



CHAPTER 9: PLANTING HARDWOOD TREE SEEDLINGS ON RECLAIMED MINE LAND IN THE APPALACHIAN REGION

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INTRODUCTION

The Forestry Reclamation Approach (FRA) is a method of reclaiming surface coal mines to forested postmining land use (Chapter 2, this volume). “Use proper tree planting techniques” is Step 5 of the FRA; when used with the other FRA steps, proper tree planting can help to ensure successful reforestation.

Proper care and planting of tree seedlings is essential to any reforestation effort. Appalachian coal mines reclaimed by using the FRA will often be rough, rocky, and on steep terrain. Thus, hand planting is the usual method for planting hardwood tree seedlings. Professional tree planting companies with experience in hand-planting reclaimed mines can provide excellent results. Most of these companies offer a complete service that includes obtaining, handling, and planting hardwood tree seedlings. State forestry departments and consulting foresters can also provide valuable assistance.

Any tree planting process on mined land entails several steps, each of which must be executed competently to assure a successful reforestation project. They are:

- Selecting and ordering seedlings
- Site preparation
- Proper handling and storage of seedlings
- Preparing seedlings for planting
- Planting tree seedlings
- Post-planting care and assessment.

The next six sections discuss these steps, and additional resources are listed in Box 9-1.

SELECTING AND ORDERING SEEDLINGS

Nurseries produce seedlings as either bare-root or containerized stock. Bare-root seedlings grown in nursery beds (Fig. 9-1) are relatively inexpensive when purchased in bulk. Less-common species are produced in smaller quantities, usually

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Publication History

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Box 9-1. Additional Resources

Burger, J.A.; Zipper, C.E. 2009. **How to restore forests on surface-mined land.** Virginia Cooperative Extension Publication 460-123. Blacksburg, VA: Virginia Polytechnic Institute and State University. Available at http://www.cses.vt.edu/PRP/VCE_Pubs.html (accessed November 4, 2016).

Mercker, D. 2005. **SP663 Tree planting procedure for small, bare-root seedlings.** Knoxville, TN: University of Tennessee Agricultural Extension Service. 4 p. Available at http://trace.tennessee.edu/utk_agexfores/16 (accessed November 4, 2016).

Pijut, P.M. 2003. **Planting and care of fine hardwood seedlings: planting hardwood seedlings in the Central Hardwood Region.** FNR-210. West Lafayette, IN: Purdue University, Department of Forestry and Natural Resources. 8 p. Available at www.treesearch.fs.fed.us/pubs/12877 (accessed November 4, 2016).

South Carolina Forestry Commission. [N.d.]. **Tree planting guide.** <http://www.state.sc.us/forest/refplant.htm> (accessed November 4, 2016).

in containers, and are delivered in soil-filled containers or with a plug of soil surrounding the roots. Most hardwood seedlings for reforestation are purchased as bare-root stock grown in a nursery for 1 year and are referred to as 1-0 seedlings. Bare-root hardwood 1-0 seedlings should have a vigorous root system.

Mine operators and reclamation practitioners are encouraged to review the reforestation plan in the approved permit during the summer and calculate the number of trees required for the upcoming tree-planting season. Advance placement of tree orders in late summer or fall, 4 to 6 months before the planned planting date, will reserve the desired number and species of tree seedlings. If large numbers of seedlings or uncommon species are needed, coordination with the nursery a year or more in advance may be required.



Figure 9-1.—Hardwood seedlings growing in a nursery. Many State- and privately owned nurseries have increased production in response to recent demand for high-quality hardwood seedlings. Photo by V. Davis, OSMRE.

Use of seedlings grown from seed collected from the same geographic region where they will be planted will increase the long-term reforestation success. Seed origin should be as close in latitude as possible to the planting site and within the same USDA hardiness zone (map available from <http://www.usna.usda.gov/Hardzone/>). Distance in an east-west direction is less important. Ask the nursery manager for information about seed origin.

