Proceedings of

Enhancement of Reforestation at Surface Coal Mines: Technical Interactive Forum

Proceedings of the Enhancement of Reforestation at Surface Coal Mines:
Technical Interactive Forum held March 23-24, 1999
at the Drawbridge Inn and Convention Center in Fort Mitchell, Kentucky.

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FOREWORD

The Office of Surface Mining (OSM) is examining methods that would enhance post mining land use plans that promote the planting of trees on active and abandoned surface coal mines. Benefits of reforestation are many and would include: improving wildlife habitat; recreation opportunities; restoration of clean water resources; erosion prevention; and the creation of new economies based on forest products.

Based on input from the states, industry, academic research, consultants, environmental agencies, and the public, OSM has determined that although some companies have found ways to successfully establish trees on their reclaimed mine sites, there is a large concern that the potential for planting trees on reclaimed mine sites is not being realized for a wide variety of reasons.

On May 13, 1998, OSM held a planning session on Reforestation of Mined Lands and Carbon Emission Offsets in order to better define the issues and possible roles for OSM. Based on the results of this session, OSM has focused its efforts on the following activities. On January 14, 1999, OSM held a policy outreach symposium in Washington, D.C. to provide clarification on current OSM policy on tree planting. On March 23 and 24, 1999, OSM cosponsored with the Coal Research Center of Southern Illinois University, Carbondale, a technical interactive forum on enhancement of reforestation at surface coal mines. The forum, held in Fort Mitchell, Kentucky, was designed to (1) highlight information on successful reforestation efforts and technologies that are currently being used to enhance reforestation on active and abandoned coal mined lands; (2) identify region specific impediments to tree planting; and (3) review recommendations both for removing unnecessary barriers to tree planting and for promoting technologies with potential for enhancing tree planting efforts.

Based on the results of the above efforts an OSM/State Revegetation Team will assess the outcomes of the symposia and forum and make recommendations on potential revisions to OSM/State policy and plans for enhancement of outreach efforts.

I would like to sincerely thank the speakers, authors, steering committee members, and participants for their time and efforts devoted to making this program a success.

STEERING COMMITTEE MEMBERS

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REFORESTATION STEERING COMMITTEE RECOMMENDATIONS

The following are recommendations made by the Reforestation Forum Steering Committee immediately following the end of the forum. The recommendations represent areas that have potential for future efforts but do not reflect any particular priority or consensus.

OSM HEADQUARTERS LEADERSHIP ROLES

- OSM headquarters needs to produce a policy statement in writing from the Director encouraging reforestation efforts.
- OSM needs to provide a special annual award to highlight innovations in reforestation. Awards should consider several categories such as Hardwoods, Softwood, Bottomland, Riparian, Appalachian, Midwest, Arid West.
- OSM needs to continue to take the lead and keep the pressure on to produce actual change in reforestation efforts.
- OSM needs to develop a budget and plan for implementation.
- OSM needs to provide specific funding options so that State AML programs will be encouraged to plant more trees.
- OSM should have a team to evaluate regulations in light of forum results.
- OSM needs to identify one or more appropriate teams of people that will ensure that this initiative makes satisfactory progress.

OSM NTTP EDUCATION LEADERSHIP ROLES

- Develop an educational program for presentation to local schools. Could be used for Earth Day programs.
- Need to make sure that current OSM Technical Training Program classes incorporate recommendations from the forum concerning reforestation.
- Develop a specific OSM Technical Training Program class directed to field inspectors and coal operators along the lines of the Wetland course that should be very region specific.
- Emphasize efforts that promote education opportunities and communication for field people.
- Partner with industry to develop demonstration sites for educational purposes.

OSM REGIONAL LEADERSHIP ROLES—STATE–BY–STATE INITIATIVES

- Solutions need to be developed on a state-by-state basis. This is not a one size fits all issue.
- Develop state-by-state policies and guidance for reforestation enhancement.
- Need to provide state-by-state cost comparisons for producing productive forests versus low value compacted pastures.
- Need to get top levels of state governments to buy into the process.
- Attention needs to be given to developing approvable methods for reducing grading that results in lower compaction rates.
- Assess potential for approving state amendments that allow for proof of revegetation success earlier in the liability period.
- Forestry needs to be seen as a multiple land use that is favorable to wildlife.
- Plant high quality trees and shrubs and allow for including for purposes of bond release the counting of acceptable invaders.
- Look for positive incentives to encourage reforestation.
- Need to get OSM field offices on board.
- Need to sell the economic advantages of forestry.
- Need to develop native seed mixes that will enhance reforestation because of low maintenance requirements and compatibility with trees.

- Need to determine how the planting of high value trees for commercial forestry can be approved as a land use option on mountain top removal sites.

REFORESTATION STEERING COMMITTEE LEADERSHIP ROLES

- OSM needs to develop a Reforestation Website similar to the CCB Information Network Website to provide a means for maintaining ongoing communication concerning sources of information, research, upcoming events, state initiatives, educational opportunities, etc.
- OSM needs to maintain the reforestation steering committee or like national team to ensure continued progress of initiative.

WHAT IS A TECHNICAL INTERACTIVE FORUM?

Kimery C. Vories
USDI Office of Surface Mining
Alton, Illinois

I would like to set the stage for what our expectations should be for this event. The steering committee has worked hard to provide you with the opportunity for a free, frank, and open discussion on issues related to the establishment of trees on lands reclaimed after coal mining in an atmosphere that is both professional and productive. Our rationale for the format of the technical interactive forum is that, unlike other professional symposia, we measure the success of the event on the ability of the participants to question, comment, challenge, and provide information in hopes that by the end of the event a consensus will emerge concerning the issues discussed.

It has been my personal experience that the most progress I have seen toward making advances in the field of surface mining reclamation has come when we have been able to work as a team of professionals toward a consensus on (1) the facts related to the actions we have proposed, and (2) the state of the science in terms of what are our most workable options and alternatives.

During the course of participating in this discussion, we have the opportunity to talk about technical, regional, and local issues, while examining new and existing methods for finding solutions, identifying problems, and resolving issues. The forum gives us the opportunity to:

C share our experiences and expertise concerning the establishment of trees and forestry land uses,
C outline our reasons for taking specific actions, and
C give a rational for why we should or should not be promoting the planting of trees at our mines in a specific manner.

A basic assumption of this interactive forum is that no person present has all the answers or understands all of the issues. It is also assumed that issues, solutions, and concerns may be very site, regional, or state specific.

The purpose of the forum is to:

1. present you with the best possible ideas and knowledge, during each of the sessions;
2. promote the opportunity for questions and discussion by you, the participants; and
3. let each person decide what is most applicable to their situation.

We are not here to encourage the imposition of policy or regulation, but rather to empower you, the participants, with better knowledge, new contacts, and new opportunities for problem solving and issue resolution.

The format of the interactive forum strives to improve the efficiency of the discussion by providing the following:

C A copy of the abstract for each speaker's talk which you may want to read before the presentation in order to improve your familiarity with the subject matter.

C The talks and discussions are all recorded on tape for later inclusion in a post forum publication so that you do not have to worry about taking notes. For this reason, we will require that all participants speak into a microphone during the discussions.

C In the post forum publication, issues raised during the discussions will be categorized by affiliation, such as government, industry, academic, or public, and will not identify individual names. All registrants will receive one copy of this publication. This publication will be very similar to the coal combustion by-product and prime farmland publications that are available at the OSM exhibit. Additional copies will be made available for distribution to nonparticipants by the OSM Alton office. This year we will be offering the publication by CD-ROM as well as by hard copy.

It is important to remember that there are three separate opportunities for you, the participants, to be heard.

- Five minutes will be provided for questions at the end of each speaker's talk.

- Twenty minutes will be provided at the end of each topic session. The chairperson will recognize each participant that wishes to speak, and each will be required to identify him/herself and speak into one of the portable microphones so that everyone can hear the question.

- Finally you will be asked to rate the usefulness of each speaker and provide individual written comments concerning any aspect of the forum at its conclusion. The results of this forum evaluation will be analyzed and included in the final publication.

Finally, the steering committee and I would like to thank all of the speakers who have been so gracious to help us with this effort and whose only reward has been the virtue of the effort. I would also like to thank all of our participants for your willingness to work with us on this important issue.

ENCOURAGING INTERAGENCY COOPERATION AND INNOVATIVE REFORESTATION STRATEGIES

Kathy Karpan, Director[1]
Office of Surface Mining
Washington, D.C.

I would like to comment on what a remarkable change in relationships I have seen between government and the private sector and between nonprofit and profit organizations in the 30 years I have been in and out of government service. I think this is a perfect backdrop for what we are doing today. My topic is to encourage all of you to continue to extend our discussions to all of our potential constituency groups.

I loved Alvin Tofler's books *Future Shock* and *Third Wave*. One of the most important points that I got out of them was the effect that our economic order had on the way that we govern ourselves. In an earlier industrial age, when we were mobilizing great forces, building factories, establishing strong bureaucracies, and developing hierarchical relationships in order to move mass industries, we had political parties and political activities that fell into that model. There we focused on hierarchy, right and wrong, the chain of command, and orthodoxies. As we have currently given way to a brand new kind of economy, so we have seen a transformation in the kind of relationships that govern us. The old hierarchical relationships are giving way and being transformed. It began first in the private sector management and now it is occurring in government. It is more than the notion that we will have more teamwork, set goals together, and be more adaptable and permeable. It has to do with the fundamental ways that our federal government interacts with our state government, how state government interacts with local government, and all of us with the public that we serve.

It seems to me that this reforestation initiative that we have launched is a wonderful example of where we are trying to go in setting government policy. This is not reactive. We have not been forced to do this by congress, legislation, or any directive. Although the Keoto Clean Air accord is part of the context of this discussion, it by no means mandates that the agency that helps regulate the surface mining of coal should suddenly become allied with the U.S. Forest Service in trying to understand forest issues. We are also trying to look beyond the narrow confines of what we do every day. I do not look at my job as "How the surface coal mining industry is doing in terms of active mining and the abandoned mine lands programs?" and anything beyond that is not my business. That is part of the old nonpermeable world of the past.

When I went to our first National Coal Symposium, held in January 1998, we had invited all of our constituency groups to attend. We heard so much concern about the possible outcomes of the Keoto accords and what that might mean in terms of reducing coal production in this country and its potential to become a problem in meeting our energy needs. One of the ideas that began at that symposium was that our clean coal technology will finally deliver for us in controlling power plant emissions. I do not know how many decades out that is, but coal will continue to be a part of our energy picture well into the 21st century. One of the things that should occur to us is that, given how we have dealt with the clean air issues, some type of credit trading system might emerge. In that process, some policy makers might want to know, "Where do we have carbon sinks, and how can we measure them?" In trying to think beyond our narrow boundaries and pursue an energy policy that recognizes that we must produce cleaner air, we have launched a series of discussions that you have been hearing a lot about recently.

At our meeting on reforestation policy in Washington, D.C. in January, it was fascinating to me that there was not any clear information on how many trees were being planted on both active and abandoned mined lands as a result of the surface mining and reclamation programs. We do not even know as an agency how many trees are being planted, let alone how to measure the amount of carbon sequestration that is occurring.

Another thing that we must ask ourselves is, assuming we can learn about how many trees are already being planted, "Is it possible that we will learn that there is not enough reforestation occurring?" Is it possible that OSM is part of that outcome? Is there something in the way our regulations are perceived, administrated, or written that is having the unintended consequence of discouraging reforestation, where it would otherwise be appropriate or make sense. I do not think it is out of the limits of this discussion that we think about changes to our rules even though we will not do it today. I have just been talking to the head of the National Mining Association, and he thought that there has been a lot of good discussion on this issue and that perhaps the time has come where we can think cooperatively about making some regulatory changes in the near future. This point would only be reached after we thoroughly examine our existing regulatory scheme. This should be in the context that it is possible within government that we can change the way we do business without having to run to congress for a new law or to the rule writers and consume ourselves with months and months of work.

The most recent example of how that can happen is how we have worked with the states involved with mountain top removal. These states are all part of something very different but exciting that we are doing. "Are we really achieving approximate original contour in these mountainous areas?" Our agency, for a lot of reasons over the last 20 years, has not provided the fine print for this definition because it had to be a very flexible concept. It has become clear to us that we have a better job to do in understanding how approximate original contour should work and how we should explain it and enforce it with the industry. We have been under the gun, not so much from congress or even the litigation, but because the people in the affected states wanted us to do a better job. We need to look at the way we are doing business and first and foremost find a better way to communicate the concept of approximate original contour without going through years of rule making and years of litigation. We put our best people together and came up with a way of looking at our rules and standards. We have worked with the state engineering staffs and because of it the states are implementing a much better analysis of evaluating permit applications involving approximate original contour. We did it not by rushing to rule making, or because the agency had sent word down to us, but just as we are doing here; we put everyone together who was impacted by this issue and tried to determine (1) what the facts were, and (2) what the science of the issue was. We then worked toward building a consensus that we can all sign off on and a commitment to work together, not imposed by anyone, but agreed to by everyone.

We have had a nonstop series of meetings on the reforestation issue adding new participants at each step of the process. I am glad to see the U.S. Forest Service on this agenda because you can not speak on this issue without their involvement. We also have been in touch with the Department of Energy and are excited about some of their ideas in the area of energy related to trees and their plans for identifying future research needs. We have been in touch with the Environmental Protection Agency who would be involved with the quantifying of carbon sequestration. We have recently signed an agreement with the Wildlife Habitat Council to cooperate on wildlife enhancement of reclaimed lands.

Planting trees is a good idea in the right circumstances, whether or not it ever gets linked to higher air quality standards. We ought to be reforesting where ever possible in areas that were previously forested. That should be an enduring value of our agency. Although part of our interest in this area is due to contemporary concerns about clean air issues, part of it is a fundamental interest in the value of planting trees for better reclamation. We see this effort as a tremendous opportunity for our agency to benefit from your input on this issue. We are ready where ever and when ever you want us as an agency to be involved in these kinds of discussions.

I would like to put forward, as one of the possible suggestions that could come from these discussions, that a balanced team should be assembled that would consider possible changes to our regulations and policies so that the broad general goals that we are all pursuing could be put into effect.

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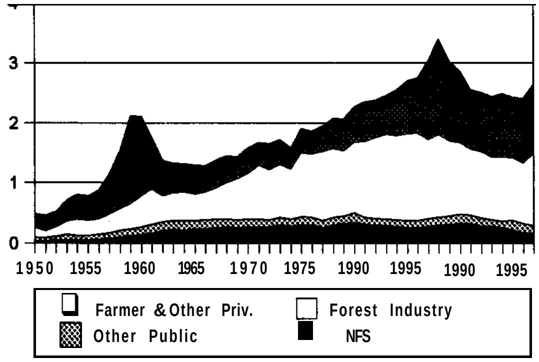
[1] Director Karpan is from the state of Wyoming where she has a long family background in coal mining. She has a long and distinguished record of public service at both the state and federal levels including serving as:

1. Assistant Attorney General for Wyoming,
2. Director of the Wyoming Department of Health and Human Services, and
3. Secretary of State for Wyoming.

She received her Bachelor's and Master's Degrees from the University of Wyoming and her Juris Doctor from the University of Oregon.



Tree Planting in the U.S.
(Millions of acres)

States that planted more than 100,000 acres of trees in FY 1997

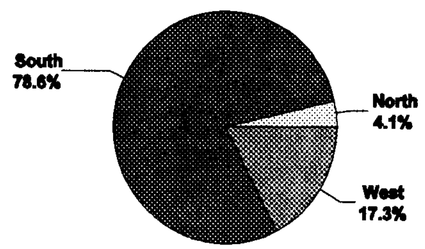
State	Thousand Acres
Alabama	438
Georgia	397
Mississippi	282
Florida	193
South Carolina	166
Washington	158
Louisiana	144
Oregon	134
North Carolina	114
Arkansas	110
Texas	108

Tree planting by ownership category in FY 1997:

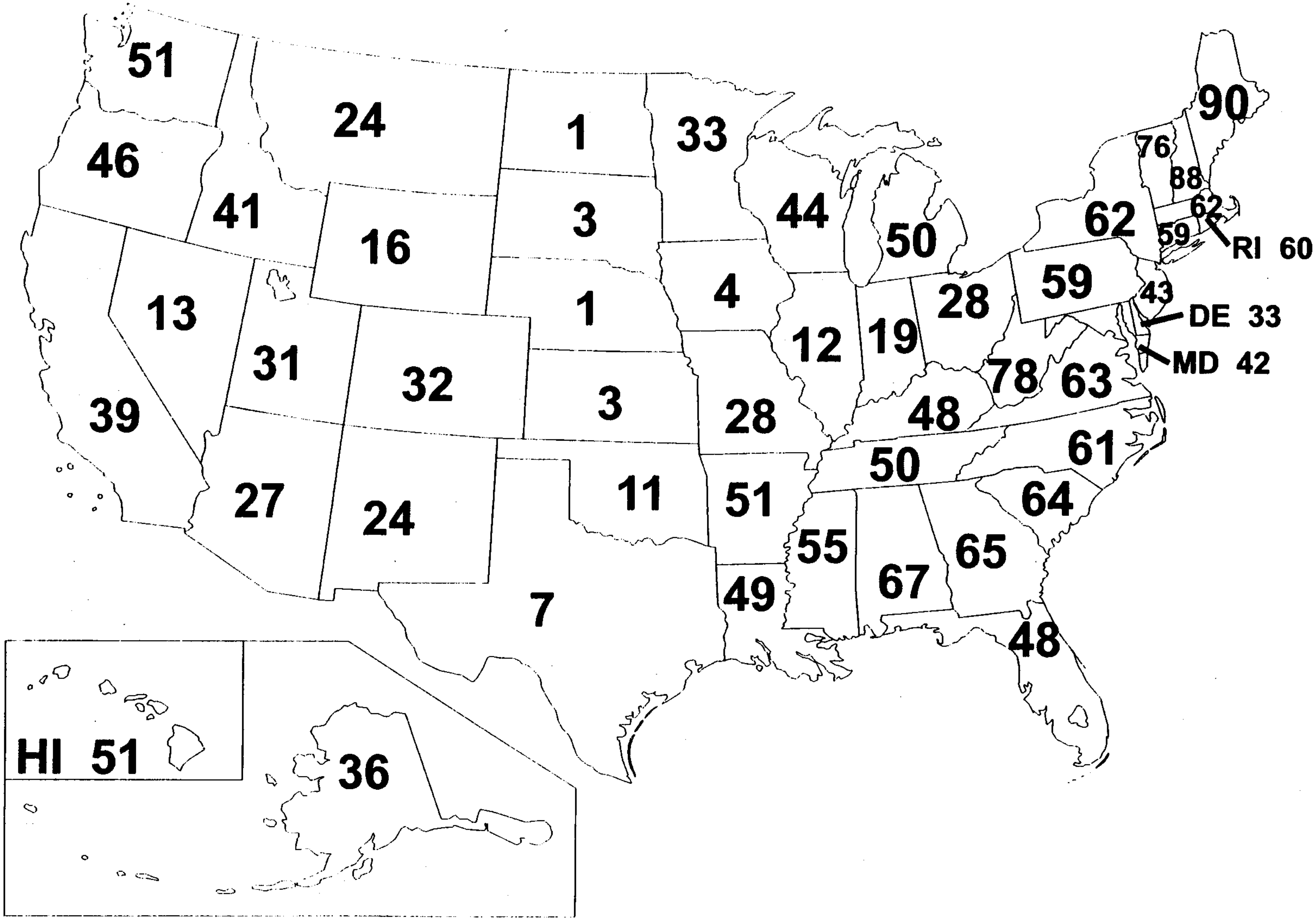
	Acres	Percent of All Planting
Federal Government		
National Forests	158,918	6.0
Department of the Interior	13,956	0.5
Other Federal Agencies	15,571	0.6
Total	188,445	7.1
Non-Federal Public		
State Forests	37,430	1.4
Other State Land	15,732	0.6
Local Government	49,551	1.9
Total	102,713	3.9
Private		
Forest Industry	1,188,362	45.1
Other Industry	56,971	2.2
Nonindustrial Private	1,099,611	41.7
Total	2,344,944	89.0
Grand Total	**2,636,102**	**100.0**

Total planting and seeding by region in FY 1997:

Region	Acres	Percent of All Planting
North	108,230	4.1
South	2,070,849	78.6
West	457,023	17.3
Total	2,636,102	100.0



FOREST LAND AS A PERCENT OF TOTAL LAND AREA



TIMBERLAND, HARVEST, AND TREE PLANTING BY OWNERSHIP IN U.S.

Ownerships	Timberland Area 1	Harvest 2 All Species	Harvest 2 Softwood	Harvest 2 Hardwood	Tree Planting 3
			Percent		
National Forest	17	12	16	4	11
Other Public	10	6	6	6	5
Forest Industry	14	33	38	23	43
Farmer & Other Pvt	59	49	40	67	41
	100	100	100	100	100

1 **Timberland** (1992): 490 **Million Acres**
2 **Timber Harvest, All Species** (1991): 16.3 **Billion Cu. Ft.**
3 **Tree Planting** (1992): **2.5 Million Acres**

WHY PLANT TREES?

Robert J. Moulton[1], Resource Economist
USDA Forest Service
Research Triangle Park, North Carolina

Introduction

This forum features an outstanding slate of experts on the science and art of reforesting strip mined lands. They will give you information on the status of reforestation efforts and the latest on emerging new technologies, address how to overcome barriers, and talk about opportunities.

This paper does not address these topics. Rather, its purpose is to establish the forestry context—to set the stage for OSM/State reforestation efforts by providing an overview of the extent, condition, trends, and importance of America's forest resources and to provide an overview of tree planting in the United States.

The Forest Land Base

The United States currently has 737 million acres of forest land, one third of its total land area. This compares with just over one billion acres (1,044,000,000 acres), or 50 percent of the U.S. land area, in 1630, when European settlement of the nation first started. Stated in another way, the United States still has almost 75 percent of its original forest area.

The natural range of forest in the United States includes most of the land area in the eastern half of the nation and significant areas in the Rocky Mountain states, the Cascades and other western mountain ranges, and the Pacific Coast states. Maine is the most heavily forested state with 90 percent of its area in forests, followed by New Hampshire (88 percent) and West Virginia (78 percent). Forests are the dominant land use in all of the eastern states (see map) with the exception of Minnesota (44 percent forested), Illinois (12 percent forested), Indiana (19 percent forested), and Ohio (28 percent forested) due to the eastern extension of natural prairies and large scale conversion of forest land to agriculture, which has occurred in all but the rougher topographic and shallower soils regions of these states.

The Great Plains states have the lowest occurrence of forests because rangeland—an important resource in its own right—is the natural cover in these states. North Dakota and Nebraska each have only one percent of their land area in forests, and South Dakota and Kansas but three percent. Low amounts of precipitation, especially during the critical growing season, has long been recognized as a limiting factor for forests in the Great Plains and, hence, trees occur mainly along water courses where moisture is more readily available. Soil chemistry, especially excessive salinity, is also a limiting factor for trees in some areas, and recent research indicates that desiccation or drying of trees by incessant dry winds during the winter months when the ground is frozen and the tree roots cannot replace lost moisture, accounts for much tree mortality in the Northern Plains. Thus, trees may be found in river and stream bottoms because these locations provide both additional moisture and shelter from wind.

During most of the course of our nation's history, forests have been a residual use of the land. While forests that have been retained in public ownerships have remained in forest cover, most forest land was quickly granted to private owners by the government, and numerous public programs and policies were implemented to encourage the conversion of forest land to agriculture and to urban and other developed uses. Forests in private hands usually remained in forest cover only if they were not well-suited to other uses.

Conversion of forests to agricultural uses, which clearly has had the greatest impact on forest land area, reached its zenith in the decade 1870-1879 when 50 million acres of forest land were converted. However, the rate of conversion declined to just over 20 million acres during the decade 1900-1909 as the supply of available forest lands declined. Net conversion of forests to agricultural uses essentially halted by 1920 with forests on 732 million acres**S**its historic all time low**S**as industrialization got under way and people began to leave the land for jobs in the growing cities. Public programs helped reforest many of the idled agricultural lands, but for the most part these acres, which had been marginal for agriculture, reverted naturally to forests.

By 1960, forest land area had increased to 762 million acres, but again started to decline slowly in response to expanded agricultural production as soybeans became a major crop (10 million acres of bottomland hardwoods were cleared for this crop). The export boom for major agricultural crops of the late 1970s and early 1980s prompted still more land use changes until forest land stood at 736 million acres in 1987. The export market then suffered a major collapse and forest land increased to its current level of 737 million acres.

There is reason to believe that forest land will hold its own or even increase in extent in the years to come. The Conservation Title of the 1985 and 1990 Farm Bills laid the foundation by creating disincentives for agricultural producers to convert fragile forest and range land wetlands (many of which are forested) to croplands, and the federal income tax code was revised to eliminate tax incentives that formerly had encouraged these land use conversions. The 1996 Farm Bill went farther by eliminating base acres and annual acreage set asides, which served to keep excessive land in crop production, and the legislation also eliminated production constraints on most major crops with the result that production likely will shift to those regions with the best soils and other competitive advantages, leaving less competitive areas to revert or to be converted to forest lands.

Urban and other developed uses also consume forest land, and these changes are largely irreversible. However, the acreage is relatively small. Of much greater concern is the continued pattern of larger forest ownership being broken into many smaller ownerships. This will be discussed later in this paper.

The Global Importance of U.S. Forests

With 737 million acres of forests, the United States has but seven percent of all the forest land in the world. Notwithstanding,

- ***The United States is the world's leading producer of wood and wood products.*** It accounts for 25 percent of all industrial wood harvested.

- ***The United States is the world's leading consumer of wood and wood products***. Per capita consumption of wood in the United States is four times the world average and two times the average for all developed countries. The United States uses relatively more wood for housing and many other products and relatively less energy intensive materials like concrete and steel. This has a double climate change benefit due to the storage of carbon in wood products and the significant avoidance of emissions in production.

- ***The United States is the world's leading importer of wood and wood products and is second only to Canada as an exporter of wood and wood products***. The United States is a net importer of wood on both a volume and value basis.

- ***The United States has 25 percent of the world's forests that are protected from timber harvest***. Ten percent of U.S. forests are in this category.

- ***The United States has 40 percent of the world's privately owned forests***.

Forest Ownership

Private landowners own 58 percent of all U.S. forest lands and 73 percent of forest lands (timberlands) that are capable of producing sustained annual crops of wood products and that are not excluded from timber harvesting due to their location within parks, wilderness, or other specially designated areas. Private forest lands provide over

80 percent of our domestic timber supply, and about 85 percent of all tree planting occurs on these private ownerships.

Forest industry. Private landowners with wood processing facilities are collectively known as the forest industry. These forest products companies acquired lands that are especially well-suited for growing timber, and these lands are typically actively managed. The forest industry owns 14 percent of U.S. timberlands but produces 33 percent of our timber harvest volume and each year does 40 percent or more of all tree planting.

Nonindustrial private forest (NIPF) landowners. NIPF landowners own 59 percent of United States timberlands, annually produce about 50 percent our domestic timber supply, and plant 40 to 45 percent of all trees. Farmers were once predominant as NIPF owners, but today only 8 percent of these private forest landowners are farmers. Instead, white collar workers (32 percent), retirees (29 percent), and blue collar workers (16 percent) account for the bulk of NIPF owners.

There are currently 9.9 million private forest land ownerships in the United States, an increase of 28 percent since the last complete survey of private landowners was made in 1978. Most of these owners (59 percent) have forest land holdings of less than 10 acres, and 94 percent have ownership of less than 100 acres. In contrast, the remaining 6 percent of NIPF ownerships contain 68 percent of the forest acres.

The loss of green space to urban sprawl and development has become an important national and local issue and, clearly forest lands are not an exception. Since 1978, the amount of private forest land in ownerships of less than 100 acres has increased by 73 percent, a process known as parcelization. With it comes the threat of disruptive effects on forest ecosystems and their abilities to perform important functions as part of the hydrologic cycle, such as homes for forest wildlife and plants, timber, and other goods and services they provide to society.

Public Forests. Public forests in federal, state, and local government ownership account for 42 percent of U.S. forests and 27 percent of its timberlands. The national forests are the largest of the public ownerships with 17 percent of the United States timberlands. In 1992, the latest year for which timber harvesting data for all ownerships are available, the national forests provided 7.3 billion board feet of timber (down from a peak of 12.71 in 1987), 12 percent of the United States total, with the bulk of this timber coming from the old growth forests of the Pacific Northwest. By 1996, only 3.72 billion board feet were harvested from the national forests, due to decreased emphasis on timber production and greater emphasis on recreation, watershed, and wildlife. Because most tree planting on the national forests was done to reestablish trees on harvested areas, tree planting on these forests dropped from 11 percent of the United States total in 1992 to 6 percent in 1997.

Tree Planting

The prompt regeneration of forest stand following timber harvests and other disturbances, such as fire and weather events (e.g., drought and hurricanes), is the major reason that the United States is the global leader in forestry, and regeneration activities must be maintained if we are to be assured of adequate supplies of wood and wood products in the future.

The South leads the nation in tree planting with almost 80 percent of annual planting. There are a number of reasons for this, including abundant rainfall, a long growing season, and soils that are often marginal for agricultural crops but excellent for trees. Moreover, the South is the lowest cost region for establishing trees and has excellent markets, as the south has the highest concentration of forest industrial capacity of any region of the world. The South is the leading region for the production of softwood lumber and construction plywood used for homes.

The major tree species planted in the South are loblolly pine, slash pine, and long leaf pine, which are used to produce softwood lumber products. Hardwood trees**S**with the exception of bottomland hardwood species used to recover lands previously converted to agriculture**S**are rarely planted, even though hardwoods are abundant in the

South and are also harvested in large amounts because established stands of hardwood trees with few exceptions regenerate naturally and do not required planting.

Very little tree planting occurs in the North, because northern hardwood trees and trees of other species generally reproduce naturally in abundance following timber harvests and other disturbances.

The West is also an important producer of softwood lumber and species like douglas fir and ponderosa pine are widely planted. Note that Oregon and Washington are listed among the top tree planting states in the addenda materials.

Closing Comments

In closing, it is interesting to observe the trend in tree planting accomplishments over the past three quarters of this century. In the late 1920s and early 1930s, the planting of 100,000 acres in a single year was a major accomplishment. Currently, we are planting in excess of 2.5 million acres every year. Generally, tree planting has increased at a moderate pace from year to year, but there have been significant peak periods. The Civilian Conservation Corps (CCC) planted 2.3 million acres in nine years in the late 1930s and early 1940s; the Soil Bank Program planted 2.2 million acres on former farmland between 1956 and 1960; and the Conservation Reserve Program (CRP) has planted over 2.5 million acres, mainly during the late 1980s. All of these programs planted many trees and provided many other environmental benefits, but none of these programs were actually created for these reasons.

The driving force behind the creation of the CCC was the Great Depression; young men were taken out of soup lines in the cities and set to work planting trees and doing other conservation work in the great outdoors. Both the Soil Bank and the CRP were created to take excess agricultural cropland out of production to relieve economic stress on our farmers. Today our nation and the world is faced with the prospect of global climate change. This might just be the driver for the largest tree planting effort of all time.

I am pleased to be here at this Reforestation Forum and I salute the leadership role that OSM is taking in promoting increased reforestation.

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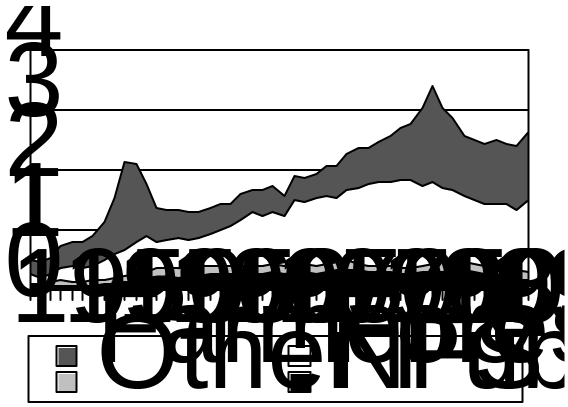
[1]Dr. Moulton has recently:

- briefed the White House and congressional staff on *Sequestering Forest Carbon to Offset Global Climate Change*,
- been an advisor to the National Academy of Sciences for their study, *Forested Landscapes in Perspective*, and
- was the architect of the tree planting and improved forest management programs in the *President's 1993 Climate Change Action Plan.*

He served as the principal advisor to the Secretary of Agriculture in the design of the tree planting provisions of the *Conservation Reserve Program,* as authorized by the 1985 Farm Bill.
He has 15 years experience as a field forester in the lake states, Missouri Ozarks, Idaho, and Oregon, and is the author of more than 60 forestry publications.



Tree Planting in the U.S.
(Millions of acres)

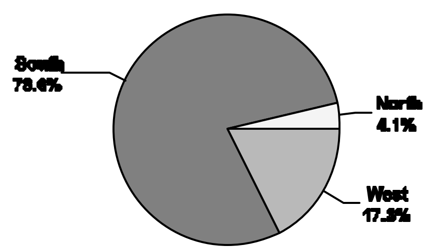
States that planted more than 100,000 acres of trees in FY 1997	
State	Thousand Acres
Alabama	438
Georgia	397
Mississippi	282
Florida	193
South Carolina	166
Washington	158
Louisiana	144
Oregon	134
North Carolina	114
Arkansas	110
Texas	108

Tree planting by ownership category in FY 1997:

	Acres	Percent of All Planting
Federal Government		
National Forests	158,918	6.0
Department of the Interior	13,956	0.5
Other Federal Agencies	15,571	0.6
Total	188,445	7.1
Non-Federal Public		
State Forests	37,430	1.4
Other State Land	15,732	0.6
Local Government	49,551	1.9
Total	102,713	3.9
Private		
Forest Industry	1,188,362	45.1
Other Industry	56,971	2.2
Nonindustrial Private	1,099,611	41.7
Total	2,344,944	89.0
Grand Total	**2,636,102**	**100.0**

Total planting and seeding by region in FY 1997:

Region	Acres	Percent of All Planting
North	108,230	4.1
South	2,070,849	78.6
West	457,023	17.3
Total	2,636,102	100.0



FOREST BANKING

Kent Gilges[1]
The Nature Conservancy
Rochester, New York

Mission Statement

The mission of the Forest Bank is to promote, in partnership with private landowners, the economic productivity of working forests while protecting the biological diversity of the landscapes in which they occur.

Background

The Nature Conservancy

Since 1951, The Nature Conservancy has been pursuing its mission of preserving biodiversity through a range of land protection strategiesCownership, conservation easements, and related management agreements that ensure conservation-oriented stewardship of ecologically sensitive places. In the past year, the Conservancy surpassed a major milestoneCsuccessful protection of over 10 million acres of important natural habitat for a variety of plant and animal species.

Although the Conservancy=s track record in land protection is noteworthy, the organization has come to recognize that in order to meet its mission with greater effectiveness and broader impact in the decades ahead, it must become even more strategic and creative in developing tools for accomplishing its conservation goals. Recently, a science-based planning exercise enabled the Conservancy to pinpoint the highest priority sites within distinct Aeco-regions@ of the United States. Given the interdependent nature of ecosystems, leadership within the Conservancy has come to recognize that land acquisition will be a necessary but not sufficient approach to the abatement of critical threats in these priority sites. Indeed, the task of developing additional, genuinely innovative and replicable strategies for conservation that can be effectively deployed in hundreds of communities may well be the Conservancy=s greatest challenge in the coming years.

The Center for Compatible Economic Development

In 1995, the Conservancy created a special operating unit called the Center for Compatible Economic Development (CCED) to be an incubator of new ideas and strategies for achieving conservation goals by developing land uses, businesses, and products that protect important ecosystems while enhancing local economies and achieving community goals. CCED began working toward this purpose by collaborating with local Conservancy staff in a handful of selected locations to plan and execute initiatives that will simultaneously accomplish conservation and development goals.

Now in its third year, CCED is expanding its reach through fellowship programs that will bring in 20 new partner sites over the next several years. CCED will select some of these Conservancy sites, as appropriate, for implementation of compatible economic development initiatives in forestry, agriculture, tourism, and related business areas. The Forest Bank idea, which is described in the pages that follow, will be piloted in several regions, beginning with the Clinch Valley in central Appalachia, and most likely followed by sites in the Great Lakes region as well as southern Indiana.

Overview

Genesis of a New Strategy for Forest Stewardship

For the past several years, CCED has been undertaking a series of assessments focused on various aspects of the forest industry in a central Appalachian region known as the Clinch Valley. As CCED and Virginia Chapter staff developed ideas for promoting sustainable forestry practices in this region, a new concept evolved. Combining The Nature Conservancy=s proven land protection strategies with current forest management and marketing ideas, CCED created an innovative concept called the Forest Bank. Designed to offer landowners a new tool for managing forest land in an ecologically sound and economically productive fashion, the Forest Bank idea has been developed and refined over an eighteen month period.

An Old Problem

Forested land often provides the ecological buffer surrounding and supporting critically threatened species and habitats. As the intensity of human use of the forest increases, the conservation buffer provided by the forest decreases. Threats such as fragmentation, erosion, and unsound harvest practice can affect many aspects of a forest, from its viability for threatened species to the secondary impacts on surrounding watersheds.

Over the coming decades, demand for domestic forest supplies is expected to outstrip supply, particularly given severe cut backs in production from the Pacific Northwest. Demand for wood products is driving prices up. And this demand for wood often hits hard on the nonindustrial private landownersSthose who have traditionally faced a very limited array of options for managing their valuable resources. A recent study by the United States Forest Service found that 90 percent of forest owners nationwide have holdings of 100 acres or less. Choices regarding harvest and development of such forest land are often made for reasons unconnected to ecological concerns. The need for cash to meet estate, education, or medical needs may force a landowner to liquidate his/her forest asset. Often, the landowner does not have the knowledge or time to monitor the cut to ensure it is done in a sustainable way. When this happens, the resource is usually degraded and conservation values are often compromised.

While these conditions present a potential ecological threat to regions with harvest-age timber, they also present an opportunity for implementation of new, market-based forest management strategies. Products derived from timber that is sustainably harvested can take advantage of increasing demand in a growing number of niche markets.

A New Solution

The Forest Bank is an idea developed for private, nonindustrial landowners. By making a depositCor a transfer to the Forest Bank of the right to grow, manage, and harvest trees while retaining fee simple ownership of underlying landCparticipating landowners would receive the following services and guarantees:

1. An ironclad promise that the deposited forest will remain forest forever and will, henceforth, be managed sustainably to contribute functionally to the ecosystem of which it is a part.

2. A modest, regular financial return, or Adividend payment,@ calculated on the basis of the deposited timber=s appraised value.

3. The option, when facing financial need, of Awithdrawing@ the deposit by obtaining cash value of the timber without having the trees cleared off their land. The right to withdraw will be made available with certain restrictions, similar to those accompanying familiar commercial bank certificates of deposit, such as Asubstantial penalty for early withdrawal.@

In contrast to virtually every other effort to promote sustainable forestry on private lands, the Forest Bank strategy *guarantees* permanent protectionCand permanent control of forest management decisionsCthrough the irrevocable acquisition of timber rights. Although certification does not guarantee perpetual protection, it does present an important, complimentary strategy that, used in combination with the Forest Bank, would provide a compelling, market-based incentive structure for promoting sustainable forest practices. The two are mutually reenforcing.

Target Participants

The Forest Bank is designed for private landowners with a desire to maintain and preserve their forests on the one hand, and a need for access to its financial value on the other hand. The following are just a few indicators underscoring the appeal that the Forest Bank is likely to have:

$ In an effort to understand the motivation behind forest ownership, the U.S. Forest Service recently conducted a survey of nonindustrial private landowners. It found more than a quarter of the respondents owned forest land because it is part of a residence; those listing recreation or aesthetic enjoyment as a primary objective accounted for another 20 percent. Only 9 percent own the asset as a land investment, and a mere 3 percent list timber management as the primary purpose.

$ In the course of completing Forest Bank feasibility analyses, one-on-one interviews were conducted with private landowners in the Clinch Valley who fit the profile of the target market. In aggregate, these landowners controlled about 4,500 acresSa mere fraction of the watershed but nonetheless a representative sample of the Clinch Valley region. About 70 % expressed a direct personal interest in the Forest Bank. Furthermore, nearly all believed the idea would appeal to other landowners in the region.

The Importance of Conserving Private Forest Land

Of all forest land in the United States, only 17 percent is under National Forest jurisdiction, with another 10 percent under other public control. The remaining 73 percent is in private hands. Furthermore, of all privately owned forest land in the United States (393 million acres), about 60 percent is held by nonindustrial interests; the remaining is split between corporate control (27 percent) and partnerships, clubs, associations, and Indian tribes (14 percent).

The nature of harvesting practices on private lands will have significant implications for the health of our nation=s forests because nearly half of all timber harvested comes off private, nonindustrial land. Measured in total cubic feet of timber harvested, the breakdown is as follows: national forest 12 percent; other public forests 6 percent; private forest industry 33 percent and other private 49 percent. As more public land is taken out of production, there is increased demand on privately owned forest land. Unlike most industrial land, nonindustrial private forest land is vulnerable to significant external pressure, which typically comes from logging and timber concerns that have no long-term interest or stake in the health of the forest. Moreover, much of this land is ripe for timber harvests. Owners of over 60 percent of private forest land indicate they intend to harvest within the next one to ten years. Owners of another 23 percent will consider harvesting.

Long-term Prospects for Broad Application

The Forest Bank model is intended to be fully and broadly developed as a widespread tool for forest conservation within The Nature Conservancy and beyond. Although the initial handful of pilots will be dealing in tens of thousands of acres, the eventual impact, in terms of replication and results, is expected to be significantly greater.

The Conservancy=s track record in land procurement, and the expertise it has accumulated, is leading the institution toward greater decentralization of staff, offices, and operations. The organization already operates through 50 state offices, each increasingly responsible for their own management, fundraising, and operations. In early 1998, The Nature Conservancy Board of Governors endorsed the decision to move the organization toward even greater decentralization. Current plans call for the establishment of hundreds more local Conservancy offices during the coming decade.

A major challenge during this next phase of the Conservancy=s development will be to effectively staff and manage local offices, and to help them become valuable agents for conservation in their communities by supplying them with innovative strategies and tools for conservation and compatible development. The Forest Bank is one of the most promising new concepts for meeting these objectives, and has great replication potential throughout The Nature Conservancy and beyond.

Feasibility Studies Completed in Support of Forest Bank Planning

Over the course of 18 months, a planning team, comprised of CCED as well as other Conservancy staff, worked with outside experts through a series of complex research exercises to determine the feasibility of the forest bank. These exercises focused on the Clinch Valley region, although additional feasibility work is currently being undertaken in other parts of the country. The Clinch Valley assessments that were conducted include:

1. Mater Engineering of Corvallis, Oregon conducted two consecutive studies:

   A. The first was a major study of the forest industry in the region. It provided a wide-ranging market assessment for wood products from the Clinch Valley, with demand and supply analyses as well as interviews with landowners, primary and secondary wood product manufacturers, and wood product retailers. This study also included interviews with private landowners about initial reactions to the Forest Bank concept.

   B. The second Mater study produced a financial feasibility analysis for the Forest Bank, using data generated through the complementary studies listed below. This exercise produced detailed financial models for determining the economic viability and the initial capitalization needs of the forest bank.

2. David Tice, President of North American Resource Management, Inc. of Charlottesville, Virginia completed comparative environmental assessments of forest harvesting regimes, and compared these with current certification standards. Tice also assessed these emerging standards in reference to the forests of central Appalachia, and used existing software for simulating various certifiably sustainable harvesting regimes on such forests.

3. Canal Forest Resources of Charlotte, North Carolina conducted a hardwood price analysis chronicling regional product prices and projecting best, worst, and most likely estimates of future prices.

4. The law firm of Winston & Strawn, headquartered in Chicago, Illinois, was commissioned to assess tax and related legal issues that need to be considered and resolved in advance of launching the pilot Forest Bank. This investigation focused not only on the proposed structure of the Forest Bank, but also on implications for transactions with depositors, with the objective of making the Forest Bank transactions simple for depositors.

Forest Bank Core Principles

$ Maintain and enhance the health of the entire forest.

$ Optimize the return to our depositors and maximize their satisfaction with our management.

$ Protect the soil productivity of our forest land and the water quality of our streams and rivers.

$ Create economic value from the forest resources by pursuing premium markets for our products.

$ Grow the highest quality timber possible of native species on any particular site.

$ Emulate the natural dynamic processes and disturbance patterns of the forest and minimize the impacts of our harvests.

$ Become a national model for the sustainable management of nonindustrial forests.

$ Continually reassess our methods and operations and look for ways to improve the Forest Bank.

[1]Kent Gilges is the Director of The Forest Bank, a new business being developed by the Center for Compatible Economic Development at Nature Conservancy. Prior to this assignment, Gilges directed the Northern Lake Huron Bioreserve in Michigan=s Upper Peninsula for the Nature Conservancy. He received his Bachelor=s degree from Cornell University and his Master=s degree from Oxford University.

Session 1

Status of Office Surface Mining/State Reforestation Efforts

Chairperson:
Mary Josie Blanchard,
Office of Surface Mining
Washington, D.C.

State Statistics on Eastern U.S. Tree Planting Efforts
Mike Sponsler, Indiana Division of Reclamation, Jasonville, Indiana

State Statistics on Western U.S. Tree Planting Efforts
Michael Long, Colorado Division of Minerals and Geology, Denver, Colorado

OSM Revegetation Team Survey Results
Scott Boyce, Office Surface Mining, Washington, D.C.

Summary Report on State Reforestation and Tree Planting Statistics
Greg Conrad, Interstate Mining Compact Commission, Herndon, Virginia

STATE STATISTICS ON EASTERN U.S. TREE PLANTING EFFORTS

Mike Sponsler[1]
Indiana Division of Reclamation
Jasonville, Indiana

Eastern State Survey

In preparation for these discussions on reforestation, the Interstate Mining Compact prepared a survey to determine the state of knowledge concerning the planting of trees on both active and abandoned coal mined lands. Please keep in mind that the following data represents a very rough estimate at this point. Some were based on real data but many are best estimates based on personal experience.

Abandoned Mine Land (AML) Survey Results

Figure 1 illustrates the percent of forest land use in each of the eastern states. Alabama, Tennessee, Kentucky, Virginia, and Maryland have a large percentage of mined land planted to a forest land use. It must be understood that the acreage may not be large on a lot of these project sites. Percentagewise reforestation has been a large part of the eastern states' AML reclamation. In some other states like Indiana, we are looking at going back to sites that have been previously stabilized with grasses and replanting them with trees. Based on the best estimates produced by this survey, it appears that there are about 32,000 acres (Figure 2); 16 million (Figure 3) trees have been planted on eastern U.S. abandoned mined land sites. Alabama appears to be the leading planter of trees on AML sites.

The cost for planting these trees is estimated at $200 to $700 per acre above that amount required to establish a grass cover. It was closer to the $200 amount in the appalachian states. In the mid-continent states, the costs were higher with the exception of Texas where planting with trees is less expensive than managing for coastal burmuda grass.

In all of the eastern states, survival of trees is being achieved. In the appalachian states, tree growth is reported as poor primarily due to compaction. In the mid-continent states, growth rates are unknown, and it is suspected that compaction is a problem in terms of limiting productivity. Estimates ranged from poor to good. In the appalachian states, there is a tendency to look at forestry and wildlife habitat as a combined land use, whereas in the mid-continent states there are distinctly different land uses.

The survey indicated that a lot of the eastern states would support policy and rule changes that would increase flexibility for wildlife habitat and in the area of bond release. They would strongly support technology exchange and landowner education. The mid-continent states endorsed tree initiatives provided that soil capability requirements are not compromised. It was noted that in many cases, landowners did not want trees because they will be using the land primarily for agriculture and livestock. Compaction is an issue if you want to restore productivity. Many of the mid-continent states have limited AML funds and would plant more trees if additional funding for that purpose was made available.

Active Mining Survey Results

In the appalachian states, with the exception of Virginia and Maryland, there was a decrease of forest land use after mining (Figure 4). Ohio showed the largest reduction from 40 percent forested land use prior to mining to 5 percent after mining. Ohio believes that landowners in that state see mining as an opportunity to get their land cleared of trees so that it can be used for agriculture. Maryland requires that anything reclaimed with over a 12 degree slope must be put back to trees.

In the mid-continent states, there are loses in forest land use for the major coal producing states of Indiana and

Illinois with the exception of Texas (Figure 5). Both Texas and Alabama show a significant increase. However, there is an incentive to plant areas with trees for wildlife habitat as you only need to plant 250 trees per acre rather than the 450 trees per acre required for forest land use. The states of Indiana, Illinois, and Alabama all show a significant increase in percentage of land planted with trees for wildlife habitat (Figure 6).

Based on the data received, I would estimate that there have been 400 million trees planted in Kentucky alone (Figure 7) even though there has been a loss of 250,000 acres of forest land use. This large number of trees planted shows that the effort at tree planting has been substantial. I assumed that West Virginia planted half as many trees as Kentucky and came up with the figure of 200 million trees planted there. This means that there has been roughly over one half billion trees planted on reclaimed sites in the eastern United States.

Summary

In the mid-continent states, four out of twelve states showed an overall increase in forest acreage after mining. Four states showed acreage decreases after mining of greater than 10 percent. All major coal producing states showed an increase in reclaimed land planted to trees when you include both forestry and wildlife land uses. In the appalachian states, one state showed an increase in forest acreage after mining and three states showed a greater than 20 percent decrease. One state showed a 10 percent decrease. Compaction was noted as the major limitation to tree productivity in all states.

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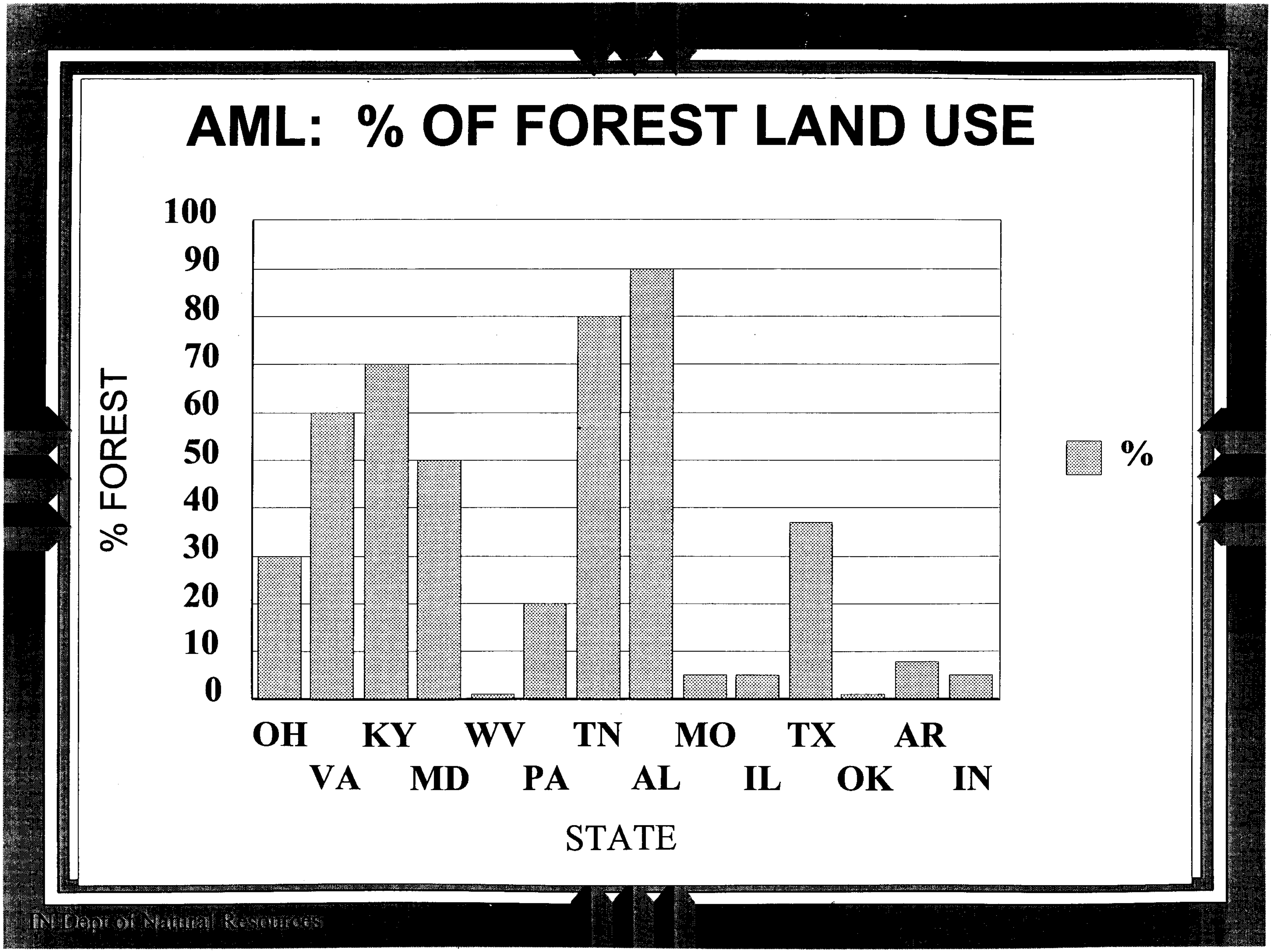
[1]Mr. Sponsler holds a B.S. in biology from the Illinois Benedictine College and a M.S. in zoology (wildlife ecology) from Southern Illinois University, Carbondale. He is the leader of the Indiana DOR, a program that regulates the tenth largest coal producing state in the nation. Permitting activities process over 8,000 acres yearly as well as reviewing over 1,000 permit applications. The Abandoned Mined Land Program receives $3-4 million annually and has performed over $70 million in mine reclamation remediation over the life of the program on over 200 sites. Previously he was assistant division supervisor from 1987 to1990 and a land reclamation specialist from 1979 to 1987 for the Illinois Department of Mines and Minerals, Land Reclamation Division. He also has served as chairman of the Interagency Stream Restoration Committee.



AML: % OF FOREST LAND USE
100
90
80
70
60
50
40
30
20
10
0
% FOREST
OH
VA
KY
MD
WV
PA
TN
AL
MO
IL
TX
OK
AR
IN
STATE
%
IN Dept of Natural Resources

Figure 1

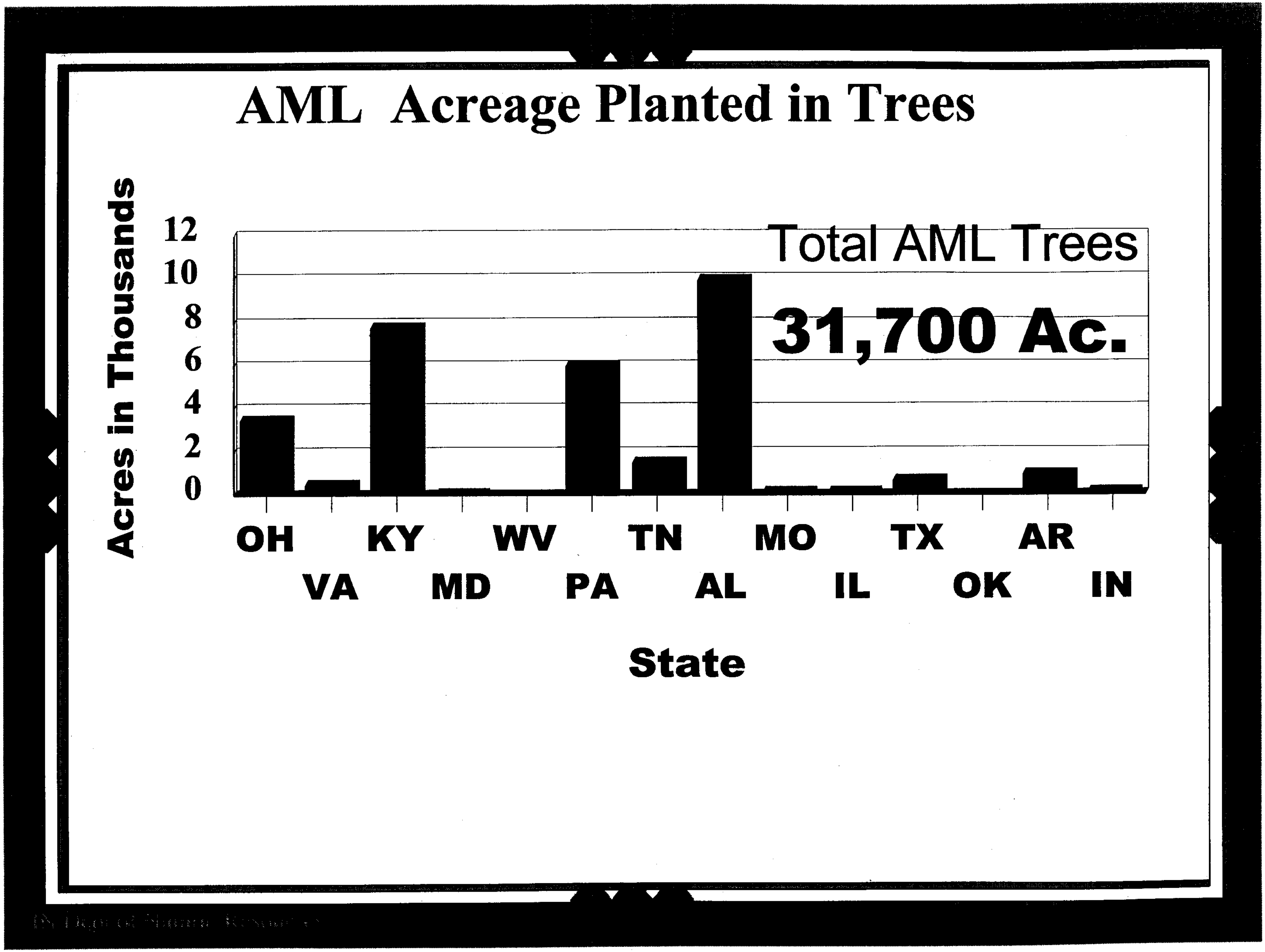

AML Acreage Planted in Trees
Acres in Thousands
12
10
8
6
4
2
0
Total AML Trees
31,700 Ac.
OH
VA
KY
MD
WV
PA
TN
AL
MO
IL
TX
OK
AR
IN
State

Figure 2

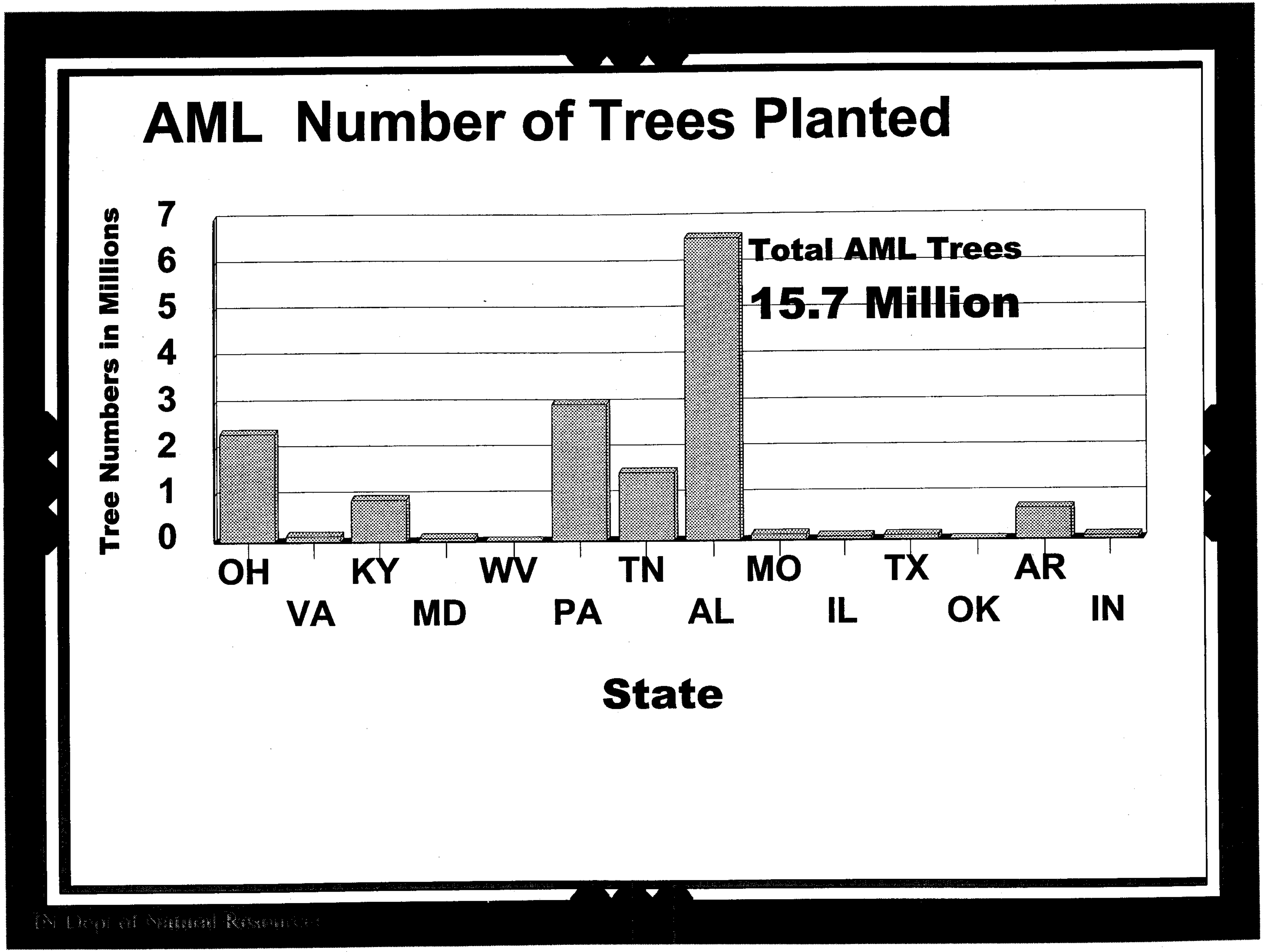
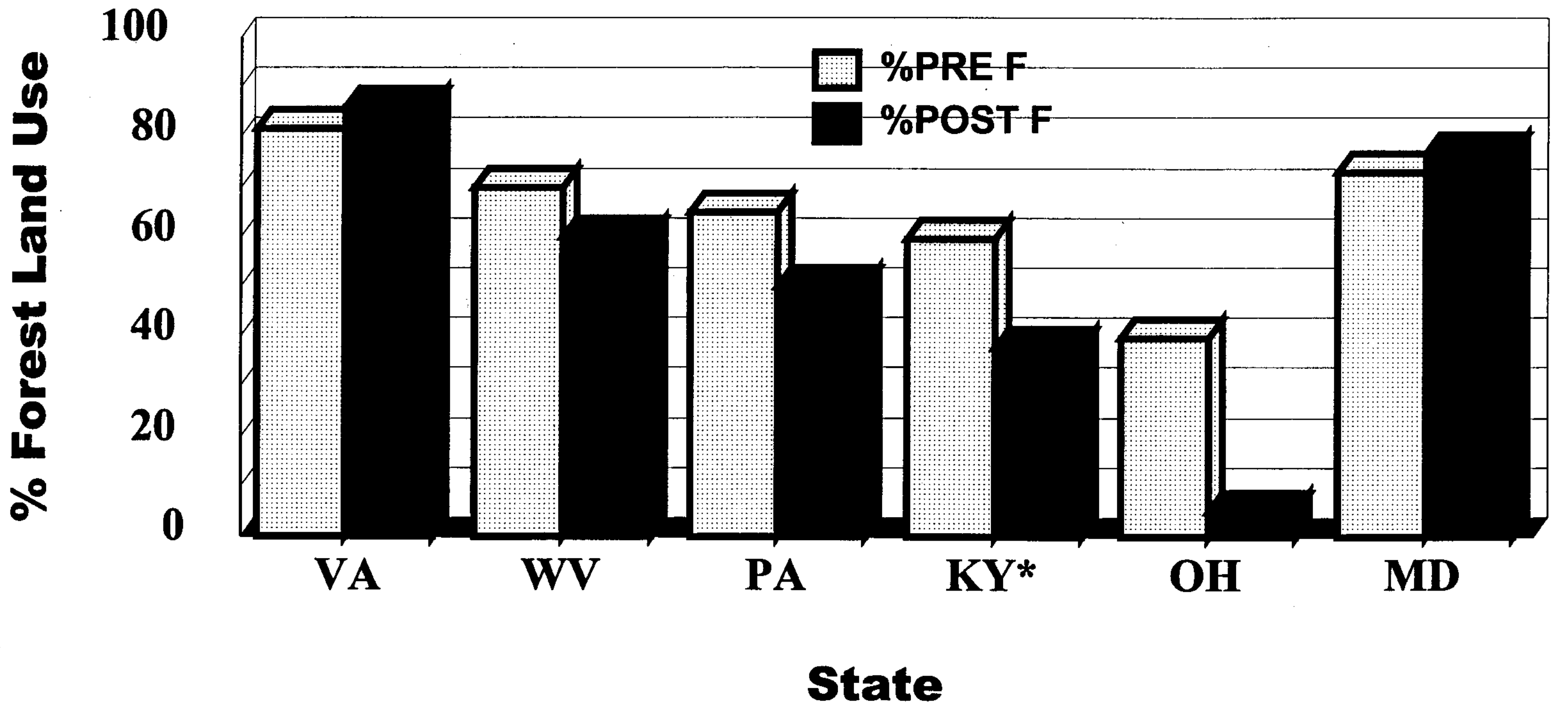

AML Number of Trees Planted
Tree Numbers in Millions
7
6
5
4
3
2
1
0
Total AML Trees
15.7 Million
OH
VA
KY
MD
WV
PA
TN
AL
MO
IL
TX
OK
AR
IN
State
IN Dept of Natural Resources

Figure 3

Title V: Appalachian Region Forest Use



* Kentucky reported loss of at least 250,000 acres of woodlands

Figure 4

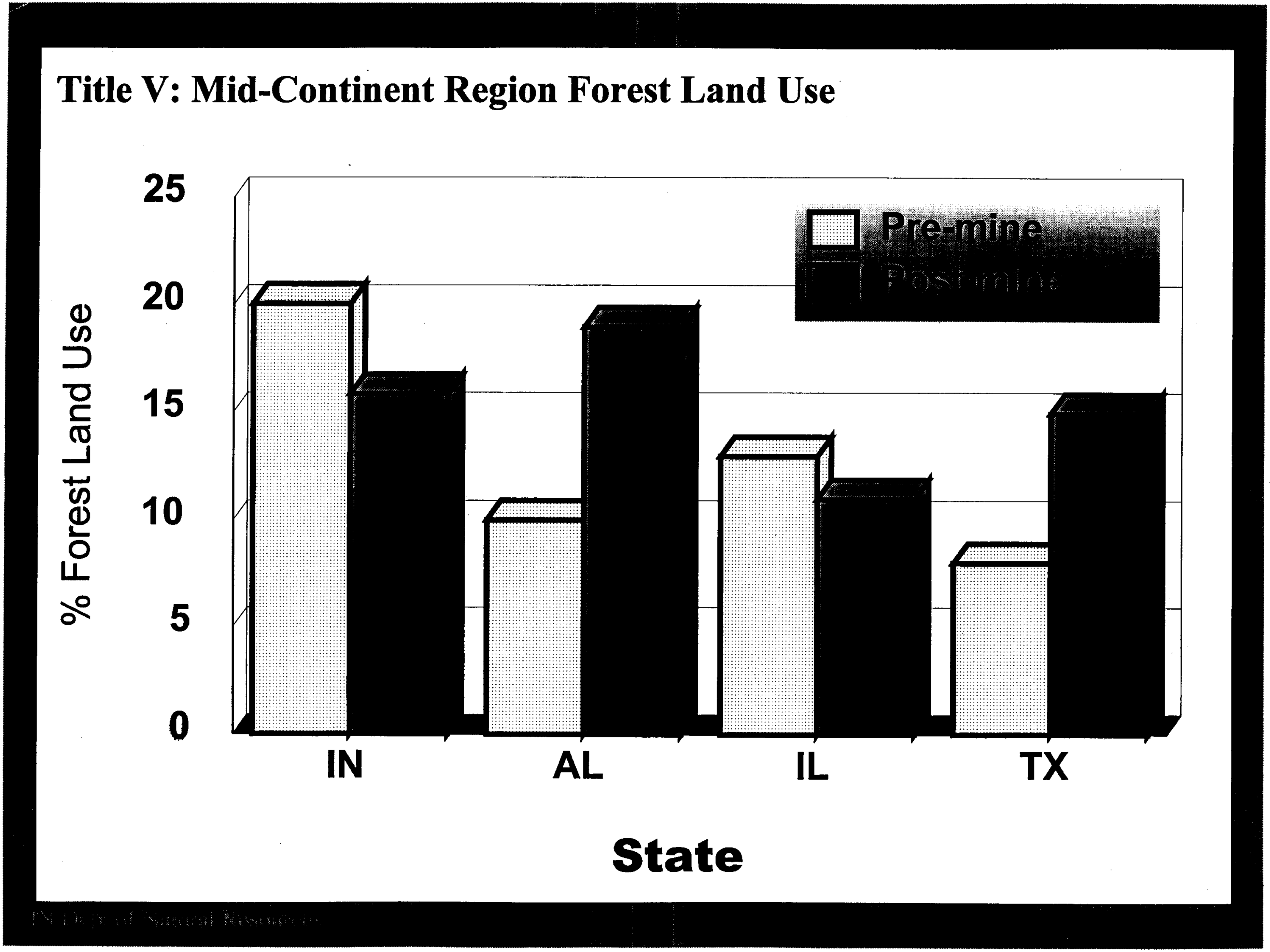

Title V: Mid-Continent Region Forest Land Use
25
20
15
10
5
0
% Forest Land Use
Pre-mine
Post-mine
IN
AL
IL
TX
State

Figure 5

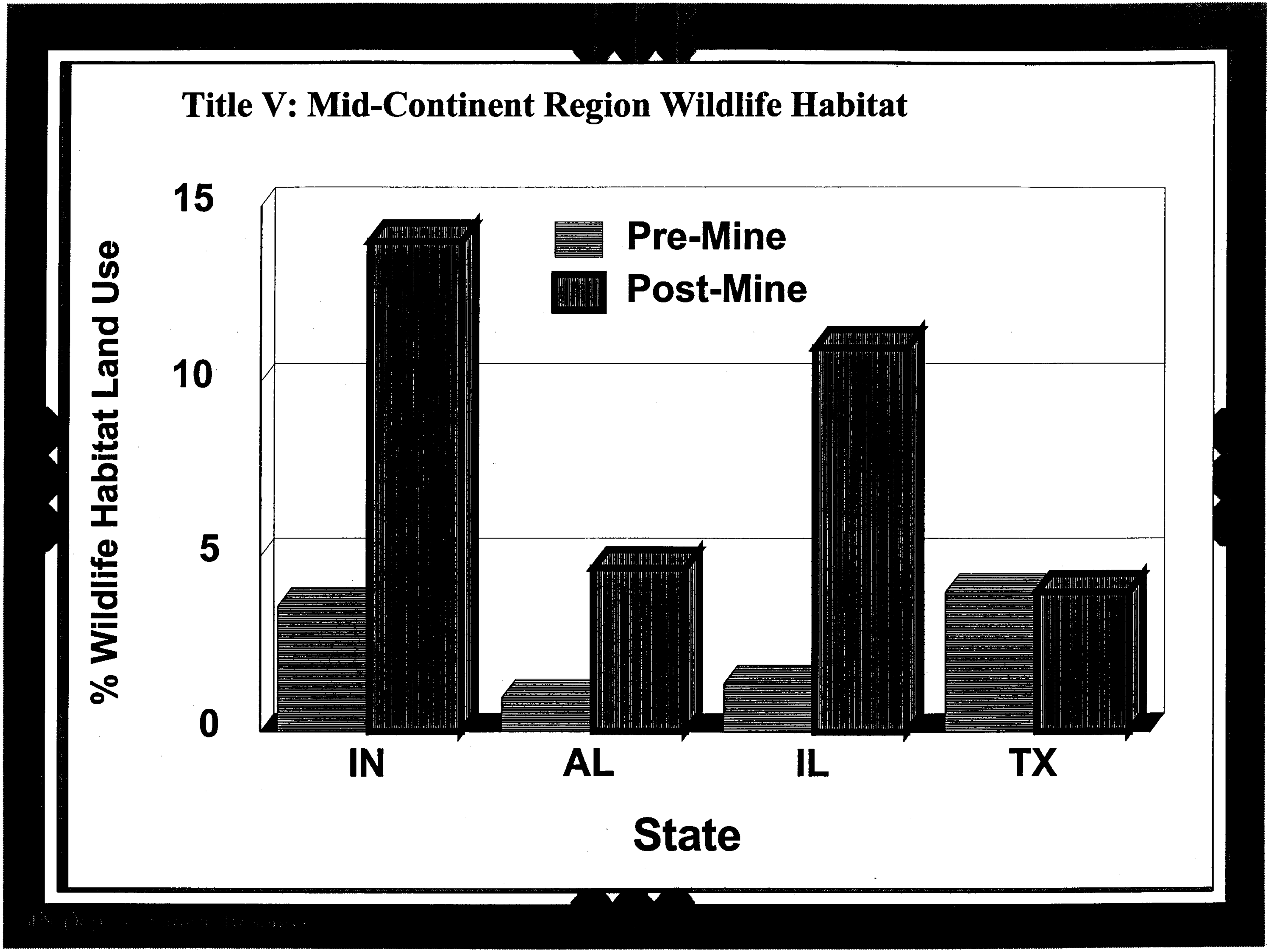

Title V: Mid-Continent Region Wildlife Habitat
% Wildlife Habitat Land Use
15
10
5
0
Pre-Mine
Post-Mine
IN
AL
IL
TX
State

Figure 6

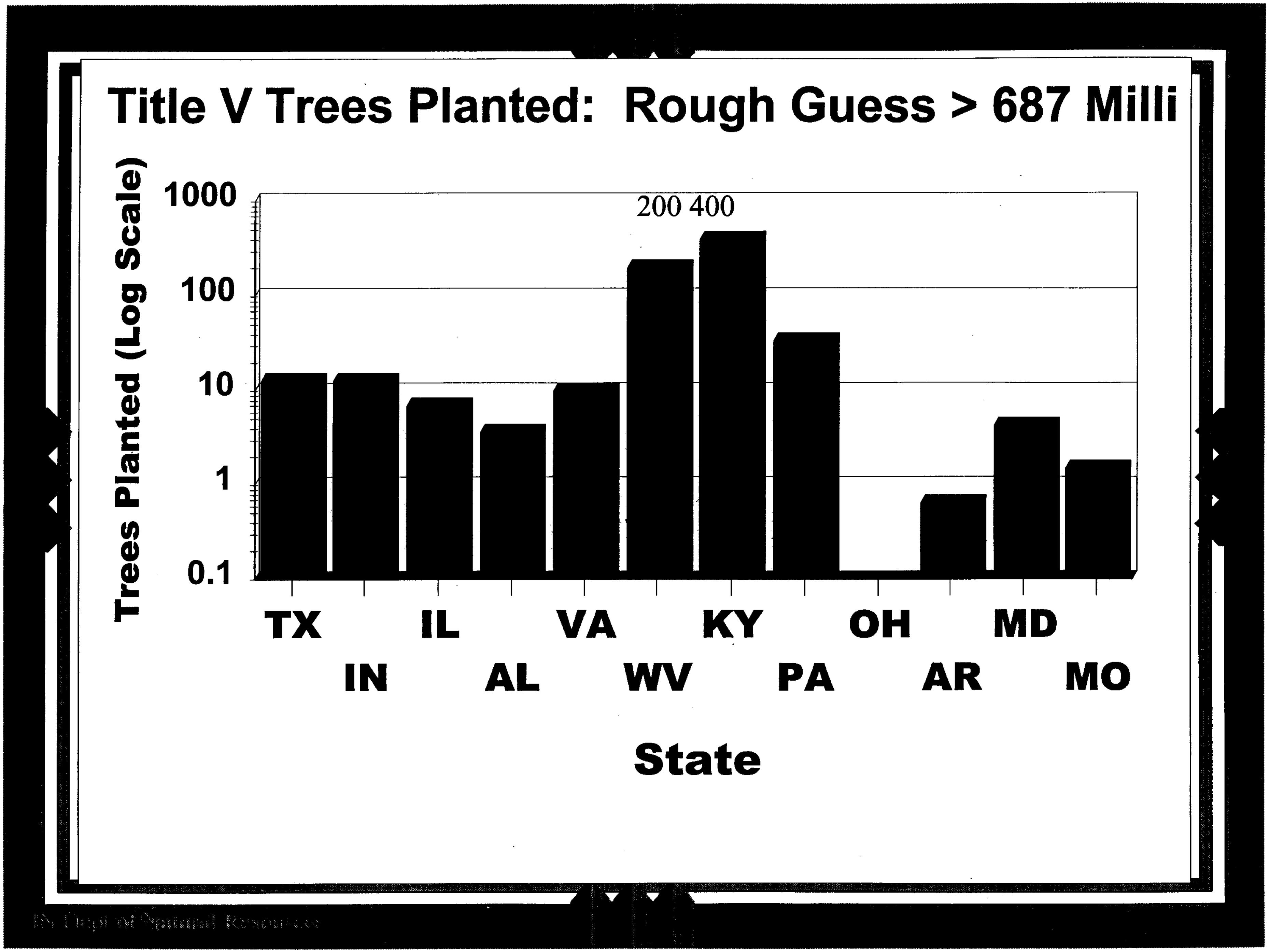

Title V Trees Planted: Rough Guess > 687 Milli
Trees Planted (Log Scale)
1000
100
10
1
0.1
200 400
TX
IN
IL
AL
VA
WV
KY
PA
OH
AR
MD
MO
State

Figure 7

STATE STATISTICS ON WESTERN U.S. TREE PLANTING EFFORTS

Michael Long[1]
Colorado Division of Minerals and Geology
Denver, Colorado

Introduction

When it comes to the coal mining regions of the West, forestry is really not a predominate land use or ecotype, with the exception of the state of Washington which is a federal program state. Currently, in the western states, the areas that are being mined are primarily range land with some woody shrubs. The only trees that you find are usually along water courses and in sheltered areas that we would consider to be wildlife habitat. We have had a significant problem related to the establishment of woody shrubs. These problems relate to climatic conditions and costs. The cost to replace shrubs is extremely high, usually around $1,000 per acre. We also face the problem of landowners who do not want shrubs reestablished. It is not unusual to spend a lot of time, money, and effort to reestablish shrubs on reclaimed areas and then have the landowner remove them after bond release. Most of the landowners in the West focus exclusively on vegetation that can be eaten by livestock.

