revegetated areas. Diversity and rank correlation indices have several shortcomings that make questionable their applicability for comparing reference and revegetated areas. The characteristics of three methods are compared in Table 15.

Statistical Procedures

Several of the references listed in the bibliography provide details on statistical procedures for determining adequacy of sampling (number of samples needed) and confidence limits and for comparing revegetated and reference areas. Also, most textbooks on statistical methods provide procedures for determining sampling errors, variances, regression, etc.

REVEGETATING COAL SURFACE-MINED LANDS IN THE EASTERN COAL REGIONS

The purpose of this chapter is to (1) briefly describe the coal regions in the eastern United States, (2) list and describe plant species suitable for revegetating surface-mined lands and criteria for selecting those species, and (3) suggest species and species mixtures for different uses of reclaimed land.

The coal and lignite regions in the eastern United States lie primarily east of the 100th meridian. They include the Appalachian Coal Region, the Interior Coal Region, and the Southern Lignite Region.

Appalachian Coal Region

The coal fields in the Appalachian Coal Region cover approximately 72,000 square miles in parts of nine states, extending from Pennsylvania to Alabama. For the purpose of this handbook, all of five states—Pennsylvania, Maryland, Ohio, West Virginia, and Virginia—and the eastern part of Kentucky are assigned to the Northern Appalachian Coal Region; three states—Tennessee, Georgia, and Alabama—are assigned to the Southern Appalachian Region (Figure 33). Eastern Kentucky, Virginia, and the southern third of West Virginia physiographically form the central part of the Appalachian Region and for revegetation purposes have commonality with both the Northern and Southern Appalachian Coal Regions.

Geology

The coals of the Appalachian Region are of Pennsylvanian Age, and are essentially coextensive with the Appalachian Plateau physiographic province. The most abundant coal-bearing rock types in Appalachia are the fine-grained siltstones and shales. Although less abundant, sandstones and conglomerates are conspicuous because of their resistant nature, frequently forming bold outcroppings and capping mountains. Limestone is prevalent in western Pennsylvania and Ohio, but in the rest of Appalachia, where present at all, lime is found mostly in calcareous shales or as a cementing agent in sandstones and siltstones. The coalbeds are distributed throughout the sequence of Pennsylvanian rocks.

Many of the coal-bearing strata contain varying amounts of the mineral pyrite, which is of considerable importance because of its potential for producing acid spoil and acid-mine drainage. However, with local exceptions, the patterns of acid-mine drainage affecting major stream systems indicate that this problem is most prevalent in Pennsylvania, portions of eastern Ohio, and a band along the boundary of Kentucky with West Virginia and Virginia in the Northern Appalachian Region and in north-central Tennessee in the Southern Appalachian Region. Coal-bearing strata that chemically are strongly alkaline are found in a few areas, but these strata are of minor consequence to the region.

Physiography

The Appalachian Coal Region occupies a high plateau that in most parts has been deeply incised by a dendritic stream pattern, giving rise to a rugged mountainous terrain. Altitudes range from 900 to 4,800 feet above sea level, with relief in the mountainous areas ranging from 500 to 1,500 feet. Slopes exceeding 30 degrees are common throughout much of the Appalachian region, with steeper slopes and vertical cliffs along major rivers. Terrain of this nature has necessitated contour and mountaintop-removal mining and has created severe erosion and stream sedimentation. In addition, transportation is hampered by the difficulty and expense of building and maintaining roads and railways.

Climate

Precipitation over all of the Appalachian Coal Region averages 47 inches annually. It ranges from 35 inches in Pennsylvania to a high of 55 inches in Alabama (Figure 34). The precipitation is fairly well distributed throughout the year, though any month could have the most or least precipitation in a given year. Approximately one-half of all precipitation is lost through evaporation and transpiration. Short periods of dry weather occur occasionally; longer periods occur infrequently, usually in late summer to early fall.

Average annual temperature ranges from about 50°F in Pennsylvania to a little over 60°F in Alabama. Average maximum temperature ranges from about 90° to 100°F, while average minimums range from around -10° to 10°F. Seasonal variations in temperature and precipitation are influenced to some extent by local topographic extremes. Some mountaintops and adjacent valleys may experience nearly as much climatic variation as occurs between the northern and southern parts of the region. However, largely because of its relative abundance overall, the variation in precipitation caused by topographic extremes is not great enough to produce extreme diversity in vegetation types. Average frost-free periods range from about 120

days in the north and high elevations in Maryland and West Virginia to 220 days in Alabama.

Native Vegetation

On the average, forest vegetation occupies about 80 percent of the land area being mined in the Appalachian Coal Region. The predominant forest type in the Northern Appalachian Coal Region is mixed hardwoods. Species composition ranges from almost pure northern red oak to pure yellow-poplar. However, the typical forest stand comprises a mixture of species. The most common species are northern red oak, yellow-poplar, sugar and red maples, white oak, American beech, white ash, American basswood, black cherry, cucumbertree, sweet and yellow birches, hickories, yellow buckeye, and black locust. Eastern hemlock and eastern white pine occur frequently in the mixture. Many other species occur occasionally.

Northern hardwoods are found in northern and eastern Pennsylvania and at higher elevations south into West Virginia. Sugar maple, American beech, and yellow birch are the predominant species in this type. Minor species include paper birch, white ash, red maple, eastern hemlock, balsam fir, and red spruce.

Along the eastern edge of the region, from southern Pennsylvania southward, the mixed hardwood type merges with an oak-pine type. Loblolly, shortleaf, and Virginia pines in mixture with northern red, white, scarlet, black, and chestnut oaks are the primary species in this type. Yellow-poplar and sweetgum are frequently associated with the oak-pine type.

The predominant forest type in much of the Southern Appalachian Coal Region is mixed hardwoods and is similar to and a continuation of the Northern Appalachian hardwood forest. However, species common to the Northern region, such as yellow birch, sugar maple, and American basswood, drop out of the mixed hardwood stands. Eastern hemlock and sweet birch occur less frequently and yellow-poplar and cucumbertree are more numerous. Species similar to those in the Northern Appalachian Region include northern red oak, white oak, white ash, red maple, black cherry, and hickories. Loblolly, shortleaf, and Virginia pines from the oak-pine type are common in the southern and eastern portions of the region.

A wide diversity of shrub species is associated with the forest types in this region. Some of the more common shrubs are dogwoods, viburnums, sumacs, cherries, hawthorns, elderberry, rhododendron, mountain laurel, alder, serviceberry, indigobush, chokeberry, redbud, witchhazel, bayberry, and honeysuckle.

Cutting of merchantable timber without regard to forest management principles has been a continual process on much of the forested land since original settlement. Today, much of the private forest land is poorly managed or unmanaged and is stocked primarily with low-quality trees, both in species and in form. Nonforested lands are mainly those where the topography and soils have allowed the development of agricultural uses, primarily pasture.

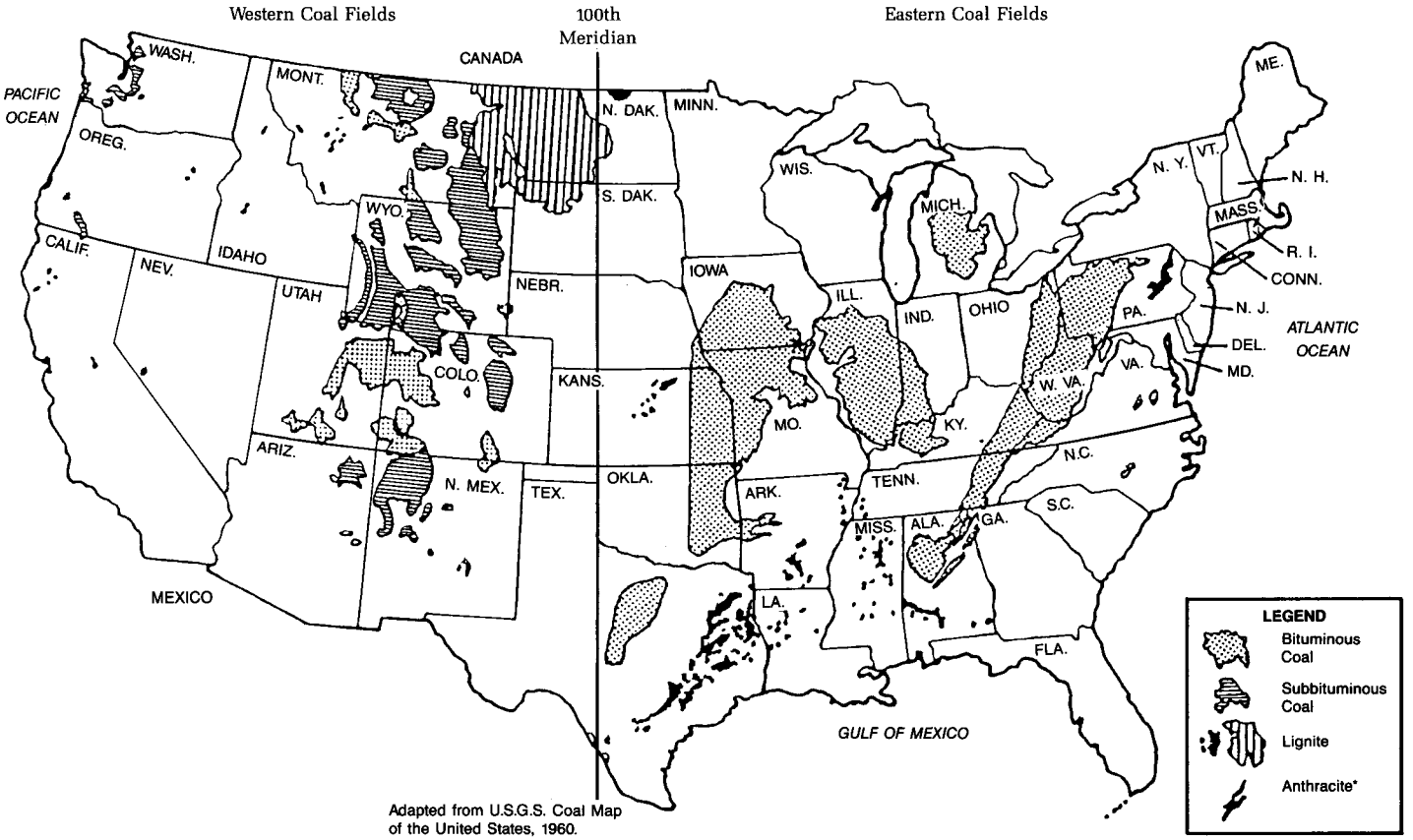

Figure 33. Coal fields of the continental United States.

Only in a few local areas does mining concide significantly with cropland uses.

Interior Coal and Southern Lignite Region

The Interior Coal Region includes two major bituminous coal producing areas: the Eastern Interior and Western Interior Coal Regions. The Eastern Interior Region, also known as the Illinois Basin, lies primarily within Illinois, Indiana, and western Kentucky. The Western Interior Coal Region lies within Iowa, Missouri, Kansas, Oklahoma, and Arkansas. Bituminous coal deposits are found also in north-central Texas and along the Rio Grande in south-central Texas (Figure 33).

Lignite deposits are found in eastern Texas and portions of Arkansas, Louisiana, Mississippi, western Tennessee, and southwestern Alabama (Figure 33). Some of these lignite reserves are being mined, others are being developed for mining, or their potential for mining is uncertain. Much of the lignite mining in this region is relatively recent; thus, less information has been published on revegetating lignite mines than on revegetating bituminous mines in the Interior and Appalachian Regions. However, many of the same problems, practices, and recommendations apply to both types of mines.

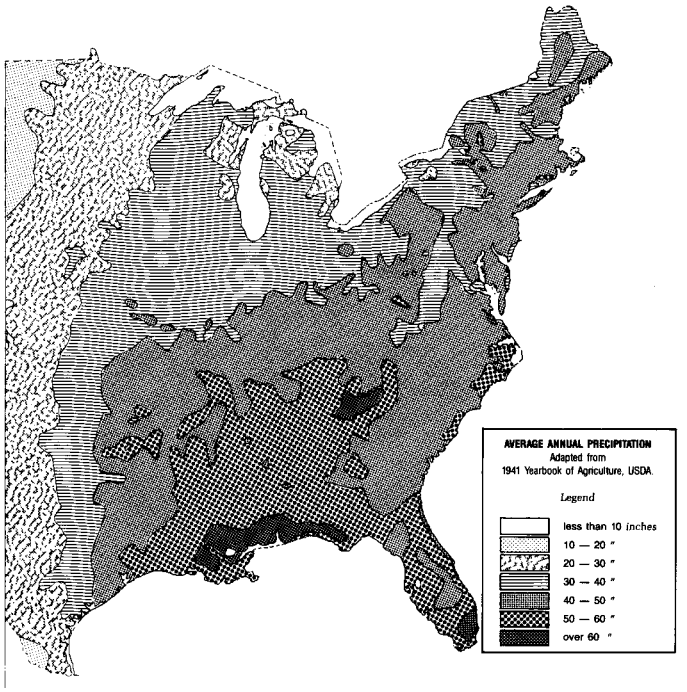

Figure 34. Precipitation zones of the eastern United States.

Geology

The coals of the Interior Region are of Pennsylvanian age. As in Appalachia coal-bearing strata are predominantly shales, siltstones, and sandstones. However, in the Interior Region a repeating marine influence is more strongly seen; hence, limestones is not uncommon.

The marine influence is seen in the more abundant, highly pyritic black shales, especially in southern Illinois and western Kentucky in the Eastern Interior Coal Region. These shales cause problems with acid spoils and acid-mine drainage. In some areas, shallow underground mines, worked-out in the past, have been broken into by subsequent surface mining, releasing copious flows of extremely acid water, and damaging streams and nearby agricultural and forest lands subject to flooding. In other cases, surface mining has sealed or eliminated old underground mines, reducing the flow of acid water.

Minesoil toxicity resulting from acid-bearing strata is relatively minor for the Western Interior Coal Region as a whole, though it is serious in some localities. Similarly, problems with acid drainage from worked-out underground mines and with flooding of adjacent lands are less severe than in portions of the Eastern Interior Coal Region. The rock strata in the Western Region dip to the west-northwest; thus, the coal outcrops and coal mining are in the eastern part of the region.

The lignite deposits are primarily of Lower Tertiary age in association with sands and clays, some of marine influence.

Physiography

Most of the Eastern Interior Coal Region in Illinois and Indiana lies within the Central Lowlands physiographic province, while the portion in Kentucky and extreme southern Illinois and Indiana is in the Interior Low Plateaus. The boundary between these two physiographic provinces marks the southern limit of glaciation.

The Central Lowlands, in the vicinity of the coal fields, consists of broad, level uplands between steep-sided valleys with broad floodplains. This area is covered with glacial till and loess deposits that, toward the Mississippi River, reach 30 feet in thickness.

The Interior Low Plateaus consist of a slightly westward sloping plateau that is deeply entrenched with meandering rivers. This area has more relief than that to the north, but still is gently rolling. The low, gently rolling topography of the Eastern Interior Coal Region has allowed extensive area-type surface mining and an easily developed road, rail, and river barge transportation system.

The portion of the Western Interior Coal Region that lies north of the Missouri River is in the Dissected Till Plain section of the Central Lowland physiographic province. The southern part, lying in Kansas, Oklahoma, and southwestern Missouri, and the bituminous coal field in north-central Texas are in the Osage Plains, the small area extending into Arkansas falls within the Ouachita Province.

The Dissected Till Plain has been glaciated and, hence, is of low relief that ranges from 100 to 300 feet. The glacial till of this area is covered in the more eastern parts with up to 30 feet of loess.

The Osage Plains lies south of the glacial limit so it is of greater relief than the glaciated area of the Central Lowlands to the north. Most of the Osage area consists of upland plains with deeply entrenched rivers, some with valleys a few hundred feet deep.

The Ouachita Province resembles the Appalachian Mountains, but altitudes and relief are lower than in the Appalachians. Ridges in the Ouachita Mountains reach a maximum altitude of about 2,600 feet, about 1,500 feet above adjoining valleys.

The lignite deposits are primarily in the West Gulf and East Gulf sections of the Coastal Plain physiographic province. The relief in these sections can vary from nearly level to hilly, and elevations range from sea level to about 1,000 feet at the Balcones Escarpment.

Climate

Average annual precipitation in the Interior Coal Regions ranges from about 30 inches at the northern and western edges to about 50 inches at the eastern and southern boundaries (Figure 34). It may exceed 50 inches in portions of the East Gulf Coastal Plain and be as low as 20 inches in the western portion of the West Gulf Coastal Plain where lignite is found. Precipitation normally is greatest during the early-summer growing season, but droughts, especially in late summer, are not uncommon. Spring and summer rains often occur as severe thunderstorms with damaging winds, hail, and flooding. Temperatures are extreme and range from an average minimum of -20°F to average maximums of above 100°F. Average frost-free periods range from about 150 days at the northern edge to 300 days at the southern edge.

Native Vegetation

Several vegetation types are native to these coal regions. Tall grass prairie originally occupied a large portion of the Interior Regions, most of which has been converted to row crop and introduced pasture types of agriculture. Forested areas in the Interior Coal Region include the central hardwood type in the southeastern part and the oak-hickory type in the western part as well as in the bituminous coal area in north-central Texas. The Lignite Region crosses portions of the South Texas Plains, Post Oak Savannah (western fringe of the oak-hickory type), and east into the southern pine and oak-pine forest types.

The central hardwood type is a transition type from Appalachian hardwoods to oak-hickory. Common species are white and red oaks, red and sugar maples, yellow-poplar, American basswood, green and white ashes, black locust, and, on the best sites, black walnut. Cottonwood was a common volunteer species on prelaw surface-mine spoils.

The southern pine and oak-pine forest types are predominantly loblolly and shortleaf pines. Associated species are oaks, ashes, elms, hickories, and maples. Hardwoods are most common in bottomland sites. Most of the south Texas plains is rangeland with a large portion devoted to primary agriculture land.

Oak-hickory is the major forest type within the states of Iowa, Missouri, Oklahoma, and part of Texas. In addition to northern red, white, and black oaks, bur, post, blackjack, and pin oaks are common in the natural stands. Shagbark, pignut, mockernut, and bitternut hickories are common throughout the type. Associated species are ashes, elms, aspens, and black locust, and occasional black walnut on the better sites.

Criteria for Selecting and Establishing Plant Species

Reclamation success depends on successful establishment of vegetation, which, in turn depends on selection of species that are suitable for site and climatic conditions and postmining land uses. Criteria for selecting plant species include the type of plants, growth characteristics of those plants, adaptation to climate and site, type and availability of planting materials, and primary purpose or use for the species.

Types of Plants (Life Forms)

The plant species are classified into three types or life forms—herbs, trees, and shrubs. Each type has an important function in revegetation efforts, but all types may not be needed in the revegetation strategy for every land use.

Herbs

Herbs, or herbaceous plants, are nonwoody and are classified as grasses or forbs. *Grasses* belong to the Gramineae (grass) family. Most species have a fibrous root system that helps bind together soil particles and prevent erosion. *Forbs* are herbaceous plants other than those in the grass, sedge, and rush families. They generally are broad-leaved plants that have a tap-root or branching tap-root system. The forbs are further classified as *legumes* or *nonlegumes*. For vegetating mined lands, legumes most often are used and are especially valuable because they are nitrogen-fixing plants, i.e., by their symbiotic relationship with *Rhizobium* bacteria they convert atmospheric nitrogen into a form in the soil that is usable by plants.

The herbs (grasses and forbs) are especially beneficial for the quick establishment of vegetative cover for erosion control. Some herbaceous species also provide long-term site protection and are suitable for agricultural uses and for wildlife habitat.

Lifespan. The lifespan of herbaceous plants is either annual, biennial, or perennial, whereas trees and shrubs all are perennial (long-lived) species. A knowledge of the lifespan of these species can help reclamation managers select those best suited to the needs and objectives of the revegetation program.

Annual plants make vegetative growth, flower, produce seed, and die all within one season or one year. Annuals reproduce only from the seed they produce during this life cycle. Some annuals, such as Korean and Kobe lespedeza, usually regenerate (volunteer) a stand each year from the seed they produce, but other annuals such as rye and millet cannot be depended on to volunteer satisfactory stands. Annuals usually are the best species to plant for the quick establishment of a vegetative cover.

Biennial plants live for only two growing seasons. Biennials such as yellow sweet clover produce most of their vegetative growth in the year they are sown. In the second year they produce vegetative growth early in the season, then flower, produce seed, and die. Few of the species listed are biennial.

Most *perennial* plants live at least 3 years and usually longer. Herbaceous perennials die back to the ground each year but regenerate new growth from roots or crowns.

They also reproduce from seed. Plants of a few perennials such as perennial ryegrass are relatively short-lived (2 to 4 years), but most perennial plants have a longer, usually indefinite, lifespan.

Season of Major Growth. A knowledge of when herbaceous plants grow is helpful in determining how and when species can be used best in the revegetation scheme. The growth period of herbaceous plants is grouped into two major seasons—cool and warm. Trees and shrubs also may have a season of major growth, but this usually has little influence on when they would be planted.

Cool-season species grow mostly in the spring and fall and usually are dormant, semidormant, or grow slowly in the summer. These plants usually are dormant in winter though in warmer regions, some cool-season species may continue to grow during the winter. Cool-season species usually are established most easily by seeding in the spring or late summer to early fall. A few species, such as alfalfa, crownvetch, and birdsfoot trefoil, continue to grow during the summer but usually are sown in the spring or fall and are classified as cool-season plants in this handbook.

