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POWELL RIVER PROJECT

RECLAMATION GUIDELINES FOR SURFACE MINED LAND

How to Restore Forests on Surface-Mined Land

J. A. Burger, Professor Emeritus, Forestry and Soil Science, Virginia Tech
C. E. Zipper, Extension Specialist, Crop and Soil Environmental Sciences, Virginia Tech

Introduction

Most coal-bearing lands in the Appalachian region were forested prior to mining. The region's forests are predominantly upland oak-hickory and Appalachian mixed hardwoods. These forests provide many benefits to landowners and the public. Solid wood and paper products are perhaps the most tangible benefits, but a predictable flow of high-quality water from forested watersheds into regional streams is another vital benefit provided by the region's forests. Forests also fix carbon from the atmosphere, provide wildlife food and cover, and provide recreational opportunities and an aesthetically pleasing environment.

Surface mining completely removes the forest. Public law 95-87, the Surface Mining Control and Reclamation Act of 1977 (SMCRA), mandates that mined land be reclaimed and restored to its original use or to a use of higher value. Restoring forests on surface-mined land is challenging; however, reforestation research by

Figure 1. A 50-year-old hardwood forest on mined land.

Figure 2. A 16-year-old pine forest on mined land.

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Virginia Tech's Powell River Project since 1980 shows that restored forests can be equally or more productive than the native forests removed by mining. In addition, reforestation can provide low-cost and timely release of reclamation bonds for coal miners, and restored forests can provide economic returns to landowners.

The purpose of this publication is to provide practical, cost-effective guidelines to ensure successful forest-land reclamation using the principles of reforestation silviculture. The following guidelines were developed from research and practical experience; they should help reclamation managers and landowners achieve reforestation success and renewal of the many benefits that forests provide.

These guidelines are consistent with the reclamation method known as the "Forestry Reclamation Approach" or FRA. The FRA was developed by the Virginia Tech Powell River Project and is advocated by the U.S. Office of Surface Mining, the Appalachian Regional Reforestation Initiative (ARRI), and state reclamation agencies. The FRA is consistent with SMCRA regulations throughout Appalachia and in the upper Midwest (see ARRI Forest Reclamation Advisories Nos. 1 and 2).

Principles of Reforestation

The eastern deciduous hardwood forest with its hundreds of species of plants and animals is one of the most complex plant systems in North America. When land is surface-mined, the entire forest — including shrub layer, tree canopy, rootstocks, seed pools, animals, and microorganisms — is removed. After mining and land reclamation, this complex forest, given enough time, will be restored to its original function and structure through a process called forest succession. Forest succession is a natural process whereby following disturbance, the forest regains its original composition through a slow process of species replacement and site amelioration.

The original forest of oak, hickory, basswood, dogwood, maple, Fraser magnolia, cucumber tree, and other mid- to late-successional species is not instantaneously restored. Instead, pioneer species, such as leguminous trees and shrubs, and pine and hardwood species that can tolerate a wide range of acidity, fertility, moisture, and temperature become established first. The pioneer species will eventually yield to the more site-sensitive hardwoods.

In the meantime, the minesoil is being conditioned, nitrogen and organic matter are being incorporated, populations of macro and micro plants and animals are increasing, a more diverse wildlife habitat is being created, and valuable wood products are being produced.

The rate at which natural forest succession proceeds depends on the nature of the reclaimed site and adjoining undisturbed sites. We believe it would require several hundred years for the mid- to late-successional hardwoods to dominate if forest restoration were left entirely to nature.

The reforestation procedures recommended below are designed to accelerate forest succession while providing land stabilization and erosion control, bond release for the mining operator, and economic returns to landowners. A combination of grasses and legumes (used when necessary for erosion control), nurse shrubs and trees, and crop trees are established more or less simultaneously. Each plant type serves a specific reclamation function, and then yields to another plant type (Figure 3).

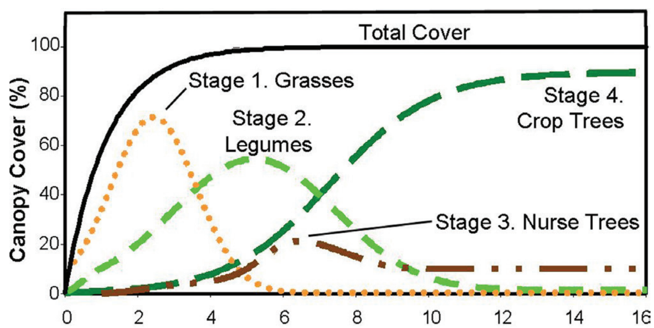

Figure 3. Reforestation silviculture seeks to stimulate natural processes known as forest succession. All vegetation types are established during reclamation. As time passes, grasses and legume groundcovers yield to nurse and wildlife trees, which are themselves overtopped by commercially valuable crop trees as the forest grows and matures.

On sites reforested using these guidelines, tree-compatible hydroseeded grasses emerge first to quickly stabilize the minesoil surface. Grasses then yield to legumes when applied nitrogen is minimized. The slow-starting, ground-sprawling legumes (white clover, birdsfoot trefoil) allow trees to become established and grow before totally covering the ground. The legumes enrich the site and eventually give way to the tree cover. Nurse trees and shrubs condition the site for the crop trees and yield to the crop trees as they close canopy. This process of matching plant species to site conditions, matching plant species for their compatibility with each other in space and time, and managing tree stands to accomplish certain objectives as they develop, is called reforestation silviculture.

Regulations and Performance Bonds

Most mined land planted with trees is designated as "unmanaged forestland" (or "noncommercial forestland") in Virginia mining permits. Another forestland postmining land-use option is known as "commercial forestland" or "managed forest."

Several Appalachian states allow miners to define forested postmining land uses as either "unmanaged" or as "managed" (or "commercial"). In Virginia, bond release requirements are similar for both commercial (managed) and unmanaged forestland, but there are some subtle differences. Typically, unmanaged forestland is planted with both timber-producing species and wildlife, and nitrogen-fixing shrub and tree species.

The commercial forestland option provides an opportunity to use alternative reclamation practices to achieve a wood-production forestry management objective and to restore the original composition of the native forest. For commercial forestry, a minimum stocking of 400 trees per acre of native, commercial species is required, in addition to 40 wildlife trees or shrubs per acre. As with any land-use designation, the coal company must submit a simple management plan that explains how the proposed postmining land use is to be achieved.

Additionally, a copy of the comments by the landowner concerning the proposed use must be submitted. These documents are required to show that the landowner is committed to the proposed commercial forestland, and that it can be reasonably achieved.

The guidelines offered in this bulletin were developed to increase the probability of timely performance bond release as well as to ensure the establishment of productive forests. Regulatory requirements in this publication are specific to Virginia, but the general guidelines are applicable to reclamation in surrounding states. In Virginia, performance criteria for bond release can be achieved for forestland.

Virginia Division of Mined Land Reclamation (2008) Guidance Memorandum 22-08 reviews information relevant to regulatory compliance for forested postmining land uses. Of particular importance are requirements relative to final surface grading, groundcover, and number of trees per acre.

