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A Guide for Revegetating Coal Minesoils in the Eastern United States

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ABSTRACT

This report provides information, recommendations, and guidelines for revegetating land in the Eastern United States that has been disturbed by coal mining. Included are brief descriptions of major coal mining regions in the East, and a discussion of minesoil properties and procedures for sampling, testing, and amending minesoils. Plant species that have been used for revegetating surface-mined lands are identified and described. Selection criteria for plant species and methods and requirements for seeding and planting are explained. Some of the data on tree species used in reforestation were obtained from recent surveys of 30-year-old experimental plantings in several Eastern States.

FOREWORD

The mining of coal, especially surface mining, often is dangerous to environmental resources. Existing vegetation is destroyed, ecosystems are altered, and unreclaimed areas are visually displeasing. One of the adverse effects of mining and vegetation removal is the degradation and pollution of water resources. Erosion on raw exposed minesoils can contribute large quantities of sediment to streams. Where the overburden contains acid-bearing rocks, streams also are polluted with toxic chemical substances.

The revegetation of land disturbed by coal mining is necessary primarily for controlling runoff, erosion, and sedimentation. Simultaneously, the establishment of vegetation improves the visual quality of mined areas and aids in or contributes directly to restoring mined land to productive uses.

The principles and guidelines in this report are applicable primarily to past and current surface-mining operations; they may also apply to surface disturbances caused by underground mining. This report is not directed to the establishment of agricultural crops on areas designated as "prime farmland," though many of the revegetation principles and practices will apply.

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SECTION 4

PLANT SPECIES FOR VEGETATING MINED LANDS

Plant species that have been used successfully in revegetating surface-mined lands are identified and described in this section. Both common and scientific (Latin) names are listed to clarify species identification (Table 1). Obviously, this list does not include all the plant species that will grow on surface-mined lands. Some species that have been planted experimentally are not listed because their success beyond initial establishment has not been documented; for others, plant survival after several years was very low. A few species, though successful in experimental plantings, are not listed because they are unsuited and have little value for most land uses. Many potentially useful species volunteer on mined land, but some of them have been unsuccessful where artificially planted. Others have not been artificially planted because planting stock or seed has not been commercially available. Use of some of the listed species, too, 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 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.

The plant species listed in Table 1 are described individually in this section. The terms used to describe them are explained below.

TYPES OF PLANTS

The plant species are classified into three types--herbs, trees, and shrubs. Each type has an important function in revegetation efforts, but all types may not be needed in every revegetation scheme.

Herbs

Herbs, or herbaceous plants, are nonwoody and are classified as grasses or forbs. Grasses all 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

TABLE 1. PLANT SPECIES FOR REVEGETATING COAL SURFACE-MINED
LANDS IN THE EASTERN UNITED STATES

Common Name	Scientific Name and Authority [#]
<u>GRASSES</u>	
Western wheatgrass	<i>Agropyron smithii</i> Rydb.
*Redtop	<i>Agrostis gigantea</i> Roth
*Big bluestem	<i>Andropogon gerardi</i> Vitm.
Tall oatgrass	<i>Arrhenatherum elatius</i> (L.) Beauv. ex J. & Presl
Oats	<i>Avena sativa</i> L.
Caucasian bluestem	<i>Bothriochloa caucasica</i> (Trin.) C.E. Hubb.
Sideoats grama	<i>Bouteloua curtipendula</i> (Michx.) Torr.
Browntop millet	<i>Brachiaria ramosa</i> (L.) Stapf
*Smooth brome	<i>Bromus inermis</i> Leyss.
Buffalograss	<i>Buchloe dactyloides</i> (Nutt.) Engelm.
*Bermudagrass	<i>Cynodon dactylon</i> (L.) Pers.
*Orchardgrass	<i>Dactylis glomerata</i> L.
*Japanese millet	<i>Echinochloa crusgalli</i> var. <i>frumentacea</i> (Link) W.F. Wight
Canada wildrye	<i>Elymus canadensis</i> L.
*Weeping lovegrass	<i>Eragrostis curvula</i> (Schrud.) Nees
Sand lovegrass	<i>Eragrostis trichodes</i> (Nutt.) Wood
*Tall fescue 'Kentucky-31'	<i>Festuca arundinacea</i> Schreb., selection Ky-
Red fescue	<i>Festuca rubra</i> L.
*Annual ryegrass	<i>Lolium multiflorum</i> Lam.
*Perennial ryegrass	<i>Lolium perenne</i> L.
*Deertongue	<i>Panicum clandestinum</i> L.
Broomcorn millet	<i>Panicum miliaceum</i> L.
*Switchgrass	<i>Panicum virgatum</i> L.
Dallisgrass	<i>Paspalum dilatatum</i> Poir.
*Pearl millet	<i>Pennisetum americanum</i> (L.) Leeke
*Reed canarygrass	<i>Phalaris arundinacea</i> L.
*Timothy	<i>Phleum pratense</i> L.
Canada bluegrass	<i>Poa compressa</i> L.
Kentucky bluegrass	<i>Poa pratensis</i> L.
*Little bluestem	<i>Schizachyrium scoparium</i> (Michx.) Nash
*Rye	<i>Secale cereale</i> L.
*Foxtail millet	<i>Setaria italica</i> (L.) Beauv.
*Indiangrass	<i>Sorghastrum nutans</i> (L.) Nash
*Sorghum	<i>Sorghum bicolor</i> (L.) Moench
*Sudangrass	<i>Sorghum sudanense</i> (Piper) Stapf
Eastern gamagrass	<i>Tripsacum dactyloides</i> (L.) L.
*Winter wheat	<i>Triticum aestivum</i> L.

(continued)

TABLE 1. PLANT SPECIES (CONTINUED)

Common Name	Scientific Name and Authority [#]
<u>FORBS - LEGUMES</u>	
Cicer milkvetch	<i>Astragalus cicer</i> L.
Partridge pea	<i>Cassia fasciculata</i> Michx.
*Crownvetch	<i>Coronilla varia</i> L.
Illinois bundleflower	<i>Desmanthus illinoensis</i> (Michx.) MacMill.
Soybean	<i>Glycine max</i> (L.) Merr.
*Flatpea	<i>Lathyrus sylvestris</i> L.
*Sericea lespedeza	<i>Lespedeza cuneata</i> (Dum.) G. Don
Prostrate lespedeza	<i>Lespedeza daurica</i> var. <i>schimadai</i> Matsamune
*Korean lespedeza	<i>Lespedeza stipulacea</i> Maxim.
*Common lespedeza	<i>Lespedeza striata</i> (Thunb. ex Murr.) Hook. & Arn.
*Kobe lespedeza	<i>Lespedeza striata</i> var. <i>Kobe</i>
*Birdsfoot trefoil	<i>Lotus corniculatus</i> L.
*Alfalfa	<i>Medicago sativa</i> L.
*White sweetclover	<i>Melilotus alba</i> Medik.
*Yellow sweetclover	<i>Melilotus officinalis</i> Lam.
Kura clover	<i>Trifolium ambiguum</i> Bieb.
Alsike clover	<i>Trifolium hybridum</i> L.
Crimson clover	<i>Trifolium incarnatum</i> L.
Zigzag clover	<i>Trifolium medium</i> L.
*Red clover	<i>Trifolium pratense</i> L.
*White clover	<i>Trifolium repens</i> L.
*Ladino clover	<i>Trifolium repens</i> L.
Bigflower vetch	<i>Vicia grandiflora</i> Scop.
Hairy vetch	<i>Vicia villosa</i> Roth
Cowpea, Black-eyed pea	<i>Vigna unguiculata</i> (L.) Walp. subsp. <i>unguiculata</i>
<u>FORBS - NON LEGUMES</u>	
*Buckwheat	<i>Fagopyrum esculentum</i> Moench
*Common sunflower	<i>Helianthus annuus</i> L.
Maximilian sunflower	<i>Helianthus maximiliani</i> Schrad.
*Japanese fleecflower	<i>Polygonum cuspidatum</i> Sieb. & Zucc.
<u>TREES - CONIFERS</u>	
Rocky Mountain juniper	<i>Juniperus scopulorum</i> Sarg.
*Eastern redcedar	<i>Juniperus virginiana</i> L.
European larch	<i>Larix decidua</i> Mill.
*Japanese larch	<i>Larix leptolepis</i> (Sieb. & Zucc.) Gord.
*Norway spruce	<i>Picea abies</i> (L.) Karst
*White spruce	<i>Picea glauca</i> (Moench) Voss

(continued)

TABLE 1. PLANT SPECIES (CONTINUED)

Common Name	Scientific Name and Authority [#]
<u>TREES - CONIFERS (continued)</u>	
Red spruce	<i>Picea rubens</i> Sarg.
*Jack pine	<i>Pinus banksiana</i> Lamb.
*Shortleaf pine	<i>Pinus echinata</i> Mill.
Slash pine	<i>Pinus elliottii</i> Engelm.
*Austrian pine	<i>Pinus nigra</i> Arnold
Longleaf pine	<i>Pinus palustris</i> Mill.
Ponderosa pine	<i>Pinus ponderosa</i> Dougl. ex P. & C. Laws.
*Red pine	<i>Pinus resinosa</i> Ait.
*Pitch pine	<i>Pinus rigida</i> Mill.
Pitch x loblolly hybrid	<i>Pinus rigida</i> x <i>P. taeda</i> (<i>P. xrigitaeda</i>)
*Eastern white pine	<i>Pinus strobus</i> L.
*Scotch pine	<i>Pinus sylvestris</i> L.
*Loblolly pine	<i>Pinus taeda</i> L.
*Virginia pine	<i>Pinus virginiana</i> Mill.
Douglas-fir	<i>Pseudotsuga</i> Carr. spp.
Baldcypress	<i>Taxodium distichum</i> (L.) L. Rich.
<u>TREES - HARDWOODS</u>	
*Red maple	<i>Acer rubrum</i> L.
*Silver maple	<i>Acer saccharinum</i> L.
*Sugar maple	<i>Acer saccharum</i> Marsh.
*European black alder	<i>Alnus glutinosa</i> (L.) Gaertn.
Sweet birch	<i>Betula lenta</i> L.
*River birch	<i>Betula nigra</i> L.
Paper birch	<i>Betula papyrifera</i> Marsh.
*European white birch	<i>Betula pendula</i> Roth
Gray birch	<i>Betula populifolia</i> Marsh.
Hickory	<i>Carya</i> Nutt. spp.
Pecan	<i>Carya illinoensis</i> (Wangenh.) K. Koch
*Chinese chestnut	<i>Castanea mollissima</i> Blume
Catalpa	<i>Catalpa</i> Scop. spp.
Hackberry	<i>Celtis occidentalis</i> L.
Flowering dogwood	<i>Cornus florida</i> L.
Russian-olive	<i>Elaeagnus angustifolia</i> L.
*White ash	<i>Fraxinus americana</i> L.
*Green ash	<i>Fraxinus pennsylvanica</i> Marsh.
*Black walnut	<i>Juglans nigra</i> L.
*Sweetgum	<i>Liquidambar styraciflua</i> L.
*Yellow-poplar	<i>Liriodendron tulipifera</i> L.
*Osage-orange	<i>Maclura pomifera</i> (Raf.) Schneid.
*Crab apple	<i>Malus</i> Mill. spp.
Royal paulownia	<i>Paulownia tomentosa</i> (Thunb.) Steud.

(continued)

TABLE 1. PLANT SPECIES (CONTINUED)

Common Name	Scientific Name and Authority [#]
<u>TREES - HARDWOODS (continued)</u>	
*American sycamore	<i>Platanus occidentalis</i> L.
*Hybrid poplars	<i>Populus</i> L. spp.
*Eastern cottonwood	<i>Populus deltoides</i> Bartr. ex Marsh.
Bigtooth aspen	<i>Populus grandidentata</i> Michx.
*Black cherry	<i>Prunus serotina</i> Ehrh.
Sawtooth oak	<i>Quercus acutissima</i> Carruth.
*White oak	<i>Quercus alba</i> L.
Shingle oak	<i>Quercus imbricaria</i> Michx.
*Bur oak	<i>Quercus macrocarpa</i> Michx.
Pin oak	<i>Quercus palustris</i> Muenchh.
Chestnut oak	<i>Quercus prinus</i> L.
*Northern red oak	<i>Quercus rubra</i> L.
*Black locust	<i>Robinia pseudoacacia</i> L.
Black willow	<i>Salix nigra</i> Marsh.
American basswood	<i>Tilia americana</i> L.
<u>SHRUBS</u>	
*Indigobush	<i>Amorpha fruticosa</i> L.
Black chokeberry	<i>Aronia melanocarpa</i> (Michx.) Elliott
Korean barberry	<i>Berberis koreana</i> Palib.
Siberian peashrub	<i>Caragana arborescens</i> Lam.
*Silky dogwood	<i>Cornus amomum</i> Mill.
Gray dogwood	<i>Cornus racemosa</i> Lam.
Red-osier dogwood	<i>Cornus stolonifera</i> Michx.
Hawthorn	<i>Crataegus</i> L. spp.
*Autumn olive	<i>Elaeagnus umbellata</i> Thunb.
*Shrub lespedeza	<i>Lespedeza bicolor</i> Turcz.
*Japan lespedeza	<i>Lespedeza japonica</i> L. H. Bailey
*Thunberg lespedeza	<i>Lespedeza thunbergii</i> (DC.) Nakai
Amur privet	<i>Ligustrum amurense</i> Carr.
Japanese honeysuckle	<i>Lonicera japonica</i> Thunb.
*Amur honeysuckle	<i>Lonicera maackii</i> (Rupr.) Maxim.
*Morrow honeysuckle	<i>Lonicera morrowii</i> A. Gray
*Tatarian honeysuckle	<i>Lonicera tatarica</i> L.
Western sandcherry	<i>Prunus besseyi</i> L. H. Bailey
Chokecherry	<i>Prunus virginiana</i> L.
*Fragrant sumac	<i>Rhus aromatica</i> Ait.
*Shining sumac	<i>Rhus copallina</i> L.
*Bristly locust	<i>Robinia fertilis</i> Ashe
Rose-acacia locust	<i>Robinia hispida</i> L.
Multiflora rose	<i>Rosa multiflora</i> Thunb. ex Murr.
Rugosa rose	<i>Rosa rugosa</i> Thunb.

(continued)

TABLE 1. PLANT SPECIES (CONTINUED)

Common Name	Scientific Name and Authority [#]
<u>SHRUBS (continued)</u>	
Memorial rose	<i>Rosa wichuraiana</i> Crep.
Purple osier willow	<i>Salix purpurea</i> L.
American elder	<i>Sambucus canadensis</i> L.
Silver buffaloberry	<i>Shepherdia argentea</i> (Pursh) Nutt.
Arrowwood	<i>Viburnum dentatum</i> L.

[#]Names and authorities mostly follow:

Terrell, E. E. 1977. A checklist of names of 3,000 vascular plants of economic importance. USDA Agric. Handbook No. 505.

and

Little, E. L. 1979. Checklist of United States Trees. USDA Agric. Handbook No. 541.

Other sources are:

Staff of L. H. Bailey Hortorium, Cornell Univ. 1976. Hortus Third: A concise dictionary of plants cultivated in the United States and Canada. Macmillan Publ. Co., Inc. New York.

*Detailed information is given on individual description sheets in this section. The other species are briefly described in Tables 2, 3, 4, and 5.

tap root or branching tap root system. The forbs are further classified as legumes or nonlegumes. For vegetating mined lands, legumes usually 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 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.

Life Span--

The life span of herbaceous plants is either annual, biennial, or perennial (long-lived), whereas trees and shrubs all are perennial species. This knowledge can help the reclamation manager in planning the best use of different species into a revegetation program.

Annuals--These plants make vegetative growth, flower, produce seed, and die all within 1 season or 1 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 are usually the best species to plant for the quick establishment of a vegetative cover.

Biennials--These are plants that live for only 2 growing seasons. Some 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.

Perennials--Most of these 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 perennials have a longer, usually indefinite, life span.

Season of Major Growth--

Knowledge of when herbaceous plants grow is helpful in determining how and when each species can be used to best advantage in the revegetation scheme. The growth period of herbaceous plants is grouped into two major seasons--cool and warm.

Cool-season species grow mostly in the spring and fall and usually are dormant, semidormant, or grow slowly in the summer. These plants normally are dormant in the winter, though there are exceptions in the southern areas of the coal regions where some of the cool-season species may continue growth during the winter months. Cool-season species normally are most easily established by seeding in the spring and late summer to early fall. A few species, such as alfalfa, crownvetch, and birdsfoot trefoil also will grow in

the summer, but usually are sown in the spring or late summer and are classified as cool-season plants in this guide.

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 of the winter annuals also produce cover when sown in the spring. Rye, winter wheat, annual ryegrass, and hairy vetch are examples of winter annuals.

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

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 drop annually.

Trees are not very effective for erosion control in the early stages of growth, but as crown closure and litter formation occur they will 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 purposes. A few species are nitrogen-fixers. Because they can improve soil conditions, 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 follows: small: 20 to 40 feet; medium: 40 to 90 feet; large: 90 to 150 feet. Knowledge of tree size may be useful in selecting trees for screening or landscaping purposes, or 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 guide is categorized and defined as follows: tolerant: trees can tolerate or withstand fully shaded conditions (low light intensity) usually 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.

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 and shade the slower growing pine, causing them 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.

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 wildlife food and cover. Some shrubs are nitrogen-fixers. Some of these are legumes; others, such as autumn olive, have different microbial associates that fix nitrogen.

OTHER CRITERIA FOR SELECTING AND ESTABLISHING SPECIES

Origin

Species are identified as either native or introduced (not native). Many of the introduced species are naturalized and, like the native species, will persist without cultivation. Knowledge of species origin may be useful to reclamation managers because the use of native species is an alternative for some postmining land uses defined by the Federal regulations on surface-mine reclamation.

Area of Use

A small map showing the eastern coal regions is included with the descriptions of the plant species. The areas that are encircled with a heavy line identify the coal regions or portions of them where a plant species has been used successfully, or its use is recommended.

For the herbaceous species, these identified areas indicate where a species is climatically adapted and expected to grow, but its use on surface mines in all of these areas is not necessarily documented.

For trees and shrubs, areas shown are those where the use of a species has been documented. Usually, these areas coincide fairly closely with the natural range of that species; for a few species the natural range is more extensive than that included in the identified areas. Conversely, some 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 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 Limits

Plants usually grow best in the climatic range in which they are adapted. Topographic elevation influences climate and so can also affect the establishment and growth of plants. For example, most of the 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. 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 in the future due to changing practices in mining and reclamation, such as segregation and planned placement of overburden strata, replacement of native soil, and treatment of acid soils. Alkalinity or high pH causes revegetation problems in only a few eastern areas. For example, in Alabama, the southern pines are difficult to establish on high pH spoils.

Planting Materials

The type of plant materials used to establish the species are identified on the description sheets. 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 parenthesis. 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, 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. Eastern gamagrass and some cultivars of Bermudagrass are species that must be planted vegetatively. 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. See Section 5, Vegetation Establishment, for a discussion and recommendations on size of planting stock, spacing of seedlings, time of planting, direct seeding, and inoculation of legume seed.

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 rates are suggested for the less humid areas of the East, and especially where seed is planted with drills. Special directions are given for tree species that can be established from planting of nuts. Discussion of seeding rates and explanation of pure live seed (PLS) are given in Section 5.

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 Section 5.

Superior Cultivars

Varieties, strains, or selections with one or more superior qualities are listed for some species. When available, the use of superior cultivars usually is recommended over unimproved cultivars. Consult agricultural agencies such as your State Extension Service or the USDA Soil Conservation Service for advice on recommended cultivars for 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 1 growing season to establish the desired cover, but may not require a full second growing season; Slow: requires more than 2 full growing seasons to establish the desired cover.

These criteria apply primarily to a species when sown alone; the rate of establishment could vary some 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 or frost-prepared seedbeds on minesoils that have been properly limed and fertilized; 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 on the description sheets. 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.

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. 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-section 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).

SPECIES DESCRIPTIONS

Descriptions have been prepared on individual pages for species that are most frequently used and recommended, and for some that have proven successful in experimental plantings but otherwise may have been little used. For species of lesser importance, and those seldom used, similar but less detailed information is given in Tables 2, 3, 4, and 5. The species descriptions are arranged by plant type in the order: grasses, forbs, trees, and shrubs.

