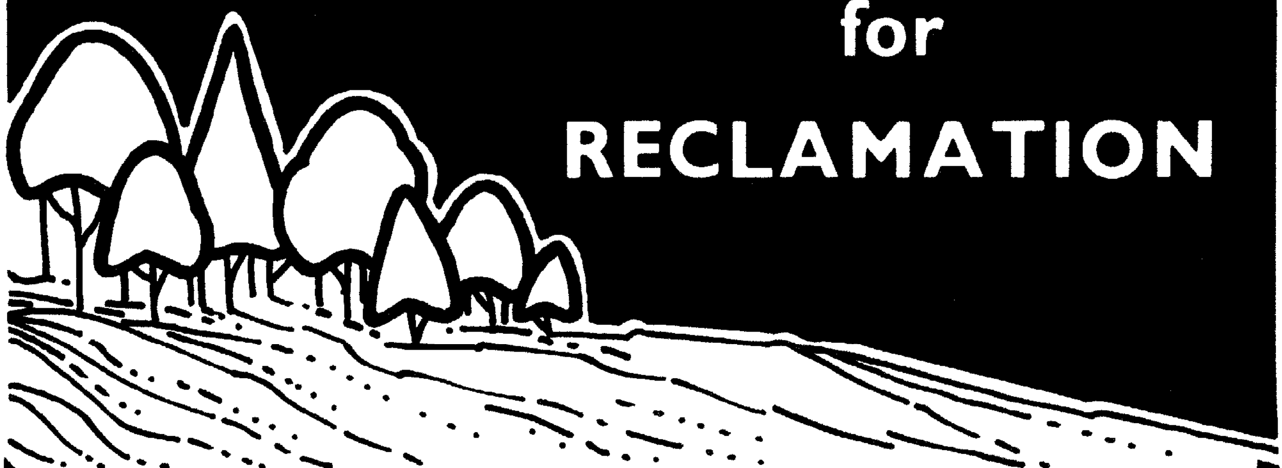
TREES for RECLAMATION



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General Technical Report NE-61

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TREES FOR TOMORROW[1]

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Abstract.--As coal production increases, forestry will become an increasingly important land use both before and after mining activity. New studies are needed to determine the long-range effect of mining in forested areas and to maximize the production of wood products on reclaimed areas.

INTRODUCTION

Chairman Kenes Bowling, fellow foresters, and reclamation specialists. I feel honored to be asked to speak here today. I have especially wanted an invitation to meet with you, so the invitation from Willie Curtis and Director Thorud struck a very responsive note. The reason is quite simple. It's because I believe that industry foresters, State foresters, and State Directors of Reclamation have a significant role to play in surface coal mining and reclamation.

I think the record of foresters associated with surface mining and reclamation proves that. More than 50 years ago, foresters were one of the first groups to undertake prompt revegetation of disturbed areas. I know that many of the State reclamation agencies originated in the forestry agencies and few people realize that through the leadership of the State Directors of Reclamation there now exists in States with commercial forest land regulatory language comparable to the California Forest Practices and similar Acts in Washington and Oregon. This is success with a capital "S". So you see, the forestry profession was leading, not following.

I don't need to tell you foresters about the many tree and shrub seedlings you plant or the direct seeding you do every year on reclamation operations on abandoned mine lands, or tell you about tree nursery production, or your work in forest-fire prevention around mined areas. You who are doing all this work already know about those things.

Instead, I want to tell you that I predict this meeting will stand out as one of your most remembered meetings, and here are some reasons why I think so.

Here is one reason: For the first time since passage of the Surface Mining Control and Reclamation Act of 1977 (P.L. 95-87) foresters in industry, States, and the Federal regulatory agencies are meeting to discuss their common interests. Just by meeting here, and reporting on this meeting, people will be made more conscious of the shorter term role of forestry in the reclamation of disturbed lands and the longer term opportunities for postmining land use in providing trees for tomorrow.

Here is another reason: For 2 days we can join in dialog on how we can help one another to implement Public Law 95-87 and the regulations under the Act. I do not know of a better place and time to discuss technically the broad area of forestry, whether as part of a State program, Federal program, Federal lands program, Indian lands program, or Abandoned Mine Lands program.

And another: Organization of this meeting by coal province and region enables industry, States, and Federal agencies to join in bringing an appreciation to the emerging opportunities, problems, and research needs for each of the coal provinces and regions.

And a fourth reason: There will be time at this meeting to discuss the process by which any person may petition to initiate a proceeding for the issuance, amendment, or repeal of any regulation under the Act.

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[1]Paper presented at the symposium "Trees for Reclamation in the Eastern U.S.", October 27-29, 1980, Lexington, Kentucky; sponsored by the Interstate Mining Compact Commission and the U.S. Department of Agriculture, Forest Service.

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It is 19 years since I helped launch the Berea, Ky., reclamation research program. The growth of this project and the research results have a very warm spot in my heart. So being here in Kentucky is like coming home.

ROLE OF FORESTRY IN SURFACE COAL MINING

Today, it is clear that there is an especially prominent role for foresters in postmining land use. But combining forestry and surface mining is a real challenge. "The past is prologue" is a statement in stone at the National Archives. Past success in planned and properly managed forests on some surface-mined sites is my greatest source of optimism for the future. And I am confident we are going to face the challenges in a realistic way, not with a torrent of words, but with teamwork in all our coal provinces. The importance of forestry becomes even more noteworthy with the inventory of land uses in surface-mined areas: 70-90 percent of the mining sites in States of the Appalachian coal province are in forest or reverting to forest, 35-55 percent of the mining sites in States of the Interior coal province are in a forest type. Thus, forest land is a concern of important proportions.

Projections of an average 4.6-percent growth rate in national coal production over the next 2 decades, pushing annual production from 700 million to almost 2 billion tons, suggest there is some hard work ahead for all of us. We cannot afford to think only in terms of total forested acres, we must focus our attention on productivity of forested areas.

And we cannot consider the role of forestry in surface coal mining and reclamation in a vacuum, as something separate and apart from other land uses. If forestry is to keep up with hayland, pastureland, and wildlife habitat as a land use, we must take steps as long as those of other uses. Let's evaluate past progress and present effort in terms of future needs and programs under the mandate of P. L. 95-87. It will be a new ball game for industry and the States once the States have achieved primacy under the Surface Mining Act.

NEED FOR RESEARCH

Forestry associated with surface coal mining provides a challenge for forestry research. Many forestry problems for surface-disturbed lands can be solved or lessened by applying knowledge and methods from the great body of technology developed for traditional forestry over the past 70 years. In other cases, disturbed-land's unique problems will require specially directed, new research efforts. Some areas where I believe research must be strengthened include:

- Techniques for promptly establishing and growing, tending, and harvesting trees or shrubs on disturbed sites and in harsh environments, including more efficient and faster planting practices
- Patterns of tree and shrub plantings for most efficiently obtaining diversity of species
- Methods to reclaim the wood fiber on areas to be surface mined
- Selection and breeding of superior species and varieties of trees or shrubs that are well adapted to living in the range of environments created by surface mining
- Macro and micro site requirements, growth and root characteristics, and nutrients to provide the basis for more intensive forest practices
- Increasing the production of high-quality seed, and better methods of harvesting, storing, processing, and certifying seeds, with emphasis on native species
- Developing improved measurement techniques and inventory procedures that are rapid, accurate, and readily adaptable for administrative use in measuring plant, root, and soil responses to surface mining

CONSIDERATIONS FOR THE FUTURE

What is immediately ahead as we enter the 80's? Increasingly, we will be challenged to truly consider all forest values, and to do something positive to enhance them. Have you ever considered the extent to which forest practices are oriented exclusively to timber production?

All too frequently, we pay little attention to lesser vegetation, to flowering trees, to shrubs, and to browse. Shouldn't our reclamation practices consider more of this? Won't we have to, as we move into the permanent regulatory programs under the Surface Mining Act.

It is my feeling that the State Foresters need to be involved in even greater measure in decision making involving the reclamation of forest sites. What does this involve? I visualize it basically as a joint State Forester and regulatory authority decision-making process based on programs, people, and funding.

On programs, I visualize for forest and related lands joint policy-making direction and thrust such as review and approval of reclamation manuals and supplements, operating procedures, and joint agreement on, and input to, experimental-practice studies.

On people, I would like to see a greater emphasis on what kind, where, and how many forestry specialists should be available for service to Directors of Reclamation. In particular, let's try to foster an interchange of forestry as well as reclamation personnel under the Intergovernmental Personnel Act procedures. I'm convinced that an employee with this experience is better qualified when he or she returns. Kipling said: "He knows not England who only England knows." We must communicate freely, exchanging views and sharing research findings. It is my earnest hope that in our discussions during the next 2 days we will be practical, and will explore a broader spectrum than usually occurs when professionals talk with fellow professionals about surface coal mining and reclamation for forest areas.

Let us consider wood production for a moment. We foresters have been indoctrinated in the merits of planting trees to grow more timber and a forest cover for watershed protection. Only of late has our thinking turned to shaping the landscape and microclimate and to improving mine-soil properties in order to maximize or optimize wood production and economic returns. As a practical matter, what are the criteria for such a forested site? In what manner and to what degree will this possibility for surface-mined areas affect priorities for postmining land use? This is the kind of problem that poses a challenge to the ingenuity of researchers and to those of us in regulatory agencies involved in rule drafting and permit, mine-plan, and reclamation approval. It should shake us foresters out of our classic patterns of thinking.

The foregoing can be equally applied to the development of wildlife habitat, range land, pastureland, or hayland.

To those of us who serve the public, there is another challenge. We have to deal with about 10,000 coal mine permits. In the Appalachians, three quarters of the surface coal mining occurs on forest land and on small holdings, many under 30 acres in extent. Kentucky alone has over 2,000 permits with an area of less than 30 acres.

State Foresters recognize the small tract as unfavorable to the practice of forestry. What, if anything, should and can be done to overcome problems associated with small tracts in the forestry information required for permit applications, reclamation plans, and monitoring, inspection, and enforcement programs?

EFFECT OF THE SURFACE MINING ACT

So far, I have talked of problems that we share as foresters. I think you will agree we will need to get more specific. Now let us get into the details for some of the State programs and rules under P.L. 95-87 which all of us -- industry, State, Federal, and university representatives -- may be discussing during the next 2 days. Let's quickly indicate the size of the subject we are talking about. I'm going to use a broad brush in painting this picture by using portions of 30 CFR Chapter VII of the Federal rules as a guide.

Summary of regulations

Subchapter A of the permanent regulatory program contains the definitions generally applicable to the programs and persons covered by the Act. The procedure for petitioning to initiate a proceeding for the issuance, amendment, or repeal of a regulation under Section 201(g) (1) of the Act is also described.

Subchapter C covers applications for, and decisions on, permanent State programs, and describes implementation of a Federal program in a State such as Georgia, which did not apply for primacy.

Subchapter D covers operations on Federal lands as opposed to State and private lands. Federal lands include federally-owned surface and privately-owned coal, as is likely to occur in a National Forest.

Subchapter F contains criteria for designating areas as unsuitable for all or certain types of surface coal mining operations and for identifying forest lands on which surface coal mining operations are restricted under Section 522(e)(2) of the Act to those that are technologically and economically feasible for reclamation.

Subchapter G covers requirements for permits and coal exploration under State programs, along with small-operator assistance. Michigan, Massachusetts, and Rhode Island are Eastern States where there is new activity in exploration.

Subchapter J contains criteria for bonding and liability insurance, including release of performance bonds on reclaimed forest lands.

Subchapter K covers the permanent program performance standards.

Subchapter R contains requirements for the Abandoned Mined Land program.

Lastly, Subchapter S covers the Mining and Mineral Resource and Research Institute program.

Permits

With that much background, let's get to the topic at hand, starting with permits (Chapter G). You are all aware that there are various court actions dealing with the permit regulations. Therefore, let's focus our attention on the Act rather than the rules. Section 507 of the Act, with its 23 subsections, contains a comprehensive tabulation of information that an applicant must assemble and submit to State or Federal regulatory authorities. Keep in mind the proportion of land that is in a forest setting.

I predict that Directors of Reclamation will be turning more frequently to State Foresters and asking what controlling watershed factors are needed to approve the site-specific permit applications. Section 507(b)(11) calls for "an assessment of the probable cumulative impacts of all anticipated mining in the area upon the hydrology of the area and particularly upon water availability." It's a new ball game for forest hydrologists. I am looking forward to hearing your views on this requirement, and the role of forestry.

Reclamation plans

Now, what about the reclamation plan requirements, Section 508 of the Act? It is my firm conviction that forestry needs to be more involved in planning for reclamation. The Act is very specific in requiring a statement on the condition of the forest land and productivity of the land prior to mining, the postmining land use, and plans to comply with the environmental protection performance standards of Section 515. Even though our knowledge of site-specific watershed behavior and the influence that mine soil and plant management have on waterflow characteristics is far from complete, we can still do much on the basis of present knowledge to increase mine-soil productivity and to make full use of mined-land resources while maintaining an optimum supply of usable water. Because so much of our forested land that is surface mined for coal is in small private ownership, with various management objectives and ownership purposes, it is a real challenge to bring these factors together successfully. The job ahead need not dismay us, for it is really a form of forest watershed reclamation, rehabilitation, or restoration planning that has been successful for decades.

Coal exploration

Coal exploration on forest lands has increased with the growth in energy needs. In many ways, we are still only at the beginning in exploration. The big job is still ahead in meeting the predicted growth rate in national coal production. Section 512 of the Act includes a requirement for an exploration permit when removing more than 250 tons. Roads are a prominent part of exploration. State Foresters should have an interest in this area because the ability to apply intensive timber-management practices, particularly timber-stand improvement, is closely correlated with access roads. Although not required in the rules, there is an opportunity for closer coordination of forestry and mine exploration in planning access-road systems.

Performance standards

Subchapter K, the permanent program performance standards, includes surface mining and reclamation operations for contour mining; area, box cut, open pit, and auger mining; mountaintop removal; and removal of coal from waste piles. I predict that as the various State programs become operational, the technical factors in this Subchapter will be reassessed from time to time by State Foresters, Directors of Reclamation, and State and Federal personnel.

In our discussions on this Subchapter let's stress what will it take to get the job done on the ground. Some of the factors which will affect trees for tomorrow are, as I see them:

- Topsoil
- Hydrologic balance
- Disposal of excess spoil
- Backfilling and grading

- Revegetation

- Postmining land use

- Protection of fish and wildlife.

The purpose of this list is to have a common point of reference to consider in some of the discussions that we are to have over the next 2 days. Time permitting, we may take revegetation, for example, and could have discussions on such topics as:

- Site evaluation

- Site preparation

- Seeding and planting techniques for trees and shrubs or nurse crop of grass

- Species selection

- Woody-plant seed laws which require seed certification and testing

- Topsoil substitution and supplements

- Monitoring

- Evaluation.

Another point in Subchapter K is that it provides for granting exemption from compliance with the performance standards of Sections 515 and 516 of the Act, on an experimental basis. One purpose is to encourage advances in mining and reclamation technologies as long as they conform with certain criteria: (1) the area used must not be larger than necessary to determine the effectiveness of the experimental practice, (2) the experiment must not reduce the protection afforded to public health and safety by the performance standards, and (3) the experiment must be at least as environmentally protective as the standard procedures would be during and after mining.

Bonding and insurance

Let's look at Subchapter J, bonding and insurance requirements. This Subchapter describes the amount of bond required to assure that the site is brought into compliance with the Act. The amount of bond must be adequate for the regulatory authority to complete backfilling, grading, topsoiling, and revegetation if an operator is unable to. The liability period for reclamation operations is required by the Act. An important concept is that while the filing and release of bond liability may be incremental, the bond liability applicable to a permit extends to the entire permit area. The amount of bond is calculated on the basis of reclamation costs and not directly on acreage. The criteria for bond release on forest sites are also included in the performance standards.

Areas unsuitable for mining

Another point is Subchapter F, areas unsuitable for mining. There are many technical and legal ramifications to these rules, which derive from Section 522 of the Act. It will be challenging to foresters to meet these requirements by developing practical local criteria for designating forest watershed sites as being so hazardous that there should not be any surface mining or land disturbance.

We should not lose sight of the fact that a substantial portion of the 20 million acres of forested U.S. Government lands was acquired by purchase under the Weeks Law of 1911 to protection watersheds and the Nation's navigable waters. In checking the justification for purchase, the U.S. Geological Survey has signed off on a substantial percentage of the land transactions as being made for watershed protection purposes. Since private lands are intermingled with many of these sites, I foresee as another challenge to the forest hydrologist, as to whether mining would be a hazard and would impact on the Nation's navigable waters.

Federal programs for States

Subchapter C involves the implementation of a Federal program on non-Federal and non-Indian lands within a State. Georgia is one State that will have such a program. Forestry will have a prominent role in the four coal-producing counties where much of the surface mining occurs on forested sites.

Abandoned mine lands

The role of trees in the abandoned mine land program is a particularly timely topic at this meeting. Subchapter R includes sources and uses of money for the abandoned mine land reclamation programs; procedures for the acquisition, management, and disposition of eligible land; reclamation on private lands; State reclamation plans and work; and the responsibility of the Secretary of Agriculture to carry out the Rural Lands Reclamation Program.

Keep in mind the U.S. Department of the Interior's Regional and Nationwide Survey under P.L. 89-5, in 1965, which reported that over 90 percent of the surface coal mining at that time was occurring on upstream sites in a forest or on land reverting to forest. Much of this area is part of the 2 million acres identified by USDA as needing land treatment. Trees have a definite, unique role in controlling runoff where it originates in headwaters and where mining was a temporary land use. Basically, the forestry measures essential to put these headwater lands in shape can only be bought, or ordered, or obtained by persuasion. One thing appears to be clear for these smaller forest areas -- persuasion alone is not getting the land-treatment job done fast enough. What, if anything, should and can be done to overcome the problem of the small size of these potential forest tracts?

SUMMARY

Part of my reason for being here is to express my appreciation to the State Directors of Reclamation and State Foresters for their interest in improving communications between our various fields of interest. We need more frequent technical meetings in the other land uses so we can better understand the problems of surface mining and reclamation, and what should be done about them. We who make reclamation our full-time, lifetime business do not know all the answers. So I'm trying to say that you get into the act from two sides: Helping to promote widespread knowledge and understanding of why surface mining and reclamation is vital, and helping to find practical answers.

You foresters and specialists in surface coal mining and reclamation are truly builders of a new landscape; your approach to your work is in the spirit of improving the forest environment, rather than merely continuing business as usual. May your plans be as wise as they are imaginative, and may your labors be your reaffirmation of the joint destiny of forestry and surface coal mining reclamation.

I am reminded of a statement attributed to Thomas Jefferson -- "It's a good thing a medal has two sides." He implied that while one side of the medal is for building up the ego of the recipient, the other side is there to remind the person of his or her responsibility.

How you use that responsibility is going to have a profound effect on trees for tomorrow.

Again, thank you for the opportunity to meet with you today.

TREES FOR RECLAMATION IN THE EASTERN UNITED STATES

LEXINGTON, KENTUCKY

OCTOBER 27-29, 1980

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The Alabama Forestry Commission promotes reclamation through forest resource education providing seedlings for reclamation and assistance to industry and landowners. Approximately 85% of the lands mined in 1979 will go into forest production. Good forest management on reclaimed lands will enable Alabama to meet its future demands for forest products.

Since the inception of the Alabama Forestry Commission in 1969, it has been charged with the responsibility of public education of the people in Alabama concerning timber and forest and other natural resources of Alabama. Educational efforts have been geared toward informing the general public of the role of forestry and how it benefits first the landowner and secondly the state.

The ultimate determinate of post mining land use is the goal or goals of the landowner. We must honor their rights or ownership and it is our hope that through a more enlightened public that landowners will choose forest management as a viable alternative in post mining land use. This is, in fact, what is happening. Of the 28,528 acres permitted for surface mining in 1979, approximately 85% of the land will be planted to a forest species.

Assistance is being provided to landowners and industry alike through the Alabama Forestry Commission specialist group. A program designed to give foresters with the Commission an opportunity and flexibility in their work schedules to address particular areas of forestry. Tom Kimbrell, the state surface mine specialist, works with both landowners and industry on specific problems they may have. Tom is also working to establish plantations of Paulonia (<u>Paulonia tomentosa</u>), an invader species on many Alabama mine spoils. Paulonia is being exported to Japan where it is used to produce a high quality veneer.

The State Nursery has long contributed to Alabama's reclamation effort by producing high quality pine seedlings for reforestation. The vast majority of the reclaimed lands that go into forest production have been regenerated to one of the major yellow pine species, that is, loblolly pine, longleaf pine, shortleaf pine and virginia pine. The Commission's nursery goal for the 1980-81 season is to produce 80 million pine seedlings. At this level of production, there should be no immediate problem meeting the states overall needs for pine seedlings in the coming seasons. Hopefully, in the not too distant future, our nursery section will be able to add to those species already being produced a number of other species that will be beneficial for improving wildlife habitat and reclamation.

The Commission's improved seedling program is young by many standards, but it is a bright ray on the horizon. Gains in both volume and quality are expected from improved seedlings from Alabama's own orchards. Our improved seedlings show promise of increase in volume production of 15-20% from first generation seedlings. Quality factors such as straightness, small knots and branching angle are more difficult to quantify, however, we expect also a 15-20% increase in quality factors from the improved seedlings. Alabama's 351 acres of pine seed orchards range in age from one to twelve years. These orchards are now producing about twelve million improved seedlings a year - 1/5 of the states needs.

Seedling orders now have to be prorated, allowing no single landowner more than 20% of his total order to be improved seedlings. It is our aim to be producing 100 million improved seedlings from our improved seed orchard by 1990.

In conclusion, I would like to say that the good reclamation effects us all, no matter what area of forestry we are pursuing. It is a fact that some of our best timber lands are going into agricultural production and that the demand for forest products will increase in coming years. If we belittle the productive capability of reclaimed lands and pass off reclamation as having only cosmetic value or just a practice to save the conscience of the general public, we will be neglecting a valuable resource. A resource that will be needed if our nation's future demand for wood products are met.

MINE RECLAMATION IN ARKANSAS

Presented at Trees for Reclamation Symposium
in Lexington, Kentucky on October 27-29, 1980 by

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Open cut mine land reclamation laws have only been effective since 1971 in Arkansas. Since that time all land affected by mining had to be reclaimed. To guarantee reclamation, the first law required a $500 per acre surety bond be posted with the Arkansas Department of Pollution Control and Ecology. The Arkansas Open Cut Land Reclamation Act of 1977 changed the bonding requirements to the estimated cost of reclamation. Even so, there were no specific guidelines setting forth required species of grass, legumes, or trees to be used in reclamation. Consequently, the trend was to revegetate with grasses or legumes for pasture.

Mining in Arkansas is done on relatively small tracts which are mostly unforested; therefore not many forested acres have been disturbed. For example just over 300 acres were considered reclaimed during the period July 1979 through July 1980. With the advent of the Surface Mining Enforcement and Reclamation Act of 1977 (Public Law 95-87) requirements are more stringent, and coal mine operators are being encouraged to plant tree seedlings as part of their reclamation efforts.

Pre-law mine spoils have revegetated naturally to mixed hardwoods and some softwoods. To effect reclamation of these lands, would, in some instances, probably do more harm than good because of destruction to established cover, notwithstanding the loss of wildlife habitat.

It is expected that in the near future, strip mining activities, especially lignite, will increase significantly. One lignite producer alone intends to disturb 1,000 acres per year. Lignite mining will be concentrated in heavily forested areas in which forest industries own significant acreages. Therefore, it is anticipated that much of this land will be reforested mostly with softwood species with some hardwoods.

The Arkansas Forestry Commission, in cooperation with the Arkansas Department of Pollution Control and Ecology, Bureau of Mining, Soil Conservation Service and other agencies, have made plans to install tests to determine which species of trees are best adapted to grow on various strip mined spoils in Arkansas. These tests are to be established on old pre-law spoils owned by the Corps of Engineers near Russellville, Arkansas, which is to be reclaimed under a research and development project financed by the Abandoned Mined Lands Program of the Office of Surface Mining. This research project should give us much needed information on appropriate species of trees to recommend for revegetation of surface mined areas.

Currently, species are recommended based on other state's research plus local tree species appearing adaptable. Arkansas Forestry Commission nurseries are presently producing limited quantities of various species of hardwood seedlings. Both regular and genetically improved loblolly and shortleaf pine are also being grown for sale to private landowners throughout the state. Special efforts can and will be made to procure from other nurseries appropriate seedlings for revegetation for reclaimed areas until such time that Arkansas Forestry Commission nurseries can produce sufficient quantities of seedlings necessary for reclamation efforts. Arkansas Forestry Commission nurseries will produce required seedlings as these are determined.

By working closely with the Department of Pollution Control and Ecology, the Arkansas Forestry Commission will be kept informed of the reclamation plans of various companies and individuals. This will give us advance information as to the species and amount of seedlings required so that the nurseries can plan accordingly.

In the event that a surface mined area has been reclaimed in grass and the landowner decides that he wants to grow trees, he can get additional financial assistance through the Forestry Incentives Program (FIP) and technical assistance from Arkansas Forestry Commission field foresters. These measures should encourage additional landowners to revegetate more reclaimed areas with tree seedlings.

A LOOK AT TREES AND RECLAMATION IN GEORGIA

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Abstract.--The author briefly reviews Georgia's land reclamation requirements when rehabilitating mined lands with trees as one's reclamation objective. Techniques used to establish two plantations are used to raise several important issues which, if resolved, can result in increased tree planting and lower land reclamation cost.

INTRODUCTION

Tree planting was recognized as a valuable land reclamation practice early in the development of Georgia's program for rehabilitation of mined lands. Original Land Reclamation Rules, promulgated January 19, 1969, established forestry as one of several objectives which a mining operator could choose when reclaiming lands affected by surface mining.

Georgia's original rules involving forestry specified: "An approved cover of trees must be established on affected areas. The character and nature of the overburden (soil fertility, pH, drainage, etc.) must indicate that same will properly support growth of the species selected for planting. On lands where tree crops are planted, a minimum of 500 uniformly distributed trees per acre must be established. No fail spots larger than one-fourth acre in size will be permitted."

In 1971, Georgia's Land Reclamation Rules were amended. Forestry was still an allowable reclamation objective and similar requirements prevailed as to the selection of species for planting, number of trees per acre to establish, size of fail spots, etc. An important addition to the Land Reclamation Rules concerning forestry was: "When affected lands are being developed for forestry the operator will, in addition to trees, establish a protective vegetative cover of some other type plant, such as grass, to assist in preventing excessive erosion pending the development of forest tree seedlings into trees."

This paper raises certain issues which are important to the reclamation of mined lands, using forestry as one's major reclamation objective. To accomplish this, a brief case review of two loblolly pine *(Pinus taeda)* plantations established by mining companies to fulfill their legal reclamation obligation is presented. Planting techniques used to establish the plantations were similar, as each site was machine planted. Cultural practices used varied and are shown in Table 1.

Table 1.--A comparison of cultural practices used by two mining companies when reclaiming mined lands using trees

Practice	Plantation A	Plantation B
Site preparation	Backfilled and graded to rolling topography.	Backfilled and graded to rolling topography
Type growing media	Low grade, kaolin-type clay and white sand. Heterogenous in nature.	Best available spoil - yellow sandy mixture.
Site preparation:		
Subsoiling	None.	18 inches.
Fertilization	None at seedling planting.	500 lbs. 6-12-12, 500 lbs. superphosphate, 1 ton dolomitic lime and 100 lbs. N. prior to seeding ground cover.
Vegetative cover	No type ground cover established prior to tree planting.	A ground cover consisting of common Bermuda, lovegrass and sericea lespedeza 1/ seeded prior to planting tree seedlings.
Post-planting treatment	6 ozs. 10-10-10 per seedling. 400 lbs./acre 10-10-10 in 1972, 200 lbs./acre of 20-20-20 in 1974, 1977 and 1979.	500 lbs. 10-10-10 one year after seeding.
Fertilization frequency	Five varied applications.	Once following planting.

1/ common Bermuda grass *(Cynodon dactylon)*, lovegrass *(Eragrostis [illegible])* and sericea lespedeza *(Lespedeza cuneata)*.

PLANTATION A

Company A, in their initial reclamation work in Georgia, chose to develop mined lands for forestry purposes. This company established loblolly tree seedlings on a previously mined area during the fall of 1969. Prior to planting, lands were backfilled and graded to a gentle, rolling topography but with long, uninterrupted slopes. No protective ground cover was established. The planting media consisted primarily of white sands and kaolin-type clays and was primarily void of plant nutrients (see Photo 1). To obtain growth of seedlings, it was necessary that each individual tree be fertilized. This was initially accomplished using crews of laborers to place 6 ozs. of 10-10-10 about 6 inches from the stem of each seedling. Ground operated fertilizer spreaders applied 400 lbs./acre of 10-10-10 in 1972. Aerial applications of fertilizer were made at 200 lbs./acre of 20-20-20 in 1974, 1977 and 1979.

Photo 2.--Plantation A - showing growth and development of planted loblolly pine during July, 1980. Note ground cover resulting from pine straw.

Photo 1.--Plantation A - Loblolly pine plantation established on kaolin mined lands to fulfill forestry reclamation objective. Note lack of protective vegetative cover, growing media and presence of erosion. Photo taken 10/73.

Statistical data on development of Plantation A is shown in Table 2. Diameter growth averaged approximately .5 inch per year. Average height growth was 2.8 feet annually. Forest floor litter, after 11 years and where present, averaged approximately one-half inch in depth (see Photo 2). Gullying by erosion from improperly managed surface runoff was present and is illustrated in Photo 3.

Photo 3.--Plantation A - showing typical gully resulting from surface runoff erosion. Photo taken 7/80.

Table 2.--Statistical data for Plantation A showing average D.B.H., height and number established stems per acre through July, 1980.

D.B.H.	Height	Stems/Acre
4	25	40
5	29	37
6	31	43
7	35	45
8	39	15
9	44	2
10	42	6
	Total	188

Average D.B.H. - 6"
Average Height - 31'

PLANTATION B

Company B elected to reclaim 600 acres of previously mined land. This company's site was graded to a rolling topography, blended into the existing landscape and planted to a permanent vegetative cover of common Bermuda grass, lovegrass and sericea lespedeza.[1/] Loblolly pine tree seedlings were planted during the spring of 1972, the first planting season after the establishment of the ground cover (see Photo 4). A commercial fertilizer (6-12-12) in the amount of 500 lbs. per acre and 1 ton of lime (dolomite), along with 500 lbs./acre of superphosphate and 100 lbs. of nitrogen, were applied prior to seeding of the permanent vegetative cover. A top dressing of 500 lbs./acre of 10-10-10 was applied about one year after seeding of the site. No additional fertilization was given to forest tree seedlings after application of the top dressing. The pine trees developed in a satisfactory manner, were never chloratic and have made acceptable growth. Trees involved have been windfirm and a minimum amount of erosion occurred on the site.

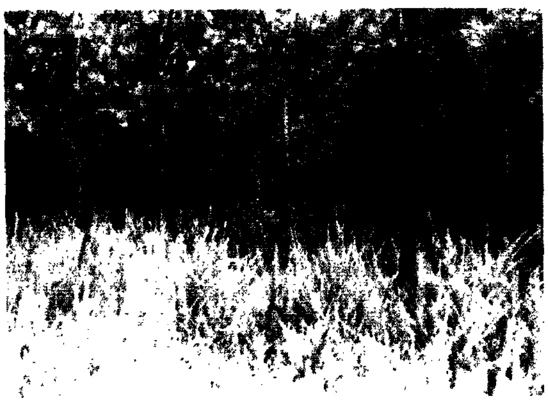

Photo 4.--Plantation B - loblolly pine trees established on mined lands in protective cover of sericea lespedeza. Photo taken 7/80.

Information concerning development of Plantation B is shown in Table 3. Diameter growth averaged .6 inch annually, while average hieght growth was 3.5 feet per year. The forest floor under this plantation, after 8 years, was completely covered with litter that averaged 1 inch in depth (see Photo 5).

Photo 5.--Plantation B - showing typical view under canopy during 7/80. Note density of protective vegetative cover and loss of same due to shading by canopy. Site had 100% cover of litter resulting from leaf and needle fall, with minimum erosion.

Table 3.--Statistical data for Plantation B showing D.B.H., height and number established stems per acre through July, 1980.

D.B.H.	Height		Stems/Acre
4	26		114
5	28		98
6	30		46
7	32		14
		Total	272

Average D.B.H. - 5"
Average Height - 28'

DISCUSSION

Several important land reclamation and forestry issues are suggested when one compares management techniques used to establish the two pine plantations. Silvilculturists would be interested in a comparison of the economics of the two cultural methods employed to establish trees and grow same to their present state. This paper has not attempted to examine the cost of management techniques involved. If one should attempt a cost-benefit ratio study, it must be remembered that a normal forestry site is not present but one on which a legal land reclamation obligation exists to rehabilitate lands drastically disturbed by mining. The legal obligation regarding the reclamation of mined lands raises the question of "how far can one go 'cost wise' applying various silviculture techniques to reclaim affected acres using forestry as a reclamation objective?"

In Georgia, tree planting on mined lands has been minimized since the Land Reclamation Rule change requiring that a permanent vegetative cover be established when trees are planted. It is accepted land reclamation procedure to require the planting of a ground cover with trees. Reclamationists have observed sites being reclaimed where erosion of bare lands under young planted trees was heavy and visually rendered a site unacceptable.

Most Georgia based mining companies assumed the attitude that it was advantageous to their operations to reclaim mined lands for pasture or grasslands rather than forest land. By following this course of action in conducting reclamation work, mining operators were not legally obligated to the State to establish tree crops and were free to conduct their tree planting activities at a later date following reclamation and release of lands involved.

Ground cover requirements for State land reclamation programs and miner's attitude resulting from same spawned an important issue regarding tree planting activities on reclaimed lands. Forest managers and reclamationists should determine the long-range economics and environmental impact of requiring a ground cover on all sites when trees are planted. Study is needed, when forestry is one's reclamation objective, to determine how much erosion and gullying one can tolerate and yet produce and harvest an acceptable tree crop. When reclaiming mined lands with trees, what period of time should one's reclamation objective be confined to? Is it proper for one to consider a short term land reclamation objective or extend reclamation to include a reasonable forestry rotation?

Twelve years ago, when I officially entered reclamation work in Georgia, I was a staunch advocate of grass first, then trees. Since I have had the privilege of observing the two plantations previously discussed, my support of the "no grass-no trees" policy is failing.

I am of the opinion that reclamation cost to industry can be minimized and increased tree planting on mined land realized if we reevaluate our land reclamation specifications. I'm convinced trees "over the long term" will accomplish more reclamation than they have been given credit for.

In conclusion, research organizations are encouraged to examine the several problems mentioned. In summary, they should provide long-range guidance to issues such as:

1. Should all reclaimed sites have a vegetative cover established when planting trees?
2. Can tree plantations established on mined lands sufficiently stabilize a site so that it can be classified as reclaimed and at what age?
3. What period of time can be considered reasonable when using forestry as a reclamation objective?
4. How much erosion, including gullying, can one accept on a reclaimed site when forestry is the reclamation objective?
5. How may visual or aesthetic problems which appear early in the life of a forest tree plantation be minimized?
6. Will tree seedlings and heavy straw mulch produce an acceptable reclaimed site?

In Georgia, we do not know the answers to questions raised. We certainly hope work will be initiated to find solutions which will stimulate tree planting during mined land reclamation activities. After all, one realizes little financial gain from grasslands without livestock; but planted trees will yield future dollars.

RECLAMATION WITH TREES IN ILLINOIS

Paper presented at the symposium,
Trees for Reclamation in the Eastern U.S.,
Lexington, Kentucky, October 27-29, 1980

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Thru private initiative, Illinois citizens historically have invented and conducted large-scale tree planting programs, starting with hedgerow fences and farmstead windbreaks and continuing with surface mine reclamation and farm woodlands. With invaluable help from public and private scientific personnel, the old and new programs hold promise of enlargement and increased success.

When talking about planting trees, whether on surface coal mines or on farms, we think Illinois has an interesting record. Historically, tens of millions of hardy osage orange seedlings were produced and planted as hedgerows for fences by private nurseries and pioneer farmers before and after the Civil War. Our pioneers planted them to confine cattle, to protect crops, to define property, and to civilize the prairie winds. Appreciated and known as hedgerows for 100 years by fencepost cutters and by sportsmen, they provided an enormous habitat for wildlife, something not originally contemplated. Unfortunately, the popularity of osage orange hedges dwindled with the coming of the bulldozer, single - crop grain farming, and intensive agriculture. Many of our citizens and foresters still mourn the passing of this excellent wildlife habitat and the durable osage orange fencepost. It is almost the only forest crop, except Christmas trees, which has been planted and grown commonly in Illinois and sold for a profit. These hedge posts have lasted in the soil for 60 years and more without failure.

Historically, Illinois experienced other enthusiastic planting programs. One promoted a surprising number of catalpa plantations along railroads for tie production. So far as is known, none were ever harvested. Other programs were moderately successful in establishing farmstead windbreaks and a few black walnut plantations.

In modern times since the institution of of State tree nurseries, public foresters, and organized conservation agencies beginning in the 1930's, Illinois strip miners and foresters have planted approximately 50 million tree seedlings. To all classes of tree planters in Illinois, the State has distributed an estimated 300 million trees since 1935. During the first half of this modern period, the surface mines generally preferred to plant conifers. Since 1955, the hardwoods have gained in popularity with the mines and with foresters advising them. The popularity of various species has changed radically over the years and is changing even now in response to improvement in mine spoil acidity (now outlawed by reclamation laws), in response to failures from insects and diseases, in response to ice storms and extreme climatic factors, and in response to a myriad of other factors foresters learned by bitter experience.

Illinois tries to learn from experience; but, unlike a farmer or an agronomist experimenting with an annual grain crop and confronted only by the potential disaster of a single year, a forester's tree crop must withstand every catastrophe common to half a century. The forester cannot plow under a 20-year-old mistake as easily as an agronomist might plow under an insect-damaged corn or alfalfa crop. The tree species he selects must be ready to withstand the worst ice storm, the worst drought, the worst insects, the worst diseases likely to appear on the horizon in 50 years. The gamble is far greater than with annual corn or soybeans. Many foresters, it seems to me, have not weighed these odds sufficiently in choosing species or combination of species and spacings to use. Possibly because of these increased risks, foresters often choose to plant legumes and grasses on surface mines instead of trees. The chance of quicker, greater and more certain profitability is often the overwhelming factor. Until timber prices rise drastically, it will be a stubborn factor to dislodge or ignore.

In Illinois, we are faced by extremes in temperature, rainfall, wind, drought, and other climatic factors affecting tree survival, growth, and damage. But among our serious risk factors in tree plantations, the principal ones seem to be insects and diseases. Furthermore, we are not well equipped to handle these problems, since forest entomologists and pathologists are not generally present on most forestry staffs and are not readily available for field advice to forest owners. In addition, the treatment of these problems often is not economically feasible. As a result, we frequently decline to plant certain species because of insects. At this time, we are inclined to favor the planting of hardwood native species.

The good news, however, is that we have many fine scientists in our land-grant colleges, our Federal and State research centers, and in our field forces. If anything can be done, it will be known to our scientists and the information will be available.

Our state is appreciative of the research which has been and is being done on surface mines in the fields of soil compaction, natural invasion of native species, soil reconstruction, and especially studies of the benefits of introduced soil mycorrhizal fungi for improved reforestation on adverse sites.

Surface coal mining is a very significant part of the economic climate in Illinois. Our mine reclamation with pastures, timber, and even with row crops has been quite successful for several decades. We hope you will have an opportunity to visit some of this work.

USING TREES ON RECLAIMED MINED LANDS IN SOUTHERN ILLINOIS

Jim Sandusky

Abstract.--In southern Illinois Peabody Coal Company included reforestation as a part of its ten year plan for the reclamation of acid mine spoil. Hand planted trees had highest survival rates. The species that proved most successful were black locust, autumn olive, sweetgum, black alder, loblolly pine, and river birch.

