CHAPTER 10: ESTABLISHING NATIVE TREES ON LEGACY SURFACE MINES

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INTRODUCTION

More than 1 million acres have been surface mined for coal in the Appalachian region. Today, much of this land is unmanaged, unproductive, and covered with nonnative plants. Establishing productive forests on such lands will aid restoration of ecosystem services provided by forests—services such as watershed protection, water quality enhancement, carbon storage, and native wildlife habitat—and will enable mined lands to produce valued products such as commercial timber.

This Forest Reclamation Advisory describes practices for establishing native forest trees on lands that were surface mined for coal and reclaimed to meet legal standards under the federal Surface Mining Control and Reclamation Act of 1977 (SMCRA), and where the mine operator no longer has any legal responsibilities ("legacy surface mines"; Fig. 10-1). These lands often differ from their pre-mining condition with respect to topography, soils, water resource influences, and vegetation.

Figure 10-1.—A legacy surface mine. The land is covered with nonforest vegetation even 15 years after reclamation in the late 1990s. Photo by N. Hall, Green Forests Work, used with permission.

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Successful establishment of native forest trees on legacy mines typically requires a sequence of steps or procedures over several years. Here, we describe those steps as the “four Ps”: Plan, Prepare, Plant, and Protect. All four steps are needed to ensure success. Some project managers may desire more technical detail than we have provided here. Hence, we refer to other Forest Reclamation Advisories that provide detail and suggest that reforestation experts be consulted if necessary.

PLAN: Assess the Site and Develop a Plan

The first step is to develop a reforestation plan or strategy by assessing site conditions. Preparing a written plan will aid the reforestation process.

Survey existing vegetation

Herbaceous plants and woody shrubs, including nonnative and invasive species, often dominate legacy surface mines. Herbaceous plants that are common on mine sites, such as nonnative grasses and sericea lespedeza, will outcompete young planted trees if not controlled. (Please see the Appendix starting on p. A-1 for scientific names of species mentioned in this chapter.) Nonnative invasive woody plants also require control because they often grow rapidly and, if present, will outcompete native tree seedlings.

First, visit the site, assess vegetation and site conditions, and develop a vegetation management strategy that will enable planted trees to survive. A site map or aerial photo will help with this task. On the map, delineate and mark areas with 1) different types and amounts of vegetation (for example, good growth of native trees, dominance of invasive species, complete herbaceous cover, extensive bare soil), 2) land slope, 3) aspect (direction the slopes are facing), 4) soil sampling locations, 5) property lines, 6) roads and access, and other information that will aid planning.

Areas with a thick cover of nonnative shrubs and trees will require clearing before replanting. Because the nonnative shrubs and trees that proliferate on Appalachian coal mines—including autumn-olive, tree of heaven, and paulownia—will resprout from living roots even if their tops are cut, they should be killed with a herbicide.

When mine sites are dominated by nonnative herbaceous species such as tall fescue and sericea lespedeza, we also advise killing them with a herbicide. This control will be temporary as seeds in the soil will germinate. But this temporary control will allow tree seedlings to get a good growing start before competing plants emerge from the soil seedbank. Successful reforestation requires control of competing vegetation until planted trees grow and become established.

Assess physical properties of mine soils

Surface soils on many sites have been compacted by mining equipment, and most mine soils have become dense over time. A dense soil restricts growth of tree roots and limits water and air movement. Therefore, loosening such soils will improve survival and growth of planted trees. Dense mine soils can be loosened by using deep tillage, a process commonly known as “soil ripping” (Chapter 5, this volume). A site survey before reforestation can determine where deep tillage can be applied. Slopes up to 30 percent can be ripped with a dozer. Slopes up to 40 percent can be ripped by using a tracked excavator with a ripping bar mounted on the end of the arm.

In our experience, almost all legacy mine sites have dense soils and will become more favorable to reforestation if loosened with deep tillage. Growth of established trees, digging of soil pits, use of soil penetrometers if spoil materials are not too rocky, and other procedures can be used to evaluate soil compaction and the need for deep tillage. The presence of wetland vegetation on upland sites may also indicate compacted areas. Ripping all areas with slopes of 30 percent or less is recommended on legacy surface mines. Flat areas are especially prone to physical settling and compaction. Steeper slopes (greater than 30 percent) may or may not require ripping.