REDTOP (*Agrostis gigantea*)

Type of plant: Grass

Origin: Introduced

Life span: Perennial

Season of major growth: Cool

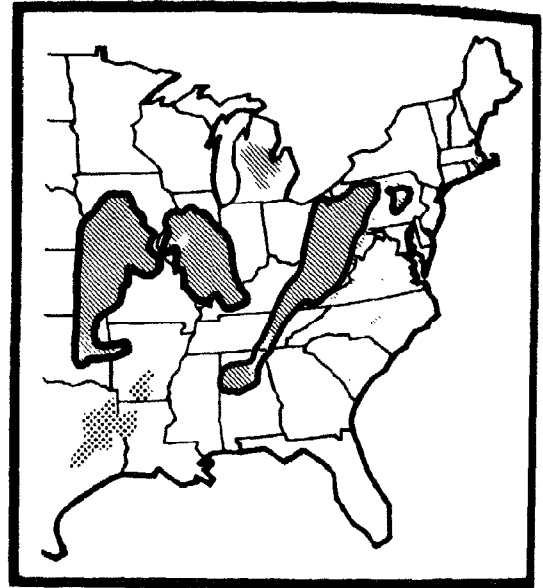
Lower pH limit: 4.0 to 4.5

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)

Comments: Redtop is tolerant of a wide variety of soil and moisture conditions. It grows on very acid and clayey soils. It is especially adapted to wet sites and poorly drained soils, but is also drought resistant when established. Spreads by seed and rhizomes. Forms a sod that is useful for controlling erosion on sites with overland flows. Sometimes recommended for use in fall seedings, but the small plants produce little cover in the fall. They do initiate new growth and produce rapid cover early the following spring. Redtop is relatively short lived; the stands usually give way to other species after 3 to 4 years. Value as a forage crop is relatively low. Adapted to most of the Eastern United States, except the deep South.

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

Type of plant: Grass

Origin: Native

Life span: Perennial

Season of major growth: Warm

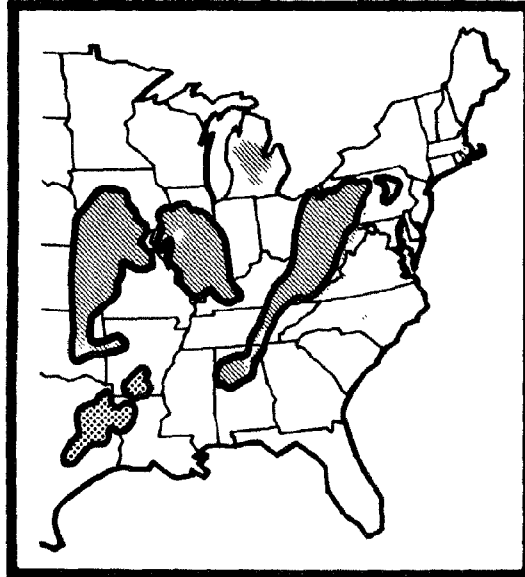
Lower pH limit: 4.5

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

Comments: Native to all Eastern States, these species may be slow to develop cover, but once established, the stands require little maintenance. Height of big bluestem may reach 6 to 7 feet; little bluestem 3 to 4 feet. To develop a more diverse stand of native plants, sow these grasses in mixtures with other native species such as partridge pea, Indiangrass, and switchgrass. Include a light seeding of rye or oats in the mixture to provide initial cover, or seed the native grasses into the residue of a summer annual crop grown the year before. Seeds of the bluestems are light and fluffy and can be more difficult to drill or broadcast than seeds of most grasses. Germination and purity of seed often is low, so be sure that seeding rates are based on PLS values. Bluestems can provide summer forage for livestock and cover for game birds and mammals. Where the herbage is not used, occasional removal of heavy litter buildup in older stands will help maintain vigorous plant growth. In pasture, rangeland, or wildlife uses, burning is the best way to remove the heavy litter.

SMOOTH BROME (*Bromus inermis*)

Type of plant: Grass

Origin: Introduced

Life span: Perennial

Season of major growth: Cool

Lower pH limit: 5.0

Planting materials: Seed

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

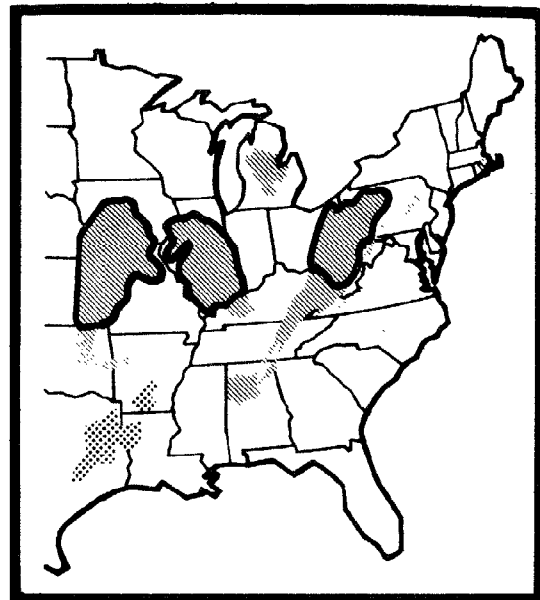
Time of seeding: Spring; late summer-early fall

Superior cultivars: Consult local agricultural agencies for recommendations

Rate of establishment: Moderate to slow

Major uses: Forage; erosion control (long-term cover)

Comments: This sod-forming grass is best adapted to the northern half of the Interior Coal Provinces and the northern third of Appalachia. Kentucky-31 fescue performs better for vegetating minesoils in the southern part of these regions. Smooth brome grass is a leafy palatable forage plant and is usually 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 vs. southern latitudes. Consult local agricultural authorities for recommendations on the variety or type suited for a given area.



BERMUDAGRASS (*Cynodon dactylon*)

Type of plant: Grass

Origin: Introduced

Life span: Perennial

Season of major growth: Warm

Lower pH limit: 4.0 (see comments)

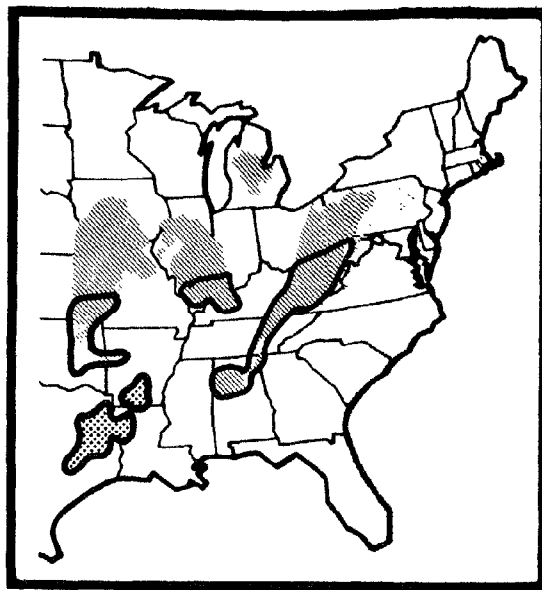
Elevation limit: May winter kill at higher elevations in Appalachians

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

Time of seeding: Mid to late spring after mean daily temperatures exceed 65°F.



Time of sprigging: Any month; spring and summer best

Superior cultivars: 'Tufcote' (sod type); Midland, Coastal (forage types)

Rate of establishment: Rapid

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

Comments: Bermudagrass is adapted to a wide range of mine-soil types; but its practical use is limited because the most winter-hardy cultivars must be planted vegetatively with pieces of rhizomes and stolons (sprigs). Common Bermuda can be seeded, but most commercial seed sources are winter hardy only in the southern part of the coal-mining areas. Midland and 'Tufcote' are more winter hardy of the superior cultivars and have survived winters in southern Indiana and northern West Virginia. 'Tufcote' is more tolerant than Midland or Coastal to low soil pH, and reportedly has grown in West Virginia mine-soils at pH 3.2. Bermudagrass grows best on moist heavy soils in warm and hot weather, but is also very tolerant of droughty soil conditions and of salty soils. Plants grow and spread rapidly by stolons and rhizomes. It is relatively long lived in its adapted climatic range when soil fertility is maintained. One of the most productive forage grasses in the South with heavy application of fertilizer.

ORCHARDGRASS (*Dactylis glomerata*)

Type of plant: Grass

Origin: Introduced

Life span: Perennial

Season of major growth: Cool

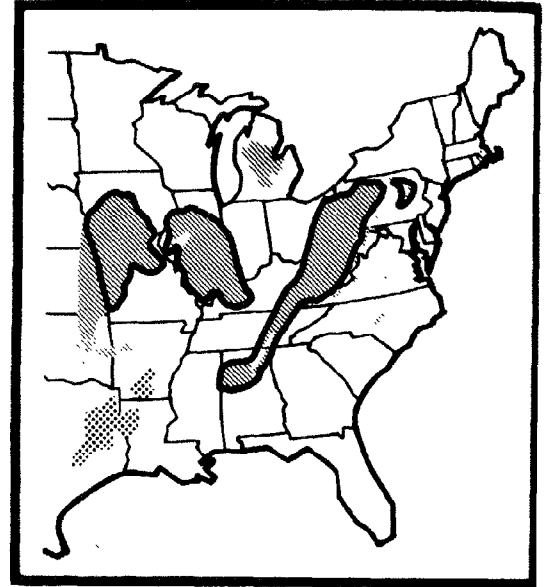
Lower pH limit: 4.5

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

Comments: Orchardgrass is similar to K-31 tall fescue in growth habits and tolerance to acid minesoil, but generally is less persistent, especially where management is not practiced to maintain it. This grass is considered superior to fescue for use in wildlife plantings, especially in food patches and clearings vegetated with herbaceous species for game birds. Grows well in combination with legumes such as alfalfa, red and alsike clovers, or birdsfoot trefoil. It is more adapted than most grasses to growing in shade.

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

Type of plant: Grass

Origin: Introduced

Life duration: Annual

Season of major growth: Warm

Lower pH limit: 4.5

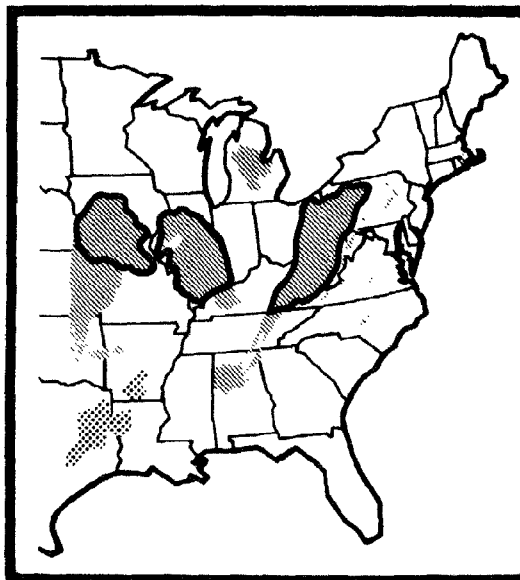
Planting materials: Seed

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



Comments: Use as a quick cover companion crop with perennial grasses and legumes, or sow alone for growing *in situ* mulch. 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 barnyardgrass. Grows better than foxtail millet in cool regions.

WEeping LOVEGRASS (*Eragrostis curvula*)

Type of plant: Grass

Origin: Introduced

Life span: Perennial

Season of major growth: Warm

Lower pH limit: 4.0

Elevation limit: Avoid higher
elevations in West Virginia

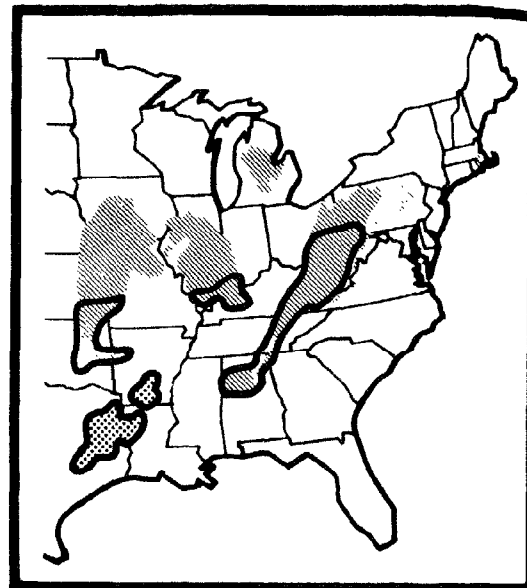
Planting materials: Seed

Seeding rate: 2 to 3 lb/acre in
mixtures

Time of seeding: Spring to early
summer

Rate of establishment: Rapid

Major uses: Erosion control (quick, temporary cover)



Comments: This grass is one of the most tolerant of extremely acid minesoils. It has grown well on some minesoils with pH 3.8. Establishes cover easily and quickly, but is relatively short lived (2 to 4 years) unless foliage is removed by mowing, burning, or grazing. It is compatible with many other species and is best used as the quick cover component in a mixture with perennial grasses and legumes, especially in mid- to late-spring seedings. Although it provides good initial cover, weeping lovegrass gradually gives way to the other perennial species. It is suited for use on warm dry sites such as south-facing slopes. The young spring growth of herbage can be used for pasture, but mature plants are relatively unpalatable to livestock. In some areas of the South, it is cut for hay when plants are heading out and the regrowth is used for winter grazing. Climatically, it is best adapted to the southern regions, but sometimes plants survive through winters even in southwestern Pennsylvania and at 2,500 to 3,000 feet in West Virginia. 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 companion perennial species. Common and 'Morpa' are the cultivars most tolerant of acid minesoils.

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

Type of plant: Grass

Origin: Introduced

Life span: Perennial

Season of major growth: Cool

Lower pH Limit: 4.5

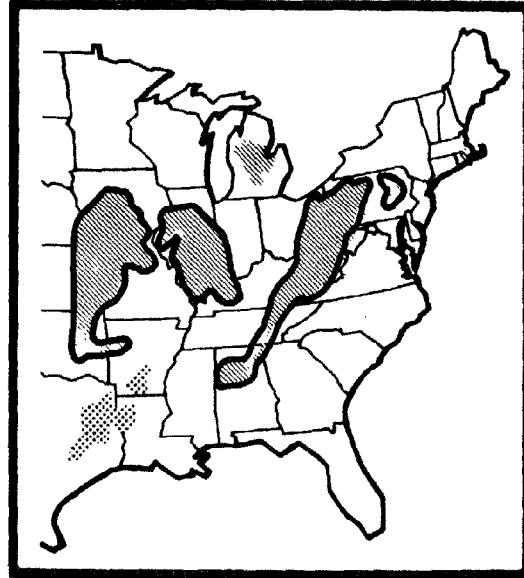
Planting materials: Seed

Seeding rate: 10 to 15 lb/acre in mixtures; 20 to 35 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)



Comments: Most used and most versatile of the grasses suited for vegetating surface mines. It is adapted to a wide range of environmental conditions including wet soils, droughty soils, acid soils, 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 occasionally refertilized. Makes luxuriant growth under black locust. Usually becomes the minor species in mixtures with sericea lespedeza, crownvetch, or flatpea. 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. Nearly all tall fescue seed available today is Kentucky-31. 'Alta' tall fescue is similar but seldom used.

ANNUAL RYEGRASS (*Lolium multiflorum*)

Type of plant: Grass

Origin: Introduced

Life span: Annual

Season of major growth: Cool

Lower pH limit: 4.5

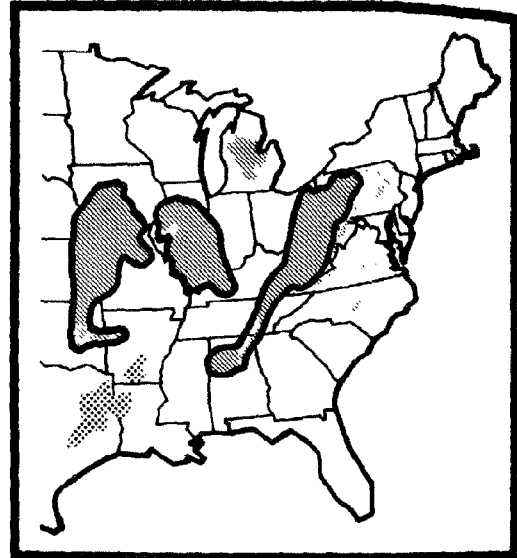
Planting materials: Seed

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



Comments: This winter annual is also known as Italian ryegrass. The 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. It can be sown in the fall or early spring, but spring seeding is advised where winters are severe. This grass is 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 strongly compete with the companion perennials; thus, its seeding rate should not exceed the above recommendation. In warmer climates, ryegrass could be sown alone in the fall for winter cover, and the component of perennial species sown the following spring or fall. Ryegrass can be pastured or cut for hay in agricultural situations, but such use on newly vegetated mine soils should be deferred until perennial species become well established. Its value for wildlife is limited.

PERENNIAL RYEGRASS (*Lolium perenne*)

Type of plant: Grass

Origin: Introduced

Life span: Perennial

Season of major growth: Cool

Lower pH Limit: 4.5

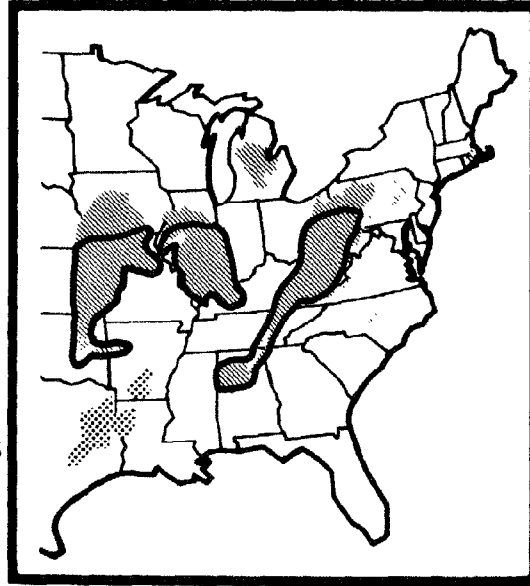
Planting materials: Seed

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



Comments: This species is a short-lived perennial. Plants usually live only 2 to 3 years and do not successfully reseed to perpetuate the stand. Plants grow from 1 to 2 feet tall. Used mostly to provide quick temporary cover where sown in mixture with long-lived perennial grasses and legumes. This species is less vigorous and less competitive than annual ryegrass with companion species. In warmer climates it 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.

DEERTONGUE (*Panicum clandestinum*)

Type of plant: Grass

Origin: Native

Life span: Perennial

Season of major growth: Warm

Lower pH limit: 4.0

Planting materials: Seed (stratify
for spring seeding)

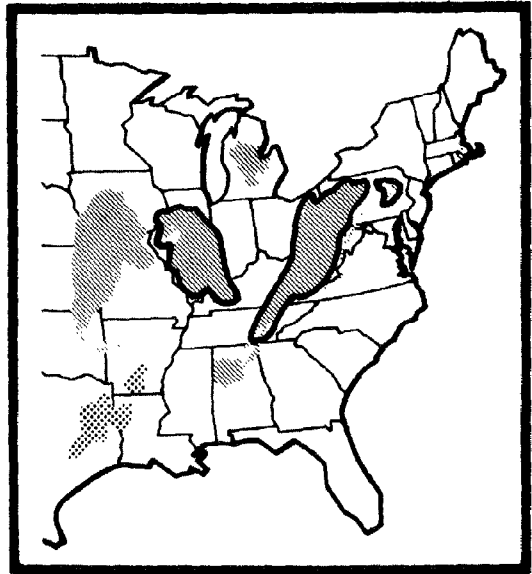
Seeding rate: 6 to 8 lb/acre in
mixture; 12 to 15 lb/acre alone

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

Superior cultivars: Tioga

Rate of establishment: Moderate to slow

Major uses: Watershed protection; wildlife habitat



Comments: This grass was 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 tested on minesoils mostly in the Northeast. Deertongue 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.

SWITCHGRASS (*Panicum virgatum*)

Type of plant: Grass

Origin: Native

Life span: Perennial

Season of major growth: Warm

Lower pH limit: 4.0 to 4.5

Planting materials: Seed

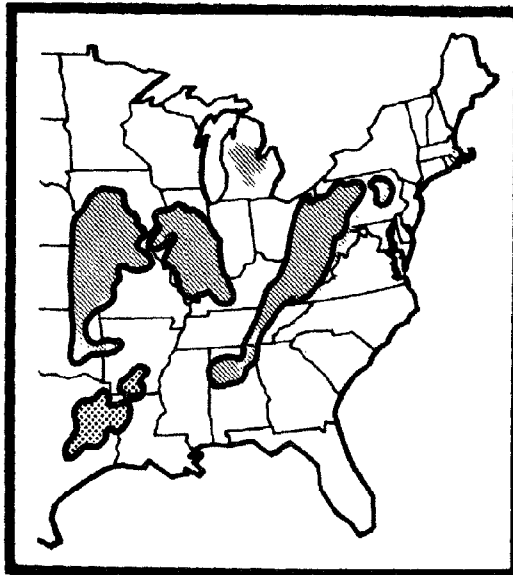
Seeding rate: 2 to 5 lb/acre in mixture; 5 to 12 lb/acre alone

Time of seeding: Spring

Superior cultivars: Blackwell; Kanlow, Caddo, Cave-in rock

Rate of establishment: Moderate to slow

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



Comments: Switchgrass has been used on minesoils in most of the eastern 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 properly managed. Switchgrass and birdsfoot trefoil are compatible for seeding in mixtures, though switchgrass will gradually dominate the stand. 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 seeding of rye, wheat, or oats also will help provide quick site protection. 'Blackwell' is the cultivar most widely used on eastern minesoils. It grows about 4 feet tall. 'Kanlow' is taller and more robust, and can tolerate inundation for up to 20 days. Many other cultivars have been tested and most have not proven appreciably better than Blackwell. There are many natural ecotypes of switchgrass, so selections can be made that are adapted to various environmental conditions. Seeding too heavily in a well-prepared seedbed can cause seedling competition.