Permitting

From a regulatory standpoint, successful reforestation starts with the mining permit. Ideally, all stakeholders — including the coal operator, landowner, regulators, and consulting service providers — are involved in permit writing and review. All should know and understand the approach, process, and expected results of the revegetation and reforestation plan. Regulatory authorities will reference the mining permit when judging reclamation success. Mine permitting for productive reforestation is discussed in *Mine Permitting to Establish Productive Forests as Postmining Land Uses*, Virginia Cooperative Extension (VCE) Publication 460-141.

Minesoil Selection and Placement

Federal and state regulations require that natural soil existing on sites prior to mining be saved and placed on the reclaimed mine site after reclamation. This rule is waived for coal operators working on steep terrain where soil is shallow and difficult to recover and when operators can show that topsoil substitutes are as good or better for the postmining land use as the original soil.

Contemporaneous reclamation close to the mine pit reduces haulage costs and allows cost-effective use of native soil on reclaimed surfaces.

When needed, topsoil substitutes — usually consisting of a mix of overburden materials — must meet certain physical and chemical criteria in order to be a suitable growth medium for plants.

Those criteria are different for native trees compared to criteria for commonly used agricultural grasses. For native hardwood trees, topsoil substitutes should be neutral to slightly acid, sandy and loamy in texture, loose and well-aerated for good drainage, fertile without excessive saltiness, and the selected material should be 4 feet deep or deeper.

For forestry postmining uses, and when FRA procedures are used, regulations in Virginia and most Appalachian states allow rougher, looser, surface soils containing organic debris in order to produce minesoil characteristics conducive to good tree survival and growth.

Final Surface Grading

In the past, establishment of smoothly graded slopes with lush vegetation during the first year was a goal for many reclamationists. Unfortunately, land reclaimed in this way is often compacted by excessive grading, and the groundcover vegetation is too dense for tree establishment. Most Appalachian forested landscapes are uneven, and many are strewn with rocks and boulders. Natural forest soils are rough and loose, allowing deeply rooted woody species to become established and grow unimpeded.

Surface grading requirements and regulations vary by state, but all Appalachian state regulatory agencies and the U.S. Office of Surface Mining support and encourage use of the Forestry Reclamation Approach methods, which include low-compaction grading.

In Virginia, the Virginia Coal Surface Mining Control Reclamation Act of 1979 specifies that graded backfills "support the approved postmining land use." Compaction is only necessary "where advisable to ensure stability" (480-03-19.816.102). Therefore, on level areas and short, gentle slopes, grading should be minimized to avoid surface soil compaction.

After groundcover and tree establishment, small-to-medium gullies need not be filled unless they are associated with sedimentation problems or grow to the point where they would hinder forestry operations. Small-to-medium gullies may interfere with hayland/pasture uses but do not interfere with forestry and wildlife habitat as they fill in and stabilize naturally. Minesoil compaction resulting from gully repair is counterproductive to successful reforestation.

Groundcover Establishment

The SMCRA and its federal regulations require vegetative groundcover to be no less than that required to achieve the approved postmining land use and control erosion. The Virginia Division of Mined Land Reclamation has issued a regulation that effectively eliminated the former 90 percent groundcover standard for mine sites on areas where the FRA is implemented. This regulation calls for minimizing groundcover competition with woody plants by limiting groundcover to that necessary to control erosion and support the postmining land use. A similar regulation is in place in Tennessee.

As of this writing, a number of other states in the Appalachian region are considering similar changes. Mining firms outside of Virginia are encouraged to check with their state regulatory authority concerning the current groundcover standard for success.

Number of Trees per Acre

In Virginia, the number of trees per acre and species selection differs between commercial forestland and noncommercial forestland. For commercial forestland, there must be at least 400 commercial trees per acre, plus 40 wildlife trees or shrubs (a minimum of 440 trees per acre) for bond release. White pine is a common commercial species in Virginia. Mixed hardwoods, including oaks, hickories, ashes, maples, and black cherry, and eastern white pine are commonly planted species that are considered commercial species.

For noncommercial forestland, there must be at least 400 trees per acre, of which at least 40 must be wildlife trees or shrubs. Native invading trees count toward bond release if they are species suitable for the postmining land use defined in the mining permit and at least 1-foot tall. Planting 550 crop trees and 60 to 100 wildlife or "nurse" trees per acre should achieve these required stocking densities if soils and groundcover vegetation are compatible with tree establishment.

Table 1 summarizes the reforestation plan components and reclamation activities that must be executed properly to assure tree survival rates adequate to achieve bond release. Each of the reclamation activities is reviewed in detail in the text that follows.

Selecting Minesoil Material

Carefully constructed minesoils can be as deep and fertile as natural soils. Natural soils in steeply sloping areas of the Appalachians may be difficult to recover, store, and replace during reclamation. "Topsoil substitutes" containing large amounts of blasted overburden materials are allowed by law in some cases and can be used successfully as plant-growth media, provided they are of equivalent or better quality than the original soil.

But in order to be as productive as natural soils, the spoil materials must have desirable physical and chemical properties that are suitable for good growth of deeply rooted trees. Natural soil should be recovered and used to the extent possible, even as a mixture with overburden materials. When natural soils are not recoverable or are insufficient in quantity, the surface 4 feet of minesoil material should be easily "weatherable" overburden, meaning that most rocks and boulders break apart and decompose quickly to fine soil materials.

The soil texture of the fine-earth fraction should be loamy to sandy, and the minesoil should be low in total

Table 1. Major reclamation activities that, if executed properly, should assure planted seedling survival rates and tree counts adequate for bond release.

Reclamation activity	FRA No.[a]	Rationale
Prepare the land for reforestation using the forestry reclamation approach: • Use soil and topsoil substitutes suitable for trees and place at least 4 feet deep.	1	Land preparation using FRA procedures will produce loose soils of good quality that aid proper tree planting, help planted trees survive and grow at expected rates, and aid establishment of native volunteer plants.
• Avoid compaction by minimizing grading and leaving soils loose.	2	For forestry postmining land uses, agricultural grasses and legumes are used only as needed to control erosion.
• Use tree-compatible groundcover when necessary to control erosion with low nitrogen and high phosphorus fertilization.	3	Minimizing groundcover with tree-compatible species increases survival and growth of planted and volunteer species.
Select species that are best-suited to the soil properties and landscape conditions that occur on the mining site.	4	Site conditions vary across the reclaimed area. Using species adapted to conditions and grouping species where they are suited will increase survival and growth rates.
Use tree planters who are knowledgeable and skilled, and assure that they use good seedling stock, properly care for the seedlings from nursery to planting, and use planting rates adequate to achieve bond release.	5	Proper care of seedlings before and during planting and use of proper planting procedures are essential to achieving adequate survival.
Example: Select 5 crop tree species: 110 each/acre = 550 crop trees/acre. Select 4 wildlife/nurse tree species: 25 each/acre = 100 trees/acre.		550 crop trees + 100 wildlife/nurse trees = 650 trees/acre. If overall survival is 70%, 455 surviving trees/acre will assure bond release.

[a] The Forestry Reclamation Approach is made up of five steps or procedures that are consistent with these guidelines (see ARRI Forest Reclamation Advisory No. 2). The "FRA" column designates steps of the Forestry Reclamation Approach that correspond with these procedures.

salts; minesoils should be moderately acid (pH 5.5 to 6.5) when native hardwoods are being planted. Most importantly, the minesoil must also be left uncompacted to a depth of 4 feet.

