Technical Reclamation Memorandum

TRM # 12

Date: July 27, 1983

From: Elmore C. Grim, Commissioner
Department for Surface Mining
Reclamation and Enforcement

E.C.G.

Subject: "Revegetation of Kentucky Surface Mined Lands" Publication

Kentucky Department for Surface Mining Reclamation and Enforcement

Attached is one (1) copy of the recently published manual entitled, "Revegetation of Kentucky Surface Mined Lands." The completion of this manual has been a personal goal during my term as Commissioner. Many people with experience in mining, reclamation, and forestry worked to put together this excellent reference manual.

The purpose of the publication is to provide easy access and reference to information on revegetation of surface mined lands, and to assist the industry in the preparation of revegetation plans. I hope that it proves useful to operators and engineers striving to comply with reclamation standards.

~~Additional copies can be requested by mail to Kathy Peters, Department for Surface Mining Reclamation and Enforcement, 12th Floor, Capital Plaza Tower, Frankfort, Kentucky 40601, or by phone (502) 564-2340.~~

**** NOTE: The referenced publication is not attached to this memo. ****
If you would like a copy of this manual, please contact Teri Welch at DSMRE, Technical Services Branch, #2 Hudson Hollow Complex, Frankfort, KY 40601 or call her at (502)564-6940.

Revegetation of Kentucky Surface Mined Lands

Department for
Surface Mining Reclamation
and Enforcement

Natural Resources and
Environmental Protection
Cabinet

Revegetation of Kentucky Surface Mined Lands

Department for Surface Mining Reclamation and Enforcement

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Commonwealth of Kentucky

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Successful revegetation of Kentucky's surface-mined lands is one of major goals of our cabinet. To meet this goal, we need to know what grasses, plants and trees are best suited for each individual site.

This document, which incorporates the hard work of many individuals in the Department for Surface Mining Reclamation and Enforcement, and the Kentucky Division of Forestry, offers detailed information on a variety of revegetation methods and materials.

The manual has been designed with Kentucky's specific climate and topology in mind. We hope that it will be useful to Kentuckians in helping to prepare any reclamation program.

Jackie Swigart

Jackie Swigart
Secretary

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Introduction

"Each permittee shall establish on all affected land a diverse, effective, and permanent vegetative cover of the same seasonal variety native to the region or species that supports the approved postmining land use."

405 KAR 16:200 1(1)

The above statement summarizes the department's major goal in the field of revegetation. Revegetation is the final and one of the most vital aspects of reclaiming surface mined lands. The impact of an operation on its locale will not begin to properly mitigate until a ground cover is restored. No site is released from the department's regulatory authority until the revegetation has been deemed successful.

This manual was compiled from a variety of respected sources in order to aid operators and consultants in preparing a revegetation plan for surface mine sites. The text of chapter one is taken largely from Willis G. Vogel's *A Guide for Revegetating Coal Minesoils in the Eastern United States* and the U.S. Department of Agriculture's *Mine Soil Classification and Use, A Kentucky Guide for Vegetative Treatment.* Chapter two is extracted almost entirely from the latter work, while chapter three is taken from Vogel's book. The various charts and tables are compiled from a variety of other sources which are referenced on the Table of Figures.

In addition to this manual, operators should also refer to the department's Technical Reclamation Memorandum #3, *"Guide for Protection and Enhancement of Fish and Wildlife Values for Surface Coal Mining and Reclamation Operations."* Where the proposed postmining land use will be *wildlife,* the applicant should contact the Kentucky Department of Fish and Wildlife Resources, Frankfort, Ky. 40601 for assistance in development of the reclamation plan.

The purpose of this manual is to provide easy access to available information on revegetation of mined lands pertinent to Kentucky. This manual does *not* establish requirements under the regulatory program. I hope that this manual will benefit you in preparing your reclamation program.

Elmore C. Grim

Elmore C. Grim, Commissioner
Department for Surface Mining
Reclamation and Enforcement

Selecting Seed Mixtures

Revegetation is not merely an afterthought to coal removal, but must be a carefully planned aspect of a successful mining and reclamation operation. Before the first disturbance, all of the major decisions on revegetation should be made. The permit application requires a revegetation plan which includes considerable detail.

One of the more difficult aspects of a revegetation plan is selecting the proper seed mixtures for the site. In fact, each site requires special consideration of its own unique features. The choice of seed mixtures should be especially tailored to a site after considering conditions, native species, adjacent areas and other such basic factors. Another major factor is the purpose of the vegetation in regard to postmining land use.

Erosion Control

Regardless of the intended use of reclaimed land, the establishment of vegetation is necessary for control of water and wind erosion. Watershed protection is especially important in mountainous and sloping areas where erosion caused by runoff is significant.

Herbaceous species are especially important for the establishment of a stabilizing vegetative cover. Herbaceous mixtures should include an annual or short-lived perennial species that provides a quick but temporary cover. The permanent mixture should also include at least one perennial grass and one perennial legume. Where there is a choice of species of grasses or legumes, the species best adapted to the minesoil properties and climate should be selected. It is especially important to follow seeding rate recommendations for the quick-cover temporary species, because higher rates of these species could produce dense stands that prevent or retard establishment of the permanent species.

The following table (I-A) displays some possible seed mixtures which are useful for erosion control. It is recommended to use a mixture for the appropriate growing season.

Table I-A
Herbaceous Mixtures for Erosion Control by Seeding Seasons

Seeding time (season)	Temporary species[a] (quick cover)	Seeding rate (lbs. of pure live seed)[d]	Permanent species (long-lived)	Seeding rate (lbs. of pure live seed)[d]
Early spring to Mid spring (Feb. 15 - May 15)	Perennial ryegrass	10	Ky-31 tall fescue	1
	Oats	48	Korean and/or Kobe lespedeza[b]	1
	Weeping lovegrass	2.5	Sericea lespedeza	1
	Annual ryegrass	5	or	
			Crownvetch	1
Mid spring to Mid summer (May 15 - August 1)	Weeping lovegrass	2.5	Ky-31 tall fescue	1
	Sorghums	18	Sericea lespedeza	1
	Pearl millet	10	Korean and/or Kobe lespedeza[b]	1
	Foxtail millet	12		
	Browntop millet	15		

Mid summer	Rye	40	Ky-31 tall fescue	2
to	Winter wheat	40	Sericea lespedeza	
Early fall	Annual ryegrass	5	(1/2 unhulled seed)[c]	2
(August 1 -	Perennial ryegrass	10	or	
Nov. 15)	Crimson clover	12	Crownvetch	1

Notes to Table I-A:

a] Use only one of the temporary species at rates shown. If more than one is used, reducing seeding rate of each species in proportion to number used, i.e., for two species use one-half seeding rate of each.

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

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

d] Seeding rates recommended in this manual are expressed in pounds per acre of pure live seed (PLS). The use of PLS seeding rates instead of bulk seeding rates will ensure that an adequate amount of viable seed is sown. This is especially important for proper seeding of species, such as some of the native grasses, that often have relatively low purity and germination. To calculate the amount of bulk seed needed to meet PLS recommendations, divide the PLS seeding rate by the percent PLS and multiply by 100. For example, if a batch of switchgrass seed has 60 percent PLS, and the recommended PLS seeding rate is 12 lb/acre, then (12/60) $\times$ 100 = 20 lb/acre bulk seeding rate. Obviously, if only 12 pounds of switchgrass seed were sown, not nearly enough viable seed would have been sown to meet the seeding recommendations.

The PLS seeding rates suggested here usually are sufficient for vegetating minesoils that have properly prepared seedbeds and are adequately fertilized, limed, and mulched. *Sowing additional seed seldom compensates for failure to prepare a seedbed or apply needed amendments. Seeding at too high a rate can cause seedling competition and result in a reduced stand, especially in drier environmental and climatic situations and in well-prepared seedbeds. In seed mixtures of herbaceous species, the temporary species especially should not be sown in excess of recommended rates because they may retard or prevent establishment of the permanent species. In some situations where temporary species are sown alone for growing mulch in place, the use of additional seed may be justified.

Some of the mixtures are also suited for forage production; however, a few of the species that are well suited for erosion control and site stabilization are not the most compatible with our land uses. For example, *Sericea lespedeza* and flatpea are excellent for long-term erosion control, but their value for forage and wildlife habitat is lower than that of other legume species. Thus, consideration should be given to selecting species for their suitability for the approved land use, as well as for controlling erosion.

**Refer to Lime, Fertilizer, and Mulching recommendations in Chapter II.*

Pasture and Hayland

The vegetation for pasture and hayland is of great significance as it must provide sustenance for the introduced grazing stock. Mine soil that is to be reclaimed for pasture and/or hayland should be graded smooth enough to permit the operation of farm equipment in the planting, harvesting and maintenance of the area. Slopes generally should not exceed 30 percent. A pH of 6.4 should be maintained.

As usual, one should prepare the seedbed, apply lime, fertilizer and seed. However, the quality of seed used should conform to or exceed the minimum requirements for purity and germination of the Kentucky Seed Improvement Association or the Association of Official Seed Certifying Agencies. For some examples of seeding rates and mixtures, see the table on Herbaceous Mixtures for Pasture and Hayland (Table I-B). For additional information consult the department's technical guides in the regional offices.

Table I-B
Suggested Herbaceous Mixtures for Pasture/Hayland

Species Seeding Mixtures	Seeding dates[1] February 1 to April 15 Seeding rates	August 1 to October 10 lbs./ac.
1. *Sericea lespedeza* (tall and/or prostrate - scarified)	30	
Ky-31 tall fescue	10	
2. Orchardgrass	12	12
Red clover	8	8
3. Ky-31 tall fescue	12	
Annual lespedeza	30	
4. *Sericea lespedeza* (tall and/or prostrate-scarified)	35	
5. Ky-31 tall fescue	15	15
6. Red clover	10	10
Sweet clover	4	4
White clover	2	2
Ky-31 tall fescue or Orchardgrass	10	10

On areas where a seedbed is not prepared and the soil is glazed or crusted, the surface should be scarified or otherwise roughened before lime, fertilizer and seed are broadcast. Fertilizer and lime shall be applied to all sites as indicated by a soil test. Follow the guidelines provided in Chapter II, Lime and Fertilizer recommendations. Mulch material should be used as needed for erosion control and/or successful establishment of vegetation. See the Mulching Guide in Chapter II.

[1]*Seeding dates are approximate.*

Maintenance of the vegetated areas should be considered and included in the landowner's plan. Maintenance may include reseeding or replanting areas where vegetation failed to become established, fertilization to keep vegetation in an active stage of growth, and mowing to control weeds etc. Another important consideration which is more concerned with establishment than maintenance is controlled grazing. Cattle should be excluded from a pasture for at least a year after seeding, and may have to be restricted in number after that period in order not to exceed the carrying capacity.

Forestland

For postmining land use of forests, the planting of trees gains a greater significance than that of other land uses.

Vegetative treatment for woodland requires that the best quality seed and planting stock available be used if maximum survival and growth are to be expected. You should select one or more species which are adapted to local soil conditions and consider the use or products for which they are to be grown.

The planting of trees differs substantially from the planting of herbaceous species. The rest of this section concerns itself with the proper techniques of tree planting.

Spring planting can begin when the ground is no longer frozen and as soon as seedlings are available from the nursery. Spring planting usually terminates in western Kentucky by April 15 and in eastern Kentucky by May 1. Fall planting may be done after the first killing frost and on into the winter as weather permits. However, these seedlings may possibly be subjected to frost heaving and winter kill.

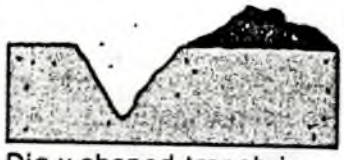
Tree seedlings require careful handling in planting in order to increase chances of survivability. All trees should be planted within two or three days after delivery. It is necessary to keep the roots of the planting stock moist at all times by covering them with wet moss or burlap until they are planted. The roots of seedlings will die rapidly if exposed to wind and sun. Most tree planting failures are the result of poor seedling care.

It is also necessary to exercise care in the actual planting of the seedling. "Heeling in" is a process by which trees are commonly planted. Table I-C illustrates various proper techniques for planting seedlings.

It is also necessary to insure that individual species are planted in a manner which aids both their survival and utility. Most tree species should be planted at approximately 6′ x 7′ spacing on mine soil. If vegetative cover is established, 8′ x 8′ spacing may be more desirable. Christmas tree species may be planted at a 5′ x 5′ spacing or wider. Cottonwood and hybrid poplar should be planted at a minimum of 8′ x 8′ spacing. A distance of 12 feet should be left between bands of hardwood and pine rows. Plant shrubs in 4′ x 6′ spacings. Exact planting arrangements vary for different species.

In general, plant pine species and sycamore in bands of five rows or more, or in pureblock plantings. Most hardwoods may be planted in mixtures with one another such as northern red oak and white or green ash with yellow-poplar. When selecting species for a mixture, however, it is important that all selected species are adaptable to the site and that slower growing species are tolerant to shade.

Heeling In



Dig v-shaped trench in moist shady place.

Break bundles and spread out evenly.

Fill in loose soil and water well.

Complete filling in soil and firm with feet.

Spade Planting

Shovel in position for starting planting hole. Blade reversed, perpendicular.

Shovel handle pushed forward. Bottom of hole opened up and out. Shovel pulled back and out of hole.

Beginning of second cut to straighten back wall of hole.

Shovel pulled back making clean hole. Tree placed in hole, roots in normal position. Plant tree one-half inch deeper than it formerly grew.

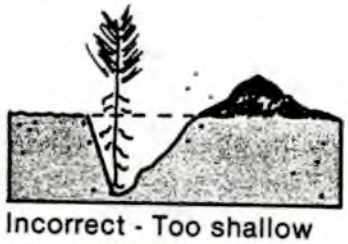
First packing, hole half filled with soil. Tree in proper position, heel used in tamping.

