



# APPALACHIAN REGIONAL REFORESTATION INITIATIVE (ARRI) FOREST RECLAMATION ADVISORY

FRA Number 2

December 2005

## THE FORESTRY RECLAMATION APPROACH

Jim Burger<sup>1</sup>, Don Graves<sup>2</sup>, Patrick Angel<sup>3</sup>, Vic Davis<sup>4</sup>, Carl Zipper<sup>5</sup>

The Forestry Reclamation Approach (FRA) is a method for reclaiming coal-mined land to forest under the Surface Mining Control and Reclamation Act (SMCRA). The FRA is based on knowledge gained from both scientific research and experience (Photo 1). The FRA can achieve cost-effective regulatory compliance for coal operators while creating productive forests that generate value for their owners and provide watershed protection, wildlife habitat, and other environmental services.

The purpose of this Advisory is to describe the FRA, which is considered by state mining agencies and US Office of Surface Mining to be an appropriate and desirable method for reclaiming coal-mined land to support forested land uses under SMCRA (Angel and others, 2005). The FRA is also supported by members of the ARRI's academic team, which is drawn from Universities in nine states, and by other groups and agencies.

### The FRA's Five Steps

The FRA can be summarized in five steps:

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 a non-compacted growth medium.
3. Use ground covers 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.

#### **Step 1. Create a suitable rooting medium.**

Tree survival and growth can be hindered by highly alkaline or acidic soils. During mining and reclamation, all highly alkaline materials with excessive soluble salts and all highly acidic or toxic material should be covered with a suitable rooting medium that will support trees. The best available growth medium

**Photo 1.** A white oak stand that grew on a pre-SMCRA surface mine in Southern Illinois. Observations by reclamation scientists and practitioners of soil and site conditions on reclaimed mines such as this, where reforestation was successful, have contributed to development of the Forestry Reclamation Approach.



should be placed on the surface to a depth of at least four feet to accommodate the needs of deeply rooted trees.

Growth media with low to moderate levels of soluble salts, equilibrium pH of 5.0 to 7.0, low pyritic sulfur content, and textures conducive to proper drainage are preferred. However, where such materials are not available, an equilibrium pH as low as 4.5 or as high as 7.5 is acceptable if tree species tolerant of those conditions are used.

**Photo 2.** A mixture of brown weathered and gray sandstones, loosely graded to form a soil medium suitable for trees in West Virginia.



Native hardwood diversity and productivity will be best on soils where the pH is between 5 and 7, and such trees generally grow best in soils with loamy textures, especially sandy loams. Such soils can be formed from overburden materials comprised predominantly of weathered brown and/or unweathered gray sandstones, especially if these materials are mixed with natural soils (Photo 2). Use of materials with soluble salt levels lower than 1.0 mmhos/cm on the surface is preferred when such materials are available.

### **Step 2. Loosely grade the topsoil or topsoil substitutes.**

Excessive soil compaction can have a major negative effect on survival and growth of trees. (Photo 3). Even if a soil's chemical properties are ideal, excessive compaction will create a soil that is poorly suited for trees. The majority of the backfill should be placed and compacted using standard engineering practices – but not the final surface. That surface layer, which will form the post-mining forest's soil, should be at least four feet deep and only lightly graded. Surface grading on longer and steeper slopes should be minimized, provided that doing so does not jeopardize stability.

**Photo 3.** Mine soil properties can have a dramatic effect on tree growth. The Eastern white pines in both photos were the same age (8 years old) when the photos were taken; the pines in the left-hand photo grew on a compacted alkaline shales, while those on the right grew on a moderately acid sandstone.



To re-establish a healthy and productive forest after mining, final grading must minimize surface compaction. This can be achieved by:

- dumping and leveling in separate operations,
- leveling with the lightest equipment available, using the fewest passes possible, and during dry conditions, and
- permanently removing all equipment from an area after leveling.

“Tracking in” operations (Photo 4) compact the soil and hinder tree-growth, and should be avoided unless necessary for slope stability. Rubber tired equipment should not be used in final grading.

### **Step 3. Use ground covers that are compatible with growing trees.**

Ground-cover vegetation used in reforestation requires a balance between erosion control and competition for the light, water and space required by trees. Ground covers should include grasses and legumes that are slow-growing, have sprawling growth forms, and are tolerant of a wide range of soil conditions. Fast growing and competitive grasses such as Kentucky-31 tall fescue and aggressive legumes such as sericea lespedeza and crown vetch should not be used where trees will be planted. Slower-growing grasses such as red top and perennial ryegrass, and legumes such as birdsfoot trefoil and white clover, when used in a mix with other appropriate species will increase seedling survival while controlling erosion over the longer term as the trees and accompanying vegetation mature to form a forest. Fertilizer rates should be low in nitrogen, relative to rates commonly used to establish pastures, so as to discourage heavy ground cover growth while applying sufficient rates of phosphorus and potassium for optimal tree growth.



**Photo 4.** Soil compaction due to equipment operation on mine soils hinders survival and growth of planted trees. "Tracking in" operations, such as those shown in the photo, are NOT recommended for mine sites on which trees will be planted, unless required to stabilize steep slopes.



#### **Step 4. Plant the right mix of tree species.**

To produce a valuable forest that supports multiple uses, plant a mix of native timber species as crop trees. Such species include those that are compatible with the landowner's post-mining forest-management goals, have the potential to grow into healthy trees where they are planted, and are found in the local area's mature forests. Depending on local conditions, such species can include the oaks, black cherry, sugar maple, white ash, and/or other species. Reforestation experts recommend that about 1/5 of the seedlings planted should be a mix of species able to survive in the open conditions commonly found on newly reclaimed sites and that support wildlife and soil improvement. Such species might include bristly locust, redbud, dogwood and crab apple, again depending on which are known to do well under local conditions. The species selected should be mixed as they are planted over the site, not planted separately as single-species blocks. When all FRA steps are used, additional native species with seeds that can be carried by wildlife or wind will volunteer and establish on their own, leading to a species mix similar to the surrounding native forests. Mine operators should work with the State Regulatory Authority to develop reforestation plans that meet State requirements.

