mined land near Colstrip, MT. Two advantages of regenerating forests on mined land over forest sites are given: (1) more money available per acre for reforestation and (2) greater control over site conditions. The plant environmental (physiological) stresses that may prevent tree establishment on mined lands are (1) air temperature stress - both low and high, (2) water stress, (3) soil nutrition, (4) high wind, and (5) high solar radiation intensity. The development of a favorable microsite and physiological toughness of the tree species, through genetic and physiologic tailoring of seedlings to a particular site, are two potential ways to alleviate environmental plant stress and keep tree seedlings alive on mined land.

609. Rutherford, G. K., D. Dimma, G. W. VanLoon, and W. G. Brech. The Pedological Properties of Tailings Derived From Three Mining Operations in the Sindberg Area, Ontario, Canada. J. Environ. Qual., v. 11, No. 3, pp. 511-518.

In this article the authors describe field and laboratory analysis of profiles in three different kinds of tailings in the Sindburg area, to evaluate their pedological properties. The analyses are excellent in relating chemical and physical properties to original conditions of the tailings, weathering, soil amendments (lime and fertilizer), and vegetative growth. On the basis of this research, absence of vegetation was determined to be due to (1) coarse material, which generally is a poor growth medium, (2) low pH, causing high concentrations of toxic elements, and (3) low organic matter and no source of N_2. This is an excellent article characterizing soils.

610. Sabey, B. R., R. L. Cuany, N. Oleski, and J. Barry. Nitrogen Supply by Legumes and Other Fertility Sources for Disturbed Lands. Ch. in Revegetation Studies on Oil Shale Related Disturbances in Colorado (U.S. DOE contract DE-A502-76EV04018, Dep. Range Sci., CO State Univ.), U.S. DOE, DOE/EV/04018-6, June 1982, pp. 67-85.

This study is part of a large project evaluating the impact of and potential for reclamation following oil shale mining and retorting processes. This paper reports on the sixth-year results of this study. The overall objective of this study was to determine the long-term fertility requirements and methods of meeting these requirements on N- and P-deficient soil materials used as plant growth media for land reclamation. Total biomass and total plant cover were significantly related to the fertility level of the soil. The maintenance of favorable fertility levels on the disturbed land included in this study depended on adequate and timely supplies of nitrogen either as fertilizer or through enhanced activity of natural elements of the ecosystem. The contribution of nitrogen to these disturbed plant-soil systems through biological and chemical pathways is discussed. This paper is an excellent reference for planning revegetation activities. Although it specifically addresses vegetation establishment on spent oil shale in Colorado, the results are probably applicable to surface mineland reclamation in general throughout much of the Northern Great Plains, Rocky Mountain, and eastern portions of the Pacific Coal Mining Regions recognized in this evaluation process.

611. Saeed, M. Use of Sorption Isotherms for Evaluating the Effect of Leonardite on Phosphorus Availability in a Coal Mine Spoil. Soil Sci., v. 126, No. 3, 1978, pp. 157-165.

This paper reports the results of a study that examined the effect of leonardite application on P availability in spoil material collected from the Glenharold coal mine area in North Dakota. There was greater P sorption by the leonardite when the P isotherms of leonardite and the spoil were compared. The addition of 10 pct leonardite to the spoil materials increased sorption by 21 pct. In growth chamber experiments the addition of leonardite depressed the uptake of P and the growth of thickspike wheatgrass (Agropyron dasystachyum) (Hook.)Scribn.), but improved the growth of alfalfa (Medicago sativa) L.). A substantial increase in the utilization of indigenous Zn and Mn was observed with leonardite. The results reported are pertinent to mineland reclamation planning and research throughout the Northern Great Plains and Rocky Mountain Coal Mining Regions.

612. Safaya, N. M. Delineation of Mineral Stresses in Mine Spoils and Screening Plants for Adaptability. Paper in Ecology and Coal Resource Development, Volume 2 (based on the Int. Congr. for Energy and the Ecosystem, Univ. ND, Grand Forks, ND, June 12-16, 1978). Pergamon, 1979, pp. 830-849.

This paper provides a concise literature review pertaining to the importance of mineral stresses in mine spoils, methods for their characterization, and the adaptability of plants to such stresses. A synchronized approach of identifying the site-specific nature of these stresses and screening plants for their specific tolerances to such stresses is emphasized by the author. The material conveyed by this paper is relevant to the revegetation of minelands nationwide.

613. Safaya, N. M., and M. K. Wali. Growth and Nutrient Relations of a Grass-Legume Mixture on Sodic Coal-Mine Spoil as Affected by Some Amendments. Soil Sci. Soc. Am. J., v. 43, 1979, pp. 747-753.

The effects of fertilizers, gypsum, H_2SO_4, and leonardite (oxidized lignite) on the growth and nutrient relations of thickspike wheatgrass (Agropyron dasystachyum (Hook.) Scribn.) and yellow sweetclover (Melilotus officinalis (L.) Lam.) are described in this paper. Laboratory and greenhouse studies were conducted to investigate the effects of the treatments on (1) properties of a calcareous sodic mine spoil, including P, Zn, and Mn availability, (2) the productivity of thickspike wheatgrass and yellow sweetclover grown as a mixture on the spoil, and (3) the mineral element composition of the two species. The spoil was from the Glenharold Mine in Mercer County, ND. The data and results are detailed in this paper.

614. Sandoval, F. M., and J. F. Power. Laboratory Methods Recommended for Chemical Analysis of Mined-Land Spoils and Overburden in Western United States. U.S. Dep. Agric. Sci. and Educ. Admin., Agric. Handbook 525, Apr. 1978, 31 pp.

This handbook is an attempt to standardize laboratory procedures for the characterization of mined-land spoils, overburden, and reconstructed soil. The laboratory procedures contained in this publication are those recommended by the U.S. Salinity Laboratory and the American Society of Agronomy. This is an excellent reference for individuals concerned with the characterization of soil material for reclamation of minelands throughout the Western United States.

615. Sandusky, J. E. The Potential for Management of Waterfowl Westing Habitat on Reclaimed Mined Land. Paper in Symposium on Surface Mining and Fish/Wildlife Needs in the Eastern United States (WV Univ., Dec. 1978). U.S. Fish and Wildlife Ser., FWS/OBS-78/81, 1978, pp. 325-327.

This paper discusses the management practices responsible for the attraction and retention of game birds on reclaimed surface-mined land in southeastern Illinois. Breeding pair census, habitat surveys, and waterfowl nest surveys were conducted. Results indicate that with proper management, surface mined lands have the potential for serving as waterfowl habitat.

616. Sandusky, J. Using Trees on Reclaimed Mined Lands in Southern Illinois. Paper in Trees for Reclamation (Lexington, KY, Oct. 27-29, 1980). U.S. Forest Ser., Gen. Tech. Rep. NE-61, 1980, pp. 17-19.

The author discusses the planting of trees and the species used since 1956 on Peabody Coal Co.'s Will Scarlet Mine in southern Illinois. A review of the various Illinois reclamation laws and requirements is also presented. In 1974 a 10-year plan was implemented which would reclaim 2,600 acres of acid spoil; reforestation was part of the plan. Tree species were chosen based on (1) commercial desirability, (2) acid tolerance, (3) wildlife, and (4) esthetics. Both mechanical and manual planting of trees were done. Areas that were hand planted tended to have the highest survival rates. The most successful species were black locust (Robinia pseudoacacia L.), autumn olive (Elaeagnus umbellata Thunb.), sweetgum (Liquidambre styraciflua L.), European black alder (Alnus glutinosa (L.) Gaertn.), loblolly pine (Pinus taeda L.), and river birch (Betula nigra L.). The results of an attempt to aerial seed black locust are also presented.

617. Sauer, R. H. Precipitation Harvesting and Restoration on Strip Mine Spoils. Paper in Ecology and Coal Resource Development, Volume 2 (based on the Int. Congr. for Energy and the Ecosystem, Univ. ND, Grand Forks, ND, June 12-16, 1978). Pergamon, 1979, pp. 729-734.

This paper provides an interim report on a water harvesting project that was conducted on the DOE Hanford Site in south-central Washington. The purpose of the project was to evaluate the feasibility of using precipitation collected from the slopes of simulated spoil banks for irrigation. The design of the project uses a portion of the ground surface to raise crops and the remainder to collect precipitation.

Topsoil is placed between the spoil banks to store the runoff and support irrigated crops. Several surface treatments have been applied to the slopes to increase surface stability and runoff. These include paraffin, rubberized asphalt, and rubber sheeting. The paper describes some unique water harvesting treatments to collect precipitation from steep slopes to increase the quality and quantity of biologic production of mined land. The methods described may be applicable throughout the arid and semi arid portions of the Western United States, including portions of the Pacific, Northern Great Plains, and Rocky Mountain Coal Mining Regions recognized in this evaluation process.

618. Sauer, R. H. Reclaiming Mined Lands in Arid Environments. Pac. NW Lab. (Battelle), Richland, WA, PNL-SA-9661, Sept. 1981, 21 pp.

This report provides the rationale for the water harvesting techniques under study by the Pacific Northwest Laboratories. These techniuqes have been implemented at three arid land sites in the Western United States: (1) Hanford Site in south-central Washington, (2) a minesite near Kayenta, AZ, on the Black Mesa, and (3) a minesite at Nucla, CO. The interim results obtained at each site are discussed generally. The author reports that the results obtained thus far indicate that water harvesting reclamation techniques are technically and economically feasible. The information contained in this report may be useful to individuals planning reclamation activities in the arid portions of the Western United States.

619. Sauer, R. H. Restoration of Surface-Mined Lands. Paper in Pacific Northwest Laboratory Annual Report for 1980 to the DOE Assistant Secretary for Environment, Part 2 Ecological Sciences (U.S. DOE contract DE-AC06-76RLO 1830). Pac. NW Lab., Richland, WA, PNL-3700 PT2/UC-11, Feb. 1981, pp. 15-16.

This paper provides a progress report for a revegetation program design to demonstrate the technical and economic feasibility of using water harvesting techniques to provide irrigation water for useful crops on arid surface-mined land. The program is gathering information on optimum crops, slope angles, and slope treatments in an effort to reduce the costs of reclamation, reduce the consumption of soil and water, and establish productive, useful crops where only weed species would otherwise grow. Three demonstration sites have been established: the Hanford Site in Washington, the Black Mesa Mine on the Navajo Indian Reservation in Arizona, and the Nucla Mine in Colorado. The article describes the experimental design employed at each site but relates little or no results. The paper has been included in this bibliography to ensure that this type of research is represented in this review.

620. Sauer, R. H., and W. H. Richard. Restoration of Surface Mined Lands With Rainfall Harvesting (U.S. DOE contract DE-AC06-76RLO 1830, Pacific Northwest Lab.). U.S. DOE, DE 83005890/PNL-4538, Dec. 1982, 41 pp.

This report provides an overview of research conducted by the Pacific Northwest Laboratory from 1976 through 1981 on an alternative method of restoring surface coal mineland in the arid Western United States. The studies examined the technical and economic feasibility of water harvesting, using partially leveled spoil banks at strip mines as catchment areas to collect and direct runoff to the topsoiled valley floor where crops were cultivated. Seven treatments were tested. The studies were conducted in arid areas of Washington, Arizona, and Colorado. Some treatments provided adequate runoff to produce a useful crop. Thus, it was concluded that it was technically feasible to use water harvesting methods to replace or augment expensive and inadequate supplies of well and river water in arid regions. The authors further concluded that water harvesting could be made more effective with further information on catchment area treatments, which crops are most adaptable to water harvesting, the optimun incline of the catchment areas, and the influence of climate. The authors report that water harvesting has the potential for reducing the cost and increasing the effectiveness of mineland reclamation in the arid areas of the Western United States.

621. Sawaryinski, T. J. Steep Slope Mining and the Surface Mining Control and Reclamation Act of 1977. Min. Congr. J., v. 64, No. 9, 1978, pp. 233-242.

This article appraises the impacts of the Surface Mining Control and Reclamation Act of 1977 on steep-slope coal mining operations and reclamation. The author believes that the impact will be great on both productivity and prices and that many of the regulations were developed without consideration for their practicability. A summary is presented on the act's requirements, which will have the greatest impact on steep-slope mining, or slopes greater than 20°. The law is, in his opinion, regulatory overkill that burdens both industry and the consumer. Industry is burdened with regulations which contain "cookbook" approaches for method specifications. The author believes that the statutory and regulatory language that is used in the regulations is unnecessary, overly restrictive, and counterproductive. The specificity of the regulations goes "hand-in-hand" with regulatory overkill. The author concludes that the impacts of the act on steep-slope mining are real and that as the coal industry works towards compliance with the law the actual impacts on the industry and consumer will become apparent.

622. Scanlon III, D. H. Direct Seeding of Pokeberry on Mine Soils. Reclam. Rev., v. 2, 1979, pp. 17-21.

This paper details the results of a greenhouse study evaluating the direct seeding of pokeberry (Phytolacca americana L.) on mine spoils. Pokeberry is a perennial forb native to the Eastern United States that occurs on disturbed ground and is an important food for songbirds and small mammals. The effects of temperature, exposure, moisture, and substrate on seed germination were analyzed in the greenhouse, and patterns of root and shoot growth on direct-seeded pokeberry grown in pots of spoil material were compared with pokeberry grown on a loam topsoil. Results indicate that pokeberry appears promising as a reclamation plant for wildlife, but that moisture may be a problem when direct-seeding it. Mulching or the other techniques that would provide a moist environment for seed germination are recommended.

623. Scanlon, D. H., and J. C. Duggan. Growth and Element Uptake of Woody Plants on Fly Ash. Environ. Sci. Technol., v. 13, No. 3, Mar. 1979, pp. 311-315.

Pulverized coal ash stored at the John Sevier Power Plant, Rogersville, TN, was tested as a substrate for eight woody plant species. Concurrent analyses of the substrates (flyash and a soil control) and plant foliage in the second and third growing seasons were compared for concentrations of As, B, Cd, Cr, Cu, Hg, K, N, Ni, P, Pb, Se, and Zn. B, Ni, and Se appeared more available to plants of all species. Cr and Pb showed no increases in foliar concentration in plants grown on fly ash as compared with soil. Plant survival was species dependent, ranging from 12 to 84 pct with a mean value of 53 pct. No improvement of plant performance resulted from the application of 10 cm of subsoil over the fly ash. Nitrogen-fixing species appeared best adapted for use in fly ash stabilization. This article would be pertinent to investigations of fly ash utilization in reclamation efforts. However, variability in elemental composition may limit the direct application of these results.

624. Schafer, W. M. Guides for Estimating Cover-Soil Quality and Mine Soil Capability for Use in Coal Stripmine Reclamation in the Western United States. Reclam. Rev., v. 2, 1979, pp. 67-74.

This paper discusses the findings of a National Cooperative Soil Survey Committee that assembled, reviewed, evaluated, and summarized available criteria for selecting cover soils throughout the Western States. Cover soils are materials placed on the surface of strip-mine spoils to enhance the establishment of vegetation and can be topsoil, subsoil, or overburden. Guidelines for rating the quality of cover soil and the agricultural capability of minesoils in the Western United States are proposed. Ratings are based on soil properties such as texture, rock-fragment content, water-holding capacity, pH, electrical conductivity, exchangeable sodium, soil depth, slope, permeability, and drainage. It is emphasized that these are guidelines only and must be updated and revised as more information becomes available.

625. Schafer, W. M. Minesoil Restoration and Maturity: A Guide for Managing Minesoil Developement. Paper in the Third Biennial Symposium on Surface Coal Mining and Reclamation on the Great Plains (cochaired by the Reclam. Res. Unit, MT State Univ. and U.S. OSM, Billings, MT, Mar. 19-21, 1983). MT State Univ. and U.S. OSM, 1984, pp. 172-185.

The author outlines the basic concepts of soil development and presents a framework for managing postmine soil development based on these concepts. The author cites previous studies that found that minesoils can develop along different pathways than those followed by natural soils. This results in minesoils that are either more or less productive than the soils that existed prior to mining. The framework proposed for soil management in reclaimed systems has five steps: (1) Set land use goals, (2) inventory soil and overburden materials, (3) create a landscape design plan, (4) create a soil-vegetation plan that complements the landscape design, and (5) apply proper postmining management to achieve previously set goals. The concepts contained in this article should be applicable nationwide.

626. Schafer, W. M. New Soils on Reclaimed Land in the Northern Great Plains. Paper in Symposium on Adequate Reclamation of Mined Land? (Billings, MT, Mar. 26-27, 1980). Soil Conserv. Soc. America and WRCC-21, 1980, pp. 13-1 to 13-10.

The author presents guidelines for selecting cover soil suitable for mined-land reclamation and a procedural framework for managing cover soil in the overall mining operation. Specific methods are not suggested. However, a review of pertinent literature and interim results of current research are used to present basic principles and major factors to be considered in managing cover soil during reclamation of mined lands. The information presented is primarily pertinent to reclamation of surface-coal-mined land in the Northern Great Plains Coal Mining Region.

627. Schafer, W. M. Productivity of Mine Soils and Native Soils in the Northern Great Plains. Paper in 1981 Symposium on Surface Mining Hydrology, Sedimentology, and Reclamation (Lexington, KY, Dec. 7-11, 1982). Univ. KY, Lexington, KY, 1982, pp. 487-492.

This study evaluates the agricultural productivity capacity of five strip-mine areas in the Northern Great Plains before and after mining. Results show that mining improved the agricultural productive capacity of three of the areas. The primary factors involved in the improvement of land capability were increased soil depth and decreased slope.

628. Schafer, W. M. Soils and Spoils. Western Wildlands, v. 7, No. 3, 1981, pp. 28-30.

The author discusses the differences that exist between native and surface mined soils in Montana. Potential uses of the soil before and after mining are compared. For three out of five mines compared, the land capability class improved as a result of mining. Older surface mines showed a decrease in land capability, while newer mines showed improved capability. Several soil factors that are limiting on Montana reclaimed lands are identified. These include compacted layers, disruption of nutrient cycles, sodium migration, and erosion.

629. Schafer, W. M. Variability of Minesoils and Natural Soils in Southeastern Montana. Soil Sci. Soc. Am. J., v. 43, 1979, pp. 1207-1212.

This paper describes a study conducted near Colstrip, MT, to compare the spatial variability of minesoils with the variability of natural, undisturbed soils. The study sites were a 400-ha area mined and reclaimed using several mining techniques and an adjacent 300-ha unmined site. Each site was divided into 500-m cells. The sampling selection resulted in five randomly chosen 10-cm cells spaced 10 cm to 1 m, 1 to 10 m, 10 to 100 m, and 100 to 500 m apart in each 500-m cell. Minesoils were found to be more variable at 0- to 10-m lateral spacing, but natural soils were more variable at greater than 500-m spacing. Only two soil families were found on the mine area, while 14 were found on the natural area. It was concluded that order 1 (less than 1:10,000) or order 2 (1:10,000 to 1:30,000) soil surveys should be used on mined land due to local variability of the minesoils.

630. Schafer, W. M., D. W. Hedberg, D. J. Dollhopf, and J. E. Olson. Water Quality and Soil Water Movement in Western United States Minesoils as Influenced by Surface Manipulation. Reclam. and Reveg. Res., v. 2, No. 1, 1983, pp. 1-12.

This study evaluated the effects of three surface manipulation treatments on soil water movement under sprinkler irrigation, deep percolation, and leachate quality below the soil zone at the Dave Johnston Mine near Glenrock, WY. Though this article does not contain specific information on revegetation, the information that is given on surface manipulation and irrigation warrants review. The three surface manipulations evaluated in this study were chiseling, gouging, and dozer basins. Chiseling is a deep cultivation treatment that serves as a temporary control for erosion and water conservation. It is temporary because the roughened surface is short-lived. Gouging is an effective method for reducing runoff from moderate intensity storms. The basin that is created facilitates collection of plant-available water and provides protection from the wind. This creates a favorable microclimate for seedling establishment. Dozer basins are large depressions which are designed to restrict runoff and promote infiltration. The authors feel that gouging is the most favorable surface treatment for general use in mine reclamation. A description is also given of the sprinkler irrigation system used in this study. The remainder of this study is devoted to describing the water quality of the mine as influenced by the three surface manipulations. Soil samples from the surface treatment plots were taken at 30 cm increments to a depth of 210 cm and analyzed. Irrigation water was added and leachate collected from lysimeters located in each of the surface treatment plots was analyzed and compared to the irrigation water that was applied to the plots. In general, the drainage from the lysimeters had a TDS that was five times higher than that of the irrigation water. This increase was due to increased concentrations of SO_4, Ca, Mg, and HCO_3 ions.

631. Schafer, W. M., and G. A. Nielsen. Soil Development and Plant Succession on 1- to 50-Year-Old Strip Mine Spoils in Southeastern Montana. Paper in Ecology and Coal Resource Development, Volume 2 (based on the Int. Congr. for Energy and the Ecosystem, Univ. N.D., June 12-16, 1978). Pergamon, 1979, pp. 541-549.

Concurrent soil development and successional trends resulting from climate and parent materials typical of the Northern Great Plains were studied using a chronosequence of strip-mine spoils ranging in age from 1 to 50 years located near Colstrip, MT. Chemical, physical, and hydrological properties were compared to the production and composition of existing plant communities at these sites to determine how various soils enhance or limit reclamation potential. It was found that 50-year-old mine spoils can develop vegetation resembling that found on undisturbed sites if soil properties approximate those of native soils. However, only a small amount of the change required to form a native soil had occurred. Restoration of productive plant communities can be more effectively realized through proper reclamation on suitable material than by 50 years of succession on unfavorable soils. Reduced productivity and slow succession may result from excessive litter accumulation. Grazing or fire are suggested for reducing litter. This article is principally relevant to the Northern Great Plains Coal Mining Region. It is a good reference for those interested in studying plant succession and soil development processes on reclaimed surface-coal-mined lands.

632. Schafer, W. M., G. A. Nielsen, D. J. Dollhopf, and K. Temple. Soil Genesis, Hydrological Properties, Root Characterisics, and Microbial Activity of 1- to 50-Year-Old Strip Mine Spoils. U.S. EPA, EPA-600/7-79-100, Apr. 1979, 212 pp.

Soil development in mine spoils ranging from 1 to 50 years in age was evaluated to determine what changes take place in minesoil over time. Of interest were soil water flow patterns, root growth and development, and soil physical, chemical, and microbiological properties of 15 sites on old spoil, new spoil and undisturbed native range (reference area) near Colstrip, MT. New minesoils (less than 10-years-old) were found to support plant communities that were functionally more similar to native plant communties than the older disturbed minesoils. The reclamation techniques that were used on the new minesoils were more effective in reestablishing productive grassland communities than was 50 years of succession on old spoils. The natural processes that were active in the development of native soils were found to occur in the 50-year-old minesoils; however, only a small amount of change had occurred and was confined to the top 5 cm of soil. Fifty years were required for organic matter and structure to reach equilibrium in the deeper soil layers. Up to 500 years may be required to achieve the levels found in natural soils. Topsoil replacement resulted in minesoils that were more similar to natural soils, but since topsoil replacement is man-caused rather than a natural process, those soils will probably always remain different from natural soils. Rapid infiltration rates were common on minesoils; even so, excessive runoff and erosion were common on poorly vegetated areas during intense storms. Because of this, rapid vegetation establishment is critical to protect minesoils during the first years after reclamation. Water use patterns also differed between natural soils, old minesoils, and new minesoils. Plant communities found on natural soils used soil water conservatively. Plant communties on old minesoils depleted nearly all of the available water in the root zone by July. This left little available water during a dry year when compared to natural soils. Three to four years were required before root systems and microbiological activity on minesoils reached levels commonly found in natural soils. The authors recommend several suitable techniques to reconstruct minesoils.

633. Schafer, W. M., G. A. Nielson, and W. D. Nettleton. Minesoil Genesis and Morphology in a Spoil Chronosequence in Montana. Soil Sci. Soc. Am. J., v. 44, 1980, pp. 802-807.

This paper reports the results of a study comparing selected soil chemical and physical parameters between minesoils from 1- to 50-years old and adjacent natural soils. Electrical conductivity, soil structure, and near-surface organic matter content were found to approach natural soil levels in tens of years. Organic matter content at depth will require hundreds of years. Carbonate distribution will require thousands of years. Some properties of minesoils such as texture, C-horizon color, rock fragment content, and depth to bedrock will remain different than in natural soils. The authors feel that, while mine soils may differ from natural soils, they need not be inferior and that opportunities exist in the mining and reclamation process of improving mine soils.

634. Schivley, W. W. Environmental Solutions for Ash Disposal. Presented at Coal Technology '81 (Houston, TX, Nov. 17-19, 1981). Gilbert/Commonwealth, Reading, PA, 1981, 9 pp.

This paper presents two specific examples of ash disposal methods: (1) structure fill and (2) soil amendment and revegetation-reuse. Complete procedural descriptions of two representative examples are presented. The structural fill method involves burying the ash in "earth cells" (trenches), covering the deposited ash with the excavated material, contouring and grading, and revegetation. Specific seeding, fertilizing, and mulching prescriptions used in the example project are clearly described. Studies using ash as a soil amendment are also reviewed. This is a good reference article for revegetation efforts in areas where ash is readily available, and/or its disposal and use are important considerations. The locations of projects described in this article were not given. Consequently, the article was evaluated for nationwide application.

635. Schmieg, T. Strip Mining: Turning a Curse Into a Blessing for Appalachia. Nature Scope, Mar. 1981, pp. 14-25.

This article provides a general overview of surface coal mine reclamation in the Interior and Eastern Coal Mining Regions. The discussion contains nontechnical descriptions of the state of the art for several areas of reclamation and examines some of the impacts the Surface Mining Control and Reclamation Act of 1977 has had on the coal mining industry. The article was reviewed and included in this bibliography for its value in providing good background information to individuals with little or no experience or knowledge of surface coal mine reclamation. Ratings for the keywords used in this evaluation indicate that these topics were considered in the article. However, this information was treated in a general manner. Few or no technical data were related in the article.