Second packing, hole completely filled. Cover packed surface with mulch of loose soil.

Correct and Incorrect Depths

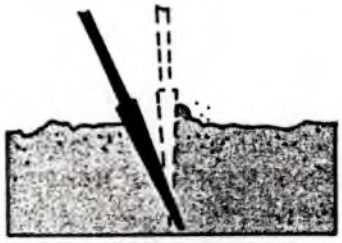
Correct - At same depth or ½ deeper than seedling grew in nursery.

Incorrect - Too deep and roots bent.



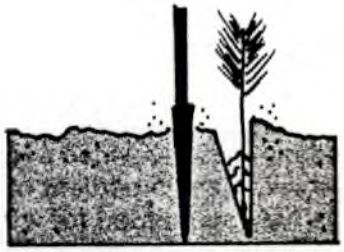
Incorrect - Too shallow and roots exposed.

Dibble Planting

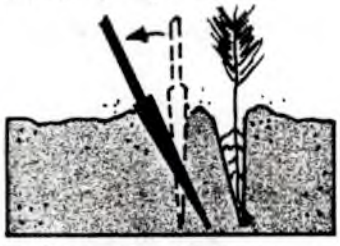


Insert dibble at angle shown and push forward to upright position.

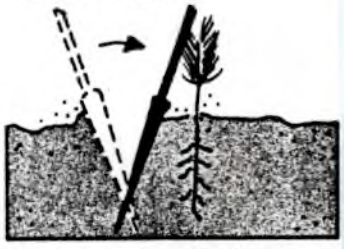
Remove dibble and place seedling at correct depth.



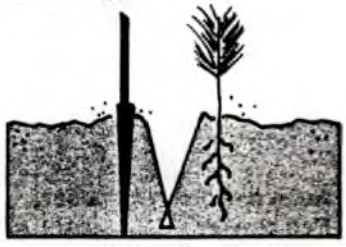
Insert dibble two inches toward planter from seedling.



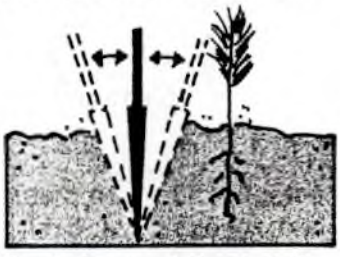
Pull handle of dibble toward planter firming soil at bottom of roots.



Push handle of dibble forward from planter firming soil at top of roots.

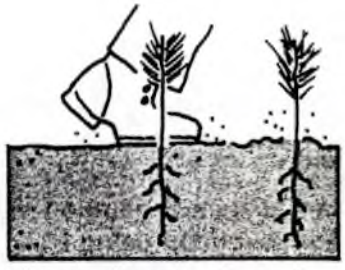


Insert dibble two inches from last hole.



Push forward then pull backward filling hole.

Fill in last hole by stamping with heel.



Firm soil around seedling with feet.

Mattock Planting

Insert mattock, lift handle and pull.

Place seedling along straight side at correct depth.

Fill in and pack soil to bottom of roots.

Finish filling in soil and firm with heel.

Firm around seedling with feet.

European black alder and black locust are nitrogen fixers, but can adversely affect the growth of other species if they are allowed to overtop or shade adjacent trees. These species shouldn't comprise more than 25 percent of the mixture unless their use is for erosion control and quick cover on a steep slope.

Planting a mixture of tree seedlings and nitrogen fixing shrubs such as autumn-olive or shrub lespedeza provides a means of improving tree growth. These shrubs shouldn't comprise more than 25 percent of the seedlings in a mixture. Small clumps or strips of trees or shrubs may be planted for wildlife habitat or for beautification purposes.

An alternative method allows for planting of seedlings at the same time as herbaceous species are seeded. It must be remembered that herbaceous species are still vital, as trees will be unable to effectively control erosion for five to ten years. When planting both trees and herbaceous plants at the same time, caution should be taken not to select herbaceous species or mixtures of species which are too competitive for tree seedlings. Low growing legumes are recommended for use and includes:

Kobe or *Korean lespedeza*	- 10 lbs/ac.	Feb. 15 - April 1
Red clover	- 8 lbs/ac.	Feb. 1 - April 15 Aug. 1 - Sept. 10
Ladino clover	- 3 lbs/ac.	Feb. 1 - April 15 Aug. 1 - April 15
Prostrate sericea	- 20 lbs/ac.	Feb. 15 - May 15

There are two possible methods of planting tree seedlings with herbaceous plantcover. These are:

a. Herbaceous vegetation may be seeded and allowed to become established. Then plant tree seedlings using a pesticide or scalping by hand to kill the herbaceous cover from an area 2 feet square around each seedling.
b. Herbaceous vegetation may be seeded in strips using conventional equipment, leaving an untreated strip 2-4 feet wide between the herbaceous strips in which tree seedlings are planted.

Direct seeding of tree species is an alternative to hand planting, especially on inacessible steep areas. However, only a few woody species have been established successfully by direct seeding. These include black locust, bicolor lespedeza, Virginia pine, shortleaf pine, loblolly pine, indigobush and green ash. These species can be established successfully when sown with mixtures of herbaceous species. The application of phosphorus fertilizer usually improves the establishment and growth of these species.

Broadcasting seed on a prepared seedbed in late fall, late winter or early spring is the most common method of direct seeding. Spot seeding is another method where several seeds are placed and lightly covered in small spots prepared by hand or mechanically. Seed should be stratified and pine seed treated with bird and rodent repellents.

Seeding rates for broadcast seeding are:

Black locust	2 - 3 lbs/ac.
Bicolor lespedeza	1 - 2 lbs/ac.
Indigobush (pods)	1/2 lbs/ac.
Shortleaf pine	1/2 - 1 lb/ac.
Virginia pine	1/4 - 1/2 lb/ac.
Green ash	2 lbs/ac.

Fertilization Fertilizing herbaceous plants to aid in their establishment may reduce woody plant survival. If possible, fertilize after woody seedlings become established or delay tree planting for a year after fertilizing the herbaceous vegetation.

Plant Survival Adequate number of seedlings (1000 seedlings/acre is recommended) should be planted so that the stocking rates for reforested areas, at the time of bond release, will meet the permanent program regulations for surface mining.

Guide to Tables Table I-D, on the next page, gives some information on tree species commonly used for reclamation of mine sites in Kentucky. Below is a log to the meaning of some of the abbreviations used in the table:

Size	**Origin**	**Shade Tolerance**
L = Large	N = Native	N = None or intolerant
M = Medium	I = Introduced	I = Intermediate
S = Small or (shrub)		T = Tolerant

Table I-E gives an estimation of the number of trees which will be in an acre depending on the spacing of the seedlings.

Table I-D
Common Tree Species for Forestlands

Hardwood	Size	Origin	Lower pH limit	Shade tolerance	Excessively dry site	Commercial use	Wildlife food	Wildlife cover	Esthetics	Comments
American sycamore	L	N	4.0	N	fair	good	poor	poor	good	Fast growth
Autumn olive	S	I	4.0	I	good	none	exc.	exc.	good	Nitrogen fixation
Black cherry	M	N	4.5	I	poor	good	exc.	poor	fair	Susceptible to Eastern Tent Caterpillar
Black locust	M	N	4.0	N	exc.	fair	good	poor	poor	Nitrogen producer
Black walnut	L	N	5.5	N	poor	exc.	good	poor	good	High value wood
Bur oak	L	N	4.0	I	fair	exc.	exc.	poor	good	Very large acorns
Chestnut oak	M	N	4.5	I	good	exc.	exc.	poor	good	Best oak for dry sites
Chinese chestnut	M	I	4.5	I	fair	poor	exc.	fair	good	Nuts excellent to eat
Crab apple	S	I	4.5	N	fair	none	exc.	good	good	Good wildlife food tree
Eastern cottonwood	L	N	4.5	N	fair	good	poor	poor	fair	Fast growing
European black alder	M	I	3.5	N	good	fair	good	poor	good	Nitrogen fixing
Flowering dogwood	S	N	4.5	T	poor	none	exc.	good	good	Good wildlife tree
Green ash	M	N	4.0	I	fair	exc.	exc.	poor	good	High value wood
Hybrid poplar	M	N	4.0	N	fair	good	poor	poor	fair	Fast growth
Northern Red oak	L	N	4.0	I	poor	exc.	exc.	poor	good	High value wood
Osage orange	S	N	4.5	I	fair	none	exc.	good	fair	Good wildlife tree
Pin oak	L	N	4.0	N	poor	good	exc.	poor	exc.	Fast growth for oak
Red maple	M	N	4.5	I	fair	good	exc.	poor	good	Fast growth
River birch	M	N	4.0	N	poor	fair	fair	poor	fair	Scaly pink bark
Royal paulonia	M	I	4.5	I	fair	exc.	poor	poor	fair	Fast growth-High export values
Russian olive	S	I	5.5	I	good	none	exc.	exc.	good	Good for wildlife food and cover
Silver maple	M	N	4.0	I	poor	good	exc.	poor	good	Fast growth
Sugar maple	M	N	4.5	T	poor	exc.	exc.	poor	good	High shade tolerance
Sweet birch	M	N	4.0	N	poor	fair	good	poor	good	Wintergreen twig
Sweetgum	L	N	4.0	N	poor	good	good	poor	good	Has 5 point leaves
White ash	L	N	4.0	I	fair	exc.	exc.	poor	good	High value wood
White oak	L	N	5.0	I	poor	exc.	exc.	poor	good	High value wood
Yellow poplar	L	N	4.5	N	poor	good	good	poor	good	Fast growth
Conifers										
Bald cypress	L	N	5.0	I	poor	good	fair	poor	good	Good for wet sites
Eastern white pine	L	N	4.0	I	fair	good	fair	exc.	exc.	Excellent cover
Loblolly pine	L	N	4.0	N	good	good	fair	good	good	Quick cover. Subject to snow damage
Pitch pine	M	N	4.0	N	good	good	fair	good	good	Quick cover
Scotch pine	M	I	4.0	N	fair	fair	fair	exc.	exc.	X-mas tree species
Shortleaf pine	L	N	4.5	N	good	good	fair	exc.	good	Quick cover
Virginia pine	S	N	3.5	N	exc.	good	fair	exc.	good	Excellent-quick cover

Table I-E
Trees Per Acre by Spacing

Spacing (feet)	Trees (number)	Spacing (feet)	Trees (number)
4 x 2	10,890	10 x 10	436
4 x 3	4,840	10 x 12	363
4 x 4	2,722	10 x 15	290
4 x 5	2,178	10 x 18	242
4 x 6	1,815		
4 x 7	1,556	11 x 11	360
4 x 8	1,361	11 x 12	330
4 x 9	1,210	11 x 15	264
4 x 10	1,089	11 x 20	198
		11 x 25	158
5 x 5	1,742		
5 x 6	1,452	12 x 12	302
5 x 7	1,245	12 x 15	242
5 x 8	1,089	12 x 18	202
5 x 9	968	12 x 20	182
5 x 10	871	12 x 25	145
6 x 6	1,210	13 x 13	258
6 x 7	1,037	13 x 15	223
6 x 8	908	13 x 20	168
6 x 9	807	13 x 25	134
6 x 10	726		
6 x 12	605	14 x 14	222
6 x 15	484	14 x 15	205
		14 x 20	156
7 x 7	889	14 x 25	124
7 x 8	778		
7 x 9	691	15 x 15	194
7 x 10	622	15 x 20	145
7 x 12	519	15 x 25	116
7 x 15	415		
		16 x 16	170
8 x 8	681	16 x 20	136
8 x 9	605	16 x 25	109
8 x 10	544		
8 x 12	454	18 x 18	134
8 x 15	363	18 x 20	121
8 x 25	218	18 x 25	97
9 x 9	538	20 x 20	109
9 x 10	484	20 x 25	87
9 x 12	403		
9 x 15	323	25 x 25	70

Recreation Land

Vegetative treatment for recreation land requires that the treatment be according to the type of planned activity. Select plant species that will tolerate a wide range of environmental conditions including heavy fertilization, close and frequent mowing, and excessive traffic by people, vehicles, or animals. The vegetative treatment should also enhance the esthetic value of the area and provide food and cover for wildlife. Seeding mixtures for grasses and legumes should be those normally used in Kentucky.

Use applicable information from other sections within Chapter I including Vegetative Treatment for Erosion Control, Vegetative Treatment for Wildlife, etc.

Wildlife Land

The best opportunities for managing mine soil for wildlife are in those areas where the topography was originally undulating to hilly, and mine operators graded the soil to approximately the original slope of the land. Here the soil can be seeded or planted in either herbaceous or woody plants that have value as wildlife food or cover.

Any planting pattern that puts adequate vegetative cover on the land, effectively controls soil erosion, and provides food and cover is of value to wildlife. However, some planting patterns are more attractive than others. Strip plantings of either herbaceous plants and/or trees and shrubs are more attractive than solid plantings. A typical example of such a preferred pattern is one consisting of strips of grasses and legumes 30 to 50 feet wide alternating with strips of either trees or shrubs, or both, of similar width.

Where strip plantings are not possible or practical, solid plantings of either herbaceous or woody plants are in order. Seeding of wheat or other small grains for temporary cover on areas to be later seeded to grasses and legumes or planted to trees and shrubs is desirable.

You should select seeding mixtures for wildlife plantings from *Herbaceous Mixtures for Wildlife* (Table I-F). For establishment of herbaceous cover, prepare a seedbed, apply lime, fertilizer and seed. The quality of seed used should conform to or exceed the minimum requirements for purity and germination of the Kentucky Seed Improvement Association or the Association of Official Seed Certifying Agencies. Fertilizer and lime should be applied as indicated by a soil test. Follow the guidelines provided in the tables of Lime and Fertilizer recommendations (Tables II-A and II-B).

On areas where a seedbed will not be prepared and the soil is glazed or crusted, the surface should be scarified or otherwise roughened before lime, fertilizer and seed are broadcast. Apply mulch as needed for erosion control and/or successful establishment of vegetation.

