RESULTS OF EASTERN WHITE PINE ESTABLISHMENT STUDY IN SOUTHERN WEST VIRGINIA AFTER FOUR YEARS[1]

by

Timothy Probert, Ronald E. Gallimore,
John L. Torbert, James A. Burger[2]

Abstract In 1986 a study was established in Wyoming County, WV to compare several methods of establishing Eastern white pine (Pinus strobus) and black locust (Robinia pseudoacacia) on reclaimed surface mined lands in order to determine whether direct seeding was a practical alternative to handplanting seedlings. Three tree establishment treatments and two ground cover treatments were factorially arranged and replicated three times with 0.1 acre plots. Results after the fourth growing season indicate that the most cost-effective way to establish a commercial white pine plantation is to plant bare rootstock 2-0 seedlings and direct seed the black locust at a rate of less than 0.5 pounds per acre. Although some white pines were established by direct seeding, the spacing was erratic and the growth of direct seeded trees lagged behind the hand planted trees by several years.

Additional Key Words: Reclamation, Reforestation, Revegetation

Introduction

Most lands surface-mined for coal in the Appalachians were originally forested. However, in many instances surface mined lands have been reclaimed as hayland or pasture land. These post mining land uses may be useful on lands mined by mountain top removal methods if lands will indeed be used for grazing or growing and harvesting hay. However, lands with steep slopes that are mined by contour mining methods and reclaimed as hayland and pasture land are not ideally suited for grazing or harvesting hay. In most instances, these lands, along with a large percentage of reclaimed mountain tops are abandoned following bond release and revert to relatively unproductive stands of understocked and undesirable tree species. Unless the intent is to actually manage these lands following bond release, the best and most logical approach for effective reclamation is to reforest these lands in a manner that will increase the likelihood that an economically viable forest will be established.

Forest land does not require intensive management during and after bond release and a crop of trees will grow into a valuable product for the landowner, while providing soil stability and wildlife habitat. Reforestation will be more successful and less expensive in the long run if the final stages of reclamation (overburden selection, topsoiling and grading) and revegetation are modified to recognize establishment and long term growth requirements of trees.

Eastern white pine is a good tree species for planting on reclaimed mine land in the Appalachians. On good sites, white pine is unrivaled in its ability to produce sawtimber. A natural stand of white pine has about three times the merchantable volume of a natural oak stand at age 50. (Doolittle, 1958). White pine is relatively free of insect problems in the Southern Appalachians and will probably be avoided by the oncoming gypsy moth infestation. Several characteristics of white pine make it adaptable for use on reclaimed mine land. White pine has the ability to withstand limited amounts of shade compared to other trees. This results in better survival rates when planted in grass cover. White pine is less nutrient demanding than some hardwood species and can tolerate moderately acidic sites. Since white pine stands produce more merchantable timber when seedlings are planted on a wide spacing (300 trees/acre) (Balmer & Williston, 1983), fewer trees need to be established for reclamation purposes.

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2/ Timothy Probert is Forester and Ronald E. Gallimore is Manager Mining and Reclamation, Pocahontas Land Corporation, Bluefield, WV 24701. John L. Torbert is Research Associate and James A. Burger is Associate Professor, VPI and SU, Blacksburg, VA 24061

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Pines can be established by hand planting seedlings or direct seeding. Planting is the best way to ensure establishment and proper spacing, and it enables the use of genetically superior trees and fertilizer tablets which can give seedlings an early boost. However, since planting must be limited to a short period of time (late winter), labor availability and weather restrictions may constrain the amount of land that can be reforested by planting each year. Hydroseeding may be a good technique for reforesting large tracts of land quickly if tree seed can be sown together with a compatible ground cover species in the fall or spring.

A major problem associated with attempting to establish trees by direct seeding on minesoils is competition from the herbacous ground cover. Grasses and legumes commonly established to control erosion have historically made tree establishment difficult. Competition effects become especially severe when trying to establish trees from seed. A reforestation ground cover mixture of short grass and legumes was recommended by Vogel (1981). A similar ground cover mixture has been used in conjunction with direct seeded trees (Torbert and Burger, 1989a,b).