Tree planting on surfaced mined land in Illinois began in the spring of 1920. Approximately 9,000 mixed pines and hardwoods were planted on a mine site near Danville, Illinois. However, it wasn't until the 1930's that mined lands were planted to trees on a large scale. In 1937 a cooperative program was initiated between six coal companies and the Illinois Division of Forestry. This initial agreement resulted in over a quarter of million trees in the spring of 1938.

In 1939 the Illinois Coal Strippers Association made an arrangement with the Illinois Forestry Division to plant an equal amount of acreage that was stripped annually by the coal companies. This resulted in the planting of over seven million trees from 1941 to 1945.

Planting of trees on Peabody Coal Company's Will Scarlet Mine began in 1956. This was five years prior to Illinois' first reclamation law effective January 1962. At first, large blocks of pines were planted, chiefly loblolly pine (Pinus taeda) and Virginia pine (Pinus virginia). These plantings were chiefly for esthics and for covering the un-reclaimed mine spoil.

After 1961 a larger variety of species was used. The species included black locust (Robinia pseudoacacia), sweet gum (Liquidambar styraciflua), sycamore (Platanus occidentalis), river birch (Betula nigra), red oak (Quercus rubra), silver maple (Acer saccharinum) and white pine (Pinus strobia). Introduced species included such trees as autumn olive (Elaeagnus umbellata), and European black alder (Ulnus glutinosa). At this time the Open Cut Land Reclamation Act (OCLR) of 1962 came into affect.

This law made no requirements on grading other than firelanes be constructed to a minimum width of ten feet and be located every 440 yards. A minimum number of 680 trees per acre was required to be planted. No sampling procedure was required and, after ten years the reclamation bond was released even if no tree survival was evident.

In 1968 the Surface-Mined Land Reclamation Act (SMLR) was passed. This act was more strigent than the first (OCLR) in regulating survival rates of 450 trees after the second growing season. A sampling procedure was also implemented. Fire lanes of 25' width had to be constructed at 440' intervals.

The Surface-Mined Land Conservation and Reclamation Act (SML) was implemented in 1971. With the passing of this act (SML) the pendulum swung from forestry practices to the establishment of permanent pastures on the reclaimed mined lands. The reason for this change away from trees was the new grading requirements. The grading requirements passed in this act stated that all exterior slopes must be graded to 30% and interior slopes graded to 15%. With the elimination of the spoil ridges, farm machinery could traverse the entire area, making it much easier to establish permanent pasture as a vegetative cover. This method was much more favorable, especially to the larger area surface mines which where affecting 50 to 400 acres annually.

In 1974 Peabody Coal Company's Will Scarlet Mine began a ten year plan which would reclaim 2600 acres of acid mine spoils. This included a large watershed which was located adjacent to the South Fork of the Saline River. A multiple land use for this area was designed with four categories. These were forestry, wildlife, livestock management and recreation. This land use plan had two purposes: to rid the area of an environmental hazard of acid mine drainage and to create a higher and better land use.

Tree species used for this project were selected for the following criteria: 1) commercial forest; 2) acid tolerance; 3) wildlife, and 4) esthics.

Those trees selected for their commercial desireability were black walnut (Juglans nigra) red oak, yellow poplar (Liriodendron tulipifera sycamore, sweet gum, cottonwood (Populus deltoides), and southern yellow pines (Pinus spp). Site selection for these species was determined from those spoils that had the highest soil pH. These species were planted on 6 x 7 spacing giving a planted seedling population of 1037 trees per acre. All species were mixed during planting giving a heterogenous stand.

Both mechanical and manual planting was employed the first three years. The fourth year all trees were planted manually. Those areas planted by hand tended to have the highest rate of survival. The loose shaley material of spoil along with the tendency to get J-rooting of seedlings necessitated the elimination of the mechanical tree planters.

Since over 90% of the pre-law mined lands in the Will Scarlet Mine area was created from strip spoils of the Davis and Dekovan seams, high acidity problems developed. These two coal seams are very high in sulfur and the overburden covering them is also very acidic. Soil test on some spoils showed a pH from 2.8 to 3.4 with total sulfur exceeding 8%. Therefore, in grading of these pre-law spoils new unleached toxic materials were brought to the surface. To counteract this acidity, 12 to 30 tons per acre of agriculture limestone were broadcast spread. After the areas had been limed they were disced. Acid tolerant tree species were then selected for planting. These tree species included black locust, European black alder, river birch, autumn olive and bristly locust (Robinia hispida).

The plant methodology of these acid tolerant species included small blocks and strips. We found that both black locust and autumn olive planted as close as 4' x 4' spacing on steep slopes created very good erosion barriers.

In the planting schematic high emphasis was made on establishing herterogenous stands of hardwoods planted in strips or bands. These bands were layed out in such a manner as to create as much wildlife "edge" as possible. The contour of the topography was followed in using these bands much in the same manner as contour farming is practiced. Open strips between the tree bands were left and were seeded to grasses and legumes.

Where possible, the outer perimeter of the hardwood strips was planted to loblolly pine, white pine, autumn olive and black locust. Cypress (Taxodium distichum) was used extensively to border the small ponds and the longer lakes.

Screenings of loblolly pine and white pine have been planted around the exterior perimeter mainly for aesthetic purposes. Volunteer cottonwoods, willow, and river birch have come in on most of the areas planted.

The species numbers and stocking rates per acre reflect the adverse conditions encountered on this one particular area.

Tree mortality during the first year is extremely high. In three of the past five years extremely dry weather has followed the spring planting season. Droughty conditions coupled with the highly acidic spoils have greatly reduced survival. Therefore, large tree populations of over 1000 trees per acre have been planted. In 1979 the most favorable spring of the past five occurred. After one year's growth, mortality was recorded at its lowest. Survival for this particular year was 63%, giving approximately 600 live trees per acre after one year. The spring of 1977 survival was as low as 13% of the total trees planted. An extremely dry spring, coupled with receiving planting stock late from the nurseries, led to this high mortality.

The success in 1979 was attributed to three factors: All areas to be planted were seeded to cover crop of Balboa rye the preceding fall. Planting stock was obtained from the nursery in February, and all planting was completed by the end of March. During the spring and summer growing season adequate precipitation fell.

Sampling procedures to determine survival were carried out by running transects of 100 tree counts and averaging the number of transsect lines. No statistical averages or other computations were made.

Planting methods consisted of mechanical, manual and direct aerial seeding.

Mechanical planting was accomplished by using a double and single row tree planter pulled behind a D-4 cat tractor. This method of planting was eliminated due to the poor survival that resulted from it. The reason for this was the failure to close the trench properly, letting the tree roots dry out. Also a high degree of J rooting was caused because the shaley soils did not permit the trenching plow to penetrate deep enough.

A higher degree of survival was obtained from using manual hand planting. Forestry technology students from Southeastern Illinois Junior College were employed and paid on a per tree basis.

In the spring of 1980 an attempt was made to aerial seed black locust. Two pounds of seed to the acre were aerial broadcast using a helicopter. Inaccessible areas such as high walls and final cut spoils above water impoundments were seeded in this manner.

The black locust seed was scarified prior to being aerial seeded. The method for scarifying was soaking the seed in weak solution of sulfuric acid for forty-five minutes and rinsing with water and baking soda. At this time no seedlings have been noticed on the areas that were aerial seeded.

In 1978 fertilizer pellets of 18-8-3 analysis were used. A pellet was placed adjacent to each tree as it was manually planted. Both black locust and loblolly showed some response to this fertilizing. No specific data was correlated on these plantings other than visual observations.

On one site of black locust, the trees on one side of an access road were fertilized while the trees on the opposite side of the road were not. The fertilized trees seemed to have a higher rate of survival and greater degree of total height. Some individual trees grew to heights of six feet the first growing season.

Loblolly pine showed also a higher degree of survival with fertilized trees. However, severe infestation of Nantucket Pine tip moth (Rhyocionia frustrana) on both fertilized and unfertilized trees greatly surpressed growth.

SUMMARY

1) The first planting of trees in Illinois began in the spring of 1920 and by 1938 a cooperative program had materilized with coal companies and the Illinois Division of Forestry.

2) Tree planting on voluntary basis began on Peabody Coal Company's Will Scarlet Mine in 1956. Loblolly and Virginia Pine were the principal species used.

3) In 1961 a larger variety of both hardwoods and pines were used.

4) Earlier reclamation laws made forestry a higher priority in the reclamation strip mined lands.

5) In 1974 a ten year program was initiated at the Will Scarlet Mine to clean up 1600 acres of pre-law spoils. Due to the high acidic nature of the regraded spoils, large amounts of agricultural limestone was applied.

6) Species in the clean up progr chosen for: commercial forest; aci wildlife, and esthics.

7) Trees were planted both mecha manually. A higher degree of survi plished by manual plantings.

8) Aerial seeding and fertilizin been attempted. No favorable resul have been attributed to either prac

FORESTRY AS A RECLAMATION PRACTICE

ON STRIP MINED LANDS IN KANSAS[1]

Harold G. Gallaher and Gary G. Naughton[2]

Abstract.--A general description of the significance of coal strip mining in Kansas and the current efforts to reclaim spoil banks to forest uses. Landowner's objectives are shown to be the most limiting factor in forestry operations.

Strip mining for coal in Kansas began in the 1860's with horse-drawn equipment and hand tools, working on seams exposed at the surface along creeks and bluffs. Drift and tunnel mines began at about the same time. By 1877, a steam-operated shovel had been introduced and stripping of surface overburden began. In 1918, the first electrically powered shovel was used and strip mining rapidly displaced tunnel mining in the region (Pierce and Courtier, 1937).

Kansas coal occurs in the eastern one-fourth of the state in what is part of the Western Interior Bituminous Coal Province (Powell, 1974). Currently, there are six commercial seams of bituminous coal in southeastern Kansas occurring in association with shales, limestones, and sandstones of the Pennsylvanian Era sediments. Some commercial grades of fire clay are also found at some sites.

The occurrence of large amounts of iron pyrites in Kansas coal causes three significant problems:

1) The sulfur fraction of the pyrite gives an average yield of over 3% sulphur to our coal, which in turn causes problems in combustion from the air pollution point of view.

2) The weathering of these exposed pyrites left on old mine dumps and tipple sites is a source of sulfuric acid pollution in pit waters and local streams.

3) The oxidation of pyritic materials creates "hot spots" of toxic wastes which occur randomly throughout the spoil banks and inhibit reclamation efforts.

The reclamation problem in Kansas is not large in scope. Since 1969, we have had the Mined Land Reclamation and Conservation Act (Kansas, 1968), which requires new mines to be leveled to a substantially flat surface. The visible results of this "reclaim as you go" requirement, are readily apparent. Revegetation is predominantly to fescue pasture or wheat, both of which are common local products of farming practices on un-mined lands. Other common perennial forages used include alfalfa, clover, vetch, and warm season native grasses.

Prior to the 1969 law, some 46,000 acres of strip mined lands were unreclaimed and not subject to the provisions of the new law. This represents only .08% of the land in Kansas and is thus not a massive problem from the State perspective.

However, most of this abandoned land is in a two-county area which has been impacted by the ups and downs of the coal-mining economy for over a century. In these two counties unreclaimed strip mined lands cover approximately 6% of the area--still not a massive problem. But, there are some townships which are nearly 50% strip mined due to the concentration of the commercial coal seams. As in all problems, the perspective is important.

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[1]Paper presented at the Trees for Reclamation Symposium, Lexington, Kentucky on October 27-29, 1980.

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As early as 1935, the U.S. Forest Service established tree plantation research plots in Kansas strip mines (Roger, 1949). In 1967, the Forestry Department at Kansas State University initiated research in the strip mines based upon the work of the USFS and designed to evaluate tree species selection and management practices which would be feasible and practical for the reclamation of strip mines as productive forests, (Geyer, 1971).

Hardwood forests occur naturally on about 10% of the land in the region of Kansas where strip mining has been concentrated. Our work with private landowners and public officials has been based upon the concept that, ideally, 10% of land reclaimed would return to forest uses so that the agricultural economy of the area would approach normalcy.

The Forestry Department began a detailed study of the spoil bank lands in May of 1980 for the purposes of determining the feasibility of establishing energy forest plantations on these lands as a reclamation technique. The study is designed to assimilate all the past research data from spoil bank experimentation plus the inputs from a recently completed study on short rotation energy forests, (Naughton, 1980).

Two possible outcomes are anticipated:

1) production of cordwood fuels for direct consumption as home heating fuel.

2) production of woodchips for combustion in mixture with high sulfur coal for industrial use.

In the first case, our study is showing that reclamation is relatively low cost, reliable, but also low in total economic productivity because of the time required to produce a crop and the low stumpage value per cord.

In the second case, reclamation costs will be higher because spoil banks will need to be leveled sufficiently prior to planting to allow for mechanized planting and harvesting of trees. The returns per acre will also be higher because of the shorter rotation and the higher yield per acre.

In both cases, the concept of reclamation to forestry uses takes into consideration the value of the head-wall pits for fishing and water based recreation and intends to develop and enhance these values by:

1) improving the accessibility to pit waters.

2) controlling on-site erosion which pollutes these waters.

3) planting shoreline vegetation for aesthetic purposes which would not be included in the normal harvesting cycle.

4) excluding use by domestice livestock so that wild game habitat will be enhanced.

PAST RECLAMATION EFFORTS

Over the years, the Kansas Fish and Game Commission has acquired control of approximately 6,500 acres of these spoil banks for management as public hunting and fishing reserves. The preponderance of this acreage is is wooded, some of it having been planted by the Civilian Conservation Corps in the mid-1930's under the direction of the U.S. Forest Service. A larger portion of this public land is naturally re-forested as the result of management policies which favored trees by excluding domestic livestock.

There are three recreation developments by private individuals established on a fee basis. They have received some public financial support in the past for partial reshaping of the spoil banks and for some revegetation work. For the most part, these operations are only modestly successful, the owners all having other primary sources of income.

Individual landowners have not typically planted trees in their efforts to reclaim spoil banks. There are, however, a few notable exceptions which have been quite successful. For the most part, tree planting is viewed as an aesthetic correction to the landscape. In one case there is a modestly successful Christmas tree plantation.

A few small areas of spoil banks close to Pittsburg have been reclaimed for country homesites. These are extremely popular but there is little hope that such highly developed use will have a major impact on reclamation.

We currently estimate that nearly 3,000 acres of formerly abandoned spoil banks have been reclaimed to pasture--mostly fescue--by private individuals using one or more of available federally financed grants through the Resource Conservation and Development District or the Agricultural Stabilization and Conservation Service.

This leaves us approximately 32,000 acres still inadequately treated.

FOREST MANAGEMENT CONSIDERATIONS

The abandoned spoil bank lands we are dealing with were all mined prior to 1969, the median age of the acreage being over 30 years old. Substantial weathering of spoils has taken place during that time, and to some extent, time has already healed the wounds.

Natural revegetation by cottonwood has been substantially successful on 20% of the area, and almost 60% of the unreclaimed area has cottonwood and other volunteer hardwood cover between 20% and 50% stocking.

It is our conclusion that we can expect biological success in tree planting most of the time if we use cottonwood, black locust, loblolly pine, and pin oak. Black walnut, bur oak, European alder, and autumn olive are also highly reliable species for vegetation.

Economic success of reforestation appears to be marginal at best. It is our current belief that salable quantities of cottonwood and black locust can be produced from plantations, and there is some hope for loblolly pine. The other species appear to be submarginal.

Socio-political successes in reforestation seem to be geared to the fact that the local public will accept a limited amount of "forest" in the region. It is also important to realize that these forest areas are acceptable to the public from the viewpoint of aesthetics, recreation and wildlife habitat. Economic productivity is not a significant public issue at the levels of forest which will be readily acceptable.

The critical considerations for us are the wants, needs, and attitudes of the individuals who own the mined lands in question. It is generally true in Kansas that people who make their living directly from the land don't plant trees, while those people with other primary sources of income do plant trees. Thus, reforestation efforts on Kansas mines are more limited by landowner attitudes than by biological, economic or political constraints.

In cases where stands of trees are already established, we still find the landowners divided as to what production alternatives they will consider, although we do have broader general acceptance of forestry practices on existing stands from all classes of owners.

Reclamation of naturally stocked spoil banks is relatively easy. In most cases, the principal requirements are to (1) develop access routes into the areas for logging purposes and (2) to find markets for relatively low-value products. In the first case, we are developing a reclamation model which will use public funds for development of low-cost access routes. In the second case, we are depending upon the increased market for fuelwood to consume the majority of our product output.

A general guide for the reclamation of spoils in Kansas was prepared by the Soil Conservation Service and Kansas State University (USDA, 1969). Spoils classification, site preparation, species selection, management practices, and conservation measures are outlined.

OTHER CURRENT STUDIES

The Center for Public Affairs and the Kansas Applied Remote Sensing Program of the University of Kansas are jointly conducting an inventory of abandoned mined lands in Kansas. The project is funded by the Office of Surface Mining. The primary objective of the inventory is to identify health, safety and environmental problems associated with abandoned coal mines in the state. Interviews with county agency personnel, local officials, and area residents are being conducted to identify specific problem areas. In addition, existing medium-scale and high altitude color infrared photography are being used to evaluate general site conditions and to identify problems resulting from acid spoil conditions and consequent poor revegetation. On-site visits are conducted to evaluate and document the problems. The information gained from this inventory will be used by the Office of Surface Mining for prioritizing the reclamation of abandoned mined lands in Kansas.

This same team is also conducting a Prototype Study in southeastern Kansas which will be used to assist OSM and the coal producing states in improving the quality and utility of inventories. The tasks of the Prototype Study are included among six major research components. These components are as follows:

1) Assessment of Mine Spoils and Mine Soils.
2) Assessment of Erosion-Sedimentation Problems.
3) Assessment of Vegetation Problems.
4) Assessment of Water Quality Problems.
5) Assessment of Socio-Economic Factors and Problems.

6) Assessment of Research Methodologies, i.e., Photo Reconnaissance, for components 1 through 5.

A considerable amount of previous research has focused on mine soils associated with reclaimed lands. In contrast, little research has been directed towards the conditions of mine spoils or mine soils on abandoned mined lands. The Prototype Study will determine the specific physical and chemical properties of mine spoils that should be measured prior to reclamation. This information can be used to determine reclamation alternatives and reclamation techniques. In addition, sampling methods are being tested in the Prototype Study to determine the most efficient and economical means of collecting the mine soil and mine spoil data. Refinement of these methodologies will lead to the development of systematic sampling schemes for use in states that are involved with the reclamation of abandoned mined lands.

Erosion and sedimentation have been identified as major problems associated with abandoned mined lands in Kansas. The Prototype Study is being used to (1) determine whether there are significant flood hazards associated with sedimentation in problem areas, (2) assess the impacts of erosion and sedimentation on vegetation in problem areas, and (3) test data collection techniques and identify the best methods for acquiring the data. In order to maximize the understanding of the interactions involved with the aging of mine spoils, erosion and sedimentation are being assessed in areas coincidental with and immediately adjacent to those selected for vegetation and spoil analyses. Both studies will be completed in February, 1981.

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KENTUCKY'S NURSERY SITUATION[1]

Raymond J. Swatzyna[2]

Abstract.--The Kentucky Division of Forestry operates three tree nurseries producing approximately 12.5 million seedlings. Production is 60% hardwoods and shrubs and 40% pine. Production could be increased to 18 million and species added to meet demand.

Kentucky's interest in reforestation dates from 1914 when the General Assembly authorized the establishment of two small nurseries, one in Frankfort and the other at the old State Fairgrounds in Louisville. At present the Division of Forestry operates three nurseries. The Pennyrile Forest Nursery was established in 1946, the John P. Rhody Nursery in 1956, and the Morgan County Nursery in 1960. These nurseries are currently producing approximately 12.5 million seedlings annually. Some 20 different species are raised for distribution, with five - black alder, black locust, bicolor lespedeza, autumn olive, and virginia pine - being grown primarily for reclamation purposes, though other species such as loblolly, shortleaf, and white pine are also used to some extent. During the past planting season over 1.5 million seedlings were used in reclamation work.

At present 60% of our production is in hardwoods and shrubs, and 40% in pine. Our production could be expanded to 18-20 million seedlings if the demand increases and the current 60% hardwood-40% pine mix was maintained.

We recently added a cold storage unit at our John P. Rhody Nursery. Depending on species this unit will hold between 3 and 4 million seedlings. It will allow us to lift in good weather and stockpile seedlings for packaging at a later date, thus we can make more efficient use of our time. With this unit we expect that we can extend the planting season up to two months.

[1]Paper presented at the Trees for Reclamation in the Eastern United States Symposium, Lexington, Kentucky, October 27-29, 1980.

[2]Raymond J. Swatzyna, Director, Kentucky Division of Forestry, Bureau of Natural Resources, Department for Natural Resources and Environmental Protection, 618 Teton Trail, Frankfort, Kentucky 40601.

The Division of Forestry is cooperating with the U. S. Forest Service Northeastern Forest Experiment Station at Berea on a study to evaluate 14 different woody species for reclamation purposes. The study has several purposes. One is to determine if present nursery practices have a detrimental effect on the growth of beneficial symbionts on seedling roots. There is some evidence to indicate that modern fumigation practices result in seedlings lacking in sufficient quantities of these beneficial symbionts to do well on some of the mined sites. To carry out this portion of the study, we will be raising half the seedlings under normal fumigated conditions at the John P. Rhody Nursery and the rest at the Pennyrile Nursery in an area that has not been fumigated for three years.

The 14 species being raised include species that were raised by some nurseries in the past but are now not generally available for reclamation studies. They include such species as hazel alder, indigo bush, silky dogwood, shining sumac, smooth sumac, and siberian pea shrub.

If the test plantings of these species prove successful, we could make them available for reclamation plantings if a sufficient demand develops.

Our Tree Improvement Program is currently working with three species that are used for reclamation, European black alder, virginia pine, and black locust. At this point in time we are concerned with the establishment of reliable seed sources adapted to the harsh environment of reclaimed lands, and showing suitable rates of growth. We have two virginia pine seedling seed orchards located in Eastern and Western Kentucky. Each orchard encompasses 14 acres. The seed source for the orchards were open-pollinated seed from a first generation progeny test of a clonal orchard established by the University of Tennessee. The seedlings were established during the spring of 1977. We expect seed production to begin within three years, full scale seed production within seven years. In 1979 we established 4 acres of European black alder seed production areas in two sites in Western Kentucky. The original European seed source has been observed through repeated regeneration in the United States. The seed source shows a rapid growth rate during the early years of establishment. We expect some seed production within two years, with full scale production in five years. The Tree Improvement Program is a cooperator in a black locust variation study with two outplantings of 5 acres each. The study is regional in scope and is coordinated by the University of Tennessee. We also plan to establish a seedling seed orchard for black locust to supplement the nursery program's seed needs. Seed sources will be from across the State of Kentucky. Selection criteria will emphasize disease and insect resistance while also stressing straight single stems, good crown form, and self pruning ability.

In summary, I would like to say that our working relations with Commissioner Grim and others in this field are excellent, and we stand ready and willing to do whatever we can to produce the species and quantity that are needed to get the reclamation job done in Kentucky.

TREE PLANTING - STRIP-MINED AREA IN MARYLAND

Part I

Paper Presented at the

Symposium on Trees for Reclamation in the Eastern U.S.

in Lexington, Kentucky

October 27-29, 1980

Fred L. Bagley
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INTRODUCTION

Maryland is relatively small in relation with other coal-producing states. Only one and one-third Counties in extreme Western Maryland is involved in mining. Elevation for the mining region is from a low of 1200 feet to a high of 3800 feet. Rainfall is well distributed ranging from 40 to 48 inches per year.

Until 1975, the revegetation of strip mined areas was the responsibility of the Maryland Forest Service, thus the concentration on tree planting. Since 1975 all mining responsibilities have been transferred to the Bureau of Mines.

Planting of trees on strip-mined areas began in 1963 with herbaceous planting, a requirement beginning in 1974. Trees were the primary revegetation method with an average of 350-400 thousand trees planted each year. Since 1974, the trend has been for herbaceous planting, consequently tree planting has declined considerably (approximately 150 thousand per year in recent years). However, because of the Office of Surface Mining's requirements, the future dictates a substantial increase in tree planting.

PROBLEMS EXPERIENCED WITH TREE PLANTING

The problems we are encountering with tree planting at the present time are (1) establishment in heavy herbaceous cover, and (2) the people of Western Maryland would like replanting with more hard wood species (Oak, Hickory, Maple, Cherry, etc.). Past year's tree planting has leaned heavily on pine species.

SOLUTIONS TO PROBLEMS OF TREE ESTABLISHMENT ON STRIP-MINED AREAS

To help alleviate these problems and to get good practical reclamation of strip-mined land, we in Maryland are planting Black Locust and Black Alder as a first crop tree. We decided this was the best method to follow because these trees were leguminous; Black Locust is a natural invader and we have an easily accessible market. Westvaco has a paper mill located in the center of our coal region.

The problem of heavy herbaceous cover curtailing the survival and growth of trees, can be overcome with proper care and planting techniques.

I would like to point out Part II of this paper on the methods we have found to be successful. In particular the conclusion.

We in Maryland believe that four basic requirements must be met to ensure successful tree planting on strip mined areas.

1. The planting stock must be properly cared for from the time of lifting until the actual planting on the mining site. We do not recommend long storage periods. Less than four weeks is preferred.

2. It is absolutely essential that proper supervision of the tree care and the planting practices are maintained at all times. Many agencies or coal companies do not want to spend the money that is needed for this supervision.

3. Planting of trees as early as possible in the spring. We recommend the planting season not to exceed April 20th in Maryland. In other words, start as soon as frost leaves the ground and complete planting within a four week period. Here again, pre-planning such as having trees ordered, crews hired, job sites determined, etc., is very important so time will not be wasted during the actual tree planting period.

4. Last, scalping an area of approximately 12 to 18 inches in diameter will be needed where herbaceous cover is heavy.

RESEARCH

The Bureau of Mines and Forest Service in Maryland has worked closely with the Agriculture Research Service located in Beltsville, Maryland during the early and mid-1970's in conjunction with revegetation research projects of strip mined land. However, the emphasis was for herbaceous establishment. The planting of trees and shrubs has been done since 1963, basically using practicality, natural species approach, availability of species and good seed and planting techniques.

Parts III and IV of this paper has been the results of many years of revegetation experience in Maryland. Our research and experience results has always been towards the goal of being able to apply and relate to the normal daily reclamation and revegetation encountered by the coal operators. We feel research has fallen short if results cannot be applied in a reasonable and practical sense including the economic consideration. We would like to have more data on direct seeding of tree species and hardwood species planting. Possibly we will obtain data from this Symposium.

CONCLUSION

Maryland has a very small area where strip mining is conducted. That is an asset because the Bureau of Mines has a much closer relationship and possibly better control over the mining process, particularly reclamation and revegetation.

Our revegetation standards are high. Our efforts to date are producing good results which we hope to continue. Thank you.

TREE PLANTING - STRIP-MINED AREA IN MARYLAND

Part II

Fred L. Bagley
Energy Resources Officer

This report is written to elucidate some of the problems encountered in the planting of trees on strip-mined areas in Maryland. When problems are recognized, normally a solution (or at least, an improvement) can be instituted to alleviate the problem.

The methods cited herein are those of experienced foresters engaged in strip-mine planting during the past seventeen years. Although these methods might seem very basic, the procedure and tools explained in this report give the best results with the least amount of confusion.

MECHANICS OF PLANTING

The State of Maryland does have certain guidelines for planting trees in the State. Briefly, these guidelines are as follows:

1. Spacing: 6' x 7' (or 1,000 trees per acre).

2. Planting season in Western Maryland: March 20 to April 20 for strip-mined areas. The earlier trees are planted the higher the survival will be.

3. Planting methods:

a. Hand - areas one acre or less in size, odd areas, coal-stripped areas, steep or rough areas.

b. Machine - Three acres or more on even slopes. Odd areas on machine sites are planted by hand.

4. Planting precautions:

a. Protect plantation from grazing and fire.

b. Plant as soon as possible after trees are received.

c. Keep seedling roots moist at all times.

d. Plant properly. Do not jam or push roots into the hole. Do not insert seedling at an angle. Plant at proper depth, which is the same depth as in the nursery.

Points b and c are usually overlooked but are extremely important to good survival.

5. Proper supervision must be maintained at all times.

Strip-mine planting is a special operation. In some respects, it is a better planting than old fields or woodlands because heavy sod, roots, brush, and stumps are not present. However, there can be problems. A strip-mine will dry out considerably faster; in fact, with the ever present winds, they can go from an extremely wet to a very dry condition within a few days. For these reasons, a rather heavy mattock is recommended. The five pound mattock head seems to be the best size available. With this size mattock, a good hole can be dug to plant the seedling without much over-exertion by the planter.

Slit planting has proven to give much lower survival than planting by digging a hole. Slit planting tends to produce a J-rooted condition and, unless the first few years after planting are extremely wet, many seedlings will die. Slit planting must NOT be used.

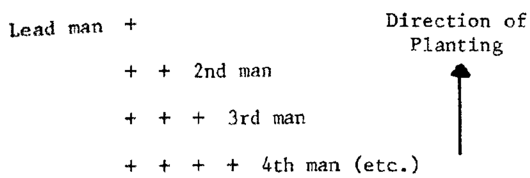
Digging a hole too shallow will produce the same results as slit planting. The correct (and best) method to plant seedlings is to dig a hole several inches longer and wider than the root system of the seedling. If a hole is dug properly, one side will be vertical to the width of the hole. Hold the tree at the root collar with the thumb and forefinger, and place the tree roots into the hol until the finger and thumb touch the origina soil line.

Be careful that the seedling is in an u right position. Then use the foot to push t freshly dug soil back into the hole around t roots. Care should be used not to put stone around the seedling roots. The final step i the planting order is to place the foot over this soil, to compact it around the seedling

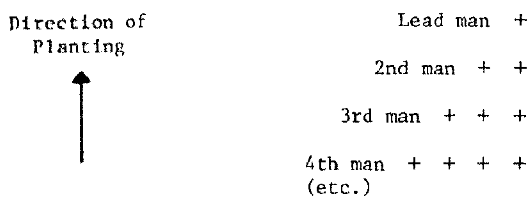
Another problem to be considered when planting is that of spacing. Two methods ca be used to maintain the desired spacing. Or method is to instruct the planter that, wher he compacts the soil with his foot, he is tc make one normal additional step and sink the mattock into the ground in front of himself; this will provide approximately six feet between each tree. The other method is to maintain close supervision of the planting crew, with the foreman paying particular attention to the spacing of each planter. Also, the best planting method establishes a good lead man, with each planter to stay one tree behind the man he is using for a guide. See illustration:

Step Method

Guiding Left



Guiding Right



MECHANICS OF RUNNING A CREW

Before the actual planting operation begins, it is necessary that the planters be instructed as to what performance is expected of them. Then divide the men into crews and assign, or have, a crew boss or foreman. Each planter is then given his particular species of tree to be planted. In most cases, alternate rows of compatible tree species are required. When all members of the crew have trees, assign a lead man and place the crew. Normally, a lead man is a good planter and can follow instructions. Inform the lead man of the area he is to plant. Each crew should use the Step Method of planting, as previously described.

Crew size and necessary crew control will determine the best planting results. Without such control, it is better not to plant an area at all.

The best planting unit is composed of 8-10 men per foreman. When a planting unit grows any larger, control is lost by the foreman and, usually, poor planting results.

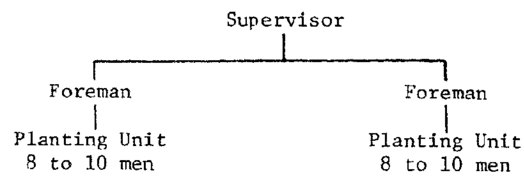
In Western Maryland, experienced crew sizes have ranged from 4-65 men. As you can imagine, different crew sizes present different problems.

For best control, the smaller crew is desirable. A small crew is considered to be 20 men or less. With a crew of this size, less supervisors are needed and general confusion is minimized.

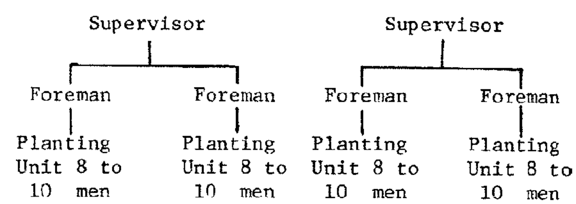
Unfortunately, small crews cannot be used at all times--especially when large acreages are to be planted in a short period of time. When large crews are used, it is advisable to have several experienced men to supervise the planting job. These supervisors will then instruct and reorganize the crew into the smaller planting units.

The following is a diagram of different size crews:

Small Crew Less Than 20 Men



Large Crew More Than 20 Men



The foreman's duties consist of maintaining spacing, supplying planters with trees, tools, etc., and maintaining good tree planting methods.

Prior to planting, a map should be studied by the supervisor to determine the size, the shape, and the hazards (if any) of the planting area. Although each strip-mine is unique, basic methods can be used to prevent confusion in tree planting. Normally, strip-mines are long narrow strip cuts around a hillside, and they vary in width at different points. If the crews do not plant properly or are not closely supervised, small areas are not planted. Also, if the crews are not supervised properly, near the end of the planting job all the planting units will converge, thus creating poor planting, confusion and, ultimately, time and money lost. The ideal method is to keep the planting units working in one direction and as far apart as possible. This is best accomplished by the crews planting in a circular pattern.

MACHINE PLANTING

With the passage of recent strip-mining laws in Maryland, the requirements for backfilling were strengthened. Areas less than 12° are backfilled to the original contour creating, in many cases, relatively flat areas for planting. Also, the contour method of backfilling is creating better planting areas. With these better areas, a tree planting machine can be used. The planting machine has very definite advantages, which include:

1. Fewer men are needed (however it is imperative that the planting machine is followed for corrective planting where needed).

2. More trees can be planted in a given time.

3. Survival is better.

4. Planting is cheaper.

Disadvantages include:

1. Steepness of slope.

2. Stoniness.

3. Breakdowns.

Breakdowns could be somewhat eliminated if a tree planting machine especially designed for strip-mines would be purchased.

Steeper areas must still be planted by hand, and the Step Method is essentially the best planting method to use.

PLANTING CREW

Harmony of the planting crew and lead man importance have both been discussed. Our records of twelve years show that the average rate per man per eight hour day is 625 trees. Of course, individual planter rates may vary from 400-1500 trees per man per day.

CONCLUSION

Strip-mine tree planting seems to be a simple process. However, if the operation is carefully analyzed, the little operations within the total operation can be very important. Many people think that digging a hole and putting the tree in is all that is needed. With any job there are "little tricks" which make the job easier. This report was written to bring to your attention some of these tricks which make tree planting easier, quicker, more economical and, more important, insure good results.

A quick review of the most important points to successful tree planting:

1. Planting stock must be <u>properly</u> cared for from time of lifting until planting. Do not recommend long storage periods.

2. Proper supervision of tree care and planting techniques at all levels.

3. Plant as early as possible in the <u>spring</u>. Recommend no more than a four week planting season. Do not extend planting season.

4. Scalping approximately 12-18 diameter area, where herbaceous material is planted.

If any of the above steps are shortchanged, planting results will suffer.

MARYLAND'S SEEDING MIXTURES

PART III

I. Seeding Mixtures (per acre basis) for Hayland and Cropland.

   1. 50# Kentucky 31 tall fescue
      10# Birdsfoot Trefoil or 10# Crown Vetch

   2. Other mixtures may be submitted and evaluated at the time of the tri-agency review.

II. Mixture for Forestry where tree seedlings will be planted.

   1. 25# Kentucky 31 tall fescue
      10# Orchard Grass or 10# Perennial Rye Grass
      5# Red Clover
      5# Birdsfoot Trefoil

III. Mixtures for Forestry where tree seed will be direct seeded with legume tree species.

   1. 25# Kentucky 31 tall fescue
      10# Orchard Grass or 10# Perrennial Rye Grass or 10# Red Fescue or 10# Red Top
      5# Red Clover or 5# Alsike + 1# Ladino Clover
      2-3# Black Locust or Black Alder seed or Bicolor Lespedeza

IV. Mixtures for Forestry where tree seed will be direct seeded for non-legume tree species.

1. 25# Kentucky 31 tall fescue
   10# Perennial Rye Grass or 10# Red Fescue or 10# Red Top
   5# Birdsfoot Trefoil
   3# Red Clover

Non -legume tree species that will grow in Western Maryland:

Austrian Pine	Black Cherry
White Pine	Sumac
Red Pine	Sycamore
Scotch Pine	Cottonwood
White Spruce	Tulip Poplar
Norway Spruce	Japanese Larch
Pitch Pine	Sweet Gum
Red Oak	Yellow Birch
White Oak	White Ash
Sugar Maple	Sawtooth Oak
Red Maple	

V. Mixture for wildlife planting.

1. 15# Kentucky 31 tall fescue.
   15# Orchard Grass
   10# Perennial Rye Grass
   5# Birdsfoot Trefoil
   5# Red Clover

With shrub plantings. (Recommended planting in blocks, rows, or clumps not as a solid planting. Spacing will be determined at the time of planting.)

1. Autumn Olive
2. Sawtooth Oak
3. Bush Honeysuckle
4. Hawthornes
5. Hybrid Poplar
6. Black and Speckled Alder
7. Crabapple
8. Silky Dogwood
9. Red Osier
10. Conifers in 1 acre blocks or strips 30 feet wide at various lengths.

PART IV

MARYLAND'S PLANTING TIME AND SPECIES TABLE

Listed below are species which have been used and good results have been obtained. This list will be expanded when results are verified and does not mean other species are not acceptable.

SPRING (mid-March to June)	SUMMER (June to Aug.)	FALL (Aug. to mid-Sept.)
Kentucky 31 Fescue (P)	Kentucky 31 Fescue (P)	Kentucky 31 Fescue (P)
Orchard Grass (P)	Orchard Grass (P)	Orchard Grass (P)
Red Fescue (P)	Red Fescue (P)	Red Fescue (P)
		Timothy (P)
		Red Top (P)
Alsike T-2 (L)		
Birdsfoot Trefoil (P, L)		
Crown Vetch (P, L)		
		Hairy Vetch (T, L)
Alfalfa (P, L) (good sites only)		
Red Clover (T, L)		
Sweet Clover (T, L)		
Flat Pea (L)		
Ladino Clover (T, L)		
Oats	Japanese Millet	Balboa Rye
Perennial Rye Grass	Weeping Lovegrass	Annual Rye Grass
		Winter Wheat
		Winter Oats
S. Lespedeza (L) (South slopes only - Low elevations below 2000 feet)		

The time of planting is the best time and does not necessarily mean that other times for planting a particular species will not produce good results.

P = Permanent
T = Temporary
L = Legume (meaning having the ability to fix or produce nitrogen, thus reducing fertilizing requirements and topdressing).

REFORESTATION SPECIES STUDY ON A RECLAIMED SURFACE MINE IN WESTERN MARYLAND

Paper presented at the "Trees for Reclamation in the Eastern U. S." symposium on October 27-29, 1980 at Lexington, Kentucky

Jay A. Engle, Research Forester, Westvaco Research Center Box 608, Rupert, WV 25984

Abstract.--Westvaco Forest Research established a species comparison test including eighteen species of trees in the spring of 1978 on a recently reclaimed surface mine in Garrett County, Maryland. After two growing seasons height growth of all species has not been impressive. Seven species have better than 75 percent survival with pitch pine being best. Seven other species have survival rates between 50 and 75 percent. Tall herbaceous vegetation, like crown vetch, can be a major deterrent to establishing trees on reclaimed surface mine sites.

INTRODUCTION

Westvaco Corporation is a pulp and paper company with four major mills located east of the Mississippi River. One mill is located in Luke, Maryland and produces fine papers. The land surrounding this mill supplies both wood fiber and coal for the production process. Westvaco Resources Incorporated, a subsidiary company, mines coal on company land to provide the main energy source for the mill. Obviously, Westvaco is interested in using trees for reclamation on both company and other land in order to prevent or minimize reductions in local wood fiber supply to the mill.

Reforestation in the Luke area is not a new topic to Westvaco. Virginia pine plantation establishment on company land has been and is a major project. Many of the same principles and practices used in this program are also applicable to reclaimed mine sites. We know that we need good quality seedlings that have been correctly lifted from the nursery and properly stored and planted. We also know that we should match the species planted to the site. However, reclaimed sites are not representative of "normal" forest sites since they have been drastically disturbed. So the question of which species is best suited to the site is not always easily answered.