Trees have different minesoil requirements than forage grasses and legumes. Most grasses and legumes can tolerate compacted surfaces, high pH levels, and high levels of soluble salts; trees cannot. Even if trees survive under these minesoil conditions, they will not grow well. Trees require soils depths of at least several feet, while grasses can thrive in thinner soils because most of their roots are close to the surface.

As demonstrated by figures 4, 5, and 6, minesoil properties can have a major influence on the growth of planted trees.

Brown, oxidized sandstones — often found in deep layers near the land surface throughout the Appalachians — make excellent minesoils for trees, provided they are not too acidic (in rare cases they may contain pyrite or high concentrations of manganese). Research studies and many observations of reclaimed sites in Virginia, West Virginia, and Kentucky show that tree survival and long-term growth is excellent on oxidized, moderately acid mixtures of brown, weathered sandstone mixed with some siltstone/shale materials (Burger,

Figure 4. Eight-year-old white pine growing in compacted, unweathered shale minesoil.

Figure 5. Eight-year-old white pine growing in loose, weathered sandstone minesoil.

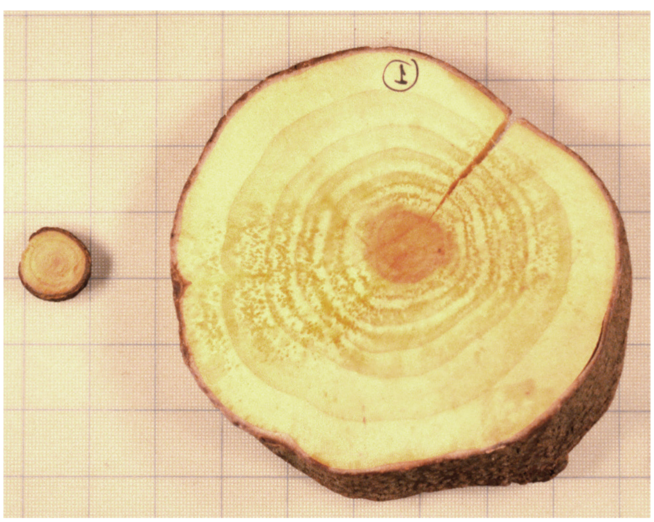

Figure 6. Cross-sections of 8-year-old white pine trees: left, growing on loose sandstone minesoils; right, growing on compacted shale minesoil.; left, growing on loose sandstone minesoils. *Note:* (Grid line spacing = 1 inch.)

Mitchem, and Daniels 2007). This rock mixture provides good drainage, aeration, and fertility; when mixed with native soil, the added organic matter and soil organisms provide an all-important biotic component that adds life to the new minesoil.

In general, siltstone and shale that occur directly above or below coal seams should be avoided. These rock types usually have high levels of soluble salts and a high or very low pH, and they compact to greater densities when trafficked. Some of the white or blue-gray unweathered sandstones that occur farther below the surface will be less productive but are acceptable for forestland when these are the "best available materials" on the mine site. However, these spoils weather very slowly and should only be used when native soil or brown, weathered sandstone and siltstone are not available.

All native topsoils should be recovered and used when possible, and mixing even small amounts of fresh soil with overburden will improve the site's suitability for trees. Fresh topsoil typically harbors seeds and roots of tree and shrub species that can grow into viable seedlings when conditions are right. Fresh, native soil aids seedling survival, as beneficial fungi and microorganisms help seedlings obtain water and nutrients.

In places where the soil handling cost makes it impractical to obtain large amounts of fresh soil for use in reclamation, small amounts of soil (a truckload here and there, placed so it can be distributed during grading) will aid reforestation success. Spoil selection guidelines for reforestation are summarized in figure 7 and table 2.

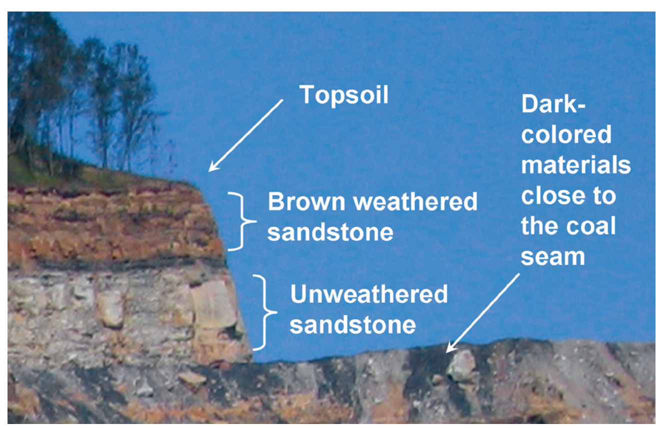

Figure 7. Overburden materials differ in suitability for use as reforestation growth media (see table 2).

Table 2. General guidelines for selecting reforestation soil materials.

Material	E[a]	G	F	P	Comment
Topsoil	✓				Includes anything that can be removed with a dozer prior to blasting. It can be mixed with other materials, even in small quantities, to provide organic matter, beneficial microorganisms, fungi, and nutrient pools.
Brown weathered sandstone	✓	✓			Includes top 20-30 feet of rock material on most sites; can be used alone or mixed with suitable materials from deeper in the overburden sequence.
Unweathered sandstone		✓	✓	✓	Materials that break down into smaller particles and achieve pHs in the range of 5.5-6.5 are good. Sandstones suitable for “durable rock” should be avoided. If used, unweathered sandstone should be mixed with topsoil or weathered sandstone.
Unweathered siltstone and shale			✓	✓	Should not be used alone; can be mixed with topsoil or weathered sandstones to form good-to-excellent reforestation materials.
Rocks from directly above or below the coal seam				✓	Generally high in soluble salts and a poor choice for reforestation, even when mixed in significant ratios with more favorable materials. Black shales are especially poor for reforestation.
Rocks containing pyrites or high levels of metals				✓	Any material that stabilizes at pH < 4.0 or > 7.5 within a year or two after surface placement should not be used in reforestation, either alone or in mixes.

[a] E = excellent, G = good, F = fair, P = poor (should be avoided).
Note: The term “mixed” as used above refers to the intermingling of rock materials that occurs routinely during operations such as blasting, loading, hauling, and dumping. These are general guidelines that can be applied with overburdens typical of southwestern Virginia’s coalfield. On some mining operations, specific overburden materials may have properties that are not well-suited for these general guidelines.

Placing and Grading Minesoil Material

Reclaimed minesoils must be left loose and uncompacted to ensure successful establishment and long-term growth of trees. Prior to seeding groundcovers, reclaimed sites are often cleared of large boulders, gullies are filled, and the surface is graded smooth and “tracked in” with bulldozers to create a seedbed for groundcovers. Smooth-graded, tracked-in spoils are very undesirable for tree establishment and long-term forest growth.

Powell River Project research shows that minesoil compaction is the single factor most limiting to reforestation success on older mine sites in central Appalachia. When soils are excessively graded and tracked in, trees are often not planted deeply enough because of the physical effort required to open a suitable planting hole. This results in poor survival and permanently reduces the minesoil quality. Compacted minesoils reduce water infiltration, reduce plant-available water, increase sheet erosion, and restrict root growth.

