



PLANTING HARDWOOD TREE SEEDLINGS ON RECLAIMED MINE LAND IN APPALACHIA

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Introduction

The Forestry Reclamation Approach (FRA) is a method of reclaiming surface coal mines to forested post-mining land use (see Forest Reclamation Advisory No. 2). "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 reforestation success.

Proper care and planting of tree seedlings is essential to any reforestation effort. Appalachian coal mines reclaimed 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 mined-land tree planting process 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

Selecting and Ordering Seedlings

Nurseries produce seedlings either as bare-root or containerized stock. Bare-root seedlings grown in nursery beds are relatively inexpensive when purchased in bulk. Less common species are produced in smaller quantities, usually 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 one 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, four to six months prior to 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.



Photo 1. Many state and privately owned nurseries have increased production in response to recent demand for quality hardwood seedlings.

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/>), while distance in an east-west direction is less important. The nursery manager should be able to provide information concerning seed origin.



Photo 2. Tree seedlings should be kept in cold storage with bags unopened until just prior to planting. Seedlings are separated carefully, roots are dipped in a hydrating gel, then immediately placed in a planting bag to reduce root drying.

Site Preparation

The FRA includes construction of a growth medium with favorable properties, placement and minimal grading of that material while avoiding compaction, and using tree-compatible ground cover (see Forestry Reclamation Advisory Nos. 2, 3 & 6). On active mines reclaimed using the FRA, additional site preparation will not be required and trees can be planted 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 using methods that compacted the soil, dozer ripping can be used to loosen soils (see Forest Reclamation Advisory No. 4). 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, seedlings are preferably planted before or closely following the ground cover seeding.

Native hardwoods normally grow at a soil pH in the range of 4.5 to 7.0, with the 5.0-to-6.5 range preferred by most species. Where reclamation has established mine soils favorable for trees, the site can be fertilized as recommended by Forest Reclamation Advisory No. 6. Soil samples should be taken to a soil testing laboratory, that is experienced and capable of providing recommendations for mine soils; forestry should be

identified as the land use to receive proper lime and fertilizer recommendations. Lime is generally not recommended on reforestation sites unless acid-producing materials are present and/or soil pH is below 5.0. Mine soils are commonly deficient in phosphorous (P), so fertilizer applied should include sufficient P to support the 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 limiting the level of stress between lifting and planting will increase the vigor and survival rate of planted seedlings. The nursery seedling bags should be inspected upon delivery; any holes should be mended with tape. It is preferable to arrange with the nursery to lift and ship seedlings immediately prior to planting. If seedlings arrive more than a day or two before they will be planted, the bags should be placed in regulated cold storage (33° to 40°F with humidity above 80%) until planting. Seedling bags must be protected from freezing and should never be placed in direct sunlight.

If cold storage is not available, the seedling bags should be kept cool and moist, with temperature below 40 degrees 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, bags should be inspected at least once a week to check that roots appear wet. Roots can be watered with a fine mist if needed, but standing water in the bottom of the bag should never be more than a half-inch deep. Any time the bag is opened it should be re-sealed 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, tree seedlings should be left in the bags and protected from wind and sunlight in an enclosed vehicle or covered with a tarp. While in the field, the nursery bags and planting bags should be covered 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; this operation should be performed 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. Mulch that is not saturated with water will wick moisture away from the roots. If planting bags are not available 5 gallon plastic buckets, containing 1-2" of water and loosely covered with a plastic bag, can be used.

Soil or hydrating gel clinging to the roots is beneficial and should not be shaken or rinsed off, so water should be added to the planting bags carefully. Once the seedlings are placed in the planting bag they should be planted 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, with the bag tightly closed after adding a fine mist of water if necessary to keep the seedlings moist. Unused bags should be returned 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, no additional pruning of the roots in the field should occur. 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 Appalachia 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 dryer weather arrives. The best planting days are overcast with temperatures below 50 degrees 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 ground cover or surface rock is less. Common grid patterns for planting tree seedlings are listed in Table 1. Since tree spacing depends largely on what is required for stocking by each state mining agency, mine operators should check the state regulations and revegetation plan in their permits for the required tree spacing and number of trees per acre. Planting plans are often developed assuming that 70% of the planted seedlings will survive, although actual survival may be greater or less depending on soil conditions, weather, planting practices, and similar factors.