PEARL MILLET (*Pennisetum americanum*)

Type of plant: Grass

Origin: Introduced

Life span: Annual

Season of major growth: Warm

Lower pH limit: 4.0-4.5

Planting materials: Seed

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

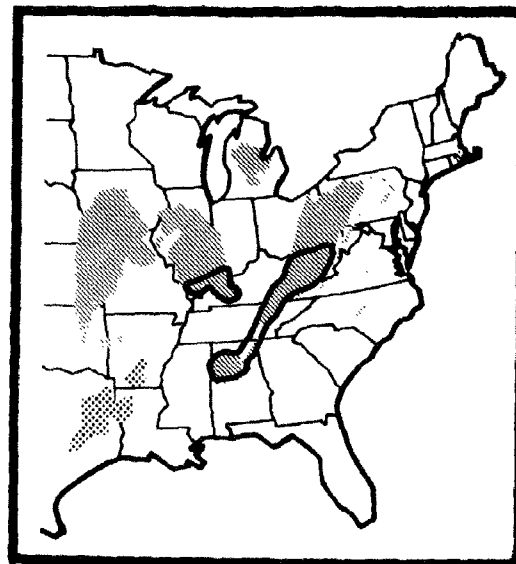
Time of seeding: Late spring to mid
summer

Superior cultivars: Gahi-1; Starr

Rate of establishment: Rapid

Major uses: Erosion control (quick, temporary cover)

Comments: Used primarily for quick, temporary cover in late-spring to mid-summer seedings. Sow as companion crop with perennials, or sow alone for growing mulch in place. Plant or sow perennials into the residue (mulch) the following spring. The plant residue is composed of large stems that will last through the second year and sometimes longer. Pearl millet may grow 6 to 8 feet tall in good fertile minesoil. Can be grown in Kentucky and southward. Will outyield Sudangrass in the Southeast and is free from prussic acid. Seeds are used by songbirds.



REED CANARYGRASS (*Phalaris arundinacea*)

Type of plant: Grass

Origin: Introduced

Life span: Perennial

Season of major growth: Cool

Lower pH limit: 4.5

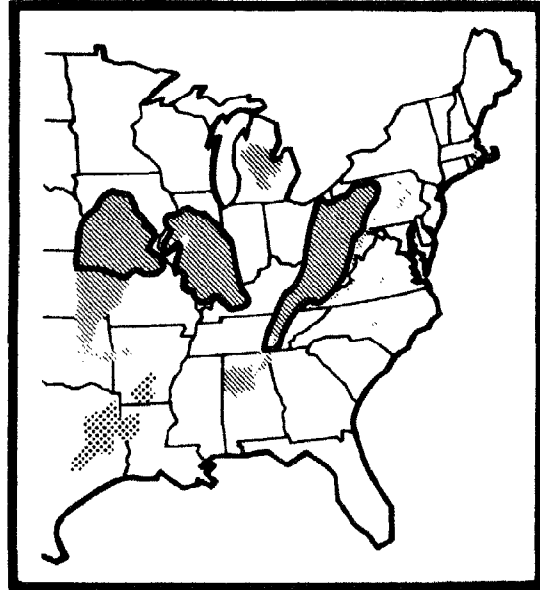
Planting materials: Seed; sprigs

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



Comments: This grass 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. This species is drought resistant and also will grow on upland sites. Generally, legumes sown with this grass are not successful. The seed is used by game birds.

TIMOTHY (*Phleum pratense*)

Type of plant: Grass

Origin: Introduced

Life span: 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

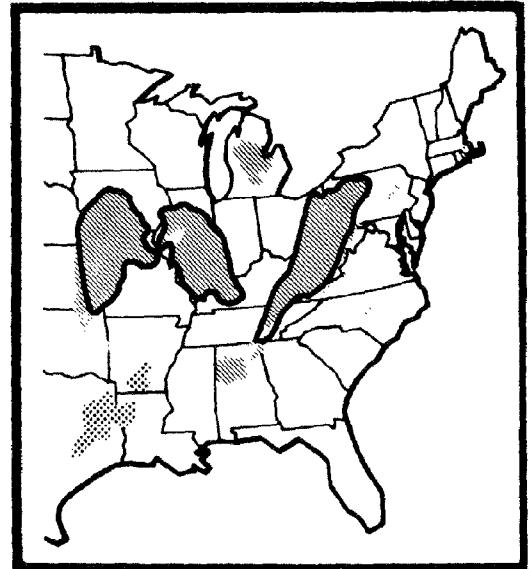
Time of seeding: Late summer-early fall; spring

Superior cultivars: Consult local agricultural agencies for recommendations

Rate of establishment: Moderate

Major uses: Forage; wildlife habitat; erosion control

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 fescue in plantings for wildlife habitat. Should be sown with legumes and other grasses. Timothy can be sown in the fall with rye or winter wheat and the legumes, such as red clover or alfalfa, sown the following spring. Timothy is a relatively short-lived perennial, usually persisting about 5 years, especially where not managed for forage production. Can tolerate partial shading.



RYE (*Secale cereale*)

Type of plant: Grass

Origin: Introduced

Life span: Annual

Season of major growth: Cool

Lower pH limit: 4.5

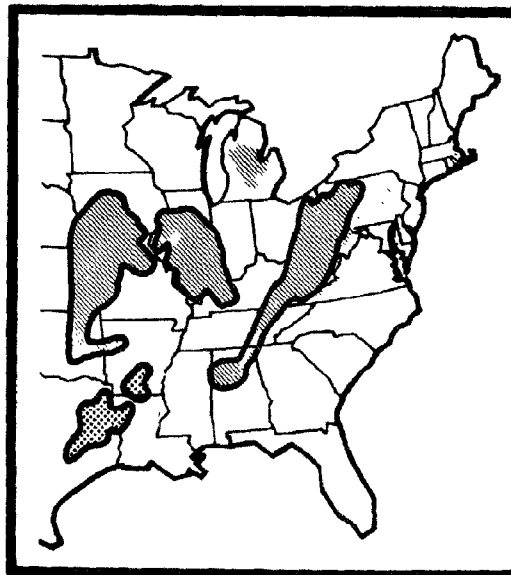
Planting materials: Seed

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

Time of seeding: Fall, spring

Superior cultivars: Balbo; Abruzzi

Rate of establishment: Rapid



Major uses: Erosion control (quick, temporary cover)

Comments: Rye is widely used 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 yet another option. Rye seed germinates rapidly; the seedlings are vigorous and quickly provide ground cover. Rye can be sown later in 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 purposes.

FOXTAIL MILLET (*Setaria italica*)

Type of plant: Grass

Origin: Introduced

Life span: Annual

Season of major growth: Warm

Lower pH limit: 4.5

Elevation limit: Avoid high altitudes

Planting materials: Seed

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

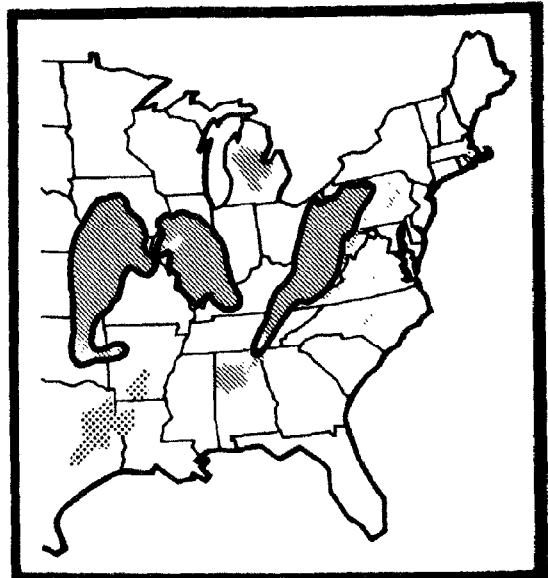
Time of seeding: Late spring to
mid summer

Superior cultivars: German

Rate of establishment: Rapid

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

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 for winter cover. The German strain has somewhat heavier stems and requires a longer growing period than common foxtail millet. The seed provides food for songbirds.



INDIANGRASS (*Sorghastrum nutans*)

Type of plant: Grass

Origin: Native

Life span: Perennial

Season of major growth: Warm

Lower pH limit: 4.5

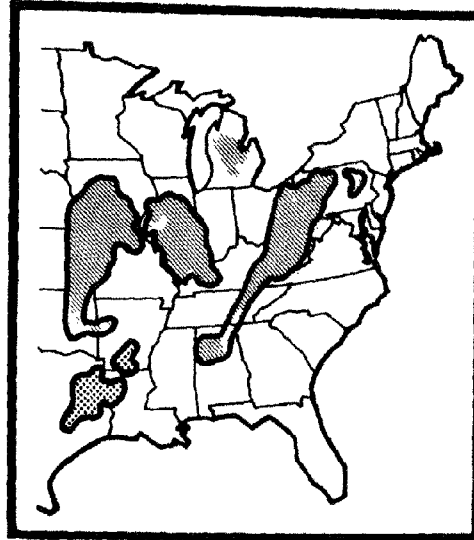
Planting materials: Seed

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)

Comments: Indiangrass is native to all Eastern States and in some regions will invade naturally into areas where woody vegetation is controlled, such as under powerlines and on roadsides. It 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. 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 mammals. Indiangrass produces good summer forage for livestock. It responds to spring burning with improved vigor, greater forage production, and more rapid stand development.

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

Type of plant: Grass

Origin: Introduced

Life Span: Annual

Season of major growth: Warm

Lower pH limit: 4.5 to 5.0

Planting materials: Seed

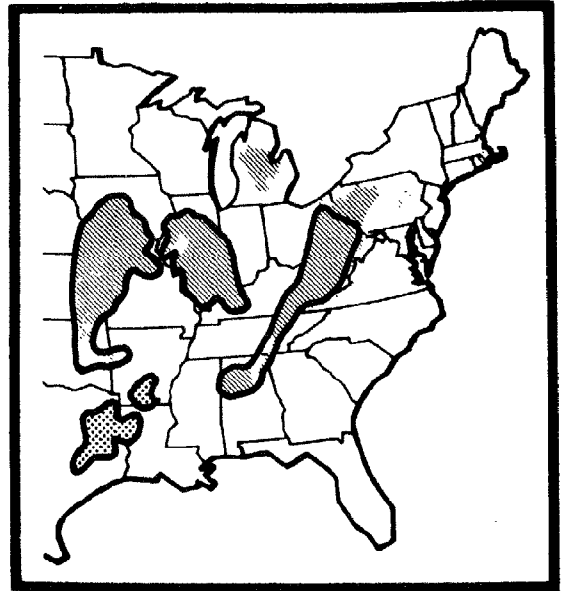
Seeding rate: 15 to 20 lb/acre in mixtures; 25 to 40 lb/acre alone

Time of seeding: Late spring to mid summer

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)



Comments: The sorghums, Sudangrass, and sorghum-Sudangrass hybrids are drought resistant and are useful as the quick, temporary cover component of herbaceous mixtures sown in late spring to mid summer. 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. Plant residues from these species will last through the second year and sometimes longer. 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. Forage and grass sorghums can be used for pasture, silage, or fodder in agricultural land uses. Superior cultivars and hybrids have not been delineated for mine-soil plantings. CAUTION: When grown under certain environmental conditions, the herbage of these species can be poisonous to livestock.

WINTER WHEAT (*Triticum aestivum*)

Type of plant: Grass

Origin: Introduced

Life span: 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 food

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 wheat is used for quick cover and harvested for the grain crop. The stubble and straw residue after harvest provide soil cover until fall seeding time 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, thus 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 can be obtained from local agricultural agents.

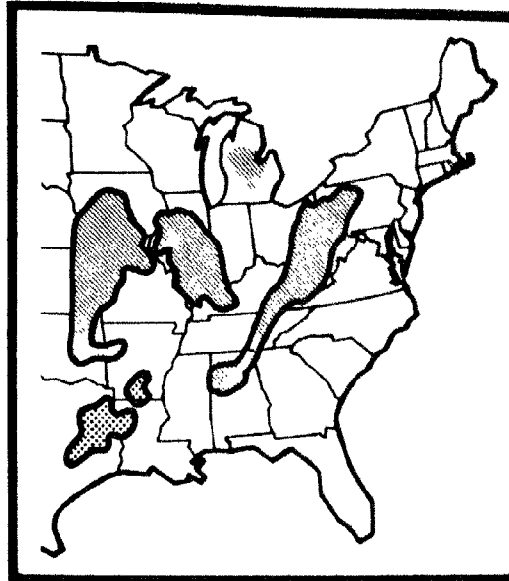


TABLE 2. GRASS SPECIES OF LIMITED IMPORTANCE OR USE

Common and Scientific Name	Origin	Life Span	Growth Season	Lower pH Limit ^a	Seeding Rate (lb/acre) PLS	States Where Used	Comment
Western wheatgrass <i>Agropyron smithii</i>	N ^a /	p ^b /	Cool	4.5	3-5 ^c / 8-10	KS, OK ^d /	Rhizomatous, sod forming. Spreads onto adjacent toxic areas. Moist swales and clayey soils.
Tall oatgrass <i>Arrhenatherum elatius</i>	I	P	Cool	4.5	10-12 15-20	PA, MD, WV, OH, IN, IL	Drought resistant. Moisture and temperature requirements similar to orchardgrass. Plants persist but not in dense stands. Seed harvesting difficult. Limit seed supply.
Oats <i>Avena sativa</i>	I	A	Cool	4.5	30-50	All States	Most often used as quick, temporary cover companion crop in spring seedings. Fall-seeded varieties also available.
Caucasian bluestem <i>Bothriochloa caucasiaca</i>	I	P	Warm	5.0	2-3 3-6	KY, MO, KS, OK	Mix with Appalow or Serala sericea lespedeza or birdsfoot trefoil, or maintain with fertilizer.
Sideoats grama <i>Bouteloua curtipendula</i>	N	P	Warm	4.5	5-10	KS, OK, MO	Sow in mixtures with other native grasses. Establishes fairly quickly. Good forage. Native to most Eastern States. 'Elreno' is superior cultivar.

(continued)

TABLE 2. GRASS SPECIES (CONTINUED)

Browntop millet <i>Brachiaria ramosa</i>	I	A	Warm	4.5	15-20 20-30	AL	Adapted to southern latitudes. For quick, temporary cover in late spring-early summer seedings. Food for song and game birds.
Buffalograss <i>Buchloe dactyloides</i>	N	P	Warm	4.5	5-10 10-20	MO, KS, OK	Adapted to droughty minesoils. Low growing. Spreads by stolons. Mix with other native grasses. Slow to moderate establishment. Excellent forage.
Canada wildrye <i>Elymus canadensis</i>	N	P	Cool	5.0	10-12	OH, IL, IA	Slow to establish. Sow in mixtures with other native grasses. Adapted to dry sites. Excellent forage. Native to Eastern States except those in South-east.
Sand lovegrass <i>Eragrostis trichodes</i>	N	P	Warm	5.0	1½-3	OH, IN, IL, IA, MO	Moderately rapid cover on most minesoils. Mix with switchgrass and other native grasses.
Red fescue <i>Festuca rubra</i>	I	P	Cool	4.5	4-6 8-10	PA, OH, MD, WV, IN, KY-E	Long lived in northern latitudes and high elevations. Fairly shade tolerant. Capable of making dense cover. Several varieties available.
Broomcorn millet <i>Pennisetum polystachyon</i>	I	A	Warm	4.5	10-12	KY	Use in summer annual mix for game bird food. Good for dove. Adapted to northern latitudes. Also called proso millet.

(continued)

TABLE 2. GRASS SPECIES (CONTINUED)

Common and Scientific Name	Origin	Life Span	Growth Season	Lower pH Limit	Seeding Rate (lb/acre) PLS	States Where Used	Comment
Dallisgrass <i>Paspalum dilatatum</i>	I	P	Warm	4.5	7-12	AL, TN, AR, OK	Bunchgrass that seldom makes full cover. Sow with legumes or other grasses. Good pasture. Seed used by song and game birds.
Canada bluegrass <i>Poa compressa</i>	I	P	Cool	5.0	5-10 15-25	OH, IL	Similar to Kentucky bluegrass but better adapted to low-fertility and droughty soils. 'Reubens' is a superior cultivar.
Kentucky bluegrass <i>Poa pratensis</i>	I	P	Cool	5.5	5-10 15-25	OH, IN IL, IA	Shallow-rooted sod-former. Adapted to limestone soils in northern latitudes. Not drought tolerant. Slow to establish cover. Has limited value for vegetating minesoils.
Eastern gamagrass <i>Tripsacum dactyloides</i>	N	P	Warm	5.0		PA, WV, KY-E, VA	Establish vegetatively. Clumps enlarge by short rhizomes. Use on moist sites. Native to most Eastern States.

a/ I = Introduced; N = Native. b/ A = Annual; P = Perennial.

c/ First line is recommended rate for use in mixtures; second line for seeding alone. Use only in mixtures where one line (range of rates) is shown.

d/ States where use on minesoils is known. States identified by two-letter abbreviation. Single letter following dash indicates portion of State where used or best adapted, e.g., KY-E = eastern Kentucky.

CROWNVETCH (*Coronilla varia*)

Type of plant: Forb-legume

Origin: Introduced

Life span: Perennial

Season of major growth: Cool

Lower pH limit: 5.0 (see comments)

Planting materials: Seed; crowns

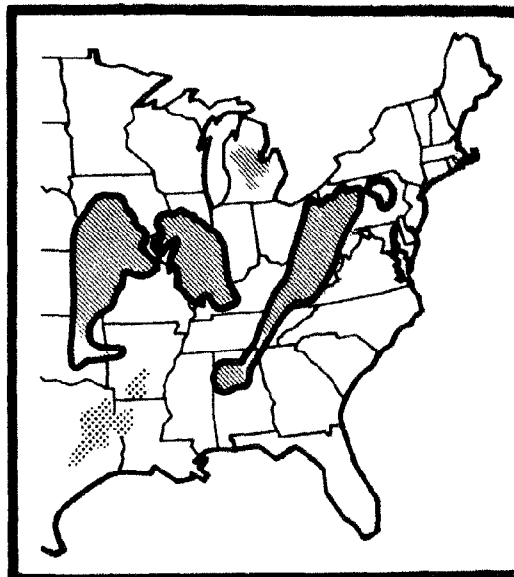
Seeding rate: 5 to 10 lb/acre in mixtures; 15 to 20 lb/acre alone

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

Superior cultivars: Penngift, Chemung, Emerald

Rate of establishment: Slow

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



Comments: Crownvetch is one of the best plants for providing continuous, maintenance-free cover for erosion control. Plants are spread by seed and by rhizomes (underground root stocks); thus they are especially useful for developing total cover on steep slopes. Usually established by direct seeding, but stands can also be started by transplanting crowns (small plants) from older established stands. Seeded stands are most easily established on minesoils with pH 5.5 and higher, but some have been established at lower pHs. As stands develop, plants will spread to and grow on minesoils with pH 4.5 and sometimes lower. Should be sown in mixture with a quick-cover companion grass such as weeping lovegrass or perennial ryegrass. Only a few plants of crownvetch may become established the first year, but they will develop full cover after 3 to 4 years and suppress associated vegetation. Do not plant crownvetch with tree seedlings. A good forage plant but stands can be weakened or lost by overgrazing or by taking more than one cutting of hay annually. Seeds mature continuously over a period of several weeks; thus, efficient and effective seed harvest is difficult. Commercial seed is usually in short supply. The cultivar Emerald is recommended in the Interior Coal Provinces; Chemung and Penngift are used mostly in the Appalachian Region.

FLATPEA (*Lathyrus sylvestris*)

Type of plant: Forb-legume

Origin: Introduced

Life span: Perennial

Season of major growth: Warm

Lower pH limit: 4.0 to 4.5

Planting materials: Seed (special inoculum)

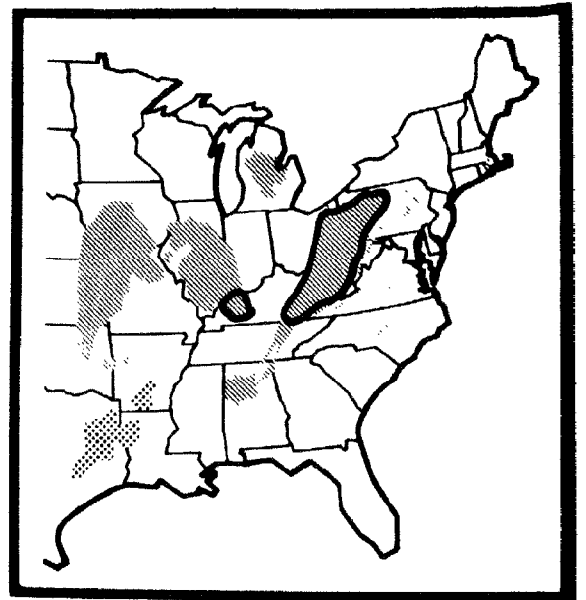
Seeding rate: 20 lb/acre in mixtures;
30 lb/acre alone

Time of seeding: Spring

Superior cultivars: Lathco

Rate of establishment: Slow

Major uses: Watershed protection (long-term cover)



Comments: Flatpea is a long-lived viny species with tendrill-bearing stems and a climbing growth habit. Stand density increases mostly by rhizomes. Stand development is slow but eventually a complete ground cover is established that suppresses associated vegetation and prevents establishment of volunteer plants. Flatpea should not be used in combination plantings with trees. It is drought resistant and more tolerant than crownvetch and most other legumes of acid mine soils. Its 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.

