TREE AND SHRUB SPECIES SELECTION FOR MINE RECLAMATION IN THE MIDWEST REGION OF USA

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INTRODUCTION

The Forestry Reclamation Approach (FRA) is a method for reclaiming coal surface mines to forested post-mining land use (Burger and others 2005; Zipper and others 2011). Favorable soil properties (Skousen and others 2009) and non-competitive ground cover (Franklin and others 2012) are essential on mine sites intended for reforestation. Operators using all five steps of the FRA will produce favorable conditions for planted trees and shrubs, and conditions suitable for natural colonization of native plants from nearby forests.

This advisory provides guidance for selecting tree and shrub species for planting on mine sites that are reclaimed using the FRA in the USA's Midwestern coalfield (Illinois, Indiana, and western Kentucky). Many areas mined for coal in this region have deep native soil and are reclaimed to an agricultural post-mining land use [Photo 1]. This guidance is intended to be used when the reclamation goal is forested post-mining landscapes that produce commercial timber and environmental services such as wildlife habitat. Landowner objectives and mine permitting and bond release requirements must also be considered when selecting species.

KEYWORDS

tree and shrub species for planting on mine sites, reclaiming coal surface mines to forested post-mining land use, Midwest coal fields, forestry reclamation approach, local seed sources, tree prescriptions, species diversity and healthier forests, landscape position, native tree species

PLANTING SITE

More than 100 native tree species and numerous native shrub species (Weeks and others 2005) grow within the Midwestern coalfield region. This diversity reflects the many different site conditions found across the region. Growing conditions in forests are affected by factors such as tree species, sunlight, moisture, soil properties, topography, and competing vegetation. Some species grow best within a narrow range of conditions, while others are adapted to a wider range. The trees and shrubs most likely to produce healthy, productive forests on reclaimed mine sites

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are those that are well suited to the site's growing conditions (Photo 2). Selecting native species grown from local seed sources helps ensure that planted trees and shrubs are adapted to these growing conditions and will be an asset to future users.

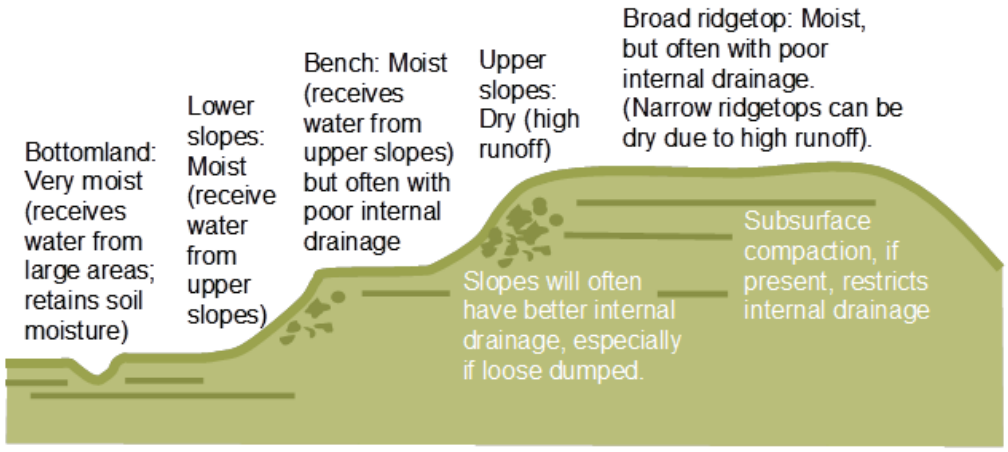
Site Types for Species Selection

Previous reclamation practices often produced harsh site conditions for tree growth. Large flat areas on mine sites often have poor "internal drainage," meaning they lack the sloping grade or subsurface channels to carry infiltrating water downward below the rooting zone. This occurs because mine reclamation processes often compact the materials within and below flat-lying land surfaces. Over time, the physical settling and consolidation of these materials can further restrict internal drainage. Poor internal drainage is a problem for planted trees because such soils retain excess water that prevents roots access to needed soil aeration. These problems can

PHOTO 1. Because of deep native soils in many parts of the Midwest coal fields, large areas of mined land are reclaimed to prime farmland. Tree planting is often reserved for the steeper slopes and poorly drained areas.

PHOTO 2. Healthy native hardwood trees planted on a reclaimed mine in southern Indiana.

FIGURE 1. Soil moisture conditions will be affected by both landscape location, as depicted above, and slope and aspect (see figure 2). Such conditions must be considered in tree species selection.



be avoided with loose dumping, minimal grading of both surface soils and subsoils, and providing some surface sloping for better internal drainage (Sweigard and others 2007a). The loose soil conditions that result will allow water to move within these soils more freely.