This study was designed to demonstrate the productive potential of white pine on properly constructed minesoils and to compare several tree-establishment techniques. Specifically, the objectives of this study were:

1) To evaluate the establishment of white pine and black locust by hand planting vs hydroseeding.

2) To compare two ground cover mixes for use with trees: a conventional hayland/pasture land mix vs. a reforestation mix.

3) To evaluate the effects of fertilizer tablets (applied at planting) on the establishment of white pine.

Materials and Methods

The study was established in Wyoming County, WV on a 40% return-to-contour slope. The area had been backfilled with brown sandstone overburden. Final grading was kept to the minimum requirements under the regulatory guidelines and "tracking-in" was eliminated in order to minimize minesoil compaction. At time of seeding and tree planting the soil was loose and uncompacted. Although there were numerous large rocks, trees were easily planted in the soil around the rocks.

The study consisted of three tree-establishment treatments and two ground cover treatments factorially arranged to produce six treatment combinations. Each treatment was replicated three times producing a study with 18 plots. Plot size was 72 ft. x 60 ft. (0.1 acre).

The three tree-establishment treatments were:

1. Hydroseeding in one mix ground cover, black locust, and white pine. Seeding rates were 2 lbs/acre for white pine and 0.5 lbs/acre for black locust.
2. Hydroseeding ground cover and black locust and hand planting (with dibble bar) Eastern white pine on a 12 ft. x 12 ft. spacing. These plots were split so half the trees received a fertilizer tablet.
3. Hand planting Eastern white pine on a 12 ft. x 12 ft. spacing and interplanting black locust on a 12 ft. x 24 ft. spacing. Half the Eastern white pines received a fertilizer tablet.

The two ground cover treatments included a "conventional" hay-land/pasture land seed mix and a "reforestation" seed mix which included grass and legume species considered to be more compatible with tree seedlings (Table 1).

Table 1. Seed and fertilizer rates used for ground cover treatments.

- - - - - - - - CONVENTIONAL MIX - - - - - - - -	
Species	Rate (lbs/acre)
Kentucky-31 tall fescue	33.8
perennial ryegrass	17.0
annual ryegrass	11.5
orchard grass	10.7
highland bentgrass	2.0
birdsfoot trefoil	7.3
mammoth red clover	8.0
yellow sweet clover	4.8
Nitrogen	72.0
Phosphorus	89.0
Potassium	16.7
- - - - - - - - REFORESTATION MIX - - - - - - - -	
Species	Rate (lbs/acre)
foxtail millet	5.0
perennial ryegrass	5.0
redtop	3.0
birdsfoot trefoil	5.0
'Appalow' serecia lespedeza	10.0
Nitrogen	36.4
Phosphorus	92.8
Potassium	55.1

Ground cover seed and fertilizer were applied by hydroseeding in early May 1986. Since it was not logistically possible to hydroseed tree seed onto each randomly selected plot, Eastern white pine and black locust seed was spread by hand prior to the hydroseeding. To simulate the conditions to which the tree seed might be exposed to in the hydroseeder, the seed was soaked in water for 30 minutes prior to application. White pine seedlings (2-0) were obtained from the Virginia Department of Forestry and black locust seedlings (1-0) were obtained from the Kentucky Division of Forestry. Seedlings were heavily graded such that only half the trees with the greatest root caliper were used. White pines had root calipers that measured about 0.25 inches and a stem height between 8 inches and 12 inches. Black locust stem heights averaged 24 inches.

Seedling roots were hand pruned to a length of about eight inches and dipped in a soil moisturizer slurry. Hand planting with dibble bars occurred during mid April, 1986. Soil moisture levels were good for planting, and several days of cool, rainy weather followed.

