REFORESTATION OF MINED LAND FOR PRODUCTIVE LAND USES AND ENVIRONMENTAL QUALITY

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PROGRESS REPORT (2002-2003)

PROJECT OVERVIEW

Mined land reforestation and forest land uses of mined land are becoming more important to landowners and the public in Southwest Virginia as we demonstrate the economic value of mined land forests and the role they play in flood control, water quality, biodiversity, and carbon sequestration. During the year (2002-2003) our forestry research and outreach program has made good progress toward our goals of forest restoration on mined land.

Several of our research study sites are now over 20 years old. They are at an age that shows convincingly that properly reclaimed and reforested mined land can be very valuable and productive. A technical article based on one of our Powell River Project research sites is featured as part of this report (attached). It shows that mine soils can be as productive as high quality undisturbed soils.

Ted Auch, a Master of Science student in the Virginia Tech Forestry Department, is completing a five year assessment of our native hardwood establishment trial, the plots of which are located in Virginia, Kentucky, and West Virginia. Some of the results were published in the proceedings of the annual meeting of the American Society for Mining and Reclamation. This work shows the importance of mine soil quality on reforestation success.

With the help of Red River Coal Company, we installed a major hardwood trial adjacent to the PRP demonstration area. This trial will address the use of herbicides for reducing ground cover effects on trees, and the trade-off between erosion control and tree survival. These trees are in their second growing season. They consist of a mixture of native hardwood species and wildlife shrubs.

Fifteen years ago we established a 3-acre sugar maple “sugar bush” plantation on the PRP demonstration area. This winter we installed a replicated study investigating the benefit of husbandry practices including fertilization and weed control. This study will demonstrate the management practices needed for the care and culture of trees for maple syrup production.

A major outreach activity was the establishment, last year, of an 80-acre native hardwood planting on Rapoca Coal Company land. This cooperative effort between Rapoca, Virginia Tech, and the Virginia DMME will serve as a model for the application of Powell River Project reforestation guidelines. This year we established test plots within the area across a gradient of site quality classes. We will monitor tree survival and growth as a function of site quality class. Thanks go to Carol Zipper, John Galbraith, Pat Donovan, Bill Wampler and other folks with Rapoca Coal and DMME for their help with project.

Why is it important to restore forests on mined land?

The land and coal in this predominantly forested region are finite, and when coal passes as the economic mainstay, mined land, if properly reclaimed and managed, will support the renewable and sustainable resources of forests, watersheds, and wildlife, all of which will play increasingly important roles in the economic, environmental, and social health of the region.

The surrounding native hardwood forest of the central Appalachians is one of the most diverse, productive, and valuable temperate forests in the world. In the past five years there has been a major resurgence in the hardwood timber and wood-using industries throughout the coal fields region. Furniture, flooring, and paneling are made from many fine hardwood species, while softer woods are used for plywood, oriented-strandboard, and wood pulp. "Soft hardwoods" such as tulip poplar, red maple, and bigtooth aspen, all of which have good potential as reclamation species, are being sought along with the traditionally-valuable species such as the oaks. With this new and potential market for timber, owners of mined land, who were once content to have their land reclaimed to grassland and shrubland, are keenly interested in reforestation with commercially-valuable hardwoods.

The public at large is also concerned about the environmental effects of land use change caused by mining. USDA Forest Service inventories show that about 25,000 acres per year are being converted from forests to abandoned grassland in the Central Appalachian Region. According to scientists with the U.S. Fish and Wildlife Service, Environmental Protection Agency, and Army Corps of Engineers, watershed hydrology, stream water quality, and wildlife habitat are being degraded in the process.

Furthermore, conversion of forests to abandoned grassland and shrubland increases the contribution that mining makes to net emissions of CO_2 to the atmosphere. Re-establishing forests is a way to produce a significant carbon sink to offset carbon emissions from burning coal. With officials from OSMRE and DOE, we are currently exploring market-based carbon-credit incentives to encourage reforestation by the mining and utilities industries.

What are the benefits of this reforestation research?

The people of the Appalachian region will always depend on its forest resources for socio-economic well-being. The importance of the timber industry is increasing. Worldwide demand for Appalachian timber will increase as the U.S. Forest Service reduces its harvest on national forests. Demand for forest products will create significant opportunities for the owners of Appalachian forest land. Timber harvesting and value-added opportunities in sawmills and wood processing plants will help diversify the economy. Much of this forestry activity will occur on reclaimed mined land. Economic analyses have shown that the economic return on mined land reclaimed according to guidelines based on PRP research can be several times higher than land currently reclaimed to unmanaged land uses. While improving the value of mined land for the landowner, coal operators benefit through more timely and successful recovery of performance bonds, and local communities benefit from land reclamation that improves water quality, reduces flooding potential, is more aesthetically pleasing, and more valuable for a diversifying economy.