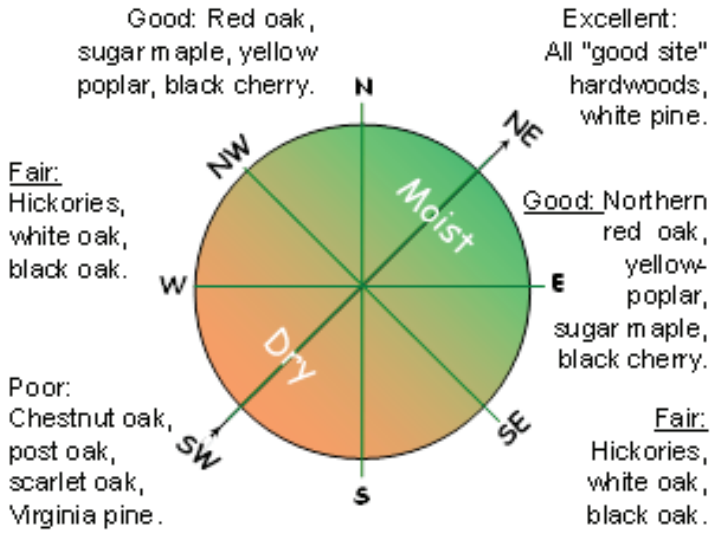
Tree and shrub species selection for any portion of a reclaimed mine should be determined in part by the site's location on the landscape. This is because *landscape position* influences availability of soil moisture, nutrients, and sunlight. *Landscape position* is a combination of the planting site's *aspect* and *topography* (Figure 1).

Bottomland sites are usually floodplains of permanent streams and rivers or are associated with low-lying wetlands (Photo 3). They are characterized by periodic and sometimes extended flooding, a high water table, and poorly drained soil. Bottomlands may vary little in elevation, but small changes in elevation often result in significant differences in drainage within the site.

Upland sites (upper slopes, Figure 1), on the other hand, are elevated above

PHOTO 3. American sycamore seedlings planted on reclaimed bottomland site.

FIGURE 2. The direction in which a slope faces (its aspect) will influence soil moisture and sunlight availability and should be considered in tree species selection. Aspect is rated as having excellent, good, fair, or poor tree growth potential in the diagram. Some tree species suited to these aspects are also given.



bottomlands, have sloping land that sheds water and have well-drained soils. Lower slopes are located, topographically, between uplands and bottomlands. Lower slopes can receive moisture from adjacent uplands but are not as moist as bottomlands nor prone to flooding. The mining operation may produce other landforms, such as benches and broad ridgetops (Figure 1) that would likely have soil conditions similar to uplands if located in natural terrain, but will generally have seasonally wet soil conditions on mine sites if subsoils drain poorly. Ridge tops and benches often provide intermediate tree growth conditions when soils are left loose, but poor conditions if compacted.

Aspect is the direction that a slope faces. Slopes facing south receive more solar radiation than north facing slopes (Figure 2). While east and west facing slopes receive similar hours of sunlight, the west facing slopes receive sunlight during the hottest part of the day—mid and late afternoon. As a result, slopes with south and west aspects will experience hotter temperature extremes in the summer and have drier soils than those that face north and east. Northeast and east facing slopes are generally most favorable for tree growth because of cooler temperatures and higher levels of soil moisture (Photo 4), while southwestern slopes are generally least favorable.

For purposes of species selection, we simplify the complex interaction of previously described site factors into the following general classifications: upland or bottomland; and dry, moist, or wet (poorly drained). The species recommendations made in Appendix A are based primarily on these site classifications.

Tree Prescriptions

A *tree prescription* is a list of species to be planted, with planting rates, for any portion of a mine or for the entire area. Most large mines will have several site types, each of which can be targeted for planting with its own tree prescription.

PHOTO 4. Bur oak and tulip poplar planted on a northeast aspect on a Midwest reclaimed mine site.

Here, we provide examples of tree prescriptions that can be applied on mined lands in the Midwest (Figure 3 and Table 1; see also Appendices). The example prescriptions are for mines where the reclamation goal is to restore native forestland that will produce commercial timber and environmental services such as wildlife habitat and good watershed conditions.

Mine operators can change these prescriptions as needed to meet specific landowner objectives or site requirements. Appendix A provides a more comprehensive list of tree and shrub species suitable for reclaimed mine reforestation using the FRA for the major site types found in the Midwest.