When forestland is the postmining land use, grading should be limited to the extent needed to shape the final landform and ensure the stability of slopes. On level and gently sloping areas, spoil placement should be planned so that once a pile is dumped in place, no more equipment passes over it except for a final, light grading with a small dozer. Minesoil compaction can be

Figure 8. Typical grading and tracking-in operations for nonforest postmining land uses.

Figure 9. Example of uncompacted, roughly graded surface ideal for tree planting.

minimized by grading when minesoil materials are dry and by using small dozers with low ground pressures.

Natural forestland in the Appalachians is usually rougher than pastureland. Reclaimed forestland with boulders and uneven surfaces will not adversely affect forest management activities. When topsoil from the premining forest is available for use in preparing the final surface, leaving any stumps, logs, or other woody debris that is in that topsoil on the final land surface will aid reforestation.

Using Tree-Compatible Groundcovers While Controlling Erosion

Grass and legume groundcovers are typically seeded with fertilizer and mulch hydromixes. Even though trees are being planted, these herbs are sometimes needed to reduce erosion and stabilize sloping terrain. Commonly used agricultural grasses and legumes are not natural components of forest ecosystems in this area. Trees planted in aggressive, tall, heavily fertilized groundcovers usually fail because they are overcome by the groundcover.

When forestland is the intended land use, reforestation requires a carefully planned balance between groundcover for erosion control and the trees' requirements for light, moisture, and space. Forage species commonly used to create hayland or pasture such as Kentucky-31 tall fescue (*Festuca arundinacea*, "K-31") and red or sweet clover are not compatible with trees; they grow too tall and too dense for trees to emerge.

A tree-compatible groundcover mix should include annual and perennial grasses and legumes (table 3)

Table 3. Recommended groundcover seeding and fertilizer application rates for reforestation of reclaimed lands.[a]

Species/fertilizer	Rate (lb/acre)
Grasses	
Foxtail millet (spring seeding only)	5
Annual ryegrass (fall seeding only)	10
Timothy	5
Perennial ryegrass	10
Orchardgrass (steep slopes only)	5
Legumes	
Birdsfoot trefoil	5
Ladino or white clover	3
Fertilizer[b]	
Nitrogen	50-75
Phosphorus (as P)	80-100
(as P_2O_5)	180-230

[a] For further detail, see VCE publication 460-124.
[b] Can be achieved by applying 400 lb/acre di-ammonium phosphate, by blending 200 lb/acre concentrated superphosphate with 300 lb/acre 19-19-19 fertilizer, or with other fertilizer blends.

and should be used only as needed to control erosion at acceptable levels. Because soil conditions typically differ across the site, species adapted to a variety of site conditions should be included in the mix.

Annual grasses such as foxtail millet (*Setaria italica*), and annual ryegrass (*Lolium multiflorum* Lam.) provide quick, initial protection to the surface by reducing the impact of raindrops and minimizing soil movement. Foxtail millet is the preferred annual grass to use for spring or summer seeding; annual ryegrass should be used for fall seeding. These grasses germinate quickly and provide good cover during the first year.

Because most annual grasses are tall, they must not be so dense as to adversely block light from tree seedlings. The limited shade and protection from wind provided by these annual grasses reduce seedling moisture stress. Rye grain and wheat grain should not be used in groundcover mixes for hardwood plantings. Their grain production attracts rodents that chew the bark of seedlings, thus killing them.

If a heavier-than-normal groundcover is desired for reforestation due to a localized circumstance, the annual ryegrass seeding rate can be increased up to 20 pounds per lbacre, although the 10 pounds per acre rate provided in table 3 should be adequate to control erosion on most Virginia mine sites when the surface soils are left in a loose condition, as is recommended for reforestation.

After the first growing season, slower-growing perennial grasses and legumes should satisfy groundcover requirements. They should be adapted to low pH and fertility levels, and most grasses should be cool-season species to reduce competition with trees for moisture during midsummer.

Perennial groundcover species should not grow so tall or dense that the establishment of trees is hindered. Perennial ryegrass (*Lolium perenne*) and timothy (*Phleum pratense*) are low-statured grasses that become established on relatively acid, infertile soils. They are quickly established and decline after several years, providing space for developing legumes.

On long, steep slopes, orchardgrass (*Dactylis glomerata*) can be included to provide additional protection against erosion. Kentucky-31 tall fescue “”should not be used with trees. K-31 competes excessively for light and moisture; it produces allelopathic substances (phytotoxic chemicals) that retard tree growth, and it attracts rodents that chew on the stems of trees.

Weeping lovegrass (*Eragrostis curvula*) is tolerant of very acid spoil and germinates within a few days, thus contributing to early erosion control. Where pockets of acidic spoils (pH less than 4.5) are present, weeping lovegrass can be added to the reforestation groundcover seeding mix at low seeding rates (approximately 2 pounds per lbacre).

A leguminous groundcover can enhance soil nitrogen levels by as much as 50 pounds per lbacre per year. Legumes — in conjunction with *Rhizobium* bacteria — enhance the nitrogen status of the soil by fixing atmospheric nitrogen. Nitrogen released by decomposition of legume foliage and sloughed roots quickly becomes available to trees.

Birdsfoot trefoil (*Lotus corniculatus*) is a perennial legume that has performed well in numerous research studies and on operational sites on minesoils in Virginia. The “Fergus” variety of birdsfoot trefoil is better adapted to Virginia than most of the northern varieties. Birdsfoot trefoil and white clover are a good combination because they are cool-season plants and are tolerant of moderately acid soils. This combination provides an actively growing groundcover from spring through the fall season.

Kobe lespedeza (*Lespedeza striata var. Kobe*) is a low-statured annual legume that can be added to the reforestation seeding mix at low rates (3 to 5 poundslb per acre) if a heavier-than-normal groundcover is desired for reforestation due to a localized circumstance, although it is not a necessary or desirable addition to the above seeding mix for reforestation on most Virginia mine sites.

Sericea lespedeza (*Lespedeza cuneata*), formerly widely used in reclamation, is not an acceptable legume for use in reforestation: It is too tall and competitive, and it has become an invasive weed throughout the coalfields.

As a group, the clovers are less suitable for reforestation groundcovers. Most clovers require soil pH and fertility levels that are higher than needed for trees, and most clover species are too aggressive during the first year to be used with trees. An exception is white or ladino clover (*Trifolium repens*): It is tolerant of acidic minesoils and produces a short cover that does not excessively compete with tree seedlings. It produces good cover for the first two years and then yields to the birdsfoot trefoil.

Figure 10. Example of noncompetitive, tree-compatible groundcover.

Figure 11. Example of competitive groundcover compromising the survival of trees.

Importance of Using Tree-Compatible Groundcovers

Unlike standard hayland and pasture forages that are lush during the first year and gradually decline without additional fertilizer, tree-compatible covers are designed to be sparse during the first year and become increasingly dense by the second and third years. This allows tree seedlings to emerge above the groundcover and aids their survival.

Despite relatively low recommended seeding rates, sufficient groundcover can be achieved for partial bond reduction during the first year. Most of the first-year cover results from the annual grasses, while the legumes dominate after several years.

