Powell River Project

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Restoring the Value of Forests on Reclaimed Mined Land

James A. Burger, Professor Emeritus, Forestry and Soil Science, College of Natural Resources, Virginia Tech; Carl Zipper, Extension Specialist, Department of Crop and Soil Environmental Sciences, Virginia Tech.

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Introduction

The central Appalachian region of eastern Kentucky, West Virginia, and southwestern Virginia is blessed with abundant and commercially valuable natural resources, especially timber and coal. Huge amounts of virgin timber were cut and marketed during the late 19th and early 20th centuries. Towards the end of this virgin timber harvest, coal mining became the region's economic mainstay. After the virgin timber cut, the Appalachian forest grew again as a sustainable, renewable, and economic resource. The annual value of the timber and wood products industry is $7.7 billion in Virginia, $23 billion for the central Appalachian coalfield states (Table 1), and $46 billion for states comprising the Appalachian region as it extends northward to Pennsylvania and Ohio. Today, both coal and timber are natural resources produced in central Appalachia that make significant contributions to the regional economy.

Table 1. Forestry and wood product statistics for the central Appalachian coalfield states.

	KY	TN	VA	WV
Percent of land forested	50	55	63	79
Total timberland (millions of acres)	12.3	13.9	15.4	11.9
Forest industry employment (millions)	26.3	39.7	35.7	11.5
Annual payroll ($ millions $)	1,160	2,255	1,720	430
Value of industry wood and paper shipments ($ billions)	6.3	7.2	7.7	1.8

Source: American Forest and Paper Association (2006), Virginia Tech Department of Forestry.

Reforestation of land that has been surface mined for coal can produce high-value commercial forests while providing watershed protection and wildlife habitat. Prior to the 1977 Surface Mining Control and Reclamation Act (SMCRA), most surface-mined land in the east and Midwest was reclaimed with trees. These reclaimed lands varied in their quality and productivity, but reforestation was often successful and commercially valuable forests were created. Many of these new forests are maturing (Rodrigue and others 2004) and are providing landowners with revenues.

In the early years of the Surface Mining Control and Reclamation Act, few forests were being restored, although the amount varied by state. Thousands of acres of Appalachian mined lands that were originally forested have been reclaimed as hayland, pasture, or wildlife habitat. Such land is usually left unmanaged after bond release and it slowly succumbs to brushy, woody vegetation with little or no commercial value. Even in states such as Virginia where reclamation to forestry was encouraged since the 1990s, many of the mined lands that were restored to forest were planted with low-value, non-commercial species because the spoil grading and revegetation practices of that time created conditions that were hostile to tree survival; therefore, mining firms planted species such as black locust and pines that had a better chance of surviving than the more sensitive native hardwoods such as the oaks. Eastern white pine is the one commercial species that was widely planted during those years, but its growth was often hindered by poor soil properties. An Appalachian Regional Reforestation Initiative (ARRI) publication, Forest Reclamation Advisory No. 1 whose lead author is with the US Office of Surface Mining (see reference below) describes the historical context and reasons why these reclamation practices were widespread.

Today, that picture is changing as mining firms in Virginia and elsewhere in Appalachia are adopting a new reclamation method called the Forestry Reclamation Approach (see VCE Publication 460-123 and ARRI Forest Reclamation Advisory No. 2). When mined land is restored to productive forests, landowners can enjoy the economic benefits of commercial forestland while creating lands that support wildlife habitat, watershed protection, and similar environmental values that benefit the public. The purpose of this bulletin is to provide information that will aid landowners in estimating the effects of reclamation practices on forestland values, while emphasizing that creating productive mine soils for native trees can be accomplished at no additional cost to the mine operator.

Reclamation to Produce High-Quality Forest Soils.

Research by reclamation forestry groups throughout the Appalachian and Midwestern coalfields has shown that productive mine soils and forests can be restored by using “five steps” that are the Forestry Reclamation Approach (FRA).

1. Create a suitable rooting medium for good tree growth that is no less than 4 feet deep and comprised of topsoil, weathered sandstone and/or the best available material.
2. Loosely grade the topsoil or topsoil substitute established in step one to create an uncompacted growth medium.
3. Use ground covers, when required, that are compatible with growing trees.