Select Species Suited to Site Conditions

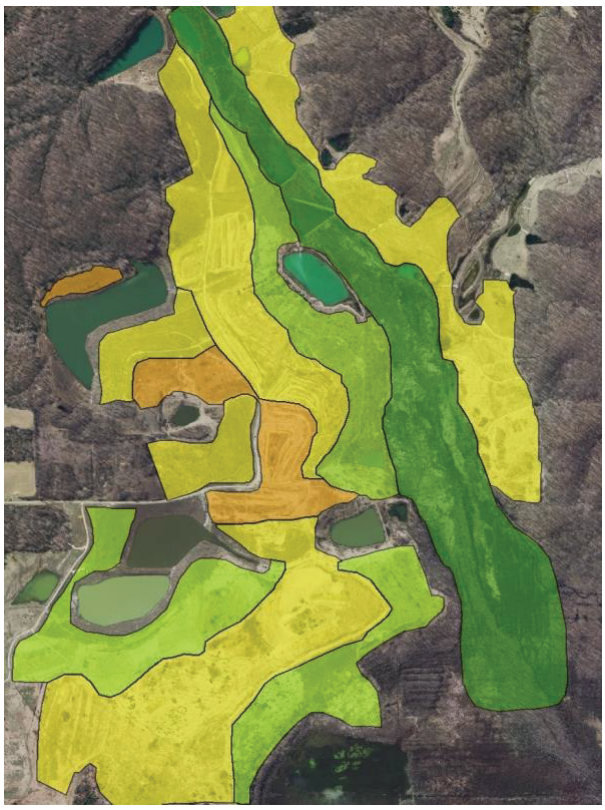
Species should be prescribed by a person who is knowledgeable of local tree species and seedling availability, mine site conditions, and landowner and reclamation goals. The sample prescription provided in Table 1 only provides an example that may or may not be applicable to any given coal mine reclamation site in the Midwest. State forestry or mine reclamation agencies or local OSMRE offices may have foresters or other qualified personnel on staff to provide advice on suitable species for specific mine sites. Private-sector forestry consultants who are familiar with mine reclamation can also assist.

The replaced mine soil must be able to provide trees with moisture, nutrients, and a drained and aerated soil condition. Soils selected and replaced using FRA practices should have adequate depths of favorable materials with good water and nutrient-holding capacity and as such will support a large selection of timber crop tree and wildlife species (Appendix A). However, some soil conditions will limit species selection. A common mistake in many tree plantings in the Midwest is to plant nutrient and moisture demanding species like black walnut on dry, nutrient poor sites with insufficient soil depth. Black walnut will grow slowly, have poor form for timber, and may have poor survival when not planted on deep, moisture- and nutrient-rich

soils. Dry sites such as a south facing, upper slope site should be planted with drought tolerant species like white and black oaks and Virginia pine (Table 1). Bottomland sites that flood and/or have a high water table should be planted with trees adapted to those conditions, like bur, swamp white, swamp chestnut, and Shumard oaks. Other bottomland species include sweet gum, river birch, silver maple, and sycamore.

Most native tree species grow well in moderately acidic soils, with soil pH in the 5.0 to 6.5 range. Alkaline conditions with a pH above 7.0 are often found in unweathered spoil materials and will limit tree species selection. The FRA prescribes soil construction that results in successful mine land reforestation (Skousen and others 2009). On most mines, materials will be available to enable construction of moderately acidic soils. This is fortunate because only a few of the species available for planting are able to tolerate alkaline or very acidic soil. Bur, chinkapin and Shumard oaks can tolerate soil pH a little above 7.5, while a few species, including pin oak, can tolerate soil pH below 4.0 (Table 2).

FIGURE 3. This Midwest mine site has been mapped to designate different species mixes for various areas of the site. Each species mix is comprised of species selected to be well adapted to the site conditions that occur within the mapped areas.



= dry, well drained: upper- to mid-slopes with south to west aspects;

= intermediate soil moisture, well drained: upper slopes with southeast or northwest aspects;

= moderately moist with good drainage: upper slopes facing north and east, lower slopes;

= high moisture, well-drained: bottom lands and riparian areas with deep, uncompacted soils.

Table 1 provides an example of species prescriptions based on site conditions.

Soil compaction is detrimental to tree survival and growth in general. A few native species such as river birch and sycamore can survive and maintain positive growth in compacted soils, but most species will not thrive. Even where tree survival meets short-term bond release requirements, compacted soils greatly diminish future forest productivity. The FRA recommends leaving soils loose and uncompacted (Sweigard and others 2007a). However, even where the FRA is used to reclaim mined land, there may be some areas where compaction is difficult to avoid. The FRA recommends that compacted soils be ripped to produce loose conditions prior to planting (Sweigard, and others 2007b).

TABLE 1. An example of a-species selection prescription that could be applied for the reclaimed mine site of Figure 3. Timber and nurse trees would typically be planted together in the main planting blocks, while wildlife species would be planted along borders and riparian areas.

	Site Description	Species	Planting Rate (seedlings/acre)
	dry, well drained: upper- to mid-slopes with south to west aspects	Timber	
		black oak, white oak	125 ea.
		scarlet oak, post oak, chinkapin oak, hickory, black gum	50 ea.
		Nurse trees	
		Virginia pine	50
		bristly locust, black locust	25 ea.
		Total timber + nurse trees	**600**
		Wildlife	
		American plum, blackhaw, indigobush, leadplant, New Jersey tea, persimmon, eastern redbud, serviceberry	50 ea.
	intermediate soil moisture, well drained: upper slopes with southeast or northwest aspects	Timber	
		northern red oak, white oak	120 ea.
		black oak, chinkapin oak, yellow-poplar (on better sites)	90 ea.
		hickory	50
		Nurse trees	
		Virginia pine	50
		bristly locust, black locust	25 ea.
		Total timber + nurse trees	**660**
		Wildlife	
		American plum, blackhaw, chokeberry, chokecherry, crabapple, flowering dogwood, hawthorn, persimmon, eastern redbud, serviceberry	50 ea.