SITE PREPARATION

The FRA includes construction of a growth medium with favorable properties, suitable placement, and minimal grading of that material while avoiding compaction, and the use of tree-compatible ground cover (Chapters 2, 4, and 6, this volume). On active mines reclaimed using the FRA, additional site preparation will not be required. Plant trees directly into the surface materials. In areas of high soil compaction such as temporary roads or equipment work areas, or on mines that were reclaimed years ago by using methods that compacted the soil, dozer ripping can be used to loosen soils (Chapter 5, this volume). On older sites, thick and vigorous ground covers may be temporarily controlled by ripping, disking,

or herbicide so that young tree seedlings have a better chance to compete. On active mines, plant tree seedlings in winter before seeding the ground cover the next spring, or plant tree seedlings shortly after seeding the ground cover.

Native hardwoods normally grow at a soil pH in the range of 4.5 to 7.0; most species prefer a pH of 5.0 to 6.5. Where reclamation has established mine soils favorable for trees, fertilize the site as recommended in Chapter 6 of this volume. Soil samples should be taken to a soil testing laboratory that is experienced and capable of providing recommendations for mine soils; specify that forestry is the land use so as to receive proper lime and fertilizer recommendations. Lime is generally not recommended on reforestation sites unless acid-producing materials are present or soil pH is less than 5.0. Mine soils are commonly deficient in phosphorus (P), so apply fertilizer that contains sufficient P to support tree establishment and long-term growth but relatively low rates of nitrogen (N) to avoid stimulating herbaceous competition that will depress planted seedlings' survival and growth.

PROPER HANDLING AND STORAGE OF SEEDLINGS

Bare-root tree seedlings are lifted from the nursery after the seedlings enter winter dormancy. Depending on the nursery location, seedlings are generally available for distribution by late December through the end of March. Tree seedlings are living organisms, so limit the level of stress between lifting and planting to increase the vigor and survival rate of planted seedlings. Inspect nursery seedling bags upon delivery; mend any holes with tape. If possible, arrange with the nursery to lift and ship seedlings immediately before planting. If seedlings arrive more than a day or two before they will be planted, place the bags in regulated cold storage (33 to 40 °F with humidity above 80 percent) until planting (Fig. 9-2). Protect seedling bags from freezing and never place them in direct sunlight.



Figure 9-2.—Tree seedlings in cold storage. Seedlings should be kept in cold storage with bags unopened until just before planting. Photo by M. French, Green Forests Work, used with permission.

If cold storage is not available, keep the seedling bags cool and moist, with temperature below 40 °F but above freezing. Higher temperatures may cause seedlings to break dormancy, increasing transpiration and drying out the roots. Storage for more than 10 days is not recommended. If seedlings must be stored for an extended period in cold storage, inspect bags at least once a week to check that roots appear wet. Water roots with a fine mist if needed, but do not let standing water in the bottom of the bag be more than a half-inch deep. Any time you open the bag, reseal it with tape to prevent water loss. Ensuring cool temperatures and moist roots will reduce losses during storage and after planting.

PREPARING SEEDLINGS FOR PLANTING

Again, cool temperatures and moist roots are the keys to success. During transportation, leave tree seedlings in the bags and protect them from wind and sunlight in an enclosed vehicle or covered with a tarp. In the field, cover the nursery bags and planting bags with light-reflecting tarps so they are not exposed to sun and wind. Planting a mixture of tree species will require opening the individual nursery bags, separating the seedlings, and mixing the various species together in the tree planting bags; perform this operation in the staging area, in the shade.

Commercially available tree planting bags are designed for easy use and help to protect the seedling roots from drying. Placing wet mulch in the planting bag, or dipping the seedling roots in a hydrating gel, can provide extra protection (Fig. 9-3). Mulch that is not saturated with water will wick moisture away from the roots. If planting bags are not available, use 5-gallon plastic buckets containing 1 to 2 inches of water; cover the buckets loosely with a plastic bag.

Soil or hydrating gel clinging to the roots is beneficial and should not be shaken or rinsed off, so be careful when adding water to the planting bags. Once the seedlings are placed in the planting



Figure 9-3.—Preparing seedlings in the field: (A) Seedlings are separated carefully; roots are dipped in a hydrating gel, then (B) immediately placed in a planting bag to reduce root drying. Photos by K. Schmidt, University of Kentucky, used with permission.

bag, plant them as soon as possible. If the roots dry out for even a few minutes, seedling mortality will increase significantly, so it is important to work quickly and keep the roots moist at all times. Any seedlings that are not immediately used should remain in the nursery bag; after adding a fine mist of water if necessary to keep the seedlings moist, keep the bag tightly closed. Return unused bags to cold storage to reduce the chance of seedling damage.