4. Plant two types of trees--early successional species for wildlife and soil stability (no more than 20% of total stocking), and commercially valuable crop trees (80% or more total stocking).
5. Use proper tree planting techniques and good planting stock.

The FRA reclamation method has been used operationally and successfully by many coal mining firms. It is described with some detail in ARRI Forest Reclamation Advisory No. 2 and Virginia Cooperative Extension publications 460-123 and 460-124. An important feature is that it can cost the mine operator hundreds of dollars less per acre than traditional reforestation practices due to reduced grading costs and less expensive ground cover seed mixtures. Recent experience by mining operators indicates that 2 to 4 hours of unnecessary grading per acre can be avoided when loose-grading practices, consistent with FRA reclamation practices (see ARRI Forest Reclamation Advisory No. 3) are used as an alternative to traditional smooth grading with "tracking in." If ownership, operating, and maintenance costs for a dozer are $200 per hour, the result is a cost savings of $400 - $800 per acre for the mining operator. Additional cost savings can be realized by replacing the traditional revegetation practices, which use fast-growing grasses, with "tree compatible" revegetation which uses less seed and fertilizer. Although purchase of hardwood seedlings for planting costs the mining operator more than the pines, black locust, and other lower-value species that were used commonly prior to FRA reclamation, these costs are offset by the reduced grading and revegetation cost savings.

The Forestry Reclamation Approach is consistent with SMCRA regulations at the federal level, in Virginia (see Virginia Division of Mined Land Reclamation Guidance Memorandum 22-08, "Forestry Reclamation Approach"), and in other eastern states (see ARRI Forest Reclamation Advisories Nos. 1 and 2).

Minesoil Quality Measured by "Site Index"

Reclaiming mined land for forestry is compelling because the productivity of forests and value of wood produced on reclaimed lands *after mining* can be greater than *prior to mining* – but only if FRA or comparable reclamation practices are used. Instead of agricultural productivity measures such as bushels/acre or tons/acre, foresters judge minesoil quality based upon the average height of trees at a given index age, such as age 25 or 50 years. As illustrated in Figure 1, trees grow slowly on poor-quality mine sites and are relatively short by age 25 (site index = 45 ft) compared to trees of the same age on average minesoil quality (site index = 55 ft) or trees of the same age on good mine soil quality (site index = 70 ft). Tree height can vary greatly at the same tree age due to mine soil and mine site quality. This height comparison at a selected age (age 25 for conifers and age 50 for hardwoods) is commonly used to "index" soil, site, or land potential for forestry and is referred to as "site index" (SI).