Designate areas that are suitable for soil ripping (not steeply sloped) on a site map similar to that used for the vegetation survey. The area designated for ripping can be used to estimate the cost.

Assess chemical properties of mine soils

Many legacy mine sites have soil chemical properties that are adequate for trees (Zipper and others 2011), but it is prudent to check soil properties. This can be accomplished by obtaining soil samples while walking the site. Collect a soil sample from each area expected to have a different type of soil, or with differing vegetation that indicates possible soil differences. In areas with only sparse vegetation, the soil may be strongly acidic (pH less than 5) or have other major problems. Vegetation which is yellow or otherwise discolored can indicate poor soil quality, lack of adequate soil nutrients, or soil moisture problems. Sample those areas separately.

Procedures for obtaining a soil sample are described in publications of soil testing laboratories. Sampling procedures recommended for natural soils can also be applied to mine soils. Record the location for each sample taken, and the area it is intended to represent, on the site map. The soil sample can be sent to a soil testing laboratory for analysis. If the soil testing lab provides special tests for mine soils, request those tests. When sampling mine soils, be aware that mine operators may have applied a layer of topsoil, subsoil, or soil substitute material on the surface to serve as the growth medium. Soil ripping may pull up subsurface mine soils that are different from the surface layer. If possible, check the mining and reclamation history of the site or dig several test pits down to 2 or 3 feet as needed to check subsoil materials.

Common soil testing procedures are intended for garden or agricultural soils, which are quite different from mine soils. Hence, much of the information provided by the soil testing lab will not apply and can be ignored. Essential soil test results for mine soils are:

- **Soil pH**—If pH is between 5.5 and 6.5, soil chemical properties are likely to be suitable for native hardwood trees. If soil pH is less than 5.0, apply lime as recommended by the soil test report to raise soil pH to the 5.5 to 6.5 range, or plant acid-tolerant trees such as pines and selected hardwoods. If pH is less than 4.0 or if you suspect acid-producing minerals are present, conduct more detailed soil investigations. If soil pH is 7.0 or higher (highly alkaline), the tree-planting prescription should use species that can tolerate high-pH soils.
- **Salinity**—On the surface of mine soils that have been in place for at least 5 years, soluble salts should be similar to the range that is typical for natural soils in the area. If soluble salt levels at the surface remain significantly above what is typical for natural soils, a more detailed soil investigation is advised.
- **Minor nutrients**—If the soil test shows low levels of one or more micronutrients, include a micronutrient mix in the fertilizer application. Standard soil tests for nitrogen (N) and phosphorus (P) are unreliable when applied to mine soils constructed from rock spoils. Fertilizer with N and P should always be applied because most mine spoils contain little of these nutrients in plant-available forms. Other essential macronutrients—calcium (Ca), magnesium (Mg), potassium (K), and sulfur (S)—are usually present in mine soils in adequate quantities.

If the site is so acidic or alkaline that very little vegetation is growing, the soils are likely to contain problematic minerals. For such lands, more detailed soil investigations are advised. The guidelines of this Advisory may not be an appropriate treatment for such lands. Similarly, use alternative procedures if highly acidic mine spoils underlie a thin capping of soil-like surface material.

Plan for tree planting

An essential planning step is to select the types of trees to be planted. The landowner's intended use for the site will influence this choice. In most cases, mined land will be suitable for mixed Appalachian hardwoods. Consult Chapter 7 of this volume for assistance with tree species selection and planting design. If the landowner intends to produce woody biomass, fast-growing species can be planted. Tree selection can also consider habitat needs for rare species such as the Indiana bat (Chapter 11, this volume). Landowners may consult a forester who has experience with mined land for advice on selecting tree species.

Make tree-planting arrangements in the summer or fall prior to planting. As explained in Chapter 9 of this volume, you may order seedlings from private sources or from State nurseries. If a contractor will do the planting, the contractor may also be willing to order and provide the seedlings.

Figure 10-2.—A legacy surface mine where the dominant plant species is sericea lespedeza. Successful reestablishment of forest trees planted as young seedlings will require temporary suppression of this species. Photo by N. Hall, Green Forests Work, used with permission.