Maintenance of vegetated areas should be considered and included in the reclamation plan. Maintenance may include reseeding and replanting areas where vegetation failed to become established, and fertilization to keep vegetation in an active stage of growth.

Table I-F suggests certain herbaceous plant species useful for erosion control and suitability of wildlife postmining land use. These herbaceous mixtures are grouped by seeding dates.

Table I-G lists many plant species (including trees, shrubs, and herbs) which are of particular value to wildlife maintenance.

Finally, Table I-H details the type of vegetative and site requirements preferred by different wildlife animal species.

Table I-F
Suggested Herbaceous Species for Wildlife Habitat and Erosion Control by Seeding Season

February 15 to May 15

Permanent Species Mixtures

	Species	Seeding rate[a] pounds/acres PLS
I.	Orchardgrass or	10
	Timothy	8
	White or Ladino clover	2
	Red clover	6
II.	Orchardgrass or	10
	Timothy	8
	White or Ladino clover	1
	Red clover	4
	Korean and/or Kobe lespedeza	10
III.	Orchardgrass or	10
	Timothy	8
	Birdsfoot trefoil or	8
	Alfalfa	15
IV.	Wheat or	25
	Spring oats	32
	Switchgrass	10
	Indiangrass	10
	Big bluestem	5
	Little bluestem	5
	Birdsfoot trefoil	6

Temporary (quick cover) Species

Add one of the following species to permanent mixture I, II, or III. Do not add to mixture IV.[b]

Wheat (before April 25)	30
Spring oats (before April 15)	32
Balbo rye (before April 15)	30
Perennial ryegrass	10
Annual ryegrass	5
Weeping lovegrass (after April 1)	2

May 15 to August 1

Permanent Species Mixtures

Species	Seeding rate[a] pounds/acre PLS
I. Orchardgrass or	10
Timothy	8
Korean and/or Kobe lespedeza	15
Red clover	4
White clover or	1
Birdsfoot trefoil or	6
Alfalfa	12

Temporary Species

Add one to the permanent mixture.[b]

Sorghum	20
Foxtail (German) millet	12
Soybeans	40
Cowpeas	40
Pearl millet	10

August 1 to October 1

Permanent Species Mixtures

Species	Seeding rate[a] pounds/acres PLS
I. Orchardgrass or	10
Timothy	8
White or Ladino clover	2
Red clover	6
II. Orchardgrass or	10
Timothy	8
Alfalfa or	15
Birdsfoot trefoil	8
III. Deertongue	12
Birdsfoot trefoil	8

Note: If the perennial legumes or grasses fail to establish from the summer seeding, they can again be sown in late summer (August 15 to September 15) or early the following spring.

Temporary Species
Add one to a permanent mixture.[b]

Winter wheat	30
Balbo rye or winter rye	30
Winter oats	32
Perennial ryegrass	10
Annual ryegrass	5

Mixtures for wet or poorly drained areas and pond borders

Spring Seeding (February 15 to May 15)

I. Redtop	2
Ky-31 tall fescue or	10
Reed canarygrass	15
Alsike clover	4
Common annual lespedeza	10

Spring or Fall (August 1 to October 1) Seeding

II. Redtop	3
Reed canarygrass or	15
Ky-31 tall fescue	10
Alsike clover	6

a) Seeding rates are for Pure Live Seed (PLS). Seeding rate of the permanent species can be increased if desired, but do not exceed the seeding rate of the temporary species.

b) Use only one of the temporary species at the rates shown. If more than one is used, reduce the seeding rate of each species according to number of species used; i.e., for two species use one-half seeding rate of each.

Table I-G
Usefulness to Wildlife of the Recommended Plant Species as Cover (c), Browse (b), Herbage or Foliage (h), Mast (m), Fruit (f), or Seeds (s)[a]

Plant	Uses[b]
Trees	
Ashes - *Fraxinus spp.*	SB
Birches - *Betula spp.*	BSC
Black locust - *Robinia pseudoacacia*	SCB
Black walnut - *Juglans nigra*	M
Chinese chestnut - *Castanea mollissima*	MB
Crabapples - *Malus spp.*	FCB
Eastern redcedar - *Juniperus virginiana*	CFB
European black alder - *Alnus glutinosa*	CSB
Flowering dogwood - *Cornus florida*	FBC
Maples - *Acer spp.*	SB
Oaks - *Quercus spp.*	MBC
Pines - *Pinus spp.*	CSB
Russian olive - *Elaeagnus angustifolia*	FC
Sassafras - *Sassafras albidum*	BFCS
Spruces - *Picea spp.*	CSB
Sweetgum - *Liquidambar styraciflua*	SC
Sycamore - *Platanus occidentalis*	SB
Tulip poplar - *Liriodendron tulipifera*	SB
Shrubs	
Amur privet - *Ligustrum amurense*	FC
Autumn olive - *Elaeagnus umbellata*	FBC
Bayberry - *Myrica pennsylvanica*	FCB
Bicolor lespedeza - *Lespedeza bicolor*	SHC
Bristly locust - *Robinia fertilis*	CS
Bush honeysuckle - *Lonicera spp.*	FBC
Coralberry - *Symphoricarpos orbiculatus*	FBC
Cranberrybush, arrowwood - *Viburnum spp.*	FBC
Dogwoods — *Cornus spp.*	FBC
Hawthorns - *Crataegus spp.*	CFB
Indigobush - *Amorpha fruticosa*	CBS
Japanese honeysuckle - *Lonicera japonica*	CBF
Rose - *Rosa spp.*	CFBS
Sumacs - *Rhus spp.*	FBC

Plant	Uses[b]
Herbs (Grasses)	
Bermudagrass - *Cynodon dactylon*	HS
Bluestems - *Andropogon spp.*	CHS
Deertongue - *Panicum clandestinum*	HSC
Foxtail millet - *Setaria italica*	S
Indiangrass - *Sorghastrum nutans*	CHS
Ky-31 tall fescue - *Festuca arundinacea var.*	HSC
Oats - *Avena sativa*	SH
Orchardgrass - *Dactylis glomerata*	HSC
Pearl millet - *Pennisetum glaucum*	S
Proso millet - *Panicum milaceum*	S
Redtop - *Agrostis alba*	CHS
Reed canarygrass - *Phalaris arundinacea*	SC
Rye - *Secale cereale*	SH
Ryegrass - *Lolium spp.*	HS
Sorghums - *Sorghum spp.*	S
Switchgrass - *Panicum virgatum*	CSH
Timothy - *Phleum pratense*	SH
Weeping lovegrass - *Eragrostic curvula*	CHS
Wheat - *Triticum aestivum*	SH
Herbs (Leguminous forbs)	
Alfalfa - *Medicago sativa*	HSC
Annual lespedeza - *Lespedeza spp.*	S
Birdsfoot trefoil - *Lotus corniculatus*	HC
Clovers - *trifolium spp.*	HS
Cowpea - *Vigna sinensis*	SH
Crownvetch - *Coronilla varia*	CH
Flatpea - *Lathyrus sylvestris*	CHS
Hairy vetch - *Vicia villosa*	HSC
Partridge pea - *Cassia fasciculata*	S
Sericea lespedeza - *Lespedeza cuneata*	CSH
Soybean - *Glycine max*	SH
Sweet clover - *Melilotus spp.*	SH
Herbs (Non-leguminous forbs)	
Buckwheat - Fagopyrum spp.	SH
Sunflower - *Helianthus annuus*	S

a) Classification system adapted from McAtee, 1926. Mast = nuts and acorns. Seeds = dry fruits in addition to grains, achenes, and other plant fruitifications popularly called seeds. Browse = bark, buds, catkins, whole pods, whole heads of fruits, twigs, small branches.

b) The uses of each plant are arranged in descending order of their overall importance to wildlife. The relative importance of these uses can vary for different species of wildlife.

Table I-H
Habitat Requirements and Management of Primary Wildlife Species

Species	Range reg. acres	Preferred Food	Water	Cover
Raccoon	200	Varied diet, hardwood mast, wild & cultivated fruits, insects & earthworms, aquatic crustaceans & reptiles, crops such as corn.	Required daily. A permanent source within 1/4 mile.	Wide ecological tolerance but primarily forest & marsh.
Cotton-tail Rabbit	100A	Greenfoods: shrubs, grasses, legumes, and herbs.	Not essential but used, generally by plant succulence and dew.	Open acres with low ground cover.
Songbirds	Local to migratory	Most fruits, seeds, insects, small animal life.	Necessary for drinking and bathing. Pools should be no more than 2″-3″ deep, have a bottom and edges clean for 10′-15′.	Individual requirements unique a wide variety of habitats are necessary from grasslands to mature woodland. The majority nest in shrub type vegetation less than 15′ above ground. Others nest in tree cavities, caves, cliffs and bare ground.
Bobwhite Quail	40	Field and open forest feeders. Varied diet, mainly vegetative. Legume seeds include lespedezas & partridge peas. Grasses, thick trefoil sedges. Grains, mast, cultivated grains and green forage.	Open water not essential. Receive water from dew. Succulent leaves & vegetation.	Interspersion woodland, brush, grass and cultivated lands. Nests in edges.

Breeding potential	Key areas	Special requirements management remarks, etc.
Annual	Bottomland & upland hardwoods & marshland with den-trees, interspersed cultivated.	Need access to mature timber for mast & dens. Raccoons do poorly in extensive pinestands. Compatible with squirrel, deer, and turkey. Will destroy eggs of ground nestingbirds such as quail.
Two or more litters annually, nests in grass and herbaceous cover.	Old homesites, abandoned orchards, sedge fields sumac & honeysuckle thickets, old brushpiles.	Openings with grass, herbs & low ground cover. Forest habitat will carry about one rabbit per 5 acre while agricultural habitat can support 2-3 rabbits/acre.
Annually	Will vary by species. An abundant food supply over a small area is necessary.	Approximately 175 species spend a significant part of their life in Kentucky; Generally favor vegetation which fruits or seeds prolifically and is herbaceous to shrubby. Some species require large areas of mature stands of pine, hardwood, or pine-hardwood timber.
Annual 10-15 eggs per nest, will renest. Weather and grain harvest important mortality factors.	Field and border edges for nesting. Old house sites.	Intersperse clearcutting. Provide openings, sod plantings or emphasize adjacent to cultivated fields. Young forest limited for quail. One quail per 3 acres is desirable hunting population. To create habitat, prescribe burn southern pine stands.

Table I-H
Habitat Requirements and Management of Primary Wildlife Species (continued)

Species	Range reg. acres	Preferred Food	Water	Cover
Ruffed Grouse	40	Omnivorous. Consume both animal & vegetable matter. Leaves, buds, twigs, fruits, seeds and flowers. Grapes, haws, dogwoods, blackberries & sumac.	Important, Free water dew, snow fruits, succulent vegetation & insects.	Diversity perferred Conifers important, especially for adult birds.
Squirrel	5	Mast of scattered mixed oaks, hickory, beech, gums, viburnums, butternuts & black walnuts.	Not essential but taken when available.	Den trees essential throughout range for overwintering. Leaf nests used in summer. Den boxes satisfactory.
Turkey	700	Insects, salamanders, grass, seeds, fruits, mast — mostly acorns and tubers.	Essential. Well distributed throughout range.	Mature conifers for roosting and protection in severe weather.
White-tailed Deer	300	Wide variety: forbs, mast, mushrooms, fruit & browse (dogwood, sourwood, oak, honeysuckle, chestnut, etc.)	Use daily. Ideal if available within 1/2 mile.	Mixed hardwoods and conifers.

Nurturing Plant Growth

There are many steps, both before and after planting, which can be taken to promote the healthy growth of plant species. These operations include the additional lime, fertilizer, and mulch.

Lime

Lime is used on mine soil to neutralize acidity. How much lime to apply is dependent on the acidity of the soil, potential acidity of the soil, and the acidity tolerance of the vegetation to be established. Enough limestone should be applied to mined land to raise the soil pH to at least 6.4 for all land uses. This should allow for long term, top production of legumes as well as meet the pH level required by Kentucky.

Breeding potential	Key areas	Special requirements management remarks, etc.
Annual about 10-12 eggs. Will renest if destroyed. Weather an important factor on ground.	Forest openings and sod plantings for nesting and insects. Old house sites.	Seldom do well under 2,000 foot elevation. Cyclic populations. Prefer interspersion of mature hardwoods and conifers, pole stands, brush lands and fields. Encourage distribution of small even-age stands. Large uniform stands undesirable. One per 10 acres is desirable hunting population.
Two litters annually - spring & fall. 3 young per litter.	Interspersed mixed hardwood mast species with dens.	Need 1-1/2 pounds mast per week. Favor red oaks 2-1 over white oaks. Retain larger (16" + DBH) mast species. Retain portion of woodlot in older mast producing age-classes. One per two acres desirable hunting population.
Annual. Hen will nest until successful. 12-14 eggs. 3-4 raised to maturity.	Spring seeps, grape & dogwood clumps, sod plant - (insects & forage).	One per 100 acres desirable hunting population. Scatter clearcuts. Provide mixture of mast and fruit at all elevations. Favor fruit bearing vines, shrubs and trees. Provide 2 acre food patches throughout woodlot unless planted fields are within 1/4 mile. To create habitat, prescribe burn southern pine stands.
Annual 1-2 fawns (rarely 3) per year. About May.	Mast producing oak stands, apple orchards, clearcut acres. Old house sites.	Consume 6-8# browse per 100# body weight per day. 50% brush lands, 25% woods and 25% fields ideal range. Retain mast component in stand at all times. One per 30 acre desirable hunting population. Scatter clearcuts.

Recommendations for liming mine soil are based on the University of Kentucky's *"Lime and Fertilizer Recommendations for Reclamation of Surface-Mined Soils,"* Agricultural Bulletin 40.