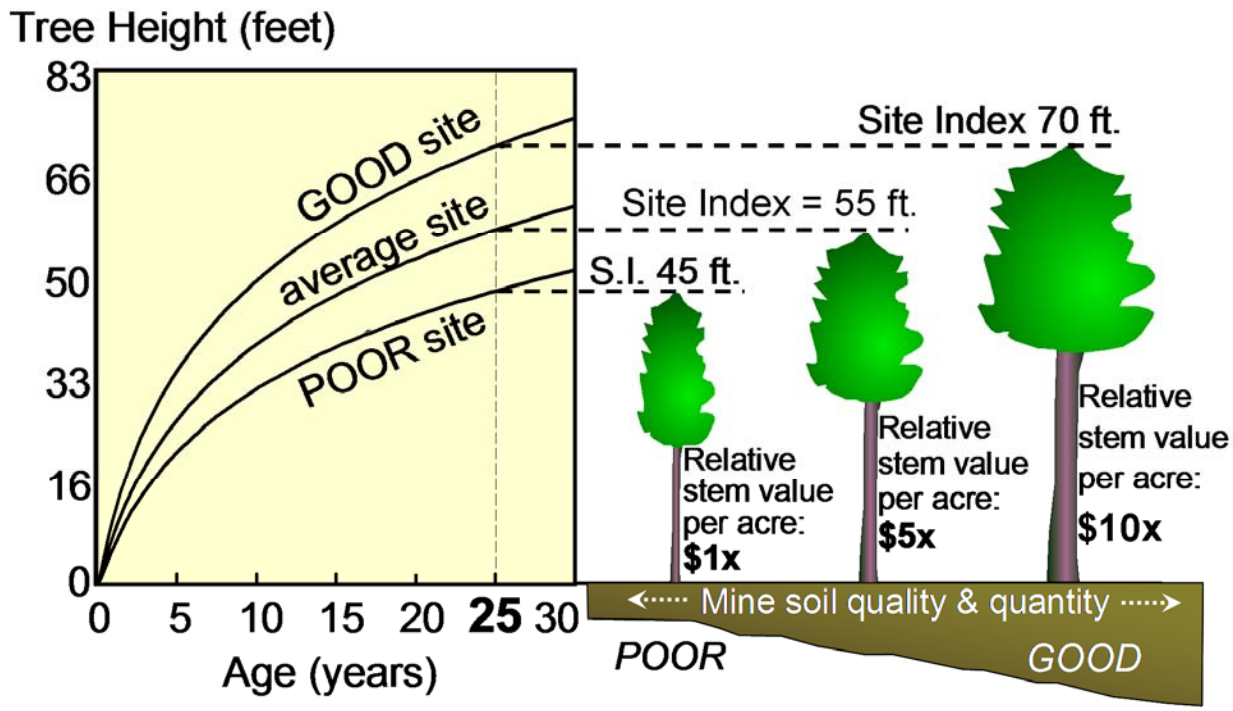

Figure 1. Tree growth as a function of minesoil quality and quantity. Relative stem value increases exponentially with tree height as mine soil quality/quantity increases.

A generalization for most tree stands is that wood volume and wood value increase exponentially with tree height or site index (SI). This is also illustrated in, Figure 1 which shows that trees on good-quality mine soils can be 1.5 times taller than trees on poor quality mine soils (45 versus 70 ft) – but those taller trees can be as much as 10 to 20 times more valuable due to (i) their disproportionately-greater stem volume; (ii) the disproportionately-greater value of the large dimensional wood contained in the log, and (iii) the fact that more valuable species like black cherry, red oak, and sugar maple grow best on good sites. For example, 10 cubic feet of wood as one piece from a large tree is many times more valuable than 10 cubic feet of wood in many pieces from several small trees – especially if those smaller trees are of less valuable species. As shown by Figure 2, site quality can have a significant influence on tree growth.

To illustrate how site quality affects timber value, two examples using timber species that are commonly planted on reclaimed mine sites follow.