Some cool-season plants are called winter annuals. They normally are sown in the fall. After the seeds germinate, the plants make some growth before going dormant or semidormant over winter. These plants resume growth in the early spring, produce seed in late spring or early summer, and then die. Most winter annuals also produce cover when sown in the spring. Rye, winter wheat, annual ryegrass, and hairy vetch are examples.

Warm-season species grow mostly during the late spring and summer and are dormant in early spring, fall, and winter. Warm-season species usually are sown in the spring. Summer annuals, such as foxtail millet and sorghum, normally are sown in late spring and early summer and are especially useful for the quick establishment of vegetative cover. Summer annual species complete their life cycle during late summer and early fall. Both summer and winter annuals can be grown to produce mulch in place.

Shrubs

Shrubs are plants with few to many persistent woody stems arising from the ground and without definite crown shape. Shrubs usually are smaller than trees, though in other literature some large shrubs may be classified as trees. Most of the species listed as shrubs herein do not exceed a height of 20 feet at maturity. Shrubs usually do not provide good erosion control in the early stages of growth, but within a few years will provide site protection and can be used for screening. They are especially valuable for providing food and cover for wildlife. Some shrubs are nitrogen-fixers. Some of these are legumes that fix nitrogen through association with *Rhizobium* bacteria; others, such as autumn olive and black alder, host a different kind of nitrogen-fixing microbial associate.

Trees

Trees are large woody plants that generally have a single stem and a definitive crown shape. They are classified as *conifers* (cone bearers) or *hardwoods*. Most conifers belong to the pine family and are evergreen (three of the listed conifers are deciduous). Hardwoods belong to plant families other than pine and most are deciduous, i.e., their leaves are dropped annually.

Trees are not effective for controlling erosion in the early stages of life, but as the tree canopy closes and litter accumulates they provide long-term or permanent cover and site protection. Given sufficient time, some trees produce wood or timber products of commercial value. Many species provide food and cover for wildlife. A few tree species are nitrogen-fixers. Because they can improve soil conditions, these nitrogen-fixers may serve as "nurse" species where interplanted with other tree species.

Tree Size. The relative height of a mature tree growing in its natural range and on natural soils is classified and defined as *small*— 20 to 40 feet; *medium*— 40 to 90 feet; *large*— 90 to 150 feet. A knowledge of tree size may be useful in selecting trees for screening or landscaping purposes, and to help envision the future appearance of a forest plantation.

Shade Tolerance. Shade tolerance is the term commonly used to express the capacity of a tree or shrub to develop and grow in the shade of other trees. Although oversimplified, shade tolerance for the purpose of this handbook is categorized and defined as: *tolerant*— trees can tolerate or withstand fully shaded conditions (low light intensity) for long periods of time; *intolerant*— trees cannot tolerate shaded conditions (require relatively high light intensity); *intermediate tolerance*— trees can tolerate partial shading or can tolerate full shade for short periods.

A knowledge of the shade tolerance of a species may seem unimportant in vegetating a newly mined site. Often, however, several species of trees and shrubs are planted together or plantings may be staggered over a period of several years. As plant growth progresses, some species overtop and shade others. Some species are adversely affected by shading but others are not. For example, hardwoods, where interplanted with intolerant species of pine, often overtop, shade, and cause the slower growing pine to lose vigor and eventually die. Conversely, species tolerant of shade such as spruce may initially grow slowly in the shade of larger or faster growing plants, but eventually will equal or emerge above them.

Origin

Species are identified as either *native* or *introduced*. Many of the introduced species are naturalized and, like the native species, will persist without cultivation. A knowledge of species origin may be useful to reclamation managers because the use of native species is a requisite for some postmining land uses and is an alternative to using introduced species for other land uses.

Regions Where Adapted

The species described later in this chapter are recommended for the appropriate coal region(s) or part of them. In some cases, these species may grow satisfactorily in

more of the region than indicated, but their use on mined lands in all parts of the region has not been documented. The region or parts of it coincide fairly closely with the natural range of most of the recommended native tree and shrub species.

A few species have been used successfully beyond their natural range. For example, the natural range of red pine and jack pine is the northernmost part of the United States and adjacent southern Canada. Yet, these pine have been used far south of this range.

The probability of long life or permanence of a species usually is greater where planted in or near its natural range (or environment similar to its natural one in case of an introduced species) than outside its natural range. Planted outside their natural range, some species or some plantings of a species may succumb to extremes in weather, fail to regenerate, or be susceptible to disease and insect pests that usually are not a problem in their natural range.

Elevation Limit

Plants usually grow best in the climatic range in which they are adapted. Topographic elevation influences climate and so can affect the establishment and growth of plants. For example, most of the Northern Appalachian Region is in the natural range of Virginia pine. But this tree does not grow well above 2,500 feet, especially in the northern half of the Appalachians. Similarly, a warm-climate forb, such as sericea lespedeza, may germinate and grow at the lower elevations in northern West Virginia, but winter temperatures at the higher elevations may be too severe for the success of that species. Most of the Southern Appalachian Region is in the natural range of loblolly pine, but this tree does not grow well or may suffer winter damage at higher elevations in the northern part of this region. Limits are shown for species where elevation is known or suspected to be a factor hindering their establishment.

Lower pH Limit

Acidity (low pH) is a major factor limiting the establishment of vegetation on some of the mined lands in the East. Knowing the acidity tolerance of a species can be helpful in selecting those most suitable for vegetating acid minesoils. However, selecting plants for acid tolerance may be less important now than in the past due to changing practices in mining and reclamation, such as segregation and planned placement of overburden strata, replacement of native soil, and amendment of acid soils. Alkalinity or high pH seldom causes revegetation problems in the eastern coal regions; thus, upper limits of pH tolerance are not given. However, pH of overburden materials in some areas, such as the Warrior Basin of Alabama, are high enough to cause problems with species such as pine that grow best in acid soils. The upper limit for good growth of most plants is about pH 8.0. For pine trees, the upper limit is somewhat lower (6.5).

Planting Materials

The type of plant materials used to establish the species are identified in the plant descriptions that follow. With few exceptions, trees and shrubs are most often established by planting nursery-grown seedlings. The age of nursery seedlings recommended for planting on mined lands is shown in parentheses. However, seedlings of the same age are not always the same size; thus, the buyer must be sure that the seedlings are of the proper size for planting. Hybrid poplars, willow, and sometimes cottonwood can be established by planting either rooted or unrooted cuttings.

A few of the woody species can be established by direct seeding. Treatment of the seed is recommended for some species. The herbaceous species generally are established from seed. Crowns, sprigs, and sod are used to a limited extent for establishing a few species. Most cultivars of Bermudagrass must be planted vegetatively (by sprigging). Seed of herbaceous legumes and some of the shrubby legumes should be inoculated with the appropriate *Rhizobium* bacteria. Wide-spectrum or standard inoculants are available commercially for most of the commonly used legumes. Species that require specially prepared inoculum are identified.

Insofar as possible, attention should be given to seed source for all species planted, but especially for tree species. In general, when reforesting an area, it is best to use local seed sources because they have a better chance than outside seed sources of being adapted to the local environment. See the chapter on *Vegetation Establishment and Cultural Practices* for a discussion and recommendations on size of planting stock, spacing of seedlings, time of planting, direct seeding, inoculation of legume seed, and seed sources.

Seeding Rate

Rates of seeding are recommended for herbaceous species and for tree and shrub species that can be direct seeded. The rates are given as pounds per acre of *pure live seed* (PLS). For some species, a range in rates is suggested both for use in mixtures and, where advisable, for seeding alone. The higher rates should be used where environmental conditions are least favorable for seedling establishment, such as on poorly prepared seedbeds and steep slopes. Seeds of some species are susceptible to damage when sown with a hydroseeder; thus, using the higher rates helps compensate for the damaged seeds. The lower seeding rates are suggested for well-prepared seedbeds and especially where seed is planted with drill seeders. Special directions are given for tree species that can be established from planting of nuts. A discussion of seeding rates and an explanation of pure live seed are given in the chapter on *Vegetation Establishment and Cultural Practices.*

Time of Seeding

The season or seasons of the year is indicated when a species normally is seeded. Additional information on time of seeding is discussed in the chapter on *Vegetation Establishment and Cultural Practices.*

Superior Cultivars

Varieties, strains, or selections that have one or more superior qualities are listed for some species. When available, the use of superior cultivars usually is recommended

over unimproved cultivars. Exceptions may be where the postmining land use is wildlife habitat or forestry. Consult agricultural agencies such as your State Extension Service or the USDA Soil Conservation Service for advice on recommended cultivars for agricultural uses in your locality.

Rate of Establishment

This qualitative rating is the length of time usually required for a herbaceous species to become established and develop sufficient foliage to cover 70 percent or more of the ground surface. The rates are: *Rapid*— the desired cover is established within the first growing season after seeding (for fall-sown species, this includes the fall plus the next spring growing periods); *Moderate*— requires more than one growing season to establish the desired cover, but may not require a full second growing season; *Slow*— requires more than two full growing seasons to establish the desired cover.

These criteria apply primarily to a species when sown alone; the rate of establishment could vary when the species is sown in mixtures. These criteria also assume that (1) seeding is done in the appropriate season for that species; (2) seed was sown on mechanically prepared or frost-loosened seedbeds on minesoils that have been limed and fertilized properly; and (3) the minesoils do not have other chemical or physical properties that would hinder usual seed germination and plant development.

Major Uses

Major uses of species planted on mined lands are listed in the plant descriptions. Erosion control and watershed protection are provided by nearly all plants at some stage of development. However, these uses are not listed for most of the tree and shrub species because these plants usually provide little site protection during the first few years after planting. Conversely, many of the herbaceous species provide rapid cover and are especially important for erosion control and watershed protection. Nearly all species contribute to esthetics; for a few species, esthetics and screening can be major uses. Forest products are a potential long-range use for many of the tree species listed.

Comments

This item includes other factors of interest or importance, and data on growth performance of some of the tree species. Much of the tree-growth data was gathered in a recent survey of 30-year-old experimental plantings throughout the eastern coal regions. Data on tree performance are averaged from a number of test sites in the States indicated and include percent survival, average diameter at breast height (dbh), average height, and basal area (an indicator of stand density). Most of the basal-area values were calculated by multiplying the number of surviving trees per acre (determined from percent survival) by the mean cross-sectional areas of the trees (determined from average dbh). Trees in the experimental plantings were on a 7- by 7-foot spacing (890 trees per acre).

Plant Species for Revegetation

Plant species that have been used and are recommended in revegetating coal surface-mined lands in the Eastern Coal Regions are identified and described in this chapter. Both common and scientific (Latin) names are listed to clarify species identification (Table 16). This list does not include all the plant species that will grow on reclaimed surface-mined lands. A few species that were successful in experimental plantings are not listed because they are unsuited or have little value for most land uses. Many species besides those listed volunteer on mined land, but some of them have not been successful where artificially planted. Others have not been artificially planted because planting stock or seed has not been commercially available. Also, use of some of the listed species may be limited at times when planting stock or seed are in short supply or are unavailable.

Several of the listed species have been grown successfully in experimental plantings but have not been used, or are seldom used, in large-scale or commercial plantings. In fact, on the majority of successfully reclaimed surface mines, revegetation has been accomplished with the use of relatively few plant species. Greater use could be made of many of the listed species—some for commercial forestry and agricultural uses, and others for increasing vegetative diversity for wildlife habitat and for restoring vegetational types similar to those that existed before mining. Where the native surface soils are being replaced it is reasonable to assume that most of the species growing naturally on such soils could be reestablished. However, due to compaction and changes in soil structure and possibly other characteristics, some of these species may not be easily reestablished immediately. Least risk probably is incurred by using species that have tested successfully on reclaimed mines.

Some of the plant species described in this chapter are suitable for use in all of the Eastern Coal Regions, however, most species are adapted or suited to one region or part of a region better than they are to other regions or parts of a region.

Species Descriptions

The descriptions that follow have been prepared for species that are used and recommended most frequently, and for some that have proven successful in experimental plantings but otherwise may have been little used. For species of lesser importance, and those that are seldom used, similar but less detailed information is given in Tables 17-20. The species descriptions are arranged by plant type in the order: grasses, forbs, shrubs, and trees.

Table 16. Plant species for revegetating coal surface-mined lands in the Eastern Coal Regions. Detailed information on species in bold face type is given on individual descriptions in the following pages. The other species are described briefly in Tables 17–20.

Common name	*Scientific Name and Authority**
GRASSES	
Bahiagrass	*Paspalum notatum* Flugge
Highland bentgrass	*Agrostis tenuis* Sibth.
Bermudagrass	*Cynodon dactylon* (L.) Pers.
Canada bluegrass	*Poa compressa* L.
Kentucky bluegrass	*Poa pratensis* L.
Big bluestem	*Andropogon gerardi* Vitm.
Caucasian bluestem	*Bothriochloa caucasica* (Trin.) C.E. Hubb
King ranch bluestem	*Bothriochloa ischaemum* va. *Songarica* (Rup. ex Fisch. & Mey.) Celar. & Harlan
Little bluestem	*Schizachyrium scoparium* (Michx.) Nash
Smooth brome	*Bromus inermis* Leyss.
Buffalograss	*Buchloe dactyloides* (Nutt.) Engelm.
Reed canarygrass	*Phalaris arundinacea* L.
Corn	*Zea mays*
Dallis grass	*Paspalum dilatatum* Poir.
Deertongue	*Panicum clandestinum* L.
Red fescue	*Festuca rubra* L.
Tall fescue 'Kentucky-31'	*Festuca arundinacea* Schreb., selection Ky-31
Sideoats grama	*Bouteloua curtipendula* (Michx.) Torr.
Indiangrass	*Sorghastrum nutans* (L.) Nash
Weeping lovegrass	*Eragrostis curvula* (Schrad.) Nees
Browntop millet	*Brachiaria ramosa* (L.) Stapf
Foxtail millet	*Setaria italica* (L.) Beauv.
Japanese millet	*Echinochloa crusgalli* var. *frumentacea* (Link) W.F. Wight
Pearl millet	*Pennisetum americanum* (L.) Leeke
Tall oatgrass	*Arrhenatherum elatius* (L.) Beauv. ex J. & C. Presl
Oats	*Avena sativa* L.
Orchardgrass	*Dactylis glomerata* L.
Redtop	*Agrostis gigantea* Roth
Rye	*Secale cereale* L.
Annual ryegrass	*Lolium multiflorum* Lam.
Perennial ryegrass	*Lolium perenne* L.
Sorghum	*Sorghum bicolor* (L.) Moench
Sudangrass	*Sorghum sudanense* (Piper) Stapf
Switchgrass	*Panicum virgatum* L.
Timothy	*Phleum pratense* L.
Western wheatgrass	*Agropyron smithii* Rydb.
Winter wheat	*Triticum aestivum* L.
FORBS-LEGUMES	
Alfalfa	*Medicago sativa* L.
Illinois bundleflower	*Desmanthus illinoensis* (Michx.) MacMill.
Alsike clover	*Trifolium hybridum* L.
Arrowleaf clover	*Trifolium vesiculosum* Savi.
Crimson clover	*Trifolium incarnatum* L.
Kura clover	*Trifolium ambiguum* Bieb.
Ladino clover	*Trifolium repens* L.
Red clover	*Trifolium pratense* L.
Subterranean clover	*Trifolium subterraneum* L.
White clover	*Trifolium repens* L.
Cowpea, Black-eyed pea	*Vigna unguiculata* (L.) Walp. subsp. unguiculata
Crownvetch	*Coronilla varia* L.
Flatpea	*Lathyrus sylvestris* L.
Common lespedeza	*Lespedeza striata* (Thunb. ex Murr.) Hook. & Arn.
Kobe lespedeza	*Lespedeza striata* var. Kobe
Korean lespedeza	*Lespedeza stipulacea* Maxim.
Prostrate lespedeza	*Lespedeza daurica* var. *schimadai* Matsamune
Sericea lespedeza	*Lespedeza cuneata* (Dum.) G. Don
Cicer milkvetch	*Astragalus cicer* L.
Partridge pea	*Cassia fasciculata* Michx.
Purple prairie clover	*Petalostemum purpureum* (Venten.) Rydb.
Soybean	*Glycine max* (L.) Merr.
White sweetclover	*Melilotus alba* Medik.
Yellow sweetclover	*Melilotus officinalis* Lam.
Birdsfoot trefoil	*Lotus corniculatus* L.
Bigflower vetch	*Vicia grandiflora* Scop.
Hairy vetch	*Vicia villosa* Roth
FORBS-NONLEGUMES	
Buckwheat	*Fagopyrum esculentum* Moench
Japanese fleeceflower	*Polygonum cuspidatum* Sieb. & Zucc.
'Eureka' Thickspike gayfeather	*Liatris pycnostachya* Michx.
'Sunglow' Grayhead prairie coneflower	*Ratibida columnifera* (Nutt.) Woot. and Standl. var.
'Nekan' Pitcher sage	*Salvia azurea* var. grandiflora Benth.
Common sunflower	*Helianthus annuus* L.
Maximilian sunflower	*Helianthus maximiliani* Schrad.

*Names and authorities mostly follow Terrell 1977 and Little 1979. Another source is L.H. Bailey Hortorium 1976.

Table 16. Plant species for revegetating coal surface-mined lands in the Eastern Coal Regions. Detailed information on species in bold face type is given on individual descriptions in the following pages. The other species are described briefly in Tables 17–20.

Common name	Scientific Name and Authority*
SHRUBS	
Blueberry	*Vaccinium* L. Spp.
Silver buffaloberry	*Shepherdia argentea* (Pursh) Nutt.
Chokecherry	*Prunus virginiana* L.
Gray dogwood	*Cornus racemosa* Lam.
Red-osier dogwood	*Cornus stolonifera* Michx.
Silky dogwood	*Cornus amomum* Mill.
American elder	*Sambucus canadensis* L.
Grape	*Vitis* L. Spp.
Hawthorn	*Crataegus* L. spp.
Amur honeysuckle	*Lonicera maackii* (Rupr.) Maxim.
Japanese honeysuckle	*Lonicera japonica* Thunb.
Morrow honeysuckle	*Lonicera morrowii* A. Gray
Tatarian honeysuckle	*Lonicera tatarica* L.
Indigobush	*Amorpha fruticosa* L.
Japan lespedeza	*Lespedeza japonica* L. H. Bailey
Shrub lespedeza	*Lespedeza bicolor* Turcz.
Thunberg lespedeza	*Lespedeza thunbergii* (DC.) Nakai
Bristly locust	*Robinia fertilis* Ashe
Rose-acacia locust	*Robinia hispida* L.
Autumn olive	*Elaeagnus umbellata* Thunb.
Amur privet	*Ligustrum amurense* Carr.
American plum	*Prunus americana* Marsh.
Rugosa rose	*Rosa rugosa* Thunb.
Western sandcherry	*Prunus besseyi* L. H. Bailey
Fragrant sumac	*Rhus aromatica* Ait.
Shining sumac	*Rhus copallina* L.
Viburnum	*Viburnum* L. Spp.
Purple osier willow	*Salix purpurea* L.
TREES—CONIFERS	
Baldcypress	*Taxodium distichum* (L.) L. Rich.
Douglas fir	*Pseudotsuga* Carr. spp.
Fraser fir	*Abies Fraseri* Pursh.
European larch	*Larix decidua* Mill.
Japanese larch	*Larix leptolepis* (Sieb. & Zucc.) Gord.
Austrian pine	*Pinus nigra* Arnold
Eastern white pine	*Pinus strobus* L.
Jack pine	*Pinus banksiana* Lamb.
Loblolly pine	*Pinus taeda* L.
Longleaf pine	*Pinus palustria* Mill.
Pitch pine	*Pinus rigida* Mill.
Pitch X loblolly hybrid pine	*Pinus* X *rigitaeda* (*rigida* X *taeda*)
Red pine	*Pinus resinosa* Ait.
Scotch pine	*Pinus sylvestris* L.
Shortleaf pine	*Pinus echinata* Mill.
Slash pine	*Pinus elliottii* Engelm.
Virginia pine	*Pinus virginiana* Mill.
Eastern redcedar	*Juniperus virginiana* L.
Norway spruce	*Picea abies* (L.) Karst
White spruce	*Picea glauca* (Moench) Voss
TREES—HARDWOODS	
European black alder	*Alnus glutinosa* (L.) Gaertn.
Crab apple	*Malus* Mill. spp.
Green ash	*Fraxinus pennsylvanica* Marsh.
White ash	*Fraxinus americana* L.
Bigtooth aspen	*Populus grandidentata* Michx.
European white birch	*Betula pendula* Roth
Gray birch	*Betula populifolia* Marsh.
Paper birch	*Betula papyrifera* Marsh.
River birch	*Betula nigra* L.
Sweet birch	*Betula lenta* L.
Catalpa	*Catalpa* Scop. spp.
Black cherry	*Prunus serotina* Ehrh.
Chinese chestnut	*Castanea mollissima* Blume
Eastern cottonwood	*Populus deltoides* Bartr. ex Marsh.
Flowering dogwood	*Cornus florida* L.
Hackberry	*Celtis occidentalis* L.
Hickory	*Carya* Nutt. spp.
Black locust	*Robinia pseudoacacia* L.
Red maple	*Acer rubrum* L.
Silver maple	*Acer saccharinum* L.
Sugar maple	*Acer saccharum* Marsh.
Red mulberry	*Morus rubra* L.
Bur oak	*Quercus macrocarpa* Michx.
Chestnut oak	*Quercus prinus* L.
Northern red oak	*Quercus rubra* L.
Pin oak	*Quercus palustris* Muenchh.
Sawtooth oak	*Quercus acutissima* Carruth.
Shingle oak	*Quercus imbricaria* Michx.
White oak	*Quercus alba* L.
Other oaks	*Quercus* spp.
Russian olive	*Elaeagnus angustifolia* L.
Osage orange	*Maclura pomifera* (Raf.) Schneid.
Royal paulownia	*Paulownia tomentosa* (Thunb.) Steud.
Pecan	*Carya illinoensis* (Wangenh.) K. Koch
Hybrid poplar	*Populus* L. spp.
Yellow-poplar	*Liriodendron tulipifera* L.
Sweetgum	*Liquidambar styraciflua* L.
American sycamore	*Platanus occidentalis* L.
Black walnut	*Juglans nigra* L.
Black willow	*Salix nigra* Marsh.