Lime rates assume use of quality agricultural limestone and that representative soil samples were taken. All lime should be incorporated into the soil to a depth of at least 6 inches. For determining how much lime is required to raise the pH of soil to 6.4 refer to Table II-A.

Table II-A
*Limestone Rates for Soil-Buffer pH Readings.**

Buffer pH readings	Agricultural limestone (tons/acre) required to adjust soil to pH 6.4
6.7 - 6.3	2-4
6.3 - 5.9	4-6
5.9 - 5.3	6-8
5.3 - 5.0	8-11
5.0 - 4.5	11-15
4.5 - 4.0	15-25
below 4.0	25*

**When lime rates are 25 or more tons/acre, refer to section on Lime Requirement for Highly Acidic Spoils in Agricultural Bulletin 40.*

Fertilizer

Recommendations for fertilization of mine soil are based on (1) establishment of vegetative cover for erosion control only, and (2) establishment of grass-legume stands for erosion control and hay-pasture production. Recommendations are based on the University of Kentucky's *"Lime and Fertilizer Recommendations for Reclamation of Surface-Mined Spoils"* Agricultural Bulletin 40. Consult this publication for further information, especially for fertilizer requirements for hay-pasture maintenance.

For fall seeding, apply 60 lbs. of nitrogen (N) per acre. An additional 30 lbs. should be top-dressed the following spring if the area is being seeded for hay-pasture production. For spring seeding, apply 60 lbs. nitrogen per acre at seeding and an additional 30 lbs. in the fall if the area is for hay-pasture production. It is recommended that, for seedings in which the objective is only surface cover, an additional 30 lbs. nitrogen per acre be applied during the spring of the second growing season.

If fertilizer recommendations must be made without soil samples being tested, apply at least the minimum fertilizer rates of 120 lbs. available phosphate (P_2O_5) per acre, 60 lbs. available nitrogen (N) per acre, and 30 lbs. potash (K_2O). There is no "best" way to apply fertilizer. The important thing is to apply it when it is needed and in the amount required.

Potential problems exist when fertilizer and seed are mixed:

1. Hydroseeder. A salt solution forms when water and fertilizer are mixed. This solution damages seeds especially grass seeds. The effectiveness of the innoculating bacteria for legumes is also reduced. The slurry should be kept at a pH above 5. For 1000 gallons of water mix 100 pounds of calcium hydroxide (hydrated lime), wait at least 15 minutes to add the bacteria innoculant, use two 6.7 ounce packages of innoculant, spread within 3 hours.

2. Cyclone or dry mixes. You must keep the mix dry. Dampness will allow the salt solution to form.

Table II-B gives recommendations of fertilizer additions for new seedlings by the test level of the site.

Table II-B
Fertilizer Requirements for New Seedlings[a]
Pounds of P_2O_5 and K_2O to Apply Per Acre

	Surface Cover[b]		Hay and Pasture[c]	
Test level (lbs/acre)	P_2O_5	K_2O	P_2O_5	K_2O
Very low (below 10P; 75K)	120-140	30-60	150-200	60-90
Low (10-30P; 75-165K)	100-120	0-30	100-150	30-60
Medium (31-60P; 165-25OK)	50-100	0	50-100	0-30
High (above 60P; 25OK)	0-50	0	0-50	0

(a) If medium or high test levels of either phosphorus (P) or potassium (K) are obtained, keep in mind that the operator must obtain special permission from the Kentucky Department for Surface Mining to use fertilizer rates lower than the minimum levels required.

(b) If soil tests are very low, retesting is recommended prior to planting trees since additional P_2O_5 may be needed to maintain surface cover.

(c) For alfalfa production increase rates to 20-40 lbs P_2O_5 and 20-40 lbs. of K_2O/acre.

Mulching

Mulching is the process of spreading materials on the ground in order to prevent erosion and the evaporation of water. Mulching helps protect the soil while the ground cover is still new and enhances growth of the ground cover. Table II-C which follows examines the use of different possible mulch materials.

Table II-C
Mulching Guide

Mulching Material	Rates	Remarks
Small grain straw, fescue straw, or hay	Apply uniformly with chopper-blower at the rate of 1.5 to 2 tons (60-80 bales) per acre	One of the better mulching materials when tacked down with asphalt emulsion or other chemical binders, or when pressed into the soil with a crimper. Can be applied by hand or power mulcher.

Table II-C
Mulching Guide (continued)

Mulching Material	Rates	Remarks
Shredded bark	Apply at rate of 45 cu. yds. per acre	Excellent mulching material that will stay in place without tacking down. Bark can be applied on leveled and sloping areas with the truck mounted spreader. It can be applied with a manure spreader on leveled areas.
Wood fiber	Apply at rate of 1,400 to 1,600 lbs. per acre	Processed wood or cellulose fibers and some reprocessed paper materials are popular because they can be mixed with seed and fertilizer in a hydroseeder and applied all at one time. Most cellulose materials are colored for visibility.
Leaves	Apply at rate of 2-3 tons per acre or 100 bales per acre	Use of deciduous tree leaves for mulching is limited to level areas because light disking is necessary to hold them in place. Leaves can be spread with a power mulcher or with a manure spreader.
Other waste products	Apply at rate of 10 tons per acre	Waste products such as processed or compost garbage and dewatered sewage sludge can be used as mulches and organic amendments. Application can be made with truck mounted spreader followed with a light disking.

In chapter III, different species commonly used in the revegetation of mined land reclamation are discussed. The most significant plant species are divided into four groups (grasses, forbs, trees, and shrubs) and are presented alphabetically within the group. Finally, after each group, species of lesser importance are discussed.

Refer to the index of species in the appendix of this book for information pertaining to a particular plant species.

Grasses

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

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 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.

Bermudagrass

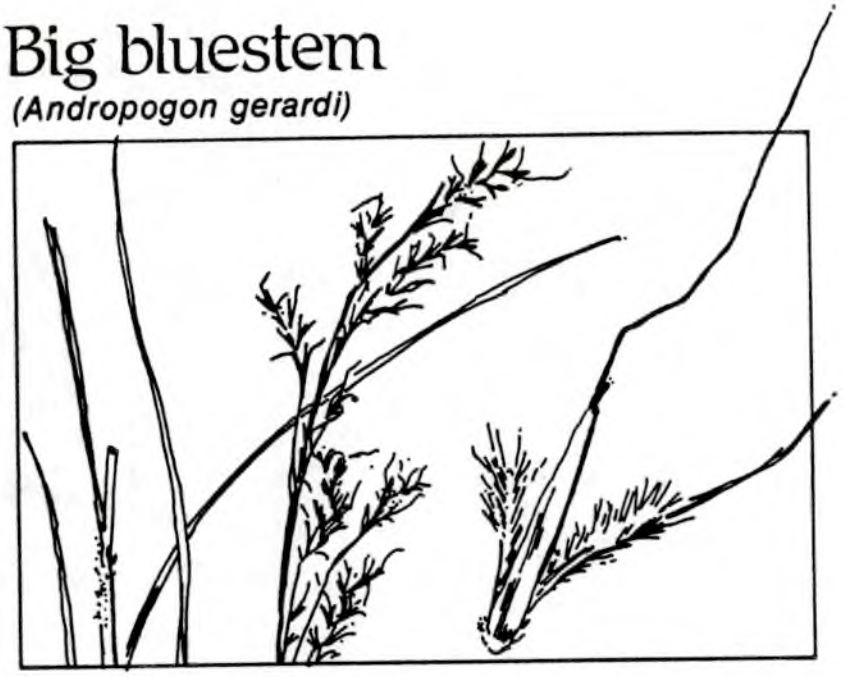
(Cynodon dactylon)

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

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 grown 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.

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 mixtures; 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

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.

Deertongue

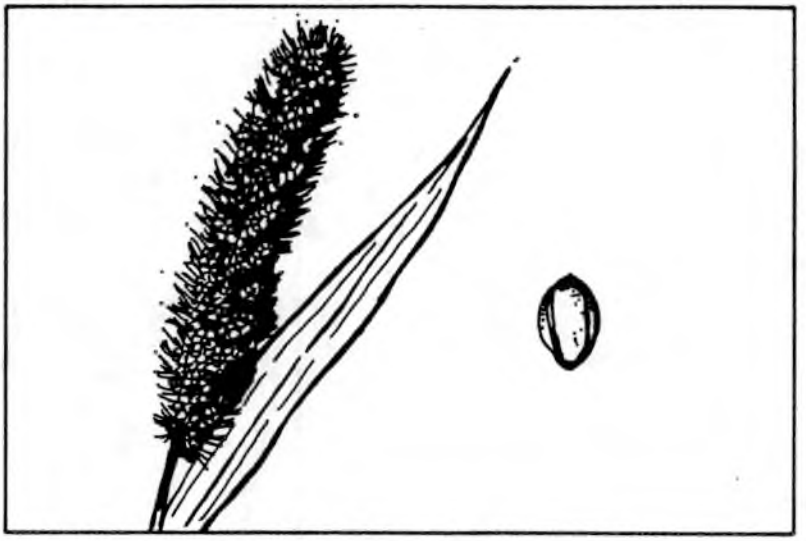
(Panicum clandestinum)

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 mixtures; 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

This grass was selected for use on acid mine soils 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 mine soils 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 seeding 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.

Foxtail millet

(Setaria italica)

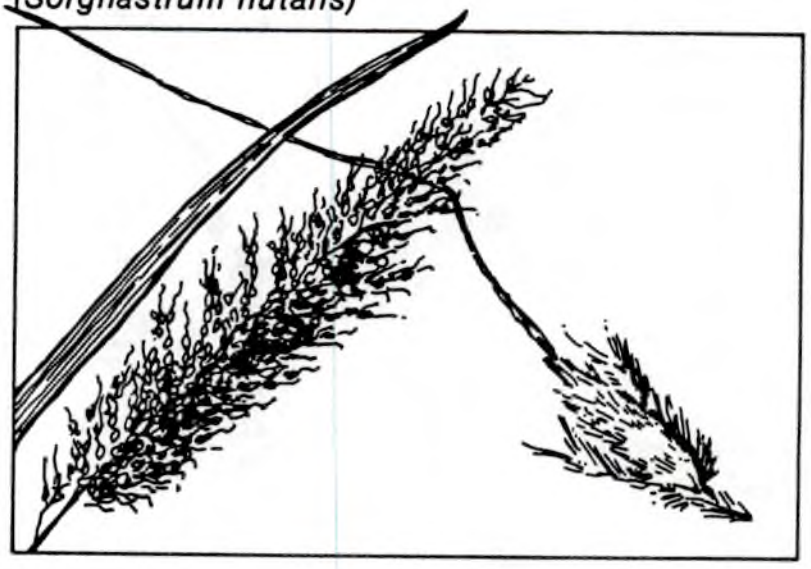


Type of plant: grass
Origin: introduced
Life Span: annual
Season of major growth: warm
Lower pH limit: 4.5
Elevation limit: avoid high altitudes
Planting materials: seed
Seeding rate: 10 to 15 lb/acre in mixtures: 20 to 30 lb/acre alone
Time of seeding: late spring to mid summer
Superior cultivars: German
Rate of establishment: rapid
Major uses: erosion control (quick, temporary cover); wildlife food

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)

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.

'Kentucky-31' Tall fescue

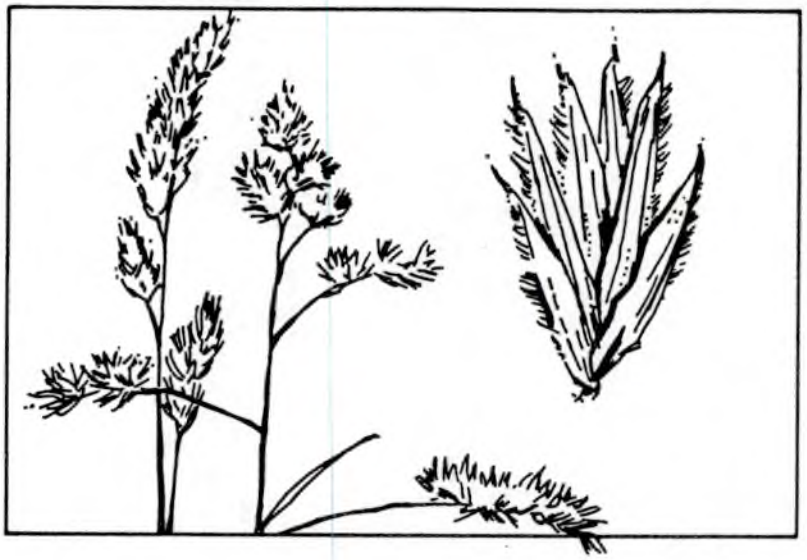
(Festuca arundinacea, Selection Ky-31)

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)

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.

Orchardgrass

(Dactylis glomerata)

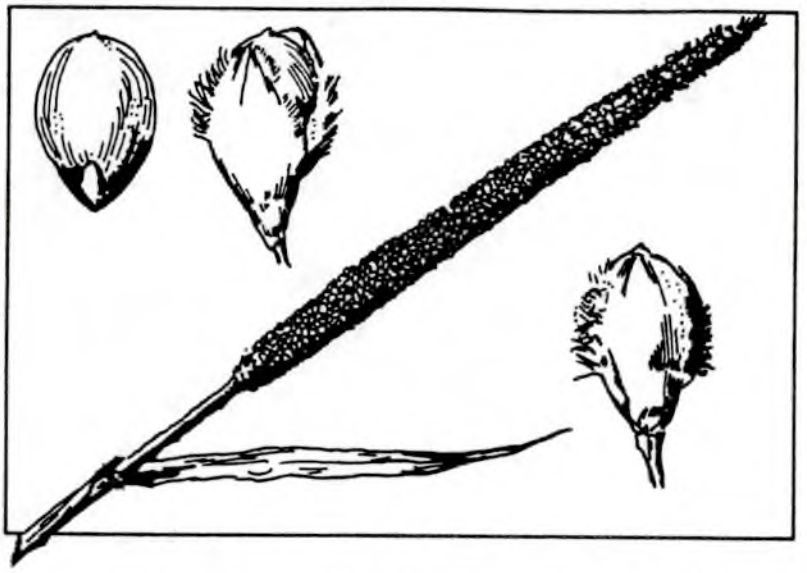


Type of plant: grass
Origin: introduced
Life Span: perennial
Season of major growth: cool
Lower pH limit: 4.5
Planting materials: seed
Seeding rate: 5 to 8 lb/acre in mixtures; 10 to 15 lb/acre alone
Time of seeding; spring, late summer to early fall
Superior cultivars: consult local agricultural agencies for recommended cultivars
Rate of establishment: moderate to rapid
Major uses: forage, wildlife habitat; watershed protection

Orchardgrass is similar to K-31 tall fescue in growth habits and tolerance to acid mine soil, 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.

