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

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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

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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.

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).

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.

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

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 (3^{rd} 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).

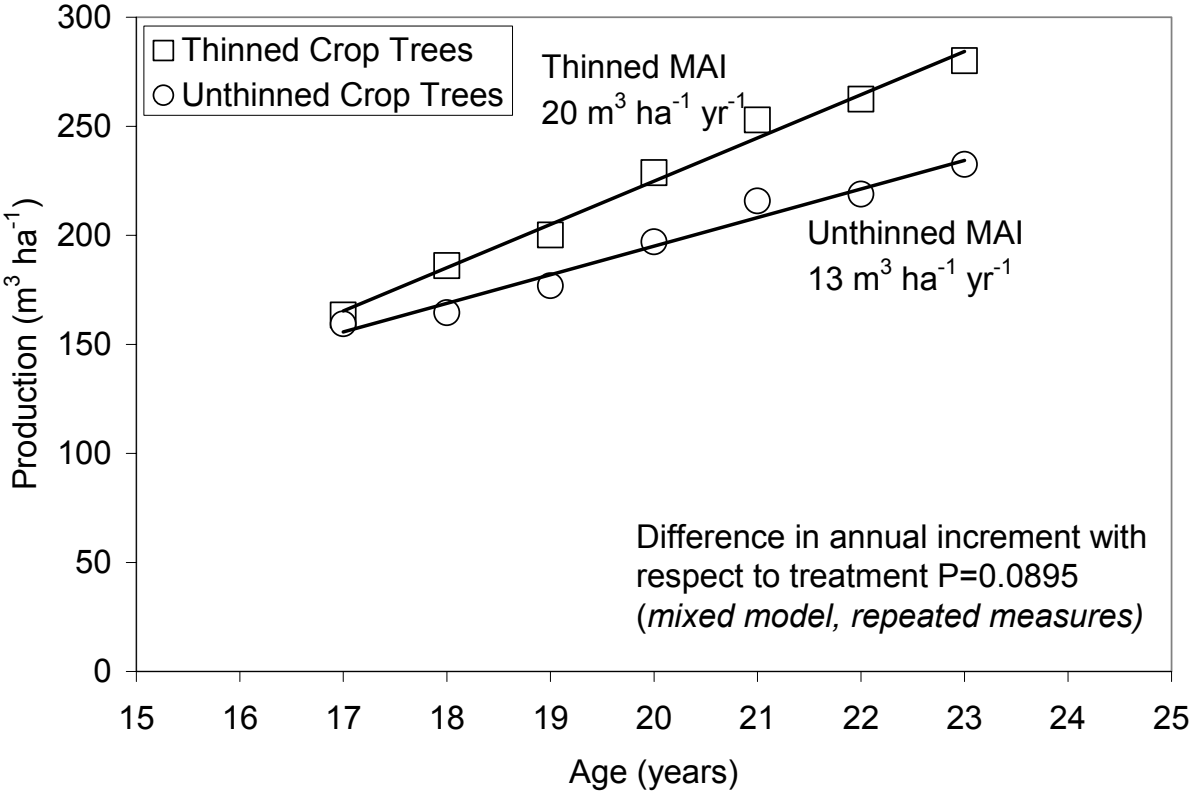

Figure 2. White pine response to thinning. Thinning was done at age 17; the thinning response was measured for 6 years.

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† ($m^3 ha^{-1}$)	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 (c*ondensed 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 (c*ondensed from Timber Mart-South* by permission*)

Projected to age 30, the age at which the stand will be harvested, stand volume will be 404 $m^3 ha^{-1}$ versus 306 $m^3 ha^{-1}$ 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.

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.

Literature Cited

Burger, J. A., and C. E. Zipper. 2002. Restoring forests on surface mined land. Virginia Coop. Extension Pub. 460-123. 16 p.

DeLong, T. S. 1955. Yield and stand tables for plantation white pine in Pennsylvania. PA Dept. For. Waters Note 8-b. 6p.

Doolittle, W. T. 1958. Site index comparisons for several forest species in the Southern Appalachians. Soil Sci. Soc. Amer. Proc. 22:455-458.
http://dx.doi.org/10.2136/sssaj1958.03615995002200050023x

Kelting, D. L., C. M. Siegel, and J. A. Burger. 1997. Value of commercial forestry as a post-mining land use. p. 344-348. *In* J. E. Brant (ed.). Proc. 14th Ann. Natl. Meeting, Amer. Soc. for Surface Mining and Reclamation, Austin, TX.

Lancaster, K. F. 1984. White pine management: A quick review. USDA Forest Service Northeastern Area NA-FR-27.

Rodrigue, J. A., and J. A. Burger. 2002. Forest productivity and commercial value of mined land reclaimed prior to enactment of federal reclamation law. N. J. Appl. For. 19(3):000-000. (In press).

SAS Institute. 1999. SAS System for Windows V8. SAS Institute Inc., Cary, NC.

Timber Marts. 2002. Timber Mart-South. T. Harris. (ed.). Warnell School of Forest Resources, Athens, GA.

Torbert, J. L., A. R. Tuladhar, J. A. Burger, and J. C. Bell. 1988. Minesoil property effects on the height of ten-year-old white pine. Journal of Environmental Quality 17:189-192.
http://dx.doi.org/10.2134/jeq1988.00472425001700020004x

Torbert, J. L., J. A. Burger, J. E. Johnson, and J. A. Andrews. 1994. Indices for indirect estimates of productivity of tree crops. OSM Coop. Agreement OR 996511 Final Report. Virginia Polytechnic Inst. and State Univ., Blacksburg, VA.

USDA Forest Service. 1986. Service Forester's Handbook. USDA Forest Service Misc. Rep. SA-MR-10, Southern Region State and Private Forestry, Atlanta, GA.