CHAPTER 2
THE FORESTRY RECLAMATION APPROACH

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INTRODUCTION

The Forestry Reclamation Approach (FRA) is a method for reclaiming coal-mined land to forest under the federal Surface Mining Control and Reclamation Act of 1977 (SMCRA). The FRA is based on knowledge gained from both scientific research and experience (Fig. 2-1). The FRA can achieve cost-effective regulatory compliance for mine operators while creating productive forests that generate value for their owners and provide watershed protection, wildlife habitat, and other environmental services.

Forest Reclamation Advisories are guidance documents that describe state-of-the-science procedures for reforestation of mined land. The purpose of this Forest Reclamation Advisory is to describe the FRA. State mining agencies and the U.S. Department of the Interior's Office of Surface Mining Reclamation and Enforcement (OSMRE) consider this approach to be an appropriate and desirable method for reclaiming coal-mined land to support forested land uses under SMCRA (Chapter 1, this volume). Members of the Science Team of the Appalachian Regional Reforestation Initiative (ARRI), which is drawn from universities and other research organizations in nine states (Preface, this volume), and other groups and agencies also support this approach.

THE FIVE STEPS OF THE FORESTRY RECLAMATION APPROACH

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 consists of topsoil, weathered sandstone, or the best available material, or a combination of these materials.
2. Loosely grade the topsoil or topsoil substitutes established in Step 1 to create a noncompacted growth medium.

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Publication History

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Figure 2-1.—A northern red oak stand that grew on a surface mine reclaimed pre-SMCRA 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. Photo by J. Burger, Virginia Tech, used with permission.

3. Use groundcover species 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 the best available rooting medium that will support trees. Place the growth medium on the surface to a depth of at least 4 feet to accommodate the needs of deep-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.

Native hardwood diversity and productivity will be best on soils where the pH is between 5.0 and 7.0, and such trees generally grow best in soils with loamy textures, especially sandy loams. Such soils can be formed from overburden materials composed predominantly of weathered brown sandstones, especially if these materials are mixed with natural soils (Fig. 2-2). Use of materials with soluble salt levels less than 1.0 mmhos/cm on the surface is preferred when such materials are available. See Chapter 3 of this volume for further information about FRA Step 1.

Step 2. Loosely grade the topsoil or topsoil substitutes

Excessive soil compaction can severely reduce survival and growth of trees (Fig. 2-3). Even if a soil's chemical properties are ideal, excessive compaction will create a soil that is poorly suited for trees. Use standard engineering practices to place and compact most of the backfill—but not the final surface. The surface layer, which will form the soil for the postmining forest, should be at least 4 feet deep and only lightly graded. Surface grading on longer and steeper slopes should be minimized, provided that doing so does not jeopardize stability.

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

Figure 2-2.—A mixture of weathered brown and unweathered gray sandstones, loosely graded to form a soil medium suitable for trees in West Virginia. Photo by J. Burger, Virginia Tech, used with permission.

- 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 (Fig. 2-4) compact the soil and hinder tree growth. Avoid these operations unless necessary for slope stability. Rubber-tired equipment should not be used in final grading. See Chapters 4 and 5 of this volume for further information about FRA Step 2.

Figure 2-3.—Photos showing how 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 compacted alkaline shales; the pines in the right-hand photo grew on a moderately acid sandstone. Photos by J. Burger, Virginia Tech, used with permission.

Figure 2-4.—Soil compaction due to heavy 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. Photo by J. Burger, Virginia Tech, used with permission.

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

Groundcover vegetation used in reforestation requires a balance between erosion control and competition for the light, water, and space required by trees. Groundcover species 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 crownvetch should not be used where trees will be planted. Slower-growing grasses such as red top and perennial ryegrass, and legumes such as bird’s-foot trefoil and white clover, will increase seedling survival when used in a mix with other appropriate species. (Please see the Appendix starting on p. A-1 for scientific names of species mentioned in this chapter.) This slower-growing vegetation will also control erosion over the longer term as the trees and accompanying vegetation mature to form a forest. Apply fertilizer at rates lower in nitrogen than those commonly used to establish pastures, so as to discourage heavy groundcover growth. Rates of phosphorus and potassium should be targeted toward optimal tree growth. See Chapter 6 of this volume for further information about FRA Step 3.

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 postmining forest-management goals, have the potential to grow into healthy trees where they are planted, and are found in the local mature forests. Depending on local conditions, such species might include the oaks, black cherry, sugar maple, and white ash. Reforestation experts recommend that about one-fifth 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 species are known to do well under local conditions. Mix the selected species when planting them over the site, rather than planting them 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 become established 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. See Chapter 7 of this volume and Rathfon and others (2015) for further information about FRA Step 4.

Step 5. Use proper tree planting techniques

Poor tree survival is often due to improper handling or planting of seedlings. 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 before planting. Plant the seedlings in late winter to early spring at the proper depth and firmly enough to ensure survival (Fig. 2-5). Reputable and experienced crews are recommended for broad-scale, operational tree planting. See Chapter 9 of this volume for further information about FRA Step 5.

Members of the ARRI Science Team have studied and field tested these five steps (Fig. 2-6). They have determined that these steps can be implemented readily and successfully. Plantings on active mine sites by coal mining firms using these techniques have established productive young forests. Additional information on each of these five steps is provided by other Forest Reclamation Advisories (Chapters 3 through 12, this volume).

Figure 2-5.—Planting a seedling at a reforestation project on a reclaimed mine site in Tennessee. Because the soil has not been compacted, a planting hole of the correct depth for the seedling can be opened easily. The seedling is being planted while still dormant, during the late winter season. Photo by R. Williams, Williams Forestry, used with permission.

Figure 2-6.—An emerging hardwood forest established on an active mine in Virginia as a demonstration of the Forestry Reclamation Approach. Photo by J. Burger, Virginia Tech, used with permission.

The FRA is intended to be compatible with mine operators' 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 at a reasonable cost, and are best seeded with fertilization rates lower than those used commonly for grassland establishment.

Avoidance of soil compaction will make it easier for tree planters to plant seedlings firmly and at the proper depth, thereby increasing survival rates. Survival of planted seedlings will also increase if surface materials are selected with chemical and physical properties suitable for trees and if less-competitive ground covers are successfully established. These two steps will allow for recruitment by native tree species from the surrounding forest as well.

HOW DOES THE FORESTRY RECLAMATION APPROACH 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 groundcover species are meant to be sparse and slow growing in the months following 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 ground cover will yield to native forest through the process of natural succession (changes in the composition of the plant community with time).

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

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 landowners' goals. In such cases, all of the five steps apply except that a tree crop is planted instead of a native hardwood mix. Tree crops will benefit from FRA reclamation.

Figure 2-7.—Red oaks established on the Starfire mine in eastern Kentucky using the Forestry Reclamation Approach. Photo by J. Burger, Virginia Tech, used with permission.

LITERATURE CITED

Rathfon, R.; Groninger, J.; Jacobs, D.F.; Burger, J.A.; Angel, P.N.; Zipper, C.E. 2015. **Tree and shrub species selection for mine reclamation in the midwest region of USA.** ARRI Forest Reclamation Advisory No. 13. Pittsburgh, PA: Appalachian Regional Reforestation Initiative. 12 p. Available at arri.osmre.gov/Publications/Publications.shtm#FRAs (accessed September 18, 2016).