Some pruning of the root system occurs at the nursery while processing tree seedlings for distribution. Because carbohydrates stored in the seedling's roots are used for initial shoot development, do not do additional pruning of the roots in the field. Keeping as much of the root system intact as possible will increase both the initial survival rates and early growth rates of the planted seedlings. The best way to plant a hardwood seedling with an extra-large root system is to dig a bigger hole.

PLANTING TREE SEEDLINGS

Desirable planting dates in the Appalachian region range from December to mid-April depending on the latitude and elevation of the planting site (check with your State forestry department or consulting forester). Planting trees early in the planting season will allow development of the root system before the drier weather arrives. The best planting days are overcast with temperatures below 50 °F when the soil is moist but not frozen. A staging area, protected from wind and direct sunlight, should be located on the planting site and used to distribute the seedlings from the nursery bags to the planting bags.

Most reforestation plans prescribe the desired tree spacing. However, if the spacing location falls in an area of heavy ground cover or surface rock, seedling survival will be increased by moving the planting spot a few feet to a place where there is less ground cover or surface rock. Common grid patterns for planting tree seedlings are listed in Table 9-1. Tree spacing depends largely on what is

Table 9-1.—Trees per acre planted and surviving assuming 70-percent survival rate for common grid patterns for planting tree seedlings

Spacing (feet)	Trees per acre	
	Planted	Surviving
7 × 7	889	622
7 × 8	778	544
8 × 8	681	476
8 × 9	605	423
9 × 9	538	376
9 × 10	484	338
10 × 10	436	305

required for stocking by each State mining agency, so check the State regulations and the revegetation plan in the mining firm's permits for the required tree spacing and number of trees per acre. Planting plans are often developed assuming that 70 percent of the planted seedlings will survive. But actual survival may be greater or less depending on soil conditions, weather, planting practices, and similar factors.

The most common tree planting tools on mine sites in the Appalachian region are the hoedad, the KBC planting bar, the sharpshooter spade, and the dibble bar (Fig. 9-4). Most planting contractors prefer the hoedad because the wooden handle



Figure 9-4.—Tree-planting tools commonly used on mine sites. From left to right: hoedad, KBC planting bar, sharpshooter spade, and dibble bar.

absorbs some of the impact shock encountered when planting in rocky soil, and it is easier to use on steep slopes (Fig. 9-5). Both the KBC planting bar and the sharpshooter spade have long pointed blades that can make a hole deep enough for 1-0 hardwood seedling roots in rocky soils (Fig. 9-6). The shorter, blunt dibble bar blade works better for planting pine seedlings with smaller root systems.

Regardless of the tool, the planting procedure is basically the same. The hardwood seedlings' root system is generally larger than that of pine seedlings of the same age, so extra time may be required to make a hole to accommodate the 1-0 hardwood roots. Generally, the planting hole should be vertical or near vertical so that planted seedlings can stand straight up when planted.