PROCEDURE

In order to obtain more information with a variety of species a study was established on a recently reclaimed surface mine site located on Backbone Mountain in Garrett County, Maryland. Prior to study establishment, a literature search was conducted to determine which species have been planted successfully on mine sites in the northeast. A list from this search and personal observations of species growing well on mined sites was prepared. Seedling sources for as many of these species as possible were located. However, some species like bigtooth and quaking aspens, and black, yellow, and gray birch are not being grown commercially and could not be included in the study.

A total of 18 species, 11 hardwood and seven conifer, were used in the study and are shown on the following list:

Hardwoods

1. Hybrid poplar
2. Hybrid poplar*
3. Hybrid aspen
4. Paper birch
5. European white birch
6. Red oak
7. Red oak*
8. Black locust
9. Red maple
10. American chestnut
11. White ash
12. Chestnut oak
13. American sycamore

Conifers

1. Red pine
2. Red pine*
3. White pine

Procedure (continued)

Conifers (continued)

4. White pine*
5. Virginia pine
6. Containerized Virginia pine
7. Pitch pine
8. Scotch pine
9. Japanese larch
10. Austrian pine

*Interplanted with European black alder

Three replications of these species-treatments were planted. Hybrid poplar, red oak, red pine and white pine were duplicated within each replication; interplanting one plot with European black alder. The purpose of the interplanting treatment is to determine if the alder can fix enough nitrogen to be beneficial to the other species. Virginia pine was also duplicated by including seedlings grown in containers to see if containerized stock might have better survival and growth.

RESULTS

Height and survival results after the second growing season since planting are shown in the following table:

Species-Treatment	Height	% Survival	Rank by Survival
Pitch pine	1.1	94	1
Chestnut oak	1.2	88	2
American chestnut	1.6	88	2
Austrian pine	0.9	85	3
Hybrid poplar	1.0	81	4
Hybrid aspen	2.0	77	5
Scotch pine	0.8	77	5
White ash	0.8	71	6
Red pine*	1.1	69	7
Virginia pine	1.2	69	7
Hybrid poplar*	1.0	69	7
Red maple	1.6	69	7
Containerized Virginia pine	0.6	65	8
European white birch	1.1	60	9
Red oak	0.6	46	10
Red oak*	0.6	44	11
Black locust	2.3	44	11
Paper birch	1.1	42	12
Japanese larch	0.9	42	12
Red pine	0.9	29	13
White pine	0.8	27	14
White pine*	1.0	27	14
American sycamore	0.4	6	15

*Interplanted with European black alder

Results (continued)

Height growth has not been impressive. European black alder, which is not listed on the table because it was planted only as a nitrogen fixing nurse tree, had the best height growth. Alder was not planted as a crop tree because our past experience has shown that after fast initial growth to a size of 15 to 20 feet it discontinues growth and funnels all its energy into seed production. Black locust is the tallest test species averaging 2.3 feet.

Survival results at this stage might be more important than height results. Seven species have survival that could be rated as good (>75%) with pitch pine being best. Seven other species have fair survival (50-75%), and nine species would have to be classified as having poor (<50%) survival.

Some of the poor survival can be related to poor seedling stock quality. We did have to go to different nurseries to obtain the variety of species used for this study. Variation in seedling stock quality is also the probable cause of the large survival difference between the two red pine treatments. Most of the survival and height growth problems, however, can be attributed to the harsh site and competition from herbaceous vegetation. Grass competition has certainly held back seedling growth, but in plots where crown vetch is present the seedlings have been completely smothered. Vetch is also spreading and we anticipate the loss of other seedlings before they grow above this competition. If we are to establish trees on our reclaimed mines we will have to develop herbicide treatments to at least spot kill the ground cover now being established in the areas.

CONCLUSION

Our preliminary results show that height growth has been slow for all species other than European black alder. Several species have good survival after two years in the field. Tall herbaceous vegetation, like crown vetch, can be a major deterrent to establishing trees on reclaimed surface mine sites.

AN EVALUATION OF RECLAMATION TREE PLANTING
IN SOUTHWEST VIRGINIA

PRESENTED AT

TREES FOR RECLAMATION IN THE EASTERN UNITED STATES

LEXINGTON, KENTUCKY

OCTOBER 27-29, 1980

DANNY R. BROWN, COMMISSIONER

DONALD L. BRANSON, AREA SUPERVISOR

DEPARTMENT OF CONSERVATION AND ECONOMIC DEVELOPMENT

DIVISION OF MINED LAND RECLAMATION

P. O. DRAWER U

BIG STONE GAP, VIRGINIA 24219

Surface mining began in Southwest Virginia in the mid-1940's, however, few or no records were kept before 1950 and it was not until 1966 that the first Virginia reclamation law was passed. Two years later in 1968, the Division of Mined Land Reclamation was created and tree planting began on a uniform basis in Virginia surface mines.

Historically, however, tree planting was one of the first general reclamation techniques on coal surface mined lands and many plantings were done prior to 1968 by various coal operators, Soil Conservation Service personnel, personnel of the Virginia Division of Forestry and others. The much used practice of sowing black locust seed on earlier reclamation areas should also be noted.

From a lowly beginning then in 1968 of 1,000 tree seedlings planted, to a high of just over four million seedlings planted in 1975, and 1980's total through June of 76,000 tree seedlings planted, the coal surface mining operators of Virginia have continued to plant seedlings. (Table 1). The decrease from 1975 to 1980 coincides with a corresponding decrease in acreage disturbed due to decreased mining activity because of a depressed coal market and/or increased regulation.

Current permit figures also reflect a recent trend towards a post mine land use of hay and/or pasture.

Table1.--Tree Seedling Informatic

Calendar Year	Operating Permits Issued	Acres Disturbed	Acres Reclaimed
1966			
Coal	62	200.76	67.20
MOTC	0	0	0
1967			
Coal	74	1.660.45	1.326.85
MOTC	0	0	0
1968			
Coal	74	2,702.56	2,008.22
MOTC	0	0	0
1969			
Coal	103	2,763.95	1,915.70
MOTC	169	0	0
1970			
Coal	175	2,893.48	2,682.54
MOTC	36	0	0
1971			
Coal	186	5,322.59	3,013 12
MOTC	19	6,197.75	346.97
1972			
Coal	253	6,539.80	5,931.50
MOTC	44	6,805.10	535.28
1973			
Coal	193	5,898.11	6,091.41
MOTC	39	7,479.92	710.26
1974			
Coal	358	5,692.13	5,880.63
MOTC	38	9,008.18	1,148.89
1975			
Coal	321	9,381.80	7,490.24
MOTC	19	10,310.01	1,482.43
1976			
Coal	258	10,084.47	9,508.19
MOTC	26	970.59	550.57
1977			
Coal	264	8,080.91	6,895.18
MOTC	36	1,865.55	244.48
OL-TVA			2,704.97
1978			
Coal	373	8,614.85	9,607 09
MOTC	35	967.99	223.26
OL-TVA			2,154.47
1979			
Coal	248	4,126.89	7,368.58
MOTC	36	805.17	104.91
OL-TVA			1,488.30
1980 - (Thru June)			
Coal	58	1,698.31	4,048.45
MOTC			
OL-TVA			428.30

As of the 58 surface mine permits issued thus far in 1980, fifteen have requested a hay and/or pasture type post mine land use. This compares with twelve of 248 permits issued in all of 1979.

During the past five years, the Virginia Division of Mined Land Reclamation has also participated in the federally funded Abandoned Land Reclamation Program with the Tennessee Valley Authority. This program was designed to provide for intensive tree and shurb planting, seeding and limited regrading of abandoned mine lands, mined and abandoned before the states involved passed surface mining and reclamation laws. This would provide long term soil stabilization, blend the "orphan" land with the surrounding landscape and provide additional benefits of forest and wildlife production.

Thus from its initiation in 1975 until its termination on August 10, 1980, this program provided for the planting of approximately 3,650,000 tree and shrub seedlings with an approximate projected 45-50 percent survival rate.

The Division of Mined Land Reclamation is indebted for the past cooperation of the Virginia Division of Forestry, the Soil Conservation Service, coal mine operators, the U. S. Forest Service and their experimental stations, and others for their continued cooperation in the tree planting program.

It is hoped as this cooperative effort continues on coal surface mined land where forestry is designated as the post mine land use, we will truly be involved in reforestation, not just tree planting for reclamation on Virginia surface mined lands.

REFORESTATION PROGRAM IN SOUTHWEST VIRGINIA[1]

Wallace F. Custard[2]

The State Division of Forestry has been actively concerned with mined land reclamation for 25 years. The results show that successful introduction of forest tree seedlings can be carried out on those areas that require revegetation. Early experimental work has assisted in developing standards and procedures for reforestation work on these lands. Cooperative efforts between the Division of Forestry and the Division of Mined Land Reclamation and other State resource agencies has resulted in excellent field cooperation and applied techniques.

The Virginia Division of Forestry has been interested in the reforestation of strip mined areas in Southwestern Virginia since 1955. Trial plantings, direct seeding and natural seeding occurrences have been established and/or monitored. Grasses and shrubs as well as tree species were evaluated in cooperation with the Soil Conservation Service and the Division of Mined Land Reclamation.

Our current role is to provide assistance to the Division of Mined Land Reclamation in species selection, planting procedures and nursery production. Division nurseries contract the production of forest tree seedlings to meet annual planting requirements estimated by Division of Mined Land Reclamation. Grading, packing, storage and delivery of requested species assures a supply of seedling stock to meet individual orders. Both Virginia Division of Forestry nurseries and the Abingdon District Office coordinate field program needs.

The District Office has assisted Mined Land Reclamation in developing planting guidelines for specific species. Recognition is also given to necessary erosion control and soil stabilization. Evaluation of the early plantings has provided excellent guidelines for successful planting projects today. A knowledge of soil and site characteristics has also been useful in determing proper species selection. Demonstration and training sessions have been carried out for new planting crews and Mined Land Reclamation field supervisors. Well planted tree seedlings are the key to good survival and healthy stands.

The Division's role has been one of a consultant to Mined Land Reclamation. It has been a very beneficial exposure for both agencies. We have learned something useful from our joint discussions, field programs, and follow-up evaluations.

I have every reason to believe that a sound reforestation program can be carried out on Virginia's mined land areas.

[1]TREES FOR RECLAMATION IN THE EASTERN U.S.
Lexington, Kentucky
October 27-29, 1980

[2]State Forester
Virginia Division of Forestry
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dot grid tally. Plot locations were chosen by randomly selecting a starting point on a mine, then taking a one-five-hundredth acre circular plot every one-tenth mile along the mine. Because of the variability in conditions along these mines, plot sites were divided into the categories of inner bench, middle bench, outer bench, upper outslope, middle outslope and lower outslope. The placement of the plot center was determined by randomly drawing a card specifying one of the six locations, then pacing to the proper spot.

A total of 752 trees and tree seedlings was tallied on 215 sample plots, for an average of 3.5 trees per plot or 1,750 trees per acre. An estimated 5,400 acres have been affected by surface mining activities on VICC property in Virginia.

Table 1 gives the number of seedlings inventoried on VICC surface mines by position on the mine (see Table 1 below). This table shows the difference in number of seedlings present on the areas which have been planted compared to the inner and middle bench areas which were not. However, few areas were found on any part of the surface mines which did not have an adequate stocking of tree seedlings unless there was a heavy stand of sericea lespedeza, common on many inner and middle bench areas.

Table 1.--VICC Surface Mine Tree Seedling Inventory
Number of Trees By Position On Mine

	Position on Surface Mine					
	Inner Bench	Middle Bench	Outer Bench	Upper Outslope	Middle Outslope	Lower Outslope
Number of Plots	29	38	38	36	41	33
Number of Trees Tallied	60	83	160	144	154	151
Trees Per Plot	2.07	2.18	4.21	4.00	3.76	4.58
Trees Per Acre	1,035	1,090	2,105	2,000	1,880	2,290

The distribution of tree species on VICC's surface mined lands is shown in Table 2 (see Table 2 below). Virtually all of the pine and most of the black locust seedlings tallied were established by planting, although some black locust originated from seed frequently included in the grass seed mixture. No known planting of hardwood seedlings other than black locust has taken place on VICC property. Only an estimated twenty-nine percent of the total number of seedlings tallied were the result of planting or direct seeding. However, on the average, the planted trees have achieved a much larger size over the period since mining, since more time is required for natural seeding to take place.

Table 2.--VICC Surface Mine Tree Seedling Inventory
Species Distribution

Species	Total Number Tallied	Percent of Total Tally	Average Number Trees Per Acre
Black Locust	176	23.4	410
Red Maple	166	22.1	387
Black Birch	157	20.9	366
Yellow Poplar	72	9.6	167
Sourwood	38	5.1	88
Ash	31	4.1	72
White Pine	20	2.7	46
Sassafras	19	2.5	44
Yellow Pine (Shortleaf, Loblolly) Pitch	18	2.4	42
Sycamore	17	2.3	40
Elm	9	1.2	21
Willow	7	0.9	16
Sugar Maple	5	0.7	12
Beech	4	0.5	9
Serviceberry	4	0.5	9
White Oak	3	0.4	7
Red Oak	2	0.3	5
Black Cherry	2	0.3	5
Buckeye	1	0.1	2
Red Cedar	1	0.1	2
TOTALS	752		1,750

Table 3, showing the diameter distribution of the tallied trees, and Table 4, showing the height distribution, indicate that the average size of the tree seedlings on VICC surface mines is quite small, with about 60 percent of the trees being less than one inch in diameter and about 80 percent being 10 feet or less in height. Of course, this is to be expected since most of the lands have been mined or remined during the past eight years.

Table 3.--VICC Surface Mine Tree Seedling Inventory
Diameter Distribution

Diameter Class (Inches)	Number of Trees Tallied	Average Number Per Acre
Less than 1	455	1,058
1	95	223
2	88	205
3	50	116
4	20	46
5	7	16
6	8	19
7	6	14
8	7	16
9	4	9
10	6	14
11+	6	14
TOTAL	752	1,750

Table 4.--VICC Surface Mine Seedling Inventory
Height Distribution

Height Class (Feet)	Number of Trees Tallied	Average Number Per Acre
Less than 1	193	452
1 - 5	261	607
6 - 10	158	367
11 - 20	90	209
21 - 30	20	46
31 - 40	20	46
41 +	10	23
TOTAL	752	1,750

Conclusions

VICC surface mines have an adequate number of tree seedlings per acre, although the distribution of seedlings is not uniform due to past reclamation practices. Provided that suitable conditions exist for seedling establishment, natural reseeding of trees can be expected to reforest most of these surface mines where trees are not presently found.

Pioneer tree species comprise most of the trees included in the seedling inventory. Future tree planting on surface mined areas should be aimed at increasing the growing stock of the more valuable hardwood species, such as the oaks, or of pure stands of the more easily managed pines.

LAND RECLAMATION WITH TREES IN IOWA[1]

Richard B. Hall[2]

Abstract.--The most important considerations in revegetating reclaimed lands are soil pH, moisture availability, and the restoration of fertility and good nutrient cycling. Green ash, cottonwood, alder, Arnot bristly locust, and several conifers are used most in plantings. Emphasis is placed on the use of symbiotic nitrogen fixation and mycorrhizae to improve establishment and growth of trees.

INTRODUCTION

As an aid to reclamation efforts in Iowa and surrounding areas, this paper reviews the findings of revegetation studies done on old spoil areas, discusses current work being conducted on the Iowa State University demonstration mine site, and projects some of the techniques likely to be useful once the necessary developmental research is completed. Most of the results discussed are based on coal mine reclamation work, but they also should have general applicability to other reclamation efforts.

A total of about 12,000 acres of mined lands are in need of reclamation in Iowa. New mining activity has produced an average of only 400 additional acres to revegetate each year, but this figure could increase with changes that may occur in the Iowa coal industry. At present, only a small percentage of the land reclamation efforts in Iowa involves the planting of trees; most of the landowners have preferred to return the land to row crops or pasture. Recreation, aesthetics, and wildlife habitat improvement have been the major reasons for the tree planting that has been done. Future interest in fuelwood plantations might increase the percentage of reclaimed land to be reforested.

Although the surface mining of sand, gravel, limestone, gypsum, clay, and coal all contribute significantly to land reclamation needs in Iowa, coal mining has drawn the most attention. Iowa's coal deposits are confined to the south-central and southeastern portions of the state, areas characterized by a rolling topography and soils high in clay content.

The coal deposits are relatively high in sulfur content, a factor delaying current use of the resource. As the technology of sulfur removal improves and the price of coal imported to the state escalates, strip mining for Iowa coal could return to its former level of 400-500 acres per year (80-100 acres per year currently).

The high sulfur content in Iowa coal deposits has created other problems. It has been estimated that 38%, the highest percentage in the central states, of the old mine sites had toxic spoils with a pH of less than 4.0 (Lorio et al. 1964). New mining practices have eliminated most of that problem, but the "tight" nature of the soils in the area still makes tree establishment difficult. In addition, the more mechanical reclamation a site has received, the greater is the soil compaction and the greater the difficulty in revegetating with trees. A second potential problem on even the sites reclaimed by new mining technology is the reestablishment of good nutrient-cycling relationships. Newly reclaimed sites are likely to have poor internal drainage, low surface-soil organic-matter content, and reduced microbial activity to aid in the breakdown and availability of soil nutrients. There is likely to be some difficulty in getting good mycorrhizae established on tree roots, and those tree species capable of symbiotic nitrogen fixation may not encounter the necessary microbial symbionts in these

[1]Journal paper no. J-9987 of the Iowa Agriculture and Home Economics Experiment Station, Ames, Iowa. Projects No. 2294 and 2210. Presented at the Symposium on Trees for Reclamation in the Eastern U.S., Lexington, Kentucky, Oct. 27-29, 1980.

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reconstituted soils.

OLD MINE SITES

Spoil characterization and revegetation trials were started in 1952, and several general summaries of that work have appeared previously (Hansen et al. 1962; Lorio et al. 1964; Lorio and Gatherum 1965). On a few sites, there has been a natural reinvasion of cottonwood, boxelder, and American elm. However, on many sites natural revegetation is extremely slow because of a combination of low pH, steep topography, infertility, and insufficient seed source or germinaton conditions. A total of 15 tree species was tested in plantations on these spoils and the following conclusions were drawn (Lorio et al. 1964):

1. Green ash had the best survival across all conditions, but is best adapted to more moist sites with a pH near 7.

2. Cottonwood had good survival and the best growth rate on a variety of sites. It had double the height growth of green ash.

3. If evergreens are desired, only eastern redcedar should be used on calcareous sites. On dry, low-pH sites, jack and Virginia pine can be used. Red and eastern white pine should be used only on moist, well-drained sites with good fertility and slightly acid pH's.

One woody shrub species also has shown considerable potential for use. Arnot bristly locust, a cultivar of *Robinia fertilis*, can be established on low pH spoils (survival rate drops significantly only below a pH of 3.5), and it will subsequently spread as a ground cover by means of root sprouting (Helgerson and Gordon 1978).

Soil moisture and pH characteristics are the primary determinants of what tree species can be established on a site (Lorio and Gatherum 1965). Where these two characteristics are not extreme, the next most important limitations are nitrogen and phosphorus availability (Lorio and Gatherum 1966). Therefore, planting nitrogen-fixing tree species alone or in combination with other species is likely to increase growth rates. European alder (*Alnus glutinosa*) is a leading candidate for use as the nitrogen-fixing component of tree plantations (Dale 1963; Plass 1977), and a major research project on this species is in progress at Iowa State University (Hall et al. 1979; Maynard and Hall 1980). Black locust (*Robinia pseudoacacia*) is another nitrogen-fixing tree species that might be used. The Arnot bristly locust previously discussed could be used as a nitrogen-fixing shrub layer in tree plantations.

The phosphorus-deficiency problem should be reduced if trees can be planted with appropriate mycorrhizal fungi already established on their root systems (see article by Marx elsewhere in this proceedings). We also have evidence that at least one mycorrhizal fungus (*Pisolithus tinctorius*) offers a direct protective effect for root systems exposed to low pH soils where toxic levels of aluminum are in solution (Cochrane and McNabb 1979).

NEW MINE SITES

Less experience is available on establishing tree plantations on sites mined with the new technology. A few landowners have successfully planted walnut and white pine. The author has established a research planting of European alder and hybrid poplar (*Populus alba X P. grandidentata*) on a terrace at the Iowa State University Demonstration Coal Mine near Oskaloosa, Iowa. After three growing seasons, the survival is 37% for the alder and 87% for the hybrid poplar. Initial growth rate was best for the hybrid poplar, up to 3.6 ft. in the first year. Once the alder became established, rapid growth started, adding at least 3 ft. of growth during the third growing season. Root excavations have shown that the alder is capable of sending a "sinker-root" system down through the compacted, high-clay-content soil to a depth of approximately 3 ft., while the roots of the hybrid poplar are confined to a wide horizontal spread in the upper 6 in. of soil. Future evaluations of this study should provide insights on the ability of alder to improve a reclaimed site by breaking up compacted zones in the soil and supplying nitrogen through leaf fall and root decomposition.

Other studies are needed to gauge the suitability of a range of other tree species for use on reclaimed sites and to determine the best site preparation and planting techniques. The establishment of tree plantations that help to restore a nutrient balance to mined sites while providing fuelwood, wildlife, and recreational benefits may then become an alternative to the more costly reclamation of sites for row-crop production.

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TREE PLANTING IN RECLAMATION

TREES FOR RECLAMATION
LEXINGTON, KENTUCKY
OCTOBER 27 - 29, 1980

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While fifteen years ago we depended on trees as the primary tool of reclamation, today regulators, based on soil loss studies, have determined that trees are not sufficient to prevent erosion by themselves. This is particularly true during the first 10-15 years after mining. While ten (10) years ago most permits listed forest as a postmining land use, today only ten (10) percent of our permits contain forest land as a postmining land use and a good many of those may modify their reclamation plan to eliminate the trees these plans now contain.

The other two gentlemen representing the great state of Ohio have discussed some of the reasons that trees are not the valuable tool they were fifteen years ago. I am both an environmental lawyer and the assistant regulatory authority for the administration of coal mining regulations in the State of Ohio. I will try and outline our position on this matter and discuss some of the things we have done to curb this trend away from tree planting.

Now in Ohio we operate a two-prong regulatory system. On the one side we operate an incentive program. An operator posts cash or bonds in a large sum and these funds are returned only if all regulations are complied with and the land reclaimed. On the other side we run a penal system of compliance. Non-compliance results in civil penalties, criminal fines, jail sentences, and/or the termination of the operator's business completely. One bond forfeiture in Ohio precludes any future permits being issued to the operating company, officers of the corporations, and even major stockholders.

The penal aspects of our program are only effective in the situations where an operator is operating under a plan calling for trees to be planted and he does not plant trees. It is not a criminal offense to turn a state from a forest land to a rangeland. The operator submits a reclamation plan when the operation is proposed and it is up to the state to provide incentives so that the operators voluntarily plant trees. As stated above trees are not planted for economic, technical, and social reasons. Without adequate incentives we will not find tree planting - we must find ways to encourage tree planting.

The first step we have taken in this direction was a new standard for revegetation when trees are planted. When an area is backfilled and graded we require successful establishment of a vegetative cover. If grasses and legumes are planted the site must contain a seventy-five per cent cover. However, if trees are planted the success rate is reduced to sixty per cent. We have the discretion to reduce this to fifty per cent. The obvious advantage being the survival rate of trees will improve with reduced vegetative cover. This step was taken at the request of a few operators in Ohio who wanted to plant trees and it is partially successful.

A second step we are taking is requiring revegetation to remain successful for a full five year period after establishment. Operators in some areas find that their grasses and legumes will not always last for the necessary period due to the poor quality of spoil below the topsoil and other factors mentioned by the other speakers.

Lastly we face the problem of the operator who wants to mine forest land, but reclaim the area for another land use. Recently we decided to fight only for those areas with valuable forests and concentrate our efforts rather than to resist any effort to permanently eliminate woody species. When in doubt the Division of Forestry will assist us in evaluating a specific area. If the trees are without commercial value, it is much easier not to replace them. However, valuable forest lands must be replaced or undergo time consuming and expensive land use change procedures. Public notice, landowners consent and impact statements from cooperating agencies are the key procedures. It is a procedure that the operators want to avoid where possible - thereby an incentive is created for tree planting. To give you an idea how successful this procedure is I might note that from 1972 to 1977 when these requirements took effect only 1% of our postmining land uses were forest lands. Today we are looking at a 10% figure for forests.

The incentives described above are only important beginnings to bring tree planting back into reclamation. We are cooperating with several agencies in Ohio in the study of the problem of the disappearing forests. Those studies and meetings such as this one may result in additional incentives being developed to solve this very serious problem.

Finally, I must point out that any actions on our part must be discussed with the U.S. Office of Surface Mining pursuant to the Surface Coal Mining Control and Reclamation Act of 1977 P.L. 95-87. While we at the Ohio Department of Natural Resources are now and plan to continue to be the primary agency regulating coal mining in Ohio, this federal law provides us with oversight assistance from this federal agency. We do not look at these discussions as a major stumbling block but it points out the advantages of the type of organized concern we show here today. If Ohio argues for a procedure to encourage tree planting, it will not carry the weight of a group of professional experts from concerned states addressing a common problem. This type of group input is essential to the implementation of immediate and long range solutions.

TREES FOR OHIO

Ernest J. Gebhart

Other members of this panel are going to reveal the basic statistics about the coal strip mining industry in Ohio so I will confine my remarks to the revegetation of the spoil banks. So it doesn't appear that Ohio confined its tree planting efforts to spoil banks alone, I will rely on a few statistics.

The Division of Forestry started operating tree nurseries in the early 1900's at Wooster and Chillicothe. These efforts were consolidated on the Marietta Nursery in 1925. Species grown were primarily conifers with some of the better hardwoods which were distributed to the state forests and private landowners for planting on abandoned agricultural land. The program was increased in 1948 with the opening of the Green Springs Nursery in Sandusky County. A new Ohio strip mine law requiring some limited grading and revegetation of spoil banks prompted the Division to devote this nursery exclusively to the growing of deciduous species. In the early 1950's, the Zanesville SCS Nursery was transferred to the Division making the Reforestation Section capable of producing 15 to 17 million trees. For a number of years, shipment of trees to strip miners for planting disturbed soils absorbed about half of the nursery production.

This all changed abruptly after the passage of the 1972 Ohio Strip Mine Law. This legislation provided the mine operator with an option of revegetating with a heavy stand of grasses and legumes or a lighter seed mixture and the establishment of a satisfactory stand of trees. Economical influences took over at this point and most miners discontinued the use of trees in their planting plans. There was some tapering off as pre 1972 mined land was required to be planted to trees. The end effect of this change of tactics was to reduce the demand for hardwood planting stock by about seven million trees a year and to create vast areas of grasslands. It should be recognized here that experience had shown that the survival of trees planted in an area seeded to grasses for erosion control was at least doubtful.

We have not felt that this endeavor was lost for all time and have kept our nursery production capability intact for a rebound into the future when tree planting on mined lands will again come into proper perspective. There are several significant factors working toward this end which give us encouragemen The 1977 federal strip mine law and accompanying rules require or encourage the planting of trees on areas that before mining supported tree cover. Recent amendments of Ohio's law tend to support this requirement. While planting trees on replaced topsoil and with erosion control grass cover being a possible deterrent is a new concept for us, I am sure that with proper soil amendment and seeding practice it can be done. This is the area where we see the first significant return to tree planting.

A second area that we believe will, could or should utilize trees is the revegetation of unreclaimed mined lands. Most of these lands were mined prior to 19 and topsoil was neither saved or restored. In most cases, it is not now available to the reclaimer. These spoils, with proper grading, can be revegetated with trees. This is apparent from the many successful operations prior to 1972. With the magnitude of funding that is or will be available for this type of reclamation wor we see a considerable demand for tree planting stock developing, particularly fo legumes and quality hardwoods.

A third area is one that has not beer explored to any extent but will be confronting us in Ohio in the not too distant future. It has been well demonstrated the with the use of heavy applications of lime and fertilizer various types of grasses can be established on quite acid spoils or soils. Frequent reapplication of these amendments will undoubtedly sustain them for long periods. The obvious flaw here is that the strip miner is responsible fo the revegetation only until his bond is released. If he does not own the surface as well as the coal, his interest ceases here. It is then incumbent upon the landowner to provide the necessary cultural practices to keep the grass cover intact. He will only do so if he is utilizing the grass and making a profit from it. Otherwise, it will deplete the initial application of lime and fertilizer and start to thin out. Eventually barren are will develop and the once secured spoil will be subject to further erosion and weathering. I am not predicting how rapidly this could or will take place but am proposing a solution when it does occur.

As the heavy foliage encouraged by the initial application of lime and fertilizer starts to dissipate, the landowner has an opportunity to reforest the area as he would any old field. If by this time he has not brought the mined area into his farm plan for annual crops or livestock pasture, he would be well advised to get it into a permanent tree cover. This will require a minimum of cost outlay to maintain and will have the potential of some future monetary return. It is difficult to predict when this will reach significant proportions but we anticipate having the capability of meeting the demand.

You can see from these remarks that we have not abandoned the idea of trees on spoil banks and do not intend to do so. Therefore, I have some suggestions for your consideration:

1. On selected mined areas, trees and grasses can be grown together if the rate of grass seeding is kept at the minimum necessary to prevent erosion. The grass becomes a nurse crop to reduce soil surface temperatures and aid tree survival. Rough grasses, such as Kentucky 31 tall fescue, orchard and rye grasses, are suggested at a rate of 20-25 pounds per acre. The trees should be spaced 7' x 7' with about 900 per acre.

2. Some upgrading of nursery stock quality will be necessary. We propose to retain the 2-0 conifer and 1-0 hardwood age classes with oversized stock being graded out. Large seedlings do not do well on spoil banks and are difficult to hand plant. No fall planting is recommended. Even though topsoil is replaced, I doubt if machine planting can be satisfactorily accomplished. Hand planting will still prevail.

3. We are suggesting two basic tree mixtures for your consideration:

   A. Acid spoils or soils: Black locust, Rose acacia, European black alder, sweet gum, autumn olive, silver maple, and Norway spruce.

   B. Alkaline spoils or soils: White and green ash, cottonwood, silver and sugar maple, red, white and black oak, tuliptree and white pine.

   There are other species and combinations of species that will survive and do well on selected mine sites. Each revegetation plan must consider all the parameters involved and options available.

I feel strongly that the conversion of former woodland to grass, where the raising of livestock is not a viable industry, is a disservice to landowners and communities that will require considerable unnecessary expense in the future. There will never be a better time than at the conclusion of the mining process to establish tree cover if the mining and reclamation plan is tailored to the long term needs to permanently stabilize the land. The expedient release of a bond or the minor cost differential is not sufficient justification to leave this part of the job undone.

HAS ANYONE NOTICED THAT TREES ARE NOT BEING PLANTED ANY LONGER?[1]

Walter D. Smith[2]

Abstract.--Trees provided the coal surface mining industry with a means of restoring the land's productivity at a minimum expense. Trees may still be included in the reclamation plan but tree planting in Ohio was drastically reduced by the 1972 Ohio Surface Mining and Reclamation Law. The basic reasons are categorized as technical, social and economic. The revegetation phase of coal surface mined land is most vital to successful reclamation and hopefully trees will continue to contribute to such success.

In Ohio, the historical relationship between the coal surface mining industry and trees has been of mutual benefit. Trees provided the industry with a means of restoring the land's productivity at a minimum expense. Where care was taken in the planting of the fragile tree seedling on the harsh, mined land environment, the small tree seedlings did wonders. Sometimes with the assistance of natural herbaceous cover but often times alone, the collective impact of the tree seedlings ameliorated the environment of the reclamation area to the point that a stranger to the site would speak only of the young forest that is growing there.

If you wish to plant trees in your reclamation operation, please do. Plant one thousand tree seedlings per acre. Plant a row of nitrogen-fixing tree species, i.e., black locust, black alder, and/or autumnolive. Plant a row, maybe two, of your favorite commercial deciduous and/or coniferous species, i.e., red oak, white oak, white or green ash, sycamore, silver maple, maybe black walnut, white pine, red pine, shortleaf pine, maybe Austrian pine and maybe Paulownia. Be site specific, more so than in the past. Plan your planting arrangements. And if you need further information, start with Chapman (1944); Limstrom (1948); Lowry (1956); Knudsen (1952); and later Funk (1961); and today Plass (1968) and Vogel (1973). For bibliography sources start with Limstrom (1953); Knabe (1958); Funk (1962); and today Czapowskyi (1976). Those references are just a very few of much valuable research conducted of yesteryear and continuing today.

Having been a direct party to the planting of some 19.4 million tree seedlings in fifteen years and observing the results of the total planting of thirty-eight million tree seedlings on both mined and unmined land over a thirty year period, I can look anyone in the eye and say that the trees will grow and produce forests on coal surface mined land.

But before you run out and type "tree planting" into your revegetation plan, look around. Has anyone noticed that we are not planting as many, if any, trees any longer? I categorize the basic reasons as TECHNICAL, SOCIAL and ECONOMIC.

The 1972 Ohio Surface Mining and Reclamation Law had many of the mining and reclamation provisions and most of the intent of Public Law 95-87. The effects of the law extinguished slowly but almost completely the use of trees in surface mined land reclamation revegetation operations. The Ohio law drastically altered the site conditions upon which the vegetation was to be established. The law with its mining-grading-topsoiling requirements brought about higher soil pH values with attendent improvement in the types, availability and amounts of nutrients and a decrease in toxicity levels. The topography became almost one hundred percent traversible by rubber-tired tractor vehicles and was complimentary to the undisturbed lands. The long, uninterupted slopes posed problems, especially erosion and consequently sedimentation, so herbaceous

[1]Paper presented at the Trees for Reclamation in the Eastern U.S. Symposium, Lexington, Kentucky, October 27-29, 1980.

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vegetation versus deciduous was required to combat these problems. Pollution abatement played a major role in the 1972 Ohio law.

The technical reasons trees were eliminated from the reclamation revegetation plan were (1) compaction, (2) herbaceous competition, and (3) erosion and survival repair work. The compaction problem voiced in the early 1950's by Deitschman (1950); Merz-Finn (1951); Finn (1952); and Limstrom (1952) were compounded by the grading requirements of the 1972 Ohio law. Compaction is a problem both from getting the tree seedling planted in the soil and in getting growth and survival.

Competition from herbaceous vegetation is fierce. Intense fertilization required to quickly establish herbaceous vegetation for soil surface protection from impact and rill erosion and consequently sedimentation prevents seedling establishment in at least the early phase of the revegetation effort. And finally there comes the reclamation supervisors nightmare -- repair work. Repair work of herbaceous vegetated areas is an anytime job. But tree planted areas can only be repaired each spring.

As an example, we planted in the spring of 1974 using herbicides and in the spring of 1975 using eighteen-inch diameter, fiber glass, weed chek discs, two hundred acres of 1972 Ohio law graded spoil banks to trees. In quick summary, the combined impacts of compaction, herbaceous competition and repair efforts, effectively stopped any tree planting on active, bonded licenses for Central Ohio Coal Company. In 1977, on bond-released but similarly reclaimed areas upon which the vegetation was now two to three years old, we band sprayed with herbicides and planted tulip poplar, red oak, white oak, white ash and red gum. Results were decent considering the species used but not acceptable. We have not planted another tree seedling from that date.

The social reason is more subtle but very much real. The approximate original contour grading requirement of the Ohio law coupled with the use of herbaceous vegetation made for land that was at least topographically better than the original. The slopes were less steep - they could not ever be steeper: were more uniform: and were easily traversible. To the private landowner, he liked what he saw and demanded that the revegetation plan state "grass cover for pasture and forage production" even if there had been trees growing on the site prior to surface mining. Central Ohio Coal Company is presently approaching ten thousand acres in surface mined grassland acreage. Much of it is presently under lease arrangement for livestock pasture and hay production. Travel eastward from Zanesville, Ohio, on I-70 to Wheeling, West Virginia, and view the various surface mining operations and observe the vegetation cover being used. It will be grass.

Economically speaking tree planting is now an additional expense to the operator, not a necessary expense. Tree planting is an additional expense in terms of the (1) original planting; (2) of repair planting; and (3) in delay-related expense associated with compliance time and bond release. To the operator, such delays have many implications. The multiplicity of standards which the operator must comply-with forces the operator to adopt those reclamation procedures that in this day of spiraling costs get the job done the most efficient and most effective.

Earlier this year I was somewhat optimistic that forestry and tree planting for reclamation purposes was on the upswing. I felt that land use statutes of Public Law 95-87 would have a positive impact on reclamation tree planting on prior forested areas. But now, for the short term, valid forces are at work which just prevent tree planting. For the long term, I am most concerned that the necessary and proper management of the grasslands will be implemented. Inadequate or improper management of the grasslands will impart a very negative impact to the public eye. The surface mining image is always at best tolerable.

In conclusion, some suggestions. It would appear at first glance that a tree seedling of greater than usual historical height and size, and one that had a self-contained growing environment that would last for at least the first to maybe three years of its life, would prove helpful to successful plantation establishment. Furthermore, plantings techniques necessary to overcome mined land soil physical problems may also require a seedling package that affords the seedling's roots and top greater protection from physical damage. I feel that given a "wooden" nickel out of every dollar spent on total reclamation compliance costs, tree planting on mined banks would become a viable enterprise.

If and whenever I return to the reclamation business, I would slowly but definitely install tree planting as an integral part of the reclamation plan. As the technical problems are solved with attendent enforcement agency edification, the economic problem will dissolve. In my opinion, tree planting costs would be the least expensive of all reclamation requirements for long term benefits received but the revegetation phase - both herbaceous and deciduous - if most vital to successful reclamation. The social problem will continue to exist and be influential. Forestry and tree planting have always played an important part in coal surface mining reclamation. Given this short intermission, it is my hope that the historical beneficial relationship previously expressed would continue.

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REVEGETATION OF SURFACE-MINED LANDS IN PENNSYLVANIA[1]

G. Nevin Strock[2]

BACKGROUND

The reforestation of surface mines in Pennsylvania became prevalent in the middle 1940's with enactment of state legislation to regulate surface mining of bituminous coal. Though this early legislation did not provide for intensive environment protection standards in comparison to state legislation which followed in the early 1960's and early 1970's and in contrast to today's standards, it did establish the beginning of large scale surface mine reclamation activities. The planting of trees became a significant part of the reclamation process. Tree planting continues to be a land reclamation practice for providing permanent, long-term vegetation for watershed protection, wildlife habitat and timber production.

The trend with regard to changes in land use as a result of surface mining are not readily discernable because of the unavailability of statistics for making such a determination. However, a statewide land use report for Pennsylvania showed that for the period from 1958 to 1974 there was a 9.7% increase in woodland acreage while pastureland and cropland acreage showed decreases of 26.6% and 15.7%, respectively. Though these figures do not directly reflect changes in land use patterns as a result of surface mining, the figures do indicate the general trend for land use changes in Pennsylvania. Over 17 million acres or more than 60% of the land surface in Pennsylvania is covered by forest growth. A large portion of the mineral resource in Pennsylvania is overlain by forests, so it is reasonable to assume that extraction of these minerals by surface mining would have a significant impact on the overall forested acreage within the state. State land-use studies indicate that forestland management policies should assure a continuous and adequate supply of timber to meet projected demands. Pennsylvania is expected to experience about a 50% increase in demand for timber by the year 2000. Pennsylvania recognizes the importance of forestland for timber, for protection of other forest related resources including water and wildlife, and for the benefits derived from forestland for aesthetics and recreational purposes.