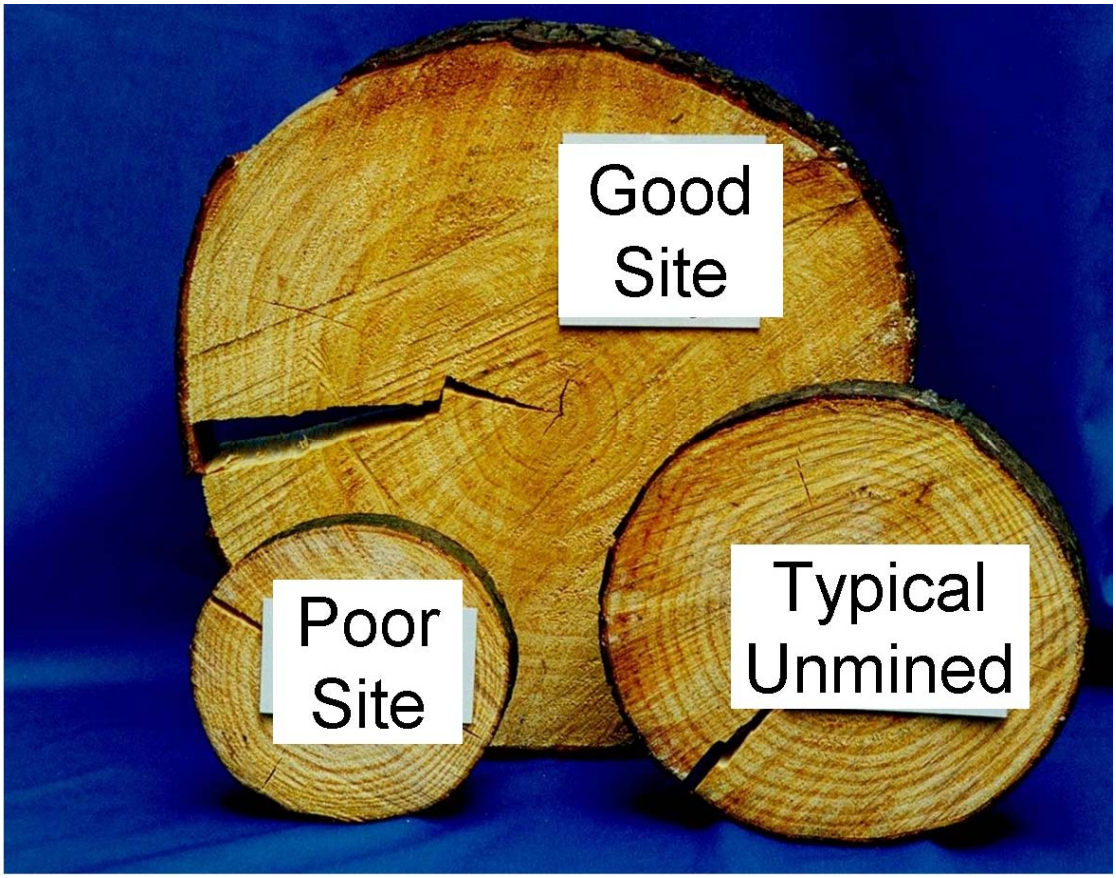

Figure 2. Cross-sections taken from trees cut the same distance from the ground. All of these cross-sections were from 17 year old eastern white pines. The bottom right tree grew in a natural Appalachian forest that was never mined. The bottom left tree grew on a reclaimed mine site where the soil was heavily compacted using the traditional reclamation techniques that included smooth grading and "tracking in" operations that were common in the central Appalachians up through the mid-2000s and persist in some areas as of this writing. The largest section is from a tree growing on the mine site pictured in Figure 3 which is the basis for Case III estimates in Table 2.

Effect of Site Index on Timber Value: White Pine

Research data can be used to demonstrate the effects of reclamation technique on white pine productivity and stand value at age 30 (Table 2). For perspective and reference, Case I shows the estimated value of an average 30-year-old white pine stand growing on undisturbed soils in the Appalachians. Average site quality measured by site index (height at age 25) is 55. Under typical management at the harvestable age of 30, eastern white pines growing on Site Index 55 will produce about 28,000 board feet per acre as small sawtimber, and that wood will be worth an estimated Total Value of $1400 per acre "on the stump," based on average prices in the central Appalachian region over the 10 year period beginning in 1999 and extending to this writing.

Based on our research on 78 reclaimed mined sites in Virginia, Kentucky, and West Virginia on which conventional pre-FRA reclamation procedures were used, we estimate that forest site quality was reduced to an average value of site index 45 (Case II in Table 2) (Andrews and others, 1998). The productive capacity is greatly reduced compared to pre-mining conditions, and the total value of timber growing on the mine site will be just a fraction of its original potential, $100 per acre in this example, compared to $1400 per acre for white pine stand of equivalent age and density on a typical natural soil prior to mining.

Case III represents data from a site that was mined and planted to white pine (see Figure 3), which was 17 years old when measured for site index in 1997. Minesoil and ground cover conditions at time of planting were similar to those that occur when the Forestry Reclamation Approach is used. The measured site quality is 70 and the projected volume at harvest age 30 is 37,000 board feet per acre. Due to the higher value of large sawtimber, the value per acre would be $2800/acre.These data show that mined land, when properly reclaimed, can be very productive. Because mine soils are deeper than those that occur on mountain slopes prior to mining, the mine soils can be more productive for forest products than the pre-mining soils if appropriate reclamation techniques are used. Furthermore, the value of wood products is disproportionately higher on better-quality sites because large timber is worth more than small timber. To say it more academically: the $ value increases exponentially with site quality.

Table 2. The effects of reclamation technique on white pine productivity and stand value at 30 years with average management.

Case	White Pine Site Type	Site Index[a]	Timber Volume (MBF/ac)[b]	Harvestable Wood Products	Harvest Price ($/MBF)[c]	Total Value ($/acre)
I	Average quality of an undisturbed Appalachian forest site (Doolittle 1958)	55	28	small sawtimber	50	$ 1400
II	Average quality of a post-SMCRA non-FRA mine soil (Torbert and others, 1994)	45	5	pulp	20	$ 100
III	Actual quality of a white pine stand on a good minesoil in Virginia (Kelting and others, 1997)	70	37	large sawtimber	75	$ 2800

[a] Site Index = Expected eastern white pine height after 25 years, in feet.