Birdsfoot trefoil and white clover emerge slowly by producing only a few plants per square foot, and these plants are generally less than 6 inches tall after the first season. By the third season, however, they develop into a complete cover, replacing the grass and filling in under emerging trees. These legumes persist beneath the trees, increasing organic matter and nitrogen levels for several years until trees eventually shade them out.

Another purpose of low groundcover seeding rates is to allow the invasion of native plant species such as yellow poplar, red maple, birch, and other light-seeded trees. Dense groundcovers prevent the natural "seeding-in" of native plants. An additional benefit of a tree-compatible cover is that some tree and shrub species can be established by direct-seeding. When conventional groundcovers are used, direct-seeded trees will not emerge and survive due to dense shading.

For further information on reforestation groundcovers, see *Establishing Groundcover for Forested Postmining Land Uses,* VCE publication 460-124.

Tree Species Selection

A sufficient number of desirable trees must be established during reclamation in order to achieve multiple uses from a developing and mature forest. Two categories of tree species are recommended:

1. Crop trees: commercially valuable, native, timber crop species.

2. Nurse trees/wildlife trees: trees and shrubs that fix nitrogen and/or attract wildlife, including birds.

Crop trees are long-lived species that offer value to landowners as saleable forest products. Yellow poplar (*Liriodendron tulipifera*), oaks (*Quercus* spp.), ash (*Fraxinus* spp.), maple (*Acer* spp.), and other hardwood species are commonly planted as crop trees on mining operations that are reclaimed using the Forestry Reclamation Approach.

Nurse trees are planted to assist the crop trees by enhancing the organic matter and nitrogen status of the soil and improving soil physical properties, and by attracting seed-carrying wildlife such as birds onto the site. Nurse trees will die or can be cut out after 15 to 20 years when crop trees need additional growing space. Nurse trees help achieve the minimum number of stems and groundcover required for bond release, and they provide food and cover for wildlife.

Recommended nurse species are flowering dogwood (*Cornus florida*), redbud (*Cercis canadensis*), blackhaw (*Viburnum prunifolium*), native crabapple or hawthorn (*Rosacea* species), shagbark hickory (*Carya ovata*), and white pine (*Pinus strobus*). Black locust (*Robinia psuedoacacia*) and autumn olive (*Elaeagnus umbellata*) were commonly used in the past but are not recommended today. Autumn olive, Russian olive (*Elaeagnus angustifolia* L.) and related species, and bicolor lespedeza (*Lespedeza bicolor*), are non-native species that are listed as invasive in Virginia and neighboring states (Miller, Chambliss, and Bargeron 2008) and should be avoided.

Crop Tree Selection

Hardwoods: Most native hardwood species grow well on well-constructed minesoils. The critical factors that

Figure 12. Northern red oak crop trees on mined land after 55 years.

affect tree survival and growth are spoil type, compaction, slope aspect and position, and competition from groundcover grasses and legumes. Ideally, these factors should be optimized during the reclamation process, as described above. Most reclaimed sites, however, contain a variety of soil conditions. A key to successful reforestation with hardwoods is tailoring the species to minesoil conditions.

Tree species can and should be selected to "fit" the final combination of conditions found on a reclaimed site. For example, hardwoods recommended for good sites are red, white, and black oak; tulip poplar; sugar maple; black cherry; and white ash. When available, blight-resistant American chestnut hybrids are also recommended as part of the native hardwood species mix. Sycamore, green ash, and red maple are more tolerant of sites that are compacted, poorly drained, or have minesoils primarily derived from siltstones or shales (figure 13).

Slope aspect and position (figure 14) influence water availability through the growing season. The best sites for the most water-demanding trees and the most valuable species are slopes with a north and east aspect and a position toward the toe of the slope. Red oak, sugar maple, and tulip poplar are examples of species that should be planted on such sites.

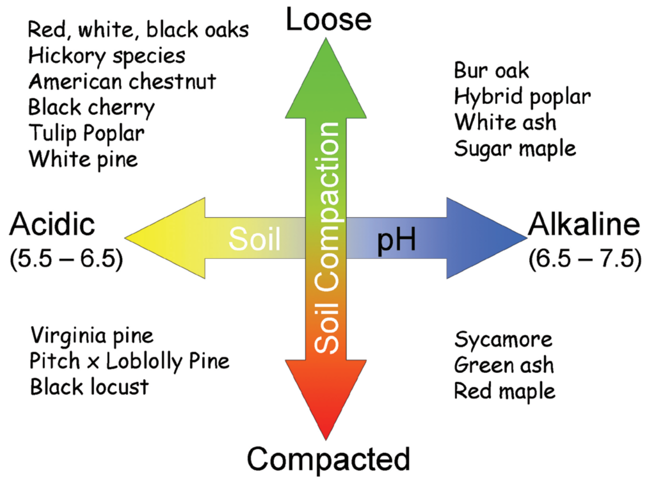

Figure 13. Tree species recommended for different spoil types and levels of compaction.

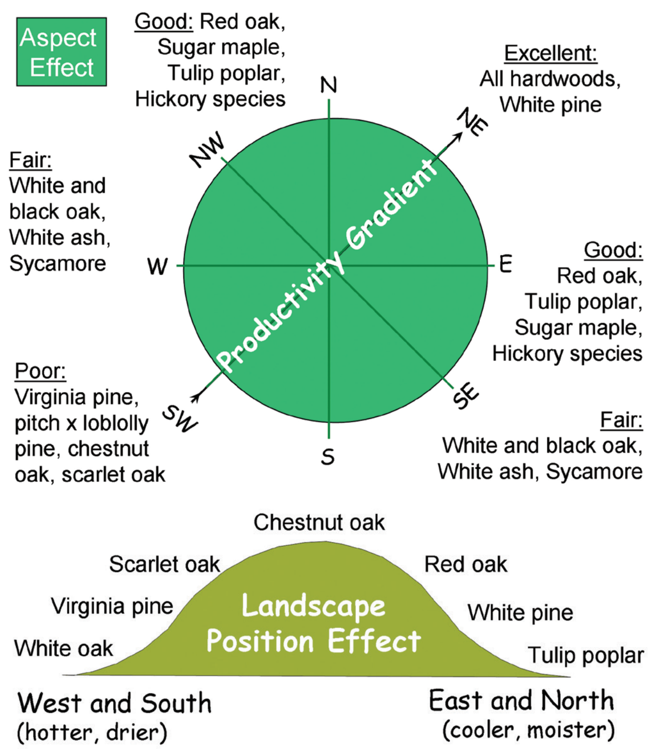

Figure 14. Tree species recommended for: *upper*, different slope aspects; *lower*, different positions.

Southwest aspects toward the tops of slopes are the driest; therefore, drought-tolerant hardwoods such as scarlet and chestnut oaks should be planted in these positions. Good tree-planting contractors can do site-specific tree selection and planting. Site-specific planting should be specified and described in mining permits and tree-planting contracts.

Many minesoils are excessively wet during much of the growing season because of poor internal drainage or because of compacted layers that perch water. Most high-value crop trees are intolerant of wet soils; however, sycamore (*Platanus occidentalis*), eastern cottonwood (*Populus deltoides*), and black alder can tolerate wet sites and should be used under these conditions.