636. Schneider, K. R., R. F. Wittwere, and S. B. Carpenter. Trees Respond to Sewage Sludges in Reforestation of Acid Spoil. Paper in 1981 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Dec. 7-11, 1981). Univ. KY, Lexington, KY, 1981, pp. 291-296.

The objectives of this study were to test sludge metal levels, fertilizer values, and application rates on the early growth of five tree species. European black alder (Alnus glutinosa (L.) Gaertn.), black locust (Robinia pseudoacacia L.), cottonwood (Populus deltoides Bartr. ex Marsh.), and loblolly pine (Pinus taeda L.) were established as 1-0 seedlings in the spring, while northern red oak (Quercus rubra L.) was direct-seeded in the spring. Four sludge treatments (high and low metals with either 100 kg/ha or 200 kg/ha of soluble N present) were compared with two fertilizer treatments (100 kg/ha N or 700 kg/ha N in a slow release fertilizer). Survival of the tree species was highest in the plots with the high metal sludge additions when compared to the fertilizer treatments. Growth and vigor increases were also found for the high metal treatments, except for Pinus taeda and Populus deltoides, where the growth responses were not very dramatic. Leaf samples analyzed for heavy metal and nutrient concentrations showed significantly greater foliar N levels with fertilizer than with sludge, except for black locust. Visual metal toxicity symptoms were not observed during the first growing season. However, cadmium levels were within the phytotoxicity range for Populus deltoides and very high for Pinus taeda. Both species may be showing toxicity responses along with a growth stimulation from other metals and nutrients in the sludge. The authors conclude that growth and survival increases due to sludge applications were unexpected and may have been related to improvements in the soil condition.

637. Schoenholtz, S. H., and J. A. Burger. First Year Survival and Growth of Containerized Pine (Pinus spp.) Seedlings on Strip Mined Lands as Affected by Cultural Treatments and Edaphic Factors. Paper in Proceedings of the Second Biennial Southern Silvicultural Research Conference (Atlanta, GA, Nov. 4-5, 1982). U.S. For. Ser. GTR SE-24, 1983, pp. 134-140.

This study evaluated the effects of ectomycorrhizal inoculation, chemical weed control, and slow-release fertilization on the first-year survival and growth of container-grown white pine (Pinus strobus L.), Virginia pine (Pinus virginiana Mill.), and loblolly pine (Pinus taeda L.) planted on two strip-mined sites in Wise County, VA. The two sites consisted of a flat bench site and a return-to-contour site. None of the cultural treatments used in this study had a significant effect on the survival of the planted pine species. However, mycorrhizal inoculation (Pt. mycelia), fertilization (21 g slow-release tablet), and weed control (glyphosate) improved the growth of all three species. When fertilizer and weed control were combined, the most substantial growth response occurred. All of the treatments resulted in foliar nutrient concentrations that were above deficiency levels. This indicates that P, K, Ca, and Mg, were not limiting seedling growth; however, the stimulatory effect of fertilization suggests that N may have been limiting. The authors conclude that cultural treatments can be used to improve the growth of pine species on strip mined lands.

638. Scholl, D. G., and S. Miyamoto. Response of Alkali Sacaton and Fourwing Saltbush to Various Amendments on Coal Mine Spoils From Northwestern New Mexico. I. Acid Spoil. Reclam. and Reveg. Res., v. 2, No. 3, 1983, pp. 227-236.

Two greenhouse experiments were conducted to test chemical and physical amendments for use in revegetation of acid spoils. The spoil materials used in these experiments were collected from the Fruitland formation of northwestern New Mexico. The response of alkali sacaton (Sporobolus airoides (Torr.) Torr.) and fourwing saltbush (Atriplex canescens (Pursh) Nutt.) to the applied amendments was monitored. The chemical amendments used consisted of applications of phosphorus (CaH_2PO_4), lime ($CaCO_3$), and a wetting agent ("Soil Pen", linear sulfonate, anionic compound). The physical amendments and P application are essential, along with water and possibly nitrogen, for growing alkali sacaton and fourwing saltbush on acid spoil. The following amendments showed promise for improving the growth of alkali sacaton and fourwing saltbush: (1) sand or ash mulch spread over the P- and lime-treated spoil, (2) shale or sand incorporation in the P- and lime-treated spoil, and (3) sand topdressing over P-amended spoil. Wetting agents may be necessary for (1) and (3) if the spoils are strongly water repellent. Field tests are needed in order to make specific management recommendations.

639. Schrand, W. D., and H. Holt. Herbicides and Plantation Establishment on Reclaimed Mined Lands. Paper in Third Annual Conference on Better Reclamation With Trees (cosponsored by AMAX Coal Co., Purdue Univ., South. IL Univ., and Madisonville Comm. Coll., Terre Haute, IN, June 2-3, 1983). Purdue Univ., West Lafayette, IN, 1983, pp. 146-147.

The authors provide an excellent and practicial discussion of the use of herbicides to control weeds and to establish woody species in herbaceous ground cover. The discussion includes helpful information for several herbicides. Application methods, timing of application, relative costs, and associated problems are stressed. Much of the information is based on experience obtained by the AMAX Coal Co. in their reclamation work. This paper is a good reference for herbicide use in mineland reclamation. It provides useful information for planning reclamation activities. No specific coal region is indetified by the authors. Based on plant species mentioned, the article has been considered pertinent to the Interior Coal Mining Region recognized in this evaluation process. With prudent consideration the information may be applicable to a broader geographical area.

640. Schroeder, S. A., M. W. Pole, and A. Bauer. Water Use Efficiency as Influenced by Topsoil Thickness and Fertility on Reclaimed Land. ND Farm Res., v. 37, No. 6, May 1980, pp. 24-26.

This article reports the results of a study conducted near Beulah, ND, that examined changes in water use efficiency (WUE) in response to increasing thickness of topsoil or first-lift material. WUE in corn (Zea mays L.) silage production increased with increased topsoil thickness in 2 out of 5 years. Similarly, WUE in wheat (Triticum aestivum L.) production increased in 3 out of 5 years. Application of nitrogen fertilizer increased WUE for corn silage production. The results and discussion contained in this report are pertinent to reclamation planning where the postmining land use is agricultural cropland.

641. Schuman, G. E., and J. F. Power. Plant Growth as Affected by Topsoil Depth and Quality on Mined Lands. Paper in Symposium on Adequate Reclamation of Mined Land? (Billings, MT, Mar. 26-27, 1980). Soil Conserv. Soc. America. and WRCC-21, 1980, pp. 6-1 to 6-9.

The authors discuss the benefits of topsoiling and review pertinent research results from Wyoming and North Dakota. Adequate depth of topsoil applications is very site specific, and such recommendations must be based on the availability of material and the quality of the subsoil and overburden. In some cases good-quality subsoil or overburden can be used to supplement limited topsoil resources. The major focus of the paper is the effect of topsoil depth on the water relations and plant productivity of the reclaimed minesoil. The information presented is primarily applicable in the Northern Great Plains Coal Mining Region.

642. Schuman, G. E., E. M. Taylor, Jr., F. Rauzi, and G. S. Howard. Standing Stubble Versus Crimped Straw Mulch for Establishing Grass on Mined Lands. J. Soil Water Conserv., v. 35, No. 1, 1980, pp. 25-27.

This study was done to determine the feasibility and effectiveness of planting a spring small grain to help stabilize the soil and act as a mulch for establishing a permanent grass cover by fall seeding. This study was conducted on a topsoiled, regraded spoil dump at the Pathfinder Mines Corp. Shirley Basin uranium mine near Shirley Basin, WY. Twenty plots, each 5 by 45.7 m, were established and fertilized. Ten plots were seeded in the spring to 'Otis' barley (Hordeum vulgare L.), while the other 10 plots were left fallow over the summer. The following fall, the barley stubble plots and fallow plots were seeded with a mixture of perennial grasses. Barley straw was scattered on the seeded fallow plots at a rate of 5 t/ha and then crimped. Of the straw mulch applied in the fall, only 47 pct remained the following spring, while 94 pct of the stubble residue remained after the same period. Plant establishment along a 3.05-m transect was 54 plants and 48.6 plants for the stubble and crimped residue treatments, respectively. Stubble residue plots also showed less temperature fluctuation in the upper portions of the soil, had more soil moisture, and produced 25 pct greater cumulative water infiltration than did crimped straw. Stubble residue costs were also 75 to 95 pct lower when compared with the costs for crimped straw or hay. The authors concluded that stubble mulch was statistically as good or better than straw mulch for the establishment of perennial grasses.

643. Schuster, W. S., and R. J. Hutnik. Strip-Mine Test Plantings in Pennsylvania After 35 Years. Paper in Third Annual Conference on Better Reclamation With Trees (cosponsored by AMAX Coal Co., Purdue Univ., South. IL Univ., and Madisonville Comm. Coll., Terre Haute, IN, June 2-3, 1983). Purdue Univ., West Lafayette, IN, 1983, pp. 119-128.

A reexamination of tree species trials made on bituminous spoil banks in Pennsylvania is reported. These spoil banks are primarily composed of shales and sandstones with pH varying between 4.0 and 6.7. Some piles had been partially or completely regraded, while others had been left as steep-sided piles. These piles are small compared to modern spoil banks. Mining had occurred between 1943 and 1948. After 35 years, 10 of the 22 original plantings remained intact and essentially undisturbed. Spoils were sampled at these 10 sites. Survival and basal area were determined for the 16 species planted. Wood production was calculated for the better stands. Of the 10 conifers tested, red pine (Pinus resinosa Ait.) was most successful, whereas Scotch pine (Pinus sylvestris L.) had significantly deteriorated. Wood production of the better stands compared favorably with that of natural stands. Tree survival was correlated with spoil acidity and degree of slope. Active soil formation processes were indicated by small changes in particle size distributions and potassium enrichment in surface spoil layers. While the most acidic spoils and the steepest slopes remained barren after 35 years, most of the banks have been successfully revegetated through the combination of tree planting and natural invasion. This report provides long-term data that are somewhat unique for reclamation literature. For that reason it has excellent potential application to reclamation planning. While the study is specific for Pennsylvania, application to a broader geographical area would be possible, particularly for spoil materials with similar characteristics.

644. Scott, M. D. Computerized Evaluation of the Wildlife Habitat Option as a Post-Mining Land Use. Paper in The Mitigation Symposium: A National Workshop on Mitigating Losses of Fish and Wildlife Habitats. (CO State Univ., Fort Collins, CO, July 16-20, 1979). U.S. For. Ser. Rocky Mountain For. and Range Exp. Sta., GTR RM-65, 1979, pp. 622-623.

This article briefly describes a computerized land reclamation planning system, called CLAIM. The basic ouput of CLAIM is a ranking of the relative feasibility of reclaiming a parcel of land to each of five land uses: cropland, rangeland, wildlife management, recreation, and high human occupancy. The system also lists techniques and costs for reclaiming the land to each of the five land uses. The general trend, based on data sets from several mining areas in the Northern Great Plains, is that the wildlife management land use option is often the cheapest. The computer system described is designed for use in the Northern Great Plains Coal Mining Region.

645. Scott, M. D. Computerized Reclamation Planning System for Northern Great Plains Surface Coal Mines. Paper in Ecology and Coal Resource Development, Volume 1 (based on the Int. Congr. for Energy and the Ecosystem, Univ. ND, Grand Forks, ND, June 12-16, 1978). Pergamon, 1979, pp. 412-420.

The paper provides a concise description of a computer-based reclamation planning system developed at Montana State University. The system, called CLAIM, summarizes relevant reclamation data and permits the reclamation manager to quickly analyze the available options before developing the final reclamation plan. The program acts on the following general classes of data input: average slope, stage in mining sequence, dragline mine description, shovel and truck mine description, climatic parameters, topsoil parameters, subsoil parameters, overburden characteristics, surface water hydrology, ground water hydrology, vegetation community types, wildlife types, and socioeconomic parameters. The program ranks the critical environmental parameters by assigning feasibility rating units to them. The program then permits comparisons of reclamation costs based on the choice of postmining land use. While this paper is a status report of an ongoing program, it may be of interest to individuals working in reclamation planning in the Northern Great Plains Coal Mining Region. The ratings for keywords used in this evaluation process represent the apparent treatment of these subject areas in the process of developing the model and the conceptual basis for the model.

646. Scott, M. D. Northern Great Plains Reclamation Cost Projections By Computer. Paper in Conference on the Economics of Mined Land Reclamation (cosponsored by the Land Reclam. Program, Argonne Natl. Lab., and U.S. Dep. of Energy, Chicago, IL, Sept. 1-2, 1981). Argonne Natl. Lab., ANL/LRP-TM-20, Sept. 1981, pp. 191-202.

This paper contains a description of a computer program called CLAIM that was designed to act as a reclamation planning tool. The program will predict the costs of reclaiming coal surface mined land in the Northern Great Plains to any of five major land uses. The 10 most commonly used reclamation techniques are ranked according to general cost from highest to lowest: (1) toxic spoil rehandling, (2) topsoil stripping and replacement, (3) subsoil stripping and replacement, (4) spoil grading and contouring, (5) reclamation program administration, (6) ripping of compacted soils, (7) hand planting of shrubs and trees, (8) mulching, (9) fencing, and (10) purchasing seed. The relative costs of reclaiming mine sites to the five major uses recognized in the computer model are, in decreasing order: (1) high human use such as homes or industry, (2) cropland, (3) water-based recreation, (4) native revegetation (rangeland), and (5) wildlife management. The computer program described will allow the mine planner to evaluate different land-use options and reclamation techniques in advance of the actual operation. The program described in this article was specifically designed for the Northern Great Plain Coal Mining Region; however, the techniques and analyses used may find application in other areas as well. Since this report deals with a computer model and not an actual field study, the ratings for the keywords used in the evaluation process represent the apparent treatment of these subject areas by the computer model.

647. Seaker, E. M., and W. E. Sopper. Production and Quality of Forage Vegetation Grown on Municipal Sludge-Amended Mine Spoil. Paper in 1982 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Dec. 5-10, 1982). Univ. KY, Lexington, KY, 1982, pp. 715-720.

The authors present the 5-year results of eight demonstration sites that were amended with various types of municipal sludges and at various rates in the anthracite and bituminous coal regions of Pennsylvania. Each site was treated with a single application of sludge at rates ranging from 11 to 202 dry t/ha. Following sludge application, the sites were broadcast-seeded with 'Pennlate' orchardgrass (*Dactylis glomerata* L.), 'Ky-31' tall fescue (*Festuca arundinacea*, Schreb.) and 'Empire' birdsfoot trefoil (*Lotus corniculatus* L). Vegetation was sampled over a 2- to 5-year period for elemental analyses of plant nutrients and trace metals. Yields were determined from 100.09 m^2 samples collected along transects at each site. Over the 5-year period N, P, K, and Cu concentrations remained constant; there were slight decreases in Ca, Mg, and Cd concentrations, and substantial decreases in Mn, Fe, Al, Zn, Cr, Co, Pb, and Ni concentrations. By the fifth year all metals except Cd were within average ranges for agronomic crops. Cadmium was well below the tolerance level. Dry matter production was higher on the sludge-amended strip-mine sites than on undisturbed farmland (reference area) in the same area. The authors conclude that by using good-quality sludges, low in trace metals and having sufficient plant nutrients, strip-mined land can be successfully reclaimed with forage species of such quality that any potential risks to plant or animal health are minimal.

648. Severson, R. C. Evaluating Chemical Character of Soil Material for Suitability in Rehabilitating Mined Land in the San Juan Basin, New Mexico. Soil Sci. Soc. Am. J., v. 45, 1981, pp. 296-404.

The author offers an excellent method of characterizing mine land (before and after mining) in the San Juan Basin of New Mexico, to determine which horizons would be best used as media for revegetation. He points out the importance of the form of elements contained in the soils. Although different soils may contain similar amounts of the same elements, if they are in different forms and/or associated with different constituents their effects on subsequent revegetation will vary.

649. Severson, R. C. Soil and Overburden Sampling Needs and Programs. Paper in the Third Biennial Symposium on Surface Coal Mining and Reclamation on the Great Plains (cochaired by the Reclam. Res. Unit, MT State Univ., and U.S. OSM, Billings, MT, Mar. 19-21, 1984). MT State Univ. and U.S. OSM, 1984, pp. 211-222.

The author outlines a sequence of steps that are necessary to develop a soil and overburden sampling program to characterize a mine site before development. The suggested sequence in this program is (1) problem statement, (2) sample design, (3) sample collection, (4) sample preparation, (5) laboratory analysis, and (6) data interpretation. The importance of each step is discussed, and some important considerations for each are pointed out. While specific reference to the Western United States is made in the article, the concepts conveyed are relevant to the design of soil and overburden sampling programs nationwide.

650. Severson, R. C., and L. P. Gough. Boron in Mine Soils and Rehabilitation. Plant Species at Selected Surface Coal Mines in Western United States. J. Environ. Qual., v. 12, No. 1, 1983, pp. 142-146.

This study assessed boron availability in mine soil and boron uptake by plant species used in strip-mine rehabilitation at 11 mine sites in North Dakota, Montana, Wyoming, and Colorado. The plant species tested were initially planted in a seeding mixture which consisted of a wheatgrass and a legume. The following species were used in the mixtures: crested wheatgrass (Agropyron cristatum (L.) Gaertn.), intermediate wheatgrass (Agropyron intermedium (Host) Beauv.), or slender wheatgrass (Agropyron trachycaulum (Link) Malte) along with either alfalfa (Medicago sativa L.) or fourwing saltbush (Atriplex canescens (Pursh) Nutt.). The following evaluations were made at each site: (1) differences in boron concentration among similar rehabilitation plant species, cover soil, and spoil among mines, (2) differences among samples of mine soil and a single plant species within a mine, and (3) the potential boron phytotoxicity and deficiency conditions. Results indicate that except for one site, boron levels in both the mine soils and plants are not deficient or toxic over the region. The authors feel that soil electrical conductivity measurements should be the first step to determine if boron is deficient or toxic. If problem areas are indicated, the hot-water-soluble-boron analysis could confirm or reject the initial results. Using the boron results, along with electrical conductivity and pH, predictions can be made for boron accumulation in plants.

651. Severson, R. C., and L. P. Gough. Rehabilitation Materials From Surface Coal Mines in Western U.S.A. 1. Chemical Characteristics of Spoil and Replaced Cover-Spoil. Reclam. Reveg. Res., v. 2, No. 2, 1983, pp. 83-102.

This study evaluated the soil chemical characteristics of replaced cover soil and spoils of 11 mines located in the Fort Union (Montana and North Dakota), Powder River (Wyoming), and Green River (Wyoming and Colorado) coal basins. Three mines per State (two in Colorado) were selected based on the following criteria: (1) The area had been rehabilitated in the past 3 to 5 years, (2) cover soil had been used in the rehabilitation process, and (3) a wheatgrass-legume had been used in the seeding mixture. The specific objectives of the study were to (1) document the expected ranges in the soil chemical characteristics found at the mines, (2) assess the variability in the soil chemical characteristics among the mines and among the samples collected at a single mine, and (3) compare the soil chemical characteristics of mine land with those of natural soils of the areas studied (reference area). DTPA-extractable Cd, Co, Cu, Fe, Pb, Mn, Ni, and Zn, organic matter, and pH were the soil parameters measured at the 11 sites. A large amount of variability was found for measurements taken among mines and among the samples taken at a single mine. For example, pH ranged from 3.9 to 8.9. These results suggest the limited value that a simple average concentration would have for characterizing all mines or samples collected at a single mine. The authors suggest that an expected range in concentration is a better method for estimating the chemical characteristics of cover soil or spoil. The elemental concentrations of the metals analyzed for in the spoil and cover soil did not deviate much from the concentrations found in the natural A and C horizons of the area. However, minesoils (youthful) and natural soils represent different stages of soil development and the authors feel that the comparison between the two may be inappropriate. Rapid changes in the chemical equilibrium of mine soils are expected.

652. Shaw, N. Propagating and Outplanting Shrubs on Mine Sites. Paper in Shrub Establishment on Disturbed Arid and Semi-Arid Land (Proc. Symp., Laramie, WY, Dec. 2-3, 1980). WY Game and Fish Dep., 1981, pp. 47-56.

This article focuses on the use of bare-root stock in revegetating disturbed land. Seed collection procedures, nursery propagation of bare-root stock, and outplanting considerations are discussed. Important propagation characteristics of selected shrubs used in revegetation programs in the Rocky Mountain and Northern Great Plains Coal Mining Regions are included. This article contains information valuable to planning revegetation activities where shrub species will be used.

653. Sheets, P. J., V. V. Volk, and E. H. Gardner. Plants and Soil Reactions to Nickel Ore Processed Tailings. J. Environ. Qual., v. 11, No. 3, 1982, pp. 446-451.

This article deals with greenhouse and laboratory experiments conducted to determine the effect of nickeliferous laterite ore tailings on plant growth and soil properties. Chemical analysis of the tailings revealed high soluble salts, low concentrations of P and Ca, and high conductivity. Soil was amended with the tailings and tall fescue (Festuca arundinacea Schreb.) was planted in greenhouse experiments. Plant establishment was slow on soils with a high tailings amendment and on pure tailings; however, once established, growth was fairly good and matter yields were comparable to those of soils treated with lower tailings rates. The serpentine tailings used in the experiment was from the Riddle, OR area, where Ni and Co are recovered. Although the information is not directly related to coal mining, the methods used in the testwork could be applied universally.

654. Sherman, R. M., J. A. Kinkead, G. J. Campbell, and G. M. Alder. Irrigation for Reclamation of Strip Mined Lands (contract J0199088, Sherman and Sullivan, San Jose, CA). BuMines OFR 12-82, 1980, 127 pp; NTIS PB 82-163395.

This report documents the results of a study that (1) investigated the environmental characteristics of coal mines in the arid and semiarid regions of the Western United States, (2) evaluated potential irrigation systems for use at these mines, and (3) identified those irrigation systems that are economically and technically feasible. The authors recommend that the use of irrigation be temporary and limited to the germination and establishment of vegetative growth. A solid-set sprinkler irrigation system combined the most favorable characteristics by allowing efficient and frequent application of small quantities of water in the reclamation process. It is portable and adaptable to a range of field characteristics. The results and discussion contained in this report are applicable in portions of the Rocky Mountain and Northern Great Plains Coal Mining Regions.

655. Sindelar, B. W. Achieving Revegetation Standards on Surface Mined Lands. Paper in Symposium on Adequate Reclamation of Mined Lands? (Billings, MT, Mar. 26-27, 1980). Soil Conser. Soc. America and WRCC-21, 1980, pp. 22-1 to 22-15.

Preliminary analyses based on revegetation studies conducted at Colstrip, MT, are presented. The author identifies some of the problem areas encountered in achieving revegetation standards. Erosion control, comparable production, and native species dominance were not found to be problems. The most serious problem areas were found in achieving comparable life form composition and seasonality. Excessive litter buildup and lack of adequate nutrient recycling are identified as major factors limiting revegetation success at the sites studied. This article is particularly applicable to revegetation in the Northern Great Plains Coal Mining region. However, the revegetation analysis used and the discussion of revegetation problem areas are potentially applicable in other areas.

656. Sindelar, B. W. Establishment, Succession, and Stability of Vegetation on Surface Mined Lands in Eastern Montana. Three Year Project Summary (U.S. DOE contract EY-76-S-222 8 No. 3). U.S. DOE, TID-28791, July 1978, 14 pp.

This publication is an interim report summarizing the activities, progress, major findings, and preliminary conclusions resulting from an ongoing long-term study of revegetation success near Colstrip, MT. Other interim reports, together with the final report, are included in this bibliography. The study examined plant succession on revegetated plots ranging in age from 0 to 50 years. Preliminary conclusions contained in this report are based on two years of field data collection. Species seeded, weather conditions seeded mined land. This report contains information pertinent to revegetation planning in the Northern Great Plains Coal Mining Region. However, it contains few or no hard data. Susequent reports on this study are more useful as references.

657. Sindelar, B. W. Native or Introduced Species in Mined Land Reclamation? Paper presented at the 1982 Society for Range Management Annual Meeting, Calgary, Alberta, Canada, Feb. 10, 1982, 4 pp.

The author discusses several aspects of a controversy that involves the use of native and introduced species in mined-land reclamation. His discussion is based on reclamation research conducted on semiarid mined land in Montana. The beneficial aspects or the problems encountered when using either type of species are the main emphasis of this paper. The author feels that both native and introduced plant species are valuable in revegetation and have been used in range and other cultural practices. The artificial distinction between native and introduced species should be disregarded in mined-land reclamation. In his conclusion the author states that the continental origin of a plant species is not as important as its suitability for the purpose at hand.

658. Sindelar, B. W. Rate of Plant Succession on Mined Land in Montana. Presented at the 1981 Society for Range Management Annual Meeting, Tulsa, OK, Feb. 10, 1981; U.S. DOE Rep, DOE/EV/70003-14, 1981, 10 pp.

The major objective of the study reported was to examine the kind and rate of plant succession that has occurred on revegetated mineland. The report is based on vegetative data collected for 5 consecutive years on revegetated sites ranging in age from 0 to 5 years located at or near Western Energy Co.'s Rosebud Mine at Colstrip, MT. Vegetation data collected during the study included plant density, foliar cover, phytomass yield, frequency, species diversity, floristic richness, constancy, reproduction and mortality. The trend of succession was found to be toward plant communities similar to those of adjacent native ranges. The rate of succession was less than that required to achieve the species diversity and plant community stability presently required within a 10-year bonding period. The author feels that more recent seedings could have a greater potential for success because aggressive introduced species were largely excluded from the seeding mixtures. The results and discussions contained in this report are highly pertinent to revegetation planning and the design of revegetation monitoring plans in the Northern Great Plains Coal Mining Region.

