OHIO'S ABANDONED MINED LANDS REFORESTATION PROGRAM: A DECADE OF SUCCESS[1]

by

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Abstract. Millions of acres of abandoned mined lands (AML) in the United States are in need of reclamation. Ohio alone contains 200,000 acres of inadequately reclaimed strip mines. It is impracticable to restore all of these sites, at current funding levels, using traditional reclamation practices.

Alternatives for stabilizing strip mines at less cost than full-scale reclamation are available. Reforestation, for example, requires no site preparation such as earth moving or soil amendments necessary for successful establishment of grass/legume cover. Reforestation has worked well in Ohio and can work in other states' AML Programs.

Ohio's Division of Reclamation AML Section has been utilizing reforestation since 1981 as a cost effective and low maintenance alternative to traditional reclamation techniques. The cost to reforest one acre of AML averages $300; in contrast, complete site restoration averages $7,000. During the past ten years 2.7 million tree seedlings have been planted in Ohio to stabilize 1,786 acres of unreclaimed AML sites. Much of Ohio's reforestation success is attributed to the extensive use of mycorrhizal seedlings, specifically seedlings inoculated with the ectomycorrhizal fungus *Pisolithus tinctorius*.

Introduction

Millions of acres of abandoned mined lands (AML) in the United States are in need of reclamation. Based on the 1990 Abandoned Mined Lands Inventory, it would cost approximately $3 billion to correct AML health and safety problems nationwide (OSMRE 1990). In addition, an estimated $57.8 billion will be required to reclaim environmental problems assigned third priority by Section 403 of the Surface Mining Control and Reclamation Act of 1977 (SMCRA) (Bureau of Mines 1979). Ohio alone contains 200,000 acres of inadequately reclaimed strip mines. It would cost $1.5 billion to restore these areas utilizing traditional grading, resoiling, and revegetating methods (Ohio AML 1986). At Ohio's current funding level ($3-4 million annually) restoring all 200,000 acres using traditional techniques seems improbable.

Since the enactment of SMCRA in 1977 (Public Law 95-87) active strip mine reclamation has focused on grading to approximate original contour, replacing topsoil, and establishing a dense herbaceous cover to quickly control erosion, thus assuring prompt bond release. Today, reforestation may not play a significant role in the reclamation phase of active operations, but it can be successfully utilized as a reclamation "tool" by AML Programs.

Reforestation is not a new or innovative idea but it is something that deserves renewed consideration. Planting trees on mined land is a good idea that was abandoned, perhaps too readily, during the time period in which were developed, regulations and policies following the enactment of environmental laws passed in the 1970's.

The purpose of this paper is to highlight significant aspects of the AML Reforestation Program and to provide some insight into its evolution as a viable reclamation tool in Ohio.

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Ohio's Reforestation Program

Enthusiasm for reforestation of AML areas was sparked in 1981 when the Office of Surface Mining Reclamation and Enforcement, in cooperation with the state governments of Ohio and Indiana and the U.S. Forest Service, initiated a research development, application, and demonstration project to determine the benefits of planting *Pisolithus tinctorius* (P.t.)-inoculated pine tree seedlings on AML reclamation sites in Ohio (Wolf et al. 1982).

Consequently, Ohio's first "reclamation through reforestation" project was undertaken, a decade ago, in the spring of 1982. A total of 59,000 pine seedlings were planted at a 5-by 5-foot spacing on 33 acres of barren coal spoil. Since then, a total of 2.7 million tree seedlings comprised of both pine and hardwood species have been planted on 1,786 AML acres.

In the beginning, many of Ohio's AML personnel considered tree planting as secondary to traditional reclamation. If the tree seedlings survived, they would serve only to supplement vegetative diversity or contribute insignificantly to the reclaimed area's stability. In other words, reforestation would have very limited application.