On very low-quality sites, with limitations due to compaction, acidity, or high soluble-salt levels, the concept of selecting a long-term crop tree should be abandoned. Emphasis should be placed on stabilizing the site with trees and shrubs that are commonly used as nurse trees. As already mentioned, sycamore, green ash, and black alder are suitable for wet sites. Black alder and bristly locust are both tolerant of very acid sites.

Pines: On good sites, white pine can produce more merchantable volume than any other native species. White pine on 12- by 12-foot to 15- by 15-foot spacing (200 to 300 trees per acre) can produce merchantable timber in 30 to 40 years (Balmer and Williston 1983). However, white pine requires higher-quality sites than other pines. White pine should be planted in areas that have at least 4 feet of uncompacted soil. It does best on deep, brown, well-drained, sandy minesoils.

On sites that are unsuitable for white pine or quality hardwood growth due to depth, acidity, salinity, or drainage, other pine species can be planted. On shallow sites or sites with a large amount of coal refuse, Virginia pine (*Pinus virginiana*) and loblolly pine *(P. taeda*) are good choices for crop trees. Both species are more drought-tolerant than white pine.

Virginia pine is an excellent pulpwood species that is native to the region and is adapted to harsh sites. It has a shallow root system, which makes it a suitable species for shallow soils. It is also tolerant of acid minesoils with pH levels as low as 4.0.

Loblolly pine is not native to the mountainous regions of Virginia, but it has been successfully planted and grown on many reclaimed sites. Some winter damage has been reported in the northern part of Virginia's coal-mining region, but the problem seems to be no more severe than in the northern Piedmont of Virginia where loblolly pine is grown commercially. Good stands can produce pulpwood and sawtimber-sized trees in 20 to 40 years.

Pitch x loblolly pine hybrid (*P. rigida x taeda*) may be the best commercially valuable pine species for planting on dry minesoils because of its tolerance to a variety of soil and site conditions and its rapid growth. It is a cross between loblolly and pitch pine, which is native to the region. It has the rapid growth rate and good form of loblolly pine and the cold hardiness and strength of pitch pine.

Loblolly pine, pitch x loblolly, and Virginia pine are more susceptible to damage by the southern pine beetle than white pine.

Wildlife/Nurse Tree Selection

The nurse tree and nurse shrub species recommended for reclamation planting are nitrogen-fixing plants that benefit crop trees and provide food and cover for wildlife. Nurse trees contribute to groundcover requirements and help stabilize the site. Recommended species include flowering dogwood (*Cornus florida*), redbud (*Cercis canadensis*), blackhaw (*Viburnum prunifolium*), native crabapple or hawthorn (*Rosacea* species), shagbark hickory (*Carya ovata*), and white pine (*Pinus strobus*). Dogwood, redbud, blackhaw, and hawthorn produce soft fruits for wildlife; shagbark hickory provides nesting habitat for the endangered Indiana bat; and whitre pine provides winter cover for a variety of wildlife.

Historically, black locust was the most commonly planted nurse tree species in Virginia. Black locust is easily established and grows rapidly; unfortunately, it is very competitive and should not be planted with crop trees in a commercial forest mix. Black locust is too aggressive and the thorns on its branches can damage the branches and terminal leaders of adjacent trees.

European black alder (*Alnus glutinosa*) is non-native, but it fixes nitrogen and tolerates salty, acidic sites. It grows nearly as rapidly as black locust but is less competitive and has no thorns. It is very susceptible to sooty mold and anthracnose fungi and usually succumbs to these pests by age 10 in most areas of the Appalachian coalfields.

Establishing Trees

Planting Contractors

The successful establishment of trees is highly dependent on selecting good nursery stock, using proper handling before planting, and employing proper procedures during planting. In most cases, tree planting is best left to a professional tree-planting crew that guarantees its work in a written contract. With proper, long-range planning, a good professional tree planter will arrange for seedling production at nurseries, plant at the appropriate time, and do follow-up inspections to ensure survival.

Figure 15. A professional tree-planting crew in action on a mine site.

Seedling Procurement

Most states in the Appalachian coalfield maintain state nurseries that grow and can supply seedlings for a variety of tree species in large quantities at reasonable prices. A number of commercial outlets for tree seedlings are also available. For best results, seedlings should be obtained from a grower within the general area (i.e., within the state or an adjacent state) and with climatic conditions similar to the planting site.

Companies that know they will require large numbers of seedlings can work with state nurseries or commercial suppliers a year or more in advance to assure that the seedlings of desired species are available when needed. Most commercial tree planters will also procure and provide the seedlings if that service is included in the tree-planting contract. Working with the tree-planting contractor to procure the seedlings has the advantage of placing full responsibility for successful planting with the tree planter.

Virginia residents can purchase a variety of tree species from the Virginia Department of Forestry (VDOF). Many species from the state nursery are grown from genetically superior seed and should perform better than other seed sources on Virginia minesoils. If planting is managed directly by coal companies, supervisors should work carefully with their local VDOF forester when ordering and picking up seedlings.

A common reason for poor seedling survival is that planting crews pick up more seedlings than they can reasonably plant within a short period of time. If planting crews cannot keep seedlings in cold storage until planting, they should arrange with the supplier to pick up smaller numbers of seedlings on a more frequent basis.

Use Healthy Seedlings

Seedlings should be graded prior to planting so that only healthy seedlings are used. Healthy pine seedlings should have a root collar diameter of 4/32 to 9/32 inch. Very small pine seedlings (less than 4/32 inch diameter) and very large seedlings (more than 10/32 inch diameter) do not survive well. Very large seedlings are difficult to plant correctly.

Root pruning is not recommended; there is a tendency to chop off too much of the root system. With root pruning now being done in the nursery beds, none is needed at the planting site. Overall survival is better when tree planters do not prune roots. Seedlings should not be planted if the roots are dry. Air-dried roots have less growth potential than roots that remain moist.

Seedling Storage

Proper seedling storage and handling before planting is critical to ensure good survival and growth. Seedlings must not be allowed to get hot or dry. If planting is delayed, the bags of seedlings should be wetted and roots dipped in a moisture-retaining gel specifically designed to keep roots from drying. The seedlings should then be rebundled and placed in cold storage (32-36 degrees Fahrenheit (°F)) for no more than four weeks. If cold storage is not possible, they should be stored in a cool, damp basement for no more than a week. At temperatures above 40°F, mold develops and seedlings are killed. Without cold storage, it becomes more important to dampen the roots as soon as they are delivered.

Figure 16. Proper storage and handling of seedlings is critical to reforestation success.

Figure 17. Roots of seedlings must be kept moist prior to planting.

Tree Planting

Seedlings should be planted as soon as possible in late winter or early spring (February-April) after the ground has thawed. Early planting is preferred because the soil is usually wetter and more conducive to root growth. Root growth decreases during periods of rapid shoot elongation; therefore, it is important that the seedlings be planted early in the season so roots can become established before the weather turns warm enough for shoot growth to begin.

During planting, crew leaders need to make certain that planters do not expose roots to the air by carrying seedlings in their hand. Seedlings should be carried in a planting bag and not removed until the planting hole is opened. Planting holes must be opened deeply enough so that the roots can be evenly spread in the hole. Seedlings should be planted about one inch deeper than grown in the nursery. Finally, the planting hole must be completely closed because any air spaces around the roots will cause those roots to die.