[b] Harvestable timber volume at Age 30, expressed as thousand board feet per acre (MBF), based on yield tables prepared by Vimmerstedt (1962).

[c] Harvest price, estimated as an average of what was typical over the 1999-2009 period. Actual harvest prices vary with market conditions.

Figure 3. The eastern white pine stand represented in Table 2 as Case III. This photo was taken in September, 2008, when the trees were 29 years old.

Effect of Site Index on Timber Value: Red and White Oak

White pine was used in the analysis above because of its predominant use on post-law mined land up through the mid-2000s. Although total wood volume would be less for hardwoods, the same general relationships between site quality and value per acre would hold true. Because eastern white pine is sensitive to soil properties, we can use its known productivity to estimate comparable productivities for oaks on mine soils. A site with a white pine site index of 55 (age 25) can be expected to have an oak site index of 65 (age 50), which is an average value for oaks across most of the Appalachians. This species-to-species relationship shows that average post-SMCRA but pre-FRA reclamation site quality for oaks would be about SI 50, and the site quality potential for oaks of FRA-reclaimed mine sites would be about SI 85. This estimate is confirmed by Ashby and others (1984) who evaluated mine soil productivities for oak species.

Table 3 shows the relative influence of soil and site properties on oak site index, wood yield, and harvest value, as we expect it to be affected by reclamation practices. Average oak sawtimber value at age 60 on average quality sites (SI = 65) is about $3400 per acre under

average management. If forest sites are degraded from SI 65 to SI 50 by the non-FRA reclamation practices that were used commonly up through the mid-2000s, potential harvest value becomes one-fourth of what it was originally. If sites are upgraded through reclamation using the Forestry Reclamation Approach (FRA) to SI 85, harvest value doubles compared to the pre-mining conditions and are more than 5x the value of what could be expected of oaks that are planted on a non-FRA mine site (Figure 4). In reality, the Total Value of oaks growing on the non-FRA mine site (Case I below) may be overestimated because reclamation practices affect tree survival as well as growth while the yield tables upon which these figures are based assume fully stocked timber stands.

Table 3. The relative effect of site quality on Appalachian red and white oak harvest volumes and stumpage value at age 60 (price varies with time and region; price is an average over the past 10 years).

Case	Oak Site Type	Site Index	Timber Volume (MBF/ac)[a]	Harvestable Wood Products	Harvest Price ($/MBF)[b]	Total Value ($/acre)
I	Average undisturbed Appalachian forest site.	65	9.4	sawtimber	360	$ 3400
II	Average quality of a post-SMCRA non-FRA reclaimed mine soil.	50	4.5	small sawtimber	200	$ 900
III	Estimated quality of a post-SMCRA reclaimed mine soil when FRA reclamation is used.	85	13.0	large sawtimber, veneer	520	$ 6800

[a] Site Index = Expected red or white oak height after 50 years, in feet.

[a] Harvestable timber volume at Age 60, expressed as thousand board feet per acre (MBF), based on yield tables prepared by Schnur (1937).

[b] Harvest price, estimated as an average of what was typical over the 1999-2009 period Actual harvest prices vary with market conditions.

Both of the examples above show the dramatic effect site quality has on forest land value, and they show why landowners and the mining community should strive for proper reclamation of forest land (Figure 5).

Figure 4. Red oaks growing at the Starfire mine site in eastern Kentucky at age 9. Mine soils on this site were reclaimed using procedures that allow them to be highly productive. (Photo by Vic Davis).