PREPARE the Mined Site for Planting

Control competing vegetation

It is essential that preexisting vegetation be controlled because otherwise it will compete with planted trees for sunlight, water, and nutrients (Fig. 10-2). Herbaceous vegetation can be killed during the growing season with a tractor- or ATV-mounted herbicide application. Mowing thick herbaceous vegetation with a bush-hog and then allowing it to grow back for a week or two before spraying can improve contact of the herbicide with actively growing leaves and therefore increase chances of mortality. Apply the herbicide in the summer prior to deep tillage and tree planting. If herbaceous vegetation is not killed before tree planting, it is still possible for the planted trees to be successful if post-planting vegetation control is applied (as described next).

We recommend killing nonnative woody plants with herbicide prior to tree planting. This can be accomplished by an aerial application during the growing season if the site is remote and if the woody vegetation is dense. Otherwise, it must be accomplished manually. If nonnative woody plants are small, they can be killed by applying herbicide to the leaves with a backpack sprayer during the growing season. If they are too large for that, an application to the lower stem, using a basal-bark application approved for the herbicide, will often kill the plant. Another method is to cut the tree and apply herbicide to the stump immediately after the cutting (Fig. 10-3). Basal-bark and cut-stump applications typically require a stronger mix of herbicide than leaf application, but these methods work well in late summer, fall, and early winter when leaf applications are not effective.

Consider the type of vegetation present when selecting a herbicide and the season of application. Sericea lespedeza, for example, will not respond to certain herbicides intended to control grasses and is difficult to kill late in the growing season. Only herbicides intended to control woody vegetation will be effective for that purpose. Detailed herbicide recommendations are available in publications such as Miller and others (2010). For all herbicide applications, follow label directions

Figure 10-3.—A nonnative invasive shrub being cut down. Nonnative invasive trees and shrubs should be removed before reforesting legacy mine sites. Shortly after the plant is cut, roots should be killed by applying a concentrated herbicide to the upper surface of the cut stem. Photo by P. Angel, OSMRE.

and assure applicator safety by using appropriate safety procedures and equipment.

Loosen the soil

When mine soils have become dense, loosening is needed to allow root growth, water infiltration, soil drainage, and air movement for growing trees. Use a deep tillage device ("soil ripper") to loosen the soil to a depth of 3 feet or more before tree planting on most mine sites (Fig. 10-4). Application of deep tillage to active mines is described in Chapter 5 of this volume; these practices can also be used on legacy mines.

The most common method of soil loosening is to use a stout single-shank ripping tooth on the back end of a large dozer, bigger than a Cat® D-8 (Caterpillar Inc., Peoria, IL). Generally, single rips should be oriented across slopes to minimize soil erosion and potential gullying. On steeper slopes, a tracked excavator with a ripping tooth mounted on the end of the arm can be used (Fig. 10-5).

Figure 10-4.—Ripping tooth on the back of a dozer. The ripping tooth can be inserted into and pulled through the ground to loosen the dense mine soil, improving its physical properties and ability to support planted trees. Photo by N. Hall, Green Forests Work, used with permission.

Ripping should occur when the mine soil is relatively dry, usually in the late summer or fall prior to planting. When compacted mine soils are dry, they are loosened more effectively by the ripping tool. When soils are wet, the dozer will compact the soil where it tracks, making tillage less effective.

When sites are heavily compacted, this initial ripping operation can be followed by ripping another set of parallel rows in a direction perpendicular to the initial rips ("cross-rips").

Figure 10-5.—An excavator outfitted with a ripping tooth. This equipment can loosen compacted soils on slopes that are too steep for a dozer. Photo by N. Hall, Green Forests Work, used with permission.

Cross-ripping is desirable because planted trees tend to extend roots preferentially along the ripped channel. Cross-ripped sites will give the planted trees greater stability and capability to resist windthrow than a single-directional rip.

When cross-ripping slopes, operating the ripper in the up-down slope dimension first, followed by a second rip running either across the slope (along the contours) or at an angle to the slope (creating a pattern called diamond rips) will help to stabilize the surface and to hinder the waters from gullying in the up-down slope channels. It is also desirable to break up the soil surface by using smaller shanks on either side of the main ripping tooth, especially if the site is not cross-ripped. The loosened surface aids growth of planted trees' lateral feeder roots.

