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Powell River Project

Reclamation Guidelines for Surface-Mined Land

Establishing Groundcover for Forested Postmining Land Uses

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Introduction

Productive native forests create economic value for landowners while providing landscape benefits such as watershed control, water-quality protection, carbon sequestration, and native plant diversity. In the Appalachian region, owners of lands mined for coal are increasingly interested in assuring that productive forests are restored after mining.

Revegetating mined lands with grasses and legumes (groundcover) is essential to mine reclamation under the Surface Mining Control and Reclamation Act (SMCRA). This publication describes how mining firms can establish groundcover while reclaiming land to forested, postmining land uses.

The Forestry Reclamation Approach

The Forestry Reclamation Approach (FRA) is a method for reclaiming coal-mined land to forest under SMCRA (see VCE publication 460-123 and Appalachian Regional Reforestation Initiative (ARRI) Forest Reclamation Advisory No. 2). The FRA differs from common reclamation practices of past years that utilize agricultural grasses and legumes such as K-31 tall fescue and red clover. The FRA has five steps:

1. Create a suitable rooting medium for good tree growth that is no less than 4 feet deep and is composed of topsoil, weathered sandstone, and/or the best available material.
2. Loosely grade the topsoil or topsoil substitute established in step No. 1 to create a noncompacted growth medium.
3. Use groundcovers that are compatible with growing trees.
4. Plant two types of trees: early successional species for wildlife and soil stability and commercially valuable crop trees.
5. Use proper tree-planting techniques.

This publication deals with the FRA's third step; it describes how to establish groundcover vegetation while controlling erosion, without hindering the survival and growth of planted trees.

Revegetation for the FRA

The revegetation method described here differs from the grassland reclamation approach that has been commonly used by coal-mining firms in past years to establish both hayland/pasture and unmanaged forest postmining land uses. The grassland reclamation approach uses fast-growing agricultural grasses and legumes to achieve rapid and complete groundcover. In contrast, FRA reclamation establishes tree-compatible grasses and legumes to minimize competition with tree seedlings.

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In order to establish a tree-compatible groundcover, mine operators seed in a manner that differs from common grassland reclamation by:

- Using less-competitive grass and legume species;
- Using lower seeding rates;
- Using less nitrogen fertilizer; and
- Accepting a lower herbaceous groundcover in the first few years after seeding.

The result will be a lower-growing, less-vigorous, sparse groundcover that allows planted tree seedlings to survive and grow, allows more invasion by plant species from nearby areas, and achieves complete cover over time (see figures 1a-c).

Recommended species, seeding rates, and fertilizer rates are shown in table 1. The grass and legume species are selected to be slow- and low-growing and tolerant of low fertility and pH, and to grow in bunches rather than as a continuous cover. Legume inoculants should also be included in the planting mix so as to assure that the legumes are able to convert ("fix") atmospheric nitrogen to plant-available forms. Recommended seeding rates are lower than those used for grassland reclamation approaches so that openings are left to allow for invasion by native plants. Lower nitrogen-fertilizer rates are used to minimize groundcover height. Instead of the high-nitrogen and low-phosphorus rates used for grassland reclamation, FRA reclamation uses low nitrogen to reduce the vigor of the early growing grasses and high phosphorus to nourish the trees for the long term. The fertilizer rates in table 1 are adequate to establish seeded grasses and legumes; as the legumes mature, they convert nitrogen from the atmosphere to plant-available forms.

Using tree-compatible groundcover as an alternative to the faster-growing grasses and legumes used in grassland reclamation approaches can help establish forested postmining land uses in several ways:

- The lower-growing, tree-compatible species allow more sunlight to reach the planted tree seedlings.
- The tree-compatible species withdraw water and nutrients from the soil more slowly than faster-growing agricultural grasses and legumes, leaving more of these essential resources for the planted trees.
- The tree-compatible species do not cover the ground as rapidly or completely, allowing more of the seeds

Figure 1a**.** Tree-compatible groundcover in midsummer, about three months after planting. The cover is sparse but planted trees are able to survive and grow, and native plants can seed in and become established.

Figure 1b**.** A grass-dominated groundcover that is typical of conventional grassland reclamation three years after planting. The site is fully covered, but the tree pictured is growing at less than half its potential and is exposed to predation.