659. Sindelar, B. W. Successful Development of Vegetation on Surface Mined Land in Montana. Paper in Ecology and Coal Resource Development, Volume 2 (Based on the Int. Congr. for Energy and the Ecosystem, Univ. ND, Grand Forks, ND, June 12-16, 1978). Pergamon, 1979, pp. 550-556.

The purpose of this paper was to report successional development and plant community characteristics observed during the first year of a long study on sites ranging in age from 1 to 50 years located near Colstrip, MT. The study monitors plant cover, yield density, frequency, species composition, soil moisture content, soil temperature, and weather conditions at biweekly intervals throughout the growing season from 14 exclosures. Comparisons are made on individual sites over time as well as simultaneously among sites. Preliminary analyses indicated that some early successional stages associated with soil formation might be bypassed in reclamation by topsoiling, fertilization, mulching, and seeding mixtures of plant species. Species seeded, initial seeding success, cultural practices, and weather strongly influence plant succession. This article is an excellent reference for those interested in studying plant succession on reclaimed surface mined lands in the Northern Great Plains Coal Mining Region.

660. Sindelar, B. W., and P. L. Plantenburg. Establishment, Succession, and Stabilty of Vegetation on Surface Mined Lands in Eastern Montana (U.S. DOE contract EY-76-5-06-2228 No. 3, MT State Univ.). Annu. Prog. Rep., July 1979, 55 pp.

This is an annual progress report for a study initiated in 1975. The study was conducted on strip mined land in Colstrip, MT, to examine the development, stability and performance of plant communities established on semiarid mined land. Areas studied included native range, 48- to 50-year-old naturally revegetated coal spoil, and 2- to 9-year-old seeded spoil. Density, frequency, cover, biomass, and species compositon data were taken on each plot. Results showed that the 50-year-old naturally revegetated areas were either highly advanced or locked into lower series, depending on spoil texture and management practices. Success of the younger seeded communities were influenced by using introduced species, cover crops, and fertilization, as well as by weather. Problems with declining yield, limited success of native species, limited species diversity, and soil functioning are discussed, along with suggestions for improving reclamation in semiarid areas of the Western United States.

661. Sindelar, B. W., and P. L. Plantenberg. Establishment, Succession, and Stability of Vegetation on Surface-Mined Lands in Eastern Montana (U.S. DOE contract DE-AT06-76 EV70003). Final Rep. DOE/EV/70003/17, 1982, 33 pp.

This study examined and documented the development, stability, and permanence of plant communities established on 15 different semiarid sites near Colstrip, MT. Thirteen sites were located on mine spoil, one on unmined native range (reference area), and one on a pipeline construction site. Reclamation sites were seeded between 1969-77, and naturally revegetated sites were abandoned in 1928 and 1930. The specific objectives of the study were (1) plant establishment and succession on mined land, (2) stability and permanence of artificial and natural communities on mined land, and (3) the kind and rate of concurrent soil and vegetation establishment on mined land. The authors found that the migration of native plants from surrounding plant communities was common. The most common migrants were the forbs, which enhanced species diversity. Migration of native grasses was slow. The migration or invasion by volunteer species onto spoil material was dependent upon the density of the seeded cover crops. The less dense the cover crop was, the greater was the variety of grasses and forbs which invaded an area. The natural revegetation of spoil material indicates that the potential for reclamation success at Colstrip is very good. The results of this study are intended to enable reclamation workers to develop a better understanding of the revegetation process on mined lands and the primary and secondary succession that occurs.

662. Singleton, P. C., and D. A. Barker. Soil Development and Nitrates in Minesoil. Paper in Symposium on Adequate Reclamation of Mined Land? (Billings, MT, Mar. 26-27, 1980). Soil Conserv. Soc. America and WRCC-21, 1980, pp. 14-1 to 14-14.

Chemical and physical properties of 16- and 40-year-old mine spoils from the Hanna Basin in south-central Wyoming were analyzed to determine the extent of pedogenesis over that period of time. Potassium enrichment in the upper 2 inches in both the 16- and 40-year-old minesoils, together with some downward movement of soluble salts, indicated incipient pedogenesis had occurred. Minesoils used in the study exhibited nitrate levels higher than those found in surrounding undisturbed soils. However, these amounts were within the range normally expected in available soils. Nitrate levels in the minesoils appeared to decrease with age.

663. Skelly and Loy. A Compliance Manual: Methods for Meeting OSM Requirements. McGraw-Hill, 1979, 705 pp.

This manual is designed to arm the mine planner and operator with some concepts, design procedures, and operating techniques to help them meet the requirements of the 1977 Surface Mining Control and Reclamation Act. It includes interpretive summaries of most of the Federal permit requirements and performance standards. It reviews revegetation regulations in detail. Information is included on soil testing and sampling, fertilization, liming and mulching requirements. There is an extensive discussion of species selection, including a list of Soil Conservation Service Plant Materials Centers. Tables of herbaceous and woody species recommended in the temperate East and Midwest as well as in arid and semiarid climates are given. Methods of planting and stand management are outlined. Various methods of measuring productivity, ground cover, and the use of reference areas are given. This is an excellent review of revegetation regulations and methods of meeting them.

664. Skogerboe, J. G., C. R. Lee, and R. B. Sneel. Quantification of Erosion Control and Runoff Water Quality from Pyritic Soil Restoration Demonstration Plots. Paper in 1983 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Nov. 27-Dec.2, 1983). Univ. KY, Lexington, KY, 1983, pp. 149-154.

Field rainfall simulations were conducted at the Tennessee-Tombigbee Waterway, Divide Section, to verify laboratory lysimeter data and to evaluate the effects of different soil amendments on runoff water quality from pyrite soil restoration plots. The soil amendments used were (1) lime, (2) lime and rock phosphate (3) lime and chicken manure, and (4) lime, rock phosphate, and chicken manure. Plants species used were Ky-31 tall fescue (<u>Festuca arundinacea</u> Schreb.), sericea lespedeza (<u>Lespedeza cuneata</u> (Dum.) G. Don), weeping lovegrass (<u>Eragrostis curvula</u> (Schrad.) Nees), and pensacola bahiagrass (<u>Paspalum notatum</u> Flugge). Significant differences in biomass, runoff water quality, and erosion control were found for different combinations of soil amendments and plant species. The effects of different biomasses and plant species were determined using the laboratory rainfall simulation-lysimeter system. In this system the best erosion control was obtained from the Ky-31 tall fescue. The field simulation not only verified the lysimeter system, but measured the effects of different soil amendments on runoff water quality. Different soil amendments produced wide ranges in biomass, but the use of organic matter as a soil amendment significantly increased vegetation biomass and erosion control. A decrease in soil loss by 50 pct was observed when chicken manure was used. However, the nutrient concentrations and loads observed in the runoff water from chicken manure amended plots were also higher during the first year following application. Yearly monitoring is needed in order to determine if these trends will continue.

665. Slauson, W. L., and R. T. Ward. Ecotypic Variation in Winterfat (Ceratoides Lanata) in Relation to Reclamation in Oil Shale Lands. Reclam. Reveg. Res., v. 1, No. 4, 1982, pp. 249-257.

Ecotypic variation among populations of winterfat (Ceratoides lanata)(L.) C.A. Mey.) was studied in a common garden established in the Piceance Basin oil shale region of northwestern Colorado. This study was an attempt to match the different ecotypes of winterfat with sites that need to be reclaimed. Attributes that differ genetically among populations of a species may be related to the success of a species on specific sites. These attributes include phenology; life form; height, leaf, and reproductive growth; drought adaptations; and juvenile success. Seven populations of winterfat, six from various environments in the Piceance Basin and one from south-central Colorado, were transplanted into an enclosed 0.25-ha common garden. Five other species of shrubs, two grasses, and one forb were also studied. Only the data for winterfat are presented in detail. The winterfat population from south-central Colorado exhibited very slow phenological progression and would not produce seeds in the oil shale region. A high-elevation population within the Piceance Basin was able to set seed in the garden but is questionable for reclamation purposes because of its small vegetative growth. It is less competitive than the other five populations from the region. The five populations were similar and had a favorable balance between phenological progression and plant size. The results indicate that those five populations of winterfat could be used interchangeably for reclamation at midelevation sites in the Piceance Basin oil shale region.

666. Slick, B. M. Revegetation for Aesthetics. Paper in Trees for Reclamation (Lexington, KY, Oct. 27-29, 1980). U.S. For. Ser., Gen. Tech. Rep. NE-61, 1980, pp. 75-84.

The author discusses the aesthetic visual aspects of the landscape in the analysis, planning, and design of revegetation strategies for surface-mined lands. The evaluation of the visual resources involves inventory, analysis, and determination of objectives and incorporates them into a resource planning process. Existing visual elements (form, line, color, and texture) of the vegetation and land form provide the basis for designing the visual aspects of reclamation. To assure a high-quality landscape, the selection, function, arrangement, and spacing should be considered. By applying architectural design techniques in the revegetation of surface-mined lands, the visual character of the mined landscape will be enhanced.

667. Smith, D. F. Options for Evaluation of Prime Farmland Reclamation Success (Soil Survey Versus Crop Production as a Measure of Soil Productivity). Paper in 1983 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Nov. 27-Dec. 2, 1983). Univ. KY, Lexington, KY, 1983, pp. 489-494.

The author discusses the need for an alternative method of estimating soil productivity based on postmining soil parameters. The paper is divided into sections which deal with the problems of evaluating soil productivity within Public Law 95-87 and the technical difficulties in regulation (soil handling methods, crop management systems, disease or pest circumstances, and weather variability). Two soil productivity measurement options are presented along with the procedures needed to prove that soil productivity has been achieved. The author concludes that in dynamic agricultural systems, stringent controls cannot be regulated intelligibly. What is needed are estimates of soil productivity based on the knowledge of soil properties; accepted management practices are all that is needed where acceptable ranges in soil properties are delineated.

668. Smith, R. K. The Effects of Mulches and Fertilizer on Vegetation Establishment in Southwestern Wyoming. Paper in Shrub Establishment on Disturbed Arid and

Semi-Arid Land (Proc. Symp., Laramie, WY, Dec. 2-3, 1980). WY Game and Fish Dep., 1981, pp. 123-137.

The study evaluated the effectiveness of seven combinations of mulch and fertilizer treatments in aiding seedling establishment and biomass production. Native grass hay mulch in a 2 t/acre application was superior to fabric mulch and nonmulch treatments for seedling establishment of grasses and some species of Atriplex but was detrimental to shrub biomass production. Fertilization increased the establishment of grass and weedy species but not the establishment of seeded shrubs. However, individual weights of all species planted were increased with fertilizer applications. Fabric mulch reduced the establishment of winterfat (Ceratoides lanata (L.) C.A. Mey.), did not affect the establishment of grasses and Atriplex, and improved the establishment of weed species.

669. Smith, R. M. Update on Overburden Characteristics. Paper in 1977 Coal Convention Session Papers Set No. 3 (Am. Min. Congr. Coal Conv., Pittsburgh, PA, May 1-4, 1977). Am. Min. Congr., Washington, DC, 1977, 17 pp.

Methods of sampling and physically and chemically characterizing coal mine overburden are outlined in this article. The author briefly describes sampling approaches for soil (top 5 ft) and overburden properties that are useful for designing a mining and reclamation plan. These tests include methods for determining liming requirements and available plant nutrients. A discussion of costs for overburden sampling versus potential benefits completes the article.

670. Smith, W. D. Has Anyone Noticed That Trees Are Not Being Planted Any Longer? Paper in Trees for Reclamation (Lexington, KY, Oct. 27-29, 1980). U.S. For. Ser., Gen. Tech. Rep. NE-61, 1980, pp. 53-55.

The author discusses why trees are not being used in the reclamation of surface-mined lands in Ohio. The reasons are divided into technical, social, and economic. The technical reasons why trees have been eliminated from reclamation plans are due to the 1972 Ohio Surface Mining and Reclamation Law, which required mining, grading, and topsoiling. This has resulted in compaction, herbaceous competition, and erosion and survival repair work. The social aspect is the result of the approximate original contour grading requirement coupled with the planting of herbaceous species. The private landowner liked what he saw, and this had resulted in revegetation plans with grass cover for pasture and forage production, even on lands that had been growing trees prior to mining. Economically, trees have an additional expense in terms of (1) original planting, (2) repair plantings, and (3) delay-related expense in terms of compliance time and bond release. Although the social reasons will always exist, the author feels that both tree and herbaceous plantings are vital to successful reclamation.

671. Snarski, R. R., J. B. Fehrenbacher, and I. J. Jansen. Physical and Chemical Characteristics of Pre-Mine Soils and Post-Mine Soil Mixtures in Illinois. Soil Sci. Soc. America J., v. 45, 1981, pp. 806-812.

The authors report an evaluation of the chemical, physical, and mineralogical properties of the Sable soil series (Typic Haplaquoll) from west-central Illinois and the Darmstadt soil series (Albic Natraqualfs) from southern Illinois to determine the value of solum and subsolum material as plant growth media. The B2-horizon of the Darmstadt soil was the least suitable for plant growth. Incorporation of A-horizon into a mix of the top 3 m of the soil profile did not significantly enhance the chemical or physical properties of the mix without the A-horizon in the case of either soil. By comparing tested and calculated soil chemical and physical values, the authors found that many of these parameters could be reasonably predicted for solum and subsolum mixtures. The information presented in this article is particularly relevant to topsoil and rooting medium handling and placement for reclamation of agricultural land in the Interior Coal Mining Region.

672. Snyder, B. D., and G. L. Potter. The Critical Links Between Baseline Studies and Development of Revegetation and Wildlife Restoration Plans. Paper in 1981 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Dec. 7-11, 1981). Univ. KY, Lexington, KY, 1982, pp. 507-510.

This general article discusses the purpose of premining baseline studies. Several common deficiencies are identified, and recommendations to correct them are given. A seven-step approach is presented which the authors believe will integrate quantitative vegetative and wildlife baseline data into products that satisfy the intended purpose of baseline studies.

673. Sobek, A. A. Characterizations of Minesoils Developing in Coal Refuse. Abstract of paper presented at the Meeting of the American Council for Reclamation Research (Univ. AL, University, AL, Sept. 19-20, 1979). Reclam. Rev., v. 3, 1980, pp. 61-64.

The author compares the soil properties and vegetative development of (1) a 53-year-old coal cleaning refuse material, (2) a 3-year-old portion of the refuse which had been regraded, amended to adjust pH, and covered with 30 cm of glacial till, and (3) an undisturbed soil near Staunton, IL. The old refuse exibited little soil development, lack of vegetation, low pH, and high sulfur content. The treated refuse had a 95-pct cover of a grass-legume mix, a higher pH level, lower sulfur, and soil development in the upper 30 cm due to the action of the plants. The reclaimed mine soil compared favorably to the undisturbed soil.

674. Sobek, A. A., and J. E. Bogner. Using the Acid-Base Account To Predict Acid Potential of Coal Overburden. Paper in the Third Biennial Symposium on Surface Coal Mining and Reclamation on the Great Plains (cochaired by the Reclam. Res. Unit, MT State Univ. and U.S. OSM, Billings, MT, Mar. 19-21, 1984). MT State Univ. and U.S. OSM, 1984, 21 pp.

This paper evaluates methods for determining the acid-generating potential of unweathered rock and sediments. The component parts comprising the acid-base account are reviewed. Weathering methods used to estimate the acid potential are briefly described. Examples are given of two coal mines in Pennsylvania and two mines in Wyoming to illustrate the potential problems in using these methods. The authors conclude that the acid-base account is still the best available technique for characterizing acid potential of coal overburden materials. The information conveyed is applicable nationwide.

675. Soil Conservation Society of America. Surface Mine Reclamation: A Position Statement by the Soil Conservation Society of America. Supplement to the J. Soil Water Conserv., v. 35, No. 6, 1980, 6 pp.

The purpose of this statement is to provide general guidelines to be used for implementing conservation activities that are related to surface mining and reclamation. Nine principles are presented which the Society believes should be considered when policies and regulations are formulated that affect surface mining and reclamation. These principles are recommendations of the Society for restoring mine land to a productive and beneficial use. The role that the Society should play in bringing about the adoption and implementation of these principles is also discussed.

676. Somme, H. Revegetation of Pipeline-Disturbed Land. Paper in Vegetative Rehabilitation and Equipment Workshop, 36th Annual Report (Denver, CO, Feb. 4-5, 1982). U.S. For. Ser. Equip. Dev. Cen., Missoula, MT, 1982, pp. 19-20.

This article contains general information on drill seeding of land disturbed by pipeline construction and surface mining. Information is presented on drill equipment that has been developed for both types of disturbance that allows planting of three different unlike seeds (medium, small dense, light fluffy) at the same time in one pass while also dispensing fertilizer.

677. Sopper, W. E., L. T. Kardos, and S. N. Kerr. Revegetation of Anthracite Refuse Banks Treated With Municipal Sewage Effluent and Sludge: Phase II (BuMines project G0166049). Inst. for Res. on Land and Water Resources, PA State Univ., 1978, 80 pp.

This study was designed to evaluate the overwinter survival and second- and third-year growth responses of planted tree species and seeded grass and legume species on sludge amended anthracite refuse banks located near Scranton, PA. Tree seedling survival was higher at lower sludge application rates, while greatest height growth was obtained at higher sludge application rates. Hardwood tree species were superior to conifers in terms of survival and growth responses. During the first growing season dry matter production and vegetative cover were highest for the lower sludge application rates. By the third year these parameters were higher for the higher application rates. Of the grasses and legumes tested, the best overall response was obtained from reed canarygrass (Phalaris arundinacea L.), tall fescue (Festuca arundinacea Schreb.), orchardgrass (Dactylis glomerata L.), birdsfoot trefoil (Lotus corniculatus L.) and 'Penngrift' crownvetch (Coronilla varia L.). The higher sludge rate (150 t/ha) produced the best overall herbaceous vegetation growth response. Water quality was not impaired by the sludge application by the third growing season. The results of this study are applicable to reclamation efforts in the Eastern Coal Mining Region.

678. Sopper, W. E., and S. N. Kerr. Revegetation of Mined Land Using Wastewater Sludge. Public Works, v. 111, No. 9, Sept. 1980, pp. 114-116.

This article describes demonstration projects where different types of municipal sewage sludge were incorporated into surface-mine reclamation and revegetation activities. The sites of these demonstration projects were in Pennsylvania. This is a very good, semitechnical paper on the subject and could be useful to individuals with little background in the use of sewage sludge as a soil amendment, as well as acting as a reference for proposed reclamation activities. The information contained in the paper is most relevant to the Eastern Coal Mining Region.

679. Sopper, W. E., and S. N. Kerr. Revegetating Strip Mined Land with Municipal Sewage Sludge. U.S. Environmental Protection Agency, EPA-600/52-81-182 (Project Summary), Oct. 1981, 7 pp.

The authors summarize sludge demonstration projects initiated on three sites that were representative of abandoned bituminous strip-mined land and anthracite coal refuse in Pennsylvania. The types of sludge used were (1) liquid digested, (2) dewatered by centrifuge, vacuum filter, and sandbed drying, and (3) compost (sludge-cake mix). Different rates of sludge were applied and the sites were seeded with a mixture of grasses and legumes. Over a 3-year period the sludge applications ameliorated the harsh conditions of the test sites. Vegetative cover stabilized each site and has persisted and improved each year since establishment. Sludge applications did not cause a reduction in yield or quality of the vegetation. Sludge applications did increase the concentration of some metals in the vegetation, but all concentrations were below phytotoxic levels. There have been no adverse effects on the chemical or bacteriological quality of soil water due to sludge applications. The authors conclude that stabilized municipal sludges can be used to revegetate bituminous strip-mined land and anthracite refuse banks in an environmentally safe manner with no adverse effects on vegetation, soil, or ground water quality, and with little risk to animal and human health.

680. Sopper, W. E., S. N. Kerr, and E. M. Seaker. The Pennsylvania Program for Using Municipal Sludge for Mine Land Reclamation. Paper in 1981 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Dec. 7-11, 1981). Univ. KY, Lexington, KY, 1982, pp. 283-290.

The purpose of the article was to discuss the Pennsylvania program using municipal sewage sludge for mine land reclamation in both the anthracite and bituminous regions. Federal and State guidelines and regulations for land application of sludge are discussed. A series of demonstration sites were established, and the results indicate that stabilized municipal sewage sludge can be used to revegetate land disturbed by mining with few adverse effects on vegetation, soil, or ground water quality.

681. Sopper, W. E., and E. M. Seaker. A Guide for Revegetation of Mined Land in Eastern United States Using Municipal Sludge. Sch. For. Res. and Inst. for Res. on Land and Water Res., PA State Univ., University Park, PA, Mar. 1983, 93 pp.

This document presents discussions of pertinent State and Federal legislation, site investigations, vegetation selection and management, sludge analysis, sludge transportation and application methods, sludge application rates, and monitoring methods. An appendix containing a literature review of land reclamation projects using municipal sludge is included. The research reviewed and the discussions and recommendations contained in this document are principally relevant to the Interior and Eastern Coal Mining Regions. It is highly recommended as a reference manual for reclamation planning in areas where municipal sludge application is an alternative.

682. Sorenson, D. L., D. A. Klein, W. J. Ruzzo, and L. E. Hersman. Enzyme Activites in Revegetated Surface Soil Overlying Spent Paraho Process Oil Shale. J. Environ. Qual., v. 10, No. 3, 1981, pp. 264-371.

Several key microbiological parameters related to soil development and biogeochemical cycling processes were monitored to evaluate possible relationships between surface soil management and soil microbiological responses in surface soil used in covering Paraho retorted oil shale. Appreciable reduction in nitrogenase (acetylene reduction), dehydrogenase, and phosphatase activities were found in surface soil of 30, 61, and 91 cm depths placed directly over the processed shale when compared with surface soil not in contact with the processed shale. The soil had nitrogenase and phosphatase activities that were comparable to those of the control soil when a 30-cm coarse rock capillary barrier was placed between the 61-cm layer and the processed shale. The authors suggest, based on these field results, that better maintenance of microbial processes in soils placed over Paraho retorted shale during revegetation may be obtained by incorporating a capillary barrier in the reclaimed profile. This paper reports the results of a 2-year study conducted in the Piceance Basin of Colorado. The experimental methods and portions of the results are also applicable to surface coal mine reclamation efforts in the Rocky Mountain and Northern Great Plains Coal Mining Regions.

683. Sorensen, D. L., W. A. Kneib, D. B. Porcella, and B. Z. Richardson. Determining the Lime Requirement for the Blackbird Mine Spoil. J. Environ. Qual., v. 9, No. 1, 1980, pp. 162-166.

The objective of this research was to develop a procedure for determining the total lime requirement of the copper-cobalt Blackbird Mine spoil near Salmon, ID. The approach and methodologies used in this study have application to other mineral mine revegetation efforts. The reason the lime requirements of a spoil are important to revegetation is that the production of acid from the oxidation of pyrite may prevent the revegetation of a spoil. A total lime requirement must be determined in order to control existing acidity and to prevent reacidification as the oxidation of pyritic material continues. The total lime requirement consists of the amount of ground limestone needed to neutralize the acidity present due to the buffering capacity of the soil, the acidity generated from the oxidation of sulfide-sulfur in the fine highly reactive fraction of the soil, and the oxidation of sulfide-sulfur exposed by weathering of larger diameter soil material. At the Blackbird Mine both the soil buffering capacity and potential acid production due to sulfide mineral oxidation contribute significantly to the lime requirement. The total lime requirement has to be met before revegetation can begin. Once a plant community is established and the respiration of roots and microorganisms begins, the concentration of oxygen in the soil water system available for sulfide oxidation will decrease. This would cause a slowing of the soil acidification process. The authors conclude that adequate lime application combined with revegetation will assure control of spoil pH.

684. Sowards, W. E. Achieving an Adequate Sample Size for Vegetation Analyses. Paper in Symposium on Western Coal Mining Regulatory Issues: Land Use, Revegetation, & Management, ed. by E. F. Redente, W. E. Sowards, D. G. Stewards, and T. L. Ruiter (Western Reclamation Group, Denver, CO, Apr. 1982). CO State Univ., Range Sci. Dep., Fort Collins, CO, Sci. Ser. No. 35, Aug. 1983, pp. 63-71.

The statistical formula for determining sample size used by the agencies regulating coal mines in Colorado, New Mexico, Utah, and Wyoming was shown to require a larger sample the majority of the time than was needed to obtain acceptable precision. In a study conducted at the Trapper coal mine in northwest Colorado, it was shown that sample size was influenced by field sampling procedures and population distribution. A nonstatistical method of evaluating sample adequacy for herbaceous plant production is proposed. This method is based on graphing the running consecutive means as a function of sample size. Sampling adequacy was defined to be when any of 10 consecutive running means varied no more than 2.5 pct from the mean of the same 10 consecutive running means. This article provides a good reference for planning reclamation monitoring programs. While it was written with particular reference to the Northern Great Plains and Rocky Mountain Coal Mining Regions, it could find application nationwide.

685. Spaniol, J. A. Establishment of Black Walnut Seedlings on Topsoiled and Nontopsoiled Minesoils. Paper in 1982 Seminar on Post-Mining Productivity with Trees (Carbondale, IL, Mar. 31-Apr. 2, 1982). South. IL Univ., Carbondale, IL, 1982, pp. 141-150.