In the fall of 1987, 1988 and 1989, measurements were made of all plots. Measurements included ground cover percentage, number of trees established from seed, and survival and growth of hand planted Eastern white pines. Ground cover was determined for each plot by averaging visual estimates for the four quadrants in each plot. These estimates were made independently by the same two individuals each year. The number of hydroseeded trees was determined by counting the seedlings that grew within two 75 ft. x 3 ft. transects which ran along two diagonals in each plot. Planted pines were measured for total height and ground line diameter. From these measurements, tree volume was calculated as 1/3 $(radius)^2$ x height.

Analysis of variance techniques were used to determine the effects of ground cover treatment on percent ground cover, number of pines and locusts established by seeding, and planted pine survival and growth. Analysis of variance was also used to evaluate the effects of fertilizer treatment on the survival and growth of planted pine.

Results and Discussion

Minesoil properties.

The minesoil used in this study consisted primarily of a mix of native topsoil and brown sandstone overburden. The soil texture was a sandy loam, composed of 67% sand, 21% silt, and 12% clay. Typical of most brown sandstones, the pH (4.8) was low compared to desirable levels for most grasses and legumes, but it was appropriate for reforestation. Soluble salt levels were only 0.3 umhos/cm. Because the minesoil had not been tracked-in, the soil was uncompacted and easily planted.

Comparison of Ground Covers.

The reforestation ground cover treatment contained less than one-third as much seed and was fertilized with only half as much nitrogen as the hayland/pasture treatment. (Table 1). The reforestation cover did not include Kentucky-31 tall fescue. Perennial ryegrass (Lolium perenne) and redtop (Agrostis gigantea) were the grass species included in the reforestation cover. Both treatments included birdsfoot trefoil (Lotus corniculatus) which was a dominant legume in this study. The reforestation treatment also included 'Appalow' lespedeza (Lespedeza cuneath cv. 'Appalow') which is a cultivar of serecia which tends to sprawl along the ground rather than grow upright.

The conventional cover increased from 87% during the first year to 93% after four years. (Figure 1). The reforestation cover was 80% during the first year and increased to 97% after four years. There were no significant treatment effects on ground cover in any years.

There was a large variation in ground cover across the study site, mostly reflecting variable site conditions. Several conventional ground cover plots were located in an area that consisted largely of replaced topsoil; these plots had nearly 100% ground cover. At the other extreme, the poorest ground cover occurred in conventional and reforestation plots in an area where the