TABLE 1. An example of a-species selection prescription that could be applied for the reclaimed mine site of Figure 3. Timber and nurse trees would typically be planted together in the main planting blocks, while wildlife species would be planted along borders and riparian areas. *(Cont.)*

	Site Description	Species	Planting Rate (seedlings/acre)
	moderately moist with good drainage: upper slopes facing north and east, lower slopes	Timber	
		northern red oak, white oak	150 ea.
		yellow-poplar, black cherry, black walnut (on best sites)	100 ea.
		Nurse trees	
		bristly, black locust	50 ea.
		Total timber + nurse trees	**700**
		Wildlife	
		American plum, arrowwood, crabapple, elderberry, flowering and gray dogwood, hazelnut, hawthorn, persimmon, redbud	50 ea.
	high moisture, well-drained: bottom lands and riparian areas with deep, uncompacted soils	Timber	
		bur, cherrybark, Shumard, swamp white, swamp chestnut oak	80 ea.
		river birch, shellbark hickory, sycamore, sweetgum	50 ea.
		Nurse trees	
		honeylocust	50
		smooth alder	50
		Total timber + nurse trees	**700**
		Wildlife	
		Chokeberry, chokecherry, deciduous holly, elderberry, gray, silky, and red osier dogwood, hawthorn, hazelnut, buttonbush (around shoreline of permanent wetlands and shallow lakes), smooth alder (riparian and wetland areas)	50 ea.

TABLE 2. Tree and shrub species that are adapted to soil pH conditions outside of the 4.5–7 range considered optimal for most native forest species (Burns and Honkala 1990, Ashby and Willis 1993).

Low pH (3.5–4.5)	High pH (7.0–8.5)
Pitch x loblolly pine	Eastern redcedar
Virginia pine	Bur oak
Pin oak	Chinkapin oak
Shingle oak	Shumard oak
River birch	Redbud
Sweet gum	
Bristly locust	
Black locust	
Silky dogwood	

Plant Enough Seedlings

Enough trees should be planted to meet management objectives, achieve expected survival targets, and take into consideration natural seeding of desired species. Many foresters in the Midwest recommend planting 600 to 800 trees per acre where timber production and native hardwood forest restoration are objectives and where no natural seeding is expected. Spacing between planted trees for these densities is roughly equivalent to 8 x 9 feet to 7 x 8 feet (Figure 4). These higher densities provide the following advantages:

1. Results in earlier canopy closure shading out competing vegetation.
2. Improves the genetic potential of the stand by increasing the probability that trees with superior growth traits will be included in the planting.
3. Provides a larger number of potential crop trees to choose from when conducting a first thinning.
4. Stimulates more rapid height growth.
5. Promotes a straighter tree bole with less lateral branching, resulting in increased timber value.

Planting at these higher densities also mean higher planting costs and require a commitment to long term management as many tree plantations may need thinning between 10 and 20 years of age.

Fewer trees may be planted where seedling survival is expected to be high, or where natural seeding from near-by forest trees of desirable species is likely to occur. In this situation, 430 to 540 trees per acre (10 feet x 10 feet to 9 feet x 9 feet) may be adequate. Fewer trees may also be needed where timber production is not a priority and maintaining herbaceous and shrub vegetation habitat is an important objective. If tree plantation maintenance includes mowing, enough space should be provided between rows for the equipment.

It is important to work closely with the state regulatory authority to identify and establish the tree stocking standards that will be applied at bond release, and to plant enough trees to provide a margin of safety to ensure compliance with bond release standards.

Plant a Mix of Species

For all tree prescriptions, species should be planted as a diverse mix across the landscape, not as single-species rows or blocks (except in the case of pines used for winter wildlife cover—see "Plant Wildlife Trees and Shrubs" section). Past reforestation reclamation relied too heavily on a few species such as black locust and green ash (Rathfon and others 2004). Planting sites with multiple species helps ensure long-term reforestation success if an insect or disease outbreak affects one of the planted species. For example, emerald ash borer threatens the extermination of all native ash species in the eastern U.S. (see Box 1). Mixing species will also increase the likelihood that some trees will be able to survive and thrive on all areas of the mine site, even though site conditions vary, sometimes within short distances.