CURRENT RESEARCH ACTIVITIES: 2002-2003

1. ***Woody species diversity, forest and site productivity, stumpage value, and carbon sequestration of forested mined lands reclaimed prior to SMCRA***

- This PRP project was completed by Jason Rodrigue, a PRP-funded graduate student. Much of his work has been published. During the past year we have worked on the following publications that are in review with scientific journals.

  Rodrigue, J. A., and J. A. Burger. 2001. Forest soil productivity of mined land in the midwestern and eastern coalfield regions. Currently under review by *Soil Science Society of America Journal.*

  Rodrigue, J. A., and J. A. Burger. 2001. Woody species diversity on mined land in the Midwestern and eastern coalfield regions. Currently under review by *Forest Ecology and Management*.

2. ***Hardwood establishment field trials:***

- This is a large study with 10 three-acre sites located in three states. We completed tree, ground cover, and site measurements for 7 continuous years. A preliminary analysis of this project was presented and published at the annual meeting of the American Society of Mining and Reclamation in Lexington, KY in 2002. Ted Auch, a Powell River Project graduate student, is in the process of collecting data on 10 sites:

  Burger, J. A., D. A. Scott, and D. O. Mitchem. 2002. Field assessment of mine soil quality for establishing hardwoods in the Appalachians. p. 226-240. In: R. Barnhisel and M. Collins (ed.). Reclamation with a Purpose. 19th Annual Meeting, American Society of Mining and Reclamation. Lexington, KY.

3. ***Response of reclaimed forests to silvicultural treatments:***

- Our long-term silvicultural treatments study located on the PRP was remeasured, analyzed, and reported in the proceedings of a meeting on mined land reforestation sponsored by the American Society for Mining and Reclamation. A version of this report is attached.

  Burger, J. A., W. E.Auch, R. G. Oderwald, and M. Eisenbies. 2003. White pine growth and yield on a mined site in Virginia: Response to thinning and pruning. p. 226-240. In: R. I. Barnhisel (ed.). Working Together for Innovative Reclamation. 20th National Conf. American Society of Mining and Reclamation. June 3-6, 2003. Billings, MT.

4. ***Restoring forests on mined land for wood products and carbon sequestration:***

- This study is largely funded by the Department of Energy. It is a multiple investigator project that entails replicate study areas in Ohio, West Virginia And Virginia. The productivity of several forest types across several different mine soils is being tested. Sites are being ameliorated with tillage, fertilization, and weed control. The costs and benefits of different forest management scenarios are being compared. The economic and policy implications of forest management on mined land for products and carbon sequestration will be analyzed for the Appalachian region.

Burger, J. A. and J. A. Rodrigue. 2003. Carbon inventory of reforested mined lands in the eastern United States: Preliminary results. DOE/NETL 2nd Annual Carbon Sequestration Conference. May 5-8, 2003. Washington, D. C.

CURRENT EXTENSION AND OUTREACH ACTIVITIES: 2001-2002

- An 80-acre native hardwood planting on Rapoca Coal Company land is being maintained for demonstration purposes. This cooperative effort between Rapoca, Virginia Tech, and the Virginia DMME will serve as a model for the application of Powell River Project reforestation guidelines.
- Jim Burger serves on the program committee of OSMRE reforestation initiative.
- Jim Burger provided input for new reclamation regulations being developed by the WV Department of Environmental Protection.
- Jim Burger served as the Forestry Division Chair of the American Society of Mining and Reclamation.
- Our Forestry Research Field Tour Guide, an in-house publication, has received wide distribution and has had significant on-the-ground impact. It summarizes the results of our major reforestation projects.
- We presented a field tour during the PRP Leadership Field Tour in September 2002.

WHITE PINE GROWTH AND YIELD ON A MINED SITE IN VIRGINIA: RESPONSE TO THINNING AND PRUNING[1]