Efforts on Abandoned Mine Lands

We do a lot of work on abandoned mine lands (AML) resulting from hard rock mining that usually occurred in the higher elevations that are forested. We have worked hard to reestablish trees on many of these high altitude AML sites where it makes sense. One of the biggest impediments to reforestation with trees in the West is due, not so much to the regulations as with constraints placed on the funds we receive for reclaiming abandoned mine lands. If we are able to start spending AML funds in the West to enhance the environment through revegetation, then I think we can begin to do more with reforestation in the higher elevations. We hope to discuss this more in the near future with the director of OSM. Currently, the priorities for these AML funds limit us to applications that focus on health and safety.

Active Mining Efforts

North Dakota is the leader in planting trees on active mine sites. They have established about 220,000 trees, which is a lot of trees for North Dakota. These are planted primarily along water courses and in wind breaks as wildlife habitat. Alaska has planted about 5,000 trees per year in both their active and AML programs for wildlife habitat. In Colorado, we are planting about 3,800 trees per year, mostly on forfeited bond sites and in the AML program. Utah has been replacing about 1,800 trees per year. In Wyoming, they are replacing primarily grasses and shrubs because that was the premining vegetation.

Summary

The opportunity for encouraging reforestation in the West really lies in the AML program. In terms of the active mining, it is a matter of encouraging the companies to reestablish the trees that were there prior to mining. This would include shelter areas for wildlife and along the water courses such as the cottonwood gallery forest. I do think we have a big education process that must be done for landowners. If there is an opportunity in the West, it may be in AML and where mining occurs on federal land. We should talk to the federal agencies that work with the coal mines on federal lands concerning their ideas for postmining land use where it is climatically and economically possible and beneficial to plant trees. We are supportive of OSM's initiative to encourage reforestation. We are now trying to determine what our role is in the process. We do want to look at ways that we can improve our reforestation efforts in the future. We are looking for ways to find research funds and additional AML funds to increase our tree planting efforts and success.

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[1]Mr. Long holds a B.S. from Southern Illinois University. He also did graduate work at SIUC and Western Michigan University. He has been with the Colorado Mined Land Reclamation Division since 1981. He has been Director of the Mined Land Reclamation Division since1992. In that capacity, he also has assumed responsibility for the Mine Safety and Training Program, the Colorado Geological Survey, and the Oil and Gas Conservation Commission. Previously he served as Deputy Director for the Indiana Department of Natural Resources.

OFFICE OF SURFACE MINING (OSM) REVEGETATION TEAM SURVEY RESULTS

Dr. Scott Boyce[1]
Office of Surface Mining
Washington, D.C.

Background

On May 13, 1998, OSM headquarters held a planning session entitled Reforestation of Mined Lands and Carbon Emission Offsets. I left that planning session with the sense that a lot of land that should be returned to forestry for a whole host of reasons, only one of which was carbon sequestration, was not being planted to trees.

The OSM Revegetation Team met the next day as part of the planning for the Reforestation at Surface Coal Mines: Policy Outreach Symposium, which was held in Washington, D.C. on January 14, 1999. The OSM Revegetation Team is a group of six individuals within OSM who have met over a number of years to address issues associated with revegetation. In the meeting, we considered the question of what OSM needed to do to encourage reforestation of lands mined and reclaimed under Title V of the Surface Mining Control and Reclamation Act (SMCRA). It was our view that the low utilization of the forestry land use option following mining was primarily due to the way the Act was being implemented rather than being due to technical constraints. The fix, we felt, would in all likelihood require changes to policy, and perhaps regulations, of both OSM and the states. We also felt that industry mind set and culture, right down to the level of the dozer operator, was part of the problem. Given the prevalence of long standing practices and a "culture" of reclamation, some of it going back to before SMCRA, we felt that education would in all likelihood be part of the solution to the problem. We also recognized a tension between need to protect water quality in the short run and the longer view needed for the establishment of trees on mined land.

Another factor that we thought might play a role is the fact that some state regulations are "<u>stricter</u>" than federal regulations in that they still reflect the interim regulations requiring the elimination of gullies that are greater than 9 inches deep. Alternately, these regulations might be considered to be not as effective as the federal regulations in that they discourage forestry as a land use and encourage the production of an over compacted landscape stabilized with sod forming grasses and with reduced biological productivity compared to levels that potentially could be achieved. A search of COALEX indicated the following states have the gully rule in their regulations: Pennsylvania, Alabama, Kentucky, Mississippi, Illinois, Louisiana, Texas, Colorado, Montana, North Dakota; Maryland and Missouri have the rule with modifications attached.

The team also recognized that certain practical impediments to reforestation exist owing to the lack of readily available and appropriate planting materials, inherent risks from drought and animals (deer, mice), and competition from grasses required for erosion control.

The problem we faced, then, was to determine how to obtain creditable information that would confirm or refute our initial view and that would reflect on the factors affecting land use choice in the states.

OSM Reforestation Survey

Our solution was to request that the National Mining Association (NMA), the Interstate Mining Compact Commission (IMCC), and the Western Interstate Energy Board (WIEB) conduct a survey concerning certain reforestation information. On August 4, 1998, we sent a letter to NMA, IMCC, and WIEB requesting that they identify:

- impediments to planting trees under OSM and state regulations;

- regulatory or policy changes that would eliminate or offset these impediments;
- research that might offset the identified impediments; and
- incentives that would prove helpful in significantly increasing the use of forestry as a postmining land use.

We also asked these organizations to suggest state personnel who would be appropriate to be part of a team that will address the issues identified as a result of the questionnaire and to suggest industry contacts who would be willing to review and comment on team products. The reason for this peculiar structure lies in the Federal Advisory Committee Act which governs the interaction of the Federal Government and industry advisory groups.

Responses to the Reforestation Survey

Certain themes were clear in the responses to our questionnaire:

- Cost was clearly an issue affecting land use choice. It is probably worth noting that the regulations relating to land use and revegetation are unique among our regulations in that they provide a selection of performance standards from which the industry may choose. That is to the extent that the operator, working with the landowner, can determine the land use choice from among various land use/revegetation options that have different costs associated with them.

- Risk was also identified as a factor in land use choice. In the simple model, risk translates into potentially greater costs, and there is an obvious need for the coal industry to try to minimize both.

- Research, or lack of technology, was not considered to be part of the problem. However, based on information presented at the policy outreach symposium, I have modified my views on this subject as will be discussed later.

- Second guessing relates back to risk and cost again. One respondent clearly articulated the idea that industry prefers rules where the meaning is clear and not subject uncertain interpretations by the state regulatory authority or OSM. In light of this concern, the pastureland use is a clear first choice for many coal operators. But we are not dealing with a simple independent variable here; the possibility of second guessing translates into risk which affects potential costs.

- Nine inch gully rule. As mentioned earlier, enforcing this rule, which requires any gully greater that nine inches deep to be eliminated, would tend to discourage reforestation where development of large but stable gullies is more likely than in the pastureland use and fixing them is more difficult.

- 80 - 60 rule. The requirement that at the time of bond release 80% of the woody vegetation be in place for 60% of the applicable minimum period of responsibility was seen as discouraging reforestation as it portends the possibility of delayed bond release. But again, repairing gullies and delaying bond release ultimately effect the cost of reclamation.

Observations After the Reforestation Symposium

My mind set before the policy outreach symposium was that reclamation before SMCRA often involved refore-station, but after the passage of SMCRA reclamation usually resulted in pasture. The frame of reference here is primarily appalachian and midwestern areas. After the symposium, I had to modify my view. The situation apparently varies widely by state. The qualitative information presented at the policy symposium indicates that a significant amount of mined land is being reforested in some states and very little in others. In Virginia, for example, 86 percent of the land mined since 1991 is reported to have been reclaimed to forest and in Maryland the figure is 70 percent of the land since 1988 (data submitted in response to our questionnaire). In Ohio, on the other hand, since the implementation of SMCRA , only one percent of the land has been returned to forest whereas 90 percent was forested before mining (Kaster, Gary and John P. Vimmerstedt, 1996). In West Virginia, a similar situation exists. A Forest Service inventory of the acreage of forest lost to mining (111,000 acres between 1989 and 1995) closely compares to the acres disturbed as recorded by OSM (Burger, James A. and William R. Maxey, 1998). One must view these numbers with a good bit of caution. Some represent best guesses that are taken on faith and others come from published materials. But it does seem safe to conclude that the situation varies widely from state to state.

A significant question before us relates to the quality of the reclaimed forest land. If there is one idea that came out of the policy symposium loud and clear it is that overcompaction of the rooting medium is the norm. But why is this the case? To some degree, I believe it relates to fundamental tensions in the Act.

There are tensions in SMCRA and its regulations that are germane to the issues at hand. An example of a tension in the regulations is the need to protect water quality and the need, or at least desire, to encourage reforestation. Sod-forming grasses can't be beat for stabilizing soil and preventing sedimentation problems. However, if one wants to establish trees, it is necessary to reduce the use of sod-forming grasses for erosion control and find either a more complex, more expensive, or higher risk method of preventing erosion. Programmatic overemphasis on erosion control (the term erosion appears 95 times in the federal regulations) may militate against forest as a land use choice. If we as regulators are going to "hammer the industry" for sediment violations, why should they choose a final land use that is likely to result in water quality violations or necessitate rill and gully repairs. I have heard the idea expressed that even pre- SMCRA emphasis on erosion control reduced tree planting. We apparently are dealing with fundamental tradeoffs here; you can't maximize erosion control in the short run and reforestation at the same time. Ironically, forests, once established, result in excellent erosion control and water quality.

There is another more fundamental tension in the act itself that I believe is very relevant to our desire to encourage reforestation. We are instructed in SMCRA to meet the energy needs of the nation and protect the environment (two instructions that may be in conflict). It appears that in order to meet energy needs we approve permits for operations that inevitably will result in overcompaction.

Consider the following:

> Sec. 515(b)(2) of the Act. — "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 reasonable likelihood"
> Sec. 102(d) of the Act — "assure that surface coal mining operations are so conducted as to protect the environment"
>
> Sec 102(f) of the Act — "assure that the coal supply essential to the Nation's energy requirements, and to its economic and social well-being, is provided and strike a balance between protection of the environment and agricultural productivity and the Nation's need for coal as an essential source of energy"

But, to the best of my knowledge, we never articulate how the balance is being struck!

As stated earlier, it was clear at the reforestation policy symposium that overcompaction is the norm on reforested land. It can be argued that overcompaction is part of the price we pay for balancing the need for energy production against protection of the environment within the context of currently available technology. Our unwritten policy apparently is that we allow overcompaction as a necessary price of coal production in today's world.

To the extent the above is true, the solution to the problem of overcompaction lies more in the realms of research than policy. Perhaps research along the lines of that currently going on in Kentucky is necessary to reduce the environmental impacts of the unstated compromise, where reduced grading may provide a key to cost effective production of forest land with a high site index.

But judging from discussions, both formal and informal, at the policy symposium, this is not the whole story. Other parts of the problem includes an operator culture that desires precise grading, lapses in management that allow dozer operators to kill time while appearing productive through excessive grading, and simply failing to recognize that driving over recently replaced soil (rooting medium) with a scraper or truck in the process of replacing the topsoil is very damaging to the rooting medium and the future plant community.

I left the policy symposium with the impression that the percentage of land being returning to forest, where such is the appropriate land use, is greater than I anticipated, but that the quality of that land might prove to be unacceptable in the long run. Additionally, for the purposes of the symposium, we used a rather liberal definition of forest; a definition that included fish and wildlife land with woody vegetation. Thus, while it appears that a significant amount of mined land is being returned to forest in some states, it is not clear at this point whether or not all of this land should properly be classified as forest.

We came under criticism at the policy symposium for not considering productivity as a criteria for bond release of forest land. It is, after all, productivity that translates into board feet of lumber, tons of carbon sequestered, and dollars in the bank. Also, restoring the productivity of the land is necessary to fully meet the requirements of Sec. 515(b)(2) of the Act, i.e., "restore the land affected to a condition capable of supporting the uses which it was capable of supporting prior to any mining." I was curious how the authors of our regulations viewed the subject of productivity. While I was not able to research the subject in depth, a quick look at the preamble to the 1979 Permanent Regulatory Program (44 FR 14902, 15241, March 13, 1979) offers an interesting insight into what the authors of the regulations intended to accomplish. In response to a commenter addressing reforestation, it is stated that "(t)he regulations have a self-regenerative requirement for vegetation and the operator is held liable until the regulatory authority is satisfied that the status required by the regulations is achieved. When this is achieved, as in successful reforestation activities, the vegetation will continue to increase and the former biomass will be achieved in the future." At the present time, this looks like wishful thinking. But, the important point here is that appar-ently the authors of the revegetation regulations thought they were drafting regulations that would result in productive forests.

If indeed the regulations are not producing the desired result, perhaps they should be revised. Torbert et al. (1994), in a project funded by OSM, proposed a "white pine bioassay" as a way of evaluating the productivity of reclaimed forest lands. In the proposed test, the annual growth of young white pines, at least 25 per acre, planted as part of the tree crop or for test purposes, would be used to predict the site index of the reclaimed land. Another approach to overcompaction and the resultant low forest productivity, might be to frame the regulations in terms of rooting media design standards and stocking specifications. The design standards would address how the top four feet of material is placed, and the stocking standards would continue to specify the number of live stems per acre required for bond release. The idea here is that appropriate design standards, if enforced, would result in a superior growth medium compared to what is currently being produced. In this case, the design standard and performance standard address variables that are, in a practical sense, independent. Thus, we avoid the undesirable situation of requiring the industry both to do something in a particular way and to obtain a particular result.

The concern was expressed at the policy symposium that allowing rough grading of spoil material, as a way of improving reclaimed forest land, might be used as a tool by the coal industry to avoid reclaiming the agricultural capability of the land in the Midwest. This does not appear to be an idle concern, but reflects political pressures that currently exist in at least one state. I believe this concern deserves our attention. Sec. 515(b)(2) of the Act makes a clear statement of the requirement to reclaim "the uses which it (the land) was capable of supporting prior to any mining." Reduced grading and planting with trees in the Appalachian environment is clearly an effort to reclaim the land use capability that is not currently being reestablished. Applying such an approach in the Midwest, where typically arable soils exist before mining, would fly in the face of the requirement of Sec. 515(b) (2). But, from a legal perspective, just how vulnerable to challenge are the regulations aimed at reclaiming the multiple capabilities of the land? My sense is that, if logic prevails, deep productive soils that provide multiple land use capabilities cannot be replaced with overburden that is capable of supporting tree growth but which is of limited utility for supporting agricultural production. OSM articulated a position in its approval of an Ohio Regulatory Program Amendment addressing undeveloped land which I believe has relevance here (59 FR 22507, 22514, May 2, 1994). In that rule, the requirement for reclamation of the uses the land was capable of supporting before mining is separated from the revegetation standards. The document states "section 508(a) of SMCRA and its legislative history (S. Rep. No. 128, 95th Cong., 1st Sess. 77 [1977]), provide that the demonstration that premining capability can and will be restored must be made as part of the reclamation plan submitted with the permit application. Thus, the land use restoration requirements of section 515(b)(2) are addressed primarily through the permit application review process, and compliance is achieved by adherence to the reclamation plan and other performance standards such as those pertaining to toxic materials, topsoil, and backfilling and grading."

Given that the Act at Sec. 515(b)(2) requires that the uses (plural) that the land was capable of supporting prior to mining are to be restored, I find it difficult to understand how a mining and reclamation plan could be approved that significantly reduced the agricultural capability of the land. Unfortunately, countering this argument is the realization that arable land in the Midwest has often been reclaimed to pasture that is no longer arable. Is this reduction in land use capability part of the unstated compromise to allow coal mining to occur? Once again, I don't know the answer, but experience indicates that we cannot categorically deny the possibility that forests would be established on reclaimed land which has significantly reduced capability compared to the premined land. Ultimately, protection of the agricultural resource requires an ongoing commitment to that end and the political will to make it happen.

Considerations for the Future

As we look to the future and try to facilitate reforestation where it is appropriate, I think there are some questions we as regulators need to ask ourselves:

- How much of the overcompaction we accept today is necessary to allow mining to occur and how much represents regulatory failure?

- Does our failure to directly address the productivity of reclaimed forest lands represent a regulatory failure?

- Maybe there are other approaches to regulation that we should consider, e.g., design standards for the replacement of the top four feet of material.

- Maybe we simply need to enforce existing soil handling regulations. 30 CFR 816.22 requires that soil substitutes be the best available in the permit area to support vegetation and that excess compaction be prevented. My impression is that we give little attention to selective overburden handling beyond that required to keep toxic materials out of the surface, and it is clear that we allow excessive compaction to occur.

- And, the ultimate question, do we have to revise the regulations to encourage reforestation in order to improve the quality of the reclaimed forests, or can adequate improvement be achieved through policy initiatives and research?

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SUMMARY REPORT ON STATE REFORESTATION AND TREE PLANTING STATISTICS

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Introduction

On November 23, 1998, in anticipation of the Office of Surface Mining's (OSM) Policy Outreach Symposium on Reforestation at Surface Coal Mines on January 14, 1999, the Interstate Mining Compact Commission (IMCC) distributed a survey to all coal-producing states seeking information and statistics on state reforestation and tree planting efforts. A request for supplemental information was sent to these same states on February 1. As of March 15, 1999, 21 states had responded to the survey. A copy of the survey and a summary of the responses (by OSM region) are attached to this report. Of the 21 states that responded, several provided reforestation and tree planting information for both their Title IV (Abandoned Mine Lands) and Title V (active mining) regulatory programs, including Ohio, Virginia, Arizona, New Mexico, Utah, Iowa, Illinois, Indiana, Kentucky, Maryland, Missouri, Pennsylvania, West Virginia, Colorado, Arkansas, and Wyoming. Other states provided separate reports for each program area, including Alabama, Texas, and North Dakota. Two states, Oklahoma and Tennessee, provided information for only their Title IV AML programs. An analysis by OSM region of the responses to the survey follows.

Western Region

It will come as no surprise, given the geographic and climatic conditions of the arid West, that tree planting and reforestation efforts are quite minimal. Any tree planting that does occur is usually done in conjunction with a wind erosion control plan or as a wind breaking technique associated with farmsteads. Any woodlands that are created are usually part of a wildlife habitat enhancement project, not as commercial forest land. Most of the active mining areas in the West are classified as grazing land/wildlife habitat and consist of dry grassland and low shrubs. The same is true of abandoned mine land areas, where trees may be selectively placed for diversity as part of a wildlife habitat enhancement plan.

Those western states that responded to the survey indicated that they would endorse appropriate initiatives to enhance reforestation efforts on reclaimed lands for both Title IV and V programs. However, there was concern about lessening reclamation standards or environmental protection; demonstrating that the post-mining land use makes sense; and assuring surface owner consent for additional tree plantings.

Among the various initiatives that attracted the most interest from the western states were appropriate rule changes, technology exchange, education of landowners, and awards or recognition programs.

In terms of actual tree plantings, a total of 215,000 trees were reported planted at active mining sites in the region; a total of 22,000 trees were planted on Title IV sites.

Mid-Continent Region

Although the states reporting for the Mid-Continent Region did not show significant percentages of forest land as a postmining land use (the average being about 18 percent), the actual number of tree plantings is encouraging. This is especially true in those instances where tree plantings occur as part of a wildlife habitat enhancement program. The quality of the forest land was reported as medium to high for most states. Percentages of abandoned mine land reclaimed to forest is generally in the 5 to10 percent range, except for Alabama, where remarkable progress has been made. In terms of the relative cost of planting trees in comparison to other postmining revegetation efforts, trees typically cost more, in some instances up to 50 percent more.

The mid-continent states generally endorse initiatives to enhance reforestation efforts, but with several caveats. There is a universal concern that any enhancement efforts not reduce the quality of reclamation under the banner of a reforestation initiative. This is particularly true in the areas of soil capability standards, compaction require-ments, and soil resources. States expressed concern about reforestation initiatives reducing the capability of the land to support the same or similar land uses that existed prior to mining. Landowner support for increased tree planting was also identified as potentially problematic. On the AML side, there was universal agreement that the best enhancement for increased tree planting at AML projects was more AML money being allocated to the states from the AML Trust Fund. Landowner buy-in also was cited as a concern at AML sites.

In terms of the initiatives with the most promise, the mid-continent states supported policy/guidance changes and enhancements, particularly in the area of fish and wildlife habitat; regulation/rule changes; and education of land-owners and the public regarding the benefits of planting trees. This latter initiative was prevalent throughout the survey responses.

Actual tree plantings were remarkable for the Mid-Continent Region. A total of 20 million trees have been planted at active mining sites, mostly over the past three to five years. On the AML sites, 7,798,300 trees have been planted, with 6.6 million being planted in Alabama alone.

Appalachian Region

The average percentage of forest land as a postmining land use is the highest in the Appalachian Region, approximately 50 percent. Virginia was the highest at 86 percent. The appalachian states also reported the highest percentage of abandoned mine land being reclaimed to forest, an average of 60 percent. Interestingly, the relative cost of planting trees in Appalachia is the lowest in the country, averaging $250 per acre (although these figures may refer to incremental costs for planting trees).

With regard to initiatives to enhance reforestation efforts, the eastern states endorse such initiatives as long as they do not undermine existing regulatory requirements. One state, Maryland, actually requires trees and shrubs to be planted on all reclaimed areas. On the AML side, while states supported various initiatives to increase tree planting, they expressed concern about adequately resolving landowner desires. And in terms of those initiatives that received the most interest from the eastern states, policy/guidance changes or enhancement, technology exchange, education of landowners, and research topped the list.

Finally, tree planting efforts in the east were very encouraging. A total of 33.8 million trees were planted on actives sites over the past several years in Pennsylvania alone. Maryland has planted 4,273,000 trees on some 9,449 acres since 1943. On the AML side, 13,744,000 trees were planted throughout the region. Significant tree plantings on active sites (in the 100 million range) are likely in both Kentucky and Virginia.

Conclusion

The states have demonstrated a commitment to the planting of trees on both active and AML sites where it is possible to do so from a geographic and climatic perspective. Tree planting efforts have been remarkable, with at least 57 million trees having been planted on active sites over the past several years, and another 22 million trees having been planted on AML sites. These numbers do not reflect the significant tree plantings that have likely occurred at active mining sites in Ohio, Kentucky, and Virginia. The latter three states could easily account for another 300 million trees, based on estimates provided by academia and landholding companies. The states generally support initiatives to enhance reforestation efforts, as long as environmental protection and land use capability are not sacrificed or undermined. Perhaps the two most promising incentives to encourage tree planting are education of landowners and the public about the value of trees and appropriate policy and/or guidance changes that would clarify certain regulatory requirements such as wildlife habitat as a postmining land use and limitations

of the extended liability period where replanting occurs. For AML sites, a key element is increased funding for state AML projects.

It is likely that we will see continued efforts by the states to encourage the planting of trees at active and AML sites in the future. As long as this can be done in an environmentally sensitive manner, everyone will win.

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SUMMARY OF REFORESTATION SURVEY RESULTS — MID-CONTINENT REGION

1. Pre/post mining land uses — (see attached tables)

2. Quality of reclaimed forest land:
   - Arizona, Missouri, Texas — Medium
   - Alabama, Alabama-AML — High
   - Indiana — Unknown; survival is good; however, productivity is estimated to be low to medium based upon visual observations and site conditions that have thin or compacted soils.

3. Percentage of pasture that is abandoned post bond release:
   - Alabama — 0%
   - Alabama-AML — 0%
   - Arkansas — 14%
   - Illinois — 5%
   - Indiana — 5%
   - Missouri — unknown

4. Percentage of abandoned mine land under Title IV of SMCRA that was reclaimed to forest:
   - Alabama-AML — 90%
   - Arkansas — 8% (does not include wildlife shelter belts along drainage ditches)
   - Illinois — 25% (161 acres)
   - Indiana — 5 - 10%
   - Missouri — 5%
   - Oklahoma — Less than 1%
   - Texas — 37% (720 acres)

5. If information is available, please relate the relative cost of planting trees in comparison with other postmining land uses in your state. (NOTE: Some of the following figures may refer to the incremental cost of planting trees, not the total revegetation/reclamation cost.)
   - Alabama — Trees = $740 per acre; pasture = $640 per acre; undeveloped = $640 per acre
   - Alabama-AML — $252 per acre (cost of trees and labor to plant)
   - Arkansas — Less expensive than pasture due to less preparation and maintenance.
   - Indiana — $1400 per acre for trees; $700 per acre for grasses.
   - Missouri — Trees are more expensive than pasture but initially are less expensive than native grasses for wildlife habitat.
   - Texas — Tree planting is more expensive by about 50%.

6. With regard to initiatives to enhance reforestation efforts on reclaimed lands as part of the Title V regulatory program, our state:
   - Strongly endorses such initiatives: Alabama; Alabama-AML
   - Endorses such initiatives with qualifications:
     - Arizona — Concern about OSM efforts to abridge Arkansas' authority to plant conifers (i.e., shortleaf pine or loblolly pine) in a guise to subvert commercial monoculture. Also, would not want to see significant changes to recent forestry guidelines.
     - Illinois — We are concerned that there could be efforts to use this initiative to do away with soil capability standards.
     - Indiana — The premining capability of the land to support a variety of uses must be maintained by restoration of thick uncompacted soil layers. Soil resources should not be destroyed nor should inferior reclamation practices be allowed as an encouragement

of tree planting. We are leery that this initiative, as applied to our state, could be used as a platform to reduce the quality of reclamation under the banner of reforestation and to undermine currently pending court cases.

Missouri — Landowner must be committed to maintain reforested land approved in the permit application and not mow the trees down after final reclamation bond release in an attempt to convert the property to "more productive use."

Texas — Concerned about dealing with landowner preferences; concerned about land being reclaimed to a lower standard not capable of supporting land uses that existed before mining. Need to assure appropriate reconstruction of postmined soils.

7. With regard to initiatives to enhance reforestation efforts on reclaimed lands as part of the Title IV AML program, our state:

Strongly endorses such initiatives: Indiana, Alabama, Alabama-AML. However, this is dependent upon increased AML moneys to fund such initiatives.

Endorses such initiatives with qualifications:

Arizona — Trees are generally planted at the invitation of the landowner or when it is prudent to do so.

Missouri — Education of landowners regarding reforestation is essential. Also, need more AML moneys. Finally, OSM needs to endorse effective tree planting on priority three AML lands to promote reforestation and improve wildlife habitat.

Has some interest in such initiatives: Oklahoma; Texas (concerned about need for more AML moneys and landowner preferences).

8. What types of initiatives would you support (please mark in order of priority/preference with "1" being most important). The following numbers reflect the various "ranks" listed by the states with respect to such initiatives.

Actual Ranking	Average Ranking	Initiative
1/7/3/7/1/1/7	3.6	Policy/guidance changes or enhancements
2/3/7/4/3	3.8	Technology exchange
4/4/1/2/6	4.0	Financial assistance for regulatory authorities or coal operators
3/6/8/6/1/1	4.2	Education (landowners, public, etc.)
5/5/5/8/2/2	4.5	Generating more data to support any particular initiative
4/2/9/5/4	4.8	Research
9/2/2/8	5.3	Regulation/rule changes
9/3/1/3	5.3	Statutory changes
1/6/9/5	7.0	Awards or recognition programs

9. If available, please provide statistics, estimates, etc., regarding the number of trees planted on reclaimed sites over the past several years in your state. In doing so, please differentiate between Title V and Title IV sites.

Alabama — AML: 6.6 million trees on reclaimed AML sites; Title V: 3,700,000 trees over last three planting seasons.

Arizona — Title IV: 154 acres with 69,300 seedlings at a cost of $7,561.40; Title V: 108 acres at approximately 600 trees per acre.

Illinois — Title IV: 93,250 trees; Title V: 50,000 trees.

Indiana — Orders to the state forester from the state nursery amount to about one million trees per year for mined land reclamation.

Iowa — AML: 20,322 trees; Title V: 37,000 trees.

Missouri — Title V: 1,545,000 trees from 1990 to present; Title IV: since 1984, approximately one million seedlings planted on AML lands.

Oklahoma — Trees are planted occasionally for wildlife habitat at AML sites.

Texas — Title IV: 129,000 trees; Title V: 13 million trees.

Pre/Postmining Land Uses — MidContinent Region

State	Percentage Forest[1]		Percentage Pasture		Percentage Wildlife		Percentage Other		Notes
	Premining	Postmining	Premining	Postmining	Premining	Postmining	Premining	Postmining	
Alabama	10	19	5	13	1	5	84	63	
AL AML		90		8				2	
Arkansas	23	4	38	79			39	17	
Illinois	13	11	19	34	2	12	66	43	
Indiana[2]	20.1	15.9	13.5	23.3	3.6	14	62.8	46.8	1982 - Present
Indiana (1982 - 1990)	18.6	12.8	16.8	39.8	2.3	10.6	59.3	36.8	
Indiana (1990 - 1998)	23.1	22.1	7.1	8.7	5.4	20.5	64.4	48.7	
Missouri[3]	34	19	28	43			38	38	
Texas	8	15; AML-37	70	60; AML-53	4	4	18	21	

[1]All percentages based on best estimates, except for Alabama-AML and Texas-AML, which are based on actual data.

[2]In Indiana, the primary value of most woodlands is as wildlife habitat. In order to encourage tree planting and mitigation of fish and wildlife habitat impacts, much forest is allowed to be converted to wildlife habitat postmining land use which requires 250 stems/acre for bond release as opposed to 450 stems/acre for forest land use. When the program began in 1982 until 1990 fish and wildlife habitat mitigation and land use balancing was not a priority. In 1990, the Natural Resources Commission required greater mitigation of fish and wildlife habitat. The first listing of numbers reflects total acreage figures for the program, 1982 to present. The second set of numbers shows changes that occurred beginning in 1990 and the progress that has been made since that time in replacing forest and wildlife habitat.

[3]In Missouri, trees generally are planted to support wildlife habitat (225 stems per acre), not for timber production.

SUMMARY OF REFORESTATION SURVEY RESULTS — WESTERN REGION

1. Pre/postmining land uses — (see attached table)

2. Quality of reclaimed forest land:
   North Dakota — Medium

3. Percentage of pasture that is abandoned post bond release:
   North Dakota — 0%

4. Percentage of abandoned mine land under Title IV of SMCRA that was reclaimed to forest:
   Arkansas — 0%
   Colorado — 0%
   Wyoming — less than 1%

5. If information is available, please relate the relative cost of planting trees in comparison with other postmining land uses in your state.
   Colorado — 40% higher

6. With regard to initiatives to enhance reforestation efforts on reclaimed lands as part of the Title V regulatory program, our state:
   Endorses such initiatives with qualifications:
      Colorado — Any reforestation effort must not result in the lessening of reclamation standards or environmental protection and must demonstrate a postmining land use that makes sense. Reforestation should not be done just to satisfy some "initiative."
      North Dakota — Surface owners need to agree to additional tree plantings.
   Has some interest in such initiatives: Arkansas

7. With regard to initiatives to enhance reforestation efforts on reclaimed lands as part of the Title IV AML program, our state:
   Strongly endorses such initiatives: North Dakota
   Has some interest in such initiatives: Arkansas, Colorado

8. What types of initiatives would you support (please mark in order of priority/preference with "1" being most important). The following numbers reflect the various "ranks" listed by the states with respect to such initiatives.

Actual Ranking	Average Ranking	Initiative
2/3/2	2.3	Education (landowners, public, etc.)
1/4/3	2.7	Technology exchange
1/5	3.0	Awards or recognition programs
3/4	3.5	Research
6/2	4.0	Policy/guidance changes or enhancements
7/1	4.0	Financial assistance for regulatory authorities or coal operators
4	4.0	Generating more data to support any particular initiative
8/1	4.5	Regulation/rule changes
9	9.0	Statutory changes

9. If available, please provide statistics, estimates, etc., regarding the number of trees planted on reclaimed sites

over the past several years in your state. In doing so, please differentiate between Title V and Title IV sites.

Arkansas — Title IV: 5,000 seedlings (willow, birch, cottonwood) annually in 1997 and 1998. Seed (willow, birch, cottonwood, aspen) hand-cast over 60 acres. Intended land use = wildlife habitat and recreation. Title V: 7,000 seedlings (alder, white spruce, willow) planted on reclaimed sites in 1998. Land use = wildlife habitat.

Colorado — Approximately 3,800 trees planted at a Title V bond forfeiture site; approximately 4,000 trees planted at five Title IVsites over 12 years.

North Dakota — Approximately 220,000 trees planted (primarily for windbreaks) since 1980.

New Mexico — Title IV: Limited by geography and climate. Trees used have included juniper, pinon, sagebrush, salt bush, mahogany, oak, sumac and locust. About 1,000 trees planted. Title V: All sites located on arid lands; when seedlings have been planted, elk tend to eat them.

Utah — 1,800 trees (aspen, cottonwood, white pine, spruce, and fir) and 4,000 small trees or shrubs (gamble oak, mahogany, choke cherry) have been planted.

Pre/Postmining Land Uses — Western Region							
State	Percentage Forest[1]		Percentage Pasture		Percentage Other		Notes
	Premining	Postmining	Premining	Postmining	Premining	Postmining	
Alaska	0	0	0	0	100	100	
Colorado	1	0	4	4	95	96	
North Dakota[2]	2	2	25; AML - 20	20; AML - 30	73; AML - 80	78; AML - 70	
Wyoming					100	100	Grazing; wildlife habitat

[1] All percentages are based on best estimates.

[2] In North Dakota, mining companies are generally requested to provide acreage for natural woodlands and man-planted shelterbelts (for wind erosion or windbreaks).

SUMMARY OF REFORESTATION SURVEY RESULTS — APPALACHIAN REGION

1. Pre/postmining land uses (see attached table)

2. Quality of reclaimed forest land:
   - Low — Ohio, Kentucky, Tennessee
   - Medium — Pennsylvania, Maryland, West Virginia, Virginia

3. Percentage of pasture that is abandoned post bond release:
   - Ohio — 60%
   - Maryland — 90%
   - Pennsylvania — could be as high as 80%
   - West Virginia — 10%

4. Percentage of abandoned mine land under Title IV of SMCRA that was reclaimed to forest:
   - Kentucky — 60 - 75% (2,242 acres)
   - Maryland — 22% (108 acres)
   - Ohio — 30%
   - Pennsylvania — 24% (6,000 acres)
   - Tennessee — 80% (1,561 acres)
   - West Virginia — 1%
   - Virginia — 60% (500 acres)

5. If information is available, please relate the relative cost of planting trees in comparison with other postmining land uses in your state. (NOTE: Some of the following figures may refer to the incremental cost of planting trees, not the total revegetation/reclamation cost.)
   - Kentucky — $200/acre for trees
   - Maryland — $250/acre for trees; $650 - 800/acre for grasses and legumes
   - Pennsylvania — $250/acre for trees
   - Tennessee — $270/acre + labor
   - Virginia — $120 per acre increase

6. With regard to initiatives to enhance reforestation efforts on reclaimed lands as part of the Title V regulatory program, our state:
   - Strongly endorses such initiatives: Kentucky, Maryland
   - Endorses such initiatives with qualifications:
     - Ohio — The initiatives should not be used to undermine existing regulatory requirements.
     - Pennsylvania — Regulatory standards such as alternative soil conservation and replacement should not be considered. Other regulatory standards could be reduced (e.g., eliminating the requirement that extends the five year liability period when replanting trees). Also, landowner concerns must be addressed.
     - Maryland — The State Land Reclamation Committee generally requires trees and shrubs to be planted on all reclaimed areas exceeding 12 degrees or 22 percent slope.

7. With regard to initiatives to enhance reforestation efforts on reclaimed lands as part of the Title IV AML program, our state:
   - Strongly endorses such initiatives: Ohio, Tennessee
   - Endorses such initiatives with qualifications:
     - Maryland — Need to accommodate landowners' desires.
     - Pennsylvania — Need for more AML moneys; landowner concerns need to be resolved.

Virginia — The type of AML project, landowner wishes, and adjacent land uses often direct revegetation options.

8. What types of initiatives would you support (please mark in order of priority/preference with “1" being most important). The following numbers reflect the various “ranks” listed by the states with respect to such initiatives.

Actual Ranking	Average Ranking	Initiative
1/5/1/2/3	2.4	Policy/guidance changes or enhancements
3/2/4/3/6/1	3.2	Education (landowners, public, etc.)
2/3/7/23.5	3.5	Technology exchange
5/1/3/4/5	3.6	Regulation/rule changes
8/4/5/1/2	4.0	Research
4/6/6/1/9/4	5.0	Financial assistance for regulatory authorities or coal operators
9/7/2/4	5.5	Statutory changes
5/9/8/8/3	6.6	Awards or recognition programs
6/8/9/7	7.5	Generating more data to support any particular initiative

9. If available, please provide statistics, estimates, etc., regarding the number of trees planted on reclaimed sites over the past several years in your state. In doing so, please differentiate between Title V and Title IV sites.

Kentucky — AML: 923,060 trees from 1990 - 1998 covering 2,242 acres; bond forfeiture sites: 798,804 trees from 1990 - 1998 covering 2,843 acres.

Maryland — Total acres planted to trees from 1943 to 1997: 9,449; Title V: 4,273,000 trees since 1978; Title IV: 81,000 trees on 108 acres.

Ohio — Title IV: From 1981 - 1991, 2,360,245 trees on 1,612 acres; 5 million trees since 1991; Title V: not available.

Pennsylvania — 33.8 million tree seedlings have been planted on Title V sites since 1980; AML: 3 million trees.

Tennessee — AML: from 1996 - 1998, 1,561,000 trees

Virginia — Title IV sites: 5,000 trees per year average for past four years.

Pre/Postmining Land Uses — Appalachian Region							
State	Percentage Forest[1]		Percentage Pasture		Percentage Other		Notes
	Premining	Postmining	Premining	Postmining	Premining	Postmining	
Kentucky	48	38	6	17	46	45	
Maryland	36	24	26	45	38	31	
Ohio	40	5	30	70	30	25	
Pennsylvania	65	50	20	30	15	20	
West Virginia	70	60	25	30	5	10	
Virginia	82	86	2	11	16	3	

[1] All percentages based on best estimates, except for KY, MD and VA, which are based on actual data.

Session 2

INTEREST GROUP PERSPECTIVES ON CONSTRAINTS, EXPERIENCES, TRENDS, AND NEEDS

Chairperson:
Vann Weaver
Office of Surface Mining
Pittsburgh, Pennsylvania

Ohio's Perspectives on Constraints, Experiences, and Needs: A Practitioner's View
Jim Stafford, Ohio Division of Forestry, Zanesville, Ohio

Reforestation Constraints, Experiences, Trends, and Needs: A Landowner's Perspective
Timothy Probert, Pocahontas Land Company, Bluefield, West Virginia

Wildlife Perspectives of Reclamation
Robert M. Morton, Kentucky Chapter of the Wildlife Society, Corydon, Kentucky

EASTERN STATE PERSPECTIVES ON TREE RECLAMATION

Mike Sponsler[1]
Indiana Division of Reclamation
Jasonville, Indiana

Appalachian Perspective

I looked at some of the literature from the people who are doing most of the work in Appalachia and most of them are from Virginia Tech. The following sums up their perspective. Most of the reclaimed land in Appalachia is of limited capability due to the terrain, limited and rocky soil materials, the climate, and the culture of the industry. Most of the current and potential land use is forestry. The land cannot be reclaimed for anything other than forestry that will provide any significant economic return. Restoration of productive forest land requires a deep, noncompacted, nontoxic mine soil, and the absence of a competitive ground cover.

In Appalachia, there have been many acres that have been lost for use as forests. Since the passage of SMCRA, fewer forests are being restored. Virginia has begun to make progress on restoring forests during the 1990s. Kentucky has indicated a loss of about 250,000 acres of forest land. In terms of forest productivity, despite the potential to create productive forest land, much of the surface mined land in Appalachia is reclaimed to a very low level because of compaction. Root zone quality is a big issue. Some coal mine operators will have to change the way they have been operating if they want to increase tree productivity. There was a statement made earlier that the regulations require compaction. That is not the case. From a productivity standpoint, the regulations definitely discourage compaction. There is an opportunity in these steep slope areas to create deeper soils than existed prior to mining. If equipment travel is limited, then grading costs can be reduced while improving the soils for tree growth.

The guidelines for planting trees in the Appalachian area are: (1) replace 3 to 4 feet of surface soil and/or weathered sandstone overburden taken from the surface 10 feet; (2) loosely grade a noncompacted topsoil or topsoil substitute; (3) revegetate using native, noncompetitive, domestic, ground cover species; and (4) plant nurse trees for wildlife and mine soil improvement as well as valuable crop trees.

Mid-Continent Perspective

In the Mid-Continent, the situation is different. Most of the land is either prime farmland or capable of crop production. The land can be used for a wide variety of things if the soils are replaced properly. These lands include some of the most productive in the world as they were originally developed under tall grass prairie. From a habitat standpoint, some would say that the tall grass prairie habitat is a lot more endangered in the Midwest than the forest habitat. They would be encouraging us to reclaim many of these sites to tall grass prairie rather than forest in states like Illinois and Indiana.

The guidelines for planting trees in the Mid-Continent area are: (1) use the same practices used to restore land to its original premine capability for prime farmland or cropland; this also will make the land productive for trees; (2) replace 4 to 6 feet of uncompacted rooting material (B or C Horizon materials or subsoil substitute); (3) truck/shovel equipment can best be used to limit compaction during soil handling operations; and (4) replace topsoil to premine thickness. We are hearing the same arguments for limiting compaction to restore tree productivity that we have found is necessary to restore crop land productivity.

Summary

In the East, you have land that has very limited ability to be used for anything other than forests. In the Mid-Continent, you have soil conditions and resources that give you a lot of options in terms of land use.

[1] Mike Sponsler, Division Director, Indiana Department of Natural Resources, Division of Reclamation, Jasonville, Indiana. Mr. Sponsler holds a B.S. in biology from the Illinois Benedictine College and a M.S. in zoology (wild-life ecology) from Southern Illinois University at Carbondale. He is the leader of the Indiana DOR, a program that regulates the tenth largest coal producing state in the nation. Permitting activities process over 8,000 acres yearly as well as review over 1,000 permit applications. The Abandoned Mined Land Program receives $3-4 million annually and has performed over $70 million in mine reclamation remediation over the life of the program on over 200 sites. Previously he was assistant division supervisor from 1987 to1990 and a land reclamation specialist from 1979 to 1987 for the Illinois Department of Mines and Minerals, Land Reclamation Division. He also has served as chairman of the Interagency Stream Restoration Committee.

REFORESTATION IN THE WESTERN STATES

Michael Long[1]
Colorado Division of Minerals and Geology
Denver, Colorado

Introduction

I would like to look at just what we are trying to encourage in this process. We are trying to develop an energy resource and keep the economy strong. We are trying to encourage reclamation and productive postmining land uses. Where we usually get at odds with each other has to do with "What is a productive postmining land use?"

Diversity

The key that we are trying to get to, and have not focused in on, is the concept of diversity. There are times and places and situations where crops make sense, grasslands makes sense, or forests make sense. We are driven to the postmining land use usually by the premining land use. Unfortunately, there are a lot of situations where that premining land use is neither good for, or the most productive use of, the land. This is because there are people who are trying to use the land for the greatest amount of economic gain in the shortest amount of time. We are all used to making investments this way. Now you are going to get at odds with someone when you suggest that the premining land use is not the best use of the land. The way you may be able to get past this point is with lots of discussion and education as to the real capability and best use of a particular piece of land. This is where we need to start when we first get a permit in the door as regulators. Perhaps what we may give up in short-term profit will actually pay off in the long run. This educational process is important, not only for the landowner, but for the regulators, the state and local planning organizations, etc. That education needs to focus on the proper steward-ship and use of the land. We need to realize that the use of forests for diversity has a certain amount of economic value beyond its value for cutting trees.

Land Value

I am glad to see that, some 20 years after the initiation of SMCRA, we are finally getting around to discussing the values inherent in these land use decisions we are making. We are currently trying to minimize erosion, get a quick sustainable vegetative cover, have vegetative productivity, and other things in order to obtain bond release. What we have done in the development of these programs is to drive the system so that it does not recognize forces beyond our control. If you look at a natural landscape, you do not see pristine systems with grass three feet tall and no erosion or sedimentation on the site. You do see this at mine sites. Is this good? Well, in the eyes of regulators during the early days of SMCRA, yes, this was good because we had erosion control and sediment control and we got bond release. What this did was to stifle diversity. This put the blinders on us as regulators so that we could say to the public that we were able to control erosion and sedimentation, clean up the water, and establish a good looking stand of grass, and get bond release in five years. The whole idea of setting a specific time limit on obtaining a bond release is artificial. What is the relevance of the time limit, if our goal is really to restore the land to a productive and diverse land use? Some of the constraints are artificial ones that we have placed on ourselves. In terms of the vegetative cover that will ultimately occupy the site and be best for the long-term land use, some things may take place that mother nature may want to have happen that are not in our plans. There is going to be erosion. Water channels are going to be reestablished where the water wants to go rather than where it was engineered to go. The same with the vegetation. We should be looking at what plants are going to naturally want to inhabit the site and try to incorporate that into our plans. We are presumptive in thinking that we can actually control what vegetation will ultimately occupy the site. We have looked at this in terms of our short-term benefits and gains, even in terms of benefits to the environment.

Summary

We need to look at our vegetation standards and at what we need in order to obtain bond release whether it be statistical vegetation sampling or soil replacement. We need to focus on education of the landowners and regulators as to what makes sense for the ultimate use of the land in terms of both the environment and the economy. I think we need to take this opportunity to explore and think about this issue. Where can we make significant improvements with some creative thinking?

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[1] Michael Long, Director, Colorado Mined Land Reclamation Division, Denver, Colorado. Mr. Long holds a B.S. from Southern Illinois University. He also did graduate work at SIUC and Western Michigan University. He has been with the Colorado Mined Land Reclamation Division since 1981. He has been Director of the Mined Land Reclamation Division since1992. In that capacity he also has assumed responsibility for the Mine Safety and Training Program, the Colorado Geological Survey, and the Oil and Gas Conservation Commission. Previously he served as Deputy Director for the Indiana Department of Natural Resources.

IMPEDIMENTS TO REFORESTATION: WHO OWNS THE PROBLEM?

David Finkenbinder[1]
National Coal Association (NMA)
Washington, D.C.

NMA Survey

I asked five questions of our members concerning this issue: (1) Do NMA members want to use forestry more often as a postmining land use?; (2) There have been a number or recent talks concerning the science of reforestation showing great successes; are there portions of the regulations that have the unintended consequences of discouraging the planting of trees where it might otherwise make sense, or is this whole thing a waste of time?; (3) Would you plant more trees and reclaim to forest if such impediments were removed?; (4) Are the cost comparisons for reclamation to forest as compared to other uses substantial?: (5) List any changes you would recommend.

Although there were significant differences in some of the responses, there were some trends. The answer to the first question is yes. Planting trees in general is good for public relations and the environment. We would like to plant more trees. Many companies we have heard from are already planting more trees than they planted before SMCRA, such as Texas Utilities. Others feel constrained by the rules and their application but otherwise would plant more trees in certain situations, but not necessarily for commercial forestry.

Generally, in the West the industry supports forest uses in water courses as wildlife habitat. The locals, however, are not supportive of planting trees for use other than this. Also, the cost for tree planting in the West is considered to be prohibitive, and survival is so low that the risk is too great.

I have combined the responses to the rest of the questions. There is a consensus that grading, ground cover, land use issues, and revegetation success standards all discourage the planting of trees. The industry is asking for the flexibility to grade in such a way as to promote tree growth. The type of grading that benefits the establishment of pasture does not benefit the establishment of trees. The increased cost, of first having to establish an herbaceous cover to control erosion and then later plant trees that must compete with that cover, deters many companies from planting trees. There needs to be more flexibility in determining the appropriate percentage of ground cover necessary to achieve different land uses. In the East, vandalism and theft was identified as a problem with tree planting. Many landowners view the pasture land use as a quicker economic return that is less risk than forestry. Some landowners do not like the tree species that have been planted, such as black locust. There is a good consensus that stem counts rather than a stocking standard is unreasonable as it increases the liability, increases replanting, and extends the responsibility period. These requirements to do not take into account natural succession. In terms of cost, many are concerned about the $1,000 per acre that some are reporting. This contrasts with Texas Utilities; it finds that the costs for planting trees is less than that required to plant pasture. For many miners, their profit margins are so small that they just can not assume the risks involved with planting trees.

Summary

Essentially my responses looked like a typical bell curve. Some companies are heavily involved with tree planting and have been for a long time. Most would like to plant more trees and believe that they would if conceived constraints were removed. Some would not increase tree planting under any scenario. These responses hinge on several factors. Certainly the size of the mining operation, whether or not the land is owned by the mine or leased, the relationship the mine has with the state regulatory authority, and the geography of the mine are all factors in determining a companies willingness to plant trees. A consensus between the mine operator, landowner, and regulatory authority must be reached if there is going to be progress in this area. Changes in the regulations may, in some cases, make tree planting more possible, but they will not make people want to plant trees. The industry needs both flexibility and dependability in terms of its relationship to the regulatory environment.

[1] David Finkenbinder, Director Environmental Policy, National Mining Association, Washington, D.C. Since 1994, Finkenbinder has been with the National Mining Association. Previously he was senior council for regulatory affairs and director of governmental affairs for AMAX Coal from 1980 to1992. He has served as a hearings commissioner for the Indiana Department of Natural Resources and as Indiana State Attorney General. He has represented the Indiana Coal Association and Indiana Coal Council and served on the Board of Trustees for the Eastern Mine Law Foundation. He holds a B.S. and Juris Doctor from the University of Kansas.

HISTORIC REVIEW OF MINESITE REFORESTATION IN TENNESSEE

Joseph Strange[1]
Office of Surface Mining
Knoxville, Tennessee

I began inspecting coal mines in 1974 for the Tennessee Valley Authority (TVA) out of Norris, Tennessee after graduating from college. In those days TVA had reclamation provisions in their contracts. I started with OSM in July, 1978 as a Reclamation Specialist in London, Kentucky. That makes 25 years in this business, so I have seen a mine or two. During all those years, I have inspected mines in Tennessee, Kentucky, Virginia, West Virginia, Ohio, Pennsylvania, Alabama, and Oklahoma.

In Tennessee in the late 1950s and early 1960s, steam coal sold for $1.50 to $2.00 per ton. Most mining in those days was done by deep mining techniques, but some surface mining was being done using steam shovels. No reclamation was required during those early years, so the spoil was just dumped over the hill to reclaim itself. In most cases, these old areas healed over just fine, except in places where the spoil was too acid. Many of these old sites have reclaimed themselves so well that most people don't even recognize then as minesites. Highwalls were generally fairly short and have fallen in over the years, leaving only a slope. Most of these old mines were very narrow cuts around the side of the mountain. Today they are used as paths or trails for 4X4s and are revegetated by native tree species of oak, poplar, locust, black cherry, sycamore, sourwood, dogwood, and a few introduced species like *Paulonia tomentosa*. The nearness of the seed source contributed greatly to the successful reforestation of most of these early strip mines.

While working at TVA, I was asked to conduct a tour of some mines. The group I was touring was comprised of several members of a garden club. After explaining to these ladies about mines that were being reclaimed to the standards of the time, we came to an old mine that was all grown over with trees and had an impoundment in the pit below an old collapsed highwall. The group could not believe it had been a mine. They asked why the company we just left was doing all that reclamation if this is what it looked like when nothing was done. I explained that new mining techniques had made it possible to mine much larger cuts than the old mine we were standing on and that disturbing larger areas left more area to erode during rainfall events. Along with this was the fact that there were many more mines now than when the mine we were on was mined.

In the early 1970s, mining began to increase in Tennessee. One factor in this increase was the introduction of much larger and more efficient equipment. Mining companies were required to do some minimal reclamation, such as grading the soil so the bench sloped back toward the highwall and planting trees. Silt structures were constructed of rock and logs, but sediment ponds were not required. The trees that were planted were mostly virginia pine or locust. Most of the areas mined during that time are now well forested with native trees that have seeded themselves.

One of the first mines I was on is located in the Ollis Creek watershed in Campbell County, Tennessee. This area was mined in the early 1970s and TVA minerals were extracted for use in one of their steam plants. I mention that the minerals were owned by TVA because this mine was located at the upper reaches of the watershed that contained the water supply of a nearby town. The water began to be adversely impacted by the mining and the town complained to TVA. It appears that sediment and water of low pH was flowing off this mine into the lake from which the town got its drinking water. TVA began a multiyear project to reclaim this mine. Initially, improvements in the sediment controls were made. Several ponds were constructed below the mine. The next thing to do was to increase the spoil pH so revegetation could begin. The pH was found to be low over most of the mine, with the pH averaging around 3.0 over a large portion of the mine. Lime was spread and incorporated into the soil at a rate of 10 tons per acre. This had to be done three years in a row over part of the mine in order to get grasses to grow. Fertilizer was spread at the rate of 200 lbs/ac. The outslopes were stabilized by staking hay bales and planting pine trees on them. Other species of trees also were planted. They include sawtooth oak and cherry along with virginia pine, shortleaf pine, and loblolly pine. Shrubs also were planted, including autumn olive and bi-color lespedeza. These trees and shrubs were planted over a four year period from 1974 to 1977. Some of the pines now have a diameter of 12 to 14 inches and the oaks are up to 10 inches.

Today, the area is so well vegetated that if you were shown the portions without the highwall, you could not tell you were on a mine. The area is now part of a state wildlife management area. I don't know the cost of the work done at this site, but it had to be high, even though most of the labor was done by employees of the CETA program. This was a program similar to the WPA for unemployed young people.

During the 1970s, mining laws changed to require the addition of grasses along with the trees. Figure 1 is from this time period. This particular mine is located on land that was owned by a land company that only wanted white pines planted. It was like pulling teeth to get the man that owned the company to allow the mining company to plant any grasses at all. And don't even think about planting or seeding a locust on his property. The man that owned the company that did the mining on this property was all for sowing the area with grass and did what he called mulching with seed. When he seeded an area, the ground would almost be covered with seed. He said he thought it was easier and cheaper to seed that way than to go back and do it over later. He would put down four to five times the recommended seed for a given area. It seemed to work, but I don't recommend it.

As you all know, OSM came into existence in 1978. The date for compliance with these new regulations was May 3, 1978. Anyone mining on this date had to begin returning their mined areas to approximate original contour. Figure 2 was mined shortly after this date. Originally it was seeded with lespedeza and planted with only locust trees. As you can now see, the mine is completely covered with trees. The mined area was a relatively narrow cut around the contour of a mountain that provided an abundant seed source. The locust trees originally planted are mostly dead, and maples, oaks, sourwood, and dogwood have taken their place.

In the 1980s, mines seemed to get larger and, as a result, seeding from nearby natural sources became physically more difficult. This is evident when viewing large reclaimed areas. You can see where natural reseeding is occurring around the edges and not as much towards the center of these larger mines. The planting or seeding of these larger mines with a single species of trees has created monocultures that are vulnerable to disease or insect infestation. In late summer, mined areas that are covered in locust trees appear from the distance to be brown, dead strips of land, due to infestations of leaf borers turning all the leaves brown. I don't know if that is what eventually kills these trees, but about 15 to 20 years seems to be the life span of a locust tree in these locations. I have not noticed similar problems where pines were planted.

The 1990s brought about more changes for the mining industry. Falling coal prices forced more and more companies out of business, leaving a few large companies with the majority of the remaining permits. In the past few years, I have noticed fewer trees are being planted. Most permits issued in the past few years in Tennessee have had a postmining land use of "undeveloped land." These mines are sown in grasses with some wildlife shrubs planted. The mines that have been reforested have been sown with locust or planted in pines. Mining companies have been reluctant to plant hardwoods because of the difficulty in achieving the required success rate; however, changes are in the works. A new mine site reforestation policy in Tennessee will be out soon for comment. This policy will give the landowner more say in the species of trees planted on his land. Other topics addressed include grading and spoil compaction; topsoil and topsoil substitutes; tree species; survival rates; and ground cover species selection. This new policy will be out for public comment within the next 30 days. Hopefully, this new policy will promote a more diverse species selection when trees are planted on mine sites in Tennessee.

Over the past 25 years, there have been many changes in the mining industry as far as reclamation goes, and I'm sure there are many more changes to come. I plan on inspecting mines for a few years yet and I hope to see still more improvements in mine site reforestation.

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[1] Joseph Strange, Reclamation Specialist, Office Surface Mining (OSM), Knoxville, Tennessee. Received a B.S. in biology from the University of Tennessee in 1974. Worked for TVA as a mine inspector until 1978. He has been an OSM Reclamation Specialist since 1978 in Kentucky and Tennessee. He has spent ten years with OSM as a Special Investigator assisting the Solicitors Office with alternative enforcement investigations.

Figure 1. Area mined and reclaimed in the 1970's prior to May 3, 1978.

ACADEMIC RESEARCH PERSPECTIVE ON EXPERIENCES, TRENDS, CONSTRAINTS, AND NEEDS RELATED TO REFORESTATION OF MINED LAND

James A. Burger[1]
Virginia Polytechnic Institute and State University
Blacksburg, Virginia

Introduction

Reforestation of mined land during the past 50 years in the United States has been influenced by many factors, including silvicultural technology, availability of plant materials, mining procedures, economic incentives, landowner objectives, and federal and state regulations. The amount of disturbed land planted to trees, as well as the success of these plantings, has varied greatly from state to state during this 50-year period. A major factor reducing the amount and quality of reforested land was the implementation of the Surface Mining Control and Reclamation Act of 1977 (SMCRA). Prior to 1977, most mined land was reforested and reforestation success was primarily a function of applying good silvicultural techniques, but implementation of the law created a number of disincentives caused by a combination of economic, legal, engineering, land use, and physical constraints.

The purpose of this paper is to review how reforestation of mined land has changed over time, the factors that have influenced the amount of land reforested, the success of the trees and stands planted, the constraints and impediments affecting reforestation, and research, policy, and operational needs that, if fulfilled, would improve reforestation. An emphasis is placed on the influence of federal and state regulations since the implementation of the SMCRA because of the profound effect this law has had on land use conversion, productivity, and function.

Forest Functions

In order to fully appreciate the importance of mined land reforestation and its success, I believe it is important to review what forests "do" for us. The following is a list of several important forest functions:

- wood and fiber production
- hydrologic control
- water quality maintenance
- wildlife habitat
- plant and animal diversity
- carbon sequestration
- air pollution mitigation
- aesthetic landscapes
- ecosystem stability

The first item on the list, wood and fiber production, is the most tangible and provides direct benefits to forest landowners. Most of the remaining forest functions on the list are services that forests provide to the public at large. Most people recognize and appreciate these services, but it is difficult to measure their true dollar value. The value of these forest functions is invariably underestimated. A full accounting is needed in order to understand the implications of mining effects on the forest landscape.

We also must realize that the relative importance of land uses is a function of region. Table 1 shows the order of relative importance of traditional postmining land uses in the Western, Midwestern, and Eastern coalfield regions. Rangeland is clearly the dominant premining land use in the West, so it is reasonable that it is the preferred and dominant postmining land use, with shrub and forestland playing a tertiary role. In the Midwest, cropland is dominant, therefore reclamation is predominantly and properly targeted towards cropland postmining land uses. However, due to the low abundance of forest land in both regions, its replacement, when disturbed, is important, especially when it is needed to provide the service functions listed above.

Table 1. Land uses – relative importance.

Western Coalfields	Midwestern Coalfields	Eastern Coalfields
1. Hayland/pasture 2. Cropland 3. Forest/shrub land	1. Cropland 2. Hayland/pasture 3. Forest/shrub land	1. Forest land 2. Hayland/pasture 3. Cropland

In the Eastern coalfield region, forests dominate the landscape and they are the dominant renewable resource underpinning the long-term economies of many of the Appalachian states. Huge amounts of virgin timber were cut and marketed during the 50-year period between 1880 and 1930. Towards the end of this virgin timber harvest, coal mining became the region's economic mainstay, with timber and wood products playing a secondary role. However, the value of the second-growth forest is resurging, with nationwide demand for hardwood products and the advent of wood-processing mills that use timber of all quality grades. This wood-product resurgence is evidenced by many new paper, fiberboard, and lumber mills built or proposed throughout the region during this decade. Water quality, wildlife habitat, and biodiversity are additional forest functions that are highly valued in the region. Land use diversity is clearly desirable when the uses are productive, but the landscape, history, and economy of the region dictates forest land uses as the logical postmining alternative.

Experiences

Pre-SMCRA: During the 30-year period from 1947 to 1977, most mined land was reforested. In the Appalachian coalfield region most mined land had been forested originally, and so disturbed forests were returned to forests. In the Midwestern coalfields, much of the mined land had been cropland and pastureland originally, but the majority was reforested because cast overburden was not graded and topsoiled. Because most spoil materials were left ungraded, they were loose and uncompacted. Trees were planted directly into the loose spoil and were unencumbered by competitive ground covers. With a few exceptions, trees survived and grew very well, and today there are many 30- to 60-year-old stands that will bring landowners considerable revenue from the wood products these forests contain.

Revegetation research conducted during this prelaw period by company reclamation specialists, academic and Forest Service scientists, and other agency researchers was focused on species selection, seeding and planting techniques, improving planting stock, developing mycorrhizal planting stock, and improving minesoil fertility. By the mid-1970s, reforestation biology and silviculture was well established and successful.

Post-SMCRA: After the implementation of the SMCRA, the revegetated landscape, and the techniques used to achieve it, changed dramatically. Federal and state regulations and regulators emphasized short-term hydrologic impacts, sediment control, surface stability, and complete ground cover. In response, coal operators established lush stands of grasses and legumes to prevent soil erosion, vegetation that was sown on compacted fill material engineered for stability. In the Appalachian coalfields, land was reclaimed using one of three revegetation scenarios:

Scenario #1: Forest converted to hayland/pasture:

- Topsoil substitutes chosen for ground cover success
- Minesoils compacted while preparing sites for grass
- Lush ground cover created with heavily fertilized domestic grasses and legumes
- After bond release, hayland/pasture abandoned of further management

- Natural forest succession proceeds, but at a very slow pace due to compacted, inappropriate minesoils and the presence of competitive exotic grass and legume species.

Scenario #2: Forest converted to "wildlife habitat":

- Topsoil substitutes chosen for ground cover success
- Minesoils compacted while preparing sites for grass
- Lush ground cover created with heavily fertilized domestic grasses and legumes
- Woody wildlife species planted
- After bond release, wildlife habitat abandoned of further management
- Natural forest succession proceeds, but at a very slow pace due to compacted, inappropriate minesoils and the presence of competitive exotic grass, legumes, and woody shrub species.

Scenario #3: Forest returned to forest:

- Topsoil substitutes chosen for ground cover success
- Minesoils compacted while preparing sites for grass
- Lush ground cover created with heavily fertilized domestic grasses and legumes
- Plant forest trees, the permanent cover, in conditions created for the temporary ground cover
- Frequent establishment failures, slow tree growth, and poor productivity due to unnatural competition from exotic grasses and legumes and compacted spoils of the wrong type.

In the Midwestern coalfield region, forest land also is being converted to other uses. In the event forests are returned to forests, productivity is often degraded because clayey, dense, and impervious subsoils are replaced in a compacted condition near the surface.