Planting a mixture of *early-succession*, *late-succession*, *nurse*, and *wildlife trees and shrubs* help provide species diversity that results in healthier forests in the long-term. *Early-succession* tree and shrub species generally establish quickly, stabilize the soil and shade out grasses and other competing vegetation within 10 to 20 years. Some of these species also fix atmospheric nitrogen in their roots, and thus enrich the soil (Table 3). These early-succession trees improve soil and site growing conditions for the crop trees. When used in this manner, such species are referred to as *nurse* trees and shrubs. Black locust, honey locust, bristly locust, and the alders are often used as nitrogen-fixing nurse species.

Although native in the eastern U.S., black locust and bristly locust are not considered native in many parts of the Midwest. They are even considered by some to be invasive in this region. Although black locust was extensively planted on Midwestern reclaimed minelands, the locust borer has limited its growth and spread in many areas. In any event, nurse trees and

FIGURE 4. Equations for calculating number of trees per acre, spacing, and total number of trees needed to plant selected area.

$$\text{TPA} = \frac{43560\ \text{ft}^2/\text{A}}{\text{Space}_{\text{wr}}(\text{ft}) \times \text{Space}_{\text{br}}(\text{ft})}$$

$$\text{Spacing}\,(\text{ft}^2) = \sqrt{\frac{43560\ \text{ft}^2/\text{A}}{\text{TPA}}}$$

$$\text{No. Trees Needed} = \frac{\text{A}_{\text{p}} \times 43560\ \text{ft}^2/\text{A}}{\text{Space}_{\text{wr}} \times \text{Space}_{\text{br}}}$$

TPA = trees per acre
wr = within row
br = between row
A = acres
A_p = total project acres

BOX 1. LOSS OF A GREAT MINE RECLAMATION TREE

Until recently, white and green ash were widely planted on reclaimed mines with success (Rathfon and others 2004). They were favored species due to their high survival rates, enabling mining companies to obtain timely bond release. Ash species are no longer recommended because of the spread of an invasive insect pest, the emerald ash borer (EAB), first introduced into North America from Asia. EAB destroys all ash trees in its path. The many acres of Midwestern reclaimed mined land planted with ash species are now threatened by this aggressive pest.

White ash growing on a reclaimed mine in southern Indiana.

shrubs should only be planted in small quantities and careful consideration should be given on whether to plant black and bristly locust. Other early-succession species may be planted to provide fruit and seed that can serve as wildlife food sources. Only about 25% of the planted tree species mix should be early-succession and nurse trees.

Many early-succession trees mature at relatively young ages and eventually make way for the longer-lived crop trees. However, some species that often establish early in the succession process, such as yellow-poplar, black walnut, and black cherry, can also continue growing when in favorable growing conditions, becoming commercially valuable crop trees.

Selection of early-succession species may consider proximity of the planting site to natural seed sources. Some tree species, like yellow-poplar, cottonwood, willows, sycamore, and Virginia pine, have small, wind-blown seed. For instance, yellow-poplar seed can travel up to 600 feet (Beck 1990) and cottonwood seed up to several miles or more (Braatne and others 1996) in the wind. Others, like black cherry and persimmon, have seed that is transported by birds and mammals. If an adequate seed source for early-succession species exists near the mine site, then

TABLE 3. "Nurse" tree and shrub species that improve soil fertility by fixing atmospheric nitrogen. Selection of species for planting should also consider landscape and soil drainage conditions, as detailed in the Appendix.

Upland	Bottomland
Black locust	Honeylocust
Bristly locust	Smooth alder
Indigobush	Indigobush
Leadplant	

fewer trees of such species need to be planted. In areas where natural seeding cannot be relied on, several early-succession tree and shrub species—both wildlife and nurse species—should be planted.

Late-succession species are those that grow slower or become established later than early-succession species. These species, often eventually replace most early successional species in natural forests. Many commercially valuable timber species are late-succession species. Oaks and hickories, which often dominate the region's upland forests, are considered late-successional on the driest sites. On sites with better moisture and nutrient conditions, shade-tolerant species like sugar maple, red maple, and beech will replace oaks and hickories over a long period of time. On these sites, oaks and hickories are considered intermediate between early and late successional. Oaks, hickories, and black walnut have heavy seeds that are not carried easily by natural processes far from parent trees (Photo 5). Thus, heavy seeded, intermediate and late-succession tree species that are important components of mature native forests should make

PHOTO 5. White oak is valued both for timber and wildlife habitat. Because of its large acorns, it and other heavy-seeded species may be planted in larger numbers on reclaimed mines where they would otherwise take decades or longer to establish on their own.

up a larger proportion of planted tree seedlings when the reclamation goal is restoration of native forest.

Plant Wildlife Trees and Shrubs

Although many timber crop tree species provide important wildlife benefits, tree and shrub species of lesser commercial timber value, but of significant wildlife value, should also be planted. Tree species like persimmon, black cherry, flowering dogwood, serviceberry, plum and native shrub species like hazelnut, dogwoods, elderberry, and arrowwood provide valuable food and cover for wildlife (Photo 6, Table 4). Waterfowl habitat may be enhanced by planting preferred mast species like buttonbush, pin oak, and other bottomland oak species around the edges of open wetlands, lakes, and ponds.