SERICEA LESPEDEZA (*Lespedeza cuneata*)

Type of plant: Forb-legume

Origin: Introduced

Life span: Perennial

Season of major growth: Warm

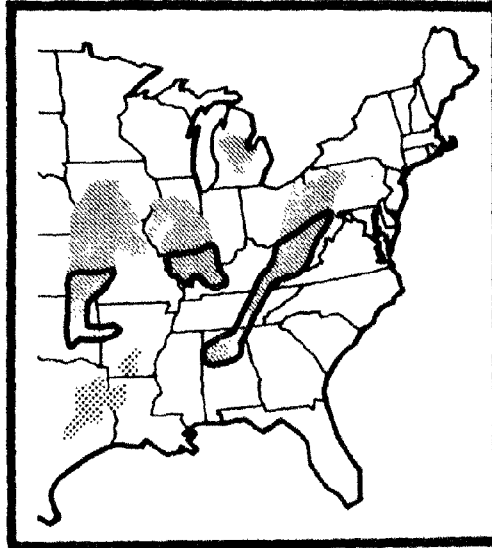
Lower pH limit: 4.5

Elevation limit: Not above 2,000 feet
in northern West Virginia or 1,200
feet in Pennsylvania

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 (In mid summer to early fall,
at least one-half of seed should be
unhulled)



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

Rate of establishment: Slow

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

Comments: Sericea is widely used for erosion control and soil building, especially in the central and southern Appalachian Coal Field. Use in northern latitudes is limited by short growing season that prevents seed set. Stand establishment is relatively slow; thus it should be sown with a "quick cover" grass, such as weeping lovegrass. In mixture with grass, sericea usually becomes the dominant species after about 3 to 4 years. It usually forms dense stands that prevent or retard the natural invasion of other plants. It is considered low in value for wildlife by most biologists. Sericea can be used for grazing and cut for hay when the forage is young and tender (plants should not be over 10 to 12 inches tall for these uses). Can benefit tree growth in combination plantings providing trees grow above the lespedeza (see section on combination plantings). The main advantage of sericea for reclamation is that it provides a long-term or permanent cover that requires little or no maintenance.

KOREAN LESPEDEZA (*Lespedeza stipulacea*)

Type of plant: Forb-legume

Origin: Introduced

Life span: Annual

Season of major growth: Warm

Lower pH limit: 5.0

Elevation limit: Not above 2,000 feet
in northern West Virginia or 1,200
feet in Pennsylvania

Planting materials: Seed

Seeding rate: 6 to 12 lb/acre in
mixtures; 20 to 25 lb/acre alone

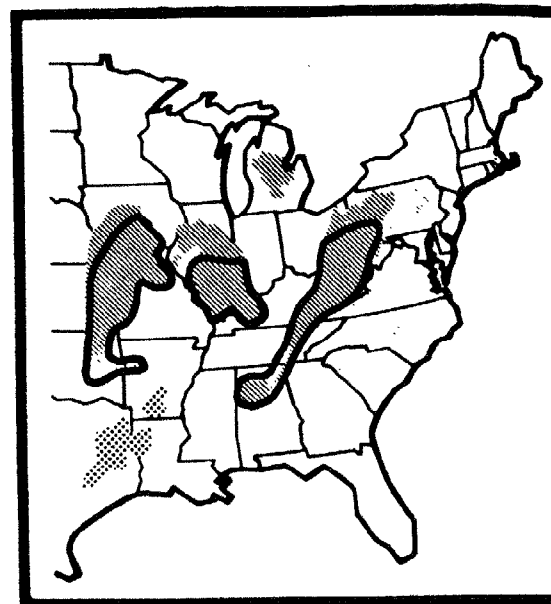
Time of seeding: Spring

Superior cultivars: Climax (late maturing); Iowa 6 (early maturing, use
in northern part of lespedeza region); Rowan (intermediate maturing)

Rate of establishment: Moderate to rapid

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

Comments: Readily reseeds in adapted climatic range; thus it can be con-
sidered 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. Seed of Korean is
a preferred food by quail. Produces high-quality hay.



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

Type of plant: Forb-legume

Origin: Introduced

Life span: Annual

Season of major growth: Warm

Lower pH limit: 4.5

Elevation limit: Below 2,000 feet at
northern limits of range

Planting materials: Seed

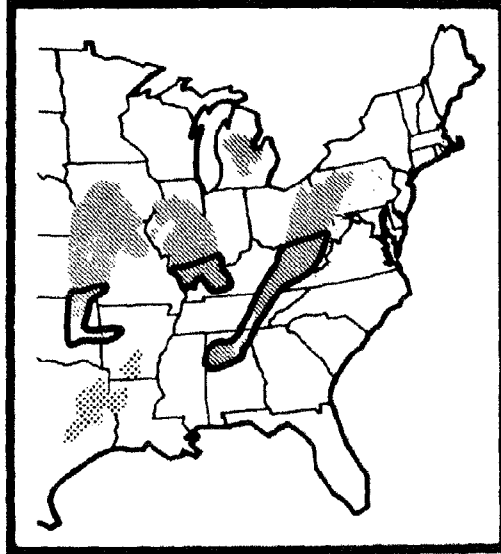
Seeding rate: 8 to 15 lb/acre in
mixtures; 25 to 30 lb/acre alone

Time of seeding: Spring

Superior cultivars: Kobe, Tenn. 76

Rate of establishment: Rapid to moderate

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



Comments: Common lespedeza is also called Japanese lespedeza, Japanese clover, and striate lespedeza. It has a low-growth form and is less productive of herbage than the varieties Kobe and Tenn. 76. Kobe is the most widely used and most familiar cultivar of this lespedeza. It is similar to Korean in growth form but it matures later and is not adapted as far north. It is more tolerant than Korean of high levels of manganese in the soil. Readily reseeds in its adapted climatic range. Generally used for quickly establishing a legume in mixtures with grasses or with grasses and perennial legumes. Recommended as a ground cover species for use with pine in the southern pine region. Growth stops after first killing frost and cover value of plant residue diminishes as winter progresses.

BIRDSFOOT TREFOIL (*Lotus corniculatus*)

Type of plant: Forb-legume

Origin: Introduced

Life span: Perennial

Season of major growth: Cool

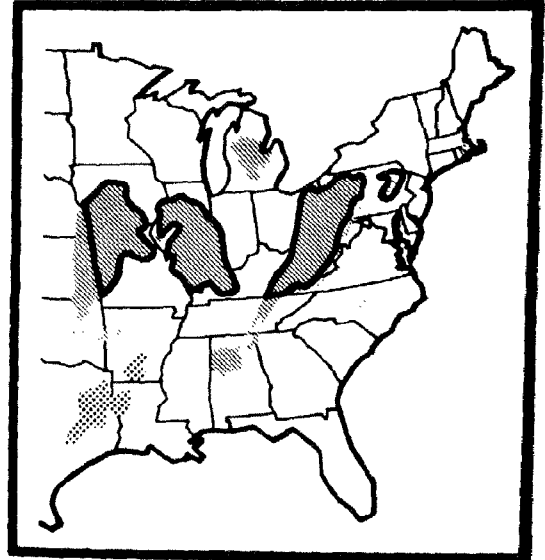
Lower pH limit: 4.5

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



Rate of establishment: Rapid to moderate

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

Comments: This relatively low-growing legume grows best in the northern half of the coal mining regions. Stands also are easily established near the southern limits of the adapted area (Kentucky and southern West Virginia) but their life span usually is shorter than in the northern areas. Trefoil has a 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, flatpea, and sericea lespedeza. Generally, trefoil is 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. Narrowleaf trefoil (var. *lanceifolium*) is a linear-leaved variant that has a more prostrate growth form than birdsfoot. Its performance is similar to birdsfoot on minesoils. Dawn is a disease-resistant cultivar used in southern Missouri. Research in several Southern States is underway to select and breed cultivars adapted to southern regions.

ALFALFA (*Medicago sativa*)

Type of plant: Forb-legume

Origin: Introduced

Life duration: Perennial

Season of major growth: Cool

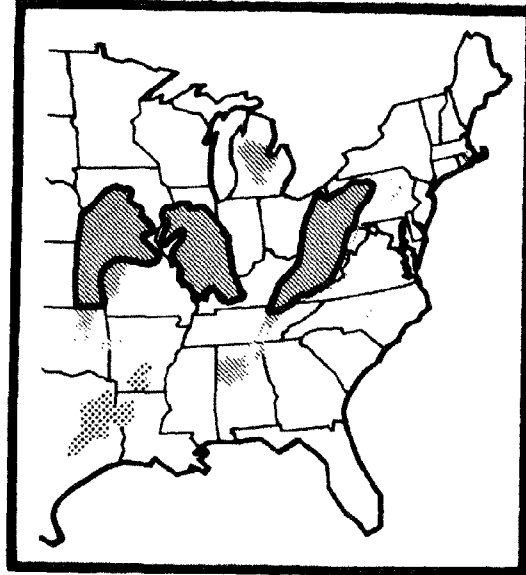
Lower pH limit: 5.5

Planting materials: Seed

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

Time of seeding: Spring; late summer

Superior cultivars: Ranger, Buffalo.
Consult local agricultural agencies for recommendations



Rate of establishment: Rapid to moderate

Major uses: Forage; wildlife habitat; erosion control

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 of alfalfa on mined lands has been mostly in northern Illinois and similar areas where the 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 adequately fertilized with phosphorus. Use primarily on areas that will be managed for forage production or wildlife openings. It makes good pasture when mixed with orchardgrass, smooth brome grass, or tall fescue. Although generally considered a cool-season species, alfalfa makes 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.

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

Type of plant: Forb-legume

Origin: Introduced

Life span: Biennial

Season of major growth: Cool

Lower pH limit: 5.5

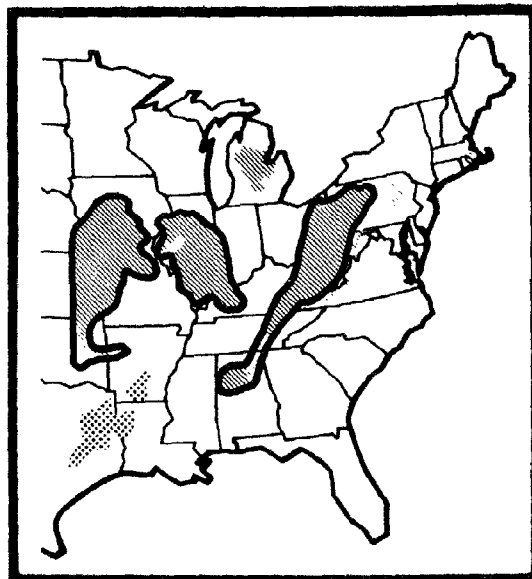
Planting materials: Seed (scarified)

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)



Comments: Sweetclover generally is considered intolerant of acid soils, but resistant to drought. It makes rapid growth and quickly provides a vegetative cover. On suitable soils it 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 will volunteer from seed most years thereafter. Sweetclover is a valuable plant for bee pasture (honey production). In agriculture, it is used mainly 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.

RED CLOVER (*Trifolium pratense*)

Type of plant: Forb-legume

Origin: Introduced

Life span: 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

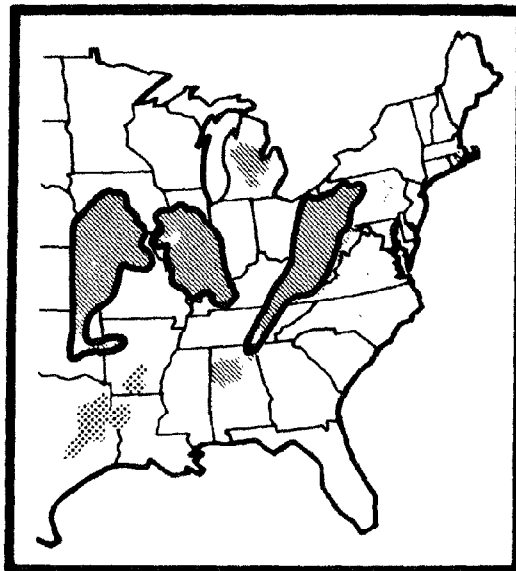
Time of seeding: Spring; late summer (southern U.S.)

Superior cultivars: Kenland; Pennscott

Rate of establishment: Rapid

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

Comments: Red clover is one of the most important hay crops grown on farms in the Northeastern United States. Its use on mined lands is primarily to improve or enrich the minesoil and to add to species diversity in food plantings for wildlife. It should be sown with long-lived grasses and legumes because it has a biennial or short-lived perennial growth habit. It is used as a winter annual in the South. Although stands of red clover thin out, a few plants will continue to volunteer for several years from seed. Red clover requires a high level of soil phosphorus. It is less drought resistant than alfalfa and is best adapted where adequate moisture is available throughout the growing season. It is subject to damage and stand reduction by several diseases and insect pests.



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

Type of plant: Forb-legume

Origin: Introduced

Life span: Perennial

Season of major growth: Cool

Lower pH limit: 5.5

Planting materials: Seed

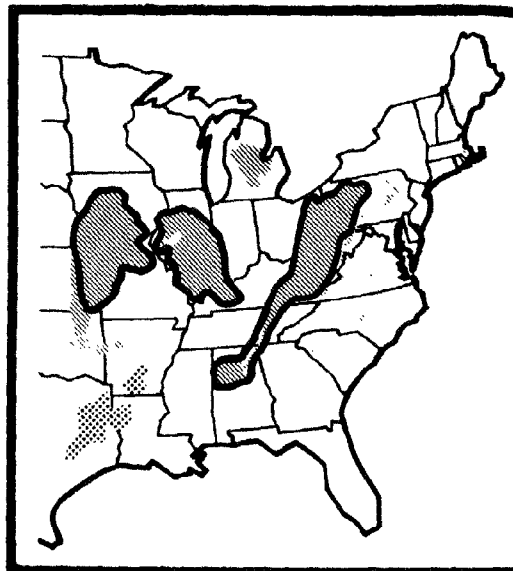
Seeding rate: 2 to 4 lb/acre in mixtures

Time of seeding: Spring; late summer

Superior cultivars: Ladino

Rate of establishment: Moderate to rapid

Major uses: Wildlife habitat; forage



Comments: Common white clover is used for pasture throughout the Eastern United States. However, on mine soils it should be used primarily to provide diversity in species composition, especially in food patches or openings planted for wildlife. It 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.

BUCKWHEAT (*Fagopyrum esculentum*)
COMMON SUNFLOWER (*Helianthus annuus*)

Type of plant: Forb-nonlegume

Origin: Buckwheat--Introduced
Sunflower--Native

Life span: Annual

Season of major growth: Warm

Lower pH limit: Buckwheat--4.5
Sunflower--5.0

Planting materials: Seed

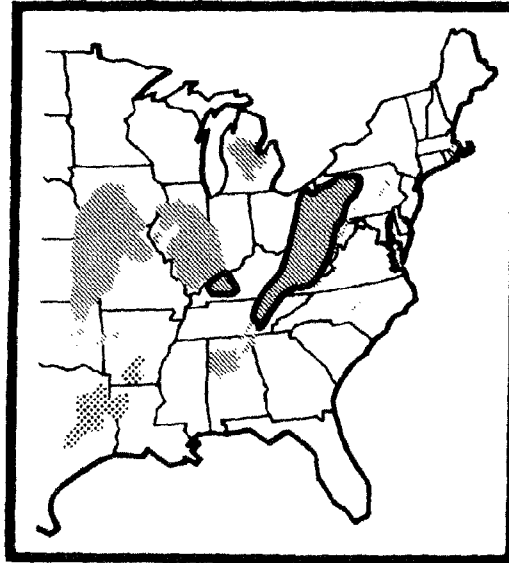
Seeding rate: Buckwheat--25 to 40
lb/acre in mixtures; Sunflower--4
to 6 lb/acre in mixtures

Time of seeding: Late spring-early
summer

Rate of establishment: Rapid

Major uses: Wildlife habitat; quick, temporary cover; esthetics; food crop

Comments: Mix with other summer annual species to provide diversity in fall and winter foods for wildlife, especially for song and game birds. Neither species should be depended on alone for cover. Buckwheat can make late summer cover but the plant residue is insufficient for *in situ* mulch over winter. Sunflower plants usually are too sparsely spaced for good cover on the soil surface. Thus, these species usually should be sown with perennial grasses or legumes, or be followed in the fall with a seeding of another quick cover crop such as rye or wheat. Buckwheat is excellent for bee pasture (honey production). Both species add to the visual appeal (esthetics) when in full bloom.



JAPANESE FLEECEFLOWER (*Polygonum cuspidatum*)

Type of plant: Forb-nonlegume

Origin: Introduced

Life span: Perennial

Season of major growth: Warm

Lower pH limit: 3.5

Planting materials: Seed; crowns

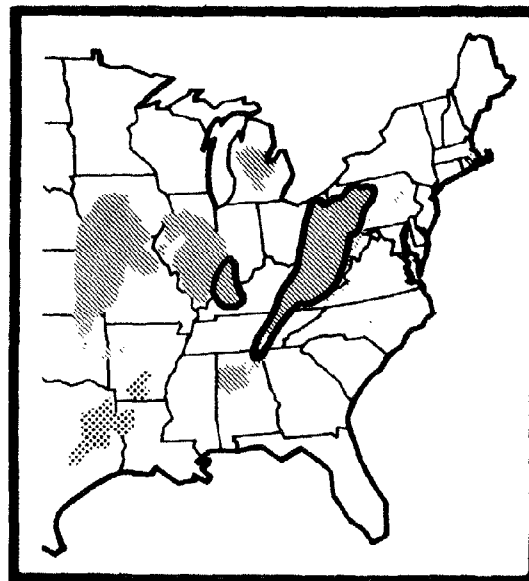
Seeding rate: 3 to 5 lb/acre

Time of seeding: Spring

Superior cultivars: Belmont
(exceptionally tolerant of acid);
v. compactum (dwarf fleeceflower)

Rate of establishment: Slow

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



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. This species will grow and spread on extremely acid minesoil. The accession 'Belmont' was collected from plants that reportedly were growing on minesoil with a pH as low as 3.2. It is 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, it does not readily spread by seed into stands of established vegetation. 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 or 'Belmont' fleeceflower.

TABLE 3. FORB SPECIES OF LIMITED IMPORTANCE OR USE

Common and Scientific Name	Origin	Life Span	Growth Season	Lower pH Limit	Seeding Rate (lb/acre) PLS	States where used	Comment
<u>LEGUMES</u>							
Cicer milkvetch <i>Astragalus cicer</i>	I ^a /	b/	Cool	5.0	8-12 ^c / 15-20	KS ^d /	A long-lived legume for dryland conditions. Spreads slowly by rhizomes.
Partridge pea <i>Cassia fasciculata</i>	N	A	Warm	5.0	20-30	KY, IN	Reseeds, usually in sparse stands. Seed is eaten by game birds. Sow in mixtures. Native to most Eastern States.
Illinois bundleflower <i>Desmanthus illinoensis</i>	N	P	Warm	5.0	5-10	KS, OK	Reproduces from seed. Drought resistant. Component of native prairie. High forage value.
Soybean <i>Glycine max</i>	I	A	Warm	5.0	30-50	KY, AL, IL, KS (Adapted to all States)	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 <i>in situ</i> mulch. Cash crop on prime farmland.
Prostrate lespedeza <i>Lespedeza daurica</i> var. <i>schimadai</i>	I	P	Warm	4.5	15-20	IN, IL, IA, MO, KS	Similar to sericea, but low growing. A good ground cover to plant with trees. Not successful in Appalachia.

(continued)

TABLE 3. FORB SPECIES (CONTINUED)

Common and Scientific Name	Origin	Life Span	Growth Season	Lower pH Limit	Seeding Rate (lb/acre) PLS	States where used	Comment
Kura clover <i>Trifolium ambiguum</i>	I	P	Cool	5.0	6-8 8-12	WV	Slow to establish. Spreads by rhizomes, forms a sod. Drought resistant, also tolerates wet soils. Requires special inoculum. Seed supply scarce and uncertain.
Alsike clover <i>Trifolium hybridum</i>	I	P	Cool	5.0	3-5	MD, WV, KY, OH, IN, IL	Adapted to wet soils and sites with overland flows. For wet sites mix with grass such as redbud and Ky-31 fescue. Provides food for wildlife.
Crimson clover <i>Trifolium incarnatum</i>	I	A	Cool	5.0	10-15 15-25	WV, TN, AL, AR, TX	Winter annual grown mostly in the Southeast. Sow in late summer and fall. Can be used alone for winter cover, and sow perennial species the next spring. Reseeding varieties preferred. Adapted northward to Maryland, Ohio, and Illinois.
Zigzag clover <i>Trifolium medium</i>	I	P	Cool	5.0	6-8 8-12	WV	Long lived, disease and insect resistant. Spreads by rhizomes. Tolerant of wet and dry soils. Requires special inoculum. Seed supply scarce and uncertain.