Trends In Reforestation and Restored Forests

The SMRCA has been a very important law that has accomplished a great deal and brought great benefits to the coalfields of the United States, the most important of which were in the areas of human safety and environmental quality. The entire mining community can feel justifiably proud of these accomplishments. Regrettably, the law has failed in one important area; it has caused a systematic reduction in the amount, diversity, and productivity of forest land throughout the coalfield areas of the country. The general trend in mined land reforestation before the implementation of the SMRCA was toward increasing amounts of mined land restored to healthy, productive forests, followed by a dramatic decrease in both the amount and productivity of mined land reforested during the 15-year period following the implementation of the SMCRA.

Due to increasing landowner and public awareness of the short- and long-term loss of the multiple values forests provide, an increase in attempted reforestation has occurred during the past five years. Tree planting has in-creased in most eastern states, and increasing numbers of trees planted is often used by regulators and others as a measure of renewed reforestation success. However, real measures of reforestation success must be used and must include the following criteria:

Criteria for Measuring Reforestation Success:

- amount of mined land, originally forested, returned to forests;
- species composition and functional quality of restored forests compared to the original forest prior to mining; and
- productivity of the restored mined sites compared to the original forest sites.

The trend during the past 20 years has clearly been negative with regard to these three criteria: 1) There has been a significant net loss of forest land due to mining in every state in the east (created "wildlife habitat" is not forest land); 2) the species composition and functional quality of restored forests has been greatly reduced; and 3) the

productivity of the land, that is, the ability of the land to produce forest biomass, has declined. These postmining conditions are presented next in greater detail.

Forest Conversions to Uses of Lesser Value:

Hayland/pasture and wildlife habitat are the postmining uses imposed on the majority of mined land throughout the East. These land uses are generally chosen by the coal operator for bond-release expediency and to satisfy the regulatory authority's concern for erosion and sediment control. After bond release, 95% of the land reclaimed to these uses is abandoned and reverts to forests via the process of natural succession. This reclamation approach amounts to converting land to uses of lesser value, which is technically against the law.

Figure 1 illustrates the land-use opportunity lost when hayland/pasture and wildlife habitat is imposed on the land and then abandoned, compared to reforestation with hardwoods or conifers. The upper window of the diagram shows a time line beginning at the point of hayland/pasture or wildlife habitat establishment to a point 120 years later when an early successional forest is in place. When these land uses are abandoned from management, a slow process of species recruitment and species recombination occurs. This process is retarded 15 to 30 years because of the competitiveness of the planted exotic grasses, legumes, and shrubs. Tall fescue, sericia lespedeza, and russian olive are examples of competitive species that retard natural forest succession. Even if these species were not originally planted, they are ubiquitous in the coalfields from earlier reclamation planting and quickly invade newly established grasslands and created wildlife habitat. Tall fescue is a known alleopathic species; that is, it exudes toxic substances that prevent the germination and emergence of many native plants. Sericia lespedeza is a tall, competitive legume and a prolific seed producer. Seed is consumed by birds, but not digested because of its hard seed coat, and is widely disseminated across the landscape as it passes through birds' digestive systems. Eventually, early invaders like sumac find openings in the dense, non-native cover and start a process of autogenic succession and facilitation that finally results in a forest consisting of early successional native species. After 120 years, the plant community will have the physical stature and species diversity of a native forest, but another 50 to 80 years must pass before heavy-seeded species like the oaks become the dominant canopy component resembling the surrounding native forest.

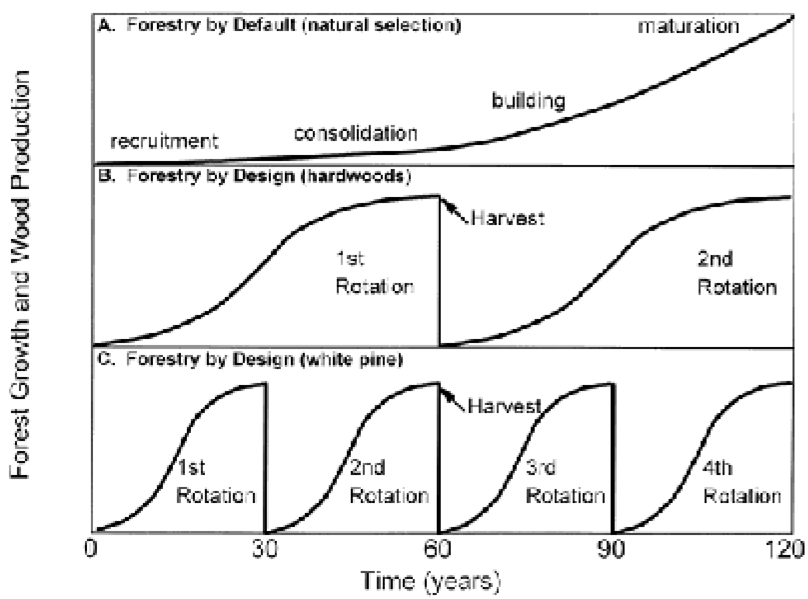

Figure 1. Generalization of wood production on reclaimed mined land.

In the same 120-year period, shown in the middle and lower windows of Figure 1, a landowner could benefit greatly from the production and harvest of two 60-year rotations of mixed stands of valuable native hardwood species, and with more intensive management, four rotations of conifer plantations could be produced and harvested. This level and rate of forest growth on mined land has been clearly demonstrated (Ashby 1998; Kelting et al. 1997).

Degraded Forestland Productivity:

The productivity of mined land for forestry in both the Eastern and Midwestern coalfield regions can be increased on some sites by the process of reclamation. If natural soils are shallow, or if they contain compacted, clayey subsoils, their quality can be improved by soil reconstruction. Conversely, soil quality can be degraded by reclamation, primarily by selecting poor soil substitutes from overburden materials, replacing undesirable subsoils, and by compacting the reconstructed soil profile. In any case, reclamation has a profound impact on the long-term productivity of restored forest soils.

Figure 2 illustrates relative tree growth rate across a minesoil-quality gradient. In the same way that bushels of corn per acre are used to measure cropland productivity, tree height after a set period of time (25 years for pines; 50 years for hardwoods) is used to measure forest land productivity. This measure is called site index (SI). The diagram shows that a poor to good minesoil quality gradient produces a SI ranging from 45 to 70. That is, 25-year-old trees growing on a poor-quality minesoil will be 45 feet tall, while 25-year-old trees growing on a good quality minesoil will be 70 feet tall. Trees growing on minesoils of average quality will be intermediate in height. The effect of minesoil quality on tree height is intuitive to most people, but not well understood is the fact that the amount and value of the wood contained in trees increases approximately exponentially as tree height increases. Therefore, a stand of trees on minesoils of average quality will be five times more valuable than trees of the same age on poor-quality minesoils, and trees on minesoils of good quality will be 20 times more valuable than trees of the same age on poor quality minesoils. Large trees of the same age have disproportionately greater amounts of wood in their stems, and large stems have a disproportionately higher value per unit of wood because of its higher quality. Therefore, increasing minesoil quality incrementally on the “good” end of the gradient is worth much more than increasing it incrementally on the “poor” end of the gradient.

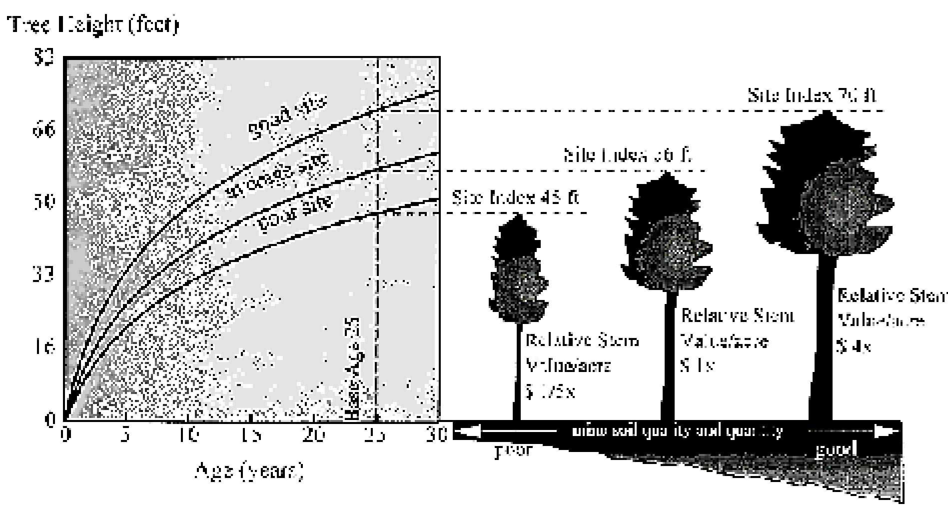

Figure 2. Minesoil quality controls forest productivity.

Torbert and coworkers from Virginia Polytechnic Institute and State University conducted a three-year study funded by the Office of Surface Mining Reclamation and Enforcement (OSMRE) that determined the effect that mining and reclamation are having on forest land productivity and value. The first row of data in Table 2 shows the average quality of an undisturbed Appalachian forest site using white pine as the indicator species (white pine is widely planted throughout the Appalachians on reclaimed sites). The average height of a well-stocked stand of white pine growing on an average undisturbed site is 55 feet (SI 55), according to USDA Forest Service data (Doolittle, 1958). If such a stand were grown to the harvestable age of 30, it would contain about 35,000 board feet per acre (Vimmerstedt, 1962) worth $1,755 per acre (Timber-Mart South, 1998). Based on the rate of white pine growth across 78 reclaimed mines in Virginia, West Virginia, and Kentucky (Torbert *et al*., 1994), the projected average quality of post-SMCRA minesoils is SI 45. By age 30, the estimated volume yield would be 6,100 board feet per acre, with a per-acre value of $122. A white pine stand growing on a good quality minesoil in Virginia (Kelting *et al*., 1997) will have an estimated 46,100 board feet per acre valued at $3,480 per acre.

Table 2. Effects of reclamation technique on white pine productivity and stand value at 30 years.

White Pine Site Type	Site Index (base age 25)	Volume at Age 30 (MBF/ac)	Harvestable Wood Products	Harvest Price ($/MBF)	Total Value* ($/ac)
Typical reclaimed minesoil (Torbert et al. 1994)	45	6.1	pulp	20	122
Undisturbed Appalachian forest site (Doolittle 1958)	55	35.1	small sawtimber	50	1755
Above-average reclaimed minesoil (Kelting et al. 1997)	70	46.4	large sawtimber	75	3480

*Stumpage value from Timber-Mart South, 1st quarter 1998.

These data show the huge difference in expected value across minesoils of different quality. They show that forest land quality can be greatly enhanced on some sites compared to the productivity of average undisturbed sites. Furthermore, these data show the extent to which current reclamation practice is degrading the value of forest land for wood production. The effect of reclamation on other forest functions and values is difficult to estimate, but there is an extensive base of forest science literature showing that amenity values are well correlated with the ability of a forest site to produce biomass; that is, as wood production capability increases, the amenity values increase proportionately.

Needs: Guideline Changes, Education, and Research

To improve the state of reforestation of mined land, the mining community needs to change its outlook on forest land, recognize its value, and realize that many traditional reclamation practices used for establishing crop and pastureland are not suitable for reforestation. Reforestation "needs" can be summarized around three initiatives: 1) changing guidelines and rules; 2) improving techniques and practices; and 3) changing mind-set and tradition through research and education. I have identified seven issues constraining successful reforestation of mined land. I maintain that mined land reforestation throughout the country would benefit by making guideline, technique, and mindset changes to each of these seven issues.

1. *Make a Full Accounting of the Value of Forestland:* As I argued above, forests are an economic mainstay of the economies of many eastern states. In addition to the products they provide, their amenity values are becoming

increasingly important to local communities and the public at large. Forest land use is currently and adequately protected by the Code of Federal Regulations (1997). A paraphrase of the rule reads:

30 CFR-715.13 Postmining Use of Land

- *(a) General: ……restore land to conditions capable of supporting uses before mining……or to higher or better use.*
- *(d) Criteria for approving alternative postmining use of land: ……approved by regulatory authority after consultation with landowner……show feasibility of proposed land use related to needs, markets, land-use trends……feasible plans for financing and maintenance of the land use.*

Based on this clearly stated rule, the common practice in the Appalachians of converting forest land to alternate uses of hayland/pasture or wildlife habitat that is subsequently abandoned after bond release should not be allowed. Forest land is actually being converted to an alternate use of *lower* value if the grassland or wildlife habitat is not maintained. As described above, when these uses are abandoned, the land becomes worthless for the foreseeable future. The criteria for approving alternative postmining uses require a show of feasibility related to needs, markets, and land-use trends, and an assumption that the designated use will be financed and maintained. There is no way a reasonable person could conclude that forest land converted to grassland or wildlife habitat that is commonly abandoned after bond release due to the lack of need, markets, and maintenance feasibility, amounts to a higher or better use than a forest restored to its original level of productivity.

The "needs" associated with this issue are simple: regulatory authorities simply need to enforce the rule. Enforcing this rule would do more for reforestation in the Appalachian region than all other recommendations combined.

2. *Revise Success Standards Based on Forest Productivity:* Returning mined land to its original level of productivity, and to a condition capable of supporting premining uses, is a fundamental provision of the SMCRA. For areas developed for use as cropland, hayland or pastureland, crop production on the revegetated area must be at least equal to that of a reference area (30 CFR, 1997). In effect, the mined land must be returned to its original level of productivity for these crops. A simple example is given in Table 3: If cropland, prior to mining, produced 150 bushels of corn per acre on average, the land must be able to produce the same amount after mining and reclamation. Similiarly, if hayland prior to mining produced, on average, 6 tons of hay per acre, the land must be able to produce the same amount after mining and reclamation. A logical follow-on is that if forest land prior to mining produced, on average, 10,000 board feet of sawtimber per acre, the land must be able to produce the same amount after mining and reclamation. After all, the forest land owner is just as dependent on the postmining productivity of the land for timber production as the farmer is for corn and hay production. To the contrary, as Table 3 shows, the postmining standard for forest land is merely a stocking level of some minimum number of trees per acre. Therefore, it is perfectly legal to degrade the productivity of forest land in the process of mining because the only requirement is that trees be planted and live for several years. This is equivalent to requiring that corn be planted on reclaimed cropland but with no expectation that it be capable of producing a marketable crop.

The current standard for success for forest land reads as follows:

30 CFR-816.116-Revegetation: Standards for success

(a) (3) For areas to be developed for fish and wildlife habitat recreation, shelterbelts, or forest products, success of vegetation shall be determined on the basis of tree and shrub stocking and vegetation ground cover.

Table 3. Post-mining productivity standards.

Land Use	Premining Yield	Postmining Standard
Cropland	150 bu/acre	150 bu/acre
Hayland	6 tons/acre	6 tons/acre
Forest land	10,000 bd.ft./acre	400 seedlings/acre

Somehow, in the process of interpreting the law, the rule makers misunderstood the nature of forests and forestry: the fact that forest quality is a function of soil quality, and that forestry, like farming, is a business that depends on the productivity of the land.

The "needs" or "need" associated with this constraint to reforestation of mined land is a rules change. In a fashion similar to that for cropland and hayland, CFR 30 should require a postmining forest land productivity level comparable to a reference area. The success standard would have to be based on a minesoil quality standard for trees because a production standard for long-lived plants is not feasible. Tree growth and productivity as a function of soil and site quality is well established (Carmean, 1975; Stone, 1984), and there are a number of studies showing that forest productivity can be estimated using minesoil properties (Torbert et al., 1998; Burger et al., 1994; Andrews et al., 1998). Furthermore, Burger et al. (1992) and Torbert et al. (1994) show that adequate minesoil quality is easily achieved by selecting proper topsoil substitutes, an existing provision of the law.

We should not be deterred from making this important rule change based on the unfounded argument that it might create another disincentive against forestry postmining land uses. Restoring productivity to original levels is one of the most fundamental provisions of the SMCRA. Because the law was not interpreted properly for forest land, land degradation is commonplace (Ashby, 1998; Burger et al.,1998). Planting more trees in degraded land is not progress. As argued above, reforestation success is not only a matter of numbers of trees and acres planted; the trees must survive and produce products and services at premining levels.

3. *Use Topsoils and Topsoil Substitutes Specific for Trees and Forestry*: Part 715.16—Topsoil handling, under the General Performance Standards (715) of 30 CFR, requires that all topsoil be removed and salvaged unless use of alternative materials is approved by the regulatory authority. To paraphrase the regulations, this includes all of the A horizon, and where the A horizon is less than 6 inches, a 6-inch layer that includes the A horizon and the unconsolidated material immediately below the A horizon shall be removed and the mixture replaced as the surface soil layer. Where necessary to obtain soil productivity consistent with postmining land use, the regulatory authority may require that the B horizon or portions of the C horizon or other underlying layers demonstrated to have comparable quality for root development be segregated and replaced as subsoil. Selected overburden materials may be used instead of, or as a supplement to, topsoil where the resulting soil medium is equal to or more suitable for vegetation. In order to use topsoil substitutes, the permittee must demonstrate that the selected overburden material is more suitable for restoring land capability and productivity by the results of chemical and physical analyses, including pH, percent organic material, nitrogen, phosphorus, potassium, texture class, and water-holding capacity, and other such analyses as required by the regulatory authority.

This regulation has been carefully and appropriately written, and it fully accommodates the needs for restoring forest land capability and productivity. However, required minesoil quality for trees and forestry is different from that for agricultural and pasture crops, and it is poorly understood by most people in the mining and regulatory communities. Topsoils and topsoil substitutes are routinely selected for the performance of the temporary ground cover rather than the permanent forest cover. In the Appalachian region, where more than 90% of all mined land will ultimately become forested, a wide variety of deep overburden materials are allowed as topsoil substitutes because they support ground cover species when heavily fertilized. In a following paper in this proceedings, I show evidence that most of these overburden materials from deep in the mine profile are not suitable for trees and forestry. On the other hand, surface soil, subsoils, unconsolidated C and Cr material, surface weathered-sandstone overburden, and mixtures of any or all of the above, have been shown to be excellent growth media for native tree species. Furthermore, in the Midwest, replacing dense, acid, finely textured B and C horizons of some soils with selected overburden materials increases forest productivity, and should improve soil quality for most land uses.

The need associated with this issue is simply the realization that forest productivity is very much a function of minesoil quality; that suitable topsoil substitutes are not being used on most mined land in the Appalachian region due to an emphasis on the performance of temporary ground cover; that selected overburden materials may be better substitutes for some B horizons in the Midwest; and that current, well-written regulations dealing with topsoiling are not properly interpreted to insure that forest land productivity is restored.

4. *Minimize Grading to Reduce Minesoil Compaction:* Another major impediment to reforestation of mined land is surface soil compaction caused by excessive grading for final site preparation. Mined sites must be reclaimed in a way that assures mass stability; therefore, overburden on slopes is compacted to meet certain engineering standards. For the most part, these procedures are not the cause of compacted surface soils that impede reforestation success. The follow-up grading of surface-soil material and tracking-in procedures cause most of the minesoil compaction problems. 30 CFR 715.14—Backfilling and Grading simply requires: "Transport, backfill, grade, and revegetate to achieve an ecologically sound land use compatible with the prevailing land use in unmined areas surrounding the permit area." Graded slopes need not be uniform, and small depressions are allowed if compatible with the approved postmining land use. Therefore, the regulations do not require a smooth, compacted surface suitable for the traverse of farm machinery; nonetheless, there is a regulatory mindset that requires this condition, no matter what the postmining land use. We estimate that operators could save between $200 and $500, and that forest productivity could be increased severalfold, by reducing the amount of final grading consistent with forest land uses. Forest land is naturally more undulating and forest soils are deep and uncompacted. Infiltration is rapid and surface erosion is virtually nonexistent. Forest operations are done with rugged equipment designed for steep slopes and uneven surfaces.

   We need to change the mind-set that expects and requires reclamation that produces an agronomic land surface when the postmining land use is forestry – because in the process of creating this surface, soils are compacted, trees are difficult and sometimes impossible to plant, water runoff increases, erosion increases, operator costs increase, and long-term forest productivity and value are degraded.

5. *Rationalize the Cost of Reforestation:* Planting trees is perceived by many as an added cost when reclaiming mined land. Using that logic, one could argue that liming and heavy fertilization, not required by trees, is an added cost when establishing pastureland. A decision to plant or not to plant trees should be based on legal and desired postmining land-uses. If forestry is the legal and desired land use, then it will obviously require planting trees. Buying and planting trees is costly, especially for mined land which normally requires more species, better planting stock, and greater planting effort than are required for establishing familiar conifer plantations on natural soils. The "needs" associated with this issue are to show that the cost of reclamation with trees can be competitive with other land uses when the appropriate techniques are used. Compared to pastureland and wildlife habitat, reforestation is less expensive because it requires less grading and less ground-cover seed and fertilizer, and it eliminates the cost of liming by choosing acid-tolerant ground-cover species that are naturally more compatible with trees (Torbert et al. 1994).

6. *Use Tree-Compatible Ground Covers and Standards:* Very few grasses and legumes grow naturally as ground covers with forest trees in the eastern and midwestern parts of the United States. In no cases are covers of grasses and legumes sown or encouraged in new tree plantings. As a matter of fact, it is common reforestation

practice to harrow or use herbicides prior to tree planting with the express purpose of eliminating competitive grasses and herbs. OSMRE regulations requiring the planting of trees in ground covers are contrary to common and well-established silvicultural practice. Nonetheless, a balance between reforestation success and erosion control is needed. Our experience throughout the east and midwest indicates that erosion control is overemphasized at the expense of reforestation success. Complete erosion control requires a dense ground cover, and a dense ground cover causes reforestation failures due to excessive competition for light, water, and nutrients. Ground cover species mixtures have been developed that are more compatible with tree establishment (see the following paper by Burger and Torbert), nonetheless, percent coverage standards need to be relaxed if trees are expected to survive and grow. More surface erosion during the first and second years after reforestation must be tolerated, provided it does not compromise water quality. The "needs" associated with this reforestation constraint are both technical and educational. We need to find the proper balance between erosion control and tree survival and growth; we need to relax the cover standards and include as "cover" nonerosive areas covered by litter, mulch, and rocks so trees can survive; and we need to change the mind-set common among regulators that tall, dense ground covers are always best.

7. *Develop Bond Release Incentives to Use Trees:* The risk of reclaiming to forest is greater than that of reclaiming to pastureland. Standards for pastureland postmining land uses are unambiguous, and confirmation of success is seldom second-guessed by regulators and operators. The current standards for forestry are not very well understood, and measuring success is open to greater interpretation. There are several "needs" that would alleviate bond-release disincentives; greater clarification of standards and means of assessment are needed on a state-by-state basis. In addition to relaxed cover standards mentioned above, greater flexibility is needed for tree establishment than is currently allowed in most states. For example, certain species mentioned in the permit may not be available at the time of planting, so substitutions should be allowed. Random mixtures of species are better than block plantings provided the species are compatible. On many mined sites, tree monocultures are appropriate and should be allowed. Abnormal weather conditions should be taken into account when enforcing the 80-60 rule. And husbandry practices, including augmented seeding and planting, could be considered normal practice under many circumstances.

Summary

Reforestation of mined land prior to implementation of the SMCRA was commonplace and largely successful. A combination of regulatory requirements created disincentives for selecting forestry as the postmining land use. As landowners and local communities realized that forestland conversions to scrubland and abandoned grassland were degrading the value of the landscape, an effort was made by landowners, regulators, miners, and researchers to determine and resolve impediments to reforestation.

Based on academic research and observations since the Federal law was implemented, I believe landowners and the mining community need to change their outlook on forestland, recognize its full value, and realize that many traditional reclamation practices used for establishing crop and pastureland are not suitable for reforestation. In the past 20 years, large amounts of forestland have been converted to other uses of lesser value and, on average, forestland productivity has been degraded. To improve this situation in the future, several regulatory guidelines and rules need to be modified, techniques and practices specific for forest land should be used, and certain traditional approaches to reclamation should be changed through research and education.

The most important needs are 1) make a full accounting of the value of forestland; 2) revise forestland success standards based on forest productivity; 3) use topsoils and topsoil substitutes specific for trees and forestry; 4) minimize grading to reduce minesoil compaction; 5) rationalize the cost of reforestation; 6) use tree-compatible ground covers and standards; and 7) develop bond-release incentives to use trees.

Academic research has shown that reclaimed forest land can be as productive as it was before mining, and that it can serve the multiple functions of producing wood, improving water quality, providing wildlife habitat, creating diversity and ecosystem stability, sequestering carbon, and providing aesthetic landscapes. Further cooperation among landowners, miners, and regulators is needed to eliminate impediments and disincentives for reforesting mined land. The OSMRE must take the leadership role in implementing changes that appear to be sound, find money to research them if they lack a scientific underpinning, develop and modify policies and procedures to effect desired change, and reach out to the mining community and show it why these changes are important.

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PERSPECTIVES ON CONSTRAINTS, EXPERIENCES, TRENDS, AND NEEDS RELATING TO THE ESTABLISHMENT OF QUALITY WILDLIFE HABITAT ON MINED LANDS IN KENTUCKY

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Introduction

The Kentucky Department of Fish and Wildlife Resources (KDFWR) is charged with the conservation and management of the fish and wildlife resources of the Commonwealth. In its simplest terms, maintaining these resources comes down to providing habitat of adequate quality and quantity for fish and wildlife to survive. Healthy and diverse forest land is high quality wildlife habitat and plays a critical role in the maintenance of healthy aquatic ecosystems. For these reasons, KDFWR maintains a keen interest in the reforestation of mined lands. KDFWR believes the goal of reclamation should be to return mined lands to their natural state of productivity.

Forest land contributes to the health of lakes and streams in a variety of ways. Perhaps the most important of these contributions is land stabilization. Trees do an excellent job of holding soil in place. Land that would otherwise be highly erodible is stable when forested. Trees growing along a stream bank stabilize the stream bank and filter sediment and other pollutants before they can enter the stream. They also provide shade that helps to moderate stream temperatures, an important habitat requirement for many species of aquatic life. Forest litter such as leaves and branches make their way into lakes and streams and are an important part of the food web.

Healthy forests also are important to terrestrial wildlife. For most areas in Kentucky, the natural land cover type is forest. This forest land is a naturally dynamic ecosystem and various wildlife species are adapted to utilize the habitat that results from the different stages of forest succession. For example, the species composition of a recently disturbed forest stand differs dramatically from that of a mature stand. Other species prefer the habitat that exists where two or more different habitat types come together. This type of habitat is commonly referred to as edge, and species that thrive in this type of environment are often called edge species. Many game species are considered to be edge species. Because different types of wildlife are uniquely equipped to live in different types of habitat, any forest disturbance benefits some wildlife species and is detrimental to others.

Wildlife Habitat on Mined Land

From the standpoint of wildlife habitat, mining can be viewed as a form of forest disturbance. Due to the nature of the disturbance, the effects are more severe than disturbances commonly considered such as timber harvest or fire. With these types of disturbance, the forest regenerates itself over time and the wildlife composition changes throughout the regeneration period. The major concern from a wildlife habitat perspective is that, since the passage of the Surface Mining Control and Reclamation Act (SMCRA) in 1977, techniques used to reclaim surface coal mines, in effect, limit the ability of the land to go through the stages of natural succession. Whereas, a forest stand disturbed through fire or harvest may return to mature forest in a period of 50 years, an area disturbed through modern mining and reclamation techniques will require considerably longer, if it recovers at all.

Such was not always the case. While pre-SMCRA mining techniques in Kentucky presented an array of environmental and other problems, the sites are, in many cases, now returning to or have already become productive forests. Because land that is capable of undergoing the natural process of succession is so important to maintaining healthy fish and wildlife populations, it is prudent to examine these prelaw sites and determine what gives them the capacity to grow trees that recently reclaimed mine sites lack.

Much can be learned from how these lands were reclaimed. The most important thing that productive prelaw mine sites have in common is a minimum of grading. Grading and shaping takes time on a dozer, and time on a dozer costs money. Therefore, this task was kept to a minimum. When we go back and look at these sites where good material was placed at the surface and little grading took place, we now typically find productive forests returning. Granted, these impacts have typically had the result that succession has taken a bit longer than is typical of other types of forest disturbance. They have not, however, precluded future forest production.

Another important aspect to consider about early mining impacts upon terrestrial ecosystems is their relatively small scale when compared to the impacts seen in more recent times. Increased mechanization and more efficient recovery techniques hastened the need for comprehensive, national mining legislation. This regulation of surface coal mining came about in the form of the previously mentioned SMCRA.

The enforcement of SMCRA has brought about drastic changes in the manner in which mined lands are reclaimed. The law sets forth standards on how land is to be reshaped and revegetated. Emphasis has been placed on smooth, well-shaped landscapes with vegetation that is thick, lush, and green. These gently rolling landscapes reclaimed with a thick grass and legume ground cover have become the industry standard.

This type of reclamation has long been viewed as a significant improvement over the type commonly seen during the prelaw era. In most ways it was. SMCRA addresses a multitude of extremely important issues. Water quality has been improved dramatically by the new standards. The law also mandates grading and shaping that eliminates many safety hazards such as highwalls and auger holes that were routinely left behind by prelaw mining operations. Perhaps just as importantly, since SMCRA, reclamation has simply looked better.

There is a downside to these well-manicured sights, however. Mined lands reclaimed in such a fashion have a heavily compacted surface layer that severely limits natural forest succession. Consequently, postlaw mining does not simply disturb existing forest land; it changes the existing habitat in a more permanent way. In most cases, postlaw reclamation has resulted in conversion of forest to grassland. As we have already discussed, conversion of forest land to another type of habitat benefits some wildlife species and harms others. This should, theoretically, increase the local populations of grassland dependent wildlife, and to some degree it does. Unfortunately, almost all of these reclaimed sites have been planted to Kentucky-31 tall fescue and sericia lespedeza. Both of these species are notorious for their limited value to wildlife for both food and cover. Consequently, the quality of this new habitat is much lower than it could be. The impact of systematic conversion of high quality forest land to low quality grassland is not desirable wildlife management.

Much of the land that has been converted from productive forest land has been reclaimed to a fish and wildlife postmining land use (PMLU). This land use type is allowed under current regulation and is primarily centered around providing habitat for edge species. As we have already discussed, many highly desirable game animals are considered to be edge species; therefore, it is easy to understand why the creation of edge habitat has been so prominently featured in the fish and wildlife PMLU. Mined lands reclaimed to fish and wildlife habitat are reclaimed as grassland and required to have at least 30 percent of the area planted to trees and shrubs. Additional wildlife habitat enhancement components such as shallow water depressions, nest boxes, and brush piles are encouraged. Unfortunately, mine sites reclaimed as fish and wildlife habitat have often been reclaimed in the same manner as sites having a hayland pasture PMLU. They are heavily compacted and in most cases the grass and legume components are dominated by Kentucky-31 tall fescue and sericia lespedeza.

New State Policies that Enhance Fish and Wildlife Habitat

An update to the fish and wildlife PMLU standards took effect in 1994 in the form of Technical Reclamation Memorandum (TRM) #21. These new standards allowed for a decrease in the stocking density of trees and shrubs from 450 stems per acre to 300 stems per acre on the 30 percent of the area required to have them. However, new specifications were put into place that required these species to be of higher quality to wildlife. Of the 300 now required, 90 stems are to be hard mast producing species, 30 stems must be conifers, and 30 stems each must be at least two soft mast producing trees or shrubs. These tree and shrub species are to be chosen from an approved list included as Appendix A of TRM #21. Additionally, guidance is provided that steers operators to more wildlife friendly herbaceous species and away from fescue and sericia lespedeza.

The fish and wildlife PMLU has proven extremely popular with the industry. A major factor in this popularity is the absence of the productivity standards that exist with the hayland pasture PMLU. Just as is the case with both the commercial and noncommercial forest PMLUs, the fish and wildlife PMLU establishes success standards based solely on the establishment of ground cover and living stems at the time of bond release. The capacity for long-term productivity is not considered; therefore, there is no requirement that land be reclaimed in a way that allows forest regeneration or plant succession toward a mature, productive forest land.

Concerns over long-term forest productivity on reclaimed mine lands has been mounting for some time in the state of Kentucky. Many individuals feel strongly that reclaiming mined lands means more than grading the land smooth, establishing a thick carpet of something green, and keeping trees alive until bond release. Fortunately, measures have been undertaken to address this issue. Based on a recommendation to the Governor's Office by the Kentucky Environmental Quality Commission, a working group was established to review current reclamation techniques and provide guidance as to how to address the issue. KDFWR participated in and supported this process. The working group determined that existing surface mining regulations do not need to be revised to accomplish the goal of mined land reforestation and a reforestation initiative was issued in the form of Reclamation Advisory Memorandum (RAM) #124.

RAM #124 outlined reclamation techniques that are in compliance with current regulations and when employed will provide for the reforestation of mined lands. Recommendations include selection of appropriate spoil material for utilization as growth medium, decreased compaction, and proper selection of vegetation. Use of the methods outlined in RAM #124 provide a landscape that is more capable of undergoing normal forest succession and, therefore, more adequately addresses long-term habitat needs.

KDFWR supports the implementation of RAM #124. When sites are to be reclaimed under the existing fish and wildlife PMLU, the single most important aspect of the reclamation should be to establish a good rooting medium. Species established as herbaceous cover should be chosen based on usefulness as food and cover for wildlife, as well as compatibility with tree growth. Tree and shrub species with food and cover value to wildlife should continue to be selected. Of particular importance is the planting of hard mast species which require a much longer period of time to invade a site naturally. Species of trees with wind borne seeds, such as sweet gum, tulip poplar, and the maples, will invade the site on their own, given (1) time, (2) an appropriate rooting medium, and (3) a less aggressive species as ground cover. The invasion of native vegetation should be encouraged. Current regulation does stipulate that invading trees and shrubs be counted toward meeting success standards. This same attitude should be taken when considering ground cover requirements. There is, in some cases, a mind-set that a reclaimed area should meet ground cover requirements based solely on planted vegetation. An area dominated by native weeds, such as goldenrod, ironweed, and broom sedge, can be as beneficial to wildlife as an area with a weed-free stand of orchard grass and clover.

Another issue to consider with planted vegetation is the creation of edge. Planning for optimal edge habitat is called for in the Kentucky surface mining regulations. In an attempt to accomplish this goal, companies often simply plant all trees and shrubs in long linear plantings a few rows wide throughout the entire permit area. Rows of trees and shrubs do serve an important function as travel corridors and should certainly be used to connect important habitat components such as water sources and undisturbed (unmined) forest. Scattered trees and shrubs also can be beneficial to some species; however, KDFWR recommends that sites reclaimed to a fish and wildlife PMLU also should consider other important aspects of reclamation. The primary objective should be to speed up the natural process of forest succession. Planting tree and shrub species in larger clumps will allow these areas to grow more quickly into young stands of woods. Planting them adjacent to existing woodland will provide more of a "feathered edge" an area where one habitat type (mature forest) intergrades into another (grassland). This type of edge habitat is much more beneficial to edge adapted species than a "hard edge" such as mature woods bordered by grassland. At the same time, it more accurately imitates the process of forest succession. For example, when a farm field is abandoned, woody growth encroaches from the outside edges until the entire field eventually becomes a young woodland.

In addition to providing a growth medium and planting to encourage natural succession, wildlife habitat enhancement practices should be included to the extent practicable. Brush piles and rock piles can be important cover components for many species. Shallow water depressions left randomly scattered on the landscape provide breeding areas for frogs, toads, and salamanders, as well as watering sites for other species. Retention of dugout and on-bench sediment structures also provides sorely needed sources of water for wildlife. KDFWR supports the modification of existing regulation to allow operators to partially regrade and leave such structures anytime they do not pose a serious hazard.

Perhaps as important as changing the current methods of reclaiming to a fish and wildlife PMLU is to realize that any PMLU creates a new type of habitat. It has been a common misconception that KDFWR would prefer all mined land be reclaimed to a fish and wildlife PMLU. This is not the case. As has been stated earlier, forest land is excellent wildlife habitat. If the premining habitat type is forest land, KDFWR recommends the area be returned to forest unless the landowner specifically desires another land use type. This statement, as well as any requiring reclamation of undisturbed forest back to forest land, tends to lead to the discussion of the landowners' right to choose his desired PMLU. KDFWR is not proposing infringement upon the rights of private landowners that currently exist in the surface mining regulations. However, it is common knowledge that quite often surface owners simply allow the mining company to return the land to whatever PMLU they desire. When the company does not own the land, they typically choose the reclamation option that is cheapest. Often these areas are hayland pasture or fish and wildlife PMLUs. If it can be shown that reclamation to forest land will save the operator money because of decreased grading, and bond release is possible because trees will survive, we may hear fewer arguments that the landowner has a right to a hayland pasture PMLU. If then, the landowner truly does desire a pasture, he has that right under existing regulation. The problem is that, until now, the forest land PMLU has not been a truly practicable option.

The success of implementing RAM #124 is contingent upon the education of both mine operators and the enforcement community. A wealth of information exists that indicates that decreasing the amount of final grading can result in a substantial savings to the mining company. Significant cooperation among engineers, operators, and mine inspectors must occur for operators to make sure that surfaces needing heavy grading to maintain stability are graded adequately and areas not needing such treatment are identified and handled appropriately.

Future Efforts

KDFWR supports the establishment of cooperative projects between the (1) Kentucky Department for Surface Mining Reclamation and Enforcement, (2) Office of Surface Mining, (3) Kentucky Division of Forestry, (4) KDFWR, (5) University of Kentucky (UK), and (6) the mining industry to establish demonstration areas for the practices outlined in RAM #124. These demonstration areas should be set up on mine sites that are permitted, bonded, mined, and reclaimed in the standard manner. Work such as that being done by Dr. Don Graves on UK's Starfire project provides invaluable information about the effects of various levels of soil compaction on tree growth and on the tree species that grow best on mined lands. Unfortunately, but understandably, many people in the coal industry may simply view this as "research." Therefore, it is desirable that demonstrations be set up throughout both the eastern and western coalfields of Kentucky that use RAM #124 in a variety of geographic locations and reclamation scenarios. Efforts are already underway to do this type of work. These endeavors should be continued and increased because they can accomplish the important goal of demonstrating that decreased grading and reforestation is practicable.

KDFWR supports all efforts to reclaim mined lands in a more environmentally responsible manner. Certainly providing for long-term forest productivity fits this description and is important to the goal of improving the quality of wildlife habitat on reclaimed lands. It is crucial to remember that mining is in most cases a form of forest disturbance and the goal of forest land reclamation should be to reestablish sites with the capacity to undergo natural forest succession. This requires reclamation to be considered much more than a process resulting in a certain number of stems per acre and adequate ground cover five years after mining ceases. We must begin to view reclamation as a process that allows us to restore the future productivity of our land.

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OHIO'S PERSPECTIVES ON CONSTRAINTS, EXPERIENCES, AND NEEDS: A PRACTITIONER'S VIEW

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History

On AEP land in 1967, a combination of pioneer species, interim species, and climax species was planted. The pioneers would include black locust because it was aggressive and would quickly die out. The interim species are those that are disseminated by air like cherry, white and green ash, and elm. The climax species in southeast Ohio would be oaks and hickories. They began with a stocking level of over 1,000 trees per acre. The first year survival was about 70 percent. By 1992, the survival rate had dropped to 307 stems per acre. That would be about what would be expected in a natural state based on the climate and soils of southeast Ohio. We expect at the maturity of the stand (an age of about 80) that this site will carry about 100 trees per acre. This tract would represent a successful planting. Just as important as the number of trees per acre is their growth rate. Our growth rate for yellow poplar was 1.4 feet per year. The white ash was about 1.0 foot per year. Typically on soils in southeast Ohio, yellow poplar would be expected to grow 80 to 90 feet tall in 50 years. So this site would have had a site index of around 70 for yellow poplar. That would be within an acceptable range for growth of yellow poplar.

After 1970, AEP was no longer faced with tree planting on ungraded spoils and was now faced with planting trees on compacted graded soils. This resulted in a very low success rate with attempts at reforestation with the species mixtures that had been planted prior to 1970. On post 1972 plantings at AEP when the trees faced heavy competition from herbaceous species and heavy soil compaction, they reduced the initial number of trees planted and experienced a reduced first year survival rate of 50 percent. This results in too few trees to change the soil environment into a forest soil. You will not get the necessary microbial activity typical of a forest soil. Also the trees will not grow straight and be self pruning at these low numbers of trees per acre. Also, the growth rates were much reduced. White ash was down to 0.6 feet per year and yellow poplar dropped to about 0.3 feet per year. This reduced the site index to below 30 feet per 50 years, which would not be an acceptable forest production rate. As a forester, if a landowner talked to me about planting trees on land with a site index of 30, I would tell him not to bother.

Conclusion

I am now working with landowners who have had their final bond release and are telling me that they want their woods back. We need to get back to reclamation with trees. The native climax community in southeast Ohio is not grasslands, it is and oak/hickory forest. The creation of thousands of acres of grassland is of no benefit to the wildlife as they are adapted to forest not grassland. Ohio has a $7 billion dollar a year timber industry and grasslands do not help them. Grasses and trees do not mix. The result of planting trees in grass is that the tree growth is much reduced. You must eliminate the grasses in order to get tree growth. We need to find a better way to place the top 6 feet of plant growth material in place so that compaction is minimized. I do not see any significant difference between how coal mines are reclaimed and highways are built. They use the same equipment and the same methods and get the same results, maximum compaction. I know I would never be able to establish trees in an interstate highway right of way. I can not comment on how this should be done, but we need to find a way to replace the root zone so that compaction is reduced. We need to continue to look at seed sources to ensure that we get adapted species that would do well on the sites on which they are planted.

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Champion International at a plywood mill in Cordova, Alabama until 1978. He supervised the Alabama State Nursery in Autaugaville, Alabama until 1981. He supervised Green Springs Nursery until 1984. He supervised the Tree Improvement program until 1994. Currently, he is an Ohio Service Forester assisting landowners in Muskingum, Coshocton, Guernsey, and Belmont counties since 1981. He also is a member of the Ohio Chapter of the Society of American Foresters, the Ohio Mine Land Partnership, and the Ohio Nurseryman's Association.

REFORESTATION CONSTRAINTS, EXPERIENCES, TRENDS, AND NEEDS: A LANDOWNER'S PERSPECTIVE

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Bluefield, West Virginia

Through decades of research by Clark Ashby, Don Graves, Jim Burger, and many others, science has shown us that we can create a productive site to grow commercially valuable hardwood and pine species on reclaimed surface mine sites throughout most of the United States. Using the guidelines and techniques described in research, it is time we as landowners take a more active roll and have more input into the reclamation process.

Landowners – Get involved!!!

If landowners want a productive commercial forest following surface mining, they need to be involved in the reclamation process from the beginning of the permitting process and follow through to vegetation establishment and tree planting. A landowner can't be forced into taking an active role in the reclamation of his land, but if he wants to insure the productive potential of his land is reached, he best **get and stay involved.** A landowner must first be convinced that a commercial forest is his best land use alternative. If surface mined land can be commercially developed to give the landowner a greater return on his land than forest land, he will more than likely lean toward that use. In the Midwest, farmland may be more valuable to the landowner, but for the most part, in the Appalachian coalfields of West Virginia, Kentucky and Virginia, the best use for the majority of reclaimed surface mined land is commercial forestry. Whether the landowners' objectives are to create wood for fiber, quality saw timber or to create a forest for aesthetics, and increase wildlife habitat, the same type of quality site must be created during the reclamation process to insure the greatest survival, growth, and value of timber is realized.

Some landowners will need to be educated in some basic forestry to learn what the potential value of an acre of reclaimed land could be. Even large landholding companies that regularly harvest timber off their nonmined lands may need to be shown the economic incentives to persuade management to invest in commercial forests following surface mining. A landowner will have a sizeable amount of money invested in his future forest and also has the risk of forest fire, insects and disease, deer browse damage, and ATV damage during the time the trees are growing from seedlings and saplings into the pole stage and on to mature saw timber. Landowners need to be aware that growing timber is a long-term investment. But the long-term benefits not only provide a future income from timber production, they also add to the aesthetics of the land, benefit wildlife with food and cover, better stabilize the mine spoil, reduce erosion, improve water quality, and generally improve the quality of the land.

Some good things happening

Several years ago, it seemed like we were banging our heads against the wall when we advocated less compaction, less competitive groundcover**,** burying the shales and putting the brown sandstone on the surface, and recommending coal operators use a reputable tree planting contractor to plant the trees. The coal operators and contractors didn't seem to pay much attention and reclaimed the sites the way they always had**S**Kentucky 31 tall fescue, red and yellow clover, and compaction. But through several years of repeating the same story over and over in workshops and seminars, I believe we are beginning to see some progress. With our company assisting with the cost of reforestation, many of our coal lessees are now utilizing the techniques shown through research to create good sites for commercial forestry.

Planted in 1986, a site in West Virginia was left uncompacted. Where tree compatible ground cover was used and brown sandstone was the dominant spoil material, the area now has trees over 30 ft tall and 8 inches in diameter. This stand is well on its way to becoming a productive forest once again.

Another site, planted in 1990 in eastern Kentucky, shows trees growing in the uncompacted sandstone had a three times better growth rate than trees in areas where conventional reclamation procedures were used, with yellow poplar 12 feet tall and sycamore 20 feet tall. Again, these areas are showing great promise for the future. These sites have been used over the years to show coal operators that productive sites and productive forests can be created after mining. Over the last few years, several positive changes have been made within the states of Kentucky, Virginia, and West Virginia's regulatory agencies that make it more practical and affordable to use commercial forest land as the preferred postmine land use.

Rate of return

By creating the most productive site possible for trees following surface mining, a site index of 75 or better can be attained. (Site index is used as a measurement of sited quality, estimating tree height at a given age based on soil and physiographic variables.) This site should be able to generate a stand of yellow poplar pulpwood by year 20 and small saw timber, utilized for peeler logs in the plywood market, by year 30. With fast growing species like poplar and sycamore, it is likely to have a commercially harvestable stand of timber in 30 years. If the stand was planted with 545 trees per acre and had an 80 percent survivial rate, these trees could generate 33,540 board feet of timber per acre and be worth $3,857.10 per acre. With an initial planting cost of $218.00 per acre, and including an annual management fee and taxes, this stand of timber could generate a **10.2 percent return** on investment. If the land-owner was sharing the cost of tree establishment, the rates of return would be even higher. A 10 percent return looks like a good enough reason for a landowner to want to establish commercial forests after mining.

Where we're missing opportunity

Unfortunately, landowners, especially ones owning smaller acreage, often do not take the initiative, but let the coal operator or mining contractor handle all phases of the mining and reclamation operation—from permitting to mining, grading, and seeding. Some landowners and coal operators are in it for the short-term gains of coal royalties and coal sales and not interested in the long-term investment of timber. Often, when a landowner decides to plant trees after the fact, he may find the postmine land use in the mining permit will make it difficult for him to establish trees or he may have to amend his permit.

If a landowner decides on a postmine land use of commercial woodland, and then has little interaction with his coal operator or contractor and does not follow-up with inspections to the mine site, he might be in for a big surprise. Even though many more surface mines in Kentucky, Virginia, and West Virginia are using forests as the postmine land use, mine sites are still being reclaimed to have the manicured "golf course" look. A landowner must take the time to work with the operators of the mining equipment **on the job** to be sure they understand his desire to leave the surface as uncompacted as possible and, also, what is the best spoil material available on site to be used for establishing trees. It is hard to get a dozer operator who has been used to compacting spoil material for the last 20 years to now leave it uncompacted with minimal grading, or ask a hydroseeding contractor to change to a new tree compatible seed mix when he knows he can get the required ground cover with the "old standard" mix. Attitudes must change and the landowner must be willing to get involved to make this happen.

I have had coal operators tell me they can't get trees to grow and have given up trying to establish commercial woodland on reclaimed mine land. An inspection of the site usually reveals that they are inadvertently doing everything possible to create the worst site for tree survival and growth, including overcompacting flats and gentle slopes, not using enough spoil material to cover the hardpan in flat areas, using the wrong spoil type, and using a too aggressive ground cover. Even when the operator does create a pretty good site, he may still have a problem with tree establishment. We've had instances where a tree planting contractor used some "bargain basement" seedlings to save himself some money and ended up with very high mortality. The same contractor root pruned the seedlings until there was nothing left to stick in the ground; all to make it easier for his crew to plant seedlings in compacted ground. It only takes a few times with poor results to have a coal operator and landowner convinced that tree planting is too hard and costly compared with hayland/pasture or fish and wildlife habitat.

Over the last 20 years since SMCRA, landowners are losing what could have been productive forest land created during surface mining reclamation. Through ignorance, operator attitude, interpretation and enforcement of SMCRA, and lack of landowner involvement, thousands of reclaimed acres of potentially productive timberland actually have been degraded, with a loss of site productivity and lowered site index due to the old standard of mining reclamation practices used. This has cost landowner reduced productivity on reclaimed surface mined sites and reduced future income and value from timber grown on this land.

Loss of return

In contrast to our productive site, a poorly created site after mining that has a site index of 45 might generate 45 tons of pulpwood per acre in 30 years and have a value of $90.00 per acre. With initial planting costs of $218 per acre and the associated management fee and taxes, a landowner would stand to lose his money trying to establish a forest, having a rate of return of **- 4.1 percent**. No wonder so many coal operators say they can’t get trees to grow and opt for the fish and wildlife option. Too many times in mining reclamation this type of situation has occurred in the past**S**and it’s still occurring !

This kind of site degradation must not be allowed to continue. As landowners we are losing productivity and future income off our property, which must be used to offset the tax burden of owning land. If we are going to reclaim mine land to productive forests, we need to **promote** ways to create the best possible growing medium and do what is necessary to help the landowner and coal operator accomplish this task.

What can we do? Some suggestions for discussion

According to most state groups that responded to the OSM letter, they do not believe any regulations or policies need to be changed. I believe most of all, the attitudes and mind-sets of all those involved need to be changed. We need to stop preaching “golf course” landscape reclamation and preach that rills and rocks and loose, rough terrain is better for growing trees.

Get the word out. Finds from research and proven reforestation techniques must transfer from academia to the regulatory agencies and to the field inspectors on the federal and state level. Get the word out to the coal operators, too, through state mining associations and to the landowners through state landowners and forestry associations. Let’s get everyone on the same wavelength too, so a state inspector isn’t worried about what a federal inspector might say or do when the landowner opts for commercial woodland.

There needs to be some cost savings to the landowner or operator who is bearing the additional cost of reforestation. One way would be to reduce the stems per acre required for bond release. After all, if a good site is created, survival will be higher and less trees per acre would need to be planted. Who determines optimum spacing of seedlings anyway? If as a professional forester I felt that a spacing of 12' x 12' between seedlings was desirable to meet my planting objectives, I would only need 302 trees per acre. To guarantee this survival, I may plant 400 per acre, but not the 600 seedlings as is required by many states for commercial forest land.

Let’s give a break to the guys out there trying to do it right. Why must we go back and disturb a site that has stabilized erosion and is growing trees because of a few exposed rills that are deeper than 18 inches. If the site is stable and no sediment is moving off the site, is it necessary to destroy several hundred trees with equipment to “fix” an area? Can less destructive measures be used to address the problem? Or what about giving a break for a small “hot spot” where trees will not grow for one reason or another. Leave it as an open area instead of making an operator go back and plant it again and again and again.

Are our ground cover requirements too heavy? We definitely need to make sure Kentucky 31 tall fescue and red and yellow clover stay out of the seed mix, for they are too aggressive when establishing trees. One planting contractor mentioned to me that he noticed a higher mortality of seedlings in areas that were planted in a heavy cover crop of winter rye. Areas void of the cover crop had much better survival.

Could we offer an incentive to the coal operator to get more trees planted? A cost share program with the states or federal government? How about lowering the amount of bond required per acre if the operator or landowner goes to commercial forestry? In West Virginia, a tax incentive is already in place which reduces the tax on land that is under long-term forest management. This can be quite a savings in taxes over time and should have most landowners favoring forestry over fish and wildlife.

I think the fish and wildlife land use is one that may even need to be eliminated. It has been used by many because it was the cheapest option. We get a lot of pastureland with a few rows of noncommercial species growing out there. Most of the varieties wildlife biologists request for these sites are too demanding and die within a few years, leaving autumn olive thickets and rows of european alder, with a block of pine here and there. If you create a good forest, with diverse species, the site will provide food and cover for wildlife habitat anyway. If we don't eliminate the fish and wildlife option, how about requesting that 100 oak trees per acre be planted on 20' centers to insure that some **commercially valuable** timber will be established for the future, while giving wildlife extra mast?
Maybe we need a law to protect the landowner's property rights when it comes to reclaiming mine land. If a poor site is created through improper reclamation, and the landowner's potential productivity of land for growing timber is reduced, he stands to lose future income from the timber on his land when it is harvested. The site quality has been reduced to a point where the timber investment may not be economically feasible. This should not be happening.

I look forward to a day when our state and federal inspectors visiting a reclaimed mine site with a postmine land use of forest land say, "If this is to be commercial forest land the spoil needs to be less compacted, and if you don't loosen it up and get more brown sandstone on the surface, I'll have to write up a violation. Instead of the violation, I'd like to show you how to create a better site for growing trees. It should help increase seedling survival and growth rates, and help you to meet the bond requirements.

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WILDLIFE PERSPECTIVES OF RECLAMATION

Robert M. Morton[1]
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Preface

I am a wildlife biologist with 20 years of field experience. I am going to discuss fish and wildlife resources and their resulting recreational use. I do not pretend that I am going to offer a series of new ideas or methods to make reclamation practices more wildlife friendly. I am sure that we all know of practices which are successful and provide for productive habitats. So, for all of those in the audience who expect me to stand up here and present the cure-all for fish and wildlife resource reclamation ills, well, you are going to be sadly disappointed.

Introduction

I will present the issues of what happens to the fish and wildlife resources as a result of mining and the postmine uses of the land and what I see that can be done to improve the situation. However, to do this there are a few things that we are all going to have to agree on before we begin this discussion. One is that forest lands, wetlands, and grasslands all hold unique communities of fish and wildlife resources. Some of those species and communities are prized from a recreational standpoint; some for their potential future production values; others are valued because of their unique diversity and mix of species; some are of serious concern because of their apparent declines in the overall landscape; and still others could be considered as indicator species of what we as humans have done to the landscape. Also, when I speak of wildlife during this presentation I am including both fish and wildlife resources in the term of "wildlife."

Grasslands in general and Kentucky in particular are of high value to wildlife, especially to upland game, neotropical birds and some small mammal species. Also, these habitat types are greatly diminished in both quantity and quality due primarily to conversion to agricultural production and the broad scale planting of fescue. The biggest problem with grassland habitat is not the lack of acreage, but the overall decline in the quality of the habitat.

Wetlands, especially shallow, seasonally flooded forest habitats are probably some of the most prized, complex, and diverse communities on the earth. Wetlands are the transitional habitats between the terrestrial and the aquatic worlds. Therefore, these habitats benefit both the upland and the aquatic communities. Species such as waterfowl, frogs, turtles, shorebirds, fishes, aquatic invertebrates, and others all live in, migrate to and from, feed in, escape to, and reproduce in wetlands. Wetland habitats are of concern due to their reduced acreage through their con-version and declines in quality due to human impacts. Over 80% of Kentucky's wetlands are gone and they are not likely to be replaced or restored. This is the reason why these habitats are of such interest.

Obviously, forest land communities also are very species rich from both a recreational and consumptive aspect. These communities produce wildlife species such as white tailed deer, squirrels, raccoons, wild turkey, and a host of nongame bird life, as well as forest products and other unique communities of plant life. These communities produce natural resource forest products such as lumber, food, and herbaceous materials, all of which have other values to humans. Concerns about forest land habitats center around their decline in quality and declines in present and future production potential. This is due to shifts in age structure and communities by ill planned harvest and conversion to other habitats. This, however, is a habitat that is actually growing in acreage in Kentucky, according to Kentucky Division of Forestry records, but the quality and future production potential appears to be going down.

I am here to discuss reforestation and wetland reclamation practices. What is needed to provide more of these valued wildlife friendly habitats? How do we improve the resulting quality for wildlife communities?

Present Situation

Coal mining in Kentucky, the Midwest, and the country is a fact of life. The real issues, from a wildlife perspective, are (1) what habitat types are going to remain after reclamation, and (2) what will the quality of that habitat be? It is pretty much a given that wildlife resources will utilize the available and quality habitat if allowed to and when it is present.

I mentioned earlier that the biggest question of wildlife habitat centers around what type of habitat will remain as a postmine cover. In many instances reclamation practices do not "restore" the original habitats but simply replace them with other more easily and economically restorable habitats. Now we cannot condemn the companies for exercising their available reclamation options; however, I feel that we do need to review the intentions of the reclamation laws and see if they address the issues of reclamation. This must be reviewed in a present and future generational light to determine what effects these practices really have had.

Now by textbook definition to reclaim or to perform reclamation requires actions that provide for the "return of, or restoration of, use. " My questions are: Do the present reclamation practices really address the "restoration" of habitats? Is the conversion of quality forest to low quality pasture habitat restoration? Does the conversion of seasonally flooded and shallow water wetlands to deep water habitats and uplands qualify as reclamation? I realize that it depends on where you sit for the answers to those questions. In many instances present "reclamation" by legal definition has been accomplished; however, from a wildlife resource perspective there have been significant, long-term and in many cases, nonreversible changes in the habitats and a resulting decline in wildlife use of those habitats. Most, if not all, of these situations lead to reductions in biological viability and diversity due to losses of species and the resulting decline in their use. There also are losses in other natural resource products for both present and future generations and these too will result in losses in recreational opportunities for the populace.

Now I am not an all or nothing type of person. I can accept that with mining there are going to be changes in the landscape. Anyone who thinks that the surface layers of the earth can be turned upside down, the coal veins removed, and the overburden put back so that it is going to look like it did prior to mining is living in a fantasy world. I also will admit that reclamation activities have changed greatly since I began my career 20 years ago. However, have the changes been the best for wildlife or future forest production? I think most will agree there have been significant improvements in water quality from mined lands and there has been increased vegetation covers applied to the landscape. However, many of these situations have come with the application of low quality fescue grasslands and at the expense of future forest production. There has not been universal acceptance or application of practices that will ultimately restore forest communities or the wildlife resources that utilize them.

The next big question is, what is the quality of habitat after reclamation? Quality can be described in many ways, such as (1) accessability to wildlife, (2) diversity of vegetative communities, (3) interspersion of habitat types, and (4) diversity of both topography and hydrology. Conversion of a productive upland forest to a smooth graded, gently rolling, mono-culture fescue stand is similar to a limited nuclear war treatment of the landscape from a wildlife perspective. Not much survives! The trees are gone and not likely to be back in our lifetimes, if ever. The resulting grassland community is not receptive to most species of wildlife and is actually toxic to some, and it would cost millions of dollars to put it back to a valued mix of habitat types, if it can be converted back. A seasonally flooded forest that is a levee away from the stream or headwater source that seasonally flooded it, recontoured into 20 foot slopes rather than the 5 foot slopes it once had, or has a final cut lake of 30 feet deep, bears little resemblance to the original bottomland topography and hydrology of the lands prior to mining. The shape of the reclaimed landscape, the final cut lake, and the contours of the resulting hydrology all affect the resulting natural resource potential of the land. A final cut lake with side slopes the shape of the walls of this building offers little in the ways of transitional habitats, temperature and dissolved oxygen bands, and accessability for many species of wildlife or for human use. In each case, all of these losses in habitat and wildlife resources are mirrored as losses in recreational opportunities, for things such as hunting, fishing, bird watching, etc.

So now that I have condemned much of what has been done in the past, it is about time to present what I see that needs to be done to improve the situation. First, we need to determine what our reclamation objectives are. Do we want to restore the land? Do we want to restore the land use? Do we want to provide vegetative cover for erosion control? Or, do we simply want to apply a given set of prescribed practices to obtain bond release?

Second, we need to review what reclamation practices were done, or are being done, and identify what needs to be done to obtain the desired resulting habitats.

Third, we need to ask ourselves, do the present reclamation practices meet our goals of reclamation and restoration of the landscape from a wildlife view? In many instances, I think the answer is yes; but in some cases we have lost sight of our goals and objectives or the goals and objective are conflicting. If we want smooth grades, solid vegetative cover, and future forest we have to give up something, in most cases it is our future resources! Or do we need to fine tune the application of some techniques or policies? We all can sit here and second guess what was done or would have been better done back then, but now we can only address what should be done or will be done better in the future.

Needs

So now the issue from a wildlife perspective is how do we put the landscape back together in a form that will (1) allow for good water quality; (2) provide for wildlife resources; (3) provide for future natural resource (forest) production; and ultimately, (4) will provide for recreational opportunities. I feel that if you accomplish the objectives of protection of water quality and provide for the future forest production you will likely meet the goal of providing for wildlife resources, and this will in turn allow for the recreational use of the land.

The question is how do we get there from here? I would suggest that we begin by better describing our goal of reclamation. Is it restoration, reclamation, or replacement? If the goal is restoration, we have a long way to go on many techniques and policies. We need to work aggressively on things which are proven to produce more future timber production even if the result is not as eye appealing in the short-term.

Secondly, we should bracket or frame what reclamation practices are acceptable for a given habitat type. Conversion of dominantly forest land to all pasture, should simply not be acceptable. Just as conversion of all pastureland to all forest land should be just as unacceptable. Conversion of seasonally flooded wetlands and forested wetlands to a mix of rolling uplands and a permanent final cut lake should not be acceptable either. To do this we need to focus reclamation activities on what habitats were on the land prior to mining, and determine in con-sultation with the regulatory and managing agencies if restoration of those same percentages of forest, water, and grassland are really in the best interest of reclamation and the resources. This would take agreement with reg-ulatory agencies and mining companies when any changes in habitats were proposed.

Third, I feel that we must look at the habitats that resulted from some of the reclamation practices of 20 to 30 years ago. If we look at some of the resulting forest lands from older reclamation sites, we will see that rough grading does result in a better reforestation substrate and ultimately will result in a better future forest, and this will be better wildlife habitat. Ultimately, we may have missed out on an opportunity for future natural resource, forest production, fish and wildlife habitats, and the resulting recreational opportunities by requiring smooth grading, uniform vegetative covers, and elimination of shallow sediment basins. However, the methods employed to preserve and enhance water quality have benefitted all wildlife resources and should be maintained!

We need to propose changes that will result in the improvement of the quality of reclaimed lands in terms of water quality, future timber production, and the resulting wildlife resources of the land. These conditions and habitats would all allow for recreational use of the land.

Specific items that I would like to see addressed include (1) reduced grading for reduced compaction and enhanced reforestation efforts; (2) permit designs that leaves permanent water bodies with a variety of depths; (3) shallow and seasonally flooded silting basins, again with variations in water depths; (4) access points to allow for improved recreational use; and (5) restored “normal” hydrology (overflow) of the property where areas had been levied off from mining by breaching the levees as one of the last reclamation activities.

We also need to discuss the issue of what really costs more in reclamation dollars. Lots of grading and a smooth grassland or less grading and a future forest. I think you will have to agree that dozer time is expensive and any reduction in it saves dollars.

Future

The future begins with planning, and this begins before the property is permitted and mined. This involves determination of what reclamation practices will be employed as a postmine land use treatment and future uses of the property. It is obvious by many of the resulting habitats that we have restored that we can make good quality wildlife habitats and restore future natural resource production of the lands, if we try. We have to accept that many practices take time to realize the results.

Reforestation is a practice that takes 50 to 100 years to generate a viable harvestable natural regenerating forest. The goals of forest reclamation should be to reestablish a forest on the land that will be capable of producing forest products, sustaining hard mast production for wildlife use, and ultimately natural regeneration of the stand for future production. This can only be accomplished if there is adequate substrate in a suitable condition, not com-pacted to the point where root growth is restricted, and successfully planted to a mix of species which will provide for a future forest. Will this happen with the present grading and shaping practices? It is doubtful! It may require that the surface layers be left rougher than traditionally accepted to be successful. It requires planting with a mix of hard seed plant species, leaving islands of native forest to act as a seed source, and allowing light seeded species to move in on their own. This maybe the best approach for future forest production.

Water quality is important and is dependent on the types of spoil material, slope, and hydrology of the area. Ideally, access points should be designed into any permanent water bodies that are left on mined land. This does not have to be an elaborate concrete ramp but simply sites of adequate rock substrate to reduce erosion and provide a stable platform.

All of this happens only if (1) there is interest from the company for reclamation other than the cheapest reclamation options available; (2) there is an involvement of what the final mining use of the property will be prior to the permitting process; (3) there is an openness in the process from both the company’s side, to tell what they want to do and the regulatory agency side, to determine what the resource needs are of the site, region, and state; and (4) the key element for any reclamation process to work, involvement of the staff involved in the mining and recla-mation. Let’s face it. If the equipment operators can see the goals, they can see the reasoning behind doing certain practices. This all happens only if there are changes in philosophy from the company’s staff and regulatory agency sides to make any significant change in reclamation practices for increased and successful reforestation efforts.

It may sound like I am proposing significant changes in the process and, in some ways, I am; however, we can not lose sight of certain objectives in the reclamation process. While many of these issues such as reforestation, permanent water, fisheries resources, etc., may take years to develop, in the short-term we must protect the environment from erosion, further damage, and degradation of water quality, and preserve the physical stability of the land.

Wildlife friendly reclamation can only happen if the reclamation options provided to the companies are habitats that are ultimately restorable, potentially productive, and economically viable. Temper all of that with the reality of dealing with the physical conditions of the site given the spoil, hydrology, grade, and compaction of the materials.

Wildlife as Indicators of Successful Reclamation

Wildlife has been termed many times as being indicators of the overall health of habitats and environmental conditions. Years ago, miners used canaries in shaft mines to determine air quality; in many fisheries, invertebrate life can be and is used as indicators of water quality in streams and lakes. Grassland birds are indicators of overall habitat quality in grassland. Wetland species such as the copperbelly watersnake (species of special concern) are indicators of man's impacts on the availability and quality of wetland habitats. We need to look at the quality and quantity of wildlife to assist us in answering the question of "did we restore the land?"

Summary

The final reality is that mining will happen; that is given! We should attempt to obtain the best possible habitats after land is mined and put it back into a condition to provide for future natural resource production.

However, we must remember that a mix of habitats is diversity. The question is how do we have that diversity, allow for the interspersion of habitats, and provide for the protection of water quality, and still meet the reclama-tion bond requirements? Leaving a final cut lake will provide for a permanent fisheries resource and recreational opportunities; it simply needs to be designed into the landscape prior to mining. Something as simple as leaving the silting basins as permanent features allows for seasonal variations in water depths, interspersions of habitat types, and increased wildlife, as well as recreational uses of the land.

To accomplish the goal of reclamation, we need to (1) restore quality habitat; (2) prescribe and use techniques that are realistic; (3) be adaptable; and (4) involve the organization's company executives, engineers, supervisors, equipment operators, and regulatory agency staffs.

We have to accept that mining will cause some environmental problems, but with proper management we can still protect it from undue damage. We must maintain water quality protection in the short- and long-term and focus on the long range future conditions and potential productivity and uses of the land.

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Session 3

STATUS OF REFORESTATION TECHNOLOGY

Chairperson:
Paul Rothman
Kentucky Department for Surface Mining Reclamation and Enforcement
Lexington, Kentucky

Status of Reforestation Technology: The Appalachian Region
Dr. James A. Burger and John L. Torbert, Virginia Polytechnic Institute and State University, Blacksburg, Virginia

Status of Reforestation Technology and Science in Southern Illinois
Dr. Clark Ashby, (Retired) Southern Illinois University, Carbondale, Illinois

Low Mine Soil Compaction Research
Don Graves, University of Kentucky, Lexington, Kentucky

Use of Field Compaction Measurement to Predict Reforestation Success
Dr. Richard Sweigard, University of Kentucky, Lexington, Kentucky

STATUS OF REFORESTATION TECHNOLOGY: THE APPALACHIAN REGION

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Introduction: The Opportunity

Reclaimed Appalachian surface mines can be an excellent place to grow trees. Mine soils are often deeper, more fertile, and more productive than natural soils. Landowners or foresters managing mined land also have the opportunity to change the species composition of the forest. Native forests are often dominated by poorly formed trees and unmerchantable species resulting from past mismanagement. After mining and reclamation, these forests can be replaced with fully stocked stands of whatever species landowners choose. For the most part, it is possible to establish any of the common native tree species if the land is properly reclaimed. Pines, oaks, yellow-poplar, and ash have all grown well under the right circumstances. Finally, through the process of mining and reclamation, landowners have the opportunity to have good roads constructed to provide permanent access to their new forests, greatly reducing future management and harvesting costs. These combined factors make forestry a tremendous long-term financial opportunity for owners of mined land. However, proper reclamation and reforestation techniques must be used to ensure that this opportunity is realized.

Research by reclamation forestry groups throughout the Appalachian and midwestern coalfields has shown that productive mine soils and forests can be restored using a "forestry reclamation approach," which basically entails: (1) cooperation among the coal operator, landowner, and regulatory authority in developing the mining permit that details and describes reclamation procedures specifically for forestry land use; (2) replacing desirable topsoil or mixing any recoverable soil with slightly acid, brown, weathered sandstone overburden and applying it a minimum of 4 feet deep; (3) loosely grading noncompacted topsoil or topsoil substitutes that include, when possible, woody debris and native seed pools; (4) using native and noncompetitive domestic ground covers that quickly protect the site from erosion, encourage forest meso- and macro-fauna, and serve a noncompetitive, facilitative role in plant, animal, and forest succession; and (5) planting a proper silvicultural mix of crop trees for their commercial value along with nurse trees for wildlife and soil improvement.

The details of this reclamation approach are described by Burger and Torbert (1992) in a Virginia Tech Extension bulletin (460-123) called *Restoring Forests on Surface-Mined Land*. This forestry reclamation approach has been approved, used, and proven successful, and is the status of reforestation technology in the Appalachian region. However, the process of planting and successfully establishing trees has not been accomplished in many cases due to a lack of understanding of these steps, a resistance toward changing established techniques, and a lack of careful preplanning, supervision, and follow-through. This paper describes a process that helps overcome the constraints, and one that leads to successful reforestation in the Appalachian region.

Reforestation Objectives

Reforestation must serve the combined goals of the landowner and coal operator while meeting standards set forth in regulations derived from the Surface Mining Control and Reclamation Act of 1977 (SMCRA). Therefore, the purpose for tree planting is to establish a community of tree species that will: (1) provide enough ground cover and tree stems of a certain height to achieve bond release for the operator; (2) provide trees of commercial value that will produce timber and other forest values for the landowner; and, to a degree, (3) mimic the natural forest ecosystem with respect to plant diversity, species distribution, aesthetics, and wildlife benefits as required by some regulations in some states. Therefore, there are some aspects of tree planting that are unique to mine soils; however, we believe tree planting, and the forestry opportunities that follow, can be successful and profitable by adhering to a few legal, management, and biological procedures, and by following several steps that are described in the following sections. The objective of this paper is to present the step-by-step guide that has led to successful establishment of trees for future forests in the Appalachian coal region.