Mine operators are advised to plant enough trees to assure survival that is adequate to achieve bond release. When a competent tree-planting contractor plants healthy seedlings on a site that has been prepared properly for reforestation and summer conditions are not excessively dry, survival rates of more than 70 percent should be achieved. If 650 trees per acre are planted and achieve 70 percent survival, the 455 surviving trees per acre will easily meet bond release requirements for forestland. Planting on an 8-foot by 8-foot spacing will require 650 trees per acre.

Figure 18. Seedlings must be planted properly in order to survive.

Supervision

Planting crews should be given instructions on proper techniques prior to planting, and crew leaders should start quality checks immediately so that needed corrections can be made before much of the area is planted. In Virginia, the VDOF will do planting quality checks for landowners or operators who want to verify and/or improve seedling survival. This involves careful lifting of planted seedlings on random plots to check on seedling health, tightness, depth of planting, straightness, spacing, and density. Seedlings are carefully replaced after each one is inspected.

Establishing Trees When Dense Groundcover Is Present

Sometimes it is necessary to establish trees in an existing cover of dense grasses or legumes such as K-31 tall fescue or sericea lespedeza. In order to ensure survival and good growth, herbicides and slow-release fertilizer pellets are highly recommended. Chemical weed control (herbicides applied via backpack sprayer) helps maintain the seedlings free of overtopping competition. By controlling dense vegetation with herbicides, seedlings will receive adequate sunlight and more soil water to ensure their survival.

In conjunction with weed control, slow-release fertilizer pellets can speed growth during the first few years to help the trees grow above surrounding grasses. Fertilizer pellets should be placed in the closing hole about 2 inches from the roots during planting. Fertilizer pellets slowly decompose and release nutrients needed by the trees. By using pellets, it is possible to selectively fertilize seedlings without fertilizing surrounding grasses. Although fertilizer pellets are usually not available locally in the coalfields, they can be obtained from regional or national forestry product supply companies that can be found on the Internet; these companies routinely ship products to purchasers throughout the country.

Herbicide technology changes rapidly. New chemicals appear on the market annually and herbicide labels and regulations change almost as quickly. For these reasons, a timely discussion of the best herbicide treatments is not possible. Contact your county Extension agent — or your local VDOF forester in Virginia — for current recommendations of specific herbicide products and application rates.

Hydroseeding Trees

Some nurse species can be hydroseeded with the groundcover, provided an appropriate groundcover mix is used. Many direct-seeding efforts have failed in the past because the accompanying groundcover was too tall and dense for tree germinants to become established.

Black locust is most easily and inexpensively established by direct-seeding. If black locust is seeded as a nurse tree, the seeding rate should be no more than 1/2 ounce per acre.

A disadvantage of hydroseeding nurse trees is the loss of control with respect to tree number and spacing. Too many nurse trees can reduce the amount of growing space for crop trees, and wind-blown locust branches can damage the tops of trees growing in close proximity. Therefore, hydroseeding trees is not recommended for most mined-land reclamation.

Economic Considerations

Costs of Reforestation

The cost of reclaiming mined land with trees using the methods recommended in this publication (Forestry Reclamation Approach) can be comparable to or less expensive than reclamation for hayland/pasture and less expensive than reforestation using conventional reclamation methods. Table 4 shows that the use of these suggested guidelines for forestland can save several hundred dollars per acre compared to reclamation for hayland/pasture.

The greatest cost savings occurs due to reduced grading. Our discussions with mine operators indicate that, on average, about two to four hours of bulldozer work

Table 4. Relative costs of two common reclamation methods, compared to quality reforestation with native hardwoods using the Forestry Reclamation Approach:

(1) hayland/pasture reclamation, and (2) reforestation using methods that were commonly employed prior to the FRA using heavy surface grading and thick grass cover (pre-FRA). Costs are illustrative, based on discussions with mining firms, and are meant to be typical as of the mid-to-late 2000s.

	$/acre		
Operation	**Hayland/ pasture**	**Pre-FRA reforestation**	**FRA reforestation[a]**
Grading cost difference	+400-800	+400-800	–
Seed and fertilizer cost difference	+75	+75	–
Gully repair	+125	-	–
Tree planting	-500	-250	–
Replanting trees due to poor survival	–	+100	–
Increased cost for sediment pond cleanout	+?	+?	–
Total	+100-5,000	+300-700	–

[a] Baseline or reference; hayland/pasture, and pre-FRA reforestation costs are estimated as differences relative to FRA reforestation.

per acre can be saved by leaving level areas and short slopes in a rough-graded condition and not tracking-in the surface (the cost of a D-9 bulldozer with operator was estimated to be $200 per hour).

Coal companies doing reforestation should be able to realize additional cost savings on regrading and reseeding expenses because groundcover and gully elimination requirements for forestland are not as strict as for hayland/pasture; we have estimated that savings at about $125 per acre. Seed and fertilizer for the tree-compatible groundcover (table 3) costs less than hayland/pasture seed mixtures with high rates of K-31, clovers, and other species. In table 4, we have estimated that cost difference at $75 per acre.

Forestland reclamation does involve tree-planting costs. Planting 650 trees per acre will affect reclamation cost for reforestation. We estimated this cost at $250 per acre for the conventional reclamation, because the low-value species that have the best chance of survival on such sites will also be less expensive to purchase as seedlings than the native hardwoods — such as the oaks — that can be planted and survive if the Forestry Reclamation Approach is used. We have estimated the cost of planting a site with high-quality hardwoods at $500 per acre.

If compaction has been avoided by reduced grading and a tree-compatible groundcover is used (FRA method), a sufficient number of trees will become established

Table 5: Summary of benefits that occur when mining firms restore high-quality forests when reclaiming mine sites.

Beneficiary	Nature of benefit	Further details
Mine operator	**Cost-effective reclamation** and prompt bond release.	As described in this publication (see table 4).
Landowner	**Postmining economic value:** Trees growing on sites reforested using FRA practices will produce thousands of dollars per acre in economic value for the landowner.	See VCE publication 460-138.
Coal industry	**Positive public perceptions:** Mine sites are visible elements of the landscape, from the ground and from the air.	Public concern with environmental impacts of coal mining is increasing. Mines that demonstrate environmental stewardship help the industry.
Coal purchasers	**Positive public perceptions:** Electric utilities can inform the public that they purchase coal from mines that reclaim the land effectively.	Public concern with environmental impacts of electric power generation is increasing; that concern extends to energy and fuel sources.
General public	**Economic impacts**: Wood products from reclaimed mines generate economic impacts when harvested.	See VCE publication 460-138.
	Environmental impacts: Productive forests, when growing on mine sites or on natural soils, provide numerous "ecosystem services" that benefit people who reside in coal-mining areas and beyond.	**Examples** (partial listing): • Serves as wildlife habitat. • Holds soil, prevents soil erosion. • Maintains clean water quality. • Protects the watershed by enhancing groundwater recharge and reducing peak stormflows to help prevent flooding. • Stores carbon so as to aid in mitigating climate change. • Maintains landscape aesthetics.

through the combination of planting and natural invasion to satisfy bond release requirements and result in a well-stocked forest without any replanting of trees. If FRA is not used, traditional reclamation approaches that emphasize smooth grading and thick grass cover will have a negative effect on tree survival, and replanting may be required even with the lower-value and more easily established species that are commonly use in those approaches. We estimated the cost of replanting non-FRA areas at $200 per acre.