Most of the mine land reclamation in Pennsylvania is performed in conjunction with the active surface mining of coal under the legal requirements which regulate such mining. Pennsylvania has had an abandoned mine land reclamation program since 1968 following the enactment of the Land and Water Conservation and Reclamation Act. This Act provided funding for acid mine drainage abatement, extinguishing of underground mine fires and burning refuse banks and backfilling of open mine shafts. The acreage reclaimed in the state's abandoned mine land reclamation program is small in comparison to acreage reclaimed on active surface mining operations as required by the Pennsylvania Surface Mining Conservation and Reclamation Act and the Federal Surface Mining Control and Reclamation Act of 1977. The requirements with respect to revegetation of active surface mine operations is to revegetate with grasses, legumes, trees, shrubs or any combination of these which provides permanent vegetation capable of soil stabilization, control of erosion and sedimentation and supporting the postmining land use. The accepted revegetation practice for soil stabilization and erosion and sedimentation control is to establish a herbaceous vegetative cover. Consequently, all surface mine sites are initially established with herbaceous species and tree and/or shrub planting is accomplished in combination with herbaceous vegetation if required for soil stabilization, erosion and sediment control, permanent vegetative cover, or for development or improvement of land for commercial forestland, wildlife habitat, recreational land uses or any other land use requiring trees and shrubs in the plant community.

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[1] Paper presented at the symposium - Trees for Reclamation in the Eastern U.S.- Lexington, Kentucky, October 27-29, 1980.

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The sources of tree seedlings for planting on surface mine sites has been primarily the state forest tree nurseries and private nurseries located within the state. The greater portion of the tree seedlings planted on mine sites are obtained from the state forest tree nurseries. During the past three years, the number of tree seedlings, from the state nurseries and planted on surface mine sites, has ranged between 2 and 2½ million seedlings per year. During this same three year period the demand for tree seedlings from the state forest nurseries has exceeded the supply. It has been difficult for the state nurseries to determine the demand for tree seedlings from year to year and to establish production levels accordingly. The standard application form for ordering seedlings from the state forest tree nurseries for planting on surface mine sites has been revised to provide more information by the landowner as to acreage anticipated to be planted in the future and the projected year of planting.

REVEGETATION PRACTICES

Tree planting practices with regard to species selection, establishment techniques and recommended timing of planting have changed somewhat over the years. It was once the recommended practice to plant tree seedlings during the Spring and Fall seasons. The U.S. Forest Service research conducted during the 1960's evaluated Fall and Spring planting of tree and shrub seedlings on surface mine spoil in the Bituminous region of Pennsylvania (Davis 1973). Results of that research study showed consistently higher survival rates of seedlings when planted during the Spring season. The advantages of Spring planting were greater on the sites with the more acid spoil. Current state regulations require seedlings to be planted during the Spring planting season and no later than May 15 except where cold storage nursery stock is utilized. The planting season may be extended to June 1.

Most reforestation on surface mine sites has been with planted seedlings. Nursery stock is generally 1-0, 2-0 or 3-0 bare-rooted seedlings with the exception of hybrid poplar which is planted as an unrooted cutting. Some efforts have been made to establish trees by direct seeding. However, with the exception of black locust (*Robinia pseudoacacia*), direct seeding has been unsuccessful. There is substantial interest among wood-using industries which own surface mined land to establish commercial hardwood species by direct seeding.

Since planting requirements and practices changed to require the initial planting of herbaceous vegetation following backfilling and grading, there were concerns that those sites which would also be planted with trees would be adversely affected by the competitiveness of the herbaceous vegetation. We initially shared these concerns. Currently, we do not see this as a significant problem if herbaceous species and rates of application are carefully selected and timely planting of the trees is accomplished. We recommend low-growing, non-agressive herbaceous species and planting of the tree species at the same time or as soon as planting conditions and the planting season permits following seeding of the herbaceous species. Some of the planted herbaceous species we have observed which are extremely competitive with trees includes crownvetch (*Cornonilla varia*), sericea lespedeza (*Lespedeza cuneata*), flat pea (*Lathyrus sylvestais*), white sweet clover (*Melilotus alba*), and yellow sweet clover (*Melilotus officinalis*). Weeping lovegrass (*Eragrostis curvula*) when seeded in excess of 2 lbs./acre can become competitive with tree seedlings. Of the herbaceous legume species, birdsfoot trefoil (*Lotus corniculatus*), particularly the lower-growing empire variety, has been commonly planted in conjunction with tree seedlings.

The establishment of trees on surface mines by interplanting with black locust (*Robinia pseudoacacia*), European alder (*Alnus glutinosa*) and Autumn olive (*Elaeagnus umbellata*) appears to have some significant benefits. Such leguminous tree and shrub species planted as nurse trees has improved the growth rate of the other tree species interplanted with the nurse trees. A 7 year old planting of black locust (*Robinia pseudoacacia*) and hybrid poplar (*Populus spp.*) in alternate rows at a spacing of 8 feet within the row and 10 feet between rows has been documented with having hybrid poplar (*Populus spp.*) with dbh's as large as 9.5 inches and 60 feet in height. The planting was performed on acid mine spoil without the benefit of soil amendments.

The tree species commonly planted on surface mined land in Pennsylvania include red pine (*Pinus resinosa*), Eastern white pine (*Pinus strobus*), Japanese larch (*Larix leptolepsis*), Austrian pine (*Pinus nigra*), Norway spruce (*Picea abies*), European alder (*Alnus glutinosa*), black locust (*Robinia pseudoacacia*), hybrid poplar (*Populus spp.*) and northern red oak (*Quercus rubra*).

In summary, Pennsylvania recognizes the importance of tree species for surface mine land reclamation and the potential these reforested lands have for timber and enhancement of other forest related resources and Pennsylvania encourages revegetation of surface mined land to maximize resource productivity.

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TREES FOR RECLAMATION IN THE EASTERN UNITED STATES

A WEST VIRGINIA PERSPECTIVE

BY: James E. Pitsenbarger, Chief
Division of Reclamation
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Traditionally, in West Virginia, trees have been an integral and important part of the reclamation program. Moreover with the advent of Public Law 95-87, it certainly would appear that trees are destined to play increasingly diverse and important roles in the field of reclamation.

This symposium presents a unique opportunity for a state regulatory agency to present its problems and views with regard to the utilization of trees for reclamation.

A chronological evaluation in West Virginia of reclamation laws and regulations show that trees were the primary revegetation and stabilization tool utilized in the era prior to 1967. In 1967, the State Legislature passed a completely revamped surface mining act which recognized the value of quick stabilization and mandated increased emphasis on grass species toward this end. Tree species, however, remained an important utility revegetation tool.

The passage of the 1971 Surface Mining and Reclamation Act saw increased importance placed on fast growing, effective and permanent vegetative species which would enhance and promote effective stabilization. Obviously, an increased emphasis on grasses and legumes resulted. In fact, trees were only required on slopes that were generated in excess of 20° at which point dual grass and tree treatment were required. This is not to say that trees were disapproved of, they were merely deemphasized in favor of promoting quick stabilization of disturbed lands.

The Surface Mining Control and Reclamation Act of 1977 passed by Congress in August of that year, places renewed interest in tree species for reclamation. The Act and the myriad of regulations subsequently promulgated placed new mandates on land use restoration, post mining land uses and the establishment of vegetative cover of the same seasonal variety native to the area.

The apparent result of this federal legislation will be increased demand for tree seedlings and seed in greater numbers and varieties than ever before. Therein, however, lies some of the problematical factors involved in mandates such as those suggested by the Federal Surface Mining Act.

With this in mind and as a state regulator facing imminent deadlines and fully realizing that trees are a very important and integral portion of any effective reclamation program, we in the West Virginia Division of Reclamation would like to detail problems we foresee or have experienced and request research where appropriate and also to offer our assistance wherever it may be helpful.

The planting of tree seedlings has been the most proven technology of establishing a viable stand. Beyond traditional species (black locust, pines sp., black alder, etc.) it is difficult to find sources for additional and perhaps, more beneficial species. It remains difficult for state nurseries to provide additional stocking species unless specific commitments are established. Many other states probably share this problem.

West Virginia would like to suggest that further research be established which would promote and define additional species which would be economical and adaptable for reclamation usage in the Appalachian Region. The Division of Reclamation, in concert with the Division of Forestry, will also be working on this problem with hopes of obtaining a vigorous program of forest restocking beneficial to all concerned.

Direct seeding of tree species is becoming an increasingly interesting concept which is not new to West Virginia. Direct seeding of some species, particularly black locust, has been used for several years with good success.

Direct seeding of most other species has met with mixed success, unfortunately, most have resulted in failures. Largely due, most experts feel too intense competition with the grass species which must be planted.

West Virginia again would like to suggest that research be intensified in this regard which would provide additional seed sources and provide an economical and efficient method of obtaining a viable tree stand through direct seeding methodology. West Virginia is also currently exploring direct seeding techniques in cooperation with the Steering Committee on Surface Mining which is made up of the Department of Natural Resources, United States Forest Service and West Virginia Surface Mining and Reclamation Association under a tripartite agreement for surface mining research.

West Virginia is also exploring through new regulations the concept of commercial forest lands as a viable alternate post mining land use for mountain-top removal operations. We anticipate considerable resistance on this course of action from the Office of Surface Mining. However, West Virginia feels the intent of the federal law was not to negate a very valuable resource, particularly in a timber producing state such as West Virginia. West Virginia solicits any support, both from the research or experience standpoint, that any agency or state may be able to provide.

The results of this symposium should provide many opportunities to renew old research or establish new avenues for research and West Virginia's Department of Natural Resources is ready to avail its expertise towards this end and to provide whenever possible support for research activities which would enhance the art or as we prefer, the science of reclamation.

We would also like to commend the organizers of this symposium for their farsightedness and look forward to more regular gatherings where we can advance the State of the art through cooperation to everyone's mutual benefit.

THE ROLE OF WEST VIRGINIA'S DIVISION OF FORESTRY

Paper presented at the Trees for Reclamation in Eastern U.S. Symposium in Lexington, Kentucky, October 27-29, 1980

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Abstract.--Trees are best suited for reclaiming stripped areas with a valuable product. Wildlife and forestry considerations should be the concern of operators, landowners, foresters, and wildlife biologists with an objective of returning the disturbed land to its most capable productivity. In West Virginia, trees are the most logical and realistic product of the land.

Mr. Moderator, members of the panel, dignitaries, ladies and gentlemen. As State Forester of West Virginia, the heart of Appalachia and the coal mining region, I must point out that this so-called pocket of poverty is very rich both in renewable and nonrenewable resources. More than 75% of our 15 million acres is forest land. The Division of Forestry (DOF) of the Department of Natural Resources (DNR) has within its jurisdiction and supervision woodland areas, the protection of forest acres from damage by fire and other forces, the administration of compacts and agreements relating to forestry area management and husbandry and the administration and enforcement of all laws pertaining to the conservation, development, protection, use and enjoyment of all forest land areas of the state. Herein lies some of the reasoning for the DOF to be concerned in the reclamation work.

Much of the area has been surface mined and much more will be. It so happens that most of the area surface mined or could be, is, or has been forest land and is best suited for forest production. In fact, most of the mined areas have an unacceptable low value for any land use other than forest production.

In most cases, the philosophy of grass and legumes is not the best permanent surface cover for the area. The landowner should be helped to get his property back into production of a crop that will provide a monetary return and still hold the soil. On the steep slopes, properly selected trees are the most reasonable and practical cover.

One of the problems encountered is the resistance of some operators to go further than the immediate quick cover route of grass with some seed producing sedges, etc. that appear to bolster the wildlife theory. Forestry has no quarrel with this. In fact, we support the quick cover procedure, but know that it is not adequate for the long range needs nor will it produce a crop commensurate with the capability of the soil.

The DOF believes that quick cover, followed by tree planting, is the most reasonable and equitable procedure. Immediate soil holding action can be effective and the long range production of a merchantable crop is launched.

Direct seeding can be successful with certain species on acceptable soils; however, each type and site should be evaluated by a forester to determine the best method of establishing the best land use. The DOF has that expertise.

Of course, the availability of the recommended species can be a problem, but with the results of research already published and/or currently in progress, the only need is assurance that the trees will be bought and planted when they reach the proper planting age and size, usually 1-2 growing seasons in the seedbed. The cost of "gearing up" the nursery to grow three million seedlings is approximately $200,000 per year and going up each year. Therefore, there must be a commitment before we can invest taxpayer money wisely. West Virginia experienced this unfortunate circumstance several years ago by seeding for approximately 5,000 acres of reclamation work without a firm commitment. When the time came two years later, direct seeding by helicopter was chosen and most of the investment to produce the needed seedlings was lost.

Under Public Law 95-87, it appears that trees will be required to meet the mandates of the law, but the required public participation, input, and additional work prior to establishing regulations are taking time.

In a way, there is a general acceptance of the philosophy that all the operator needs to do is get a green cover on the disturbed and regraded surface and the nice "manicured" appearance will be adequate. Any forest or tree cover needed will come in naturally from existing nearby seed trees.

Such procedures frequently establish an attractive scene for a few years, but usually deteriorates after the care and fertilize treatments are discontinued. Natural reseeding is very slow and frequently provides inferior species. The real need is halfway met, but a planned and professionally conceived permanent and productive cover should be established after the quick cover has stabilized erosion tendencies.

This permanent cover should be hand planted trees and shrubs known to be suitable for the area. Frequently, the controversy rages about wildlife planting versus forest tree planting. This conflict should not be. In this business, we need and can have both. Most landowners want wildlife on their property; however, wildlife does not bring any appreciable income to the landowner, nor does it help pay the taxes. Trees can. Pulpwood, fuelwood, lumber, veneer, etc. can be quite profitable when properly managed. The planting plan for a reclamation job should include the quick cover to hold the soil and the tree species best suited to the area interspersed with open areas designed for wildlife food and cover.

There is no place for the "tunnel-visioned" forester or wildlife biologist. In reclamation work where forest cover is required they should have as their number one objective to get that land developed into an economically productive tract. In most of the surface-mined areas of West Virginia such a program will require trees. Forestry and wildlife are compatible and should complement one another on a reclamation project.

Let us go back to the quick cover. Frequently, this becomes a temporary mat of grass and legumes that will smother any tree seedling or shrub planted with or soon after the original treatment of fertilizer and mulch. Therefore, the planting plan should consider the selection of species that can be compatible with the planned permanent cover, perhaps, even considering a "nurse-crop" for soil build-up purposes prior to the establishment of the final crop trees that ultimately will be harvested. Such considerations are for the professionals.

Soil scientists, foresters, and wildlife biologists should work together. Research in all fields concerned has been done and is continuing; however, we must avoid the pitfall of "re-inventing the wheel." There are indications of duplicating work already done. Perhaps, a study of all strip mine reclamation research projects completed and on-going would be in order to assure that new projects were not directed toward a problem already addressed.

I do hope we continue to approach the problem of reclamation wisely and I expect the several diciplines involved to be cooperative. In Appalachia, there are thousands, yes, even millions, of acres of disturbed land being or to be reclaimed with a vegetative cover. Already, "quick cover" of unproductive grasses, clover, and lespedza have been successful, but their conversion from a soil stabilizing nuisance to a productive forest with the by-product of wildlife and recreation must be accelerated. Steps must be taken not to re-create the problem in the reclamation of the abandoned surface mine areas now under consideration and the new surface mined areas of the future. Trees are our most valuable renewable natural resource and must receive their proper stature in the field of wise use of our natural resources.

TREES FOR RECLAMATION IN THE EASTERN UNITED STATES

THE CHANGING PERSPECTIVE

BY: James R. White, Vice-President
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Ten years ago a typical Eastern U.S. reclamation project was pictured with a prominence of trees on a bench in front of a wall with little or no ground cover evident.

That typical picture today has changed a great deal. Present surface mine reclamation is generally pictured as a thickly-grassed "inslope" if contour mining, or a wide expanse of level, heavily-vegetated land in the case of mountain-top mining. Trees are no longer prominent.

Why the difference?

There are a number of reasons. They involve economics, logistics, changes in laws, methods of operation, differing characteristics of trees, and manpower availability. Some of these may seem unrelated to tree use, but when considered in the vernacular of the mining industry, they are intricately related.

I do not mean to imply that trees are never used in reclamation today. They are and they are used extensively. However, they are no longer the prominent ingredient. The use of trees has been overshadowed, not discouraged, by the use of grasses and legumes as the dominant component in a reclamation plan.

Neither do I mean to imply that the use of trees is not important in the reclamation and stabilization of surface mined land. I have always felt they have an important part and I continue to profess their significance. To exemplify my feelings, I can point to more than 20,000 acres of land which I have reclaimed or overseen the reclamation of in West Virginia, Virginia, and Kentucky. On those acres, I have planted more than 40 million trees, either by direct seeding or seedling plantings. That estimate may sound exaggerated, but I have practiced reclamation in all types of terrain, which were mined by all methods of mining ever known to the industry over the past 30 years. Trees were an absolute necessity.

Being a strong supporter of tree use in reclamation, I maintain hope that their use will once again gain prominence. Nevertheless, it has changed over the last decade an I wish to briefly discuss my observations as to why they have been de-emphasized as well as offer recommendations which might increas their use.

As I mentioned, I have dealt with all types of mining by all sorts of methods. In reclaiming those lands, I have planted trees both seeds and seedlings, in every conceivab manner: by hand, conventional machine, hydr seeder, helicopter, and tree spades. Overal success has been excellent, but some methods species, and types of stock have outdistance others.

For instance, in 1968, we direct seedec some 6,500 acres by helicopter. This was th largest helicopter direct seeding project ev undertaken on mined land in this country. I may, perhaps, be the largest single reclamation project undertaken at any one time or mined land in the world. The 6,500 acres were located in Raleigh and Boone Counties i southern West Virginia.

On that project, we used a varied mixture, but the dominant tree species were locust, white birch, and a mixture of Virginia, pitch and white pine. Besides the locust, which of course, was most effective the white birch was most successful with the pine doing quite well. Although it was several years before we could actually evaluate the effort, we were exceptionally pleased with the overall results.

With the magnitude of that particular project and the accessibility of the sites, as well as spring weather uncertainty, the helicopter was the logical and most economical means of direct seeding. Today, however, the methods of mining and emphasis on concurrent reclamation do not lend themselv to helicopter application.

In another project we hired 32 high school students for a planting crew. In a three-month period, they planted 700,000 Virginia pine (1.0) seedlings. That effort was quite successful. The problem with that sort of effort today is the availability of manpower, however, in West Virginia, we are fortunate in that the Soil Conservation Districts maintain planting crews, although their capacity may be limited. Nevertheless, these crews are available for planting trees where they are needed or desired.

These two projects were undertaken in the late 60's and early 70's. During that period, the use of trees in reclamation in West Virginia was at an all time high. The methods of mining, regrading, and overall overburden handling techniques made the use of trees more desirable than concentrating on ground cover.

Since that time, an intertwining change in laws, methods of mining, equipment, and reclamation standards have caused the emphasis to shift from trees to ground cover. Although trees were still encouraged on slopes, grasses and legumes provided a quicker means of stabilizing disturbed lands.

As the decade proceeded, increased attention was placed on erosion and sediment control. The logical tool to enhance control was grass and legume cover. Of course, with a permanent cover of grasses and legumes being acceptable for bond release, the shift was accelerated because ground cover was effectively established before direct seeded trees could ever be evaluated for survivability, much less long-term success. This meant the bond could be released in shorter time. That was an advantage to the industry.

With all the changes in every aspect of the surface mining industry, there has been a considerable refinement of technology and methods of operation. Such refinement has provided a more acceptable medium for plant growth, both grasses and trees. Today, I feel that any herbaceous or woody species suitable to the area and its climate will have a high rate of survival under normal conditions.

This improved medium provides an advantage to tree planting. For instance, we have found that three pounds of locust seed, instead of the six pounds we used to apply, is more than adequate. Also, we have been able to introduce other seedling species into West Virginia with a good rate of livability. For example, we have had good success with 2.0 Aspen seedlings from Minnesota. Although not alien to West Virginia, the local source of supply is nonexistent. That is why we had such a difficult time obtaining the stock.

While discussing refinement and the advantages it has offered to revegetation, I will mention one other matter which has enhanced tree life on modern surface mining operations. That is, we have found that tall growing legumes such as sericea lespedeza inhibit tree growth and development through undue competition. Therefore, in areas where we plant trees, we use a lower growing species such as birdsfoot trefoil. The result has been noticeably good.

Recent Agricultural Research Service investigators have noted a possible problem relating directly to this increased refinement. That is particularly true in steep slope areas, where compaction of the "backstack" is required or on a mountain-top operation where compaction is inherent to the haulage of material, tree growth may be inhibited by this overcompaction. It is not overcompacted from a stability standpoint, but it may be from a tree planting, growth, and development standpoint. Our problem--how do you resolve the stability question v. optimum tree growth conditions and satisfy the regulatory agencies? If compaction continues to be noted as an inhibitor to tree growth, it is one area that should warrant the immediate consideration of the forestry profession in concert with the regulatory agencies.

As the methodologies have changed and the refinement of soil manipulation has progressed, so have the types of equipment organic to a surface mine operation. There are those which practically every surface mine operator has, such as a hydroseeder, and there are those which are unusual, but seem to have a place in surface mine reclamation.

Throughout the decade, the use of the hydroseeder has increased substantially. Because of more emphasis on concurrent reclamation and the availability of water, it has been a logical means of applying seed, fertilizer, and mulch. It is quick, cost effective, and highly mobile. The results with hydroseeding have been most successful, particularly with the grass/legume mixtures. The disconcerting factor with such increased hydroseeder use is the availability of seed stocks which can be effectively applied with this machine. Other than the typical, i.e., locust and a few species of pines, there are few that can be direct seeded successfully. This is an area in which we need to also direct our concerted research efforts. If a greater variety of seed stock was available and proven successful with hydroseeder application, there would be greater tree usage in surface mine reclamation. It is a question of adaptability and it is incumbent on all of us to provide such information.

There is one other method of tree planting that I recently experimented with on mountain-top operations near Beckley in Raleigh County, West Virginia. It was the "tree spade." It is an unusual piece of equipment to find on a surface mine operation, but it seems that it might certainly have a place in the reclamation community. It would be particularly effective in areas which are to be developed for a more intensive use, such as housing or industrial development. The "spade" is a hydraulically powered inverted cone which cuts (or digs) a cone of earth from the place designated for tree planting. The soil is then removed from the area. Once the hole is prepared, the "spade" moves to the local surrounding woodland, which is usually near a surface mine, and the tree is removed in the same manner as the hole was dug. The inverted cone comprises the root ball for the tree and the size of the cone governs the size of the tree which can be effectively transplanted. The tree, with root ball or cone, is then transported to the original hole and placed in the ground. Of course, more expensive nursery stock can be used if local sources are not available.

As I mentioned, I feel the "tree spade" has a place in today's refined reclamation industry. It permits the use of native species which are generally readily available from the adjacent woodland. Also, it prepares a planting hole and root ball of the same dimensions so that it can be used on an area already stabilized with grasses and legumes without fear of destroying the vegetation. Although unique to the mining industry today, we may see more of these "spades" in the next few years. Our experiment was successful.

Additionally, there are two other points I feel worthy of mention in the context of this paper. One is discouraging and relates more to a by-product use of trees than to tree planting. The other is encouraging and is related to the new West Virginia Surface Mining Control and Reclamation Act's recognition of woodland as an acceptable post-mining land use. Both of these issues erupted with the enactment of the federal surface mining enforcement program.

The first point is the federal program's prohibition of placing trees on the outside edge of the lowest coal seam being mined. For years, we "windrowed" this woody material along the outside perimeter of the haulroads for enhancement of sediment and drainage control, protection and encouragement of new growth, as well as providing escape habitat and browse for wildlife. It had been pioneered by the U.S. Forest Service in the mid-sixties, yet the Office of Surface Mining, in their regulations, prohibit the placement of this cleared material below the haulroad. That prohibition disturbs me because they are neglecting a most beneficial use of non-merchantable timber and woody material without any justifiable explanation. It is my hope that OSM will consult with the Forest Service and resolve this matter to the benefit of the industry and the environment.

The other point is "upbeat" in that it recognizes woodland as an acceptable post-mining land use. The federal government's program (OSM) would not permit private woodland as a goal of reclamation capable of bond release. West Virginia's new law, which was written to achieve primacy of the federal program, recognizes commercial woodland as an acceptable post-mining land use for surface mine reclamation in our state. To do otherwise would have been a total disregard for many people and agencies, such as the University's College of Forestry, the Department of Natural Resources' Division of Forestry, the state's hardwood forestry industry, the U.S. Forest Service, the Soil Conservation Service, as well as years of beneficial experience in stabilizing our state's lands. That inclusion in our state law is being opposed by the federal government. Why? The only reason we can find is that it does not read the same as the federal law because the federal law does not specify that particular use. We feel that its silence on the subject should not be interpreted as a prohibiting it, particularly when history has reflected such an effective use of trees in reclamation. As the state holds firm in its position, I am encouraged that it will increase the use of and attention to trees.

Through the years, we have had vast experience with tree planting on Eastern U.S. reclamation projects. Since the mid-fifties, the West Virginia surface mining industry has cooperated with practically every agency involved in the use of trees for land stabilization. Those years have proven beneficial toward improved technology.

In spite of the beneficial experiences of the past years, much has changed in the surface mining and reclamation history. Trees are no longer the prominent ingredient in a reclamation effort. Many things have contributed to this decline in prominence, as I have briefly described. However, there are many things which we, the industry, in concert with you, the professional foresters and regulators, must do to regain the significance of trees in reclamation.

Above all, we must concentrate on adapting trees, their souces, and their use to the revised and refined methods of reclamation now practiced in the East. Although still in use, we must move from the "planting mattock" and "dibble bar" era to the age of the hydroseeder and automatic machines. We must make tree planting as economical and available as it once was. We must research and experiment with alternatives to increase the availability of planting methods which are cost competitive. We must provide adequate seed sources of differing species which have been proven successful by automatic application in our region. And, there must be greater planning and direction to insure that tree survivability and growth are enhanced, not inhibited through unnecessary competition or inappropriate soil preparation.

It can be done. We did it before and, with all the technological armament we have today, we can do it again.

INTRODUCTION TO PINE REFORESTATION ACTION PLAN (SLIDE TAPE PRESENTATION)

George N. Brooks

Trees for reclamation can mean many things to different people. Understandably, the primary thrust of this symposium is the use of trees in the reclamation of lands formerly and currently mined for coal. This is a worthy goal, one that the Southeastern Area, State and Private Forestry, earnestly supports. My discussion today, however, will not focus specifically on the reclamation of coal (other minerals) mined lands, but will include them as a part of the potential forest land base in need of reclamation which can contribute to the nation's growing appetite for wood fiber.

The 1980 Forest and Rangeland Renewable Resource Assessment (RPA) projects a 2 billion cubic feet supply deficit by 1990, increasing to 3.5 billion cubic feet by the year 2030.[1] The South's projected share indicates 1.0 and 2.2 billion cubic feet deficits for these same periods. Non-industrial acres of private lands (NIPF) in the South occupy 71 percent of the 63,700,000 acres of forestland capable of growing 85 cubic feet or more of wood per year and offer opportunity for meeting future softwood demand.

What is alarming has been the trend in reforestation on private, non-industrial lands. Between the years of 1970 and 1977, the acreage of pine seedling and sapling size classes on private, non-industrial ownerships declined by nearly eight million acres. When sawtimber and poletimber size classes are included, the total net loss in yellow pine and oak-pine types was over four million acres, an average of more than 625,000 acres per year. To continue this trend would result in a loss of over 30 million acres by 2030.

In a moment, we will see a slide-tape presentation of the Pine Reforestation Action Plan developed by the Southeastern Area Office of State and Private Forestry. This Action Plan focuses on the 1977 Pine Reforestation Task Force Report recommendations.[2] The Task Force Report parallels and complements other efforts to stimulate non-industrial private forest (NIPF) landowner participation in reforestation such as the South's Third Forest Report and the Society of American Forestry Task Force Report on "Improving Outputs From Non-industrial Private Forests", Forest Industries' Council's productivity studies, and the findings of five non-industrial landowner conferences sponsored by the Association of State Foresters.[3,4,5,6]

Much concern is expressed today that our nation must increase its level of productivity. The reforestation of mined and harvested land can contribute significantly to the formation of capital for increased productivity and for meeting the projected needs of the nation for wood fiber.

(Slide-Tape Presentation--Southern Pine Reforestation--An investment for the Future).

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[1]USDA-RPA Assessment p.

[2]Williston, H.L., 1977, Pine Reforestation Task Force Report, SA, State and Private Forestry, p. 40.

[3]Anonymous, 1969. The South's Third Forest, A report of the Southern Resource Analysis Committee, p. 111.

[4]1979, Improving Outputs from nonindustrial private foresters. Report of a task force, Society of American Forester, Journal of Forestry, 77 (3): p. 11, insert.

[5]1979, State Forest Productivity Reports, Forest Industries Council.

[6]Towell, W.E., 1980, Blueprint for Private Forestlands, American Forests 86 CS; p. 30-33, 44-46, 49, 50.

FORESTATION OF SURFACE MINES FOR WILDLIFE[1]

Thomas G. Zarger[2]

Abstract--This report reviews TVA program efforts to promote the use of wildlife shrubs in mined-land reclamation including work on plant materials development, demonstrations to acquaint landowners with a variety of food and cover plants, and action programs to incorporate wildlife plants into postmining land use. It deals briefly with wildlife considerations under Public Law 95-87 and the wildlife seedling needs and supply problem.

INTRODUCTION

The remoteness of most Appalachian surface mines logically dictates these lands be returned to their original forest and wildlife condition. While there may occasionally be other land-use options--agriculture, housing, or other community uses--the long-term reclamation goal for most sites should be to ensure their productivity for forestry, fish, and wildlife.

There will be disagreement between resource groups--foresters and wildlifers--as to what portion of the stripped land (and water) should be devoted to each resource. In looking at forest management from a wildlifer's point of view, Ripley (1973) states:

> Conflicts will arise but our mutually shared resource, the forest, is not and should not be the sole concern or property of any group or profession. As long as we, as functional specialists, can accept production realities that are submaximal (we cannot maximize both timber objectives and wildlife target species at one time), progress is possible. . . . It does mean single resource objectives will be subordinate to other multiple goals.

Determining whether disturbed acreage should be managed primarily to yield forest products or provide wildlife habitat will depend on landowner objectives. Resource professionals can help the landowner design an overall management plan for the land, but one of the resource objectives must be given importance over the other. The kind of vegetation that performs well on the site could influence the landowner in making the final selection.

Some will call the title of this paper ambiguous and even question how one can conduct "reforestation for wildlife." The term "forestation" implies a planting action is being carried out either to convert land into a forest or to replant with trees. Funk and Wagnall's New Practical Standard Dictionary defines "forest cover" as the sum total of vegetation in a forest--more especially trees, shrubs, and all the litter on the forest floor. Presumably, this would include all biological activity. And, one of several definitions for a "forester" is a person in charge of a forest, its timber, and its game. Under English law, the forest is wild land belonging to the Crown and kept for the protection of game. Based on these definitions, we feel comfortable with our title, "forestation for wildlife," and consider it appropriate terminology when applied to the planting of trees and shrubs for the benefit of wildlife populations.

This paper reports on Tennessee Valley Authority program efforts to develop and promote the effective use of wildlife food and cover plants in surface mine reclamation as a site restorative measure and for habitat improvement. A plea is also made to the State and private nursery sector to provide an adequate and dependable supply of seedlings to meet current and future revegetation needs.

WILDLIFE PLANT SELECTION AND IMPROVEMENT

An enormous body of literature covers research dealing with problems encountered in mined-land reclamation. A glance at bibliographies spanning the period of formal

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[1]Paper presented at Symposium on Trees for Reclamation in the Eastern U.S., Lexington, Kentucky, October 27-29, 1980.
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and informal research emphasizes the importance of vegetation in the reclamation scheme. While studies on the performance of forest tree species predominate, the more recent literature shows an expanding interest in wildlife shrub development and use. The U.S. Fish and Wildlife Service guide (Rafaill and Vogel 1978) for vegetating surface-mined lands for wildlife in eastern Kentucky and West Virginia reflects this interest.

Most plant materials improvement has been by the U.S. Soil Conservation Service (SCS). Ruffner (1965) and Ruffner and Steiner (1973) summarized shrub evaluations on strip mines and provided species recommendations. Among the SCS's more successful shrub selections are the familiar Cardinal autumn olive (Elaeagnus umbellata), Arnot bristly locust (Robinia fertilis), and Remred amur honeysuckle (Lonicera maackii). Studies by the U.S. Forest Service (Plass 1975) and Pennsylvania State University (Horn 1968) involved comparisons on the performance of different shrub species. Several species with good reclamation potential were identified.

Plant research by TVA covers efforts to: (1) provide a wide variety of species for reclamation and (2) develop improved strains through progeny testing and selection. Fowler and Adkisson (1980) studied the survival and growth of 17 species--both trees and shrubs--over a range of acid spoil conditions at two locations near the eastern slope of the Cumberland Plateau in east Tennessee. They recommended autumn olive, elaeagnus cherry (Elaeagnus multifloria), Arnot bristly locust, sawtooth oak (Quercus acutissima), red maple (Acer rubrum), and Toringo crabapple (Malus sieboldi) for quick improvement of wildlife habitat. Autumn olive was given the highest habitat index rating in a ranking of mast, browse, and cover parameters.

Genetic improvement research at TVA is aimed at providing selections for food for a diversity of wildlife, both birds and animals (Scanlon 1979). The selection and evaluation involve 31 tests of 15 species established from 1974 to 1978. Species include the shrub dogwoods (Cornus), shrub oaks (Quercus), wild grape (Vitis), cherries and plums (Prunus), and American elder (Sambucus). The payoff from these tests in terms of seed production is only two or three years away. Selections already completed for silky dogwood (C. amonum) are now in nursery propagation for seed orchard use. Selections of the best families and individuals in the other tests can be initiated at any time. Through selection, gains in food production of 100 percent or more may be realized.

PLANTING DEMONSTRATIONS

A brief historical account of TVA's efforts to promote the use of wildlife shrubs through the demonstration approach is presented to illustrate the growing interest in improving habitat for wildlife. In 1963, food and cover plants were included in the planting plans of four reclamation demonstrations--three in Tennessee and one in Virginia--dealing with the abandoned mined land problem. Holland (1973) reported on how the combination of planting and natural plant succession worked to provide a productive wildlife habitat. Another early 1960 demonstration established on a 300-acre tract of TVA land near the Paradise Steam Plant in western Kentucky showed that when surface mined lands are well reclaimed, biological productivity develops in a relatively short time (TVA 1969).

These early demonstrations included cooperative plantings in southwestern Virginia with the Penn Virginia Corporation and the Commonwealth of Virginia. During 1970-72 over 135,000 wildlife trees and shrubs were set out on surface mined sites within a 10,000-acre area devoted to wildlife management (Fowler and Perry 1973). The mined areas either predated reclamation legislation or had been legally reclaimed under State provisions. Management planning and practice were geared to maximize wildlife benefits.

All these demonstrations have provided valuable input helping to assess wildlife potential of surface mined lands and improve reclamation technology. Results on planting performance have application in planning postmining land use for abandoned lands and current and future mining as well.

ACTION PROGRAMS

Considerations for wildlife have played a significant role in two major action programs. One dealt with the reclamation requirements built into the Agency's coal purchase contracts. The other dealt with the Orphan Land Reclamation Demonstration conducted in four Valley coal States (Alabama, Kentucky, Tennessee, and Virginia) between 1976 and 1979.

Coal purchase contracts

TVA coal purchase contracts let between January 1971 and November 1978[1] contained very demanding revegetation requirements. Unless the postmining land use was for agriculture, mine operators were required to revegetate the disturbed acreage with trees, shrubs, and herbaceous ground cover. The planting requirement included wildlife shrubs--some 225 on each acre. These plantings represent perhaps the first large-scale "forestation for wildlife" in southern Appalachia.

TVA used the planting opportunity to acquaint mine operators with a variety of wildlife plants suitable for mine planting and to show landowners how their use improves existing habitat structure and enlarges the food base available to wildlife. TVA provided the seedlings, and mine operators did the planting as part of the revegetation required by State and TVA standards. The improvement plantings ranged from 5 to 10 acres each and involved species selected for their tolerance to acid mine conditions and for their habitat diversity. Some 88 plantings, totaling 503,000 wildlife trees and shrubs, were set out over a range of site conditions between 1973 and 1979. The extensive plantings are available to biologists for monitoring and evaluation and can provide a ready source of seed when needed for nursery production of seedlings in future planting programs.

Orphan Land Reclamation

This Federal-State-landowner action program carried out in a 38-county area over three planting seasons--fall 1976 through spring 1980--involved extensive "forestation for wildlife." The cooperative effort was designed to alleviate offsite impacts by reclaiming orphan mines in a demonstration of techniques and administrative arrangements that could be applied on old minesites elsewhere in Appalachia.

In treating 14,514 acres, more than 4.6 million of the 10.4 million seedlings planted were wildlife shrubs. The wildlife resource should benefit significantly in years to come from the establishment of these food and cover plants. Game enthusiasts will share immeasurably in the wildlife recreational opportunities presented on thousands of acres of land.

WILDLIFE FORESTATION AND PUBLIC LAW 95-87

Frequent references to wildlife in the Federal Office of Surface Mining's Permanent Regulatory Program (Public Law 95-87) should alert biologists to the opportunity for further developing this resource. Major beneficial impacts are predicted and will come about if biologically sound reclamation considerations are integrated into the mining process.

Under the Act and its supporting regulations, the back-to-contour provision should favor wildlife habitat development. The land configuration resulting from steep-slope mining limits land use, except for forestry and wildlife. The proper selection and placement of wildlife food and cover plants on these sites can contribute significantly to habitat improvement. Permissible land surface modifications to provide water, which animals need along with food and cover, would assure successful development of this resource as a postmining land use. Even fish can be incorporated if provisions for ponded water are allowed.

WILDLIFE PLANT NEEDS AND SUPPLY

A dependable future supply of wildlife plants and seed is a requisite to meeting reclamation needs throughout southern Appalachia. The demand for seedlings will become more pressing as planting programs visualized under Public Law 95-87 get underway.

Needs

Any projection of needs must consider estimates of abandoned land acreage that can be improved through planting of wildlife food and cover plants and acreage that is disturbed annually in current mining. The SCS (1978) estimates some 160,000 of the 227,000 abandoned acres in southern Appalachia (five Valley States) is suitable for wildlife habitat development. Also, TVA estimates some 9,000 acres is disturbed annually in the Tennessee Valley coalfield by active mining. Another 15,000 to 20,000 acres can be added for active surface mining in the eastern Kentucky and southern West Virginia fields. To translate these land requirements into seedling production, a base production rate of 10 million wildlife plants per year will be required. This estimate is subject to change depending on emphasis given to wildlife in State regulatory programs under OSM's Permanent Regulatory Program.

Generally, there has been a shortage of the kinds of wildlife plants needed for mined-

[1]Contracts let after this date require operators to comply with all State and Federal regulations.

land reclamation. In 1971 when TVA first required its coal suppliers to include wildlife shrubs in their reclamation plans, there was a short supply and very limited species diversity of planting stock for revegetation. A similar condition prevailed in fall 1976 when TVA initiated the orphan land reclamation demonstration. State nurseries responded by increasing forest tree and wildlife shrub production by some 4.9 million seedlings. Shrubs made up about 40 percent of this production.

While the States expanded production in response to these needs, seedling supply is still short of demand. Increases in production are limited by a shortage of nursery bed space at some of the nurseries. Significant increases of wildlife plants are also unlikely because of the prior emphasis on production of timber species for general reforestation. Commercial nurseries can be relied on to produce some of the planting stock, but mine operators find many of the private nurseries cater to the ornamental trade, and the cost of seedlings reflects these values.

When apprised of the need, the State and private nursery sectors should respond and provide much of the required production. Some incentives to producers may be required, but this will help ensure the availability of planting stock needed in the region's planting programs.

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REVEGETATION FOR AESTHETICS[1]

Bernard M. Slick[2]

Abstract.--Surface mining is changing the landscape character of forests in the East. Aesthetic visual aspects of the landscape are considered in the analysis, planning, and design of revegetation strategies. Application of landscape architectural design techniques in the revegetation of surface-mined lands, as well as knowledge of biological characteristics, will enhance the visual character of the mined landscape.

INTRODUCTION

From the time the first colonists arrived in the East, natural processes (soil and climate, fire, and insects) and man (axes, plows, and bulldozers) have shaped the land, forest vegetation, and openings into patterns which today lend variety to the landscape. These events have varied in location, time, and intensity but most of the landscape has been impacted by man at one time or another. Alterations in the visual character of the landscape in the decades ahead will be a result of man's continuing use, management and mismanagement of the land.