Figure 1c**.** A tree-compatible groundcover, also three years after planting. The site is also fully covered, but at least half the cover is made up of native plants, including trees that seeded in via wind and wildlife. Trees are growing faster because the cover is less competitive. In and among the native plants, trees are less exposed to predation.

Table 1. Recommended seeding and fertilizer application rates for reclamation using the Forestry Reclamation Approach (FRA).

Species/Fertilizer	Rate (lb/acre)
Annual grasses:	
Foxtail millet (spring seeding only)	5
Annual ryegrass (fall seeding only)	10
Perennial grasses:	
Timothy	5
Perennial ryegrass	10
Orchard grass (steep slopes only)	5
Legumes (with inoculant):	
Birdsfoot trefoil	5
Ladino or white clover	3
Fertilizer*:	
Nitrogen	50-75
Phosphorus – as P	80-100
– as P_2O_5	180-230

* Recommended fertilizer rate 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.

that are carried to the site by wind and wildlife to land on the soil surface, germinate, and become established. In Appalachian coal-mining areas, most of these seeds are generally of native forest species.

- The tree-compatible species are less attractive to animals such as deer and rodents that may damage the planted tree seedlings through browsing or other means.

Revegetation using the FRA typically is done in two steps: (1) plant bare-root tree seedlings and (2) hydroseed grass and legume seeds, fertilizer, mulch, and lime, if needed. Herbaceous groundcover aids in controlling erosion, but it often competes with the trees, reducing their survival and growth. Therefore, whenever possible, the trees should be planted first in late winter, followed by hydroseeding the following spring or even the following fall if allowed by the regulatory authority. Hydroseeding overplanted seedlings in the spring should be done prior to leaf formation by the trees, while any fall over-tree hydroseeding should be delayed until after tree leaves change color so as to avoid the possibility of seedling damage. Planting trees in established groundcover can reduce seedling survival, especially if the young seedlings experience drought or near-drought conditions.

FRA Groundcover With Loose Grading Controls Erosion

The recommended seeding rates will not accelerate erosion when used in association with FRA step No. 2 ("Loosely grade the topsoil or topsoil substitute…."; see ARRI Forest Reclamation Advisory No. 3). Step No. 2 leaves the surface soil looser than conventional grading that compacts the soil. Loose soil allows more rapid water infiltration, which means that rainfall causes less surface runoff and more rainwater enters the soil where it can be used by plants. Thus, when the soil is not compacted, erosion can be controlled without establishing dense, sod-forming, groundcover vegetation.

Figure 2 shows results from a study on an active coal surface mine in eastern Kentucky (Torbert and Burger 1994). Areas of the site were graded and tracked in using practices conventional at that time; some areas received moderate grading (two passes with a D-10 dozer), while others received intensive grading (three dozer passes plus tracking). Some of the graded areas were "ripped" (i.e., disturbed to a depth of about 4 feet by a heavy, steel, single-shank ripper pulled by a D-10 dozer). The data show that moderate grading reduced soil loss compared to intensive grading, while the rough surface created by ripping nearly eliminated soil loss. The amount of groundcover (>80 percent) was essentially the same on all treatments, showing that a heavily graded, tracked-in surface is not necessary for establishing groundcover vegetation. Interpretation of these data and subsequent observations indicate that roughly graded, noncompacted mined land reduces and slows surface-water movement, thus increasing water infiltration for plant use and reducing erosion.

FRA Groundcover Encourages Ecological Succession

Succession is a term used to describe natural changes in plant community composition over time (see ARRI Forest Reclamation Advisory No. 5). Figure 3 represents