Pearl millet

(Pennisetum americanum)

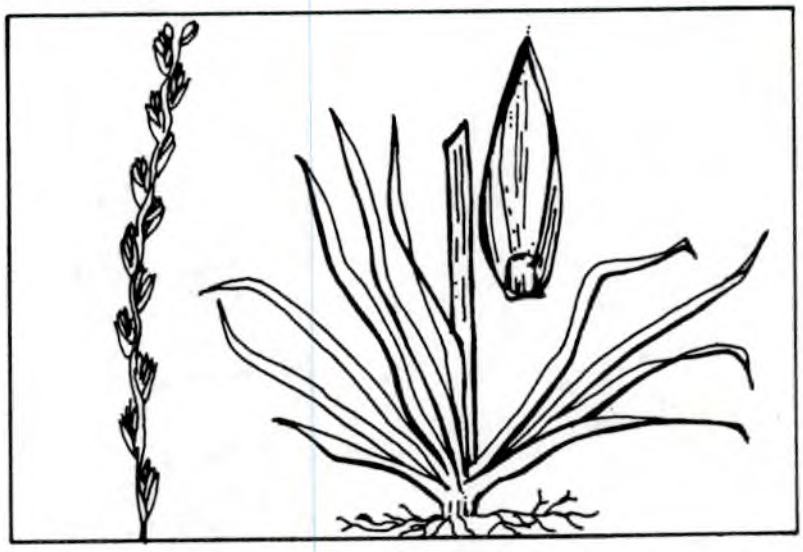


Type of plant: grass
Origin: introduced
Life Span: annual
Season of major growth: warm
Lower pH limit: 4.0 - 4.5
Planting materials: seed
Seeding rate: 8 to 12 lb/acre in mixtures; 20 to 25 lb/acre alone
Time of seeding: late spring to mid summer
Superior cultivars: Gahi-1; Starr
Rate of establishment: rapid
Major uses: erosion control (quick, temporary cover)

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 mine soil. Can be grown in Kentucky and southward. Will outyield Sudangrass in the Southeast and is free from prussic acid. Seeds are used by songbirds.

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

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 along 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 mine soils should not be grazed until perennial vegetation is well established.

Redtop

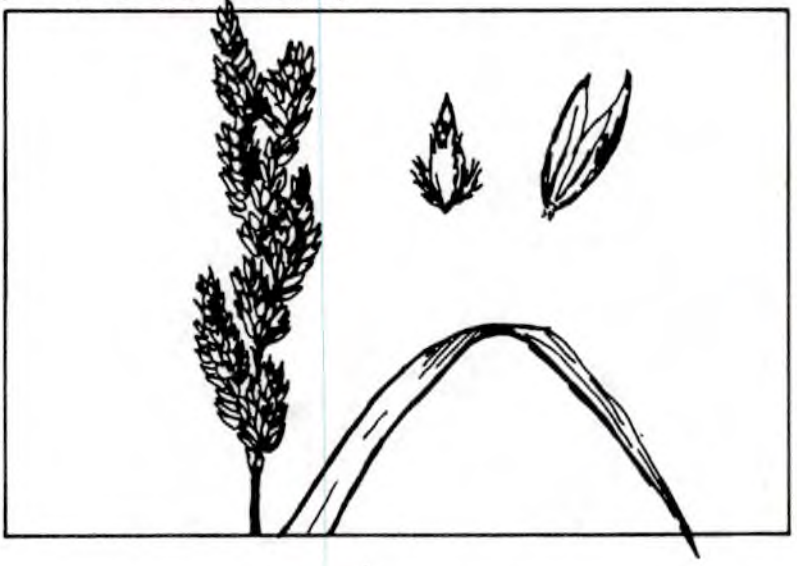
(Agrostis gigantea)

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 mixtures; 3 to 6 lb/acre alone
Time of seeding: spring; late summer
Rate of establishment: moderate to rapid
Major uses: erosion control (temporary cover)

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. Will 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.

Reed canarygrass

(Phalaris arundinacea)

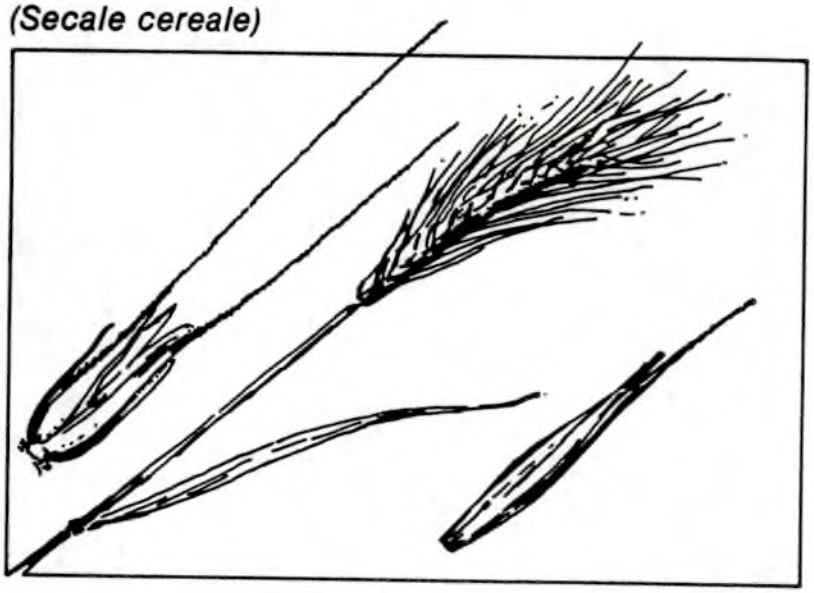


Type of plant: grass
Origin: introduced
Life Span: perennial
Season of major growth: cool
Lower pH limit: 4.5
Planting materials: seed; sprigs
Seeding rate: 5 to 8 lb/acre in mixtures; 8 to 12 lb/acre alone
Time of seeding: spring; late summer
Rate of establishment: moderate
Major uses: erosion control; wildlife habitat

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.

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 mixtures; 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)

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.

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 4.0
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)

The sorghums, Sudangrass, and sorghum-Sudangrass hybrids are drought resistant and are useful as a 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 sorghum. They are classified on the basis of use as (1) grass sorghum; (2) grain sorghum; (3) forage sorghum; (4) syrup sorghym; 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.

Switchgrass

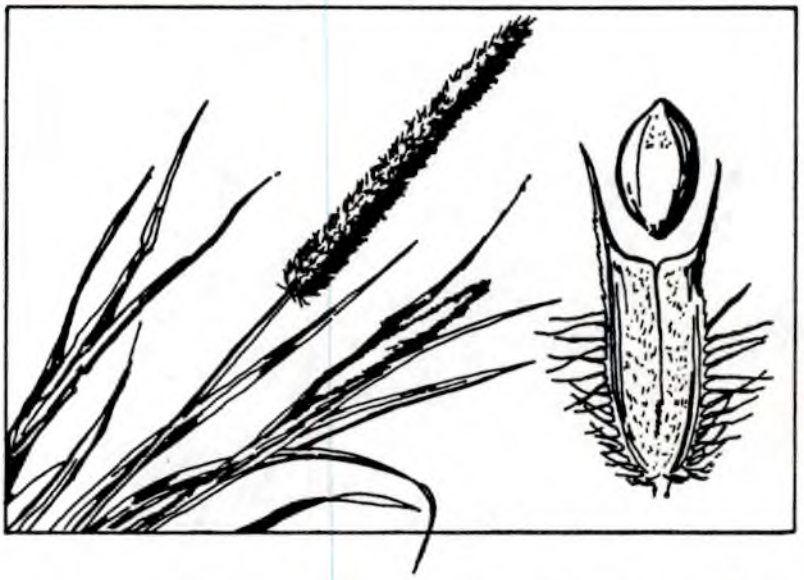
(Panicum virgatum)

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 mixtures; 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

Switchgrass has been used on mine soils 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 mine soils. 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.

Timothy

(Phleum pratense)

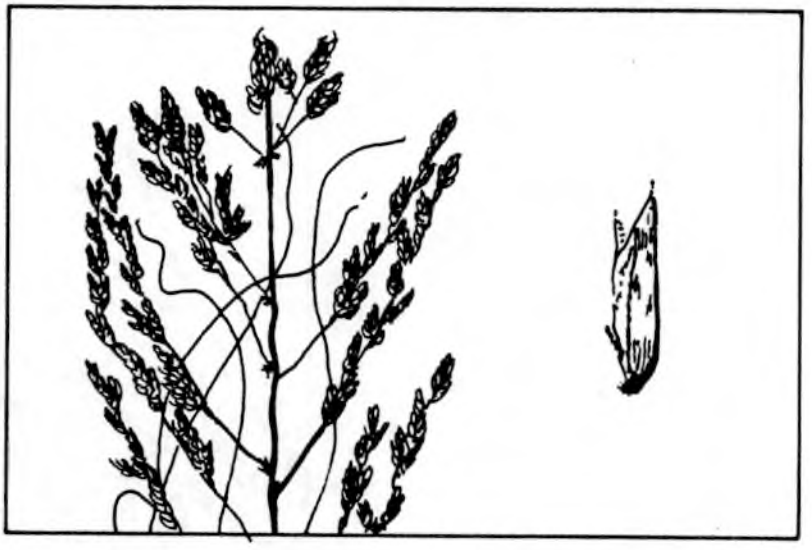


Type of plant: grass
Origin: introduced
Life Span: perennial
Season of major growth: cool
Lower pH limit: 4.5 to 5.0
Planting materials: seed
Seeding rate: 4 to 7 lb/acre in mixtures
Time of seeding: late summer-early fall; spring
Superior cultivars: consult local agricultural agencies for recommendations
Rate of establishment: moderate
Major uses: forage; wildlife habitat; erosion control

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.

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)

This grass is one of the most tolerant of extremely acid mine soils. It has grown well on some mine soils with pH 3.8. Established 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 a 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 mine soils.

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

Similar to rye in growth habit and adaptation to site and mine soil 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 mine soil, 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 III-A
Grass Species of Limited Importance or Use

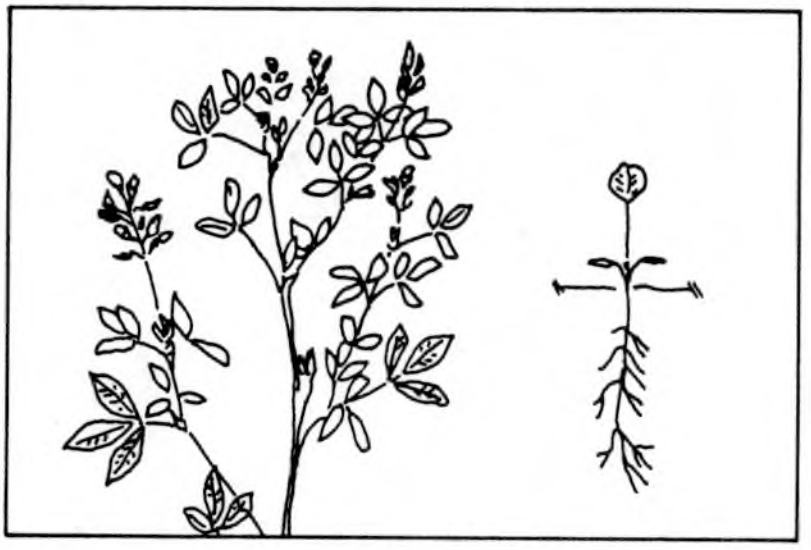
Common & scientific name	Origin	Life span	Growth season	Lower pH limit	Seeding rate (lb/acre) PLS	Comments
Broomcorn millet *Panicum miliaceum*	I[a]	A[b]	warm	4.5	10-12[c]	Use in summer annual mix for game bird food. Good for dove. Adapted to northern latitudes. Also called proso millet.
Caucasian bluestem *Bothriochloa caucasica*	I	P	warm	5.0	2-3 3-6	Mix with Appalow or *Serala sericea lespedeza* or birdsfoot trefoil, or maintain with fertilizer.
Eastern gamagrass *Tripsacum dactyloides*	N	P	warm	5.0		Establish vegetatively. Clumps enlarge by short rhizomes. Use on moist sites. Native to most eastern states.
Oats *Avena sativa*	I	A	cool	4.5	30-50	Most often used as quick, temporary cover companion crop in spring seedings. Fall-seeded varieties also available.
Red fescue *Festuca rubra*	I	P	cool	4.5	4-6 8-10	Long lived in northern latitudes and high elevations. Fairly shade tolerant. Capable of making dense cover. Several varieties available.

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.