*Names and authorities mostly follow Terrell 1977 and Little 1979. Another source is L. H. Bailey Hortorium 1976.

GRASSES

BERMUDAGRASS
(*Cynodon dactylon*)

Type of plant: Grass

Origin: Introduced

Lifespan: Perennial

Season of major growth: Warm

Lower pH limit: 3.5 to 4.0

Elevation limit: Avoid higher elevations in Appalachian Region

Planting materials: Sprigs; seed (common Bermuda only)

Seeding rate: 3 to 5 lb/acre in mixtures, 7 to 12 lb/acre alone

Sprig spacing: 2 to 3 feet apart in rows 3 to 4 feet apart (4,000 to 6,000 sprigs/acre) or 20 to 35 bu/acre broadcast.

Time of seeding: Spring after mean daily temperatures exceed 65°F.

Time of sprigging: Any month; spring and summer best

Superior cultivars: Midland, Coastal, Tifton 44, Quicksand common, Hardy, 'Tufcote'

Rate of establishment: Rapid

Major uses: Erosion control (quick, short-to-long-term cover); forage

Regions where adapted: Southern Appalachian, southern part of Interior, Southern Lignite

Comments: This semitropical grass grows best on moist, heavy-textured soils in hot weather, but tolerates a wide range of minesoil conditions, including extremely acid, salty, and drouthy conditions. Common Bermuda can be established from seed, but commercial sources usually are not winter-hardy in the northern parts of the Coal Regions. Superior cultivars including the more winter-hardy ones (Midland, Hardy, Tifton 44, Quicksand common) are established by planting sprigs. Quicksand common is a recent selection that may survive winters in the southern half of Illinois and eastward through most of the Appalachian Region. This cultivar also is more productive in soil of low fertility, establishes more rapidly, initiates growth at cooler temperatures, and is more drought-tolerant than the other cultivars listed. 'Tufcote' is a cultivar reported to grow in spoils with pH as low as 3.2. Bermudagrass is a highly productive and valuable forage species in southern areas when management and soil fertility are maintained at high levels. Plants spread quickly by rhizomes and stolons and provide good ground cover.

BIG BLUESTEM
(*Andropogon gerardi*)
LITTLE BLUESTEM
(*Schizachyrium scoparium*)

Type of plant: Grass

Origin: Native

Lifespan: Perennial

Season of major growth: Warm

Lower pH limit: 4.5

Planting materials: Seed

Seeding rate: 4 to 8 lb/acre in mixture, 8 to 15 lb/acre alone

Time of seeding: Spring

Superior cultivars: "Kaw" big bluestem, "Aldous" and "Blaze" little bluestem

Rate of establishment: Slow to moderate

Major uses: Watershed protection (long-term cover), forage, wildlife habitat, esthetics

Regions where adapted: All

Comments: Bluestems are native to all Eastern States and are important components of tall grass prairie. Seeded stands may be slow to develop full cover, but once established, the stands require little maintenance. Big bluestem may reach 6 to 7 feet tall; little bluestem 3 to 4 feet. Usually sown in mixture with other native grass and forbs species. Include a light seeding of oats or rye to provide initial cover, or seed the native grasses into residue of a summer annual crop grown the year before. Unprocessed seeds are light and fluffy and can be difficult to drill or broadcast. Processing seed to remove fluffy appendages shortens the period of seed viability. Germination and purity of seed may be low, so be sure seeding rates are based on PLS values. Bluestems are valuable summer forage for livestock and provide cover for game birds and small mammals. When herbage is not used, occasional removal of heavy litter buildup will help maintain vigorous plant growth. Where land uses permit, heavy litter can be removed by burning. The superior cultivars listed are adapted to most parts of all regions, but check for locally recommended cultivars, especially in western and southwestern parts of Interior Region.

SMOOTH BROME
(*Bromus inermis*)

Type of plant: Grass

Origin: Introduced

Lifespan: Perennial

Season of major growth: Cool

Lower pH limit: 5.5

Planting materials: Seed

Seeding rate: 10 to 15 lb/acre in mixture, 20 to 25 lb/acre alone

Time of seeding: Spring, late summer-early fall

Superior cultivars: Consult local agricultural agencies for recommendations

Rate of establishment: Moderate to slow

Major uses: Forage, erosion control (long-term cover and waterways)

Regions where adapted: northern Appalachian, northern half of Interior

Comments: This sod-forming grass is best adapted to the northern regions. Not recommended in Kentucky, Virginia, and further south. Smooth bromegrass is a leafy, palatable forage plant and often is sown with a legume such as alfalfa. Where established alone it produces a dense sod that provides good erosion control in areas such as grassed waterways that are subject to overland flows. Old stands develop nitrogen deficiency and require fertilization for maintenance. Selection of appropriate seed sources and varieties is important for northern versus southern latitudes. Consult local agricultural authorities for recommendations on the variety or type suited for a given area.

REED CANARYGRASS
(*Phalaris arundinacea*)

Type of plant: Grass

Origin: Introduced

Lifespan: Perennial

Season of major growth: Cool

Lower pH limit: 4.5

Planting materials: Seed; sprigs

Seeding rate: 5 to 8 lb/acre in mixture, 8 to 12 lb/acre alone

Time of seeding: Spring, late summer

Rate of establishment: Moderate

Major uses: Erosion control, wildlife habitat

Regions where adapted: Interior and Northern Appalachian

Comments: Adapted over most of the Interior Coal Province but thrives especially in the northern half. It is recommended primarily for moist or wet sites, such as pond shorelines, drainage ditches, grassed waterways, and stream channel banks. This sod-former can be started in gullies by planting sprigs (small pieces of sod) or by covering the joints of freshly cut mature stems with 1 to 2 inches of wet soil. Reed canarygrass shoots will push up through as much as 6 to 8 inches of sediment. Seed often has low germination, so pay attention to the PLS seeding rate. Drought resistant and will grow on upland sites. Generally, legumes sown with this grass are not successful, especially in wet sites. Seed is used by game birds.

DEERTONGUE
(*Panicum clandestinum*)

Type of plant: Grass

Origin: Native

Lifespan: Perennial

Season of major growth: Warm

Lower pH limit: 4.0

Planting materials: Seed (stratify for spring seeding)

Seeding rate: 6 to 8 lb/acre in mixture, 12 to 15 lb/acre alone

Time of seeding: Late fall, winter, spring (stratified seed)

Superior cultivars: Tioga

Rate of establishment: Moderate to slow

Major uses: Watershed protection, wildlife habitat

Regions where adapted: All except Southern Lignite

Comments: Selected for use on acid minesoils because it frequently volunteers on low fertility and eroded acid sites. Stands usually develop slowly, but once established they persist without additional fertilizer or maintenance. Probably adapted to all coal mining regions, but has been tested on minesoils mostly in the Northeast. Seed becomes dormant soon after it is harvested and requires cold stratification to produce acceptable germination. Late fall and winter seedings allow natural stratification of seed. Before spring seeding, stratify seed by moist refrigeration at about 37°F for 4 weeks. Deer and turkey use seed and foliage in the rosette stage (new green growth). Stands establish best where seeded alone, but obviously will have to be sown in mixture with species that produce quick ground cover.

'KENTUCKY-31' TALL FESCUE
(*Festuca arundinacea*, Selection Ky-31)

Type of plant: Grass

Origin: Introduced

Lifespan: Perennial

Season of major growth: Cool

Lower pH limit: 4.5

Planting materials: Seed

Seeding rate: 10 to 15 lb/acre in mixtures, 20 to 30 lb/acre alone

Time of seeding: Spring and fall

Rate of establishment: Moderate

Major uses: Watershed protection (medium to long-term cover); forage (pasture and hay)

Regions where adapted: All

Comments: Most used and most versatile of the grasses suited for vegetating surface mines. Adapted to a wide range of environmental conditions, including wet, droughty, acid, and alkaline soils. Stand establishment is reasonably fast, but usually should be sown with a "quick cover" grass such as rye in the fall, or weeping lovegrass in mid to late spring. As with most cool-season grasses, stands usually do not thrive unless mixed with a legume or refertilized occasionally. Makes luxuriant growth under black locust. Usually becomes the minor species in mixtures with sericea lespedeza or crownvetch. Value for wildlife, especially for game birds, considered low by most biologists, but sometimes provides winter forage for deer. Generally not recommended for planting in or near wildlife habitat areas. Most of the tall fescue seed available today is Kentucky-31. 'Alta" tall fescue is similar but seldom used. Kenhy, a new variety of tall fescue, is superior to Ky-31 in forage quality and palatability to livestock, but its adaptability to minesoils is uncertain.

INDIANGRASS
(*Sorghastrum nutans*)

Type of plant: Grass

Origin: Native

Lifespan: Perennial

Season of major growth: Warm

Lower pH limit: 4.5

Planting materials: Seed

Seeding rate: 5 to 12 lb/acre in mixtures

Time of seeding: Spring

Superior cultivars: Cheyenne, Osage

Rate of establishment: Slow to moderate

Major uses: Wildlife habitat, forage, watershed protection (long-term cover)

Regions where adapted: All

Comments: Native to all Eastern States and in some regions will invade naturally in areas where woody vegetation is controlled, such as under powerlines and on roadsides. Can be sown in mixtures with other native grasses and legumes to help develop or restore a facsimile of native grassland types. It is also possible, but more difficult, to establish this grass in pure stands. Like that of the bluestems, Indiangrass seed is light and fluffy, and is more difficult to sow than seed of most other species. Application of fertilizer will help establish new seedings but established stands generally require little or no maintenance fertilization. Clumps of this grass provide some of the cover requirements for some species of game birds and small mammals. Produces good summer forage for livestock. Responds to spring burning with improved vigor, greater forage production, and more rapid stand development. Superior cultivars listed are adapted to most of Interior Coal Region, but check for locally recommended cultivars, especially in western and southwestern areas. Superior cultivars from Appalachian ecotypes are being selected, but seed is not yet available commercially. A selection (TO 2936) by the SCS Plant Materials Center, Quicksand, Kentucky, shows promise for use in Northern Appalachia.

WEEPING LOVEGRASS
(*Eragrostis curvula*)

Type of plant: Grass

Origin: Introduced

Lifespan: Perennial

Season of major growth: Warm

Lower pH limit: 4.0

Elevation limit: Avoid higher elevation in Appalachian Region

Planting materials: Seed

Seeding rate: 1 to 3 lb/acre in mixtures, 4 to 6 lb/acre alone

Time of seeding: Spring to early summer

Superior cultivars: Morpa, Ermelo

Rate of establishment: Rapid

Major uses: Erosion control (quick, temporary cover), forage

Regions where adapted: Southern two-thirds of Appalachian, southern third of Interior, Southern Lignite

Comments: Not winter-hardy in the northern two-thirds of the Interior Coal Provinces or northern third of Appalachian Region. One of the most tolerant to extremely acid minesoils, has grown well on some minesoils with pH 3.8. Establishes cover easily and quickly, but may be relatively short-lived (2 to 4 years) unless foliage is removed by mowing, burning, or grazing. Compatible with many other species and in much of the East is used mainly as quick, temporary cover component in a mixture with perennial grasses and legumes, especially in mid- to late-spring seedings. Although it provides good initial cover, gradually gives way to the other perennial species. Suited for warm dry sites such as south-facing slopes. Young growth of herbage can be used for pasture, but mature plants are relatively unpalatable to livestock. Because of its tiny seed, only a low seeding rate is needed. Where used in mixtures, exceeding the recommended seeding rate may cause extremely dense stands that retard the establishment of the perennial companion species. Dense stands burn readily in dry periods when plants are dormant, so the use of this grass for ground cover in tree plantations is risky. Common and 'Morpa" are the cultivars most tolerant of acid minesoils.

FOXTAIL MILLET
(*Setaria italica*)

Type of plant: Grass

Origin: Introduced

Lifespan: Annual

Season of major growth: Warm

Lower pH limit: 4.5

Elevation limit: Avoid high elevations in Appalachian Region

Planting materials: Seed

Seeding rate: 10 to 15 lb/acre in mixture, 20 to 30 lb/acre alone

Time of seeding: Late spring to midsummer

Superior cultivars: German

Rate of establishment: Rapid

Major uses: Erosion control (quick, temporary cover), wildlife food

Regions where adapted: Appalachian and Interior except as noted below

Comments: This summer annual grows rapidly and matures in 60 to 80 days after seeding. Requires high summer temperatures for best growth. Plants are leafy with slender stems that provide dense cover while green, but the plant residue decays much more rapidly than that of sorghum, Sudangrass, pearl millet, or Japanese millet. Thus, foxtail millet is less suitable as an *in situ* mulch grown in place for winter cover. The German strain has somewhat heavier stems and requires a longer growing period than common foxtail millet. Seed provides food for songbirds. Use for quick, temporary cover in seeding mixes with perennial grasses and legumes. Recommended for all Coal Regions except Southern Lignite Region and southern-most part of Appalachian Region and Western Interior Province.

JAPANESE MILLET
(*Echinochloa crusgalli* var. *frumentacea*)

Type of plant: Grass

Origin: Introduced

Lifespan: Annual

Season of major growth: Warm

Lower pH limit: 4.5

Planting materials: Seed

Seeding rate: 8 to 12 lb/acre in mixture, 20 to 25 lb/acre alone

Time of seeding: Late spring-early summer

Rate of establishment: Rapid

Major uses: Erosion control (quick, temporary cover), wildlife habitat

Regions where adapted: Northern Appalachian, Interior Coal

Comments: Use as quick-cover companion crop with perennial grasses and legumes, or sow alone for growing mulch in place. Similar to foxtail millet but taller, coarser, more productive of herbage, and provides more residue for overwinter cover. Grows well in wet soils and low places with occasionally standing water. Seed eaten by song and game birds. Used for food plantings for game birds in swampy areas and around ponds. Japanese millet is a cultivated variety of wild barnyard grass. Grows better than foxtail millet in cool regions. Not recommended for southernmost areas.

PEARL MILLET
(*Pennisetum americanum*)

Type of plant: Grass

Origin: Introduced

Lifespan: Annual

Season of major growth: Warm

Lower pH limit: 4.0 to 4.5

Planting materials: Seed

Seeding rate: 8 to 12 lb/acre in mixture, 20 to 25 lb/acre alone

Time of seeding: Spring to midsummer

Superior cultivars: Gahi-l, Starr

Rate of establishment: Rapid

Major uses: Erosion control (quick, temporary cover)

Regions where adapted: Southern Appalachian, southern part of Interior, southern Lignite

Comments: Used in southern climates primarily for quick, temporary cover in late-spring to midsummer seedings. Sow as companion crop with perennials or alone for growing mulch in place. Plant or sow perennials into the residue (mulch) the following spring. Plant residue is composed of large stems that persist and provide mulch through the second year and sometimes longer. Pearl millet may grow 6 to 8 feet tall or more in good moisture conditions on fertile minesoil. Will outyield Sudangrass in the Southeast and is free of prussic acid. Seeds are used by songbirds. Herbage may be used for pasture, fodder, or ensilage in agricultural situations. Not recommended in northern two-thirds of Interior Coal Region.

OATS
(*Avena sativa*)

Type of plant: Grass

Origin: Introduced

Lifespan: Annual

Season of major growth: Cool

Lower pH limit: 4.5

Planting materials: Seed

Seeding rate: 30 to 50 lb/acre in mixture, 60-90 lb/acre alone

Time of seeding: Spring, fall

Superior cultivars: Consult local agricultural agencies for recommended cultivar

Rate of establishment: Rapid

Major uses: Erosion control (quick, temporary cover), silage, feed crop

Regions where adapted: All

Comments: Most often used as a companion crop with perennial species in spring seedings in northern climates. Fall-seeded (winter) varieties seldom available or used in the northern climates; more often used in southern climates. Could be harvested for silage or grain followed by sowing of perennial species into the stubble.

ORCHARDGRASS
(*Dactylis glomerata*)

Type of plant: Grass

Origin: Introduced

Lifespan: Perennial

Season of major growth: Cool

Lower pH limit: 4.5

Planting materials: Seed

Seeding rate: 5 to 8 lb/acre in mixtures, 10 to 15 lb/acre alone

Time of seeding: Spring, late summer to early fall

Superior cultivars: Consult local agricultural agencies for recommended cultivars

Rate of establishment: Moderate to rapid

Major uses: Forage; wildlife habitat, watershed protection

Regions where adapted: All except as noted below

Comments: Similar to Ky-31 tall fescue in growth habits and tolerance to minesoils, but generally is less persistent, especially where fertilization and management are not practiced to maintain it. Considered superior to fescue for use in wildlife plantings, especially in food patches and clearings vegetated with herbaceous species for game birds. Where managed properly, considered more desirable than tall fescue as forage for livestock. Grows well in combination with such legumes as red and ladino clovers. More adapted than most grasses to growing in shaded sites. Not recommended for Southern Lignite Region or southwestern part of Interior Coal Region.

REDTOP
(*Agrostis gigantea*)

Type of plant: Grass

Origin: Introduced

Lifespan: Perennial

Season of major growth: Cool

Lower pH limit: 4.0 to 4.5

Planting materials: Seed

Seeding rate: 2 to 4 lb/acre in mixture, 3 to 6 lb/acre alone

Time of seeding: Spring, late summer

Rate of establishment: Moderate to rapid

Major uses: Erosion control (temporary cover)

Regions where adapted: All except as noted below

Comments: Tolerates a variety of soil and moisture conditions. Grows on very acid and clayey soils. Especially adapted to wet sites and poorly drained soils, but is drought resistant when established. Spreads by seed and rhizomes. Forms sod that is useful for controlling erosion on sites with overland flows. Sometimes recommended for fall seedings, though the small plants produce little cover in the fall. Plants initiate new growth and produce rapid cover early the following spring. Redtop is relatively short-lived, especially in mixture with other species; the stands usually give way to the companion species after 3 to 4 years. Value as a forage crop is relatively low. Sometimes used in seed mixtures primarily to indicate areas or spots of minesoil that are acid or poorly drained. Not recommended for Southern Lignite Region or southwestern part of Interior Coal Region.

RYE
(*Secale cereale*)

Type of plant: Grass

Origin: Introduced

Lifespan: Annual

Season of major growth: Cool

Lower pH limit: 4.5

Planting materials: Seed

Seeding rate: 30 to 60 lb/acre in mixture, 80 to 120 lb/acre alone

Time of seeding: Fall

Superior cultivars: Balbo, Abruzzi

Rate of establishment: Rapid

Major uses: Erosion control (quick, temporary cover)

Regions where adapted: All

Comments: Used widely as a quick-cover companion crop with perennial species. It is most useful and effective in fall seedings and can be sown alone to produce mulch in place. The plants could be killed with herbicide the following spring and perennial grasses and legumes sown into the dead material. Another seeding option is to not use herbicide but sow the perennial species into the matured rye in late summer. Harvesting the rye grain and seeding perennial herbs into the stubble after harvest is another option. Seed germinates rapidly; seedlings are vigorous and quickly provide ground cover. Rye can be sown later into the fall than most species and still be expected to produce some winter cover. Superior cultivars normally are recommended, but common rye, also called winter rye, is suitable for cover crop. Seeding in spring usually produces sparse stands and cover.

ANNUAL RYEGRASS
(*Lolium multiflorum*)

Type of plant: Grass

Origin: Introduced

Lifespan: Annual

Season of major growth: Cool

Lower pH limit: 4.5

Planting materials: Seed

Seeding rate: 4 to 7 lb/acre in mixtures, 20 to 25 lb/acre alone

Time of seeding: Fall or spring (south); spring (north)

Rate of establishment: Rapid

Major uses: Erosion control (quick, temporary cover), forage

Regions where adapted: All

Comments: This winter annual also known as Italian ryegrass. Commercial seed of this species may include seed of common or domestic ryegrass, which is a genetic mixture of Italian and perennial ryegrasses. Annual ryegrass grows 2 to 3 feet tall and is taller and more vigorous than common and perennial ryegrasses. Can be sown in the fall or early spring, but spring seeding is advised where winters are severe. Used mostly for quick, temporary cover and sown in mixtures with long-lived (perennial) grasses and legumes. The rapid-growing vigorous plants of annual ryegrass can compete strongly with the companion perennials; thus, its seeding rate should not exceed the recommended rate. In warmer climates, ryegrass can be sown alone in the fall for winter cover, and the complement of perennial species in the seed mixture sown the following spring or fall. Can be pastured or cut for hay in agricultural situations, but such use on newly vegetated minesoils is not advised. Value for use by wildlife is limited.