Table 1. Common grid patterns for planting tree seedlings: trees per acre planted and surviving assuming 70% survival rate.

Spacing (feet)	Trees per acre	
	Planted	Surviving @ 70%
7 x 7	889	622
7 x 8	778	544
8 x 8	681	476
8 x 9	605	423
9 x 9	538	376
9 x 10	484	338
10 x 10	436	305



Figure 1. Four tree-planting tools that are used commonly on mine sites, from left to right: Hoedad, KBC planting bar, sharpshooter spade, and dibble bar.

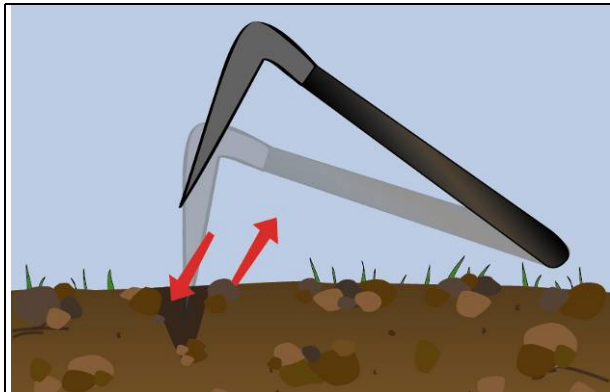
The most common tree planting tools on mine sites in Appalachia are the hoedad, the KBC planting bar, the sharpshooter spade and the dibble bar (Figure 1). Most planting contractors prefer the hoedad because the wooden handle absorbs some of the impact shock encountered when planting in rocky soil, and it is easier to use on steep slopes. 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. 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.

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 (see Figure 4). The hardwood seedling should be planted one to two inches below the top of the root collar, which will allow for some soil settlement without exposing the roots. Care must be taken to ensure that all roots are pointing down and contained within the planting hole.

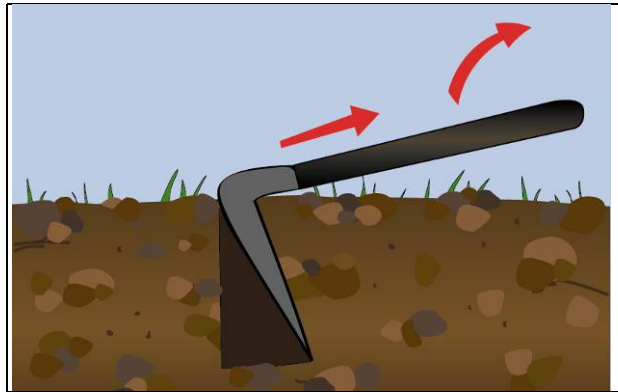
When planting, remove one seedling at a time from the planting bag and do not hold more than one in your hand. Seedling roots should not be forced or twisted into the planting hole, as this practice will cause bent or broken roots and impair new root development, and may eventually cause the tree to die. The tree seedling should be planted 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 (see Figures 2 and 3)

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.



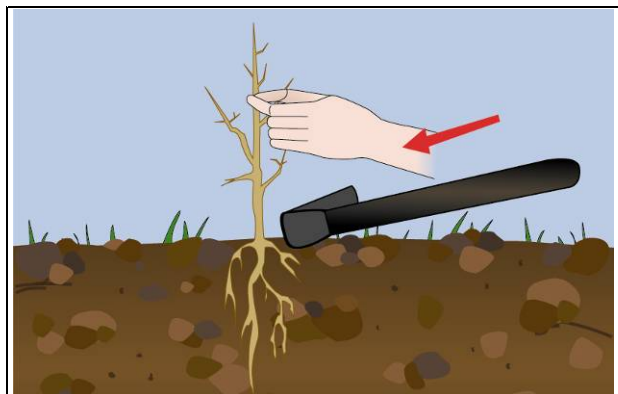
Step 1: Start by driving the hoedad into the soil to the depth necessary to accommodate the entire root system.



Step 2: Pull the handle up to open the bottom of the hole, and then pull the handle toward you to open the top of the hole.