Use of coulter wheels to create a "mound" of soil over the rip is also recommended (Fig. 10-6). This treatment is especially desirable on near-level sites where water is unable to drain freely. Planting trees on the mound can aid tree survival if mine soils are poorly drained, and also makes it easy to locate seedlings for post-planting herbicide treatments and assessments. Mounding soil over the rip makes it easy to plant the tree, orients the tree directly above the rip for the best rooting opportunity, and provides a stable surface for the new seedling. Use of coulters is especially beneficial in fine-textured mine soils with few rocks, as such soil materials tend to restrict water drainage. In contrast, use of coulters in rocky mine soils can be problematic given the tendency of coulters to ride up over the rocks.

Figure 10-6.—Coulter wheels on the back of a dozer, with ripping tooth inserted into the soil. The coulter wheels pile loosened soil into a mound, allowing seedlings to be planted at a slightly elevated position above the land surface. Use of coulter wheels is advised for mine soils with poor water drainage and few large rocks. Photo by J. Burger, Virginia Tech, used with permission.

Design the ripping or tillage operation with spacing to accommodate the tree planting plan, as trees should be planted on or near the deep rips. Ripping at spacings of 8 to 10 feet will accommodate plantings of 600 to 700 trees per acre (Chapter 7, this volume).

In rocky mine soils, the dozer operator should attempt to pull the rocks up or twist them around for greater soil fragmentation. The operator should not lift the ripping shank to ride over the rocks unless the rock is so large that it cannot be moved. The ripped area may have rocks pulled up to the surface, creating a rocky, rough appearance.

If the soil ripping operation is expected to create disturbance with potential to allow soil movement offsite, apply best management practices (BMPs) to limit soil erosion and losses. Most States have manuals that describe BMPs for erosion prevention and sediment control (for example, see Kentucky Department of Water 2007). In our experience, soil ripping operations in Appalachian mine soils rarely cause or allow extensive soil movement.

Improve soil chemical properties

Soil nutrients—especially N and P—are essential to tree growth. Adequate plant-available nutrients will enable quick growth of planted seedlings. This is desirable because planted trees' likelihood of survival is improved once they become "free to grow" by overtopping their competition. Over the longer term, soil nutrients are essential to forest productivity.

Most unmanaged mine soils are low in plant-available N and P. Therefore, apply fertilizers with these nutrients. Soil pH affects plant availability of soil P, so apply lime if soils are strongly acidic (pH less than 5).

If soil pH is less than 5.0, apply lime according to the soil test recommendations to raise soil pH to between 5.5 and 6.5. Lime can be broadcast over the site prior to tillage using agricultural methods such as truck- or tractor-mounted spreaders.

Apply fertilizers in a manner that confines availability to planted trees. Fertilizers should not be broadcast over the entire area, as that will stimulate rapid growth of competing vegetation (Evans and others 2013, Sloan and Jacobs 2013). If possible, apply fertilizer in narrow bands over the tree-planting row produced by soil ripping. On most mined lands, application of 50 to 75 lbs N, 100 lbs P (230 lbs P_2O_5), and 40 lbs K (48 lbs K_2O) per acre will be adequate.

A way to stimulate early tree growth on nutrient-deficient mine sites is to use fertilizer pellets or tablets. Place the pellets below the surface and about 2 to 4 inches from each planted seedling. Fertilizer pellets contain sufficient nutrients to help the seedlings become established but not enough nutrients to support long-term growth.

Fertilizer can be applied by a dispenser mounted on the front of the tillage dozer, allowing the fertilizer to be incorporated into the soil by the tillage operation. If this method or other mechanical methods of application are not possible, apply fertilizer by hand to the soil surface near each planted tree. Spread about one 16-ounce cup of di-ammonium phosphate fertilizer (18-46-0) in a circle around the stem of each tree, keeping it about 12 inches from the stem and spreading it evenly. If fertilizer is applied at planting as pellets, an additional application around the stem is also advised as a means of ensuring adequate nutrients for long-term growth. If the site survey or soil test reveals a likelihood of micronutrient deficiency, use fertilizers with micronutrients.