J. A. Burger[2], W. E. Auch, R. G. Oderwald, and M. Eisenbies

ABSTRACT

Owners of reclaimed mined land are interested in the feasibility and benefits of re-establishing forests for a variety of products and ecosystem services. We reported the projected rotation-age volume yields and timber value for a thinned and pruned white pine stand growing on mined land in Wise County, Virginia. Tree growth from age 17 to 23 increased significantly in response to thinning. The mean annual increment (MAI) of the unthinned stand was 13 $m^3ha^{-1}yr^{-1}$, compared to 20 $m^3ha^{-1}yr^{-1}$ for the thinned stand; this amounted to a 62% increase in the rate of growth due to thinning. Projected to age 30, the age at which the stand will be harvested, stand volume will be 404 $m^3\,ha^{-1}$ versus 306 m^3ha^{-1} for the thinned versus unthinned, respectively. Thinned harvest volume of crop trees will be 25% greater than that of crop trees in stands left unthinned. The sawtimber value based on current prices is \$2211 ha^{-1} versus \$1689 ha^{-1} for the thinned versus unthinned stands, respectively. This amounts to a 31% increase in the value of the thinned stand. Depending on current markets, pruning trees up to 5 m can bring a 17% stumpage premium. The results of this study show that thinning and pruning are viable options and good investments, provided that the tree stand has adequate mine soil resources for rapid growth.

Additional Key Words: reclamation, forest site quality, reforestation, mine soil quality

INTRODUCTION

Most of the land mined in the Appalachian coal fields was previously covered with forests and managed for a variety of forest products and services. With a regulatory emphasis on erosion control, most mine operators reclaim mined land to hayland, pasture, or wildlife habitat instead of returning the land to forest. Since the implementation of the Surface Mining Control and Reclamation Act in 1978, we estimate that 80% to 90% of forested surface mined land has been converted to grassland in the process of reclamation. After bond release, these grasslands are mostly abandoned from management because the livestock industry in the mined areas is small or nonexistent. Furthermore, the mined areas are remote, at high elevation, and usually devoid of water and fencing infrastructure suitable for livestock. Given that reclaimed mined land is most suited to forests, and that forests provide the best opportunity for an economically-viable use of mined land, landowners are interested in the feasibility and benefits of re-establishing forests for a variety of products and ecosystem services.

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[1] Paper was presented at the 2003 National Meeting of the American Society of Mining and Reclamation and The 9th Billings Land Reclamation Symposium, Billings, MT, June 3-6, 2003. Published by ASMR, 3134 Montavesta Rd., Lexington, KY 40502.

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White pine (*Pinus strobus* L.) is a native, early-successional species that has been widely planted on mined land. Seedlings are inexpensive and widely available from state and private nurseries. White pine seedlings are easy to plant and they survive and grow across a fairly wide gradient of mine soil conditions. Where used, they have mostly been planted in wildlife habitat arrangements; in very few cases have white pine been planted at a density or spacing appropriate for timber production. Therefore, little is known about the performance of older, contiguous stands of white pine managed for timber production, and little is known about the economic opportunity and value of white pine grown for timber on mined land.

We reported the growth performance of a 17-yr-old white pine stand on mined land in Wise County, Virginia (Kelting et al., 1997). The stand was overstocked by age 17, so we thinned it and pruned it in 1996 using standard silvicultural procedures. The purpose of this paper is 1) to report the stand response to thinning, and 2) to report projected rotation-age volume yields and timber value for this thinned and pruned white pine stand.

METHODS AND PROCEDURES

The study site is a 2-ha white pine plantation located on a pre-SMCRA reclaimed contour mine located in Wise County, Virginia. The white pine stand was established in 1978. In 1996 we conducted a timber inventory and thinned the stand to stocking standards recommended for white pine in the region (USDA Forest Service, 1986). The remaining trees were pruned to approximately 5 m (16.5 ft) to increase the future value of the sawtimber at final harvest (Fig. 1).

Figure 1. Thinned and pruned 17-yr-old white pine stand growing on mined land in Virginia.

Prior to thinning, six 0.02-ha plots were randomly located within the plantation. Plots were paired as three blocks and a randomly-selected plot of each pair was left unthinned; this provided three replications of a thinned versus unthinned comparison. The diameters of trees in each plot were measured each year for six years following thinning. A white pine volume equation (Vimmersdedt, 1961) was used to calculate wood volume for each tree each time it was measured as a function of its diameter.

The statistical significance of change in volume with respect to thinning treatment over time was tested using a repeated measures, mixed model procedure for a randomized block design (SAS, 2002). Tree volume was projected to a rotation age of 30 yr using a volume equation as a function of age (DeLong, 1955). The relative value of thinned versus unthinned stands, and pruned versus unpruned trees were compared. Stumpage value was based on Timbermart-South (3rd quarter) values (2002), and an estimate of the value of pruning was based on data by Lancaster (1984).