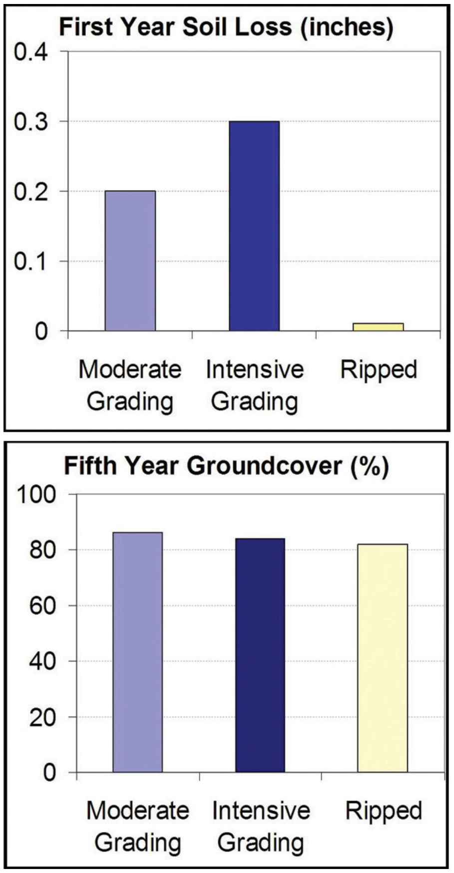

Figure 2.

Top: Ripping compacted minesoils reduced soil loss on an eastern Kentucky coal-mining site; leaving minesoil loose and uncompacted can have a similar effect.

Bottom: Groundcover was adequate on both the graded and the ripped portions of the site (Torbert and Burger 1994).

how the vegetation mix established by FRA reclamation changes over time. Four vegetation types are established during reclamation, but they grow at different rates and flourish, or dominate, at different times. Vegetative cover is provided by a combination of grasses, legumes, nurse/wildlife trees, and crop trees. As represented by the top bold line (total cover), the revegetation mix is designed to provide vegetative cover of at least 80 percent by the end of the second growing season and to approach 100 percent by the fifth growing season.

Four stages of plant community development occur (see figures 3 and 4):

Stage 1: Grasses dominate and provide most of the cover. The slow-growing, bunch-forming grasses of table 1 will be sparse at first – especially during the first year – but will produce more groundcover during the second and third years. When fertilizer nitrogen has been fully utilized, the grasses thin, creating openings for plants that are carried onto the site as seed by birds, other wildlife, and wind.

Stage 2. Legumes dominate and provide most of the cover between years four and six. The legumes add nitrogen to the soil and are less competitive than grasses. The herbaceous legumes persist until trees shade them out.

Stage 3: Fast-growing nurse/wildlife trees make up 10 percent to 20 percent of the total trees planted in the FRA (see ARRI Forest Reclamation Advisory No. 2). Some of these trees fix nitrogen from the atmosphere, and all provide habitat for wildlife and canopy cover for erosion control. Those nurse trees that grow edible fruits and seeds attract seed-carrying birds and other wildlife, thus aiding establishment of plant species from nearby unmined areas.

Stage 4: By the time the trees close canopy (i.e., when the tree tops grow together), the crop trees dominate and provide most of the cover. Fallen leaves and other organic litter accumulate and begin to decompose, providing additional fertility for the trees. Because trees shade much of the ground, the nontree vegetation closer to the ground (the "understory") remains sparse. Hydroseeded groundcover remains sparse during the first few years, allowing native plants, including forest trees, to invade. Thus, the plant community at this stage is composed of many species in addition to those established intentionally by the mining firm during reclamation. Over time, the plant community has changed to become more similar to the region's native forest.

The recommendations of table 1 are intended to establish vegetation that can aid in controlling erosion, allow invasion by native plant species for increased diversity, fix nitrogen from the atmosphere, create wildlife habitat, and develop into a productive and valuable forest dominated by native hardwoods. Experience has shown that invading species often include trees from the surrounding forest, which can help the mining firm to satisfy regulatory stem-count requirements if the mining permit describes those species as components of the postmining land use.

FRA Groundcover: How It Looks and Works

Tree-compatible FRA groundcover (table 1) is designed to be less competitive than grassland-reclamation groundcover. The FRA groundcover looks short and sparse on a rough-graded surface, especially during its first year. This is by design. Some miners and inspectors familiar with grassland reclamation may have trouble accepting the look of the FRA reclamation at first. What is important, however, is not the look but how it works. The use of tree-compatible groundcover within the FRA allows operators to establish a productive forest while meeting regulatory standards. When reforesting nonmined sites, foresters usually kill competitive