The landscape has taken on meaning because of the variety and composition of patterns that exist. Landscapes rich in variety are likely to have more visual appeal and aesthetic value than ones tending toward monotony. In recent years man's activities have had a profound effect on the face of our forested landscapes. More and more land has been visibly affected. The American people have become increasingly aware of and concerned about the aesthetic quality of their environment. Among these concerns has been the visual effects of surface mining which are often immediate and noticeable from a distance. Often these effects weigh heavily in the rejection or appreciation and acceptance of a project by the public. Because of these concerns recent national policies and legislative actions have legitimately recognized formal consideration of aesthetics along with other environmental values in planning and decision-making.

LANDSCAPE CHARACTER

Aesthetics involves all of the senses--sound, smell, touch, taste, sight, and movement. However, it is most often equated in a visual sense to denote quality and attractiveness associated with the appearance or visual appeal of the landscape being viewed.

Regardless of the size or segment of the landscape being viewed, it has an identifiable character. The landscape character is described in terms of land and rock forms, vegetative patterns, water forms, and structures as seen by an observer in terms of four basic elements--form, line, color, and texture. These are components of the visual resource that when seen in varying combinations can be used to evaluate aesthetics or visual quality of an area. In providing resources for the Nation's economy, we often have no choice but to create alterations from the surrounding landscape. Acceptable alteration is based upon the degree of change, measured in terms of visual contrast, allowed in the form, line, color, and texture of the characteristic landscape.

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[1]Paper presented at the "Trees for Reclamation in the Eastern U.S." symposium, Lexington, Kentucky. October 27-29, 1980.

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An examination of the landscape character of the coal regions of the eastern United States reveals one of their most valuable resources is the scenic quality of their rural landscape in each of the physiographic regions. The attractiveness is derived from a variety of features with the integral scenic element being the vegetative cover and patterns that give character to the visual resource. Cropland and grassland are the dominating vegetation of the Interior regions while the Appalachian region is dominated by mixed hardwoods in the north and pine-hardwood forests in the south. There is considerable range in vegetative types in both deciduous and coniferous species. Understories include a wide variety of shrubs, forbs, and grasses. There are seasonal color contrasts which greatly contribute to the interest. Each of these regions is relatively well defined not only in terms of terrain and vegetation patterns but also in terms of visual characteristics.

More than one-third of the total of the East and South is forested. It has been estimated 90 percent of the surface mining has been or is being conducted on forested areas where 65-85 percent of the landscape is steep. The removal of vegetation during mining and its reestablishment during reclamation creates significant changes in the visual patterns of the cover types and open spaces. This is especially noticeable when there is a continuous forest cover.

Private lands provide 94 percent of the total timber in the East and accommodate intensive recreational and wildlife use and development. However, much of this forest land is poorly managed and stocked with trees of poor quality due to earlier "highgrading" or removal of quality trees. Many opportunities will be available to improve plant community characteristics that will provide recreation, wildlife potential, and landscape character through pre-planning of reclamation on those lands subjected to surface and underground mining impacts.

PLANNING PROCESS

Evaluation of the visual resource involves inventory, analysis, and determination of objectives or standards, and incorporates all of these (together with other resource information) into the resource planning process. It should also include post-evaluation of planning and project accomplishments concerning the visual resource.

VISUAL INVENTORY

"When needed" to support conditions at the pre-mine planning stage, a visual inventory is utilized to identify, classify, evaluate, and map the visual resource according to variety classes and distance zones and to delineate physical landscape quality in relation to user concern or preference. This baseline information is used for:

1. Identifying the existing visual condition of the landscape at a given time.
2. Judging landscape quality.
3. Determining the ability of the land to absorb change.
4. Predicting the visual impacts and consequences of a proposed project.
5. Determining the need for modification of proposals.
6. Monitoring the effects of the applied reclamation treatment over time.

In addition the data can be very useful in identifying areas aesthetically unsuitable for mining and existing reclaimed areas in need of rehabilitation and/or enhancement. Also, it may be used for gaining support of proposals to change prior land uses to alternative post mining uses which may contribute more to improving landscapes than retaining pre-mining use.

Vegetative data needed by the reclamationist generally will be satisfactory for visual analysis. This includes such factors as existing on and off site species of trees, age and size of trees, mixture of different species, even aged or uneven aged stands, productivity, cover density, ground cover, understory condition, layering, shrub and tree ratio, diversity of stands, and openings, and prior use. Additional consideration must be given to native versus introduced species, threatened and endangered plants, animals supported by the vegetation, yearly and seasonal variability, exposure of stands, windfirmness, insect and disease condition, potential for revegetation, and other relevant information of the area.

VISUAL ANALYSIS

The level of the anlaysis should be commensurate with the level of visual resource sensitivity and the magnitude of proposed impacts. The analysis must be sufficient to ensure a reclamation scheme that best satisfies the environment, postmining, local, and regional land use objectives, or area development plans.

The area used to study the landscape and the visual impacts of activity alteration is called a viewshed. It is the total landscape seen or potentially seen from all or a logical part of scenic areas, travel corridors, use areas, and water bodies which are frequented by and readily visible to large numbers of users and visitors.

In predicting and monitoring the visual effects of mining in the viewshed it is desirable to establish an appropriate number of on and off site view points, either moving or non-moving, with typical views of activity. These points are documented on a map with lines drawn to the activity from those views which are deemed important to area residents and potentially obvious to visitors to the region. It is the views from the critical points (often locations from which activity is most seen) which will identify potential for visual concern. Project location, observer position, and distance zones are recognition factors which will help to determine what the aesthetic pictorial or visual effect of changes in the landscape will be from the view points due to viewer location and position, area and angle of view, length of view, number of viewers, duration of view, times seen, and focal point sensitivity. Observations are supported by topographic maps, sketches, photos, and computer printouts.

Location

This is a very important factor because there are really few places in the landscape where excessive vegetative clearing can go unnoticed. Mining, because of the area disturbed, results in a focus of attention. Location is critical because of varying capabilities of the land to withstand modification and varying degrees of visual sensitivity for each area. Some parts of the landscape will be recognized as being more sensitive to impacts than others. Changes on steeper upland slopes are more conspicuous than on flatter ground. The higher the deposit location on a slope or ridge, the more extensive the view points and greater the distance from which mine activity can be seen.

Topographic orientation can be associated with different visual effects. South-facing slopes usually have greater visibility than those facing north because they receive more direct and greater amounts of sunlight. Patterns in vegetation vary due to elevation and orientation. Conifer hardwood patterns in particular are traced to orientation contrasts.

Many primary transportation corridors follow old mine haul road locations. Often they pass by or through the center of the mining district with many aspects of mining in the viewshed visible to highway travelers.

Distance Zones

These are divisions of a particular landscape being viewed. They are used to describe the part of a landscape that is being inventoried or evaluated from key viewing points. These varying zones of distance are concerned more with the horizontal relationship of the observer to the activity and are classified and quantified in distances at which details can be seen as:

foreground (0 - 1/2 mile)
middleground (1/2 - 3-5 miles)
background (3-5 miles - infinity)

One or more of these visual zones may be readily perceived in most landscapes.

Distance zones establish a distinctive relationship between the viewer and the seen landscape. An activity or scene may be viewed from any one of a number of distances. As these distances differ the observers impression of the visual contrast will vary as perception decreases with increasing distance. For example, the size and shape of a reclaimed area appears larger to an observer who is relatively close to it and smaller when they are some distance away.

Observer Position

This is the elevation of the observer relative to the activity being viewed in the landscape. It focuses on the vertical relationship between observer and activity.

Slope angle and its aspect relative to the observer position affects the visibility of the slope and the development or activities that take place upon the slope. This range of positions is classified as:

1. Observer below (inferior)

2. Observer level (normal)

3. Observer above (superior)

View position influences perception. The apparent size of mine disturbance is directly related to the angle between the viewer's line of sight and the slope being viewed. As this angle nears 90° the situation reaches its maximum contrast and becomes more critical. A change in apparent size and/or shape also occurs when disturbance is viewed from different horizontal angles and the observer remains at the same elevation.

LANDSCAPE DESIGN

The existing visual elements--form, line, color, and texture of vegetation and landforms provide the basis for designing the visual aspects of reclamation. The degree to which these elements are altered by an activity are measured in terms of visual contrast with the characteristic landscape as to qualities of size, scale, amount, intensity, direction, pattern, etc.

The following guidelines, while by no means complete, are intended to provide direction for measuring the visual resource change that will be introduced by the activity and the anticipated viewer response to that change. They may be applied not only in sensitive areas or unusual circumstances, but routinely in all activities, and by all disciplines.

Contrast

When we view the visual resource as we move from one position to another we realize that there is an apparent harmony and unity of the natural features. When man manipulates the features he alters the elements and produces many artificial characteristics which modify the landscape character in acceptable or unacceptable degrees of contrast.

Contrast is the result of differences rather than similarities between adjacent parts. Activities that create no visual contrast are simply not noticed. Those that create extensive contrast, such as abrupt edges, unnatural form, and vegetative patterns, can be picked out instantly even by the most inexperienced observer. In most cases we want to reduce contrasts but there are cases where purposeful creation of sharp contrasts (such as the addition of flowering plant material) can be beneficial.

Visual quality is often reduced the more an activity contrasts with or visually dominates the landscape. Therefore, the more an activity repeats or borrows from the basic elements (form, line, color, and texture) the less visual contrast and the more it becomes visually pleasant. Landscapes with unacceptable contrast can usually be designed to achieve visually acceptable variety.

It is possible that the quality of surrounding landscape is so low or lacking in variety that almost any activity would improve visual quality and relieve monotony by providing variety and visually acceptable contrast. Conversely, surroundings could be of high quality and an activity could be very destructive to visual quality.

Form

Vegetative form is expressed in the shape of individual, groups, or masses of plantings and clearings. Differences in height, depth, and width promote changes in shape and size or silhouette which create contrast. Light shades and shadows accent form.

Shape--

The shape of an opening created by surface mine clearing is one of the most important aspects in the visual landscape. If the shape of the opening can be related to the surrounding landscape so that it appears natural, a minimal contrast will be the end product. In some areas there may be an absence of natural openings to simulate. The problem then of making a clearing appear natural is very difficult. It can be overcome though, by repeating the directional emphasis of patterns in the landscape forms from ridgelines and drainages.

Shape of vegetative patterns, especially those large and geometric or unnatural in form, can dominate a landscape. Irregular and free-form shapes expose less area to view, soften the visual contrast between plantings and openings, and simulate natural conditions or traditional forms of land use in the vicinity. Strategically located islands, clumps, groups, or fingers of vegetation help to alter the shape and apparent size of openings.

Where a large area is to be disturbed in a series of clearings over a period of years the effect must be considered not only from the first clearing but from the distribution of subsequent ones. The cumulative effect is important.

Scale--

Scale refers to the relative size of clearings or openings in relation to the surrounding landscape being viewed. For aesthetic improvement, size of openings or plantings should be varied according to the viewing distance. The scale of many mining activities is expressed in undertakings of collosal size even in the expansiveness of their surroundings. All are on a scale totally divided from our varied and intimately humanized landscape. There is no doubt that large acreages of disturbance attract attention and have the properties of being aesthetic misfits.

Scale is a vital factor in the absorption of surface mine clearings into the view of the landscape. When the size or amount of clearing is extensive it may quickly adversely change the landscape character beyond acceptable limits. Because of their size, clearings are visible from great distances, are obvious through all seasons of the year, and show up under practically all atmospheric conditions.

Proper size is dependent upon the nature, quality, and character of the surrounding landscape. Small scale projects may stand out due to their form, line, color, and texture. When the width of a clearing is no more than several times the height of the surrounding trees the space itself becomes sharply delineated in an alley-like enclosure. The wider the opening the less enclosure and the greater the feeling of space.

Large elements require a sufficient amount of space to permit retention of naturalness. As soon as the proportion of manmade form is great enough to challenge nature's supremacy the spell of natural surroundings is broken.

Ground form--

The basic form of topography (mountains, plains, hills) is repeated in the form (conical, horizontal, rounding) of native plants. The effects of reclaimed mine landforms can be modified by plantings. Plants can be used to accentuate or to mask surface changes. Pointed planting masses accentuate; rounded masses blend and merge. Plantings can cause a slope to merge with a plane such as a bench and may be used to visually increase or decrease height of a slope.

<u>Line</u>

Lines distinguishing vegetative forms may be continuous or isolated objects or points along the surface which are connected by our eyes to form a linear path of vision. Lines may be represented by the silhouette of a tree, the edge of a meadow, a forested ridgeline, contour, or a tree trunk. All lines have direction - horizontal, vertical, or oblique. Contrast results from lines of differing character or direction. The forms of contour mine clearings often have a linear configuration with lines that may lead the observer's eye toward focal points of interest or draw attention to incongruous elements.

Edge--

Edges where dissimilar features come together are especially conspicuous to change. Attention is directed to the maximum contrasts. For instance, skyline--the silhouette where sky meets forest or land; waterline--where water meets the forest or land; and vegetative edge--where grass and forest meet, or where conifer meets hardwood.

<u>Skyline edge</u>--Frequently mine clearings are prominently displayed against or near the skyline. The darker color of the terrain is in sharp contrast to the lighter color of the sky and clouds. Ridgeline junctures can be skyline but are usually viewed against other surface backgrounds.

<u>Vegetative edge</u>--Changes in vegetational types often create abrupt visual contrast due to differences in soil or vegetation color. For example, in Appalachia many contour surface mines are located in forests. Reclamation with herbaceous material creates an abrupt sharp boundary line or edge between the stark openings and the surrounding wall of dense undisturbed woods which stops eye movement and draws attention. This unnatural strong line configuration can be modified by planting shrubs and small trees to undulate or feather the edge between the grass opening and the forest. The edge of the woods should be maintained as an irregular line and generally follow the contour.

Thinning of edges exposed as a result of clearing is important in some sensitive situations. Unprotected exposed edges have greater potential for wind damage and visually have a "raw" impenetrable wall-like appearance.

Selective removal of vegetation back 50 to 100 feet or so from new edge reduces the impact of wind by filtering movement and disrupting its force, reduces the abrupt edge, and extends the boundaries of the perceived space. Existing ground and shrub vegetation should be retained as it provides a gradual slope or drift transition in size from grass to trees and is essential for erosion control. Visually the result after a period of time will allow a more natural appearing healthy forest edge which will also benefit wildlife.

During clearing operations new edges should be upgraded by removing weak rooted, dead, broken, leaning, hung, or visually unattractive trees and cutting and distributing slash (if not removed) close to the ground.

Waterline edge--This edge is a very dominant focal point due to the flatness of the surface of the water which is seen as a definite line against the land. Plantings which border the shores or banks of lakes, ponds, or streams should bear much the same relation to the water surface that tree plantings surrounding an opening might have to a grass surface.

Planting irregular masses to the water's edge produces harmony between planting and water and masks the harsh shoreline edge. Also, shoreline plantings are mirrored in form by their reflection on the water. Plantings near water can provide an interesting and natural diversity of view especially for areas which are subject to public use.

Color and Lighting

Color and lighting enable us to distinguish between objects of identical form, line, color, and texture. They can also be used to subdue man-made and natural objects.

Color contrasts are expressed as hue or chroma (red, blue) intensity or brillance (purity of color) and as value (light, dark). Contrasts may vary significantly with the time of day, weather, distance, and season of the year. In order to use color successfully it must be studied under local atmospheric conditions. Consideration must be given to how it will be seen from crucial view points.

Color and lighting contrast is often the most noticeable result of surface mine operations as adjacent contrasting colors and shadows stop the eye. The removal of plant material and exposure of the surface establishes a significant contrast with darker adjoining undisturbed vegetation.

Texture

Texture results generally from the pattern created upon the terrain by vegetation and other surface elements. Texture ranges from fine or smooth to coarse or rough. Smooth and dull surfaces affect light reflection and absorption. The perception of texture and patterns varies with observer position and distance zones. Contrasts between textures result from smooth elements against course and light and dark differences in color tone. The more variety there is in the landscape the easier it is to design for texture.

Variety

Variety is an assortment of different parts of the landscape. "Richness" or diversity both carry the same concept. However, quantity of varied parts is no assurance of quality. Landscapes ranking high in visual value are usually those of above average variety.

Landscapes rich in variety are desirable. Vegetation can enhance an area where little variety now exists. For example, species can be introduced to provide spring color, highlight fall color, and to create contrast in form, foliage growth habit, and size. Openings can add variety to a forested landscape that otherwise might be a monotonous cover of trees. The same can be said for the addition of trees to large openings.

Ordinary or minimal variety landscapes with simple and uniform texture of vegetation are weak landscapes. There is little variation in species or vegetative patterns and openings into which changes can be incorporated. The very fine vegetative texture of Appalachian hardwoods explains in part why vegetative clearing for mining is so visible.

In any ecological system, a diverse assortment of plant material is a positive attribute. It enhances aesthetics, provides a diversity of habitat, reflects stability, and promotes resistance to adverse conditions such as disease, drought, and fire.

Vistas and Views

A view is an unobstructed sight of a specified landscape (panorama). This definition differs significantly from a vista which may be defined as an enframed sight of a specified landscape. In this sense a vista has greater visual impact as well as more intense focus on a given landscape.

Vistas and views are desirable where worthwhile opportunities exist. Individuals or groups of trees such as conifers and flowering trees are used to accentuate, focus, enframe, and give scale and dimension to outstanding vistas of physical features such as rock outcrops, lakes, streams, ponds, and falls. Unobstructed openings are retained or vegetation is removed to provide panoramic views in the landscape.

Structures

The impacts of vegetative cover and patterns during mining and reclamation operations usually are greatest in foregrounds and middlegrounds most often visible from public roads near or adjoining mining property. Intensive planning and management practices are needed most in these visual zones of a viewshed to control the composition, quality, and growth for visual impacts and without adding unreasonable costs to reclamation.

Time

Time or duration of visual impact of mining is long-term when compared to other activities that alter the land. Although one of the goals of reclamation is to reduce adverse visual impacts, the visual contrast between reclaimed areas and surrounding undisturbed areas can remain for several years. However, recent emphasis in concurrent reclamation will go a long way in reducing and limiting the amount of area disturbed at any one time. This will provide for an early use and for woodlands being on their way to maturity by the time extraction operations have been completed.

VEGETATION PLAN

Much emphasis is placed on prompt use of herbaceous vegetative cover and its ability to control runoff and erosion but it alone will not always make a site visually compatible. However, little is known about the influence of other vegetation or the ability of the most effective revegetation methods and species in relation to visual quality objectives. In addition to successfully stabilizing a disturbed area, vegetation can have varying visual effects depending on the species selected. Guidelines for maximizing vegetative characteristics to improve the visual condition that are compatible with cover establishment and erosion control are essential.

Because of better placement of overburden, segregation of acid and toxic spoils, use of topsoil or acceptable growth medium and soil amendments, the quick establishment of a vegetative cover in mine reclamation is less of a problem. However, the long term effect and stability needs continuous evaluation especially as an aid to land use, desirable plant succession, wildlife benefits, and aesthetics. With better planting conditions more emphasis is needed on improving plant material selection. Repeated use of plant species such as black locust, lespedeza, and autumn olive are making them as common and as monotonous as the over-used and banned multiflora rose.

Revegetation treatments and aesthetic design must be responsive to land use objectives and an evaluation of the characteristic landscape. The design should be based upon and respond directly and specifically to both visual and functional needs. Revegetation for aesthetics is concerned with reestablishment of the visual landscape character by integrating the post-mining land use(s) of the reclaimed area with surroundings. Vegetation should be planned to facilitate the customary potential land uses of range, fish and wildlife habitat, recreation, forest, crop and pasture lands, residential, industrial, and commercial. Having established the post-mining land use and with the detailed description and design plan for reclamation indicating how the total site will be utilized, vegetative treatments can be developed.

The choice of planting schemes for aesthetic enhancement of surface mined lands is based on the objectives of the person or agency responsible for the planting. The options available and the success of a program depend on the planner's and designer's ability to recognize the opportunities and limitations of each site.

Planting design is a complex task. Considerable study is required to achieve the maximum functional and aesthetic effect. There is no precise formula or procedure for devising a vegetation plan which will effectively encompass all the land use potentials of a reclaimed site. The possible solutions are as many as there are land use types. However, one thing in common to all is that they involve a transition in land use from the original landscape. If the site exhibits vegetative features similar to those inherent in the proposed land use it will be easier to plan and correlate reclamation and land use.

Planning for revegetation requires the ability to envision the maturity of the planting scheme years ahead. The desired character or effect does not exist when plantings are first established but are realized only with the passage of time. Many years are often required to cultivate and develop a stand of trees to alter the appearance of the landscape. Designers often will not be around to observe the outcome of their vision.

To assure a high quality landscape, especially in highly sensitive areas, surface mine reclamation personnel should consider the following plant materials criteria in developing a vegetation plan.

Selection

Several factors may influence the selection of plant species for a given job. These include an analysis of the predominant regional vegetation, land use objective, functional considerations, planting arrangements, future maintenance, and ecological factors associated with climate, season, geographic location, species, and individual site conditions.

In selecting plants, consideration must be given to their ability to adapt to the climatic and edaphic factors which influence the plant's ability to survive and grow. Aesthetic reasons for selection are associated with the growth habits of plant material with due consideration given to size (height, width) form (columnar, pyramidal shapes) and character (texture, dense or open, coarse or fine) needed to achieve desired visual effect.

Rate of growth is important where early results require maximum effect from the initial planting. Growth rates vary considerably, especially for trees. Care should be exercised in selection, as many rapidly growing plants are usually brittle and short lived. Perhaps a well-conceived mixture of fast and slower growing species is best.

Although sometimes less important than the habit and rate of growth, the effects of foliage, fruit, bark, color, and texture nevertheless can add a significant finished effect to individual plants or groups of plants. This is particularly important with deciduous plants which change dramatically with seasons.

A wide range or mixture of vegetation should be used to avoid a monoculture effect. Likewise native species or those that have visual similarity to species in surrounding unmined areas can be used to minimize form, line, color, and texture contrasts.

Plant species selected should generally have been proven successful in the area over the years. However, experimentation with other species or new varieties is encouraged. Avoid exotics or extensive plantings of untried species. New introductions must have a tolerance for surface mine environment and should have sufficient similarities to the existing vegetation in the area to assure that the distinctive character and sense of local identity are not lost.

Aesthetically desirable species do not necessarily mean desirable timber. They may include unmerchantable trees such as ironwood or beech and trees that are twisted or low branched with a picturesque quality. Many colorful shrubs and small trees have special value for wildlife food and cover.

Function

In meeting reclamation and post mining land use vegetation objectives plant materials are used to serve definite functions or to solve specific problems. In addition to providing a permanent stabilizing cover for controlling erosion, plant materials of varying height and configuration are used to separate areas, screen unpleasant views, give privacy or enclosure, enhance desirable features and structures, and enframe views. Plants are often used to protect adjacent land values, control site circulation, buffer hazardous areas, control glare, reduce scale, augment sparse or inadequate cover, and provide wildlife shelter. Stands of trees create micro climates that are of great importance to residential and recreational developments by acting as windbreaks, filtering dust and noise, and providing shade for various activities.

Arrangement

The proposed location and arrangement of plants selected to achieve planned objectives are shown in a general way on the vegetation plan. The desired visual effect will depend upon how well the proposed composition and patterns of openings in forested lands or plantings of trees, shrubs, croplands, or other vegetation in open non-forested lands relate to the natural patterns of surrounding existing vegetation.

Vegetation is normally not seen as individual plants. What is seen are masses, forms, textures, silhouettes. The contrast of large masses and voids, openness and enclosure, or an irregular flowing mass of shapes are constantly changing as the observer moves around. It is a diversity of forest types and vegetative cover, maximizing forest edge through optimum relationship between forest cover and forest openings. Planting masses should be expressive of the land use function yet not convey an artificial physical appearance. Some plantings will be permanent forests of extensive size, others will be alternated with grassland openings located so as to accent attractive vistas and some will serve as screen.

The composition of the planting varies in two principal ways, pure planting of a single species and mixed plantings of two or more species. Single species plantings are usually easier to establish, manage, and harvest but they are more susceptible to fire, insects, disease, wind, and other natural damage. An example are the decadent stands of black locust that have been disfigured by borers and leave miners. When and where possible these should be underplanted with more desirable species. Pure plantings are usually associated with a single species such as pine. Trees are normally planted on a grid or row system with little variation in spacing. If pine mixtures are desired, small groups or rows or blocks with variable spacing of plantings are recommended.

Based on past and present experience and observation mixtures offer the best patterns and better possibilities for regeneration. Mixtures provide visual variety and wildlife diversity, accommodate variations in topography orientation and soil moisture, promote stability, and ensure against risk of loss that may be encountered in pure stands.

Each type of mixture has particular application for certain conditions which should be identified and considered in planning an area. If a planting goal is to establish a forest stand with variety, mixed plantings of five or more species should be used. With few exceptions deciduous plantings should be mixed.

Shrub plantings usually are made in block or clump plantings of a single species. If more than one species is used they are placed in drifts (shorter plants in front or on edge) to avoid overtopping due to differences in growth.

Patterns of mixtures which may be used in planting or seeding an area are random, single row, and multiple row mixtures. For visual harmony rows should run parallel with the contours, rather than at right angles.

Spacing--

Openings and plantings that are uniform and regimented in size, shape, and spacing seldom are visually pleasing and lead to monotony and lack of unity in the landscape. Dispersal and irregular spacing can be used to minimize contrast.

CONCLUSION

Regardless of how successful revegetation for a post-mining land use may be in terms of erosion control and good soil cover, the area should also be developed with consideration of its success in exhibiting appropriate visual quality. By applying the preceding principles, processes can be developed by which the positive visual attributes of reclamation can be enjoyed while minimizing the negative visual aspects of surface mining.

The criteria are new in approach with regard to mined land revegetation and can help provide analysis of the landscape only as they are researched and tested through application. The purpose in discussing these criteria now is to seek their recognition by those who will be working with landscape architects in integrating reclamation and landscape quality.

There is more to revegetation for aesthetics than mere cosmetic beautification. The key to a better end product is coordinated design based upon research and a clear understanding of the interrelationship of all variables of the revegetation activity.

Aesthetics or landscape quality is a shared responsibility often mandated by law. It is a concern that must be shared by everyone and the quest for improvement must be the job of all of us. We need to establish genuine understanding and conscientious cooperation between regulatory authorities, operators, and public in managing and protecting landscape quality. We all must learn to recognize aesthetic values and incorporate and apply criteria and principles routinely in our everyday work and activities. As a result the land will be developed and managed with due consideration of its landscape qualities.

Success with aesthetics will depend mainly upon the sensitive application of fundamental principles by operators who have recognized and accepted the benefits to be derived from implementation of this concept.

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TREE PLANTING EXPERIENCES IN THE
EASTERN INTERIOR COAL PROVINCE

Paper Presented at the Symposium on Trees for Reclamation in the Eastern U.S. Lexington, Kentucky October 27-29, 1980

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Abstract.--Fruit trees were planted successfully in 1918 and organized afforestation began in 1928. Professional foresters had a hand in some of the very earliest planting projects. Formal reclamation research played an important role in applying science to early reclamation technology; however, considerable work has preceded the scientists. Some success has been experienced with tree planting on coal waste slurry, a problem site with uniquely adverse conditions. Some indications were found showing early Chinese Chestnut tree plantings developing into timber form trees, under some conditions. It was also observed that Chinese Chestnut trees are reproducing naturally from trees planted on mine spoils as young as 12 to 15 years of age.

INTRODUCTION

Subject of this paper deals with the Eastern Interior Province (E.I.P.). Though the bulk of this region is in Illinois, the E.I.P. area extends over Southwestern Indiana and the northern part of Western Kentucky. All of the coal mining activity in Illinois and Indiana is within the E.I.P.; however, Kentucky occupies parts of two coal provinces of which only Western Kentucky is within the E.I.P.

Generally, the E.I.P. geographically is characterized by relatively low relief to level or nearly level land topography. Lesser portions of all three states within this province have commercial coal mining operations on steeper topography which occasionally also may include steep (over 37%) slopes. Unlike steep slope areas of Appalachia; however, steep slopes of the Eastern Interior Coal Province tend to be relatively short in slope length.

Bulk of the surface mining in Illinois and about half of that in Indiana occurs within the glaciated region, with relatively low relief topography. Another feature common to this area is generally thick unconsolidated overburden materials lying above shale, sandstone, limestone, or a combination of the three, which form the balance of the overburden above coals in this area.

There is considerable similarity between surface mining conditions in the Illinois and Indiana unglaciated regions. Unconsolidated materials layers are generally thinner than in the glaciated region, with about three feet to ten or twelve feet of unconsolidated material commonly occurring.

The E.I.P. of Kentucky resembles the unglaciated coal region of Southern Illinois and Southern Indiana to some degree; however, topographic relief is somewhat greater and existing natural soils are part of the total unconsolidated materials layer which is significantly thinner. The more undulating topography and thinner soils of the unglaciated region stand as a striking contrast to the level to nearly level topography and thick soils (up to 16 inches of A-horizon soil) in the prairie region of West Central and Northern Illinois, which comprises some of the nation's most productive agricultural lands.

Rainfall generally is about 40 inches or more annually in the E.I.P., decreasing slightly as latitude increases northward. Climate in the entire province is favorable for a wide variety of commercial crop production and also favorable for commercial forest production.

RECLAMATION HISTORY

Some of the oldest, if not the oldest, land reclamation effort in the country occurred in the E.I.P. This would seem not too surprising, since the earliest commercial coal surface mining in the country is reported to have occurred near Danville, Illinois in 1866 (Illinois Blue Book 1971-1972).

Peach, apple and pear trees were successfully planted on mine spoils in Clay County, Indiana in 1918. Though some small forest plantings occurred earlier, an organized afforestation program on mine spoils in Indiana started in 1928 (Medvick 1973).

An interesting early influence in Illinois involved the tree nursery program developed in connection with the Civilian Conservation Corps program. Discontinuation of that program in the late 1930's made surplus trees available which were purchased by coal operators and planted on strip mine spoils (Illinois Blue Book 1971-1972).

A land reclamation law in Indiana came about in 1941 (the second one in the nation). Kentucky came out with a land reclamation act in 1954, and Illinois passed their first effective law in 1962, after an act passed many years earlier was declared unconstitutional.

There were numerous common traits among the early state land reclamation laws. Both pre-law and during early periods under these laws, land reclamation and tree planting were almost synonymous terms.

RECLAMATION TECHNOLOGY

Very little if anything was known initially about tree planting methodology on mine spoils. There was obviously a lot of guess work; however, it is known that professional foresters had a hand in some of the very earliest planting projects as early as 1928 (Medvick 1973).

Tree "wildlings" were used prior to availability of nursery grown planting stock. Walnuts were direct seeded possibly because there was no tree nursery growing such planting stock. Tree planting stock was shipped by rail from eastern tree nurseries, prior to the time tree nurseries were established locally.

Under these conditions, both planting success and planting failures were experienced. To those who came along on the scene later, these early successes and failures became laboratories from which to learn. As such, results preceded the science.

Eventually individual state coal operator associations enlisted the aid of forestry researchers from the U.S. Forest Service and from the various university agricultural experiment stations. The science of land reclamation began to take shape. Some tree species selection began to emerge and some recognition of different spoil conditions permitted some unsophisticated -- yet real effort to include or exclude certain species on some generally specific sites (Limstrom and Deitschman 1951).

By around 1950, afforestation was no longer a hit and miss situation. Trying to establish a "preferred" type forest on varying sites became the major objective. Technically, afforestation on mine spoils, in a rough fashion, at least, was a known practice and this fledgling science preceded statutory requirements calling for mandatory planting of disturbed lands in all three states of the Eastern Interior Coal Province (Arnott 1950).[1]

Probably the 1950's and 1960's were the big "growth years" in surface mining land reclamation - just as it was in surface mining afforestation. Following are some highlights of this period:

(1) There were about a handful of "experts" across the country and these people all knew each other and, by keeping in close communication, they learned from each other's mistakes -- and successes.

(2) Development of technology on strip mine forage establishment brought about opportunity to choose another land use option. It was this fact which caused a sharp decline in afforestation in Illinois (Grandt and Lang 1958).

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[1]Arnott, Donovan, Jr. 1950. Initial survival of planted hardwoods on strip mine spoil banks of Indiana. Purdue University, Dept. of For. Unpublished Thesis.

(3) Exposure to repeated failures helped discerning land reclamationists to learn where options were real and where they were just imaginary. The trend from afforestation to forage reclamation in Illinois was followed in Indiana; however, in Indiana, this did not come about until the late 1960's.

(4) Many thousands of acres of productive strip mine forests in the E.I.P. stand today as silent monuments to the success of phenomenal growth of strip mine afforestation of this period. Afforestation continued as a major land reclamation practice in Kentucky even beyond the period of extensive grading work which, by law, eliminated the ridge and valley topography on mine spoils areas.

(5) During this time period, the science of land reclamation changed a great deal; however, field conditions -- the spoils being planted -- changed very little, until the late 1960's.

(6) Early land reclamation laws in the E.I.P. required some minor grading work -- but not enough to change site conditions. This fact helped a great deal to perfect afforestation practices with minimal confounding.

ARRIVAL OF THE BULLDOZER

In the late 1960's, Kentucky, followed by Indiana, enacted legislation calling for elimination of spoil ridges and valleys. Illinois followed suit in 1971.

In addition to changing the topography, bulldozers have a way of affecting other parameters also -- the site itself becomes "something different". There might be a better expression for it; but, soil compaction surely comes close, until a better expression is found.

One need only review a modest sampling of land reclamation literature to discover that effects of soil compaction on mine spoil afforestation has a wide following among both proponents and protagonists. As a result, any serious student of land reclamation is entitled to be, at least somewhat, confused.

If we refer back to our discussion of the "big growth" years in surface mining reclamation, it should be noted that, over a significant period of years, spoil conditions remained generally unchanged and only the techniques employed changed. Thus, it was easier to evaluate cause and effect. It is a fairly safe prediction to state that anyone who tries to duplicate results of afforestation on ungraded mine spoils by application on graded mine spoils, is in for a few surprises.

Most perplexing of all is the fact that one can establish an excellent stand one year and a complete fizzle the very next year on what appears to be and might really be identical spoil.

A "hidden" problem in dealing with graded mine spoils is the fact that we are dealing with both cuts and fills and, in any given spot, we don't know which is the case. One need not be a soils specialist to know that amount of site compaction, soil air space and surface water insoak rate may not be the same on cuts as it is on fills. How much confounding such factors cause, one can only speculate about. For those who propose to do research on graded spoils, in order to overcome confounding caused by cut and fill differences, this writer advises designing plots and rows long enough to overlap both site types and to orient rows at right angles to original spoil ridges. This would avoid, for example, comparing a row planted on a fill with a row planted on a cut.

Graded spoils, if not too rocky, can be planted with a specially adapted tree planting machine; however, use of the planting machine might justify change of tree species.

Conifers seem to tolerate graded spoils; however, in the hardwood region, the idea of having to abandon hardwoods carries a negative image among many reclamationists. Both silver maple and red maple seem to be out-performing other hardwoods and may prove to be exceptions. Black locust can be established, if cover alone is the objective.

TREES VS FORAGE

It is some indication of advance in the state of the art which permits one to be able to choose between establishing either trees or forage on graded mine spoil. In many situations, either is possible. Except for climatic limitations (not a problem in the E.I.P.) any spoil which will grow forage also will grow trees. However, some sites may be too sandy, too coarse in texture, or too acidic for forage and yet support acceptable and maybe even excellent afforestation possibilities.

Heretofore, it has been the presumption that the existing site, in general, must be dealt with under the conviction this is a fixed condition and the only options available had to do with finding a species that will tolerate or adapt to the given site.

For many years, about the only site improvement considered practical would have been fertilization.

During the past decade or so, it has been established that site can, in fact, be changed and changed drastically. Not only that it can be done, it has been done on a significant scale. In some cases, toxic spoils have been ameliorated by application of neutralizing agents (this has been widely practiced in West Kentucky). More drastically, toxic spoils have been simply covered over by applying a suitable mantle of neutral earth.

Successful site correction, of course, brings one back to the pleasant dilemma of being able to deliberately choose between vegetating with whatever is desired, for whatever land use one might prefer. In such circumstances, afforestation may or may not prevail.

TOPSOILED SPOILS -- A NEW DAY

On the presumption that present federal requirements for coal surface mining reclamation survives the U.S. Supreme Court, both present and future reclamation on coal surface mined areas involves something approaching "original land" conditions. As a result, it must be readily apparent that one engaged in revegetation of such areas need be not necessarily a land reclamationist. If we refer back to former problems of having to plant raw spoils, by comparison, past experience may be of only limited benefit.

If we can agree that we are now working in a "new day", we must also recognize that we have at hand an opportunity to create, by deliberate plan, almost precisely that which we envision should be established. We should be able to reclaim to row crops where that is desired and to forest where such is desired. Each should have their rightful place. We may have finally circumnavigated the circle.

It should be a real pleasure to be a land reclamationist now and to exert one's efforts toward establishing, for example, not just a forest, but the very best forest. The fact that there are no existing large scale good examples to follow for reclaiming fully restored and topsoiled mine spoils should be a disadvantage only to the unimaginative.

Although the new land reclamationist might be able to ignore the site problems which plagued his predecessors, it should be pointed out emphatically that trees of the type preferred have a way of not planting themselves where we want them. Consequently, there is no escape from strict adherence to proper tree planting methodology. If this sounds a bit trite, it is pointed out that this writer has already observed complete tree planting failures on fully restored and topsoiled coal surface mined spoil areas. Problems do still abound and they have only shifted to new dimensions.

Unfortunately, legal constraints require that herbaceous cover must accompany tree planting and there must be effective erosion control measures applied. Under such circumstances, tree planting failure cannot be corrected by simple replanting or interplanting, unless effective herbicide or comparable treatment also is used.

Much more research is needed to determine, for the different geographic regions, acceptable companion herbaceous species and to develop acceptable timing sequences with actual tree planting. Can selection of proper herbaceous species allow tree survival and growth; or, will it be unavoidable to use herbicides? If herbicides are to be used, chemical choice and technique of application, for large scale plantings, will likely become new areas of specialization for the new land reclamationist.

AREAS WITHOUT TOPSOIL

Some areas do not have topsoil present due to natural conditions, neglectful erosion, or, the area may have been previously surface mined. Thus, restoration of such area unavoidably may have raw spoil as the best available surface material. Revegetation problems on such areas, of course, should generally resemble those immediately preceding federal interim standards, except that herbaceous, companion cover becomes a factor.

Although specially adapted tree planting machines are available and most graded spoils are amenable to such machine planting, greater selectivity in species choice seems to be called for. In general, conifers seem to be adapted to machine planting; whereas, only a limited number of hardwood species seem to be so adapted.

In general, this writer's experience and observations suggest machine planting requires tree species choice be those with root system displaying generally high fibrosity (numerous small rootlets). Conifers generally meet this criteria. Among the hardwoods, soft maples and, to some degree, European Alder, give some indication of promise. Among non-arborescent species, autumn olive has shown good survival and growth.

Hand planting, by the use of a planting bar, seems to have achieved more consistent tree planting survival than has machine planting on graded spoils. Erratic success; however, suggests there is still more to be learned before we can expect "routine success" from graded spoils afforestation. Some suggestions for improving survival include the following:

(1) Planting as early in the planting season as possible makes planting work easier because freeze and thaw soil conditions seem to somewhat ameliorate compacted spoil conditions and workmen tend to do better work and plant deeper under less difficult planting conditions. Early planting also helps improve survival due to longer growth and development period, allowing better root development, prior to dry, hot weather stress period arrival.

(2) The later in the season planting is done, the more care and supervision becomes critical to success. Planting stock care is essential and merely keeping seedling roots wet is not adequate. A seedling can be just as dead from root mold as it is from desiccation. This writer observed a fairly large scale tree planting failure during the spring of 1980 where hardwood seedlings did not even open their buds to begin spring growth. It seems fair speculation that the seedlings planted probably were not viable plants at the time of planting.