Certain species produce wildlife habitat structure as they mature. For example, pines planted at low densities will not interfere with hardwood forest development but will provide winter cover that can be used by wildlife species such as white-tailed deer. Interspersing ½ to 1 acre pockets of pine provides thermal cover for both turkey and deer in the winter.

Wildlife trees and shrubs can be mixed with other trees as they are planted, or they can be concentrated in certain areas such as along planting block borders, streams, wetland borders and along lake shores, and in small niches, to maximize long-term wildlife benefits. Most wildlife species, when mixed in with forest canopy species, do not persist in the forest stand, but they do provide early wildlife benefits, prior to seed and mast production by crop trees.

Attracting wildlife can aid natural succession and forest development, as wildlife often bring viable seed to the mine site from adjacent areas. Mammals and birds feed on fruits in native habitats and then carry the seed to reclaimed mine areas. Many of the ingested seeds pass through the animals and germinate where deposited.

PHOTO 6. Planting native fruit and nut-bearing shrubs like this elderberry enhances wildlife habitat on reclaimed mineland.

See Forest Reclamation Advisory No. 10, Reforestation to Enhance Appalachian mined lands as habitat for terrestrial wildlife for more information on improving wildlife habitat (Wood and others 2013).

Select Local Seed Sources

Trees selected for planting should originate from seeds collected from local trees, or as near to local as feasible. Within the natural range of species that grow over broad areas, genetic variation can influence cold hardiness, heat and drought tolerance, leaf-out time in the spring, timing of fall dormancy, and other essential growth factors. Local seed sources would be those that occur within the mine site's general region and with similar climate and growing conditions. For instance, northern red oak ranges from Alabama to Minnesota and east to Maine, but northern red oak seedlings planted on a southern Indiana mine site should be grown from seed collected from trees within 100–200 miles north or south of the planting site. Planting red oak seedlings grown from an Alabama seed source where the growing season is longer would pose risk of damage from a late spring frost or early fall freeze. Purchasing seedlings grown from local seed sources helps ensure that planted trees are well adapted to the mine site's climate. Range maps for most native trees can be found in *Silvics of North America* (Burns and Honkala 1990). Many good nurseries outside your region will produce good quality seedlings from seed collected in your area so don't rule out potential nurseries based on their address.

Use Native Species

Past mine reclamation plantings often included non-native tree and shrub species. However, the same characteristics that allowed such species to grow well on older mined lands also make them invasive and problematic elsewhere. For example, Asian bush honeysuckle and autumn olive were commonly planted on mine sites in past years but are now considered noxious pests because they invade native forests where they crowd out native vegetation. Some regulatory authorities prohibit the use of non-native species in mine reclamation plantings while some states provide lists of species considered invasive (IISC 2014). Species considered to be invasive should not be planted. We recommend use of native forest species for mine-site forest plantings (see Box 2).

Standards for Success

SMCRA requires coal mining operations to restore the land's pre-mining capability. Many mining operations are conducted on lands that were forested prior to mining. Proper use of the Forestry Reclamation Approach should produce a healthy forest that satisfies the SMCRA mandate. Selecting and planting tree species that are well suited to site conditions is essential to successful mined land reforestation with the FRA. The following general prescription summarizes the important principles that should be followed when selecting tree and shrub species for surface mine reclamation using the FRA in the Midwest coal fields.

1. Determine landowner objectives and regulatory mandates (requirements).
2. Obtain expertise of a forester or other forestry reclamation specialist.
3. Map the planting site for properties that will influence species choices, such as soil properties, aspect, landscape position, and drainage. On the map, partition the site into areas with similar characteristics.
4. For each mapped area, select a mixture of appropriate species to meet landowner objectives and to match site conditions, considering the following recommendations:

BOX 2. RETURN OF A NATIVE

Historically, American chestnut was a dominant forest species throughout the Appalachian Mountains and west into southern Indiana and western Kentucky and Tennessee. However, most American chestnut succumbed in the first half of the 20th century to an exotic pathogenic fungus commonly known as the chestnut blight. Efforts are underway to develop blight-resistant hybrids of American chestnut. Early tests show that American chestnut performs well on mine sites reclaimed using the Forestry Reclamation Approach (McCarthy et al. 2008). Years of breeding, testing, and seed orchard development lie ahead before large numbers of blight-resistant American chestnut hybrids will be available for large-scale restoration plantings on reclaimed mined land (French et al. 2015).

American chestnut hybrid trees in an Indiana seed orchard.