(continued)

TABLE 3. FORB SPECIES (CONTINUED)

Bigflower vetch <i>Vicia grandiflora</i>	I	A	Cool	5.5	15-20	PA, OH KY	Winter annual. Can be seeded into existing stands of grass. Reseeds itself.
Hairy vetch <i>Vicia villosa</i>	I	A	Cool	5.5	20-30 40-50	WV, KY, IN, IL	Winter annual. Sow in fall. Mix with perennial grass such as Ky-31 fescue, or sow with rye for overwinter cover; then seed perennials the next year.
Cowpea <i>Vigna unguiculata</i>	I	A	Warm	4.5	20-30	KY	Grown in the Southeastern States. Use for summer cover and wildlife food. Provides little residue for winter cover. Mix with sorghum or Sudangrass for overwinter <i>in situ</i> mulch.
<u>NONLEGUMES</u>							
Maximilian sunflower <i>Helianthus maximiliani</i>	N	P	Warm	5.0	3-6	KS	Successfully established with native grasses on abandoned spoils graded to rolling topography, limed, and disced. For wildlife and range. SCS cultivars 'Prairie Gold' and 'Aztec'

EASTERN REDCEDAR (*Juniperus virginiana*)

Type of Plant: Tree-conifer

Size: Small

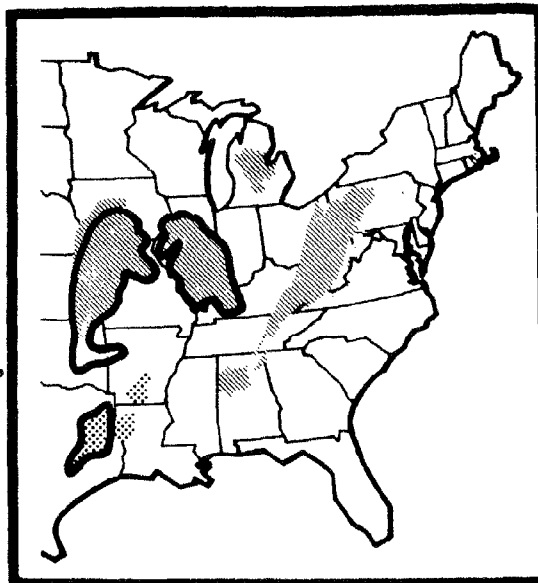
Intolerant to shade

Origin: Native

Lower pH limit: 5.0

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

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



Comments: Eastern redcedar is commonly believed to be associated primarily with limestone-derived soils, and will perform best on calcareous and mildly acid minesoils. However, soil acidity may be less critical than soil surface conditions or the presence of competing woody vegetation. In Illinois, redcedar appeared suited for most mined-land conditions except those with unstable sandy surfaces. Trees at 30 years were being shaded out by planted and volunteer hardwoods. Ohio plantings gave poor results. Will probably grow, but has had little or no testing in the other Appalachian States. Probably best suited for use in Western Interior and Lignite Regions.

Growth performance:

<u>Location</u>	<u>No. test sites</u>	<u>Age (years)</u>	<u>Percent survival</u>	<u>Dbh (inches)</u>	<u>Height (feet)</u>	<u>Basal area (ft²/acre)</u>
Mo., Kans., Okla.	9	30	22	5.0	27	27
Illinois, Indiana	11	30	22	4.4	--	21
Iowa	3	8	39	--	5	--

JAPANESE LARCH (*Larix leptolepis*)

Type of plant: Tree-conifer

Size: Medium

Intolerant to shade

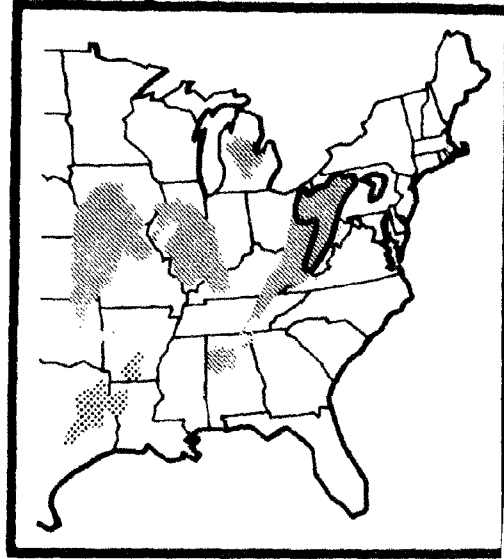
Origin: Introduced

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, lumber, boxes, crates,
and planing-mill products);
esthetics and screening



Comments: This deciduous conifer is used mostly in Pennsylvania. Growth is more rapid than for other conifers. Provides more ground cover than most conifers due to greater needle fall. Growth rate greatly reduced on leveled, compacted mine soils. Japanese larch is easier to establish and its growth rate and form are superior to European larch. Larch initiates spring growth early, sometimes before seedlings can be dug in the nursery. Thus, planting stock may become damaged by heating during shipment and cause increased mortality of the planted seedlings.

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

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

Type of plant: Tree-conifer

Size: White--Medium

Norway--Large

Tolerant to shade

Origin: White--Native

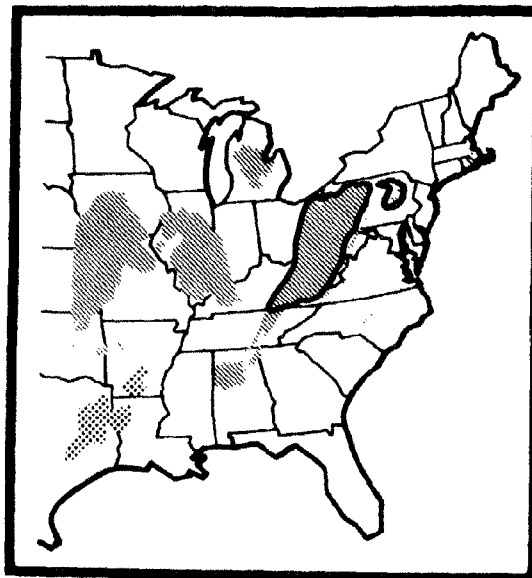
Norway--Introduced

Lower pH limit: 4.5 to 5.0

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

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

Major uses: Wildlife cover and food;
esthetics and screening; forest
products (pulp, musical instruments,
general building purposes, and
interior parts of furniture);
Christmas trees



Comments: Spruce occur naturally in northern temperate regions of the world. Their 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. They are widely used for shelterbelts, screening, and esthetic purposes.

JACK PINE (*Pinus banksiana*)

Type of plant: Tree-conifer

Size: Medium

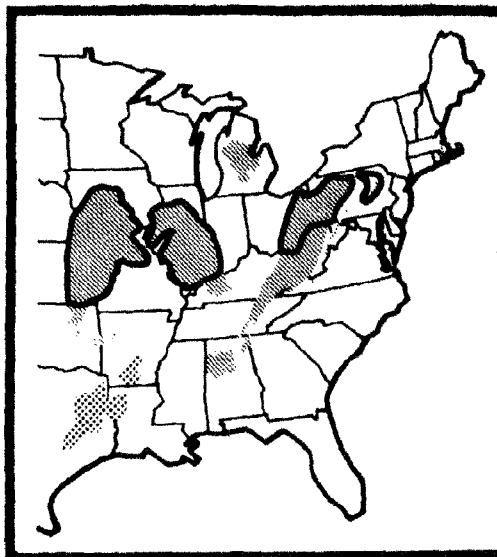
Intolerant to shade

Origin: Native

Lower pH limit: 4.0

Planting material: Seedlings (2-0)

Major uses: Esthetics and screening; wildlife cover and food; Christmas trees; forest products (pulp, poles, posts, mine timbers, and lumber)



Comments: Early survival and growth was best in northern areas, especially in pure and mixed-pine plantings. Performed well in block plantings on anthracite spoil in Pennsylvania. Survival was low in Missouri, Kansas, and Oklahoma plantings. Performed poorly in mixed plantings with hardwoods in Illinois and Indiana. Adapted to acid, dry, and sandy site conditions. Subject to damage and mortality by the pine sawfly. Can be planted for Christmas trees. Provides relatively good ground cover with an abundant layer of pine straw. Known also as Banks pine. Natural range is northernmost States.

Growth performance:

Location	No. test sites	Age (years)	Percent survival	Dbh (inches)	Height (feet)	Basal area (ft ² /acre)
Mo., Kans.	7	30	13	6.0	33	23
Illinois, Indiana	11	30	8	3.8	--	6
Pennsylvania	4	30	-- ^{a/}	4.7	30	--

^{a/}48 percent survival at age 10 (23 sites).

SHORTLEAF PINE (*Pinus echinata*)

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

Origin: Native

Lower pH limit: 4.5

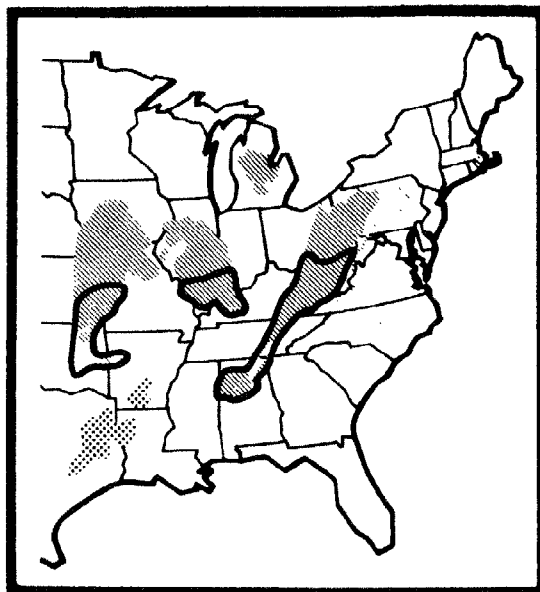
Elevation limit: Not above 2,500 feet

Planting material: Seedlings (1-0, 2-0), Seed (stratified, insect and rodent repellent)

Seeding rate: 1/2 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



Comments: Best performance of this southern pine is mainly within its natural range. Adapted to a wide variety of mined sites, but not 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. In eastern Kentucky, survival of this pine was not affected but growth was increased where interplanted with European alder. Young trees often are subject to damage by pine tip moth, but usually recover.

Growth performance:

Location	No. test sites	Age (years)	Percent survival	Dbh (inches)	Height (feet)	Basal area (ft ² /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

AUSTRIAN PINE (*Pinus nigra*)

Type of plant: Tree-conifer

Size: Medium

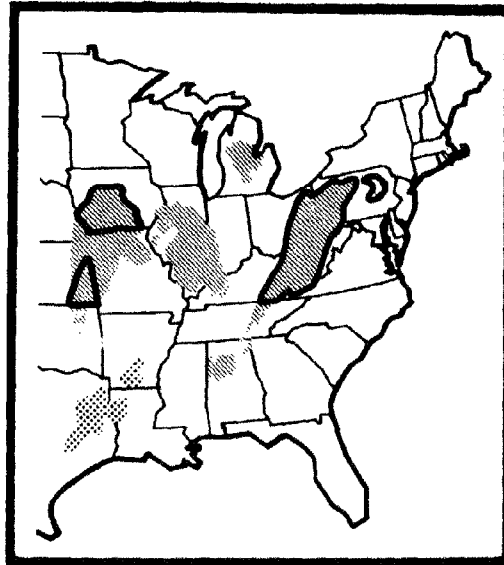
Intermediate tolerance to shade

Origin: Introduced

Lower pH limit: 4.0

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

Major uses: Esthetics and screening;
wildlife cover; Christmas trees;
forest products (pulpwood, lumber)



Comments: This pine, introduced from Europe, probably has not been widely used for surface-mine plantings. It is similar to the native red pine in appearance, climatic adaptation, and growth performance on acid minesoils. Survival of Austrian pine was poor in eastern Kentucky and was lower than for other pines on anthracite minesoils in Pennsylvania. Not as susceptible as red pine to pine shoot moth. Young seedlings are reportedly damaged from girdling by rodents. Recommended in Ohio for use on fine-clay minesoils that are poorly drained and with pH 5.0 to 7.0, but should not take preference over native pines on sites that are suitable for them. Has been used in the United States chiefly for windbreaks, ornamental, and esthetic purposes.

RED PINE (*Pinus resinosa*)

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

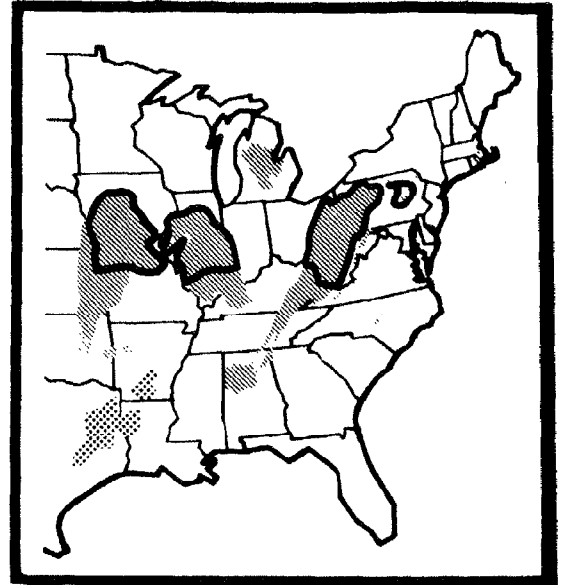
Origin: Native

Lower pH limit: 4.0 to 4.5

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

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

Major uses: Forest products (pulp,
 planing-mill products); esthetics
 and screening; wildlife cover and
 food; Christmas trees



Comments: An attractive tree that performed well on a variety of mine soils, especially in the northern Appalachian region. Highly susceptible to European pine shoot moth; thus it should not be planted in areas that have a high incidence of this insect. Red pine can be used for Christmas trees and is excellent for screening. Has been successful in alternate row plantings with hybrid poplar in Pennsylvania. Its wood is used for many purposes. 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 ^{a/}	7.2	36	50
Pennsylvania	2	30	-- ^{a/}	7.3	29	--

^{a/} 49 percent survival at age 10 (8 sites).

PITCH PINE (*Pinus rigida*)

Type of plant: Tree-conifer

Size: Medium

Intolerant to shade

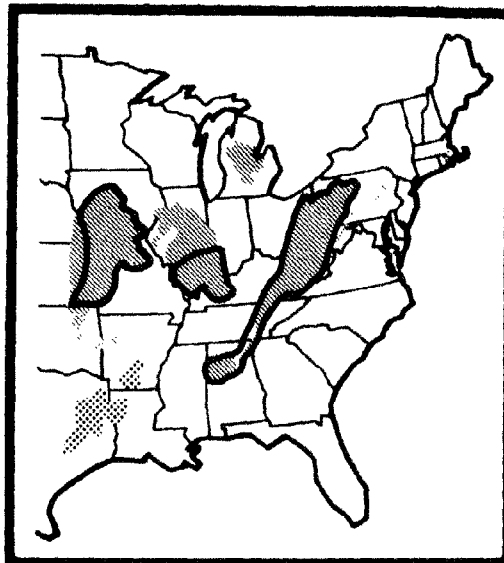
Origin: Native

Lower pH limit: 4.0

Elevation limit: Not above 3,000 feet

Planting material: Seedlings (1-0)

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



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. Survival was poor in plantings in the Interior Coal Provinces, especially in Missouri, Illinois, and Indiana. Best performance is in the Appalachian Coal Province. Often planted in mixtures with other pines, but normally not with hardwoods. In eastern Kentucky, survival of this pine was not affected but growth was increased where interplanted with European alder.

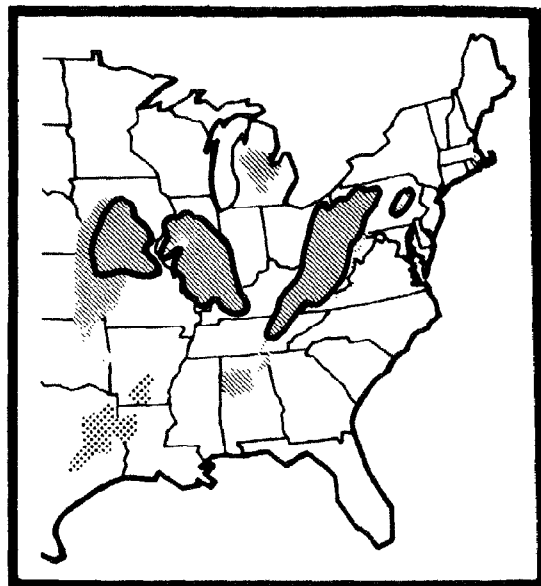
Growth performance:

Location	No. test sites	Age (years)	Percent survival	Dbh (inches)	Height (feet)	Basal area (ft ² /acre)
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
Western Kentucky	1	20	25	5.4	30	35
Pennsylvania	4	30	-- ^{a/}	4.7	23	--

^{a/} 36 percent survival at age 10 (18 sites).

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 material: Seedlings (2-0, 3-0)
 Major uses: Esthetics and screening;
 forest products (Christmas trees,
 mill work); wildlife food and cover



Comments: A widely planted desirable timber species for moderately acid mine spoils. Has been used primarily on sandstone sites (acid to neutral) in Indiana. More tolerant than most pine species of higher pH spoils. Growth for first few years after planting is notoriously slow but is very fast after this species reaches the sapling stage. Height and dbh were increased where interplanted with European alder in eastern Kentucky. Is 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:

<u>Location</u>	<u>No. test sites</u>	<u>Age (years)</u>	<u>Percent survival</u>	<u>Dbh (inches)</u>	<u>Height (feet)</u>	<u>Basal area (ft²/acre)</u>
Illinois, Indiana	11	30	10	5.1	--	13
Ohio	7	30	26 _{a/}	8.0	42	81
Pennsylvania	2	30	-- _{a/}	6.1	27	--

_{a/} 39 percent survival at age 10 (16 sites).

SCOTCH PINE (*Pinus sylvestris*)

Type of plant: Tree-conifer

Size: Medium

Intolerant to shade

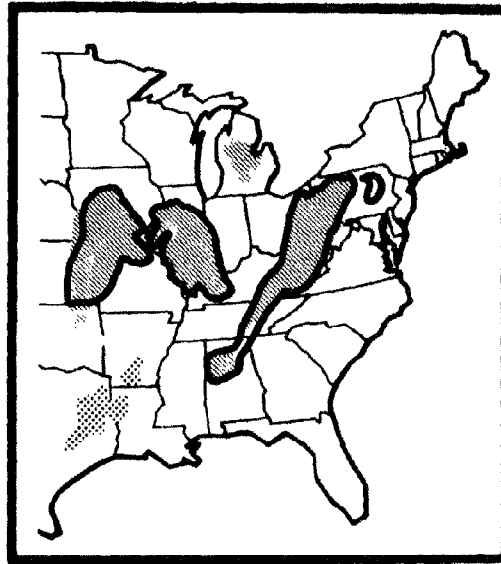
Origin: Introduced

Lower pH limit: 4.0

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

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

Major uses: Christmas trees; esthetics and screening; wildlife cover and food



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. Widely planted for Christmas trees both on and off mined sites. Seed source is important because some Scotch pine turn yellow in the fall. Has also been used in reforestation but has reputation for crookedness of young stem. Choice of seed source is important to avoid this characteristic.

LOBLOLLY PINE (*Pinus taeda*)

Type of plant: Tree-conifer

Size: Large

Intermediate tolerance to shade

Origin: Native

Lower pH limit: 4.0

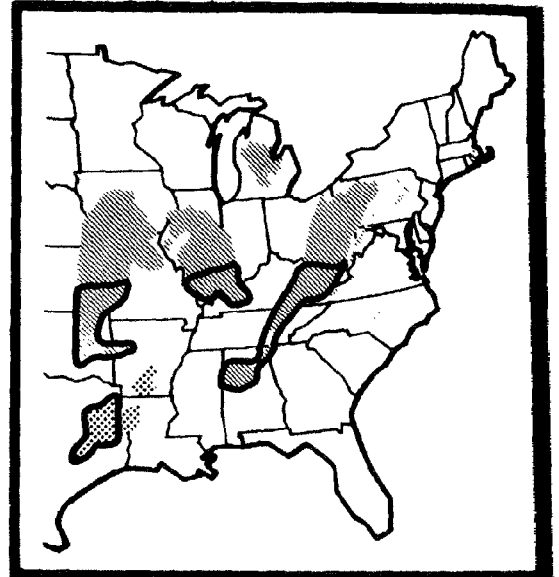
Elevation limit: Not above 2,500 feet

Planting material: Seedlings (1-0);
Seed (stratified, bird and rodent
repellent)

Seeding rate: 1 to 1-1/2 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



Comments: Loblolly is a fast-growing southern pine adapted to a wide range of mine-soil types. Its natural range is southward from central Arkansas and southern Tennessee, yet it is often planted and usually thrives several hundred miles north of this range. However, natural reproduction and success of direct seeding diminishes outside of its natural range. The 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 plantings. Growth rate of loblolly can be improved by planting it with a legume such as Kobe, Korean, or sericea lespedeza. In eastern Kentucky, planting in alternate rows with European alder increased growth of loblolly.