Use of controlled-release fertilizers, which dissolve and release nutrients slowly over time, has been found to provide good results in mine reforestation plantings (Sloan and Jacobs 2013). Organic amendments, such as manures and composts, have been applied to improve soil properties on many mine sites. The precautions for using such materials on farmlands also apply to legacy mines. Additional precautions are in order for high-nutrient organic materials, such as fresh manures, given the sensitivity of Appalachian native trees to soil properties.

PLANT Native Trees

Hand-plant seedlings on or along the deep rips to enable tap roots to penetrate the soil easily. We recommend that trees be planted at rates of 600 to 700 per acre.

On mine lands with little surface relief, plant trees in a manner that places them in high ground, either over or adjacent to the ripped channel. On sites that are cross-ripped, plant trees near where the rips intersect to enable the lateral roots to extend easily in all four directions. On sites that are sloped and able to drain water easily, plant the trees in a position that is close to the natural ground surface. When possible, plant trees in soil that has been loosened by the ripping operation. See Chapter 9 of this volume for a description of how to plant trees on mine sites.

Many legacy mine plantings use bare-root seedlings with no protective devices installed (Fig 10-7). For large-area plantings with thousands of seedlings, this practice can result in successful reforestation if most of the planted seedlings survive and grow. However, survival prospects can be improved by installing protective devices such as tree tubes, weed mats, or both for individual seedlings.

Tree shelters (plastic cylinders that are placed around seedlings to create moist microenvironments) have been shown to both protect seedlings from browsing animals and increase tree growth (Fig. 10-8). Fabric mats are another option for improving tree growth. Seedlings are placed in the center of a fabric mat (about 18 inches × 18 inches in size), and the edges of the mat are staked into the ground. These

Figure 10-7.—Volunteers planting tree seedlings on a legacy surface mine that has been prepared for reforestation by using the guidelines described in this chapter. If adequate finances are available, professional firms can be engaged to plant trees. Photo by P. Angel, OSMRE.

Figure 10-8.—Tree tubes in use on a legacy mine site with the intent of increasing survival and growth of high-value seedlings. Photo by P. Angel, OSMRE.

mats allow rainfall infiltration but prevent growth by competing plants in soil close to the seedling. The best protection is provided by protective devices that combine tree tubes with weed mats. When cost prevents use of protective devices for the entire job, they can be installed to improve success in high-visibility areas or for high-value seedlings.

PROTECT Planted Trees

Control competing vegetation

Because young trees are vulnerable, they should be protected. A primary threat is competing vegetation that prevents seedlings from reaching sunlight, water, and soil nutrients. Rodents may be attracted and sheltered by heavy herbaceous competition; they can kill the trees by girdling or debarking them as a winter food source. Control of competing vegetation will be essential on virtually all reforested legacy mines.

Immediately after planting while seedlings are still dormant, a preemergent herbicide can be applied to reduce emergence of herbaceous plants from seeds. This application can occur in a circle around each seedling or, if applied using a tractor or ATV, in bands over the tree rows.

In late spring or early summer, a post-emergent herbicide can be applied by “spot spraying” a circle around each planted tree, using tree shields or other means to ensure that no herbicide contacts tree leaves (Fig. 10-8). Herbicide applicators should be trained to recognize any problematic invasive shrubs and trees (Table 10-1), especially species present prior to clearing or along site borders. Spray these plants when they appear. Herbicides should be applied only under calm atmospheric conditions, following label directions, and by applicators wearing protective gear. Repeat spring preemergent and summer post-emergent herbicide applications in subsequent years until most of the trees have grown so they are above the herbaceous competition. Here, we have not specified herbicide types. The herbicide should be selected after determining the types of plant species that require control and consulting a reference such as Miller and others (2010).

Apply additional protection if needed

Apply additional common-sense protective measures as well. Once the site is planted, it faces threats from livestock and wildlife browsing, insects, humans, and invasive plants. Occasional browse will slow the growth of young hardwood tree seedlings but usually will not kill them. Repeated browse, however, will be more

Table 10-1.—Partial list of invasive species that are problematic on legacy mine sites and are capable of interfering with successful reforestation if not controlled. For photographs of these species, see Natural Resources Conservation Service (2016), the Southeast Exotic Plant Pests Council (2013), or State conservation agency Web sites.