PERENNIAL RYEGRASS
(*Lolium perenne*)

Type of plant: Grass

Origin: Introduced

Lifespan: Perennial

Season of major growth: Cool

Lower pH Limit: 4.5

Planting materials: Seed

Seeding rate: 5 to 10 lb/acre in mixtures, 20 to 25 lb/acre alone

Time of seeding: Fall or spring (south), spring (north)

Rate of establishment: Rapid

Major uses: Erosion control (quick, temporary cover), forage

Regions where adapted: All except northern most latitudes

Comments: A short-lived perennial. Plants usually live only 2 to 3 years and do not reseed successfully to perpetuate the stand. Plants grow 1 to 2 feet tall. Used mostly to provide quick temporary cover where sown in mixture with long-lived perennial grasses and legumes. Less vigorous and less competitive than annual ryegrass with companion species. In warmer climates can be sown alone in the fall for winter cover. Seeding or planting of permanent or long-lived perennial species could be made the following year. Spring seeding is advised in the northern latitudes because winter killing may occur. Can be used for pasture or hay, especially in the South, but newly seeded minesoils should not be grazed until perennial vegetation is well established.

SORGHUM
(*Sorghum bicolor*)
SUDANGRASS
(*Sorghum sudanense*)

Type of plant: Grass

Origin: Introduced

Lifespan: Annual

Season of major growth: Warm

Lower pH limit: 4.5 to 5.0

Planting materials: Seed

Seeding rate: 15 to 20 lb/acre in mixtures, 25 to 40 lb/acre alone

Time of seeding: Spring to midsummer

Superior cultivars: Piper Sudangrass. Consult local agricultural agencies for recommendations on sorghum and sorghum-Sudangrass hybrids

Rate of establishment: Rapid

Major uses: Erosion control (quick, temporary cover), wildlife food

Regions where adapted: All

Comments: The sorghums, Sudangrass, and sorghum-Sudangrass hybrids are drought resistant and are useful as quick, temporary cover component of herbaceous mixtures sown in late spring to midsummer. They also can be sown alone to grow mulch in place; perennial species can be planted or sown into the plant residue (mulch) the following spring. Residues from these species usually last through the second year. In the southernmost areas, seeding can be done throughout the summer. There are several types and many cultivars of sorghums. They are classified on the basis of use as (1) grass sorghum; (2) grain sorghum; (3) forage sorghum; (4) syrup sorghum; and (5) broomcorn. The grass sorghums include Sudangrass and the sorghum-Sudangrass hybrids and are the most likely choice to seed for quick cover for erosion control. Grain sorghums can be used in wildlife food patches and for livestock feed in agricultural situations. Forage and grass sorghums can be used for pasture, silage, or fodder in agricultural land uses. Superior cultivars and hybrids have not been delineated specifically for minesoil plantings. CAUTION: When grown under certain environmental conditions, the herbage of these species can be poisonous to livestock.

SWITCHGRASS
(*Panicum virgatum*)

Type of plant: Grass

Origin: Native

Lifespan: Perennial

Season of major growth: Warm

Lower pH limit: 4.0 to 4.5

Planting materials: Seed

Seeding rate: 2 to 5 lb/acre in mixture, 5 to 12 lb/acre alone

Time of seeding: Spring

Superior cultivars: Blackwell, Cave-in-Rock, Kanlow, Caddo

Rate of establishment: Moderate to slow

Major uses: Watershed protection (long-term cover), forage, wildlife habitat

Regions where adapted: All

Comments: Has been used on minesoils in most of the eastern and midwestern coal States and could be used in all of them. Plants are tall, large-stemmed, and spread by short rhizomes and seed. Unlike some native grasses, switchgrass seed is easy to handle and sow. Stands usually require 2 to 4 years to develop good cover. Once established, stands require little or no maintenance except occasional burning where left solely for cover. They can be highly productive of summer forage if managed properly. A mixture of switchgrass and other native grasses such as Indiangrass, big bluestem, and little bluestem provides a diversity of species similar to that in some natural grassland areas. It also provides cover for some game birds and mammals. A light companion seeding of rye, wheat, or oats helps provide site protection while the switchgrass becomes established. 'Blackwell" is the cultivar used most often on eastern minesoils. It grows about 4 feet tall. Other cultivars are available for selected uses and some are recommended for specific areas. There are many natural ecotypes of switchgrass, so selections can be made for different environmental conditions.

TIMOTHY
(*Phleum pratense*)

Type of plant: Grass

Origin: Introduced

Lifespan: Perennial

Season of major growth: Cool

Lower pH limit: 4.5 to 5.0

Planting materials: Seed

Seeding rate: 4 to 7 lb/acre in mixtures

Time of seeding: Late summer-early fall, spring

Superior cultivars: Consult local agricultural agencies for recommendations

Rate of establishment: Moderate

Major uses: Forage, wildlife habitat, erosion control

Regions where adapted: Northern Appalachian, Interior except southern most part

Comments: Adapted to cool, humid climates. Used mostly in northern half of eastern United States. Used primarily for hay. Often used on mined lands as a substitute for Ky-31 tall fescue in plantings for wildlife habitat. Should be sown with legumes and other grasses. Can be sown in the fall with rye or winter wheat, and companion legumes such as red clover or alfalfa sown the following spring. A relatively short-lived perennial, usually persists for about 5 years, especially where not managed for forage production. Can tolerate partial shading.

WINTER WHEAT
(*Triticum aestivum*)

Type of plant: Grass

Origin: Introduced

Lifespan: Annual

Season of major growth: Cool

Lower pH limit: 4.5

Planting materials: Seed

Seeding rate: 30 to 60 lb/acre in mixture, 80 to 120 lb/acre alone

Time of seeding: Fall

Superior cultivars: Consult local agricultural agencies for recommendations

Rate of establishment: Rapid

Major uses: Erosion control (quick, temporary cover), grain crop, wildlife habitat

Regions where adapted: All

Comments: Similar to rye in growth habit and adaptation to site and minesoil conditions. Can be used as a quick-cover companion crop with perennial species or can be sown alone to produce mulch in place. In some areas, used for quick cover and harvested for the grain crop. The stubble and straw residue after harvest provide soil cover until fall when perennial herbs can be sown or another crop of wheat planted and the grain-harvest cycle repeated. The straw residue adds organic matter to the minesoil, improving the minesoil for subsequent growth of perennial plants. Wheat grain is preferred over rye as food by most wildlife species. Recommendations on fall seeding dates and on best varieties should be obtained from local agricultural agents.

Table 17. Grass species of lesser importance or use.

Common and Scientific Name	Origin*	Lifespan†	Growth Season	Lower pH Limit	Seeding Rate‡ (lb/acre) PLS	Seeding Period
Bahiagrass *(Paspalum notatum)*	I	P	Warm	4.5	25-35; 35-45	Fall; spring
Comments: Adapted climatically to the Gulf Coast Area, so use in reclamation limited to Southern Lignite Region. Forms dense, tough sod even on sandy soils. Ideal species for erosion control and grassed waterways. Also used for pasture. Can be seeded most anytime of year but fall through spring best. Pensacola most common and most used variety.						
Highland bentgrass *(Agrostis tenuis)*	I	P	Cool	4.0-4.5	2-4; 3-6	Fall; spring
Comments: A variety of Colonial bentgrass naturalized in Northeastern States. Similar to and sometimes substituted for redtop in seeding mixtures. Value for reclamation is poorly documented because of limited use. Northern Appalachian Region.						
Canada bluegrass *(Poa compressa)*	I	P	Cool	4.5	5-10; 15-25	Spring; fall
Comments: Low-growing species similar to Kentucky bluegrass but better adapted to acid, infertile, and droughty soils. "Reubens" is a superior cultivar. Has potential as little-competing cover species in forestry land use. Northern Appalachian and northern part of Interior Regions.						
Kentucky bluegrass *(Poa pratensis)*	I	P	Cool	5.5	5-10; 15-25	Spring; fall
Comments: Low-growing, shallow-rooted sod-former. Not drought tolerant. Slow to establish cover and best adapted to well-drained topsoiled sites in northern latitudes. Can be used in Northern Appalachian and most of Interior Region. May have limited value for revegetating minesoils.						
Caucasian bluestem *(Bothriochloa caucasica)*	I	P	Warm	5.0	1-3; 3-6	Spring
Comments: Used for range, pasture, and hay in southern part of Western Interior Province and northern parts of Lignite Region. Performed well on mine spoils in western and eastern Kentucky. Has potential for use in much of East. Good seedling vigor. Can be sown with legumes such as Appalow or Serala sericea lespedeza, or birdsfoot trefoil for cover, pasture, or hay. Plains and WW-spar bluestems are similar and potentially useful on minesoils, at least in Oklahoma and Kansas.						
King Ranch bluestem *(Bothriochloa ischaemum)*	I	P	Warm	5.0	2-6	Spring
Comments: Use for range and pasture in lignite region and southernmost part of Western Interior Province (Oklahoma).						
Buffalograss *(Buchloe dactyloides)*	N	P	Warm	4.5	5-10; 10-20	Spring
Comments: Adapted to droughty minesoils. Low growing. Spreads by stolons. Mix with other native grasses for rangeland seedings. Slow to moderate establishment. Excellent forage. Used mostly in Kansas and Oklahoma.						
Corn *(Zea mays)*	N	A	Warm	5.5	See below	Mid-spring
Comments: Adapted varieties available for most parts of Eastern Coal Regions, but in mineland reclamation corn is an important crop mainly on replaced prime farmland soils in the cornbelt area of the Interior Region. Prior to PL 95-87, corn was successfully grown on "wheel spoils" in that area. Several years of alfalfa usually preceded planting of corn. Follow local agronomic guidelines for selecting varieties, seeding rates, and fertilizer needs.						
Dallisgrass *(Paspalum dilatatum)*	I	P	Warm	4.5	7-12	Spring
Comments: Bunchgrass that seldom makes full cover. Sow with legumes or other grasses. Good pasture. Seed used by song and game birds. Adapted to southern areas.						
Red fescue *(Festuca rubra)*	I	P	Cool	4.5	4-6; 8-10	Spring; fall
Comments: Long-lived in northern latitudes and high elevations. Adapted to most of Interior region. Fairly shade tolerant and low growth habit; suitable for ground cover with forest plantings. Capable of making dense cover, but somewhat slow in establishment. Several varieties available.						
Sideoats grama *(Bouteloua curtipendula)*	N	P	Warm	4.5	2-4	Spring
Comments: Sow in mixtures with other native grasses for rangeland. Establishes fairly quickly. Good forage. Native to most Eastern States. 'Elreno" is a superior cultivar. Used mostly in Kansas, Oklahoma, Missouri, and Texas.						
Browntop millet *(Brachiaria ramosa)*	I	A	Warm	4.5	15-20; 20-30	Late spring
Comments: Adapted to southern latitudes. For quick, temporary cover in summer seedings. Food for song and game birds. Used mostly in Oklahoma and throughout Southern Lignite Region.						
Tall oatgrass *(Arrhenatherum elatius)*	I	P	Cool	4.5	10-12; 15-20	Spring
Comments: Drought resistant. Moisture and temperature requirements similar to orchardgrass. Plants persist but not in dense stands. Limited seed supply due partly to harvesting difficulties. For Northern Appalachian and Interior Region except southwestern part. Tualatin is a superior cultivar used in mineland plantings in the East.						
Western wheatgrass *(Agropyron smithii)*	N	P	Cool	4.5	4-6; 10-20	Spring
Comments: Rhizomatous, sod-former spreads onto adjacent acid soils. Useful in clayey soils, moist swales, and grassed waterways. Used mostly in Kansas and Oklahoma. 'Barton' recommended cultivar.						

*I = Introduced; N = Native.
†A = Annual; P = Perennial.
‡First rate is recommended rate for use in mixtures; second rate for seeding alone. Use only in mixtures where one rate (range of rates) is shown.

FORBS-LEGUMES

ALFALFA
(*Medicago sativa*)

Type of plant: Forb-legume

Origin: Introduced

Lifespan: Perennial

Season of major growth: Cool

Lower pH limit: 5.5

Planting materials: Seed

Seeding rate: 4 to 12 lb/acre in mixtures, 10 to 18 lb/acre alone

Time of seeding: Spring, late summer

Superior cultivars: Consult local agricultural agencies for recommendations

Rate of establishment: Rapid to moderate

Major uses: Forage, erosion control, wildlife habitat

Regions where adapted: Northern Appalachian, Interior

Comments: This widely grown species is one of the most valuable forage plants in the United States. It thrives on fertile, nonacid, and well-drained soils. Use on mined lands has been mostly in areas where minesoils do not require additions of lime or fertilizer. Not recommended for acid minesoils unless the soils are limed to near neutrality (pH 7.0) and fertilized adequately with phosphorus. Use primarily on areas that will be managed for forage production or wildlife openings. Makes good pasture when mixed with orchardgrass, smooth bromegrass, or tall fescue. Although generally considered a cool-season species, with adequate precipitation or irrigation can make succulent growth in the summer as well as in spring and fall. Stands are subject to damage by alfalfa weevil and several diseases. Some varieties are not winter-hardy. Consult local agricultural authorities for advice on cultivars that are winter hardy and resistant to diseases and insects. In northern latitudes, stands usually are established more successfully by seeding in spring than in fall. Seldom grown in the deep South.

LADINO CLOVER
(*Trifolium repens*)
WHITE CLOVER
(*Trifolium repens*)

Type of plant: Forb-legume

Origin: Introduced

Lifespan: Perennial

Season of major growth: Cool

Lower pH limit: 5.5

Planting materials: Seed

Seeding rate: 2 to 4 lb/acre in mixtures

Time of seeding: Spring, late summer to fall

Superior cultivars: Ladino, Regal, Tillman

Rate of establishment: Moderate to rapid

Major uses: Wildlife habitat, forage

Regions where adapted: All

Comments: Common white clover is used for pasture throughout the eastern United States. However, on minesoils it is best used primarily to provide diversity in species composition, especially in food patches or openings planted for wildlife. Should be planted with grasses and other legumes. Planted alone, white clover provides inadequate ground cover during the winter. Due to peculiar growth and reproductive habits, there is no assurance of stand persistency from year to year. Although usually considered a perennial, much of the new growth each year may volunteer from seed. Ladino, a large form of white clover, is the most widely sown cultivar for use as hay and pasture.

RED CLOVER
(*Trifolium pratense*)

Type of plant: Forb-legume

Origin: Introduced

Lifespan: Biennial-perennial

Season of major growth: Cool

Lower pH limit: 5.0

Planting materials: Seed

Seeding rate: 4 to 8 lb/acre in mixtures, 8 to 12 lb/acre alone

Time of seeding: Spring, later summer

Superior cultivars: Kenland, Pennscott, Redland

Rate of establishment: Rapid

Major uses: Erosion control (short-term cover), wildlife habitat, forage

Regions where adapted: All except Southern Lignite and southern most part of Appalachain

Comments: One of most important hay crops grown on farms in the Northeastern States, and sometimes used for hay and pasture in Interior Coal Region. Its use on mined lands is primarily to improve or enrich the minesoil and to add to species diversity in food plantings for wildlife. Should be sown with long-lived grasses and legumes because it has a biennial or short-lived perennial growth habit. Although stands of red clover thin out, a few plants will continue to volunteer for several years from seed. Requires a high level of soil phosphorus. Less drought resistant than alfalfa and best adapted where adequate moisture is available throughout the growing season. Subject to damage and stand reduction by several diseases and insect pests. Seedings usually more successful in spring than in fall.

CROWNVETCH
(*Coronilla varia*)

Type of plant: Forb-legume

Origin: Introduced

Lifespan: Perennial

Season of major growth: Cool

Lower pH limit: 5.0 (see comments)

Planting materials: Seed; crowns

Seeding rate: 5 to 10 lb/acre in mixtures, 15 to 20 lb/acre alone

Time of seeding: Spring, late summer to early fall (plant crowns in spring to early summer)

Superior cultivars: Emerald, Penngift, Chemung

Rate of establishment: Slow

Major uses: Watershed protection (long-term cover), forage, esthetics

Regions where adapted: All

Comments: One of the best species for providing continuous, maintenance-free cover for erosion control. Plants are spread by seed and by rhizomes; thus, are especially useful for developing total cover on steep slopes. Usually established by direct seeding, though stands can be started by transplanting crowns (small plants) from older established stands. Seeded stands established most easily on minesoils with pH 5.5 and higher, but plants will spread and grow on minesoils with pH 4.5 and sometimes lower. Sow in mixture with a quick-cover companion grass such as weeping lovegrass or perennial ryegrass. A few plants of crownvetch established the first year are capable of developing full cover after 3 to 4 years and suppressing associated vegetation. May compete strongly with tree seedlings. Can be used for forage but stands may be weakened by overgrazing or by taking more than one cutting of hay annually. Seeds mature over a period of several weeks, making efficient and effective seed harvest difficult. Commercial seed is sometimes in short supply. Emerald most used cultivar in Interior Region; Penngift and Chemung in Appalachian Region.

FLATPEA
(*Lathyrus sylvestris*)

Type of plant: Forb-legume

Origin: Introduced

Lifespan: Perennial

Season of major growth: Warm

Lower pH limit: 4.0

Planting materials: Seed (needs special inoculum)

Seeding rate: 20 lb/acre in mixtures, 30 lb/acre alone

Time of seeding: Spring

Superior cultivars: Lathco

Rate of establishment: Slow

Major uses: Watershed protection (long-term cover)

Regions where adapted: Northern Appalachian and probably most of Interior

Comments: A long-lived viny species with tendril-bearing stems and a climbing growth habit. Stand density increases mostly by rhizomes. Stand development usually is slow but eventually a complete ground cover is established that suppresses associated vegetation and prevents establishment of volunteer plants. Should not be used in combination plantings with trees. Drought resistant and more tolerant than crownvetch and most other legumes of acid minesoils. Primary value is for erosion control on critical slope areas. Where given free choice to graze a number of grasses and legumes, cattle did not eat flatpea but horses did. This species may have greater use in revegetating abandoned than current mined lands. Experience with use in Interior Region is limited, but probably adapted to most of it.

COMMON LESPEDEZA
(*Lespedeza striata*)
KOBE LESPEDEZA
(*Lespedeza striata* var. Kobe)

Type of plant: Forb-legume

Origin: Introduced

Lifespan: Annual

Season of major growth: Warm

Lower pH limit: 4.5

Elevation limit: 2,000 ft at northern limits of range

Planting materials: Seed

Seeding rate: 8 to 15 lb/acre in mixtures, 25 to 30 lb/acre alone

Time of seeding: Spring

Superior cultivars: Kobe

Rate of establishment: Rapid to moderate

Major uses: Wildlife food, forage (hay and pasture), forestry (companion legume with trees)

Regions where adapted: Southern and Central Appalachian, Southern Lignite, southern part of Interior

Comments: Common lespedeza also called Japanese lespedeza, Japanese clover, and striate lespedeza. Has low-growth form and less productive of herbage than improved variety Kobe, which is the most widely used and most familiar cultivar of this lespedeza. Similar to Korean lespedeza in growth form but it matures later and is not adapted as far north. More tolerant than Korean of high levels of manganese in the soil. Reseeds readily in its adapted climatic range. Generally used for quickly establishing a legume in mixtures with grasses or with grasses and perennial legumes. Recommended as ground-cover species for use with pine in Southern Pine Region. Growth stops after first killing frost and cover value of plant residue diminishes as winter progresses.

KOREAN LESPEDEZA
(*Lespedeza stipulacea*)

Type of plant: Forb-legume

Origin: Introduced

Lifespan: Annual

Season of major growth: Warm

Lower pH limit: 5.0

Elevation limit: 2,000 ft in Northern Appalachians

Planting materials: Seed

Seed rate: 6 to 12 lb/acre in mixtures, 20 to 25 lb/acre alone

Time of seeding: Spring

Rate of establishment: Moderate to rapid

Major uses: Wildlife food, forage (hay and pasture), forestry (companion legume with trees), watershed (early cover)

Regions where adapted: All except as noted below

Comments: Reseeds readily in adapted climatic range; thus, it can be considered as a long-term component of vegetative cover. Provides early or quick legume component in spring-sown grass-legume mixtures. Plant residue provides poor ground cover in winter. More sensitive than sericea and Kobe lespedeza to excess soil manganese and soil acidity. Seed is preferred food by quail. Produces high-quality hay. Similar to Kobe lespedeza but has shorter growing season and can be used farther north. Generally not recommended for northern most parts of Appalachian and of Interior Regions. An early maturing variety, Iowa 6, has been used in northern part of Interior Region.

SERICEA LESPEDEZA
(*Lespedeza cuneata*)

Type of plant: Forb-legume

Origin: Introduced

Lifespan: Perennial

Season of major growth: Warm

Lower pH limit: 4.5

Elevation limit: 2,000 ft in Northern Appalachian

Planting materials: Seed

Seeding rate: Hulled and scarified seed—10 to 20 lb/acre in mixtures, increase rate by 10 to 15 lb/acre for unscarified or unhulled seed

Time of seeding: Late winter to early summer (If sown in midsummer to early fall, at least one-half of seed should be unhulled)

Superior cultivars: Interstate, Appalow (a low-growing form), Caricea, Serala

Rate of establishment: Slow

Major uses: Watershed protection (long-term cover), esthetics, forage

Regions where adapted: Central and Southern Appalachian, Lignite, southern third of Interior

Comments: Used widely for erosion control and soil building throughout the Central and Southern Appalachians and the South. Use in northern latitudes is limited by short growing season that prevents seed maturity. Stand establishment is relatively slow; thus, should be sown with a quick-cover grass such as weeping lovegrass. In mixture with grass, usually becomes the dominant species after 3 to 4 years. Usually forms dense stands that retard the natural invasion of other plants. Considered low in value for wildlife by most biologists. Can be used for grazing and cut for hay when forage is young and tender (plants should not be more than 10 to 12 inches tall for these uses). Benefits tree growth in combination plantings provided trees are able to grow above the lespedeza. Stands are weakened or eliminated when shaded by forest species. Provides long-term or permanent cover that requires little or no maintenance.