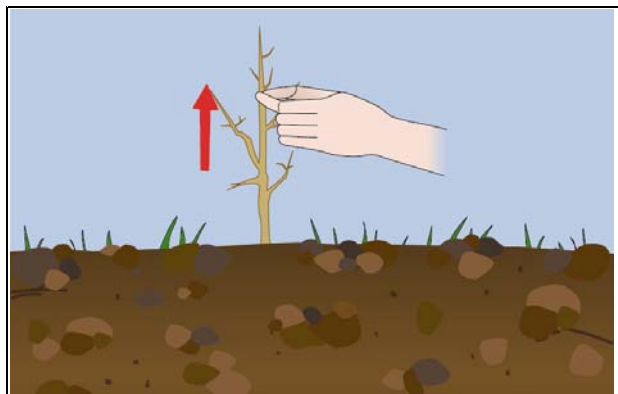
Step 3: Leave the hoedad blade in the ground and place the seedling in the hole 1-2 inches below the root collar, making sure that all roots are pointing down and contained within the planting hole.



Step 4: Hold the seedling vertically, remove the hoedad and push the soil back into the hole with the hoedad blade.

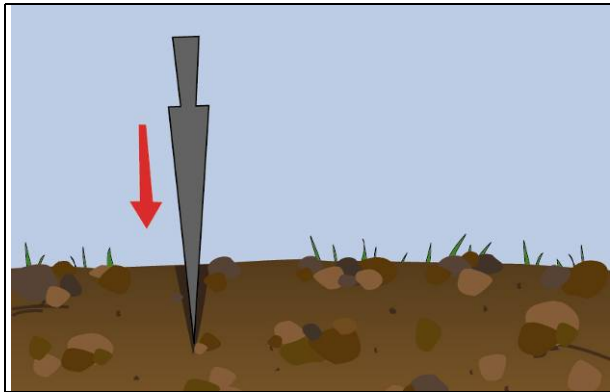


Step 5: Pack the soil firmly around the tree seedling with your heel, to make sure that all air pockets are removed and the entire root system is in contact with the soil.

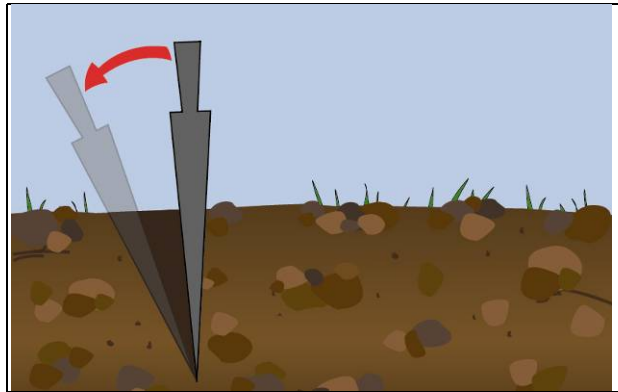


Step 6: Test for secure planting by grabbing the top shoot between two fingers and pulling up. If the seedling is loose, repeat step 5.

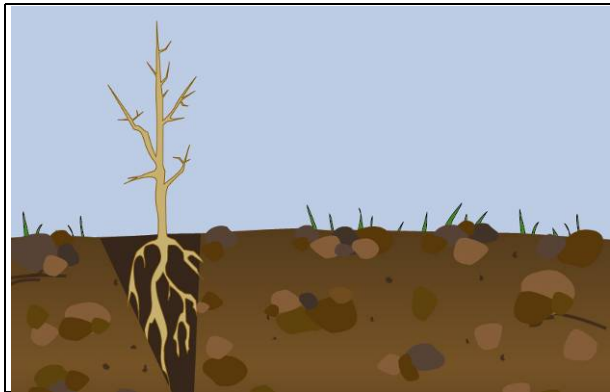
Figure 2. Tree planting using a hoedad.



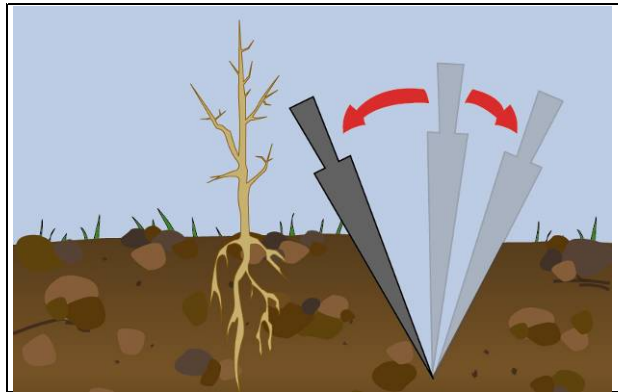
Step 1: Drive the planting bar into the soil to the depth necessary to accommodate the entire root system.