Forbs

Alfalfa

(Medicago sativa)

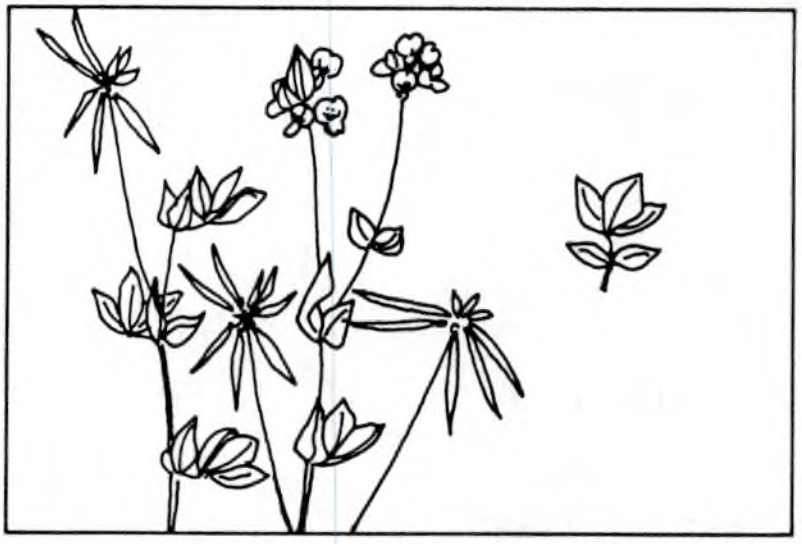


Type of plant: forb-legume
Origin: introduced
Life duration: perennial
Season of major growth: cool
Lower pH limit: 5.5
Planting materials: seed
Seeding rate: 4 to 12 lb/acre in mixture; 12 to 18 lb/acre alone
Time of seeding: spring; late summer
Superior cultivars: Ranger, Buffalo. Consult local agricultural agencies for recommendations
Rate of establishment: rapid to moderate
Major uses: forage; wildlife habitat; erosion control

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 mine soils do not require additions of lime or fertilizer. Not recommended for acid mine soils 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 bromegrass, 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.

Birdsfoot trefoil

(Lotus corniculatus)



Type of plant: forb-legume
Origin: introduced
Life duration: perennial
Season of major growth: cool
Lower pH limit: 4.5
Planting materials: seed
Seeding rate: 5 to 8 lb/acre in mixture; 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

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 that most legumes to excess manganese in mine soils. 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. *tenuifolium*) is a linear-leaved variant that has a more prostrate growth form than birdsfoot. Its performance is similar to birdsfoot on mine soils. 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.

Buckwheat

(Fagopyrum esculentum)

Common sunflower

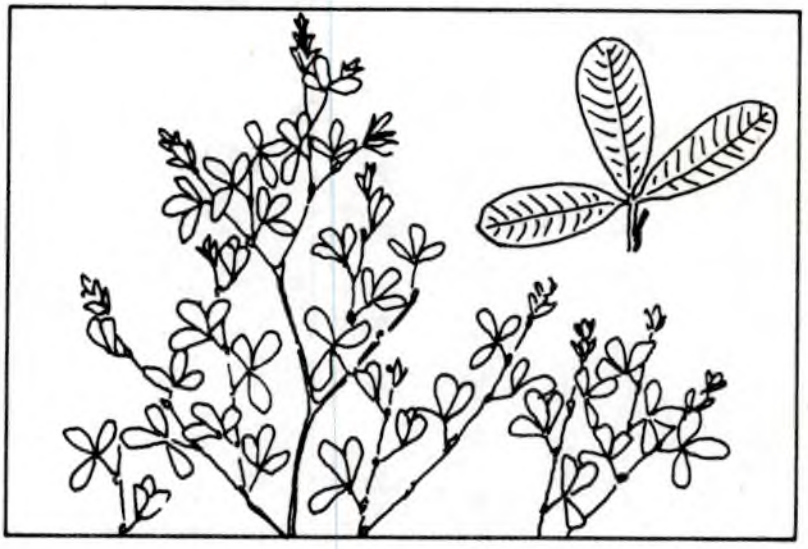
(Helianthus annuus)

Type of plant: forb-nonlegume
Origin: Buckwheat—introduced
Sunflower—native
Life duration: 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

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.

Common lespedeza

(Lespedeza striata)



Kobe lespedeza

(Lespedeza striata) var. Kobe

Type of plant: forb-legume
Origin: introduced
Life duration: annual
Season of major growth: warm
Lower pH limit: 4.5
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)

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.

Crownvetch

(Coronilla varia)

Type of plant: forb-legume
Origin: introduced
Life duration: 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

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 mine soils with pH 5.5 and higher, but some have been established at lower pHs. As stands develop, plants will spread to and grow on mine soils 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 duration: 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)

Flatpea is a long-lived viny species with tendril-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.

Japanese fleeceflower

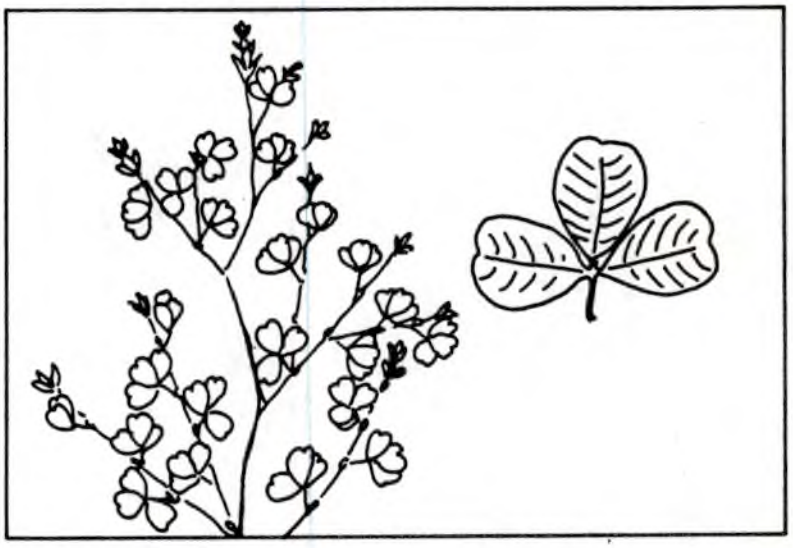
(Polygonum cuspidatum)

Type of plant: forb-nonlegume
Origin: introduced
Life duration: 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

This escaped ornamental, also called Japanese knotweed and Mexican bamboo, is a large, multi-stemmed, 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 mine soil. The accession 'Belmont' was collected from plants that reportedly were growing on mine soil 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.

Korean lespedeza

(Lespedeza stipulacea)

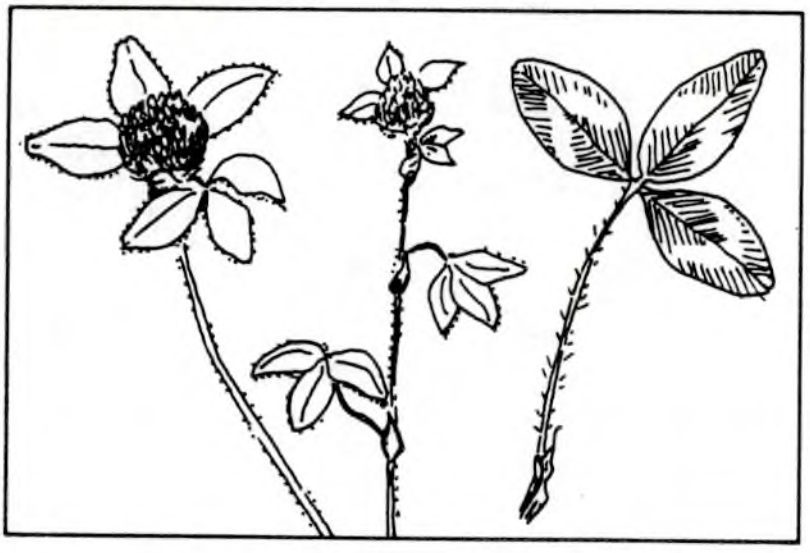


Type of plant: forb-legume
Origin: introduced
Life duration: annual
Season of major growth: warm
Lower pH limit: 5.0
Planting materials: seed
Seeding rate: 6 to 12 lb/acre in mixtures, 20 to 25 lb/acre alone
Time of seeding: spring
Superior cultivars: Climax (late maturing); Iowa 6 (early maturing, use 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)

Readily reseeds in adapted climatic range; thus it can be considered as a long-term component of vegetative cover. Provides early or quick legume component in spring sown grass-legume mixtures. Plant residue provides poor ground cover in winter. More sensitive than sericea and Kobe lespedeza to excess soil manganese. Seed of Korean is a preferred food by quail. Produces high-quality hay.

Red clover

(Trifolium pratense)

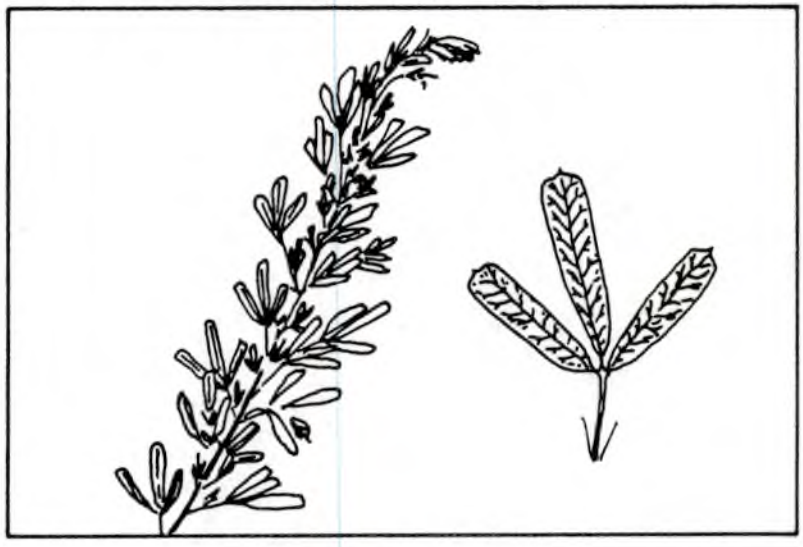


Type of plant: forb-legume
Origin: introduced
Life duration: biennial-perennial
Season for major growth: cool
Lower pH limit: 5.0
Planting materials: seed
Seeding rate: 4 to 8 lb/acre in mixtures; 8 to 12 lb/acre alone
Time of seeding: spring; late summer (southern U.S.)
Superior cultivars: Kenland; Pennscott
Rate of establishment: rapid
Major uses: erosion control (short-term cover); wildlife habitat; forage

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 mine soil 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.

Sericea lespedeza

(Lespedeza cuneata)

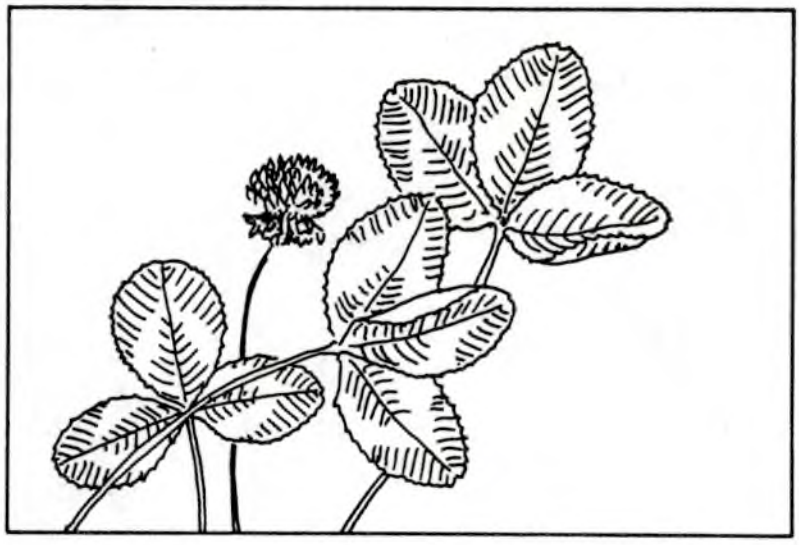


Type of plant: forb-legume
Origin: introduced
Life duration: perennial
Season of major growth: warm
Lower pH limit: 4.5
Elevation limit: not above 2,000 feet in northern West Virginia or 1,200 feet in Pennsylvania
Planting materials: seed
Seeding rate: hulled and scarified seed—10 to 20 lb/acre in mixtures; Increase rate by 10 to 15 1lb/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

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.

Ladino (White) clover

(Trifolium repens)

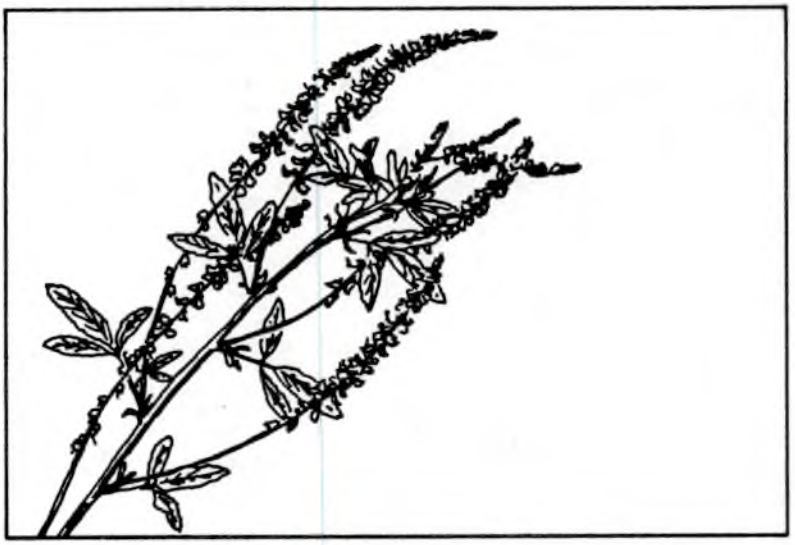


Type of plant: forb-legume
Origin: introduced
Life duration: perennial
Season of major growth: cool
Lower pH limit: 5.5
Planting materials: seed
Seeding rate: 2 to 4 lb/acre in mixtures
Time of seeding: spring; late summer
Superior cultivars: ladino
Rate of establishment: moderate to rapid
Major uses: wildlife habitat; forage

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.