Common name	Scientific name	Plant type
silktree (mimosa)	*Albizia julibrissin*	Tree
tree of heaven (ailanthus)	*Ailanthus altissima*	Tree
Russian-olive	*Elaeagnus angustifolia*	Tree
autumn-olive	*Elaeagnus umbellata*	Shrub
Japanese knotweed	*Fallopia japonica*	Shrubby forb
shrubby lespedeza	*Lespedeza bicolor*	Shrub
sericea lespedeza	*Lespedeza cuneata*	Forb, legume
Japanese honeysuckle	*Lonicera japonica*	Shrub/woody vine
bush honeysuckle	*Lonicera maackii*	Shrub
white sweet clover	*Melilotus alba*	Forb
Japanese stiltgrass	*Microstegium vimineum*	Grass
Chinese silver grass	*Miscanthus sinensis*	Grass
paulownia (princesstree)	*Paulownia tomentosa*	Tree
mile-a-minute vine	*Polygonum perfoliatum*	Vine
kudzu	*Pueraria montana*	Woody vine
multiflora rose	*Rosa multiflora*	Shrub
tall fescue*	*Schedonorus* spp.	Grass
johnsongrass	*Sorghum halepense*	Grass

* Also known as *Schedonorus phoenix*.

damaging. Fencing can exclude grazing animals and prevent emerging vegetation from being damaged or destroyed by vehicles (for example, ATVs, tractors, 4×4s). Signage can be used to mark the planting boundaries if fencing is not used. Maintaining locked gates at critical access points can help limit uncontrolled human access and guard against these hazards.

Assess survival and replant if needed

The money and effort invested in the site should also be protected by assessing survival after the first growing season, generally in September or October, after stressful mid-summer conditions have passed but while living trees retain their leaves. Survival can be assessed by sampling or counting living trees within areas selected to represent the rest of the site. It is not necessary to count all surviving trees over the entire site.

A common method of survival assessment is to establish circular sampling plots at random locations and to count surviving trees within those plots. To define the plots, place a stake at the center point and use a rope of fixed length or tape to measure distances from the center point (Fig. 10-9). For example: to assess survival within a 1/20th-acre sampling plot, count every surviving tree within a circular area up to 26 feet 4 inches of a center point.

Sampling plots should be distributed evenly but located randomly over the site. This can be done by determining in advance how many plots are needed, then defining straight-line transects over the site and locating the plots at predefined distances along those transects. For example, if 10 plots are needed within a site that is long and rectangular, two transects could be defined

Figure 10-9.—Personnel preparing to assess survival and growth of planted tree seedlings on a legacy surface mine. Photo by N. Hall, Green Forests Work, used with permission.

along the site's long dimension with 5 plots located along each transect. Plot center points can be located along the transect while distance is estimated by counting paces. It is essential that plots be located using a predetermined method that considers the planted area's configuration and size; plots should not be located by walking over the site, seeing what is out there, and on that basis deciding that "this looks like a good spot."

The number of plots that should be established is a matter of judgment. The sampling plots are intended to represent the entire site. More sampling plots, when appropriately placed, will provide a more accurate survival estimate than fewer plots. The following rule of thumb can be followed: For mine sites with fairly uniform soils and topography, a 5-percent sample or one 1/20th-acre plot per acre should be adequate; for areas with highly variable soils and topography, or mine sites for which irregular survival across the site is suspected for any reason, a 10-percent sample, or two 1/20th-acre plots per acre should be measured.

Count the number of living trees within each 1/20th-acre circular plot and multiply that number by 20 to estimate the number of trees per acre. Record this per-acre number for each plot for a per-acre estimate for that particular area. Estimate the overall per-acre number for the entire site by averaging the per-acre estimates for all 1/20th-acre plots. Also record the species of each surviving tree.

Where weeds have been controlled successfully and the summer has not been unusually hot and dry, average survival should be higher than 70 percent after the first year—490 trees per acre if 700 trees per acre were planted. If stocking is below this level, the site manager should determine the cause, working with the tree planter if a contractor was employed. If poor survival was due to poor seedling quality or improper planting, the manager can determine who is responsible and seek to engage that party in remedial replanting. If first-year survival is not satisfactory, "holes" left by nonsurviving trees should be replanted during the next winter.