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

VIRGINIA PINE (*Pinus virginiana*)

Type of plant: Tree-conifer

Size: Small

Intolerant to shade

Origin: Native

Lower pH limit: 3.5 to 4.0

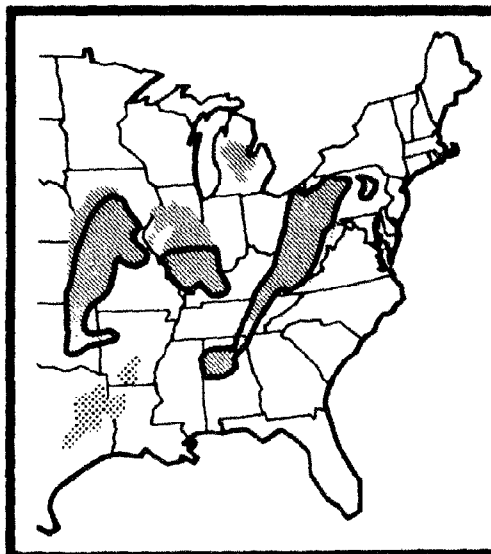
Elevation limit: Not above 2,500 feet
in West Virginia

Planting material: Seedlings (1-0);
Seed (stratified, insect and rodent
repellent)

Seeding rate: 1/4 to 1/2 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



Comments: Virginia pine is the most widely planted conifer on minesoils, especially in the Appalachian Region. It is adapted to a wide range of mineso types and is especially useful for vegetating acid and droughty sites. Within its natural range this pine often is a pioneer species on minesoils and other disturbed lands. Plantings established in the Eastern and Western Interior Coal Provinces, which are outside its natural range, generally give way after 15 to 20 years to volunteer hardwood species. Direct seeding is sometimes successful, but chances of success are less than for planting nursery seedling. This pine has high value for wildlife cover and food, especially when planted in blocks or strips that alternate with herbaceous and other woody species.

Growth performance:

Location	No. test sites	Age (years)	Percent survival	Dbh (inches)	Height (feet)	Basal area (ft ² /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

RED MAPLE (*Acer rubrum*)

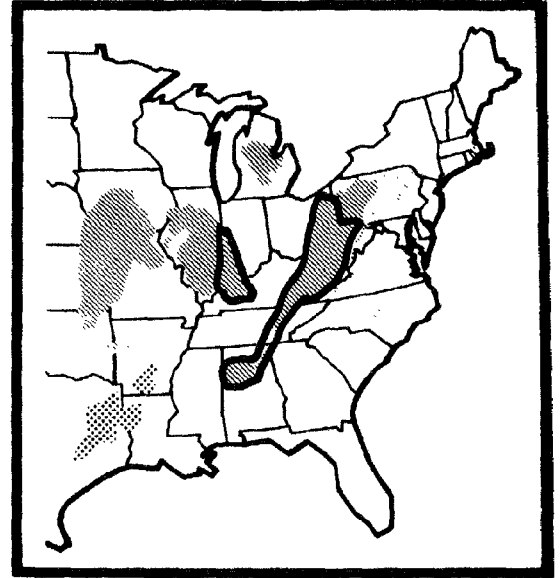
Type of plant: Tree-hardwood
Size: Medium
Intermediate tolerance to shade

Origin: Native

Lower pH limit: 4.5

Planting material: Seedlings (1-0)

Major uses: Forest products (pulp,
core stock, veneer, crates, and
planing-mill products);
wildlife food



Comments: A fairly fast-growing, short-lived tree. Adapted to a range of minesoil conditions--from quite wet to dry sites, both fine- and coarse-textured minesoils, and pH 4.5 to 7.0. Most often planted in mixtures with other hardwoods. Usually will reproduce by natural seeding. Should not be planted in pure stands. In Indiana, pure stands with closed canopies are nearly devoid of herbaceous and woody understory vegetation.

Growth performance: In Indiana, 28-year-old plantings at four sites averaged 6.0 inches dbh, 47 feet in height, and 60 ft²/acre basal area.

SILVER MAPLE (*Acer saccharinum*)

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

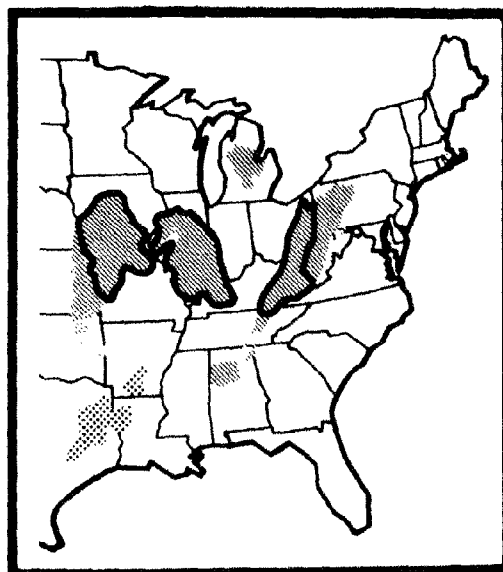
Origin: Native

Lower pH limit: 4.0

Elevation limit: Not above 2,500 feet

Planting material: Seedlings (1-0)

Major uses: Forest products (fuel, pulp, corestock, veneer, crates, and planing-mill products); wildlife food



Comments: Grows on most minesoil types but does best on loamy ones with fair drainage and pH 4.5 to 7.0. Most frequently planted in mixtures with other hardwoods. A relatively fast-growing, short-lived tree with poor form. Most of the trees are multistemmed (70 to 80 percent in Illinois and Indiana plantings). Usually maintains itself in the stand by natural seeding. Grew well when underplanted in black locust.

Growth performance:

Location	No. test sites	Age (years)	Percent survival	Dbh (inches)	Height (feet)	Basal area (ft ² /acre)
Illinois, Indiana	11	30	29	5.1	--	37
Ohio	1	30	26	5.7	35	41

SUGAR MAPLE (*Acer saccharum*)

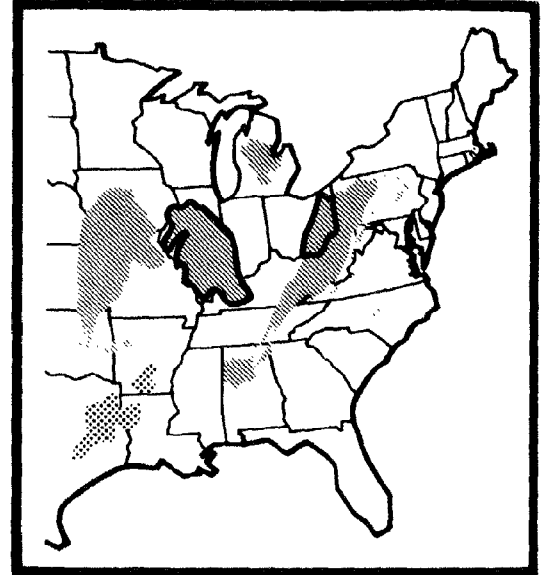
Type of plant: Tree-hardwood
Size: Medium
Tolerant to shade

Origin: Native

Lower pH limit: 4.5

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

Major uses: Forest products (furniture, veneer, gunstocks, and cabinet work); wildlife food and cover



Comments: This tree, also called hard maple, has not been widely planted on surface-mined lands. Yet it could be one of the more valuable species for planting in mixtures with other hardwoods. Does 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 where it was grown in a 50-percent mixture with black locust on lower slopes and well-drained bottoms. Many of the maples had single, straight, and well-formed stems; but on ridges, upper slopes, and in pure stands, more than one-half of the trees had multiple stems. The seed are used by various species of wildlife.

EUROPEAN BLACK ALDER (*Alnus glutinosa*)

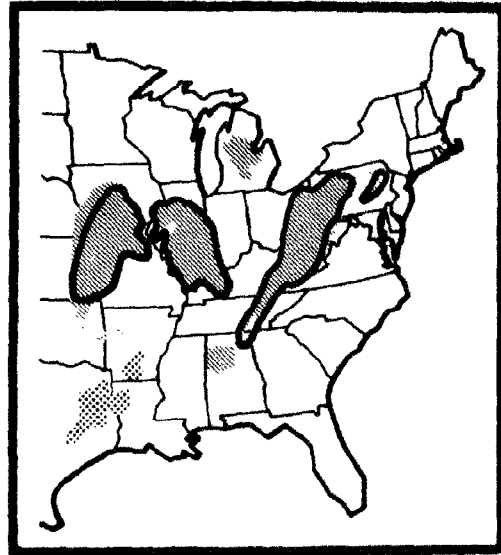
Type of plant: Tree-hardwood
(Nitrogen-fixer)
Size: Medium
Intolerant to shade

Origin: Introduced

Lower pH limit: 3.5 to 4.0

Planting material: Seedlings (1-0)

Major uses: Esthetics and screening;
forestry (nurse tree, site
improvement); watershed protection;
wildlife cover and food; pulpwood



Comments: Adapted to a wide range of minesoil types. Good early survival and rapid growth in most areas. Especially valuable on extremely acid minesoils in the northern regions. Performs better than black locust at elevations above 2,500 feet. Valuable as a nurse crop for other tree species. For a nurse crop, plant alder in every other row or every third row with other species. Alder has persisted for 15 to 20 years in the northern regions, but in eastern Kentucky stands start to die back at about 10 years. Longevity in southern Appalachia is uncertain, but stands up to 10 years old are still thriving in Alabama. Survival usually is low in droughty situations.

RIVER BIRCH (*Betula nigra*)

Type of plant: Tree-hardwood

Size: Medium

Intolerant to shade

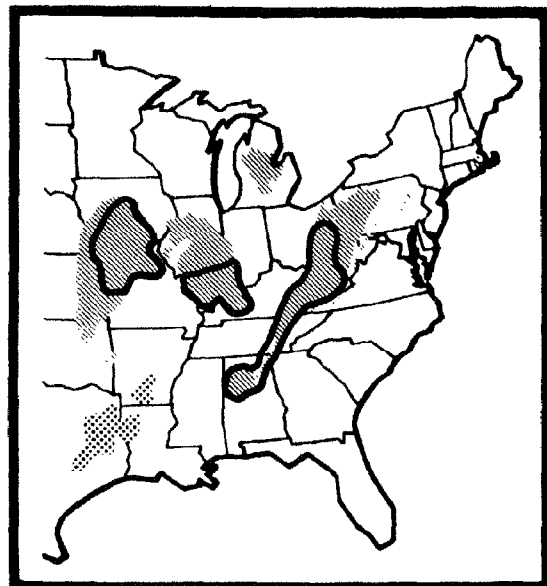
Origin: Native

Lower pH limit: 4.0

Elevation limit: Not above 2,000 feet

Planting material: Seedlings (1-0)

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



Comments: The only southern species of birch. Grows naturally on banks of streams, ponds, and swamps where soil is often flooded for part of the year, and is well suited for fair to poorly drained acid mine soils. Should be planted in mixtures and used primarily where the soil is too acid for other hardwoods. Trees usually have poor form. In Missouri, trees growing on the more acid spoils are taller, have better form, and fewer multiple stems than trees on the better sites where ground cover is greatest.

EUROPEAN WHITE BIRCH (*Betula pendula*)

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

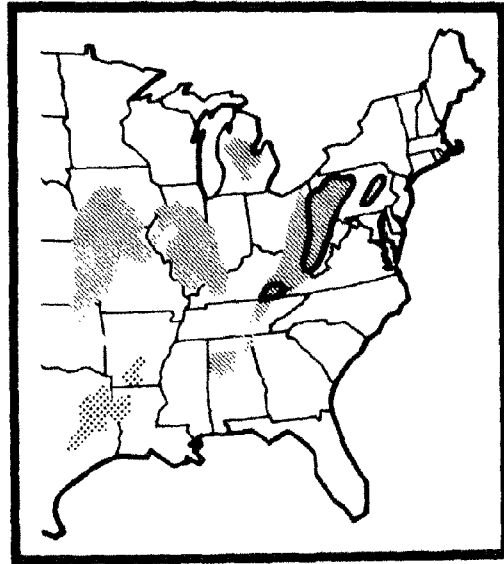
Origin: Introduced

Lower pH limit: 3.5 to 4.0

Elevation limit: Higher elevations in
West Virginia

Planting material: Seedlings (2-0)

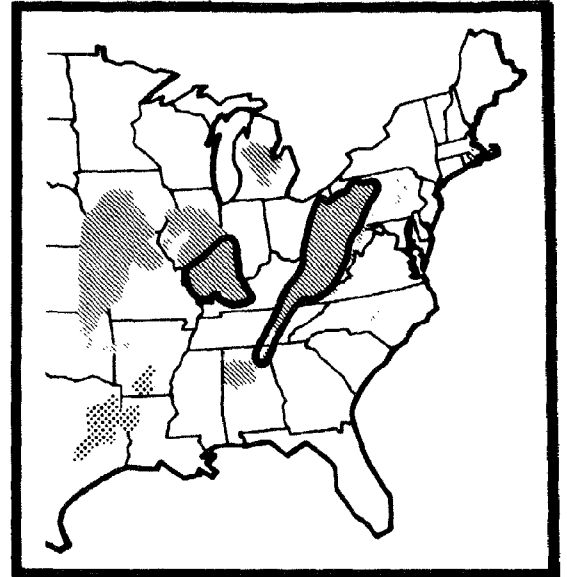
Major uses: Esthetics and screening;
forest products (veneer, furniture,
pulpwood, planing mill products);
wildlife food and cover



Comments: One of the most successful species for planting on extremely acid spoils in Pennsylvania. Young trees may start producing seed 3 to 4 years after establishment. Numerous seedlings often become established on adjacent areas by natural seeding from the planted trees. Attempts at establishment by artificial seeding are seldom successful. The native gray birch (*Betula populifolia*) and paper birch (*B. papyrifera*) perform similarly on mine spoils in Pennsylvania. White birch made rapid early growth on acid mine soils (pH 3.8) at two sites in eastern Kentucky. Natural range is Northern and Northeastern States.

CHINESE CHESTNUT (*Castanea mollissima*)

Type of plant: Tree-hardwood
Size: Medium
Intermediate tolerance to shade
Origin: Introduced
Lower pH limit: 4.5
Planting material: Seedlings (1-0)
Major uses: Wildlife food and cover



Comments: An exotic species that has been planted in an attempt to replace the native American chestnut, but 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. This tree 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 of Chinese chestnut 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 to be occurring in stands over 12 to 15 years old.

WHITE ASH (*Fraxinus americana*)

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

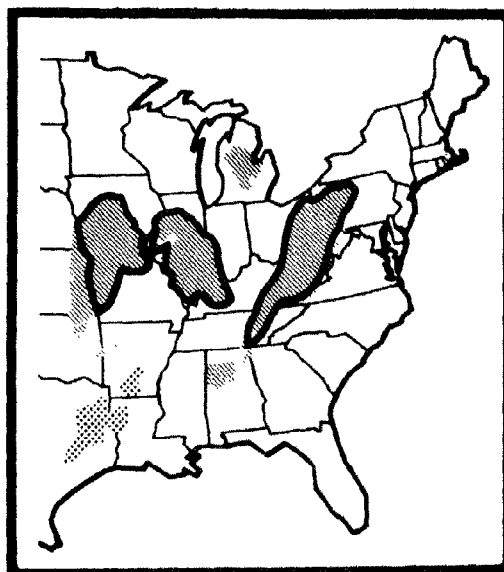
Origin: Native

Lower pH limit: 4.0

Elevation limit: Not above 3,000 feet

Planting material: Seedlings (1-0)

Major uses: Forest products (pulp, tool handles, furniture, veneer, baseball bats, and tennis rackets); wildlife food and cover



Comments: Long-term survival on surface mines is relatively good but growth is usually slower than for other hardwoods. Has not been planted as extensively as green ash. Climatically adapted to all eastern coal regions but not tested on surface mines in all States. Should be planted in mixtures with other hardwoods. Interplanting with European alder nearly doubled height and dbh of white ash in eastern Kentucky. Direct-seeding trials in Ohio produced poor results. White ash is a valuable forest species. The trunk usually is long, straight, clear and cylindrical. White ash grades much higher than green ash.

Growth performance:

Location	No. test sites	Age (years)	Percent survival	Dbh (inches)	Height (feet)	Basal area (ft ² /acre)
Ohio	4	30	45 _{a/}	5.0	36	55
Pennsylvania	2	30	--	2.5	19	--

_{a/} 65 percent survival at age 10 (13 sites).

GREEN ASH (*Fraxinus pennsylvanica*)

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

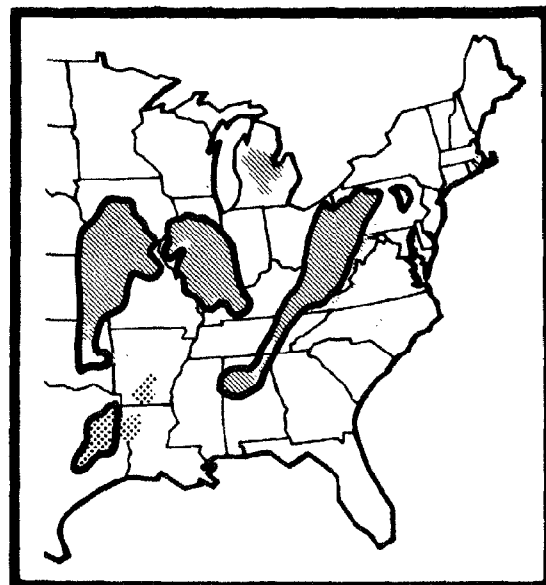
Origin: Native

Lower pH limit: 4.0

Elevation limit: Not above 2,500 feet

Planting material: Seedlings (1-0)

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



Comments: Green ash has been widely planted on surface mines mainly because of its relatively good initial and long-term survival. But, growth is generally 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 usually have poorly formed trunks that detract from their value.

Growth performance:

<u>Location</u>	<u>No. test sites</u>	<u>Age (years)</u>	<u>Percent survival</u>	<u>Dbh (inches)</u>	<u>Height (feet)</u>	<u>Basal area (ft²/acre)</u>
Mo., Kans., Okla.	9	30	33	3.8	28	23.0
Illinois, Indiana	11	30	53	4.7	--	56.8
Ohio	4	30	55 ^{a/}	4.0	27	42.7
Pennsylvania	2	30	-- ^{a/}	2.5	15	--

^{a/} 69 percent survival at age 10 (15 sites).

BLACK WALNUT (*Juglans nigra*)

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

Origin: Native

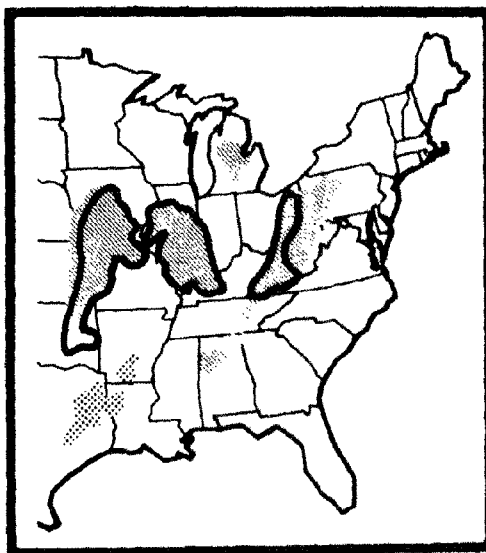
Lower pH limit: 5.5

Planting material: 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



Comments: Black walnut has performed best in Indiana, Illinois, and Missouri on moist sites on ungraded mine soils 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 on Appalachian mine soils, probably due to greater acidity. Although initial growth is relatively slow, black walnut 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, the 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.

Growth performance:

Location	No. test sites	Age (years)	Percent survival	Dbh (inches)	Height (feet)	Basal area (ft ² /acre)
<u>DIRECT SEEDED</u>						
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
<u>PLANTED SEEDLINGS</u>						
Illinois, Indiana	11	30	21	5.2	--	28
Western Kentucky	1	20	25	2.8	21	9
Illinois	1 ^{a/}	30	42	7.3	--	108

^{a/}Planted under decadent black locust.