Reforestation Technology

Step 1: Landowner (forester), coal operator, regulator coordination prior to, during, and after mining.

Reclamation is a complex process involving landowners, coal operators, and regulators (Figure 1). At the end of the process, the reclaimed mined landscape, its use, productivity, and long-term value, will be determined by the mine operator as he interacts with the landowner and the regulatory authority and follows the requirements of reclamation law. The Office of Surface Mining Reclamation and Enforcement's (OSM) performance standards for mined land reclamation are contained in the Code of Federal Regulations Title 30, Chapter III. One of the objectives is striking a balance between the goals of protecting both the environment and land productivity and the nation's need for coal as an essential source of energy. These goals are basically mutually exclusive; therefore, reclamation success hinges on preplanning and cooperation among the regulatory authority, landowner, and coal operator. The landowner can and should have input into the reclamation process through the development of the mining permit, and the state regulatory authority will ensure that the plan is completed as spelled out in the permit and according to current regulations and guidelines that have been approved by the U.S. Office of Surface Mining.

A landowner who wants to manage reclaimed land for productive forests must make sure the mining permit allows the mine operator to create proper conditions for reforestation. The mining permit application may consist of hundreds of pages, but only a few are related to revegetation. These pages are a very important part of the permit, and their content will determine the future land use, its productivity, and its value.

Reclamation bond monies cannot be returned to the mine operator until reclamation is approved by the reclamation inspector. The inspector's role is to be sure that everything specified in the mining permit is adhered to. Therefore, the permit needs to be written to give inspectors the opportunity to accept conditions that are specific for reforestation. A mining permit application should include sections on premining land use, postmining land use, topsoiling, surface grading, ground covers, and tree planting specifications.

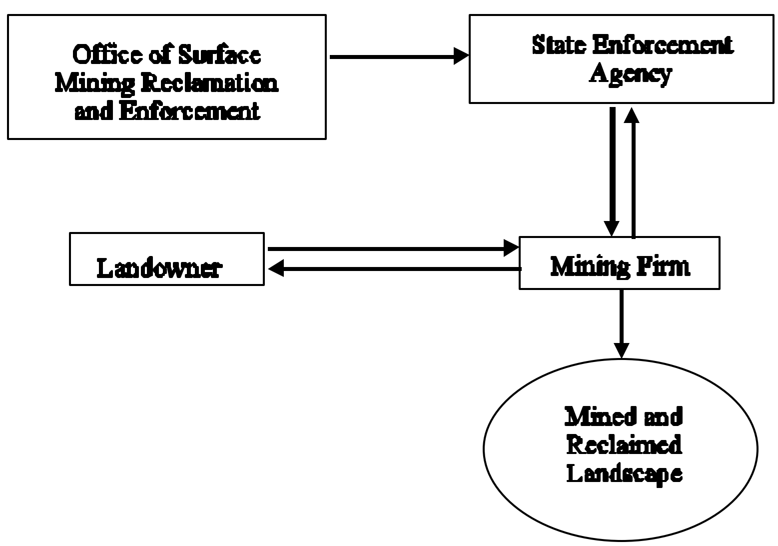

Figure 1. Interactions of the parties and agencies involved in the land reclamation outcome.

The permit should explicitly specify that the premining land use was managed forest. The SMCRA mandates that land be returned to its premining land use or a higher-value use. Therefore, land should not be converted to uses of lesser value such as hayland/pasture or wildlife habitat that will not be actively managed after bond release. Most surface-mined forest land is owned by private and corporate landowners who have long-term economic interests in their forests. Furthermore, in some states, land is taxed at a lower rate if it is managed for forestry. For private or corporate landowners with active or passive timber management programs, land obviously has a premining land use of managed forest.

The permit should also explicitly specify that the *post*mining land use be forestry. The advantages of forestry versus unmanaged land are outlined in Virginia Tech Extension Bulletin No. 460-136 by Torbert et al. (1994) called *Commercial Forestry as a Postmining Land Use*. The coal operator can benefit from reduced grading costs, and the landowner benefits from receiving reclaimed land capable of growing desired tree species at rates that will be profitable. These benefits are seldom realized unless the permit specifies commercial forestry or managed forest as the postmining land use.

The permit can be made specific in order to achieve certain commercial forestry objectives. For example, the permit could specify that the land be used to produce hardwood sawtimber and provide wildlife benefits. The objective could be the creation of a mine soil with a hardwood site index (SI_{50}) of 65 feet or more, which is the average productivity of forest land in the Appalachians. Landowners should confer with the regulatory agency to find out if a forest management plan is necessary, and if so, what is required. It will usually require some estimate of the number of years until harvest and an estimated harvest yield. Forest management plans are simple, easy to write, and help, if needed, can be gotten from a state extension or consulting forester.

Step 2: Topsoil or a suitable substitute selected for trees must be placed, uncompacted, 4 feet thick on the surface of properly reclaimed spoil.

Permits should specify the makeup and final preparation of the site to ensure that reclamation is compatible with a productive forestry land use. Probably the *most* important factor affecting tree survival, growth, and productivity is the quality of the mine soil placed on the surface. Specify that the best available growth medium on the permit area be placed on the surface to an average depth of 4 feet. The growth media should consist of soils or soil substitutes that have low to moderate levels of soluble salts, an equilibrium pH of 5.0 to 7.0, low pyritic sulfur content, and a sandy loam texture conducive to good internal drainage.

The SMCRA requires that topsoil be replaced after mining; however, a waiver of this requirement can be obtained if topsoil is of insufficient quantity or quality for sustaining vegetation. If the topsoil is less than 6 inches thick, the operator may remove the topsoil and unconsolidated materials below it and treat the mixture as topsoil. Selected overburden materials may be substituted for, or used as a supplement to topsoil if the operator demonstrates that the resulting soil medium is equal to or more suitable for sustaining vegetation than the existing topsoil.

Topsoil substitutes are commonly used throughout the Appalachian region, but they are most often selected and justified based on their ability to temporarily sustain the growth of temporary ground covers. These ground covers are made up of introduced species of grasses such as tall fescue that require annual fertilization to remain productive. Most soil substitutes are alkaline, salty, finely textured siltstone materials that are easily compacted and are poorly drained and aerated. They are usually found deep in the profile adjacent to coal seams, and operators find it expedient to place these materials on the surface. However, our research shows definitively that soil substitutes adequate for exotic grasses such as tall fescue are not suitable for native trees.

Figure 2 shows the productivity of trees and grass growing on a gradient of soil substitutes consisting of sandstone media, mixtures of sandstone and siltstone media, and pure siltstone media. Tall fescue grows equally well across these overburden types when its fertility level is maintained by fertilizing. Tree productivity, on the other hand, was adversely affected by the presence of siltstone media. The figure shows a precipitous drop in productivity as siltstone is added to sandstone-derived mine soils. Table 1 contrasts selected chemical and physical properties of these growth media. The sandstone-derived medium had fewer coarse fragments, higher sand content, better water

retention, pH levels similar to native forest soils, and lower total salt levels as shown by electrical conductivity of the soil solution.

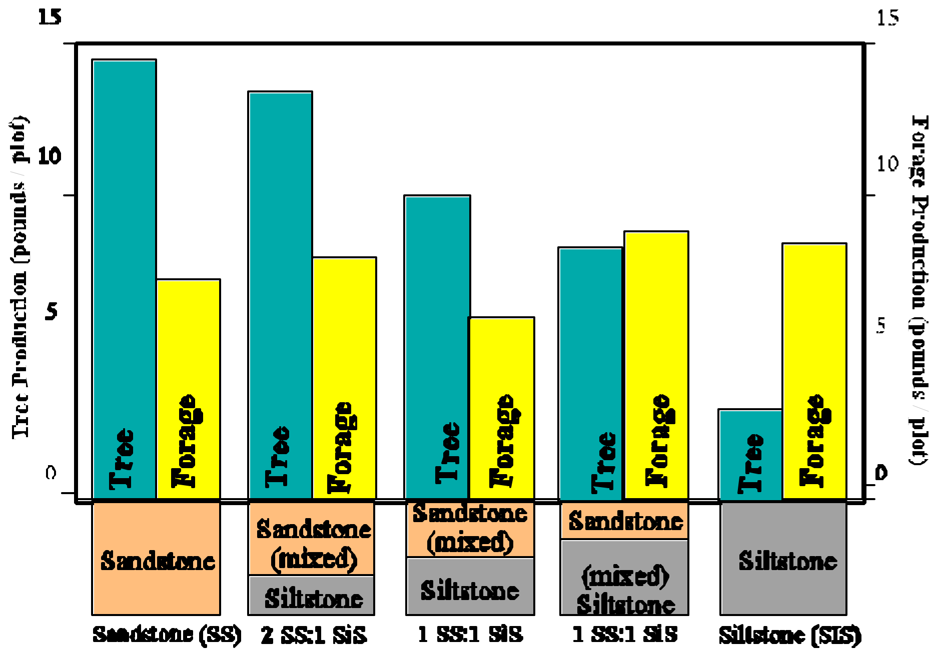

Figure 2. Topsoil substitute effects on tree and forage production (Torbert *et al*. 1990).

This research and years of practical experience show that the best growth medium for trees in the Appalachians is a mixture of the surface soil layers and consolidated but heavily weathered sandstone bedrock beneath the soil surface. The sandstone near the surface is physically and chemically weathered tens of feet deep and quickly breaks up with time to form a high-quality forest soil when mixed with topsoil materials and placed on the surface. Therefore, we recommend this soil substitute for the following reasons: (1) the law requires that appropriate productive topsoil substitutes be used when a topsoiling waiver is obtained; (2) trees and forests will be the permanent vegetation on 95 percent of the mined land, regardless of claimed postmining land uses; abandoned grassland and wildlife habitat become forests via natural succession; (3) due to the profound effect of overburden type on tree growth, weathered sandstone materials near the surface of most Appalachian sites should be used as a

Table 1. Selected chemical physical properties of mine soil (0-20 cm) as affected by mixture of overburden spoil (Torbert et al. 1990).

Rock Mix Treatment	pH	Electrical Conductivity	Exchangeable Nutrients				Available Mn
			P	K	Ca	Mg	
		dS m^{-1}	------------------- mg kg^{-1} -------------------				
Sandstone (SS)	5.7 c*	0.4 d	47	49 c	435 d	162 b	216
2:1 SS:SiS	6.2 b	0.7 c	56	62 b	548 c	206 a	194
1:1 SS:SiS	6.4 b	0.7 c	53	60 b	562 c	215 a	185
1:2 SS:SiS	6.6 b	0.9 b	51	63 b	666 b	220 a	164
Siltstone (SiS)	7.1 a	1.3 a	42	73 a	777 a	227 a	115

*Values followed by the same letter are not significantly different (a = 0.1).

topsoil substitute if a mined area is destined for trees either by design or default (natural succession); (4) our work shows that in nearly all cases, any mix of the surface 10 feet of soil and rock makes an excellent growth medium for virtually all native tree and herbaceous species; (5) applying a minimum of 4 feet of this mix of material without compaction creates a topsoil substitute that is usually as productive or more productive than the original soil `ue to its greater depth; (6) woody debris mixed in or laying on the surface creates microsites for native species; and (7) less grading and seeding is needed for forestry land uses, making the use of this topsoil substitute cheaper for the mine operator.

Step 3: Minimize grading and tracking of the surface.

Permits should specify that level areas and gentle slopes be lightly graded to avoid compaction, and that final surface roughness resemble natural forest land. Uncompacted soil is essential to achieve postmining land use of forestry. Minimizing soil compaction during the application of the surface materials and final grading is extremely important.

Compaction can be minimized by dumping and leveling in separate operations. To achieve this on relatively flat areas, the rooting medium should be placed in tightly placed piles that abut one another across the entire area. Once the material is in place, a bulldozer can be used to grade the tops off the piles and gently level the area with one or two passes. For those mining operations that utilize draglines, the soil material can be cast and shaped in a manner that reduces the amount of final grading needed by tracked equipment. The final surface layer of material should first be placed in tightly spaced piles or ridges that abut one another across the entire area and subsequently graded in a gentle fashion with one or two passes using low-ground-pressure equipment. On steeper areas, the suitable growth medium should be dumped over the top of the outslope on the previously compacted backfill. Again, one pass with a bulldozer should be sufficient to minimally shape the slopes.

There are many research reports and demonstrations showing the effects of compaction. The results of a Powell River Project study (Torbert and Burger, 1994), conducted in cooperation with Pocahontas Land Corporation and Martiki Coal Company in eastern Kentucky, clearly show the effects of compaction on tree survival and growth after five years (Table 2). The study was installed on a recently reclaimed area with a 40 percent slope. Typical and traditional site preparation is depicted by the "intensive" grading treatment. "Moderate" grading consisted of complete leveling of the surface with three to four passes of a bulldozer. The "low" grading level, striking the surface with a single pass, originally planned for this study was untested because we were unable to obtain approval for this treatment. The "ripped" treatment consisted of ripped planting rows on typical, intensively graded surfaces created by a standard 2-foot rock ripper pulled by a dozer. The greatly improved survival and growth of the nonstandard, less compacted treatments is striking (Table 2). Based on our other studies and observations, we found that low-level grading produces early results similar to those of the ripping treatment, and low-level grading outperforms heavily graded ripped sites as trees try to use the whole soil volume. Because compaction can be avoided in the first place, we recommend ripping only as a last, expensive resort.

Table 2. Grading intensity effects on soil erosion, ground cover, and tree growth.

Grading Treatment	1st Year Soil Erosion	5th Year Ground Cover	Fifth-Year Tree Survival and Growth							
			Yellow Poplar		Sycamore		Sweetgum		White Pine	
			Survival	Ht.	Survival	Ht.	Survival	Ht.	Survival	Ht.
	(in)	(%)	(%)	(in)	(%)	(in)	(%)	(in)	(%)	(in)
Intensive	0.3	85	3	17	50	32	39	20	0	---
Moderate	0.2	90	38	39	63	43	41	33	7	20
Low* (untested)	?	?	?	?	?	?	?	?	?	?
Ripped	nondetectable	83	69	31	77	56	74	24	2	17

*This planned treatment was not installed because approval could not be obtained.

First-year erosion on the treatment areas, measured with erosion rods, showed increasing amounts of erosion with increasing amounts of grading. Compacted mine soils increase surface runoff and soil movement. Ground cover was equally good across all treatments at 85 to 90 percent cover. Tracking-in slopes is not required to achieve a ground cover suitable for erosion control. The additional compaction caused by tracking-in operations reduces water infiltration and increases runoff and erosion.

The cost of preparing the final surface of mined land is approximately $300, $200, $100, and $400 for the intensive, moderate, low, and ripped treatments, respectively. We estimate that the operator could save $200 to $400 by properly preparing sites for trees, mainly by reducing the amount of grading that is commonly applied to all reclaimed surfaces regardless of the permitted postmining land use.

Regardless of whether the mined area is a mountaintop, dragline, or steep slope operation, minimizing tractor traffic minimizes compaction, which minimizes the negative effect on forest site quality. Natural forest sites and soils have a diverse microtopography with large amounts of organic matter and coarse woody debris. Many natural forest sites are also rocky, yet very productive. The combination of microtopography created by small depressions, hills, gullies, mounds, rocks, and coarse woody debris is more natural and creates a surface more amenable to recruitment, establishment, and survival of diverse, native forest species, both flora and fauna. Therefore, to the extent possible, final grading should be conducted to minimize compaction, create a surface microtopography, leave as much organic debris as possible, and leave occasional rocks, especially when their removal becomes counterproductive due to additional tractor traffic. Erosion rills and gullies should not be filled if the gullies are stable.

Step 4: Use tree-compatible ground covers to achieve necessary erosion control.

The permit should specify that a tree-compatible ground cover (Table 3) will be used to control erosion, facilitate tree establishment, encourage native plant establishment, and develop a diverse plant community that is typical of native forest ecosystems. Reforestation requires a carefully planned balance between ground cover and tree requirements for light, water, and space. Ground cover should include grasses and legume species that are slow-growing, are tolerant of low to moderate soil acidity (pH 4.5 to 6.5), and can be established in a bare mineral spoil.

Table 3. Species and fertilizer recommendations for a tree-compatible ground cover for recommended mine soils in the Appalachians.

Species	**Application Rate (lbs/acre)**
Grasses:	
Winter Rye (*Secale cereale*) or Wheat (*Triticum aestivum)* (fall seeding)	15
Foxtail Millet (*Setaria italica*) (summer seeding)	5
Redtop (*Agrostis gigantea*)	2
Perennial Ryegrass (*Lolium perenne*)	2
Orchardgrass (*Dactylis glomerata*)	5
Weeping Lovegrass (*Eragrostis curvula*)	2
Legumes:	
Kobe Lespedeza (*Lespedeza striata* var. Kobe)	5
Birdsfoot Trefoil (*Lotus corniculatus*)	5-10
Ladino or White Clover (*Trifolium repens*)	3
Fertilizer (elemental rate):*	
nitrogen	50-75
phosphorus	80-100

* Blend 200 lbs/acre concentrated super phosphate with 300 lbs/acre 19-19-19 fertilizer, or equivalent.

Tree-compatible ground covers are relatively sparse during the first year and become increasingly lush by the second and third years. This allows tree seedlings to emerge above the ground cover and ensures their survival. The success that occurs with the ground cover mix shown in Table 3 is based on the ecological concept of “initial floristics” that entails full recruitment (planting, sowing, and natural invasion) of all species at the point of disturbance, followed by successive dominance at different times by each vegetation type (Figure 3). For example, the grasses dominate the first two years providing erosion control. The annual cereal grains grow quickly but sparsely, and when they lodge after the first growing season, their stems mulch the surface. The legumes are selected to establish slowly, but provide nearly complete ground cover by the third or fourth year, displacing the grasses and fixing soil nitrogen at a time when fertilizer nitrogen has played out. These legumes are acid-tolerant, persistent until shaded out by a tree canopy, and have a sprawling growth form to prevent overtopping of tree seedlings. Nitrogen fixing nurse trees that benefit wildlife dominate from age five to ten without competing excessively with the crop trees. By age ten to fifteen, the permanent tree species close canopy and dominate the site. Species for all the vegetation types, grasses, legumes, nurse trees, and crop trees, are carefully selected to play a specific facilitative role in this successional process. All planting and seeding is done at the time of disturbance, and the vegetative system will take care of itself as it provides the functions of erosion control, soil building, nitrogen fixation, water infiltration, wildlife food and habitat, carbon sequestration, and forest establishment.

Kentucky-31 fescue, sericia lespedeza, all vetches, clovers (except ladino or white clover), and other aggressive or invasive species should be avoided. To be compatible with trees, a herbaceous seed mixture should contain grasses, legumes, and small grains. A balanced seed mixture will provide short-term and long-term erosion control without inhibiting tree growth or survival. The fertilizer applied with ground covers should have a high rate of phosphorus and a low rate of nitrogen. Blending 200 lbs/acre of concentrated super phosphate with 300 lbs/acre of a standard 19-19-19 fertilizer will achieve this high phosphorus, low nitrogen, fertilizer mix. The low rate of nitrogen (compared to typical rates used for hayland/pasture mixes) reduces the height of the ground cover but not its density. By the third year, the inoculated legumes will provide an adequate supply of nitrogen.

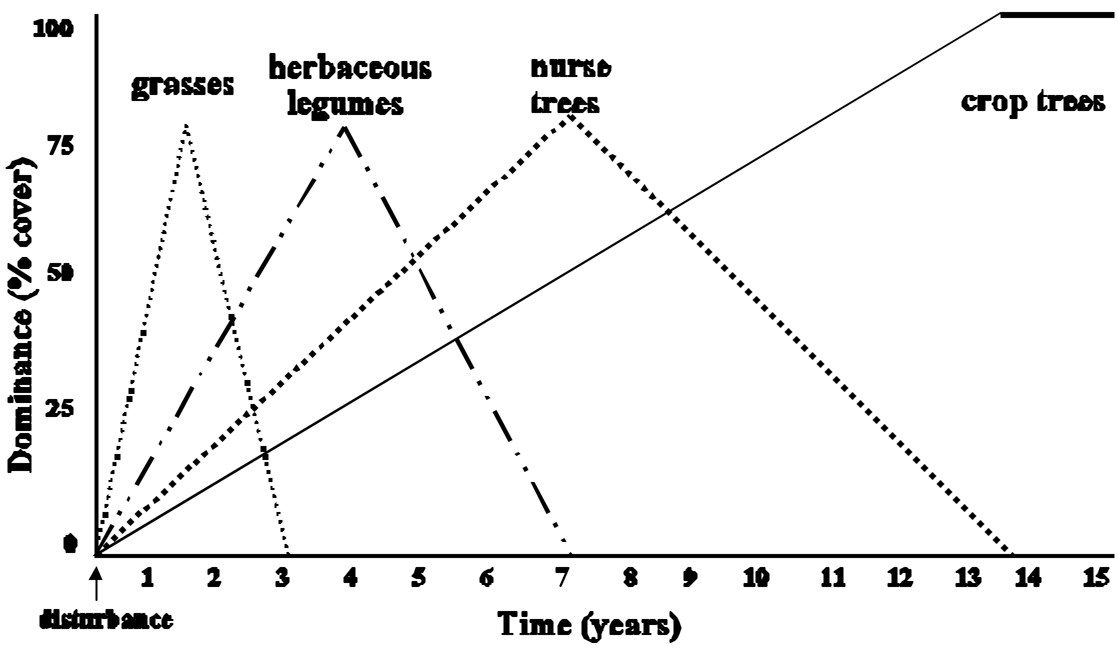

Figure 3. Initial floristics succession: All vegetation types are sown or planted at the point of disturbance, but each type facilitates and yields to another at the appropriate time.

Step 5: Select proper tree species and hire a reputable tree planter.

a. Permits**S**Mining permits must be written to give the mine operator and tree planter some flexibility with regard to which species to plant where. In the past, problems have occurred because permits were too narrowly worded. For example, if a permit specifically listed only four species to be planted, then those four trees had to be planted. If the list specified white pine, black locust, autumn olive, and bicolor lespedeza, they all had to be there for bond release. If for some reason the operator substituted virginia pine for white pine, the inspector could require the operator to either replant with white pine or change the permit. Both are expensive. Bond release can be, and has been, denied because one of the trees listed in the permit was not present in a sufficient proportion to satisfy the inspector. The reclamation inspector does not have the authority to change a permit. This is done by another part of the regulatory agency.

The following paragraph is an example of language that provides needed flexibility while ensuring proper reforestation and compliance with the law:

> *The area will be planted or seeded with at least four species from the following list: white pine, virginia pine, norway spruce, white oak, red oak, white ash, green ash, yellow poplar, red maple, sugar maple, sycamore, black locust, bristly locust, black alder, bicolor lespedeza, or other native trees designated by the landowner. At any given location, the specific species selection will be based on good silvicultural composition, seedling availability, and the suitability of the planting site for each species' site requirements based on spoil type, degree of compaction, ground cover competition, topographic position, and aspect. In addition to those planted, some of these species may be established by direct seeding, and some invasion of native species is expected.*

b. How Many Trees to Plant**S**In most states, bond release requires 400 stems per acre. To guarantee bond release, approximately 600 stems per acre is a good planting density. Approximately 200 per acre can be expected from sowing nurse tree seed and from natural invasion if a tree-compatible cover is used on a suitable soil. If pines are selected as the crop tree, about 400 per acre should be planted. If hardwoods are planted, 200 to 300 trees per acre comprised of several species should be planted. However, certain species mixes can and should be specified in the permit to meet landowner objectives. With planting, seeding, and natural invasion, this should provide enough stems for bond release. With the pines or hardwoods, another 100 nurse trees per acre should be planted, in addition to the seed sown, to guarantee stocking and to provide some diversity and wildlife benefits.

c. Direct Seeding Trees**S**Direct seeding can be an important part of the reforestation strategy because it provides the opportunity to establish nurse tree species at very little cost. This cost savings can offset the increased cost of planting some of the crop trees. Black locust is the most reliable species to hydroseed. Historically, the use of black locust has been abused by sowing excessive rates that produced thousands of trees per acre. If black locust is desired as part of a mix of tree species, no more than 200 trees per acre should be allowed in the stand. If the recommended tree-compatible ground cover is used, one-half ounce of locust seed per acre with the ground cover seed mix should provide the right number of established seedlings. Autumn olive and bicolor lespedeza can also be established by direct seeding; however, we do not have enough experience to make a seedling rate recommendation. Operators can start by applying one ounce per acre and increase or decrease rates based on experience.

d. When to Plant**S**Regulations require trees to have been planted for at least two years before final inspection. Sometimes it is advantageous to delay planting until two years before bond release. Waiting defers the cost of planting. It also provides time to determine the success of direct seeding and allows for fine-tuning the number of trees to plant. Furthermore, in the event that aggressive ground covers containing Kentucky-31 fescue and red clover were planted, they will usually become less aggressive with time; after three years the clover may be gone, thereby increasing tree survival. On the other hand, if a tree-compatible ground cover is used, trees should be planted as soon as possible because the ground cover becomes more aggressive with time.

If mine soils were improperly selected and prepared, decide as soon as possible what to plant based on soil/site conditions. For example, if it is obvious that a lot of compacted, gray mine soil is present, don't plan to use white pine. Instead, choose several appropriate species and place an order with a good nursery as soon as possible. Try to arrange a firm pickup date, and be sure a reliable tree planting crew will be available when trees need to be planted (December to March).

e. What to Plant—Most pine and hardwood species that are native to the region should grow well, provided all of the appropriate mine soil conditions exist. To achieve the multiple objectives of erosion control, bond release, nitrogen fixation, wildlife benefit, and native trees that will eventually have commercial value, a mixture of "nurse" trees and "crop" trees is recommended. Nurse trees and shrubs like bristly locust, bicolor lespedeza, autumn olive, and black alder help meet several reforestation objectives, but will eventually yield to the crop tree species that will dominate the canopy in the future. Crop trees on moist to wet sites could include red oak, green ash, yellow poplar, and sugar maple. On drier sites, a mix of white oak, chestnut oak, black oak, white ash, and red maple is recommended. Pure stands of white pine will be successful on moist sites. For the driest, harshest sites on steep south and west aspects, pitch x loblolly pine hybrids and virginia pine will be most successful.

In some cases, the landowner might be interested in growing a specialty forest crop such as Christmas trees or royal paulownia. These tree crops can be successfully produced on mine soils. Several Virginia Tech Extension publications listed in the reference section describe the procedures for establishing these crops (Torbert *et al*. 1989; Torbert and Johnson 1990).

f. Matching Species and Site Types**S**The best mine soils for tree establishment and growth have a sandy loam texture, are loose, uncompacted and well drained, and have slightly acid pH levels. In many cases, these conditions don't exist, and tree species specifically suited to the mine soil and site conditions must be planted to ensure reforestation success. There are several soil/site conditions that influence tree survival and growth and the selection of certain species. These conditions are (i) spoil type, (ii) degree of compaction, (iii) herbaceous vegetation, (iv) wetness, and (v) slope aspect. Table 4 contains a species/site matrix that provides a tolerance rating of various species for different mine soil conditions. For any particular condition, a rating of "good" indicates that the species is more tolerant of the condition than most of the other species and would, therefore, be a good choice. A rating of "poor" indicates a distinct nontolerance, and the species should be avoided. A rating of "fair" indicates an average tolerance. A designation of "good" does not mean the species, prefers the condition, but it is merely more tolerant than the other species on the list. For example, white ash (*Fraxinus americana*) does not prefer compacted soils, but experience has shown that it will survive, and its growth does not seem to be as badly affected as the other crop trees listed (Zeleznik et al. 1993).

Soil pH seems to influence a suite of chemical properties that determine plant growth (nutrients, soluble salt concentrations, P-fixing capacity, etc.). A pH range of 4.5 to 6.5 is suitable for most tree species and typical of natural soils. In the southern Appalachians, the weathered, brown-colored spoils, especially sandstone, fall within this range. The natural occurrence of plant species such as broomsedge, coltsfoot, and lespedeza often indicate mine soil conditions that will result in the successful establishment of most tree species. The presence of broomsedge is an especially good site indicator for white pine.

Occasionally, low-pH spoils with a pH of less than 4.5 occur. Often, the natural clayey subsoils, when recovered and replaced at the surface, have a pH of 4.0 to 4.5. Sometimes oxidized sandstones have enough pyrite to produce a pH of 3.5 to 4.5. Brown spoils with a pH of 3.5 to 4.5 can often be identified by the presence of volunteer birch (*Betula nigra*) seedlings, red-colored sourwood seedlings, and reindeer moss. Some of the siltstones, especially those immediately adjacent to a coal seam, may be extremely acidic. These are often dark gray or black and support little natural vegetation. High-pH spoils are common in the southern Appalachians. Spoils with a pH of 7.0 to 8.0, usually siltstones or calcareous sandstones, are often encountered. Their presence seems to be indicated by a scarcity of any native volunteer vegetation on bare spoil. High-pH sandstones

Table 4. Species tolerance ratings for various adverse mine soil conditions.

	Mine soil Condition*

Species	pH <4.5	pH <6.5	Compacted	Wet	Tall Grass	North Aspect	South Aspect
Crop trees:							
Norway Spruce	poor	good	good	good	poor	fair	fair
White Pine	poor	poor	poor	poor	poor	fair	fair
Virginia Pine	fair	poor	good	poor	poor	fair	good
Pitch/Loblolly hybd	fair	poor	fair	poor	fair	good	good
Red Oak	fair	fair	poor	poor	fair	fair	good
White Oak	fair	fair	poor	poor	fair	fair	good
White Ash	fair	good	good	poor	fair	fair	fair
Green Ash	fair	fair	good	good	good	fair	fair
Yellow Poplar	poor	fair	poor	poor	fair	good	fair
Red Maple	fair	fair	fair	fair	fair	fair	fair
Sugar Maple	poor	poor	poor	poor	good	good	fair
Sycamore	fair	good	fair	good	good	fair	fair
Nurse trees:							
Black Locust	fair	fair	good	poor	good	fair	fair
Black Alder	good	fair	good	good	good	fair	fair
Bristly Locust	good	fair	good	fair	fair	fair	fair
Autumn Olive	fair	fair	good	fair	good	fair	fair

*A designation of "good" does not mean the species prefers the condition, but that it is relatively more tolerant than other species on the list.

seem to decrease in pH more rapidly than siltstone. Within a few years, high-pH sandstone may become tolerable to some hardwood species. A plant that seems to indicate that pH has decreased to an acceptable level is coltsfoot, which flowers early in the spring with a flower that looks very similar to dandelion. These different spoil pH types influence seedling survival and growth. Each tree species has a preferred pH range within which it has a reasonable likelihood of survival. Virtually all native species are tolerant of moderate acidity. Some hardwood species and norway spruce (*Picea abies*) are tolerant of the high-pH range, although none seem to prefer a high pH versus a moderate pH. Very few species can tolerate a pH less than 3.5 or greater than 8.0.

Compaction results from surface grading and other equipment traffic. Compaction is most severe on level areas and on the shoulders of slopes where bulldozers pivot and turn to start another pass down the slope. Compaction also tends to be more severe on siltstone-derived mine soils than sandstone-derived mine soils. Soil compaction results in less rooting volume, higher soil strength, and less available water. Furthermore, since tree planters have a difficult time opening holes in compacted soil, they tend to severely root-prune the seedlings. Most of the nurse species are relatively tolerant of compaction, as are the ash species.

Poor drainage is usually due to mine soil compaction. Compacted flat areas cause water to stand on the surface for extended periods after a rain event. Norway spruce, green ash (*Fraxinus pennsylvanica*), swamp white oak, sycamore, and black alder are tolerant of wet sites.

Slope aspect is a relatively minor consideration on many sites, but it is most important on steep slopes. Mine soils on north-facing slopes will be cooler and moister than southern aspects. Therefore, species that are less tolerant of droughty soils, such as sugar maple (*Acer saccharum*), should be planted on north slopes. Species such as virginia pine and chestnut oak are more tolerant of southern aspects.

g. Dealing with Herbaceous Vegetation**S**When a traditional reclamation seed mixture consisting of aggressive grasses and legumes is used, herbaceous competition can be severe for tree seedlings during the first few years. The problem is most severe when trees are planted the spring following a fall hydroseeding of annual rye, Kentucky-31 tall fescue, and red clover. The combination of these three species produces a tall, dense ground cover. This ground cover is most aggressive on near-neutral to high-pH mine soils. As already mentioned, these are the spoils that are not very conducive to tree growth and, therefore, the trees are already somewhat stressed by the unfavorable mine soil chemistry. The cumulative effects of undesirable spoil type and excessive competition can be lethal.

Some species are better suited for dense ground covers because the seedlings are taller than the grass. It's possible to get many hardwood seedlings that are 50 to 100 cm tall and still relatively easy to plant. Sycamore and yellow poplar are two examples.

Another option for dense ground covers is to spray herbicide around each seedling after planting. This will be time-consuming and expensive, but it may be warranted under some circumstances.

h. Seedling Handling and Planting Techniques—Many attempts to establish trees have failed because of poor planting techniques or mishandling of seedlings before planting. Most coal operators rely on tree planting contractors for planting. Many contractors working on mined land do not understand the factors influencing tree survival and growth and, consequently, they are unable to consistently achieve good survival. Poor seedling handling and planting techniques are especially likely to result in high mortality when trees are planted on compacted mine soil or in thick grass. The most important conditions for successful planting are: (1) starting with healthy seedlings; (2) taking care of them (keeping them refrigerated) until they are properly planted; (3) matching species to site; and (4) supervising the planting operation.

Coal operators planting large quantities of seedlings should make arrangements with nurseries well in advance to be sure of an ample supply. When seedlings are in short supply, the operator may have to settle for inferior seedlings that may be smaller (or larger) than desired, they may have to come from a distant nursery, and they may not be the best species for the site. Good quality planting stock is essential for good survival and early growth. Seedlings should be large enough to have a healthy root system, but not so large that it is not possible to properly plant the seedlings.

Seedlings should be picked up from the nursery just before planting begins, and, ideally, the seedlings should be lifted from the nursery bed immediately before pickup. Seedlings must be stored in a cool, moist, and aerated environment. A refrigerated truck or storage area kept at 40ºF is ideal.

There is a tendency for some tree planters to excessively prune roots, and some have been known to top-prune shoots of hardwoods below the point of live buds on the stem. Some planters have pruned seedlings to the point where death is almost certain. Pine seedlings should not be top-pruned at all, and hardwoods should not be pruned below the point of live buds. Roots should never be pruned. During planting, roots must be protected from drying, and they should never be exposed to the sun or wind for more than a few minutes. Water-absorbing gels can be used as a root dip or spray to help prevent drying in the field before planting.
On areas being planted with a mixture of species, contractors often have each planter plant a different species. Thus, each row of trees consists of a single species, but adjoining rows are different species. Better seedling survival and growth and a better silvicultural mixture of species would result if contractors had each planter carry three or more species, and each planter made an effort to put the right species on the right site with regard to aspect, slope, degree of compaction, soil wetness, and ground cover competition (Table 4).

Proper microsite selection requires a good understanding of mine soil properties affecting tree growth, and some understanding of different species' site preferences. This may not be practical for all tree planting operations, but with proper supervision and training this can be accomplished for planting reclaimed mine sites. For example, if planters were carrying red oak with large roots, white pine, autumn olive, and black alder, they could plant the oak whenever an excellent planting hole in loose soil was encountered. White pine and black alder could be alternated on average spots, and autumn olive could be used on rocky and compacted spots. White ash also seems to be relatively tolerant of compaction and could be planted on average to harsh sites.

Site selection should also be based on slope position and aspect. For example, red oak, green ash, sycamore, and black alder should be planted at the toes of slopes where it is likely to be wetter. White ash and white oak should be planted further up the slope on drier positions. Red oak and sugar maple are better suited to northern aspects, whereas white oak and red maple are better for southern slopes. Very often planters can select microsites between patches of dense vegetation without significantly affecting the overall spacing of planted trees.

i. SupervisionSA lack of supervision of tree planters and some planting contractors is clearly an important reason for many of the tree planting failures that have occurred on mine soils. Planting contractors paid on a per-seedling basis often lack the incentive to carefully plant each seedling or to plant seedlings on a desired spacing. It is common to see seedlings planted on a very wide spacing on poor soils where it is difficult to make a good planting hole, and to see trees planted less than a meter apart from each other on uncompacted mine soils where it is easy to plant trees. A representative of the landowner or coal operator knowledgeable in tree planting should supervise the actual planting operation to make sure that trees are planted on a proper spacing, planted sufficiently deep, and that holes are properly closed. Planting holes should be at least 6 to 8 inches deep, and the seedling should have all of its roots in the hole. If handplanted, planting holes should be made with "dibble bars" or "hoedads." Hoedads are faster and are commonly used for planting on sandy soils in the southern U.S. Conscientious planters can successfully plant trees in mine soils with hoedads if mine soils are uncompacted.

Applying Reforestation Technology

In the past three years, regulatory agencies of three Appalachian states, Virginia, Kentucky, and West Virginia, have developed new guidelines and procedures for reclaiming mined land permitted for a postmining land use of forestry or forest land. These new guidelines and procedures are largely based on the research results conducted by the Powell River Project throughout the Appalachian coalfields.

In July 1996, the Virginia Department of Mines and Minerals and Energy, Division of Mined Land Reclamation, issued Memorandum 3-96 to coal operators, consultants, and DMLR personnel that described *guidelines for husbandry and reclamation practices appropriate for forestry postmining land uses*. Four reclamation practices including spoil selection, grading, tree-compatible ground covers, and tree species selection are described that are based on the steps for reforestation outlined above. Since 1997, more than 85 percent of new permits were written with forestry as the postmining land use. This represents a complete reversal given that only about 15 percent specified forestry in 1987.

In March, 1997, the Kentucky Department for Surface Mining Reclamation and Enforcement issued a Reclamation Advisory Memorandum 124 describing the rationale for new reclamation guidelines and the new reclamation practices that would accomplish reforestation goals. These guidelines were more detailed than those in Virginia's memorandum, but they covered the same practices and essentially made the same recommendations.

The Kentucky reforestation initiative was prompted by a resolution sent to the governor of Kentucky from the Kentucky Environmental Quality Commission called a *common sense initiative to enhance tree planting as a viable reclamation option to promote more productive postmining land uses while minimizing reclamation costs*. It resolved that a work group (1) review current practices that inhibit tree planting and develop other options, allowable under PL 95-87, to promote forestry land uses; (2) conduct training programs for field inspectors and permit writers; (3) develop a technical assistance program and demonstration projects to better inform landowners about the multiple values of forest land; (4) promote tree planting on abandoned mined land; (5) convene a task force to assess postmining land uses and reclamation practices and report findings to the secretary of the Natural Resources and Environmental Protection Cabinet; (6) recognize the important role that research plays in improving reclamation practices; and (7) support efforts to phase out non-native and invasive species and provide greater diversity of native tree species.

This resolution provided the foundation to change the troublesome 20-year mindset within the reclamation community that caused the use of intensive grading to create mostly unwanted grasslands, consisting of exotic, invasive species, in the name of erosion control.

The actions that followed, in particular RAM 124, provided the authority and technical guidelines to accomplish the goals of the reforestation initiative. This process, developed and used in Kentucky, is a good model for other states to emulate.

A third and most recent initiative in West Virginia also encourages reforestation of mined land. In June, 1998, a memorandum of understanding between the Division of Forestry and the Division of Environmental Protection, Office of Mining and Reclamation, was signed. It recognizes "*the desirability of a healthy forestry industry in the state,*" and the need to "*provide assistance to those mining companies and landowners who wish to develop commercial woodland as the postmining land use on their properties.*" It provides for reduced stocking rates, but requires that the permittee have an approved management plan prepared by a registered professional forester. Detailed procedures have been outlined for developing the permit which are easy to follow and accomplish. Reclamation guidelines for preparing mined sites for reforestation are also included. They are similar to those used by Virginia and Kentucky and are also based on Powell River Project research. An important difference is the requirement for a professional forester to review the plan. This is desirable and will help ensure the success of the reforestation plan.

The development of these reforestation initiatives by regulatory personnel in these three states is commendable and an encouraging development. It shows that new techniques, underpinned by sound research and common sense, can be incorporated in reclamation procedure for the benefit of all involved. Furthermore, this conference pro-ceedings is an encouraging development; it is an example of the positive and proactive role that OSM can play to advocate and enhance better reclamation and postmining productivity and land use while ensuring energy pro-duction for the nation's needs.

Conclusion

Establishing productive forests on reclaimed mined land is both possible and profitable, but this land use opportunity must be properly planned, managed, and coordinated. This report encourages cooperation between the landowner, coal operator, and regulator in the mining permitting process; outlines the proper reclamation techniques specific to forestry; and recommends the hiring of foresters and tree planting crews that understand the special conditions and requirements for reforesting reclaimed mined land. The combination of these activities will ensure that the mine operator will achieve timely, cost-effective bond release, and that the landowner will achieve a productive use of his or her land. Other reports referenced below provide more detail of the land reclamation process needed to achieve productive forests.

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STATUS OF REFORESTATION TECHNOLOGY IN SOUTHERN ILLINOIS

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Abstract

Reforestation can be successful when seed or seedlings of desired tree species are planted in a suitable rooting medium. The technology of tree planting is well-developed and has been presented in various manuals and handbooks. This technology has not led to successful reforestation post-SMCRA due to several reasons, primarily the widespread absence of a suitable rooting medium. The widely replaced fine-textured prime farmland with fragipan and claypan subsoils in southern Illinois is inherently massive with deficient aeration and deficient water entry and drainage essential for root growth. The separated and replaced surface unconsolidated materials are readily compacted and further limit soil aeration and water movement. When dry, they have excessive soil strength that precludes adequate root growth. Tree roots and tree seedlings on these restored pan soils die during seasonal stress periods from saturated or from dry soils.

Potential forest biomass accumulation is further limited by planting competitive ground cover to control the erosion resulting from excessive water runoff on lands with replaced impermeable soils. The adverse effects of ground cover are exacerbated by resulting excessive animal populations that eliminate portions or all of annual tree plantings.

These causes of failure in forestation would be minimized if a suitable rooting medium were available for fast-growing trees using available tree planting technology. The cast overburden after mining is naturally rich and productive with desirable water relations. If mixing the mineral riches of coarse fragments from lower in the overburden with top-dress material were permitted, reforestation problems would greatly be lessened. Forestry is a longer-term, higher, and better land use than restored marginally productive corn fields that likely will be abandoned. With no diagnostic criteria for prelaw forest land, have the permitted acreages designated as forest in the lower midwest been adequately reported, or have forest lands been converted to other uses? Forestry is a logical and necessary beneficial land use that should be implemented on a greatly increased scale for mined lands in the lower midwest.

Introduction

The vast coal reserves of Illinois are overlain by strata of nutrient-rich limestones, sandstones, and/or shales; by unconsolidated weathered rocks, glacial drift, and/or loess; and by varied types of soils with regionally distinctive soil horizons and with equally distinctive presettlement vegetation types. Northern and central Illinois lands that were "strip-mined" by the Wisconsin glacier in relatively recent geologic time have fresh, mineral-rich, highly productive soils developed under prairie. Southern Illinois has ancient, weathered, relatively unproductive soils developed under forests.

Standard practices for mining the underlying coal may be applicable for northern, central, and southern Illinois. Attempting to apply standard reclamation practices to replace the overburden in the diverse ecosystems is, however, counterproductive and ecologically irresponsible. Different reclamation/revegetation practices are needed for the forest soil types and climates of southern vs. the prairie region of central/northern Illinois.

A chief visual distinguishing feature of forests as ecosystems is high biomass values, resulting from large-scale, long-term carbon sequestering. The underlying necessary high rates of photosynthesis depend on a capacious underground root system, and an ample aerial canopy of trunks and branches. An unsuitable rooting medium limits or eliminates successful tree growth. The potential for reforestation success or failure is largely determined before a tree seedling is put in the ground.

Reforestation from the 1930s to the 1960s, when state laws in Illinois began to affect lands surface mined for coal, was overall highly successful on mixed overburden minesoils, also called spoil (Ashby 1996A). Those ecosystems today have sustainability, resistance to invasion, nutrient retention, high water quality, and productive biotic interactions. Planting conditions and success greatly changed with the implementation of P.L. 95-87, The Surface Mining Control and Reclamation Act of 1977 (SMCRA 1977), with its emphasis on restoration (preservation) of pre-mining soils, especially "prime farmland." "Prime farmland" and "topsoil" seem to be elusive or elastic concepts and are not defined in the Illinois Act (Illinois Mines and Minerals [IDMM] 1980). Preservation is not necessarily, or even commonly, the most responsible stewardship of natural resources. Government does tend to resist new ideas. New people tend to make the old mistakes.

In 1982, IDMM promulgated a "prime farmland fragipan soil" rule #1823.14 to include the Ava, Grantsburg, and Hosmer soil series in contradiction to extensive published soils data. Grossman *et al*. (1967) noted that biequal soils with fragipans are common in southern Illinois. Fragipans are examples of massive structure (Kohnke 1968). Much acreage restored with fine-textured, massive, acidic, and infertile prime farmland soils does not have potential long-term productivity. Because corn and other crops must be grown to "prove" productivity for bond release, trees are outlawed (IDMM 1993).

Actually corn production today is a highly intensive gamble, with an army of specialists to take care of everything on nonflooded soils except the weather. A lucky high-yield year proves little. An appropriate test for long-term productivity would be to plant tuliptree or black walnut. Crops could simultaneously be tested using agroforestry practices developed by Dr. Gene Garrett at the University of Missouri.

Trees are a product of the soil. High quality hardwoods such as black walnut and tuliptree (yellow poplar) that need good soil drainage have not successfully been grown on the post-SMCRA restored soils to my knowledge. Species able to tolerate seasonally perched water tables with limited aeration and excessively high soil strength in the dry season are needed. Tree species planted to get adequate survival for bond release on the restored soils now commonly come from bottomland habitats.

My use of the term "topsoil" simply means top-dress material (USDA 1951). The typical premining worn-out, eroded, abandoned fields in southern Illinois commonly have little or no A_1 topsoil remaining to put back, and inferior, unproductive A_2- and B-horizons are replaced as top-dressing material or top dirt.

This paper evaluates why tree planting is a limited postmining land use in southern Illinois. The factors tending to advance or to constrain reforestation acreage and success are grouped and evaluated under four categories (Table 1).

External Technological Factors Tending to Constrain Reforestation Acreage and Success

1. **Minor status of forestry as one of the authorized and appropriate postmining land uses.** Postmining land uses specifically mentioned in SMCRA and in the Illinois Act include intensive agriculture, fish, and wildlife. There are a dozen places in the Illinois regulations where crops or fish or wildlife are specified, and not forestry. Despite studies showing greater long-term economic returns and ecological benefits on appropriate sites from forests than crops, forestry invariably seems not to be accepted as a higher or better land use.

   Neglect or suppression of forestry is evident in other ways. No review of permits by a forestry agency or forest soils person is indicated in the Mines and Minerals annual reports. In contrast, crop production requirements in a permit are reviewed by the USDA Natural Resources Conservation Service (NRCS), the Illinois Department of Agriculture, and a crops soils person.

2. **Lack of criteria for specifying forested acreage.** What is forest, or more importantly, what premining lands should be designated as forested? With the absence of criteria both in the federal and in the state legislation

and regulations, and lack of permit review by foresters or forest soil specialists, chances of proper designation and/or enforcement are unduly limited. How much of the premining acreage now termed "wildlife" should properly be reported as forest? Why is there not a "historically used for forest" as well as the "historically used for cropland" provision in the regulations? Are forested lands that have commonly been harvested or otherwise disturbed before mining no longer called forest? Such lands rapidly regenerate in an ongoing cycle of forest development.

3. **Inadequate designation in permits of premining forested acreage.** Guidelines and standards are needed so that forest cover is properly accounted for at all stages in permitting and reclamation. Was SMCRA intended to be a mechanism for eliminating forestry acreage? Let us look at the record.

   Whether forest acreage is restored after surface mining for coal is determined in part by the permitting process that may or may not provide for tree planting. If trees are planted, there will be a ground cover. If the trees fail or are not planted, a permit modification can accommodate an herbaceous wildlife designation. Of the 14,087 acres permitted to forest from 1983-93, only 30 acres or 0.2% had Phase III bond released by 1994. Perhaps some of the originally designated 14,087 acres had bond released under another land use than forest. I do not have sufficient information to document how much postmining forest acreage may be lost in this way.

   Two recent permit applications in southern Illinois were analyzed for pre- and proposed postmining forest acreage. Both lie within 50 miles west of Evansville, Indiana and are bordered by the Ohio/Wabash River system. A Gallatin County application was for 1500 acres and a White County application for 2402 acres. All forest is to be eliminated in the mined areas of both permits, 90 and 353 acres, respectively (Table 2). These two examples illustrate the superficiality of claims that forest acreages are being replaced. The acreages for unspecified wildlife vegetation increased by 172 and 354 acres, respectively. Areas designated wildlife are reclaimed to diverse land uses such as wetland, herbaceous, shrubland, or woodland. Of the total acreage for these mining permits, 68 percent and 51 percent, respectively, are set aside even if in forest premining by being designated “prime farmland.” If mined, these acres must be returned to row crops regardless of previous land use (IDMM 1993). The U.S. National Erosion Inventory 1977 reported 602,000 Illinois acres of prime farmland in forest. Illinois also has a "high capability" land use category. On any land so labelled, "The total soil profile, including subsoil and topsoil, must be a minimum of 48 inches for prime farmland and high capability land, including fragipan soils" (IDMM 1993). What use really are these lands?

   Tree planting is not forbidden on land designated high capability as it is for prime farmland. Trees are, however, unlikely to be planted on poorly drained, fine-textured, compacted soils with a required highly competitive ground cover and associated dense animal populations that together lead to failure of the plantings.

4. **Lack of regulator support for industry tree-planting operations and company downsizing of reforestation programs.** The pre-SMCRA choice of reclamation to trees on lands surface mined for coal was based on a national consensus in the 1930s and 1940s that endorsed tree planting for conservation purposes. Pine trees were planted by the Civilian Conservation Corps on the worn-out agricultural fields purchased for national forests and by other agencies for shelter belts in the Dust Bowl. Thus in 1977 when SMCRA was passed, the coal industry had an invaluable cadre of dedicated reclamation personnel with years of experience in successful tree planting. These people were given budgets to hire dozens of recent forestry and other graduates and started ambitious tree planting programs. Research money was given to universities in eastern and midwestern coal-mining states.

   A recognition of the values of tree planting vanished in the confrontations of the 1960s and 1970s. When SMCRA was drafted, the forestry community was sidelined and idealistic and ignorant, feed-the-world activists resolved to have soils restored at any price for crop production. Buzz words such as "prime farmland" became almost sacred, and its restoration/preservation the political touchstone to success. Unfortunately, the restoration of worn-out, eroded fields did not, and could not, restore long-term productivity.

   The coal industry soon realized that to achieve successful reforestation required drastic changes in tree planting to accommodate the drastic changes on the post-SMCRA lands. Requests for needed changes based on planting experience and research were ignored and opportunities for experimental practices were unful-filled. The companies gave up the unequal struggle, let most of their reforestation people go, and reassigned some others. Wetland and herbaceous wildlife acreages took over the noncropped lands to a great extent.

Technological Factors Tending to Constrain Reclamation Success

1. **Restoration of an unsuitable rooting medium on planting sites.** Logically the places to plant trees after mining would be the kinds of places they grew before mining: along drainages; around lakes, ponds, and wetlands; and on steep slopes. These are topographic features typically not cleared and used for crop production. Similar topographic features with no expectation of growing crops are designated on permits. The coal companies have been required to replace "topsoil" (top dirt) on the topography obviously not usable for crops such as the steep banks of ramps leading to a strip mine lake. These slopes with massive, fine-textured soils have accelerated runoff that enhances erodability. In contrast, a minesoil with coarse fragments would form an erosion-resistant surface mulch. The coarse fragments would facilitate water infiltration and percolation and root growth, and would weather to release nutrients, thus greatly enhancing forest produc-tivity (Ashby *et al*. 1984). Unfortunately, even places uniquely destined for trees cannot be reclaimed with a suitable rooting medium.

   What justification is there for not allowing alternative, productive minesoils in these noncrop areas? Although not widely known, many reclaimed areas have been planted twice or even three times after massive failures. Of the acres planted to trees in Illinois in 1990, approximately 20 percent were replanted in 1991 and 10 percent in 1992.

   Is there a justification for restoring the predominantly highly weathered and leached soil fines of southern Illinois "prime farmland" soils that readily compact and are highly unsuited for long-term tree growth? When wet they are anaerobic and toxic, and when dry become indurated, like brick. The failure of roots to penetrate pan soils is complicated by nutrient deficiencies and unfavorable pH (USDA 1951). Compared to minesoils, they have much less potential for support of a vigorous sustainable forest ecosystem. Acceptance of alternative land uses agreeable to the land owner should not be controlled by so-called environmental groups or compliant county agents with no forestry background. Every soil is stony; the only question is what size rock, and what is magical or meaningful about the 2 mm size barrier? Soils with coarse fragments are commonly more productive than without, and become more productive as the fragments weather. Is SMCRA fulfilled by reclamation mistakenly carried out with degraded rather than renewed soils?

2. **Restricted selection of tree species able to tolerate restored fragipan soils.** Forest restoration in southern Illinois will have to be reinvented to cope with site conditions unlike those prelaw. The prevailing forest cover at settlement was cleared by early settlers, followed by loss of topsoil with unwise farming practices. Reclam-ation should recreate soils similar in productivity to those forested before the topsoil was eroded off.

   Tree species found to be successful on minesoils have died or grown poorly on restored topsoils. Much of the first 20 years under SMCRA was therefore spent in species trials to find out whether any of the species optimistically recommended in various reclamation manuals were indeed adapted to the new post-SMCRA rooting medium. New species have been added and are still being added for trial to the reclamation roster (Ashby 1996B).

   A unique forest type in which bottomland species predominate is being developed for the unique postmining upland soils in southern Illinois. Even though they are soils on the upland, they commonly are waterlogged after precipitation events so that oxygen becomes depleted and roots of most upland species die in the anaerobic rooting medium. Seedlings of baldcypress, pin and bur oak, green ash, and other lowland trees have to date been relatively most successful as a potential forest canopy.

   Bond release based on number of trees after five years is technologically feasible. No one knows if these species can continue to survive and grow on the restored upland soils. There are indications that woodlands with scattered trees rather than forests will be the final result. Has reforestation under SMCRA sec. 515 (b)(2) "restore the land affected to a condition which it was capable of supporting before any mining,..."or (19) "establish...a diverse, effective, and permanent vegetative cover of the same seasonal variety native to the area..." been fulfilled? Soil types in nature vary in a catena or chain with changes in topography, drainage, and vegetation. A diverse postmining vegetative cover requires diverse soils.

3. **Excessive runoff from compacted, fine-textured soils.** Excessive runoff on graded, easily compacted, fine-textured soils results both from lack of water movement and storage in the soils and from long, smooth slopes as shown in the universal soil-loss equation. Limited soil moisture recharge in such a soil accentuates drought stress. Potential soil erosion by surface runoff leads to other reforestation problems.

4. **Adverse water relations on restored prime farmlands.** The restored, fine-textured, massive prime farmlands do hold, and also keep holding, more water than minesoils (mixed overburden). Plant water uptake also is limited by failure of root-system development on saturated or brick-hard subsoils.

5. **Unsuitable and excessive ground cover on tree planting sites. Some recent improvement can be noted.** The absence of meso- and micro- topographic diversity on intensely graded, fine-textured soils together with excessive runoff leads to accelerated erosion and a consequent use of ground cover to control erosion. An absence of coarse fragments eliminates potential for stone surface mulches that retard runoff and provide micro-habitats for successful establishment of tree seedlings.

   Ground covers, primarily grasses and legumes, planted for erosion control typically are over-planted to ensure thick stands, and are highly competitive with juvenile tree seedlings. Adverse direct effects on tree growth of thick ground cover, especially with highly competitive species, include competition for soil water, allelopathy by which a plant poisons its neighbors, and reduction of available light for photosynthesis. There are favorable direct effects of thin ground cover especially with woodland herbs, including protection from excessive evapotranspiration with less wind movement and shading with moderated leaf and soil temperatures.

6. **Extensive and continuing damage from excessive animal populations with grass/legume ground covers.** Voles repeatedly have decimated tree plantings in fields with grass swards, in the 1980s and 1993 and 1994 locally. A year for bond release is lost each time. Rabbit nipping may eliminate some species. Grassy areas planted with trees that attract deer are likely to develop as shrubland or woodland rather than as productive forests. Deer damage includes browsing and buck rub and causes extensive tree mortality for some species (Ashby 1996C, 1997). Damaged trees with poor form and apparently healthy sprouts with increased incidence of disease and insect damage may lead to a woodland rather than a forest.

New or Revised Technology Tending to Foster Reforestation Success

1. **Recently increased availability of suitable planting stock from cooperating tree nurseries.** Availability of seedlings suitable for reforestation can be a major problem. During the prelaw government-industry cooperative program of planting an acre of trees for every acre mined, the state tree nurseries in Illinois supplied graded seedlings of requested species to the mining companies. That program ended and orders for trees from mining companies were the last to be filled if any seedlings were left. Desirable species became rarely available; seedlings were ungraded and, in most years, were received too late in the season for successful planting. The companies turned to private nurseries and found that needed kinds of seedlings were unavailable. In recent years, two large mining companies have contracted with a nursery to grow quality seedlings and the reforestation programs of those companies have shown noticeable improvement. Trained personnel that understand species selection and handling of tree planting stock are required for successful reforestation. Poor planting stock should be rejected or thrown away.

2. **Use of less competitive ground cover species.** Ever since the implementation of SMCRA, industry reclamation specialists as well as university research personnel have noted competitive ground cover as a significant limiting factor of tree seedling survival and growth (Ashby 1990). Commonly used pasture species

conspicuously limiting for tree survival were tall fescue (*Festuca elatior*) and alfalfa (*Medicago sativa*). They become even more limiting with higher fertility levels. Companies with experienced reclamation personnel now plant species such as redtop grass (*Agrostis gigantea*). Ground cover requirements could be relaxed to promote development of a tree canopy and litter with minor if any increase in erosion.

3. **Timing of planting ground cover and trees.** A key to success of tree plantings is rapid early growth. Seedlings that fail to get ahead of the ground cover typically have high mortality rates, slow growth, and greatly increased animal damage. Rapid growth results from planting ahead of or with a ground cover on well-drained, permeable soils. If a planting is delayed until ground cover is established, and especially if unsuitable ground-cover species are planted, prospects of successful tree planting for many species are very limited. This varies among tree species (Ashby *et al*. 1988). Knowledgeable reclamation personnel are needed to select species suitable for each site.

4. **Selected use of seed to extend planting opportunities.** As shown in tables 3, 4, and 5, tree planting with seed has been successful with red oak, black walnut, and other large-seeded species (Ashby *et al.* 1995, Ashby 1996C). Most small-seeded species are typically not successful. Planting trees as seed is uncommon in southern Illinois.

   Seed has the advantage of small bulk and tolerance to wide ranges of moisture and temperature for relatively long storage periods. Seed can thus be available for planting whenever soil and weather conditions are favorable. Please note that acorns and some other fleshy-seeded species are not tolerant to drying out, and must have storage conditions and planting seasons similar to those for seedlings.

   Disadvantages of seed differ with species. They include physiological lack of seed production (alternate-year bearing) found especially with oaks, loss of seed crops from late frosts and other adverse weather conditions, internal damage to seeds from insects and disease, animal use of seed including after planting, and lack of germination from varied causes. Many kinds of seed have dormancy processes that affect time of germination and require special handling by trained personnel.

5. **More skillful use of herbicides.** Herbicide applications to eliminate herbaceous cover typically greatly increase tree survival and to a lesser extent growth (Ashby 1997). Use of herbicides at or before tree planting has become almost standard procedure. If not repeated, ground cover closes in again after about two years.

   Repeated herbicide applications in research studies have given additional marked benefits up to canopy closure and are rarely, if ever, carried out by mining companies. Some tree species are sensitive to herbicides. More effective herbicides continue to come on the market and first-time use of a new herbicide can bring surprises. Timing of application is very important. Herbicide use must be carried out intelligently and carefully for environmental and safety reasons.

6. **Use of planting machines.** Planting machines are widely used and generally successful for initial establishment related to skill of operator, moisture conditions of soil, and suitability of available tree seedlings. The machines greatly cut down on labor requirements and speed up planting. In a recent survey, seven larger mines in southern Illinois contracted out planting operations and only one company owned a planting ma-chine. If because of prolonged wet soils planting by machine cannot be carried out and labor is not available, planting may have to be delayed a year. Wet fine-textured soils also may affect success of establishment if hand planting is used.

7. **Research and applications for remediation of AML sites.** Prior to the 1960s about ten percent of the mined acreage in Illinois was barren for a few to many years. If adjacent areas had acid-tolerant species such as river birch or pin oak, they invaded to form forested patches that coalesced in later years. The minesoil pH of such areas tended to converge toward values typical of regional soils (Davidson *et al*. 1988), and tree species less acid-tolerant later invaded. An unfortunate feature of AML reclamation projects has been the bulldozing of established trees to start over on graded, compacted soils with dense ground cover in which tree seedlings typically die. These AML lands are not prospective cropland needing such intensive reclamation. The best

management for many areas would be to let nature take its course of natural succession.

For cosmetic or other reasons these sites can routinely be reforested by applying limestone and planting adapted species. Having skilled personnel who know how to choose the right species to plant on a site is a fundamental rule for successful reforestation.

8. **Reclamation technology to recycle waste materials and reforest barren sites.** Forests with significant environmental and economic value have been created on barren sites by simultaneously disposing of otherwise waste material. In a 1975 cooperative USDA Forest Service, industry, and university reforestation project, sewage sludge was brought from the Chicago area to prelaw Palzo/Will Scarlet mine sites in Williamson County. Most tree species planted after sludge incorporation established well. Although some species later died out, after 15 years many of the plots had a well-developed forest cover (Van Sambeek *et al*. 1992).

   Studies of reclamation on landfills and mined lands have shown trees to be effective in ameliorating adverse conditions by sequestering toxic ions. Growth of other species and water quality are improved.

9. **Soil ripping or subsoiling including biological compaction mitigation.** I apologize for even bringing up ripping because it would not be needed with better reclamation practices. There are established techniques to return a mined area to approximate original contour (AOC) with minimal compaction. These include dragline pullback or truck haul with restricted traffic paths. Tree growth has been successful on such lands appropriately returned to AOC. Compaction also could be lessened if fine-textured soils are not segregated and returned as massive layers but rather with a mixture of coarse fragments.

   Where unfortunately needed, ripping of inherently massive, fine-textured, and/or compacted soils increases soil aeration and water entry and storage. We do not know how soon or how likely the rips will disappear as a homogeneous fine-textured soil mass flows together when saturated, or whether roots will later be able to grow beyond a rip furrow to support long-term biomass production. To some extent, ripping physically eliminates herbaceous ground cover competition along a soil rip. Tree seedling survival and root and top growth have increased greatly on ripped soils (Josiah 1986). Significantly greater height growth was found with ripping for red oak and black walnut after 12 years (Table 4) (Ashby 1996C). Both were planted as seed on graded, compacted minesoil with 40 percent coarse fragments greater than 2 mm in diameter.

   Conventional wisdom assumes deep-rooted plants are of value for opening root channels in compacted soils. Roots of a few tree species were found to be exceptionally able to penetrate deeply into compacted, fine-textured, restored soils (Ashby and McCarthy 1990). The most effective species in our study were baldcypress and hybrid cottonwood (*Populus* x), followed by sycamore. An ability of their roots to tolerate seasonally saturated/anaerobic soils may be the key to their deep-rooting. Alfalfa, deep-rooted on some soils, did not survive on the poorly drained soils (Raisanen 1982).

10. **Tree tubes and other planting techniques.** Tree tubes or shelters have given variable results. If damage from animal populations could otherwise be lessened, not likely these days, tree tubes may not be worth the cost and labor. Plastic mats a meter square around the base of a tree seedling seemed to be of little use (Ashby 1995).

    A plastic sheet having slits for water entry that covered a much larger planting area has given greatly increased survival and growth. Baldcypress, a swamp species that can tolerate saturated soils, is highly

    sensitive to ground cover competition otherwise eliminated by flooding on natural sites. Baldcypress seedlings on a tight, poorly drained, restored soil covered with a plastic sheet averaged 1.5 m tall after four years, and died out in an adjacent plot even with initial herbicide control of ground cover.

    Organic mulches—bark, sawdust, etc.—give variable results related to weather conditions, type of material, thickness, tree species, etc. Local testing and experience are recommended. As noted in section C.8, sludge and other waste products greatly increased tree survival and growth on barren sites. These materials vary greatly in local availability and quality and their use must be carefully monitored.

Broadcast fertilization on tree-planting sites is generally not recommended. Increases in herbaceous cover seem to offset benefits, if any, for tree growth. Fertilizer tablets that can be beneficial when properly placed in the ground around lawn trees have not seemed of particular benefit to seedlings in reclamation plantings.

Mycorrhizal fungi commonly have been found on tree roots of reclamation plantings, with spores evidently carried by wind, rain, or animals, and inoculation of seedling roots does not seem to be needed. Mycorrhizae make calcium, phosphorus, and other nutrients in coarse fragments available for tree growth.

Potential For Successful Reforestation

1. **Prelaw tree plantings on mixed overburden minesoils throughout southern Illinois were widely successful.** In Illinois prelaw, the coal associations voluntarily planted an acre of trees for each acre mined, and the Illinois Department of Conservation Division of Forestry grew the needed tree seedlings. These cooperative arrangements fulfilled the goal of successful reforestation deemed appropriate at that time to give us thousands of acres of productive forests today. A wide choice of high-quality tree species planted on minesoils for timber, wildlife, recreation, and other needs had good to excellent growth. The overburden of mined lands when suitably replaced had desirable physical and chemical properties for superior tree growth. Coarse fragments in the cast overburden rapidly weathered when brought near the land surface to form silt loam soils. Several studies by the USDA Soil Conservation Service (SCS, now NRCS) reported these soils to be deep and well-drained minesoils.

   Average height growth on the Sahara Coal Co., Inc. Mine No. 6 in Saline County of trees planted chiefly in the 1940s ranged in 1993 from 33 m for red/shumard oak, to 24 m for walnut planted as seed (Table 5) (Ashby 1996A). Similarly good growth was measured in Perry and Randolph counties in 1993.

   Growth of tree species planted in 1981 on mixed overburden mined pre-SMCRA in Saline County compared to the same lot of seedlings planted on replaced "topsoil" was without exception greater on the minesoil (Table 6). Black walnut, basswood, and especially tuliptree, ecological indicators of good to excellent drainage in their natural habitats, clearly show the limitations to tree growth of replaced "topsoil." Unlike corn, that is adapted for high yields with intensive management on a wide range of upland soils, any of these tree species is much more sensitive to inferior soil conditions and a better index plant for assessing soil quality.

2. **Cultural information has been available from manuals and other literature on need for suitable rooting medium, choice of species, planting practices, and other elements for success of tree plantings.** Prelaw and early postlaw, the USDA Forest Service had reclamation research centers (that have been eliminated) at Carbondale, Illinois; Berea, Kentucky; and other locations in the eastern United States. Part of their legacy, in addition to valuable long-term research plots, has been a substantial and valuable ongoing reclamation literature. Much resulting cultural information for successful reforestation with a suitable rooting medium has been available for 40 years (Limstrom 1960). Unfortunately, this type of information was overlooked or ignored in drafting SMCRA 15 years later.

   Users of these studies have included the USDI Office of Surface Mining (OSM) that over a period of years sponsored training sessions on reclamation including reforestation. Willis G. Vogel of the then Forest Service research office in Berea, Kentucky prepared for the OSM sessions *A Manual for Training Reclamation*

   Inspectors in the Fundamentals of Soils and Revegetation. This 1987 manual incorporated findings from Forest Service and university research and from coal company reforestation plantings in the eastern and western coal regions. Most of the available information, and all information for trees older than ten years, came from trees planted on minesoils before the passage of SMCRA that eliminated minesoils in favor of replaced fine-textured top dressings.

   In 1993, Ashby and Vogel published *Tree Planting on Mined Lands in the Midwest A Handbook*, related more specifically to midwest conditions and still largely based on pre-SMCRA minesoil tree plantings. Some earlier statements from the 1987 publication were modified based on post-SMCRA research findings. New sections were added on topics not earlier recognized to be of great importance in reforestation, for example extensive wildlife damage to tree seedlings planted in post-SMCRA grassy swards.

Although manuals based on longer-term tree growth on lands reclaimed under post-SMCRA regulations in southern Illinois are not available, numerous reforestation research papers have been published in conference proceedings and in reclamation or restoration journals. Trees planted post-SMCRA on restored prime farm-land are now sufficiently old for meaningful comparisons with trees planted much more successfully pre-SMCRA or contemporaneously on cast overburden minesoils from pre-SMCRA mining operations.

3. **The components for successful reforestation could readily be in place if the regulatory authorities would accept needed changes in reclamation requirements.** The mining industry could readily shift to successful reforestation if the regulatory authorities would remove barriers and offer incentives. There are still plenty of reforestation personnel able and anxious to bring about successful reforestation that could be recruited and entrusted with the job. The problem areas have been identified and should not longer be left unsolved. Suitable nursery stock, planting machines, herbicides, and other needs are available.

   Today planting of trees, if any, is contracted out to commercial operators. Some of these contractors try to do a very responsible job, while others are less qualified or committed. Selection and supervision of qualified contractors is very important. Mining company reclamation supervisors have learned to handle these operations and with additional personnel could expand operations greatly. Even at best, with millions of trees to plant in a short planting season, there can be problems of delays from unsuitable weather, poor seedling handling, inexperienced planters, etc. Just anyone cannot successfully plant large numbers of tree seedlings during each annual brief period with suitable temperatures and soil-moisture levels.

4. **Tree plantings established to date on several kinds of rooting media are an invaluable resource for ongoing research studies and projections.** Trees are long-lived. Questions of reforestation success or failure can only be answered decades after trees are planted. Bond is released five or more years after planting. How well is bond release correlated with long-term success? (This type of analysis should be carried out for corn farming as well.) Are rate of tree growth or other yield measurements needed for predictability of success? How serious is deer and other animal damage for forest development? How readily do other plant, animal, and microbial forest components invade to establish a self-sustaining ecosystem?

   The varied types of company plantings and research plots established since 1977 (SMCRA) can be studied to gain as much as 20 years in answering these significant questions. Many of these plantings are recorded and documented in the *National Register of Reclamation Research and Demonstration Areas on Mined Land* funded in large part by OSM (Ashby 1992).

Conclusions and Recommendations

If a regulatory authority wished to have more mined land planted to trees, what options or requirements are there to change present practices? SMCRA is charmingly innocent of specific provisions to require planting of trees. Since forestry is not otherwise designated in SMCRA, must it not be acknowledged as a higher or better post-mining land use to encourage tree planting? Are not forest trees a crop?