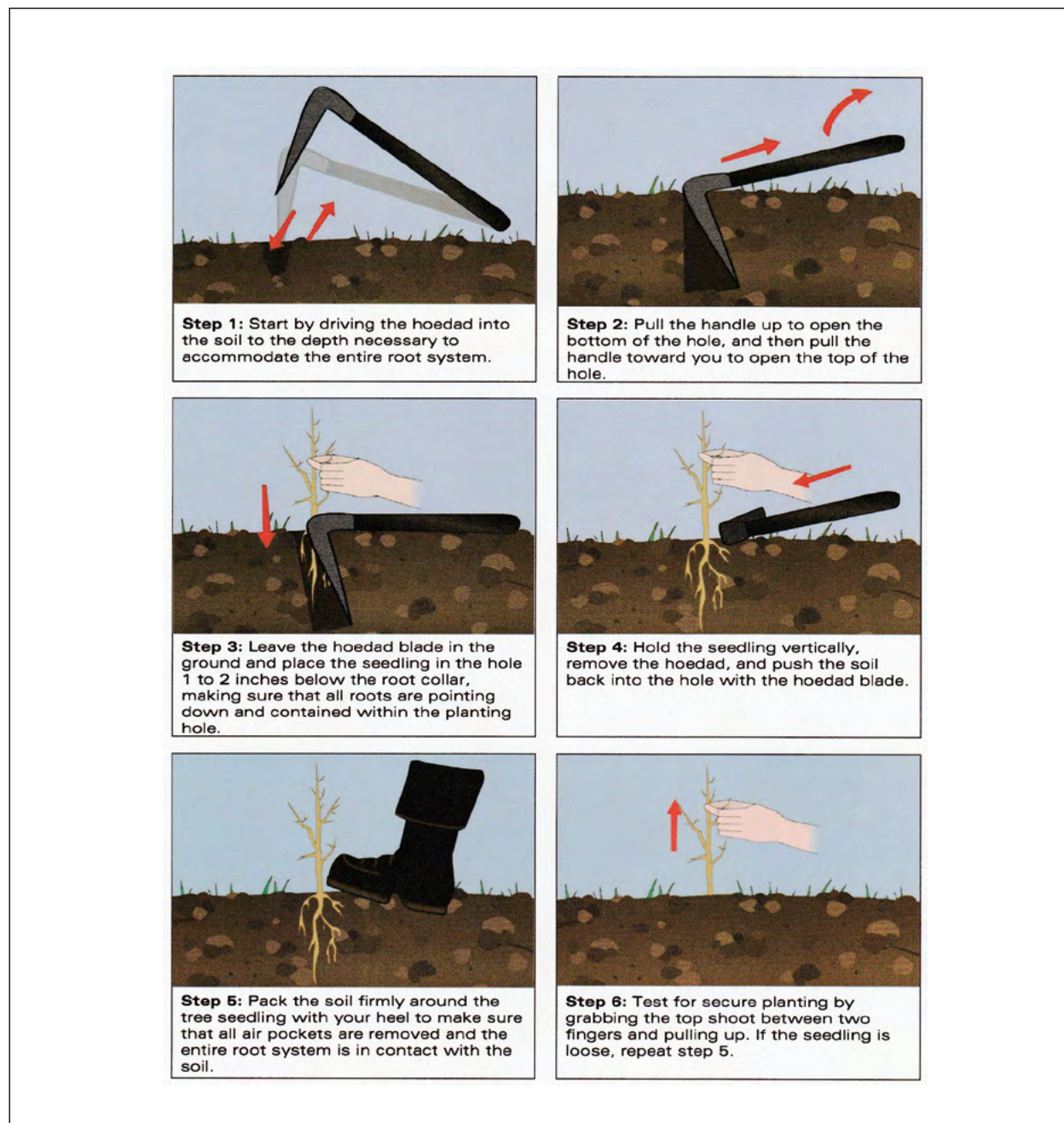


Figure 9-5.—Tree planting using a hoedad.