WHITE SWEETCLOVER
(*Melilotus alba*)
YELLOW SWEETCLOVER
(*Melilotus officinalis*)

Type of plant: Forb-legume

Origin: Introduced

Lifespan: Biennial

Season of major growth: Cool

Lower pH limit: 5.5

Planting materials: Seed (scarified)

Seeding rate: 4 to 7 lb/acre in mixture, 10 to 15 lb/acre alone

Time of seeding: Spring

Rate of establishment: Rapid

Major uses: Erosion control (quick cover)

Regions where adapted: All except as noted below

Comments: Generally considered intolerant of strongly acid soils, but resistant to drought. Often used in mixtures because it makes rapid growth and quickly provides a vegetative cover. On suitable soils may suppress slower growing companion perennial species, especially where its seeding rate is excessive. Plants mature the second year, produce seed, and die. New plants may volunteer from seed most years thereafter. A valuable plant for bee pasture (honey production). In agriculture, used primarily as a soil-improving crop. Can be used for hay and pasture, but livestock bloat is a potential hazard when grazed. Annual varieties of white sweetclover are available. Planting the yellow blossom type is recommended. Adapted and used in all regions except eastern part of Lignite Region.

BIRDSFOOT TREFOIL
(*Lotus corniculatus*)

Type of plant: Forb-legume

Origin: Introduced

Lifespan: Perennial

Season of major growth: Cool

Lower pH limit: 4.5

Planting materials: Seed

Seeding rate: 5 to 8 lb/acre in mixtures, 10 to 12 lb/acre alone

Time of seeding: Spring, late summer to early fall

Superior cultivars: Empire, Viking, Mansfield, Dawn, Fergus

Rate of establishment: Rapid to moderate

Major uses: Watershed protection (medium-term cover), forage

Regions where adapted: Northern Appalachian; Interior

Comments: This relatively low-growing legume, though adapted to most of the Interior Coal Region, grows best in the northern climates. Stands may be easily established near the southern limits of the adapted regions but life span of the plants usually is shorter than in northern climates. Has high tolerance to salt and higher tolerance than most legumes to excess manganese in minesoils. Plants are smaller, less aggressive, and inferior in cover qualities compared with those of crownvetch and sericea lespedeza. Most useful for erosion control and for forage where sown in mixture with a grass such as tall fescue, timothy, or orchardgrass. The cultivar Empire has a more decumbent growth and is more winter-hardy than Viking or Mansfield. Viking has better seedling vigor. Dawn is a disease-resistant cultivar selected in southern Missouri. Fergus is a recent release from Kentucky. Narrowleaf trefoil (var. *tenuifolium*) is a linear-leaved variant that has a more prostrate growth form than birdsfoot. Its performance is similar to that of birdsfoot on minesoils.

FORBS—NONLEGUMES

JAPANESE FLEECEFLOWER
(*Polygonum cuspidatum*)

Type of plant: Forb-nonlegume

Origin: Introduced

Lifespan: Perennial

Season of major growth: Warm

Lower pH limit: 3.5

Planting materials: Seed, crowns

Seeding rate: 3 to 5 lb/acre

Time of seeding: Spring

Superior cultivars: *v. compactum* (dwarf fleeceflower)

Rate of establishment: Slow

Major uses: Watershed protection, cover and food for wildlife, esthetics

Regions where adapted: Northern and Southern Appalachian, Interior

Comments: This escaped ornamental, also called Japanese Knotweed and Mexican bamboo, is a large, multistemmed, and heavily branched forb that grows up to 8 feet tall. It is sometimes called a shrub because the heavy robust stems give the plants a shrublike appearance. However, the stems die back to the ground each fall and new growth arises in the spring from root crowns and rhizomes. The plants produce an abundance of seed, and when in full bloom have a fleecy appearance. Will grow and spread on extremely acid minesoil. Some plants have been found growing on minesoil with a pH as low as 3.2. A good erosion control plant, especially for extremely acid spoils, because it spreads by seed into gullies and over considerable distances on barren areas. However, does not spread readily by seed into stands of established vegetation. May be more valuable for revegetating orphan mine lands than current mined ones. Dwarf fleeceflower is a low-growing variety (18 to 30 inches tall) used commercially as an ornamental ground cover. It is less acid tolerant than common fleeceflower. Probably adapted to most of eastern United States, but plantings not documented for minesoils in most of Interior and Lignite Regions.

Table 18. Forb species of lesser importance or use.

Common and Scientific Name	*Origin**	*Lifespan†*	*Growth Season*	*Lower pH Limit*	*Seeding Rate (lb/acre) PLS‡*	*Seeding Period*
		LEGUMES				
Illinois bundleflower *(Desmanthus illinoensis)*	N	P	Warm	5.0	1-5	Spring
Comments: Drought resistant. Use in range, pasture, and wildlife-habitat seeding mixtures. Component of native tall grass prairie. Used mostly in Kansas, Oklahoma, and Texas.						
Alsike clover *(Trifolium hybridum)*	I	B-P	Cool	5.0	3-5	Spring; fall
Comments: Short-lived (dies after 2 years). Adapted to wet soils and sites with overland flows and to soils too acid for red clover. Seed only in mixture with grass. For wet sites, mix with grass such as redtop and Ky-31 fescue. Provides food for wildlife. Better stands usually produced by spring seeding than by fall seeding. Adapted to northern part of Interior Region and Northern Appalachian Region.						
Arrowleaf clover *(Trifolium vesiculosum)*	I	A	Cool	5.0	10-15; 15-25	Fall
Comments: Winter annual for southern climates. Similar to crimson clover in use and adaptability. Reseeds. Amclo, Yuchi, and Meechi are recommended cultivars. Used in Southern Appalachian Region, Oklahoma, and throughout Lignite Region.						
Crimson clover *(Trifolium incarnatum)*	I	A	Cool	5.0	15-25; 25-35	Late summer; fall
Comments: Winter annual used in southern climates. Usually mix with perennials. Can be used alone for winter cover, then sow perennial species the next spring, especially for agricultural uses. Good forage species and has value for wildlife. Reseeding varieties preferred.						
Kura clover *(Trifolium ambiguum)*	I	P	Cool	5.0	6-8; 8-12	Spring; fall
Comments: Slow to establish. Spreads by rhizomes, forms a sod. Drought resistant, also tolerates wet soils. Requires special inoculum. Evaluation of this species in early stage, so seed supply scarce and uncertain. Probably adapted to all regions.						
Subterranean clover *(Trifolium subterraneum)*	I	A	Cool	5.0	15-25; 25-35	Fall
Comments: Reseeding winter annual for eastern part of Lignite Region. Use similar to crimson clover.						
Cowpea *(Vigna unguiculata)*	I	A	Warm	4.5	20-30	Late spring
Comments: Use mainly for summer cover and wildlife food. Provides little residue for winter cover. Mix with sorghum or Sudangrass for overwinter *in situ* mulch. Soil-building and forage crop in agricultural land uses. For Southern Appalachian and Lignite Regions and southern half of Interior Region.						
Prostrate lespedeza *(Lespedeza daurica* var. *schimadai)*	I	P	Warm	4.5	15-20	Spring
Comments: Similar to sericea, but low growing. Potential ground cover species to plant with trees. Not used widely. Probably adapted to most of Interior Region.						
Cicer milkvetch *(Astragalus cicer)*	I	P	Cool	5.0	2-5; 15-20	Spring
Comments: Long-lived legume for dryland conditions. Spreads slowly by rhizomes. Used in Kansas in pasture and range seedings.						
Partridge Pea *(Cassia fasciculata)*	N	A	Warm	5.0	20-30	Spring
Comments: Reseeds, usually in sparse stands. Mainly for wildlife enhancement and esthetics. Choice food for some game bird species. Use in mixtures with grass. Native to all Eastern States, use in all regions.						
Purple prairie clover *(Petalostemum purpureum)*	N	P	Warm		1-3	Spring
Comments: Component of tall grass prairie. For use mainly in seed mixtures of prairie grasses for rangeland and esthetic purposes, from Iowa to Texas. Superior cultivar 'Kaneb.'						
Soybean *(Glycine max)*	I	A	Warm	5.0	30-50	Late spring
Comments: For quick cover in early summer and for wildlife food. Provides little residue for winter cover. Sow with quick cover grasses such as sorghums for overwinter *in situ* mulch. Cash crop on reconstructed prime farmland. Adapted to Interior, Lignite, and Southern Appalachian Regions.						
Bigflower vetch *(Vicia grandiflora)*	I	A	Cool	5.5	15-20	Fall
Comments: Winter annual, similar in appearance to hairy vetch. Can be established by seeding into existing stands of grass. Reseeds itself. Improves nitrogen status of soil. Used for forage and wildlife food and cover. 'Woodford" superior cultivar. Appalachian Regions.						
Hairy vetch *(Vicia villosa)*	I	A	Cool	4.5	20-30; 40-50	Fall
Comments: Winter annual used mainly for erosion control and soil building. Mix with perennial grass such as KY-31 fescue, or sow with rye for overwinter cover, then seed perennials the next year. May have some value for wildlife. Used in all regions.						

Table 18. Forb species of lesser importance or use.

Common and Scientific Name	Origin*	Lifespan†	Growth Season	Lower pH Limit	Seeding Rate (lb/acre) PLS‡	Seeding Period
NONLEGUMES						
Buckwheat *(Fagopyrum esculentum)*	I	A	Warm	4.5	25-40	Late spring
Comments: Used mainly in Northern Appalachian Region. Mix with other summer annual species to provide diversity in fall and winter foods for song and game birds. Can make late summer cover but plant residue makes poor *in situ* mulch over winter. Excellent bee pasture and visually appealing when in full bloom.						
Common sunflower *(Helianthus annuus)*	N	A	Warm	5.0	6-8	Late spring
Comments: Mix with other summer annual species to provide diversity in fall and winter food for song and game birds. Should not be used alone for cover. Potential use in all regions.						
Maximilian sunflower *(Helianthus maximiliani)*	N	P	Warm	5.0	2-4	Spring
Comments: For use in seed mixtures for rangeland seedings and esthetic purposes in prairie areas from Iowa to Texas. Established successfully with native grasses on reclaimed abandoned spoils in Kansas. Superior cultivars are 'Prairie Gold' and 'Aztec.'						
'Eureka' thickspike gayfeather *(Liatris pycnostachya)*	N	P	Warm		1-3	Spring
'Sunglow' Grayhead prairie coneflower *(Ratibida columnifera* var.)	N	P	Warm		1-3	Spring
'Nekan' Pitcher sage *(Salvia azurea* var *grandiflora)*	N	P	Warm		1-3	Spring
Comments: These three forbs are components of native tall grass prairie. Used mainly in seed mixtures with prairie grasses for rangeland and esthetic purposes in prairie areas from Iowa to Texas. Species utilized by livestock and wildlife.						

* I = Introduced; N = Native.
† A = Annual; P = Perennial; B = Biennial.
‡ First rate is recommended rate for mixtures; second rate for seeding alone. Use only in mixtures where one rate (range of rates) is shown.

GRAY DOGWOOD
(*Cornus racemosa*)
SILKY DOGWOOD
(*Cornus Amomum*)
RED-OSIER DOGWOOD
(*Cornus stolonifera*)

Type of plant: Shrub
Shade tolerance: Silky—Tolerant
Gray—Intermediate
Red-osier—Intermediate

Origin: Native

Lower pH limit: Silky—4.0
Gray—5.0
Red-osier—4.5

Planting materials: Seedlings (1-0)

Major uses: Wildlife food and cover

Regions where adapted: Appalachian, Interior, see note below

Comments: All dogwoods are excellent species for wildlife. The fruit is used by many species of birds and mammals, and the plants provide browse for deer. Silky dogwood has been tested and used more than the others. Tolerates acid conditions better than gray or red-osier dogwoods. Red-osier best suited for moist sites, such as seepage areas and along ponds. Its dense root system provides protection against overland flow. All three species produce fruit in 3 to 5 years. Silky dogwood established successfully by direct seeding. Not tested throughout Interior and Lignite Regions, so extent of use not known.

AMUR HONEYSUCKLE
(*Lonicera maackii*)
MORROW HONEYSUCKLE
(*Lonicera morrowii*)
TATARIAN HONEYSUCKLE
(*Lonicera tatarica*)

Type of plant: Shrub
Intermediate tolerance to shade

Origin: Introduced

Lower pH limit: 5.0

Planting materials: Seedlings (1-0, 2-0)

Superior cultivars: 'Rem Red' and 'Cling red' amur honeysuckle

Major uses: Wildlife food and cover, esthetics and screening

Regions where adapted: All, see note below

Comments: These shrubs, planted in combinations with other woody species, add to the diversity in food and cover for wildlife. Plant growth is slow for the first 2 years and seedlings may be adversely affected by tall herbaceous competition. There is little difference in performance among species, except in date of fruit maturity and geographic adaptability. 'Rem Red' amur and tatarian are adapted over most of the eastern regions. Morrow honeysuckle has been more successful in southern Appalachia. Fruit of Morrow and tatarian matures in June to August and falls from the plant soon after maturing. Fruit of 'Rem Red' amur honeysuckle matures in September to November and may remain on the plant well into winter. Planting some of all species lengthens the time that they supply food to wildlife. Direct seeding has been unsuccessful, but regeneration and spread of plants to adjacent areas does occur from seed disseminated by birds. These species initiate spring growth earlier than most other shrubs; thus, freshly dug nursery seedlings already may be growing and be susceptible to heat damage while in transit or awaiting planting.

INDIGOBUSH
(*Amorpha fruticosa*)

Type of plant: Shrub-legume
(Nitrogen-fixer)
Intermediate tolerance to shade

Origin: Native

Lower pH limit: 4.0

Elevation limit: Not above 3,000 feet

Planting materials: Seedlings (1-0), seed

Seeding rate: ½ to 1 lb/acre (seed in pods)

Time of seeding: Spring, fall, winter

Major uses: Wildlife food and cover, watershed protection

Regions where adapted: All

Comments: This woody legume is native east of the Mississippi River but has been used mostly in the Appalachian Coal Region. Plants normally grow 8 to 10 feet tall on minesoils. Similar to sumacs in growth form and appearance. Establishment usually good but plant growth fairly slow; plants may average about 2 feet in height after three growing seasons. Plants of indigobush are a good site conditioner for the invasion of other native species; they often support a lush herbaceous understory due to nitrogen-fixing capability. Unwanted spreading from seed apparently is not a problem even where annual seed production is heavy. Fruit normally ripens in August. For direct seeding, seed in pods usually are sown. Because the seeds have an impermeable seed coat and high percentage of dormant seed, germination of some of the seed will be delayed for 2 to 3 years after sowing. Special inoculum is available, but inoculating seed has not been necessary for successful establishment.

JAPAN LESPEDEZA
(*Lespedeza japonica*)
SHRUB LESPEDEZA
(*Lespedeza bicolor*)
THUNBERG LESPEDEZA
(*Lespedeza thunbergii*)

Type of plant: Shrub-legume
(Nitrogen-fixer)
Intolerant to shade

Origin: Introduced

Lower pH limit: 4.5

Elevation limit: Not above 2,500 feet

Planting materials: Seedlings (1-0), seed (scarified)

Seeding rate: 1 to 3 lb/acre

Time of seeding: Spring, late winter

Superior cultivars: 'Natob' bicolor

Major uses: Wildlife food and cover, esthetics and screening

Regions where adapted: All except northern climates

Comments: The shrub lespedezas have been extensively planted throughout the South and Southeast for wildlife food and cover; the seeds are valuable food for quail and rabbits bark the stems in winter. Mature plants are 4 to 10 feet tall. Plants in full bloom are esthetically attractive and attract honey bees. Establishment usually is most rapid and assured with planted seedlings, but also is accomplished by direct seeding. Normally, seed is mixed and sown with herbaceous species; establishment of the shrub lespedeza plants may not be obvious until the second growing season. Use standard lespedeza inoculum on seed. The classification of shrub lespedeza is difficult and confused because of hybridization among species and variants of species. Common *L. bicolor* is the most abundant and widely planted. Some taxonomic authorities consider *L. japonica* as a variant of *L. thunbergii*. 'Natob' *L. bicolor* matures seed earlier and is more winter-hardy than other cultivars of shrub lespedeza grown in the United States; it has been grown as far north as Pennsylvania and recommended for higher elevations in Central and Southern Appalachia. Seed supplies of pure species and cultivars are scarce or nonexistent.

BRISTLY LOCUST
(*Robinia fertilis*)
ROSE-ACACIA LOCUST
(*Robinia hispida*)

Type of plant: Shrub-legume
(Nitrogen-fixer)
Intolerant to shade

Origin: Native

Lower pH limit: 3.5

Planting materials: Seedlings (1-0), seed (scarified, special inoculum)

Seeding rate: 2 to 5 lb/acre

Time of seeding: Spring, fall, winter

Superior cultivars: 'Arnot' Bristly Locust

Major uses: Erosion control, wildlife cover and food

Regions where adapted: All, see note below

Comments: Bristly locust is one of the best species for erosion control on extremely acid minesoils. The plants spread primarily from root suckers that begin to form during the first growing season. Dense thickets form even on eroded sites because root suckering is stimulated where the roots are exposed by erosion. Evidence of becoming a "pest" plant is not apparent even where stands are 12 to 15 years old. Root suckering is retarded or will not occur in well-sodded areas. Usually established by planting 1-year-old seedlings at 6- by 6-foot spacing, but can also be direct seeded. Seeds must be scarified before planting. Plants grow to a height of 8 to 10 feet in about 5 years. Dense thickets of this species provide cover for wildlife. Rose-acacia locust (*Robinia hispida*) is similar to bristly locust in appearance and growth habit and has the same usefulness for vegetating surface mines. Adaptation in Southern Lignite and southwestern part of Interior is uncertain.

AUTUMN OLIVE
(*Elaeagnus umbellata*)

Type of plant: Shrub
(Nitrogen-fixer)
Intermediate tolerance to shade

Origin: Introduced

Lower pH limit: 4.0

Planting materials: Seedlings (1-0)

Superior cultivars: 'Cardinal'

Major uses: Wildlife food and cover, watershed protection, esthetics and screening

Regions where adapted: All

Comments: This nonleguminous species is adapted in all of the eastern coal regions; easily established on a wide range of minesoil types and conditions. Initial survival and growth usually good even where planted in an established cover of herbaceous vegetation. Growth of adjacent plants and understory grasses enhanced by its nitrogen-fixing capability. Has been used as a nurse plant with crop trees. Plants often grow to height of about 20 feet. After 3 to 4 years, they begin producing abundant fruit that is used in the fall and winter by birds and mammals. Plants also provide browse for deer. Direct seeding on minesoils usually unsuccessful but plants can be spread by dissemination of seed by birds. Has potential to become a "pest" plant and planting it has been banned in some areas. The cultivar 'Cardinal" was selected for its high fruit yield and long retention of fruit on the plant. Other shrubby species of *Elaeagnus* have been tried in some Appalachian States. Cherry olive (*E. multiflora*) and thorny olive (*E. pungens*) performed nearly as well as autumn olive on acid spoil.

FRAGRANT SUMAC
(*Rhus aromatica*)
SHINING SUMAC
(*Rhus copallina*)

Type of plant: Shrub
Shade tolerance: Shining—Intermediate
Fragrant—Tolerant

Origin: Native

Lower pH limit: Shining—4.0
Fragrant—4.5

Planting materials: Seedlings (1-0, 2-0), rooted cuttings

Major uses: Wildlife food and cover, esthetics

Regions where adapted: All

Comments: The sumacs are native to the eastern United States. They have not been tested on surface mines in all of the coal regions, but often volunteer on minesoils that are several years old; chances for success of planted seedlings seem promising. Shining sumac has shown the best growth characteristics in test plantings and spreads by seed and root suckers. Smooth sumac (*R. glabra*) and staghorn sumac (*R. typhina*) also show promise but were not tested as much as shining and fragrant sumacs. Suggested use is for wildlife plantings in blocks of 100 to 200 plants spaced 4 to 5 feet apart. Sumac often volunteers on abandoned spoils and is considered a pest in some agricultural land uses.

VIBURNUM
(*Viburnum* spp.)

Type of plant: Shrub

Shade tolerance: Varies by species; most are tolerant, a few intermediate.

Origin: Native

Lower pH limit: 4.0

Planting materials: Seedlings (1-0 or 2-0), rooted cuttings

Major Uses: Wildlife food and cover

Regions where adapted: All

Comments: The characteristics of viburnums make them an important genera for wildlife habitat. The dense growth form of many species provides good nesting or escape cover for small birds and mammals. Fruits are eaten by numerous birds and mammals, and the twigs, bark, and leaves are eaten by deer, rabbits, and beaver. *Viburnum dentatum*, arrowwood, has the widest distribution. Planting stock of this species would most likely be available throughout the coal regions. Other species should not be overlooked. Hobble bush, *V. alnifolium*, mapleleaf viburnum, *V. acerifolium*, and nanny berry, *V. lentago*, are more tolerant than arrowwood of acid soils. Species adapted to dry sites include withe-rod, *V. cassinoides*, and mapleleaf viburnum. Local experience and seedling availability will be the major factors influencing the use of viburnums.

Table 19. Shrub species of lesser importance or use.