The Illinois Act in Section 3.15. Vegetation. (a) states "The Department may approve vegetation plans for the purpose of soil building..." Farming, row cropping as traditionally practiced in this country, constitutes low scale strip mining. The topsoil is progressively eroded off and surface mining later simply more drastically disturbs the remaining overburden of the worn-out fields. As considered elsewhere in this paper, forests are ideal for the long-term building from mixed overburden of a soil bank to support future agricultural needs.

The value of forests to control soil erosion, reduce stream pollution, enhance soil productivity, and sequester carbon has been recognized as a higher and better land use in the USDA Conservation Reserve Program (CRP). A means to encourage forestry would be for OSM's requirements to be in line with standards for success used by the USDA. Trees are planted on former croplands and Congress appropriates millions of dollars for conservation payments to farmers.

Under the present administration of SMCRA, mining removes forests to recreate marginal agricultural lands that after bond release presumably would again be eligible for CRP payments to plant trees. Why not directly reforest mined lands? If so, tree growth could be vastly improved by using not restored degraded soils typical of CRP worn-out fields but long-term rich and productive postmining soils from mixed cast overburden. Mined lands are ideal for large blocks of forest to reduce edge effects and cowbird predation of song bird reproduction. Mineland forests have been refuges for endangered species.

These needed changes have not been authorized and supported. The experimental practices provisions of SMCRA clearly encouraged soil-building demonstrations. Our national goal should be to restore the type of naturally rich and productive forest soils that once existed in premining areas. Restoration to that level of productivity requires mixing of mineral-rich coarse fragments from lower in the overburden with the top-dressing materials currently replaced.

If past is prologue, prospects for effective reforestation on surface-mined lands in southern Illinois are dim indeed. How to grow trees is not a major problem. Just as the best technology in the world has yet to produce a car that would run or a plane that would fly without fuel, so effective reforestation is dependent on a suitable rooting medium.

The powers-that-be in Illinois seem not even to have considered what is a suitable rooting medium for reforestation. Soil science, SMCRA, and common sense are flouted to restore the local relatively unproductive "prime farmlands." Producing an occasional acceptable corn crop at great cost only proves that corn can be grown on any nonflooded soils. My research group (ms in preparation) has successfully grown corn on minesoils (mixed cast overburden). This type of study of minesoil productivity should be tested and, when proved, implemented to benefit both crop and forest productivity.

Once major blockages to successful reforestation are removed, trained reclamation personnel are available that mining companies have on staff or could rehire to meet those needs. There also is suitable talent and experience in Mines and Minerals that could work cooperatively with industry reclamation personnel toward a common reforestation goal. The cooperative relations prelaw between government and industry for successful reforestation should be restored. The goals of SMCRA are not unattainable. More attention to creativity and less emphasis on unwarranted restrictions are needed.

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Table 1. Factors that foster and hinder reforestation acreage and success.

A. External technological factors tending to constrain reforestation acreage and success
1. Forestry omitted in regulations
2. Lack of criteria for forests
3. Forest acreage omitted on permits
4. Incompatible reclamation goals

B. Technological factors tending to constrain reforestation success
1. Unsuitable reforestation soils
2. Compacted rooting zones
3. Excessive runoff
4. Adverse water relations
5. Unsuitable/excessive ground cover
6. Excessive animal damage

C. New or revised technology tending to foster reforestation success
1. Better planting stock
2. Less competitive ground cover
3. Timely planting operations
4. Demonstrated seed potential
5. Improved use of herbicides
6. Use of planting machines
7. Remediation of AML sites
8. Recycling of waste resources
9. Remedies for compaction
10. Tree tubes, plastic mulches, misc.

D. Potential for successful reforestation with suitable rooting medium
1. Successful plantings prelaw
2. Available reforestation literature
3. Latent reforestation potential
4. Legacy of research plots

Table 2. Pre- and postmining acreages of forest and wildlife habitat for two mining permit submittals in southern Illinois.

Permit Acreage	Forest Areas: Mined		Forest Areas: Support		Wildlife[a] Areas: Mined		Wildlife[a] Areas: Support	
	Pre-	Post-	Pre-	Post-	Pre-	Post-	Pre-	Post-
1500[b]	89	0	154	154	54	197	103	132
2402[c]	352	0	24	24	(4)[d]	343	(4)[d]	359

[a] Vegetation type not specified
[b] 1022 acres must be reclaimed to crops as Prime Farmland
[c] 1216 acres must be reclaimed to crops as Prime Farmland
[d] 4 acres total premining wildlife

Table 3. Species survival and height on four kinds of rooting medium at age 12 years, or 13 years if *. The bolded numbers in each row are the greatest survival or height.

Species	Survival (%)				Height (m)			
	Cast	Graded	Topsoil	Place	Cast	Graded	Topsoil	Place
Sweetgum *Liquidambar styraciflua*	31	1	66	**78**	6.7	3.0	4.5	**6.8**
River birch *Betula nigra*	46	4	26	**48**	**7.3**	4.9	4.3	4.6
Sycamore *Platanus occidentalis*	76	17	52	**98**	**7.9**	6.2	4.1	7.2
Bur oak* *Quercus macrocarpa*	75	**90**	28	47	**4.5**	3.7	3.4	2.0
Red oak *Quercus rubra*	66	19	**87**	78	**5.2**	1.9	3.4	2.2
White ash *Fraxinus americana*	59	62	86	**98**	3.7	**4.1**	3.3	4.0
White oak SD *Quercus alba*	**61**	4	34	4	**3.9**	1.3	2.9	1.3
Black oak* *Quercus velutina*	**31**	21	1	17	3.7	2.1	2.7	**3.9**
Shumard oak SD *Quercus shumardii*	44	16	**72**	59	**4.7**	1.7	2.6	2.3
Red oak SD	43	1	**70**	58	**5.5**	1.4	2.6	1.2
White oak	57	20	**84**	80	**3.8**	2.0	2.5	1.6
Pin oak *Quercus palustris*	47	8	**93**	84	**4.8**	2.7	2.4	1.4
Silver maple *Acer saccharinum*	47	17	**52**	87	**6.0**	5.2	2.4	3.7
Baldcypress *Taxodium distichum*	33	0	79	**92**	**2.7**	died	2.1	2.3
Persimmon *Diospyros virginiana*	18	8	76	**83**	**3.6**	2.0	1.7	2.2
Black walnut* *Juglans nigra*	57	**71**	8	19	**3.7**	3.0	1.5	0.9
Black walnut SD	11	49	80	**93**	**4.1**	**4.1**	1.0	2.5
Tuliptree *Liriodendron tulipifera*	19	0	5	**64**	**6.0**	died	0.7	4.7
Basswood *Tilia americana*	**79**	29	73	23	**4.0**	3.4	0.5	1.0
	Cast	Graded	Topsoil	Place	Cast	Graded	Topsoil	Place
# **Bolded**	**3**	**2**	**6**	**8**	**16**	**2**	**0**	**2**

Table 4. Effects of ripping on growth of 13-year-old red oak and black walnut planted as seed on graded cast overburden.

Species	Survival (%) Ripping		Heights (m) Ripping	
	-	+	-	+
Red oak SD	8	61	2.2	4.5
Black walnut SD	38	69	2.6	5.5

Table 5. Age in years and height growth of tree seedlings or seed planted on ungraded cast overburden chiefly in the 1940s and measured in 1993.

Species	Age	Height (m)	Species	Age	Height (m)
Red/Shumard oak	55	33	Sweetgum	47	26
Tuliptree	40	30	White oak	55	26
Black walnut	47	27	Black walnut SD	47	24

Table 6. Average height (m) of six hardwood tree species 13 years after being planted on "topsoil" and on minesoil.

Species	Height (m)	
	"Topsoil"	Minesoil
Sweetgum	3.9	7.1
White oak	3.5	3.9
Red oak	3.2/2.2[a]	5.0/5.0[a]
Black walnut	1.5/0.9[a]	3.7/5.3[a]
Basswood	0.6	3.7
Tuliptree	died	4.6

[a]Planted as seedlings/seed.

LOW MINE SOIL COMPACTION RESEARCH

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Abstract

A multidisciplinary group of researchers at the University of Kentucky initiated a diverse study to evaluate the effects of soil compaction on the survivability and growth of high value tree species. This study was established on the Starfire Mine owned by Cyprus-Amax in Perry County, Kentucky. The team of researchers encompassed the various expertise areas in the departments of agricultural engineering, forestry, mining engineering, and ecology.

Since its initiation, a weather station has been established, over 57,000 trees have been planted, a passive dewatering system initiated, and a fertigation study constructed. The trees consisting of seven species have been planted on areas that were compacted, partially compacted and uncompacted.

Bulk densities and penetrometry data have been gathered on all the planted sites to determine the relative compaction of each planting area. Compaction is already a contributing factor to either or both tree survival and growth.

Additional studies being conducted include the effects of alternative ripping methods on reclaimed areas that were compacted in the normal manner prior to the concept of a new grading standard. These plots were mulched and planted this month. Additional studies will be planned depending upon the availability of funds.

Introduction

The University of Kentucky Department of Biosystems and Agricultural Engineering, Department of Forestry, and Department of Mining Engineering began an extensive reclamation research project in 1995. This project is intended to extend the efforts of past and ongoing research programs at the University of Kentucky, Southern Illinois University, and VPI's Powell River project. It also was designed to be an integrated effort that would utilize as many areas of expertise as possible.

The basis for justifying this research was the established facts presented by the Kentucky Reclamation Association that they had reclaimed 187,000 acres since 1948. Prior to 1980, 101,000 acres were planted primarily to trees. Since 1980, 86,000 acres were reclaimed with 1,500 acres being a return to forest land. Most of the area returned to forest land does not meet minimum stocking standards. Three thousand acres were planted to shrub species. The result has been the establishment of 81,500 acres of lespedeza and tall fescue.

Early research at Southern Illinois University found that by simply striking off old prelaw strip mine spoils created areas that resulted in the highest site index areas in the state for yellow poplar, white oak, and walnut. VPI (The Powell River Project) reported that applications of uncompacted spoil at a depth of 12 inches resulted in a white pine site index of 60 while 4 feet resulted in a site index of over 100. The result would be that an acre at site index 60 would be worth $100 in 30 years while an acre at site index 100 would be worth over $2400 at the same age.

Since the project was initiated the total area impacted has grown to approximately 83 acres. These include nine 3-acre cells that contain twenty one 1/10-acre plots that are comprised of seven species replicated three times. The cells consist of three that are compacted in the normal manner that has been accepted since the initiation of PL95-87. Three were back-dumped and left ungraded and three were back-dumped and "lightly graded." Lightly graded depended on how closely the dozer operator was supervised in the process.

One cell in each grading treatment was mulched with 45 ton per acre of hardwood bark, one mulched with 45 ton per acre barn litter, and one was left unmulched. Berms were constructed around each cell to contain all rainfall and eliminate any runoff that might be construed as detrimental to any surrounding area.

A fully automated recording weather station was placed on the research site. A passive dewatering sediment pond was constructed adjacent to the three compacted cells. All precipitation from the cells was diverted through the dewatering structure and recorded.

Additionally, a 1.5-acre area has been created to study sedimentation and a two-acre area to evaluate trickle irrigation and infiltration. These also have been mulched and planted with trees. To study methods of modifying existing reclaimed mine spoil to facilitate productive tree growth, six 2.5-acre cells have been mechanically ripped. Three were cross-ripped on approximately 6 foot centers to a depth of 30 inches or more. Three were ripped with conventional multitined rippers at a depth less than one foot. These areas were mulched as the other cells and planted with the same seven species replicated three times.

Additionally, a 20-acre area of moderately graded to ungraded dragline spoil was planted to simulate the planting systems common prior to PL95-87. These installations provide data that range from the completely ungraded to that completely compacted with additional information concerning the redisturbance of compacted sites.

To date approximately 57,000 trees have been planted with more planned, depending on availability of resources, for further expansion of treatment modifications. Equipment has been designed to make more radical modification of previously reclaimed areas, but we have not had the resources to initiate trials using the system.

Rick Sweigard will discuss the bulk density and penetrometer data that is being gathered on these areas. Tree survival and growth information is being correlated to the density measurements that are found with each treatment.

We have had to install 2.5 miles of high tensil electric fences to prevent cattle, deer, and elk damage to the trees. An additional 1.5 miles will be necessary this year.

Results

This project is expected to continue for 20 years or more. It is now in its infancy but beginning to yield some interesting results. In the uncompacted dragline spoil after three years, white ash has an average survivability of 91 percent and has averaged 24 cm of height growth. Yellow poplar is the least successful survivor with an average of 44 percent and walnut has only averaged 1 cm of height growth.

In the compacted dragline spoil, white ash still has a survivability rate of 87 percent. White ash and northern red oak have averaged 7 cm of height growth. Yellow poplar averaged only 13 percent survivability and walnut averaged a negative 7 cm of height growth during the three years. Negative height growth is a result of dieback and browse damage.

Survival in the loose-dumped cells after three years are very good. White ash averages 88 percent but is closely followed by northern red oak, yellow poplar, and white pine. Paulownia averaged only 37 percent survivability. This survivability can primarily be attributed to the planting stock. Those paulownia that survived averaged 47 cm of height growth. White ash had averaged 11 cm of height growth after two years. Black walnut averaged a negative 1 cm after two years. The overall survival averaged 76 percent with 11 cm height growth.

Black walnut was the leading average survivor in the rough-graded cells at an average of 92 percent followed closely on white ash. The lowest survivability was paulownia with an average of 48 percent. Paulownia height growth averaged 52 cm for the two years, and white ash averaged 13 cm. Black walnut averaged a negative 10 cm of height growth while the northern red oak averaged a negative 1 cm. The overall survival of these cells was 74 percent and had an average growth of 9 cm. White ash was the leading survivor in the compacted cells averaging

87 percent. The lowest survival was again paulownia which averaged only 11 percent. The surviving paulownia height growth averaged 33 cm for the two years, while black walnut averaged a negative 28 cm over the same period. The average survival in these cells was 45 percent and averaged a negative 1 cm for two years with ash

being the only species with a positive growth other than paulownia.

When we look at the average survival from 1996 to 1998 in the loose dragline spoil, we see that northern red oak, yellow poplar, and black walnut are slowly declining. White oak, white ash, and white pine are showing increases from resprouting dieback or browse. On the compacted dragline spoil only black walnut is increasing after initial dieback or browse damage. White ash resprouted and then declined the next year. Northern red oak is decreasing each year, while white oak, yellow poplar, and white pine are holding their own after the initial mortality.

Survivability is decreasing slowly in the loose-dumped cells for every species except paulownia and black walnut. In the rough-graded cells, all species are declining except white oak and black walnut. The survivability of all species are decreasing in the compacted cells.

The average height growth was greater for all species in the uncompacted dragline spoil, except white oak. The compacted cells resulted in a decreased height growth for all species. Greatest height growth averages were attained in rough-graded areas by white ash, paulownia, and white oak. White pine, walnut, yellow poplar, and northern red oak appear to prefer the loose-dumped cells.

Conclusion

There are some very positive trends beginning to appear in the data from this research area. There is not much doubt that compaction has a very negative effect on both survival and growth for the species selected in this study. We are seeing at this time that light compaction is not detrimental to some species at this stage of development. We also see that no compaction is beneficial to those species not affected by light grading. Time will be the determinate of which system works best but evidence from past research indicates that growth, yield, and soil formation are increased by either having little or no compaction by heavy equipment and are, in fact, better than undisturbed areas since more root development depth is attained than in normal natural stands.

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USE OF FIELD MEASUREMENTS TO PREDICT REFORESTATION SUCCESS

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Abstract

Measurements of dry bulk density and penetration resistance have been made on nine reforestation test cells at the Star Fire Mine in eastern Kentucky. Both properties are indicators of soil compaction. Dry bulk density was measured using a density gauge. Penetration resistance was determined using a recording cone penetrometer. This technology, which was developed for prime farmland soils, has produced useful data in terms of average penetration resistance (an indirect measure of soil strength). Both dry bulk density and penetration resistance results have been compared to tree survival rates on the various cells. It is believed that such measurements will ultimately be useful in predicting tree survival rate and site index for reclaimed surface mined land.

Introduction

It has been known for some time that excessive soil compaction is detrimental to the establishment of forests with high-value tree species. Due to the amount of grading involved, current reclamation practices in the central Appalachian region typically result in a highly compacted surface that inhibits root growth and development. These conditions lead to high mortality rates for seedlings planted on reclaimed surfaces.

Upon removal and replacement, the soil is compacted with earthmoving equipment to the extent that the original structure is destroyed. A crust is typically found on the surface layers due to final grading and leveling of the soil. There are no apparent lines of weakness with the exception of desiccation cracks near the surface due to wetting and drying. This reduces water infiltration and transmission through the soil. Layers of extremely compacted soil develop at various levels in the profile due to the intensity of traffic. The pore space is greatly reduced by the loss of macropores. These factors combine to produce a soil with poor physical properties that inhibits root growth (Dollhopf and Postle, 1988). Soil compaction is an inevitable result of soil transportation due to the breakup of its structure.

Several soil properties change as a result of soil compaction. Soil density increases as the soil particles move closer together. The mechanical resistance to penetration increases, depending on moisture content and size of soil grains. The hydraulic conductivity is reduced due to an increase in compaction (Barnhisel, 1988). These changes occur as a consequence of soil movement and restoration. Mine soils generally show little or no structure throughout their profile. Structure may begin to appear in mine soil within 50 years (Dollhopf and Postle, 1988).

Bulk density is a common method used to measure compaction of the soil. Freitag (1971) reviewed methods of measuring bulk density. Wet bulk density is defined as total mass per unit volume and is expressed as g/cm^3 (lb/ft3). Due to varying moisture content, this is rarely reported. Dry bulk density is defined as the dry soil weight divided by wet volume and is expressed as g/cm^3 (lb/ft3) and will be referred to as “bulk density “ or “density.” This value is typically reported in compaction studies. A low bulk density value corresponds to a less compact soil. As the bulk density increases, the soil particles come closer together. Smaller particles start to fill in the voids between the larger particles. Bulk density measurements may be taken gravimetrically or with a nuclear device.

Manufacturers of nuclear devices provide operational and scientific information for measuring bulk density (CPN Corporation, 1988). Radioactive methods measure in situ bulk density and utilize two forms of radiation: gamma and neutron. The unstable isotopes contained within the source will slowly decay to a more stable state. This act of decay produces emissions of energy as the atoms disintegrate. Two types of gauges are available: single probe and dual probe. The dual probe nuclear gauge contains two source isotopes in one probe (one emits gamma; one emits neutron radiation). The gamma radiation detector is located in the other probe, while the neutron radiation detector is located in the source probe. The single probe gauge also contains two source isotopes, but both detectors are located at the base of the instrument, which remains on the soil surface. Due to decay of the radioactive sources over time, new standards were established to calculate the soil count ratio, which is used in bulk density determinations (CPN Corporation, 1988).

Soil strength is related to mechanical resistance and is defined as "the ability or capacity of a particular soil in a particular condition to resist or endure an applied force" (Gill and Vandenberg, 1968).

Resistance to penetration depends upon soil properties such as texture, mineralogical composition, moisture content, and density. A coarse-grained soil will have a large average pore diameter and a low resistance to penetra-tion. A soil with a well-developed structure will contain macropores, which can easily be penetrated. Soils with a high moisture content have a lower resistance to penetration than a soil with lower moisture content. Generally, soils with a low bulk density have lower resistance to penetration (Thompson, Jansen, and Hooks, 1987).

A common method used to measure the soil's resistance to penetration requires forcing a shaft with a cone-shaped tip into the soil. In addition to the above mentioned items, the mechanical resistance encountered also depends upon the interaction of the soil with the cone. This includes the cone's diameter and angle, material of composi-tion, and rate of advancement. Since there are many factors affecting the resistance of penetration, this index can be used only when all other factors are held constant (Vomocil, 1957).

The mechanics of soil failure during penetration include shear failure, plastic flow, and compression. Direct interpretation of the penetrometer results in terms of soil strength is currently unavailable. However, the penetration resistance is considered to be related to the strength of the soil and is termed penetrometer soil strength (Hillel, 1980).

Field Study

An investigation was initiated at the Star Fire Mine in Perry County, Kentucky to study the impacts of varying degrees of compaction on tree growth. Research plots were constructed as follows: (1) three with loose-dumped spoil and no grading; (2) three with moderate grading to strike-off the tops of the spoil piles; and (3) three that were graded to a smooth surface typical of current surface mine reclamation practices. The three cells in each group then received different surface treatments: (1) one cell received bark mulch; (2) one received composted straw and horse manure; and (3) a control cell received no surface treatment. All nine cells were planted with seven hardwood species located in 21 randomly placed plots.

Field measurements were taken initially during the summer of 1997 on each of the nine cells. Resistance to penetration was measured with a custom-built, constant-rate recording cone penetrometer. The penetrometer was advanced until refusal. The depth to refusal and the average resistance over that depth were recorded. Two dry bulk density measurements were taken at each location. One was taken at the maximum depth of penetration achieved by the penetrometer and another measurement was made at a depth of two inches in each hole.

Penetrometer and bulk density measurements were taken at 28 locations in each of the nine cells. A second complete set of measurements was taken during the summer of 1998.

A recording cone penetrometer was obtained from the Southern Illinois University/University of Illinois Cooperative Reclamation Research Station. General design specifications for the penetrometer can be found in Hooks and Jansen, 1986. The fabrication began with a three point tractor-mounted Giddings soil coring machine.

The hydraulic system allows a constant penetration rate to be set. A load cell and computerized data acquisition system allow the penetration resistance to be measured over the depth penetrated. The machine is capable of penetrating to a depth of 50 inches; however, due to the rocky nature of the spoil at the site, much shallower depths were realized. This technology was originally developed for use on prime farmland. Figures 1 and 2 illustrate the different types of resistance profiles typically obtained for midwestern prime farmland and appalachian mountaintop removal sites, respectively.

Bulk density measurements were obtained using a CPN Model MSLA-OOA nuclear gauge. Gamma and neutron radiation is emitted from 10 mCi Cs-137 and 50 mCi Am-241/Be sources. The gauge has dual probes with a maximum penetration depth of 36 inches. One probe houses the radioactive sources and the other probe contains the sensors. Standard one-minute readings were used in all cases.

The penetrometer and density data were compared to the tree survival data that were obtained after each growing season. The tree data were taken by researchers from the Department of Forestry and the soil properties were measured by researchers from the Department of Mining Engineering. Tree survival data from two growing seasons have been compared to soil properties measured during those years. The field investigation is ongoing and additional data sets will be collected.

First Year Results

The compiled results by cell for the first year are given in Table 1.

Cells #2, #3, and #4 were uncompacted; cells #5, #6, and #1 were moderately compacted or graded lightly; and cells #7, #8, and #9 were fully compacted. The average depth to refusal, average penetration resistance, and average dry bulk density for the three conditions are listed in Table 2. The tree survival rate for each of the cells is given in Table 3. It can be seen from tables 1 and 2 that there is a recognizable difference in average penetration resistance, depth to refusal, and dry bulk density between the uncompacted, light graded, and compacted cells. As expected, the uncompacted cells (#2, #3, #4) had the lowest average penetration resistance (742psi), the deepest average depth to refusal (1.41ft), and the lowest average dry bulk density (91.3pfc). The lightly graded cells (#1, #5 #6) had intermediate values of 851psi for average penetration resistance, 1.13 ft for average depth to refusal, and 94.5 pcf for dry bulk density. The compacted cells (#7, #8, #9) represented the other extreme with an average penetration resistance of 1094psi, average depth to refusal of 0.97 ft, and average dry bulk density of 102.6 pcf. These findings are very important because they validate the assumption that these parameters can be used to quantify these parameters for the central appalachian region. At the present time, the data are not sufficient to draw any conclusions about the differing mulch applications that were used on the various cells.

Figure 3 illustrates the composite impact of surface condition on first year tree survival. Although there was not much difference between uncompacted and lightly graded cells, the compacted cells had a much lower survival rate. Figures 4 and 5 show survival rate as a function of refusal depth and average penetration resistance, respec-tively. A very interesting observation can be drawn from Figure 5-Survival Rate vs. Resistance to Penetration. The data seem to indicate that survival rate declines very slightly as average resistance increases up to some point. Preliminarily, this point appears to be around 1050 psi. However, at resistance above this level, survival rate decreases dramatically.

Second Year Results

The analysis of the second year results are not yet complete; however, some preliminary observations are possible. One of the objectives of the study was to see how mine soil properties change over time as a result of weathering and root penetration. The initial results are somewhat confusing. Figures 6, 7, and 8 show the bulk density, average penetration resistance, and depth to refusal, respectively, for the two years. The same measurement techniques were used for both years.

While it was anticipated that penetration resistance would decrease gradually over time, the large decrease from one year to the next is puzzling (Figure 7). Likewise, the reduction in refusal depth is difficult to explain in light of the reduction in penetration resistance (Figure 8). The dry bulk density measurements reported are taken at the two-inch depth. The results from the second year indicate a slight increase in bulk density at that depth.

A graph of tree survival rate as a function of average penetration resistance for the second year is given in Figure 9. Although the shape of the graph is generally similar to the one from the previous year, the data do not exhibit that same sharp cutoff point that was observed from the first set of data. It must be emphasized that these data were tabulated very recently and, as such, have not been thoroughly checked for calibration errors.

Conclusion

It is important to understand that this is work in progress and final conclusions cannot be drawn at this point. Some initial data were very encouraging that a simple relationship may exist between average penetration resistance and tree survival rate.

The second year results were less dramatic in regard to survival rate as a function of average penetration resistance. The changes in penetration resistance and refusal depth from one year to the next are currently unexplained. Subsequent measurements should indicate whether this is a real trend or simply a load cell recalibration issue.

No attempt has been made at this time to relate these physical properties of the soil to site index. This is certainly an objective; however, the data is too sketchy at this point to make this kind of projection. While there are certainly some interesting results to date, the primary conclusion is that additional data sets must be collected over the next several years to produce the kind of predictive tool that is desired.

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Table 1. 1997 Soil Properties for Each Cell.

cell #	Depth to Refusal (ft)	Dry Bulk Density (pcf)	Average Penetration Resistance (psi)
1	0.82	97.4	861
2	1.32	92.2	720
3	1.6	88.1	709
4	1.31	93.6	798
5	0.98	90.8	935
6	1.6	95.2	758
7	1.06	106.0	1122
8	0.91	98.2	1102
9	0.92	103.5	1057

Table 2. 1997 Average Soil Properties for Each Surface Condition

	Depth to Refusal (ft)	Dry Bulk Density (pcf)	Average Penetration Resistance (psi)
Compacted	0.97	102.6	1094
light graded	1.13	94.5	851
Uncompacted	1.41	91.3	742

Table 3. Survival Rate of Tree Species.

Survival Rate of Tree Species in Percent									
	BW	PA	RO	WA	WO	WP	YP	Average	
Cell									
1	95	38	91	94	91	87	92	84	SO
2	95	55	93	89	90	92	90	86	UC
3	98	50	100	92	94	95	95	89	UC
4	97	17	97	99	87	85	94	82	UC
5	96	45	94	99	93	87	97	87	SO
6	97	72	99	97	96	83	94	91	SO
7*	0	15	52	82	21	14	15	28	C
8*	29	25	96	97	53	15	41	51	C
9	95	25	100	95	91	82	98	84	C

Note: BW - black walnut, PA - paulownia, RO - red oak, WA - white ash, WO - white oak, WP - white pine, YP - yellow poplar

*cells 7 and 8 planted in April 96, the rest planted in March 1997

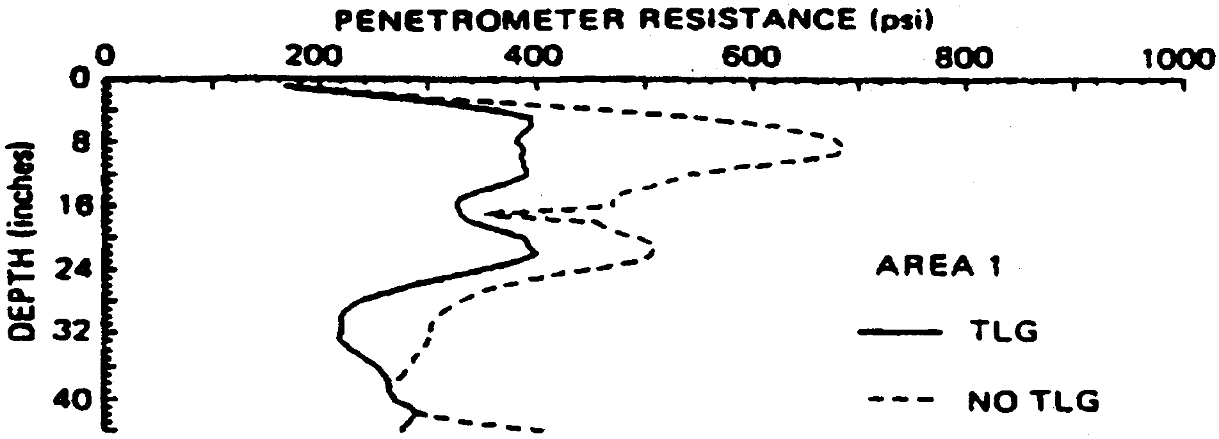

Figure 1. Typical penetrometer resistance profile for prime farmland soil (similar to Hooks and Jansen, 1986).

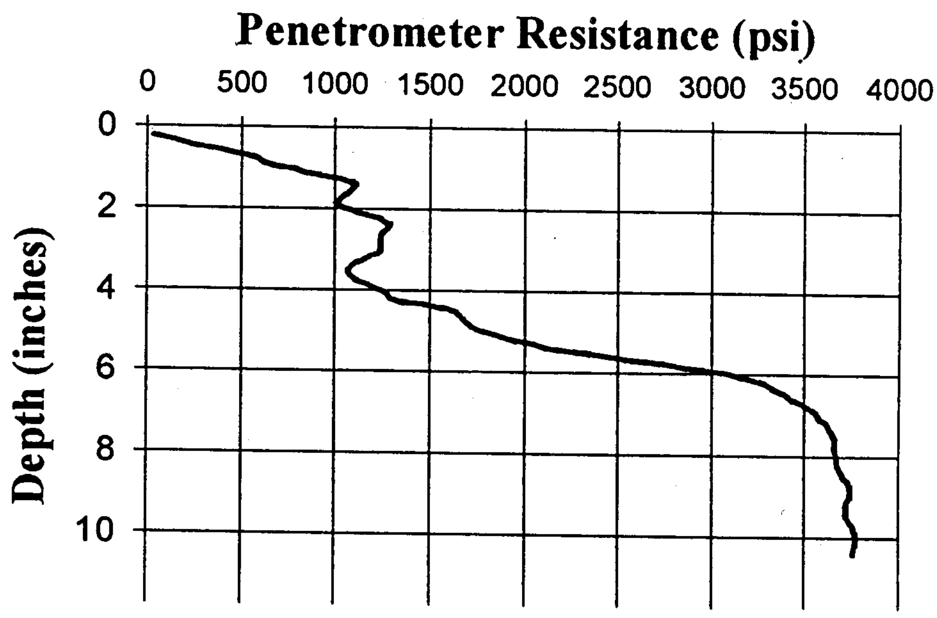

Figure 2. Typical penetrometer resistance profile for spoil material at the Star Fire Mine.

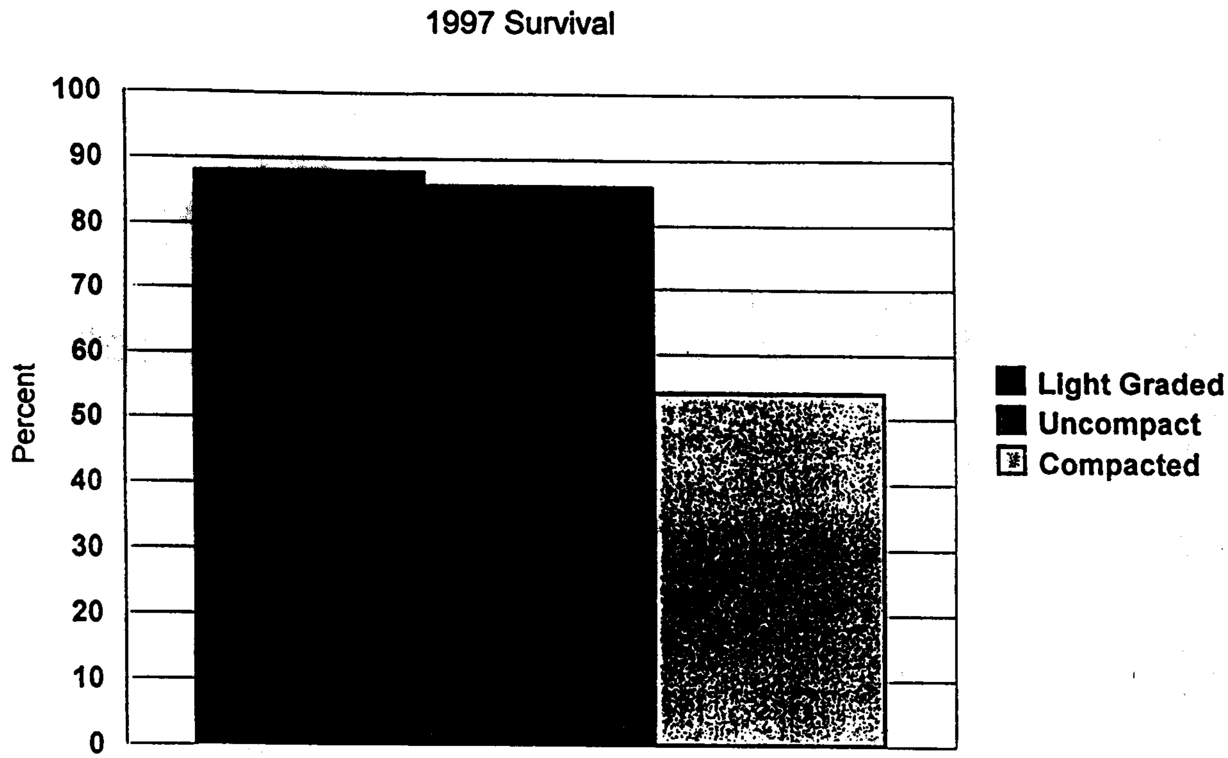

Figure 3. 1997 tree survival rate at the Star Fire Mine as a function of surface condition.

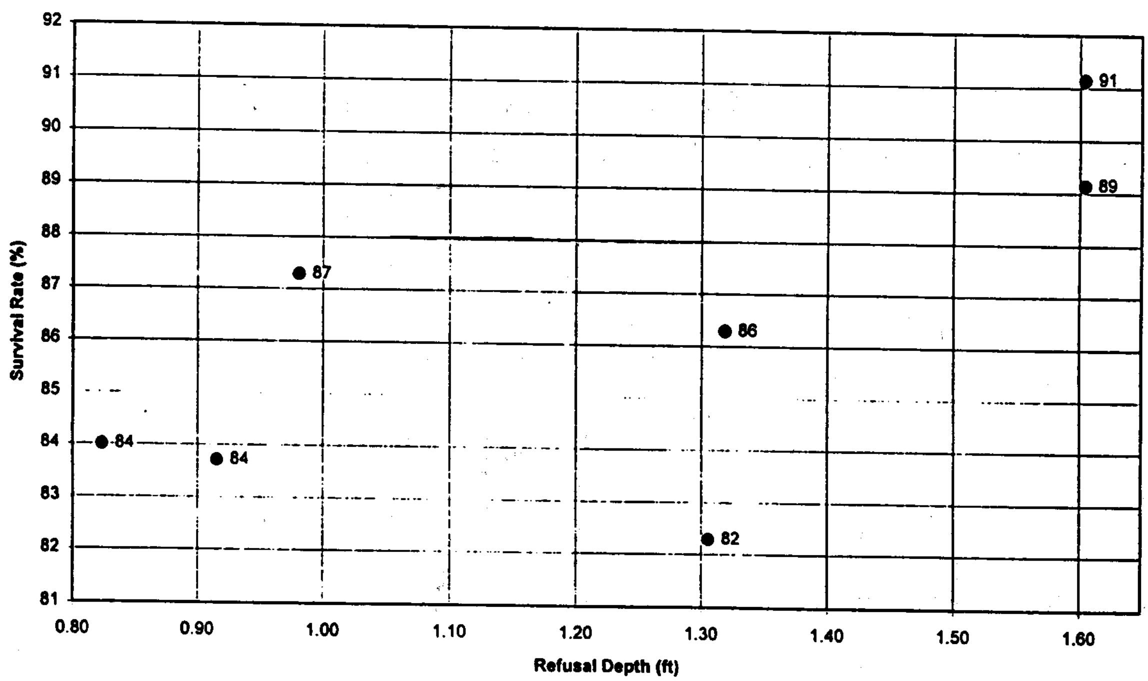

Figure 4. 1997 tree survival rate at the Star Fire Mine as a function of refusal depth.

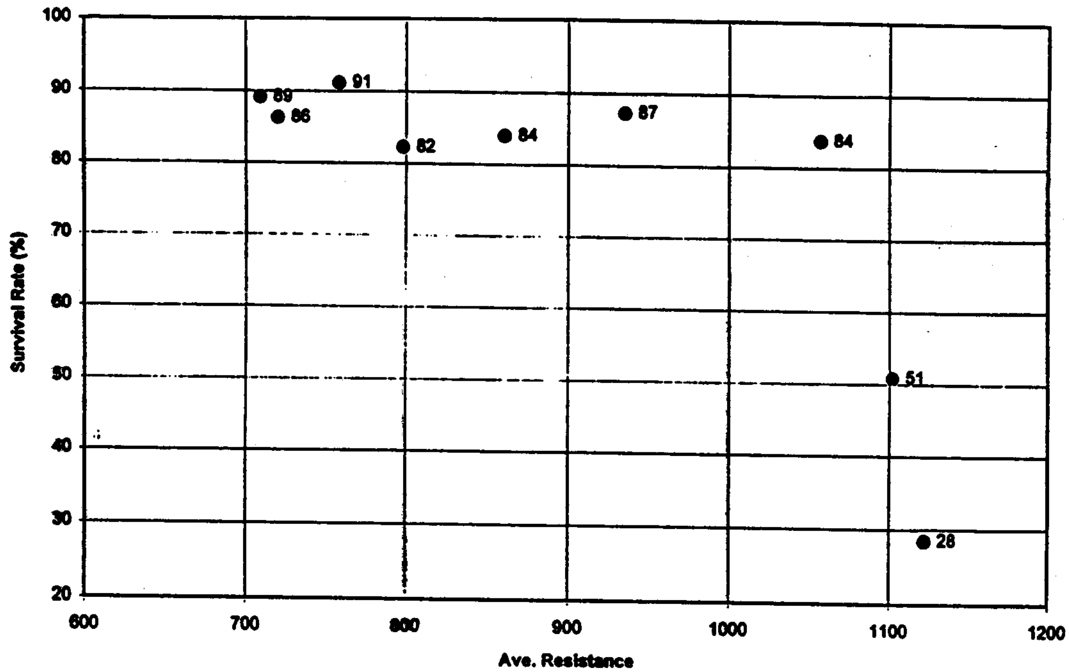

Figure 5. 1997 tree survival rate at the Star Fire Mine as a function of average penetration resistance.

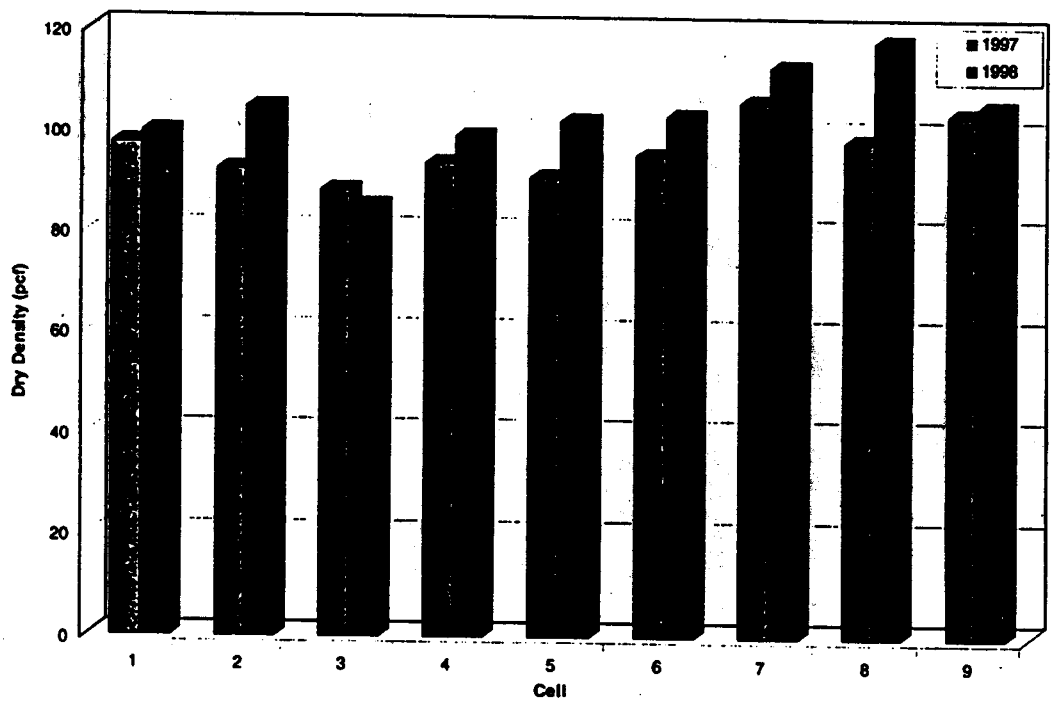

Figure 6. Two-year dry bulk density comparisons.

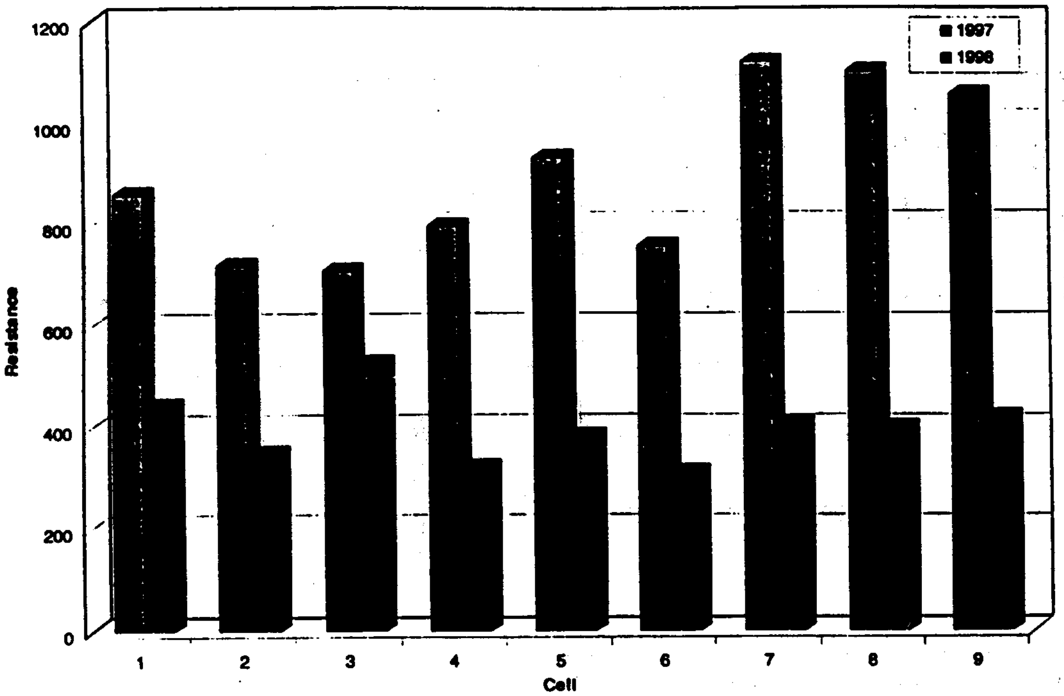

Figure 7. Two-year average penetration resistance comparisons.

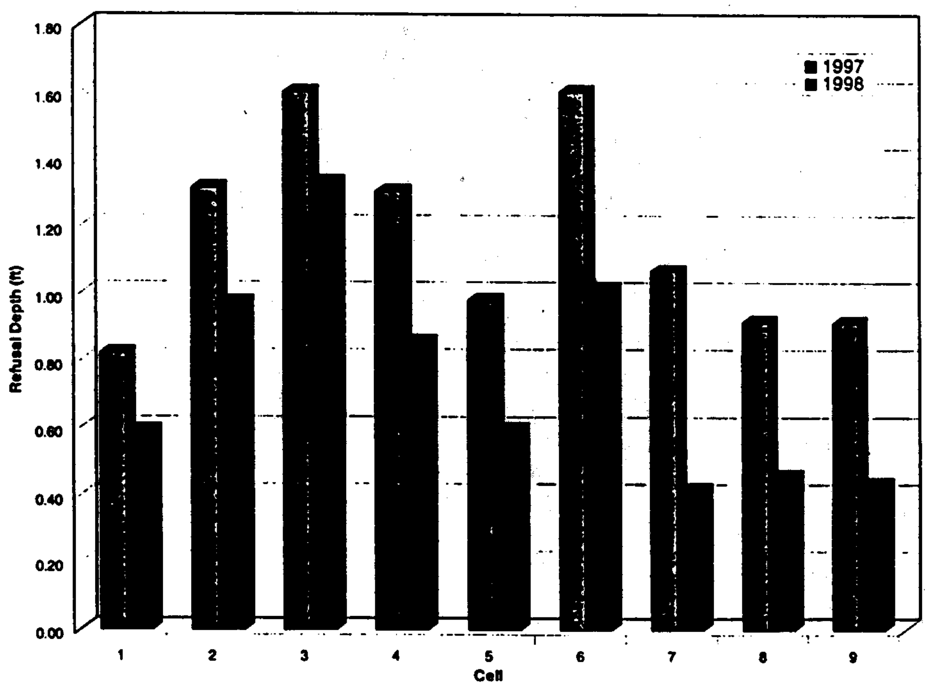

Figure 8. Two-year refusal depth comparisons.

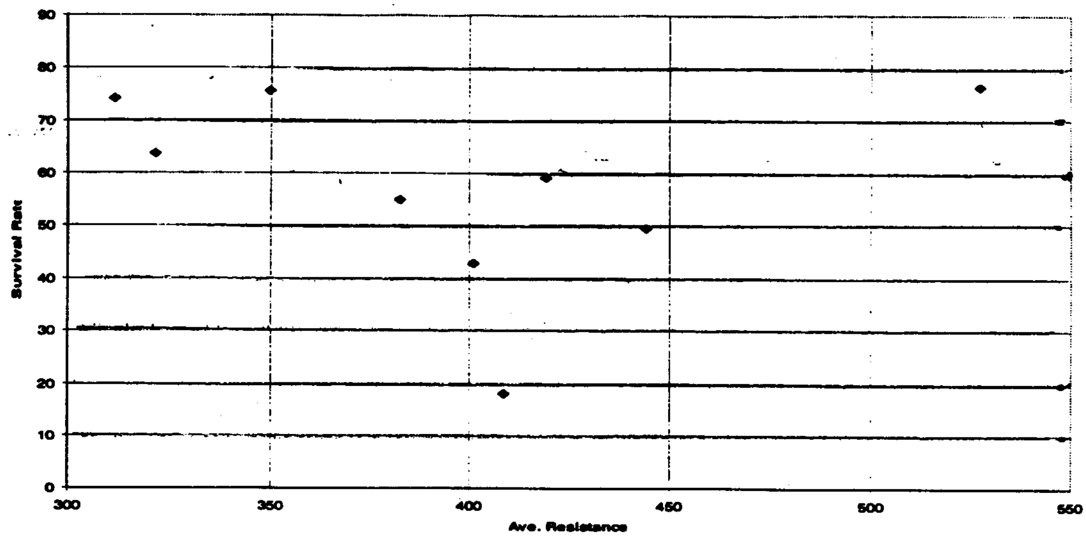

Figure 9. 1998 tree survival rate at the Star Fire Mine as a function of average penetration resistance.

Session 4

CASE STUDIES OF REFORESTATION IN MINING RECLAMATION: SUCCESS AND FAILURE

Chairpersons:
Steve Aaron
ARCH of Illinois
Percy, Illinois

John Mead
Coal Research Center
Southern Illinois University
Carbondale, Illinois

Stuart Miller, Missouri Land Reclamation Program, Jefferson City, Missouri

Illinois/Indiana
Chris Liebering, Liebering and Sons Reforestation, Lamar, Indiana

American Electric Power Company Reforestation History on Reclaimed Mined Lands
Gary Kaster, AEP Land Management, McConnellsville, Ohio

Mycorrhizal Fungi and Trees—A Successful Reforestation Alternative for Mine Land Reclamation
Charles E. Cordell, Plant Health Care, Asheville, North Carolina

Kentucky Reforestation Case Study
Dan Williamson, Kentucky Reclamation Association, Madisonville, Kentucky

Forest Productivity of Reclaimed Mined Land: A Landowner's Perspective
Timothy Probert, Pocahontas Land Company, Bluefield, West Virginia

PACIFIC NORTHWEST

Glen Waugh[1]
Office of Surface Mining
Olympia, Washington

Background

Most of what I will be talking about relates to the Centralia Coal Mine in southwestern Washington. This mine started in 1971 and has about 14,500 permitted acres. It produces marginal quality coal that is burned by an adjacent power plant. It does do fairly high quality reclamation. The area was forestry premining and most of the reclaimed land is returned to forestry. Forestry is big business in this area. They have currently reclaimed about 3,000 acres. They have a lot of acres exposed at one time because of the low coal quality. They have about 20 years experience with tree planting. The overburden that is used for subsoil is a weathered sandstone.

Sewage Sludge Application

Early on the company used sewage sludge to amend the topsoil. The sludge was injected to a depth of 3 feet on the reclaimed area which also had the advantage of breaking up compaction at depth. When the company changed hands in 1991, the new company ceased the sludge application because of potential liability issues and because the sludge resulted in a ground cover that was too dense for good results with the tree planting. Herbicides had to be used to kill the grass prior to tree planting, and the dense cover encouraged rodents that would girdle the new trees.

Control of Surface Water Runoff

The biggest problem for this mine site is the control of water runoff. They use very large rock lined drainage channels to convey the water off the site. The drainages can provide some very good riparian habitat on the mine site. They will usually plant willows in the drainage channels.

Revegetation Plan

The revegetation plan calls for establishing an herbaceous ground cover for about two years. Then they herbicide strips in the ground cover in order to plant the trees. They do not have any problems with acidic toxic spoil material. They will then break up the compaction in these strips by ripping it at depth. They have had their best success by planting douglas fir on the tops of the furrows left by the ripping. On areas that have received topsoil, they plant douglas fir. On areas without topsoil, they plant red alder. They leave open areas and edge areas within the tree stands to improve the area for wildlife. The seedlings used are a genetically improved commercial stock from the Weyerhouser Nursery. Their key to survival is to have hardy planting stock with a good root system. They prune the roots to about 6 inches in length prior to planting. The trees are harvestable at about 18 inches in diameter when they are 45 to 50 years of age. The stocking requirements were established by the Department of Forestry at 190 trees per acre. They have found by planting the trees on a 10 foot by 10 foot spacing that they get the best results. They commercially thin the stand for pulp wood at about 15 to 20 years.

Wildlife Enhancement

In order to create diversity in the vegetation, they create open areas and establish riparian areas with alder, willow, and cat tails. They end up with a lot of open water areas surrounded by wetlands. They have a resident elk herd that has caused problems by girdling trees. After extensive studies by the Department of Wildlife, they have come up with a limited hunting program managed by a local sportsman club. They now have a handicapped hunting program for people who are wheelchair bound, on crutches, and even blind. They also work with Ducks Unlimited because of the water fowl that use the area. They have worked with the Boy Scouts who use the site for Eagle projects to build nesting boxes, bird houses, and other wildlife habitat enhancements.

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[1] Glenn Waugh, Senior Regulatory Program Specialist, Office of Surface Mining (OSM), Olympia, Washington. Glenn has been in the OSM Olympia Area Office since 1986 involved with permitting, inspection, and enforcement in the state of Washington, which is a federal program state. He has worked on revegetation and reforestation issues since 1973, either with the Ohio Division of Reclamation or OSM. He holds a Bachelor's degree in natural resources from Ohio State University and a Master's degree in environmental studies from Evergreen State College.

MONTANA: SITE ADAPTED CONTAINER GROWN WOODY PLANTS FOR MINE RECLAMATION

Len Ballak[1]
Bitterroot Restoration Inc.
Corvallis, Montana

Introduction

Beginning in 1986, Bitterroot Restoration Inc. has done a lot of mine land reclamation all over the country from wetlands to arid regions. We grow our own native plant seedlings in a nursery. We also do our own seeding and outplanting.

Concerning planting trees and shrubs in the West, they are not easily established. It also can be expensive and difficult to get appropriate planting materials. Competition with herbaceous species can be a difficult problem. The postmining substrate also may be very different from what was found in the premining condition. We also have a problem with the reduced levels of soil microoganisms. Another big problem can be periodic droughts or other extreme weather conditions.

Methods for Improving the Odds for Success

In order to obtain the best results, we have to control all controllable variables. This includes site preparation by minimizing compaction and retention of organic materials in the rooting zone. You also have to be careful with fertilizers so that you do not create a problem with excessive herbaceous competition. You need to create micro-sites and not end up with the uniform compacted sites found with highway site reconstruction techniques. You need to contour the sites in order to enhance site diversity.

We can control seed sources. We need to produce site adapted planting stock. This is the type of problem where you may plant nonsite adapted species and not be aware of the problems for many years until the climatic conditions occur for which the stock is not adapted.

Another thing you can control is plant material. In the West, wild dug plants can be successful. These are site adapted and inexpensive if available close by. They also bring the right soil microoganisms with them. You also can use cuttings of woody species. Success is limited to a few species, and you may limit your genetic diversity. Bare root plantings are inexpensive and may work well in areas where there is sufficient moisture. Bare root plantings are, however, very limited to the time that is best for planting. Containerized planting stock increases the time that planting can be done and still result in a successful planting. Usually we can produce site adapted planting stock from seed for containerized planting within a year of seed collection. We can control species selection. You need to carefully examine whether or not you should be planting climax species when the early successional species may be more adapted to the site. You need to have a good program for seed collection, handling, and storage. You can control planting standards by having the appropriate size of planting materials, root to shot ratio, making sure that the plants are dormant.

You also can control the most appropriate mycorhizzal inoculation in the nursery. We are set up to collect root portions from the site and culture the site specific microoganisms for the nursery stock. Inoculation is not infection and that is what you need. In order to ensure infection, we are committed to checking all of our seed stock to determine that they have been appropriately infected with the right microorganisms. We tested the effectiveness of our inoculation efforts by dividing one planting effort in thirds. One third used site adapted microorganisms, one used a commercial inoculant, and the last third was not inoculated. On the difficult to establish species like Chokecherry, we had a 98 percent survival rate with the site adapted innoculate, and about 45 percent with the commercial and noninoculated trees. On the easier to establish species like rose, both the side adapted and commercial inoculated trees had a 98 percent survival and the noninoculated trees even had a 90 percent survival.

Planting quality can be controlled. We use hoedads for planting because planting bars often compact the sides of the hole. This can result in frost heaving during fall plantings. You also can use tree protectors to protect them from browsers and environmental extremes. The only way you can get better is to find out how you did. When you set up a project, you also need to set up standards and methods for determining success.

Field Results

The first field project I would like to discuss is from northwest Colorado. We planted chokecherry, service berry, aspen, and some gambel oak. Our main problems at this site are competition from herbaceous vegetation, summer drought, and browse damage. In order to improve our success, we have not seeded the planting areas, used pre-emergent herbicides, and planting in shallower soils. We have only had mixed success at this site. In order to combat the summer drought problem, we inoculate all of the seedlings with site adapted microorganisms.

On the Big Sky Coal Mine in eastern Montana, we plant ponderosa pine, juniper, and several shrubs. The main problems are poor survival from drought years and competition from herbaceous vegetation and some loss from browsing. In order to improve our success, we have modified the planting mix and switched from machine planting to hand planting in order to take advantage of microsites. We have had both successes and failures.

At the Basin Creek Mine at 10,000 feet on the continental divide in Montana, the problem we have here is called "Red Belt." When the wind comes up and the ground is still frozen, the tree will not be able to obtain moisture and will dry out and die. An extremely windy site, you can not plant in the spring because the snow stays on the ground so long that by the time it all melts it is too late to plant. We have adapted to this with fall plantings. We did a lot of planting close to rocks and logs in order to take advantage of natural wind breaks. We also have tried tree protectors. We also have come up with a strategy to do summer plantings in July on north facing slopes and are getting 70 to 80 percent survival. This was the way we were able to get our conifers established.

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[1] Leonard Ballak, Vice President/Director of Sales and Marketing, Bitterroot Restoration Inc., Corvalis, Montana. Ballak holds a B.S. in forest resource management from the University of Idaho. Has been with Bitterroot Restoration since 1987. He has spent 16 years with the U.S. Forest Service. He has extensive experience in all aspects of severely disturbed land restoration. His main areas of expertise are mined land reclamation, erosion control techniques, tree physiology, outplanting techniques, and plant propagation.

THE ARID AND SEMIARID WEST

Vernon Pfannenstiel[1]
Peabody Coal Co.
Flagstaff, Arizona

Introduction

What I will be talking about should reflect on what the major coal operators are doing to establish woody plants in the states of New Mexico, Arizona, Montana, and Colorado. I am used to working in many areas that only get nine to ten inches of precipitation per year. Our Black Mesa Mine in Arizona is in a 9 inch precipitation zone where it is extremely difficult to establish woody species. It would be a stretch to use the term "reforestation" in the West. We do not plant large contiguous areas to woody plants and then not in high densities.

Natural Vegetative Communities and Mining in the West

In eastern Montana, the natural vegetation is dominated by ponderosa pine and juniper. These species tend to predominate on sandstone outcrops and colluvial slopes. The mining usually occurs in the alluvial valley, up the side drainages, and on the benches. Most of the mining does not occur in areas with heavy stands of trees.

In Wyoming, the natural vegetation is dominated by shrub grasslands with occasional ponderosa pine on scoria ridges. Riparian tree communities are more important in this environment. Many of these communities are maintained by specific soil and geologic conditions that do not exist after mining such as perched water tables and bedrock sandstone subsoils.

In Arizona, New Mexico, and Utah, mining occurs in pinyon and juniper communities on the rocky slopes and hill sides.

SMCRA requires us to reestablish many of these tree and shrub communities, but most of the land use is grazing. We establish woody plants is small blocks for wildlife and community and biological diversity. There are no commercial forestry plantings.

Tree Planting Efforts

We tended to pick our trees for the earliest industry plantings from tree lists and windbreak lists. We planted both native and introduced species. These early plantings were too ambitious and did not take an ecosystem approach. We did not know why or how these species existed where they did. We also tried to plant trees on soils that were better suited to shrub grasslands because of their heavy soil texture. Our early results were poor with few survivors. Over the years we have emphasized more native tree plantings.

Our current technology is based on being able to control the factors that will give us the best results. In order to get better results, we now collect native adapted seed sources to develop our planting stock. Our sites are subject to extreme variations in climatic conditions. At Black Mesa, we have had as high as 15 inches of precipitation and as low as 3 inches. Of course, you never know when you are going to get the extreme conditions. If you do a fall planting just before a 3 inch precipitation year you can bet you will be replanting. We usually partner with a good nursery who has developed the appropriate cultural practices to improve our chances for success. Infection of planting stock with appropriate mycorrizhae is critical to most plantings. Microsite selection is crucial to success in woody establishment. We tend to stick to north facing slopes. We do not do irrigation. We try to plant into soils that came from native tree sites and use direct haul soils as much as possible in order to quickly reestablish the soil ecosystem. If we are lucky, we may even get some volunteer regeneration of species. I like to keep the herbaceous cover competition down to the minimum and do not think that a little erosion is a problem. We seed with a low competition native species for our herbaceous cover.

I have found that on some sites we are able to keep out the noxious annual weeds like kochia, russian thistle, and cheat grass by planting native annuals such as rocky mountain bee plant and annual sunflower. The large leaves of the sunflower also shade the site and reduce the soil temperature.

We have gone mostly to hand plantings of woody stock in order to take advantage of microsites and plant on areas that are too rough and rocky to machine plant. We have to fence the areas to control livestock and wildlife. We are starting to plant pinyon seedlings around our sagebrush because we noted that this seemed to be happening in the natural environment. These planting have been quite successful. We are establishing islands of woody species with direct transplant of some trees and shrubs.

In Montana, we have planted about 275,000 ponderosa pine and 1,300,000 rocky mountain juniper on a 900 acre site with about a 20 to 30 percent survival. In Colorado, we planted about 400,000 to 500,000 seedlings of tall shrubs and aspen. Of that we planted about 20,000 aspen with less than 10 percent survival; service berry had 20 to 60 percent survival; choke cherry 10 to 50 percent; and gambel oak 10 to 30 percent.

In Arizona and New Mexico we planted nearly 200,000 pinyon seedlings with 20 to 25 percent survival. We have planted about 10,000 transplants with a tree spade with about 75 percent survival. In addition we have planted several thousand gambel's oak.

Future Efforts

We will be planting more trees in the future but we will be working hard on our research and development that will emphasize an ecosystem approach to improve the odds for survival. We need to reconsider some of the regulatory requirements such as the need for some areas to have less herbaceous cover and the nine inch rill and gully rule may not always be appropriate. We need to continue cooperative efforts between the industry and the regulatory community.

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[1] Vern Pfannenstiel, Environmental Scientist, Peabody Western Coal Company, Kayenta, Arizona. Pfannenstiel graduated from Colorado State University in 1978 with a BS in rangeland ecology and a minor in mined land reclamation. Following graduation he spent 3 years with the Soil Conservation Service in Colorado and Idaho. For the past 18 years he has worked as an environmental scientist for Peabody Coal Company and Peabody Western Coal Company in Arizona, Colorado, Montana, and Wyoming. He has extensive experience in baseline vegetation studies, permitting, and reclamation planning and implementation. In particular, his efforts have been directed towards reestablishing native species, including woody plants, on reclaimed lands. He received the ASSMR Special Award in 1996 for these efforts and led a team at the Black Mesa Mining Complex that received the 1998 Excellence in Surface Mining Reclamation Award from OSM for revegetation with native and culturally significant plants.

TEXAS UTILITIES' COMMITMENT TO REFORESTATION

Sid Stroud[1]
TU Services
Dallas, Texas

Abstract

Texas Utilities Company (TU) operates three surface coal mines in east Texas where, since 1971, it has mined and reclaimed over 44,000 acres and currently mines about 1,800 acres annually, of which 72 percent is returned to forest uses. Reforestation efforts began in 1975 as wildlife corridors in pastureland. As of December 1998, TU has planted 12.7 million trees on reclaimed soils to establish 21,000 acres of commercial forestland and wildlife habitat. Annual planting efforts include 26 different tree species and result in normal survival rates of 75 to 90 percent.

Constant improvement in the reforestation program is maintained through a continued approach of applying findings from research and field trials. Keys to reforestation success at TU mines have been found to include: (1) soil quality; (2) quality control that begins at the seed source; (3) advance planning and ordering of seedlings; (4) cold storage facilities at or near the mine site; and (5) planting techniques. The most significant key to success was finding a companion plant as a ground cover that provided effective erosion control, but minimized competition with seedlings for moisture and nutrients. Resolution of ground cover concerns was found in use of cool season annuals, and in use of herbicides to control competition from established forage grasses. Other challenges to making a successful reforestation program include standards for erosion control and ground cover performance.

TU views mine reclamation as a unique opportunity for establishing productive forestland and a commitment to the future supply of woodlands for environmental, economic, and wildlife benefits.

Introduction

Texas Utilities Company (TU) provides electric and natural gas utility services for one-third of the population of Texas. Approximately 42 percent of the electric service provided our customers in Texas is fueled by coal principally from TU mines. The purpose of this paper is to review TU's experiences (both successes and failures) in mine reforestation and present our commitment to fostering increased use of reforestation as a reclamation method.

Texas Utilities Mining Company (or TUMCO) conducts Texas Utilities' surface mining operations. TUMCO is a wholly owned subsidiary of Texas Utilities and operates three surface mines in east Texas where, since 1971, we've mined over 603 million tons of coal, and currently mine 29 million tons annually. As of December 1998, TU has mined and reclaimed over 44,000 acres; over half of which is reclaimed to forestland. Out of the total acres reclaimed, 42 percent has received Phase III bond release, 20 percent has received Phase I and II release, and 23 percent more is in the five-year extended responsibility period. Currently, about 1,800 acres are mined annually, of which 72 percent is being returned to forest uses of commercial forestland and wildlife habitat. Other minor postmine land uses are pastureland and water resources. With seedling survivals that range between 75 and 90 percent on normal years, TU considers its reforestation program to be very successful, yet on a constant improvement trend. This improvement is maintained by applying the same approach that TU has used to develop the program beginning in 1971: through research and field trials and then application of findings.

The early TU reclamation program emphasized pastureland. This would remain the dominant postmine land use for 20 years. Until 1973, little was known about mine reforestation in our region. Studies completed that year demonstrated the potential for reforestation success on TU mine soils and helped in developing reforestation program goals that included:

- Diversity (both in species and land use),
- Fully stocked stands with minimal replanting,
- Use of native or locally adapted species,
- Sustainability of the forest cover,
- Soil stability,
- Low Maintenance, and
- Low Cost.

These goals have been achieved. Through long-range planning TU now has several sources and adequate supply of seedlings. Where once only half a dozen species were planted, now TU plants 26 different species including 12 varieties of oaks. Where once only meager survivals resulted, now there are fully stocked stands at the end of the critical first two years. The established stands are sustaining growth at or better than premine forests with natural regeneration occurring. Forested sites have remained stable, with substantially less maintenance. And, planting and management of these forests are being accomplished at less cost than for our pastureland over the five-year period of extended responsibility.

Since 1975, 12.7 million trees have been planted on TU reclaimed sites. During this time reclamation personnel resolved many of the problems that were impacting success. While many of these problems are common to other regions, it is unlikely that the solutions are applicable to all other regions. TU found that for its region and mine sites:

- Selected overburden materials provided superior productivity over native soils.

  TU's use of the dragline side-cast method allows placement of selected stratigraphic materials in the near surface of spoil as a topsoil substitute. The most common postmine soil is loamy textured with high productivity potential for forage grasses, crops, or forests. These soils often meet prime farmland criteria as set forth by the NRCS.
- Use of low ground pressure track equipment for soil reconstruction prevented development of the dense soils that existed prior to mining.
- Localized or regional nurseries should be used.
- Improved genetic material should be used if possible.

  TU plans seedling orders at least two years in advance with nurseries to ensure that cultural practices used by nurseries will result in seedlings that meet the height, root collar diameter, and root-to-crown ratio that has been determined to enhance survival and growth.
- Bare-root and plug seedlings provided more rapid and consistent success than direct seeding.
- On site cold storage and proper handling and protection of seedlings is critical.

  Each mine has a cold storage facility on-site, which is essential for holding such a large quantity of seedlings while planting is ongoing. Cold storage allows the mine to extend the planting season by maintaining dormancy of the seedling until it is planted.
- Machine planting was more economical and provided better quality control during planting.

  One automatic machine planter can enable TU to plant 10,000 seedlings a day. TU mines may have up to 12 planters operating on days of good ground conditions. Some areas still require hand- planting, and the program should be flexible to continue under various seasonal conditions.
- Minimize fertilization to levels ensuring vigor.

  Fertility is another key to success. Over fertilization in the first two years, while it may favor ground cover, could prove fatal in extended periods of low rainfall and high temperatures. TU has found that utilizing residual nutrients from ground cover establishment is normally sufficient to ensure initial seedling survival and health. Light applications of a balanced fertilizer (a maximum of 50# N annually) over the next one or two years aid in seedling vigor as organic matter begins to contribute to the nutrient cycle. Another approach is use of fertilizer tablets at planting. The tree gets the benefit of the slow release fertilizer and micronutrients without overstimulation of the ground cover.

Many of these problems were simple adjustments of cultural practices to fit the circumstances. Others required extensive studies and field trials. But above all, the most difficult obstacle was to find a ground cover or companion plant that: (1) has the height to protect the seedling from wind and sun desiccation, yet will not shade the seedling out; (2) keeps soil temperatures down in the summer but does not compete with the seedling for water or nutrients; and (3) has a cover that does all this while having adequate root mass and cover to prevent 9-inch rills.

With annual rainfall averaging 40+ inches, often in intense events, erosion on native soils is commonplace. So, numerous field trials were conducted on ground covers and maintenance practices that would balance erosion control with seedling survival. TU found two approaches to be most dependable:

1. Utilize cool season annuals (such as wheat, oats, or rye) as ground cover. Seedlings are planted in the established cover, which provides the needed erosion control without moisture competition after the plant matures. The wheat stubble is left standing throughout the summer, and native grasses and legumes are inter-seeded; however, sometimes a more aggressive ground cover is required.

2. When planting in a ground cover of established forage grasses, band-spraying of herbicides can be used to kill competition to the seedling while leaving soil stabilizing cover in place. This is not the preferred approach, but it has been cost effective for converting pastureland to trees and on more erosive sites.

The greater success in seedling survival has been with the cool season annuals as ground cover; yet, while this method provides the needed survival, the site is still more prone to erosion over the first two years than if it were planted in forage grasses. The cost of erosion repair may significantly impact the economic benefits of reforestation. Again, quality control in use of field cold storage and proper handling to prevent exposure of roots until planted is critical, as is the planting of the seedling at the proper depth and root posture. Since there is no control for the timeliness of rainfall, proper techniques could give the seedling the needed advantage that means survival during extended dry periods.

Yes, reforestation can be successful; however, surface mining regulations do present factors that have negatively influenced the success of reforestation, yet, this is often due more to the interpretation of those regulations rather than the intent. These factors may dramatically impact the cost of reforestation and influence operators to utilize other vegetative types for reclamation purposes. TU and several mining companies in Texas favor reforestation for our region, and encourage other operators in Texas to do the same. Some operators consider there to be too much uncertainty in reforestation and choose other cover types that prove to be more straightforward in ensuring compliance, demonstrating success, and achieving bond release. Reforestation can work; but the extent of focus on erosion control and success validation procedures effectively favor monocultures and continue to discourage reforestation. Instead, operators and regulators should rely on the long-term watershed benefits that forest cover types offer.

Although the federal program has recognized the certainty of erosion as a natural process, Texas, among other state programs, still uses the 9-inch rill standard that has often been interpreted to restrict operators to total pre-vention of 9-inch rills. Operators are forced to make decisions that minimize the short-term risk of erosion, and that usually leads to an aggressive grass as a ground cover (which is a barrier to reforestation success). States' rulemaking initiatives to adopt federal language found in 816.95(b) will help to encourage other companies to re-forest mined land and aid others in reducing unnecessary costs of reforestation. The fact is, in erosive soils, trees present better long-term watershed management, but a higher short-term risk to compliance. Absolute prevention of erosion is a great goal, but in our circumstance, not practical, natural, or realistic. Further improvements may be realized through reducing the extent of final grading once the target postmine grade has been reached. Forestland does not need the smooth surface of a pasture or meadow, yet many operators and regulators alike still approach all final grading with a pastureland mentality.