TABLE 4. Selected native shrub species providing wildlife benefits (MacGowan and Miller, 2002)

Common Name	Scientific Name	Wildlife Benefits
American plum	*Prunus americanum*	Reddish drupes eaten by birds and mammals.
Arrowwood	*Viburnum dentatum*	Blue-black drupes eaten by songbirds.
Black cherry	*Prunus serotina*	Fruit eaten by many species songbirds, ruffed grouse, and pheasant.
Blackhaw	*Viburnum prunifolium*	Dark blue drupes eaten by songbirds, quail, and fox.
Bristly locust	*Robinia hispida*	Cover. Legume, fixes nitrogen in the soil.
Buttonbush	*Cephalanthus occidentalis*	Round nutlets eaten by waterfowl. Beneficial structure for many amphibians.

TABLE 4. Selected native shrub species providing wildlife benefits (MacGowan and Miller, 2002) *(Cont.)*

Common Name	Scientific Name	Wildlife Benefits
Chokeberry	*Aronia melanocarpa*	Dark purple fruit eaten by songbirds.
Chokecherry	*Prunus virginiana*	Dark purple fruit eaten by songbirds, grouse, and fox.
Crabapple	*Malus coronaria*	Yellow-green apples eaten by fox, raccoon, and upland game birds.
Deciduous holly	*Ilex decidua*	Red fruits eaten by small mammals and birds.
Elderberry	*Sambucus canadensis*	Dark purple clusters of fruits eaten by many species of birds including pheasant, quail, dove, and turkey.
Flowering dogwood	*Cornus florida*	Glossy red drupes eaten by songbirds, quail, turkey, and some small mammals.
Gray dogwood	*Cornus racemosa*	White drupes eaten by songbirds, quail, turkey, raccoon, and fox.
Hawthorn	*Crateagus spp.*	Red fruit eaten by deer, fox, grouse, pheasant, and songbirds. Excellent nesting cover for songbirds.
Hazelnut	*Corylus americana*	Small nut and catkin eaten by squirrels, deer, grouse, quail, and pheasant. Good cover and nesting.
Indigobush	*Amorpha fruticosa*	Cover for quail and other birds. Legume, fixes nitrogen in the soil.
Leadplant	*Amorpha canescens*	Browse. Legume, fixes nitrogen in the soil.
New Jersey tea	*Ceanothus americanus*	Three-celled seed capsules eaten by quail and turkey.
Ninebark	*Physocarpus opulifolius*	Cover for songbirds
Persimmon	*Diospyros virginiana*	Orange fruit relished by raccoons, fox, opossum, deer, and some songbirds.
Red osier dogwood	*Cornus stolonifera*	White drupes eaten by songbirds, grouse, and quail. Twigs browsed by deer and rabbits.
Eastern redbud	*Cercis canadensis*	Legume seeds eaten by a few songbirds.
Serviceberry	*Amelanchier arborea*	Dark red to purple fruit eaten by songbirds and quail.
Silky dogwood	*Cornus amomum*	Bluish fruit eaten by songbirds, quail, turkey, raccoon, and fox. Twigs browsed by deer and rabbits.
Smooth alder	*Alnus serrulata*	Browse for rabbits, cover for mammals, songbirds, and game birds.
"Shrub Willow"	*Salix spp.*	Various native species provide browse and cover, particularly in riparian habitats.

- Select three or more primary forest canopy species, and two or more early-succession "nurse" species for forest structure and soil development; and three or more species for wildlife enhancement for most areas.
- When there is a high likelihood that certain early-succession species will seed in naturally from nearby forest, reduce the number of such species to be planted and replace with late-succession species.
- Select later-succession species as the majority (50% or more) of most hardwood forest plantings.
- Intermix forest canopy species—do not separate individual species into large monoculture blocks except for small blocks of pines for wildlife cover.
- Select trees and shrubs from local seed sources.
- Only plant tree and shrub species native to the region.

5. Provide careful supervision of planting crews to ensure proper mixing, distribution, and placement of species.

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APPENDIX A: Tree species suitable for major site types on mine land in the Midwest coal fields reclaimed using the Forestry Reclamation Approach.