Another significant cost savings using FRA is associated with sediment pond clean-out. Our discussions with mining operators indicate that less sediment moves off the site when loose grading practices are used, because loose spoils allow rainwater to infiltrate while tightly graded spoils cause more rainwater to run off the surface. Because less rainwater runs off the surface of loosely graded spoils, less soil is eroded and carried to the sediment pond.

Based on our discussions with coal operators, FRA-prepared land can eliminate the need for sediment pond clean out. Clean-out costs range from $10,000 to $50,000, depending on the size and complexity of the sediment pond, and cleaning without FRA site preparation may be required two or more times during the bond period. Cost savings associated with reduced-sediment pond cleaning is very mine-site specific and hard to estimate, but on average is very significant.

Benefits of Quality Reforestation

Numerous benefits are created when coal-mining firms establish productive forests on land that has been mined for coal (see table 5). One way to describe that outcome is to say that the opportunity for quality reforestation is a "win-win-win" situation: The mining firm wins because quality reforestation is cost-effective and helps to achieve prompt regulatory compliance; the surface owner wins because the land created through use of these reclamation methods is more productive and more valuable than the coal-mined land that is produced using traditional reclamation methods; and the general public wins because of the economic and environmental benefits that result from quality reforestation, in addition to enjoying the benefits of cost-effective, coal-generated electric power. *Maximizing the Value of Forests on Reclaimed Mined Land*, VCE publication 460-138, describes the postmining land value that is created through quality reforestation.

Figure 19. A mine site reclaimed using the guidelines in this publication at age 7. As the native trees pictured in this photo grow and mature, the vegetation will become more like the native forests that occupy most of the unmined landscape in the coalfield region, and the area will become less visible as a former coal mine.

SMCRA requires that mine reclamation operations "restore the land affected to a condition capable of supporting the uses which it was capable of supporting prior to any mining, or higher or better uses of which there is reasonable likelihood." Numerous Appalachian coal mines have been reclaimed to support improved postmining land uses such as pasture land for grazing; development for housing, commercial activity, or industry; and public purposes such as recreation. However, the majority of coal-mining sites become forested after mining. Such lands can be reclaimed using the procedures described in this publication to create the economic and environmental benefits summarized by table 5.

Summary

The purpose of this publication is to provide practical, cost-effective guidelines for reclaiming surface-mined land to forests using the principles of reforestation silviculture. These guidelines should benefit coal mine operators by helping ensure timely release of reclamation performance bonds. The guidelines also include procedures that help improve the quality of minesoils and sites for timber production and other forest values.

Reclamation procedures for forestland differ in several important ways from procedures for hayland/pasture or other postmining land uses. The key principles for timely and successful reforestation of mined land are summarized below.

Selecting, Placing, and Grading Minesoil Material

Spoil Selection

Four feet or more of good quality mine spoil and/or topsoil should be placed at the surface to accommodate deeply rooted trees. Mine spoils with low-to-moderate levels of soluble salts, an equilibrium pH of 5.5 to 6.5, and a sandy loam texture are preferred. A mixture of two parts brown, oxidized sandstone and one part siltstone or shale found near the surface in most areas of Virginia's coalfields weathers quickly into a good soil medium for trees. If native topsoil is available, mixing even small amounts of fresh soil into the surface will increase volunteer establishment and seedling survival.

Loose Grading

Minimizing soil compaction is extremely important. Compaction on level areas can be minimized by end-dumping spoil piles and waiting until all piles are in place before lightly leveling them, using a small bulldozer if possible. Restrict traffic on leveled areas to specific, designated roads and parking areas. Do not track-in or compact surface soils unless compaction is necessary for stability. Fforestland surfaces are naturally rough; rough grading and grading for slope stability are usually adequate.

Selecting and Establishing Groundcover Vegetation

Tree-Compatible Groundcover

Reforestation requires a carefully planned balance between groundcover for erosion control and trees' requirements for light, water, and space. Groundcovers that include grass and legume species that are slow-growing, have a sprawling growth form, and are tolerant of acidic, infertile minesoils should be used for reforestation when required to control erosion at acceptable levels. Fast-growing grasses and legumes such as K-31 tall fescue and most clover species (except white and ladino), should be avoided.

Selecting Tree Species and Establishing Trees

Tree Species Selection

When mined land is reclaimed according to these guidelines, a variety of hardwood and softwood species can be planted and established successfully. When reestablishing native forest for reclamation, the tree species mix should be approximately 80 percent crop trees and 20 percent nurse and wildlife trees. The crop trees are commercially valuable species such as the oaks. Wildlife/nurse trees of pioneer species such as nitrogen-fixing trees and shrubs are easily established by planting seedlings. Additional hardwood species from the native forest will eventually seed in and flourish when proper groundcovers and woody species are planted during reclamation. For good forest stand development, 600 to 700 trees per acre should be established by a combination of planting, seeding, and natural invasion.

Seedling Handling and Planting Techniques

Poor tree survival and early growth are usually due to improper seedling handling or planting. Trees must be kept dormant until planted; they should never be allowed to dry out; they should be planted in late winter to early spring; and they should be planted deeply and firmly enough to ensure survival. Only reputable and experienced tree-planting crews should be used for tree planting.

Establishing Trees in Dense Groundcover

Herbicide should be sprayed in spots or strips (along the contour) in order to ensure seedling survival and emergence above established groundcovers. Fertilizer pellets can be placed in the planting bar closing hole next to the tree (never in the planting hole) to speed early growth and emergence above groundcovers. On newly reclaimed sites, it is preferable to use tree-compatible groundcovers that allow planted seedlings to survive without using herbicides.

Costs and Benefits of Quality Reforestation

Costs: Quality reforestation can be less expensive than reclamation for hayland/pasture use because forestland reclamation requires less grading, less repair work, and less seed and fertilizer for groundcovers. Extensive grading compacts minesoils, which decreases tree survival and growth. Rougher ground surfaces and less aggressive groundcovers are consistent with forestland uses.

Benefits: Use of quality reforestation procedures in reclamation creates a "win-win-win" situation: The mine operator benefits because of prompt bond release and cost-effective reclamation procedures; the landowner benefits from the resulting increase in postmining land capability and value; and the public benefits from the environmental services that reforested mined landscapes can provide. Use of quality reforestation by mining firms creates benefits for the coal industry through positive impacts on public perceptions of coal and coal mining.

Bottom Line

Coal mines can be reclaimed to create productive, high-quality forests. Such practices are cost-effective and can achieve regulatory compliance. The practices outlined in this publication are intended to achieve that goal. Coal-mining firms can execute the practices most effectively when reclamation personnel are aware of basic reforestation principles and how reclamation practices affect the chemistry, physical properties, and biology of the mining site. When minesoils are capable of producing high growth rates, other forest values such as wildlife habitat, water quality, and recreational opportunities are also maximized.

Restoring economically viable postmining forests requires little or no additional effort or expense compared to other land uses. Use of the reclamation procedures outlined in this publication will help create highly productive forests in a timely manner so that the mine operator, landowner, and local communities will benefit.

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