Flexibility in ground cover success standards is also important. A significant component to long-term ground cover, stability and watershed benefits is the litter naturally resulting from the canopy. All such litter should count toward ground cover performance. In addition, percent ground cover standards should be reviewed to seek increased flexibility to speed establishment of trees. Ground cover standards also should allow for annuals to be counted in the permanent plant community. A hardy ground cover is needed that may include perennials or annuals, but likely a combination of the two. Finally, consideration should be given to establishing a shorter extended responsibility term specific to forestland. This could help encourage reforestation by allowing release sooner after seedling establishment.

TU strongly supports the recent initiative to identify regulatory barriers to reforestation and develop action steps to encourage use of reforestation, but the regulatory authority and operators alike should also recognize that the post-mine level of reforestation land uses should be appropriate for local and regional environmental and economic needs. The supply of timber in the South is currently being consumed at a greater pace than growth on privately owned lands. TU views mine reclamation as an opportunity for establishing healthy, well managed forests with excellent wildlife value and economic return.

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[1] Sid Stroud, Environmental Waste Manager, Texas Utilities Services, Dallas, Texas. Sid Stroud has been involved in mine reforestation since 1975. He has been directly involved in the research, program development, and operational aspects of Texas Utilities' mine reforestation efforts, which now include over 21,000 reforested acres from planting of 12.7 million seedlings. Prior to September 1998, Sid was reclamation manager for Texas Util-ities, where he was responsible for developing and managing the reclamation, land-use, and bond release pro-grams for the company's 105,000 permitted mine acres. He is a graduate of Stephen F. Austin State University, College of Forestry in 1978.

SUCCESSFUL FORESTRY RECLAMATION IN LOUISIANA/MISSISSIPPI

Marty Walker[1]
North American Coal Corp.
Ackerman, Mississippi

Introduction

The two projects I will be speaking on are joint ventures between the North American Coal Corp. and Phillips Coal Corp. North American Coal Corp. has received ten awards for reclamation excellence from the Office of Surface Mining.

Oxbow Mine, Louisiana

The Oxbow Mine is located near Coushatta, Louisiana. It disturbs about 100 acres per year to produce about 750,000 tons of lignite for the Dolet Hills power plant. It is located in the Red River floodplain and receives about 46 inches of precipitation annually. The mine site had a hill within the permit area that lends itself to reforestation with loblolly pine. The floodplain itself will be reforested with bottom land hardwoods. Topsoil substitution has been approved for this site. We do an extensive overburden analysis comparison between the overburden materials and the existing unmined soil materials. The undisturbed soil series is made up primarily of the moreland clay (92.9 percent) and has a site index for yellow poplar of about 80 for a 50 year growth period. Currently, we have reclaimed and revegetated about 305 acres of which about 228 have been returned to a forest land use.

Our method of reclamation is to cast the overburden by dragline, grade the overburden with dozers, and establish a permanent cover crop consisting of bermuda grass. We plant our trees and then over spray with an herbicide. We are moving away from the over spray method because of potential damage to the tree seedlings. The tree species we are currently planting include loblolly pine, bald cypress, nutall oak, shumard oak, sawtooth oak, bitter pecan, and wild plum. We have had some problems obtaining good planting stock of the hardwoods and shrubs. Now we have several vendors that are growing the high quality hardwood stock that we need, especially for wildlife plantings. We plant the pine on a 6 by 10 foot spacing (726 seedlings per acre) and the hardwoods on an 8 by 10 foot spacing (544 seedlings per acre). We have had a 90 percent survival on our pine plantings.

Our biggest challenges have been related to controlling aggressive herbaceous vegetation, especially with a legume called hairy vetch. It is very hard to keep this plant out, as is comes in the mulching materials. Because we use graded overburden materials, we do not have a lot of problems with compaction. We have also experienced poor seedling vigor in the early years of establishment. The high pH of the overburden material (7.0 and higher) negatively impacts the early vigor of the loblolly pine. At about year three, the new trees seem to get over this low vigor phase and begin to do well.

Red Hills Mine, Mississippi

The status of our Mississippi lignite mine is that although we will not produce coal until 2000, we have planted 250 overcup oak, 750 shumard oak, and 750 willow oak on diversions necessary for water control at the mine site. This mine is located in the Red Hills of east central Mississippi and will generate 3.3 million tons of lignite on 125 acres per year for the Choctaw power plant. It receives about 56 inches of precipitation per year. Most of the soils are associated with the hilly topography and have a B horizon with a clay content of 35 to 55 percent. By selectively handling the overburden material, we can achieve a better plant growth medium than existed prior to mining. Yellow poplar has a very high site index of 110 and loblolly pine has a site index in the low 80s. About 73 percent of the county is in commercial forest land.

The reclamation plan calls for a truck/shovel haul back. We will then establish a grass cover followed by tree planting. Special techniques we will employ include the use of a chisel plow to rip the soil on a 9 foot spacing and band apply Roundup herbicide in July. This rip fills back in during the fall rains and the Roundup controls the herbaceous vegetation. We plant the trees into the ripped row in mid-December. This allows us to avoid the over spray damage to seedlings we experienced with other methods. We will plant the pine on a spacing of 6 by 9 feet (807 seedlings per acre) and the hardwoods on a 14 by 14 foot spacing (222 seedlings per acre). The pine will be planted on the upland sites and the hardwoods in the drainages and wetter wildlife sites. The postmining land use will be 90 percent forest land use.

Quality planting stock is becoming difficult to obtain because there currently is a very high demand as many private landowners are replanting areas that have been recently harvested. We have a lot of damage from rodents girdling the trees.

Recommendations

We recommend that we could encourage tree planting by keeping revegetation and soil monitoring simple and reduce the length of the extended responsibility period for forest and wildlife land uses. We will discourage tree planting with complex monitoring procedures that require expensive consultants in order to determine vegetation success.

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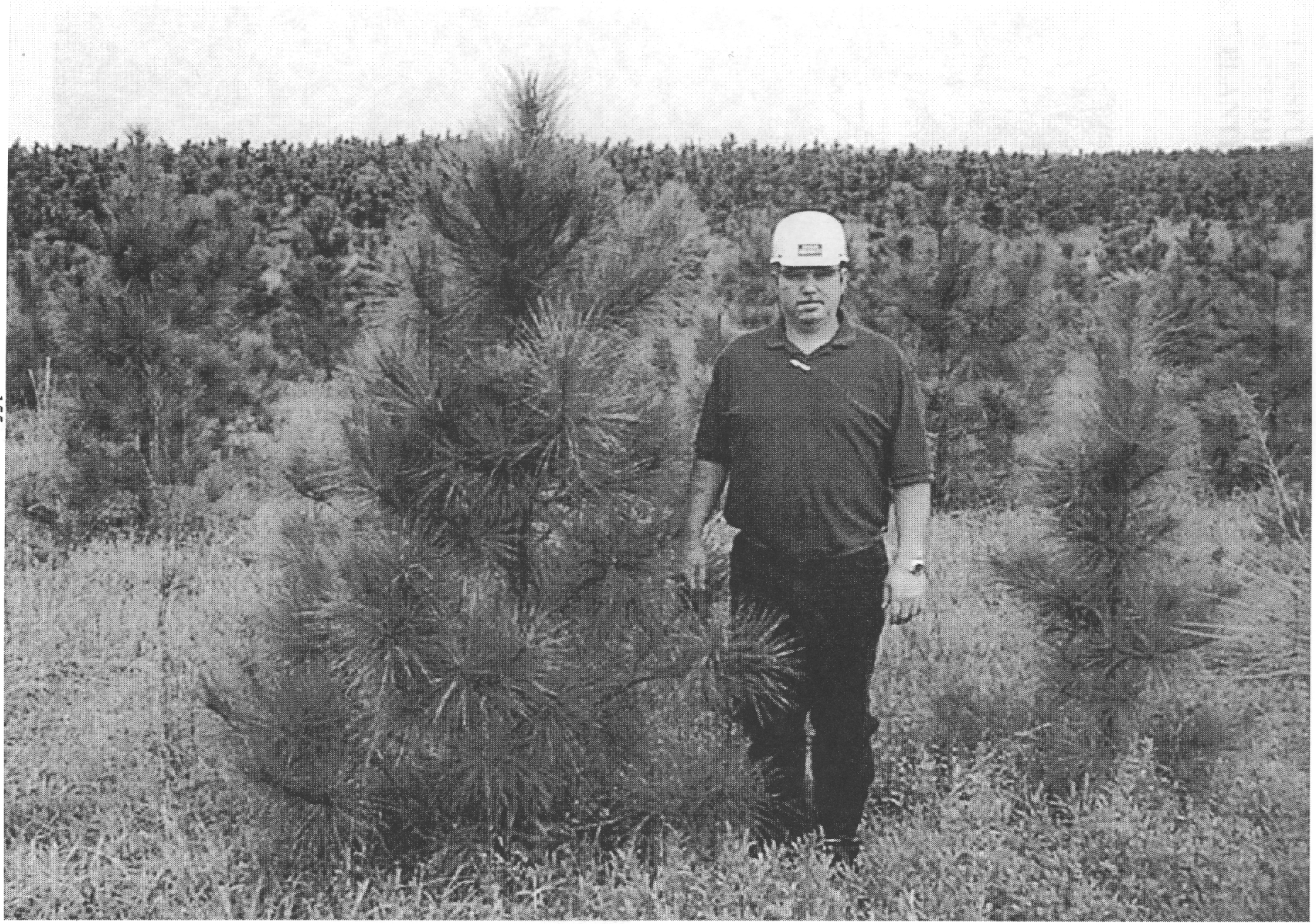

SUCCESSFUL TREE PLANTING TECHNIQUES FOR DRASTICALLY DISTURBED LANDS: A CASE STUDY OF THE PROPAGATION AND PLANTING OF CONTAINER-GROWN OAK AND NUT TREES IN MISSOURI

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Abstract

Successful tree seedling establishment on drastically disturbed lands is contingent on seven major variables: (1) selection of proper native species; (2) purchase of the best quality planting stock; (3) correct handling of planting stock; (4) correct planting techniques; (5) effective control of competing vegetation; (6) proper soil conditions and preparation; and (7) weather. Exotic species should not be planted to avoid past mistakes such as kudzu, japanese honeysuckle, sericia lespedeza, and chestnut blight. A major concern of reclamation specialists and ecosystem res-torationists is obtaining high-quality plant materials with the correct provenance. Ecosystem restorationists, rec-lamation specialists, park managers, and private landowners can easily and cheaply propagate native oak or other hardwood species from local parent stock using Whitcomb bottomless containers. Proper seed collection, storage and preparation techniques as well as propagation methods are critical for seedling growth and development into quality air-pruned planting stock. Air-pruned seedlings of local provenance can be outplanted in the fall after one growing season with little transplanting shock while developing extensive root systems prior to soil freezing in winter. Establishment success of container-grown seedlings greatly exceeds that of spring-planted, bare-root seedlings. Fall-planted, container-grown seedlings have a decided advantage since their roots continue to grow throughout the fall and much of the winter, enabling them to better withstand summer drought and weedy competitors. Container-grown seedlings also allow a five- to six-month planting season compared to bare-root seedlings' four to six weeks. Since propagation costs are minimal, planters who grow their own save money on the planting stock. Because the quality is higher, home-grown seedlings have greater establishment success, saving labor, time, and money. With better survival rates, far fewer trees need be planted as compared to bare-root seedlings.

Introduction

Many hard-earned lessons learned by reclamation specialists are frequently ignored or forgotten by their successors. Successful tree planting is dependent upon a few simple techniques. Trees are effective in reclamation because mining can create deep, nontoxic mine soils that are often more productive than many adjacent forest soils. AML and SMCRA Title V mine lands can become important commercial and recreational forest resources with proper planning and management.

Trees produce large amounts of organic matter in mine soils that promote nutrient cycling, particularly that of nitrogen and phosphorus. Tree roots break up compaction by creating root channels. Large tap-rooted species such as bur oak (*Quercus macrocarpa*), swamp white oak (*Quercus bicolor*), and baldcypress (*Taxodium distichum*) are particularly effective (Ashby and Vogel, 1993). Tree root systems stabilize the reclamation site by reducing erosion and sedimentation. Certain trees species tolerate high acidity and low fertility, typical soil conditions found on many mine sites. Trees are extremely important for wildlife habitat. In midwest farm country, mine lands may be the only “dense” timber in the landscape.

Early reclamation efforts of mine lands in the East and Midwest centered on afforestation. Early tree planting efforts in the East and Midwest were based on observation of woody invasion and natural succession of trees on abandoned mine spoils (Croxton, 1928). Clark (1954) found that tree planting success on mine lands depends on soil chemistry, soil texture, water-holding capacity, and effects of erosion and sedimentation. This assumes planting materials and methods are uniformly good and that compaction is not a problem.

Ashby and Vogel in their excellent reference *Tree Planting on Mined Lands in the Midwest: A Handbook* (1993) argue that there are seven major environmental factors and physical characteristics in tree planting success: (1) climate (macro- and micro-climate); (2) soil physical factors (texture, organic matter, coarse fragments, surface roughness, compaction, and drainage); (3) soil chemical factors (reaction or pH, toxic elements and soil infertility, particularly of nitrogen and phosphorus); (4) competition with herbaceous groundcovers; (5) lack of soil organisms; (6) mammals and birds; and (7) fire.

Vogel (1987) writes that the reclamation specialist ***can control*** six factors that influence planting success: (1) quality of planting stock; (2) care of planting stock; (3) method of planting; (4) time of planting; (5) competition from herbaceous vegetation; and (6) soil compaction. Vogel also argues that following proper establishment techniques is as important as selecting the appropriate plant species.

Reclamation specialists must combine these environmental factors and physical characteristics with correct administrative and technical procedures. Hence, successful tree establishment on drastically disturbed lands such as coal mine sites is contingent upon seven major variables: ***(1) selection of proper native species; (2) purchase of the best quality planting stock; (3) correct handling of planting stock; (4) correct planting techniques; (5) effective control of competing vegetation; (6) proper soil condition and preparation; and (7) weather.***

These variables are omnipresent, regardless of unique regional conditions. It does not matter whether the reclamation specialist is planting gamble oak (*Quercus gambelii*) under 15 inches of annual precipitation in Utah or northern red oak (*Quercus rubra*) with 45 inches in Pennsylvania. The utilization of specific establishment techniques largely depends on the reclamation budget. However, the reclamation specialist must be aware that the most expensive parts of tree establishment are buying the planting stock and paying the planter. Without proper establishment techniques, the very best stock, planted with the best care, may be nothing more than food for soil decom-posers.

Forest restoration is becoming increasingly important in reclamation of eastern mine lands. High hardwood lumber prices and the new demand for wood chips for paper production has awakened the realization that the demand for hardwoods is increasing at a time when coal mining, among other competing developments in the East, is removing forests at an ever increasing rate. In the Midwest, the demand for hardwood also is increasing, putting greater demand on slower growing oak forests. Forested mine lands could play a role in easing this demand for hardwood while providing recreation and improving wildlife habitat and water quality. Tree planting on mine lands is very important because many high value tree species such as black walnut (*Juglans nigra*), pecan (*Carya illinoensis*), and oaks (*Quercus spp*.) may not easily or quickly colonize these areas because natural seed transport is limited unless a seed source is close by.

Black walnut can be effectively grown on high quality, uncompacted mine spoil with limited herbaceous competition (Ashby and Kolar, 1998). North America's most valuable hardwood can achieve very high growth rates, often exceeding growth on native soils. The lack of high quality native soil sites limits production of high quality timber due to black walnut's exacting edaphic and ecological demands. Property owners may find a large return in nuts and timber from black walnut on high mine soils.

The author has propagated approximately 1,500 container-grown oak and nut tree seedlings per year since 1990, outplanting on abandoned mine lands and old fields in central and western Missouri. Seedlings grown in the Whitcomb bottomless containers result in the taproot being "air-pruned." The taproot grows through the bottom of the container and is exposed to the air. The apical meristem desiccates and die which stimulates lateral root development throughout the container. Once planted, a lateral root establishes a new taproot or multiple laterals that form codominant, branched main roots (Whitcomb, 1988). First-year establishment success for container-grown seedlings is approximately twice the success of bare-root seedlings in side-by-side field trials in Missouri. White *et al* (1970) planting hardwoods and McDonald (1991) using pines and douglas-fir, confirm higher establishment success rates for container-grown seedlings in native soils.

Greatest mortality of container-grown seedlings in Missouri resulted largely from excessive competing vegetation and rodent damage in winter. It was not obvious than any container-grown seedlings were lost due to moisture stress. Bare-rooted seedlings were usually lost in the initial flush of growth or in midsummer due to moisture stress. Tap-rooted hardwoods such as oak, hickory, and walnut responded well to air-pruning, which resulted from using bottomless containers. In many oak plantings, the tops of seedlings die back in midsummer but later sprout back from adventitious buds located at the root collar. This is a common survival mechanism of most oak species (Olson and Boyce, 1971; Dixon, *et al*. 1984; Merz and Boyce, 1956; and Liming and Johnston, 1944). Seedlings were propagated in the author's backyard, placed upon a raised, welded hog or cattle panel, with four-inch squares, and protected from squirrels by a wood frame and chicken wire. Bare-root seedlings were purchased from the Forrest Keeling Nursery in Elsberry, Missouri and from the Missouri Department of Conservation George O. White State Forest Nursery.

Discussion

Selection of native species is important for reclamation success, particularly for ecosystem functioning. The Surface Mining Control and Reclamation Act, Section 515(b)(19) requires Title V reclamation to create "...a ***diverse***, effective, and permanent vegetative cover of the same seasonal variety ***native*** to the area affected and capable of ***self-regeneration*** and ***plant succession*** at least equal in extent to the natural vegetation of the area..." Reclamation in this country has not often achieved this goal, largely because of the next clause, which reads "...except that ***introduced species*** may be used in the revegetation process where desirable and necessary to achieve the postmining land use plan." (SMCRA, 1993) (italics are the author's). The use of trees for reclamation must function as a part of the natural ecosystem of the region. The reclamation specialist must work with these natural processes rather than against them. Native cover crops that promote native tree seedling establishment also tend to promote natural succession. Although Title IV (AML) is not required to adhere to Section 515, AML programs should set goals to enhance and restore diversity and ecosystem functioning of reclamation sites, rather than create more low-quality pasture composed solely of alien monocultures.

Many mine soils are extremely productive for hardwoods. Burger and Torbert (no date) report that reforestation efforts at the Powell River Project in southwestern Virginia indicate that "... restored forests on mine lands can be equally or more productive than the forests that were removed." Deep, uncompacted mine spoils can lead to the development of extremely productive forest soils. The author has observed excellent growth of black walnut; pecan; white, red, and bur oaks; and even drought sensitive tulip poplar *(Liriodendron tulipifera*) on 30 year old, uncompacted, neutral pH mine soils in western Missouri, 250 miles west of its native range in the Ozarks. Tulip poplar has thrived in protected mesic sites on mine lands. Typically, tulip poplar will not survive in this region on native soils without supplemental watering in the summer.

The author has observed nut trees growing on uncompacted, high quality mine soils producing abundant seed crop, often producing in years when trees growing in native soils do not. While limited to mere observation of pecan, black walnut, and various oak species, it is deductive to assume that deep rooting and high water availability during critical points in the development of nuts may lead to greater nut production during favorable years and important smaller yields in "off years." This may help smooth the typical boom and bust years that are hard on wildlife and nut growers' pocketbooks.

Native tree species are often adapted to the environmental conditions of the reclamation site (Limstrom, 1963). Many native species in the humid East and Midwest are tolerant of acidic natural soil conditions; therefore, these species may be effective since they tolerate acidic mine soil conditions as well. Observing natural invasion and succession of native species on acidic AML spoils may provide clues for species selection. The reclamation specialist can purchase such seedlings from regional nurseries specializing in or growing large selections of native species. Seeds or propagules can be collected from specimens growing on the mine site, grown by the specialist as described in the case study, and planted on the reclamation site. The reclamation specialist should avoid planting native species that are overly aggressive. Black locust (*Robinia psuedoacacia*) is native to the East and is commonly used as a nurse crop. It has sometimes proven to be overly aggressive and persistent in mine lands, slowing natural succession and limiting species diversity due to its dense shade and ability to spread by root sprouts. Plass (1977) found that the exotic black alder (*Alnus glutinosa*), grown as a nurse crop, can be effective in enriching mine soils, but can overtop desired species of hardwoods and conifers, limiting their establishment success. Species such as black locust and black alder should have limited use in reclamation plantings, unless the reclamation specialist is prepared to remove these species once the soil is properly developed and replant with more desirable species (Seidel and Brinkman, 1962).

The disastrous ecological effects of aggressive exotic and naturalized plant species on native plant communities is well-documented. Kudzu (*Pueraria lobata*) and japanese honeysuckle (*Lonerica japonica*) are two examples of "conservation" species that have escaped from mine and roadside stabilization plantings and pose significant threats to adjacent native plant communities. Other exotic pests have been introduced by accident by importing infected wood products, plant materials, and other commodities. Chestnut blight, dutch elm disease, and the gypsy moth are three of the best known and well-documented examples of pathogens and pests that were inadvertently introduced into North America. Reclamation specialists must avoid the desire of quick and easy plant establishment by using exotics, and focus on the long-term effects of reclamation and ecosystem functioning. Many exotic plants delay native plant invasion and natural succession of drastically disturbed lands.

Purchase of or propagation of quality planting stock is obviously important. This includes selecting materials propagated from stock adapted to local conditions and climate (Limstrom, 1963). The reclamation specialist should purchase planting stock or collect seed from trees growing within the correct climatic zone. Authorities specify that seed provenance (the place of seed origin) be a certain number of miles north or south and east or west of the planting site. Elevation also should be considered in mountain regions. The best rule is to select stock that can tolerate the planting site's minimum low temperature and survive the region's usual drought conditions. These can be determined from meteorological data. Drought effects on drastically disturbed lands may be of much greater duration and intensity than on a region's native soils.

The stock should be healthy, showing little damage to roots or shoots, and have no mold, offensive smell, or dry roots. Planting stock is expensive. Poor-quality stock has little chance for survival and should be returned for replacement or credit. The reclamation specialist can propagate stock in-house. Using container-grown stock greatly improves seedling establishment. Seed can be selected by the reclamation specialist from plants that are from local sources and adapted and growing under similar environmental conditions. Seed collected from plants growing on drastically disturbed lands may have a "genetic" advantage under these conditions and may prove effective in reclamation success. The container-grown case study emphasizes these points.

Typically, bare-root seedlings with larger calipers (the diameter of the seedling at its root-collar) have much greater establishment success than smaller ones. Vogel (1987) recommends that most conifers and hardwoods have a minimum caliper diameter of 0.1 to 0.15 inches (2.5 to 4mm). Thompson and Schultz (1995) suggest that nurseries should focus on root system development and grade seedlings on root system classification rather than shoot growth. Survival, height, and diameter growth of red oak seedlings was significantly greater in Iowa when the seedlings had ten or more first-order lateral roots.

Bare-root seedlings are grown in nursery beds from one to several years. They are removed (called "lifting") from the beds while dormant and sold or transplanted to a different bed for further growth. Nursery stock is sold based on the age and number of times the seedling has been transplanted. For example, seedlings grown in a bed for one season and sold are 1-0 stock. Seedlings grown two years with one lift and transplanted to a bed for the second season growing are 2-1 stock. The first number refers to seedling age, while the second refers to the number of times lifted and transplanted. Lifting cuts the deep roots of tap-rooted species which stimulates lateral root growth. This is physiologically similar to the air-pruning treatment described in the container-grown seedling case study. Both stimulate lateral root development. Improper lifting can result in shock to the seedling, leading to delayed growth or even death.

Correct handling of planting stock is crucial to establishment success. The reclamation specialist should inspect the nursery prior to purchasing stock to ensure the material is handled correctly. Seedlings should be free of defects, correctly sized and graded, and properly stored, packaged, and shipped. Nurseries that cannot meet these high standards should be avoided. No matter how good the nursery, some material may be shipped that does not meet these quality standards. A good nursery will accept the return of defective material and replace it or credit it to a future purchase. Nurseries that refuse returns should not be used.

Once the stock is delivered, it should be protected from drying winds, freezing or hot temperatures, and direct sunlight. Stock can be covered in the field by straw, tarps, or reflective heat blankets. The best protection is in a cool, dry barn, garage, or other structure. Stock should be planted quickly following its shipment from the nursery. Bare-root stock should be inspected for defects once the bundles are opened. Roots should be protected from drying with moist, shredded papers, peat moss or other water-absorbent materials. Water-absorbent gels can be used to keep the roots moist while planting.

One issue that always arises is that of pruning. Most experienced tree planters agree that the root-to-shoot ratio should be maintained around 1:1. Conifers should never have leaders pruned. Most hardwood species can be root-pruned to facilitate planting, only if the pruning is less than one/three the total root area. Root pruning of hardwoods may require shoot pruning to maintain the 1:1 ratio. Shoots should be pruned slightly above a live lateral bud to allow it to develop into a terminal shoot.

Correct planting techniques are simple but often overlooked. Toumey and Korstian (1931) write, "The chief aim in [tree] planting should be to interrupt growth to the least possible degree consistent with economy." The establishment success of container-grown seedlings illustrates this point. Seedlings should be planted with shoots near vertical, in a hole that is large enough to accept the roots easily without bending or twisting, and with the soil tamped gently around the roots without excessive compaction. Bare-root seedlings must be planted with the root collar at or slightly below the soil line. Bare-root seedlings must be planted after the last heavy spring frost date to minimize the potential of frost-heaving. Any deviation from these rules should not be tolerated.

Mechanical planting is a cheap alternative to hand planting. Both methods require similar correct handling and planting procedures for success. Mechanical planting is only as good as the efforts of the planting contractor and his or her equipment. Select a proven type of mechanical planter and an effective operator. Consult with state and federal foresters about the types of machines available and the operator's credentials in a region before issuing a contract. As with hand planting, find contractors who do good work.

Rugged terrain and rocky soils limit the use of mechanical planters. Wet soil conditions are not conducive to effective planting. Mechanical planters increase compaction on wet soils. Mechanical planting is quicker than hand-planting. This can be important when there are many acres to plant and the planting window is short.

Inspect the trees following planting. Place a guarantee clause in the tree planting contract to compel the contractor to perform correctly. Require performance bonds and reference checks. Good tree planters want these contract conditions because they can compete with and outbid the marginal operators.

Effective control of competing vegetation often is overlooked prior to tree planting. Dense ground cover is desirable to prevent erosion and sedimentation on a reclamation site; however, it may increase rodent populations that can destroy tree seedlings. It also may enhance browsing by deer and rabbits. Established herbaceous ground covers typically can out-compete tree seedlings, particularly during the first growing season. Water is usually the most limiting factor in tree-seedling establishment on mine lands (Munshower, 1994; Ashby and Vogel, 1993; Limstrom, 1960; Vogel, 1980; and Clark, 1954). The extensive root systems of herbaceous plants out-compete young seedling roots for water and nutrients as the seedlings overcome transplant shock and summer droughts. Competing herbaceous plants can overtop tree seedlings, reducing photosynthesis and cause shoot die-back and sometimes complete mortality.

Researchers suggest that competition for sunlight can be the chief limiting factor for successful establishment when water is not limiting (Holch, 1931; Toumey, 1929; Carvell and Tryon, 1961). The container-grown case study supports this belief. Anderson, *et al.* (1989) believes that vegetation must be controlled for the first four years following planting to ensure successful establishment. This time period may be excessive in the Midwest for some tree species, although growth will certainly be affected by the extra competition in the seedlings' early years.

Aggressive alleleopathic species, such as tall fescue (*Festuca arundinacea*), should not be used as a cover species in areas to be planted in trees. Less competitive and aggressive species such as redtop (*Agrostis alba*), timothy (*Phleum pratense*), or perennial ryegrass (*Lolium perenne*) should be planted at rates of two to four pounds of pure live seed per acre. A low-growing legume such as white clover (*Trifolium repens*) or common lespedeza (*Lespedeza striata*) can be planted at low seeding rates to add nitrogen. Adapt cover crop selections to local conditions.

Competing vegetation can be removed by "scalping." This can be done mechanically, by discing, rototilling, or drag bucket, or manually by using hoes, mattocks, or shovels. Vegetation is "scalped," leaving bare soil to receive the planted seedlings. This process can be expensive and time and labor intensive but very effective. Applying herbicides in strips or spotting is less expensive than physical scalping and very effective for vegetation control, but the environmental and human health and safety issues must be considered. All chemical applications must be performed according to label directions. Never apply chemicals in standing water.

The reclamation specialist must not scalp vegetation in such a fashion as to permit erosion. Always disc or apply herbicides along the contour, leaving swales, ditches, and channels undisturbed and well-vegetated.

Most hardwood seedlings need only one year of scalping to become established. Although less aggressive annual weeds quickly invade the scalped areas, they typically pose little threat to healthy seedlings in the second season. If tall annual weeds overtop seedlings in the first season, a clipping with a sickle bar or a hydraulic arm mower set high enough to miss the seedling is effective. The mowed material can be raked or thrown at the base of the seedling to function as an organic mulch.

Tree shelters, ground cover control blankets, and mulches also can be very effective, but can be extremely costly and labor intensive (Ashby, 1995; Smith, 1993). Tree shelters are particularly effective in protecting seedlings from animal browsing and from spot herbicide applications. Kjelgren, *et al*. (1994) found that tree shelters with or without deep-ripping, greatly improved survival of white oak seedlings on a reclaimed dragline mine in Illinois. Birds often use the shelters for perches, sometimes breaking young shoots. Paper wasps and mud daubers build nests inside the tubes that can pose a hazard to inspectors.

Proper soil conditions and soil preparation are the foundations of successful tree establishment. Certain basic edaphic or soil conditions must be present before trees can be successfully established. Mine soils tend to be low in organic matter, nitrogen, and phosphorus. Water infiltration is slow and water-holding capacity is low in graded mine soils due to compaction. Compacted mine soils accentuates the effects of soil acidity on plants and decreases water availability. Some mine soils contain acid-forming or toxicity-forming materials that impede seedling establishment.

Reclamation is a soil-building process. In natural systems, drastically disturbed lands undergo a succession of living organisms that may take decades or even centuries for successful colonization to occur. The foundation of natural succession is the development of a biological system with the plant community being the most visible portion. However, before this plant community can be expressed, a soil biological system must be developed that creates environmental conditions that allow those plants to complete their life cycles. Plants are most susceptible to harsh environmental conditions and disturbance just after germination. Many plants produce abundant seeds because most seedlings will die. The environmental changes of the microsite that result from a developing soil biological system enable many young seedlings to survive this early establishment period (Blake, 1935; Daubenmire, 1959).

Reclamation attempts to telescope this multiseasonal development of a diverse and complex soil biological system into a few short years. Often, on drastically disturbed lands reclamation specialists attempt to create a stable soil system in one season. Reclamation failures give testimony to our lack of understanding of natural processes. Bradshaw (1987) writes that ecosystem restoration "....is a considerable intellectual challenge requiring that we not only understand the nature of the ecosystem itself, but also the nature of the damage and how to repair it...*land restoration is an acid test of our ecological understanding*." The goal should be to develop a sustainable soil biological system even if it takes several years. Unless topsoil is imported with its biological system intact, it will take time to develop such a system. In most instances, topsoil should not be "borrowed" because it is never returned, and this practice only increases the amount of disturbance.

Low pH can greatly affect seedling establishment. Acid-forming materials present in many mine spoils can lower spoil pH far below what is acceptable for most tree species. As the pH drops, metals such as aluminum, manganese, and iron increases in solution. Aluminum is especially toxic to plant root growth (Berg and Vogel, 1973). As a general rule, do not plant trees on mine soils with a surface pH of 5.0 or less. Before planting, amend acidic mine soils with neutralizing material such as agricultural lime, or use organic matter to buffer the acidity and raise the pH. Otherwise, plant trees in less acidic microsites such as protected slopes and depressions and let natural succession finish the job in later years. Natural invasion patterns can provide clues to the location of these micro-sites. Field pH determination using hydrion papers is effective in verifying these microsites.

Mine soil fertility can be improved by growing nitrogen-fixing cover crops such as legumes. Plants create soil organic matter that promotes nutrient cycling and soil microbial activity. Virtually all plant-available nitrogen and phosphorus in soils are derived from the decomposition of organic matter by microbes (Brady, 1996). Organic matter increases water-holding capacity, increases cation exchange capacity, buffers soil pH, lowers bulk density, and promotes the development of a diverse, soil microbial population. These factors greatly improve the success of seedling establishment. Green manure cover crops can be disced into graded mine spoils to improve soil fertility and organic matter levels. Organic matter can improve soil pH and buffer the exchangeable acidity, improving revegetation and seeding establishment success (Berg and Vogel, 1973; Brady, 1996).

Over time, mine soils tend to stabilize pH and nutrient cycling converging towards values that are more typical of regional native soils (Davidson, *et al*., 1988). Acidic "hot spots" or "greasy spots" are common AML problems. Incorporating organic matter and lime can accelerate plant and microbial colonization which, in turn, decreases soil pH, improves soil buffering, and increases nitrogen and phosphorus accumulation and availability. Planting calcium-enriching species such as dogwoods that accumulate calcium in their leaves results in less acidic and more fertile mine soils. Pines tend to accumulate high levels of aluminum in their needles as a way to prevent physiological damage to plant tissue. The needles acidify the soil litter layer limiting plant and microbial colonization which, in turn, limits nitrogen and phosphorus cycling and ecological succession and diversity on mine lands.

Low soil fertility also can be addressed by liming and chemical fertilization. While cheap and effective, chemical fertilizers can pose environmental hazards if improperly used and impede the development of native plants adapted to low fertility levels often associated with mine soils. The reclamation specialist must look at the long-term goals of reclamation to determine the proper course of action.

Water is the most limiting factor in tree or shrub establishment (Gjerstad *et al.*, 1984; Munshower, 1994; Ashby and Vogel, 1993; Limstrum, 1960; Vogel, 1980; Clark, 1954). Excessive compaction of clay-dominated mine soils caused by heavy earth-moving equipment decreases mine soil water-holding capacity. Tree seedling roots have difficulty penetrating compacted mine soils. The effects of drought are accentuated in compacted mine soils, and often result in transplanted seedlings dying because their root systems are not extensive or deep. Compaction also impedes the infiltration of water into the mine soil. In wet periods, this can result in waterlogged or anaerobic conditions that can kill seedlings or severely damage their root systems (Clark, 1954; Munshower, 1994; Ashby, 1993). Czapowskyj (1970) found that grading sandy or rocky, coarse-textured mine spoils improves tree seedlings' performance in Pennsylvania by reducing the slopes and thereby increasing water infiltration into the spoil. This result may be limited to extremely coarse textured spoils and cannot be considered typical of most spoil conditions in the Midwest. Grading clay-rich mine soils can result in compaction and ponding of water.

Deep ripping by ripper bars, subsoilers, V-shank rippers, or rome plows pulled by bulldozers is often effective in breaking up compaction, increasing water infiltration, and increasing penetration of tree roots. Ripping down 24 to 48 inches greatly improves seedling establishment rates. A second pass, angled on a 60 degree bias rather than perpendicular to the first, seems to be most effective in breaking up compacted spoil. In 1995, ripping costs ranged from $100 to $200 per acre, to a depth of 24 to 36 inches on 20-foot centers. Tree planting costs can total $200 to $300 per acre. Ripping increased first season bare-root survival rates from 30% to 40% to 60% to 80% for an investment of $100 to $200 per acre, resulting in a total tree-planting cost ranging from $300 to $500 per acre. Ripping may be the critical factor in stand survival in a drought year. Ripping increases surface roughness which promotes water retention in microhollows. Ripping slows near-surface wind velocities, reduces erosion, and slows evapotranspiration (Ashby and Vogel, 1993). Torbert and Burger (1996) found that minimal grading and surface roughness such as that left by ripping greatly improved tree growth and minimized erosion by increasing infiltration. Ripping also removes competing vegetation from the planting rows. Anecdotal evidence suggests that ripping may increase rodent predation of seedlings by providing habitat and easier access to roots (Ashby, 1992). While this may be locally devastating, heavy rodent predation may only be cyclical, tied to vole and other rodent population cycles. These factors tend to promote tree establishment. Additional plantings required to replace dead stock may almost double the cost of tree planting to $400 to $600 per acre. Does it not make sense to spend a few more dollars up front to ensure higher establishment rates and minimize replacement costs by ripping and scalping?

Weather can be the most crucial factor in tree-planting success. As mentioned earlier, water is usually the most limiting factor in tree-seedling establishment. All the best soil preparation, high-quality planting stock, and proper planting methods can go for naught if it does not rain. Munshower (1994) suggests planting trees and shrubs just prior to the period of maximum precipitation. Even so, droughts like that of 1980 and 1988, or even a pronounced spring drought during the first season, can destroy a tree planting. Like a farmer, the reclamation specialist must be an optimist, believing that the weather will be favorable and that the best laid plans and the expense will not be in vain. However, when the weather is not favorable, the reclamation specialist must accept failure, adapt to new conditions and revise plans, but never give up. In the arid West, optimal establishment years are few, and the native plant community ecology studies provide evidence that most seedlings are established in those optimal years (Munshower, 1996). Although, optimal establishment years are more frequent in the humid East and Midwest (Daubenmire, 1959), failures do occur and can play a major role in reclamation success.

Methods/Container-Grown Case Study

Qualitative observation of establishment success of container-grown seedlings since 1990 suggests a first-season survival rate of 90 percent for air-pruned bur oak and pecan grown in half-gallon bottomless containers. This compares to 35 percent survival of two-year-old bare-root stock grown at either a local commercial nursery or the state forest nursery. These were side-by-side plot trials of seedlings planted in prepared rows of prairie soils in Conservation Reserve Program (CRP) crop fields in western Missouri. Additonal test plots were established in neutral graded mine spoils and in a grassy old field. Rows were set along the contour at 15-foot centers, disced, and planted by hand. Container-grown seedlings were planted in the fall, and bare-root seedlings were planted in the spring. Success rates were slightly higher in very fine sandy loam soils mapped as Bates loam (2 to 5 percent slopes, fine-loamy, siliceous, thermic Typic Argiudolls), compared to silty clay soils mapped as Kenoma (2 to 5 percent slopes, fine, montmorillinitic, thermic Vertic Argiudolls) (USDA, 1995). Competition became intense in

midsummer as late-season weeds such as common and giant ragweed, giant foxtail, cocklebur, and beggar ticks germinated from the old-field seedbank. The rows were mowed in July to prevent shading of the seedlings.

A second test plot was established on rough-graded, neutral mine spoils, (silty clay texture with 15 percent shale channers, 5 percent sandstone pebbles, and few sandstone cobbles) in western Missouri. Establishment success in the first season was approximately 75 percent for container-grown bur oak and pecan, compared to 30 percent for bare-root seedlings. Compaction was minimal since all grading was performed by a D-3 dozer knocking the tops off the spoil ridges, pushing the fill into the valleys between ridges. Wind-disseminated species, particularly broomsedge, slowly colonized the plots, competing with the seedlings. Adjacent mine lands were heavily vegetated, enabling deer to browse the plot undisturbed. Japanese honeysuckle invaded the mine spoil plots from outside by rapidly spreading vines.

A third test plot was established in central Missouri on loess-derived forest soils that had been cleared in the 19th century, then farmed and planted to tall fescue in recent decades. In places, much of the A horizon had been eroded and mixed by plowing into the E horizon. The soils were classified by the author as eroded Winfield silt loam (fine-silty mixed, mesic, Typic Hapludalfs) (USDA, 1994). Fescue sod was removed with a heavy hoe around each seedling to reduce competition at the time of establishment. Spraying could be as effective, but must be done while the seedlings are dormant. First-year survival rates for container-grown bur and northern red oak were 90 percent compared to 35 percent for bare-root. Mortality was high during the first winter due to a large population of voles (*Microtus* spp.). The author suspects the rodent predation is due to the greater nutritional content of container-grown seedlings compared to natural seedlings in the grass pasture. Cattle were removed from the pasture prior to planting, and the vole population exploded afterward.

Moisture was excessive at all sites during the period of fall 1992 to summer 1995. There was a pronounced water deficit in the summer of 1990 and in 1995, resulting in correspondingly lower establishment rates. Prolonged soil saturation resulted in anaerobic conditions in upland soils due to excessive rain throughout the summer of 1993. Many seedlings were observed to have suffered extensive root rot, killing the seedlings outright or indirectly by winter kill. Success rates were high in the well-drained Bates loam during the wet period. Appendix I outlines successful oak seedling propagation techniques.

Conclusion

The container-grown seedling methodology outlined in the case study has proven successful in small-scale establishment of deep taprooted hardwoods that are extremely difficult or impossible to transplant. Species without prominent taproots such as birch, ash, and maple receive no advantage from air-pruning as compared to traditional containers. All species of oaks, walnuts, and hickories, including pecan, responded well to air-pruning via bottomless containers. Baldcypress, hackberry, tulip poplar, kentucky coffeetree, persimmon, and basswood are effectively grown and out-planted using the air-pruned method (Lovelace, 1996). Many later-successional species planted to enrich the mine land ecosystem are prevented or are limited in their natural ability to invade drastically disturbed lands due to the distance from the site to a seed source (Ashby *et al*., 1980). Out-planted container-grown seedlings are more readily established with an intact root system as compared to bare-root. Growth and development of the air-pruned root system are rapid, enabling the seedlings to more readily survive harsh competition for water and nutrients in the first growing system than bare-root seedlings. Fall planting accentuates this difference. Container-grown seedlings continue to send out roots until the soil approaches freezing temperatures, which in Missouri are from late December to February. Some of the lateral roots enlarge and grow downward, developing into a multistemmed taproot system. Container-grown seedlings have a much greater planting window than bare-root in the East and Midwest, since their roots are continually growing which reduces or eliminates transplanting shock (Tinus and Owston, 1984). Bare-root seedlings can only be planted while dormant in the spring, allowing little time to establish an effective root system that can compete against annual weeds and survive during summer drought.

Ashby (1980) found that natural succession processes on drastically disturbed lands mimic classic old-field succession. Often desirable oak and nut seed trees are not near mine lands in the Midwest, therefore cannot colonize mine lands. With the bottomless container method, hard-to-find oak and nut seedlings can be propagated from seed collected from local parent stock that are adapted to the unique growing conditions of the planting area. High-quality, container-grown, air-pruned, seedlings can be used to enhance the biological diversity and wildlife habitat of drastically disturbed lands. In 1998, the author collected 272 and 178 viable acorns from two five-year-old bur oak seedlings (Quercus macrocarpa) grown with the methodology described in this paper. Future observations are needed to determine if the container-grown methodology somehow promotes early seed production. Planting long-lived oaks and hickories passes a legacy from one generation to another that outlasts many day-to-day labors.

Successful tree-seedling establishment largely depends on the seven variables listed in the introduction of this paper. Water remains the chief limiting factor in seedling establishment. Compaction is the chief culprit in limiting tree root development, in water infiltration, and in water-holding capacity of mine soils. Soil chemistry plays a major role in establishment success since many weathering by-products of mine spoils are salts that absorb water and disperse clay particles, which further limits plant available water. Acid-forming materials directly affect root growth. Low pH solubilizes metals in soils, especially aluminum which is extremely toxic to plant roots. Low organic matter in mine soils results in low nutrient levels, particularly nitrogen and phosphorus, poor nutrient cycling, and low soil microbial populations.

These conditions can be overcome by adequate analysis of soil conditions and soil preparation. Soil preparation includes liming, ripping, scalping, and fertilizing, or the use of green manure crops. Purchase good planting stock of locally adapted native species, especially if the mine soils are acidic. The stock must be correctly handled and planted. Once all this is done, establishment is largely up to nature. If weather conditions are favorable, the stand should be successfully established in the critical first season. However, the reclamation specialist must be patient and be able to withstand the pressure of supervisors, regulators, landowners, and the general public, who may not understand that tree-planting success takes time. Finally, practioners must get out of the office and observe what works and adapt their efforts to local conditions.

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APPENDIX I
OAK PROPAGATION TECHNIQUES

Fall/Winter

1. Collect acorns that have proper color and no weevil holes, cracks, or other surface blemishes. Do not collect green seeds. Acorns with caps still affixed should be discarded. Larger acorns tend to produce larger seedlings. Whether this difference is a short-term or long-term effect is not clear. However, it is obvious that a larger transplanted seedling has greater survival rates (Downs and McQuilkin, 1944, McComb, 1934 and Korstian, 1929).
2. Acorns should be floated in water. Those that float should be discarded since they tend to be dead or damaged. Acorns that sink should be collected and allowed to dry to the touch on newspapers in a cool, dark location. Most acorns desiccate quickly, resulting in a serious reduction in viability. Sound acorns typically have a germination rate of 75 to 90 percent. For successful germination, white oak (*Leucobalanus*) group acorns must have a moisture content above 30 to 50 percent, with a minimum of 20 to 30 percent for the red oak (*Erythobalanus*) group (USDA, 1948). Bur oak acorns should have their caps removed for the float test.
3. Collect dried acorns into one-gallon sealable plastic bags, preferably freezer-type bags.
4. Place acorn-filled bags in a refrigerator set at 34EF to overwinter. Periodically, check and remove acorns damaged by weevil larvae and mold.

5. Hickory nuts, pecans, walnuts, and hazelnuts require moist stratification for proper germination. They should be stored in a moist mixture of half sand and half ground peat. Storage containers with airtight lids should be used. Place storage containers in a cool, unheated location to overwinter. Floating cannot be used to remove dead or damaged nuts. Check periodically to maintain moisture level. Do not saturate the mixture because the nuts can rot.

Spring

1. In mid-March, check *Leucobalanus* (white oak group) acorns for the emergence of the radicle (first root) from the acorn tip.
2. Plant acorns in Whitcomb bottomless containers (also called milk cartons) that are resting off the ground

after the threat of a hard freeze (around 25EF) is over. Flats with welded wire bottoms can be built to hold the containers. Acorns should be carefully planted once the radicle has emerged. The radicle should be planted with the growing tip pointed downward. Radicles planted upward cause the roots to spiral or bind. Planting can continue until the middle of June, although growth may be less than in earlier stock. *Erythobalanus* (red oak group) acorns germinate more slowly than *Leucobalanus*. Do not wait for radicle emergence to plant.

3. The potting mix that has yielded the best growth and development for the author is two parts topsoil (silt loam, very fine sandy loam or silty clay loam is preferred), two parts ground peat (commercial quality with no sticks or stems), and one part composted manure (available at nurseries and discount stores in 40-pound plastic bags). Soil compaction or dense, tight potting mix can delay radicle emergence or even damage the radicle itself. Therefore, it is imperative to have a loose potting mixture (Korstian, 1927, and Connell, 1961). White (1970) found that using soil alone in the potting mix greatly reduces seedling growth. Using topsoil from oak-hickory regions inoculates the seedling roots with mycorrhizal fungi. Although there is always a risk of introducing pathogens or pests from the topsoil, the benefits of my-corrhizal inoculation outweigh the risk (Dixon et al, 1984). The peat reduces total weight and improves the soil mix structure. Organic matter in the potting mix greatly improves seedling root development and improves water-holding capacity. This is particularly important for oak, hickory, pecan, and walnut seedlings (Lovelace, 1996). Manure in the mix provides slow-release nutrients.
4. Cover the plastic container bottoms with one layer of newspaper to initially contain the soil mix. The bottomless nature of the containers allows the taproot to grow downward until it penetrates beyond the container. At this point, the exposed root meristem dies, hence the term "air-pruned." This prevents the root spiraling and girdling common in container-grown oaks and hickories. The air-pruned taproot stimulates the growth of lateral roots, which fill the container by the end of summer. Species with strong taproot tendencies reestablish this growth pattern once outplanted (Lovelace, 1992).
5. Periodically inspect stratified hickory, pecan, and walnut seeds. Nuts that have opened or have emerging radicles should be planted immediately.
6. Protect planted containers left outdoors from squirrels. They will wipe out an entire planting within hours once they smell the nuts. Downs and McQuilkin (1944) found rodents, particularly deer mice, *Peromyscus maniculatus*, to be more damaging to dropped acorns in the forest than squirrels or chipmunks. Whether that is true in the backyard remains to be seen.
7. Do not plant defective, weevily, discolored, or excessively moldy acorns. By June 1, do not plant hickory nuts, pecans, or walnuts that have not split open for radicle emergence. Throw these to the squirrels since it is unlikely they will germinate.
8. Planted containers should have a 1/8- to 1/4-inch-thick surface layer of shredded bark or coarse sawdust. This provides a protective mulch that reduces evaporative losses and inhibits puddling and compaction of the soil surface. The mulch layer can save the seedlings from desiccation on a windy August day. This also mimics the natural revegetation process by simulating forest floor litter. Korstian (1927), Barrett (1931), McComb (1934), and Corvell (1961) all emphasize the importance of a protective organic layer for effective seed germination and seeding establishment. This remains true for outside grown, container-grown seedlings.

Summer

1. Keep the soil mix moist but not saturated during the entire growing season. Too much water causes the seeds and roots to rot. Once the secondary leaves emerge, transpiration becomes rapid and water in the plastic containers can be quickly depleted. Weeds should be pulled from the container soil.
2. In July and August, check the seedlings every day for moisture stress. Water as needed.
3. Insects usually are not a problem, but mold and mildew can cause leaf problems during a wet spring. Insect pests can be crushed by hand. Spraying should be done only as a last resort.

4. Transplant early, well-developed seedlings by late July into one-gallon, two gallon, or five-gallon plastic pots for further flushes of growth. Only air-pruned seedlings should be transplanted into the plastic pots to prevent root spiraling and binding. Potted seedlings must be outplanted in the first fall season to prevent root spiraling and binding.
5. White oak, chinkapin oak, and post oak seedlings tend to be small and slowly established in the first season. Initially, plant acorns in six-inch grow tubes and transplant to half-gallon milk carton containers by August. These seedlings will be too small to plant in the coming fall and should be stored overwinter for another growing season before planting.
6. Inspect all seedlings to ensure air-pruning has occurred. If not, prune the taproot with hand shears.
7. Seedlings grow best in full sun from the east in the morning, with light shade from midday to evening. Try to find a hedge row or large tree, and locate seedlings on its east side. Allow the canopy to shade the seedlings by midday. Deep shade is not desirable.

Fall

1. Outplant healthy, vigorous seedlings as soon as daytime temperatures begin to drop into the low 80s and the fall showers begin.
2. Scalp overly competitive grasses by hoeing or spraying around the planted seedling. Make a two- to three-foot-diameter clearing around each seedling. Plastic tree tubes can greatly increase survival and growth of transplants, but cost must be considered.

3. Discard seedlings that are too weak, spindly or short. It is too much work to plant container-grown stock that will not survive.
4. Store small, slowly established white, chinkapin, and post oaks for the winter in a cool, dark, moist place such as a root cellar or earth-contact basement. They should have undergone a good freeze to slow or stop shoot biologic activity prior to storage. Roots continue to grow in winter until the soil temperature approaches freezing.
5. Seedlings can be planted successfully until early December if properly mulched and located in a protected location. Frost-heaving can be a concern for unmulched seedlings or plantings located in exposed areas susceptible to frost-heaving. Good fall establishment enables the seedling to send out deep roots in preparation for summer drought and competition for moisture and nutrients. The result is that container-grown seedlings give the planter five to six months to plant stock as compared to the one-month bare-root seedling planting window.
6. Store extra seedlings overwinter for a spring planting. These can be planted from mid-February to the end of April.
7. **Select the correct native species and adapt to local conditions.**

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ILLINOIS/INDIANA

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Introduction

I would like to review a few common sense theories. The future is now and it is our turn. It is our turn to lead. It is our turn to create meaning for all of those around us. We must dispel the idea that trees will not grow on re-claimed land. In Indiana, we are planting nearly a million trees a year on reclaimed mine land. We are con-sistently achieving bond release and a significant growth rate. These successes came from the result of many people working together. It came from people like you and me sharing our ideas and experimenting with what we learned. The results we get when working together is greater that the sum of what we can each do individually. Often we act as a catalyst to motivate each other. Many times there needs to be a change in how companies com-municate in order to get things done. Many times a bottom up approach will find solutions to our problems. It gives employees a sense of ownership in a project that will encourage us to become proactive rather than reactive. As our nation increases in complexity, demands for clean air, water, and a better environment also will increase. We have no choice but to meet the challenge. Future generations depend on what we will do today.

Tree Planting Recommendations

What is the physical make up of a successful tree planting project? The following is an outline, in order of importance, of what I have found to be required to successfully establish trees on a reclaimed mine site, realizing that it is the sum of these factors that produces good results.

- **Seedling Quality.** The seedling must have a large, healthy, fibrous root and as large a diameter of stem, within reason, as possible. There must be a desirable root to shoot ratio. This type of seedling is being consistently produced by the Indiana State Nursery. Many tree planting contractors would prefer to plant smaller seedlings because it is easier, especially with hand-planting. Availability of a sufficient quantity of good seedlings is a problem in Indiana. Some species of trees do not respond well to planting on reclaimed mine sites in Indiana. These would include tulip poplar, eastern red cedar, and some of the shrubs for wildlife plantings. Sometimes you are compelled to use what is available because there are not sufficient quantities of the most desirable species.
- **Seedling Care After Leaving the Nursery.** They should be refrigerated as soon as they leave the nursery and until they are in the ground. It is crucial to have a good working relationship with the nursery.
- **Soil Conditions.** Soil conditions are more critical for mechanical planting than for hand-planting. These conditions are less critical early in the season but become more so as the season progresses and temperatures rise. Late in the season, wet soils will compact quickly after drying out in the sun. In this condition, good soil to root contact is impossible. I have found that I get the best results with mechanical planting by waiting for good soil conditions later in the season, rather than planting too wet too early. If I am hand-planting, then it is best to plant as early as possible.
- **Weed Control.** The improper selection and overuse of herbicides has destroyed many seedlings. By mistake, we learned that the application of one third the rate of some herbicides gave us satisfactory weed control and no problems with seedling damage from the herbicide. Different species and varieties of tree seedlings have dif-ferent tolerance levels to herbicides, which compounds our problems. Research at Purdue has shown that a successful application of the correct herbicide to control herbaceous cover for the young tree seedling invari-ably results in superior tree growth. “Milestone” appears to be the forest herbicide of the future. It is environ-mentally friendly and friendly to the tree seedlings as well. More research is needed to get better forest friendly products on the market.
- **Seedling Placement.** The mechanical equipment used to plant tree seedlings is expensive. Field conditions that prevent the use of mechanical equipment include rocks, wood, steep inclines, and washouts that cause excessive wear and breakdowns to this equipment. We started with a 4 inch planting shoe to accommodate the

largest seedling root possible, but found we could not get proper closure around the root with that large of a shoe. We soon changed to a 2.5 inch shoe and installed sod cutters on our press wheel in order to get better root to soil contact. This made a noticeable difference in our survival rate. We also cut some of our machines down and converted them to a heavy duty three point hitch machine for better maneuverability. One of our machines is a split axle planter with a crawler tractor for steeper slopes and hard to plant areas. We will install dual wheels on our four wheel drive tractors this spring. When we first started machine planting we tried to plant at root collar depth. We soon found that we had to plant much deeper. We spray the seedlings with a pollimer and water mix in order to retain as much of the nursery soil on the roots as possible. Our higher cost of planting reflects our higher capital investment cost. I have found it is better to do a good job the first time rather than risk replanting. This proves to be more economical for our clients. Because there are so many uncontrollable variables that could affect tree survival, we do not guarantee tree survival. Instead, we do everything possible to ensure that the seedlings are planted right the first time. In order to ensure a given number of healthy seedlings per acre, you must plant a higher number originally in order to cover expected mortality of a certain percentage of the seedlings. Replanting is very difficult because of the patchy nature of surviving seedlings. Replanting efforts must be done by hand, which often results in just delayed mortality as hand-planting on reclaimed lands have a much lower survival rate. Our six years of hand-planting efforts has had limited success.

- **Follow up.** Some follow up is necessary. Keeping the centers of the rows clean to conserve moisture and preventing excessive rodent damage and animal browse may be of benefit. This could reduce the possibility of replanting. Grass control is more crucial than broad leaf control. Unfortunately, the decaying vegetation that you mowed early in the season provides hiding places for rodents and highlights the tree rows for browsing animals. Each mine site is different and specific methods need to address the specific requirements of each site. It is important to inspect the site regularly to determine management needs.

Summary

The things that make tree planting efforts most likely to succeed are: (1) seedling quality; (2) seedling care; (3) soil conditions; (4) tree friendly herbicides and weed control; (5) seedling placement; (6) follow up; and, most of all, (7) developing a good attitude about tree planting. Our planet will respond graciously, preventing the detrimental repeat of history experienced by ancient civilizations and more recent developing nations.

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- Tom Wallace Forestry Award,
- Area Six Conservation Award,
- 1983 Indiana Logger of the Year Award,
- 1985 Statewide Outstanding Tree Farmer of the Year Award, and
- the 1998 Vance Pat Wiram Award.

AMERICAN ELECTRIC POWER COMPANY
REFORESTATION HISTORY ON RECLAIMED MINED LANDS

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Introduction

American Electric Power Company is one of the largest investor owned electric utilities in the United States. Its business is generating, transmitting, and distributing electricity and providing related services to seven million people throughout portions of seven mideastern states. In providing this service, extensive land reserves have been acquired by the company to support the company's generation plants, coal mining operations, coal transportation facilities, and transmission and distribution facilities. The company owns a total of 311,000 acres, the bulk of which is fuel related, surface or underground coal reserves. Ninety-five percent of American Electric Power's electric generation is fossil fuel based. In 1996, AEP burned 52 million tons of coal from surface and deep mines in eight states. Approximately 15 percent was produced by AEP's affiliated coal companies in Ohio and West Virginia.

As a consequence, American Electric Power Company has a long history and extensive experience in reforestation on reclaimed mined lands. One of the first land-oriented programs the company entered into was its tree planting or reforestation program. This began in 1946 with the planting of raw spoil banks on the company's Philo I and II strip mine ownership south of Zanesville, to return the mined land to a productive capacity. Not only was it the first planting of mixed hardwoods on strip-mined banks, but its success served as the basic building block in the company's continued policy to return mined lands to a productive capacity through the planting of trees.

When the company's mining operations expanded into the Cumberland coalfields, this reforestation commitment continued. Even though this planting was required to achieve compliance under the old reclamation laws, it has always been a sincere effort to reforest with the best species available to achieve the establishment of commercially viable, mixed-hardwood plantations. In addition, when old agricultural fields were abandoned due to marginal agricultural productivity, they were also planted to trees, predominantly mixed pine.

When the new reclamation law was enacted in 1972, the establishment of grass as a vegetative cover was required to achieve compliance. Although this diminished the extent of the company's tree planting program, efforts to establish forest plantations on the new grasslands continued, using both chemical and physical means of vegetative control to establish trees. In addition, several research studies were conducted to identify the best techniques and species to use on post-SMCRA sites.

In 1995, AEP made a commitment with the Department of Energy under its Climate Challenge Program, to plant 15 million trees on 20,000 acres of company land by the year 2000. This project will reforest 11,000 acres of reclaimed grassland areas that are no longer under bond. During the period 1996 to 1998, a total of 9,741,406 trees were planted on 12,131 acres.

The sum total of these efforts has resulted in the creation of 40,428 acres of mixed-hardwood and mixed-pine plantations involving 50 million tree seedlings.

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Also serves as Chairman, UtiliTree Carbon Company, Inc. UtiliTree is an initiative of the Edison Electric Institute which involves the oversight on the implementation of five forestry carbon sequestration projects both domestic and international. Has overseen the coordination of Abandoned Mined Lands Reclamation Projects on company lands.

MYCORRHIZAL FUNGI AND TREES—A SUCCESSFUL REFORESTATION ALTERNATIVE FOR MINE LAND RECLAMATION

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Abstract

Successful consistent revegetation of drastically disturbed mine sites (i.e., acid coal spoils and mineral waste dumps) throughout the United States and several foreign countries has been achieved by using the biological "tools"—mycorrhizal fungus inoculated tree seedlings, native shrubs, and grass species. These trees and shrubs are custom-grown in bareroot and container nurseries with selected mycorrhizal fungi and grasses, and forbs are inoculated in the field at the time of planting. On disturbed sites, specific mycorrhizal fungi such as *Pisolithus tinctorius* (PT) or VAM provide significant benefits to the plant symbionts through increased water and nutrient absorption, decreased toxic materials absorption, and overall plant stress reduction.

One of the best examples of the practical application of this symbiotic mycorrhizal fungus-host tree technology is in Ohio. During the past 18 years, the Ohio Division of Mine Land Reclamation—Abandoned Mined Lands (AML) program has utilized the combination of the PT fungus and selected tree species in a successful reforestation project to significantly improve the effectiveness and reduce the cost of AML reclamation projects. Since 1982, over 5 million PT-inoculated pine and oak seedlings have been planted on over 3,000 acres of unreclaimed AML sites. Tree survival has averaged over 85 percent in the PT-inoculated tree plantings with less than 5 percent tree failures as compared with less than 50 percent survival and over 75 percent failures in previous plantings with the same noninoculated tree species. From 1982 to 1998, the Ohio AML reforestation project with PT-inoculated trees has cost approximately $970,000 or $300/acre. In 1998, approximately 340,000 PT-inoculated seedlings were planted on 242 acres at a cost of $195,000 or $805/acre. This represents an approximate 87 percent cost reduction as compared with conventional mineland reclamation methods ($6,000/acre). The PT seedling inoc-ulation cost is only $35/acre or about 4 to 12 percent of the reforestation cost which is relatively minute when compared to the consistent tree survival and early growth benefits obtained on these highly disturbed stressful sites. Interest in the application of this natural environmentally friendly technology to mineland reclamation programs throughout the United States and several foreign countries is expanding. This "total natural systems approach" to successful mineland revegetation is available through a team of scientific and business experts offered by Plant Health Care—Reclamation, Inc.

Introduction

Vast areas of the United States have been rendered nonproductive by over 175 years of intensive, uncontrolled surface and subsurface mining (5). Millions of acres of abandoned mined lands (AML) in the United States along with additional millions in several foreign countries (Asia, Europe, Africa, and South America) are in urgent need of reclamation. The 1990 Abandoned Mined Lands Inventory revealed that it would cost over $3 billion just to eliminate health and safety hazards on AML in the United States. An additional $57.8 billion would be required to reclaim environmental problem AML sites assigned third priority by the Surface Mining Control and Reclamation Act of 1977 (SMCRA). One northcentral state, Ohio, alone contains 200,000 acres of abandoned strip mines. Using conventional AML reclamation techniques (grading, resoiling, fertilizing, and revegetating), the cost of reclaiming these sites is estimated to be $1.5 billion. Problems associated with abandoned mineland include subsidence, acid or toxic drainage, landslides, sedimentation and flooding, loss of productivity, hazardous impoundments, visual pollution, and abandoned equipment (5). Mining for natural resources also generates a variety of waste materials that differ significantly in their biological, chemical, and physical characteristics. Factors such as soil pH, organic matter, composition, fertility, moisture, temperature, and microbial composition profoundly influence successful plant (trees, shrubs, and grasses) establishment and growth on these mineland sites (19).

Increasing public awareness and intensified environmental legislation have regulated the mining industry to assure effective reclamation on mined lands. Since the enactment of SMCRA in 1997 (Public Law 95–87), active strip mine reclamation has focused on intensive soil grading, replacing topsoil, and establishing a dense herbaceous cover to quickly control erosion, thus assuring prompt bond release. Although reforestation may not be the se-lected alternative in the reclamation of active mine land operations, it is receiving considerable interest as a viable reclamation "tool" in AML programs. Reforestation, of course, is neither new nor innovative; however, it deserves renewed interest and consideration for mine land reclamation applications. Tree planting on mined land is an excellent reclamation alternative that was deemphasized during the time period in which alternative objectives, regulations, and policies were developed following the enactment of environmental laws in the 1970's (3). With today's technology, the land can be shaped to its former contour; the soil can be replaced to its approximate previous configuration; and acidic coal spoils and other mine wastes can be capped and sealed away from the environment. However, even with the most intensive procedures to improve soil fertility and structure, efforts to restore previously existing vegetation have all too often failed. Establishment of trees has been especially difficult, often requiring repeated plantings to offset recurrent mortality (8,13).

Mycorrhizae and Mined Sites

The feeder roots of most plant species (trees, shrubs, forbs, flowers, and grasses) are infected by specialized fungi that form beneficial associations called mycorrhizae (fungus roots). The most widespread symbiotic (mutually beneficial) association on plant roots is mycorrhizae. These structures greatly increase root absorption efficiency and are vital to the survival and growth of both the host tree and the fungus. Compared to nonmycorrhizal roots, those roots colonized by mycorrhizal fungi have increased water and nutrient absorptive capacity, nutrient fixation, resistance to root pathogens, and longevity. As the main interface between seedling and soil, mycorrhizae are a key measure of root system quality.

Mycorrhizae are of two primary biological types: endomycorrhizae (which penetrate host cells) and ectomycorrhizae (which grow between the root cells and cover the root surface with a mantle of fungus hyphae).

Endomycorrhizae is the most widespread type and comprises three groups–ericaceous, orchidaceous, and vesicular-arbuscular (VAM) mycorrhizae. The endomycorrhizae also are predominantly found on hardwood tree species along with some conifers. VAM occur on more plant species than all other types of mycorrhizae combined. Over 90 percent of the 300,000 species of vascular plants in the world form VAM in natural soils.

Ectomycorrhizae occur on about ten percent of the world flora, and are predominantly found on conifer species along with some hardwoods (oak, birch, beech, chestnut, hickory, and eucalyptus). Numerous fungi form ectomycorrhizae. In North America alone, at least 2,100 species of fungi form ectomycorrhizae with forest trees. The vast majority of plants in natural environments have mycorrhizae; it is the rule in nature. Therefore, a primary prerequisite of successful mine land reclamation with trees, shrubs, forbs, flowers, and grasses is the most compatible combination involving the mycorrhizal fungi, plant host species, and the soil and environmental conditions on the mine site.

One ectomycorrhizal fungus, *Pisolithus tinctorius* (Pt) has been widely used to improve mine land reclamation tree planting success. Acid coal spoils, kaolin spoils, mineral mine wastes, borrow pits, and other severely disturbed sites have been successfully forested with tree seedlings having Pt ecomycorrhizae. Although the fungus does not directly affect the quality of the mined site, it modifies the tree root system so that it can tolerate adverse soil conditions, such as low pH (3.0), high temperatures, low fertility, mineral toxicity, and drought, that usually kill other ectomycorrhizal fungi along with their host trees (4, 5). Pt offers a practical, economical, effective alter-native to intensive mine land reclamation, particularly on AML projects.

There is a large body of published scientific research showing the practical significance of the Pt ectomycorrhizae and specific VAM fungi to revegetation of mined lands and other adverse sites in the United States and other parts of the world. Most of these field research and demonstrations were done on very acid coal mined lands in the eastern United States that also were droughty with high summer soil temperatures and contained high amounts of Al, S, Mn, and Fe (11). Other research and field demonstrations have been done on kaolin, phosphate, and mineral mines; impoverished eroded soils; and borrow pit sites (10). The results from all sites have been similar. After several years, seedlings with Pt ectomycorrhizae or with selected VAM had significantly greater survival and growth and contained less heavy metals in their foliage than seedlings with ectomycorrhizae or VAM formed by other species of naturally occurring mycorrhizae fungi, (7,12).

Nursery Inoculations and Seeding Production

During the past 20 years, operational programs have been developed for the practical and effective inoculation of bareroot and container nursery seedings with Pt inocula for mine land reclamation programs. Pt was selected for its demonstrated benefits to a variety of host trees and for its adaptability to adverse soil conditions, ease of manipulation, and wide geographic and tree host range. Many conifer and some hardwood tree species on a variety of nursery sites have been artificially inoculated with Pt inocula. Effective Pt vegetative inoculum has consistently improved the quality of bareroot and container nursery seedlings along with subsequent benefits to mined land reclamation and forestation (Figure 1) (15,17). Results obtained from thirty-four bare-root nursery inoculations conducted during the three-year period, 1978 to 1980, showed that Pt inoculated southern pine seedlings had a 17 percent increase in fresh weight, a 21 percent increase in ectomycorrhizal development, and a 27 percent decrease in the percent of cull seedlings at seedling harvesting date (Figure 2). Seedlings are the most responsive when at least half or more of their ectomycorrhizae are Pt ectomycorrhizae (Pt index > 50).

Procedures for operational nursery use vary among the different commercial Pt inocula types. With any of the mycelium and spore inocula, the biological requirements of a second living organism are added to that of the seedling. Consequently, special precautions are necessary for the Pt inoculum during shipping, storage, and handling, along with certain aspects of seedling production, lifting, handling, and field planting. For successful Pt inoculation in bare-root seedbeds, populations of pathogenic and saprophytic fungi and native ectomycorrhizal fungi that may already be established in the soil must be reduced by spring soil fumigation. Prior to sowing, vegetative inoculum can be broadcast on the soil surface and incorporated into the fumigated seedbeds or it can be machine-applied with greater effectiveness and efficiency (Figure 3). For container-grown seedlings, vegetative or spore inoculum can be incorporated into the growing medium before filling the containers. Spores also can be sprayed or drenched onto container media for containerized seedlings and onto seedbeds in bare-root nurseries following seed germination and seedling emergence.

In the VAM program, bare-root and container nursery inoculations are continuing, using a multiple-fungal species VAM "cocktail" inoculum on selected hardwood tree seedling, native shrub species, native flowers, and grasses for mine land and forestation applications. Results of VAM inoculations on several hardwood seedling species in several eastern U. S. bare-root nurseries, on selected native shrubs in a western U.S. container nursery, on native shrubs in a western U.S. container nursery, and on native grasses/flowers on a copper mine site in the western United States have all been positive. Research on the consistent positive effects of VAM on eastern hardwood tree species also has been published (9). A variety of ecto and endomycorrhizal fungus species and inocula types targeted for specific applications such as mine land reclamation are presently commercially available from PHC Reclamation, Inc.

Guidelines for MycorTree™ seedling production are designed to maintain healthy root systems with abundant specific mycorrhizae. Development and retention of lateral and feeder roots and mycorrhizae must be considered from seed sowing through seedling harvest and field planting. Nurserymen, field foresters, reclamation specialists, and tree planters must remain aware of the two biological components—the tree seedling and its complement of mycorrhizal fungi.