The results of a study of black walnut (*Juglans nigra* L.) growth on topsoiled and nontopsoiled mined land and on undisturbed soil are examined. Four hundred seedlings were planted on three such sites in Saline County, IL. All three sites had well-established vegetation on them. Seedlings were hand-planted using planting bars. Data on survival, shoot length, leaf length, stem diameter, and seedling height were taken. Roots were examined, but owing to the small amount of growth no measurements were taken. Contrary to results reported in some other studies, none of the sites were well suited for walnut growth. Data on seedling survival and top growth are given, as well as an excellent discussion on the rooting characteristics and growth found on the three sites.

686. Spindler, D. Three Case Studies on Row Crop Production on Mined Land. Paper in 1981 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Dec. 7-11, 1981). Univ. KY, Lexington, KY, 1982, pp. 493-495.

Three surface-mine sites in Fulton County, western Illinois which have been successfully reclaimed to row crops (corn (Zea mays L.) and soybeans (Glycine max (L.) Merr.)) are discussed based on yield data obtained from county agricultural extension agents or individual farmers. The time from grading to initiation of row crops ranges from 1 to 16 years. Yield data indicate that each site offers the potential for row crop production based on a comparison between what the yield was on mined land and county averages for a particular year. High levels of sustained yield can be achieved on mined land with proper management of soil material.

687. Sprouls, M. W., and M. R. Guerin. Freeman United's Fidelity to the Land. Coal Min. Proces., v. 18, No. 5, 1981, pp. 48-54.

This article reviews the history of coal removal, equipment use, coal processing, and reclamation at Freeman United Coal Mining Co. Fidelity Mine No. 11 in Perry County, IL. Reclamation efforts in the past have included forest plantings (Fidelity Forest 2,200 acres), orchards, and pastureland for cattle. Bee honey has also been produced on Fidelity property. Current reclamation practices include replacing the topsoil (A horizon) over a graded B/C horizon mix which has been consolidated by a bucket-wheel excavator. While most of the reclamation activities at Fidelity No. 11 are now directed towards meeting the prime farmland requirements, experimental tree plantings have been established on a box cut spoil area.

688. Stanley, M. A., G. E. Schuman, F. Rauzi, and L. I. Painter. Quality and Element Content of Forages Grown on Three Reclaimed Mine Sites in Wyoming and Montana. Rec. Rev. Res., v. 1, No. 4, 1982, pp. 311-326.

This study was conducted to determine the nutritional quality of forage grasses grown on unmined (reference area) and mined land in Wyoming and south-central Montana. Three sites were chosen for this study: (1) Decker Coal Co. mine near Decker, MT, (2) Glenrock Coal Co. mine near Glenrock, WY, and (3) Shirley Basin uranium mine near Medicine Bow, WY. Forage samples were clipped within a randomly placed 30.5- by 58.4-cm metal frame and then air-dried for production estimates and element analysis. The plant material was analyzed for protein, phosphorus, potassium, calcium, magnesium, aluminum, iron, sodium, manganese, zinc, copper, boron, nickel, chromium, and cadmium. Statistical analysis was limited to those species occurring on both sites at each mine. The results indicate that the forage species had higher concentrations of nonnutrient metals when grown on native soils than forage grown on reclaimed mine spoil. Of the elements analyzed, only iron was consistently higher in forage species grown on reclaimed sites. Mineral deficiencies rather than toxicities appear to be of greater concern on the reclaimed sites. Both phosphorus and protein were often found to be deficient in forage species, and sodium was below the requirement for cattle in all forage. The authors recommend mineral supplements to alleviate these problems on reclaimed sites.

689. Stanton, N. L., and D. K. Rementz. Nematode Densities on Reclaimed Sites on a Cold Desert Shrub-Steppe. Reclam. Reveg. Res., v. 1, No. 3, 1982, pp. 233-241.

This study was done to determine if there were any host species or reclamation treatment effects on nematode densities and trophic diversity at the Bridger Coal Co. mine in the southwestern part of the Red Desert in Sweetwater County, WY. Samples were taken under halogeton, shadscale, and grass species growing on four different sites: (1) undisturbed native vegetation (reference area), (2) native vegetation from which 15 cm of topsoil had been removed, (3) a reclaimed area spread with topsoil removed from site 2, and (4) a reclaimed site which was spread with stockpiled topsoil. Of the four soil-plant treatments, the native undisturbed soil-vegetation supported the highest densities of all trophic groups of nematodes. Both the plant parasites and microbivores were significantly higher in the undisturbed shadscale. The four soil-plant treatments exhibited a gradual progression from high to low nematode densities in the following order: (1) native vegetation, (2) disturbed native vegetation with fresh topsoil, (3) under shadscale, disturbed native vegetation with fresh topsoil, (4) under halogeton and disturbed vegetation with stockpiled soil replacement, and (5) under halogeton. On all sites, the native shrub, shadscale *Atriplex confertifolia* (Torr. & Frem.) S. Wats.), supported the highest densities, while the introduced annual, halogeton *Halogeton glomeratus* (Bieb.) C.A. Mey), supported the lowest. The results indicate that immediate topsoil replacement provides a better habitat for the nematode component of the microfauna. It may also be possible to use nematodes as indicators of the extent of disturbance and the successional status of the soil.

690. Stark, N. A Tree For All Seasons. Western Wildlands, v. 7, No. 3, 1981, pp. 18-21.

The author discusses the factors that limit the growth of ponderosa pine (*Pinus ponderosa* Laws.) on eastern Montana coal spoils. If ponderosa pine are to be grown on regraded minesoils, it is essential to know how minesoils and native forest soils differ physically and chemically. The author discusses how ponderosa pine, an acid-loving species, has adapted to the alkaline soil of eastern Montana. Two possible reasons are given: (1) The ponderosa pine growing in eastern Montana is an ecotype or subpopulation adapted to calcareous soils, and (2) it is close to its limit of tolerance for alkaline conditions. The remainder of the paper is devoted to a discussion of the physical and chemical properties of eastern Montana minesoils. The author concludes that if trees are to be grown on regraded minesoils, they will have to be selected for the physical and chemical characteristics of the minesoil.

691. Starks, T. L. Algal Succession as an Edaphic Factor of Surface Mined Lands. Suppl. J. Phycology, v. 14, 1978, p. 20.

This study was done to determine algal species, chlorophyll "a", and major cations, anions, and trace elements on surface mined land in North Dakota. Soil enrichment cultures identified the following species: 9 *Chlorophyta*, 13 *Cyanophyta*, 3 *Bacillariophyta*, and 1 *Xanthophyta*. Trend analysis showed that time had a positive correlation with the number of species and chlorophyll "a" content. An additional analysis showed 9 new species had appeared. Algal succession indicates that a favorable change in soil chemistry had occurred. The author concludes that the presence of algae may be used as an indicator of improving soil conditions for revegetation.

692. Starks, T. L., and L. E. Shubert. Algal Colonization on a Reclaimed Surface-Mined Area in Western North Dakota. Paper in Ecology and Coal Resource Development, Volume Two (Based on the Int. Congr. for Energy and the Ecosystem, Univ. ND, Grand Forks, ND, June 12-16, 1978). Pergamon, 1979, pp. 652-660.

The purpose of this study was to identify and quantify the soil algae present on an experimental revegetation test site north of Beulah in Mercer County, ND, as well as to describe their succession and relationships to the abiotic components of the soil. Several amendments to the spoil material were tested for their effect on plant growth. These treatments included leonardite, scoria, fertilizer, and combinations of these treatments. Algal populations were monitored over three growing seasons (1975-77). Algal variety increased from year to year regardless of the type of soil amendment. The number of algal species, chlorophyll "a", and pharophytin "a" content of the spoil were compared to the soil amendments and selected soil nutrients over time in a trend analysis. Sodium, manganese, and potassium contents of the spoil, as well as time, were significantly correlated to the algal parameters measured. This article provides a unique perspective of the ecological processes occurring during surface mine reclamation. The information conveyed is primarily pertinent to the Northern Great Plains Coal Mining Region.

693. Starnes, L. B., J. B. Maddox, and T. G. Zarger. Effects of Remedial Reclamation Treatments on Terrestrial and Aquatic Ecosystems--A Progress Report. Paper in Symposium on Surface Mining and Fish/Wildlife Needs in the Eastern United States (WV Univ., Morgantown, WV, Dec. 3-6, 1978). U.S. Fish and Wildlife Ser., FWS/OBS-78/81, 1978, pp. 276-285.

This research involved remedial treatments to a 162-hectare site in Campbell County, TN, after previous revegetation attempts had failed. Treatments to the area included liming, disking, seeding grasses and legumes, and planting trees and shrubs. Increases in percent ground cover and number of woody stems per hectare resulted from the treatments. Owing to the vegetative cover, the water quality of the 2,800 hectare-ha Ollis Creek Watershed, which the site is a part of, was improved. There were decreases in the total acidity, turbidity, sulfates, and certain metals within the watershed. Major responses by wildlife to the improved water quality were limited to aquatic invertebrates, where both numbers of individuals and taxa increased.

694. Steele, B. B., and C. Val Grant. Topographic Diversity and Islands of Natural Vegetation: Aids in Re-Establishing Bird and Mammal Communities on Reclaimed Mines. Reclam. Reveg. Res., v. 1, No. 4, 1982, pp. 367-381.

The purpose of this study was to document how diverse topographic features on reclaimed mines increase species richness, species diversity, and abundance of birds and mammals. Bird and mammal populations were sampled at two locations: the McKinley Mine near Gallup, NM, and the Edna Mine near Oak Creek, CO. At the McKinley Mine, manmade cliffs and areas of undisturbed pinon-juniper contributed significantly to bird populations on reclaimed areas; 38 species were seen. These areas contributed 22 pct of bird species diversity and 35 pct of the bird species richness measured on reclaimed areas. At the Edna Mine, species diversity, richness or abundance of birds, small mammals, and large animals were higher on diverse unreclaimed mine spoil than on reclaimed spoil; 46 species of birds were seen, compared with only 15 on reclaimed spoils. Diversity and richness were only 45 pct and 28 pct, respectively, of those on unreclaimed spoils. Mean bird abundancy was four times higher on unreclaimed areas than on reclaimed areas. Abundance and species richness of larger mammals were also higher on unreclaimed spoils at the Edna Mine. The diverse topography of unreclaimed spoils has resulted in diverse vegetation, which affected the bird populations at both mine sites, while mammals were affected by the terrain. The unreclaimed spoils provide a better habitat for birds and mammals than reclaimed spoils, but the authors do not recommend that mines be left unreclaimed. They do recommend that some steep slopes, gullies, depressions, and islands of natural vegetation be left. This would result in less bulldozing time, and the cost of reclamation would be lower. At the same time this would create habitats that are favorable for bird and mammal populations.

695. Stevens, R. Techniques for Planting Shrubs on Wildland Disturbances. Paper in Shrub Establishment on Disturbed Arid and Semi-Arid Land (Proc. Symp., Laramie, WY, Dec. 2-3, 1980). WY Game and Fish Dep., 1981, pp. 29-36.

The author discusses direct-seeding and transplanting techniques for establishing shrubs on disturbed areas. Important factors that must be considered in applying either technique are presented. Species particularly well adapted for each method are listed. The information presented is valuable to revegetation efforts in portions of the Rocky Mountain and Northern Great Plains Coal Mining Regions.

696. Steward, D. G. The Effect of Soil Horizon Combination on the Production of Blue Grama and Western Wheatgrass. Paper in 1983 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Nov. 27-Dec. 2, 1983). Univ. KY, Lexington, KY, 1983, pp. 265-269.

A greenhouse study was conducted to evaluate three soil horizons (A, B, and C) and unconsolidated overburden material (D) for their suitability as plant growth material. The soil materials used for this study were taken from the Powder River Basin in northeastern Wyoming and consisted of three soil series: Decolney, Fort Collins, and Olney soils. The suitability of the soils as plant growth material was evaluated using blue grama (Bouteloua gracilis)(H.B.K.) Lag.) and western wheatgrass (Agropyron smithii Rydb.). The soil combinations used were (1) all horizons combined, (2) A + B + C horizons combined, (3) C horizon; (4) C + D horizon combined, and (5) D horizon. Each treatment was amended with 1.51 lb/acre active N, 1.44 lb/acre active P, and 1.35 lb/acre active K. In general, blue grama established more readily and grew more rapidly than western wheatgrass. The most productive soil, averaged over all horizon combinations, was the Olney series. The least productive soil was the Fort Collins series. The A + B horizon was the most productive, while the C horizon was the least productive. The A + B + C combination was less productive than the A + B, while the C + D combination was a little more productive than either the C or D alone. Approximately 52 pct of the variation in blue grama biomass can be attributed to effects of soil horizon combination; pH and clay content explained the greatest amount of variation. Of the variation in western wheatgrass biomass, 31 pct was explained by soil horizon combination; pH, clay, and organic matter were the most significant variables. The author concluded that the best possible plant growth material can be obtained by paying attention to changes in soil texture, pH, and calcium carbonate accumulation.

697. Steward, D. G. Using a Similarity Index To Evaluate Revegetation Success. Paper in Symposium on Western Coal Mining Regulatory Issues: Land Use, Revegetation, & Management (West. Reclam. Group, Denver, CO, Apr. 1982). CO State Univ., Range Sci. Dep., Fort Collins, CO, Sci. Ser. No. 35, Aug. 1983, pp. 75-83.

The Motyka Index of Similarity (also known as the Bray and Curtis Index of Similarity) is reviewed as a means of evaluating revegetation success. Examples are used to illustrate how the index may be used and statistically evaluated. The success of revegetation was found to be best evaluated at the growth form level, using cover and production as response variables. The similarity index was found to be superior to the Shannon-Wiener Index of Diversity in evaluating revegetation success. This article provides an excellent reference for designing reclamation monitoring programs. It was written with special reference to the Western United States. However, the method described in this article is applicable nationwide.

698. Stiller, D. M., G. L. Zimpfer, and M. Bishop. Application of Geomorphic Principles to Surface Mine Reclamation in the Semiarid West. J. Soil Water Conserv., v. 35, No. 6, 1980, pp. 274-277.

The authors discuss the need for a more rigorous application of geomorphic and hydrologic concepts in the design of postmining topography in the semiarid West. These concepts should provide a valuable addition to erosion control and enhance revegetation efforts. Several reclamation problems are discussed, and attention is given to minimizing erosion through topographic design that has incorporated geomorphic and hydrologic concepts. The authors concluded that successful reclamation in the semiarid West depends on precise planning of the reclaimed surface and the integration of the reclaimed surface and drainage network into the surrounding landscape.

699. Stout, W. L., H. A. Menser, O. L. Bennett, and W. M. Winant. Cover Establishment on an Acid Mine Using Composted Garbage Mulch and Fluidized Bed Combustion Residue. Reclam. Reveg. Res., v. 1, No. 2, 1982, pp. 203-211.

This study was conducted to determine the effectiveness of fluidized-bed combustion residue (FBCR), alone and in combination with composted garbage mulch (garbage two rates of agricultural lime and FBCR alone and in combination with two rates of garbage mulch. All plots were seeded with 'Ky-31' tall fescue (Festuca arundinacea Schreb.) at a rate of 90 kg/ha. Fertilizer was applied during the second season at the rate of 560 kg/ha of 10-10-10. Fertilization was delayed in order to observe the contribution of plant nutrients by the mulch and FBCR. Plant materials were harvested for yield determinations and nutrient analyses. Soil samples were also analyzed for macronutrients, micronutrients, and the presence of heavy metals. Prior to fertilization, only the plots with composted garbage mulch had a satisfactory yield. Cover was improved with fertilization, but the cover on control plots and plots with only lime and FBCR was still inadequate. Plots which had composted garbage mulch with or without lime or FBCR had adequate vegetative cover. Yields were also larger on plots treated with composted garbage mulch owing to higher nutrient inputs. Yields on plots treated with lime or FBCR alone were not significantly different than those on control plots. However, plant analyses indicated that lead levels exceeded the safe level in plant materials in several treatments that received composted garbage mulch. The authors conclude that composted garbage mulch and FBCR are useful materials in establishing vegetative cover on acid mine soils; it is also a means of disposing of these waste materials.

700. Streeter, R. G. Forging the Missing Link in the Environmental Management Chain. Paper in 1977 Mining Yearbook. CO Min. Assoc., 1977, pp. 104-108.

The author presents his opinions on the need for setting environmental goals at State and regional levels. Several specific examples of the effects that such comprehensive planning would have had on site-specific action are discussed. The principal aim is to suggest a general framework within which State and Federal reclamation guidelines could be applied. This article is one of the better papers written during this period dealing with the effects of the relatively new State and Federal laws regulating surface mining and reclamation. The article is pertinent to the Northern Great Plains and Rocky Mountain Coal Mining Regions and primarily deals with fish and wildlife concerns.

701. Streeter, R. G., R. T. Moore, J. J. Skinner, S. G. Martin, T. L. Terrel, W. D. Klimstra, J. Tate, Jr., and M. J. Nolde. Energy Mining Impacts and Wildlife Management: Which Way to Turn. Paper in Transactions of the 44th North American Wildlife and Natural Resource Conference. Wildlife Manag. Inst., Washington, DC, 1979, pp. 26-65.

This paper is a good, succinct evaluation of the activities associated with mining. Mining's major impacts are treated in sufficient detail to allow preliminary identification and ranking of their effect on wildlife resources. The presented analysis procedure uses a matrix approach which facilitates the assessment of the severity of the anticipated impacts. The long-term impacts of reclamation are considered. The mechanisms of the impacts on wildlife are reviewed. The information conveyed is a synthesis of a review of pertinent literature and the experience of the authors. The impacts of postmining land use on wildlife are stressed. The discussions are well referenced to the existing Federal regulations and potential local input as they affect wildlife management options on reclaimed mineland. The discussions are not limited to coal mining or a specific region of the United States. Many topics pertinent to this evaluation process are considered in a cursory manner, generally referenced with regard to their effect on postmining land use options and consequent direct and indirect effects on wildlife.

702. Stringer, J. W., and S. B. Carpenter. Energy Content of Black Locust Growing on Surface Mined Land. Paper in 1982 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Dec. 5-10, 1982). Univ. KY, Lexington, KY, 1982, pp. 243-248.

This study was conducted to determine the total energy content and the usable energy content of the aboveground portion of black locust (Robinia pseudoacacia L.). Biomass sample plots were established in 84 black locust stands, ranging in age from 2 to 10 years, located in eastern Kentucky. The aboveground portion of each tree within a 10 m^2-plot was harvested and divided into four parts (leaves, current growth, wood, and bark), weighed, dried, and reweighed. Heat of combustion values of each plant part were determined using a Parr 1241 adiabatic oxygen bomb calorimeter. Heat content was determined using heat of combustion and biomass data. The specific gravity of the wood was also calculated. The total biomass ranged from 4,364.9 kg/ha for 2-year-old stands to 34,878.2 kg/ha for 9-year-old stands. Average whole-tree heats of combustion ranged from 8,600 Btu/lb for 2-year-old stands to 8,539 Btu/lb for 10-year-old stands. The average energy content of 2-year-old stands was less than that of 10-year-old stands, 8,357 and 8,440 Btu/lb, respectively. Two-year-old stands contained the lowest total energy contents, averaging 82.5 and 50.9 MBtu/ha for total aboveground and woody biomass, respectively. Nine-year-old stands had the highest amount of energy upon combustion, 655.3 and 576.9 MBtu/ha, for aboveground and woody biomass, respectively. Nine-year-old stands also had the highest usable heat content for whole-tree biomass, 483.4 MBtu/ha and woody biomass, 432.8 MBtu/ha. Annual usable energy contents for the 9-year-old stands were the highest for total and woody biomass, 53.7 and 48.1 MBtu/ha, respectively. This study shows the advantages of using black locust, growing on surface-mined land, as a fuel source.

703. Strock, G. N. Revegetation of Surface Mined Lands in Pennsylvania. Paper in Trees for Reclamation (Lexington, KY, Oct. 27-29, 1980). U.S. For. Ser., Gen. Tech. Rep. NE-61, 1980, pp. 57-59.

The author discusses the reforestation of surface-mined lands in Pennsylvania. From 1958 to 1973 there was a 9.7 pct increase in forested acreage while pastureland and cropland acreage decreased 26.6 and 15.7 pct, respectively. From 1977 to 1980 between 2 million to 2.5 million tree seedlings were planted on surface-mined land per year. The accepted revegetation practice for active surface operations is to establish a herbaceous cover for soil stabilization, erosion control, and sedimentation control. If tree and shrub species are a part of the revegetation plan, they are planted in combination with the herbaceous vegetation. The author recommends that low-growing, nonaggressive herbaceous species be used when trees are planted at the same time. Birdsfoot trefoil (Lotus corniculatus L.) is a legume species that is commonly planted in combination with trees. A list of the tree species that are commonly planted on surface-mined land in Pennsylvania is given.

704. Stucky, D. J., J. H. Bauer, and T. C. Lindsey. Restoration of Acid Mine Spoils With Sewage Sludge: I. Revegetation. Reclam. Rev., v. 3, No. 3, 1980, pp. 129-139.

The authors' purpose was to study several critical factors that are necessary to provide guidelines for further applications of large quantities of sewage sludge to acidic strip mine spoil. The site of this study was the Palzo tract in southern Illinois. The objectives of this study were to determine differences among plants in their ability to (1) become established and tolerate adverse parameters such as pH and soluble salts, and (2) their ability to exclude or accumulate metals. Reed canarygrass (Phalaris arundinacea L.), switchgrass (Panicum virgatum L.), and orchardgrass (Dactylis glomerata L.) were the most successfully established species after three growing seasons. From the time of initial planting to the end of the third growing season, reed canarygrass, switchgrass, and orchardgrass increased their percent aerial cover from 27 to 94, 14.5 to 73, and 36.5 to 63.5 pct, respectively. Each species had a minimum pH which their roots would tolerate; for reed canarygrass it was 3.5, for switchgrass it was 3.7, and for orchardgrass it was 4.2. All three species were also able to establish themselves in the presence of potentially toxic quantities of cadmium, copper, lead, manganese, nickel, and zinc. For example, after one growing season the cadmium contents in the tops of reed canarygrass switchgrass, and orchardgrass were 6.5, 10, and 2.8 ppm, respectively. However, by the end of the third growing season all elements in the plant tops were within ranges that are not considered to be toxic or harmful. In general, when the pH was greater than 5.5, quantities of metals in the plants were lower than when the mean pH was less than 5.5. The authors conclude with a list of suggested guidelines for future applications of sewage sludge on acidic mine spoils.

705. Stucky, D. J., and T. C. Lindsey. Effect of Soil Compaction on Growth and Yield of Soybeans Grown in a Greenhouse on Several Reconstructed Soil Profiles From Prime Farmland in Southern Illinois. Reclam. Reveg. Res., v. 1, No. 4, 1982, pp. 297-309.

This greenhouse study evaluated the effect of soil compaction on the ontogeny and yield of soybeans (Glycine max (L.) Merr. cultivar Williams) on reconstructed prime farmland soil horizons. A Proctor test was used to gain information that might help maximize the yield of prime farmland soils reconstructed after surface mining. Soil materials used in this study were collected from two potential surface-mine sites in Perry and Jackson Counties in southern Illinois. Soil from each horizon (A, B, C, and C_2) plus a 1:3 ratio mixture of $B:C_1$ and $B:C_2$ horizons were fertilized and compacted into pots at three different bulk densities. The bulk densities were (1) not compacted (1.2 g/cm^3), (2) moderately compacted (1.4 g/cm^3), and (3) severely compacted (1.6 g/cm^3). The results indicate that yields decrease as soil compaction increases. In all cases plants grown in soil compacted to 1.4 g/cm^3 outyielded plants grown in the severely compacted soil (1.6 g/cm^3). By blending the B and C horizon material at a 1:3 ratio, significantly higher plant yields were obtained when compared to plants grown in B-horizon soil material. Yields of plants grown in the C-horizon were not significantly different than yields obtained from plants grown in the A-horizon. Potentially, the most useful information derived from the Proctor test was the determination of the soil moisture percent at which soils are least susceptible to compaction. The Proctor test can also be used to determine the effect of blending horizons or adding organic matter on the compactability of reconstructed mine soil.

706. Stucky, D. J., and A. L. Zoeller. Restoration of Acidic Mine Spoils With Sewage Sludge: II. Measurement of Solids Applied. Reclam. Rev., v. 3, No. 3, 1980, pp. 141-147.

A greenhouse study was conducted at Southern Illinois University in Carbondale, IL, prior to the reclamation of an acid mine spoil. The objectives of the study were to (1) identify the critical soil parameters, (2) provide information so an equation could be computed to determine approximate quantities of sewage sludge needed to incorporate into the spoils to achieve the desired spoil pH, and (3) provide information for an equation so, following sludge incorporation, measured quantities of critical parameters could determine the approximate amounts actually applied in the soil profile. Sewage sludge, at equivalent rates of 0, 224, 336, and 448 dry t/ha, was mixed with acidic mine spoil and placed in pots in the greenhouse. Orchardgrass (Dactylis glomerata L.) was then seeded into the pots 48 h after incorporation of the sludge. Orchardgrass was the species chosen because it had been successfully established at the Palzo tract in southern Illinois. Parameters measured were pH, organic matter, cation exchange capacity, electrical conductivity, and yield. The parameters were measured at the time of seeding (48 h after sludge incorporation) and 5 months after planting. The data collected at the time of planting had the greater predictability value. Spoil pH was the most important parameter measured in order to predict the rate of applied sewage sludge. Additional accuracy was obtained by including the cation exchange capacity in the equation. The authors conclude that soil properties can be used to estimate the amount of sewage sludge solids that are needed to reclaim acid mine spoils and to estimate the quantities incorporated.