As is the case in many biological field studies, the results obtained from this demonstration project were not what was initially anticipated (Figure 1). The goals and priorities of the Reforestation Program have evolved into planting tree seedlings as a cost effective and low maintenance reclamation method on disturbed sites that contribute minor quantities of sediment to streams, degrade esthetics, lack adequate ground cover, and are not eligible for traditional reclamation techniques (major grading, resoiling,

Figure 1. Planted in 1984, these P.t.-inoculated pines have done exceptionally well in mine spoil with 3.1 pH (photo 1989).

and revegetating) under federal AML guidelines (Caldwell 1987).

Reforestation has also been utilized in combination with other minimal reclamation techniques to address more highly erosive areas. Incorporating rapid growth ground cover, water tolerant grass and legume species (for saturated spoils), and sediment control structures along with reforestation has allowed the reclamation planner to subdivide sites into smaller units and address the requirements of each. Significant cost savings have been realized by implementing these coordinated techniques.

To date, the Reforestation Program has expended approximately $532 thousand to purchase and plant tree seedlings on 1,786 acres (at an average cost of $300 per acre). In comparison, traditional reclamation of these same 1,786 acres would have cost $12.5 million (an average cost of $7000 per acre). The reforestation alternative in Ohio resulted in a 96 percent reduction in potential reclamation expenditures (Caldwell 1990).

Reforestation Site Eligibility and Species Selection

Reforestation Site Eligibility

Prior to initiation of the Reforestation Program, a variety of sites were selected to determine the site conditions most conducive to P.t.-inoculated seedlings. The Reforestation Program objectives were to focus on areas unlikely to be funded for traditional reclamation. At the same time, there was growing interest in the potential use of P.t.-inoculated seedlings on amended spoils. The selection of a wide range of sites for field study plots was done to develop guidelines for future planting sites (Caldwell 1987).

Several significant conclusions resulted from these early trial-and-error plantings. As previous research results had suggested, P.t-inoculated seedlings responded exceptionally well on barren spoil material. However, planting sites that were poorly drained or alkaline (above pH 6.3), or that contain phytotoxic refuse and/or sludge amendments either inhibited or killed both the P.t. ectomycorrhizal fungus and its host seedlings. Planting sites with high fertility, especially high phosphorous (P) levels, tended to mask the P.t. benefits. In addition, competing ground cover can be so overwhelming that establishment of any tree seedling species is almost prohibitive unless the ground cover is suppressed prior to tree planting (Cordell et al. 1986).

Based on the results of these early field studies, which are consistent with the program goals, the following four criteria have been developed as general guidelines for determining site eligibility for areas being considered for reforestation efforts:

1. The proposed site was mined prior to April 10, 1972. This includes strip mined areas, gob piles, and industrial mineral sites.

2. Currently the site has very little, if any, vegetative cover. Therefore, the site is either devoid of any vegetation and is eroding, or if vegetation is present, it is not established well enough to stabilize the site and is insufficient to control off-site degradation.

3. No remining potential exists, and no full-scale reclamation efforts (grading, resoiling, and seeding) are proposed or likely to occur on the site.

4. Off-site damage (i.e., sedimentation) has resulted from the site's present condition.

Species Selection

Of the 2.7 million seedlings planted in Ohio since 1982, 2.14 million have been P.t.-inoculated Virginia pine (Pinus virginiana), eastern white pine (P. strobus), pitch X loblolly pine (P. rigida X P. taeda), and red (Quercus rubra) or black oak (Q. velutina). Of the remaining seedlings, black locust (Robinia pseudoacacia) and European black alder (Alnus glutinosa) have been the predominant species. Prior to 1985 nearly all of the seedlings planted were P.t.-inoculated conifers. During 1985 and 1986 one-half of the seedlings were noninoculated. During this period the primary objective was to increase the biological diversity of the plantings by determining which noninoculated species could survive and grow on the harsh sites. Following initial success, the seedling treatment type increased to an 80:20 (P.t.- inoculated: noninoculated seedling) ratio in 1987. Today, we utilize a combination of 75 percent P.t.-inoculated conifer and hardwood seedlings together with 25 percent black locust, European black alder, bristly locust (R. fertilis), sweetgum (Liquidambar styraciflua) sycamore (Platanus occidentalis), green ash (Fraxinus pennsylvanica), or autumn olive(Elaeagnus umbellata). The ultimate goal is to incorporate 30 percent of the total seedlings as P.t.-inoculated northern red oak (Figure 2). Since 1986 an average of 320 thousand seedlings have been planted each spring.