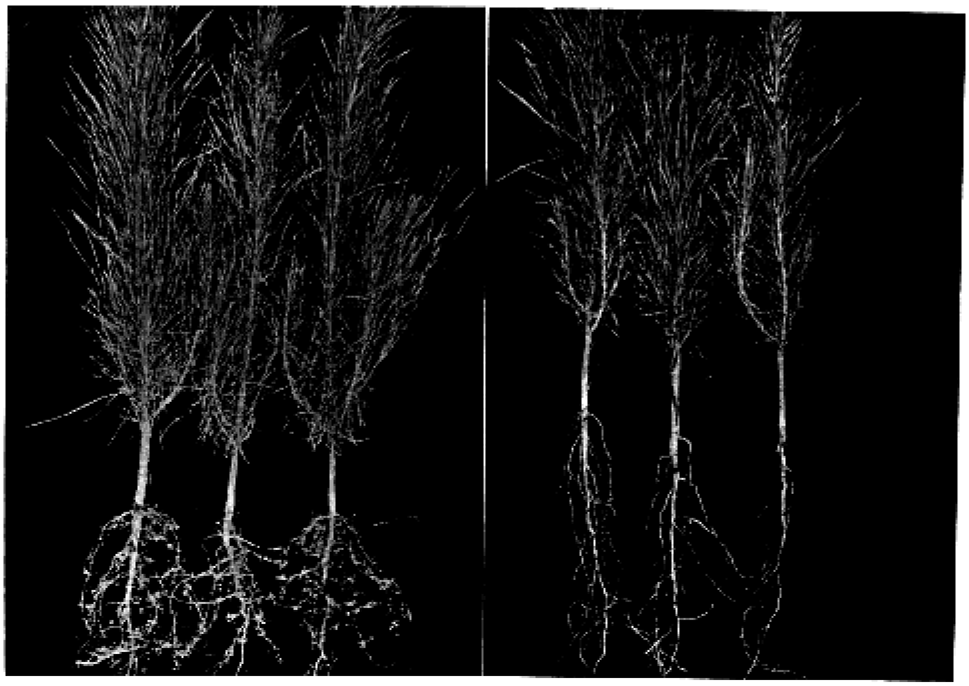

Figure 1. 1-0 loblolly pine seedlings with Pt ectomycorrhizae (left) and with only naturally occurring ectomycorrhizal fungi (right).

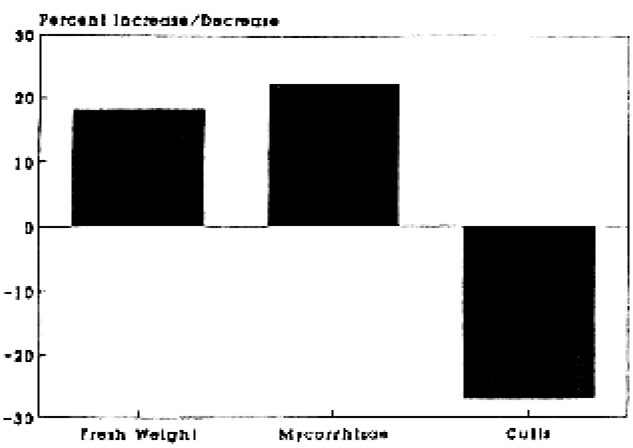

Figure 2. Effects of Pt inoculation with vegetative inoculum on seedling fresh weight, ectomycorrhizal development, and nursery cull reduction in 34 bareroot nursery studies.

Figure 3. Applicator for mycorrhizal fungus inoculations in bare-root nurseries.

Mycorrhizal fungi generally have similar moisture, fertility, and pH requirements as their host plants, but tolerance to extreme or adverse conditions varies among fungus species. Nursery soil and cultural factors that significantly affect mycorrhizal development include pH, drainage and moisture, fertility, fumigation, pesticides, cover crops, shading, seedling spacing and density, and root pruning. Soil and water pH values and water quality are three of the most limiting factors affecting the development of mycorrhizae in most bare-root and container nurseries. Soil fertility and irrigation should be based on the requirements of the seedling. Excessively high levels of phosphorus and nitrogen (particularly in VAM inoculations) along with excessive irrigation (particularly in containers and poorly drained seedbeds) should be avoided. Certain pesticides are particularly detrimental to specific ectomycorrhizae such as Pt, and they must not be used in conjunction with inoculations. Precautions also are warranted when using artificial shade on seedbeds or in greenhouses. Minimum threshold light quantities are required for adequate photosynthate production and subsequent mycorrhizal development. When day length is short, the amount of natural light in greenhouses is often inadequate and must be supplemented with artificial lighting. Proper seedling spacing and density along with custom-applied root pruning practices in bare-root nurseries contribute to high-quality seedlings with maximum lateral roots and mycorrhizae development. These traits are associated with desirable height and basal diameter characteristics (5).

Seedling harvesting, handling, storage, and planting practices also may have significant effects on the retention of lateral roots and mycorrhizae. Ectomycorrhizae are delicate structures and special care must be taken during all stages of seedling handling to retain the feeder root system and mycorrhizae. Feeder roots and their associated mycorrhizae can be ripped off and left behind in seedling beds during harvesting, desiccated in storage, or deliberately cut off prior to field planting. To maintain seedling quality, conventional nursery practices may require modification to minimize damage to feeder roots and mycorrhizae. Stripping of feeder roots has severe negative impacts on seedling field performance (16). During transfer of seedlings from the field to the packing room, and at all other times when seedlings are subject to direct environmental exposures such as wind and direct sunlight, special care is required to avoid drying of the feeder roots and mycorrhizae.

The seedling packing procedure and packing materials also may have significant effects on the ability of the seedling to endure storage, maintain root system quality, and survive field planting. Cold storage is vital to slow seedling respiration and maintain quality particularly for extended storage periods. Numerous studies have documented the effects of storage time on seedling quality. For most tree species and their associated mycorrhizae, proper storage for two to six weeks at 36EF is not detrimental (5).

Successful Mine land Reclamation

Seedlings with Pt ectomycorrhizae have been repeatedly used for successful reclamation of acid coal spoils, mineral mine wastes, kaolin wastes, borrow pits, and other disturbed sites throughout the United States and in several foreign countries. Positive field responses follow successful Pt nursery inoculations, use of suitable mine land reclamation techniques and procedures, and favorable mine land spoil and environmental factors.

Extensive reclamation research has been conducted on custom-grown seedlings with Pt ectomycorrhizae on disturbed and adverse sites of various types in the eastern United States. In 1966, Shramm made the initial observations and report of the widespread association of Pt with pines growing naturally on harsh mine land coal spoils in Pennsylvania (20). Reviews by Marx (11) and Cordell *et al*. (4) discussed improvements in survival and growth of seedlings with ectomycorrhizae on these sites. Maximum benefits were obtained on the coal spoils having higher temperatures, lower pH, and greater moisture stress.

Foliar analyses of seedlings with Pt ectomycorrhizae from mined sites show increases in macronutrients and reduced levels of potentially toxic microelements. Marx and Artman (13) found significantly more N and less S, Fe, Mn, and Al in seedlings with Pt than those with natural ectomycorrhizae on acid coal spoils in Kentucky. On mine spoils in Tennessee and Alabama, Berry (1) measured significantly lower levels of Mn in needles of Pt seedlings than in needles of control seedlings.

Consequently, these and other field planting results strongly suggest the ability of Pt and other selected species of ecto and endomycorrhizal fungi to mediate adverse factors on mine land sites. Research has shown that root systems with abundant ecto or endomycorrhizae also are apparently more effective and efficient in extracting water and essential nutrients from soil during periods of extreme water stress than root systems with either fewer or less adaptable mycorrhizae. In southern Ohio, virginia, eastern white, and loblolly x pitch pines and northern red oak (*Quercus rubra L.*) seedlings with Pt ectomycorrhizae have exhibited significant increases in tree survival and reforestation success when compared with standard nursery seedlings (Table 1) (17).

Table 1. Tree survival and reforestation success following use of Pt pine and hardwood seedlings in 356 reforestation plantings on abandoned mine lands in southern Ohio, 1982 to 1998.

Seedling Treatment	Average Survival %	Planting Success %
Pt-inoculated	85	95+
Noninoculated [1/]	<50	<25

[1/] Reforestation planting efforts using standard nursery seedlings prior to the Pt program

The great diversity of mine land and other severely disturbed sites to planted seedlings with specific mycorrhizae have revealed a number of factors that influence the success or failure of reclamation. Field results continue to demonstrate dramatic increases in survival and growth of MycorTree™ seedlings on sites with adverse pH (acid or alkaline), excessive levels of phytotoxic elements, prolonged moisture stress, high surface temperatures, and low nutrient availability. Exceptions may occur on severely compacted and/or high bulk density soils where increased MycorTree™ survival may be followed by a slowing of growth. Compacted and/or high bulk density soil conditions are most effectively mitigated by subsoiling or deep ripping prior to planting (2). Some ectomycorrhizal fungi, such as Pt, develop well and provide significant tree survival and growth benefits on porous, course, droughty sites but reduced benefits on poorly drained high bulk density soils.

Case Studies

Ohio Abandoned mine land Reforestation Program. One of the best examples of the practical application of this fungal technology is in Ohio. After reviewing the successful results of the field research and demonstration program, the Ohio Division of Mine Land Reclamation established the following criteria in 1982 for the use of tree seedlings with Pt ectomycorrhizae in their abandoned mined land reforestation program (3):

1. The strip-mined sites, gob piles, or industrial mineral sites must have been abandoned since 1972, with no present potential for full-scale reclamation.
2. The sites must presently be barren, eroded, and without adequate stabilizing vegetation.
3. The remaining potential of the site is nonexistent with no full-scale reclamation efforts (grading, topsoiling, fertilizing, and seeding) either proposed or likely to occur on the site.
4. The target sites also must have a history of off-site damage such as sedimentation that has resulted from the site's present condition.

During the past 18 years, the goals and priorities of the Ohio reforestation program have evolved into planting Pt pine and hardwood seedlings to provide a low-cost, low-maintenance, effective reclamation alternative for mined areas that contribute minor quantities of sediment to streams, degrade aesthetics, lack adequate ground cover, and are not eligible for traditional reclamation techniques under federal abandoned mine land guidelines (3). Reclamation plans also must be developed far enough in advance (one to two years) to allow adequate time for seedling production and for administrative planning and decision making.

Since its inception in 1982, the Ohio Abandoned Mine lands Reforestation Program has planted over 5 million PT-inoculated pine and oak seedlings on over 3,000 acres of unreclaimed AML sites (Figure 4). The typical site is barren, eroded with a mixture of bench slopes and out slopes of 2:1 or steeper terrain. Over 95% out of 350 plus sites have been hand-planted by local contractors. The sites also are highly acidic (pH 2.9-3.4), and no soil amendments (ie., lime, fertilizer, or water irrigation) are used. Tree survival has averaged over 85 % in the PT-inoculated tree plantings with less than 5% tree failures as compared with less than 50% survival and over 75% failures in previous plantings with the same noninoculated tree species (17). From 1982 to 1998, the Ohio AML reforestation project with PT-inoculated trees has cost approximately $900,000 or $300/acre. In 1998, approximately 340,000 PT-inoculated seedlings were planted on 242 acres at a cost of $195,000 or $805.00/acre. This represents an approximate 87% cost reduction as compared with conventional mine land reclamation methods ($6,000/acre). The Pt seedling inoculation cost is only $35.00/acre ($.02/seedling) or about 4% of the reforestation cost, which is relatively minute when compared to the consistent tree survival and early growth benefits obtained on these highly disturbed stressful sites.

Utah Copper Mine Site. This Utah copper mine has been active for over 100 years and has disrupted more than 20,000 acres of land. The disturbed areas have extensive erosion, sedimentation of drainages, dust hazards, and little or no satisfactory vegetation. The waste dump slopes are 1.5H:1.0V or steeper with highly acidic conditions. There also are numerous borrow areas with gravelly conditions and several large areas of mill tailings. There is little suitable topsoil readily available and subsoils range from poor to unsuitable quality. This high altitude mining site has low precipitation with freezing winter and hot summer temperatures.

Figure 4. Abandoned mine land (AML) Paxton Site – Perry Co., Ohio, Preplant- 1985 (top photo) and reforested with eastern white and virginia pines – 1991 (bottom photo). The spoil pH is 2.8 with available phosphorus at less than 5 ppm. Tree measurements in 1992 showed a survival of 98%, average basal diameter of 2 inches and average height of 9.5 feet.

The primary reclamation objectives on the mine waste dumps were to mitigate the production of acidic water, stabilize the dumps, mitigate soil erosion and dust, establish vegetation, and return the dumps to wildlife habitat use. The reclamation objectives for the borrow and mill tailings areas were to establish vegetation, eliminate dust hazards, mitigate soil erosion, and return the land to beneficial use (17).

The PHC-Reclamation, Inc. approach to revegetation of this mining area was to use the natural systems solution. It involved the selection of site-suitable plant species based on results from initial test plots. The best combination of site, plant species, and specific mycorrhizal fungi were identified and used in conjunction with other my-corrhizal fungi to provide suitable survival and growth benefits to tree and shrub seedlings and to grasses, forbs, and shrubs started from seed on site. Biosolids were used as a soil amendment to improve the initial adverse physical, chemical, and plant nutrient problems of some of the low quality soils (14).

Unique reclamation equipment for VAM fungal inoculation, seeding, and erosion mitigation also was developed. VAM fungal spores and beneficial bacteria in pelletized form were developed for easy and controlled field inoculation.

A container-grown tree and shrub seedling production program was established in a local tree nursery that included protocols for custom inoculation of trees and shrubs with specific ectomycorrhizal or VAM fungi and bacteria. The ectomycorrhizal fungi included Pt and a similar puffball-producing fungus, *Scleroderma cepa*, isolated from an eastern coal mined site. The VAM fungi included a species isolated from sagebrush growing on undisturbed native soil near the mine site and, also, a “cocktail” of several selected VAM fungal species isolated from other plant species in different physiographic locations.

The results have been very positive. The client's objectives have been met and compliance has been achieved with regulatory agencies. Several thousand custom seedlings have been grown in the nursery and planted on the reclaimed areas. Survival and growth rates of preinoculated trees and shrub seedlings and the grasses, flowers, and shrubs inoculated at seeding, are significantly better than the noninoculated plants.

By using the natural PHC Reclamation, Inc. biological approach to solve their revegetation problems, the client has experienced a reduction in costs ranging from 40 to 80 percent depending on the type of area being reclaimed. Savings in both short-term project reclamation work and long-term maintenance are included. Typically, reclamation and revegetation establishment costs, minus recontouring, were reduced from a range of $8,000 to $13,000 per acre to less than $1,000 (without soil placement) to $5,000 per acre (with soil placement).

Conclusions

Consistent research and field demonstration results obtained during the past two decades clearly demonstrate the benefits of utilizing selected ecto and endomycorrhizal fungi for the custom production and/or field inoculation of MycorTree™ seedlings, native shrubs, forbs, flowers, and grasses for application in mine land reclamation programs. Reforestation with selected MycorTree™ pine and hardwood seedlings is presently receiving widespread interest as a viable alternative in abandoned mine land reclamation programs in the eastern United States. Positive results have been obtained from the environmental extremes occurring in the moist East to the arid West of the United States. Major scientific breakthroughs in recent years have led to the commercial production of a variety of MycorTree™ products and their practical application in tree seedling nurseries, forestation, and mine land reclamation sites. Advanced technology discoveries also have revealed the role of a “total intergrated package” in successful mine land reclamation programs. The package includes consideration of site factors such as pH, toxicity, and compaction. Adopting remediation practices such as subsoiling and soil amendments, using of unique reclamation site seeding/inoculating equipment, and selecting the most compatible plant species and mycorrhizal fungi for the planting site are combined in a holistic approach to effective practical mine land reclamation.

This “natural systems environmentally friendly approach” to successful mine land revegetation is available through a team of scientific and business experts offered by PHC Reclamation, Inc. Reclamation costs vary considerably depending on the products and services requested by the client and the location and complexity of the mine site.

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KENTUCKY REFORESTATION CASE STUDY

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Introduction

Achieving a postmining land use of forest land is possible under the accepted interpretation of Public Law 95-87. However, as a forester, site index, tree quality, and species composition will be significantly different than the forest that originally occupied a mining site or what was attainable on ungraded or limited graded sites. What we have come to accept as forest land is a shrubby conglomerate of good surviving species with little or no foreseeable economic value.

Historically speaking it was obvious to operators that tree failures, which began with grading and revegetation requirements in the mid 1960s, combined with the great success of grass and legume systems in the 1970s, all spelled the demise of tree planting with the inception of Public Law 95-87. Revegetation to stop erosion on long compacted slopes was the primary concern.

While most operators in western Kentucky began wholesale use of the pasture/hayland postmining land use, Peabody Coal Company made a concerted effort to retain the forest land use. Nearly all the “tail-gate” research I am about to discuss was done on Peabody Coal Company lands. Together with my colleague, Brent Gray of Peabody Coal, we have tried and are still trying different methods to produce a productive forest.

History of Reforestation Efforts

Beginning in 1977 and later in 1980 when I joined Brent, the most compelling puzzle was the stark differences between the old nongraded sites and the current law. The old sites contained vigorous stands of quality hardwoods and pine. Post grading sites were characterized by stunted, irregularly stocked areas of autumn olive, black locust, black alder, bicolor lespedeza, and others. Higher quality species disappeared or existed only as resprouts. Although we were aware of the concern over grass competition and compaction, many of the areas we inherited were already seeded to tall fescue and alfalfa. Initially, site preparation was of less concern than planting stock quality and planting care. We were certain that if we addressed these issues, we could recreate the impressive stands on prelaw sites. We also expanded the species composition to include many oaks and other commercial hardwoods. Strict guidelines were imposed on our stockmen and tree planters. We also had an outside planting contractor come in so we could compare his work with our normal crews. As a rule, most trees were surviving very well through the spring and early summer. By the end of the summer, stocking rates were dropping drastically.

In the early 1980s, tree planting was on a relatively small scale (about 250,000 trees per season). It was generally accepted that a site would have to be replanted two to three times before stocking rates would be high enough for possible bond release. As tree acres increased in the 1980s (1.4 million trees in 1987), it became quite costly to keep replanting. In an effort to determine when trees were dying and what was causing mortality, we set up inventory plots at several mine sites in 1990. Plots were inventoried monthly. The results showed that we were losing most of our seedlings in August when our normal drought occurs. This was true not only of first year trees, but also for second and third year trees. By late winter rodents also were girdling surviving trees.

Seeing that our “quality” tree efforts were producing only limited increases in seedling survival, we started experimenting with herbicide applications. We made use of a wide variety of both pre and postemergent herbicides to control herbaceous vegetation. We have had mixed success with herbicides: application is another added cost; caution has to be used as to application rates; and in-house modifications need to be made to develop a sprayer that works in a specific situation. For example, in our rolling hill situation, we were forced to eliminate multirow boom sprayers because of uneven application. We feel that herbicide application is an absolute must in western Kentucky regardless of what type of permanent ground cover is used. I should mention that we also tried scalping grass competition and had very poor results. I don't recommend scalping.

By the mid 1980s, we began to realize that compaction was a more serious problem than we anticipated. Our first ripping experiment was done at Gibraltar Mine in Muhlenberg County, Kentucky. A thirteen-acre site was selected. In 1983 the site was revegetated to a tree compatible ground cover, strip sprayed, and ripped with a single shank ripper to a depth of 12" to 18". The site was hand-planted with high quality 3' to 4' bare-rooted seedlings from International Paper. This area developed into our best example of post-SMCRA tree planting. However, a similar site less than a quarter mile away was totally devastated by voles. We are finding that single shank ripping creates a vole tunnel. We now use multishanked rippers that shatter a three-foot wide zone. We feel that the lateral loosening of the soil greatly benefits tree growth.

We don't know how long the ripping effect will last. We may be only widening the problem we observed with single shank ripping. We excavated thirteen-year-old trees in our Gibraltar study and found the root system following the ripper crevice much like a phone cable. We are concerned about the stability of the trees.

This is a rather simplified discussion on the depth of our ripping experiments. Use of large dozers/tractors pulling large multishanked rippers are costly to operate, pull up many rocks, and require a very large capital investment. Although we haven't done any serious comparisons of row ripping versus block ripping over a period of time, block ripping may be more beneficial to a site. It is our opinion that ripping not only increases survival but greatly increases initial growth.

Over the years we have changed our permanent ground cover species to be more tree friendly. The particular mixes are not important. There are publications full of the perfect mix. What we have found is that on a typical site in western Kentucky, any grass legume ground cover is detrimental to tree survival. We feel that herbicides are critical in the reduction of ground cover. Permanent ground cover is not only physically competitive to trees but it is a natural habitat for voles. Voles have devastated hundreds of acres of our tree planting. To get a better understanding of how many voles were actually on our sites we set up three vole traps at Ken Mine in Ohio County, Kentucky, and checked them regularly for thirteen months. A trap consists of two fifty-foot long pieces of three-foot metal flashing arranged in a cross pattern. A five-gallon bucket is set at ground level at the end of the pieces of flashing. We captured eighty-five voles and forty-one white-footed mice.

In an effort to delay the establishment of permanent ground cover to see what influences this had on tree survival, we selected an area at Alston Mine in Ohio County, Kentucky. The area was roughly two hundred acres in size. A sorghum sudan grass cover crop was seeded on the area in the spring of 1988. The cover crop was allowed to winterkill. Trees were planted in the spring of 1989. After planting the site was aerially seeded. The planting was generally a success, however, voles damaged some sections and spot replanting was done in 1990. Although this method produced a successful planting, rodent damage is a tremendous problem and is as important a factor as compaction and grass/legume competition.

Stocking Rates

The original stocking rates that we had to deal with was 450 trees an acre for forest land. This was a crucial problem early on with operators shifting away from forest land postmining land use. After countless discussions with state and federal regulators, it still took nearly fifteen years for someone to realize this stocking level was way above timber industry standards. The stocking levels in Kentucky have dropped to 300 trees per acre, but I don't know if it will have any effect at this time.

Species Selection

We have tried dozens of various species over the years. Our main objective was to try to find hard mast (oak) and pine that would survive. We gave up a long time ago on species such as black walnut, yellow poplar, and northern red oak. Pines are continuing to be a problem.

We have determined over the years for our situation that willow oak and bur oak have the best survival of all the oak species that we have tried. Green ash will survive; however, it rarely becomes a tree of good form. Sycamore, autumn olive, and silky dogwood are still the main stays and show the best survival. Virginia and loblolly pine have very spotty survival.

Direct Seeding

In conjunction with Jim Powell, the first experiments we started were direct seeding of tree species in an effort to stave off tree planting and be able to get a better species selection as well as extending our planting window. We established an extensive plot area of both large mast and light seeded species at Sinclair Mine in Muhlenberg County, Kentucky. These areas used various grass species ground covers as well as no vegetation. The success rate was so low that we abandoned the plots. The experiment was replicated at Gibraltar Mine in Muhlenberg County, Kentucky with the same results.

We gave chestnut oak and bur oak some more attention a few years later in our reforestation planting and have had mixed results. One year the tree crews direct seeded 10,000 pounds of chestnut oak alone. We also had some success hydroseeding eastern red cedar on final impoundment slopes. It is our conclusion that direct seeding has a very limited niche in the climate, soils, and ground cover requirements of western Kentucky and should not be used as the primary method of reforestation.

Topsoil vs. Spoil

It is fairly obvious that even very acid spoils in Western Kentucky will support good tree growth if left uncompacted. But, in 1990, we felt compelled to set up a side by side comparison of graded spoil versus graded spoil with six inches of replaced topsoil. The area had been in woodland before mining and is located at Ken Mine in Ohio County, Kentucky. Both the spoil and the topsoil were slightly acid and fairly normal. The areas were revegetated with the same grass/legume mix and were treated the same as far as discing, fertilizing, liming, etc. Loblolly and virginia pine as well as various hardwoods and shrubs were planted in subplots. Planting was done on a 4 X 4 spacing or 2,722 trees per acre. The entire eight-acre experimental area was planted by a crew of three experienced planters and a great deal of care was taken to keep the seedlings in good condition.

The results were inconclusive. Neither treatment was clearly superior for tree establishment. It can be assumed that replacing what was considered topsoil in this area was much more costly than no replacement. The most puzzling problem from this experiment was the continued mortality for the planted trees and shrubs.

Hoedad vs. Dibble Bar

There has been much discussion that the hoedad is an inferior tool for tree planting. Most contract planters use the hoedad because of the speed of planting. Traditionally our in-house crews have and still use the dibble bar.

We set up an experiment in at Ken Mine in Ohio County, Kentucky in 1997 on a site that had a topsoil variance. The experiment consisted of comparing hoedad, dibble bar, and shovel planting. The area was strip sprayed and every other row was ripped with a multi-shanked ripper. Virginia pine, bur oak, and sawtooth oak were used in the experiment. No root pruning was allowed. Results showed that the hoedad planting was more successful than the dibble bar or shovel for the first year of survival. The ripped rows were far more successful than the unripped rows for each of the planting tools. From our experience and from examining sites in other states, we feel that unsupervised contractors combined with heavy root pruning may be more detrimental than the type of planting tool used.

Tree Spade

In the early 1980s, we had access to a forty-four inch Vermeer tree spade. We set up some experimental areas to see if we could get large trees to act as bird roosts and possibly encourage natural regeneration. Also we hoped that these trees would be close to seed production age. This experiment was extremely expensive and was soon abandoned. The trees we planted survived but growth had been retarded.

Tree Source

Over the years we have tried seedlings from a broad spectrum of nurseries. Pine survival is a serious problem for us. In our experience we have found a slightly higher survival for container pine versus bare root pine. We also have noticed that bare-root seedlings from the major timber companies have a slight to moderate increased survival and growth rate over state nursery trees.

Conclusion

After 20 years, over 17 million trees, and millions of dollars, it is our conclusion that soil or spoil compaction due to the current interpretation of grading in western Kentucky is by far the most detrimental problem in developing a healthy, profitable forest land postmining land use for future generations to enjoy. We can only hope that we can now reproduce the forests that we have enjoyed that were planted in the 1940s to 1960s.

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FOREST PRODUCTIVITY OF RECLAIMED MINED LAND: A LANDOWNER'S PERSPECTIVE

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Introduction

Since 1977, Public Law 95-87 drastically altered surface mining and reclamation practices. One important aspect of this law is the attention that it gives to future land use opportunities of reclaimed land. The intent of the law is to ensure that surface mined land is reclaimed to a condition capable of supporting a productive land use. As a result, coal companies must specify a postmining land use for which the land will be reclaimed. Furthermore, productivity standards were established for various land uses and coal companies must post a performance bond that can only be returned if the performance criteria for the specified land uses are achieved. Theoretically, re-claimed sites which satisfy bond release criteria after five years and have been successfully reclaimed are capable of being used for the intended postmining land use.

In the central Appalachian region of Kentucky, West Virginia, and Virginia, where prime farmland and economic development opportunities for mined land are scarce, the most practical land-use choices are hayland/pasture, wildlife habitat, or forest land. Since 1977, most of the mountainous mined land in Kentucky, Virginia, and West Virginia has been reclaimed as hayland/pasture or wildlife habitat, which is less expensive to reclaim than forest land since there are no tree planting costs. This method of reclamation has been encouraged by many land holding companies to help their coal lessees meet the requirements of regulations in the reclamation laws and at the same time keep the mining companies from absorbing extra reclamation costs. This has resulted in many acres of land producing grass, shrubs, and legumes, but few trees.

Forestry is the most logical and economical land use for large tracts of reclaimed land in the Appalachians. Most of this land was forested before mining and, whether by design or through natural succession, this land will ulti-mately return to a forested condition. The author of this paper is involved in forest management for Pocahontas Land Corporation (PLC), a large landholding company, which owns thousands of acres of surface mined land. Pocahontas would like to manage its reclaimed mined land for commercial forests, where it is economically fea-sible to do so. Timber production is often the only economically feasible land use for large tracts of steep and remote mined land. Furthermore, the economic returns on productive forest land can be very good; however, the key term is **"productive forest land."** Unfortunately, in recent years, as landowner interest in managed forest land has increased, it has become increasingly apparent that current reclamation and regulatory practices limit the creation of productive forest land.

Each year numerous photographs of award winning reclamation projects are published in various trade magazines. In all cases, these photos depict smoothly contoured surfaces with lush ground cover. For landowners with a long-term interest in timber production, these award winning reclamation projects represent lost opportunities. The presence of the tall and lush vegetation indicates that no trees are present and probably will not be established until several years after bond release. If trees have been established, they will be severely impacted by thick ground cover competing for sunlight, nutrients, and moisture. For each year the site is used to grow forage species, an additional year will be required if the site is converted to a commercial forest. The smoothly contoured surfaces of award winning reclamation projects indicate compacted surface soils that are not capable of supporting good tree growth once trees are established. The combination of delayed tree establishment and reduced growth rates will drastically reduce landowners' opportunities to derive future economic benefits from reclaimed mined land. From the landowner's perspective, these award winning reclamation projects are areas where the long-term land use opportunities are sacrificed for immediate cosmetic enhancement, but landowners simply have not had a practical and workable alternative. It is very difficult to require mine operators to employ a postmine land use that would add costs to reclamation operations and increase risk of not obtaining bond release within the specified five-year period.

In 1986, Pocahontas Land Corporation began a cooperative research project with Virginia Tech to examine some of the problems associated with tree establishment on reclaimed surface mine lands, including compaction. The results of this study showed that good tree growth could be attained by creating a “quality” site prior to tree planting. A set of guidelines was developed that coal companies could follow to establish more productive forests, and at the same time create adequate ground cover to satisfy current reclamation laws. With this information Pocahontas has encouraged its coal lessees to apply for forest land as the postmine land use when possible.

Case Studies

The purpose of this paper is to bring your attention to the impact surface mine reclamation has on site productivity and returns on investment. The data used in the case studies is based on two research projects conducted on lands of PLC. The first study contrasts the impact of site productivity and management decisions on the economic returns and timber production. The first scenario represents a common situation in the central Appalachians; land is reclaimed as hayland/pasture or wildlife habitat, and the landowner decides to plant trees after release of the reclamation bonds. Trees grow poorly as a result of compaction and harvest value is low. Some trees are lost to the competing ground cover in the year after planting. In the second scenario, the postmining land use is forest land and the coal company specifically reclaims the land to maximize forest productivity. Although this type of reclamation is not widespread, it is feasible.

A second study, established in eastern Kentucky in 1990, shows that forest productivity and landowner’s return on investment was maximized by selecting an oxidized sandstone spoil, avoiding compaction by eliminating the “tracking in” procedure, and using a tree-compatible ground cover to control erosion while allowing seedling establishment. In this study, site productivity, tree growth, and value are compared using three degrees of soil compaction, all other factors being equal.

Assumptions for each of the reclamation scenarios with respect to tree planting, grading costs, forest productivity, timber yields, and harvest values are as follows:

Case 1
Hayland/Pasture Reclamation Scenario

- Land is reclaimed as hayland pasture in year 1 and bond is released in year 5.
- After bond release, landowner plants 454 white pines at year 5 on an 8' x 12' spacing at a cost of $0.30/seedling ($136.20/a)
- Site index of the land is 60; compaction caused by intensive grading practices during reclamation limits productivity, only product produced is pulpwood.
- 65 percent reach harvest (295 trees)

Pulpwood

- After 30 years, trees have been growing for 25 years.
- At year 30, there will be an estimated tons/a of pulpwood.
- The stumpage price will be $2.00/ton; the average diameter of the trees will be 8 inches and average weight will be 0.125 tons giving the stand a weight of 36.9 tons/a; these trees can only be used for pulpwood, mine props, or other low value products.
- The timber harvest value will be 36.9 tons/a x $2.00/ton = **$73.80/a**.
- Land management cost and land tax cost the landowner $1.50/a annually.
- Rate of return to the landowner = **Negative 4.11 Percent**.

Forest Land Reclamation Scenario

Pulpwood

- Land is reclaimed as forest land in year 1 and bond is released in year 5.
- As part of the commercial woodland postmine land use, the coal company plants 454 white pines per acre at year 1 at a cost of $0.30/seedling ($136.20/a)
- Site index of the land is 100; the coal company is careful to avoid compaction; minimal grading on level areas, short slopes, and gentle slopes; "tracking in" before seeding is eliminated on all but steepest slopes, and with low growing groundcover, seedling survival has increased to 90 percent.
- Reduced grading costs saves coal company $225/a (3 hrs. of D-7 @ $75/hr.) which more than offsets the cost of planting trees.
- At year 17 the pines are thinned and pulpwood is removed leaving half the trees with a spacing of 12' x 16' with 202 left to grow into saw timber, pulpwood harvest generates .08/tree or 16.2 tons/a.
- Income generated at age 17 is 16.2 tons x $2.00/a = **$32.40/a**.

Saw Timber

- At year 30, trees have been growing for 30 years, and 203 trees will be harvested as small saw timber having a diameter of 14 inches and a volume of 50 board feet Doyle Scale.
- There will be 10,150 board feet of merchantable timber.
- The stumpage price will be $50/MBF; and the harvest value will be 10.15 MBF/a x $50/MBF = **$507.50/a**.

Pulpwood

- At year 30, there will be 37.56 tons/a of additional pulpwood harvested from topwood.
- The stumpage price will be $2.00/ton.
- Pulpwood value will be 37.56 tons/a x $2/ton = $75.12/a.
- Total value at harvest will be $507.50/a + 75.12/a = $582.62/a.
- The total income from this property for the 30 years was $615.02; costs associated with owning the land were $1.50/a for management and land tax.
- The rate of return for the landowner for this investment was **16.08 percent**. (See Table 1.)
- The coal company's cost of planting trees ($136.20/a) is offset by the savings resulting from less grading ($225/a); the net **savings to the coal company is $88.80/a**.

Case 2

In our second study, the effect that compaction, spoil type, and groundcover had on rates of return of yellow poplar was investigated. Yellow poplar was targeted because it is a relatively fast growing species like white pine, and the saw timber is worth twice as much to the landowner at harvest time. (See Table 2.)

Site index 60

- Heavily tracked site yields only pulpwood at harvest time; survival rate is 50 percent.
- As part of the commercial woodland postmine land use, the coal company plants 454 white pines per acre at year 1 at a cost of $0.40/seedling ($181.60/a).
- At year 30, 227 trees/a are harvested yielding an average of 64.24 tons/a for a value of $128.48/a.
- Taxes and management costs are $1.50 annually. Pulpwood price is $2/ ton. Yellow poplar saw timber price is $115/MBF.
- **The rate of return for site index 60 is a negative 2.20 percent**.

Site index 80

- Moderately tracked site yields pulpwood at a thinning in year 20, and saw timber and pulpwood in year 30;

survival rate is 80 percent.

- The coal company plants 454 trees for a cost of $181.60/a. Taxes and management costs are $1.50 annually.
- At year 20, 182 trees/a are harvested in a thinning operation yielding an average of 22.75 tons/a for a value of $45.50/a.
- At year 30, 181 trees/a are harvested for saw timber, and the topwood is sold as pulpwood. Yellow poplar saw timber averages 13"dbh and yields 65 board feet Doyle Scale for a total saw timber yield of 11,765 board feet/a for a value of $1,352.97/a. Pulpwood yield is 22.62 tons/a for a value of $45.24/a.
- **Total revenue generated for site index 80 is $1,443.72. Rate of return is 7.14 percent**.

Site index 100

- Minimal compaction yields pulpwood at a thinning in year 17, and saw timber and pulpwood harvest in year 30; survival rate is 90 percent.
- The coal company plants 454 trees for a cost of $181.60/a. Taxes and management costs are $1.50 annually.
- At year 17, 288 trees/a are harvested in a thinning operation yielding an average of 36 tons/a for a value of $72/a.
- At year 30, 166 trees/a are harvested for saw timber, and the topwood is sold as pulpwood. Yellow poplar saw timber averages 16"dbh and yields 140 board feet Doyle Scale for a total saw timber yield of 23,240 board feet/a for a value of $2,672.60/a. Pulpwood yield is 29.05 tons/a for a value of $58.10/a.
- **Total revenue generated for site index 100 is $2,802.70. Rate of return is 9.8 percent**.

An additional comparison was made showing the effects soil compaction mediation has on site quality and return on investment. By ripping up a compacted site an additional cost of $155/a is incurred to the landowner. A good site is created after ripping the ground, but the cost reduces the landowners rate of return to **7.52 percent.** If the site was created properly at the time of soil placement, the return on investment would have been **9.8 percent,** and if the coal operator and landowner were sharing the cost of tree establishment the rate of return could have been **12.34 percent.** (See Table 3.)

Advantages to Landowners

These scenarios are plausible representations of typical and potential reclamation practices. Although specific cost and revenue values will vary from case to case, the relative comparison will remain valid. The timber yield and harvest value will always be greater when land is carefully reclaimed to maximize forestry land-use opportunities. When site productivity is damaged by compaction (as indicated in the hayland/pasture scenario), long-term tree growth may not be sufficient to justify the cost of tree planting. Under these conditions, the land is essentially useless to the landowner; taxes and management costs will have to be paid on the land even though timber cannot be profitably grown, and other land-use opportunities are limited. In most cases, the landowner will have trouble selling the land since there is little demand for large tracts of isolated, unproductive tracts.

Advantages to Coal Companies

This paper deals with the situation where the landowner and coal company are separate entities. Although this paper concentrates on the advantages of forest land reclamation to the landowner, the author recognizes that coal companies cannot be expected to incur additional reclamation costs to maximize future economic opportunities for the landowner. Fortunately, coal companies can save money by using reclamation practices that will maximize forest productivity. The cost of planting trees will be offset by savings associated with reduced grading and the use of a tree compatible ground cover. In many cases, coal companies will be able to achieve bond release with forest land more quickly than other postmining land use plans. Experience has shown that careful planting in a loose, uncompacted mine soil in the absence of dense herbaceous vegetation will result in good tree establishment and rapid growth, which will result in release of reclamation bonds in five years. Often, bond release is delayed on grass and legumes type reclamation and the coal company incurs additional costs for gully repair and reseeding. Even when forage production is adequate to satisfy bond release requirements for hayland/pasture, the process of documenting productivity via biomass sampling can be more expensive than documenting ground cover and tree stocking levels for bond release on forest land.

Advantages for Environment

A fundamental purpose of PL 95-87 is to provide environmental protection. Some reclamation inspectors have argued that attempts to increase forest productivity by reducing grading activities and using less competitive ground covers will result in more erosion and environmental degradation. To the contrary, long-term environmental protection will be enhanced by practices which promote the development of a healthy forest ecosystem. The root system of a fully stocked, healthy forest will stabilize slopes. The litter layer which develops beneath the closed canopy of a healthy forest increases water infiltration into the soil and reduces soil erodibility to virtually zero. Regional biodiversity in the central Appalachians can be increased by establishing a mix of coniferous and hardwood species since this region is typically dominated by deciduous species such as oak, hickory, red maple, and yellow poplar. In some parts of the Appalachians the establishment of pine forests will increase wildlife populations by providing a much needed source of visual and thermal cover for winter protection, while the oaks and hickories will provide hard mast.

Conclusion

The author of this paper is involved in forest management for a company with vast landholdings in the central Appalachian coal fields. This landowner believes that long-term forestry land-use opportunities of surface mined land are still being sacrificed for short-term cosmetic benefits. The reclamation community should recognize the long-term implications of reclamation practices and understand that reclamation must be land-use specific. Productive forests can be created at the time of reclamation which would benefit both the coal operator and landowner. Hopefully someday soon, landowners will economically harvest trees from surface mined lands that were once reclaimed to roughly graded, uncompacted mine spoil which greatly resembles the natural state of the land before mining as Public Law 95-87 intended.

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Session 5

INTEREST GROUP RECOMMENDATIONS TO ENHANCE REFORESTATION

Chairperson:
Sarah Donnelly
Office of Surface Mining
Washington, D.C.

Eastern States Recommendations
Mike Sponsler, Indiana Division of Reclamation, Jasonville, Indiana

Enhancement of Reforestation at Western Surface Coal Mines
Ronald Daniels, Utah Division of Oil, Gas, & Mining, Salt Lake City, Utah

Coal Industry Recommendations
David Finkenbinder, National Coal Association, Washington, D.C.

Field Inspector Recommendations
Vic Davis, Office of Surface Mining, Knoxville, Tennessee

Interest Group Recommendations to Enhance Reforestation: Academic Research
Dr. James Burger, Virginia Technical Institute and State University, Blacksburg, Virginia

Wildlife Recommendations
Steve Beam, Kentucky Department of Fish and Wildlife, Somerset, Kentucky

Ohio Division of Forestry
Jim Stafford, Ohio Division of Forestry, Zanesville, Ohio

Land Owner Recommendations
Timothy Probert, Pocahontas Land Co., Bluefield, West Virginia

Kentucky Wildlife Society
Robert M. Morton, Corydon, Kentucky

EASTERN STATES RECOMMENDATIONS

Mike Sponsler[1]
Indiana Division of Reclamation
Jasonville, Indiana

Background

I would like to back up and look at what we are trying to accomplish under SMCRA. Section 515 (b) (2) requires that we must " Restore the land effected to a condition capable of supporting the uses which it was capable of supporting prior to any mining." This means that land capability must be restored after mining. If you do that, then land use is irrelevant. If you have restored the land to the capability it had prior to mining, then you have the option to do what ever you want with it now or in the future. We do not know what the needs will be 100 years from now. If we restore the pre-mining capability as required by SMCRA, then everything else will take care of itself.

Implement the Existing Rules

Most of the problems that we have with reforestation are already solvable with the regulatory requirements that are on the books now. If compaction is a problem, then there is the authority and obligation in the rules to minimize compaction. If soils are the problem, then there is the authority and obligation in the rules to put back a suitable soil material. If ground cover is the problem, then there are certain ground covers that the regulatory authority has the authority to not allow. For example, the state of Illinois does not allow the planting of tall fescue in forested areas. Indiana is similar in this way. If there are ground covers that are not compatible with trees then don't approve permits that propose such revegetation plans. Implement the rules that we have.

Concerning land uses, we are required to restore the same balance of land uses we had prior to mining. If forestry was a substantial part of the premining land use, then we should come very close to reestablishing the same proportions of land use after mining. In Indiana, our policy is that you need to reestablish about 80 percent of the premining land uses that had trees. In Indiana, if you need to reestablish wildlife habitat then we consider forests good wildlife habitat.

Concerning soils, if you have not restored the soils, then you do not have good reclamation. Soil and water are the two most fundamental resources that we have in reclamation. There are some that suggest that in order to expand the forest resource we must destroy the soil resource. That is absurd. The forest resource depends upon the soil resource.

We are all responsible for why trees are not planted and why we are not getting adequate quality on forest land uses. As regulators we have control over implementation and interpretation of the rules. We need to implement them in a way that insures that quality forests are replaced. Industry needs to take a look at its operations and develop systems that will minimize compaction. The technology is there.

Research on prime farmland has resulted in ways to minimize compaction. The forestry people and the prime farmland people need to get together and share information. The technology to minimize compaction is available. If it means buying some end dump trucks then buy them. No one seems to mind the fact that it costs the industry a certain amount of money to reclaim the prime farmland but when it comes down the cost of planting trees, then we seem to have a big problem with expense. That is just a part of doing business since the implementation of SMCRA. People in academia and forestry need to realize that growing trees on ungraded spoil peaks has been illegal since the passage of SMCRA over 20 years ago. We need to move on with the regulations that we have rather than continually trying to turn back the clock.

The Importance of Measurement to Ensure Success

We need to change the target. We will get what we measure. We will achieve success in those areas that we require to be measured. It is true that we have been measuring stems per acre, but we have not been measuring productivity or growth because the operators have not been required to with the result that it has not been achieved. If we want tree growth, then we will have to start measuring it. This could be done either by direct measurements of tree growth or with some kind of soil test to establish the site index.

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[1] Mike Sponsler, Division Director, Indiana Department of Natural Resources, Division of Reclamation, Jasonville, Indiana. Mr. Sponsler holds a B.S. degree in biology from the Illinois Benedictine College and a M.S. degree in zoology (wildlife ecology) from Southern Illinois University, Carbondale. He is the leader of the Indiana DOR, a program that regulates the tenth largest coal producing state in the nation. Permitting activities process over 8,000 acres yearly as well as review over 1,000 permit applications. The Abandoned Mined Land Program receives $3 to 4 million annually and has performed over $70 million in mine reclamation remediation over the life of the program on over 200 sites. Previously he was assistant division supervisor from 1987 to1990 and a land reclamation specialist from 1979 to 1987 for the Illlinois Department of Mines and Minerals, Land Reclamation Division . He also has served as chairman of the Interagency Stream Restoration Committee.

ENHANCEMENT OF REFORESTATION AT WESTERN SURFACE COAL MINES

Ronald W. Daniels [1]
Utah Division of Oil, Gas, and Mining
Salt Lake City, Utah

Introduction

The topic of reforestation of mine sites has been needed for a long time. In my survey of interest groups in several western states, the first thing I found was that one needs to consider "Whether we want to enhance reforestation efforts in the western states?" We have slow growing trees, long harvest rotation ages, poor site conditions, and water problems. The main considerations are that we need to look at the: (1) management objectives for the land needing treatment; (2) legal constraints—whether one can meet the standards; and (3) ecosystem needs and possibilities, for example, in Utah do you want to establish woody plants over 12" tall on the windswept salt desert shrub ecosystem. Situations like this present some formidable challenges.

Survey of Western Interest Groups

The interest groups that I spoke with are varied. In many cases, there are not enough coal mines where trees grow. So it became necessary for me to inventory other groups with similar challenges and regulatory constrains. My inquiries on the subject included: (1) companies mining other minerals, i.e., base metals, phosphate, iron; (2) other mineral mining and oil and gas trade associations; (3) consulting foresters; (4) petroleum companies; (5) land developers; (6) our own agency staff; and (7) ecological consultants. My results are mixed and somewhat surprising. "Why bother" was the common answer of a certain audience. In 1977, when President Carter signed SMCRA in the rose garden, a group of us gathered to talk about and critique the then-proposed interim program regulations under SMCRA. There was not a lot of time spent talking about trees. It has since taken over 20 years to have the specific conference on reforestation related to surface coal mining that we are having today.

Underground coal mines, as a rule, need to stabilize the site first with a nurse crop for one to two years. They need a diverse mixture of grasses, shrubs, and forbs to address the two to four year period for stabilization of the soils. Irrigation may be needed for initial start-up. Typically, these underground mines in the West cover a small acre-age and provide excellent wildlife habitat in a sea of trees. They would recommend that we provide the regulatory latitude for reforestation but not require it. When using reforestation as the reclamation technique, use it as an augmented planting once stabilization is achieved.

Surface coal mines recommend that we stabilize the site first, work on species diversity, and use trees as a part of the long-range plan that implements certain portions of the management objectives, such as in: (1) riparian zones; (2) aesthetically constructed islands for habitat; (3) snow collection; (4) windbreaks; or (5) other areas where trees are required for the land use. They would recommend that we allow land use options that include trees.

Oil and gas development was in a very similar situation to underground coal mines. They have a relatively small acreage, usually five to ten acres for a short period of time.

For other mineral mining in the West, their recommendations were similar to those for surface coal mining: (1) stabilize the site first; (2) work on species diversity; and (3) use trees as a part of the long range plan that implements certain portions of the management objectives. In addition, they recommended that community involvement and appreciation in the projects are essential.

Conclusions

Where are we in enhancing reforestation on mine sites in the West? I am sure that we are not in the business of creating commercial forests through revegetation. Trees are not the exclusive solution to revegetation after drastic disturbance. There are some possibilities, however, where we can use trees: (1) for land management tools; (2) to play a role in habitat for wildlife; (3) for protection and shelter for some land uses; (4) for aesthetics and carbon dioxide sequestration; (5) in some commercial applications such as fiber production and christmas tree production; (6) for water collection and stream protection and cooling; (7) for creating recreational opportunities; and (8) for riparian ecosystem restoration.

Is there a need for more regulation? Where you sit is where you stand. My answer would be that we can enhance reforestation through the creation of opportunities for the use of trees as a part of a balanced revegetation plan for land uses compatible with past, present, and possible future land uses.

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[1] Ron Daniels is currently the Coordinator of Minerals Research at the Division of Oil, Gas, and Mining within the Utah Department of Natural Resources. In his 24-year tenure with the division he has worked as an inspector, field coordinator, and deputy and associate director. He helped to develop the Utah Coal Regulatory Primacy Program under the Surface Mining Control and Reclamation Act in the late 1970s and early 1980s after organizing the division's efforts under the first Utah Mined Land Reclamation law in 1975. Prior to working in mined land reclamation, Ron worked for four years in the Utah Division of State Lands and Forestry as a service forester and forest land use planner. He holds an Associate Degree in forest technology from The Pennsylvania State University, a B.S. in forest management from Utah State University, and a Masters Degree in public administration from The University of Utah.

COAL INDUSTRY RECOMMENDATIONS

David Finkenbinder[1]
National Coal Association
Washington, D.C.

Issues

First, we have the three “Cs”: competition, compaction, and cost. Dealing with the landowners and communicating with them concerning options for land uses are important issues. Erosion control, competition, and final grading to minimize compaction is an issue. We need to allow in the requirements for vegetation cover a greater percentage of litter and annual species. One of the greatest concerns to operators is final bond release.

How do we address these issues? My first response to the issue was to get out my pen and begin making recommendations for rule changes. I now feel that we have the technology, and the ability to get trees established is available in virtually all situations where tree planting is appropriate.

Priorities

Flexibility is an important part of the process and this needs to continue in discussions on this subject in the future. Now, I think that the first priority is training and education. This would include training for the regulatory authorities both state and federal, the field inspectors, industry staff, and landowners. We need to begin a dialog that would include the public in an educational process concerning choices for land use options. We do not need to be putting out trees and then have them chained in the West and mowed in the East following bond release. If we are going to plant trees, then let’s make sure that people want them.

Secondly, there needs to be agreement on what the regulations require. If one inspector has a mind-set that a 9 inch gully is bad on our tree planting site, then we are back to the beginning of the process. If we are going to develop new attitudes toward tree planting, then we may need to write a new policy so that everyone agrees on what is required. The industry needs consistency and certainty in terms of what is required of them.

Only after we have implemented these educational, training, and policy interpretation options and have given them a chance to work should we explore the possibility of regulatory change. If rules are to be changed then that change needs to go through a very thorough and open communication process so that people can be assured that any new rules will have the desired results.

The very last thing we want to consider is any change to SMCRA.

[1]David Finkenbinder, Director of Environmental Policy, National Mining Association, Washington, D.C. Since 1994, Finkenbinder has been with the National Mining Association. Previously he was senior council for reg-ulatory affairs and director of governmental affairs for AMAX Coal from 1980 to1992. He has served as a hearings commissioner for the Indiana Department of Natural Resources and Indiana State Attorney General. He has represented the Indiana Coal Association and Indiana Coal Council and served on the Board of Trustees for the Eastern Mine Law Foundation. He holds a B.S. and Juris Doctor from the University of Kansas.

FIELD INSPECTOR RECOMMENDATIONS

Vic Davis[1]
Office of Surface Mining
Knoxville, Tennessee

Introduction

I have yet to meet a person that does not like trees. It is gratifying to see that, after 20 years, we are now finally getting around to emphasizing tree planting. This discussion is unique in that there really does not seem to be much disagreement concerning the need to plant more trees more productively. At least in the East, many of the coal mine inspectors are foresters by training so we shouldn't need to convince them about planting more trees.

The Tennessee Federal Program

As far as where we need to go from here, in the federal program in Tennessee, we have established a team to examine the issues and write some policies relative to reforestation enhancement. We hope to have a final product for public review within the next 30 days. One issue that we are dealing with is the issue of steep slope mining. Most of our mining in Tennessee is contour mining on very steep slopes (2:1 and greater in slope) with very large highwalls. Our concern, with the desire to minimize compaction in order to improve tree growth in these areas, is "How will lower rates of compaction affect the slope stability or backfill settlement in these steep slope situations?" We have had many problems in the past where backfill settlement reexposed the highwall. The highwall then needs to be regraded. We will tear up a lot of tree seedlings in the process of regrading, and then potentially have to restart the revegetation liability period. We also are concerned about the potential for surface slumping and slides in the backfill.

Once we can develop a reforestation policy for Tennessee, then the hard work will begin. The complete package must include education of the people on the front line, like the inspectors, permittees, landowners, and equipment operators. We can not expect that by making changes in policy or permitting the information will be conveyed and understood by the equipment operators who must carry out these changes. This education must emphasize why we are making the changes as much as the nature of the changes themselves.

The Need for Education

I can not overemphasize the need for education. It should start at the state level and may have some application at the regional level. We need to bring this education down to the smallest unit possible.

Revision of the Federal Regulations

I do believe that most of the reforestation technologies being advocated here can be implemented without changing the federal regulations. The federal regulations do not establish specific success standards, tree stocking, or ground cover standards. The regulations allow for each state to consult with appropriate state forestry and wildlife agencies in order to establish state specific reforestation standards. They also provide that these standards can be established on a program-wide or permit-specific basis. In Tennessee, we are looking at the possibility of evaluating each permit in terms of its unique reforestation requirements. The regulations do not require any specific levels of compaction, nor do they prohibit the use of less competitive ground covers. In fact, the regulations actually discourages the use of introduced species, which in most cases are the highly aggressive species that cause problems with planting trees. The regulations, in fact, encourage the use of native species which are more compatible with planting trees.

From my perspective as an inspector and working in bond release for the last 15 years, I have become acutely aware of the problems you run into when you try to go out to a site and evaluate revegetation success. Within OSM we have been debating the issues for some time. Whether we should be using statistical analysis or some other form of evaluation. I have heard several references to creating more productive forests. I have had some com-ments from industry people that we not create any new productivity success standards that would make it even more difficult to obtain bond release on forest land uses. This would create even more economic pressure to dis-courage industry attempts to reestablish the forest land use. I do think we need to seriously consider the impact of creating a new forestry production success standard.

Revision of State Regulations

Through the workings of the reforestation forum steering committee, we did become aware that some of the state regulations do have established revegetation standards and requirements for stocking rates or depth and size of gullies that are creating problems with reforestation. The individual states may need to look at their regulations and see if they might want to consider some state regulatory changes.

AML Recommendations

In closing, I think the greatest impact that OSM could make would be in the AML program. There could be a tremendous impact to the number of trees planted on surface mined lands if (1) there is any way that OSM could make additional funds available through state program grants when they would agree to apply it to tree planting projects; and (2) we could make the lower priority 3 and 4 sites eligible for tree planting funding.

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[1] Victor M. Davis has a B.S. in forestry from the University of Tennessee. He has served for 20 years with the Office of Surface Mining in Kentucky, Virginia, and Tennessee. As a reclamation specialist, he performed mine inspection during initial and permanent programs; as a natural resource specialist, he worked with the AML State Program development grants; and as a reclamation review specialist, he served as bond release team leader for Tennessee federal programs.

INTEREST GROUP RECOMMENDATIONS TO ENHANCE REFORESTATION: ACADEMIC RESEARCH

James A. Burger[1]
Virginia Polytechnic Institute and State University
Blacksburg, Virginia

Introduction

The following are recommendations to enhance reforestation; these recommendations are based on long-term research and observations of operational reclamation since the implementation of the SMCRA. The problems and constraints are defined and described by Burger in Session 2 of the proceedings entitled *Academic Research Perspective on Experiences, Trends, Constraints, and Needs Related to Reforestation of Mined Land*. The research base and operational experience underpinning these recommendations are presented by Burger and Torbert in Session 3 of the proceedings entitled *Status of Reforestation Technology: The Appalachian Region*. The recommendations are listed, followed by a problem statement or constraints to reforestation and the actions needed to overcome the constraints. Following each action statement is a suggestion for education, research, rule enforcement, or a rule change.

Recommendation 1: Fully Account for All Forest Values

Problem: The value of forests for products and services is underestimated. A full accounting must be made.

Action 1: OSMRE should not allow forest land conversion to lower-value land uses, e.g., wildlife habitat, abandoned hayland/pasture. (Need: rule enforcement)

Action 2: Landowners should be informed of the potential value of forests for wood products, and the many other services forests provide. (Need: education)

Action 3: Forest banking methods should be tried to ensure that forests are restored to provide community-wide services, e.g., wildlife habitat, watershed control, water quality, biodiversity, carbon capture. (Need: research)

Recommendation 2: Revise Success Standards for Forestland; Base them Partly on Forest Productivity Potential.

Problem: The success standard for forestry in CFR30 is seriously flawed because it is based on stocking and ground cover only. As a result, forest land is being degraded.

Action 1: Forest productivity must be recognized like crop and forage productivity. (Need: education)

Action 2: CFR30 should include a forest productivity standard based on mine soil quality or site index. (Need: research)

Recommendation 3: Use Topsoils and Topsoil Substitutes Specific for Trees and Forestry.

Problem: Mine soil quality for trees is poorly understood by most people. Deep, uncompacted, sandy loam, slight to moderately acid soils, or substitutes are needed for tree survival and long-term productivity. Many reforestation failures are due to improper mine soils.

Action 1: Recognize differences in soil quality for trees vs. grasses. (Need: education)

Action 2: Current regulations requiring "substitutes suitable for vegetation" should be enforced. (Need: rule enforcement)

Recommendation 4: Minimize Grading to Reduce Mine Soil Compaction.

Problem: Mine soil compaction is a serious impediment to reforestation.

Action 1: Change the embedded notion within the mining community that all reclaimed land must be smooth, free of rocks, compacted, heavily fertilized, and covered with lush grasses and legumes before trees are planted. (Need: education)

Action 2: Grade to ensure stability, but leave surfaces rough and compacted. (Need: rule enforcement)

Action 3: Require recovery of native soil, organic debris, and native seed pools. (Need: rule enforcement)

Action 4: Show, compared to other land uses, that money saved on grading, seed, and fertilizer is more than the cost of planting trees. (Need: education)

Recommendation 5: Use Tree-Compatible Ground Covers.

Problem: There is a perception that dense, lush, aggressive grass and legumes are always best. Aggressive ground covers kill tree seedlings.

Action 1: Remind operators that trees will be the permanent vegetation. Manage for trees, not grass. (Need: education and rule enforcement)

Action 2: Use short, slow-growing, acid-tolerant ground cover species, and adjust fertilizer rates accordingly: low N, high P, and intermediate K levels are needed. This cover mix should be required and enforced. (Need: education and rule enforcement)

Recommendation 6: Create Bond-Release Incentives to Use Trees.

Problem: Bond-release requirements discourage reforestation.

Action 1: Base stocking and planting arrangements on sound silviculture. (Need: research and education)

Action 2: Reduce cover standard to tolerable minimums. (Need: rule enforcement)

Action 3: Allow augmented tree planting as a husbandry practice to account for drought, animal damage, etc. (Need: rule enforcement)

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[1] Dr. James A. Burger, Professor of Forestry and Soil Science, Department of Forestry at Virginia Polytechnic Institute and State University, Blacksburg, Virginia. Teaches and does research on forest soils, silviculture, and reclamation topics. Involved in reclamation research for the past 20 years in the central appalachian coalfields, concentrating on reforestation and forest land uses of reclaimed mined land. Has researched topics that include mine soil physics and chemistry, overburden placement and site preparation, organic amendments for mine soils, nitrogen and carbon sequestration, and cycling, tree-compatible ground covers, nitrogen-fixing trees, effects of grading on mine soil compaction, and reforestation and management of native hardwoods on reclaimed mined land. Dr. Burger is a past-president of the American Society for Surface Mining and Reclamation, and currently chairs the Forestry and Wildlife Technical Division. He has written numerous technical and applied publications on the subject of reforestation, restoration ecology, and reclamation.

WILDLIFE RECOMMENDATIONS

Steve Beam[1]
Kentucky Department of Fish and Wildlife
Somerset, Kentucky

Recommendations

For the Kentucky Department of Fish and Wildlife, I have several recommendations that should be considered:

- Make people aware that forest land postmining land use is just as much wildlife habitat as a fish and wildlife postmining land use. The planting of trees on reclaimed lands creates the type of early successional habitat that is useful for wildlife. The issue is just how quickly these areas will mature into another type of habitat. If you plant more trees, you go to a mature forest at a faster rate. The Kentucky regulations require that a min-imum of 30 percent of the permit area be planted to wildlife habitat. That is not necessarily the optimum.

- When land is not going to be reclaimed to a specific land use, it should have its ability to undergo forest succession restored. In Kentucky, most of the sites that have been reclaimed for special industrial purposes are still sitting there with no sign of ever being used for the purpose that it was designated for at bond release. Large acreages of pasture are being created that have no access for water for the livestock that would use the pasture. Perhaps we should take a closer look at how this land is actually going to be used. If the landowner is not going to manage the land after bond release then it needs to be undergoing natural forest succession.

Specific tree planting recommendations would include:

- The need to select the proper growth medium.
- The need to minimize soil compaction.
- The need to establish tree compatible ground cover. (We have been establishing native warm season grasses and were encouraged to hear Stuart Miller's findings that they did not inhibit tree growth.)
- The need to plant high quality trees and shrubs. (We need to be planting the species that will not be able to easily and naturally invade the site such as the oaks and hickories because you will get the poplars, maples, and elms anyway.)
- The need to restore the soil productivity. (Encouragement of nitrogen fixers by interplanting redbud or black locust at about one ounce per acre.)
- From the fish and wildlife habitat perspective, most of our emphasis has been on edge. However, we need to mimic a natural forest by planting into trees and shrubs around the edges, planting them in clumps, and planting native grasses and forbs useful for wildlife.
- We should be counting native species useful to wildlife toward success for bond release. Sites that have grown up in blackberry briars, goldenrod, and joe-pye weed are as useful for wildlife habitat as any clean stand of orchard grass and clover.
- We need to include wildlife enhancements on all postmining land uses. The most important aspect of this is water. The forest habitat is much more useful to wildlife if there is some water impoundments present. The most valuable water would be shallow water depressions graded into the area. Leave areas that will not drain well. Retain the sediment structures. We would like to have the impoundments graded so that they have a variety of depths. Under existing Kentucky regulations, there are some problems with regrading impoundments that we would like to revisit. As long as these structures are safe, do not provide any hazard, and are stable, we would like them retained in the postmining landscape. We would like to see travel corridors through pasture areas to water areas. Concerning predators, we recommend perch poles for raptors that will help keep down the damage from rodents.
- We need to partner with industry to establish some demonstration areas of decreased compaction and high quality tree plantings on working mine sites so that we can show people what works.

- And, we need to plan reclamation for the long-term and not just measure success by whether on not we have 80 percent ground cover and a certain number of stems per acre.

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[1]Steve Beam, Wildlife Biologist, Kentucky Department of Fish and Wildlife Resources, Somerset, Kentucky. Beam has worked in the environmental section and on environmental concerns related to mining. He was a member of the Kentucky Department of Fish and Wildlife Working Group that drafted the Kentucky Reforestation Initiative.

OHIO DIVISION OF FORESTY

Jim Stafford[1]
Ohio Division of Forestry
Zanesville, Ohio

Recommendations

I would like to reenforce the recommendations that I made in my earlier presentation.

- We need to reclaim our premining forested areas back to a forest land use after mining.
- Grasses and trees do not mix.
- We need to do something during soil replacement to reduce the compaction.
- Select sources of planting stock that are adapted to the site where you are planting.

I was delighted to hear many of the other speakers reenforcing these same recommendations. The problem comes when you go to your tree nursery supplier and he doesn't have any of the trees that you wanted to plant. Let me propose what I have seen done in the Alabama. Of the 30 million southern yellow pines produced at the J.R. Miller Nursery where I worked, between 42 and 47 percent of these trees were under contract to a paper company. What the paper companies had done was to grow a tree seed nursery of the best adapted trees on their lands and then bring the seed to the nursery for them to grow the planting stock. If you do find a species that you want to grow on your site, you should make local collections of seed and then contract with a nursery to grow them for planting stock. I have never heard of a nurseryman turning down such a request.

The bottom line for the operators is cost. This is the challenge that faces us as a group. This is going to be an educational process for regulators, operators, legislators, landowners, and field practitioners. We will all have to adjust our thinking in order to make progress in this area. This conference should be the beginning of that process.

[1]James P. Stafford, Forester, Ohio Department of Natural Resources, Zanesville, Ohio, Forester since 1981. Stafford graduated in 1976 from Ohio State University with B.S. in forest resources management. He worked for Champion International at a plywood mill in Cordova, Alabama until 1978. He supervised the Alabama State Nursery in Autaugaville, Alabama until 1981. He supervised Green Springs Nursery until 1984. He supervised the Tree Improvement Program until 1994. Currently, he is an Ohio Service Forester assisting landowners in Muskingum, Coshocton, Guernsey, and Belmont counties since 1981. He also is a member of the Ohio Chapter of the Society of American Foresters, the Ohio Mine Land Partnership and the Ohio Nurseryman's Association.

LANDOWNER RECOMMENDATIONS

Timothy Probert[1]
Pocahontas Land Co.
Bluefield, West Virginia

Recommendations

As landowners we need to get more involved and communicate to others the good things that we are doing. We have heard of all the efforts that many in the mining industry are doing to plant trees, but does anyone outside of this room know about it. Al Gore needs to know that if there is a problem with global warming we in the mining community are planting trees and doing something about it. We need to move the educational process outside of the mining community to the public. Educational efforts must be initiated that can reach school children and the teachers that teach our children about the good things we are doing.

Another thing we need to do is to promote technology transfer to the field levels where people can use this information. We need to stress the information that has been presented at this forum to field inspectors. Our dozer operators have been building highways for the last 30 years, and they need to know why they do not need to compact this ground like they learned to do when they built highways because now they are building the forests of the future. Going back to some of the stands that we have planted, we have some stands that should be ready for thinning. When these stands are about 30 years old and I am not yet retired, I would like to be harvesting some of this saw timber and proving the economic forecast that I made in 1984.

We need to develop an award system that will encourage operators to plant trees and reward operators that have done a good job.

Concerning planting on AML sites, I have talked to the state about why they are not planting trees on AML sites and their response has been that their concern is to stabilize the site, not to enhance the value of the site. Somehow we need to change how we do business in AML and find a way to get more trees planted on these AML sites.

We need to do this now! We need to have more landowners and coal operators take this information and begin planting trees on their property. In another 20 years, most of the mining in the East will be done and the opportunity will be lost.

I would like to see the day when a field inspector would tell an operator that his land is a little too compacted to be used as a forest land use and he needs to reduce the compaction. Then, instead of writing him a citation for noncompliance, he would do what he could to help the operator create a better site for forestry. I hope this day comes soon.

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[1] Timothy Probert, Pocahontas Land Corporation, Bluefield, West Virginia. Probert is Senior Forester with Pocahontas Land Corporation, a subsidiary of Norfolk Southern Corp, and manages over 500,000 acres of forest land in West Virginia, Virginia, and Kentucky. Part of his responsibility is to coordinate reforestation activities on the company's reclaimed surface mine lands. Working with mine and environmental engineers from several of Pocahontas' coal lessees, he has overseen the planting of over 6,800 acres that were returned to forest land. He has been involved with three cooperative reforestation projects with Virginia Tech and has coauthored papers on some of that research.

KENTUCKY WILDLIFE SOCIETY

Robert M. Morton[1]
Kentucky Chapter/The Wildlife Society
Corydon, Kentucky

Recommendations

I feel that the forum has been very productive and hope to see the product of our discussion on the landscape, not just in print, over the next 10 to 20 years. Not to go over what the other speakers have already addressed, I would like to reenforce the idea of cooperation with the reclamation people, the regulators, the landowners, and the operators. This is paramount to getting success on the ground.

We need to:

- Focus Reclamation on restoration not replacement.
- Do our reclamation so that productivity is restored and make a successful forest land use that is wildlife friendly.
- Consider what the actual postmining land use will be very early in the permitting process.
- Leave as much water on the landscape as possible. Shallow seasonally flooded depressions are actually very beneficial to a number of species of wildlife both resident and migratory. It is very important to leave water on the landscape for the benefit of wildlife. We should be making every effort to design the sediment ponds so that they can be retained in the postmining landscape. I don't know how many mine sites I have been at where as one of the last stages of reclamation all of the sediment ponds have been removed, removing all of the water on the landscape.
- See minimal grading to reduce compaction as the normal procedure rather than the finish grading that maximizes compaction that we see now. This is the only way that forests will stay on the landscape in the long-term.
- Put a forest on the landscape that will regenerate itself. It has to have adequate growth and productivity in its lifetime so that it will produce a seed crop and regenerate itself.
- In the short-term, we have to maintain water quality standards. Certainly one of the great achievements of SMCRA is the improved water quality produced from mine sites. Toxic water discharges from pre-SMCRA mine sites that devastated fisheries and invertebrate aquatic life is in most cases gone.
- The reforestation effort has got to involve education. This has to include the equipment operator as he is the person we have to reach in order to reduce compaction in the field.

Summary

In summary, we have to put habitats back on the landscape that are the best we can create. The speakers at this forum have demonstrated over the last two days that the technology for successful reforestation is available and we can put the landscape back in a way that is productive, friendly to wildlife, and friendly to water quality. We need to strive to put those habitats back that are self sustaining and regenerating. If we do this then we will have accomplished our goal.

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[1] Robert M. Morton, President Kentucky Chapter of the Wildlife Society, Henderson, Kentucky. Morton holds a Bachelor's degree in wildlife management from Murray State University. For the last 20 years he has worked with the Kentucky Department of Fish and Wildlife. Currently, he is the biologist/area supervisor for the Sloughs Wildlife Management Area. He was the secretary/treasurer for the Audubon Area of Ducks Unlimited for five years. He has been president of the Kentucky Chapter of the Wildlife Society since 1996.

WHERE DO WE GO FROM HERE?

Kathy Karpan, Director[1]
Office of Surface Mining
Washington, D.C.

Where do we go from here? My answer would be to go forward. Let's keep the momentum going. There is nothing more exciting than an idea whose time has come. I have always felt that any landmark piece of legislation like SMCRA is, that it is a work in progress. We grow in wisdom and understanding of what it can do. Things that were appropriate in the interpretation of SMCRA 20 years ago, may not be as relevant or valid today. I am committed to our being proactive, to changing our way of thinking.

You should look at the list of people attending this forum and look at the diversity and caliber of people in attendance. Think back over how many of the speakers here have noted the tremendous areas of consensus. When we prepare the proceedings for this event, we may find that 90 percent of the comments that have been made are compatible with each other. This moves us a long way on the path that we want to pursue.

Part of our momentum has to be along the lines of education. I have heard over and over speakers telling us that we must educate the landowners. I hope that we can have future events where we can have greater participation by landowners and the public. Ideas like the Tree Bank that we heard from the Nature Conservancy are very exciting. These types of ideas need to be encouraged and acted upon. I hope that we are able to host more conferences of this nature and to hold them in this part of the country where we are centrally located for many of the people concerned about these issues. I hope that we will follow through with developing course work on this subject.

In a very specific way, we are in the process of developing an outreach program on our revegetation success rules. We are looking at the issue of diversity and how it ties into determining revegetation success. One of the concerns is, "What is the effect that our statistical requirements have on the statutory mandate for diversity?" We are initiating an effort to collect this information over the next three months. We want to collect information from all of our stakeholders. We want to know what their thoughts are on our revegetation rules, specifically for diversity, but also on any other related aspects of the rules. We will be distributing a concept paper to all of our stakeholders. Everyone that is registered for this forum will be receiving this mailing. We are planning to hold between four and six public meetings around the country to get input on this issue.