707. Sundin, R. E. History of Reclamation in Wyoming. Paper in Proceedings of the 75th Regular Meeting of the Rocky Mountain Coal Mining Institute (Vail, CO, June 24, 1979). Rocky Mount. Coal Min. Inst., Denver, CO, 1979, pp. 77-79.

A brief historical sketch of reclamation efforts in Wyoming since 1965 is provided. A discussion of the intent and effects of the Open Cut Mine Reclamation Act of 1969, a Wyoming State reclamation regulation, and its further amended version in 1973, is included. The author describes three common violations of the state reclamation statutes. This article provides an interesting historical perspective of reclamation efforts in the Northern Great Plains Coal Mining Region.

708. Sundstrom, F., and R. Morse. Legume Inoculation Following Seedling Establishment in Mine Soils. Paper in 1981 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Dec. 7-11, 1981). Univ. KY, Lexington, KY, 1982, pp. 13-19.

The objectives of this study were to determine the influence of nitrogen availability and time of inoculation on nodulation, N_2 fixation, and growth of snap bean (Phaseolus vulgaris L.) in 4-year-old mine soil from Wise County, VA. Treatments used were (1) fertilization and inoculation at planting, (2) fertilization at planting and inoculation delayed 21 days, (3) fertilization at planting and no inoculation, (4) inoculation at planting and fertilization delayed 21 days, and (5) appropriate controls. Fertilizer rates were 0, 25, 50, and 100 kg/ha. All treatments were duplicated in a growth chamber study and a field study. Nitrogen fixation was measured by nitrogenase activity using the acetylene reduction method. At maturation both studies were terminated, and plant shoot, root, and nodule dry weights were determined along with percent total nitrogen in the roots and shoots. The nitrogen fixation responses to nitrogen fertilization and treatment were found to be complex and interrelated. However, the highest amount of nodule mass and gaseous nitrogen fixed occurred at a fertilization rate of 25 kg/ha nitrogen. No significant differences were found between nitrogen fertilizer rate and percent nitrogen in the shoots and roots. This indicates that the plants were receiving adequate nitrogen regardless of the nitrogen source (fertilizer or fixed) or the fertilization rate.

709. Swatzyna, R. J. Kentucky's Nursery Situation. Paper in Trees for Reclamation (Lexington, KY, Oct. 27-29, 1980). U.S. For. Ser., Gen. Tech. Rep. NE-61, 1980, pp. 25-26.

The author discusses the production of nursery-grown tree and shrub species for use on surface-mined land in Kentucky. Currently, 12.5 million seedlings are produced annually and consist of 20 different species. Production consists of 60 pct hardwoods and shrubs and 40 pct pine. Five species are grown primarily for reclamation purposes. These species are European black alder (Alnus glutinosa (L.) Gaetrn.), black locust (Robinia pseudoacacia L.), bicolor lespedeza (Lespedeza bicolor Turcz.), autumn olive (Elaeagnus umbellata Thunb.), and Virginia pine (Pinus virginiana Mill.) A study is being conducted in order to evaluate 14 different woody species for reclamation purposes. They include species that have been raised by nurseries in the past but are not generally available for reclamation purposes. If the test plantings are successful, these species will be made available for reclamation. A tree improvement program is also being conducted with three species that are used for reclamation. These species are European black alder, Virginia pine, and black locust.

710. Swiegard, R. J., and R. V. Ramani. Impact of Public Policy on Surface Mine Planning and Design in the United States. J. Mines, Metals, and Fuels, v. 30, No. 6, 1982, pp. 274-283.

This article identifies the Federal Surface Mining Control and Reclamation Act of 1977 and subsequent regulations based on that act as the most significant direct force in defining public policy for surface mining in recent years. The article examines the direct and indirect impacts of this legislation from a national perspective. Good background information is provided for individuals with little or no knowledge of surface coal mining and mineland reclamation in the United States.

711. Tackett, E. M., and D. H. Graves. Evaluation of Direct-Seeding of Tree Species on Surface Mine Spoil After Five Years. Paper in 1983 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Nov. 27-Dec. 2, 1983). Univ. KY, Lexington, KY, 1983, pp. 437-441.

The authors present the 5-year results of a study designed to evaluate the effects of aspect, mulch, fertilization, and competition of five tree species direct-seeded on mine spoil near Jackson, KY. Three large-seeded tree species, northern red oak (Quercus rubra L.), pin oak (Quercus palustris Muenchh.), and bur oak (Quercus macrocarpa Michx.), and one small-seeded species Paulownia (Paulownia tomentosa (Thunb.) Steud.) were spot-seeded, and European black alder (Alnus glutinosa (L.) Gaertn.) was broadcast-seeded. The treatments consisted of five mulch treatments (a control, hydromulch, shredded bark, shredded bark plus chicken manure, and "real earth" - a composted municipal waste and sewage sludge mixture), three fertilizer treatments (0, 200, and 400 lb/acre of 16-32-8), and a 1:1 mixture of yellow sweetclover (Melilotus officinalis Lan.) and tetrablend ryegrass (Lolium perenne L.) broadcast-seeded at either 0, 10, or 20 lb/acre. First-year growth was not affected by the treatment variables tested. However, after 5 years the variation in percent stocking (survival) was a function of aspect and competition. Mulching and fertilization had no significant effects on the stocking rates. Competition from ground cover plants had a significant effect on the growth of direct-seeded trees after 5 years. Grass and legume competition resulted in a 35-pct reduction in the average height growth of the seeded species. The results of this study indicate that direct-seeding of tree species on mine spoil can be successful if the proper materials and techniques are used.

712. Taki, S. K., M. H. Rowell, W. B. McGill, and M. Nyborg. Reclamation and Vegetation of Surface Mined Areas in the Athabasca Tar Sands. (Syncrude Canada, Ltd., contract 5-39619, v. 12, Dep. Soil Sci., Univ. Alberta). Syncrude Canada Ltd., Edmunton, Alberta, Environ. Res. Monograph 1977-1, 1977, 170 pp.

A growth chamber study was used to determine the performance of a number of native and cultivated plant species on oil sand mining waste materials under different salinity, soil reaction, fertility, soil mix, and oil conditions. An accompanying field trial was conducted on a vegetated area of a tailings pond dike to determine responses of the established vegetative cover to different fertility levels, and to determine the fate of added fertilizer nutrients. Both studies were conducted over a 1-year period. It is recommended that the oil-sand-bearing materials be mixed with fertilizer and a good soil material and left for a growing season before seeding, at which time fertilizers should again be applied. Where salinity levels are extreme, normal chemical means of reclaiming saline soils prior to planting should be applied. Where salinity is low to moderate, tolerant plant species could be seeded without chemical reclamation. Acidification is recommended in areas of high pH (about 10). This treatment should be accompanied by correction of salinity problems where appropriate. Legumes can be grown successfully if the soil mix is near neutral; the seeds are inoculated with proper inoculants, and plant nutrients are provided in the soil mix. Balanced stands of legumes and grasses may be obtained by using seeding mixtures consisting of species of grasses and legumes which would compete on an equal basis, or by using a larger percentage of legume seeds in the seeding mixture and by ensuring soil conditions favoring legumes in competition with grasses. Initial fertilizer rates should not be less than 80 lb N, 40 lb P, and 80 lb K per acre per year after the establishment of vegetation. A seedbed allowing for deeper root penetration is of high priortiy in establishing greater slope stability. Cultivated species tested grew at least as well as the native species in the short-term experiments. An important consideration in revegetation is the capacity of soils to withstand acidification. Tailings sand and both lean and heavy oil sands are extremely poorly buffered against acidity. Under the conditions likely to prevail near an extraction plant, they could be expected to be acidified to levels at which plant growth would be eliminated with 10 years of exposure. The buffering capacity of this material could be increased to acceptable levels by mixing with peat and overburden materials. No material tested was devoid of microbial activity. High populations of sulfate-reducing organisms were reported. Tailings materials and overburdens were shown to have a limited ability to supply available forms of nitrogen and phosphorus to plants. Natural levels of atmospheric nitrogen fixation by free-living microorganisms were low. The results reported in this publication are to some extent specific for reclamation of oil sand mining waste materials. However, they could find application, under some circumstances, in planning reclamation efforts for other materials possessing similar properties. The research reported was conducted 22 miles north of Fort McMurray, Alberta.

713. Taylor, S. L., M. McDonnell, and W. A. Niering. Recycled Industrial Wastes Aid Revegetation. Compost Science/Land Util., v. 21, No. 3, 1980, pp. 18-20.

The authors evaluated the potential value of recycled mycelium, an industrial residue produced from the fermentation processes of organic acids and antibiotics, in rehabilitating an unused gravel pit in Ledyard, CT. The experimental treatments were (1) fresh citric acid mycelium, (2) composted mycelium, (3) fresh mycelium mixed with topsoil, (4) sandy loam topsoil only, and (5) untreated control plots. The mycelium and mycelium-topsoil mixtures were spread by hand to a depth of 5 to 8 cm and covered any existing herbaceous plants. At the end of two growing seasons, percent cover of plants was estimated on all plots. The results indicate that plant cover, particularly annual species, increased in plots treated with mycelial residues when compared with topsoil-treated and control areas. The greatest increase in plant cover occurred on composted mycelium plots. Approximately 90 pct of the ground was covered with newly established plants by the end of two growing seasons. The authors conclude that the use of mycelial residues in the revegetation of sparsely vegetated or unvegetated, well-drained, nutrient-poor, gravelly sites appears to be a sound land-use practice. The application of mycelial residues hastens the natural revegetation process.

714. Thames, J. L., and T. R. Verma. Reclamation on the Black Mesa of Arizona. Min. Congr. J., v. 63, No. 9, 1977, pp. 42-46.

This article discusses reclamation efforts on the Black Mesa of Arizona. Most of the article is concerned with characterizing the climate, natural vegetation, soil, animal life, and hydrology of the area. Very little information is presented on the actual reclamation practices used by Peabody Coal in the area. However, general information is given on grading practices used by Peabody Coal on the Black Mesa.

715. Thompson, D. A. Regeneration Lessons From Ontario's Clay Belt Forests. Scottish Forestry, v. 34, No. 3, 1980, pp. 173-177.

The author describes some of the dangers associated with separating harvesting from silviculture in the Clay Belt of Ontario. A general description is given of the soils, forests, climate, management, and silvicultural techniques used in the area. Of particular interest is the increase in site deterioration due to the use of heavy harvesting equipment. Evidence is presented that in Ontario the use of heavy skidders has resulted in negligible stocking by natural regeneration on poor sites. To alleviate some of the management problems and achieve successful regeneration, the author feels that attention must be given to plant handling, storage, site preparation, and planting during restocking.

716. Thornburg, A. A. Plant Materials for Use on Surface-Mined Lands in Arid and Semiarid Regions. U.S. Soil Conserv. Ser., SCS-TP-157, EPA-600/7-79-134, Jan. 1982, 88 pp.

This publication describes the characteristics, areas of adaptation, and performance of numerous herbaceous and woody plant species that have been found to have potential for use in revegetating surface mineland in the arid and semiarid regions of the United States. Species selection, use, establishment, availability, and management techniques are discussed for a large number of native and introduced grasses, forbs, and woody plants. Sources of more specific information are suggested. This is an excellent publication and highly recommended as a reference manual to individuals considering potential species composition for surface mine revegetation.

717. Thuesen, C. A. The Aesthetics of Reclamation. Western Wildlands, v. 7, No. 3, 1981, pp. 22-25.

The author discusses the use of visual resource management in surface-mine reclamation. This approach integrates esthetic considerations into resource utilization planning. Visual contrasts are defined and quantified according to landscape variables of form, line, color, and texture as determined from selected viewpoints. The process results in definition or contrast rating units or visible areas having homogeneous vegetative, geologic, microclimatic, and soil patterns. By using visual resource management it is possible to recommend how contour grading and hydrology; placement, massing, and shape of vegetation; appropriate vegetation color and texture; and the location and appearance of manmade structures can be most effectively mixed to contribute to harmonious reclamation.

718. Tiedmann, A. R., and C. H. Driver. Snow Eriogonum: A Native Halfshrub To Revegetate Winter Game Ranges. Reclam. Reveg. Res., v. 2, No. 1, 1983, pp. 31-39.

The objectives of this study were to (1) measure the frequency and cover of snow eriogonum (Eriogonum niveum Dougl. ex Benth.) relative to associated species in two habitats of northcentral Washington, (2) determine seed characteristics and viability, (3) evaluate response to nitrogen, phosphorus, potassium, and sulfur fertilization, and (4) determine the ability of snow eriogonum to develop from direct-seeding. This study was divided into three parts: a growth chamber study, which was used to determine seed viability; a greenhouse pot study, which assessed response to fertilization; and a field study, which assessed coverage and success of direct seeding. Snow eriogonum is a pioneer plant on disturbed sites in north-central Washington. This study indicated that on such sites, snow eriogonum provides an average foliar coverage of 8.9 pct and comprises approximately one-sixth of the total vegetal cover. Germination tests revealed that the viability of the seed is within acceptable limits: 52 to 72 pct of the seeds tested germinated. Snow eriogonum responded favorably to N fertilization in the greenhouse pot trials but did not respond to P, K, or S fertilization. The direct-seeding trials indicated that snow eriogonum develops readily by this method. The authors conclude that snow eriogonum has a potential value for revegetating harsh sites.

719. Tourbier, J. T., and R. Westmacott. A Handbook for Small Surface Coal Mine Operators (U.S. OSM grant No. 14-34-0001-8900, Water Res. Cent., Univ. DE). U.S. OSM, 1980, 119 pp.

This publication interprets the regulations of the Surface Mining Control and Reclamation Act of 1977 (Public Law 95-87) as they affect the operators of small surface coal mines. It is designed to aid these operators in bringing their mining operation into compliance with the regulations. The handbook contains information which can be used by operators in planning and conducting their operations. Chapter 2 presents a concise and regionally specific review of some of the problems encountered in surface mining and reclamation. Chapters 3 and 4 contain descriptive and graphic presentations of the principal surface mining methods and equipment used by small mine operators. Chapter 5 presents information on the necessity of premining surveys, exploration and planning. Chapter 7 contains an excellent concise outline of accepted reclamation and revegetation techniques. Chapter 8 outlines necessary considerations for proposing post-mining land uses. This handbook is an excellent presentation of information pertinent to the operation of a small surface coal mine in the Eastern Coal Mining Region.

720. Tri-County Council for Western Maryland. Energy and Environmental Research for Minerals and Enterprise Development. Appalachian Reg. Comm., Washington, DC, ARC 77-122/MD-5632, June 1979, 168 pp.

This report contains an assessment of a broad range of subjects related to increasing coal production in western Maryland. The study was not a comprehensive analysis of coal development implications. It is primarily meant to provide information to planners and decisionmakers considering the role of coal in the future of western Maryland. The document was reviewed and included in this annotated bibliography primarily for its value as a guide for cost-benefit analysis of surface coal mine reclamation.

721. Tyus, H. M., and J. M. Lockhart. Mitigation and Research Needs for Wildlife on Western Surface Mined Lands. Paper in the Mitigation Symposium: A National Workshop on Mitigating Losses of Fish and Wildlife Habitats (CO State Univ., Fort Collins, CO, July 16-20, 1979). U.S. For. Ser., Rocky Mount. For. and Range Exp. Sta., GTR RM-65, 1979, pp. 252-255.

Strategy and research needs for wildlife mitigation on mined lands in the Western United States are discussed in relation to the Surface Mining Control and Reclamation Act of 1977. Preliminary results of studies designed to determine reclamation and mitigation potential for breeding golden eagles are presented as an example of the problems in developing wildlife mitigation practices. This paper has particular relevance to the Northern Great Plains Coal Mining Region.

722. U.S. Bureau of Land Management. Final Environmental Statement-Proposed Coal Leasing in Carbon Basin Area, Wyoming. July 1979, 205 pp.

General statements describing the environment and the impacts and mitigations for the proposed mining operation are contained in chapters 1-3. More specific and useful information is contained in chapters 4-7. Chapter 4 describes mitigating measures not included in the proposed action. Specific standard evaluation criteria listed include slope shaping; topsoil removal, storage, and replacement; seedbed preparation; and revegetation methods. Chapter 5 examines specific adverse impacts which cannot be avoided and includes statements on potential wind and water erosion, wildlife populations, and livestock grazing. Chapter 6 includes a comparison of short- and long-term productivity. Chapter 7 examines specific irreversible and irretrievable commitments of resources. Much of the information and discussions contained in this document are specific for this area of Wyoming. The document has been included in this bibliography for its value in providing a historical perspective for the application of reclamation laws and guidelines and for the support data it contains.

723. U.S. Bureau of Land Management. Resource and Potential Reclamation Evaluation of Beulah Trench Study Area, West Renners Cove Coalfield, Mercer County, North Dakota. EMRIA Rep. 10, 1977, and summary, 1981, 290 pp. and 27 pp., respectively.

This two-document set presents the results of an extensive study that provides information for establishing reclamation objectives and lease requirements. Detailed data are given on the geology, coal resources, overburden, vegetation, hydrology, climate, and physiography of this area. Greenhouse studies were conducted to identify potential toxicity and/or nutrient deficiency problems in the soils to be used during reclamation. A primary aim of the study was to provide data needed in the preparation of Environmental Impact Statements and Environmental Analysis Records, and to aid in the review of reclamation plans for proposed mining activities in the area.

724. U.S. Bureau of Land Management. Resource and Potential Reclamation Evaluation: White Tail Butte Study Area, Little Powder River Coal Field; Summary. EMIRA Rep. 13, 1977, 19 pp.

The White Tail Butte Study Area is in Campbell County, WY, 35 miles north of Gillette. This report summarizes a larger final report of the same title dated 1981. Information is given on geology, coal reserves, overburden, soils, vegetation, and wildlife in the study area. Some recommendations for species selection, soil preparation, and seeding are given. Detailed information can be obtained from the final report.

725. U.S. Code of Federal Regulations. Title 30--Mineral Resources; Chapter VII--Office of Surface Mining Reclamation and Enforcement, Dep. Interior, Oct. 1, 1983.

Chapter VII of 30 CFR establishes procedures for the Secretary of the Interior to use in implementing Public Law 95-87, the Surface Mining Control and Reclamation Act of 1977. These include performance standards for reclaiming abandoned coal-mined lands, surface areas of underground coal mines, and surface coal mines. 30 CFR is revised and published annually. The most timely reporting of changes in Federal laws is given in the Federal Register.

726. U.S. Congress. Surface Mining Control and Reclamation Act of 1977. Public Law 95-87, Aug. 3, 1977, 91 Stat. 445.

Public Law 95-87 is the act that authorized Federal regulations for reclaiming and revegetating surface areas of underground coal mines and surface coal mines. Regulations for implementing the act were prepared by the Office of Surface Mining and can be found in 30 CFR Chapter VII.

727. U.S. Environmental Protection Agency. Environmental Impact Statement (Draft), Martin Lake D Area Lignite Surface Mine, Henderson, Rusk County, Texas. EPA 906/9-83-003, Mar. 1983, 10 chapters.

Although quite general in nature regarding revegetation of disturbed coal-mined lands, this publication is a good example of considerations necessary for an Environmental Impact Statement. Alternatives are presented along with company policy for establishing grazingland and forest land on disturbed areas.

728. U.S. Environmental Protection Agency. Elkins Mine Draining Pollution Control Demonstration Project. Interagency Energy-Environ. Res. and Devel. Rep., EPA-G00/7-090, Aug. 1977, 316 pp.

This report describes in detail a cooperative demonstration project in the Roaring Creek-Grassy Run watersheds near Elkins, WV, to control the pollution from abandoned underground and surface mines. The main body of the report summarizes all aspects of the project and should be of value to private, State, and Federal agencies planning and conducting mine drainage and abatement projects. Scattered throughout the report are details on the revegetation of the areas under treatment, indicating that good vegetative cover was established on most disturbed areas, with legumes dominating after 8 years of establishment. Tree survival and growth were also good. Cost details are given for the entire project; revegetation costs were $620/ha (1967 dollars).

729. U.S. Environmental Protection Agency. Environmental Impact Statement: Henry W. Pirkey Power Plant, Unit-I/South Hallsville Surface Lignite Mine Project. Harrison County, Texas. EPA 906/9-82-004, Mar. 1982, 262 pp.

The proposed mine and power plant in Harrison County, TX, is located in an area of farming, pastureland, and timber production. Included in this article is an analysis of existing soils and vegetation. The listing of land uses and types of associated vegetation that dominate on those lands could be useful for anyone developing a revegetation plan in the area.

730. U.S. Enviromental Protection Agency. Surface Mining Environmental Information Resources for State and Local Elected Officials. U.S. EPA Off. Reg. Intergov. Oper., Lib. Sys. Br., Feb. 1977, 92 pp.

This guide to information sources concerning surface mining was produced by EPA to aid all those concerned with the subject. It is particularly beneficial to State and local legislators as it contains listings of Government agencies dealing with all aspects of surface mining and bibliographic listings of resource materials covering subjects such as mining impacts, pollution control, reclamation, economics, public policy, and current and future developments. Although published in 1977, this guide contains information still pertinent to the surface coal mining industry.

731. U.S. Forest Service. History of the Vegetative Rehabilitation and Equipment Workshop (VREW) 1946-1981. Equip. Dev. Cen., Missoula, MT, Rep. 2200-Range, 8222 2805, Dec. 1982, 71 pp.

This publication reviews the organization and history of the Vegetative Rehabilitation and Equipment Workshop (VREW). VREW equipment development and test projects accomplished in conjunction with the U.S. Forest Service Equipment Development Centers at Missoula, MT, and San Dimas, CA, are reviewed. Short descriptions and excellent photographs of this equipment enhance the information contained in this document. The information and equipment described are primiarily pertinent to range rehabilitation in the arid and semiarid areas of the Western United States.

732. U.S. Forest Service. User Guide to Vegetation. Mining and Reclamation in the West. Gen. Tech. Rep. INT-64, Nov. 1979, 85 pp.

This publication is offered as a guide covering planning for reclamation of mined lands. Topics covered include: exploration and baseline data, species selection, plant materials, site preparation, planting methods, cultural treatments and postmining management planning and monitoring. It will be especially useful to revegetation planning in the Northern Great Plains and Rocky Mountain surface coal mining regions. The information is presented in a discussion format and is supported by numerous graphs, photographs, references for additonal information, a glossary and an index.

733. U.S. Forest Service. Vegetative Rehabilitation and Equipment Workshop, 35th Annual Report (Tulsa, OK, Feb. 8-9, 1981). Equip. Dev. Cen., Missoula, MT. Rep. 8122 2805, 1981, 84 pp.

This publication contains concise descriptions of equipment, plant materials, and revegetation concerns as presented at a workshop attended by representatives of Federal and State agencies, private industry, educational institutions, and foreign countries. Many of the projects described and much of the information presented is applicable to reclamation of surface coal mined land. The geographic focus of the workshop was the western U.S. However, some of the equipment and problems discussed are relevent to other regions of the U.S. This is an excellent reference that could aid in planning revegetation activities. The ratings assigned to the keywords used in this evaluation process indicate major areas of equipment development considered that are applicable to surface mined lands.

734. U.S. Forest Service. Wildlife User Guide For Mining and Reclamation. Intermountain For. and Ran. Exper. Stat., Ogden, UT, Gen. Tech. Rep. INT--126, July 1982, 77 pp.

This publication is one of a series of guides that were prepared as part of the U.S. Forest Service Surface Environment and Mining (SEAM) program. It was designed to serve as a starting point for biologists to aid in the planning, evaluation, execution, and monitoring of reclamation work associated with mining and its ancillary facilities. Chapter 1 outlines the role of the wildlife or fisheries biologist in minerals management. Chapter 2 provides a synopsis of the laws and regulations governing minerals and mining that affect fish and wildlife management decisions. Chapter 3 explores fish and wildlife objectives in land management planning. Chapter 4 describes the phases of mineral activity. Chapter 5 presents a framework for analyzing the impacts and effects of proposed mining activities on fish and wildlife. Chapter 6 suggests potential effects and methods for mitigating those effects; included in this chapter are discussions on human/wildlife encounters and disturbance of habitat. Chapter 7 outlines methods available to the wildlife or fisheries biologist for coordinating efforts in achieving necessary reclamation procedure applications. The discussions contained in this guide are general in nature. Little or no hard data or guidelines are offered. The manual was written for nationwide application.

735. U.S. Geological Survey. Final Environmental Statement - Proposed Mining and Reclamation Plan, Coal Creek Mine, Campbell County, Wyoming, on Federal Coal Lease W-3446. 1979, 200 pp.

General statements describing the environment and the impacts and mitigative actions for the proposed mining operation are contained in chapters I-IV. Adverse impacts that cannot be avoided if the proposals are implemented are described in chapter V. Many of these comments pertain to natural vegetation production and site productivity for grazing and wildlife needs. Other comments on site productivity related to short- and long-term uses are contained in chapter VI. Discussions of irreversible and irretrievable commitments of resources contained in chapter VII also contain comments on site rehabilitation and revegetation and consequent site productivity for grazing and wildlife use. Chapter VIII contains a discussion of more specific rehabilitation alternatives and methods. The information and discussions contained in this document tend to be specific to this area of northwestern Wyoming. The document has been included in this bibliography for its value in providing a historical perspective for applying reclamation laws and guidelines and for the support data it contains.

736. U.S. Geological Survey. Final Environmental Statement, Proposed Mining and Reclamation Plan, Pronghorn Mine Consolidation Coal Company Coal Lease W-58112, Campbell County, WY. FES 79-13, Mar. 1979, 276 pp.