(3) A tractor with a ripper can be used to rip a furrow at the spacing planned for tree planting on graded spoils. This treatment not only should ameliorate grading compaction and make planting work easier, increased rainwater insoak also would be expected and both factors should improve tree survival. Using a tractor with ripper in this fashion has long been a standard practice for eucalyptus planting on tin mine spoils in Nigeria. Timing of ripping work should be in the fall or early winter for area to be planted the following spring (Onosode, A. T., et al. 1973).

(4) Planting graded spoils with a commercial tree planting bar becomes progressively more difficult as spring planting season advances and drier weather renders compacted, graded spoil harder and more difficult for the planting bar to penetrate. Conditions do develop where one just cannot force a commercial planting bar into the ground. With such conditions, tree planters have a tendency to "J" root the tree seedlings and planting failure is almost assured.

One solution to compacted spoil planting conditions, assuming ripping with a tractor is not available, is to have planting bars fabricated at a local blacksmith shop. A piece of large truck spring can be welded t(the end of a piece of 3/4-inch pipe. Length of truck spring piece about 10 inches would be adequate and overall length, after being welded to the piece of pipe, should be about 49 inches. The blade (end of truck spring piece) should be heated and hammered to be sharp. No foot step, as is found on the commercial planting bar, is needed. Such a tool has enough heft that it can be jabbed into the ground like a post digging spud and, even if repeated jabbing is required for hard soil conditions, eventually, a proper depth tree planting hole can be dug with this tool.

(5) It is never desirable to plant trees on freshly graded spoil. Ideal conditions are for grading work to be completed in the fall or early winter and undergo winter weathering conditions prior to planting early the following spring.

(6) Where herbicides are to be used, if pre-emergent type is chosen, significant advantage is available if ripping with a tracto is done because treatment along the tree rows (ripped furrows) can be done efficiently wher one plans to allow herbaceous cover to develo in the strip between rows.

(7) Perennial herbaceous cover, as a tree planting, companion cover, should not be established ahead of tree planting. By establishing trees and herbaceous cover at the same time, it may be possible for the trees and herbaceous growth to survive; whereas, planting trees in established cover invites tree planting failure, unless herbicide treatment is applied. This writer is of the opinion that much more needs to be learned about dealing with companion herbaceous vegetation and, hopefully, other competent researchers will join in on the type of research being done by Vogel, whose paper on this subject appears on another part of this program.

TREES ON COAL WASTE SLURRY

A number of coal waste slurry lagoons have been planted with trees. Some stands are now over ten years of age. Out of nine sites planted, all showed some degree of success, with only one complete failure. The single failure had surface pH below 4.0. The other sites had pH above 4.0.

The highest success was achieved with cypress planted in a strip around a water area and extending into the water-covered slurry as far as tree planters wearing rubber boots could walk and successfully anchor trees into the slurry. Appearance of the ten year old stand shows very few trees failed to survive and growth rate appears to be satisfactory.

On dry slurry areas, some fair stands of trees are now growing and results indicate that successful species are pitch pine, jack pine, Virginia pine, cypress, red oak and river birch. White pine proved a failure, although, in places, it survived a few years.

Although some success has been achieved, no entire slurry lagoons were completely, successfully afforested. Just why this is so still remains to be explored and elucidated. This writer's speculation is that the answer lies in variations of slurry material which are not superficially noticeable. To the naked eye, slurry areas appear to be level; however, they actually slope at about 0.7% (precise composition of different particle sizes will affect the slope and probably no two slurry lagoons are precisely similar).

It is not necessarily suggested here that slurry areas cannot be completely afforested -- just that this writer has not personally observed such. Efforts to replant failed areas would definitely seem to be worth trying; however, this writer does not know of such being done. If attempts at replanting result in failure, it may result in delineating areas which may require treatment such as possibly liming and/or fertilizing or soil covering.

Those attempting tree planting in slurry are cautioned to observe there is a special problem in planting during dry weather because the slurry surface may become extremely dry and powdery. Digging a hole through the dry surface commonly will cause dry slurry material to fall down in the hole because, when dry, slurry material is "structureless". Placing a tree seedling in a hole partially filled with dry slurry would seem to invite planting failure. To deal with this problem, it has been found that one can use a tree planting bar to rake back and forth a couple of times to scrape dry slurry aside and expose moist slurry found below. If one then digs a planting hole in the moist slurry, the hole will retain its shaped opening to allow insertion of a tree seedling and normal planting procedure can then be observed.

A LOST SPECIES RE-ESTABLISHED

A half century of surface mining afforestation experience in the E.I.P. has taught us many things and has had some significant impact in other ways. As often occurs, results other than those sought sometimes come about in a way that exceeds all expectations. Such is the case with Chinese Chestnut.

As is well known, the native American Chestnut is a thing of the past, due to the chestnut blight. A once very valuable component of the midwest and eastern hardwood forest has not been among the numerous hardwood species planted on strip mine spoils, for obvious reasons. However, in approximately 1949, it was decided to try a substitute variety -- Chinese Chestnut. This species has been regularly planted in Indiana ever since that time and, for many years, this species has been producing chestnuts for the enjoyment of local citizenry and, of course, for wildlife food.

Because typical Chinese Chestnut tree growth behavior tends to be, more or less, that associated with fruit trees (orchard form), these trees have taken on the image of being desirable nut producer components of a stand and no one is known to have given much attention to possibilities beyond that.

It is now possible to report that some chestnut trees are developing under closed canopy stand conditions in a way that original orchard form is giving way to developing a timber form character. It is still too early to determine final outcome; however, some pole size trees with fair timber form can now be found.

Something this writer has not found appearing in the literature involves reproducing capability of Chinese Chestnut -- especially on surface mine spoil areas. This writer has now observed enough instances in different stands to conclude that this species is reproducing naturally. Stands where natural regeneration was found generally are about 12 to 15 years of age or older. Thus, it soon may be possible to conclude that we have successfully re-established a lost species.

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DIRECT SEEDING FOR FORESTATION[1]

Walter H. Davidson[2]

Abstract.--Direct seeding, an attractive alternative to planting, is not a simple method of forestation. Past experiences show far more failures than successes. Well documented procedures must be followed to insure any degree of success. In general, conifers have given the best results. Black walnut and black locust are notable exceptions. Current research suggests that other hardwoods may be successfully direct-seeded.

INTRODUCTION

Direct seeding is an attractive alternative to planting seedlings. Large acreages can be seeded in a relatively short time, less manpower is needed, and seedings can be made at times when planting is not feasible. Direct seeding, however, is not a simple method of forestation and its successful application requires technical knowledge and skills. Regardless of the potentials of direct seeding, if seeding techniques are faulty or miscalculations are made, only failure will result. It is the intent of this paper to present the state of the art of direct seeding as a reclamation tool, to present guidelines for reclamation seeding, and suggest research needs to more efficiently develop seeding techniques.

PAST EXPERIENCE

Early reports of reclamation for forestation indicate that direct seeding was attempted in many regions as an alternative to tree planting. Among the earliest attempts was direct seeding of black walnut made in 1939 in Illinois (Schavilje 1941). He reported good first year germination and survival with average seedling height of 12 inches. Limstrom (1960), however, discourages the use of direct seeding due to inconsistent results and failures of earlier trials. A seeding of black walnut, black cherry, and bur oak on 13 sites in Missouri, Kansas, and Oklahoma, resulted in complete failure of the black cherry. After 6 years black walnut survival was 15 percent and bur oak was 24 percent. Other seedings of black walnut resulted in survivals ranging from 6 to 82 percent. Additional testing included more species, both conifers and hardwoods, but again the results can only be classed as fair to poor. He attributed the failures to, "(1) drying out of germinating seedlings, (2) mice and other rodents pilfering the seed, and (3) erosion and siltation".

Rodents were cited as the major limiting factor to early direct seeding trials in central Pennsylvania (Bramble and Sharp 1949). However, trials in the anthracite region of Pennsylvania showed spring seeding of red oak, Virginia pine, pitch pine, and red pine gave satisfactory germination. White oak, Norway spruce, white pine, and Japanese larch either failed completely or gave very poor germination.[3]

Loblolly pine was successfully seeded on steep spoil banks in a 1961 experiment in Tennessee (Thor and Kring 1964). This study of seeding versus planting showed that planted seedlings produced higher survival rates, but cost of planting exceeded that of seeding. The major disadvantage of direct seeding was poor distribution of stocked seed spots.

Between 1930 and 1940, black walnut seed was available for reclamation seeding in Indiana (Medvick 1973). Apparently the results were unsatisfactory and seedlings were planted

[1]Paper presented at the "Trees for Reclamation in the Eastern U.S." symposium, Lexington, Kentucky. October 27-29, 1980.

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[3]Unpublished report on forest planting and seeding experiments on lands stripped for coal in the anthracite region. 1951. Pennsylvania Bureau of Forests and Waters.

in the period 1941 to 1950. Direct seeding was tried again in 1950. About 1960, acceptable walnut planting stock was developed and there is no record of further direct seeding trials.

Thirty-year evaluations of plantations in Illinois indicate that the performance of seeded black walnut is comparable to planted seedlings (Ashby et al. 1978). In addition, seeding of black walnut is recommended on sandy, unvegetated areas.

Direct seeding of black locust was a common reclamation practice in West Virginia during the 1940s and 1950s. An evaluation of about 20,000 acres of these seedings showed only about 20 percent had successful establishment of trees (Brown and Tryon 1960). About 50 percent of the stands were rated as complete failures. In an attempt to determine the causes of failure, a series of experiments were established in 1958 to 1960. The effects of site factors and seeding methods on germination and survival of black locust, Virginia pine, pitch pine, and white pine were investigated (Brown 1973). Black locust and pitch pine gave the best results. Spoil moisture, seed bed condition, seed treatment, seed coverage, and competition from herbaceous plants, were listed as factors affecting germination and initial survival.

Other recent experimentation includes tests with loblolly, shortleaf, Virginia, and white pine by the Tennessee Valley Authority (Zarger et al. 1973). In these 1966 trials, stratified seed treated with bird and rodent repellants was used. Seed was broadcast by hand or cyclone seeder and also by helicopter. First year results showed Virginia pine gave the best and most consistent results; white pine was the poorest.

Field tests in West Virginia have indicated that bicolor lespedeza, false indigo, black locust, green ash, Virginia pine, shortleaf pine, and loblolly pine can be recommended for direct seeding in the southern region of the state (Plass 1976). Shortleaf and loblolly pine have also shown greater olerance to a range of spoil conditions in greenhouse test (Plass 1974). Identification of the promising species resulted from species evaluation trial in which 34 species of trees and shrubs were hydroseeded on ive sites. The sites were classified by levation and species were selected for testing on the basis of planting recommendations or the site class. Results at higher elevations and in the northern region of the state are variable. Some species show promise but none can be recommended except for additional testing.

Direct seeding as a reforestation technique has been extensively practiced in the South. Nevertheless, in a survey of direct seeding in the South (Mann 1968), the only reference to reclamation seeding is for loblolly pine on Alabama spoils.

At a direct seeding symposium in 1973, Abbott reviewed direct seeding programs in the United States. Only West Virginia was mentioned for direct seeding a sizeable acreage of surface mined lands. Reference was made to direct seeding black locust which accounted for 62 percent of the State's acreage reforested in 1972.

In a publication on plant performance on surface mines (Soil Conservation Service 1978), Virginia pine, loblolly pine, and black locust are listed as tree species most likely to produce acceptable stands from direct seeding.

Reviewing the past experiences with direct seeding for reclamation illustrates the need for selecting the right species, preparing a suitable seed bed, providing protection to the seed, and seeding at the proper time.

CURRENT RESEARCH

In spite of the problem associated with direct seeding, many operators are attempting to establish trees from seed and research to find acceptable species and dependable seeding techniques is continuing. I installed a series of study plots in late April and early May using a variety of species. Grass species were seeded at the same time in an attempt to meet reclamation requirements for erosion control and site protection. Because of the late timing of the trials, early results are not promising.

Another current study on direct seeding is being done by Clark Ashby.[4] This work involves studies using the spot seeding technique with a variety of species. Early results are encouraging for black walnut, several oak and hickory species, and silver maple. Black locust is acceptable but is poorer than some of the other species. Black cherry and hackberry have performed poorly.

Undoubtedly more research is being conducted throughout the region. New regulations and standards for reclamation have become more stringent and direct seeding must

[4]Ashby, W. Clark. 1980. Personal communication.

be demonstrated to be a reliable technique for forestation.

GUIDELINES FOR DIRECT SEEDING

Many guides have been published on direct seeding for reforestation. The principles of direct seeding apply both to reforestation and forestation of surface mined lands. However, there are differences that must be recognized when the seeding is for reclamation. A surface mine is not the same as a logged area or old field. Soil conditions may be considerably different. Erosion potential is high and must be considered. In addition, a defined measure of success must be achieved within a set time frame.

The following guidelines are general rules which must be considered to insure the highest chance of success when direct seeding.

Species selection

Native species usually have the highest potential for success. Priority should be given to species that are successfully planted in the region. Some species, such as black cherry, are difficult to seed successfully. Use of such species should be limited to small trials until seeding techniques are perfected.

Seed quality

Only good quality seed should be used. Certified seed is recommended. Geographic source of the seed may also influence its quality (Belcher 1976).

Seed treatment

Seed having internal or seed coat dormancy should be scarified and/or stratified to insure prompt germination. Treatment to protect the seed from birds and mammals should also be applied. There are restrictions on chemicals used for seed protection which require state certification of the user. Many seed companies can provided treated seed.

Seedbed preparation

A freshly prepared seedbed will give the best conditions for germination and establishment.

Time of seeding

Early spring is usually the best time to seed. Fall seeding is acceptable if the soil conditions are such that the seed will not be washed away or covered too deeply by siltation. Fall seeding can provide natural stratification.

Seeding method

Broadcast seeding is the easiest method to use. It can be by hand, cyclone seeder, hydroseeder, helicopter, or fixed-wing aircraft. However, large quantities of seed are required and unless discing or some other treatment is applied, the seed may not be covered properly. Spot seeding or drilling uses less seed and provides better seed coverage ensuring better germination and more uniform spacing. This can be an important factor if seed is scarce or high priced seed is used.

Liming and fertilizing

Liming and fertilizing can improve germination and seedling growth (Vogel and Berg 1973). However, invading herbaceous plants will be encouraged and the competition could be detrimental to the tree seedlings.

Combination seedings

Herbaceous plants are needed for cover and erosion control. However, competition from herbaceous plants will reduce the success of tree seedings. At this time, the options are to seed the herbaceous species one year and spot seed the following year in spots prepared by scalping or using herbicides. Another possibility is to spring seed trees, then over-seed with grasses in the fall. There has been limited success seeding both herbaceous species and trees at the same time. If this technique is used species selection is critical and fertilization should be minimal to inhibit rapid development of the grasses.

These guidelines show that direct seeding is not an easy alternative to planting. Any landowner wishing to obtain trees by direct seeding must be prepared to follow the guides and must be willing to accept failures if weather conditions or other factors occur which cause poor germination, seed losses, or seedling mortality.

RESEARCH NEEDS

Much is known about direct seeding. However, when seeding for reclamation, there are areas which need to be investigated to determine more practical techniques to insure successful seeding.

Among the primary needs are evaluations of various tree and herbaceous combinations to allow for one time seeding operations. Additional testing of hardwood seeding is needed. Timing of lime and fertilizer applications needs to be studied to maintain a herbaceous cover that will not compete too strongly with seedlings.

Continued species evaluations and testing new species is needed to give the landowner a greater selection of species which can be seeded. Seeding rates for hydroseeding need to be evaluated.

Economic studies are also needed to determine if the costs of seeding justify the end result.

SUMMARY

Past experiences have shown that in some instances direct seeding has given satisfactory stands of trees on surface mined lands. In many instances, the results were less than desirable. However, the procedure has appeal for reclamation in that it may be possible to obtain a mixed cover of herbaceous and woody species on a site in a single operation.

Current seeding operations should use species and techniques that have given the best results in the past.

Research is needed to identify species combinations for one step operations and to develop procedures which will give the highest chances for success.

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Now we give an overview of what thirty years' experience has revealed. First we describe our methodology and general results. Next we review special features of individual plantings, examine general characteristics of each species' growth, and briefly discuss the broader considerations of diversification, soil development, and prospects for the future. This includes a perspective on applying these results toward achieving the goals of the Federal Surface Mining Control and Reclamation Act of 1977 (P.L. 95-87).

METHODOLOGY AND GENERAL RESULTS

The plots we examined were located in Indiana, Illinois, Missouri, Kansas, and Oklahoma. We had enough information to locate 867 study plots or sub-plots with a total of 28 species. Trees were planted on a 7-foot by 7-foot spacing, which gave an original planting rate of 889 trees per acre. To sample a plot we typically measured diameter breast height (DBH) of 36 interior trees, or fewer if there were fewer surviving trees. The measurements from the trees in one plot were averaged, and our performance analyses are based on comparisons of these plot averages.

Tabulated, by state, are the number of plots in which all trees of a given species died, the number in which live trees were present and measured, and the percent plots for each species with living trees sorted by mean DBH size classes (Table 1). Species with a relatively low survival rate are identified in the review of individual species. Our data are on all trees, not just the dominant and co-dominant trees.

After 30 years most trees in the strip-mine plantings were in the small-pole size class (4.0 to 7.9-inch DBH). Numerous species were represented in the sapling (0 to 3.9-inch) class and others in the larger pole (8.0 to 11.9-inch) class. Relatively few species were found with plot averages greater than 12 inches. Moderate differences were found in the relative size-class distributions among the several states.

Only 4 species (green ash, black walnut, shortleaf pine, and black locust) were planted and grew successfully in all the states. Of these, green ash was consistently found only in the smaller two size classes, shortleaf pine grew better in Kansas and Oklahoma than elsewhere, black walnut had less good growth in Kansas and Oklahoma, and results with black locust were variable.
If present in a state, these species had the largest trees: sweet (red) gum, tulip tree (yellow poplar), loblolly pine, cottonwood, and to some extent sycamore.

Flowering and fruiting were observed for many species and volunteers of the planted species were recorded for many plots. The likelihood of other seed sources for these volunteers was not investigated.

Planting plans

Differences in planting on various plots allowed us to study several interesting problems. Other differences were often not intentional or controlled.

Mixed plantings with black locust.--Some studies in Indiana, Illinois, and Kansas were designed to evaluate the influence of black locust planted with or before other species on their growth. Because some stands were of young (1-3 year) locust interplanted with hardwoods while other stands were of hardwoods planted under older locust already ravaged by the locust borer (*Megacyllene robiniae*), exact comparisons were not possible. In general, locust promoted the growth of tulip tree, black walnut and silver maple, and supressed the growth of pines. In one planting comparing growth under shortleaf pine with growth under black locust, tulip tree, black walnut, silver maple, and osage orange all grew better under the black locust (Fig. 1); only the sweetgum grew better under the pine (Ashby and Kolar 1977). However, all species except silver maple had much greater survival under the pine than under the locust.

Also of note is that the locust stands were vigorously invaded by volunteer species. Unfortunately, in Indiana Japanese honeysuckle (*Lonicera japonica*) often formed dense cover in locust plots and smothered out young trees and herbs.

Row vs. block plantings.--Plantings with several species side by side in rows were used widely in Illinois, and to a lesser extent in Indiana and Kansas. Plantings with just one species in a block were also used, typically ¼ (or ½) acre size in Indiana and 1/10 acre in Missouri, Kansas, and Oklahoma. The chief effect noted was that in Indiana and Illinois pines did considerably better when planted with pines of their own or other species than when interplanted with hardwoods.

Grading.--Studies in Missouri and Kansas, and comparisons in Indiana and Illinois, evaluated the effects of grading on tree growth. The grading was generally less intensive than is carried out under present regulations.

Table 1.--Species Performance by State

Species	No. of Plots Trees Died	No. of Plots Live Trees	% Live Tree Plots by M 0 to 3.9"	4.0 to 7.9"	8.0 to 11.9"
			INDIANA		
Acer rubrum (Red maple)	--	8	--	100	--
A. saccharinum (Silver maple)	--	21	--	86	14
A. saccharum (Sugar maple)	--	1	--	100	--
Ailanthus altissima (Tree-of-heaven)	--	2	50	50	--
Alnus glutinosa (European alder)	--	2	50	50	--
Fraxinus pennsylvanica (Green ash)	--	8	38	62	--
Juglans nigra (Black walnut)	1	13	8	84	8
Liquidambar styraciflua (Sweetgum)	--	19	--	69	26
Liriodendron tulipifera (Tulip tree)	2	14	--	36	57
Pinus banksiana (Jack pine)	6	2	--	100	--
P. echinata (Shortleaf pine)	6	1	--	100	--
P. resinosa (Red pine)	6	3	--	100	--
P. rigida (Pitch pine)	6	--	--	--	--
P. strobus (White pine)	3	3	--	67	33
P. taeda (Loblolly pine)	3	--	--	--	--
P. virginiana (Virginia pine)	6	--	--	--	--
Platanus occidentalis (Sycamore)	--	2	--	50	50
Populus deltoides (Cottonwood)	--	4	--	--	75
Quercus prinus (Chestnut oak)	--	4	50	50	--
Q. rubra & shumardii (Red & shumard oak)	--	10	--	50	50
Robinia pseudoacacia (Black locust)	1	3	33	67	--
			ILLINOIS		
Acer saccharinum (Silver maple)	2	14	14	64	22
Fraxinus pennsylvanica (Green ash)	2	14	29	71	--
Juglans nigra (Black walnut)	1	26	12	76	12
Juniperus virginiana (Red cedar)	6	9	33	67	--
Liquidambar styraciflua (Sweetgum)	1	15	27	46	27
Liriodendron tulipifera (Tulip tree)	5	12	--	50	50
Maclura pomifera (Osage orange)	--	17	53	47	--
Pinus banksiana (Jack pine)	2	12	42	58	--
P. echinata (Shortleaf pine)	7	6	--	100	--
P. resinosa (Red pine)	7	8	12	88	--
P. rigida (Pitch pine)	7	5	20	40	40
P. strobus (White pine)	6	7	29	57	14
P. sylvestris (Scots pine)	--	2	50	50	--
P. taeda (Loblolly pine)	6	6	17	33	33
P. virginiana (Virginia pine)	5	7	14	57	29
Populus deltoides (Cottonwood)	6	10	--	10	60
Quercus alba (White oak)	--	1	--	100	--
Q. rubra & shumardii (Red & shumard oak)	--	2	--	--	100
Robinia pseudoacacia (Black locust)	--	14	--	93	7

Table 1.--Species Performance by State (continued)

Species	No. of Plots		% Live Tree Plots by Mean DBH			
	Trees Died	Live Trees	0 to 3.9"	4.0 to 7.9"	8.0 to 11.9"	Over 12.0"
MISSOURI						
Fraxinus pennsylvanica (Green ash)	--	13	69	31	--	--
Juglans nigra (Black walnut)	--	15	13	67	20	--
Juniperus virginiana (Red cedar)	1	11	--	91	9	--
Pinus banksiana (Jack pine)	7	2	--	100	--	--
P. echinata (Shortleaf pine)	--	10	--	100	--	--
P. ponderosa (Ponderosa pine)	6	--	--	--	--	--
P. rigida (Pitch pine)	6	2	--	50	50	--
P. taeda (Loblolly pine)	2	8	--	62	38	--
P. virginiana (Virginia pine)	1	8	--	100	--	--
Plantanus occidentalis (Sycamore)	--	11	18	46	27	9
Prunus serotina (Black cherry)	--	13	23	62	15	--
Prunus serotina seed	3	--	--	--	--	--
Quercus macrocarpa (Bur oak)	--	32	44	47	9	--
Robinia pseudoacacia (Black locust)	--	18	--	100	--	--
KANSAS						
Fraxinus pennsylvanica (Green ash)	3	17	82	18	--	--
Juglans nigra (Black walnut)	2	31	84	16	--	--
Juniperus virginiana (Red cedar)	5	17	12	88	--	--
Pinus banksiana (Jack pine)	3	11	--	100	--	--
P. echinata (Shortleaf pine)	--	14	--	86	14	--
P. ponderosa (Ponderosa pine)	10	3	--	--	100	--
P. rigida (Pitch pine)	5	9	--	89	11	--
P. taeda (Loblolly pine)	1	13	--	24	38	38
P. virginiana (Virginia pine)	1	13	--	100	--	--
Platanus occidentalis (Sycamore)	2	18	5	78	17	--
Prunus serotina (Black cherry)	1	13	46	54	--	--
Quercus macrocarpa (Bur oak)	1	28	54	46	--	--
Robinia pseudoacacia (Black locust)	--	25	--	96	4	--
OKLAHOMA						
Fraxinus pennsylvanica (Green ash)	--	3	--	100	--	--
Juglans nigra (Black walnut)	--	3	33	67	--	--
Juniperus virginiana (Red cedar)	--	3	--	100	--	--
Liquidambar styraciflua (Sweetgum)	1	2	--	--	--	100
Pinus banksiana (Jack pine)	3	--	--	--	--	--
P. echinata (Shortleaf pine)	--	3	--	33	67	--
P. taeda (Loblolly pine)	--	3	--	--	33	67
P. virginiana (Virginia pine)	--	3	--	33	67	--
Platanus occidentalis (Sycamore)	--	3	--	33	67	--
Prunus serotina (Black cherry)	--	3	--	100	--	--
Quercus macrocarpa (Bur oak)	--	9	33	67	--	--
Robinia pseudoacacia (Black locust)	--	3	--	67	33	--

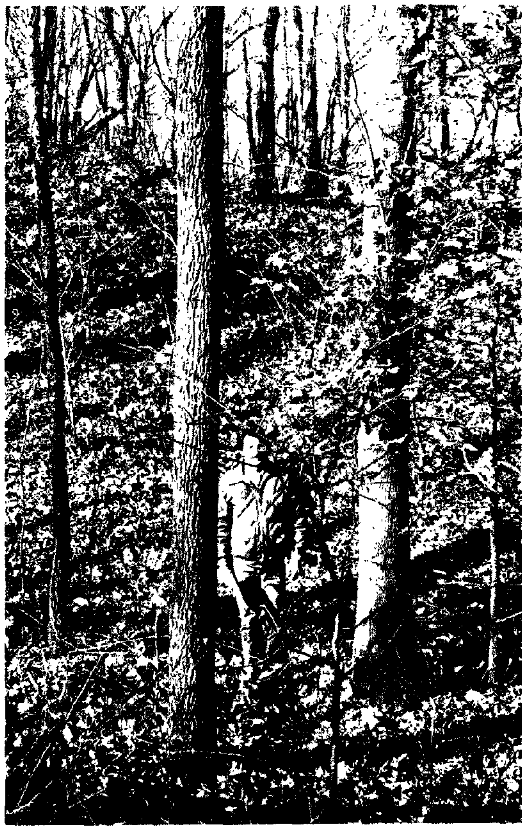

Figure 1.--Decadent black locust stands were characterized by a friable, humus-stained soil enriched in nitrogen and protected from erosion by litter. Black walnut (on the left) and tulip tree (on the right) made superior growth with good form in this southern Illinois stand, which was also rapidly invaded by a diversity of forest species.

In Missouri, growth on graded plots was equal or better than on the ungraded, but the ungraded plots had 68 percent rock compared to only 48% on the graded spoils.[3] Spoil moisture and physical conditions affecting compaction were reportedly ideal at the time of grading. The chemical composition of the spoils seemed to be uniform. These two sets of plots in Bates County had the best growth of any of the Missouri plantings.

In Kansas, grading scarcely affected ash, red cedar, or black locust plot averages. Grading reduced the DBH of black walnut and bur oak, while it increased the size of loblolly and shortleaf pine. Soil tests detected little difference between the two spoil areas.

In an Illinois study, most species grew better on a plot graded by dragline pullback than on an ungraded plot. These results may, however, be questioned because substantial differences in rock content and pH (graded plot pH 6.1, ungraded plot pH 3.4) undoubtedly influenced the tree growth.

The most dramatic effects of grading were on apparently uniform Indiana site graded by bulldozer about 1940 and planted to black walnut. In 1977 the walnut averaged 7.4 inches DBH on the ungraded banks and 4.2 inches on the adjacent graded area. While the trees on the graded area had grown well for the first 18 years (Deitschman and Lane 1952), by 1977 they were conspicuously stag-headed with poor canopies and yellow-green leaves. Trees on the ungraded area showed good form and color. Small differences were found in soil pH, phosphorus, and potassium analyses.

Selective placement of overburden.--At one northern Illinois mine calcareous deep sands overlay a dense clay in the overburden. Where a shovel and dragline operation worked in tandem the sand was replaced as the surface rooting medium. On these sites, black locust and black walnut survived better and grew considerably larger than on sites where the dense, less productive clay was left as the rooting medium by a shovel or dragline working by itself. The dramatic differences in tree performance between these two sites indicates the potential benefits of selectively placing or mixing the different layers of overburden.

Use of seed.--Black walnut and bur oak, both with large seed, grew about equally well planted as seedlings or seed. Black cherry did not grow well from seed.

Review of species

Maples.--In pure stands, red and to a lesser extent other maples produced dense canopies with little ground cover beneath them. Silver maple had poor form for a timber tree. Of the silver maples, 53% had multiple stems, regardless of whether they were in pure or mixed stands, while multiple stems were found on only 39% of the red maples and on only 8% of the one stand of sugar maple.

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[3] Rogers, N.F. 1947. Establishment report for spoil banks planting experiment no. 1. Pittsburg Branch Station of the Central States Forest Experiment Station. Tests of species adptation and growth on strip-mined lands in Oklahoma, Kansas and Missouri. 135 p. and maps.

Green ash.--In mixed plantings in Illinois, green ash had the highest survival rate of any species after 30 years.

Black walnut.--Black walnut seemed to be very site sensitive. Its occurrence in three size classes could be related to soil pH, drainage, and other factors. In Indiana and Illinois, where it was often associated with black locust, the tree form of the larger black walnuts was good. The understory or ground layer in walnut stands was visually different from other planting areas. Honeysuckle did not invade beneath walnut in Indiana; instead white snakeroot (Eupatorium rugosum) was a common ground cover there.

Sweetgum.--This species had both good survival and growth after 30 years in the southern part of the Central States. It grew very well at low pH. Some regeneration, probably by both root sprouts and seedlings, was found.

Tulip tree.--Tulip seemed similar to black walnut in site sensitivity. It grew well at lower pH values. Climatically it was limited to the southern parts of Indiana and Illinois, and was not tried in the other states.

Pines.--All pines had better performance overall in pure than in mixed plantings, and in southern compared to northern areas where such comparisons were possible. Loblolly pine outgrew other pines in southern areas, but did not survive on northern plots. Virginia pine, which had poor form, consistently had moderately good survival and growth, except in Indiana where it was planted only under young black locust. Earlier survival and growth of the pines in mixed plantings were commonly good, based on published results and on standing or fallen dead trees observed in the 30 year survey.

Sycamore and cottonwood.--Although these species had some of the largest trees, generally growth was not particularly good compared to what is possible for these species. Mortality of planted trees was high, and volunteer trees of the same species often equalled or exceeded planted trees in size. Tree form of these species was often poor.

Oaks.--The ecological potential of oaks was largely ignored in the early stripmine plantings. Bur oak, planted in the western part of the area, had good stands (Fig. 2). These stands consistently included saplings and small poles. Red oak stands, composed of Q. rubra and the often larger Q. shumardii, were highly successful in southern Illinois and in Indiana, with little understory or ground layer. Chestnut oak in Indiana performed similarly to the bur oak further west.

Black locust.--This leguminous tree made very rapid early growth before succumbing to the locust borer. It built up soil nitrogen levels of over 100 pounds per acre compared to a pine stand (Ashby and Baker 1968, Finn 1953), and contributed a readily-decomposed litter. Soils under locust were relatively loose with a darkened surface layer. Locust grew well over a wide pH range.

Although locust early lost favor for planting, the excessive competition attributed to locust in young stands of interplanted species is scarcely justified by 30-year results of locust with several hardwoods. Locusts may have been harmful to pines, but after 30 years pines exibited poor performance in the absence of locust as well.

Other than limited cutting for fence posts, these locust stands lacked the management needed if high productivity under short-rotation forestry were desired.

BROADER CONSIDERATIONS

Enhancement of diversity

Invasion of trees and herbaceous plants into the tree plantings was considerable.[4] After 30 years, the number of naturally established trees often exceeded the number of planted trees. Volunteer tree sizes were smaller, presumably because the volunteers were younger. Natural invasion was far greater in tree plots than on adjacent unplanted areas. Because of the enhanced diversity, many stripmine plots superficially resembled areas of natural forest regrowth.

However, dense stands of pines, maples, and to a lesser extent, oaks and black walnut, discouraged invasion. Allelopathic chemicals or heavy leaf litter may have reduced invasion on some plots.

Cottonwoods and sycamores, while commonly found in and around the plot areas prior to plantings, did not invade established plantings.

The major invaders under tree cover in all areas were elms (Ulmus spp.), hackberry (Celtis occidentalis) and box elder (Acer

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[4]Ashby, W.C., N.F. Rogers, and C.A. Kolar. 1980. Forest tree invasion on stripmines. The Third Central Hardwood Conference. University of Missouri, Columbia. In press.

 

Figure 2.--These well settled slopes in Kansas were seeded with bur oak seed in 1947. Thirty years later the bur oak stand of 275 trees per acre, about 4" dbh and 25 feet tall, was increased by invading black locust, elm and mulberry. The soil was mellow under a leaf and twig litter of more than one inch. Many of the black locust were larger than the bur oak. The tree cover has transformed the once barren landscape. USDA Forest Service photos.

negundo). Other invaders important more locally were black cherry, ashes (Fraxinus spp.), pin oak (Quercus palustris), shingle oak (Q. imbricaria), and sassafras (Sassafras albidum).

Diversity of invading trees was greatest in Indiana with 48 species, and diminished to the west, likely partly as a function of the availability of naturally occuring species. Oklahoma had only 17 species. Many plots not planted in black locust were invaded by black locust in nearby plots. The black locust plots themselves were preferentially invaded by hackberry in Indiana or red mulberry in Missouri and Kansas.

Shrub invaders were chiefly dogwoods (Cornus spp.). Grape (Vitis spp.) had a lesser distribution while other species such as sumac (Rhus spp.) were evident locally.

Many plots had a dense herbaceous layer. Species composition related to type and density of tree canopy and varied from old-field components such as lespedezas (Lespedeza spp.), to pokeweed (Phytolacca americana), to mesic forest species such as white snakeroot. White snakeroot was particularly important in older stands with black locust.

Animal life readily invaded the plot areas. Early invaders such as rabbits damaged the original plantings, particularly sweetgum in Kansas. Locust borer caused severe damage after 10 to 15 years, apparently especially in Indiana and Illinois. Abundant later wildlife includes game and song birds, groundhogs, deer, racoons, and beavers.

Development of minesoils

Our forested plots developed well-recognized O1 litter, O2 fermentation, and A1 humus-stained surface layers. B2 horizons were sometimes suggested by an increase in reddish color or in clay content several inches down in the profile.

Ten soil samples were taken and analyzed in each plot in Indiana and Illinois. Most soils were judged to be loams, based on the feel method and some Bouyoucos analyses for texture. The soils were often neutral-to-alkaline, and rarely more acid than pH 5. Correspondence of tree growth and pH, which could be found for individual species such as poor black walnut growth on acidic soils, was not characteristic for tree growth overall.

Available phosphorus by either the Bray-1 acid-fluoride or the Olsen sodium bicarbonate methods was commonly less than 10 ppm, as is typical of midwestern forest soils. Available potassium was in the general range of 100 to 200 ppm, with occasional appreciably lower or higher values. No deficiency symptoms for either phosphorus or potassium were noted. Chlorotic leaves, possibly from iron deficiency, were noted for sweetgum on a calcareous silty-clay loam soil in southern Illinois.

Prospects for the future

The extensive acreages of pre-law mined land planted to trees will continue to provide the amenities of forest cover for years to come. Stands of red or bur oak, black walnut, or tulip tree offer great potential for later timber harvest. The diverse forests of sycamore, ash, silver maple, and other species have great potential for wildlife, recreation, and high environmental quality.

The planting of new forests on mined lands can serve many of these same needs. Lessons from the past, however, are likely not immediately applicable to present mining practices. The Surface Mining Control and Reclamation Act of 1977 both sets goals for reclamation, and regulates the practices in overburden handling and land restoration. These practices differ in several ways from those of 30 years ago.

To achieve the goals of P.L. 95-87, we must focus our attention on several considerations:

1. In the Central States, trees on mined lands have proven to be a diverse, effective and permanent vegetative cover of the same seasonal variety native to the area and capable of self-regeneration.

2. At least 28 species of trees have already been shown to be successful candidates when properly used. Many more candidate species should be evaluated.

3. Surface mined lands vary greatly with respect to climate and soil conditions. Tree species selection must be matched to local planting conditions.

4. A planting program at least commensurate with the acreage of the forest land being mined will necessitate a yearly supply of millions of tree seedlings and seed of many different species. New sources will need to be developed.

5. Due to the grading requirements of P.L. 95-87, the regular use of tree-planting machines is now feasible. New successful and efficient planting methods will sustain an interest in using trees rather than encouraging the conversion of forest land to other uses.

6. It seems possible that considerable grading may actually be detrimental to many desired species of trees. Both soil properties and tree response should be studied to understand better the role of grading in tree establishment and growth to maturity.

7. Successful combinations of ground cover for erosion control and of desirable tree species must be established for each reclamation region or area.

The keys to achieving the goals of P.L. 95-87 are, then, building on the lessons of the past and developing new understanding for the future. Successful reforestation requires much thought and effort before the trees ever go into the ground. And without continued experimentation, we shall deprive ourselves of the full benefits trees can bring to reclaimed areas.

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ROLE OF MYCORRHIZAE IN FORESTATION OF SURFACE MINES[1]

Donald H. Marx[2]

Abstract.--A brief introduction to ecto- and endomycorrhizae and their importance to plants is presented. Recent findings confirm the significance of ectomycorrhizae, particularly those formed by *Pisolithus tinctorius* in nurseries, to survival and growth of pine seedlings on strip-mined lands. Commercial inoculum of this fungus may be available in 1981. Recent research shows that endomycorrhizal fungi affect growth of grasses and certain hardwood trees on coal spoils.

INTRODUCTION

Mycorrhiza (fungus-root) is a symbiotic association between the fine feeder roots of green plants and highly specialized root-inhabiting fungi. Each partner in the mycorrhizal association depends on the other to one degree or another for existence. In natural forest soils, which are low in fertility in comparison to artificially fertilized agricultural soils, mycorrhizal associations are essential to forest plants. These associations increase (1) nutrient and water absorption and, thus, nutrient cycling, (2) feeder root health and longevity, and (3) tolerance to drought, high soil temperatures, soil toxins (inorganic and organic), and extremes of soil pH. Most trees must have mycorrhizae to survive; other plants may only need them for maximum growth in natural soils.

With the exception of aquatics, some halophytes and a few other plants, the majority of flowering plants in the world form either ecto- or endomycorrhizae in natural soils (Mollock and others 1980).

Ectomycorrhizae occur naturally on many important forest tree species around the world. All members of the gymnosperm family *Pinaceae* (pine, spruce, fir, larch, hemlock, etc.) as well as certain angiosperms (willow, poplar, aspen, hickory, pecan, oak, birch, beech, eucalypt, etc.) normally form ectomycorrhizae. Some of these trees can be either ectomycorrhizal or endomycorrhizal, depending on soil conditions. Ectomycorrhizal fungal infection is initiated from spores or hyphae (propagules) of the fungal symbionts inhabiting the rhizosphere of the feeder roots. Propagules are stimulated by root exudates and grow over the feeder root surface and form a fungus mantle. Then hyphae develop around root cortical cells and form what is called the Hartig net. The Hartig net is the main distinguishing feature of ectomycorrhizae. Ectomycorrhizal roots may be unforked, bifurcate, multiforked (corralloid), nodular, or in other shapes. The color of an ectomycorrhiza is usually determined by the color of the hyphae of the fungal symbiont and may be brown, black, white, red, yellow, or blends of these colors. Individual hypha, strands of hyphae, or rhizomorphs may radiate from the fungus mantles into the soil and to the base of the fruit bodies of the fungi.