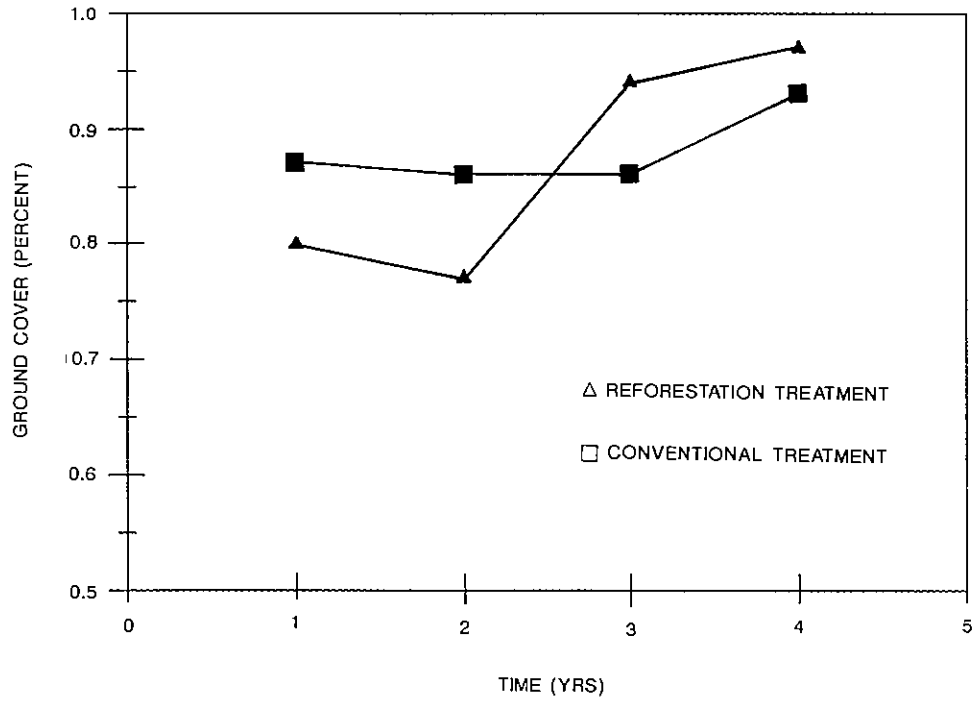

FIGURE 1. EFFECTS OF GROUND COVER TREATMENT ON PERCENT OF GROUND COVER ESTABLISHED

presence of pyritic minespoil produced a pH of 4.0. Some gullies were bare after the first growing season, but became vegetated by the end of the second season.

When the study was designed, it was anticipated that the two ground cover treatments would produce drastically different ground covers. However, throughout the four years of this study the two treatments have appeared to be very similar. Because the average mine soil pH was only 4.8, many components of the conventional ground cover treatment did not grow as vigorously as they would have on a minesoil with a higher pH. Consequently vegetation in the conventional treatment was not as high and lush as it often is on other sites.

Birdsfoot trefoil and 'Appalow' lespedeza have performed well in this study. Both species were sparse during the first year but became dense by the third year. Both treatments included birdsfoot trefoil. 'Appalow' lespedeza was seeded in the reforestation treatment but invaded the conventional treatment plots over a period of three years presumably by seed dispersal. The birdsfoot trefoil seemed to be most vigorous in the spring and fall while 'Appalow' lespedeza dominated during the summer. Thus the combination of these two species in the reforestation treatment provided a good legume cover throughout the growing season.

'Appalow' lespedeza was observed to be a very aggressive species capable of growing on a very low pH. In one of the conventional cover plots where the pH was 3.8, all of the species in the conventional mix died and by the third year the plot had been invaded by Appalow which is now the dominant component of cover.

Direct Seeding of Trees

Eastern white pines. The number of direct seeded Eastern white pines averaged 290/acre in the conventional ground cover treatment plots (range was 0 to 484 trees/acre) and 100 trees/acre in the reforestation treatment plots (0 to 194 trees/plot). Because of the large variability between plots within each ground cover treatment, the differences between numbers of trees established were not statistically significant (Table 2).

The growth of direct seeded pines was slow compared to planted trees. Most seeded pines were less than 12 inches tall (smaller than the size of the bare root nursery stock). It may take several years for direct seeded pines to become as large and vigorous as two-year-old seedlings that were hand planted. In addition to having a slower establishment growth rate, the distribution of direct seeded pines was too uneven for direct seeding to be a reliable method for the establishment of a well stocked forest.

Black locust. Black locust was successfully established by direct seeding. The use of 0.5 lb/ac of black locust seed per acre produced more than 1000 stems per acre which ranged from approximately 1 to 6 ft tall after the fourth season. This rate has produced too many locusts for use as a nurse tree with white pine. A rate of 0.1 - 0.3 lb/ac should result in a more desirable level of 100-300 locusts per acre.

Hand Planted Trees

Eastern white pine. Survival and growth of hand planted Eastern white pines has been very good. Despite two very dry summers, overall survival was 74% on the conventional ground cover treatment plots and 71% on the reforestation ground cover treatment plots. There was no significant difference between the two ground cover treatments on tree survival. Most of the mortality in this study occurred when seedlings were washed from the ground during several unusually heavy storms that occurred shortly after planting. During the second through fourth growing season, very few trees have died. Growth of these trees was excellent. Overall, the average tree height was 4 ft, and some trees were more than 8 ft tall. Research has shown that excellent white pine growth can result in the Appalachians when deep minesoils are created with acidic sandstone overburden (Torbert et al. 1988). This study further demonstrates the growth potential that can be achieved when an overburden is selected to favor tree growth and compaction associated with grading practices is minimized.