SWEETGUM (*Liquidambar styraciflua*)

Type of plant: Tree-hardwood

Size: Large

Intolerant to shade

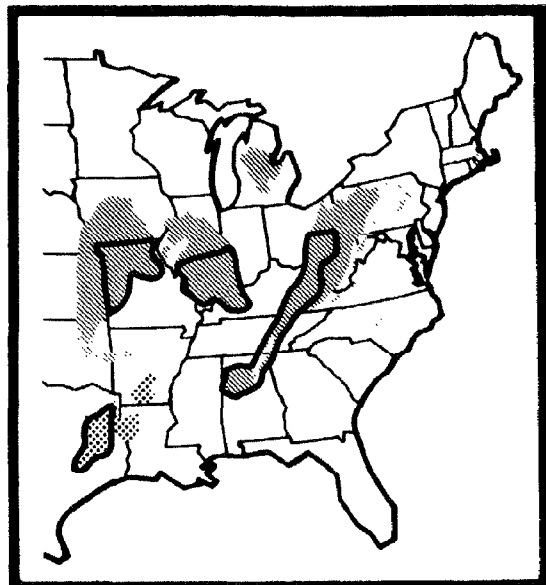
Origin: Native

Lower pH limit: 4.0

Elevation limit: Below 2,500 feet

Planting material: Seedlings (1-0)

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



Comments: Survival of planted seedlings of this valuable commercial hardwood has been erratic among areas. Best survival has been in Indiana, southern Illinois and southern Ohio; survival was poor in northern Illinois, West Virginia, and some sites in Kentucky and Alabama. 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 mine soils on moist sites. In Illinois, best growth was on mine soils in the 4.0 to 5.0 pH range. Planting sweetgum in a mixture with other valuable hardwoods such as black walnut, tulip-poplar, and northern red oak is recommended. In eastern Kentucky, 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	--

YELLOW-POPLAR (*Liriodendron tulipifera*)

Type of plant: Tree-hardwood

Size: Large

Intolerant to shade

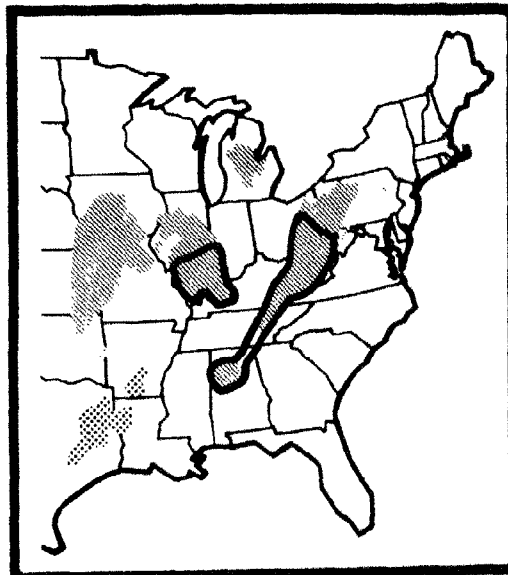
Origin: Native

Lower pH limit: 4.5

Elevation limit: Not above 3,000 feet

Planting material: Seedlings (1-0)

Major uses: Forest products (pulp, lumber, veneer, plywood, furniture, mill work); wildlife food and cover



Comments: Results (survival) with this valuable forest species have been variable on surface-mined lands, but total failures are rare. Performs best on fine-loamy mine soils that have fair to good drainage and pH 5.0 to 7.0. Should be planted in mixtures with other hardwoods. In Illinois and Indiana, growth was especially good where planted under decadent black locust. In eastern Kentucky, height and dbh were nearly doubled where interplanted with European alder. The trunk is tall, straight, and usually free of side branches. The flowers are an excellent source of nectar for honey bees. This tree also is 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
West Kentucky	1	20	24	3.5	33	14
Illinois	1 ^{a/}	22	--	8.1	58	--
Illinois	1 ^{a/}	30	23	8.4	60	79

^{a/}Planted under decadent black locust.

OSAGE-ORANGE (*Maclura pomifera*)

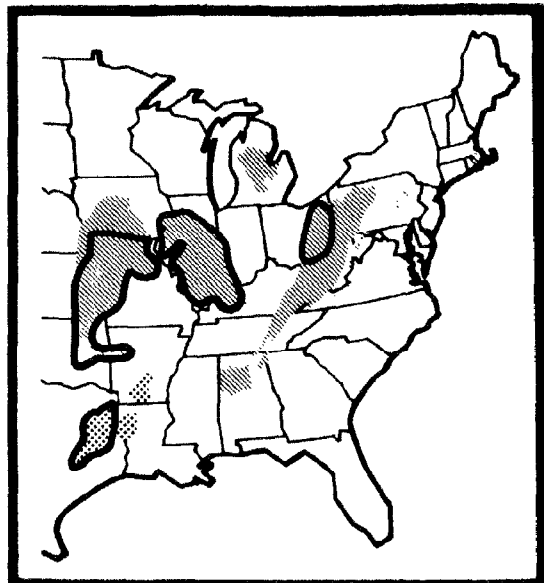
Type of plant: Tree-hardwood
Size: Small
Intermediate tolerance to shade

Origin: Native

Lower pH limit: 4.5

Planting material: Seedlings (1-0)

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



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 of the 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. Osage-orange has relatively little value as a forest species. It 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:

<u>Location</u>	<u>No. test sites</u>	<u>Age (years)</u>	<u>Percent survival</u>	<u>Dbh (inches)</u>	<u>Height (feet)</u>
Illinois, Indiana	11	30	33	4.4	--
Ohio	2	30	39	3.1	20

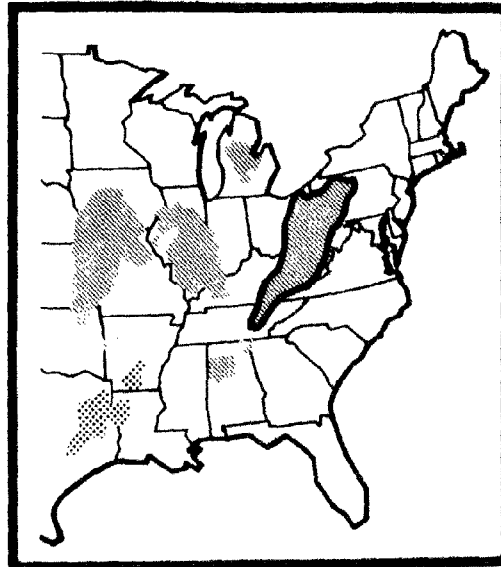
CRAB APPLE (*Malus* spp.)

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

Origin: Introduced

Lower pH limit: 4.5

Major uses: Wildlife food and cover;
esthetics



Comments: The small tree is 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 central and northern Appalachians, but probably are adapted in most of the coal-mining States. 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 subject to damage by deer browsing and rodents. Fertilizer to stimulate growth of crab apples is not recommended because it increases palatability of seedlings over other woody plants not fertilized.

AMERICAN SYCAMORE (*Platanus occidentalis*)

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

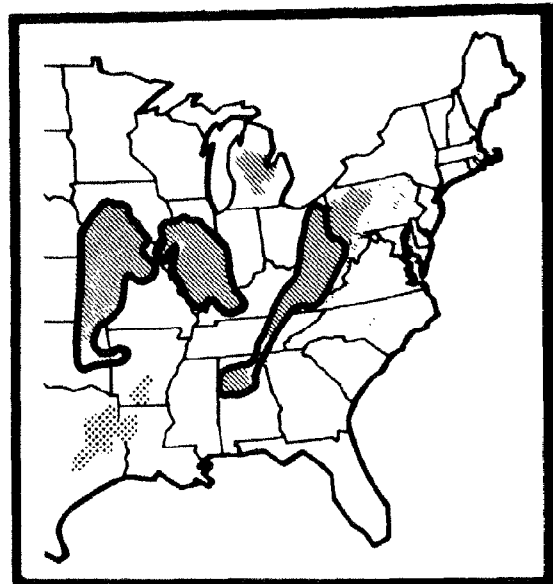
Origin: Native

Lower pH limit: 4.0 to 4.5

Elevation limit: Not above 2,500 feet

Planting material: Seedlings (1-0)

Major uses: Forest products (pulp,
lumber, veneer, mill work,
furniture, and gunstocks)



Comments: 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. Plant in pure blocks, or in multiple row mixtures with other hardwoods, but planting in mixture with black locust may reduce survival. In eastern Kentucky, survival of sycamore was not affected but height and dbh were doubled where interplanted with European alder.

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 ^{a/}	1.7	17	--

^{a/} 5-year survival.

HYBRID POPLARS (*Populus* spp.)

Type of plant: Tree-hardwood

Size: Medium

Intolerant to shade

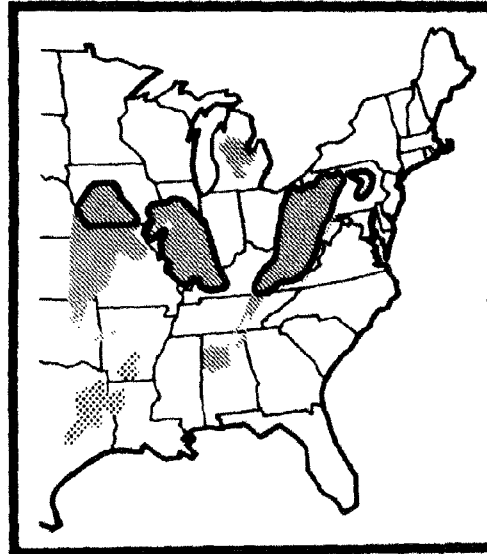
Origin: Crosses of several native and introduced species

Lower pH limit: 4.0 to 4.5

Planting material: Rooted cuttings;
unrooted cuttings (8-10" long)

Spacing: 8- x 8-foot minimum

Major uses: Esthetics and screening;
forest products (pulp, corestock,
and crates)



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. Select trees that have performed well. Make cuttings in late winter or early spring before sap starts to rise. Select branches that are between 3/8 and 3/4 inches 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:

<u>Location</u>	<u>No. test sites</u>	<u>Age (years)</u>	<u>Percent survival</u>	<u>Dbh (inches)</u>	<u>Height (feet)</u>	<u>Basal area (ft²/acre)</u>
Eastern Kentucky	1	9	95	3.1	27	44
Pennsylvania	8	10	45	5.4	31	64
Pennsylvania	2	30	--	9.0	63	--

EASTERN COTTONWOOD (*Populus deltoides*)

Type of plant: Tree-hardwood

Size: Large

Intolerant to shade

Origin: Native

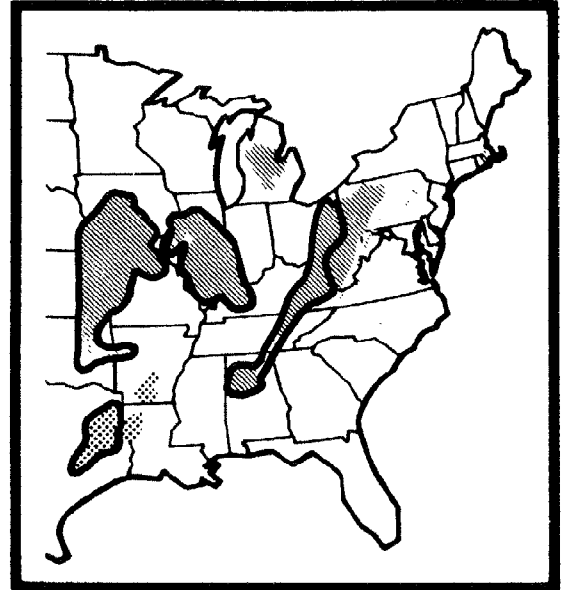
Lower pH limit: 4.5

Elevation limit: Not above 2,500 feet

Planting material: Seedlings (1-0);
cuttings

Seedling spacing: 8 x 8 feet

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



Comments: A rapid-growing tree that often establishes by natural seeding on barren minesoils, especially in the Interior Coal Provinces. This species has survived and grown surprisingly well on upland mined sites in eastern Kentucky and Tennessee. Recommend planting in blocks or in bands of several rows in mixtures with other hardwoods. In eastern Kentucky, interplanting with European alder 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 ft²/acre basal area at age 30.

BLACK CHERRY (*Prunus serotina*)

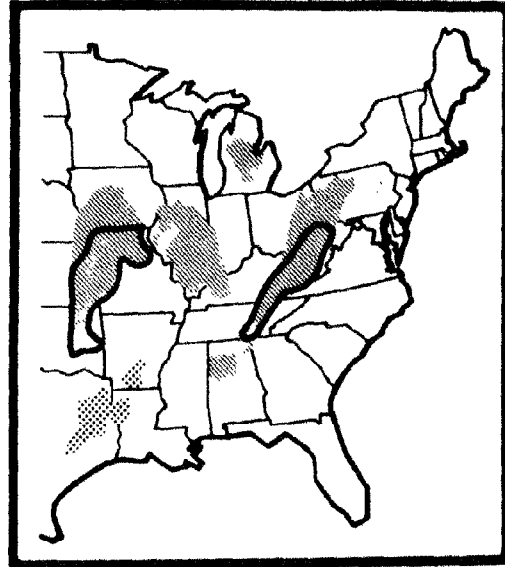
Type of plant: Tree-hardwood
Size: Medium
Intermediate tolerance to shade

Origin: Native

Lower pH limit: 4.5

Planting material: Seedlings (1-0)

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



Comments: Experimental plantings have been made mostly in Missouri, Kansas, and Oklahoma, where growth performance of black cherry was similar to that of other hardwoods. A few plantings in West Virginia and Pennsylvania reportedly had good survival, but black cherry is not generally recommended in these states. Attempts at establishment by direct seeding have failed, yet black cherry is one of the more abundant volunteer species on naturally and artificially reforested surface mines. Grows best on moist sites and is tolerant of competition. Should be planted in a mixture with other hardwoods or underplanted in deteriorated black locust stands.

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 ft²/acre basal area.

WHITE OAK (*Quercus alba*)

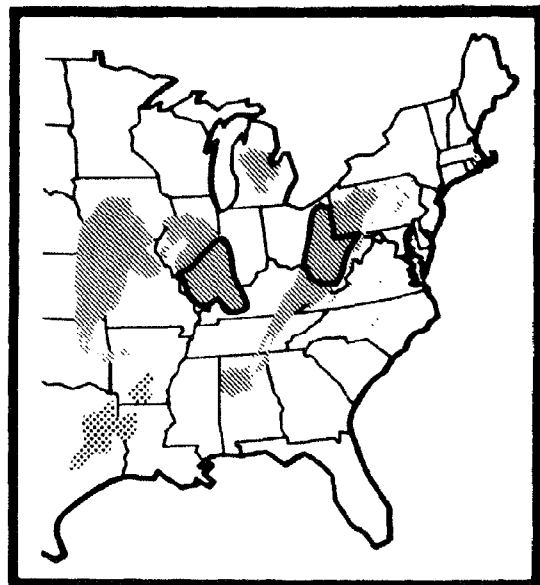
Type of plant: Tree-hardwood
Size: Large
Intermediate tolerance to shade

Origin: Native

Lower pH limit: 5.0

Planting material: Seedlings (1-0)

Major uses: Forest products (flooring, cooperage, and furniture); wildlife food



Comments: Survival and growth of this oak usually is best in mixed plantings with black locust. In western Kentucky, red and white oaks grew best in mixtures of 25- to 50-percent black locust and survived best with 75 percent locust. White oak has not been widely planted on mined lands, probably because of relatively poor survival. Occasional successes and high value of this species warrant further testing. Seedlings and saplings will persist for many years where overtopped by faster growing trees.

Growth performance: In Ohio, 30-year-old plantings at three sites averaged 7 percent survival, 5.0 inches dbh, 30 feet in height, and 8 ft²/acre basal area. In southern Illinois, 30-year-old trees at one site averaged 5.1 inches dbh.

BUR OAK (*Quercus macrocarpa*)

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

Origin: Native

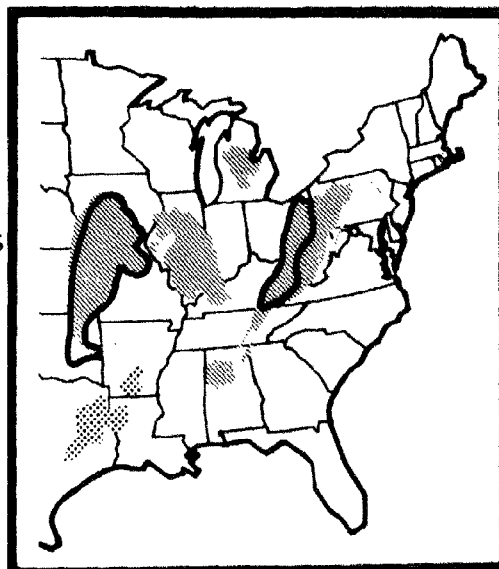
Lower pH limit: 4.0

Planting material: 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)



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 does well on exposed sandy sites. Tolerates heavy 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 1/2 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.

Growth performance:

<u>Location</u>	<u>No. test sites</u>	<u>Age (years)</u>	<u>Percent survival</u>	<u>Dbh (inches)</u>	<u>Height (feet)</u>	<u>Basal area (ft²/acre)</u>
<u>DIRECT SEEDING</u>						
Mo., Kans., Okla.	10	30	24	4.8	28	27
Ohio	3	30	37	5.8	33	60
<u>PLANTED SEEDLINGS</u>						
Mo., Kans., Okla.	9	30	39	5.0	29	47

NORTHERN RED OAK (*Quercus rubra*)

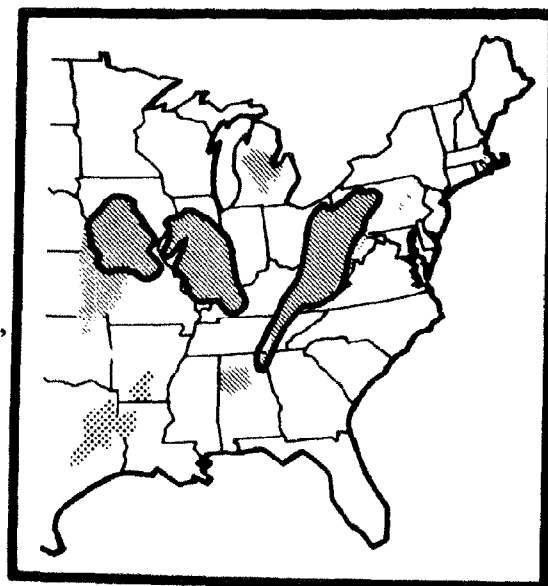
Type of plant: Tree-hardwood
Size: Medium
Intermediate tolerance to shade

Origin: Native

Lower pH limit: 4.0

Planting material: Seedlings (1-0)

Major uses: Forest products (sawtimber, veneer, furniture, paneling, flooring, and pulp); wildlife food and cover



Comments: Has relatively slow early growth, but growth rate increases with age and red oak becomes one of the better performing hardwoods. Performs best on moist sites on mine soils with high percentage of soil-size (<2mm) particles. Young seedlings subject to damage from rodents and deer. May be planted in pure stands, but planting in mixtures with other hardwoods is preferred. Direct-seeding trials in Ohio produced poor results.

Growth performance:

Location	No. test sites	Age (years)	Percent survival	Dbh (inches)	Height (feet)	(ft ² /acre)
Illinois	2	35	--	9.8	72	137
Ohio	3	30	14 ^{a/}	5.7	33	22
Pennsylvania	5	30	-- ^{a/}	5.3	37	--

^{a/} 62 percent survival at age 10 (9 sites)

BLACK LOCUST (*Robinia pseudoacacia*)

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

Origin: Native

Lower pH limit: 4.0

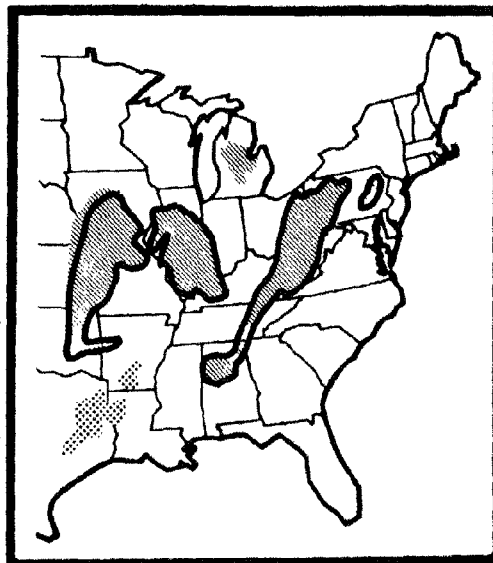
Elevation limit: Not above 3,000 feet

Planting material: 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



Comments: Most frequently and widely used tree for surface-mine plantings, adapted to a wide range of minesoil types. Easily established 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 percent of a 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	--

TABLE 4. TREE SPECIES OF LIMITED IMPORTANCE OR USE

Common and Scientific Name	Origin	Tolerance	Lower pH Limit	Major Uses	States Where Used	Comment
<u>CONIFERS</u>						
Rocky Mountain juniper <i>Juniperus scopulorum</i>	N ^{a/}	I ^{b/}	5.0	H, E ^{c/}	KS ^{d/}	Western species used in recent plantings
European larch <i>Larix decidua</i>	I	I	5.0	F	PA, WV, OH	Deciduous. For northern Appalachians and high elevations.
Red spruce <i>Picea rubens</i>	N	T	5.0	H, E, F	WV	For northern Appalachians and high elevations.
Slash pine <i>Pinus elliotii</i>	N	M	4.5	F, H, E	AL	Plant or direct seed in pure stands. For southern latitudes. Has grown well in northern Alabama.
Longleaf pine <i>Pinus palustris</i>	N	I	4.5	F, H, E	AL	Plant or direct seed in pure stands. For southern latitudes. Well suited on spoils where surface soil is not replaced.
Ponderosa pine <i>Pinus ponderosa</i>	N	I	3.5*	F, E, H, C	PA, KS	*On Pennsylvania spoils. Western species; seed source important. Older plantings in Kansas damaged by needle cast fungus.