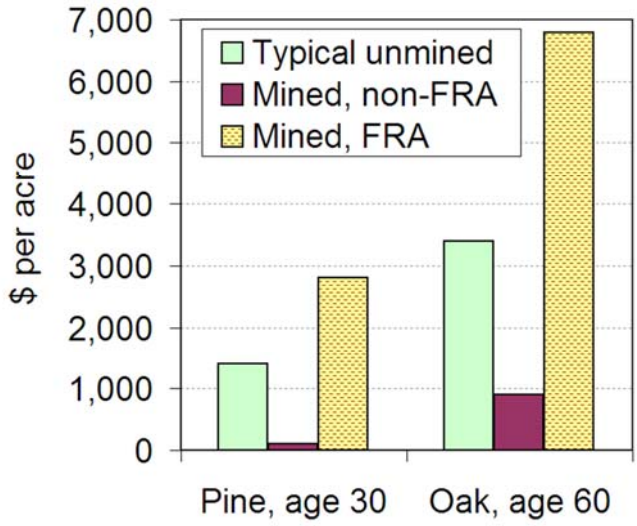

Figure 5. Influence of site quality and reclamation method on timber value in the Appalachians, using data from Tables 2 and 3. Mining can either degrade or improve the value of mountainous land for timber production, depending on the reclamation practices used.

Other Values of Mined Land Reforestation

Tax treatment in some states may be a further short-term incentive for landowners to choose productive forestry post-mining land use. In West Virginia, for example, the Managed Timberland Tax Incentive Act provides for taxation based on timber capability class. If a landowner's timber capability was good to average before mining, but poor after mining, he or she will be paying a post-mining tax rate based on the pre-mining productivity which can be higher than the post-mining land can support.

Another reason for coal operators to promote forestry as a post-mining land use is to enhance relationships with their business partners – resource owners and coal-burning electric power producers. Resource owners that control both mineral and surface have an economic interest in maintaining the forest productivity of lands mined for coal. Thus, mining firms that can demonstrate capability to restore or enhance pre-mining forest productivity through FRA reclamation can cite that capability in coal-leasing contract negotiations with mineral owners that retain surface interest.

If carbon-emission restrictions become law at a future time, it is likely that coal-burning electric-power producers will be called upon to offset carbon emissions to the atmosphere. Much of the surface mining in central Appalachia today occurs on sites that include some previously mined lands where forests were not restored. If purchases of coal from mines that increase the land's carbon storage potentials through reforestation can be used by the power producers to help meet their carbon-emission offset requirements, coal producers with excellent reforestation programs will have a marketing advantage. Planting trees on productive mine soils after mining is a way to produce a measurable carbon sink (Amichev and others 2008). Forests growing on good quality mine sites can sequester 3 to 5 times more carbon than grassland. Similar to the wood volume increases with productivity shown in Figure 1 and Tables 2 and 3, sequestered carbon increases exponentially with mine site quality, with average values of 0.5, 1 and 2 tons/acre/year for poor, fair, and good sites, respectively.

Society at large also benefits from mine reclamation practices that restore productive forests. In addition to establishing commercially valuable trees that sequester atmospheric carbon, the Forestry Reclamation Approach allows return of the full forest community through ecosystem succession processes (see ARRI Forest Reclamation Advisory No. 5). Such forests stabilize mine soils, maintain clean water in rivers and streams that drain coal mining areas, provide watershed protection services such as reduction of the peak flows that can cause flooding, enhance wildlife habitat, and improve landscape aesthetics.

The coal industry can benefit from more widespread use of reclamation practices, such as the Forestry Reclamation Approach, that restore native forests. Public perceptions of coal and coal mining in many areas of the US are negative because many among the general public believe that mining destroys the land's biological capacity. More widespread and successful application of the Forestry Reclamation Approach by the coal industry can help to counteract such perceptions by demonstrating the industry's capability to restore and enhance mined land's biological capability, as is required by SMCRA.

Conclusion

Proper reclamation and reforestation techniques can meet the spirit of the law requiring that forest land be returned to its former use and level of productivity. The Forestry Reclamation Approach (FRA), which is becoming widely used by coal operators in Virginia and other Appalachian states, restores productive forests through reclamation of coal mine sites. Landowners, miners, and society at large benefit when improved forest reclamation techniques are employed:

- Landowners benefit from a post-mining timber resource of significant economic value;
- Miners benefit from reduced reclamation cost, SMCRA compliance, and prompt bond release when reforestation is done properly;
- Society benefits from wildlife habitat, watershed protection, carbon sequestration, and other ecosystem services, and the jobs and other economic benefits that are made possible by the valuable timber products that can be grown and harvested from reclaimed mines.

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