Black locust. Almost all the black locust trees planted in this study have survived, and many are more than 15 feet tall after the fourth season. These trees were planted at a rate of 100 trees/ac and are intended to provide a long-term source of

Table 2. Effect of ground cover treatment on percent ground cover and number of trees established by direct seeding.

	GROUND COVER TREATMENT			
	Conventional		Reforestation	
	Mean	Range	Mean	Range
Year 1	87	(58-100)	80	(51-92)
Year 4	93	(64-100)	97	(93-100)
Eastern white pine	290	(0-484)	100	(0-194)
black locusts	1080	(97-2,320)	1,050	(388-1,548)

biologically fixed nitrogen. The effects of locust on pine needs to be monitored in the next few years, and the benefits and disadvantages of seeding locust versus planting locust needs to be evaluated.

Effect of Ground Cover Mix and Fertilizer Tablets on Eastern White Pine Growth

Tree volume was significantly affected by ground cover treatment for all four years. Tree volume was significantly greater in the conventional treatment than the reforestation treatment (Table 3). At year 2, trees in the conventional treatment averaged 87% more volume than trees in the reforestation treatment. At year 4, the trees in the conventional treatment averaged 54% more volume than trees in the reforestation treatment (Figure 2). Although the initial results show a greater relative difference in tree volume between the conventional cover and the reforestation cover, as time goes on the relative difference has become smaller.

During the design of this study, it was hypothesized that trees in the reforestation ground cover treatment would be larger because there would be less competition compared to the conventional ground cover treatment. However, because the conventional ground cover was not as vigorous as expected, due in part, to acidic site

Table 3. Effect of ground cover treatment on average tree volume.

Year	Conventional	Reforestation
	- - - - - - - - - - - - - - cm^3 - - - - - - - - - - - - - -	
1	1.51 a	1.23 b
2	7.27 a	3.88 b
3	34.78 a	20.35 b
4	145.80 a	94.25 b

Values for a given year followed by different letters are significantly different, (p = 0.05).

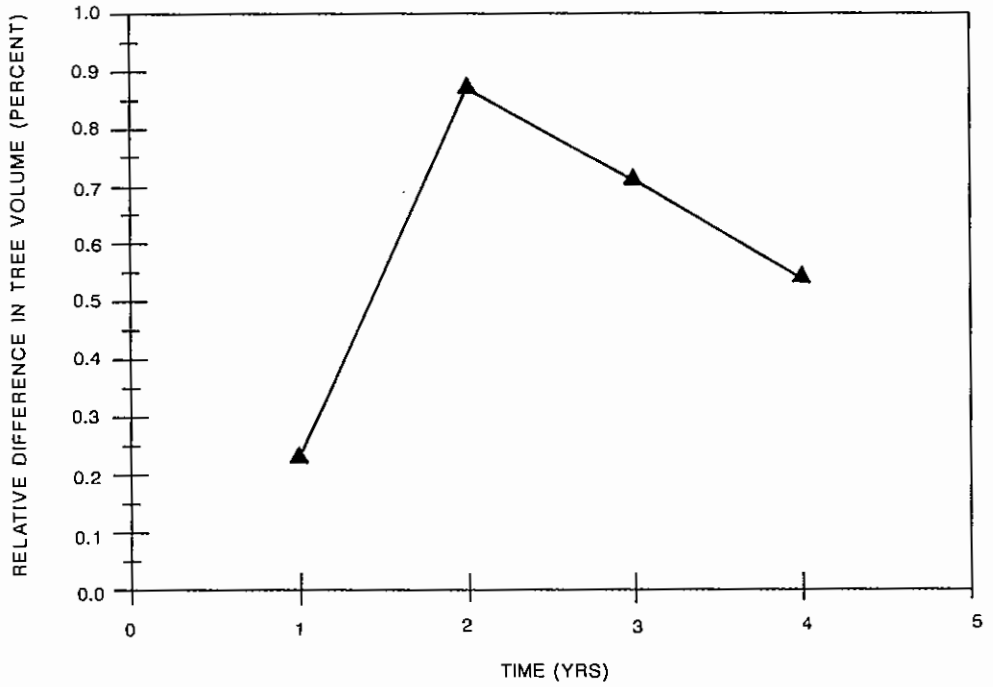

FIGURE 2. RELATIVE DIFFERENCE IN TREE VOLUME BETWEEN CONVENTIONAL GROUND COVER TREATMENT AND REFORESTATION GROUND COVER TREATMENT