Most fungi which form ectomycorrhizae with forest trees are Basidiomycetes that produce mushrooms or puffballs (fruit bodies). Certain Ascomycetes such as truffles also form ectomycorrhizae. One genus of mushroom-producing fungi, *Cortinarius*, is composed of over 2000 species distributed throughout the forests of the world; all species form ectomycorrhizae. If other genera are considered, over 5000 ectomycorrhizal fungus species probably exist--including 2100 in North America. The fruit bodies of these fungi produce billions of spores that are widely disseminated by wind and water. Most ectomycorrhizal fungi depend on their hosts for simple carbohydrates, amino acids, vitamins, etc. necessary to complete their life cycles. Ectomycorrhizal development,

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therefore, is a prerequisite for fruit body production by these fungi. Not all fungi which form mushrooms and puffballs are ectomycorrhizal; many are litter decomposers and a few are pathogenic on trees.

Endomycorrhizae are formed on most economically important agronomic and forage crops, woody perennials, ornamentals, fruit and most nut trees, as well as maple, elm, green ash, sweetgum, sycamore, black walnut, and other important forest trees. Alder can form both endo- and ectomycorrhizae as well as symbiotic N-fixing nodules--three different symbiotic root associations at one time. Endomycorrhizal fungi form a loose network of hyphae on feeder root surfaces and do not develop the dense fungus mantle of ectomycorrhizae. These fungi often form large, conspicuous, thick-walled spores both on the root surfaces and in the rhizosphere, and sometimes in feeder root tissues. Hyphae of endomycorrhizal fungi penetrate the cell walls and progress into the cortical cells of the root. These infective hyphae may develop specialized absorbing or nutrient-exchanging structures (haustoria) called arbuscules in the cytoplasm of the cortical cells. Thin-walled, spherical to ovate vesicles may also be produced in cortical cells by these fungi. The term "vesicular-arbuscular" mycorrhizae has been coined to denote this type of endomycorrhizae. As in ectomycorrhizae, endomycorrhizal fungus infection rarely occurs in meristematic or vascular tissues. Endomycorrhizal infection, however, does not cause major morphological changes in roots. Endomycorrhizae, therefore, cannot be detected with the unaided eye; they must be assessed microscopically.

The fungi which form endomycorrhizae with trees are mainly Phycomycetes. They do not produce large, above-ground fruit bodies or wind-disseminated spores as do most ectomycorrhizal fungi, but some of them produce large spores on or in roots. Some species also produce large sporocarps (5 to 10 mm diameter) containing many spores on roots. These fungi spread through the soil by growing from feeder root to feeder root; they are also disseminated by moving water, soil, insects, or animals. They are so widespread that it is nearly impossible to find natural soils anywhere in the world that do not contain them. Spores of these fungi are able to survive in soil for many years without a plant host. Based on the limited research done on endomycorrhizal fungi, most species appear to have very broad host ranges. For example, *Glomus mosseae* is known to form endomycorrhizae with grasses, cotton, corn, pepper, tomatoe, peas, soybean, and sorghum, as well as sycamore, black walnut, sweetgum, citrus, peach, black locust, green ash, black cherry, boxelder, sugar maple, and red maple. It undoubtedly can infect numerous other plant species as well. Since endomycorrhizal fungi cannot be grown routinely in the laboratory, production of inoculum is difficult. Usually a fast growing plant, such as sorghum, is used to culture these fungi. Roots and soil from these plants containing the introduced fungus are harvested and used as inoculum.

Many factors affect mycorrhizal development. Some factors affect the tree and others affect the fungal symbionts. Generally, any soil or above-ground condition which influences root growth also influences mycorrhizal development. A susceptible feeder root must be formed by the tree before mycorrhizal infection can occur. The main factors influencing susceptibility of tree roots to mycorrhizal infection appear to be photosynthetic potential and soil fertility. High light intensity and low to moderate soil fertility enhance mycorrhizal development; the other extremes of these conditions (light intensity below 20 percent of full sunlight and excessively high soil fertility) reduce, or may even prevent, mycorrhizal development. Light intensity and fertility appear to influence either the biochemical status of feeder roots, such as controlling levels of simple sugars, or the synthesis of new feeder roots, both of which are prerequisites to symbiotic infection. Roots growing rapidly because of very high soil fertility contain few simple sugars and they are not highly susceptible to ectomycorrhizal fungus infection (Marx and others 1977).

The factors that affect the fungal symbionts directly are those which regulate survival of the fungus in the soil or its growth on roots. Extremes of soil temperature, pH, moisture, etc., and the presence of antagonistic soil microorganisms can affect the survival of symbionts and thereby influence the mycorrhizal potential of the soil. Mycorrhizal fungi cannot grow and reproduce in soil unless they are in symbiotic association with plant roots. These fungi are capable, however, of surviving in a dormant condition for several years without a plant host.

There are several excellent reviews available on ectomycorrhizae (Malloch and others 1980, Marx and Krupa 1978, Marks and Kozlowski 1973) and endomycorrhizae (Malloch and others 1980, Sanders and others 1978, Hayman 1978).

Mycorrhizae and forestation of undisturbed soils

Failures in artificial regeneration programs have shown that many forest trees will not survive long after transplanting if the seedlings do not have an adequate complement of mycorrhizae from the nursery. Most reports deal with trees such as pines, spruces, oaks, and eucalypts and their establishment in areas of the world void of naturally occurring ectomycorrhizal fungi. Mikola (1969) and, more recently, Marx (1980) discussed the need for a parallel introduction of ectomycorrhizal fungi into these areas. This introduction is especially critical in the successful establishment of exotic pine plantations in the tropics. These various reports have conclusively shown that (1) ectomycorrhizae formed by any fungus on roots of seedlings is better for the seedling than no ectomycorrhizae at all, and (2) ectomycorrhizae formed by certain species of fungi are more beneficial to seedlings on certain sites than ectomycorrhizae formed by other fungi. The value of specific ectomycorrhizae, such as that formed by *Pisolithus tinctorius*, to the improved survival and rapid early growth of pine seedlings has been demonstrated on various reforestation sites in the Southern United States (Marx 1980). Little work has been reported on the significance of endomycorrhizae to the artificial regeneration of hardwoods. It is known, however, that endomycorrhizae improve the quality of hardwood seedlings in the nursery (Kormanik and others 1977) which should also improve their field performance.

Ectomycorrhizae and forestation of surface mines

Marx (1975, 1976, 1977a) has reviewed the significance of specific ectomycorrhizae to survival and growth of pines on various spoils left after surface mining for coal and kaolin. Only a few key reports are mentioned here.

Schramm (1966) published a comprehensive report on plant colonization of anthracite wastes in Pennsylvania. He found that early ectomycorrhizal development was essential for the establishment of *Betula, Pinus, Populus,* and *Quercus* spp. seedlings which developed from seed on the wastes. Fruit bodies of the major fungi that developed near the surviving seedlings were the mushroom-forming fungi *Inocybe lacera, Amanita muscaria,* and *Thelephora terrestris*, and the puffball-producing fungi *Scleroderma aurantium* and *P. tinctorius*. The latter fungus appeared to be dominant and Schramm was able to trace its unique gold-yellow hyphal strands from similarly colored ectomycorrhizae to the base of the puffball. He associated this specific fungus with the most vigorously growing seedlings. Since Schramm's original work, numerous other reports on the occurrence of *P. tinctorius* on coal spoils and other adverse sites have been published.

Based on these observations and the conclusion that the natural occurrences of *P. tinctorius* ectomycorrhizae on seedlings growing on adverse sites were instrumental in their establishment and growth, we developed techniques to "tailor" bareroot and containerized seedlings in nurseries with *P. tinctorius* ectomycorrhizae. Briefly, the techniques involve growing mycelium of *P. tinctorius* in pure culture in the laboratory in vermiculite-peat moss-nutrient substrate. After 2 to 3 months growth, the substrate is leached with water, broadcast onto fumigated nursery soil, and mixed thoroughly into the soil. The bed is then seeded. By the end of the growing season, abundant *P. tinctorius* ectomycorrhizae are developed on seedling roots. The seedlings with *P. tinctorius* ectomycorrhizae also have various quantities of wild-type ectomycorrhizae formed by naturally occurring fungi whose spores are wind disseminated into the fumigated nursery soil. The most prevalent wild-type fungus encountered is *Thelephora terrestris*. *T. terrestris* ectomycorrhizae are the most commonly found ectomycorrhizae on seedlings used for reforestation throughout the United States and in many other parts of the world. This fungus is ecologically adapted to good soil conditions such as those found in nurseries. It is highly beneficial to seedlings planted on routine sites, but is not well adapted to the harsh soil conditions normally encountered on strip-mined lands.

In earlier reviews (Marx 1975, 1976, 1977a), preliminary data showed the advantage of *P. tinctorius* ectomycorrhizae to survival and growth of pine seedlings on adverse sites as compared to seedlings with *T. terrestris* ectomycorrhizae. Very little work has been done on the significance of endomycorrhizae to hardwoods since the earlier reports. The following is the state of the art since the last review on the significance of mycorrhizae to forestation of surface-mined lands.

Ectomycorrhizae and forestation of strip-mined lands

Harris and Jurgensen (1977) observed that cuttings of willow and hybrid poplar grew poorly on copper tailings in Michigan. Ectomycorrhizae were not present even on cuttings inoculated with a forest soil extract supposedly containing ectomycorrhizal fungi. Copper tailings may have been toxic to indigenous or introduced inoculum of ectomycorrhizal fungi, or the physiological conditions of the rooted cuttings may have been inadequate for root infection to occur. A similar study was installed on iron tailings. Seedlings of both hardwood species grew well and formed abundant ectomycorrhizae from indigenous fungi and from those contained in the forest soil inoculum. Better seedling growth and development of ectomycorrhizae on the iron tailings could have been due to better soil fertility or fewer toxic chemicals.

Marx and Artman (1979) reported that bareroot loblolly pine seedlings with abundant *P. tinctorius* ectomycorrhizae had a 400 percent greater plot volume after 3 years on an acid coal spoil (pH 4.1) in Kentucky than seedlings with *T. terrestris* ectomycorrhizae. On plots where fertilizer starter tablets were used volumes for *P. tinctorius* seedlings were nearly 250 percent greater. In the same test, shortleaf pine seedlings with *P. tinctorius* ectomycorrhizae were also over 400 percent larger without fertilizer tablets and over 100 percent larger with fertilizer tablets than seedlings with *T. terrestris* ectomycorrhizae. Seedlings with *P. tinctorius* ectomycorrhizae also contained more foliar N and less foliar S, Fe, Mn, and Al than seedlings with *T. terrestris* ectomycorrhizae. The fertilizer starter tablets stimulated seedling growth for the first and second growing seasons, but once the nutrients in the tablets were depleted growth increment slowed and N deficiency symptoms appeared on foliage. This deficiency was less striking on *P. tinctorius* seedlings than on seedlings with *T. terrestris*. In this same report, plot volumes for loblolly pine with *P. tinctorius* ectomycorrhizae were over 180 percent greater than those for seedlings with *T. terrestris* ectomycorrhizae after 4 years on an acid coal spoil (pH 3.4) in Virginia.

In two other experiments (C. R. Berry, unpublished data), container grown (root medium with 20 percent sewage sludge) loblolly, pitch, and loblolly x pitch pine hybrids with *P. tinctorius* or *T. terrestris* ectomycorrhizae were outplanted on acid coal spoils in Tennessee and Alabama. All loblolly pines were from a single parent and pitch pine were from two parent trees. After two and one-half growing seasons the results were striking (Table 1). On the Tennessee spoil, *P. tinctorius* ectomycorrhizae increased loblolly pine plot volumes by 585 percent and pitch pine plot volumes by 12 percent for one parent and 125 percent for the other. *P. tinctorius* ectomycorrhizae increased hybrid plot volumes by 120 to 575 percent. Overall, volumes on plots with *P. tinctorius* ectomycorrhizae were over 200 percent greater than plot volumes with *T. terrestris* ectomycorrhizae. On the Alabama spoil, loblolly pine plots with *P. tinctorius* ectomycorrhizae had nearly 300 percent greater volumes than those with *T. terrestris* ectomycorrhizae. The advantage in plot volumes of *P. tinctorius* over *T. terrestris* ectomycorrhizae was 150 and 240 percent for the pitch parents. The pitch pine parent that benefited relatively little on the Tennessee spoil (parent #78) was strongly stimulated by *P. tinctorius* ectomycorrhizae on the Alabama spoil. The reason for this is being investigated. The response of the hybrids to *P. tinctorius* ectomycorrhizae on the Alabama spoil was between 400 and 1400 percent. The overall increase in plot volume attributable to *P. tinctorius* on this spoil was over 350 percent. Regardless of genotype, seedlings with *P. tinctorius* ectomycorrhizae had more N and less Ca, Mn, Zn, Cu, and Al in foliage than seedlings with *T. terrestris* ectomycorrhizae.

Many construction projects, such as dams, highways, and buildings, require extensive earth fill to meet design criteria. When insufficient soil fill is available on site it becomes necessary to "borrow" soil from another location. Generally, the resulting borrow pits are stripped excavations from which all the A and B soil horizons have been removed which present special problems in revegetation. Unlike coal or other surface mining spoils, borrow pits usually do not have toxic levels of heavy metals, extremes of soil acidity, or extremely high soil temperatures. Frequently, however, soil in borrow pits is highly compacted with poor internal drainage and have low levels of available plant nutrients and organic matter.

Two studies were installed on a borrow pit in Aiken, South Carolina, in which soil amelioration techniques and specific ectomycorrhizae were studied to determine their effects on the establishment of pines and grasses. The entire borrow pit was subsoiled to a depth of 0.9 m on 1.2 m centers in two directions. The first study (Berry and Marx 1980) measured effects of applying processed sewage sludge or fertilizer (560 kg/ha of 10-10-10) and dolomitic limestone (2240 kg/ha) with and without bark and/or bottom furnace ash on growth of loblolly pine and fescue grass. In the fall of 1975, sludge, bark, and ash were applied 1.3 cm deep (125 m^3/ha), and all plots were double disked. The following winter, loblolly pine seedlings with either *P. tinctorius* or *T. terrestris* ectomycorrhizae formed in a bareroot nursery were planted. By the end of the first growing season, root evaluation revealed that indigenous *P. tinctorius* on the borrow pit formed ectomycorrhizae on *T. terrestris* seedlings and, thus, negated the effects of "tailoring" seedlings with *P. tinctorius* in the nursery. However, sludge with or without the other organic amendments increased pine seedling volumes by 2800 percent and biomass of fescue grass by 500 percent. Soil amended with sewage sludge also contained more N, P, and organic matter, as well as a higher cation exchange capacity, than soil from non-sludge plots. Seedling foliage contained more N and less Ca in sludge plots. In the second test (Ruehle 1980), sludge or fertilizer + lime were similarly applied in the fall of 1975, but the container-grown loblolly pine seedlings with either *P. tinctorius*, *T. terrestris*, or no ectomycorrhizae (produced in a special growth room) were not planted until the fall of 1977. The interim between sludge application and seedling planting significantly decreased the indigenous levels of *P. tinctorius*

Table 1.--Survival and growth of loblolly and pitch pines and their hybrids with *Pisolithus tinctorius* ectomycorrhizae after 2-1/2 growing seasons on coal spoils in Tennessee and Alabama (C. R. Berry, unpublished data).

Pine line	Ectomycorrhizae at planting	Survival %	Height cm	Stem caliper cm	PVI[a] (x 10^2)
		Tennessee Spoil			
Loblolly 23	*P. tinctorius*	38	70	2.5	48
	Natural	48	40	1.3	7
Pitch 62	*P. tinctorius*	88	62	2.8	81
	Natural	93	47	2.0	36
Pitch 78	*P. tinctorius*	85	46	2.2	36
	Natural	94	42	1.8	32
62 x 11-9	*P. tinctorius*	88	89	3.3	169
	Natural	74	49	1.8	25
62 x 23	*P. tinctorius*	89	82	3.4	156
	Natural	76	55	2.0	41
62 x 11-20	*P. tinctorius*	90	84	3.2	156
	Natural	95	64	2.4	71
78 x 23	*P. tinctorius*	91	86	3.4	175
	Natural	81	54	2.1	48
58 x 11-20	*P. tinctorius*	90	87	3.1	162
	Natural	83	56	2.1	51
62 x 11-10	*P. tinctorius*	100	100	3.3	219
	Natural	85	66	2.2	78
Overall mean (TN)	*P. tinctorius*	85	79	3.0	133
	Natural	81	53	2.0	43
		Alabama Spoil			
Loblolly 23	*P. tinctorius*	79	76	2.9	126
	Natural	73	51	1.7	32
Pitch 62	*P. tinctorius*	41	57	3.0	41
	Natural	46	38	1.7	16
Pitch 78	*P. tinctorius*	69	52	2.6	48
	Natural	44	37	1.7	14
62 x 11-9	*P. tinctorius*	70	67	2.9	101
	Natural	59	46	1.6	19
62 x 23	*P. tinctorius*	63	69	3.2	106
	Natural	44	36	1.3	7
62 x 11-20	*P. tinctorius*	76	80	3.6	154
	Natural	68	50	1.7	30
Overall mean (AL)	*P. tinctorius*	66	67	3.0	96
	Natural	56	43	1.6	20

[a]Plot volume index (PVI) computed by $(\text{stem caliper, cm})^2$ x height, cm x number of surviving seedlings per plot.

ectomycorrhizae in the soil, since the integrity of the ectomycorrhizal treatments on seedlings was reasonably maintained for the duration of the study. The effects of sludge and specific ectomycorrhizae were significant. After 2 years in sludge plots, seedlings with *P. tinctorius* ectomycorrhi had 265 and 528 percent greater plot vol than seedlings with *T. terrestris* or no mycorrhizae at planting. In the fertili + lime plots, the initially nonmycorrhiz seedlings had plot volumes 158 percent l than the seedlings with either of the two ectomycorrhizal treatments. As a group, seedlings on sludge plots had 900 percent greater plot volumes than those on fertilizer plots. Differences in soil and foliar analyses and grass biomass were similar to those obtained in the other borrow pit study. After 2 years, the initially nonmycorrhizal seedlings had abundant ectomycorrhizae; *P. tinctorius* accounted for about 10 percent of these.

There appears to be little doubt that pine seedlings with *P. tinctorius* ectomycorrhizae survive and grow faster on adverse sites than routine nursery seedlings with naturally occurring ectomycorrhizae. These results indicate that seedlings for planting on adverse sites should be tailored in the nursery with *P. tinctorius* ectomycorrhizae. Until now, the only inoculum of *P. tinctorius* available was produced in small quantities on highly defined growth medium under rigidly controlled conditions in research laboratories. For commercial use, large volumes of highly functional inoculum of *P. tinctorius* are required. In 1976, the Institute for Mycorrhizal Research and Development, Athens, Georgia, joined with Abbott Laboratories[1] to devise means of producing vermiculite-based vegetative inoculum of this fungus in large fermentors. After 4 years of testing different formulations of inoculum in over 40 nurseries in 33 States and Canada, adequate procedures for producing functional inoculum have been accomplished. Preliminary results from our 1980 bareroot and container nursery tests in five Southern States are excellent. In 1980, a modified seeder was used for the first time to apply inoculum. This machine broadcasts inoculum, incorporates the inoculum into the root zone, levels the soil, and sows the pine seed in one pass over the nursery bed. This machine greatly simplifies application of vegetative inoculum. If the final results from the 1980 tests are as good as the preliminary results, inoculum will be available from Abbott Laboratories by early 1981.

The use of basidiospores of *P. tinctorius* as inoculum instead of the vermiculite-based inoculum also shows promise. There are certain advantages to the use of basidiospores: (1) no germ-free growth phase is required in fermentors, (2) they are easy to apply via hydromulch to nursery soil (Marx and others 1979), (3) after drying they store for years under refrigeration, and (4) they can be collected directly from adverse sites by the user. Unfortunately, basidiospores also have certain disadvantages: (1) there are good and poor years for production of *P. tinctorius* fruit bodies in the field, (2) basidiospore collections are often contaminated with other microorganisms and insects which may or may not be harmful to nursery seedlings, (3) viability of basidiospores cannot be determined prior to use since successful germination procedures have not been developed, and (4) by far the most important disadvantage, basidiospores are usually not as effective in forming abundant *P. tinctorius* ectomycorrhizae early in the growing season on nursery seedlings as is properly produced vegetative inoculum. This latter point is very important since research results show that in order for seedlings to obtain maximum benefit from this fungus, at least half of all the ectomycorrhizae on the seedling roots must be formed by *P. tinctorius* (Ruehle and others[2]). For the past 3 years, adding basidiospores of *P. tinctorius* to encapsulated pine seed has also been studied; results look very promising. Since *P. tinctorius* forms ectomycorrhizae with numerous tree species (Marx 1979), namely, species of *Pinus, Quercus, Betula, Picea, Tsuga, Carya, Salix, Populus, Abies*, and *Eucalyptus*, its use could significantly improve reclamation efforts of a variety of strip-mined lands.

Endomycorrhizae and forestation of strip-mined lands

With the exception of the outplanted sycamore and sweetgum studies on kaolin spoils reported earlier (Marx 1977a), there are no published works on the effects of endomycorrhizae on growth of hardwoods or other plants tested directly on strip-mined lands. Since the last review, field observations and greenhouse studies have been reported on various plant species.

In Wyoming, Miller (1979) collected root samples from plants growing on a 2-year-old revegetated strip-mined spoil (previously segregated and stored topsoil replaced to a depth of 1 foot) and an adjacent undisturbed site. He found no endomycorrhizae on plant roots growing on the disturbed site but, with few exceptions, abundant endomycorrhizae were found on the diverse plant species growing on the adjacent undisturbed site. Inoculum of endomycorrhizal fungi was present in the disturbed soil, but was not infective. Miller speculated that the absence of infectivity by

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[1]Dr. Donald S. Kenney, Abbott Laboratories, Agricultural Chemicals Research, 36 Oakwood Road, Long Grove, Illinois 60047.

[2]Ruehle, J. L., D. H. Marx, J. P. Barnett, and W. H. Pawuk. [In Press] Survival and growth of container-grown and bareroot shortleaf pine seedlings with *Pisolithus* and *Thelephora* ectomycorrhizae. Southern J. Appl. For:

the inoculum may be due to the presence of *Halogeton*, a herbaceous plant with suspected allelopathic capacity. He further speculated that disturbed areas are first colonized by pioneer plant species (*Halogeton* and other species) which are nonmycorrhizal and possibly allelopathic. Miller concluded that succession to mycorrhizal-dependent plant species should follow the elimination of *Halogeton*. Reeves and others (1979) found that 99 percent of the plant cover on a natural, undisturbed sage community in Colorado were endomycorrhizal, and that less than 1 percent of the plant cover on a disturbed area (subsoiled roadbed) were endomycorrhizal. In their opinion, the reestablishment and maintenance of the mycorrhizal fungus component is vital in producing stable plant ecosystems on disturbed areas. Using soils from these same sites in an endomycorrhizal bioassay, Moorman and Reeves (1979) found that the disturbed soil produced only 1/40 as much endomycorrhizal infection on corn as did the undisturbed soil. They concluded that the reduction of active inoculum in the disturbed soil was an important ecological factor in subsequent plant succession.

Daft and Hacskaylo (1976) found that most of the herbaceous plants sampled from anthracite and bituminous coal wastes in Pennsylvania were infected with endomycorrhizae; five naturally occurring plant species had both nodules and endomycorrhizae. In an inoculation test in a greenhouse, lucerne that was nodulated and infected with endomycorrhizae grew 700 percent better in limed (pH 6.4) anthracite waste than control lucerne plants. Regardless of inoculation treatment, however, lucerne plants died in limed (pH 5.8) or nonlimed (pH 2.7) bituminous wastes and unlimed (pH 4.1) anthracite wastes. In a later greenhouse study, Daft and Hacskaylo (1977) reported that red maple seedlings with endomycorrhizae were about 400 percent larger and contained more major elements in foliage after 70 days growth in limed (pH 6.2) anthracite wastes than seedlings without endomycorrhizae.

As discussed, the survival of endomycorrhizal inoculum on strip-mined lands appears important in plant succession. Various mechanical procedures carried out during strip mining can affect inoculum survival. Ponder (1979) assayed recently graded strip-mined coal spoil and found that plants grown in the spoil formed abundant endomycorrhizae in the greenhouse. He concluded that grading during reclamation could be an important means of dispersing endomycorrhizal inoculum in spoil. In unpublished reports[1], survival of endomycorrhizal fungi in piles of topsoil removed prior to strip mining of coal in Wyoming and North Dakota was found to be significantly reduced after 2- to 3-years storage as compared to survival in non-disturbed topsoil or topsoil immediately replaced over the mine spoil.

[1]Fourth North American Conference on Mycorrhizae, Colorada State Univ., Fort Collins, Colorado, June 24-28, 1979.

CONCLUSION

It should be apparent from this discussion and earlier reviews (Marx 1975, 1976, 1977a) that mycorrhizae are not only essential to growth and development of trees in natural forest ecosystems, but are especially significant to their performance on strip-mined lands and other adverse sites. This biological fact has not been applied on any practical scale because procedures to manage the fungi have not been available to the land manager. The availability of commercial inoculum of *P. tinctorius* to tailor seedlings in the nursery prior to outplanting is the first step in closing this technology gap. We still have a long way to go, however, in the selection, inoculum production, manipulation, and management of other important ectomycorrhizal fungi, as well as all endomycorrhizal fungi. Research in these and related areas must continue so that sound scientific practices can be used in the forestation of adverse sites and in reforestation of routine forest sites.

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REVEGETATING SURFACE-MINED LANDS WITH HERBACEOUS AND WOODY SPECIES TOGETHER[1]

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Abstract.--Herbaceous cover is required for erosion control on surface-mined lands even where forests are to be established. Where planted with trees, herbaceous species usually cause an increase in tree seedling mortality and retard tree growth, especially in the first few years after planting. Trees seem to be affected most by competition for moisture because their survival is least affected where spring and summer precipitation is abundant. Tree survival often is reduced most by dense stands of some legumes, especially crownvetch, flatpea, and sericea lespedeza; but in some plantings, growth of surviving trees was later increased in the legumes. Planting trees in existing stands of herbaceous cover usually resulted in poor survival. Herbicides or scalping to control competing cover is suggested, but there is little supporting data from research and experience. Planting trees and seeding herbaceous species in alternate strips appear feasible for combination plantings on areas where the appropriate seeding and fertilizing equipment can be used.

INTRODUCTION

Much of the early effort to revegetate surface-mined lands in the eastern United States was with trees planted on spoil banks that were ungraded, unamended, and not seeded to herbaceous vegetation. The establishment of herbaceous vegetation for erosion control usually was not emphasized, especially on area-type stripping in the interior coal provinces where much of the sediment from the erosion that did occur was trapped in the valleys between the ridges of ungraded spoil. Besides, foresters had learned from experience and research that planting trees with herbaceous cover, such as in old fields, usually hindered tree establishment and growth.

Beginning in the 1960s more emphasis was given to the use of herbaceous vegetation. Emphasis on its use for erosion control coincided somewhat with the increased contour surface mining activity in the Appalachian region where runoff and erosion from steep slopes caused serious sedimentation problems in streams. Greater use of herbaceous species was also induced by legal requirements for grading and the development of land uses such as pasture. At the same time interest in tree planting was discouraged by legal, social, and economic pressures.

Within the past few years, interest in planting trees has been renewed partly in response to Federal regulations that encourage, imply, or require planting of woody species. At the same time herbaceous species must be sown to protect the mined land from erosion, but where planted with herbaceous vegetation, the survival and growth of tree and shrub seedlings may be jeopardized by interference from the herbaceous cover. This interference often is attributed to competition for nutrients, moisture, and light; it also may be due to allelopathic effects, or combinations of all these factors.

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Obviously, where tree planting is desired or required as a post-mining land use, the mine operator or reclamation contractor would like to establish herbaceous cover and trees as quickly as possible and obtain bond release in the minimum permissible time. Thus there is need for information on the probable success of establishing woody plants and herbaceous cover together. In this paper I will discuss some recent experimentation and observations of planting both types of vegetation together.

PLANTING METHODS AND RESULTS

Methods used for establishing woody plants in association with herbaceous cover include: (1) planting or seeding trees, and at the same time seeding herbaceous cover either (a) on the entire area or (b) in strips between tree rows, (2) seeding herbaceous cover first and planting or seeding trees later, and (3) planting or seeding trees first and seeding herbaceous cover later. Each method has advantages and disadvantages depending on climatic and weather conditions, plant species selected, season that area is ready for planting, terrain or other minesoil characteristics, available labor, available seeding and planting equipment, and approval by regulatory agencies.

Experiments with these methods have been or are being conducted by the U. S. Forest Service, U. S. Soil Conservation Service, Tennessee Valley Authority, Southern Illinois University, University of Kentucky, and University of Tennessee. Undoubtedly, similar work is being done by other agencies, universities, and some mining companies, but I am not familiar with it.

Planting trees and seeding herbaceous species at the same time

Seeding of herbaceous species with this method may be (1) a solid seeding, i.e., done on the entire area to be planted with trees or (2) in strips that alternate with strips left unseeded and planted to trees.

Solid seeding--

In 1968, a field study was begun by the Forest Service on two nearly level strip-mine sites in southeastern Kentucky (Bell County) to measure the effect of herbaceous cover on tree survival and growth. We found that, after 10 years, the legumes seeded concurrently with tree planting actually favored tree growth. Grass alone, however, suppressed tree growth. In this study, 1-0 seedlings of cottonwood, sycamore, loblolly pine, and Virginia pine were planted concurrently with four cover treatments: (1) a control (not seeded to herbaceous species or fertilized); (2) not seeded, but fertilized with N at 60 lb/acre and P at 43 lb/acre; (3) fertilized and broadcast seeded to grass (weeping lovegrass at 4 lb/acre, Ky-31 tall fescue at 16 lb/acre); and (4) fertilized and broadcast seeded to a grass-legume mixture (weeping lovegrass at 2 lb/acre, Ky-31 fescue at 12 lb/acre, common sericea lespedeza at 20 lb/acre, and Korean lespedeza at 10 lb/acre). Simazine 4G at 100 lb/acre was applied to treatments 1 and 2 to prevent initial establishment of herbaceous cover.[3] The minesoils (spoils) in this study were mixed shale and sandstone overburden materials that varied in pH from about 5.0 to 8.0. Lime and mulch were not applied on any treatment (Vogel 1973). Precipitation in most years of this study has been near normal, with generally favorable moisture conditions during the growing season.

The herbaceous vegetative cover in the two seeded treatments (3 and 4) averaged about 70 percent after the first year. Cover was 95 percent by the third year and consisted mainly of Ky-31 fescue in treatment 3 and sericea lespedeza in treatment 4. In the two unseeded treatments herbaceous cover ranged from 10 to 25 percent after 3 years and consisted of native and seeded species. Herbaceous cover has gradually increased in density in the unseeded plots and after 10 years consisted mainly of sericea lespedeza that has seeded-in from adjacent plots.

Except for sycamore, survival of the trees was not seriously affected by either type of seeded vegetative cover. Fifth year survival of all tree species was least in the grass-legume seeding (treatment 4) where it averaged 65 percent for cottonwood, 41 percent for sycamore, 86 percent for Virginia pine, and 81 percent for loblolly pine (Table 1). Apparently, sericea lespedeza

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[3]This publication reports research involving pesticides. It does not contain recommendations for their use, nor does it imply that the uses discussed here have been registered. All uses of pesticides must be registered by the appropriate State and/or Federal agencies before they can be recommended.

CAUTION: Pesticides can be injurious to humans, domestic animals, desirable plants, and fish or other wildlife--if they are not handled or applied properly. Use all pesticides selectively and carefully. Follow recommended practices for the disposal of surplus pesticides and pesticide containers.

contributed to the greater mortality of trees by overtopping and smothering the smaller and weaker seedlings.

Table 1.--Fifth year survival of trees.

Tree Species	Cover[a/] Treatment	Percent[b/] Survival
Cottonwood	1	71
	2	73
	3	71
	4	64
Sycamore	1	67
	2	81
	3	50
	4	41
Virginia pine	1	91
	2	92
	3	88
	4	86
Loblolly pine	1	92
	2	90
	3	93
	4	81

a/1 = None, 2 = fertilizer, 3 = fertilizer + grass, 4 = fertilizer + grass + legume

b/Based on 288 trees (6 reps, 48 trees/rep)

In the first three years, the growth of trees, especially hardwoods, was suppressed by the herbaceous cover in both seeded treatments. By the end of the fifth year, the growth of trees still was suppressed in the seeding with grass only. But, in the cover treatment seeded to both grasses and legumes (treatment 4), the growth rate of trees was exceeding that in all other treatments, although the trees still were not as tall as those in the unseeded treatments (Table 2).

Table 2.--Average height of trees planted with and without herbaceous ground covers.

Species	Cover Treatment[a/]	Height after:		
		3 yr	5 yr	10 yr[b/]
		----------	feet	----------
Cottonwood	1	7.0	11.4	23.7
	2	7.6	12.5	24.5
	3	3.4	6.6	17.0
	4	4.1	10.4	25.8
Sycamore	1	5.2	8.5	18.0
	2	5.5	9.0	18.7
	3	1.9	3.3	11.4
	4	2.1	6.9	19.2
Virginia pine	1	2.7	4.8	10.5
	2	2.9	5.6	14.2
	3	2.1	4.1	12.6
	4	2.2	5.1	14.9
Loblolly pine	1	3.0	5.6	12.3
	2	3.3	5.8	15.3
	3	2.1	4.1	13.5
	4	1.8	4.7	15.8

a/1 = no treatment; 2 = fertilizer applied (60 lb/acre N and 43 lb/acre P); 3 = fertilizer and grass ('Ky-31' fescue and weeping lovegrass); 4 = fertilizer, grass, and legumes (sericea and Korean lespedezas).

b/Nine years for the pine species.

By the tenth year after planting (9 years for the pine) trees in the cover treatment that had been seeded to the grass-legume mixture (treatment 4) were growing at a faster rate and were taller than trees in any other treatment. In plots seeded only to grass (treatment 3) the growth rate and height of trees, especially hardwoods, still lagged behind trees in the other cover treatments. Pine trees planted in the control plots had made the least growth. This may be partly due to minesoil nutrient deficiency as indicated by the better growth of pine in treatment 2 that was fertilized with N and P.

A probable explanation for the growth pattern of trees in the seeded treatments is that during the first 2 to 3 years after planting, the herbaceous cover in both treatments 3 and 4 was predominantly grass. But, in the third year, sericea lespedeza, one of the seeded legume species, became the dominant cover plant in treatment 4; and thereafter, the growth of trees was accelerated by nitrogen that was fixed by the legume plants. Trees growing in cover that remained predominantly grass (treatment 3) were suppressed because the grass was competing with the trees for nitrogen.

Similar results on spoils in northern Alabama were reported by TVA scientists (Bengtson and Mays 1978). They found that loblolly pine fertilized with nitrogen for two or three years after planting grew faster initially than pine that had been seeded with sericea lespedeza but not fertilized with nitrogen after the first year. But after 6 years, the pine in the lespedeza were growing as well as or better than the pine that received the second and third applications of N fertilizer. Survival of pine seedlings was excellent in all cover treatments.

In a Forest Service experiment in western Kentucky, 8 hardwood species and 4 cover treatments were planted on a leveled mined site in 1976. Spoils were predominantly gray shale with pH about 7.0. The ground cover treatments were similar to those used in our eastern Kentucky study but different legume species were used. Survival varied greatly for the various tree species; but when averaged over all species, first year survival was best in the control plots (43 percent). Survival was 31 percent on the fertilizer alone and the fertilizer plus herbaceous species treatments. There was only a sparse herbaceous cover established in the plots, thus the differences in survival were seemingly due to the fertilizer application. In the third year, sericea lespedeza, that apparently had been sown by the mining company a year prior to our planting, became so dense that it was nearly impossible to walk through it let alone find any trees.

In an identical planting made the following year (1977) on a nearby site, overall tree survival the first year was less than in s planting. A moderate to good r of red clover, birdsfoot trefoil, lespedeza was established that in- density for the next couple of vival in this planting was as fol-

	Percent Survival		
tment	1977	1978	1979
	28	20	17
	25	19	18
gumes	20	13	8
es, and grass	18	12	5

s latter planting tree survival d more by the herbaceous cover tilizer. Other factors, too, prob- buted to poor tree survival in Kentucky plantings, especially hot dry weather in the summer that e longer in duration and more n those in eastern Kentucky. Be- mmer droughts, spring seeding in tucky of even herbaceous vegeta- is discouraged in preference to g.

eriment in Pennsylvania to evalu- ect of 6 grasses and 3 herbaceous the survival and growth of red ngs was begun in 1976 by person- Big Flats Plant Materials Center e U. S. Soil Conservation Serv- plantings were in Tioga County oil (spoil) material on a strip lled to the original contour and milar area covered 8 to 10 inches opsoil. One-half of each test eated with lime at 2 ton/acre plus rtilizer at 400 lb/acre; the oth- not treated. A similar experi- de in 1977 in Indiana County where d unrooted hybrid poplar cuttings ted on a topsoiled site only.

s of these studies showed that, rs, tree survival and growth did significantly due to the influence erent herbaceous species or amounts us cover when averaged across all (Table 3). Tree survival and influenced more by topsoiling and ion of lime and fertilizer than by ous cover. Survival of red pine ent in the topsoil plots and 60 the subsoil plots. In both top- bsoil plots, tree survival was the areas that were not limed and

Table 3.--Percent survival of red pine in herbaceous species; second year. (Data from Big Flats PMC, SCS.)

Herbaceous Species	Survival %
A-67 Weeping lovegrass	68
Tioga deertongue	69
Reuben's Canada bluegrass	70
Commercial redtop	73
Pennlawn red fescue	65
Lathco flatpea	61
Empire birdsfoot trefoil	66
Chemung crownvetch	62
Ky-31 tall fescue	65
Control	72

Although they did not benefit the trees, lime and fertilizer were beneficial for the establishment of herbaceous species, especially on the subsoil. The herbaceous species produced the most ground cover on limed and fertilized topsoil plots; the cover varied from 85 to 100 percent. Cover on the untreated subsoil varied from 0 to 25 percent.

In the 1977 PMC planting, first year survival of hybrid poplar was not significantly affected by the different herbaceous species or amount of cover. Survival of red pine was reduced by a drier-than-usual spring and may have been affected by species with the greatest density, especially by Lathco flatpea in the unlimed and unfertilized plots.

Results of another Pennsylvania experiment indicated that first-year survival and growth of several hardwood tree species were not affected where planted concurrently with various herbaceous species or mixtures of species. In most seedings, the herbaceous cover was considered inadequate for erosion control, but survival of trees was not adversely affected even where they were planted into an established herbaceous cover. Abundant precipitation in the establishment year was credited as the major reason for tree success in all vegetational covers (Carlson 1979).

Wheeler (1976) made observations of several mined areas in Pennsylvania that had been planted with trees in association with seeding of grasses or legumes. On some sites the planting and seeding had been done at the same time. On others, grasses such as perennial ryegrass were sown in the fall previous to planting of trees. Wheeler's observations indicated that a cover of grass did not adversely affect most trees planted at or near the same time that seeding was done. In some plantings, however, some legumes appeared to reduce survival of most tree species. Deer damage to trees was apparent where legumes had been sown.

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im report by USDA Soil Conservation ant Materials Center, Big Flats, In a Tennessee study, pitch and Virginia pine seedlings raised in containers (tubelings) were planted with and without a grass cover on intensively amended spots called minisites and on untreated minesoils. The minisites were prepared by mixing pine bark, vermiculite, lime, and fertilizer with minesoil augered from the planting spots. Grass cover caused an increase in the first year's mortality of pine seedlings on both untreated and minisites, but mortality was much greater on the control sites. During the first winter, however, frost heaving of the tubelings on the bare, ungrassed control sites was so severe that, by spring, tree mortality was greater on the bare area than on the grassed areas. A few tubelings frost heaved also on the bare minisites but none heaved on the grassed minisites (Woods et al. 1978).

In southeastern Kentucky, it was shown that herbaceous ground cover established with European alder caused increased moisture stress and thereby contributed to increased mortality of the alder seedlings (Albers and Carpenter 1979).

A large experiment was begun in 1980 by Ashby and others at Southern Illinois University to evaluate techniques for the establishment of woody plants in association with herbaceous cover. First year results were not available when this paper was prepared.