(continued)

TABLE 4. TREE SPECIES (CONTINUED)

pitch x loblolly hybrid pine <i>Pinus rigida</i> x <i>P. taeda</i>	N	I	4.0	F, E, H	WV, KY-E	Experimentally planted only. Growth faster than either parent. Research underway to increase planting material.
Douglas-fir <i>Pseudotsuga</i> spp.	N	T	4.0	F, E, H, C	PA	Western species; seed source important.
Baldcypress <i>Taxodium distichum</i>	N	M	5.0	F, H	OH, IN, IL, KY-W, OK, MO	Deciduous. Used on poorly to well-drained sites. Often planted near lakes and wet sites.
<u>HARDWOODS</u>						
Sweet birch <i>Betula lenta</i>	N	I	4.0	H, F	PA, MD, WV, OH, KY-E	Value to wildlife greatest in northern Appalachians.
Paper birch <i>Betula papyrifera</i>	N	I	3.5	F, E, H	PA	For northern Appalachians and high altitudes.
Gray birch <i>Betula populifolia</i>	N	I	3.5	E, H	PA	For northern Appalachians and high altitudes. Similar to European white birch.
Hickories <i>Carya</i> spp.	N	I	5.0	H, F	IL	Species used in recent plantings include: <i>C. ovata</i> , <i>C. tomentosa</i> , <i>C. cordiformis</i> , <i>C. glabra</i> , and <i>C. laciniata</i> . No older plantings for long- term evaluation. Grow best on neutral soils.

TABLE 4. TREE SPECIES (CONTINUED)

Common and Scientific Name	Origin	Tolerance	Lower pH Limit	Major Uses	States Where Used	Comment
Pecan <i>Carya illinoensis</i>	N	I	5.0	H, F	IN, MO, KS, OK	Older plantings in Missouri and Kansas damaged by repeated browsing by deer.
Catalpa spp. <i>Catalpa</i>	N	M	5.0	E, F	AL, IL, MO, KS, OK	Mostly in older experimental plantings. Species <i>bignonioides</i> does well in Alabama.
Hackberry <i>Celtis occidentalis</i>	N	M to T	5.0	H, F, E	IL, MO, KS	Often numerous volunteer seedlings on older sites where forest vegetation is becoming reestablished. Artificial plantings mostly recent.
Flowering dogwood <i>Cornus florida</i>	N	T	4.5	H, E	KY-E, IN, IL, MO	Fruit and browse for wildlife. Survival often quite low. Natural seedlings sometimes found in established woody vegetation.
Russian olive <i>Elaeagnus angustifolia</i>	I	M	5.5	H, E	PA, KY-E, OH, IL, IN, TX	Small tree or large shrub. Much used for shelterbelts in Midwest.
Royal paulownia <i>Paulownia tomentosa</i>	I	M	4.5	F, E	WV, KY-E, TN, AL	A rapid growing tree with high market value for export to Japan. Has escaped from cultivation but difficult to

(continued)

TABLE 4. TREE SPECIES (CONTINUED)

Bigtooth aspen <i>Populus grandidentata</i>	N	I	4.0	H, F	OH, WV	seed artificially. Nursery seedlings and plantation programs available from American Paulownia Corporation. Will not reproduce in shade. Plant in pure blocks. For northern latitudes and higher elevations in Appalachia.
Sawtooth oak <i>Quercus acutissima</i>	I	I	4.0	H	PA, OH, WV, KY-E, TN, AL	Performed moderately well in Appalachian test plantings, especially where soil moisture was favorable. Planted mainly for acorn production. Not recommended above 2,500 feet. Plant 1-0 seedlings.
Shingle oak <i>Quercus imbricaria</i>	N	I	4.5	H, F	IL	Often volunteers on older sites where forest vegetation is becoming reestablished. Artificial plantings mostly recent.
Pin oak <i>Quercus palustris</i>	N	I	4.0	H, F, E	KY-E, KS, MO	Use below 1,500 feet. Volunteers on older forested sites.
Chestnut oak <i>Quercus prinus</i>	N	M	4.5	F, H	OH, KY-W, IN, IL, IA	Similar site requirements as white oak.

(continued)

TABLE 4. TREE SPECIES (CONTINUED)

Common and Scientific Name	Origin	Tolerance	Lower pH Limit	Major Uses	States Where Used	Comment
Black willow <i>Salix nigra</i>	N	I	4.5	H, E, F	IL, TX	Most suited for low wet sites and stream margins. Can withstand flooding and silting. Artificial plantings mostly recent.
Basswood <i>Tilia americana</i>	N	M	5.0	F, H	OH	Use in mixtures of hardwoods.

a/ I = Introduced; N = Native.

b/ T = Shade tolerant; I = Shade intolerant; M = Intermediate tolerance.

c/ F = Forest products; H = Habitat for wildlife; E = Esthetics and screening; C = Christmas trees.

d/ States identified by two-letter abbreviation. Single letter following dash indicates portion of State where best adapted, e.g., KY-W = western Kentucky.

INDIGOBUSH (*Amorpha fruticosa*)

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

Origin: Native

Lower pH limit: 4.0

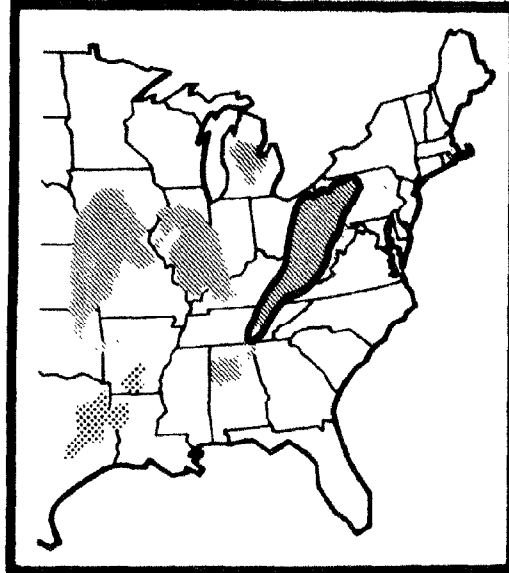
Elevation limit: Not above 3,000 feet

Planting material: Seedlings (1-0);
seed (special inoculum)

Seeding rate: 1/2 to 1 lb/acre
(seed in pods)

Time of seeding: Spring, fall, winter

Major uses: Wildlife food and cover;
watershed protection



Comments: This woody legume is native east of the Mississippi river but has been used mostly in the Appalachian Coal Region. Plants normally grow to about 8 to 10 feet tall on minesoils. They have a growth form and appearance similar to the sumacs. Establishment is usually good but plant growth is fairly slow; plants may average about 2 feet in height after 3 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 their nitrogen-fixing capability. Some observers reported little or no regeneration even though annual seed production was 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 of plants.

SILKY DOGWOOD (*Cornus amomum*)

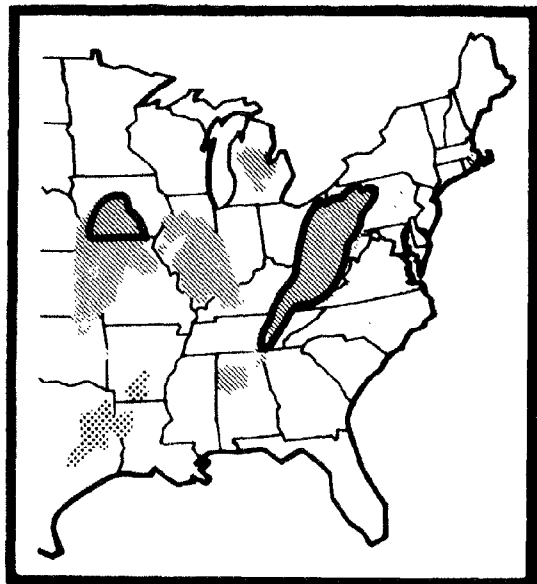
Type of plant: Shrub
Tolerant to shade

Origin: Native

Lower pH limit: 4.0

Planting material: Seedlings (1-0)

Major uses: Wildlife food and cover



Comments: Silky dogwood has been tested and used more than other species of dogwood for revegetating surface mines. It will begin producing fruit after 3 to 5 years of age. Fruit matures in late summer and falls soon after. It is an excellent food source for many species of birds and mammals. Dogwoods also provide excellent browse for deer. Gray dogwood (*C. racemosa*) has similar qualities and uses, but has been planted less widely. Silky dogwood has been established successfully by direct seeding. Its native range is mainly east of the Mississippi River.

AUTUMN OLIVE (*Elaeagnus umbellata*)

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

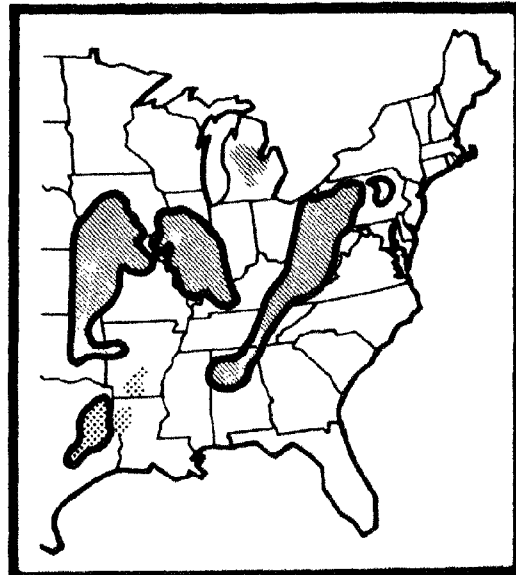
Origin: Introduced

Lower pH limit: 4.0

Planting material: Seedlings (1-0)

Superior cultivars: 'Cardinal',
'Elsberry'

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



Comments: This nonleguminous nitrogen-fixing species is adapted in all of the eastern coal regions. It is easily established on a wide range of minesoil types and conditions. Initial survival and growth usually is good even where planted in an established cover of herbaceous vegetation. Growth of adjacent plants and understory grasses is enhanced by its nitrogen-fixing capability. It has been used as a nurse plant with crop trees. Plants often grow to a 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 is usually unsuccessful but plants can be spread by dissemination of seed by birds. Has the potential to become a "pest" plant and has been banned in some counties in West Virginia. The cultivar 'Cardinal' was selected for its high fruit yield and longer retention of fruit on the plant. Other shrubby species of *Elaeagnus* have been tried in some of the Appalachian States. Cherry olive (*E. multiflora*) and thorny olive (*E. pungens*) performed nearly as well as autumn olive on acid spoil in eastern Kentucky. Silverberry (*E. commutata*) performed poorly on slightly acid spoil in Pennsylvania.

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

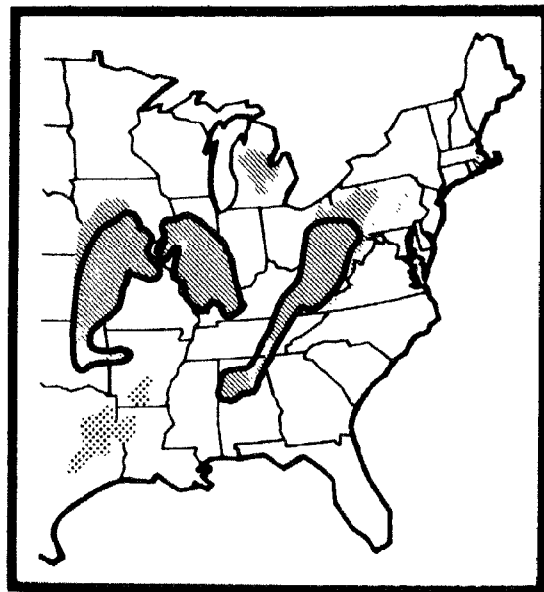
Planting material: Seedlings (1-0);
Seed (scarified)

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



Comments: The shrub lespedezas have been widely planted for wildlife food and cover; the seeds are a valuable food for quail, and rabbits bark the stems in winter. Mature plants are from 4 to 10 feet tall. Plants in full bloom are esthetically attractive and attract numerous honey bees. Establishment is usually most rapid and assured with planted seedlings, but is also accomplished by direct seeding. Normally, seed is mixed and sown with herbaceous species; establishment of the shrub lespedeza plants may not be readily obvious until the second growing season. Use standard lespedeza inoculum on seed. Three species of shrub lespedeza are identified above, but their classification 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 can be grown as far north as Pennsylvania. Common *L. bicolor* and *L. japonica* are recommended for the mid and southern regions and only at lower elevations in West Virginia. *L. thunbergii* is recommended for the southern areas. Seed supplies of pure species and cultivars are scarce or nonexistent.

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

Type of plant: shrub
Intermediate tolerance to shade

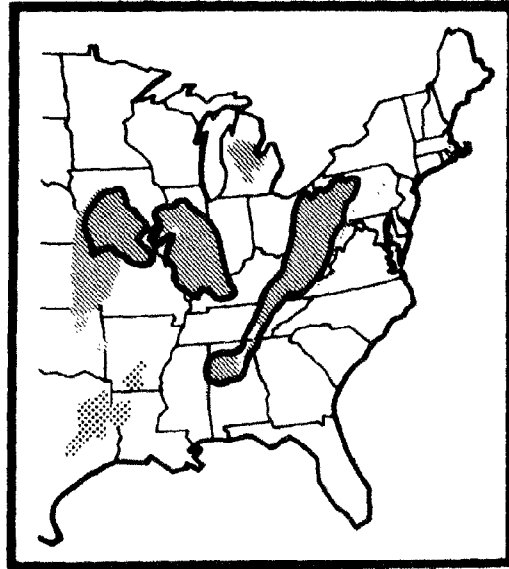
Origin: Introduced

Lower pH limit: 5.0

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

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

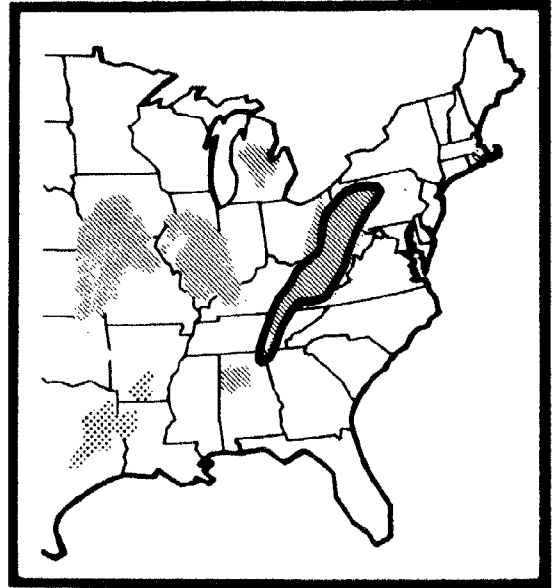
Major uses: Wildlife food and cover;
esthetics and screening



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 is adapted over the entire range shown; tatarian is adapted to all areas except Tennessee and Alabama, where Morrow honeysuckle has been used successfully. 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 from established plants that is disseminated by birds. These species initiate spring growth earlier than most other shrubs; thus, freshly dug nursery seedlings may already be growing and be susceptible to heat damage while in transit or awaiting planting.

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 material: Seedlings (1-0,
2-0); root cuttings
Major uses: Wildlife food and cover;
esthetics



Comments: The sumacs are native to all of the Eastern United States. They have not been tested on surface mines in all of the coal regions, but they 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. In West Virginia, 15-year-old plantings of shining sumac had developed full stands and height of 6 to 7 feet. Fragrant sumac had open stands and height of 3 to 4 feet. Suggested use is for wildlife plantings in blocks of 100 to 200 plants spaced 4 to 5 feet apart. Sumac volunteers on abandoned spoils in some areas.

BRISTLY LOCUST (*Robinia fertilis*)

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

Origin: Native

Lower pH limit: 3.5

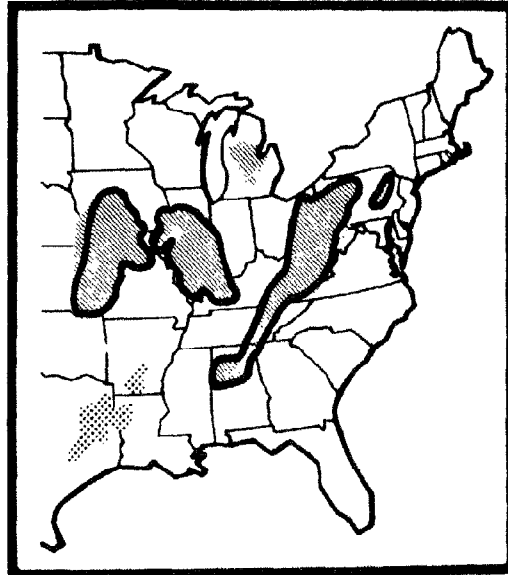
Planting material: Seedlings (1-0),
Seed (scarified, special inoculum)

Seeding rate: 2 to 5 lb/acre

Time of seeding: Spring, fall, winter

Superior cultivars: 'Arnot'

Major uses: Erosion control; wildlife
cover and food



Comments: Bristly locust is one of the best plants to use for erosion control on extremely acid mine soils. The plants will spread primarily from root suckers that begin to form during the first growing season. Dense thickets will 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.

TABLE 5. SHRUB SPECIES OF LIMITED IMPORTANCE OR USE

Common and Scientific Name	Origin ^{a/}	Lower pH Limit	Major ^{b/} Uses	States ^{c/} where Used	Comment
Black chokeberry <i>Aronia melanocarpa</i>	N	4.5	H, E	PA, OH, IN	Small shrub. Field plant 2-0 seedlings.
Korean barberry <i>Berberis koreana</i>	I	4.0	H, E	PA, KY-E, IN	Small shrub. Field plant 2-0 seedlings.
Siberian peashrub <i>Caragana arborescens</i>	I	4.0	H	Ky-E	Has grown well on acid mine soil in east Kentucky. Reported use in Poland on fly ash piles with pH 10 to 11.
Gray dogwood <i>Cornus racemosa</i>	N	5.0	H, E	WV, KY-E, VA, TN, AL	Similar to silky dogwood. Produces fruit in 4 to 5 years. Intermediate shade tolerance.
Red-osier dogwood <i>Cornus stolonifera</i>	N	4.5	H, W, E	PA, WV, KY-E, VA, TN	Suited for seepage areas and along ponds. Spreads by underground shoots. Dense root system provides protection against overland flow.
Hawthorn <i>Crataegus</i> spp.	N	5.5	H, E	PA, WV, KY-E	Tall shrubs; there are many hybrids and varieties. Washington hawthorn (<i>C. phaenopyrum</i>) is the most widely used and available. Field plant 1-0 seedlings. Intermediate tolerant.
Amur privet <i>Ligustrum amurense</i>	I	4.5	H, E	PA, WV, KY-E, OH, VA, TN	Naturalized in Southeastern United States. Medium-size shrub. Field plant 1-0 or 2-0 seedlings. Tolerant.

(continued)

TABLE 5. SHRUB SPECIES (CONTINUED)

Japanese honeysuckle <i>Lonicera japonica</i>	I	4.5	H	All States	Naturalized in all Eastern States. Seldom planted but often present due to natural invasion. Can become a "pest" in agricultural and forestry land uses. One of the best species for wildlife habitat. Retains green foliage in winter. 'Halls' improved cultivar. Tolerant.
Western sandcherry <i>Prunus besseyi</i>	N	4.0	H	KY, TN, OH, IN, AL	A 3- to 6-foot bushy shrub good for wildlife cover and food. Produces fruit in 2 to 3 years. Plant 1-0 seedlings.
Chokecherry <i>Prunus virginiana</i>	N	5.0	H	KY-E, TN	Tall shrub, 8-18 feet, widely adaptable. Excellent food and cover plant for wildlife. Spreads from root sprouts. Easily established from 1-0 seedlings.
Rose-acacia locust <i>Robinia hispida</i>	N	3.5-4.0	W, H, E	PA, MD, WV, KY, VA, TN, OH, IN	Similar to bristly locust (<i>R. fertilis</i>). Plant 1-0 seedlings or direct seed. Intolerant.
Multiflora rose <i>Rosa multiflora</i>	I	5.0	H, W	PA, WV, MD, KY, VA, OH, IN, IL	Has become "pest" plant in many agricultural areas and now is seldom planted. An excellent plant for providing cover and food for game birds and small mammals.

TABLE 5. SHRUB SPECIES (CONTINUED)

Common and Scientific Name	Origin ^{a/}	Lower pH Limit	Major ^{b/} Uses	States ^{c/} Where Used	Comment
Memorial rose <i>Rosa blanda</i>	I	5.5	H, W	PA, MD, WV, KY, VA, OH, IN, IL	A good plant for wildlife habitat but spreads by runners that will climb on trees and shrubs. Also spreads by seed and can be a "pest" plant similar to multiflora rose. Establish with 1-0 seedlings.
Purpleosier willow <i>Salix purpurea</i>	I	5.0	H	PA, WV, VA, OH, IN, IL	Useful along ponds, seepage areas. Grows best in pH range 5.0 to 6.0
American elder <i>Sambucus canadensis</i>	N	5.0	H, E	KY-E, TN, AL	Excellent food and cover plant for wildlife, especially songbirds. Establish with 1-0 seedlings.
Silver buffaloberry <i>Shepherdia argentea</i>	N	4.0	H, W	PA, OH, IN	Thorny shrub 6 to 10 feet tall. Fixes nitrogen. Growth similar to autumn olive, but no spreading by seed noted. Field plant 2-0 seedlings.
Arrowwood <i>Viburnum dentatum</i>	N	4.5	H, E	PA, KY-E	Field plant 1-0 or 2-0 seedlings. Also propagated by cuttings or by layering. Tolerant. Other species of <i>Viburnum</i> may be useful.

^{a/} I = Introduced; N = Native.

^{b/} H = Habitat (food and cover) for wildlife; E = Esthetics and screening; W = Watershed protection (erosion control)

^{c/} States identified by two-letter abbreviation. Single letter following dash indicates portion of State where best adapted, e.g., KY-E = eastern Kentucky.