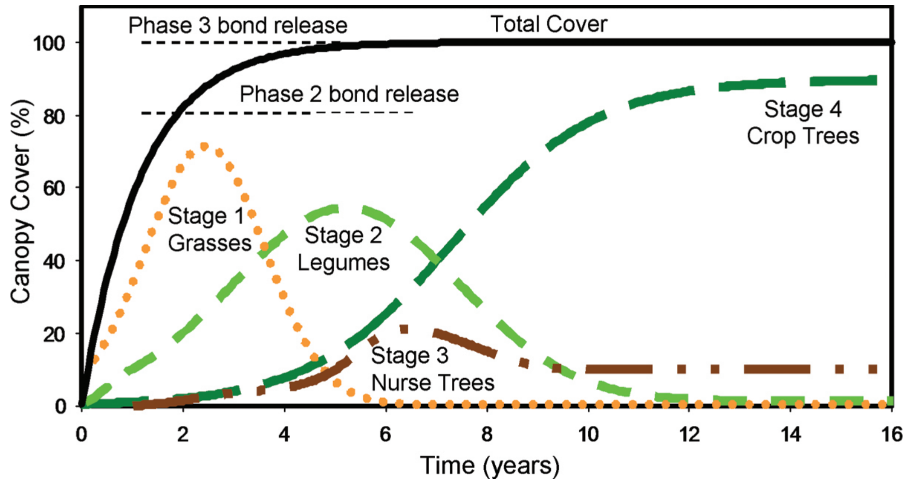

Figure 3. This figure represents how vegetative cover changes through time when the Forestry Reclamation Approach is used. All four vegetation types are sown or planted during reclamation, but each type is dominant at a different stage.

Figure 4. Photographic examples of the four vegetative cover stages.

grasses and weeds with herbicides as a standard practice before planting trees. Conventional mine reclamation has taken the opposite approach, sowing competitive grasses and legumes and then planting trees. Mine reclamation procedures for establishing forests differ from those for establishing hayland/pasture and other uses that require agricultural grasses. The two reclamation approaches look different because they are intended to achieve different purposes.

In a study at Powell River Project, Burger and others (2008) demonstrated the effect of groundcover on native hardwood trees over five growing seasons. The minesoils were prepared using FRA procedures, but a grassland-reclamation approach groundcover was seeded, as was standard practice at that time. A mix of native Appalachian trees was planted into the groundcover, and a glyphosate herbicide was applied on part of the area by spraying a 3-foot diameter circle around each tree, reducing average groundcover to approximately 70 percent for the first three years. Tree survival and growth in areas that received no herbicide (full cover) were compared to sprayed areas (reduced cover).

The planting plan called for 700 trees per acre (8-foot by 8-foot spacing): six timber-producing species (crop trees) at 100 per acre each, and four wildlife tree species at 25 per acre each. The actual numbers of trees planted were 687 per acre for the full-cover treatments and 663 per acre for the reduced-cover treatments (table 2). In Virginia, required stocking rates for commercial forestry are 400 crop trees and 40 wildlife trees per acre (400/40). The counts after five years were 335/80 and 394/52 trees per acre, respectively, for the full-cover and reduced-cover areas. The wildlife trees are a minor component of the overall stocking requirement, but they were adequately stocked in both reduced and full cover. The data suggest that several wildlife species survived better in full cover, but those in reduced-cover plots may have suffered herbicide damage because of their small size when planted.

More importantly, the crop-tree survival on the reduced-cover plots was 69 percent of the original planting – nearly adequate to meet the regulatory target of 400 crop trees per acre (table 3). A 70 percent survival rate is common for hardwoods in reforestation projects on nonmined land. At 69 percent survival, the commercial forestry performance standard of 400 crop trees per acre would have been met easily if the prescribed 700 trees per acre had been planted. Furthermore, trees of several species that had not been planted, including black cherry and sycamore, became established within the reduced-cover areas. With a survival rate of only 58 percent, the full-cover plots did not meet the crop-tree performance standard and would not have met it in any case.

Crop-tree growth was also affected by the competitive groundcover (figure 5). White ash, sugar maple, and the oaks grew two to three times larger on sites with reduced groundcover. Because all experimental areas were prepared using similar soils and grading practices, these results indicate that differences in tree growth were caused by differences in groundcover competition.