#### **Step 5. Use proper tree planting techniques.**

Poor tree survival is often due to improper seedling handling or planting. Tree seedlings should never be allowed to dry out during storage and handling prior to planting, and should be kept dormant until planted. Seedlings should be kept cool, but should not be allowed to freeze, and should be protected from direct sunlight and high temperatures prior to planting. The seedlings should be planted in late winter to early spring at the proper depth and firmly enough to ensure survival (Photo 5). Reputable and experienced crews are recommended for broad-scale, operational tree planting.

These five steps have been studied and field tested by ARRI Academic Team members from several of the universities contributing to this advisory (Photo 6), and plantings on active mine sites by coal mining firms using these techniques have been successful. ARRI members have determined that these steps can be implemented under current Federal and State regulations. We expect to provide additional information on each of these 5 steps in future Forest Reclamation Advisories.

The FRA is intended to be compatible with the mine-operator goal of cost-effective regulatory compliance. Avoidance of soil compaction requires that leveling and grading operations be minimized, which helps the operator control equipment operation costs. The species recommended for forest-compatible ground covers are widely available for reasonable costs, and are best seeded with fertilization rates lower than those used commonly for grassland establishment.

Selection of surface materials with chemical and physical properties suitable for trees and successful establishment of less-competitive groundcovers will increase survival of planted seedlings while allowing for invasion by native tree species from the surrounding forest. Avoidance of soil compaction will make it easier for tree planters to plant seedlings firmly and at the proper depth, thereby increasing survival rates.

**Photo 5.** Planting a seedling at the White Oak reforestation project in Tennessee. Because the soil has not been compacted, a planting hole of the correct depth can be opened easily. The seedling is being planted while still dormant, during the late winter season.



**Photo 6.** An emerging hardwood forest established on an active mine in Virginia as a demonstration of the Forestry Reclamation Approach.



## How Does the FRA Improve Value, Diversity, and Succession of Reclaimed Forests?

The FRA is designed to restore forest land capability. When these five steps are followed, forest land productivity equal to or better than that which preceded mining can be restored. Furthermore, the FRA accelerates the natural process of forest development by creating conditions similar to those of natural soils where native forests thrive. By limiting compaction during reclamation, the growth medium becomes deep and loose, similar to the best forest soils. Temporary erosion-control ground covers are selected to allow native herbaceous and woody plants to seed in, emerge, and grow. The ground cover species are meant to be sparse and slow growing in the months after seeding, after which they will yield to a more diverse species mix that will control erosion and will be self-sustaining as required by SMCRA. Over the longer term, the herbaceous groundcover will yield to native forest through the process of natural succession.

Natural succession is further accelerated by planting late-successional, heavy-seeded species such as the oaks, which are not dispersed from the native forest easily by wind and wildlife. Planting these heavy-seeded species puts them on site right away, allowing them to emerge with other species that can seed in on their own (Photo 7). When a good growth medium is established, as outlined in Steps 1 and 2 of the FRA, late-successional plants will thrive, especially when native soil is used or mixed with the suitable overburden materials. When native forest soils are used as a part of the growth medium, native vegetation establishment will be accelerated due to vegetation that sprouts from those seeds of forest understorey and tree species that remain viable. Overall, such reclamation practices create a diverse and valuable forest of native trees that produces wood products and habitat for wildlife.

The FRA does not preclude mine operators from establishing tree crops such as biomass plantations, Christmas trees, or nut orchards, if such reclamation satisfies permit requirements and meets landowner goals. In such cases, all of the above steps apply except that a tree crop is planted instead of a native hardwood mix. Tree crops will benefit from FRA reclamation.

Faculty and researchers from the following universities and organizations contributed to this publication: Ohio State University, Pennsylvania State University, Purdue University, Southern Illinois University, University of Kentucky, University of Maryland, University of Tennessee, Virginia Polytechnic Institute and State University, West Virginia University, and United States Forest Service (retiree).

**Photo 7.** Red oaks established on the Starfire Mine in Eastern Kentucky using the Forestry Reclamation Approach.



## References

P. Angel, V. Davis, J. Burger, D. Graves, C. Zipper. 2005. The Appalachian Regional Reforestation Initiative. U.S. Office of Surface Mining. Forest Reclamation Advisory Number 1. 2 p. (available from <http://arri.osmre.gov/>).

## Authors

<sup>1</sup> Dr. James Burger, Virginia Polytechnic Institute and State University, Blacksburg, Virginia. [jaburger@vt.edu](mailto:jaburger@vt.edu)

<sup>2</sup> Dr. Donald Graves, University of Kentucky, Lexington, Kentucky. [dgraves@uky.edu](mailto:dgraves@uky.edu)

<sup>3</sup> Patrick Angel, Office of Surface Mining, U.S.D.I., London, Kentucky. [pangel@osmre.gov](mailto:pangel@osmre.gov)

<sup>4</sup> Vic Davis, Office of Surface Mining, U.S.D.I., Knoxville, Tennessee. [vdavis@osmre.gov](mailto:vdavis@osmre.gov)

<sup>5</sup> Dr. Carl Zipper, Virginia Polytechnic Institute and State University, Blacksburg, Virginia. [czip@vt.edu](mailto:czip@vt.edu)