General statements describing the environment and the impacts and mitigations for the proposed mining operation are contained in part A, sections I-VI. More specific information appears throughout part B. In this section impacts and mitigation measures are discussed. Much of the information and discussions contained in this document are specific for this area of Wyoming. The document has been included in this bibliography for its value in providing a historical perspective for the application of reclamation laws and guidelines and for the support data it contains.

737. U.S. Geological Survey and Montana Department of State Lands. Draft Environmental Statement - Proposed Expansion of Mining and Reclamation Plan, Big Sky Mine, Peabody Coal Company, Rosebud County, Montana, Federal Lease M-15965. 1978, 128 pp.

General statements describing the environment and the impacts and mitigative actions for the proposed mining operation are contained in chapters I-IV. Adverse impacts

that cannot be avoided if the proposals are implemented are described in chapter V. Many of these comments pertain to natural vegetative production and site productivity for grazing and wildlife needs. Other comments on site productivity related to short- and long-term uses are contained in chapter VI. Discussions of irreversible and irretrievable commitments of resources contained in chapter VII also contain comments on site rehabilitation and revegetation and consequent site productivity for grazing and wildlife use. Chapter VIII contains a discussion of more specific rehabilitation alternatives and methods. The information and discussions contained in this document tend to be specific to southeastern Montana. The document has been included in this bibliography for its value in providing a historical perspective for the application of reclamation laws and guidelines and for the support data it contains.

738. U.S. Geological Survey and Montana Department of State Lands. Final Environmental Statement-Proposed Expansion of Mining and Reclamation Plan, Big Sky Mine, Peabody Coal Company, Rosebud County, MT, Federal Lease M-15965. V. 2, 1979, 66 pp.

This document contains revisions in the mine plan as received through July 11, 1979. General statements describing the planned mining and reclamation acitivies, including proposed seeding and planting mixtures, subsoil contouring, and topsoil handling methods are contained in chapter I. The remaining portions of this volume deal with consultation and coordination with other government agencies and with private organizations and individuals. The information and discussions contained in this volume form an addendum to the Draft Final Environment Statement published in 1978 and tend to be specific for southeastern Montana. This was included in this bibliography for its value in providing a historical perspective for the application of reclamation laws and guidelines.

739. U.S. Geological Survey and Montana Department of State Lands. Final Environmental Statement-Proposed Mining and Reclamation Plan, Spring Creek Mine, Spring Creek Coal Company (A subsidary of Northern Energy Resources Company, Inc.), Big Horn County, MT, on Federal Lease M-069 782, 1979, 470 pp.

General statements describing the environment and the impacts and mitigations for the proposed mining operation are contained in part A, sections I-VI. More specific information appears throughout part B, where impacts and mitigation measures are discussed. Much of the information and discussions contained in this document are specific for this area of Wyoming. The document has been included in this bibliography for its value in providing a historical perspective for the application of reclamation laws and guidelines and for the support data it contains.

740. U.S. Office of Surface Mining (Dep. Interior). 522 SMCRA Evaluation Utah Petition Evaluation Document. Final. OSM-PE-1 and OSM-EIS-4, Nov. 1980, 265 pp.

This document contains an evaluation of the suitability of certain lands in southern Utah for surface coal mining and reclamation. The document combines a petition to designate this Federal land as unsuitable for surface coal mining operations, with an evaluation of that petition and an environmental impact analysis of the effect of various potential Federal actions on the petition. The discussions pertaining to the affected environment, potential impact, and reclamation opportunities are some of the best that appeared in documents of this type. However, the information was included in this annotated bibliography because of its value in providing a historical perspective for the application of reclamation laws and guidelines and for the support data it contains. The publication documents the first time a petition to designate Federal lands as unsuitable for surface coal mining was filed under the Surface Mining Control and Reclamation Act of 1977.

741. University of North Dakota. Ecological Studies on the Revegetation Process of Surface Coal Mined Areas in North Dakota (contract J0295015). BuMines OFR 47-83, 1982, 13 v.

This excellent minerals research contract report contains 13 separate volumes consisting of: (1) executive summary, (2) physical and chemical properties of overburden and topsoils as affected by time and amendments, (3) soil and vegetation development of abandoned mines, (4) soil and vegetation development on topsoiled areas, (5) plant production on spoils and topsoils as affected by time and amendments (fertilizer and leonardite), (6) relationship between cover and aboveground biomass, (7) mineral analysis of plants grown on spoils and topsoils, (8) soil algae, (9) viability and diversity of the seed bank, (10) elements of macro- and microclimate, (11) effect of amendments on soil-plant-nutrient relations under controlled conditions, (12) screening plants for phosphorus requirements, and (13) statistical analysis. Excellent reference lists are included with each volume. The volumes are available from the National Technical Information Service, as follows: OFR 47(1)-83, NTIS PB83-171322; OFR 47(2)-83, NTIS PB83-171330; OFR 47(3)-83, NTIS PB83-171348; OFR 47(4)-83, NTIS PB83-171355; OFR 47(5)-83, NTIS PB83-171363; OFR 47(6)-83, NTIS PB83-171371; OFR 47(7)-83, NTIS PB83-171389; OFR 47(8)-83, NTIS PB83-171397; OFR 47(9)-83, NTIS PB83-171405; OFR 47(10)-83, NTIS PB 83-171413; OFR 43(11)-83, NTIS PB83-171421; OFR 47(12)-83, NTIS PB83-171439; and OFR 47(13)-83, NTIS PB83-171447.

742. Vail, J. A., and R. F. Wittwer. Biomass and Nutrient Accumulation in 10-Year Old Eastern Cottonwood, Virginia Pine, and Black Locust Plantations on Eastern Kentucky Mine Soil. Paper in 1982 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Dec. 5-10, 1982). Univ. KY, Lexington, KY, 1982, pp. 237-242.

This study was conducted to compare the biomass production and nutrient accumulation in 10-year-old plantations of eastern cottonwood (Populus deltoides Bartr. ex Marsh.), Virginia pine (Pinus virginiana Mill.), and black locust (Robinia pseudoacacia L.) in Bell County, KY. Two of the treatments that were used by the Forest Service in 1968 were investigated in this study: (1) tree species grown with grasses and legumes and (2) tree species grown alone. Total aboveground biomass and nutrient accumulation (N, P, K, Ca, and Mg) were determined for each species treatment combination. Ten-year-old spoil and litter samples were also analyzed. No significant differences were found for total tree biomass. However, nutrient accumulations were found to be different between species: black locust accumulated the greatest amount of N, while cottonwood accumulated the greatest amount of Ca and Mg. There were no significant differences in the accumulation of P and K. Litter weights and nutrient content ranked in the general order of black locust > eastern cottonwood > Virginia pine. Spoil analysis showed no trends involving N, P, K, Ca, and Mg. Even though there was more spoil N under the black locust, it was not significantly higher. The pH of the spoils under eastern cottonwood were significantly higher than for either black locust or Virginia pine, probably due to the amount of Ca that has accumulated in the foliage of eastern cottonwood and then deposited on the forest floor each year. These results indicate that spoils have the potential to become productive soils in a relatively short time.

743. Vandevender, J. C., and J. C. Sencindiver. The Effects of Three Forms of Nitrogen Fertilizer, Phosphorus, and Hydrated Lime on Abandoned Mine Land Reclamation. Paper in 1982 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Dec. 5-10, 1982). Univ. KY, Lexington, KY, 1982, pp. 497-502.

This study evaluated the effects of lime, P, and three forms of N fertilizer on selected minesoil properties and establishment of vegetation on two surface-mined sites in West Virginia. Nine treatments, replicated four times, were used: (1) control, (2) lime, (3) lime plus phosphorus, (4) lime plus phosphorus plus ammonium nitrate, (5) lime plus phosphorus plus sodium nitrate, (6) lime plus phosphorus plus nitroform, (7) lime plus ammonium nitrate, (8) lime plus sodium nitrate, and (9) lime plus nitroform. Each of the above treatments were seeded to the following mixture: 'Empire' birdsfoot trefoil (Lotus corniculatus L.), 11.2 kg/ha; 'Ky-31' tall fescue (Festuca arundinacea Schreb.), 16.8 kg/ha; redtop (Agrostis alba L.), 3.4 kg/ha; 'Tioga' deertongue (Panicum clandestinum L.), 1.1 kg/ha; and 'Lathco' flatpea (Lathyrus sylvestris L.), 1.1 kg/ha. Prior to treatment the experimental areas were devoid of vegetation and had the following spoil characteristics: an average pH of 4.1, low levels of Ca, Mg, and sodium bicarbonate-extractable P, medium to high levels of K and double acid extractable P, and total N of 0.18 to 0.36 pct. Applications of hydrated lime significantly increased the neutralization potential, the pH (average value of 1.7), Ca levels, and the quantity of double-acid-extractable P and sodium bicarbonate-extractable P. This indicates that liming increased the solubility of P in these minesoils. Nitrogen applied to limed plots, as either NH_4NH_3, $NaNO_3$, or UF, had no effect on the total N levels of the minesoils. Vegetation establishment was significantly enhanced by lime and the lime plus P treatments. However, the lime plus N treatments and the lime plus P plus N treatment did not cause a significant increase in percent ground cover over the lime or lime plus P treatments, respectively. These results indicate that vegetative ground cover is not increased by adding N to limed or lime plus P treatments. Lime, P, and mulch were more important than N for establishing vegetative cover on these minesoils.

744. Van Epps, G. A., and M. McKell. Revegetation of Disturbed Sites in the Salt Desert Range of the Intermountain West. Coll. Nat. Resour., UT State Univ., UT Agric. Exp. Sta. Land Rehab. Series, No. 5, Sept. 1980, 37 pp.

This publication reports the results of a study conducted in a major oil shale area near Vernal, UT. The study was designed to evaluate the effects of various propagation methods, planting seasons, and other treatments on shrub establishment and survival. The survival of bare-root stock was generally high in relation to that of container-grown plants. The authors state that it is advantageous to use bare-root stock for early season plantings because it is faster, easier, and more economical. However, inexperienced planting crews, late season planting, and the time when plant dormancy is broken can present situations that reduce the advantages of planting bare-root stock. Few or no survival benefits were obtained from applying additional moisture at the time of planting. Control of weed competition was found to be important to the survival of planted shrubs. The results of these studies indicate that plantings need to be observed for a minimum of 3 to 4 years before concluding that plants are in a permanent survival condition. While not specific for revegetation of surface-coal-mined land, the results and discussion presented in this publication are applicable to such activities in the arid regions of the Rocky Mountain and Northern Great Plains Coal Mining Regions.

745. Van Luik, A., and W. Harrison. Reclamation of Abandoned Mined Lands Along the Illinois Waterway Using Dredged Material. Argonne Nat. Lab., ANL/ES-127, Jan. 1982, 112 pp.

This report examines the feasibility of using river sediments from the Illinois, Kankaku, and Des Plaines Rivers in Illinois to reclaim abandoned surface mined areas near those rivers. Sediments were sampled from 28 proposed or actual dredging sites. The samples were analyzed, and found to be a suitable topsoil and/or reclamation medium. Problem abandoned surface-mined land sites were identified, and three were designated as being particularly well suited as dredged material reclamation sites. Economic analysis showed that using the dredged material as a reclamation medium would be competitive with near-source confined disposal.

746. Van Ormer, D. E. Harvesting and Timber Management Considerations on Reforested Mine Lands. Paper in 1982 Seminar on Post-mining Productivity With Trees (Carbondale, IL, Mar. 31-Apr. 2, 1982). South. IL Univ., Carbondale, IL, 1982, pp. 9-13.

This article outlines factors that determine the potential use and economic value of trees as a timber crop. These factors need to be considered when determining if a mined area should be reclaimed to a forestry land use classification. Characteristics of the timbered area that affect logging costs are reviewed, as well as considerations in determining the value of timber.

747. Visser, S., J. Zak, and D. Parkinson. Effects of Surface Mining on Soil Microbial Communities and Processes. Paper in Ecology and Coal Resource Development, v. 2 (Based on the Int. Congr. for Energy and the Ecosystem, Univ. ND, Grand Forks, ND, June 12-16, 1978). Pergamon, 1978, pp. 643-651.

This article provides a unique view of the effects of mining and reclamation in an often-overlooked area of reclamation, soil microbiology. The authors relate the results of a study conducted in a subalpine spruce-fir forest area near Luscar, Alberta, Canada. The authors investigated the effects of mining disturbance on soil microbial communities, the development of microbial communities, and activities in mine spoils following treatment with various organic and inorganic amendments.

748. Vogel, W. G. A Guide for Revegetating Coal Minesoils in the Eastern U.S. For. Ser. Gen. Tech. Rept. NE-68, 1981, 198 pp.

This report contains information, recommendations, and guidelines for the revegetation of land in the Eastern United States disturbed by coal mining. Included are brief descriptions of Eastern Coal Mining Regions along with their respective minesoil properties and procedures for sampling, testing, and amending these soils. Plant species suitable for revegetating surface mined lands are identified and described in tabular form. Selection procedures for plant species are described, and methods and requirements for seeding and planting are explained. Reforestation methods and results are described from recent data on 30-year-old plantings in the Eastern States. This report is a good treatment of the revegetation procedures and considerations necessary for coal-mined lands of the eastern coal fields. It contains extensive bibliographic listings and a glossary of terms.

749. Vogel, W. G. Revegetation Research on Surface-Mined Land in Eastern Kentucky. Paper in Proceedings Fourth KY Coal Refuse Disposal and Utilization Seminar (Pineville, KY, June 6-7, 1978). Inst. Min. and Miner. Res., Univ. KY, Lexington, KY, 1978, pp. 5-15.

The author discusses some of the U.S. Forest Service's revegetation research and its application to mined-land reclamation in eastern Kentucky. Research has been conducted on the suitability of woody and herbaceous species; effects of spoil properties on plants; requirements for fertilizer, lime, mulch, and seedbed preparation; feasibility of all-season seeding; compatibility of trees with herbaceous cover; and microbial associations. Research studies initiated by other Federal and state agencies are also discussed. The author feels that one of the current problems associated with reclamation is how to devise revegetation strategies for specific land uses.

750. Vogel, W. G. Revegetating Surface Mined Lands With Herbaceous and Woody Species Together. Paper in Trees for Reclamation (Lexington, KY, Oct. 27-29, 1980). U.S. For. Ser. Gen. Tech. Rep. NE-61, 1980, pp. 117-126.

The author reviews the literature which deals with the use of seeded grasses and legumes, fertilizers, and herbicides to increase the survival and growth rates of planted and direct-seeded hardwoods and conifers on surface-mined lands in the Eastern United States. The importance of establishing a herbaceous cover, excluding grass species, to provide adequate erosion control is demonstrated. Climatic factors and the tree species used are important variables to consider when reclaiming mine spoils. The survival and growth rate of planted trees can be significantly affected by the yearly precipitation and how resistant the tree species is to competition and drought. When tree species and herbaceous species are planted in combination, the best method of planting is to use alternate strips of seeded herbaceous and tree species. This paper provides the reader with a clear understanding of all the factors affecting the establishment of trees on surface-mined lands.

751. Voorhees, L. D., M. J. Sale, J. W. Webb, and P. J. Mulholland. Guidance for Disposal of Uranium Mill Tailings: Long-Term Stabilization of Earthen Cover Materials (U.S. NRC contract B0279). Oak Ridge Nat. Lab. ORNL/TM-8685, Oct. 1983, 101 pp.

The purpose of this document is to provide the technical information necessary for NRC to evaluate plans for stabilizing uranium mill tailings over a wide range of site and environmental conditions. It specifically addresses means to minimize long-term erosion, disturbance, and dispersal of uranium mill tailings by natural forces. This document provides excellent literature reviews of the physical and biological factors and processes of soil surface stabilization. The variations of the environmental characteristics at existing and potential uranium mill sites are discussed. The concept of an optimal plan is addressed and the information necessary to judge whether a proposed plan constitutes an optimal design for long-term tailings disposal with respect to site-specific conditions is outlined. While this manual was designed to provide guidance in assessing plans for the stabilization of uranium mill tailings, it provides an excellent reference to soil surface stabilization in general. Consequently it is applicable to reclamation planning for surface coal minelands. Because of the preponderance of uranium mill sites in the Western United States, this document tends to be more relevant to the Northern Great Plains and Rocky Mountain Coal Mining Regions.

752. Voorhees, L. D., M. J. Sale, J. W. Webb, and P. J. Mulholland. Long-Term Stabilization of Uranium Mill Tailings. Paper in International Conference on Radioactive Waste Management (Seattle, WA, May 16, 1983). NTIS PC A02/MF A01, 15 pp.

An analysis is presented on the design of earthen cover materials, recent research and development, and policy for minimizing erosion, disturbance, and dispersion of uranium mill tailings. The major natural causes for disturbance of uranium mill tailings are water and wind soil erosion. There are three major options available for stabilizing uranium mill tailings: (1) rock cover, (2) soil and revegetation, or (3) a combination of both. The best method to use depends on site specific characteristics such as climate, geomorphology, soils, and the design variables involved (location of the disposal site, embankment height, embankment slope, etc.). The authors conclude that disposal plans should be evaluated in terms of site-specific environmental characteristics, proposed design configurations, and the ability to satisfy long-term performance requirements.

753. Wadsworth, S. Surface Mining Control and Reclamation Act of 1977: Regulatory Controversies and Constitutional Challenges. Ecol. Law Quart., v. 8, 1980, pp. 762-773.

The author describes issues surrounding the promulgation of the permanent regulations under which the act (SMCRA) is to be implemented and recent consitutional challenges to the act. Although dealing totally with the act at the time of writing in a legal setting, the article provides background information for all interested in compliance with SMCRA in all phases of the coal mining industry.

754. Wagenet, R. J., C. M. McKell, and A. Malek. Hydrologic Properties of Processed Oil Shale. Reclam. Reveg. Res., v. 1, No. 1, 1982, pp. 33-50.

Two separate studies, a field study and a laboratory study, were conducted to assess the potential for water harvesting and to determine the salt release and movement in the water harvested from a processed oil shale disposal pile in Anvil Points, CO. This study is of interest because the water harvested from these sites could be used to irrigate rehabilitation plantings. The field study utilized several proven soil stabilizing materials to test their water-harvesting effectiveness. The materials used were compacted shale, polyvinyl acetate (PVA), styrene butadiene latex (Petroset SB), paraffin, and fiber mulch (silva fiber). Four simulated rainfall storm periods of constant intensity and various intervals were tested on the plots treated with the stabilizing materials. Runoff, infiltration, electrical conductivity, and sediment yields were collected. It was found that Petroset SB and paraffin were superior in their water-harvesting efficiency. However, Petroset SB resulted in the highest sediment production, while the paraffin treatment resulted in the lowest amount of sediment. Salt release, determined from laboratory lysimeter studies, was significantly different among the treatments. Plots that were treated with paraffin produced runoff that had the lowest salinity. Petroset SB produced the highest runoff salinity. Except for the paraffin treatment, excessive amounts of salt and sediment in harvested water from surface-treated plots make this water unsuitable for non-salt-tolerant plants.

755. Wagner, W. L., W. C. Martin, and E. F. Aldon. Natural Succession on Strip Mined Lands in Northwestern New Mexico. Reclam. Rev., v. 1, No. 2, 1978, pp. 67-73.

This study compared plant species composition and diversity on mined and unmined areas (reference area) at the McKinley coal mine in northwestern New Mexico. The eight mined sites sampled date from 1961 to 1972. The unmined sites were adjacent to the mined sites. Vegetation was surveyed with respect to life forms, density, and importance value (dominance × frequency). Vegetation on the mined area was composed primarily of introduced annuals and herbaceous perennials, which suggests a n early seral stage of primary succession. Unmined areas had greater species diversity than mined areas in all life forms except annuals. On unmined areas, 95 pct of the vegetation was composed of native herbaceous perennials and woody taxa (sub-shrubs, shrubs, and trees). The importance values of annual species decreased and that of herbaceous perennials increased with time since mining. This indicates a trend towards dominance by longer lived taxa. The authors recommend that reseeding programs should involve various native species since they are natural colonizers, and as early seral species they could speed the natural successional pattern of mined land.

756. Walker, R. F. The Growth, Nutrient Absorption, and Moisture Status of Selected Woody Species in Coal Mine Spoil in Response to an Induced Infection by the Ectomycorrhizal Fungus _Pisolithus Tinctorius_. Ph.D. Thesis, Univ. TN, Knoxville, TN, 1982, 106 pp.

The growth, nutrient absorption, and internal moisture status of certain woody species inoculated with the mycorrhizal fungus _Pisolithus tinctorius_ and planted on coal mine spoil are examined in this report. Nursery-grown loblolly pine (_Pinus taeda_ L.) and Virginia pine (_Pinus virginiana_ Mill.) seedlings infected with _Pisolithus_ were outplanted on coal mine spoil in Tennessee that had been previously hydroseeded with a mixture of herbaceous species. Fertilizer was then applied. Sweet birch (_Betula lenta_ L.) and European black alder (_Alnus glutinosa_ (L.) Gaertn.) were grown under high, intermediate, and low fertility regimes in sand culture containing _Pisolithus_ for 5 months prior to transplanting onto spoil in the greenhouse. This article contains an excellent background discussion concerning mycorrhizae on coal spoil in the Eastern United States, as well as an excellent reporting of the study itself. Significant differences in the effects of inoculating with _Pisolithus_ on the four species were found, as well as fertilizer effects. However, the loblolly pine and sweet birch that were innoculated with Pisolithus showed considerable potential for use in revegetating coal mine wastes.

757. Walker, R. F., D. C. West, and S. B. McLaughlin. Pisolithus tinctorius Ectomycorrhizae Enhance the Survival and Growth of Pinus taeda on a Southern Appalachian Coal Spoil. Paper in Proceedings of the First Biennial Southern Silvicultural Research Conference (Atlanta, GA, Nov. 6-7, 1980). U.S. For. Ser., South. For. Exp. Sta., GTR 50-34, 1981, pp. 29-33.

The effects of Pisolithus tinctorius ectomycorrhizae on the establishment and growth of loblolly pine (Pinus taeda L.) on surface-mined sites were evaluated in a study conducted on coal spoil in Campbell County, TN. P. tinctorius significantly improved the survival and growth of loblolly pine seedlings on coal spoils where a grass cover had been previously established. Fertilization improved seedling growth but substantially reduced seedling survival. Unfertilized seedlings inoculated with P. tinctorius produced the best survival and growth. The results of this study are applicable to revegetation of surface-mined lands in the southern portion of the Eastern Coal Mining Region.

758. Walker, R. F., D. C. West, and S. B. McLaughlin. Pisolithus tinctorius Ectomycorrhizae Reduce Moisture Stress of Virginia Pine on a Southern Appalachian Coal Spoil. Pres. at the North American Forest Biology Workshop (Lexington, KY, July 25, 1982). Oak Ridge Nat. Lab., KY, CONF-820793-1, 1982, 10 pp.

This study examined the effect of Pisolithus tinctorius ectomycorrhizae on the internal moisture status of Virginia pine (Pinus virginiana Mill.) outplanted on sites disturbed by surface mining in Campbell County, TN. The study incorporated nursery-grown seedlings with three levels of infection with this fungal symbiont and control seedlings without the symbiont. A split-plot design was used so that each ectomycorrhizal treatment contained seedlings fertilized at a rate of 336 kg/ha NPK and non-fertilized seedlings. All seedlings had additional minor infections with another ectomycorrhizal species, Thelephora terrestris. A pressure chamber technique was used to determine the internal water status of the seedlings during a period of high moisture stress. During this period xylem pressure potential was measured at dawn, when internal water stress was least, and again at midnight, when it was greatest. The seedlings infected with Pisolithus exhibited lower moisture stress than seedlings not infected or infected at the lowest rate. The effect of fertilizer was not significant. The results and discussion contained in this report are important to planting trees on mined sites, not only in the Eastern Coal Mining Region, but in other areas of the United States as well.

759. Wallace, A., E. M. Romney, and R. B. Hunter. The Challenge of a Desert: Revegetation of Disturbed Desert Lands. Paper in Transuranics in Desert Ecosystems (NV Applied Ecology Group Prog. Rep. Meet., Las Vegas, NV, Mar. 2, 1977). U.S. Dep. Energy, NV Oper. Off., Las Vegas, NV, NVO-181, UC-11, Nov. 1977, pp. 17-40.

This report describes factors and natural processes that are of importance when revegetating areas in the northern Mohave and southern Great Basin Deserts. Aspects of desert ecosystems discussed include use of water by plants, amount of soil used by plants as a growing medium, soil characteristics, plant population dynamics, availability of plant nutrients, and plant population characteristics of disturbed sites. Measures to enhance vegetation success, such as transplanting clumps of shrubs and selecting seed from pioneering shrub species, are also discussed. While this report deals with very arid desert conditions, principles of desert ecosystems covered here may be applicable to other desert regions.

760. Wallace, P. M., and G. R. Best. Enhancing Ecological Succession: 6. Succession of Vegetation, Soils and Mycorrhizal Fungi Following Strip Mining For Phosphate. Paper in 1983 Symposium on Surface Mining, Hydrology, Sedimentology, and

Reclamation (Lexington, KY, Nov. 27-Dec. 2, 1983). Univ. KY, Lexington, KY, 1983, pp. 385-394.

This study was conducted to investigate aboveground and belowground changes during succession following phosphate mining in southwestern Polk County, FL. Six different aged nonreclaimed phosphate mined areas were studied. The sites ranged in age from an area presently being mined to 60 years old. Four major variables were of interest in this study: (1) aboveground vegetation composition changes, (2) organic matter dynamics and soil nutrient parameters, (3) changes in root structure, and (4) mycorrhizal population density changes through time and the identification of indigenous mycorrhizae. Assessment of the aboveground structure indicated that within 60 years after mining a well-developed ecosystem was present. Data collected on root length and biomass indicate that belowground root structure increased with time. The majority of plant species invading phosphate-mined areas exhibited extensive mycorrhizal infection within 3 years. This indicates the importance of endomycorrhizal fungi to the succession of native forest ecosystems on phosphate-mined areas, warranting continued investigation into the potential use of mycorrhizal inoculation as a reclamation tool.