RESULTS

The average stand height and tree diameter at age 17 were 14.3 m (47 ft) and 20 cm (7.9 in), respectively. Site index was 35 m (110 ft) using a base age of 50 yr (i.e., this stand will be 110 ft tall at age 50) (Doolittle, 1958). Stand basal area was 31 m^2ha^{-1} (131 ft^2ac^{-1}); it contained 1438 trees ha^{-1} (582 trees ac^{-1}) and a volume of 325 m^3ha^{-1} (4640 ft^3ac^{-1}) (Table 1). The stand was thinned to a basal area of 20 m^2ha^{-1} (90 ft^2ac^{-1}), which left 652 trees ha^{-1} (264 trees ac^{-1}) with a volume of 230 m^3ha^{-1} (3294 ft^3ac^{-1}). (USDA Forest Service 1986).

Table 1. White pine stand characteristics before and after thinning at age 17 years.

Status	Basal Area m^2ha^{-1} (ft^2ac^{-1})	Volume m^3ha^{-1} (ft^3ac^{-1})	Stems ha^{-1} (ac^{-1})
Cut	11 (41)	94 (1346)	785 (318)
Leave	20 (90)	230 (3294)	652 (264)
Total	**31 (191)**	**325 (4640)**	**1438 (582)**

Tree growth from age 17 to 23 increased significantly in response to thinning (Fig. 2). The mean annual increment (MAI) of the unthinned stand was 13 $m^3ha^{-1}yr^{-1}$, compared to 20 $m^3ha^{-1}yr^{-1}$ for the thinned stand; this amounted to a 62% increase in the rate of growth due to thinning. Since age 17 when the stand was thinned, the unthinned plots increased in volume by 5%, while the thinned plots increased by 22%. By age 23, thinned stand volume was 280 m^3ha^{-1} compared to 241 m^3ha^{-1} in the unthinned plots, a 16% overall increase in volume (Table 2).

Projected to age 30, the age at which the stand will be harvested, stand volume will be 404 m^3ha^{-1} versus 306 m^3ha^{-1} for the thinned versus unthinned stands, respectively. Thinned harvest volume of crop trees will be 25% greater than that of crop trees in stands left unthinned. The sawtimber value at harvest age 30 based on current prices is \$13495 ha^{-1} versus \$10290 ha^{-1} for the thinned versus unthinned stands, respectively. This amounts to a 31% increase in the value of the thinned stand. Depending on current markets, pruning trees up to 5 m can bring a 17% stumpage premium (Lancaster, 1984), which amounts to \$15789 ha^{-1} and \$12039 ha^{-1} for the thinned and unthinned stands, respectively.