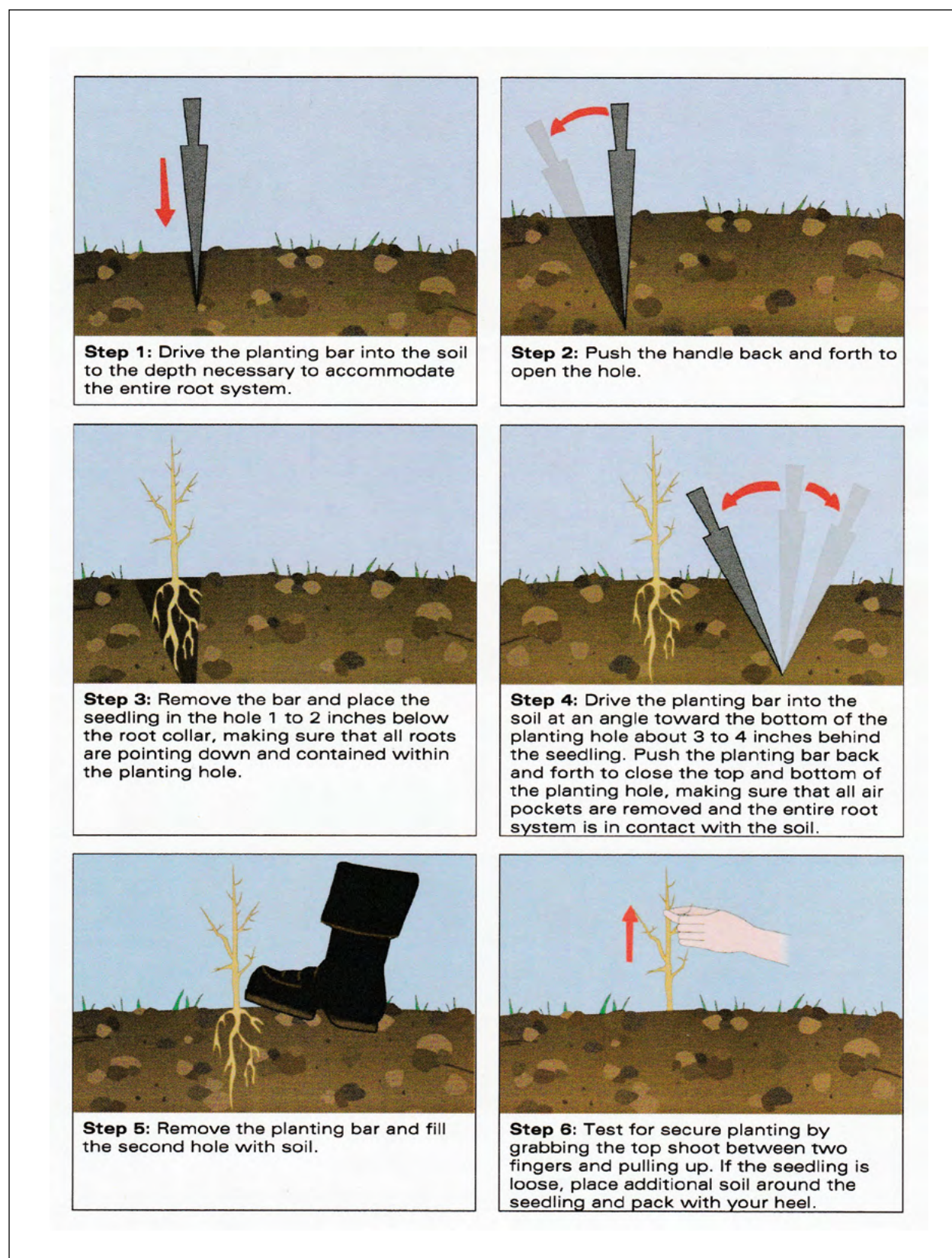


Figure 9-6.—Tree planting using a KBC bar, sharp-shooter spade, or dibble bar.

Seedlings must be planted at the proper depth, or initial survival and long-term growth will be compromised. The seedling root collar is the transition zone between the root system and the stem (Fig. 9-7). Plant hardwood seedlings 1 to 2 inches below the top of the root collar, which will allow for some soil settlement without exposing the roots. Take care to ensure that all roots are pointing down and contained within the planting hole. When planting, remove only one seedling at a time from the planting bag. Seedling roots should not be forced or twisted into the planting hole, as this practice will cause bent or broken roots and impair new root development, and may eventually cause the tree to die. Plant the seedling in a vertical position with the soil packed firmly around the roots so that all air pockets are removed and the entire root system is in contact with the soil. On steep slopes, the hole may be oriented slightly away from the vertical position if necessary to ensure that the seedling will remain stable and roots can contact deeper soil layers. Keep all seedlings, except the one being planted, in the planting bag, where they are protected from drying out.

Test for secure planting by grabbing the seedling's top shoot between two fingers and pulling up. If the seedling is loose, place additional soil around the seedling and pack firmly (Fig. 9-8).

Personnel from the mining firm should be present during the planting operation to ensure that seedlings are handled and planted using proper procedures. Close supervision of the planting crew and inspection of planted trees will help to control quality and provide consistent results.