Figure 2. This two year old P.t. northern red oak is one of 85,000 oaks established on AML. Oaks have proven to be excellent P.t. host species.

Planting Sites

Ohio's 137 reforestation sites are located in 20 of the 28 counties containing abandoned mined lands. The planting sites range in size from two to 75 acres. There are several reforestation areas that exceed 200 acres and are being planted in subdivided units. This allows for additional smaller sites to be planted in different locations within the state during the same year. Typically, the planting sites are barren, moderately eroding strip mines (95%), coal refuse piles (4%), or industrial mineral sites (1%). As might be expected, the majority of Ohio's planting sites are "bench" areas. Nevertheless, outslopes of 2:1 or steeper are commonly encountered and planted. Of the 137 sites, 85 percent have had no mechanical alterations or improvements since mining. The remaining planting sites consist of areas mined under Ohio's Interim Regulatory Program, forfeited permits, and several reclaimed AML project sites. More than 95 percent of the sites are hand planted due to their irregular topography. The mean chemical characteristics of a reforestation site are 2.9 pH, 19.4 ppm phosphorous, 129.6 ppm potassium, and 2,062 ppm calcium.

It was apparent from field observations made during the first few years of the program that using quality P.t.-inoculated seedlings and planting on close spacings could effectively control erosion from the AML area. While somewhat postponed, tree crown closure and root contact can nevertheless be expected to occur within five to ten years. Scheduled field study measurements and routine planting site observations suggest that at least 85 percent of the seedlings planted to date have been successfully established.

Case Study: The Paxton Reforestation Site

The Paxton site is an eight acre tract of AML located three miles north of New Lexington, in Perry County, Ohio. The site is bordered by mixed hardwoods planted by a mining company in the 1950's. Adjacent land uses are pasture and recreation.

Mining at the site occurred in the late 1940's and early 1950's. The #5 and #6 Coal, Lower and Middle Kittanning, were mined. The site was partially graded or "contoured" and it gently slopes to a self-contained 1/4 acre impoundment created by the final mining cut. A partially backfilled highwall has 2:1 slopes. The mine spoil is black in color and consists of various sized fragments of predominantly siltstone, sandstone, and shale with some coal and carbonaceous shale. The site was devoid of vegetation except for small patches of poverty grass (Graminae), one black oak, and several aspen trees (Populus sp.). The chemical characteristics of the coal spoil are 2.8 pH, less than 1 ppm phosphorous, 32.5 ppm potassium, and 145 ppm calcium.

The site was hand planted in March, 1986, with P.t.-inoculated Virginia and eastern white pines and non-inoculated European black alder, black locust, silky dogwood (Cornus amomum), gray dogwood (C. racemosa), and tatarian honeysuckle (Lonicrea tatarica). All seedlings were planted on a 5-by 5-foot spacing. The P.t.-inoculated pines comprised 70 percent of the seedlings planted and were evenly distributed throughout the site. One black locust was planted for every eight pines. One thousand black alder were planted in a seasonally-wet depression adjacent to the water impoundment. The three wildlife species (two dogwoods and honeysuckle) were planted in "pockets" to provide biological diversity and a food source for wildlife.