Common and Scientific Name	*Origin**	*Lower pH Limit*	*Major Uses†*
Blueberry (*Vaccinium* spp.)	N	4.0	H, O
Comments: Planted successfully in several areas in Appalachian Region. Grows slowly but not a hindrance to planting as cash crop. Species and varieties adapted to the local area should be selected. In wildlife plantings, provides both food and cover. Only horticultural varieties available commercially.			
Silver buffaloberry (*Shepherdia argentea*)	N	4.0	H, W
Comments: Thorny shrub 6 to 10 feet tall. Fixes nitrogen. Growth similar to that of autumn olive, but no spreading by seed noted. Field plant 2-0 seedlings. Northern Appalachian Region.			
Chokecherry (*Prunus virginiana*)	N	5.0	H
Comments: Tall shrub, 8 to 18 feet, widely adaptable. Excellent food and cover plant for wildlife. Spreads from root sprouts. Established easily from 1-0 seedlings. Potential use in all regions.			
American elder (*Sambucus canadensis*)	N	5.0	H, E
Comments: Excellent food and cover plant for wildlife, especially songbirds. Establish with 1-0 seedlings. Test plantings on mined lands are few. Potential use in all regions.			
Grape (*Vitis spp.*)	N	4.5	H, O
Comments: Grapevines can be used as component of wildlife plantings or in pure plantings to establish vineyards. Fox grape, *Vitis labrusca*, is native to the Appalachian Region and is important wildlife food. Cultivated varieties of *V. labrusca* are major component of grape culture in the Appalachian Region. Use on reclaimed land has been limited.			
Hawthorn (*Crateagus* spp.)	N	5.5	H, E
Comments: Tall shrubs; there are many hybrids and varieties. Washington hawthorn, *C. phaenopyrum*, is the most widely used and available. Field plant 1-0 seedlings. Intolerant. Potential use in all regions.			
Japanese honeysuckle (*Lonicera japonica*)	I	4.5	H
Comments: Naturalized in all eastern States. Seldom planted but often present due to natural invasion. Excellent species for wildlife habitat but can become a pest in agricultural and forestry land uses. Retains green foliage in winter. 'Halls" improved cultivar. Tolerant.			
Amur privet (*Ligustrum amurense*)	I	4.5	H, E
Comments: Naturalized in southeastern United States. Medium-size shrub. Field plant 1-0 or 2-0 seedlings. Tolerant. Successful on several minesoil plantings in Appalachian Region. Probably adapted to most of Interior and Lignite Regions.			
American plum (*Prunus americana*)	N	5.0	H, E
Comments: Recommended for wildlife plantings in most of Interior and Lignite Regions. Large shrub or small tree.			
Rugosa rose (*Rosa rugosa*)	I	5.0	H, E
Comments: Excellent food and cover plant for wildlife; survival and growth on minesoil plantings in Appalachian Region were less than desired. Intolerant.			
Western sandcherry (*Prunus besseyi*)	N	4.0	H
Comments: A 3- to 6-foot bushy shrub good for wildlife cover and food. Produces fruit in 2 to 3 years. Plant 1-0 seedings. Successful on minesoil plantings in Central and Southern Appalachian Region and southeastern Interior Region.			
Purpleosier willow (*Salix purpurea*)	I	5.0	W, H
Comments: Useful along ponds, seepage areas. Grows best in pH range 5.0 to 6.0. Adapted in most of eastern coal regions.			

*I = Introduced; N = Native.

†H = Habitat (food and cover) for wildlife; E = Esthetics and screening; W = Watershed protection (erosion control); O = Other horticulture land uses.

JAPANESE LARCH
(*Larix leptolepis*)

Type of plant: Tree-conifer
Size: Medium
Intolerant to shade

Origin: Introduced

Lower pH limit: 4.0 to 4.5

Elevation limit: Not below 3,000 feet in West Virginia

Planting materials: Seedlings (1-0, 2-0)

Major uses: Forest products (posts, mine props, and lumber), esthetics and screening

Regions where adapted: Northern Appalachian

Comments: This deciduous conifer has been used mostly in Pennsylvania and higher elevations of West Virginia. Growth is more rapid than for other conifers. However, growth rate is greatly reduced on leveled, compacted minesoils. Annual needle fall produces more ground cover than most conifers. Superior to European larch in survival, growth rate, and form. Larch initiates growth early in the spring, sometimes before seedlings can be dug in the nursery, so care should be exercised during shipment and storage to prevent heating and subsequent mortality of the seedlings.

Growth Performance: 5.4 inches dbh and 31 feet tall, averaged at three 30-year-old plantations in Pennsylvania.

EASTERN WHITE PINE
(*Pinus strobus*)

Type of plant: Tree-conifer
Size: Large
Tolerant to intermediate tolerance to shade

Origin: Native

Lower pH limit: 4.0

Planting materials: Seedlings (2-0, 3-0)

Major uses: Forest products (lumber), wildlife food and cover, Christmas trees, esthetics and screening

Regions where adapted: Northern and Central Appalachians, Interior except southwestern part

Comments: Widely planted, desirable timber species for moderately acid mine spoils. More adapted than most pine species to higher pH spoils. Growth for first few years after planting is notoriously slow but can be very fast after reaching the sapling stage. More shade tolerant and, thus, better suited than other pines for mixed plantings. Natural range is Northern and Northeastern States and Appalachian Mountains. Seedlings from North Carolina seed source should be planted south of 39th parallel. Use northern seed sources above this latitude.

Growth performance:

Location	No. Test Sites	Age (years)	Percent Survival	Dbh (inches)	Height (feet)	Basal Area (ft^2/acre)
Illinois, Indiana	11	30	10	5.1	—	13
Ohio	7	30	26	8.0	42	81
Pennsylvania	2	30	*	6.1	27	—

*39 percent survival at age 10 (16 sites).

LOBLOLLY PINE
(*Pinus taeda*)

Type of plant: Tree-conifer
Size: Large
Intermediate tolerance to shade

Origin: Native

Lower pH limit: 4.0

Elevation limit: Not above 2,500 feet

Planting materials: Seedlings (1-0), seed (stratified, bird and rodent repellent)

Seeding rate: 1 to 1½ lb/acre

Time of seeding: Spring (stratified seed), late fall-early winter (unstratified seed)

Major uses: Forest products (pulp, poles, lumber), esthetics and screening, wildlife cover and food

Regions where adapted: Southern and Central Appalachian, southern part of Interior, Lignite

Comments: Fast-growing southern pine adapted to wide range of minesoil types. Natural range is southward from central Arkansas and southern Tennessee, yet often planted and usually thrives several hundred miles north of this range. However, natural reproduction and success of direct seeding diminishes outside of natural range. Trees are vulnerable to damage from ice and heavy snow and cannot withstand prolonged periods of subzero temperatures. Only ecotypes from the northern part of its natural range should be used in the northern-most plantings. Growth rate of loblolly can be improved by planting with a legume such as Kobe, Korean, or sericea lespedeza, or by planting in alternate rows with European alder.

Growth performance:

Location	No. Test Sites	Age (years)	Percent Survival	Dbh (inches)	Height (feet)	Basal Area (ft^2/acre)
Mo., Kans., Okla.	8	30	21	9.8	43	98
Illinois, Indiana	11	30	15	7.6	—	42
Western Kentucky	1	20	28	5.0	37	34
Tennessee Valley	19	8 to 22	—	5.4	34	—
Eastern Kentucky	1	10	52	3.9	21	38
Eastern Kentucky	1	18	—	9.2	50	190

PITCH PINE
(*Pinus rigida*)

Type of plant: Tree-conifer
Size: Medium
Intolerant to shade

Origin: Native

Lower pH limit: 4.0

Elevation limit: Not above 3,000 feet

Planting materials: Seedlings (1-0)

Major uses: Esthetics and screening, wildlife cover and food, forest products (pulp and lumber)

Regions where adapted: Appalachian

Comments: Similar to Virginia pine in adaptation, site requirements, and uses. Has better esthetic and wood qualities than Virginia pine. Especially useful for extremely acid and relatively dry sites that are not suitable for more valuable tree species. Often planted in mixtures with other pines, but normally not with hardwoods. Poor survival in most test plantings in Interior Region.

Growth performance:

Location	No. Test Sites	Age (years)	Percent Survival	Dbh (inches)	Height (feet)	Basal Area (ft^2/acre)
Missouri	4	30	1	7.6	25	1
Kansas	4	30	16	6.6	31	34
Illinois, Indiana	11	30	6	5.3	—	8
Ohio	1	30	34	6.5	37	70
Eastern Kentucky	1	10	93	3.4	16	52
Eastern Kentucky	1	18	—	5.6	35	142
Western Kentucky	1	20	25	5.4	30	35
Pennsylvania	4	30	*	4.7	23	—

* 36 percent survival at age 10 (18 sites).

RED PINE
(*Pinus resinosa*)

Type of plant: Tree-conifer
Size: Medium
Intermediate tolerance to shade

Origin: Native

Lower pH limit: 4.0 to 4.5

Elevation limit: Not below 2,200 feet in West Virginia

Planting materials: Seedlings (2-0, 3-0)

Major uses: Forest products (pulp, poles and lumber), esthetics and screening, wildlife cover and food, Christmas trees

Regions where adapted: Northern Appalachian

Comments: An attractive tree that has performed well on a variety of minesoils, especially in the Northern Appalachian Region. Highly susceptible to European pine shoot moth, it should not be planted in areas that have a high incidence of this insect. Can be used for Christmas trees and is excellent for screening. Has been successful in alternate row plantings with hybrid poplar in Pennsylvania. Natural range is northernmost States.

Growth performance:

Location	No. Test Sites	Age (years)	Percent Survival	Dbh (inches)	Height (feet)	Basal Area (ft^2/acre)
Illinois, Indiana	11	30	8	4.3	—	7
Ohio	6	30	20	7.2	36	50
Pennsylvania	2	30	*	7.3	29	—

*49 percent survival at age 10 (8 sites).

SCOTCH PINE
(*Pinus sylvestris*)

Type of plant: Tree-conifer
Size: Medium
Intolerant to shade

Origin: Introduced

Lower pH limit: 4.0

Planting materials: Seedlings (2-0, 3-0)

Seedling spacing: 5 × 5 feet or 6 × 6 feet (for Christmas trees)

Major uses: Christmas trees, esthetics and screening, wildlife cover and food, forest products (pulp and lumber)

Regions where adapted: Appalachian, Interior (except southwestern most part)

Comments: Most widely planted introduced tree species in the United States. It is the pine with the greatest natural range and it grows in many different ecological situations. Sources differ in many characteristics, such as seed size, tree color, form and susceptibility to heat, cold, and drought. Planted widely for Christmas trees both on and off mined sites. Seed source is important because some Scotch pine turn yellow in the fall. Has been used in reforestation but has reputation for crooked stem. Choice of seed source is important to avoid this characteristic. Not recommended for use in Southern Lignite Region.

SHORTLEAF PINE
(*Pinus echinata*)

Type of plant: Tree-conifer
Size: Medium
Intermediate tolerance to shade

Origin: Native

Lower pH limit: 4.5

Planting materials: seedlings (1-0, 2-0), seed (stratified, insect and rodent repellent)

Seeding rate: ½ to 1 lb/acre

Time of seeding: Spring (stratified seed), late fall-early winter (unstratified seed)

Major uses: Forest products (pulp, poles, mine timbers, building materials), wildlife cover and food, esthetics and screening

Regions where adapted: Southern and Central Appalachians, southern part of Interior, Lignite

Comments: Adapted to variety of mined sites, but not recommended in minesoils above pH 6.0. Often competes poorly where interplanted with hardwood species that will overtop it. Generally should be planted in pure stands or can be mixed with other pines. Growth was increased where interplanted with European alder. Young trees often subject to damage by pine tip moth, but usually recover. Natural range similar to loblolly pine.

Growth performance:

Location	No. Test Sites	Age (years)	Percent Survival	Dbh (inches)	Height (feet)	Basal Area (ft²/acre)
Mo., Kans., Okla.	8	29	23	6.6	33	49
Illinois, Indiana	11	30	6	5.0	—	7
Ohio	1	30	11	5.1	34	14
Indiana	1	35	—	8.1	50	190
Tennessee Valley	13	14 to 25	—	3.9	29	—
Eastern Kentucky	1	10	75	3.7	19	50

VIRGINIA PINE
(*Pinus virginiana*)

Type of plant: Tree-conifer
Size: Small
Intolerant to shade

Origin: Native

Lower pH limit: 3.5 to 4.0

Elevation limit: Not above 2,500 feet in West Virginia

Planting materials: Seedlings (1-0), seed (stratified, insect and rodent repellent)

Seeding rate: ¼ to ½ lb/acre

Time of seeding: Spring (stratified seed), late fall-early winter (unstratified seed)

Major uses: Esthetics and screening, wildlife cover and food, forest products (pulp), Christmas trees

Regions where adapted: Appalachian, Interior

Comments: Planted widely on minesoils throughout the eastern United States, even in the Interior Coal Region which is outside its natural range. Adapted to wide range of minesoil types and especially useful for vegetating acid and droughty sites. Within its natural range, often a pioneer species on minesoils and other disturbed lands. Direct seeding sometimes successful, but chances of success are less than for planting nursery seedlings. Valuable for wildlife cover and food, especially when planted in blocks or strips that alternate with herbaceous and other woody species. Use identified seed sources for Christmas tree plantings.

Growth performance:

Location	No. Test Sites	Age (years)	Percent Survival	Dbh (inches)	Height (feet)	Basal Area (ft²/acre)
Mo., Kans., Okla.	8	30	20	6.5	30	41
Illinois, Indiana	11	30	11	7.0	—	26
Western Kentucky	1	20	27	5.3	30	37
Tennessee Valley	3	12	—	3.9	25	—
Eastern Kentucky	2	10	84	3.4	20	47
Eastern Kentucky	1	18	—	6.0	43	221

EASTERN REDCEDAR
(*Juniperus virginiana*)

Type of Plant: Tree-conifer
Size: Small
Intolerant to shade

Origin: Native

Lower pH limit: 5.0

Planting materials: Seedlings (1-0, 2-0)

Major uses: Wildlife cover and food, esthetics and screening, forest products (fenceposts, Christmas trees)

Regions where adapted: Interior, Southern Lignite

Comments: Commonly believed to be associated primarily with limestone-derived soils, performs best on calcareous and mildly acid minesoils. However, soil acidity may be no more critical than other soil conditions or the presence of competing woody vegetation. In Illinois, appeared suited for most mined-land conditions except those with unstable sandy surfaces. Trees in 30-year-old plantings were being shaded out by planted and volunteer hardwoods. Probably best suited for use in Western Interior and Lignite Regions. Spreads by seed. Limit or avoid use where spreading may interfere with proposed land use.

Growth performance:

Location	No. Test Sites	Age (years)	Percent Survival	Dbh (inches)	Height (feet)	Basal Area (ft^2/acre)
Mo., Kans., Okla.	9	30	22	5.0	27	27
Illinois, Indiana	11	30	22	4.4	—	21
Iowa	3	8	39	—	5	—

NORWAY SPRUCE
(*Picea abies*)
WHITE SPRUCE
(*Picea glauca*)

Type of plant: Tree-conifer
Size: White—Medium
Norway—Large
Tolerant to shade

Origin: White—Native
Norway—Introduced

Lower pH limit: 4.5 to 5.0

Elevation limit: Not below 2,500 feet in West Virginia and eastern Kentucky

Planting materials: Seedlings (2-0, 3-0)

Major uses: Wildlife cover and food, esthetics and screening, forest products (pulp, musical instruments, and lumber), Christmas trees

Regions where adapted: Northern Appalachian

Comments: Spruce occur naturally in northern temperate regions. Use is recommended primarily in the northern Appalachians and at the higher elevations of the central Appalachians. Because they are less adapted than pines to dry, low-fertility sites, spruce should be planted on better quality minesoil and on cool, moist sites. Growth is slow for the first few years, but growth rate usually increases after this period. Because they are shade tolerant, spruce persist at a reduced growth rate in the understory of other woody species. In West Virginia, the growth of spruce interplanted with autumn olive was very slow for the first 3 to 4 years, but by age 10 the spruce were matching or exceeding the height of the autumn olive. Spruce are valuable for providing winter shelter for some species of wildlife and they are widely used for shelterbelts, screening, and esthetic purposes.

EUROPEAN BLACK ALDER
(*Alnus glutinosa*)

Type of plant: Tree-hardwood
(Nitrogen-fixer)
Size: Medium
Intolerant to shade

Origin: Introduced

Lower pH limit: 3.5 to 4.0

Planting materials: Seedlings (1-0)

Major uses: Esthetics and screening, forestry (nurse tree, site improvement, and pulp), wildlife cover and food

Regions where adapted: Northern and Central Appalachian, Interior except southern-most part

Comments: Nitrogen-fixing (nonlegume) tree adapted to wide range of minesoil types except droughty situations. Good early survival and rapid growth in most areas. Especially valuable on acid minesoils in cooler climates. Alder plantings have persisted for more than 20 years in northern regions, but in eastern Kentucky began to die back at 10 years. Longevity in southern climates uncertain. Growth rate of hardwoods and pines can be increased by interplanting with black alder; plant alder in every other row or every third row.

CRAB APPLE
(*Malus* spp.)

Type of plant: Tree (or large shrub)-hardwood
Size: Small
Intolerant to shade

Origin: Introduced

Lower pH limit: 4.5

Planting materials: Seedlings (1-0)

Major uses: Wildlife food and cover, esthetics

Regions where adapted: Appalachian, Interior

Comments: Classified as a shrub in some literature. Several introduced species and horticultural varieties have been established successfully, including Siberian crab apple (*M. baccata*), Japanese flowering crab apple (*M. floribunda*), tea crab apple (*M. hupehensis*), toringo crab apple (*M. sieboldii*), and others not identified. These have been tested on numerous sites mostly in the Appalachian Region but probably are adapted in most of the coal-mining States. Highly successful for revegetating abandoned spoils in Tennessee. Planted primarily for wildlife habitat and esthetic purposes. Usually produces an abundant crop of fruit. Recommend planting in small scattered blocks or on a 20- by 20-foot spacing over larger areas. Seedlings are especially susceptible to deer browsing and rodent damage.

GREEN ASH
(*Fraxinus pennsylvanica*)

Type of plant: Tree-hardwood
Size: Medium
Intermediate tolerance to shade

Origin: Native

Lower pH limit: 4.0

Elevation limit: Not above 2,500 feet

Planting materials: Seedlings (1-0)

Major uses: Wildlife food and cover, forest products (pulp, tool handles, and baseball bats)

Regions where adapted: All

Comments: Has been planted widely on surface mines and has consistently provided good initial and long-term survival. But growth generally has been poor compared with most other hardwood species. Best growth is on moist sites in minesoils containing a relatively high proportion of soil-size (< 2mm) material. Ash should be planted in mixtures with other hardwoods. Trees of this species often have poorly formed trunks that detract from their value. Native in nearly all of eastern United States.

Growth performance:

Location	No. Test Sites	Age (years)	Percent Survival	Dbh (inches)	Height (feet)	Basal Area (ft^2/acre)
Mo., Kans., Okla.	9	30	33	3.8	28	23.0
Illinois, Indiana	11	30	53	4.7	—	56.8
Ohio	4	30	55	4.0	27	42.7
Pennsylvania	2	30	*	2.5	15	—

*69 percent survival at age 10 (15 sites).

WHITE ASH
(*Fraxinus americana*)

Type of plant: Tree-hardwood
Size: Medium
Intermediate tolerance to shade

Origin: Native

Lower pH limit: 4.0

Elevation limit: Not above 3,000 feet

Planting materials: Seedlings (1-0)

Major uses: Forest products (pulp, veneer, lumber, tool handles, and baseball bats), wildlife food and cover

Regions where adapted: All

Comments: Long-term survival on surface mines is relatively good but growth usually is slower than for other hardwoods. Has not been planted as extensively as green ash. Native in all eastern coal regions but not tested on surface mines in all States. Should be planted in mixtures with other hardwoods. Direct-seeding trials generally produced poor results. A valuable forest species, its trunk usually is long, straight, clear, and cylindrical.

Growth performance:

Location	No. Test Sites	Age (years)	Percent Survival	Dbh (inches)	Height (feet)	Basal Area (ft^2/acre)
Ohio	4	30	45	5.0	36	55
Pennsylvania	2	30	*	2.5	19	—

*65 percent survival at age 10 (13 sites).

RIVER BIRCH
(*Betula nigra*)

Type of plant: Tree-hardwood
Size: Medium
Intolerant to shade

Origin: Native

Lower pH limit: 4.0

Planting materials: Seedlings (1-0)

Major uses: Esthetics and screening, wildlife food and cover, forest products (furniture, cabinets, crates)

Regions where adapted: All

Comments: The only southern species of birch. Grows naturally on banks of rivers, streams, ponds, and swamps where soil may be flooded for part of the year. Suited for poorly drained acid minesoils and should be used primarily where soil is too acid for most other hardwoods. Trees usually have poor form. In some areas, trees found growing on the more acid spoils were taller, and had better form and fewer multiple stems than trees on the less acid sites where ground cover was greatest. Adapted climatically to most regions except northern-most Appalachian. Plant in mixture with other hardwoods. May have greatest potential for reclaiming remined areas and abandoned mine sites.

BLACK CHERRY
(*Prunus serotina*)

Type of plant: Tree-hardwood
Size: Medium
Intermediate tolerance to shade

Origin: Native

Lower pH limit: 4.5

Planting materials: Seedlings (1-0)

Major uses: Forest products (furniture and veneer), wildlife food

Regions where adapted: All

Comments: Native in most of eastern United States, but most of the experimental plantings of this species have been made in Missouri, Kansas, and Oklahoma, where growth performance was similar to that of other hardwoods. Good early survival in Pennsylvania and West Virginia plantings, but development and growth usually prevented by deer browsing. Attempts at establishment by direct seeding have failed, yet black cherry often is one of the more abundant volunteer species on naturally and artificially reforested surface mines. Grows best on moist sites and is somewhat tolerant of competition. Should be planted in a mixture with other hardwoods.