White sweetclover

(Melilotus alba)



Yellow sweetclover

(Melilotus officinalis)

Type of plant: forb-legume
Origin: introduced
Life duration: 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)

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.

Table III-B
Forb Species of Limited Importance or Use

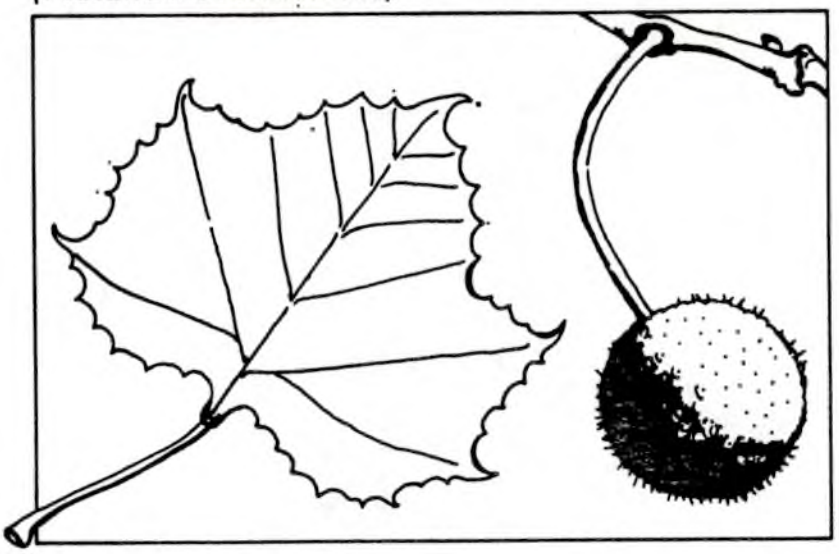
Common & scientific name	Origin	Life span	Growth season	Lower pH limit	Seeding rate (lb/acre) PLS	Comments
Alsike clover *Trifolium hybridum*	I[a]	P[b]	cool	5.0	3-5[c]	Adapted to wet soils and sites with overland flows. For wet sites mix with grass such as redtop and Ky-31 fescue. Provides food for wildlife.
Bigflower vetch *Vicia grandiflora*	I	A	cool	5.5	15-20	Winter annual. Can be seeded into existing stands of grass. Reseeds itself.
Cowpea *Vigna unguiculata*	I	A	warm	4.5	20-30	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 *in situ* mulch.
Hairy vetch *Vicia villosa*	I	A	cool	5.5	20-30 40-50	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.
Partridge pea *Cassia fasciculata*	N	A	warm	5.0	20-30	Reseeds, usually in sparse stands. Seed is eaten by game birds. Sow in mixtures. Native to most eastern states.
Soybean *Glycine max*	I	A	warm	5.0	30-50	For quick cover in early summer and for wildlife food. Provides little residue for winter cover. Sow with quick cover grasses such as sorghums for overwinter *in situ* mulch.

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.

Trees

American sycamore

(Platanus occidentalis)

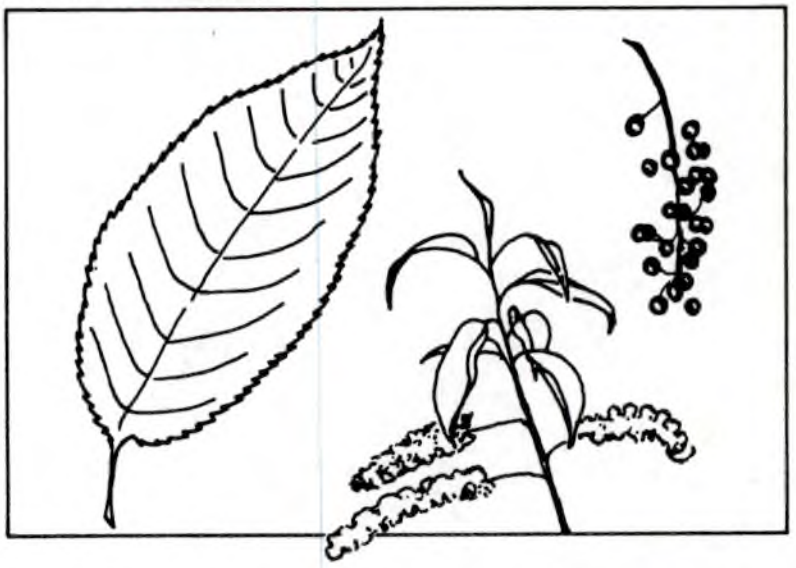


Type of plant: tree-hardwood
Size: large
Intolerant to shade
Origin: native
Lower pH limit: 4.0 to 4.5
Elevation limit: not above 2,500 feet
Planting materials: seedlings (1-0)
Major uses: forest products (pulp, lumber, veneer, mill work, furniture, and gunstocks)

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 by height and dbh were doubled when interplanted with European alder.

Black cherry

(Prunus serotina)

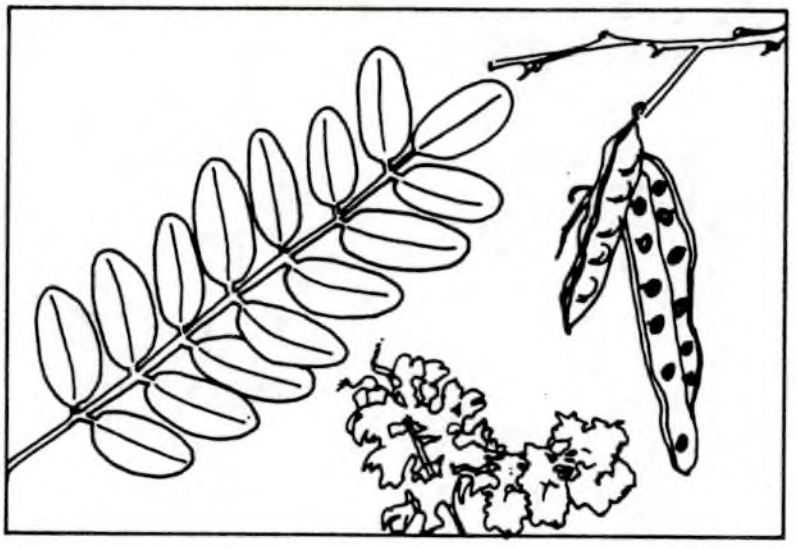


Type of plant: tree-hardwood
Size: medium
Intermediate tolerance to shade
Origin: native
Lower pH limit: 4.5
Planting materials: seedlings (1-0)
Major uses: forest products (furniture and veneer); wildlife food

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.

Black locust

(Robinia pseudoacacia)

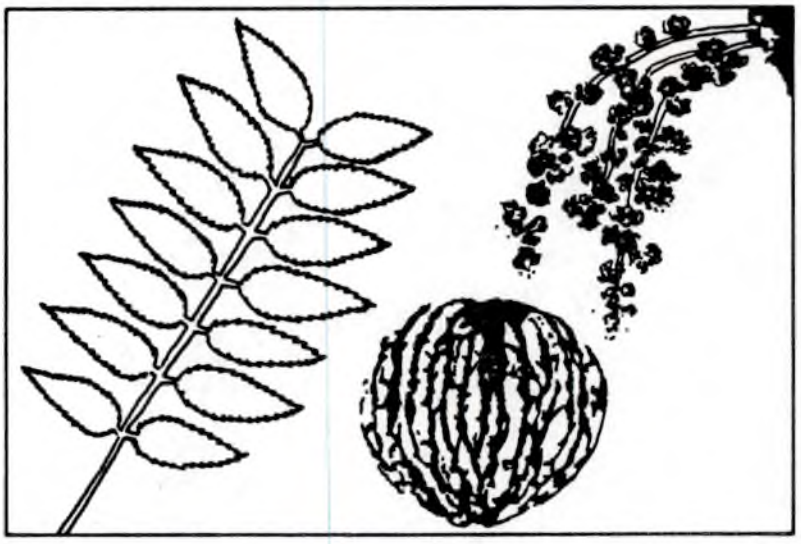


Type of plant: tree-hardwood (Nitrogen-fixer)
Size: medium
Intolerant to shade
Origin: native
Lower pH limit: 4.0
Elevation limit: not above 3,000 feet
Planting materials: seedlings (1-0), seed (scarified)
Seeding rate: 1 to 3 lb/acre (in mixture with herbaceous species)
Time of seeding: spring, fall, winter
Major uses: site improvement (nurse tree with hardwood); wildlife food and cover; fenceposts, fuel; watershed protection

Most frequently and widely used tree for surface-mine plantings, adapted to a wide range of mine soil 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.

Black walnut

(Juglans nigra)

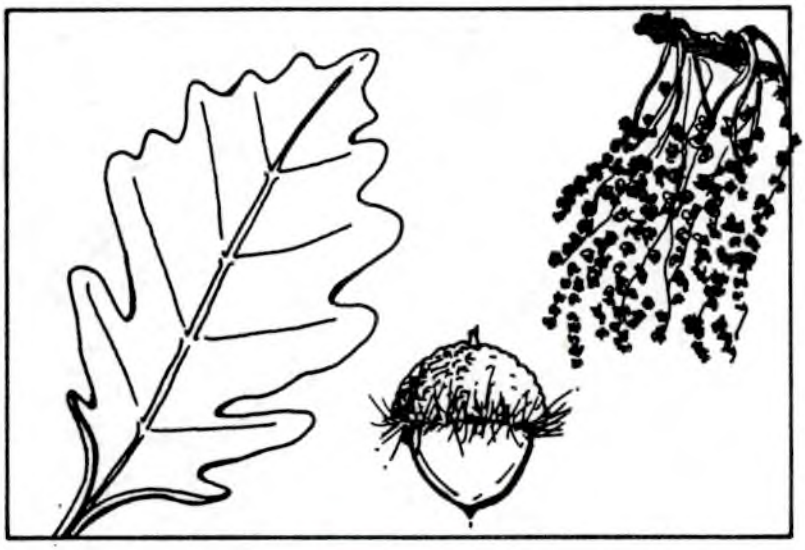


Type of plant: tree-hardwood
Size: large
Intolerant to shade
Origin: native
Lower pH limit: 5.5
Planting materials: seedlings (1-0); Seed (stratified for spring seeding)
Seeding rate: 2 or 3 seeds (nuts) per spot
Time of seeding: fall (unstratified seed), spring (stratified seed)
Major uses: forest products (veneer, furniture, gunstocks, novelties); wildlife food

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.

Bur oak

(Quercus macrocarpa)

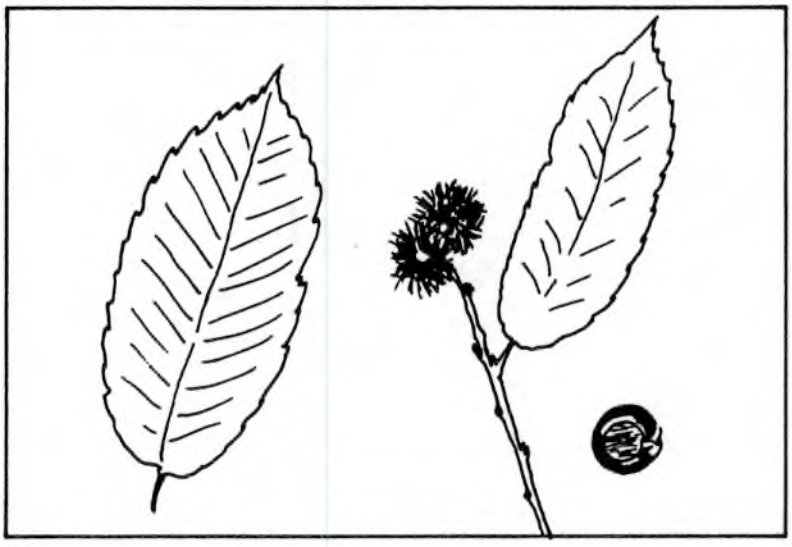


Type of plant: tree-hardwood
Size: large
Intermediate tolerance to shade
Origin: native
Lower pH limit: 4.0
Planting materials: seedlings (1-0, 2-0) Seed (acorns)
Seeding rate: 2 or 3 acorns per planting spot
Time of seeding: fall
Major uses: forest products (rough lumber, barrel staves, flooring, railroad ties, and pulp); wildlife food (acorns)

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 mine soil 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.

Chinese chestnut

(Castanea mollissima)



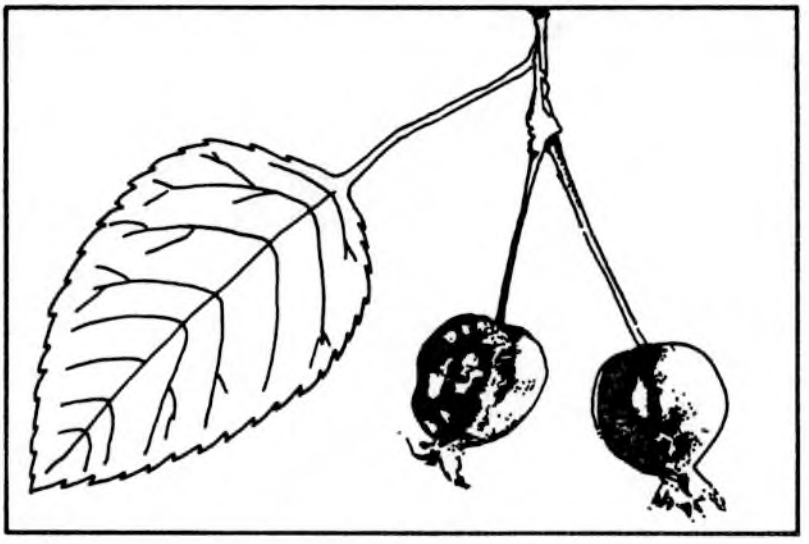
Type of plant: tree-hardwood
Size: medium
Intermediate tolerance to shade
Origin: introduced
Lower pH limit: 4.5
Planting materials: seedlings (1-0)
Major uses: wildlife food and cover

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 mine soil 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.