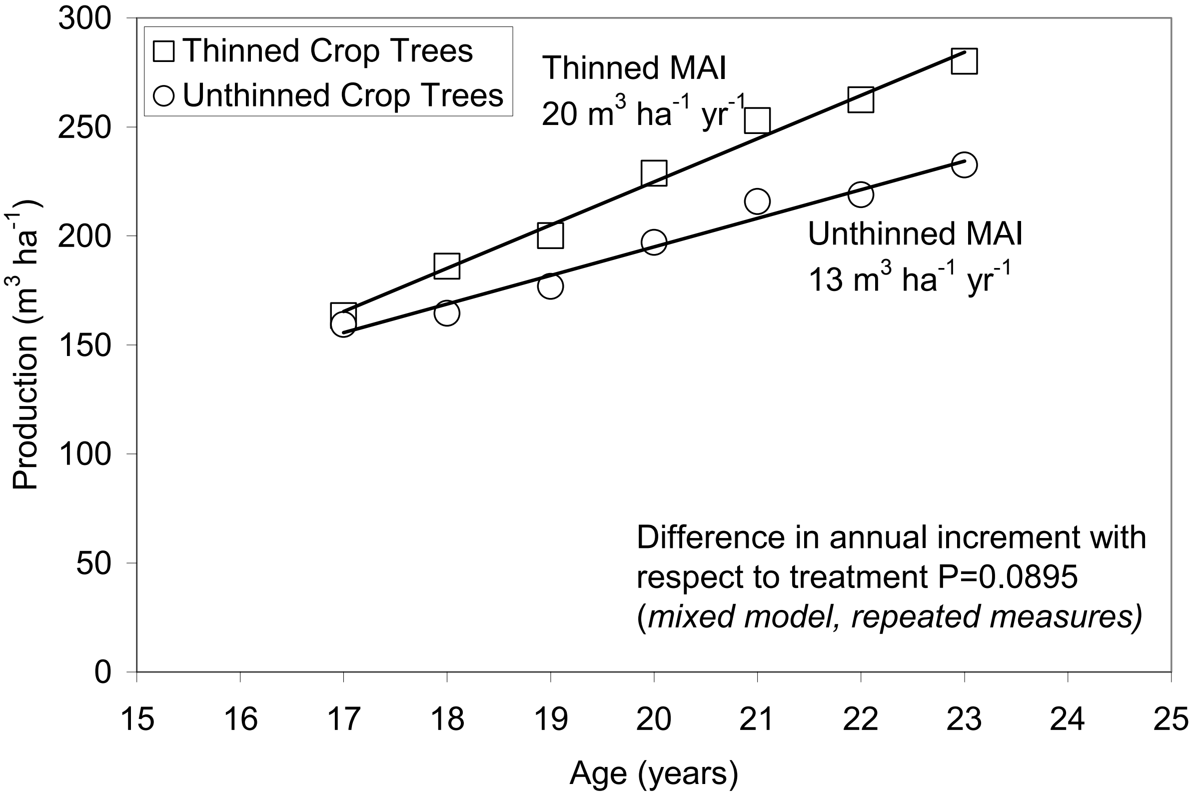

Figure 2. White pine response to thinning. Thinning was done at age 17; the thinning response was measured for 6 years.

Table 2. White pine diameter, height, volume and value of unthinned, thinned, and pruned stands at age 23. Values were projected to age 30 using white pine volume equations.

Metric Units

Treatment	DBH (cm)	Height* (m)	Volume† (m^3ha^{-1})	Sawtimber Value‡ ($ ha^{-1})	Sawtimber Pruned Value‡ ($ ha^{-1})
Age 23:					
Unthinned	25.4	16.3	241	7764	9084
Thinned	27.4	16.8	280	9366	10958
Age 30:					
Unthinned	27.7	16.9	306	10290	12039
Thinned	30.5	17.7	404	13495	15789

* Total tree height in feet. Height-diameter relationship for trees on this site = 28.68 + (2.45 * DBH)

† Volume equation: (Vimmerstedt, 1961).
Inside bark cu.ft vol. to a 4-inch top = −.5352208 + .00228831 * ((DBH^2) * ht)

‡ Virginia Cooperative Extension Service Stumpage Prices in Virginia, Third Quarter 2002 (*condensed from Timber Mart-South* by permission*)

English Units

Treatment	DBH (in)	Height* (ft)	Volume† ($ft^3 ac^{-1}$)	Sawtimber Value‡ ($ ac^{-1})	Sawtimber Pruned Value‡ ($ ac^{-1})
Age 23:					
Unthinned	10.0	53.3	3326	3143	3677
Thinned	10.8	55.1	4012	3792	4437
Age 30:					
Unthinned	10.9	55.4	4409	4166	4874
Thinned	12.0	58.1	5782	5464	6393

* H = Total tree height in feet. Height-diameter relationship for trees on this site = 28.68 + (2.45 * DBH)

† Volume equation: (Vimmerstedt, 1961)
Inside bark cu.ft vol. to a 4-inch top = −.5352208 + .00228831 * ((DBH^2) * ht)

‡ Virginia Cooperative Extension Service Stumpage Prices in Virginia, Third Quarter 2002 (*condensed from Timber Mart-South* by permission*)

DISCUSSION

The stand was very productive, with an average site index (SI) of 110. It was growing at a higher rate than white pine stands on undisturbed soils of average productivity (Doolittle, 1958). At its current rate of growth, it will be harvestable for sawtimber at age 30. Thinning and pruning increased the value of this white pine stand given its potential uses as shelving, molding, and furniture stock. This white pine stand growing on mine spoil responded well to thinning, increasing in value by about 30%. White pine does not self-prune very well, causing knots in the sawtimber which decrease its value. Pruning increases the amount of clear wood in the stem, which may or may not be a good investment depending on local markets.

The performance of this stand shows that pine plantations can be established and become an economically-viable forestry enterprise. However, tree growth and yield are functions of mine site quality. Torbert et al. (1988 and 1994) showed that white pine growth and yield vary greatly depending on the physical and chemical characteristics of mine soils. They found that good- quality forest sites have deep, loose mine soils consisting of weathered sandstones and shales that have chemical properties similar to those of native soils. This mined site had soil properties (Kelting et al., 1997) similar to the good sites described by Torbert (1994). Burger et al. (2002) described mined land reclamation procedures that, if followed, will result in productive forests with growth potentials similar to this white pine stand.

CONCLUSIONS

There is clearly an opportunity for landowners to re-establish a commercial forestry enterprise on their reclaimed mined land. If reclaimed correctly, pine plantations can reach harvestable age in 30 years on productive sites, while native hardwoods will reach commercial maturity by age 60 (Rodrigue and Burger, 2000). The results of this study show that thinning and pruning are viable options and good investments, provided that the tree stand has adequate mine soil resources for rapid growth.

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