Growth performance: In Missouri, Kansas, and Oklahoma, 30-year-old plantings at nine sites averaged 22 percent survival, 5.2 inches dbh, 36 feet in height, and 29 ft^2/acre basal area.

CHINESE CHESTNUT
(*Castanea mollissima*)

Type of plant: Tree-hardwood
Size: Medium
Intermediate tolerance to shade

Origin: Introduced

Lower pH limit: 4.5

Planting materials: Seedlings (1-0)

Major uses: Wildlife food and cover, nut orchards

Regions where adapted: Appalachian, Eastern Interior

Comments: An exotic species that has been planted in an attempt to replace the native American chestnut. The commercial value of its wood is uncertain. It has been planted mostly for nut production and as an ornamental. Four superior strains have been selected for the quality of their nuts and are propagated for orchard purposes. Has performed fairly well in test plantings on surface mines, especially on sites with moderately good exposure and minesoil quality (pH 5.0 to 7.0). For surface-mine reclamation, its value appears greatest for use in wildlife habitat plantings. In 20- to 30-year-old plantings in Indiana, some of the trees in stands with closed canopies are changing from an orchard-form to a timber-form characteristic. Natural reproduction was observed in stands more than 12 to 15 years old.

EASTERN COTTONWOOD
(*Populus deltoides*)

Type of plant: Tree-hardwood
Size: Large
Intolerant to shade

Origin: Native

Lower pH limit: 4.5

Elevation limit: Not above 2,500 feet

Planting materials: Seedlings (1-0), cuttings

Seedling spacing: 8 x 8 feet or greater

Major uses: Forest products (pulp, lumber, and veneer)

Regions where adapted: All except northern-most Appalachian and higher elevations

Comments: This rapid-growing bottomland species has been planted widely on minesoils and survived and grown surprisingly well even on some upland mined sites in Central and Southern Appalachian Region. Also has been common volunteer on minesoils throughout the Interior Coal Region. Is native in all of the Interior and Lignite Regions. Long-term growth and development is best on moist, well-drained soils. Where considered for commercial use, recommend planting in blocks or in bands of several rows in mixtures with other hardwoods. Interplanting with European black alder has increased height of cottonwood by 30 percent and dbh by 20 percent after 10 years of growth.

Growth performance: Volunteer trees that are 30 to 35 years old often attain height of 65 to 70 feet and dbh of 12 to 15 inches. Planted cottonwood in Illinois and Indiana averaged 11 inches dbh and 104 ft^2/acre basal area at age 30.

BLACK LOCUST
(*Robinia pseudoacacia*)

Type of plant: Tree-hardwood
(Nitrogen-fixer)
Size: Medium
Intolerant to shade

Origin: Native

Lower pH limit: 4.0

Elevation limit: Not above 3,000 feet

Planting materials: Seedlings (1-0), seed (scarified)

Seeding rate: 1 to 3 lb/acre (in mixture with herbaceous species)

Time of seeding: Spring, fall, winter

Major uses: Site improvement (nurse tree with hardwoods), wildlife food and cover, fenceposts, fuel, watershed protection

Regions where adapted: All

Comments: Most frequently and widely used tree for surface-mine plantings; adapted to a wide range of minesoil types. Established easily by direct seeding and planted seedlings. Provides quick overstory cover due to rapid growth. Phosphorus fertilizer benefits seedling growth, especially where direct seeded. Spreads by root sprouting and seed. Susceptible to damage by locust borer that may cause trees to die 10 to 20 years after planting. Surviving healthy trees can be cut for fenceposts. Locust seed is prime quail food in some areas. Use as a "nurse" tree is controversial. Locust improves a site for growth of other trees, especially for natural invasion of hardwoods; but its thorny branches can physically damage leaders and bark of smaller, slower growing adjacent trees. Locust should make up no more than 25 to 33 percent of a planted hardwood mix.

Growth performance:

Location	No. Test Sites	Age (years)	Percent Survival	Dbh (inches)	Height (feet)	Basal Area (ft^2/acre)
Mo., Kans., Okla.	10	30	35	6.1	42	63
Illinois, Indiana	11	30	36	6.4	—	72
Ohio	7	30	24	5.9	36	41
Western Kentucky	1	20	50	4.6	36	51
Tennessee Valley	7	11 to 19	—	4.4	39	—

RED MAPLE
(*Acer rubrum*)
SILVER MAPLE
(*Acer saccharinum*)

Type of plant: Tree-hardwood
Size: Medium
Intermediate tolerance to shade

Origin: Native

Lower pH limit: 4.0 to 4.5

Planting materials: Seedlings (1-0)

Major uses: Forest products (pulp, lumber, and veneer), wildlife food

Regions where adapted: All except as noted below

Comments: These maples, collectively called soft maples, are relatively fast growing. Adapted to a range of minesoil conditions—from fairly wet to dry, fine and coarse-textured, and pH 4.0 to 7.0—but grow best on loamy soils with good drainage. Both species usually reproduce by natural seeding. Pure stands of red maple can produce a dense canopy that inhibits growth of understory vegetation. Silver maple often are multistemmed. Neither species considered high-quality hardwood. Plant in mixtures with other hardwoods. Both species native to most of eastern coal regions except silver maple in Lignite Region and red maple in northwestern part of Interior Region.

Growth performance:

Location	No. Test Sites	Age (years)	Percent Survival	Dbh (inches)	Height (feet)	Basal Area (ft^2/acre)
RED MAPLE						
Indiana	4	28	—	6.0	47	60
Eastern Kentucky	1	18	—	5.7	43	72
SILVER MAPLE						
Illinois, Indiana	11	30	29	5.1	—	37
Ohio	1	30	26	5.7	35	41

SUGAR MAPLE
(*Acer saccharum*)

Type of plant: Tree-hardwood
Size: Medium
Tolerant to shade

Origin: Native

Lower pH limit: 4.5

Planting materials: Seedlings (1-0, 2-0)

Major uses: Forest products (lumber and veneer), wildlife food and cover

Regions where adapted: Northern and Central Appalachian, Eastern Interior

Comments: Also called hard maple, has not been planted widely on surface-mined lands. Yet it could be one of the more valuable species for planting in mixtures with other hardwoods. Grows best on moist but well-drained minesoils with predominantly loamy texture and pH 5.5 to 7.5. Initial growth is slow. In western Kentucky, sugar maple was more successful planted in mixture with black locust than in pure stands. At 10 years, the best survival and growth occurred on lower slopes and well-drained bottoms where many of the maples had single, straight, and well-formed stems. In pure stands and on ridges and upper slopes, more than one-half of the trees had multiple stems.

BUR OAK
(*Quercus macrocarpa*)

Type of plant: Tree-hardwood
Size: Large
Intermediate tolerance to shade

Origin: Native

Lower pH limit: 4.0

Planting materials: Seedlings (1-0, 2-0), seed (acorns)

Seeding rate: 2 or 3 acorns per planting spot

Time of seeding: Fall

Major uses: Forest products (rough lumber, barrel staves, flooring, railroad ties, and pulp), wildlife food (acorns)

Regions where adapted: Interior, Lignite, and Central Appalachian except as noted below

Comments: One of the better performing hardwoods in surface-mine plantings in Missouri, Kansas, and Oklahoma. Established successfully from both seedlings and seed. Grows on a variety of minesoil types. Reportedly one of the most drought-resistant oaks and performs well on exposed sandy sites. Tolerates competition from herbaceous cover and grows well in mixture with black locust and other species. Acorns of bur oak have no seed dormancy and germinate almost immediately after falling. Collect acorns immediately after they have fallen and plant in the fall. Plant acorns ½ to 1 inch deep, using two or three per seeding spot to increase chances of getting a fully stocked stand. Space the seeding spots the same as for planted seedlings. Native in all of Interior Coal Region and western part of Lignite. Some successful plantings in Ohio and eastern Kentucky.

Growth performance:

Location	No. Test Sites	Age (years)	Percent Survival	Dbh (inches)	Height (feet)	Basal Area (ft^2/acre)
			DIRECT SEEDED			
Mo., Kans., Okla.	10	30	24	4.8	28	27
Ohio	3	30	37	5.8	33	60
			PLANTED SEEDLINGS			
Mo., Kans., Okla.	9	30	39	5.0	29	47

NORTHERN RED OAK
(*Quercus rubra*)

Type of plant: Tree-hardwood
Size: Medium
Intermediate tolerance to shade

Origin: Native

Lower pH limit: 4.0

Planting materials: Seedlings (1-0)

Major uses: Forest products (lumber, veneer, and pulp), wildlife food and cover

Regions where adapted: Appalachian, Eastern Interior

Comments: Has relatively slow early growth, but growth rate increases as trees reach sapling size. Has been one of the better performing hardwoods. Performs best on moist sites on minesoils with high percentage of soil-size (< 2mm) particles. As with many hardwoods, young seedlings subject to damage from rodents and deer. Can be planted in pure stands, but planting in mixtures with other hardwoods is recommended. Direct-seeding trials have produced mixed results, but most have been unsatisfactory. Rodent pilferage often claims much of the seed.

Growth performance:

Location	No. Test Sites	Age (years)	Percent Survival	Dbh (inches)	Height (feet)	Basal Area (ft^2/acre)
Illinois	2	35	—	9.8	72	137
Ohio	3	30	14	5.7	33	22
Pennsylvania	5	30	*	5.3	37	—
Eastern Kentucky	1	18	—	4.1	34	72†

* 62 percent survival at age 10 (9 sites).
† Basal area of mixed hardwood planting in which northern red oak is present.

SAWTOOTH OAK
(*Quercus acutissima*)

Type of plant: Tree-hardwood
Size: Small
Intermediate tolerance to shade

Origin: Introduced

Lower pH limit: 4.0

Planting materials: Seedlings (1-0)

Major uses: Wildlife food and cover, forest products (pulp)

Regions where adapted: Appalachian, see note below

Comments: This naturalized oak is an excellent species for wildlife plantings. Heavy mast crops are produced at regular frequency and at an early age. Has survived well in test plantings throughout the Appalachian Region. Was highly successful in plantings on abandoned acid spoils in Tennessee Valley Region. Probably adapted to at least the eastern part of Interior Coal and Southern Lignite Regions, but use is not documented. Pulp and fuelwood are known forest products. In a forest situation, small sawlogs for lumber are a possibility.

OSAGE-ORANGE
(*Maclura pomifera*)

Type of plant: Tree-hardwood
Size: Small
Intermediate tolerance to shade

Origin: Native

Lower pH limit: 4.5

Planting materials: Seedlings (1-0)

Major uses: Wildlife food and cover, hedgerows and screening, forest products (posts)

Regions where adapted: Interior, western part of Lignite

Comments: A small tree native to a small area of eastern Texas, southeastern Oklahoma, and southwestern Arkansas, but has been widely planted and naturalized in many eastern States. Adapted to most surface-mine conditions but performs best on the less acid and well-drained minesoils. In Illinois, initial mortality of planted seedlings was high, but subsequent survival has remained about the same. Has relatively little value as a forest species. Has been planted mostly for hedgerows and windbreaks, and cut mainly for fenceposts. Provides good cover and food for wildlife and could be planted along edges as a screen or barrier.

Growth performance:

Location	No. Test Sites	Age (years)	Percent Survival	Dbh (inches)	Height (feet)
Illinois, Indiana	11	30	33	4.4	—
Ohio	2	30	39	3.1	20

HYBRID POPLARS
(*Populus* spp.)

Type of plant: Tree-hardwood
Size: Medium
Intolerant to shade

Origin: Crosses of several native and introduced species

Lower pH limit: 4.0 to 4.5

Planting materials: Rooted cuttings, unrooted cuttings (8 to 10 inches long)

Spacing: 8- x 8-foot minimum

Major uses: Esthetics and screening, forest products (pulp and lumber)

Regions where adapted: Northern and Central Appalachian, Interior except southwestern part

Comments: Major assets are good survival and rapid growth. Greatest use has been in Pennsylvania. Best performing clones in one region may not be the best in another region. Cuttings can be taken from established hybrid poplar trees. For planting, select trees that have performed well, and make cuttings from the previous year's growth in late winter or early spring before sap starts to rise. Select branches that are between three-eights and three-quarters of an inch in diameter and cut into pieces 8 to 10 inches long. Cover cuttings with damp sawdust and store in cool place until ends of cuttings callous over and buds start to swell. Plant cuttings vertically with buds pointing up so that at least one or two buds are above ground (usually about 1 to 2 inches of cutting above ground). Poplars can be planted in alternate rows with conifers (except larch).

Growth performance:

Location	No. Test Sites	Age (years)	Percent Survival	Dbh (inches)	Height (feet)	Basal Area (ft^2/acre)
Eastern Kentucky	1	9	95	3.1	27	44
Pennsylvania	8	10	45	5.4	31	64
Pennsylvania	2	30	—	9.0	63	—

YELLOW-POPLAR
(*Liriodendron tulipifera*)

Type of plant: Tree-hardwood
Size: Large
Intolerant to shade

Origin: Native

Lower pH limit: 4.5

Elevation limit: Not above 3,000 feet

Planting materials: Seedlings (1-0)

Major uses: Forest products (pulp, lumber, and veneer), wildlife food and cover

Regions where adapted: Appalachian, southeastern part of Interior

Comments: Results (survival) with this valuable forest species have been variable on surface-mined lands, but either total failure or good survival is rare. Performs best on fine-loamy minesoils that have fair to good drainage and pH 5.0 to 7.0. Should be planted in mixtures with other hardwoods. The trunk is tall, straight, and usually free of side branches. The flowers are an excellent source of nectar for honey bees. Also called tulip-poplar and tuliptree.

Growth performance:

Location	No. Test Sites	Age (years)	Percent Survival	Dbh (inches)	Height (feet)	Basal Area (ft^2/acre)
Illinois, Indiana	11	30	7	7.6	—	20
Ohio	10	30	19	8.7	45	69
Western Kentucky	1	20	24	3.5	33	14
Eastern Kentucky	1	18	—	6.4	50	72†
Illinois	1*	22	—	8.1	58	—
Illinois	1*	30	23	8.4	60	79

*Planted under decadent black locust.
†Mixed hardwood planting in which yellow-poplar is present.

SWEETGUM
(*Liquidambar styraciflua*)

Type of plant: Tree-hardwood
Size: Large
Intolerant to shade

Origin: Native

Lower pH limit: 4.0

Elevation limit: Not Above 2,500 feet

Planting materials: Seedlings (1-0)

Major uses: Forest products, (pulp, veneer, plywood, interior parts of furniture, lumber), wildlife food and cover

Regions where adapted: Central and Southern Appalachian, Lignite, southeastern Interior

Comments: Survival of planted seedlings of this commercial hardwood has been erratic among areas. Early growth of seedlings is relatively slow, but later growth is rapid. In older plantings, many of the surviving trees have good form and size. Growth is best in fine loam minesoils on moist sites. In Illinois, growth was better on minesoils in the 4.0 to 5.0 pH range than at higher pHs. Planting sweetgum in a mixture with other valuable hardwoods such as tulip-poplar and northern red oak is recommended. Growth was increased where interplanted with European alder.

Growth performance:

Location	No. Test Sites	Age (years)	Percent Survival	Dbh (inches)	Height (feet)	Basal Area (ft^2/acre)
Illinois, Indiana	11	30	27	6.4	—	54
Oklahoma	1	30	2	12.8	60	16
Eastern Kentucky	1	10	65	1.7	15	—

AMERICAN SYCAMORE
(*Platanus occidentalis*)

Type of plant: Tree-hardwood
Size: Large
Intolerant to shade

Origin: Native

Lower pH limit: 4.0 to 4.5

Elevation limit: Not above 2,500 feet

Planting materials: Seedlings (1-0)

Major uses: Forest products (pulp, lumber, and veneer)

Regions where adapted: All

Comments: Planted widely on eastern mine sites. Makes rapid growth, especially on moist sites. Dieback may occur at higher elevations in the Appalachian Region. Does not establish satisfactorily in dense herbaceous or shrubby cover. Often establishes by natural seeding on mined areas. For commercial harvest, plant in pure blocks, or in multiple row mixtures with other hardwoods.

Growth performance:

Location	No. Test Sites	Age (years)	Percent Survival	Dbh (inches)	Height (feet)	Basal Area (ft^2/acre)
Missouri	3	29	15	9.1	48	60
Kansas	3	29	26	5.2	38	34
Oklahoma	1	29	7	8.2	46	23
Western Kentucky	1	20	41	3.8	33	29
Eastern Kentucky	3	10	62*	1.7	17	—
Eastern Kentucky	1	18	—	5.9	50	72†

* 5-year survival.
†Mixed hardwood planting in which sycamore is present.

BLACK WALNUT
(*Juglans nigra*)

Type of plant: Tree-hardwood
Size: Large
Intolerant to shade

Origin: Native

Lower pH limit: 5.5

Planting materials: Seedlings (1-0), seed (stratified for spring seeding)

Seeding rate: 2 or 3 seeds (nuts) per spot

Time of seeding: Fall (unstratified seed), spring (stratified seed)

Major uses: Forest products (veneer, furniture, gunstocks, novelties), wildlife food

Regions where adapted: All, see note below

Comments: Has performed best in Indiana, Illinois, and Missouri on moist sites on ungraded minesoils that were slightly acid to slightly calcareous (pH 6.0 to 7.5). Establishment was successful from both seedlings and seed. Survival and growth generally have been poor in the Appalachian Region and on acid, droughty minesoils. Although initial growth is relatively slow, can develop into a valuable forest product. Nuts are a cash crop in some localities. For a timber crop, plant in mixtures with other hardwoods. For spring seeding, nuts should be stratified outdoors over winter in moist sand, or refrigerated in plastic bags, moist peat, or sand at 34° to 41°F for 90 to 120 days. Native in most of Eastern Coal Regions.

Growth performance:

Location	No. Test Sites	Age (years)	Percent Survival	Dbh (inches)	Height (feet)	Basal Area (ft^2/acre)
DIRECT SEEDED						
Mo., Kans., Okla.	9	30	13	4.8	32	15
Illinois, Indiana	11	30	30	6.1	—	54
Ohio	5	30	4	4.1	32	3
PLANTED SEEDLINGS						
Illinois, Indiana	11	30	21	5.2	—	28
Western Kentucky	1	20	25	2.8	21	9
Illinois	1*	30	42	7.3	—	108

* Planted under decadent black locust.

Table 20. Tree species of lesser importance or use.

Common and Scientific Name	*Origin**	*Tolerance†*	*Lower pH Limit*	*Major Uses‡*
		CONIFERS		
Baldcypress *(Taxodium distichum)*	N	M	5.0	F,H
Comments: Deciduous. Most often associated with sites where water stands for several months of the year. Has been used on both poorly and well-drained mine spoils in southern Illinois and Indiana, western Kentucky, Missouri, and Oklahoma. Natural range includes most of Lignite Region.				
Douglas-fir *(Pseudotsuga* spp.)	N	T	4.0	F,E,H,C
Comments: Western species used only in Pennsylvania. Proper seed source important for success in East. Popular Christmas tree species.				
Fraser fir *(Abies fraseri)*	N	M	5.0	C,E,H
Comments: Limited to high elevations in northern part of Southern Appalachian Region and to cool, moist sites. Plant 2-0 or 3-0 seedlings.				
European larch *(Larix decidua)*	I	I	5.0	F
Comments: Deciduous. For northern Appalachians and high elevations. Less successful than Japanese larch.				
Austrian pine *(Pinus nigra)*	I	M	4.0	E,H,C,F
Comments: Similar to native red pine in growth appearance and climatic adaptation. Has not been widely planted on minesoils but has performed well in some areas of the Northern Appalachian and Interior Regions. Used mainly for shelterbelts in the Midwest and for ornamental and esthetic purposes.				
Jack pine *(Pinus banksiana)*	N	I	4.0	H,C,F
Comments: Use in Northern Appalachian and northern half of Interior Region in pure or mixed-pine plantings. Adapted to acid, dry, and sandy soil conditions.				
Longleaf pine *(Pinus palustris)*	N	I	4.5	F,H,E
Comments: Plant only in southern part of Southern Appalachian Region and Southern Lignite Region. Plant or seed in pure stands. Well suited on spoils where surface soil is not replaced.				
Pitch X loblolly hybrid pine *(Pinus rigida* X *P. taeda)*	N	I	4.0	F,E,H
Comments: Experimentally planted only in Central Appalachian Region. Early growth is faster than that of either parent. Research underway to increase planting material.				
Slash pine *(Pinus elliottii)*	N	M	4.5	F,H,E
Comments: Plant or direct seed in pure stands. For use in southern half of Southern Appalachian Region.				

*I = Introduced; N = Native.

†H = Habitat (food and cover) for wildlife; E = Esthetics and screening; W = Watershed protection (erosion control); O = Other horticulture land uses.

Table 20. Tree species of lesser importance or use.