761. Walsh, J. P., and C. C. Legal. Preliminary Reclamation and Revegetation for a Proposed Surface Coal Mine in Northwestern Colorado. Bull. Assoc. Eng. Geol., v. 15, No. 2, Spring 1978, pp. 221-230.

This article briefly describes a preliminary reclamation plan for Colowyo Coal Co.'s planned surface mine in Moffat County in northwestern Colorado. Wildlife habitat was chosen as the postmining land use, using native plants and grasses to revegetate the area. A description of a plan for upgrading adjacent areas for grazing land is also given. A very brief description of planned techniques for using topsoil, planting native plants, and habitat improvement is presented. Since reclamation had not yet been attempted at the time the article was written, no results or data are given.

762. Ward, A. D., L. G. Wells, and R. E. Phillips. Infiltration Through Reconstructed Surface Mine Spoils and Soils. Pres. at the 1981 Winter Meeting, Am. Soc. Agric. Eng. (Chicago, IL, Dec. 15-18, 1981). Am. Soc. Agric. Eng. Paper 81-2508, 28 pp.

Reconstructed profiles consisting of spoil and soil material from a surface mine location in western Kentucky were prepared in large laboratory bins and subjected to simulated rainfall. The profiles consisted of spoil material alone and topsoil over spoil material. The profiles were instrumented to measure infiltration rate, soil-spoil density, water content, soil water potential, and surface runoff. Infiltration through the reconstructed spoil profiles was very low despite the coarse texture of the material and may have been due to the well-graded nature of the material. Infiltration through the topsoil horizons was similar to that of many agricultural soils of this area. Surface sealing eventually dominated as the tests progressed, greatly reducing infiltration rates. Initial moisture content and the density of the material significantly influenced the infiltration measured for both the spoil and the topsoil. The results of this study are relevant to establishing a favorable planting medium for revegetating surface-mined lands. The information is directly appliable to the Interior Coal Mining Region, but the principles and methods discussed are applicable over a much broader geographic area.

763. Ward, R. T., W. L. Slauson, and C. W. Weldon. Ecogenic Variability in Native Shrubs Related to the Establishment of Vegetation on Disturbed Arid Shrublands. Ch. in Revegetation Studies on Oil Shale Related Disturbances in Colorado (U.S. DOE contract DE-A502-76EV04018, Dep. Range Sci., CO State Univ.), U.S. DOE, DOE/EV/04018-6, June 1982, pp. 57-65.

This study is part of a larger project evaluating the impact and potential for reclamation following oil shale mining and retorting processes. This paper reports the sixth-year results of this study. The objectives of the study were to (1) evaluate the natural variation within species (especially shrubs) native to the Piceance Basin, CO, (2) recommend source materials expected to provide long-term, natural succession on selected sites, and (3) evaluate the responses of shrub species already growing in an edaphic environment containing retorted shale. The populations of true mountain mahogany (Cercocarpus montanus Raf.), antelope bitterbrush, (Purshia tridentata (Pursh) DC), and fourwing saltbush (Atriplex canescens (Pursh) Nutt.) studied did not exhibit strong evidence of ecotypic differentiation. Ecotypic differentiation with respect to competitive ability, moisture, and short growing season stress are documented for mountain snowberry (Symphoricarpos oreophilus Gray), Utah serviceberry (Amelanchier utahensis Kochne), and winterfat (Ceratoides lanata (L.) C.A. Mey.). This paper is an excellent reference for choosing plant materials for revegetation activities. Although it addresses vegetation establishment on spent oil shale in Colorado, the results are applicable throughout much of the Northern Great Plains, Rocky Mountain and east portions of the Pacific Coal Mining Regions.

764. Wasser, C. H. Ecology and Culture of Selected Species Useful in Revegetating Disturbed Lands in the West. U.S. Fish and Wildlife Ser., FWS/OBS-82-56, Sept. 1982, 347 pp.

An excellent reference to ecological information on grasses, forbs, shrubs, and trees commonly used in revegetation and reclamation of surface mined and other disturbed lands in the Western United States. The purpose of the handbook is to assist the reader in gaining a better understanding of the ecology and culture of the species listed. For each species listed in the handbook, the following information is given; origin or the geographic area where the plant is indigenous, growth and morphological characteristics, environmental relationships, species culture information, uses and field management techniques, associated species (synecology), common insect and disease pests, and improved varieties. References used to develop the description of each species are also given.

765. Weiler G., and W. L. Gould. Establishment of Blue Grama and Fourwing Saltbush on Coal Mine Spoils Using Saline Ground Water. J. Range. Manage., v. 36, No. 6, Nov. 1983, pp. 712-717.

This article reports the results of a greenhouse study conducted in New Mexico that examined the effect of limited irrigation of topsoiled sodic shaley spoil with water of various salinities on the emergence and growth of blue grama grass (Bouteloua gracilis (H.B.K) Lag.) and fourwing saltbush (Atriplex canescens (Pursh) Nutt.). Four levels of salinity for the irrigation water were used, ranging from 750 to 12,890 μmho/cm. The sodium adsorption ratio of the irrigation water ranged from 2 to 68. The emergence and growth of blue grama were reduced with increased irrigation water salinity. The blue grama did not survive the highest salinity treatment. The highest saline water treatment reduced fourwing saltbush emergence but not growth following the seedling stage. The infiltration rate of the simulated topsoiled spoil decreased as the sodicity of the irrigation water increased. The electrical conductivity of the soil increased as the amount and salinity of the water increased. The results indicated that moderately saline water (EC $\leq$ 4230 μmho) may be suitable for revegetating mine spoils with blue grama and fourwing saltbush. The results and discussion contained in this report are pertinent to revegetation efforts in portions of the Rocky Mountain and Northern Great Plains Coal Mining Regions.

766. Weisenfluh, G. A., J. C. Ferm, A. Bailey, T. L. Despard, and W. G. Vogel. A Study of Geologic Factors Influencing Reclamation of Federal Coal Bearing Lands in Northern Alabama. Paper in 1981 Symposium on Surface Mining, Hydrology,

Sedimentology, and Reclamation (Lexington, KY, Dec. 7-11, 1981). Univ. KY, Lexington, KY, 1982, pp. 151-156.

This study was done to determine the geochemical attributes of potential overburden materials from Federal lands in northern Alabama and how these materials may affect plant growth. A second objective was to determine whether rock material could be identified as being favorable or unfavorable for reclamation purposes. The study was divided into three phases: (1) description of the geologic setting of the area, (2) analyses to determine the geochemical and mineralogical properties of the material along with a greenhouse study to determine the ability of the material to support plant growth and respond to fertilization, and (3) a statistical analysis of the greenhouse and geochemical data. The results of the study show that most of the rock material is not acid producing, but slightly alkaline. The fine-grained textured shales were found to be better suited for revegetation than the sandstones or pebbly sandstones. The best response was found when a nitrogen-phosphorus fertilizer was used. It would appear that little modification of overburden materials would be needed to enhance reclamation efforts in northern Alabama.

767. Welborn, L. E., and M. E. White. Regulations for Surface Mining Reclamation. Dames and Moore Eng. Bull., No. 52, Aug. 1980, pp. 2-12.

This article provides an excellent review of the Surface Mining Control and Reclamation Act of 1977, other regulations pertinent to surface coal mine reclamation, and the regulatory program administered under the Office of Surface Mining Reclamation and Enforcement. The implications of the successful lawsuit brought by the National Coal Association and the American Mining Congress that challenged some of the permanent program regulations of the Office of Surface Mining are discussed. This article has been included in this bibliography for its value in providing background information on surface coal mining regulations and its historical perspective.

768. Wells, L. G., A. D. Ward, and R. E. Phillips. Infiltration Characteristics of Kentucky Surface Mine Spoils and Soils. Paper in 1982 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Dec. 5-10, 1982). Univ. KY, Lexington, KY, 1982, pp. 445-456.

The results of a laboratory study on infiltration through reconstructed spoils and soils from surface mines in eastern and western Kentucky are presented. The objectives of this research were to (1) determine the hydraulic characteristics of reconstructed surface-mine spoils and soils and (2) evaluate the effects of initial soil moisture, profile bulk density, and rainfall intensity on infiltration through reconstructed profiles. Rainfall was simulated and soil moisture content was monitored using a dual-probe gamma density gauge and tensiometers were used to measure soil matric suction. Western Kentucky spoils were characterized by extremely low infiltration rates. This can be attributed to high bulk densities and well-graded particle constituency of the spoil material. Eastern Kentucky shale materials had high infiltration rates even at high bulk densities. However, the sandstone material from eastern Kentucky had infiltration rates like those of the western Kentucky spoil material. The authors state that caution should be used when interpreting these results because (1) different geologic associations will result in spoil materials with different characteristics, (2) different mining and reclamation techniques might result in profiles with different infiltration characteristics, and (3) vegetation will influence surface sealing effects. This study was conducted with bare soil.

769. Whitby-Costescu, L., J. Shillabeer, and D. F. Coates. Environmental Planning. Ch. 10 in Can. Cent. Miner. Energy Technol., Pit Slope Manual. CANMET Rep. 77-2, Feb. 1977, 93 pp.

This document is a chapter in a multivolume manual. Each chapter, as well as supplements to these chapters, has been published separately. The purpose of this chapter is to provide procedural guidelines for assessing and developing mineral exploration and mining plans, and plans for postmining land use. Topics considered in this chapter include preproduction stage, water supply and disposal, reclamation of mineral wastes, time and budget guidelines, and legislation. The section on reclamation of mineral wastes, while being relatively short, provides an excellent reference for surface-mine reclamation procedures, succinctly outlining major considerations and treatment options. While the manual was written for application in Canada, some of the information is relevant to reclamation activities in the Northern United States.

770. White, J. R. Trees for Reclamation in the Eastern United States, The Changing Perspective. Paper in Trees for Reclamation (Lexington, KY, Oct. 27-29, 1980). U.S. For. Ser. Gen. Tech. Rep. NE-61, 1980, pp. 65-68.

The author reviews tree planting projects and the methods used to establish trees on mined land in West Virginia. Some of the methods that have been used are direct-seeding by helicopter, planting of bare-root stock, hydroseeding, and using a tree spade. The reasons why tree plantings are no longer prominent on surface-mined land are also given. They involve economics, logistics, changes in laws, methods of operation, differing characteristics of trees, and manpower availability. A potential problem with the Public Law 95-87 enforcement program is also identified, i.e., the prohibition of placing trees on the outside edge of the lowest coal seam being mined. The author feels that this portion of the regulations neglects the beneficial uses of nonmerchantable timber and woody material (windrowing) for sediment and drainage control, protection and encouragement of new growth, and providing escape habitat and browse for wildlife. The author also identifies West Virginia's Surface Mining Control and Reclamation Act as encouraging for tree use because it recognizes commercial woodland as an acceptable land use for surface-mined land. The Federal Government's program does not permit private woodland as a goal of reclamation capable of land release. Trees have been overshadowed by the use of grass and legume species as the dominant component in a reclamation plan. However, with greater experimentation, planning, direction, and technological advancement, trees can regain the significance they once had in surface-mine reclamation.

771. White, R. L. Land Reclamation in Texas - An Opportunity. Paper in Proceedings Gulf Coast Lignite Conference: Geology, Utilization and Environmental Aspects (Austin, TX, June 2-4, 1976). Bureau Econ. Geol., Univ. TX, Austin, TX, 1978, pp. 199-208.

This paper gives a brief description of the land reclamation program used by Texas Utilities Generating Co. at their coal mines located near Fairfield, TX. Information is included on the characteristics of Texas lignite coal, location of the coal in eastcentral Texas, and the natural vegetation of the area. By minimizing the environmental effects of surface mining and restoring the productivity of the land, the land reclamation program used by Texas Utilities Generating Co. has proven to be successful.

772. White, S. L. A Review of Processes Used by Western States To Determine Post-Mining Use. Paper in Symposium on Western Coal Mining Regulatory Issues: Land Use, Revegetation, & Management, (West. Reclam. Group, Denver, CO, Apr. 1982). CO State Univ., Range Sci. Dep., Fort Collins, CO, Sci. Ser. No. 35, Aug. 1983, pp. 3-5.

An analysis comparing Federal regulations and proposed revisions with State regulations related to determination of postmining land use in six Western States (Colorado, Wyoming, Montana, North Dakota, Utah, and New Mexico) is presented. This analysis is based on a review of these regulations, and/or informal discussions with state Agency personnel and industry representatives. In the author's opinion the revisions proposed by the Office of Surface Mining (OSM) would simplify the process of changing land use at the Federal level and, if adopted by the States, could encourage operators and local planners to adapt land use to local or regional requirements. The author presents a clear and concise analysis that is applicable.

773. Whitmore, R. C. Managing Reclaimed Surface Mines in West Virginia to Promote Nongame Birds. Paper in Symposium on Surface Mining and Fish/Wildlife Needs in The Eastern United States (WV Univ., Dec. 1978). U.S. Fish and Wildlife Ser. FWS/OBS-78-81, 1978, pp. 381-386.

This article presents recommendations for management procedures which are designed to obtain maximum use of surface mines by nongame birds. Small changes in vegetative structure can increase avian species diversity. Management alternatives for nongame and game birds are presented using traditional range management strategies. Plant species known to provide suitable habitat for nongame birds are given.

774. Wiener, D. P. Economics of Surface Mine Reclamation. Paper in Conference on the Economics of Mined-Land Reclamation (Proc. Conf. cosponsored by the Land Reclamation Program, Argonne Nat. Lab. and U.S. Dep. Energy, Chicago, IL, Sept. 1-2, 1981). Argonne Nat. Lab., ANL/LRP-TM-20, Sept. 1981, pp. 45-54.

This paper is based on a longer study by the same author (item 775). This study was an attempt to ascertain the true cost of reclamation at 15 major surface mines in 6 Western States. Cost estimates reported ranged from \$200 to \$18,000 per acre. The author found no uniformity in accounting for or reporting such costs. The author stresses that reclamation of surface coal mines to productive, native conditions has not been achieved in the arid and semiarid regions of the Western United States.

775. Wiener, D. P. Reclaiming the West: The Coal Industry and Surface-mined Lands. INFORM, Inc., 1980, 451 pp.

This book provides the results of a survey of 15 mines operated by 13 surface coal mining companies in North Dakota, Montana, Wyoming, Colorado, New Mexico, and Arizona. The land reclamation programs at each of the 15 mine sites were evaluated against a set of 33 criteria. A synopsis of the results of the survey is provided along with a case history for each mine. The author attempts to provide an unbiased view of the reclamation program for each mine through a discussion of the methods used and the results obtained thus far in each revegetation effort. Considerable amounts of hard data are presented in each case history to substantiate the commments made by the author. In addition, the book contains sections defining the mining and reclamation techniques used in the survey. This book provides an excellent unbiased and uncompromising view of surface mine reclamation in the Western United States prior to 1980.

776. Wilkey, M., and S. Zellmer. Land Reclamation at an Abandoned Deep Coal Mine. J. Environ. Eng. Div., Proc. ASCE, (New York, NY), v. 105, No. EE5, Oct. 1979, pp. 843-853.

This article summarizes the reclamation of a 55-year-old coal gob pile near Staunton, IL. Erosion had cut deep gullies into the pile, and it was devoid of vegetation. Reclamation included recontouring, topsoiling, liming, and fertilizing prior to revegetation. Also, two revegetation studies were initiated to (1) assess overall revegetation success and (2) determine a cost effective means of achieving long-term vegetation on highly acidic (pH <3) gob material. A very brief outline of these demonstration projects is given. The projects were still ongoing when this article was written.

777. Wisdom, H. W., and W. B. Snyder. Measuring National and Regional Benefits From the Reforestation of Abandoned Mine Lands in the Southern Appalachians. Abstract of paper presented at the Meeting of the American Council for Reclamation

Research (Univ. AL, University, AL, Sept. 19-22, 1979). Reclam. Rev., v. 3, 1980, pp. 61-64.

The authors developed an economic model to evaluate the national, regional, and land owner benefits from reforestation of surface mined lands. Tentative results from application of the model in southwestern Virginia indicate that reforestation of mined lands cannot be economically justified. Absence of local markets and limited areas suitable for timber product plantings were the chief drawbacks to commercially productive forests in this area.

778. Wiseman, T. Hitting Pay Dirt With Pine Seeds: Strip Mines Reforested. Min. Congr. J., v. 64, No. 12, 1978, pp. 59-60.

This article discusses the direct-seeding of loblolly pine (Pinus taeda L.), longleaf pine (Pinus palustris Mill.) and slash pine (Pinus elliottii Engelm.) on surface-mined land near Birmingham, AL. General information is presented on the economic benefits of direct-seeding pine on disturbed sites. The total cost of using this method is estimated to be approximately one-third that of planting pine seedlings. Other benefits of direct-seeding pine species are mentioned and include erosion control and wildlife habitat. It has been shown that pines planted on mined land in Alabama grow as well as those on unmined sites.

779. Wittwer, R. F., S. B. Carpenter, and D. H. Graves. Survival and Growth of Oaks and Virginia Pine Three Years After Direct Seeding on Mine Spoils. Paper in 1981 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Dec. 7-11, 1981). Univ. KY, Lexington, KY, 1981, pp. 1-4.

Growth and survival of four tree species established by direct-seeding techniques on mountaintop removal spoils were evaluated after three growing seasons in Bell County in southeastern Kentucky. The species and seeding rates used were northern red oak (Quercus rubra L.), 2 seeds per spot; pin oak (Quercus palustris Muenchh.), 2 seeds per spot; chestnut oak (Quercus prinus L.), 1 seed per spot; and Virginia pine (Pinus virginiana Mill.), 6 to 10 seeds per spot. Treatments consisted of a control, fertilizer, bark mulch, and a fertilizer-bark mulch combination. Results indicate that stocking and height growth are improved by fertilizer and bark mulch amendments.

780. Wittwer, R. F., D. H. Graves, and S. B. Carpenter. Establishing Oaks and Virginia Pine on Appalachian Surface Mine Spoils by Direct Seeding. Reclam. Rev., v. 2, 1979, pp. 63-66.

This paper provides a brief review of a study assessing seeding of northern red oak (Quercus rubra L.), chestnut oak (Quercus prinus L.), pin oak (Quercus palustris Muenchh.), and Virginia pine (Pinus virginiana Mill.) on surface mine spoil in Bell County, KY. Seeds were planted and covered with spoil to a depth approximating their diameter. Treatments included 2.5 cm of bark mulch, fertilizer tablets, and a combination of mulch and fertilizer. Survival was increased 22 pct (31 pct vs. 53 pct) by the combined treatment over the untreated controls. The combined treatment increased first year height growth 87 pct (6.0 cm vs. 11.2 cm). The authors conclude that direct-seeding of oaks and Virginia pine offers many advantages over bare-root seedlings for revegetating mine spoils in the Appalachian region.

781. Wochok, Z. S. Alternatives for Revegetation of Disturbed Lands. Abstract of paper presented at the Meeting of the American Council for Reclamation Research (Univ. AL, University, AL, Sept. 19-22, 1979). Reclam. Rev., v. 3, 1980, pp. 61-64.

The author traces the history of containerized seedling and plant tissue culture development through the 1970's and to the present. The use of both sources will increase, particularly in the Southwest in the development of selected native and introduced species which can be mass produced through propagation. This is particularly true of species difficult to establish by seeding or cuttings.

782. Wolf, C. H. Post Mining Land Use: Economic Comparison of Forestry and Pastureland Alternatives. Paper in Trees for Reclamation (Lexington, KY, Oct. 27-29, 1980). U.S. For. Ser. Gen. Tech. Rep. NE-61, 1980, pp. 127-135.

The author describes some of the factors that influence postmining land use and explores the economics of forest and pasture land use alternatives in southeastern Ohio. Most determinants to postmining land use can be categorized into one of three groups: (1) soil properties, (2) legal requirements and constraints, and (3) economic considerations. Climatic factors are important but are beyond human control. A comparison is made on the economic potential for cow-calf operations with hybrid poplar (Populus L. spp.) and black walnut (Juglans nigra L.) plantations. Results indicate that a combination of pastureland and black walnut plantations will achieve the highest rate of return on investment. The hybrid poplar plantation had a negative land value, indicating that from a financial standpoint, it is not a desirable land-use. The author concludes that during the planning process postmining land use alternatives must be thoroughly investigated. After evaluating the financial returns for several alternatives, it would be possible to select the most favorable postmining land use.

783. Wolf, C. H. Reforestation Requirements Under the Revised Federal Surface Mine Regulations. Paper in Third Annual Conference on Better Reclamation with Trees (cosponsored by AMAX Coal Co., Purdue Univ., Southern IL Univ. and Madisonville Comm. Coll., Terre Haute, IN, June 2-3, 1983) Purdue Univ., West Lafayette, IN, 1983, pp. 11-18.

The author examines the requirements of the revised Federal rules and the Surface Mining Control and Reclamation Act of 1977 in relation to the reforestation of mined lands. These revised rules allow for greater flexibility by mine operators and State regulatory authorities. The revised Federal surface mine regulations governing backfilling and grading, topsoiling, revegetation, and postmining land use are discussed and interpreted in a clear and concise manner. The information related in this paper is central to planning and monitoring mine reclamation activities throughout the country. Consequently, this paper is highly recommended to anyone directly or indirectly concerned with surface mining and surface mine reclamation.

784. Wolf, C. H., C. E. Cordell, and S. M. Keller. Fungus Speeds Mine Reclamation. Coal Age, Sept. 1982, pp. 62-64.

This article provides a general, nontechnical review of ectomycorrhizae, in particular Pisolithus tinctorius (Pt). The authors review recent research conducted in the Eastern and Interior Coal Mining Regions involving ectomycorrhizal inoculation of pine seedlings during planting and its affect on growth and establishment. The cost of establishing Pt-inoculated pine seedlings on abandoned mine sites at a 5- by 5-ft spacing is estimated at $300 per acre, a substantial saving over the usual practice of additional grading, resoiling, and grass planting. The information contained in this article may be of interest to individuals planting coniferous trees as part of a surface mine reclamation effort.

785. Wolfe, M. H. Use of a Historical Data Base as a Revegetation Success Standard. Paper in Symposium on Western Coal Mining Regulatory Issues: Land Use, Revegetation, & Management (West. Reclam. Group, Denver, CO, Apr. 1982). CO State Univ., Range Sci. Dep., Fort Collins, CO, Sci. Ser. No. 35, Aug. 1983, pp. 47-49.

The author presents an alternative approach to the reference area method of evaluating revegetation success. This method uses a historical data base to identify habitat types for establishing success standards. The method is outlined as proposed for use on Kaiser Steel Corp's coal reserves in northeastern New Mexico and approved by the regulatory authority of New Mexico. This article was written with specific reference to northeastern New Mexico. However, it has probable application over a much broader geographic area, including the Northern Great Plains and Rocky Mountain Coal Mining Regions.

786. Wood, P. A. Characteristics, Comparisons, Classification, and Erodibility of Some Northern Alabama Coal Mine Spoils. Ph. D. Thesis, Auburn Univ., Auburn, AL, Aug. 1979, 221 pp.

Various coal mine spoils of northern Alabama are identified, characterized, and classified. The relative potential erodibility of these spoils is compared based on several erodibility indices. Recent spoils were compared on the basis of 14 physical and chemical properties. The older spoils were studied in a similar manner with the additional study of carbon and nitrogen content and subsurface materials. A classification of northern Alabama mine spoils is proposed based on three properties: (1) percent of gravel size particles (>2 mm), (2) color of the soil size fraction, and (3) reaction of the soil size fraction relationships between chemical and physical properties were developed for recently formed, dark-colored spoils. These relationships apply within a pH range of 2 to 8. The process of accumulation of gravel sized particles at the surface of spoils, termed "armoring," is discussed. Kaolinite and muscovite are the dominant clay minerals of the spoils examined. Chlorite and vermiculite were also generally present in the clay mineral assemblages. The information contained in this report is relevant to planning reclamation projects and research in the southern portion of the Eastern Coal Mining Region.

787. Woods, F. W., R. L. Hay, and G. H. Irwin. Minesite Preparation for Reforestation of Strip-Mined Lands. Paper in Symposium on Surface Mining and Fish/Wildlife Needs in the Eastern United States (WV Univ., Dec. 1978). U.S. Fish and Wildlife Ser. FWS/OBS-78/81, 1978, pp. 306-310.

This study investigated the effects of minesite preparation on the establishment of two tree species on strip mine sites in the southeast. Virginia pine (_Pinus virginiana_ Mill.) and pitch pine (_Pinus rigida_ Mill.) seedlings were used on two different sites: (1) mulched and seeded to grass and (2) no revegetation treatment. Minesite preparation consisted of removing 50 cm^3 of spoil and mixing it at a rate of 12 parts spoil to 4 parts pine bark and 1 part vermiculite. Lime and fertilizer were added, the amended spoil material was returned to the hole, and the seedlings were planted. Control seedlings were also planted without any type of site preparation. Results from the 9-month survival counts indicate that pine survival was better on minesite areas than controls for both bare and grass-covered sites. The authors believe that tree planting is feasible during the summer months if (1) the competitive effects of a dense grass cover are minimized, (2) erosion is minimized, (3) irrigatio is used, and (4) soil amendments are used.