As demonstrated by these data, groundcover affects the survival and growth of native hardwood trees. Using the seeding rates of table 1 in association with the full suite of FRA practices when establishing groundcover for forested postmining land uses allows planted trees to thrive without the application of herbicides.

Summary

The Forestry Reclamation Approach is becoming more popular with mine operators and landowners as a way of reducing reclamation costs while improving the postmining land's value as productive forest (see VCE publication 460-123 and ARRI Forest Reclamation Advisory No. 2). A slow-growing, noncompetitive, tree-compatible groundcover is essential to the FRA. Such a groundcover will have a sparse look for the first several years, but – when used within the FRA – such groundcover controls erosion while encouraging invasion by native forest species and allowing planted trees to survive and grow.

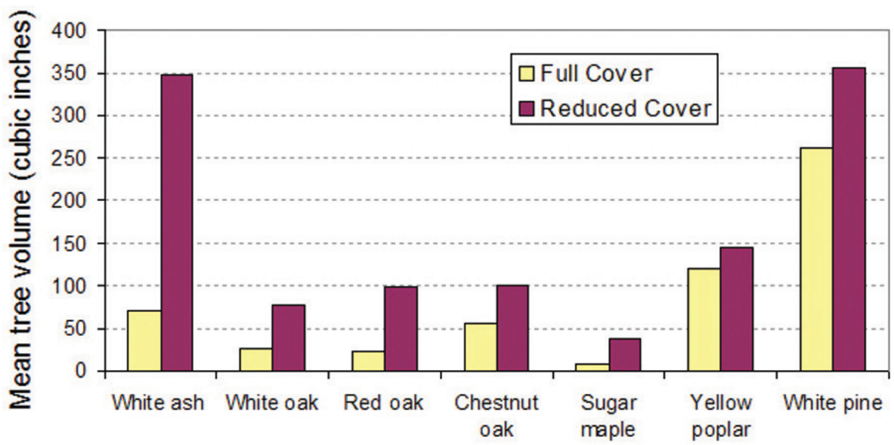

Figure 5. Effect of reduced groundcover on tree volume after five years.

Table 2. Timber crop and wildlife tree stocking immediately after planting and after five years (data from Burger et al. 2008).

Treatment	White ash	Sugar maple	Yellow poplar	Chestnut oak	White oak	Northern red oak	Total stocking
	Crop Trees						
	Prescribed stocking (trees/acre)						
	100	100	100	100	100	100	600
	Original stocking after planting (trees/acre)						
Full cover	100	99	95	94	84	102	574
Reduced cover	84	92	94	86	78	108	542
	Stocking after five years (trees/acre)						
Full cover	94	39	39	39	51	73	335
Reduced cover	73	48	45	53	70	78	367

Treatment	Crab-apple	White pine	Silky dogwood	Bristly locust	Total stocking	Total stocking
	Nurse/Wildlife Trees					**All Trees**
	Prescribed stocking (trees/acre)					**Prescribed**
	25	25	25	25	100	700
	Original stocking after planting (trees/acre)					**Original**
Full cover	28	27	32	26	113	687
Reduced cover	31	33	28	29	121	663
	Stocking after 5 years (trees/acre)					**After 5 years**
Full cover	24	10	32	14	80	415
Reduced cover	9	11	26	6	52	419

Table 3. Crop and wildlife tree survival after five years, expressed as percentages of trees originally planted (data from Burger et al. 2008).

Treatment	White ash	Sugar maple	Yellow poplar	Chestnut oak	White oak	Northern red oak	Overall survival
	Crop Trees Survival						
Full cover	92	43	43	43	57	73	58
Reduced cover	88	52	47	65	85	74	69

Treatment	Crab-apple	White pine	Silky dogwood	Bristly locust	Overall survival	Overall survival
	Nurse/Wildlife Trees Survival					**All Trees**
Full cover	84	38	100	61	71	60
Reduced cover	26	28	92	20	42	65

Over the past 30 years, common reclamation practices have not established diverse, native forests on mined land. The FRA is a new reclamation method that aids timely bond release, reduces costs, improves mine-soil quality, improves crop-tree survival and growth, and establishes productive forests on mine sites. The use of the FRA in the eastern United States is supported by federal and state regulatory authorities (see ARRI Forest Reclamation Advisory No. 1).

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