Native Forest Types Occurring on This Site Condition	Primary Forest Canopy Species	Forest Canopy Species for Diversity	Nurse Species	Wildlife Species	Planting Design Considerations
Site Type: Dry but well drained: Upper- and mid-slopes with south to west aspects; soils in any landscape with excessively coarse or rocky textures and sufficient depth to assure good drainage, etc.					
Oak-hickory Oak-pine Pine Cedar glade	oaks: black, chestnut, chinkapin[1], scarlet, white Hickory: pignut, shagbark	oaks: bur[1], post, shingle[2] black gum	pines: Virginia[2], pitch x loblolly hybrid[2], shortleaf bristly locust[2,4] black locust[4] eastern redcedar[1]	American plum blackhaw leadplant[4] New Jersey tea persimmon eastern redbud[1] serviceberry	On very poor, dry sites, increase proportion of bur, post, and shingle oak, pines, and red cedar and decrease proportionately the primary forest canopy species.
Site Type: Intermediate soil moisture, well drained: *Upper- and mid-* slopes with southeast or northwest aspects.					
Oak-hickory	oaks: black, northern red, white Hickory: pignut, shagbark	oaks: bur[1], chestnut, chinkapin[1], scarlet, shingle[2] American chestnut[5] black gum red maple yellow-poplar	pines: loblolly (south), Virginia (south)[2], pitch x loblolly hybrid[2], shortleaf (south) bristly locust[2,4] black locust[4] eastern redcedar[1]	American plum blackhaw chokeberry chokecherry crabapple flowering dogwood hawthorn indigobush[4] leadplant[4] New Jersey tea persimmon eastern redbud[1] serviceberry	Only plant blight-resistant American chestnut.
Site Type: Moist, well drained: *Upper- and mid-* slopes facing north and east; lower slopes.					
Mixed oak yellow-poplar-ash-cherry Mixed hardwoods	oaks: northern red, white yellow-poplar black cherry black walnut	oaks: black, chinkapin[1], shingle[2] American chestnut[5] black gum Kentucky coffeetree maples: red, sugar sycamore[1]	eastern white pine bristly locust[2,4] black locust[4]	American plum arrowwood flowering dogwood gray dogwood chokeberry chokecherry crabapple elderberry hawthorn hazelnut ninebark persimmon eastern redbud[1] winterberry	Plant fast growing yellow-poplar and black cherry together as mixes and separate from slower growing oaks. Black walnut for timber production should only be planted on the most nutrient rich sites with the deepest, well-drained soils.

APPENDIX A: Tree species suitable for major site types on mine land in the Midwest coal fields reclaimed using the Forestry Reclamation Approach. *(Cont.)*

Site Type: High moisture with poor internal drainage: bottomland with thin soils over compacted layer; riparian buffers; most broad benches and ridge tops with poor internal drainage						
Hardwood swamps Cypress swamps	oaks: overcup swamp white, swamp chestnut, pin[2]	maples: red, silver sycamore river birch[2] sweetgum[2] bald cypress	eastern cottonwood black willow honeylocust smooth alder[4]	buttonbush dogwood: silky[2], red osier deciduous holly	elderberry shrub willows	Most bottomland trees and shrubs cannot establish in permanent standing surface water. Bald cypress may provide greater benefit planted in small groves.
Site Type: High moisture, well-drained: bottom lands and riparian areas with deep, uncompacted soils.						
Bottomland Oak-hickory	oaks: swamp white, swamp chestnut, bur[1], cherry bark, Shumard[1] shellbark hickory	maple: red, silver shingle oak[2] sycamore river birch[2] sweet gum[2]	eastern cottonwood black willow honeylocust[4] smooth alder[4]	arrowwood chokeberry chokecherry dogwood: gray, silky[2], red osier deciduous holly	elderberry hawthorn hazelnut ninebark winterberry	

[1] Tolerates soil pH between 7 and 8.5.
[2] Tolerates soil pH between 3.5 and 4.5.
[3] The designations (south) and (north) identify species that do well in the southern and northern portions of the Midwestern coalfield, respectively
[4] Nitrogen fixing species.
[5] Plant only blight resistant hybrid seedlings.

APPENDIX B: Scientific names for the tree species named in this publication.

Common Name	Scientific Name
Ash:	*Fraxinus*
green	*pennsylvanica*
white	*americana*
Bald cypress	*Taxodium distichum*
Birch, river	*Betula nigra*
Blackgum	*Nyssa sylvatica*
Cherry, black	*Prunus serotina*
Chestnut, American	*Castanea dentata*
Cottonwood, eastern	*Populus deltoides*
Hickory:	*Carya*
pignut	*glabra*
shagbark	*ovata*
shellbark	*laciniosa*
Kentucky coffeetree	*Gymnocladus dioicus*
Locust:	
black	*Robinia pseudoacacia*
bristly	*Robinia hispida*
honey	*Gleditsia triancanthos*
Maple:	*Acer*
red	*rubrum*
silver	*saccharinum*
sugar	*saccharum*
Oak:	*Quercus*
black	*velutina*
bur	*macrocarpa*
cherrybark	*pagoda*
chestnut	*montana*
chinkapin	*muehlenbergii*
overcup	*lyrata*
pin	*palustris*
post	*stellata*

APPENDIX B: Scientific names for the tree species named in this publication. *(Cont.)*

Common Name	Scientific Name
northern red	*rubra*
scarlet	*coccinea*
shingle	*imbricaria*
Shumard	*shumardii*
swamp chestnut	*michauxii*
swamp white	*bicolor*
white	*alba*
Pine:	*Pinus*
eastern white	*strobus*
loblolly	*taeda*
pitch x loblolly hybrid	*rigidaxtaeda*
shortleaf	*echinata*
Virginia	*virginiana*
Redcedar, eastern	*Juniperus virginiana*
Sweetgum	*Liquidambar styraciflua*
Sycamore	*Platanus occidentalis*
Walnut, black	*Juglans nigra*
Willow, black	*Salix nigra*
Yellow-poplar	*Liriodendron tulipifera*