Initial first-year observations of the planted seedlings showed excellent success for all species. During the spring of 1987 observations, however, the P.t.-inoculated pines, locusts and alders appeared healthy and vigorous, while the three wildlife species were alive but chlorotic and stunted. The wildlife species continued to decline throughout the summer of the second year and by the spring of 1988 virtually all 1,500 seedlings were dead. Conversely, nearly 100 percent of the P.t.-inoculated pines were living along with approximately 75 percent of the alder and locust. A permanent circular field study plot was established in January, 1988 to monitor the survival and growth of the P.t.-inoculated Virginia pines (Figure 3). Data collected on this plot in March, 1992, after six years in the field, showed a tree survival of 98 percent, mean basal diameter of 5.14 cm, and mean height of 289.6 cm.

Figure 3. Two-year-old P.t.-inoculated Virginia pines planted in Noble County mine spoil with a pH of 2.6.

The Role of the Ectomycorrhizal Fungus Pisolithus tinctorius

Ectomycorrhizal fungi develop a beneficial symbiotic relationship primarily on conifers and certain hardwoods. The fungus develops on the host tree for simple carbohydrates, amino acids, and vitamins necessary to complete its life cycle (Marx 1976). This symbiotic association between the tree's fine feeder roots and the fungus benefits the host tree by increasing its tolerance to low pH, high levels of soluble phytotoxic microelements, extended moisture stress, high soil surface temperatures, and very low nutrient availability -- typical characteristics of abandoned strip mine sites in the eastern United States (Cordell et al. 1987). As a result of field observation in the 1960's along with studies by other research scientists, it has been repeatedly demonstrated that Pisolithus tinctorius is the most beneficial ectomycorrhizal fungus for use in reforestation of abandoned strip mined lands (Marx 1976).

The natural invasion and spread of P.t. by wind and water dissemination is a slow process. Therefore, in 1975, under the direction of Dr. Donald Marx, USDA Forest Service, a vegetative mycelial fungus inoculum of P.t. in a vermiculite peat moss nutrient substrate was produced and provided successful artificial inoculation of selected pine seedling species in fumigated nursery soils (Marx 1975). Since 1982, the P.t. vegetative mycelial inoculum used in Ohio's Reforestation Program has been commercially produced by Mycorr Tech, Inc. in Pittsburgh, PA. Mycorr Tech is currently the sole commercial producer of P.t. vegetative mycelial inoculum in the United States. This company consistently provided the high quality fungus inoculum required to grow the P.t.-inoculated customized seedlings for the Ohio Reforestation Program.

A machine was also developed by the USDA Forest Service in 1979 to effectively and efficiently apply inoculum in nursery seedbeds. The mycorrhizae inoculator machine is utilized in conjunction with a precision seeder to further improve nursery seedling quality and quantity.

Discussion: Reforestation and the Reclamation Strategy

In 1982 a research project was initiated to determine the possible applications of P.t.-inoculated seedlings for reforestation on AML in Ohio. By taking that initial step, Ohio's AML Section has been provided the opportunity to incorporate reforestation in its overall reclamation strategy. In the past, countless reclamation approaches have been explored to restore productivity to these areas. We know from experience that no single solution can be applied to all reclamation problems with 100 percent success. This is true for reforestation as well as traditional reclamation techniques.

However it is possible, practical, and profitable to combine reforestation with other reclamation techniques to address specific problem areas of a site or even a watershed. During the past five years, Ohio has incorporated rapid growth ground cover, water tolerant grass and legume species, and various sediment control structures with reforestation at considerable cost savings.

In 1991 the Reforestation Program expended $82 thousand to purchase and plant 324 thousand seedlings. This represents a considerable, highly significant cost reduction as compared to traditional reclamation projects. As funding levels decline and priorities shift, it becomes increasingly necessary to analyze future reclamation projects from a somewhat different perspective. It is now clearly evident that long-term planning, in conjunction with the utilization of available "state-of-the-art" technology, will stretch the reclamation dollar and result in more AML acres returned to productivity.

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