I hope that you will see this philosophy applied throughout our agency in all areas. We need to have an open and inquiring mind and distinguish fact from folklore in our regulatory program. I was interested today to hear that we may have some statements being made concerning what SMCRA requires that only represent one person's point of view, or may be a hand-me-down story that is not true. We will try to get to the bottom of these through training of our instructors and our inspectors.

One of the things that we have to be very careful of is the temptation to layer on new requirements. This is the practice of continually layering on new requirements without weeding out old ones. We will give our rules and regulations a very good review and seek to maximize the flexibility under our current regulatory system. Our operating assumption must be that we can do this within our existing system by changing the way we think about and do things. If we have to consider rule making in order to accomplish our goals, then we will do that, but it will be the last resort.

We need to continue to build a coalition of interest groups. I believe we have a tremendous opportunity to create new alliances for our point of view. We need to show that we are capable of holistic and long-range thinking with very positive environmental benefits, rather than just looking for easier and cheaper ways to do business. As we move forward to the promotion of reforestation, we do not want to slip back into old habits or abuses that prompted the passage of SMCRA. It is so important that we have the participation of industry at this forum. I am encouraged that the head of the National Mining Association will encourage his members to work with us on this issue.

OSM was born in conflict and brought to life in compromise and trade offs that are still bones of contention. Much of our history has been one of long and bitter litigation. It would be a wonderful time of renewal if we could find a common cause in this issue of reforestation and come to agreement without resort to litigation or rule changes. Instead, if we could, by common sense and civility, open communications and be flexible to entertain new ideas, then we could move along on a vision that future generations will thank us for. As one of our speakers said, sustainability really is the debt that our generation owes to the next generation. We need to pass on a land that will hold promise and hope for future generations.

I think the perfect way to end this meeting is to think of the values that we attribute to trees. Since I grew up in Rock Springs, Wyoming, you can appreciate why I would love trees because I never saw many of them. The first acting governor of Wyoming was quoted as saying in his first address to the new state was that "A tree is a shelter from the hot sun and those roaring western winds. The tree roots will go into the ground and hold the water and keep the soil from being blown away. A tree can provide a home for birds and habitat for other wildlife. A tree can grow food to sustain us. They are a source of adornment that can give us pleasure and aesthetic values for wherever we live." All of this 100 years before we learned that they also sequestered carbon. Trees represent renewal and growth and that is what I hope you take out of this forum.

If you will stick with us and work with us, we are capable of entertaining new common sense ideas. Help us to find any parts of the regulations that you feel stand in the way of successful reforestation where it would otherwise be appropriate. If we can have the kind of give and take, attention, respect, and creativity that I have seen at this forum, I believe we can get this job done.

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[1]Director Karpan is from the state of Wyoming where she has a long family background in coal mining. She has a long and distinguished record of public service at both the state and federal levels including serving as:

1. Assistant Attorney General for Wyoming,
2. Director of the Wyoming Department of Health and Human Services, and
3. Secretary of State for Wyoming.

She received her Bachelor's and Master's Degrees from the University of Wyoming and her Juris Doctor from the University of Oregon.

POSTER PRESENTATIONS

Woody Establishment Patterns Following Mountaintop Removal in the Coal River Valley
Stacy N. Edmonds and Olie L. Loucks, Miami University, Oxford, Ohio

Deep Soil Loosening with Sludge Incorporation Promotes Tree Establishment on Minesoils
Jack Vimmerstedt and D.A. Kost. School of Natural Resources, The Ohio State University, Wooster, Ohio and W.D. Smith, Mead Corporation, Chillicothe, Ohio

Use of Woody Plant Seed to Reforest Mined Land: Purpose, Problems, and Opportunities
Dr. Lawrence T. Beckerle, Glenville State College, Craigsville, West Virginia

Reforesting Alabama's Abandoned Mine Lands
Dr. E. S. Lyle, Jr. and J. L. Kitson, Walker County Soil & Water Conservation District, Jasper, Alabama

WOODY ESTABLISHMENT PATTERNS FOLLOWING MOUNTAINTOP REMOVAL IN THE COAL RIVER VALLEY

Stacy N. Edmonds and Orie L. Loucks
Miami University
Oxford, Ohio

Abstract

Six postmining restoration sites in the Coal River Valley, West Virginia were selected for study during 1997 and 1998. All sites had been revegetated with herbaceous legumes, grasses, and woody species, and ranged in age from two to twelve years of growth.

The sites were found to be not uniform in character despite the fact that uniformity has been a prevalent assump-tion in planning reclamation. For example, quite similar seed mixtures or plantings are applied to all conditions at a site; however, the postmining sites were found to be a mosaic of interacting landforms composed of fields, mounds, valley fills, slopes, benches, divergent ditches, and ponds. The purpose of the study was to determine whether repeating vegetation patterns exist for the man-made landforms following large-scale mining operations. The cover of bare ground, herbaceous, and woody species was determined in two meter square quadrats placed mechanically along all transect lines in relation to the man-made landforms. The seven landform types evaluated had statistically significant differences in percent cover for each vegetation type and bare ground (p-value less than 0.0001). Mountaintop removal field and mound landforms supported less than 1 to 2 percent cover in trees and shrubs. The postmining landforms that supported a somewhat higher than average cover of woody species were contour wetland-drainage areas (11 percent), valley fill landforms (10 percent), and highwall elimination slopes (8 percent). Based on this evaluation, reclamation practices can probably can be improved by targeting reseeding by landform type and addressing reforestation success in relation to specific landform characteristics.

Introduction

Advances in surface mining technologies in Appalachia have led to the increased use of a large-scale mining form called mountaintop removal. Current mining practices can disturb mountain, forest, and stream systems at a scale of hundreds to thousands of acres. Reclamation of mountaintop removal sites is often more difficult than restor-ation of conventional contour mines. Modern sites require the revegetation of large man-made drainage systems as well as sloping landforms. This study investigated whether vegetation patterns exist for specific man-made land-forms following either of the two types of mining practices, mountaintop removal or contour mining. See Figure 1.

Results I

Mine sites studied showed that none are uniform in character despite the fact that uniformity has been a common assumption in treating postmining sites (e.g., evenly applying similar seed mixtures for an entire site). The recla-mation sites were found to be mosaics of interacting landforms. The differences between landform types at a local scale are comprised of specific patterns of terrain characteristics including slope and aspect. The landforms also have distinct physical properties including differences in compaction levels and the composition of soil and parent material.

Results II

Analysis of the data suggests many effects of local landform characteristics on vegetation growth, cover, and composition.

- The four plant communities found (vegetation groups), especially woody plants, showed differences in

abundance in relation to landform types, while being characteristically absent on others.
- Woody vegetation on the reclaimed mine sites was about two times higher on contour mine sites (8 to 11 percent) than on mountaintop mine sites (2 to 6 percent), with a marginally significant difference (p-value = 0.05) (Table 1).
- The seven postmining landform types evaluated had statistically significant differences in percent cover for all vegetation types, with a p-value less than 0.0001, using ANOVA model.
- Box plots (Figure 2 and Figure 3) show individual landform types as having quite different and distinctive biotic communities beginning to be established, but with significant areas of bare ground still remaining on some landforms.
- Within the mountaintop removal field and mound landforms, the cover of trees and shrubs was less than 1 to 2 percent. (See Table 1.)

Discussion and Conclusion

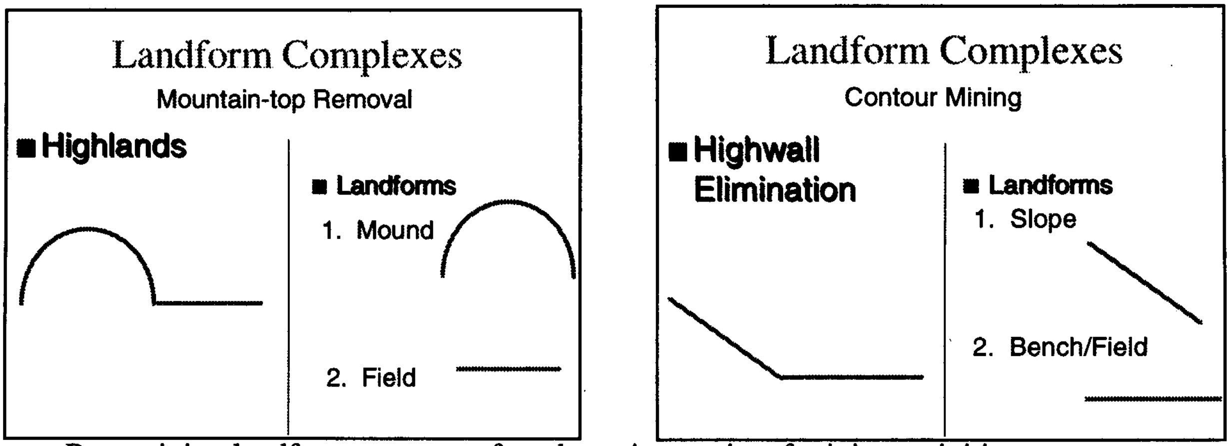
- Woody species accounted for less than 11 percent vegetation cover at any one landform type, indicating low survival of planted trees and shrubs and low occurrence of woody colonization from adjacent forests.
- The mountaintop removal highland mound and field areas have the lowest woody cover of all postmining landforms establishing only ~1 to 2 percent cover. Both types typically have hard compact soils, creating problems for root and shoot growth.

At this point in time, reestablishment of forest on these postmining sites appears questionable. Neither mountaintop removal sites nor the contour mines support a vegetation composition or structure that is likely to resemble regional forests.

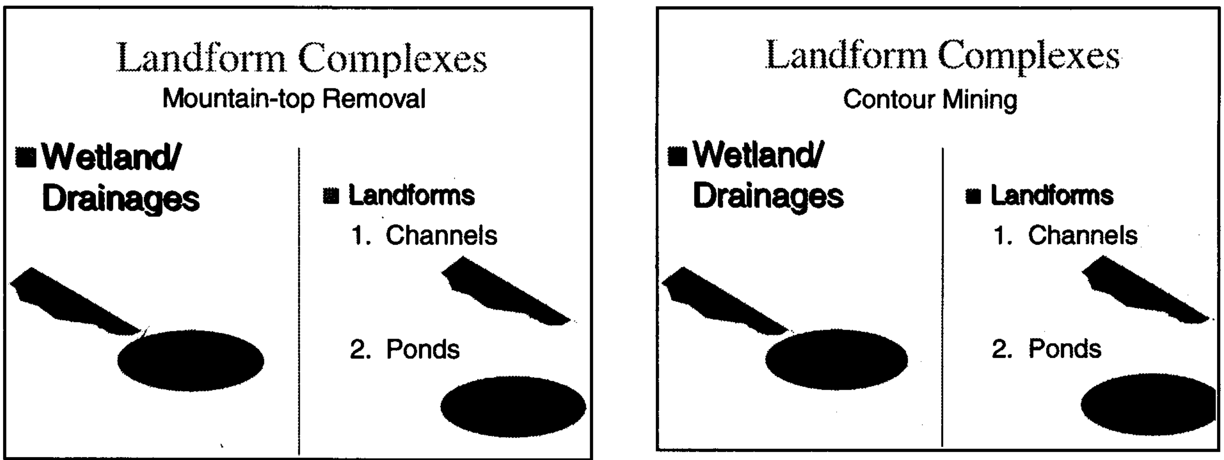
Based on this study, mine reclamation might be enhanced by targeting specific landform types with specific seeding or planting practices and addressing reforestation in relation to specific landform characteristics. Future research needs to investigate the success of vegetation associated with landform characteristics, including soil physical properties, geochemistry of drainage water, and detention export rates of water and nutrients.

Figure 1. Five surface mine landform complexes of the Coal River Valley region.

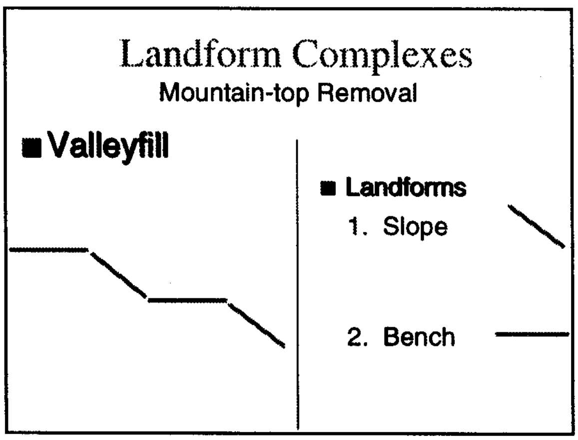
Mountaintop Removal Mine Landforms **Contour Mine Landforms**



a. Post-mining landform structures found at primary site of mining activities



b. Network of man-made waterways and the associated landform structures.

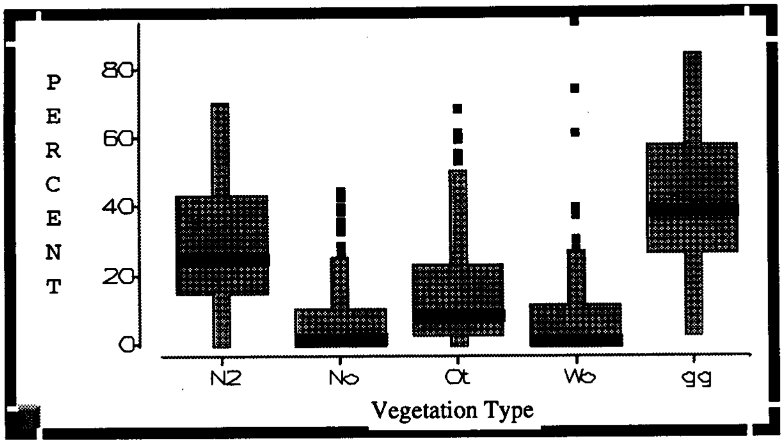


c. Overburden disposal areas located at the head of valley and stream systems.

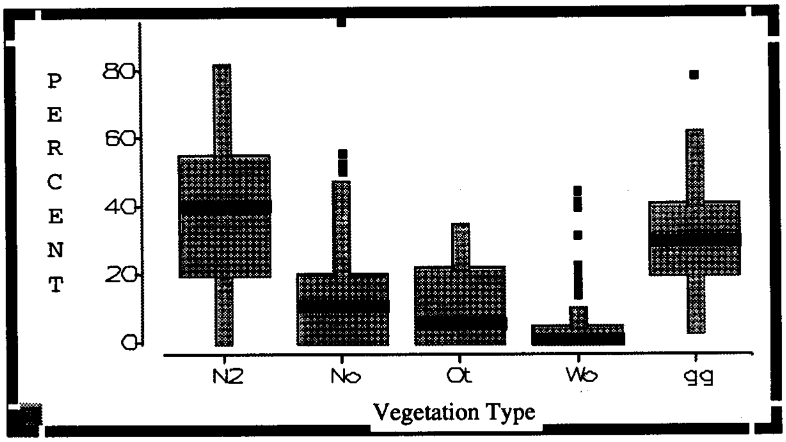
Figure 1. Five surface mine landform complexes of the Coal River Valley region.

Table 1. Mean cover and standard error from ANOVA tests, assume significance level at $\alpha=0.05$ for vegetation types sampled on specified mine landforms. Raw mean scores are presented. Means with the same lowercase superscript letter in the same column are not significantly different.

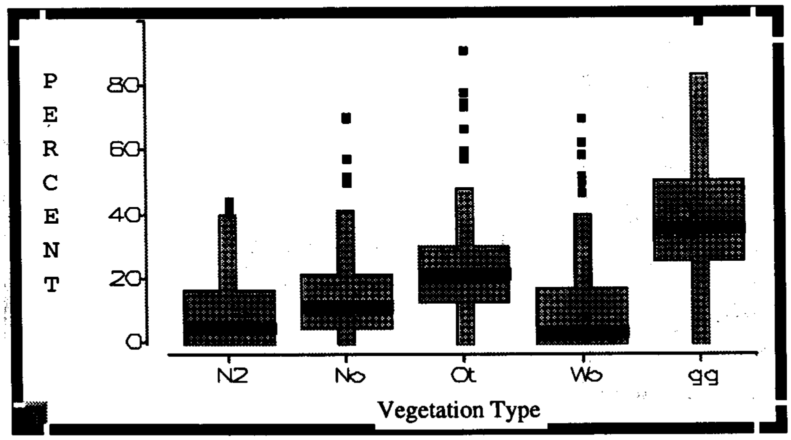
Mine Landforms		Mean Percent Cover ± Standard Deviation: Vegetation Types				
		Grasses	N2-Herbs	Forbs	Woody	Bare
Mountaintop removal						
Highland Complex						
1. field	n=45	60.4 ± 18.1^{a}	24.3 ± 15.6^{a}	1.7 ± 5.8^{a}	2.0 ± 8.4^{abc}	11.6 ± 24.3^{ab}
2. mound	n=75	51.7 ± 20.8^{b}	39.9 ± 19.8^{b}	1.5 ± 5.5^{a}	0.4 ± 2.2^{abc}	6.5 ± 9.5^{ab}
Valley fill Complex						
3. slope/ bench	n=60	40.9 ± 20.4^{c}	38.8 ± 24.2^{b}	1.9 ± 7.2^{a}	10.8 ± 19.7^{d}	7.7 ± 15.1^{ab}
Wetland Drainage Complex						
4. channels, drainages & ponds	n=90	46.8 ± 23.0^{b}	21.7 ± 22.3^{c}	13.6 ± 19.9^{b}	6.6 ± 13.4^{d}	11.3 ± 16.1^{bc}
Conventional Contour						
Highwall Elimination Complex						
1. highwall slope	n=105	41.5 ± 21.2^{c}	27.5 ± 17.7^{a}	15.8 ± 17.6^{c}	8.0 ± 15.4^{d}	7.4 ± 11.1^{ab}
2. highwall bench	n=75	31.4 ± 15.1^{d}	38.9 ± 20.7^{b}	10.5 ± 11.0^{b}	5.3 ± 10.5^{bcd}	14.5 ± 17.9^{c}
Wetland Drainage Complex						
3. channels & ponds	n=90	38.0 ± 19.8^{c}	10.3 ± 12.7^{d}	24.7 ± 18.7^{d}	11.4 ± 16.1^{d}	15.5 ± 14.9^{c}



a. Revegetated highwall slope landforms.

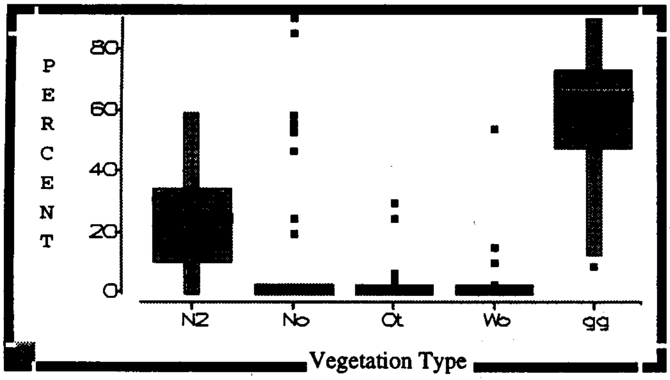


b. Revegetated bench landforms.

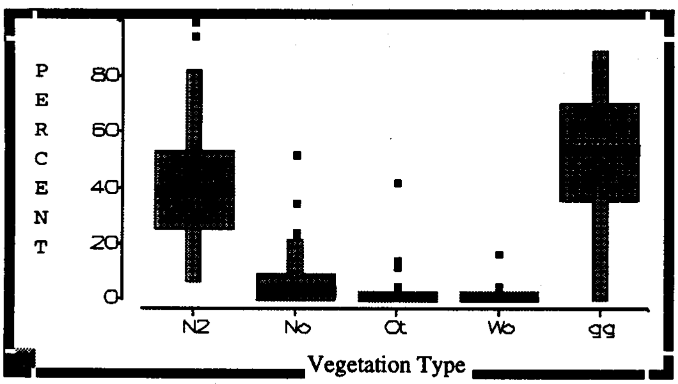


c. Revegetated contour wetland-drainage landforms.

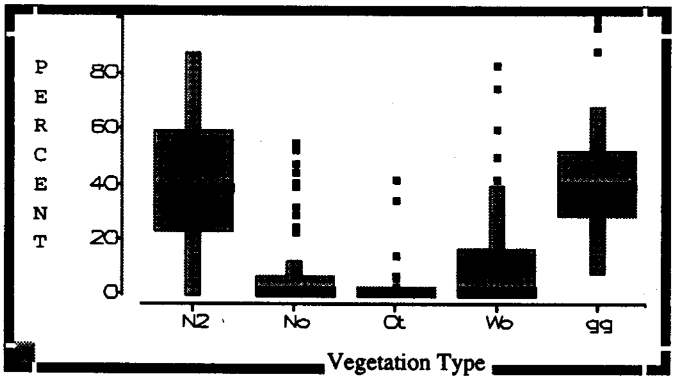
Figure 2. Boxplots of vegetation types responding to contour mine landforms: N2 is nitrogen-fixing herbs; No is bare ground; Ot is forbs; Wo is woody; and gg is grasses.



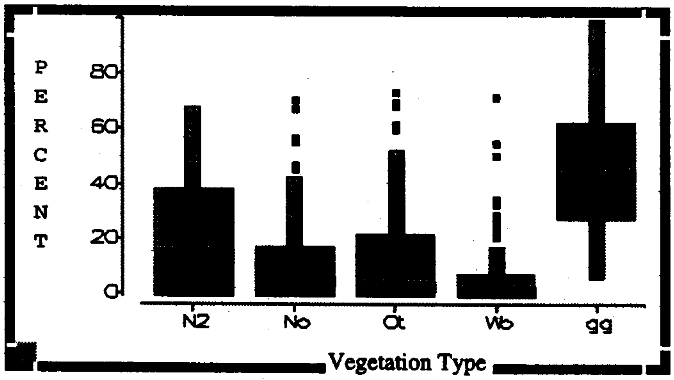
a. Revegetated highland field landforms.



b. Revegetated highland mound landforms.



c. Revegetated valleyfill landforms.



d. Revegetated mountaintop wetland-drainage landforms.

Figure 3. Boxplots of vegetation types responding to mountaintop removal landforms: N2 is nitrogen-fixing herbs; No is bare ground; Ot is forbs; Wo is Woody; and gg is grasses.

DEEP SOIL LOOSENING WITH SLUDGE INCORPORATION PROMOTES TREE ESTABLISHMENT ON MINE SOILS

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Wooster, Ohio
W. D. Smith[3]
Mead Corporation, Woodlands Division
Chillicothe, Ohio

Abstract

We measured survival and height growth of white ash (*Fraxinus americana* L,), sycamore (*Platanus occidentalis* L.), and black walnut (*Juglans nigra* L.) on a regraded acid typic udorthent of pH 2.9, and of white ash on a calcareous typic udorthent of pH 6.5-7.5. The acid mine soil had been treated with paper mill sludge incorporated by rototilling 15 cm (860 Mg of sludge per hectare) to 30 cm depth, shallow backhoeing 15 cm of sludge to 90 cm depth, or deep backhoeing 60 cm (3450 Mg per hectare) to 150 cm depth. The calcareous mine soil was either graded grey cast overburden or "topsoil" graded over graded grey cast overburden, the current standard recla-mation system. After five growing seasons on the acid mine soil, comparing shallow backhoeing versus (*vs)* deep backhoeing *vs* rototilling treatments, survival was 39 percent *vs* 30 percent *vs* 17 percent for black walnut; 38 percent *vs* 47 percent *vs* 11 percent for sycamore; and 58 percent *vs* 58 percent *vs* 38 percent for white ash. Total heights, shallow backhoeing *vs* deep backhoeing *vs* rototilling, were (cm) 140 *vs* 148 *vs* 74 for black walnut; 481 *vs* 431 *vs* 144 for sycamore; and 211 *vs* 188 *vs* 112 for white ash. After five growing seasons on the calcareous mine soil, white ash survived well (98 percent), but heights were only 102 cm on topsoil and 94 cm on graded over-burden. On the acid mine soil, we attribute the significantly better survival and height growth of trees on backhoe treatments to creation of a larger volume of soil with low bulk density and better ability to supply water, air, and nutrients. We attribute the comparatively slow growth of white ash on calcareous mine soil to absence of a sufficient soil volume with favorable water, air, and nutrient supply for root growth.

USE OF WOODY PLANT SEED TO REFOREST MINED LAND: PURPOSE, PROBLEMS, AND OPPORTUNITIES

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Abstract

Prior to the Surface Mining Control and Reclamation Act (SMCRA), a University of Auburn study found trees in Alabama to be growing 50 percent faster on mined land than on undisturbed land. Not only was reforestation of mined land productive, it could be inexpensive. Application of seed and fertilizer by aircraft at the rates of 0.5 pounds of loblolly pine, 5 pounds of kobe lespedeza, and 10 pounds of fertilizer to the acre was all that was needed to reforest regraded and partially terraced rock overburden in the Warrior coal basin. Earlier plantings using conventional methods by the same author were less successful even though mulch was applied and fertilizer rates were more favorable.

Reforestation attempts following SMCRA have not been as productive as similar attempts on undisturbed lands. Many scientific papers have been written about the effects of excessive compaction and increased vegetative competition with trees on lands reclaimed after the passage of SMCRA. Relatively few scientific papers have addressed the effect of reduced water availability for tree growth due to the effects of increased compaction and vegetative competition found on mines reclaimed after SMCRA.

On mined lands reclaimed after SMCRA, the adverse effects of water infiltration and ground water recharge can be overcome, in part, by construction of absorption terraces and other water conservation techniques. Part of the challenge with growing trees is finding ways to help trees outcompete existing grasses for light, nutrients, and especially moisture. Where economically available, sawdust and other wood industry by-products can help reduce competition and increase moisture availability. If these materials are not available, it is most important to find ways to facilitate the maximum genetic potential for taproot development. Planting trees by seed rather than seedlings avoids damage to the taproot through pruning. The adverse effects of compaction that reduce water infiltration also could be partially mitigated by the use of "green manure" cropping. On gentle slopes and/or where the potential effects of erosion are minimal, the use of annuals that would reseed themselves would greatly reduce the competition with trees in terms of top growth and root competition. The use of relay cropping techniques and some native species also would facilitate a more diverse tree cover. It is the author's observation that there has been a bias against absorption based soil and water conservation techniques as a result of:

- the lack of a clear interpretation of requirements for approximate original contour;
- the requirement to replace topsoil;
- the interim OSM regulation prohibiting depressions bigger than a square meter; and
- state regulations prohibiting depressions deeper than 0.2 feet where there is a probable flow of water.

REFORESTING ALABAMA'S ABANDONED MINE LANDS

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Introduction

Approximately 95 percent of coal surface mining land in Alabama was once forested. While the amount of land disturbed by surface mining is not great when the entire state is considered, the amount disturbed within some districts is substantial. Though site stabilization is the primary goal, it seems reasonable to assume that these mined areas will be returned to forest production for the good of state and local economies. Also, tree cover provides excellent wildlife habitat. With this in mind, in 1987 the Alabama Abandoned Mine Land Reclamation Program embarked on a program to reforest, to the extent possible, all of its AML reclamation projects.

Three problems had to be overcome in order to have successful plantings. These are competition from grasses and legumes, soil compaction, and extreme rockiness. Competition and compaction are always present and rockiness is common on many sites. Previous research in Alabama and other states had shown that competition must be controlled and compaction lessened in order to encourage tree seedling survival and growth. Rockiness interferes with the tree planting process and has to be overcome in order to speed the planting and obtain correct seedling placement.

Methods

In response to these problems, a bulldozer was equipped with a single-tooth ripper and a herbicide sprayer. In October of each year, this equipment is used to rip and spray all areas that are to be planted with tree seedlings in January and February of the following year. Ripping is done to a depth of approximately 14 inches and a 2-foot swath is sprayed on each side of the ripped line with a herbicide solution. The herbicide reduces vegetative competition to an acceptable level, and ripping reduces soil compaction, as well as moving rocks away from the planting area. This movement of rocks allows the planter to place the seedling roots at an acceptable depth. A 55-gallon mixture of 2.5 gallons of Roundup Pro, 10 ounces of Oust, and water is sprayed over 2.5 acres of the 4-foot swath. Spacing between rips is nominally 10 feet. Therefore, 6 ¼ acres can be treated with 55 gallons of solution.

Tree planting starts the first of January. Several different species have been planted over a 12-year period, with loblolly pine, autumn olive, bicolor lespedeza, and sawtooth oak the most used. Approximately 85 percent of the planting is loblolly pine. Loblolly pine is planted for commercial production and other species for wildlife food and shelter. Practically all planting stock is bare root. Seedlings are stored at approximately 40EF until needed. All species are planted on an intended 6 foot by 10 foot spacing, for a total of approximately 725 seedlings per acre. Whenever possible, a tree planting machine is used. One man follows the machine and corrects any planting mistakes such as poorly planted seedlings and unplanted areas. Hand-planting is used where the planting machine cannot function. Constant care is taken to ensure that the seedlings are not exposed to freezing, heating, or drying. Also, supervisory personnel examine each day's plantings to make certain that seedlings are handled and planted properly. This attention to quality control is critical.

Approximately 173 different areas have been planted since 1987 covering a total of approximately 2,731 acres. Areas are not ripped or sprayed when competition is not great or rockiness is not a problem. The average cost of ripping, spraying, and planting is $231.31 per acre. The range for this cost is from $200.08 per acre to $275.73 per acre, depending on size of tracts, equipment breakdowns, overtime pay, and amount of travel.

Results

Twenty-seven plantings were recently chosen at random from the one hundred thirty-nine plantings that were ripped and sprayed from 1987 to 1997. Three plots of 0.01 acre size were chosen at random in each of the plantings. The actual planting spacing, number of surviving seedlings, total height, and D.B.H. were determined for each plot. (See Table 1).

Overall survival is 86.1 percent for the eleven years in which tree planting with ripping and spraying has been performed. The range in survival is from 77.0 percent to 99.7 percent. The one to eight year old stands have a survival of 87.4 percent and the nine to eleven year old stands have an average survival of 81.0 percent. This indicates that survival is decreasing, but not at an unacceptable rate.

It is too early in the stand development to determine productivity; however, site index at age 25 will be approximately 60 feet if height growth follows the Coile and Schumacher site index equation for loblolly pines in the Piedmont region.

Historically, much of the tree planting on reclaimed coal surface mines has been unsuccessful. Some of the causal factors have been addressed in this report. Other factors such as species, topography, type of mine soil, and climate may need to be evaluated when establishing tree planting programs in other states. The basic mechanics employed in Alabama's AML Program are worth consideration.

TABLE 1 - PLOT MEASUREMENT RESULTS

Planting Site	County	Year Planted	Avg. # Surviving Seedlings Per Acre	Avg. # Seedlings Planted Per Acre	Sur-vival %	Avg. Height Feet	Avg. D.B.H. Inches	Dom & Codom Height Feet	Stand Age Years
Herman Church	Walker	1989	633	723	87.6	28.4	5.5	31.2	10
Grace Chapel	Walker	1989	700	798	87.7	28.0	6.1	28.0	10
Quarry Landing	Tuscaloosa	1989	533	663	80.4	27.0	5.4	30.1	10
Gayosa	Walker	1988	667	864	77.2	28.0	5.9	28.0	11
N. Alabama Junction	Tuscaloosa	1990	600	737	81.4	26.8	4.6	30.8	10
Peques Creek	Tuscaloosa	1990	533	666	80.0	25.7	5.3	28.4	9
Meadow Creek	Winston	1988	600	825	72.7	26.7	6.7	35.3	11
Lilly Chapel	Blount	1992	567	747	75.9	21.4	4.2	24.0	7
Kimberly N. Emer.	Jefferson	1992	667	716	93.2	9.6	1.4	11.1	7
Fairview	St. Clair	1996	900	937	96.1	7.9	1.0	10.0	3
Copeland Bend	Walker	1993	867	871	99.5	19.2	3.4	22.4	6
Allman Road	Jefferson	1993	700	842	83.1	10.7	1.7	13.0	6
Lawsontown	Jefferson	1992	767	871	88.1	23.9	4.4	25.2	7
Charlie’s Creek	Walker	1993	667	682	97.8	13.5	2.5	16.3	6
Oak Grove School	Walker	1997	1000	1031	96.7	2.3	-	2.9	2
Brookside Church	Walker	1997	1000	1048	95.4	3.2	-	3.9	2
Little Black-water	Walker	1994	733	834	97.9	13.2	2.5	15.7	5
Bankhead Forest	Winston	1996	767	918	83.6	4.3	-	5.4	.3
Panter	Fayette	1993	733	913	803.3	4.4	2.5	16.9	6
Pendley Chapel N.	Fayette	1993	900	903	99.7	18.5	3.4	20.6	6
McCollum West	Walker	1992	600	691	86.8	23.0	4.7	24.8	7
Burnwell	Walker	1992	600	6391	86.8	23.0	4.7	24.8	7
Spelunker Hollow	Walker	1995	766	871	87.9	8.8	-	10.3	4
Praco	Jefferson	1996	600	8456	71.0	7.1	0.5	9.1	3
Camp Cherry Austin	Tuscaloosa	1998	533	644	83.1	1.0	-	1.2	1
Tanyard Creek	Winston	1993	700	980	72.2	12.0	2.2	14.8	6
Wallace Drive W.	Cullman	1995	667	716	93.2	5.2	-	6.1	4
Averages			701	816	86.1				

Standard deviation for survival is 19.22.

Standard error of the mean is 3.32.

Confidence interval (t 0.05) is 92.62% to 78.98%.

Confidence interval (t 0.01) is 94.99% to 76.57%.

Compilation of the above data was completed on March 16, 1999.

SURVEY RESULTS

REFORESTATION TECHNICAL INTERACTIVE FORUM
PARTICIPANT COMMENTS AND RECOMMENDATIONS

OVERALL VALUE OF FORUM

	TOTAL RESPONDENTS	PERCENTAGE
EXCELLENT	36	55
GOOD	24	36
FAIR	5	8
POOR	0	0

COMMENTS ON VALUE OF FORUM:

COMPLIMENTS

- I appreciate OSM's effort in discussing the reforestation issue. The steering committee did a great job in getting together this mix of stakeholders and planning the forum. I am confident that this balanced approach will work to the benefit of the environment. I applaud OSM's Director Karpan for supporting this initiative.
  This program is an encouraging example of how all phases of the mining process can work together (i.e., regulatory community, research, operators, conservation, and environmental community.)
- Concept of interactive forums is very good. OSM should be commended for scheduling an interactive forum on reforestation; the need to get more mined land which was originally forested returned to forest land deserves the attention.
  A very good forum that was long overdue.
- Fabulous cross-section of speakers and topics. Best technical seminar I have been to in years.
- The forum was well put together and very useful.
- Overall an excellent program.
- I obtained a wealth of information. Extremely impressed with the presentations and the overall quality.
- I found the talks interesting, educational, and informative; glad I attended.
- Very valuable, informative, and enjoyable.
- I hope that this type of forum will continue.
- Having the diversity of speakers made this forum worthwhile.
- Well received, important issues where OSM needs to take the lead on implementation.

SUGGESTIONS

- Lots of good suggestions but getting them implemented may be another story.
- We need to build on the common theme that "Forests are good and we need to encourage them."
- I applaud OSM for taking the initiative to address this topic; hopefully, we can now work toward a common goal.
- This program is not only "politically correct," it is actually "really correct" in terms of scientific backup and common sense observations. Let's take this opportunity and momentum to get implementation in all coal states. We need some localized seminars to take this to the state regulatory staffs and field inspectors.

TOTAL REGISTRATION

	REGISTRANTS	PERCENTAGE
TOTAL:	160	100

AFFILIATION

OSM	43	27
STATE	43	27
INDUSTRY	28	18
F&W/FOREST	15	9
UNIVERSITY	14	9
CONSULTANT	11	7
CITIZEN	4	3
US ARMY CORP OF ENG.	1	1
US DOE	1	1

REGIONAL REPRESENTATION	**#**	**%**
APPALACHIAN	90	56
MID-CONTINENT	59	37
WEST	11	7

PARTICIPANTS FROM THE FOLLOWING STATES (28)

AL	IL	MS	PA
AR	IN	MT	TN
AZ	KY	NC	TX
CA	LA	NJ	UT
CO	MD	NY	VA
DC	MN	OH	WA
GA	MO	OK	WV

PARTICIPANTS WHO COMPLETED THE SURVEYS

	NUMBER	PERCENTAGE
TOTAL RECEIVED	70	100
AFFILIATION		
State:	27	39
Federal:	19	28
University:	5	7
Industry:	13	19
Public:		0
Consultant:	4	6

USEFULNESS OF TALKS

1=EXCELLENT; 2=GOOD; 3=FAIR; 4=POOR

SESSION 1 STATUS OF OSM/STATE EFFORTS

PRESENTER	AVERAGE RATING	RATING RANGE
Sponsler	1.5	1-4
Long	2.2	1-4
Boyce	2.2	1-4

SESSION 2 INTEREST GROUP PERSPECTIVES

PRESENTER	AVERAGE RATING	RATING RANGE
Sponsler	1.9	1-4
Long	2.1	1-4
Finkenbinder	2.2	1-4
Strange	2.8	1-4
Burger	1.4	1-4
Beam	2.1	1-4
Stafford	1.9	1-4
Probert	1.9	1-4
Morton	2.1	1-4

SESSION 3 STATUS OF TECHNOLOGY

PRESENTER	AVERAGE RATING	RATING RANGE
Burger	1.5	1-4
Ashby	1.9	1-4
Graves	2.2	1-4
Sweigard	2.3	1-4

SESSION 4 PRACTICAL APPLICATIONS IN RECLAMATION

PRESENTER	AVERAGE RATING	RATING RANGE
Waugh	1.9	1-4
Ballek	1.8	1-4
Pfannenstiel	1.9	1-4
Stroud	1.8	1-4
Walker	1.9	1-4
Miller	1.5	1-4
Liebering	1.9	1-4
Kastor	1.8	1-4
Cordell	1.9	1-4
Williamson	2.4	1-4
Probert	2.2	1-4

SESSION 5 INTEREST GROUP RECOMMENDATIONS

PRESENTER	AVERAGE RATING	RATING RANGE
Sponsler	1.9	1-4
Daniels	2.2	1-4
Finkenbinder	2.2	1-4
Davis	2.1	1-4
Burger	1.5	1-4
Beam	1.9	1-4
Stafford	2.0	1-4
Probert	1.9	1-4
Morton	2.2	1-4

COMMENTS ON USEFULNESS OF TALKS

COMPLIMENTS

- Good range and representation of speakers.
- Very knowledgeable group of speakers.
- Indiana speaker gave me the specific information I needed for planting on soil not spoil, best herbicides, and how to get the most out of my tree planting.
- Good wildlife perspective.
- Good topics and information. I liked the practical applications that can be incorporated into our own program.
- Excellent information transfer.
- Numerous speakers with very good credentials.

NEED FOR IMPROVEMENT

- Some of the speakers generalized too much and lost credibility.
- Speakers should not have been allowed to exceed their time.
- Chairpersons should have kept speakers on time. Many ran over way too long.
- Too many talks, days too long, need longer breaks.
- Some topics were redundant.
- Speaker on effects of compaction used technical terms I was unfamiliar with.
- The speaker representing the eastern states was not representative of many eastern state concerns.
- Some speakers could not separate their science facts from their own opinions.
- Not enough time for participant discussions.
- Speakers had more information than could be presented in the allotted 15 minutes.

SUGGESTIONS

- We all seem to want the same thing. The states need to be more forestry user friendly and allow more options for planting trees.
- Hopefully this will begin a new OSM/State initiative on forest restoration on active mines and abandoned mine lands.
- The best thing was that the issue of the use of spoil as soil was brought out in the open and discussed.
- We all seem to know what the issues are, now it is time to act.
- I am in favor of planting trees on reclaimed land but not at the expense of returning to the less restrictive environmental protections prior to SMCRA.
- Need to make tree planting more user friendly. Productivity formulas for bond release will be very counterproductive to increased forestry land use.
- May need to involve staff from university extension service and the NRCS to achieve a "grass-roots" education for landowners to get on-board with new reforestation practices.

TOPICS OR SPEAKERS THAT PARTICIPANTS FELT SHOULD HAVE BEEN INCLUDED AT THE FORUM

- The state and federal inspector point of view should have been developed better.
- Willis Vogel.
- Lawrence Beckerle.
- Needed the dozer operator point of view.
- Needed more information on wetland mitigation.
- How this is being handled in industry.
- Needed to have a geologist to relate overburden chemistry to potential for tree rooting material.
- Needed more representation from the tree planting industry and fewer university presenters.
- More state regulators and industry.
- Acid spoils, natural succession, and ecosystem function needed to be better addressed.
- Need to educate land owners in the land use process.
- Environmental law specialist and citizen environmental group.

- How states can create positive incentives for reforestation on mined land.
- Wildlife use of forests.
- More information on how reduced grading can reduce soil compaction.
- Need to discuss the use of willow cuttings to make living stream banks to control erosion.
- Large paper and timber companies have been able to provide helpful experience.
- Potential for enhanced biodiversity.
- More on AML reforestation efforts.
- Effects of tree planting related to requirements to restore the post mining land use.
- Small private landowners should have been included.
- Some of the repetitive talks could have been eliminated.
- Representative from the University of Tennessee.

HOW DID YOU LEARN ABOUT THE FORUM?

US MAIL	24	34
E-MAIL	11	16
OSM WEBSITE	12	17
WORD OF MOUTH	36	51
PERIODICAL	2	3
NEWSPAPER	0	0

QUALITY OF MEETING FACILITY

	TOTAL RESPONDENTS	PERCENTAGE
EXCELLENT	21	35
GOOD	33	55
FAIR	6	10
POOR	0	0

COMMENTS ON FACILITY

COMPLIMENTS
- Very friendly and accommodating, good location**.**
- Nice facility.
- Meeting room comfortable, spatial distribution, and setting very good.
- They did a good job accommodating individual problems.
- Nice facility, easy access, plenty to do close by.
- The person in charge of audio recording was super.

NEED FOR IMPROVEMENT
- The lighting for slides could have been better.
- Too cold the first day was a common complaint that was not rectified.
- Confusion over room rates were common.
- Lexington, Kentucky, would have been more centrally located.

- Meeting room could have been cleaner.
- Supplies for midmorning break first day were delivered much too late.
- Pencils and pads missing first day.
- No message board.
- Very poor lighting over registration area.

APPENDIX 1: RECORDED DISCUSSIONS

Edited by Kimery C. Vories
USDI Office of Surface Mining
Alton, Illinois

The following are the edited discussions that took place at the end of each speaker presentation and at the end of each topic session. The actual comments have been edited to translate the verbal discussion into a format that more effectively and efficiently communicates the information exchange into a written format. The organization of the discussion follows the same progression as that which took place at the forum. A topical outline has been developed to aid in accessing the information brought out in the discussions.

Outline of Discussion Topics

4. Use of Field Compaction Measurement to Predict Reforestation Success

Session 4: Case Studies of Reforestation in Mining Reclamation/Success and Failure

1. Pacific Northwest
   - **Soil handling and revegetation methods**
2. Montana: Site Adapted Container Grown Woody Plants for Mine Reclamation
3. Arid and Semiarid West
   - **Importance of small native pollinators**
   - **Native nitrogen fixers**
   - **Shrub transplants**
   - **Surface rock application**
4. Texas Utilities Commitment to Reforestation
   - **Regulatory restrictions on soil handling plans**
5. Successful Forestry Reclamation in Louisiana/Mississippi
6. Successful Tree Planting Techniques for Drastically Disturbed Lands: A Case Study of the Propagation and Planting of Container Grown Oak and Nut Trees in Missouri
   - **Germination inhibitors**
   - **Reforestation of AML sites**
7. Illinois/Indiana
8. American Electric Power Company Reforestation History on Reclaimed Mine Lands
9. Mycorrhizal Fungi and Trees: A Successful Reforestation Alternative for Mine Land Reclamation
10. Kentucky Reforestation Case Study
11. Forest Productivity of Reclaimed Mined Land: A Landowner's Perspective

Session 5: Interest Group Recommendations to Enhance Reforestation

1. Eastern States Recommendations
   - **Opportunities for improvement of soils**
2. Enhancement of Reforestation at Western Surface Coal Mines
3. Coal Industry Recommendations
4. Field Inspector Recommendations
5. Academic Research
   - **Erosion control and site indices**
   - **Invasive species and biodiversity**
   - **Landowner acceptance of soil substitutes**
   - **Site index development**
   - **Tree productivity and bond release**
6. Kentucky Fish and Wildlife Resources Department
   - **Creating water and wetlands**
   - **Edge species**
   - **Endangered species**
   - **Spoil settlement**
7. Ohio Division of Forestry
8. Landowner
9. Kentucky Chapter/The Wildlife Society
   - **Removal of sediment ponds**

Interactive Panel Discussion

- **Livestock for rodent control**
- **Pond design**
- **Research for forest friendly herbicides**
- **The value of topsoil**

Discussion by Session

Session 1: Status of OSM/State Reforestation Efforts

1. <u>State Statistics on Eastern U.S. Tree Planting Efforts</u> Mike Sponsler, Indiana Division of Reclamation, Jasonville, Indiana

*Academic Question (***Wildlife habitat and forest land use***):* In the Appalachian region, it is important to separate the wildlife habitat from forest land. The wildlife habitat is primarily grasses and legumes with some shrubs in Appalachia and would not fit the definition of forest lands. In almost all of the Appalachian states less than half of the land that is mined is returned to forest. The land that is reflected in your statistics as being forest land is actually wildlife habitat that would not meet the definition of forest land.

Answer: The survey was not able to make that type of distinction. If the state did not distinguish between wildlife habitat and forestry in reporting to this survey, there is no way to check it. In the mid-continent states, the pri-marily use of lands planted to trees is wildlife habitat but then most forested areas in the mid-continent states were not in commercial forestry prior to mining.

*Industry Question (***Pre-SMCRA lands reclaimed to forestry)***:* In Indiana we have a large area of pre-SMCRA cast overburden sites that are dedicated to forestry. Are these areas, or others that are developing through natural plant succession to forestry, included in your statistics?

Answer: No.

Academic Question **(Resistance to tree planting in Illinois)***:* Recently, a small mine in southern Illinois requested that they leave the whole mine in trees, and they were told by the state that they could not do it. At another mine they tried to leave 400 acres in trees and were not allowed to do that either. Is there any way that requests like this can be approved?

Answer: I assume you are referring to the desire of local soil and water conservation districts to return land to agricultural land uses rather than to trees. If the site included prime farmland, then SMCRA precludes such land use changes. If the land is high capability cropland, then there is a lot more flexibility in land use changes.

Academic Question **(Acres permitted versus acres planted to trees)***:* Less than one percent of the acreage permitted as forest land use in Illinois has achieved final bond release. Does anyone know what the difference is between the number of acres that are permitted as forest land use and how many acres are actually being reclaimed to a viable forest land use?

Answer: The numbers for Illinois are permitted acres. I really don't know what the bond release situation is.

*Academic Question (***Wildlife habitat as forest land***):* It is my understanding that the wildlife habitat includes just about any combination of species that is not forest. This would include any herbaceous species, wetlands, etc. Should wildlife habitat be counted under the definition of forest land in the mid-continent states?

Answer: It is true that wildlife habitat can include other things such as wetlands, warm season grasses, or prairie grasses. Historically about two thirds of Illinois and Indiana were tall grass prairies prior to settlement although there has not been a very large effort on reclaimed areas to return them to prairie grasses. Because of this I felt safe in including the wildlife habitat numbers in with the forested land use although there would be a small percentage of prairie grass and wetland areas included.

2. <u>State Statistics on Western U.S. Tree Planting Efforts</u> Michael Long, Colorado Division of Minerals and Geology, Denver, Colorado

Academic Question **(Landowner preferences for revegetation)***:* You keep talking about landowner dislike of trees. Don't the coal companies have a say in what will be planted?

Answer: Yes. Landownership in the West is a mixture of ownership patterns, leased land, coal company owned, and federal land. Problems are usually on leased land where it is the federal manager or the private landowner who has the final say on land use issues. In this situation, the company may be willing to go along with the state and diversify the postmining vegetation but the landowner wants vegetation that is exclusively for livestock use.

3. OSM Revegetation Team Survey Results Dr. Scott Boyce, Office of Surface Mining, Washington, D.C.

Academic Question **(Required number of trees to plant per acre)**: I have not been able to find in SMCRA the mention of the word "tree" or the word "forest." The federal regulations say that we have to have 450 trees per acre for some uses and 250 trees per acre for others. The Department of Agriculture has a CRP program where their tree planting rates are lower than the rates required at bond release on SMCRA sites. Where did all of these seemingly magic numbers for tree planting come from?

Answer: In terms of numbers of trees per acre, there is no required number of trees to be planted per land use in the OSM federal regulations. It is up to each state to work with its appropriate forestry or wildlife agency to determine the appropriate tree planting requirements.

Academic Question **(Government agency coordination)**: The Department of Agriculture seems to be encouraging farmers to plant trees on marginal croplands while miners are being discouraged from planting trees. Why can't these government agencies get together on what we need in terms of planting trees?

Answer: I have to agree that it would be desirable to get together with the Department of Agriculture to develop incentives to planting trees on reclaimed mine lands.

Session 2: Interest Group Perspectives on Constraints, Experiences, Trends, and Needs

1. Eastern State Perspectives on Tree Reclamation Mike Sponsler, Indiana Division of Reclamation, Jasonville, Indiana

Academic Question **(Fragipan soils in southern Illinois)**: In southern Illinois, we have eroded fragipan soils. Fragipan soils by definition are dense poorly drained soils that are acidic and hostile to root growth. Yet we have a prime farmland requirement to replace these fragipan soils. You may have an A2 horizon associated with these soils that is toxic. I knew one mine superintendent that was totally frustrated because he was required to replace this material. Trees do not grow on these soils. You can spend a few thousand dollars and get corn to grow on these soils but you can grow corn on any soil if you spend enough money. Why are we doing this?

Answer: In southern Illinois and Indiana, these fragipans are definitely root constricting zones. Mining does present an opportunity to break up that fragipan. By using alternative subsoil materials and by proper handling, you can eliminate that compaction and create a mine soil that would be more productive than it was prior to mining for either trees or crops. You should restore the land in a way that maximizes options for use of the land in the future.

2. Reforestation in the Western States Michael Long, Colorado Division of Minerals and Geology, Denver, Colorado

No questions.

3. Impediments to Reforestation: Who Owns the Problem? David Finkenbinder, National Coal Association, Washington, D.C.

Academic Question **(Consensus building)**: Concerning the meetings you have described between the regulators, landowners, and industry, who would attend those? I have found that in my discussions with people who work at the mine site, what they may see as concerns and what the company management people may say at meetings like this may have little in common. So I am not really sure how useful these meetings may be if the right people are not at them.

Answer: You obviously need to have the right people at these meetings. That should be part of the outreach that goes into developing these meetings. I would agree with you that although there is no way to make the right people attend these discussions, it will not succeed unless they are there. For some reason, I have seen this happen more often related to hard rock mining than with coal mining.

Industry Comment **(Regulatory predictability)***:* We have been talking a lot about incentives and options and getting people involved, which is good; but when SMCRA first evolved it was decided that this would be good for the country. Certainly as a member of industry I appreciate regulatory certainty, knowing what is expected of me. If changes are made based on these discussions, then the regulatory requirements need to be revised so that it will be fairly and consistently carried out. It is best for the industry and the landowner to know what to expect in terms of the regulatory requirements.

4. <u>Field Inspector/Historic View of Mine Reforestation in Tennessee</u> Joseph Strange, Office of Surface Mining, Knoxville, Tennessee

Regulatory Question **(Plant succession based on width of mining cut)***:* As an inspector, I remember many pre-SMCRA reclamation sites involving outslopes. Under State law the operator was able to push 80 percent of the overburden on to an outslope. I recall a lot of black locust and tall fescue being planted and nothing else with the black locust giving way to secondary successional species. Based on what you have shown here and what you are seeing, was that not the case?

Answer: Where the cuts were not too wide, then natural reseeding has occurred no matter what the area's original vegetation was. Where the cuts were wider there is less reseeding by adjacent native trees. From my experience, cuts wider than 100 yards have not reseeded naturally from surrounding vegetation.

5. <u>Academic Research Perspective on Experiences, Trends, Constraints, and Needs related to Reforestation of Mined Land</u> James A Burger, Virginia Polytechnic Institute and State University, Blacksburg, Virginia

Industry Question **(Soil characteristics for good forest soils)***:* Considering your slide showing the differences between growing trees on a poor site, an undisturbed site, and a well-reclaimed site at about 30 years of age, what were differences between the poorly and well-reclaimed sites in terms of soil characteristics?

Answer: The well-reclaimed site is a deep uncompacted mine soil that is from 3 to 5 feet deep composed of weathered sandstone overburden that is commonly found in the Appalachians in the surface overburden layer. The material quickly breaks up when brought to the surface. It creates a good forest soil that is slightly to moderately acidic. This is the material from which the undisturbed forest soils was generated and the trees are already adapted to this material. On the poorly reclaimed sites, the surface material is made up of overburden materials that come from unweathered layers at much greater depths. They are finely textured siltstone that grow grass very well. They have a pH of around 7 to 8 which is way too high for Appalachian forest trees. Water does not infiltrate these soils quickly; they are poorly aerated; and they are fairly salty, all of which makes them poor forest soils.

Industry Question **(Overburden handling for forest soils)***:* What are some of your recommendations for the treatment and storage of this soil material?

Answer: I am not talking about A horizon material. I am talking about the overburden material that is within the first 20 feet of the surface. Although, how this material is placed at a given mine site would have to be determined by the resident mining engineer, it should not be a difficult problem to obtain 3 to 5 feet of this material from the first 20 feet of overburden.

6. <u>Perspectives Relating to the Establishment of Quality Wildlife Habitat on Mine Lands in Kentucky</u> Steve Beam, Kentucky Dept. of Fish and Wildlife, Somerset, Kentucky

No questions.

7. Ohio's Perspective: A Practitioner's View Jim Stafford, Ohio Division of Forestry, Zanesville, Ohio

No questions.

8. Reforestation: A Landowner's Perspective Timothy Probert, Pocahontas Land Co., Bluefield, West Virginia

No questions.

9. Wildlife Perspectives in Reclamation Robert M. Morton, Kentucky Chapter of the Wildlife Society, Corydon, Kentucky

No questions.

Session 3: Status of Reforestation Technology

1. Status of Reforestation Technology: The Appalachian Region Dr. James A. Burger, Virginia Polytechnic Institute and State University, Blacksburg, Virginia

Academic Question **(Relative acidity with sandstone substrate)***:* Is the use of this weathered sandstone as the soil substrate compatible with getting water quality of pH 6.5 or greater as that is the requirement in Ohio?

Answer: I do not know the complete answer to that. We are still concerned about and looking at that.

2. Status of Reforestation Technology and Science in Southern Illinois Dr. Clark Ashby, (Emeritus) Southern Illinois University, Carbondale, Illinois

Question **(Site index)***:* As I have read the soil survey reports, soil types that have forest cover have a higher site index whereas the shallower, rocky soils have a lower site index. Why can't that carry through the reclamation process if the soil is properly replaced?

Answer: I think it could be, but if you look at prime farmland in southern Illinois, my question is whether or not it really is prime farmland. We need to be more careful in the classification of what is or is not prime farmland. If you really did have good prime farmland, you should have a high site index for trees.

Question **(Planting methods)***:* Concerning plant mortality in the cast ungraded overburden, do you experience higher levels of mortality because of the looseness of the soil materials? What planting methods work best in these types of material (containerized seedlings, bare root, etc.)?

Answer: Although we tried containerized seedlings, we prefer to plant bare root or direct seeding. There are areas when you have very sandy soils where the plants get washed out, but most of the material is quite rocky and has a silty to silty clay loam texture. It is fairly firm, and we do not have a problem with the trees being washed out.

3. Status of Reforestation Technology in Kentucky Dr. Don Graves, University of Kentucky, Lexington, Kentucky

No questions.

4. Use of Field Compaction Measurement to Predict Reforestation Success Dr. Richard Sweigard, University of Kentucky, Lexington, Kentucky

No questions.

Session 4: Case Studies of Reforestation in Mining Reclamation/Success and Failure

1. Pacific Northwest Glen Waugh, Office of Surface Mining, Olympia, Washington

State Question **(Soil handling and revegetation methods)***:* What were the soil handling and vegetation methods that helped most with the mines successful reforestation?

Answer: They do not have any toxic spoil materials. They have a very specific herbicide program to kill back the herbaceous species for one or two growing seasons prior to planting the trees. I do not remember any special soil handling techniques. They do not have any compaction problems with the sandstone subsoils. They do rip the herbicide strips prior to tree planting. The subsoil tends to be fairly loose.

2. Montana: Site Adapted Container Grown Woody Plants for Mine Reclamation Len Ballak, Bitteroot Restoration Inc., Corvalis, Montana

No questions.

3. Arid and Semiarid West Vernon Pfannenstiel, Peabody Coal Co., Flagstaff, Arizona

Academic Question **(Native nitrogen fixers)***:* I only heard you mention one native nitrogen fixing plant, snowberry. Have you tried any others?

Answer: No. We are using native species that are adapted to a low fertility environment. In these arid locations, if you apply any kind of extra fertilizer it is the kiss of death because the grasses and weeds take over rather than the native species that will occupy the site long term.

Academic Question **(Shrub transplants)***:* Please explain your strategy for establishing transplants of woody species.

Answer: This type of system was pioneered at the Trapper Mine in northwestern Colorado. They dig up root spouting shrub clumps with a backhoe to a depth of one to two feet and replace them in the reclaimed area and pack some soil around them and water them once with a water truck to get them started. By the next year there is quite a bit of expansion by root sprouting. It is expensive but it gets the species that you want started back on the site.

Academic Question **(Surface rock application)***:* When you hall the rocks back on some sites do you also haul topsoil?

Answer: No, we do not put topsoil back on the rocky sites. In some cases, we bring in rock scoria over the subsoil so that it will be more like the natural conditions.

Academic Comment **(Importance of small native pollinators)***:* It was interesting to see that you found some of the small unvegetated sites were important; we also have found that this is important for recruitment of woody plant species, as well as for native pollinators, many that nest on the ground. We need to encourage these small pollinators. In our studies we found most of these small pollinators utilized the erosion gullies and were not found where there was a complete grass cover.

Answer: I think this points out that erosion is not always bad. Some of what we thought were going to be our worst areas turned out to be some of our best because they developed more naturally due to the lack of competition from planted vegetation. We were able to get better vegetation in the long run on these sites.

4. Texas Utilities Commitment to Reforestation Sid Stroud, Texas Utilities Services, Dallas, Texas

Academic Question **(Regulatory restrictions on soil handling plans)***:* What type of regulatory restrictions do have on soil mixing and placement?

Answer: These decisions are ultimately determined by the Texas regulatory authority. Texas Utilities has done extensive studies on our overburden materials. These materials range from heavy clays to carbonaceous clays, acidic materials, deep sands, and gravels. We do an extensive stratigraphic overburden evaluation. We select the best available materials within a given mine area and develop overburden handling methods based on our stripping methods and meet our need to obtain plant growth media at least as good or better than that found in the premining condition. We have been very successful at getting approval for our soil handling plans using this method.

5. Successful Forestry Reclamation in Louisiana/Mississippi Marty Walker, North American Coal Corp., Ackerman, Mississippi

No questions.

6. Successful Tree Planting Techniques for Drastically Disturbed Lands: A Case Study of the Propagation and Planting of Container Grown Oak and Nut Trees in Missouri Stuart Miller, Missouri Land Reclamation Program, Jefferson City, Missouri

Regulatory Question **(Germination inhibitors)***:* You made reference to the allellopathic effects of tall fescue. Are there other species that have this same effect?

Answer: I know from the literature that there are some problems with annual rye, walnuts, and tomatoes. I have noted in the field that there seems to be some effect of pine duff that inhibits other vegetation but we need research to support this.

Regulatory Comment **(Reforestation of AML sites)***:* I would like to emphasize to the people involved with AML programs that the message presented here is that you do not need federal OSM approval to experiment with ways to improve reforestation. Alabama is a classic example in that they have made a commitment to reforestation by reforesting hundreds of acres through their AML program. This is a golden opportunity to use the present technology and funds to plant trees on AML sites.

7. Illinois/Indiana Chris Liebering, Liebering and Sons Reforestation, Lamar, Indiana

No questions.

8. American Electric Power Company Reforestation History on Reclaimed Mine Lands Gary Kaster, American Electric Power Land Management, McConnellsville, Ohio

No questions recorded.

9. Mycorrhizal Fungi and Trees: A Successful Reforestation Alternative for Mine Land Reclamation C.E. Cordell, PHC Reclamation, Asheville, North Carolina

No questions recorded.

10. Kentucky Reforestation Case Study Dan Williamson, Kentucky Reclamation Association, Madisonville, Kentucky

No questions.

11. Forest Productivity of Reclaimed Mined Land: A Landowner's Perspective Timothy Probert, Pocahontas Land Co., Bluefield, Virginia

No questions.

Session 5: Interest Group Recommendations to Enhance Reforestation

1. Eastern States Recommendations Mike Sponsler, Indiana Division of Reclamation, Jasonville, Indiana

Academic Question **(Opportunities for improvement of soils)***:* Because many of the soils that we have prior to mining have been historically mismanaged and no longer have the good topsoil material they had prior to farming, do we really want to restore it as is or should we try and use the mining operation as an opportunity to make it better for future generations? Southern Illinois has very old soils that are not very productive in comparison with the young glacial soils of northern Illinois, why shouldn't we give them a boost in productivity by using fresh overburden materials for root growth media?

Answer: I would agree with you and when I say to put back suitable soils that does not preclude the use of alternate materials. This is being done by Arch of Illinois with their bucket wheel technology that has created superior soils after mining. This is good for agriculture and for forestry. The regulations require that the operator make a demonstration that the alternative is better than the original soils then that is what should be used. There are areas in southern Illinois that have poor soil conditions like fragipans, and there are ways to overcome those problems. There also are areas that have good preexisting soil materials that will grow crops or trees if they are replaced properly. The flexibility is already there to do what you suggest. If some operators are improperly replacing and handling their soil resources in a way that produces a compacted unproductive soil then I do not agree with that. We should be planning for putting back the optimum soil.

2. Enhancement of Reforestation at Western Surface Coal Mines Ronald Daniels, Utah Division of Oil, Gas, and Mining, Salt Lake City, Utah

No questions.

3. Coal Industry Recommendations David Finkenbinder, National Coal Association, Washington, D.C.

No questions.

4. Field Inspector Recommendations Vic Davis, Office of Surface Mining, Knoxville, Tennessee

No questions recorded.

5. Academic Research Dr. James Burger, Virginia Polytechnic Institute and State University, Blacksburg, Virginia

Regulatory Question **(Tree productivity and bond release)***:* You mentioned changing the revegetation success standards, and you have demonstrated methods for measurement of mature forests; then your last recommendation was that we create incentives for bond release. Are these two suggestions working against each other?

Answer: This is not a good comparison, because the fundamental purpose of SMCRA is to return land back to its original level of productivity.

Industry Question **(Site index development)***:* I agree with your concerns about measuring forestry success by counting stems. I have problems equating that with what we get on crops or pasture. These crops are planted with standardized equipment and standardized methods. The problem is that I don't know how you can develop a valid site index within the five year liability period.

Answer: I think it should be done through the development of a mine soil quality index. If you know the soil quality is there based on the properties of the soils then you do not need any type of bioassay. Because trees take so long to grow, foresters have developed natural soil quality indices that are surrogates for the site index. There are hundreds of those types of studies that were done back in the 1950s through the 1970s. I have even done some of this for mine soils and have a pretty good initial model that is very promising. It can be done.

Industry Comment **(Landowner acceptance of soil substitutes)**: On the promotion of soil substitutes, if the incentives that are developed out of this forum that promote soil substitutes are enforced, I can take that to a landowner. If I take something I have developed on my own, I will have big problems with my landowners. If there are soil substitutes that are determined to be better than topsoil, then the regulator needs to be standing there with me when I am discussing this with the landowner and his expectations what his land will look like at bond release.

Inspector Question **(Erosion control and site indices)**: The obstacles to planting trees effectively seemed to include the 9 inch rill and gully rules. The operator wants to keep from having a 9 inch gully which makes tree planting secondary to the establishment of an aggressive erosion control cover. If we can get past the need for the 9 inch rill and gully rule on forest land uses, then perhaps we can have a companion provision in the revegetation requirements where we could have a lower minimum number of trees planted and that a certain number of them would have to reach a minimum height at the end of the responsibility period as a productivity standard.

Answer: I think that the 9 inch rill and gully requirement is going by the wayside in most states. I also think that people in mining are beginning to realize that less is more in terms of less herbaceous cover is better for trees. Also, we need to realize that there is not a problem with a little erosion as long as it is not compromising water quality or becoming a burden on the operator in terms of the need to dredge out sediment ponds. The idea of using trees as an indicator of site productivity is a little tricky. I had proposed using white pine as a site indicator be-cause it has the unique property of a 1:1 growth rate. I do think that there is a lot of promise in using a mine soil property index to evaluate the site capability.

Academic Comment **(Invasive species and biodiversity)**: We now have an executive order that we should fight the establishment of invasive species on our lands. It would seem that eventually these concerns should be incorpo-rated in the regulations to prevent species like autumn olive and other exotic species from being planted on reclaimed lands as has been done in the past. Second, there has been some discussion about increasing ecological function and biodiversity on reclaimed lands. When the target is not production forestry but habitat, then there must be a landscape perspective. Even the most concerned land manager could only introduce through active plantings perhaps a dozen species where a more representative biodiversity would be order of magnitude greater than that. Whether these species can invade at a later time depends in large part on how large the aerial extend of the mine site. As we move from a few hundred, to thousands, to tens of thousands of acres, it strikes me that the ability to invade to a premining biodiversity really is challenged. What are the effects of scale on these invasion processes and the potential to get back to a more natural biodiversity?

Answer: I can not address the question of scale. It has been shown fairly conclusively that if the land has been restored in a productive state, natural succession processes are much faster both temporally and spatially and in terms of composition. As land quality increases and productivity increases, then so does every other ecosystem function, which should include biological diversity.

6. <u>Kentucky Fish and Wildlife Resources Department</u> Steve Beam, Kentucky Department of Fish and Wildlife, Somerset, Kentucky

Academic Comment **(Edge species)**: Concerning edge species, in southern Illinois edge has become a bad thing related to cowbirds parasitizing song birds.

Answer: The reason we are talking about edge in Kentucky is because the mining regulations say the operator must optimize edge when replacing fish and wildlife habitat. We have promoted edge historically because of its use by game species. Now we are having to throw on the brakes because there are a lot of species for which edge is very detrimental.

Academic Comment **(Endangered species)**: In southern Illinois, the coal companies are selling their land as fast as possible because of concerns about possible difficulties, if rare or endangered species are found there. Also, concerning perch poles, this was tried by the operators about ten years ago with the result that people were coming along and shooting the hawks off of the perch poles. The perch poles were making the hawks very visible and easy targets. What the operators are doing now is to mow lanes so that the rodents are without cover as they cross the lanes which gives the hawks and owls a chance to catch them.

Answer: The issue of endangered species. We are talking about making an area better for wildlife habitat. You may at some point benefit some endangered species. Usually the potential for problems for a mining company comes when they first permit an undisturbed area and have to conduct a survey for endangered and threatened species.

Academic Comment **(Spoil settlement)***:* Considering the spoil settlement, some of these areas are quite unstable and settle considerably as a function of thickness and age. Many of the talks today have shown reforestation of very flat areas, over time these areas will settle up to about 1.5 feet per year during the early years. This creates depressions. When you plant trees on this type of flat area, these depressions have the potential to flood with water and drown the trees. I have had consultants come to me because they can not get bond release because of the wet depressions. I would recommend that, in addition to your emphasis on minimizing compaction, we look at developing a rolling topography or internal drainages that would allow this water to run off the site.

Regulatory Comment **(Creating water and wetlands)***:* Concerning your recommendation that we make water available on these forested sites, OSM not only allows but encourages the conversion of sediment ponds, impoundments, and the leaving of depressions to be converted into wetlands. A couple of years ago we published a directive (TSR 14) that tells how to do that. That option is available.

7. Ohio Division of Forestry Jim Stafford, Ohio Division of Forestry, Zanesville, Ohio

No questions.

8. Landowner Timothy Probert, Pocahontas Land Co., Bluefield, West Virginia

No questions.

9. Kentucky Chapter/The Wildlife Society Robert M. Morton, Kentucky Chapter of the Wildlife Society, Corydon, Kentucky

Academic Question **(Removal of sediment ponds)***:* I don’t know why the operators have to take out their sediment ponds. This is also the case in southern Illinois. Also, I have seen operators removing contour terraces. Why is this the happening?

Answer: In most of the cases I am familiar with, the sediment ponds were never approved in the permit to be retained after mining and reclamation. They were just designed for temporary use and could not meet the requirements to be included in the final bond release. I have no knowledge concerning the removal of contour terraces.

Answer: What you are usually seeing is that any impoundment that will be retained after mining and reclamation must be constructed to safely pass a particular designed flow of water. Since the impoundments were not constructed to pass the design flow for a permanent structure, the operator has the choice to make the changes so that is will meet the design flow standards for a permanent structure and will not be hazard in terms of its likelihood to wash out or to remove the structure. So it is usually an operator choice to upgrade the discharge structure or remove the pond. There is no bias in SMCRA against leaving ponds.

Answer: The landowner must also be willing to take over maintenance of the pond. Some land owners are not interested in taking on the maintenance of the ponds.

Participant Interactive Discussion

Industry Comment **(The value of topsoil)***:* From a midwestern standpoint, I would have a problem with any loss of topsoil in this region. The topsoil in this region is a very valuable agricultural resource that should not be wasted. Topsoil has been under assault ever since the beginning of SMCRA. I have witnessed thousands of acres of land in Indiana grandfathered under SMCRA that were then turned upside down. I saw an entire topsoil stockpile, including the topsoil marker sign, thrown into a pit one Sunday morning. Things like this have gone on for the last 20 years. I can support many of the incentives that I have heard talked about at the forum, as long as they are done on a site specific basis rather than broad brush. If topsoil substitution with overburden and minimal grading was applied across the board, we would be turning the clock back to pre-SMCRA days.

Why are we not able to have land use trading credits in the same way we have emission credits? If we have a company that is good at replacing crop land and pasture and another company that is better at replacing forests, maybe these companies could get together and trade land use credits.

Academic Comment **(Research for forest friendly herbicides)***:* What can OSM or anyone else do concerning conducting the necessary research to develop forest friendly herbicides?

Academic Comment **(Pond design)***:* West Virginia recently passed some new requirements for ponds and dams. I noticed that the previous ponds put in under the Soil Conservation Service are now considered to not be in compliance because they no longer meet the requirement for an adequate spillway.

Academic Comment **(Livestock for rodent control)***:* I would like to suggest that by using livestock to graze the areas planted to trees during the winter months when the trees are dormant, we may do more to reduce the rodent population than we can do with hawks and owls.

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