conditions and a conventional treatment seed mixture that did not perform well, the competition effect never occurred. The greater tree growth in the plots with the conventional ground cover treatment over the plots with reforestation cover treatment most likely resulted from the higher rate of nitrogen fertilizer in the conventional treatment (72 lbs. vs 36 lbs. N/Ac.).

Fertilization with planting tablets resulted in a significant increase in tree volume in the conventional treatment during the first year, but the effect was not statistically significant in subsequent years. The effect of fertilization was more evident in the reforestation treatment, where there was a significant effect for the first three years (Table 4). The most probable reason for the fertilizer tablet not having a lasting effect on the pines in the conventional treatment was that during establishment enough fertilizer had been applied to the conventional cover treatment that little additional benefit was realized by the use of a fertilizer tablet.

white pine stands. If the goal of the landowner is to establish commercial forest land on the reclaimed mine site, hand planting pines and hydroseeding locust or other nitrogen fixing nurse trees/shrubs is recommended. It is also recommended that the amount of locust seed be reduced to .25 lbs-.40 lbs/acre to produce the desired number of stems per acre to benefit the Eastern white pine.

It is recommended that reforestation seed mix be used to establish ground cover as it provides a better cover over time under variable soil conditions. Initially a less dense cover allows seedings to grow and overtop the ground cover before it thickens in successive years. It also provides less competition early on to the desired crop tree and maintains a higher percentage of ground cover over time. Also, the reforestation seed mix reduces planting costs by producing a thicker cover with less seed. 'Appalow' lespedza was an excellent cover and did very well in acidic sites.

Table 4. Effect of ground cover treatment and fertilization on average tree volume.

	Conventional		Reforestation	
Year	Control	Fertilized	Control	Fertilized
	- - - - cm^3 - - - - -		- - - - cm^3 - - - - -	
1	1.24 a	1.81 b	1.02 a	1.40 b
2	7.16 a	7.40 a	2.68 a	4.67 b
3	35.09 a	34.4 a	15.20 a	23.67 b
4	144.37 a	146.9 a	76.30 a	105.50 a

Values for a given year within each treatment followed by different letters are significantly different (P = 0.1)

Conclusions

The goal of this project was to develop a practical reclamation strategy that would establish an effective ground cover to prevent erosion and to allow mine operators to gain bond release while establishing forest lands with potential for future economic returns for Pocahontas Land Corporation.

Hand planting appears to be the most cost effective way to establish Eastern white pines on mined lands. Direct seeding on the other hand does not appear to be as reliable. The difference in cost between purchasing and planting 300 pines per acre versus purchasing and hydroseeding 2 lbs of Eastern white pine seed is negligible. The cost of direct seeding could even be higher if the expense of re-planting failed areas is included. The irregular spacing and slower establishment rate of direct seeded Eastern white pine will greatly decrease the economic potential of Eastern

This study has also shown that steep land can be successfully revegetated without "tracking in". The excellent tree growth on this uncompacted minesoil documents less final grading may be needed when the post mining land use is forests.

If trees are hand planted, higher rates of nitrogen fertilizer (50-70 lbs/ac) can be used with the reforestation mix. Rates in this ground cover mix were initially low so that the ground cover would not overtop pines germinating from seed. Since hand planted seedlings are taller and more vigorous, additional nitrogen can be added to stimulate the early growth of pines and aid initial ground cover establishment. Fertilizer tablets are not necessary for tree establishment. Any improvement in growth that might occur during the first several years will not be economically justified over the long-term.

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