By the end of the third, fourth, or fifth growing season, most planted trees should be above the competing herbaceous vegetation (Fig. 10-10). Make a final survival assessment after the third or fourth growing season using the same assessment procedures just described. At this time, a minimum of 400 well-distributed healthy trees per acre will ensure reforestation success. During the site surveys, visually assess the presence of invasive

Figure 10-10.—Oak seedling released from herbaceous competition by herbicide application. Photo by C. Zipper, Virginia Tech, used with permission.

species with potential to outgrow and outcompete planted seedlings. When possible, control or remove such species if they are present at densities sufficient to interfere with planted seedlings' survival within certain areas.

EXPECTED OUTCOME

Reestablishing native Appalachian forests on legacy surface mines that are not being managed for other purposes can produce marketable timber and environmental benefits such as watershed protection, carbon sequestration, and improved wildlife habitat. Until recently with the adoption of the Forestry Reclamation Approach (Chapter 2, this volume), common coal-mine reclamation practices under SMCRA often created conditions unfavorable to reforestation. When the guidelines described in this Advisory are applied, productive Appalachian forests can be restored on such mined lands (Fig. 10-11).

SUMMARY: STEP-BY-STEP GUIDANCE

A step-by-step summary and timeline for the recommended procedures is found in Table 10-2 (see next page). Depending on site conditions, all treatments may not be needed.

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Thanks to personnel with Green Forests Work (GFW) for their assistance in developing this Advisory. GFW personnel can provide technical and other types of assistance to parties who are attempting to reestablish Appalachian forest vegetation on legacy surface mines.

Figure 10-11.—Appalachian hardwood trees emerging from herbaceous vegetation on a legacy surface mine during the third growing season after using methods described in this chapter. Photo by C. Zipper, Virginia Tech, used with permission.

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Table 10-2.—Step-by-step summary of the guidelines presented in this chapter

Month	Year	Task	Task detail
		PLAN	
Prior to July	1	Survey vegetation, assess soil properties	Survey the area to assess vegetation; test soil physical and chemical properties. Use information to develop a reforestation plan for the site.
Summer or fall	1	Determine species to plant, order trees	If the site is to be planted by a contractor, that contract should be put in place. The contractor may be able to provide seedlings.
		PREPARE	
July	1	Remove and control existing vegetation	Broadcast-spray herbicide to control vegetation. If large invasive shrubs and trees are present, control via aerial herbicide or manual removal. Be sure to kill invasive shrubs and trees with capability to resprout from living roots.
Aug.-Sept.	1	Apply lime, if needed	Apply lime if needed and as needed to raise pH to between 5.5 and 6.5.
Sept.-Oct.	1	Deep-till and fertilize	Loosen soil with a deep-tillage tool, ripping with 8- to 10-foot spacing between rows. Band-apply fertilizer along the rows.
		PLANT	
Jan.-March*	2	Plant trees	Plant tree seedlings correctly (recommended planting rate: 600 to 700 per acre).
		PROTECT	
Feb.-March*	2	Weed control	Band-spray a preemergent herbicide over the tree rows.
May-June	2	Weed control	Spot-spray herbicide around each tree seedling, using tree-shields to protect seedlings from herbicide drift. Apply herbicide to emergent invasive shrubs and trees if present.
Sept.-Oct.	2	Assess tree survival	Survey tree survival; determine if replanting is needed.
Jan.-March*	3	Replant if needed	If the tree survival assessment reveals inadequate survival in any area, replant to fill in between surviving trees as needed to assure adequate stocking.
Feb.-March*	3	Weed control	Repeat the preemergent herbicide.
May-June	3	Weed control	Repeat the spot-spray herbicide.
May-June	4	Assess vegetation	Walk the site to determine if the majority of planted trees have grown so uppermost leaves are above herbaceous competition.
May-June	4	Weed control	Repeat the spot-spray herbicide (if needed).
Sept.-Oct.	4	Final survey	Survey tree stocking. Look for a minimum of 400 planted trees per acre.

* Tree planting and preemergent herbicide application can be extended through April in the northern Appalachian region.