788. World Coal. Reclamation of Surface Mined Lands. V. 5, No. 9, 1979, p. 46.

This article reviews a two-part report by W.L.G. Muir entitled "Reclamation of Surface Mined Lands." It is written from a legal and technical point of view and covers two situations: (1) the recovery of land disturbed by former mining operations before reclamation was required by law and (2) the process of reclamation as a part of the regular mining cycle. Part 1 deals with the technology of reclamation. It is divided into eight chapters and contains information on the methods of mining, procedures used in reclamation and revegetation, and costs. Part 2 deals with the law and practice in major mining nations of the West that have enacted legislation on the subject. It contains detailed information on the regulations, procedures, practices, etc., on a country-by-country basis. For more information and detail on the topics covered by Muir, one should obtain a copy from World Coal in San Francisco, CA.

789. Wyatt, J. W., D. J. Dollhopf, and W. M. Schafer. Root Distribution in 1- to 48-Year-Old Stripmine Spoils in Southeastern Montana. J. Range Manage., v. 33, No. 2, Mar. 1980, pp. 101-104.

The distribution of plant roots in strip mine soils ranging in age from 1 year to 48 years old, and in undisturbed soils, in the vicinity of Colstrip, MT was determined using three methods: (1) soil profile description, (2) root biomass, and (3) radioactive tracer ^{32}P. The results indicate that the older spoils had substantially more roots below 100 cm than the new spoils on the undisturbed soils. The authors attribute differences in root abundance and distribution between the various sites to differing species composition. Half-shrubs dominated the older spoils, while grasses were dominant on the new spoils and the undisturbed soils. In new spoils, root biomass was 44 pct less than in the undisturbed soils and 43 pct less than in the old spoils. The radioactive tracer method was used to determine maximum rooting depths of 15 important plant species. The information provided by the report has application for evaluating reclamation success and determining the necessary depth of burial for toxic overburden material. The results of this study are primarily applicable to the Northern Great Plains Coal Mining Region.

790. Yamamoto, T. Mixing Overburden To Stimulate Soil Conditions: ARCO Black Thunder Mine. Paper in Ecology and Coal Resource Development, Volume 2 (based on the Int. Congr. for Energy and the Ecosystem, Univ. ND, Grand Forks, ND, June 12-16, 1978). Pergamon, 1978, pp. 791-797.

This paper relates the results of a study conducted in northwestern Wyoming on the suitability of thoroughly mixed overburden for establishment of the Northern Great Plains short grass complex and associated woody vegetation. The paper is a good source of values for soil chemical and physical factors for mixed and natural soil that could be used for comparative purposes.

791. Yamamoto, T. A Review of Uranium Spoil and Mill Tailings Revegetation in the Western United States. U.S. For. Ser. Gen. Tech. Rep. RM-92, Oct. 1982, 20 pp.

The author conducted an extensive review of the literature describing uranium spoil and mill tailing revegetation in the Western United States. Although the principles discussed are often applicable to coal operations in the same areas (west of the Mississippi River), the main thrust was the control of radioactivity from uranium mining wastes. Site characterization, moisture considerations, erosion potential, and long-term effects are needs common to both uranium and coal. In summary, the author concludes that the most simple and effective species selection method is to use species that have invaded the waste materials. These are the ones not adversely affected by the waste characteristics. Much of the literature reviewed in this article applies to coal revegetation in the Western United States.

792. Yoakum, J. Pronghorn Habitat Requirements and Reclamation. Paper in the Third Biennial Symposium on Surface Coal Mining and Reclamation on the Great Plains (cochaired by the Reclam. Res. Unit, MT State Univ. and U.S. Off. of Surface Min., Billings, MT, Mar. 19-21, 1984). MT State Univ. and U.S. OSM, 1983, pp. 148-155.

The characteristics of good pronghorn habitat in the sagebrush-grassland and short grassland communities are described, and recommendations are made for successful restoration of pronghorn habitat. The author stresses that for resoration projects to benefit pronghorns, these projects must be designed in accordance with the ecological requirements of the pronghorn. Reclamation principles and practices are discussed, including vegetation restoration and water developments. The information contained in this paper is applicable throughout the range of the pronghorn which includes the Northern Great Plains, Rocky Mountain and the eastern portion of the Pacific Coal Mining Regions.

793. Yokell, M. D., and G. Sanders. The Economics of Reclamation. Paper in Conference on the Economics of Mined-land Reclamation (Proc. Conf. cosponsored by the Land Reclam. Prog., Argonne Nat. Lab. and U.S. Dep. Energy, Chicago, IL, Sept. 1-2, 1981). Argonne Nat. Lab., ANL/LRP-TM-20, Sept. 1981, pp. 3-36.

A conceptual approach to reclamation economics is presented, contrasting legal and economic approaches. The cost of reclamation is treated as another mining cost, with minimization of the total cost of mining as the objective. A mathmatical model is presented to illustrate the concept. The costs inherent in reclamation are divided into premining costs, topsoiling costs, regrading and backfilling costs, and revegetation costs. Preliminary total reclamation cost data are presented by category (premining, topsoiling, revegetation, etc.), region, and mining method. The analysis, results, and discussion contained in this paper attempt to be national in scope. The cost analysis model developed is meant for application throughout the United States.

794. Young, R. G., T. R. Sitler, R. A. Ralogh, and E. C. Aharrah. An Investigation of Japanese Fleece Flower (Polygonum cuspidatum) Planted on Strip Mines in Clarion and Venango Counties, Pennsylvania. Paper in 1982 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Dec. 5-10, 1982). Univ. KY, Lexington, KY, 1982, pp. 143-152.

The authors present the results of a study conducted to evaluate the condition of Japanese fleeceflower (Polygonum cuspidatum Sieb. and Zucc.) growing under a canopy of woody plants on surface-mined sites in Clarion and Venango Counties, PA. This study compares the growth of fleeceflower under canopy with open-grown plants. Herbaceous grass cover of 5 pct or greater prevented the invasion of fleeceflower onto mined land. Fleeceflower was also successfully underplanted with seedlings of sugar maple (Acer saccharum Marsh.), white birch (Betula pendula Roth.), and gray brich (Betula populifolia Marsh.). This demonstrates that fleeceflower can be crowded out by overtopping. Fleeceflower may be useful as a seral stage leading to the reforestation of abandoned mine lands.

795. Young, S. A., and E. J. DePuit. Response of Seeded Species to Temporary Irrigation and Seeding Date. Paper in 1981 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Dec. 7-11, 1981). Univ. KY, Lexington, KY, 1982, pp. 21-29.

This study was conducted to evaluate the effects of temporary irrigation on vegetation establishment on surface-mined land near Colstrip, MT. Two different types of vegetative establishment were used, spring (April) and early summer (June), along with four irrigation treatments: no irrigation, 1 month of irrigation, 2 months of irrigation, and 3 months of irrigation following establishment. The same species were used in both spring and summer plantings, followed by a fertilizer treatment once the seedlings emerged. The specific objectives of the study were to (1) evaluate the effects of temporary irrigation on establishment, productivity, structure, species composition, and diversity of seeded species during the initial year of irrigation and the subsequent years with no irrigation, (2) determine the effects of varied irrigation duration, and (3) evaluate vegetation development and composition after summer seeding and temporary irrigation. The results show that initial plant emergence was not affected by irrigation. However, after 2 years there was greater species diversity on the spring spring-seeded plots with 1 month of temporary irrigation. After 2 years following an initial period of slow development, the summer-seeded plots were dominated by cool season perennial grasses. It appears that 2 months of irrigation are necessary for the development of successful vegetation on the summer-seeded plots. Irrigation seemed to favor the establishment of perennial grasses over seeded shrubs and forbs and reduced the production of weedy species on all plots. The authors conclude that temporary irrigation could be used as a management tool for successful reclamation in the Northern Great Plains.

796. Younos, T. M., and M. D. Smolen. Simulation of Infiltration in a Sewage Sludge Amended Mine Soil. Paper in 1981 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Dec. 7-11, 1981). Univ. KY, Lexington, KY, 1982, pp. 319-324.

The purpose of this study was to simulate the effect of sewage sludge incorporation on the water infiltration properties of mine soil in the laboratory. The mine soil used to construct the model was obtained from a mountaintop removal surface mine near Beckley, WV. The results of the simulation study indicate that sludge incorporation increases the hydraulic conductivity, promotes rapid filling of soil pores, and encourages rapid saturation of amended mine soils. All three contribute to an increase in the infiltration capacity of sludge-amended mine soil when compared to unamended mine soil. The increased infiltration capacity results in a more rapid advance of the wetting front and more moisture available for plant growth.

797. Zarger, T. G. Forestation of Surface Mines for Wildlife. Paper in Trees for Reclamation (Lexington, KY, Oct. 27-29, 1980). U.S. For. Ser. Gen. Tech. Rep. NE-61, 1980, pp. 71-74.

The author reviews the Tennessee Valley Authority Program efforts to develop and promote the effective use of wildlife food and cover plants for surface mine reclamation in the Eastern United States. Information is given on plant materials that have been developed for use on surface mines for wildlife needs, planting demonstrations that assessed a variety of food and cover plants, and action programs that have been developed to incorporate wildlife plantings into postmining land use. A brief discussion is included on wildlife considerations under Public Law 95-87 and wildlife seedling needs and supply problems.

798. Zell, L. M. Determining the Research Needs of Mining and Reclamation Council of America, the Surface Coal Mining Industry, Draft Report (U.S. DOE grant DE-FG01-81FE00094). U.S. DOE, Off. Coal Min., May 1982, 122 pp.

This document is a synthesis of input from all sectors of the surface coal mining industry, academic researchers, and Government personnel. It reviews the status of present knowledge and technology pertaining to surface coal mining throughout the Nation and presents outlines for perceived research needs. These discussions are treated on a regional basis recognizing three coal mining regions nationally. The major subjects covered include hydrology, sedimentology, reclamation, air quality, and blasting. This evaluation pertains only to those portions discussing reclamation. The rating refers to the discussion and identification of specific research needs for reclamation. Some specific topics tend to be more important in one region than another. Consequently, each topic rated is not always encountered in the regional discussions contained in the document. The document has been designed for regional application and provides an excellent review of research needs. It is pertinent to decisionmaking in establishing priorities for research.

799. Zellmer, S. D. A Coal Refuse Reclamation Project. Proc. WV Acad. Sci. v. 51, No. 3, 1980, pp. 115-127.

This paper reports interim results of a project demonstrating methods that can be used to reclaim abandoned coal refuse sites. A 13.8-ha abandoned site in southwestern Illinois was reclaimed by recontouring the refuse material and covering it with a minimum of 30 cm of topsoil. A mixture of grasses and legumes was seeded on 8.9 ha of the site. A multidisciplinary approach was used to evaluate postconstruction environmental and econmic effects of the reclamation effort. The author reports establishment of plant cover, development of soil microbial populations, and formation of wildlife habitats. The results and discussions contained in this article are primarily relevant to the Interior Coal Mining Region.

800. Zellmer, S. D. Staunton 1 Reclamation Demonstration Project, Progress Report for 1977. Argonne Nat. Lab., Argonne, IL, ANL/LRP-TM-14, Dec. 1978, 70 pp.

This progress report presents first-year research results for the many studies comprising the Staunton 1 Project. The overall project objectives are to reclaim this abandoned mine site, and in the process furnish necessary design data and develop and demonstrate economic methods for future reclamation efforts of this type. The project is located in Macoupin County in southwestern Illinois. Studies monitoring ground water, surface water quality, aquatic ecosystems, revegetation, soil characteristics, erosion and runoff, soil microbial and soil fauna populations, wildlife, and economic effects of the reclamation project are described. This project is an intensive reclamation effort. The information and methods described would be most suitable for application in the Interior and Eastern Coal Mining Regions.

801. Zellmer, S. D. Staunton 1 Reclamation Demonstration Project--Progress Report II. Argonne Nat. Lab., Argonne, IL, ANL/ES-73, July 1979, 110 pp.

This document provides a status report for the Staunton 1 Reclamation Demonstration Project being conducted near Staunton, IL. The project involves an evaluation of the reclamation process on a 13.8-ha abandoned deep coal mine refuse site. Approximately 9.3 ha of refuse material was recontoured, covered with a minimum of 30 cm of soil obtained on site, and seeded with a mixture of grasses. The progress of a number of projects following 2 years of intensive monitoring and evaluation is reported. Studies being conducted at the site include monitoring of the groundwater quality, surface water quality, aquatic ecosystems, revegetation success, soil characteristics, slope angle and erosion rate, soil microbiology, wildlife, economic benefits, and site management and maintenance. Since this is a progress report, the results reported are tentative. However, the report provides an excellent reference for reclamation planning and is applicable to the Interior and portions of the Eastern Coal Mining Regions.

802. Ziemkiewicz, P. F. Determination of Nutrient Recycling Capacity of Two Reclaimed Coal Mine Sites in British Columbia. Reclam. Reveg. Res., No. 1, 1982, pp. 51-62.

This paper is a brief summary of the author's Ph. D. thesis. Studies were conducted over a 14-month period to determine if fertilization is still necessary after 3 years of maintenance on two reclaimed coal mines near Sparwood in southeastern British Columbia, Canada. Two distinct phases of revegetated plant communities were identified, the immature and the mature. Immature vegetation is characterized by small root systems with a major portion of the system's available nutrients being transferred from the shoots to the detritus in the autumn. Slow decomposition of the detritus causes nutrient deficiency, particularly in cold and dry climates, and longer periods of maintenance fertilization are necessary. The mature phase is characterized by rapid detrital decomposition and a larger root system, both of which provide a readily mineralized pool of nutrients to the soil. Mature vegetation needs no maintenance fertilization; in fact, fertilization during a drought year may damage a mature reclaimed area. Immature plant communities do not necessarily become mature, particularly at subalpine and alpine locations where maturation may not occur until adapted native species become established.

803. Ziemkiewicz, P. F., and S. M. Northway. A Species Selection Technique for Reclamation in British Columbia. Reclam. Rev., v. 1, No. 3/4, 1978, pp. 163-166.

This study determined which physiographic, soil chemical, or soil physical property had an influence on the establishment and productivity of 13 grass and legume species used to revegetate coal-mined land near Sparwood, British Columbia, Canada. The results indicate that species productivity is strongly correlated with elevation and aspect, with elevation being the most significant parameter. Along an elevational gradient two major plant groupings can be distingushed: (1) at 1,150 to 1,650 m the plants are crested wheatgrass (Agropyron desertorum (Fisch.) Schult.), intermediate wheatgrass (Agropyron intermedium (Host Beauv.), smooth brome (Bromus inermis Leyss.), Canada bluegrass (Poa compressa L.), and alfalfa (Medicago sativa L.) and (2) above 1,650 m the plants are smooth brome, orchardgrass (Dactylis glomerata L.), timothy (Phleum pratense L.), meadow foxtail (Alopecurus pratensis L.), red fescue (Festuca rubra L.), Kentucky bluegrass (Poa pratensis L.), redtop (Agrostis alba L.), alfalfa, white clover (Trifolium repens L.) and red clover (Trifolium pratense L.).

804. Zimmerman, L. J., and R. F. Wittwer. Use of Slow Release Fertilizers When Planting Sycamore, Yellow Poplar and Cottonwood Seedlings on Surface Mined Land. Paper in 1981 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation (Lexington, KY, Dec. 7-11, 1981). Univ. KY, Lexington, KY, 1982, pp. 477-480.

This study was conducted in Bell County, southeastern Kentucky, on a site that had recently been mined by the mountaintop removal method. The objectives of the study were to (1) compare the effects of two types of slow-release, tableted fertilizers at two application rates on the growth and survival of eastern cottonwood (Populus deltoides Bartr. ex Marsh.), yellow poplar (Liriodendron tulipifera L.), and Amercian sycamore (Platanus occidentalis L.) and (2) determine if the fertilizer tablet application is more effective than broadcast fertilizing for improving tree survival and growth. The fertilizer treatments were: one 9-g slow release tablet (18-8-3), two 9-g tablets, one 21-g slow release tablet (20-15-5), two 21-g tablets, and 280 kg/ha of diamonium phosphate (18-46-0) broadcast over the surface. The results show no significant effect of treatments on first year survival, growth, or nutrient content of the trees. The authors speculate that this may be due to the age of the trees, the low fertilizer application rates, or the below-normal precipitation that occurred during the first growing season.

805. Zipper, C. E. Economic Analysis and the Planting of Hardwood Trees on Surface Mined Lands. Paper in Third Annual Conference on Better Reclamation With Trees (cosponsored by AMAX Coal Co., Purdue Univ., South. IL Univ. and Madisonville Comm. Coll., Terre Haute, IN, June 2-3, 1983). Purdue Univ., West Lafayette, IN, 1983, pp. 202-216.

The economics of establishing long-rotation hardwoods on mined lands are analyzed, assuming minimal establishment problems and yields approximating those achievable on natural soil sites. Given these assumptions, internal rates of return in the 2- to 4-pct range are indicated. Calculated rates close to 5 pct result from "best case" assumptions. The report offers a hypothetical economic analysis of long-rotation hardwood sawtimber production which points out favorable potential yields if technical problems can be overcome. This report has potential application to reclamation planning in the Eastern and Interior Surface Coal Mining Regions.

APPENDIX C.--OTHER BIBLIOGRAPHIES OF COAL-MINED-LAND RECLAMATION LITERATURE

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APPENDIX D.--OSM OFFICES AND STATE AND INDIAN CONTACTS FOR ABANDONED MINE LANDS (TITLE IV) AND REGULATORY (TITLE V) GRANT PROGRAMS

OSM OFFICES

Headquarters
Office of Surface Mining
U.S. Department of the Interior
1951 Constitution Ave., NW.
Washington, DC 20240

Financial Operations
Office of Surface Mining, USDI
Branch of Financial Operations
P.O. Box 25065
Denver Federal Center
Denver, CO 80225

Technical Centers
Office of Surface Mining, USDI
Technical Center West
Brooks Towers
1020 15th St.
Denver, CO 80202

Office of Surface Mining, USDI
Technical Center East
Ten Parkway Center
Pittsburgh, PA 15220

Field Offices
Office of Surface Mining, USDI
Charleston Field Office
603 Morris St.
Charleston, WV 25301

Office of Surface Mining, USDI
Harrisburg Field Office
101 South 2d St., Suite L-4
Harrisburg, PA 17101

Office of Surface Mining, USDI
Lexington Field Office
340 Legion Dr., Suite 28
Lexington, KY 40504

Office of Surface Mining, USDI
Tulsa Field Office
333 West 4th St., Room 3432
Tulsa, OK 74103

Field Offices--Con.
Office of Surface Mining, USDI
Knoxville Field Office
530 Gay St., Suite 500
Knoxville, TN 37902

Office of Surface Mining, USDI
Columbus Field Office
2242 South Hamilton Rd., 2d Floor
Columbus, OH 43227

Office of Surface Mining, USDI
Indianapolis Field Office
Federal Building and U.S. Courthouse, Room 520
46 East Ohio St.
Indianapolis, IN 46204

Office of Surface Mining, USDI
Big Stone Gap Field Office
R.R. #3 Box 183-C
Big Stone Gap, VA 24219

Office of Surface Mining, USDI
Kansas City Field Office
818 Grand Ave., Scarritt Bldg.
Kansas City, MO 64106

Office of Surface Mining, USDI
Springfield Field Office
#4 Old State Capitol Plaza, North
Springfield, IL 62701

Office of Surface Mining, USDI
Albuquerque Field Office
219 Central NW.
Albuquerque, NM 87102

Office of Surface Mining, USDI
Casper Field Office
Freden Bldg.
935 Pendell Blvd.
Mills, WY 82644

Office of Surface Mining, USDI
Birmingham Field Office
228 West Valley Ave., 3d Floor
Homewood, AL 34209

STATE CONTACTS FOR ABANDONED MINE LANDS (TITLE IV)
AND REGULATORY (TITLE V) GRANT PROGRAMS

Title IV	Title V
ALABAMA	
Director Department of Industrial Relations 649 Monroe St. Montgomery, AL 36130	Director Alabama Surface Mining Commission P.O. Box 2390 Jasper, AL 35501
ALASKA	
Commissioner Department of Natural Resources Pouch M Juneau, AL 99811	Same
ARKANSAS	
Director Department of Pollution Control and Ecology 8001 National Dr. Little Rock, AK 72209	Same
COLORADO	
Director Mined Lands Reclamation Division Department of Natural Resources Centennial Bldg., Room 423 1313 Sherman St. Denver, CO 80203	Same
GEORGIA	
Commissioner Department of Natural Resources 270 Washington St. Atlanta, GA 30334	Same
ILLINOIS	
Director Department of Mines and Minerals Stratton Office Bldg., Room 704 Springfield, IL 62706	Same
INDIANA	
Director Department of Natural Resources State Office Bldg., 6th Floor Indianapolis, IN 46204	Same
IOWA	
Director Department of Soil Conservation Wallace State Office Bldg. East 9th and Grand St. Des Moines, IA 50319	Same

STATE CONTACTS FOR ABANDONED MINE LANDS (TITLE IV)
AND REGULATORY (TITLE V) GRANT PROGRAMS--Continued

Title IV	Title V
KANSAS	
Executive Director Mined Land Conservation and Reclamation Board 107 West 11th St. P.O. Box 1418 Pittsburg, KS 66762	Chairman Kansas Corporation Commission 915 Harrison St., Room 426 Topeka, KS 66612
KENTUCKY	
Secretary Natural Resources and Environmental Protection Cabinet Capitol Plaza Tower, 5th Floor Frankfort, KY 40601	Same
LOUISIANA	
Commissioner Department of Natural Resources and Environmental Protection P.O. Box 44275 Baton Rouge, LA 70804	Same
MARYLAND	
Administrator Energy Administration Tawes State Office Bldg. 580 Taylor Ave. Annapolis, MD 21401	Same
MICHIGAN	
Director Michigan Department of Natural Resources Stevens T. Mason Bldg. P.O. Box 30028 Lansing, MI 48909	Same
MISSISSIPPI	
Executive Director Mississippi Department of Natural Resources P.O. Box 20305 Jackson, MS 39209	Same
MISSOURI	
Director Department of Natural Resources P.O. Box 176 Jefferson City, MO 65102	Same
MONTANA	
Commissioner Department of State Lands Capitol Station Helena, MT 59620	Same

STATE CONTACTS FOR ABANDONED MINE LANDS (TITLE IV)
AND REGULATORY (TITLE V) GRANT PROGRAMS--Continued

Title IV	Title V
NEW MEXICO	
Director Mining and Minerals Division Energy and Minerals Department 525 Camino de los Marquez Santa Fe, NM 87501	Same
NORTH DAKOTA	
President Public Service Commission Capitol Bldg. Bismarck, ND 58505	Same
OHIO	
Director Ohio Department of Natural Resources Fountain Square, Bldg. B-3 Columbus, OH 43224	Same
OKLAHOMA	
Executive Director Oklahoma Conservation Commission 20 State Capitol Bldg. Oklahoma City, OK 73105	Deputy Chief Mine Inspector 4040 North Lincoln Blvd., Suite 107 Oklahoma City, OK 73105
OREGON	
Administrator Mined Land Reclamation Office Department of Geology and Mineral Industries 1129 South Santiam Rd., SE. Albany, OR 97321	Same
PENNSYLVANIA	
Director Office of Environmental Energy Management P.O. Box 2063 Fulton Bank Bldg., 7th Floor Harrisburg, PA 17120	Secretary Department of Environmental Resources P.O. Box 2063 Fulton Bank Bldg., 7th Floor Harrisburg, PA 17120
RHODE ISLAND	
Director Department of Environmental Management 83 Park St. Providence, RI 02903	Same
TENNESSEE	
Assistant Commissioner Bureau of Environment Tennessee Department of Health and Environment T.E.R.R.A. Bldg. 150 9th Ave. N. Nashville, TN 37203	Same

STATE CONTACTS FOR ABANDONED MINE LANDS (TITLE IV)
AND REGULATORY (TITLE V) GRANT PROGRAMS--Continued

Title IV	Title V
TEXAS	
Director Surface Mining Reclamation Division Railroad Commission of Texas Capitol Station P.O. Drawer 12967 Austin, YX 78711	Same
UTAH	
Director Department of Natural Resources Division of Oil, Gas, and Mining 4241 State Office Bldg. Salt Lake City, UT 84114	Same
VIRGINIA	
Abandoned Lands Manager Department of Conservation and Economic Development Division of Mined Land Reclamation P.O. Drawer U Big Stone Gap, VA 24219	Director Department of Conservation 1100 Washington Bldg. Capitol Square Richmond, VA 23219
WASHINGTON	
Commissioner Department of Natural Resources Public Lands Bldg. Olympia, WA 98504	Same
WEST VIRGINIA	
Director West Virginia Department of Natural Resources 1800 Washington St. E. Charleston, WV 25311	Same
WYOMING	
Director Department of Environmental Quality Equality State Bank Bldg. 401 West 19th St., 2d Floor Cheyenne, WY 82002	Same

STATE CONTACTS FOR ABANDONED MINE LANDS (TITLE IV)
AND REGULATORY (TITLE V) GRANT PROGRAMS--Continued

INDIAN CONTACTS FOR ABANDONED MINE LANDS (TITLE IV)
AND REGULATORY (TITLE V) GRANT PROGRAMS

Title IV	Title V
CROW TRIBE	
Chairman Crow Tribal Council P.O. Box 580 Tribal Administration Bldg. Crow Agency, MT 59022	Same
HOPI TRIBE	
Chairman Hopi Tribal Council P.O. Box 123 Kykotsmovi, AZ 86039	Same
NAVAJO TRIBE	
Chairman The Navajo Tribe P.O. Box 308 Window Rock, AZ 86515	Same

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