Common and Scientific Name	Origin*	Tolerance†	Lower pH Limit	Major Uses‡
		HARDWOODS		
Bigtooth aspen *(Populus grandidentata)*	N	I	4.0	H,F
Comments: Will not reproduce in shade. Plant in pure blocks. For use in northern latitudes and higher elevations in Appalachia.				
European white birch *(Betula pendula)*	I	I	3.5-4.0	F,H,E
Comments: Planted successfully on acid minesoils in Pennsylvania and eastern Kentucky. Longevity not known. Use recommended only on difficult sites not suited for higher value native species.				
Gray birch *(Betula populifolia)*	N	I	3.5	E,H
Comments: For northern Appalachians and high altitudes. Similar to European white birch.				
Paper birch *(Betula papyrifera)*	N	I	3.5	F,E,H
Comments: For northern Appalachians and high altitudes.				
Sweet birch *(Betula lenta)*	N	I	4.0	H,F
Comments: Early pioneer on barren acid spoils. Promising species for planting abandoned lands and as associate with forestry plantings on current-mined lands, but practical experience lacking. Appalachian Region.				
Catalpa *(Catalpa* spp.)	N	M	5.0	E,F
Comments: Mineland plantings are mostly experimental on older minespoils in Illinois, Missouri, Kansas, and Oklahoma. Species *bignonioides* performs well in Alabama.				
Flowering dogwood *(Cornus florida)*	N	T	4.5	H,E
Comments: Fruit and browse for wildlife. Survival of planted seedlings often quite low, and growth slow. Volunteer seedlings sometimes found in established woody vegetation. Native to most of eastern coal regions.				
Hackberry *(Celtis occidentalis)*	N	M to T	5.0	H,F,E
Comments: Volunteer seedlings often numerous on older sites where forest vegetation is becoming reestablished. Some artificial plantings in Illinois, Missouri, and Kansas. Native in most of Interior Region.				
Hickories *(Carya* spp.)	N	I	5.0	H,F
Comments: Species used in recent planting in Illinois include *C. ovata, C. tomentosa, C. cordiformis, C. glabra,* and *C. laciniosa*. No other plantings for long-term evaluation. Grow best on neutral soils. Native in Interior and part of Lignite Regions.				
Red mulberry *(Morus rubra)*	N	M	5.0	H
Comments: A common volunteer on older mined areas in Interior Region where forest vegetation is reestablishing. Recommended for wildlife habitat plantings in southwestern part of Interior and western part of Lignite Regions, though there are few documented plantings on mined land.				
Chestnut oak *(Quercus prinus)*	N	M	4.5	F,H
Comments: Similar site requirements as white oak. Central Appalachian.				
Pin oak *(Quercus palustris)*	N	I	4.0	H,F,E
Comments: Volunteers on older forested sites. Potential value for planting mined land probably greater than past use indicates. Adapted to wet, poorly drained shallow soils. Native in most of Interior Coal Region. Successfully planted in eastern Kentucky at lower elevations.				
Shingle oak *(Quercus imbricaria)*	N	I	4.0	H
Comments: Often volunteers on older mined sites where forest vegetation is reestablishing. Native in eastern part of Interior Region. Some successful plantings in Central Appalachian Region, but no long-term evaluation of artificial plantings.				
White oak *(Quercus alba)*	N	M	5.0	F,H
Comments: Not planted widely on mined lands. Survival of most plantings was low. In some plantings survival and growth was better where interplanted with black locust. Potentially valuable timber species. Native in most of Eastern Coal Regions.				
Other oaks *(Quercus* spp.)	N	–	–	—
Comments: Other species of oaks probably have the same potential for success on minesoils as those that have been tested and used. Some of these are black oak, blackjack oak, chestnut oak, post oak, shumard oak, and southern red oak. Selection should be based on proposed land use and adaptation of the species to site and region.				

*I = Introduced; N = Native.
†T = Shade tolerant; I = Shade intolerant; M = Intermediate tolerance.
‡F = Forest products; H = Habitat for wildlife; E = Esthetics and screening; C = Christmas trees.

Table 20. Tree species of lesser importance or use.

Common and Scientific Name	*Origin**	*Tolerance†*	*Lower pH Limit*	*Major Uses‡*
		HARDWOODS, continued		
Russian olive *(Elaeagnus angustifolia)*	I	M	5.5	H,E
Comments: Small tree or large shrub. Much used for shelterbelts in Midwest. Adapted to most of Interior and western part of Lignite Region.				
Royal paulownia *(Paulownia tomentosa)*	I	M	4.5	F,E
Comments: A rapid-growing tree with high market value for export to Japan. Has escaped from cultivation. Volunteers on some spoils, but may be difficult to establish artificially. Central and Southern Appalachian Regions.				
Pecan *(Carya illinoensis)*	N	I	5.0	H,F
Comments: Older plantings in Missouri, Kansas, and Oklahoma not successful due to repeated browsing by deer. Native in southern part of Interior and most of Lignite Regions.				
Black willow *(Salix nigra)*	N	I	4.5	H,E
Comments: Most suited for low wet sites and stream margins. Can withstand flooding and silting. Native to all Eastern Coal Regions.				

*I = Introduced; N = Native.
†T = Shade tolerant; I = Shade intolerant; M = Intermediate tolerance.
‡F = Forest products; H = Habitat for wildlife; E = Esthetics and screening; C = Christmas trees.

Suggested Species Mixtures

Revegetation strategies for most land uses require mixtures of plant species and plant types. For example, at least two herbaceous species normally are used in the establishment of pasture. Revegetation for forestry and wildlife habitat generally includes several woody species and one to several herbaceous species. In addition to being functional, mixtures of plant types improve esthetic or visual interest and diversity. Only in some agricultural uses, such as grain and row crops, is one species involved.

For most land uses, introduced species or combinations of introduced and native species are planted. Usually it is impractical to immediately reestablish stands of vegetation that are entirely "native," especially where herbaceous cover is needed quickly for erosion control. For example, in vegetating for forestry and wildlife habitat, many of the commonly used tree species are native, but most of the herbaceous species and frequently used shrubs are introduced. With few exceptions, the establishment of native herbs and shrubs will depend largely on natural seeding (invasion) from surrounding native stands. The development of predominantly native vegetation may require several to many years depending largely on the combination, density, and persistence of the introduced species used for ground cover.

Species mixtures for several land uses are discussed in this chapter. It is not feasible to list all of the species combinations that could be used. However, the several examples given may help illustrate the rationale for mixing species for the various land uses. Because the Interior Coal and Southern Lignite Regions include a wide range of climate and natural vegetational types, recommended species and mixtures may differ between and within regions.

Herbaceous Vegetation

For nearly all land uses, the quick, initial establishment of herbaceous vegetation is necessary for control of water and wind erosion. Vegetation for watershed protection is especially important in mountainous and sloping areas where erosion caused by runoff is potentially greatest. In many cases, mixtures recommended for erosion control also are suitable for forage, wildlife habitat, and ground cover in tree plantations.

Erosion Control and Agriculture

Examples of seeding mixtures suggested primarily for erosion control are shown in Tables 21 to 23. Mixtures for spring, summer, and fall seeding times are suggested. These mixtures include an annual or short-lived perennial species that provides quick but temporary cover. One of these should be chosen and added to a mixture containing at least one perennial grass and one perennial legume. Ideally, as the perennial species succeed they will replace the temporary species. Where there is a choice, the grass and legume species best adapted to the minesoil properties and climate should be selected. It is important to not exceed seeding rate recommendations for the quick-cover temporary species, because higher rates of these species could produce dense stands that prevent or retard the establishment of the perennial species.

Table 21. Suggested herbaceous mixtures for erosion control and alternatives for forage in the Northern Appalachian Region (Seeding rate: pounds per acre PLS).

Seeding Time	Temporary (quick-cover) Species* (Use One with Permanent Mix)		Permanent (long-lived) Species: Erosion Control		Permanent (long-lived) Species: Forage or Wildlife	
Early to midspring	Annual ryegrass	5	Ky-31 tall fescue†	15	Orchard grass	8
					or	
					Timothy	6
	Perennial ryegrass	10	Birdsfoot trefoil	6	Red clover	5
			or		and	
					Ladino clover	2
	Oats	48	Crownvetch	10	or	
			or		Kura clover	8
	Weeping lovegrass	2½	Flatpea	20	or	
			or		Alfalfa	10
			Sericea lespedeza	15		
Midspring to midsummer	Foxtail millet	12	KY-31 tall fescue	15	Same as above but spring or fall seeding preferred	
	Japanese millet	15				
	Weeping lovegrass	2½	Birdsfoot trefoil	8		
			or			
			Crownvetch	10		
			or			
			Flatpea	20		
Midsummer to early fall	Rye	40	KY-31 tall fescue	20	Orchardgrass	10
					or	
	Winter wheat	40			Timothy	8
			Redtop	2	Red clover and	6
	Annual ryegrass	5			Ladino clover	3
			Birdsfoot trefoil	8	or	
					Kura clover	8
			or		or	
			Crownvetch	20	Alfalfa	12

* Use one of the temporary species at rates shown; if more than one species is used, reduce seeding rate of each in proportion to number used, e.g., for two species use one-half seeding rate of each.

† All species listed in this column (except perhaps flatpea) have value for forage but the quality may be somewhat lower than those species listed under forage and wildlife.

Some of the mixtures also are suited for forage production; however, a few of the species that are well suited for erosion control and site stabilization are not the most suitable for other land uses. For example, sericea lespedeza and flatpea are excellent for long-term erosion control, but their value for forage is lower than that of other legume species, such as alfalfa. Thus, consideration should be given to selecting species for their suitability for the approved land use, as well as for controlling erosion. Some alternate mixtures for forage use also are given in Tables 21 to 23.

Forestry

The seeding of herbaceous species before or concurrent with the planting of trees nearly always is needed to prevent erosion. However, the herbaceous cover also may

slow or prevent the establishment of the trees. Where herbaceous cover is established first, it may be necessary to kill or suppress it with herbicides or cultivation before planting trees. In the more humid regions of the East, especially in Appalachia, it sometimes is possible to establish trees by planting them concurrent with the seeding of herbaceous species. The success or failure of trees so planted appears to be partly, if not largely, related to the amount and distribution of precipitation during the growing season.

Table 22. Suggested herbaceous mixtures for erosion control and alternatives for forage and wildlife for the Southern Appalachian Region (Seeding rate: pounds per acre PLS).

Seeding Time	*Temporary (quick-cover) Species** *(Use One with Permanent Mix)*		*Permanent (long-lived) Species* *Erosion Control*		*Forage or Wildlife*	
Early to midspring	Perennial ryegrass	10	Ky-31 tall fescue	15	Orchard grass or Switchgrass	10 12
	Oats	48	Korean and/ or Kobe lespedeza†	10	Korean lespedeza	10
	Weeping lovegrass	2½	Sericea lespedeza or Crownvetch	15 10	Ladino clover	3
	Annual ryegrass	5				
Midspring to mid-summer	Weeping lovegrass	2½	KY-31 tall fescue	20	Same as above or Bermudagrass could be seeded or sprigged in place of grasses. above. Little or no seed of quick cover species needed	
	Pearl millet	10	Korean and/ or Kobe lespedeza†	10		
	Sorghums	20				
	Browntop millet	15	Sericea lespedeza	15		
	Foxtail millet	12				
Midsummer to early fall	Rye	50	KY-31 tall fescue	20	Orchardgrass	12
	Winter wheat	50	Sericea lespedeza‡ or Crownvetch	20 12	Ladino clover	4
	Annual ryegrass	5			Crimson clover§	6
	Perennial ryegrass	12				
	Crimson clover	12				

* Use only one of the temporary species at rates shown; if more than one is used, reduce seeding rate of each species in proportion to number used, e.g., for two species use one-half seeding rate of each.

† These annual lespedezas usually reseed each year and may become a permanent component of the vegetative cover.

‡ One-half or more of sericea lespedeza seed should be unhulled and unscarified to reduce amount of fall germination and ensure sufficient seed for germination the next spring.

§ Reseeding varieties may become a continuing component of cover. Include a permanent component only with temporary grass species.

Results of limited research also suggest that some herbaceous species are more compatible than others with contemporaneously planted woody species. In eastern Kentucky, for example, where Ky-31 tall fescue and sericea lespedeza were planted with trees, the growth of trees was suppressed in cover that was predominantly fescue but was favored in cover that was predominantly lespedeza, a legume. Thus, legumes seem to be a better choice than grasses for use with trees, unless the legume plants grow so large and dense that the tree seedlings are smothered before they can grow above the legume plants. Low-growing legume species and varieties, therefore, are preferred for combination plantings with trees. Tall or aggressive legumes, such as common sericea lespedeza, crownvetch, and flatpea, are least recommended for combination plantings with trees. Where adapted, other low-growing legumes, such as Korean lespedeza and Appalow sericea lespedeza, could be substituted for the crownvetch, flatpea, or common sericea lespedeza. Herbaceous mixtures for use with trees could be similar to those suggested for forage and wildlife in Tables 21 to 23.

Temporary Cover. Annual species can be used effectively in tree planting programs where a temporary cover is established one year and trees are planted the following spring. Where early-spring seeding is required, a heavy seeding of oats, wheat, rye, or annual ryegrass can be used. Where adapted, an annual legume such as Korean or Kobe lespedeza can be included. For late-spring and early-summer seedings, summer annuals, such as sorghum, Japanese millet, or pearl millet, are useful. For late-summer and fall seeding, winter annuals, such as wheat, rye, annual ryegrass, hairy vetch, or crimson clover, can be used. However, winter annuals may pose a problem for tree planting the following spring in that they will be established and actively growing when the newly planted tree seedlings are trying to become established. Herbicides or tillage in spots or strips may be required to suppress the fall-planted cover before the tree seedlings are planted. But, where spring precipitation is adequate to support both the cover and woody species, these annuals may not present a problem because they will be mature before summer and, therefore, will not compete with trees for moisture during the summer when moisture is most likely to be limited.

Seeding and Planting in Alternate Strips. Trees and herbaceous cover can be established together by seeding mixtures of herbaceous species in strips or bands that alternate with strips planted only to trees. The width of the seeded strips can vary to facilitate the desired tree spacing. Where trees are planted at an 8- by 8-foot spacing, for example, 5-foot-wide strips of a grass-legume seeding could alternate with 3-foot-wide strips that are not seeded. The tree seedlings are planted 8 feet apart in the middle of the unseeded strips. The herbaceous cover in alternating strips will provide adequate ground cover for erosion control yet produce minimum competition to the tree seedlings during the initial growth period.

Alternate strip planting will work best on areas that can be traversed with farm equipment, because a grain or grass seeding drill and a drop-type fertilizer spreader would be

most useful for establishing strips that are uniform in width. On sloping land the strips should run on contour.

Wildlife Habitat

Grass-legume mixtures suggested for wildlife habitat are listed in Tables 21 to 23. These are similar to mixtures suggested for controlling erosion except that plant species considered more desirable for wildlife replace less suitable ones. For example, grasses such as orchardgrass, timothy, deertongue, reed canarygrass, switchgrass, Dallisgrass, and Kentucky and Canada bluegrasses are recommended in place of Ky-31 tall fescue. Similarly, limited use should be made of legumes such as common sericea lespedeza, crownvetch, and flatpea that will dominate the vegetational cover and limit the diversity of food and cover. Also, the dense persistent cover of these legumes may retard or prevent the invasion and establishment of native plant species that contribute to habitat diversity. Herbaceous legumes that are desirable food plants but less aggressive and persistent than the three legumes mentioned should be used. These include red clover, white clover, alsike clover, birdsfoot trefoil, partridge pea, arrowleaf and crimson clovers, or the annual lespedeza species.

Mixtures of native warm-season grasses—switchgrass, Indiangrass, big bluestem, and little bluestem—are useful for providing nesting cover for certain game birds and cottontail rabbit. Where adapted, mixtures containing Japanese millet, redtop, reed canarygrass, or alsike clover are suggested for wet or poorly drained areas and pond borders. Mixtures seeded in food patches for song and game birds could include wheat, common sunflower, foxtail millet, browntop millet, soybean, cowpea, or buckwheat.

Woody Vegetation

Timber Management

Trees can be planted either in pure stands of one species or in mixtures of two or more species. In general, stands of one species are easier to plant, manage, and harvest; but they are more susceptible than mixed planting to insect and disease epidemics and lack diversity for visual quality and wildlife habitat. Mixed plantings improve the possibilities for natural diversity and regeneration and usually occupy the site more fully than pure plantings. The following are general guides for pure and mixed plantings of trees.

1. Pure plantings of pine usually are favored over mixtures of pine. Where two or more pine species are desired, plant a block or group of several rows of one species that alternate with blocks of the other species. A block or group should consist of at least five rows. An exception may be a mixture of species with similar growth rates, such as pitch and shortleaf pines.
2. Mixing hardwoods with intolerant pine species is not recommended. Hardwoods usually shade out the pine. Mixing groups or blocks of pine and hardwoods are acceptable, especially where diversity in cover types is desired for esthetic purposes and wildlife habitat. Intimate mixing of tolerant conifers, such as spruce and white pine, with tolerant hardwoods and slow-growing hardwoods is acceptable.

Table 23. Suggested herbaceous mixtures for the Interior Coal and Southern Lignite Region (Seeding rates: pounds per acre PLS).

Region	Seeding Time	Temporary (quick-cover) Species* (Use One with Permanent Mix)		Permanent (long-lived) Species	
Interior Region, northern half	Early to midspring	Oats	40	Smooth bromegrass	15
				or	
		Annual ryegrass	5	Tall fescue	15
				or	
		Perennial ryegrass	10	Reed canarygrass	8
				or	
				Orchardgrass	6
				Alfalfa	10
				or	
				Birdsfoot trefoil	8
				or	
				Crownvetch	10
Interior Region, southern half	Early to mid spring	Perennial ryegrass	10	Tall fescue	15
		Oats	48	Korean and/or Kobe lespedeza†	10
		Weeping lovegrass	2		
				Sericea lespedeza	15
				or	
				Crownvetch	10
	Midsummer to early fall	Rye	40	Tall fescue	20
		Winter wheat	40	Sericea lespedeza‡	15
				or	
		Annual ryegrass	5	Crownvetch	10
		Perennial ryegrass	10		
		Crimson clover	12		
				Native species mix	
Western Interior Coal Province	Spring	Oats	32	Switchgrass	2
		(A temporary cover species may provide excessive competition with perennials. Mulch only may be more suitable.)		Big bluestem	3
				Little bluestem	2
				Indiangrass	4
				Sideoats grama	3
				Illinois bundleflower	1
				Partridge pea	2
Southern Lignite Region, eastern two-thirds	Spring to midsummer	Pearl millet	12	Bahiagrass	25
		Sorghum	20	Sericea lespedeza	15
		Browntop millet	20	Kobe lespedeza	10

* Use only one of the temporary species at rates shown; if more than one is used, reduce seeding rate of each species in proportion to number used, e.g., for two species use one-half seeding rate of each.

† These annual lespedezas usually reseed each year and may become a permanent component of the vegetative cover.

‡ One-half or more of sericea lespedeza seed should be unhulled and unscarified to reduce amount of fall germination and ensure sufficient seed for germination the next spring.

3. Hardwood species, such as hybrid poplar and European alder, that will produce a quick crop (pulpwood) and be harvested can be planted in alternate rows with conifers (except larch with hybrid poplar, Northern Ap-

palachian Region). A coniferous stand will follow after the hardwoods are harvested.

4. For a few hardwoods—cottonwood, sycamore, and hybrid poplar—planting in pure stands or block mixtures is preferred, especially where planned use is for pulpwood. Most other hardwoods also can be planted in pure stands or blocks, but mixtures generally are recommended. The planned utilization of the trees will determine the feasibility of planting pure or mixed stands.
5. Black locust, European alder, or autumn olive may be beneficial as "nurse" species in hardwood mixtures. Red oak, yellow-poplar, hybrid poplar, sweetgum, green and white ash, and sugar maple are some of the species suggested for planting with a nurse crop. Growth of pine also may be enhanced where interplanted with European alder. The nurse species generally should make up no more than one-fourth to one-third of a hardwood mix.
6. The presence of nitrogen-fixing trees like black locust and European alder will encourage the natural establishment of indigenous (native) forest species. Thus, planting mixtures of numerous tree species may, in the long run, offer little advantage over simple mixes that include these nurse species.

The following are examples of hardwood mixtures planted for timber production:

Northern Appalachian Region

Species	*Composition* (percent)
Example 1	
Northern red oak	25
Green or white ash	25
European white birch	25
European black alder	20
Autumn olive or Indigobush	5
Example 2	
Northern red oak	20
White or green ash	20
Sycamore	10
Yellow-poplar	20
Red maple	10
Black locust	20

Southern Appalachian Region

Species	*Composition* (percent)
Northern red oak	20
White or green ash	20
Sycamore	10
Yellow-poplar	20
Red maple	10
Black locust	20

Central Hardwoods Area of the Eastern Interior Coal Province

Species	*Composition* (percent)
Northern red oak	20
White or green ash	20
Sycamore	10
Yellow-poplar	20
Red maple	10
Black locust	20

Oak-Hickory Type in the Western Interior Coal Province

Species	*Composition* (percent)
Green ash	20
Bur oak	25
Sycamore	20
Black cherry	10
Black locust	25

Obviously, many combinations of species besides those suggested are possible, and the choice of species should be influenced by such factors as the natural range of the species, minesoil characteristics, availability of planting stock, market preferences, potential commercial value and the character of the surrounding landscape and vegetation. For a given locality, consult appropriate natural resource agencies and State revegetation and forestry guides for additional advice on forestry procedures and species selection.

Wildlife Habitat

A variety of shrubs and some trees are select choices for plantings for wildlife cover and food. Usually, small blocks or strips each containing a single species are recommended over random mixing of species. However, several blocks or strips each containing a different species can be planted on a given area. For maximum diversity, select species that are least abundant in the surrounding unmined vegetation. For example, if predominantly hardwood forest, plant patches of pine and fruit-producing trees and shrubs, such as crabapple, autumn olive, amur honeysuckle, shrub lespedeza, indigobush, and amur privet, interspersed with patches or strips of herbaceous vegetation and food patches. If predominantly a pine forest area, plant hardwoods like sawtooth oak, white ash, crab apple, and red maple and several shrub species. If the surrounding environs are mainly crop and pasture land, plant patches or strips of hardwoods, pine, shrubs, and herbaceous cover interspersed with one another.