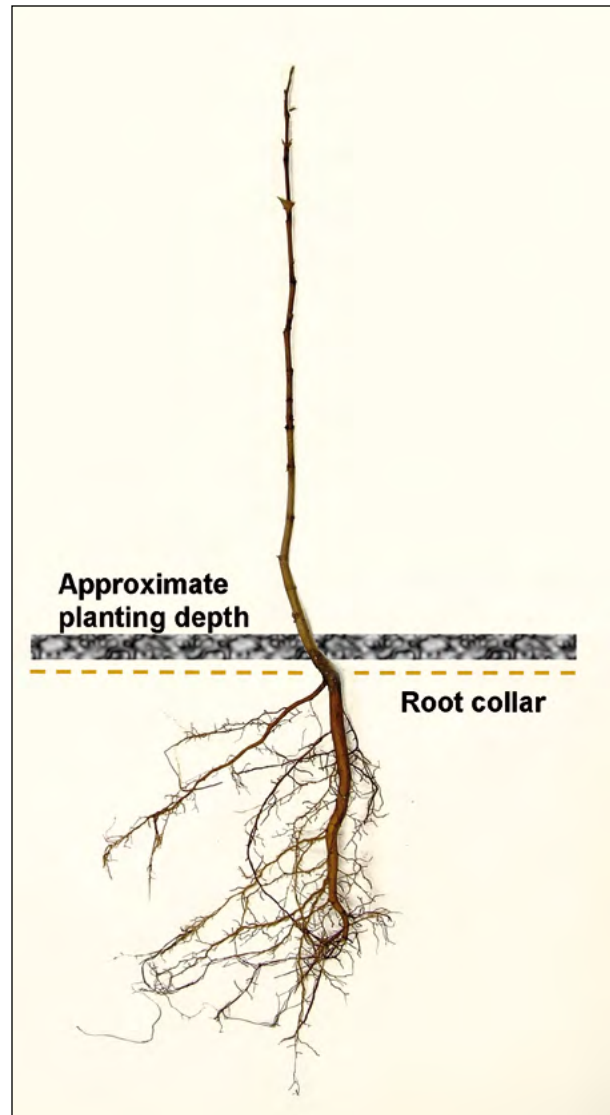


Figure 9-7.—A bare-root hardwood tree seedling before planting. The “root collar” is an area where the stem meets the roots, and is thicker than the stem above. The seedling should be planted 1 or 2 inches below the root collar, well above the highest root.



Figure 9-8.—Tree planting with a hoedad, using the steps illustrated in Figure 9-5. (A and B) Tree seedlings should be planted by making a planting hole deep enough to accommodate the entire root system. (C) The seedling is placed so that all roots are contained within the hole without forcing, bending, or twisting the roots. (D) The soil is packed firmly around the tree seedling's roots to ensure that all air pockets are eliminated and the entire root system is in contact with the soil. (E) The top shoot of the seedling is grasped between two fingers and pulled to make sure it has been securely planted. Photos by K. Schmidt, University of Kentucky, used with permission.

POST-PLANTING CARE AND ASSESSMENT

Post-planting survival assessment is essential to any reforestation project. The mine operator should conduct a survival assessment during the second growing season, before leaf fall. If survival appears adequate for performance bond release, no further action is required. The vast majority of planted trees that live into the second growing season can be expected to survive for the long term. If survival is not adequate, make arrangements for replanting during the upcoming winter season. On active mines, prompt identification and remediation of survival problems can help to achieve prompt bond release. Experience has shown that when FRA reclamation and reforestation procedures are fully employed, replanting is rarely needed.

Research has shown that hardwood tree survival in the range of 70 to 80 percent can usually be achieved when the FRA is fully implemented. In the first year after planting, most hardwood species invest the majority of their energy in the development of the root system and do not show exceptional shoot growth. During times of extreme drought or stress, hardwood seedlings may shed leaves and appear dead, but the following spring new shoots can sprout from living roots. During the third growing season, after roots are established, the shoot growth will begin to accelerate and the development of a healthy and productive forest begins.

ACKNOWLEDGMENTS

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