Strip seeding--

Establishing woody and herbaceous species together is possible by sowing the herbaceous species in strips that alternate with unseeded strips planted to trees or shrubs. Ideally, the unseeded strips will remain free of herbaceous vegetation long enough to permit tree establishment, yet the ground cover in the intervening seeded strips will provide adequate erosion control. Also, only the seeded strips need to be fertilized thus reducing possible adverse effects of fertilizer on newly planted tree seedlings. For best erosion control the strips should run on contour. Establishing cover in strips will be easiest to accomplish on land where appropriate equipment can be used to till a seedbed and place fertilizer and seed in strips of uniform width.

In a demonstration in eastern Kentucky, we successfully established hybrid poplar by planting unrooted cuttings in 3-foot wide strips that alternated with 5-foot wide strips that were tilled, fertilized, and seeded to a grass-legume mixture . The strips were on contour on a gently sloping site. The seed mixture included weeping lovegrass, Ky-31 fescue, birdsfoot trefoil, Korean and sericea lespedezas, and red clover. In the first year the herbaceous vegetation in the 5-foot strips covered 60 to 70 percent of the total site. Cover was predominantly weeping lovegrass. The unseeded tree strips were nearly free of herbaceous cover. By the third year, the unseeded strips, too, had become nearly covered with herbaceous vegetation that spread from adjoining strips, but the trees had grown well above it. The herbaceous cover was then a mixture mostly of birdsfoot trefoil, lespedeza, and fescue. Unfortunately, comparative plantings were not made in a solid seeding or with no seeding.

A comparison of strip planting with a solid planting was made in Pennsylvania by the Big Flats Plant Materials Center personnel. In 1976, they planted 2-0 red pine seedlings with a seed mixture of weeping lovegrass, Tioga deertongue, and Lathco flatpea. All plots were limed and fertilized; some plots were planted on subsoil and some on a topsoiled area.

After 2 years, tree survival on the topsoiled area was 58 percent in the strip seeding and 43 percent in the solid seeding. The herbaceous cover was predominantly flatpea and was providing adequate erosion control in both strip and solid seedings. In the solid seeding, cover was nearly 100 percent and it was choking out the young trees. In the strip seeding, tree survival had remained the same for 3 years.

On the subsoil area tree survival was higher in the solid seeding (74 percent) than in the strip seeding (64 percent), but the difference was not related to density or pattern of herbaceous cover. The herbaceous cover on both solid and strip seedings was sparse and not providing adequate erosion control even after 2 year's growth.

In a similar experiment begun by the Big Flats PMC in 1977, the survival of hybrid poplar cuttings after 2 years did not differ significantly between strip and solid seeded plots or between two herbaceous mixtures. Some differences in red pine survival may have been related to the different herbaceous mixtures, but positive relationships were not obvious.

Seeding trees and herbaceous species at the same time

Direct-seeding of woody species offers several advantages over hand planting of seedlings. It usually is easier, less costly, and circumvents many of the labor problems associated with planting seedlings. But there are relatively few species of trees and shrubs that have been successfully established on surface mines by direct seeding. Besides, competition from herbaceous cover can be a problem also with the establishment of direct-seeded woody species.

Seeding of southern pines on mine spoils in Alabama and southern Tennessee has been a common practice for many years, but usually without companion seeding of herbaceous species. In a TVA study, grass and fertilizer applied with pine seed were detrimental to pine establishment. The seeding of Bermudagrass, a warm-season species, was more harmful than the cool-season Ky-31 fescue. The growth of fescue usually slows during the hot summer period and allows some pine seedlings to develop in spots with sparse or no grass. Bermudagrass, however, grows rapidly in the summer and chokes out the emerging pine seedlings. Those that survive the first year in Bermudagrass usually are gone after the second year; but mortality of pine seedlings in fescue usually is low the second year. Seeding pine one year with fertilizer, and applying grass seed and additional fertilizer the next year was recommended for establishing a mixed pine-grass cover on areas where erosion is not a serious problem. Where erosion is a problem, Bermudagrass should be established first and pine seedlings planted the second or third year when the vigor of the grass declines due to depletion of nutrients (Bengtson et al. 1973).

Direct-seeding of black walnut and bur oak on mine spoils in the midwest produced satisfactory stands in some of the early experimental tree plantings. Ground cover of volunteer vegetation varied among sites but seldom was it considered dense.

On minesoils in eastern Kentucky, the first year survival of germinated seed of red oak, pin oak, and bur oak was reduced by a cover of ryegrass and sweetclover. Average survival of the three oak species for all treatments of mulch and fertilizer was 50 percent on the control site and about 38 percent on the sites with herbaceous cover. Height of the seedlings was not affected by the grass-legume cover (Tackett and Graves 1979).

Direct-seeding black locust with herbaceous species has been practiced in much of the Appalachian region. Establishment of the locust usually is successful but sometimes does not appear so for two or three years. This was illustrated in one of our experiments.

We evaluated the effect of several herbaceous species on the establishment of seeded black locust. The fertilized and seeded experimental plots were laid out on moderately steep slopes of spoils (pH 5.0 to 7.8) that had received minimum grading. The first year's results showed marked differences in number and height of black locust seedlings among the various herbaceous species (Table 4). It appeared that fast-growing cool-season species, especially ryegrass, were more suppressive than warm season and slow-developing species to the early survival and growth of seeded locust. But in the second year and thereafter, these differences were less pronounced among the grass and legume cover species.

Table 4.--Vegetative cover and number and height of black locust seedlings in plots seeded to herbaceous species and black locust.[a]

Herbaceous Species Seeded		Herbaceous Cover 1969	Herbaceous Cover 1970	Black locust seedlings Number 1969	Black locust seedlings Number 1970	Black locust seedlings Height 1969	Black locust seedlings Height 1970
		%		on .01 acre		cm	
None (natural seeding)		15	25	54	51	24	98
Birdsfoot trefoil	(8)[b]	40	85	18	14	18	59
Kobe and Korean lespedeza	(10)	45	70	22	24	17	94
Weeping lovegrass	(5)	80	85	24	34	17	79
Sericea lespedeza	(20)	25	55	31	26	15	61
Ky-31 tall fescue	(15)	60	75	15	22	13	58
Perennial ryegrass	(15)	70	55	9	23	10	57
Annual ryegrass	(15)	70	40[c]	9	25	7	73

[a] Seeded in March 1969; evaluated in October, 1969 and 1970. Fertilized with 60 lb/acre N and 43 lb/acre P. Black locust seeded at 3 lb/acre.

[b] Seeding rate (lb/acre).

[c] Mostly plant residue.

Seeding herbaceous cover first and planting trees later

This two-step concept for afforestation is of special interest mainly because many acres of surface-mined land have been vegetated solely with herbaceous species either for economic reasons or in compliance with regulations that require ground cover for erosion control and aesthetics. But, now, there is increasing interest or requirement to establish woody species on many of the grassed areas. This concept may be the most feasible also for afforesting many of the mined areas being reclaimed under present regulations.

With this concept, the woody species may be planted (1) directly into living herbaceous cover or (2) into herbaceous cover killed or weakened with herbicides, scalping, or cultivation. The second approach seems to hold the best chance for tree planting success because living cover usually is the most competitive with newly planted trees.

Planting trees in living cover--

In an experiment in eastern Kentucky, Plass (1968) planted seedlings of 2 hardwood and 2 pine species into a 2-year-old stand of Ky-31 tall fescue. The fescue had been established without application of fertilizer and the ground cover was described as light to moderate. The established ground cover was removed from one-half of each plot before planting trees, and the volunteer vegetation was grubbed out once or twice during each of the next 4 years. After the 4th growing season, survival of sycamore and sweetgum was not affected by the fescue cover; survival of white pine and loblolly pine was reduced slightly. The height of sycamore and sweetgum was significantly reduced by the fescue cover; height of the pines was reduced, but not significantly so. The results suggest that tree survival and growth would have been more adversely affected in a dense vigorous cover of fescue.

A revegetation demonstration was made in 1965 on a surface mine at about 2800 feet elevation in Bell County, Kentucky. Several hardwoods, conifers, and shrubs were planted in a moderate to dense stand of Ky-31 fescue and Korean lespedeza. Nitrogen-fixing trees and shrubs--European alder, black locust, autumn olive, and bicolor lespedeza--had reasonably good survival and grew rapidly. Other hardwoods--yellow-poplar, sycamore, and red oak--and Norway spruce had poor survival and initially grew slowly. Scotch pine had moderate survival and growth. About 10 years later, a few of the surviving hardwood trees were making acceptable growth, but many had poor form and were growing slowly. In contrast, some yellow-poplar trees that had become established by natural seeding in a stand of European alder were growing more rapidly than most of the artificially planted trees.

Verbal reports on results of plantings in some areas indicate complete failure of all tree species, even the nitrogen-fixers, where planted into established herbaceous cover. A few reports indicate varying levels of success, but success is mostly with black locust, autumn olive, bicolor lespedeza, and to a lesser extent European alder and pine. Developed stands of some herbaceous species such as crownvetch, sericea lespedeza, and flatpea are especially inimical to the establishment of trees.

Planting trees in cover killed with herbicide or scalping--

An alternative to planting trees in established herbaceous cover is to kill or weaken the herbaceous cover before or immediately after planting the trees. One likely method is the application of a non-residual herbicide before planting trees. This method was useful in West Virginia for killing fall-sown rye just prior to spring seeding of perennial forage species. The *in situ* mulch produced by killing the rye was equal to or more effective than applied mulches for conserving soil moisture and reducing erosion (Jones et al. 1975).

Carlson (1979) compared Roundup and paraquat[5] applied in strips with no treatment prior to planting trees on a Pennsylvania strip mine. The Roundup was more effective than paraquat in reducing herbaceous competition. But, in this planting, tree survival was not significantly increased by killing the herbaceous cover. This was attributed to abundant spring and summer rainfall.

First year results of an experiment in western Kentucky showed that herbicide applied to a fescue-alfalfa cover was responsible for greater tree survival than in the untreated cover. The herbicide was applied around the pine seedlings after they were planted (Barnhisel 1979).

This past spring, we initiated an experiment in southeastern Ohio with the use of Roundup herbicide for killing a grass-legume cover in strips and spots prior to planting several species of trees. The herbicide was applied about 7 days before the trees were planted. First-season evaluations of tree establishment have not yet been made.

Scalping and similar types of mechanical tillage will also control or reduce herbaceous competition. In one experiment in southeastern Kentucky, European alder seedlings suffered complete mortality the first year where planted in an untreated 2-year-old stand of Ky-31 fescue; but survival was 43 percent where the grass had been mechanically scalped from around the seedlings (Carpenter and Albers).[6]

Annuals for temporary cover before planting trees--

Annual species probably can be effectively used for providing temporary cover and *in situ* mulch prior to tree planting. Summer annual grasses such as foxtail millet, Sudangrass and other sorghums, and pearl millet

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[5]Mention of brand names does not imply endorsement or recommendation for use.

[6]Manuscript in press.

are especially useful for providing quick temporary cover in late spring and early summer. The residue from these crops can provide site protection over winter. The following spring, trees can be planted along with a seeding of perennial herbaceous species. A modification of this procedure is to include, where climatically adapted, Korean or Kobe lespedeza in the summer-annual seed mix. These annual legumes normally reseed and would be present to establish plant cover in the spring and summer after the trees have been planted. Perennial herbaceous species would then be sown in the late summer or fall of the second year.

Winter annuals, such as rye or wheat, sown in late summer or early fall will provide ground cover in the winter. Trees may be planted directly into the cover the following spring, but the herbaceous species may compete strongly with the trees (winter planting of trees also is possible). To reduce competition, the entire cover could be controlled with a non-residual herbicide just prior to planting of trees, and the perennial herbaceous species sown. An alternative procedure is to kill strips of the winter annual crop with an herbicide or scalping. Korean or Kobe lespedeza could be sown on the entire area or only on the strips along with the planting of trees. Perennial herbaceous species could be sown over the entire area in late summer.

Seeding annuals in the spring for temporary cover in conjunction with planting of trees showed no advantage over seeding perennial grasses and legumes as determined in a Pennsylvania study by the SCS Plant Materials Center. In some plots, tree survival was lower in the annual vegetation than in perennial vegetation.

Planting or seeding trees first and herbaceous species later

This concept normally should provide the least herbaceous competition and the best chance for initial survival of newly planted or seeded tree seedlings. Results of some of the previously described experiments verify this. For example, Bengtson et al. (1973) showed that to obtain adequate stocking, pine seed only should be sown with application of the required amount of fertilizer. Seeding herbaceous species the following year resulted in some reduction in pine stand, but much less so than where pine and herbaceous species were sown at the same time.

Under present regulations, however, this method of planting trees is not likely to be approved because the quick establishment of vegetative cover is required for all land uses. The procedure most nearly approaching this concept is planting trees and sowing herbaceous species in alternate strips as previously discussed.

DISCUSSION AND CONCLUSIONS

Results of research and experience with planting trees and herbaceous species together indicate that, generally, herbaceous cover causes an increase in mortality of tree seedlings and may retard tree growth, at least in the first few years after planting. Competition between trees and herbs seems to be primarily for moisture because survival of trees was least affected where spring and summer precipitation was most abundant. Besides total precipitation, moisture availability to plants can be influenced by the physical properties of minesoils, duration of dry periods or frequency of precipitation events, air temperature, wind, evaporation, latitude, elevation, aspect, etc.

Competition for nutrients seems to affect tree growth more than tree survival as indicated by apparent nitrogen deficiency and reduced tree growth in grass cover. Tree growth usually is better on nitrogen fertilized areas and in legume cover once trees have grown taller than the herbaceous vegetation.

Density of herbaceous vegetation can influence the degree of competition and thus the survival and growth of trees. For example, in experimental plantings in Illinois, second-year survival of 17 tree species averaged 61 percent in sparse light ground cover (less than 50 percent cover) and 27 percent in a dense heavy cover of sweet clover. Only two tree species (white ash and eastern red cedar) survived well in the dense cover (Limstrom and Deitschman 1951).

Competition for light, i.e., shading of tree seedlings from sunlight, affects both survival and growth of tree seedlings and may occur more with dense stands of legumes than with grasses. The season when the various plant species make most of their growth may interrelate with shading and competition for sunlight. For example, legumes such as birdsfoot trefoil and red clover make rapid growth in the spring at about the same time as some tree species, such as pine, make most of their growth. Perhaps the dense foliage of these legumes contributes to tree seedling mortality by excluding light from the small seedlings during the time when light is most needed for their growth. Warm-season legumes, such as sericea lespedeza, would not provide dense shade until early- to mid-summer, after the pine have made most of their season's growth. However, shade of warm-season legumes may be detrimental to tree species that continue growth through the summer. Also, warm-season species probably compete more than cool-season species for moisture during periods of summer drought. Obviously, more research is needed to elucidate some of these relationships among species.

Herbaceous species can have indirect effects on tree survival and growth. For example, herbaceous legumes are more attractive than grasses to deer. In areas with large populations of deer, trees planted with legumes, therefore, are more subject to damage by deer browsing. In such areas, the least palatable of the adapted grasses may be the best choice for combination plantings. This may warrant greater use of warm-season grasses because they do not provide green forage in the fall, winter, and early spring when it is most attractive to deer.

Although in some experiments little difference in initial tree survival was noted among several herbaceous covers, some herbaceous species usually are more competitive than others with companion trees. Several legumes--crownvetch, flatpea, sericea lespedeza, and probably red clover--are especially severe competitors where they get a quick start and overtop the tree seedlings. Competition from these legumes is less severe where the trees have a chance to become established first. The establishment of dense stands of these legumes can be slowed by sowing them at a reduced seeding rate. Another option is to sow them only in strips that alternate with unseeded strips planted to trees. Even in strips, the seeding rate should be reduced from that normally recommended for ground cover. In fact, for combination plantings, seeding rates in general should be reduced from those often recommended for ground cover.

One reason given in favor of establishing a dense legume cover in conjunction with afforestation is to keep sunlight from the soil surface and thereby aid development of a rich soil fauna in a shorter period of time. The legume cover can substitute for the closed canopy that would develop from close spacing of trees. Grass does not provide a favorable environment for forest-dwelling soil fauna (Neumann 1973).

There seems to be no "ideal" species or seed mixture for sowing with trees in all situations or all regions. Obviously, species should be adapted to the season of the year when seeding must be done. For seeding in the spring, a mixture of temporary quick cover and perennial herbaceous species may be desirable. Ideally the quick cover species should be one that is not too competitive with trees. Such a species is difficult to define. Perennial ryegrass, for example, is less vigorous and may be preferable to annual ryegrass as a quick cover species for early spring seeding. The density and vigor of cover can perhaps be controlled by the application rate of fertilizer. Nitrogen at no more than 50 to 60 pounds per acre should support adequate growth of grass without excessive vigor. Less nitrogen may be adequate on fertile topsoil. Phosphorus should be applied at rates indicated by soil test, or if not tested, at about 40 to 50 pounds per acre of P.

Summer seedings can take advantage of summer annuals for quick cover. Also, Korean and Kobe lespedeza should be used wherever possible. These annual legumes are probably some of the most compatible with trees.

Fall seeding presents a more difficult situation for establishing herbaceous cover and trees because the cover is already established before tree planting time the following spring. The use of herbicides or scalping to control the herbaceous cover in planting spots or strips may be a feasible solution for planting trees in fall-seeded cover. One problem associated with the use of herbicides in the spring is that the herbaceous vegetation should be actively growing for most effective results. But, by waiting until the herbaceous cover is sufficiently advanced for effective herbicide kill, the ideal period for spring planting of trees is nearly passed. Fall application of herbicide and winter or spring planting of trees is a possible alternative.

A labor-intensive method for conserving soil moisture and reducing immediate herbaceous competition is to apply shredded bark mulch about 4 to 5 inches deep around each tree seedling. This method would probably be feasible only with high value crops such as black walnut.

Allelopathy is another process that may hinder the establishment of trees planted or seeded with herbaceous cover. The possibilities for allelopathic effects are many, but few of the possible combinations have been studied. For example, results of studies at the Ohio Agricultural Research and Development Center showed that daily watering with a leachate from crownvetch foliage was inhibitory to the growth of newly germinated red oak seed, but had no adverse effect on fully developed seedlings (Dr. Merlyn Larson).[7]

[7] Unpublished data.

It is apparent that knowledge and experience with planting trees in conjunction with herbaceous cover is still in infancy. Various combinations of trees and herbs have worked from time to time, but probably more have failed. We usually can suggest reasons for failure, such as a drought, but find it more difficult to understand the successes. Continued applied and basic research is necessary to find more answers.

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POSTMINING LAND USE: ECONOMIC COMPARISON OF FORESTRY AND PASTURELAND ALTERNATIVES[1]

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Abstract.--The influence of soil properties, legal requirements, and economics on postmining land use is described, and enterprise budgets are prepared to demonstrate procedures for evaluating forest and pastureland alternatives. A comparison of cow-calf operations with hybrid poplar and black walnut plantations suggests that a combination of pastureland and black walnut plantations will achieve the highest rates of return on investment.

INTRODUCTION

During the past three decades there have been important changes in surface mining laws that have had a strong influence on forestry's role as a postmining land use. Prior to the 1960's most state reclamation laws did not require the grading of spoil piles or the establishment of herbaceous ground cover. Strike-off grading was required in some states but this still resulted in rough topography that was not well suited to agriculture. Large acreages were planted in trees partly because early research by the U.S. Forest Service showed that trees, over time, could stabilize mine sites and eventually produce a timber crop.

This period was followed by laws in the early 1970's that required grading and the establishment of herbaceous ground cover to control erosion. Tree planting declined precipitously because seedlings could not successfully compete with the herbaceous species. Hayland and pastureland emerged as important postmining uses in many states.

The Surface Mining Control and Reclamation Act of 1977 may cause yet another shift in forestry's role. The Act and corresponding regulations require that specific criteria be met before the approval of changes in land use from those which existed prior to mining. How these new requirements will affect postmining land use decisions is uncertain; however, there is likely to be a tendency on the part of mining companies to avoid land use changes in order to simplify the permit application process and to eliminate potential delays in permit approval. The upshot could be that where forest land is the pre-mining land use it will receive greater consideration as a postmining land use. This could reverse the present trend of converting woodlands to other land uses.

The purpose of this paper is to briefly describe some of the factors that influence postmining land use and to explore by means of enterprise budgets the economics of forest and pasture land use alternatives. This latter objective will be met by analyzing the potential for cow-calf operations, hybrid poplar plantations and black walnut plantations on reclaimed land in southeastern Ohio.

FACTORS AFFECTING POSTMINING LAND USE

Most determinants of postmining land use can be categorized into one of three broad groups: (1) soil properties, (2) legal requirements and constraints, and (3) economic considerations. Climatic factors are also important but will not be discussed in this paper because they are largely beyond man's control. The chemical and physical properties

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of the reconstructed soil can be partially controlled by selectively mixing and placing soil horizons at the time of mining.

Properties of reconstructed soil that influence the selection of postmining land use include soil reaction (pH), stoniness, particle size and slope. For use as pasture, hayland, row crops, and other agricultural uses the reconstructed soil should have a Ph of 5.5 or higher, be free of stones at or near the surface which would interfere with tillage and harvesting operations, and have slopes that are less than 20 percent. Also, the particle size distribution should be adequate to provide aeration and moisture-retention. Stoniness and slope are usually not limiting factors when selecting land for forestry and wildlife use. Trees and shrubs can survive in reconstructed soils with a pH as low as 4.5, however, growth will be greatly reduced.

Surface mining can have a detrimental effect on soil properties resulting in diminished land capability. Mining destroys soil structure. Grading and redistribution of topsoil can and often does cause soil compaction. These problems can reduce yields below premining levels by reducing water infiltration and preventing effective root penetration. Another problem is that overburden material may settle unevenly and leave depressions that trap seasonal surface runoff. Microorganism populations may also be temporarily reduced by topsoil stockpiling. Some of these problems can be alleviated through careful planning of the mining operation, the proper choice of reclamation equipment, and the use of soil restoration plans.

In some situations, surface mining can improve the chemical and physical properties of the soil. For example, fragipans, claypans, and ironpans which reduce water infiltration and root penetration are broken and dispersed during overburden removal. Root penetration for trees is improved when consolidated rock near the surface is fractured. In the western states where saline conditions are found, it is possible during mining and reclamation to replace the surface horizons with more favorable overburden materials or to dilute sodium concentrations by soil mixing. Selective soil mixing also offers an opportunity to improve thin, acidic forest soils in the eastern coalfields. These procedures must be approved in advance by the regulatory authority.

Legal requirements and constraints are the second major category of factors which affect postmining land use selections. Section 515 of The Surface Mining Control and Reclamation Act of 1977 requires all surface coal mining operations to " . . . restore the land affected to a condition capable of supporting the uses which it was capable of supporting prior to any mining, or higher or better uses of which there is a reasonable likelihood . . ." Furthermore, proposed land uses following reclamation cannot be impractical or unreasonable, inconsistent with land use policies and plans, or involve unreasonable dealys in reclamation.

The language contained in the Federal Act poses the question of what constitutes a "higher or better" land use. In his widely recognized land economics textbook, Barlowe (1958) defines highest and best use as that land use which provides an optimum return to its operators or to society. Returns may be measured in strictly monetary terms, in intangible social values, or in some combination of these values. Highest and best use also embodies the concept of comparative advantage which includes consideration of both the ability of land to produce a net return above production costs and the relative demand for uses to which it might be put. Usually land is in its highest and best use when it is used for the purpose or combination of purposes of which it has the highest comparative advantage.

The land use provisions of the Federal Act have been the subject of much discussion and debate, especially when they are operationally defined in the form of specific regulations. The Federal Rules list ten land use categories which are defined in terms of specific uses or management-related activities rather than vegetative cover. These categories include forestry, pastureland or land occasionally cut for hay, recreation, cropland, and fish and wildlife habitat. Changes of land use from one category to another are considered a change to an alternative land use and subject to approval by the state regulatory authority.

To gain approval, the landowner must be consulted and several criteria must be met (see 30 CFR 816.133 and 817.133). These criteria include but are not limited to (1) the determination that the proposed use is compatible with adjacent land use and any existing land use policies and plans, (2) the submission of plans showing the feasibility of the use, (3) evidence that public facilities will be provided if necessary, and (4) adequate plans to prevent or mitigate any adverse effects on fish, wildlife, and related environmental values. These requirements are not intended to discourge land use changes.

However, they may place an additional, but legally necessary, burden on mining companies who seek a land use change.

The final category of factors that influence postmining land use is economic in nature. As a general rule, most landowners tend to use their land for those purposes that promise the highest economic return. Sometimes surface mining can be conducted in a manner that will leave the land in a condition likely to yield greater financial rewards than were possible before mining. For example, from the forestry standpoint, mining improves accessibility by leaving a road network from which to manage and harvest timber crops. It also leaves the site free of uncommercial trees and undesirable vegetation that normally must be cleared before plantations can be established. Upon the approval of the regulatory authority, topography can be altered to provide more gently sloping landforms that permit the use of mechanized equipment needed for intensive forest management. The condition of the land can be improved for pasture, wildlife, and recreation by the creation of watering ponds and lakes where none previously existed. There must also be approval by the regulatory authority.

Thus, surface mining can improve the potential of land for a variety of uses -- recreation, forestry, livestock pastures, hayland, wildlife and cropland. The selection of the most appropriate postmining land use is often complex. The remainder of this paper concerns the financial dimension of the postmining land use decision for two competing land uses--forestry and pastureland--for coalfields in southeastern Ohio. The intent of this exercise is to demonstrate the types of economic analyses that should be undertaken when making postmining land use decisions.

FORESTRY VS PASTURELAND

In 1979, an estimated 31,600,000 tons of coal were surface mined in southeastern Ohio (U.S. Department of Energy, 1980). The forest industry of Ohio is also centered in this part of the state. There are three pulpmills and numerous small primary and secondary wood manufacturing plants that provide markets for locally grown timber. This part of the state is also a significant livestock producing area. Accordingly, forestry and pasture are both realistic postmining land uses.

Previous studies by Baker et.al. (1976) and Higgins (1973) show that satisfactory forage yields and beef calf gains can be obtained on surface mined land. Baker et.al. (1976) reports forage yields of 2.71 tons per acre for grass and legume mixtures that had been fertilized with 40 lbs of N, 80 lbs of P_2O_5 and 120 lbs of K_2O per acre. Grazing trails indicated that about three acres of a vigorous stand of Kentucky 31 fescue and sericea lespedeza are required per cow-calf unit. Higgins (1973) reported that four acres of reclaimed land were needed per cow-calf unit. The higher acreage per cow-calf unit which Higgins reported probably reflects reclaimed land that had not been topsoiled and lower fertilizer application rates.

Sutton provides the most recent forage yield data for surface mine sites in southeastern Ohio which had been reclaimed to meet current topsoiling standards.[3/] In his experimental work, which involved nine different fertilizer treatments at three sites, Sutton found nitrogen to be the limiting factor in forage production. The most appropriate fertilizer treatment--100 lbs N, 50 lbs P_2O_5, 50 lbs K_2O--produce an average yield of three tons per acre from three cuttings. Sutton also observed that reconstructed mine soils are more droughty than natural soils and that this reduces forage yields.

Hybrid poplar plantations are a second possible land use. Davidson (1979) reports that a 16 year old hybrid poplar plantation on mine spoil in Pennsylvania yielded 90 tons of pulpwood and 9,400 board feet of lumber. This is equal to a growth of about two cords per acre per year. Stone Container Corporation contends that on abandoned field sites growers in Ohio can expect survival rates of 90 to 100 percent with annual height growth rates for the first five to six years of three to five feet and diameter growth of one-half to one inch per year.

In addition to its rapid growth, hybrid poplar is a desirable species because it can be propagated from cuttings and regenerated from stump sprouts after harvesting. Poplars grow best on sites with a pH of 5.5 or above.[4/] The trees will not tolerate shade

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[3/]Personal communications with Dr. Paul Sutton, Ohio Agricultural Research and Development Center dated August 18, 1980

[4/]Davidson, W. H. 1980. Hybrid poplars for spoil reforestation. Unpublished paper presented at the spring meeting of the American Council for Reclamation Research. May 6-7, 1980. Wheeling, W.Va., 11 p.

and can only be successfully established where competing vegetation is controlled.

Black walnut provides a reforestation opportunity which might yield significantly higher economic returns than hybrid poplar. This species develops best on deep, well drained, nearly neutral soils which are generally moist and fertile (Schlesinger and Funk 1977). Because of its site requirements, black walnut should only be considered for planting on the better reclaimed surface mine soils. Previous research indicates that walnut has good survival and growth on reclaimed land if planting sites are carefully chosen.[5/]

Cow - calf enterprises

In order to develop a cow-calf enterprise budget for reclaimed surface mined land it was necessary to make several assumptions. These assumptions were derived after reviewing published and unpublished studies and consulting with a Soil Conservation Service Agronomist, Ohio Cooperative Entension Service personnel, and lease holders operating a large cow-calf operation on reclaimed land. The data that are presented represent 1980 costs and product prices which the typical investor might experience when developing reclaimed lands and marketing cattle.

The first assumption was that with the proper fertilization program, annual forage yield would be three tons per acre and that 40 lbs of forage would be needed per animal unit day (AUD). The 40 lbs per AUD may seem conservative, however it includes losses resulting from trampling and a safety factor to ensure adequate forage during dry years. During the five month period lasting from December through April the cattle would be fed baled hay. An area of 2.4 acres would be needed to support one animal unit. Beef gain was estimated to be 1.5 lbs per AUD. Calves and cows were assumed to have an average weight of 500 and 1100 pounds and to bring market prices of $81 and $44 per hundred weight, respectively.

There was no charge for planting the pasture and hayland because this expense would normally be borne by the mining operator. Also, it was assumed that the necessary watering ponds would be constructed during reclamation and not require further expenditures for use by the livestock enterprise. Other assumptions are largely self explanatory (Table 1).

Total receipts per acre were estimated to be $154.87 from which pasture cost ($50.95), livestock cost ($56.92) and hay harvest cost ($37.50) must be deducted. The return after these deductions was $9.50 per acre, excluding land and management charges. Major cost items were fencing, fertilization, interest on cow herd investment, and hay harvesting.

At present, reclaimed unimproved surface mine land in southeastern Ohio can be leased for cow-calf grazing at about $5.00 per acre. Eight thousand acres of reclaimed land owned by Ohio Power Company has recently been leased by an Iowa based cattle company for a base price of $5.00 per acre plus an additional fee which is determined by prices at feeder calf sales in the state. The 1980 rental fee for this property was $9.95 per acre, which is slightly over our estimate of the return above livestock, pasture, and hay costs. The leasee plans to invest $3.2 million in land improvements and livestock during the 20 year lease period. The cow-calf operation is not expected to show any profit for at least three years.

Hybrid poplar plantations

Woodlands personnel from Stone Container Corporation provided establishment cost and yield estimates for a hybrid poplar pulpwood enterprise (Table 2). It was assumed that poplar plantations with an eight by eight spacing would be established in herbaceous cover using two herbicide applications. Three clearcuts yielding 49 tons per acre each were planned at 14, 12 and 10 year intervals. The declining rotation age is possible because successive rotations can be established from stump sprouts. After the third cutting, the area would be replanted. The stumpage price was assumed to be $2.00 per ton which is the 1980 price for well stocked hardwood stands with good access.

Total plantation establishment cost was estimated to be $143 per acre while stumpage sales for the three cuttings produced revenue of $294 per acre. The average

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[5/] Vogel, Willis G. 1979. Are trees neglected plants for reclaiming surface mines? Unpublished paper submitted to the West Virginia Academy of Sciences, November 29, 1979, 27 p.

Table 1. -- Cow-calf enterprise budget for reclaimed surface mines in southeastern Ohio, 1980

Item/explanation	Value per acre
Receipts 225 lbs beef/ac. @ $68.80 cwt.	$154.87
Pasture costs	
Fence installation $55/ac., 20 year life, i=8%	5.60
Fence maintenance 5% of installation costs	2.75
Clipping	3.00
Annual fertilizer & lime application	
100 lbs. N @ .25/lb	25.00
30 lbs. P_2O_5 @ .22/lb.	6.60
30 lbs. K_2O @ .10/lb.	3.00
.5 tons lime @ $10/T	5.00
pasture cost =	$50.95
Livestock costs	
Building charge	1.00
Interest on investment $500/cow x 8% x 5/12	16.67
Death loss: $500 x 1% x 5/12	2.10
Replacement costs: $500 cow sold @ $400 $100 ÷ 7 yrs. x 5/12	5.95
Veterinary, salt, & minerals	8.75
Breeding charge: $10 x 5/12	4.10
Livestock taxes & insurance	2.25
Labor: $4.50/hr. x .4 hr./cow x 5	9.00
Marketing cost	2.50
Miscellaneous charges	4.60
livestock costs =	$56.92
Hay harvest costs	
Mow, rake & bale @ $30/ton 5/12 of forage baled	37.50
Return above pasture & livestock costs [a]	47.00
Return above pasture, livestock & hay costs [a]	9.50

[a] Excludes land and management charges.

Table 2. -- Hybrid poplar plantation for reclaimed surface mines in southeastern Ohio, 14 - 12 - 10 year rotations, 1980

Item/explanation	Year	Value per acre
Planting stock 8 x 8 spacing 640 trees/acre unrooted cuttings	1	$68
Planting combination machine & hand	1	40
First herbicide application simazine: pre-emergent spray round-up: post-emergent spray 3 foot wide strips	1	20
Second herbicide application	2	15
	Total establishment cost =	$143
First harvest 49 tons/ac 3.5 tons/ac./yr. $2.00/ton stumpage	14	98
Second harvest [a] 49 tons/ac. 4.1 tons/ac./yr. $2.00/ton stumpage	26	98
Third harvest [a] 49 tons/ac. 4.9 tons/ac./yr. $2.00/ton stumpage	36	98
	Total stumpage income =	$294
Average annual net revenue [b]		4.19
Internal rate of return [b]		3.06%

[a] Second and third rotations established using coppice silvicultural system.

[b] Excludes land charge, property tax, fire protection costs and management charge.

annual net revenue was $4.19 per year. The internal rate of return was equal to 3.06 percent--a rate that is far too low to attract investors.

Hardwood stumage prices for pulpwood are relatively low in Ohio because the supply of poletimber exceeds demand. This depresses oportunities for commercial forest plantations. Nevertheless, Stone Container Corporation in Coshocton, Ohio has established an eight acre nursery with the capability to produce 300,000 poplar cuttings per year. The company is currently leasing small acreages of old fields for poplar plantations and is cooperating with Peabody Coal Company in the establishment of experimental plantings on reclaimed land.

Black walnut plantations

In evaluating the financial possibilities of establishing black walnut plantations, it was assumed that only the best sites would be planted. Walnut seedlings would be planted on an 11 x 11 spacing and interplanted with autumn-olive or European black alder. Both of these species fix nitrogen which will increase the growth of the walnut. They also reduce the need for pruning and provide wildlife food and cover. Because walnut is intolerant of shade, three herbicide applications and three mowings were believed necessary. Several prunings and thinnings were included in the budget to produce high quality veneer logs and sawlogs. It was assumed that the plantation would yield 2,500 board feet of sawlogs and 5,000 board feet of veneer logs in 50 years.

Current prices for black walnut stumpage were estimated to be $.50 per board foot for sawlogs and $5.00 per board foot for veneer logs. Hoover (1978) has shown that the price of black walnut stumpage has increased historically at a rate of 1.5 percent per year above the cost of other goods and services in the economy. If we apply this rate of increase in real value to 1980 prices, black walnut stumpage at rotation age will be worth $1.05 per board foot for sawlogs and $10.53 per board foot for veneer logs. These assumptions and accompanying cost and yield data reflect the experience of Pierson-Hollowell Company, a veneer manufacturing firm that is establishing and managing walnut plantations in Indiana. During the past year this company established plantations on reclaimed land for AMAX Coal Company.

Given these assumptions, the plantation was capable of earning an annual net revenue of $1,091 per acre and an internal rate of return of 9.34 percent (Table 3). This rate of return is much higher than for the hybrid poplar plantation and is likely to attract some investors.

Comparison of alternatives

To compare the black walnut and hybrid poplar plantations to the cow-calf operation, the net present value of an infinite number of income streams was calculated for each alternative land use at eight percent compound interest.[6/]

Land Use	Net Present Value
Pasture	$119
Hybrid poplar plantation	-94
Black walnut plantation	581

The hybrid poplar plantation had a negative land value indicating that from solely a financial standpoint, hybrid poplar plantations would not be a desirable land use. Pasture had a positive land value, but not nearly as high as the black walnut plantation. These results suggest that the best land use strategy would be to plant black walnut on the most favorable sites and to use the remaining reclaimed land for a cow-calf enterprise.

ADDITIONAL CONSIDERATIONS

In addition to return on investment, there are other considerations which will influence the postmining land use choice as related to forestry and pasture alternative. Landowners tend to select those land uses which are compatible with or complement their other business ventures. For example, wood-using industries that own coal bearing land usually return these lands to forest in order to protect their investments in secondary manufacturing. They already have the technical skills to establish and manage plantations and can provide their own market for the wood that is produced.

[6/] An eight percent interest rate was suggested by Samuel M. Brock as appropriate for evaluating postmining land use alternatives when current prices are used. Unpublished paper. Selecting a higher and better postmining land use for surface mined land through budgeting. June 30, 1980. 22p.

Table 3 -- Black walnut plantation for reclaimed surface mines in southeastern Ohio, most favorable sites, 1980

Item/Explanation	Year	Value per acre
Planting stock		
Black walnut seedlings ($60/M) 360 trees/acre, 11x11 spacing	1	$22
Autumn-olive or Europeon black alder Interplant 360 trees/ac. ($35/M)	1	13
Planting & herbicide application		
Machine planting Herbicide: dalapon and atrazine Sprayer attached to planting machine 4 foot wide strips	1	432
First weed control		
Mow twice between rows	1	30
Second herbicide application	2	72
Second weed control	2	15
Third herbicide application	3	72
Third weed control	3	15
Corrective pruning	3	10
First side limb pruning	7	30
Second side limb pruning	10	30
First precommercial thinning	17	30
Second precommercial thinning	25	0
Final harvest		
50 trees x 150BF/tree = 7500 BF/ac 5,000 BF veneer logs @ $10.53 2,500 BF sawlogs @ $1.05	50	55,275
Average annual net revenue a/		1,091
Internal rate of return a/		9.34%

a/ Excludes land charge, property tax, fire protection costs, management charge and possible income from the sale of nuts.

The availability and cost of capital is a second consideration. Some postmining land uses, such as black walnut plantations, have relatively large front-end costs and long production cycles while others, such as hayland, are less costly to establish and quickly produce income. The capital position of the landowner may favor one use over another.

Risk and uncertainty will also affect land use decisions. Product prices fluctuate depending on market conditions and there is always the chance of losses from disease, draught, fire and storms. Landowners may demand higher rates of return for certain land uses simply because they are associated with higher risks.

Economic factors may suggest a combination of land uses rather than a single land use. Integrated forestry-farming enterprises have the advantage of providing early financial returns to offset establishment costs, sustained income throughout the rotation period, and an asset in the form of timber which can be liquidated on short notice if necessary. Small or isolated parcels of land with high pasture establishment and management costs per acre might be more appropriately reclaimed to forest where the adjacent land use is also forest. In some situations multicropping--planting walnut on wide spacings and grazing or harvesting hay on the same acreage--could be the most profitable land use alternative (Garrett and Kurtz 1980).

CONCLUSIONS

Surface mining is a temporary land use, which when conducted with adequate environmental safeguards, can with sufficient time achieve a postmining land condition that is equal to or better than that which existed before mining. The Surface Mining Control and Reclamation Act of 1977 provides most of these environmental safeguards.

An important requirement of the Act is premine planning. During the planning process, postmining land use alternatives should be thoroughly investigated. This paper has attempted to describe some of the factors that should be considered and to demonstrate the type of financial calculations that should be undertaken when forestry and pastureland are realistic postmining land use alternatives. In practice, each landowner or mining operator must estimate his own costs and revenues for the land uses being considered since they will vary from ones used in the examples. After evaluating the financial returns for several alternatives, the decision maker--whether he be a mining company or landowner--will be better able to select the most favorable postmining land use.

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