Step 2: Push the handle back and forth to open the hole.



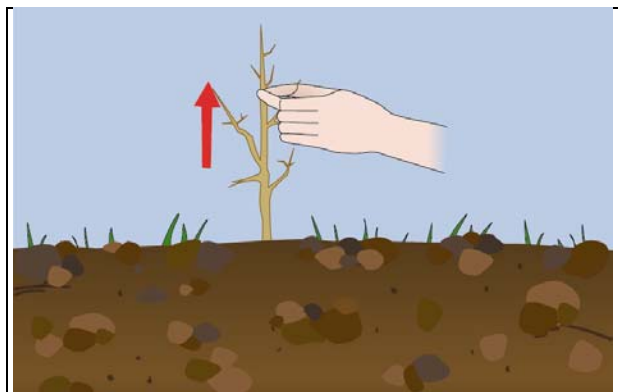
Step 3: Remove the bar and place the seedling in the hole 1-2 inches below the root collar, making sure that all roots are pointing down and contained within the planting hole.



Step 4: Drive the planting bar into the soil at an angle toward the bottom of the planting hole about 3-4 inches behind the seedling. Push planting bar back and forth to close the top and bottom of the planting hole making sure that all air pockets are removed and the entire root system is in contact with the soil.

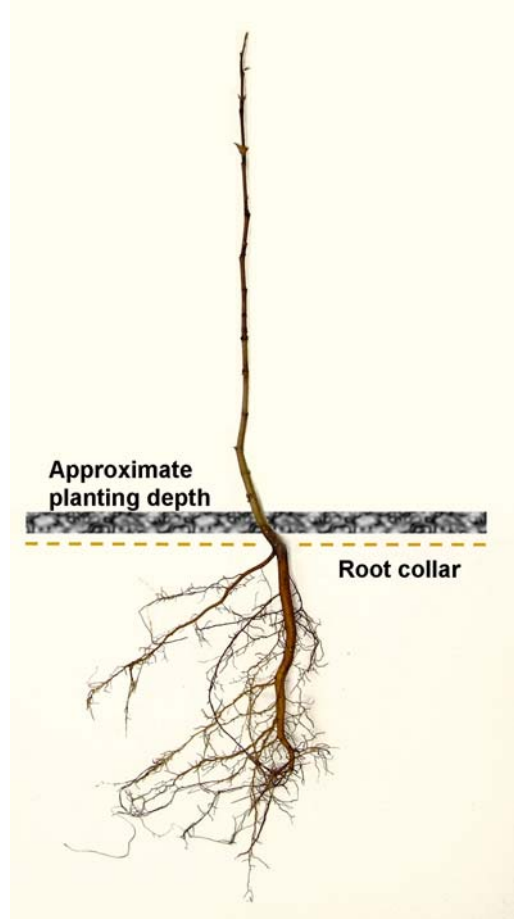


Step 5: Remove the planting bar and fill the second hole with soil.



Step 6: Test for secure planting by grabbing the top shoot between two fingers and pulling up. If the seedling is loose, place additional soil around the seedling and pack with your heel.

Figure 3. Tree planting using a KBC bar, sharp-shooter spade, or dibble bar.



Photos 3-5: (Upper left) Tree seedlings should be planted by making a planting hole deep enough to accommodate the entire root system. (Upper right) The seedling is placed so that all roots are contained within the hole without forcing, bending or twisting the roots. (Lower left) The soil is packed firmly around the tree seedling's roots, making sure that all air pockets are eliminated and the entire root system is in contact with the soil.

Figure 4: (Lower right) A bare-root hardwood tree seedling prior to 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.

Post-Planting Care and Assessment

Post-planting survival assessment is essential to any reforestation project. Mining firms should conduct a survival assessment during the second growing season, before leaf fall. If survival appears adequate for eventual 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, arrangements should be made 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 70-80% 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.

Conclusion

Most coal-bearing lands in the Appalachian region were forested prior to mining. As a result of research and recent changes in regulatory policy, many surface coal mines are now being restored to native forest after mining using the Forestry Reclamation Approach. A critical component of the FRA is step 5, "Use proper tree planting techniques." This bulletin provides guidance for successful tree planting on surface coal mine sites that are establishing forested post-mining land uses.

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