Crab apple

(Malus spp.*)*

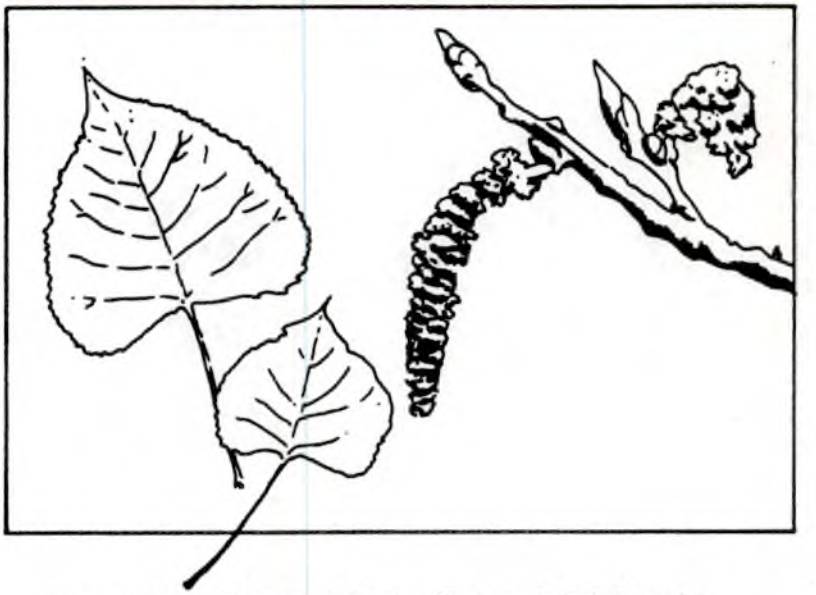


Type of plant: tree or shrub-
hardwood
Size: small
Intolerant to shade
Origin: introduced
Lower pH limit: 4.5
Major uses: wildlife food and cover; esthetics

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. Recommended 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.

Eastern cottonwood

(Populus deltoides)



Type of plant: tree-hardwood
Size: large
Intolerant to shade
Origin: native
Lower pH limit: 4.5
Elevation limit: not above 2,500 feet
Planting materials: seedlings (1-0); cuttings
Seedling spacing: 8 x 8 feet
Major uses: forest products (pulp, lumber, and veneer)

A rapid-growing tree that often establishes by natural seeding on barren mine soils, 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.

Eastern white pine

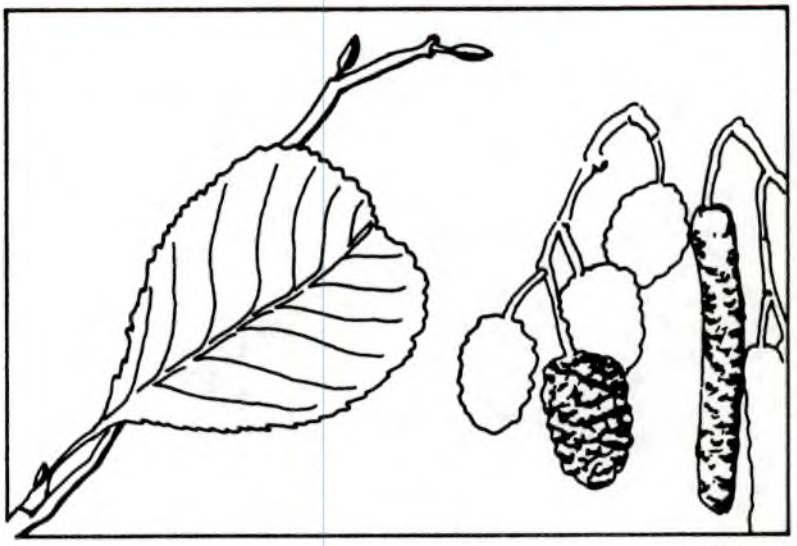
(Pinus strobus)

Type of plant: tree-conifer
Size: large
Tolerant to intermediate tolerance to shade
Origin: native
Lower pH limit: 4.0
Planting materials: seedlings (2-0, 3-0)
Major uses: esthetics and screening; forest products (Christmas trees, mill work); wildlife food and cover

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.

European black alder

(Alnus glutinosa)

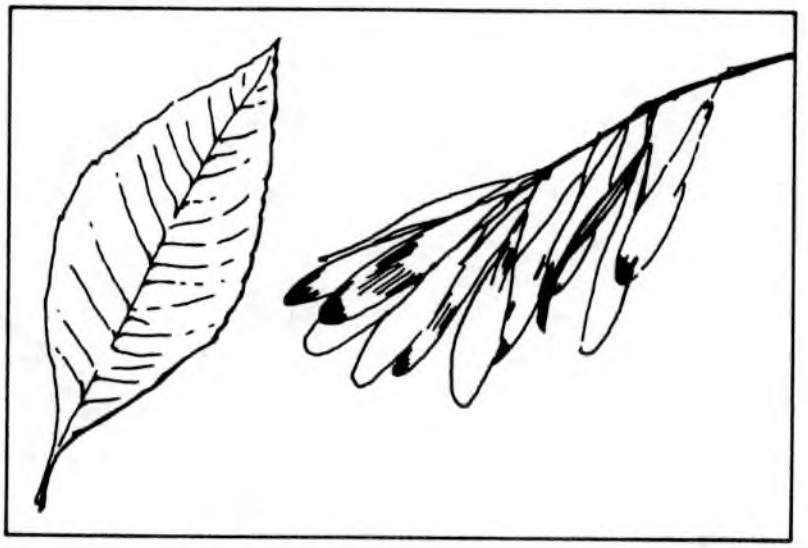


Type of plant: tree-hardwood
(Nitrogen-fixer)
Size: medium
Intolerant to shade
Origin: introduced
Lower pH limit: 3.5 to 4.0
Planting materials: seedlings (1-0)
Major uses: esthetics and screening; forestry (nurse tree, site improvement); watershed protection; wildlife cover and food; pulpwood

Adapted to a wide range of mine soil types. Good early survival and rapid growth in most areas. Especially valuable on extremely acid mine soils 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.

Green ash

(Fraxinus pennsylvanica)

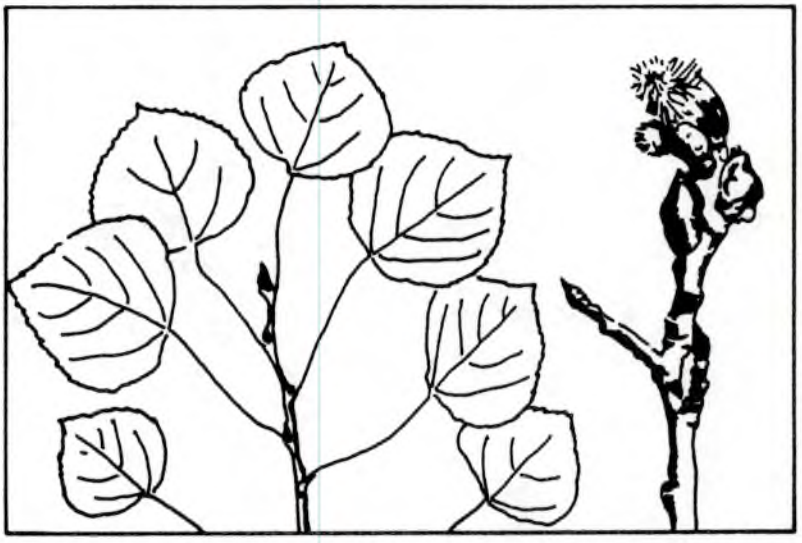


Type of plant: tree-hardwood
Size: medium
Intermediate tolerance to shade
Origin: native
Lower pH limit: 4.0
Elevation limit: not above 2,500 feet
Planting materials: seedlings (1-0)
Major uses: wildlife food and cover; forest products (pulp, tool handles, furniture, baseball bats, and tennis rackets)

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 mine soils 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.

Hybrid poplar

(*Populus* spp.)

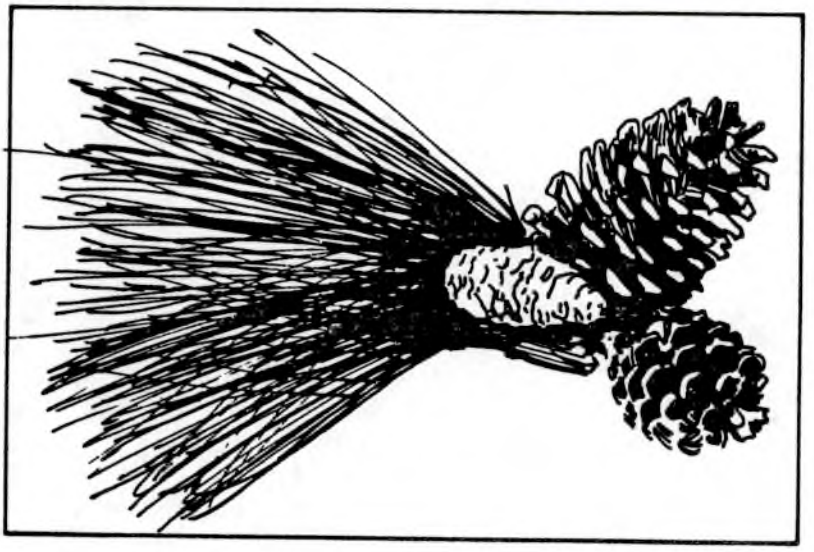


Type of plant: tree-hardwood
Size: medium
Intolerant to shade
Origin: crosses of several native and introduced species
Lower pH limit: 4.0 to 4.5
Planting materials: rooted cuttings; unrooted cuttings (8-10″ long)
Spacing: 8- x 8-foot minimum
Major uses: esthetics and screening; forest products (pulp, corestock, and crates)

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 to alternate rows with conifers (except larch).

Loblolly pine

(Pinus taeda)

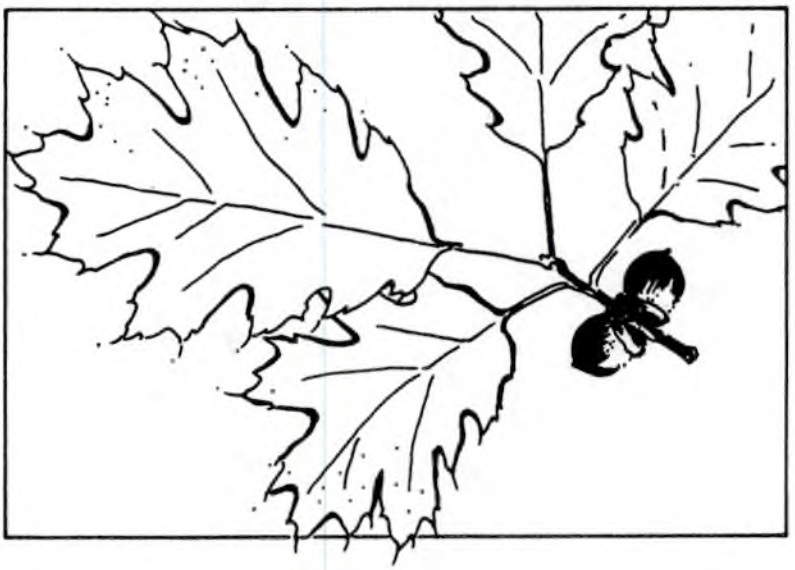


Type of plant: tree-conifer
Size: large
Intermediate tolerance to shade
Origin: native
Lower pH limit: 4.0
Elevation limit: not above 2,500feet
Planting materials: seedlings (1-0); Seed (stratified, bird and rodent repellent)
Seeding rate: 1 to 1-1/2 lb/acre
Time of seeding: spring (stratified seed); late fall-early winter (unstratified seed)
Major uses: forest products (pulp, poles, lumber); esthetics and screening; wildlife cover and food

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.

Northern red oak

(Quercus rubra)

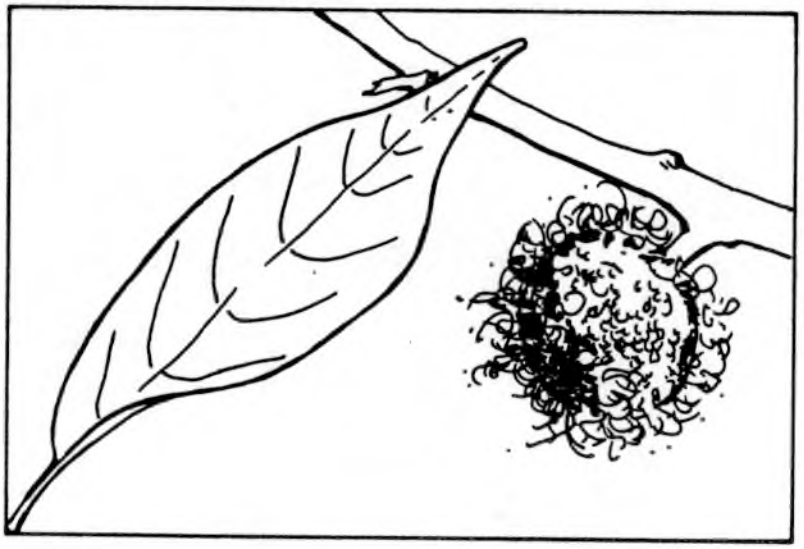


Type of plant: tree-hardwood
Size: large
Intermediate tolerance to shade
Origin: native
Lower pH limit: 4.0
Planting materials: seedlings (1-0)
Major uses: forest products (sawtimber veneer, furniture, paneling, flooring, and pulp); wildlife food and cover

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 minesoils with high percentages 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 in Ohio produced poor results.

Osage-orange

(Maclura pomifera)



Type of plant: tree-hardwood
Size: small
Intermediate tolerance to shade
Origin: native
Lower pH limit: 4.5
Planting materials: seedlings (1-0)
Major uses: wildlife food and cover; hedgerows and screening; forest products (posts)

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 mine soils. 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.

Pitch pine

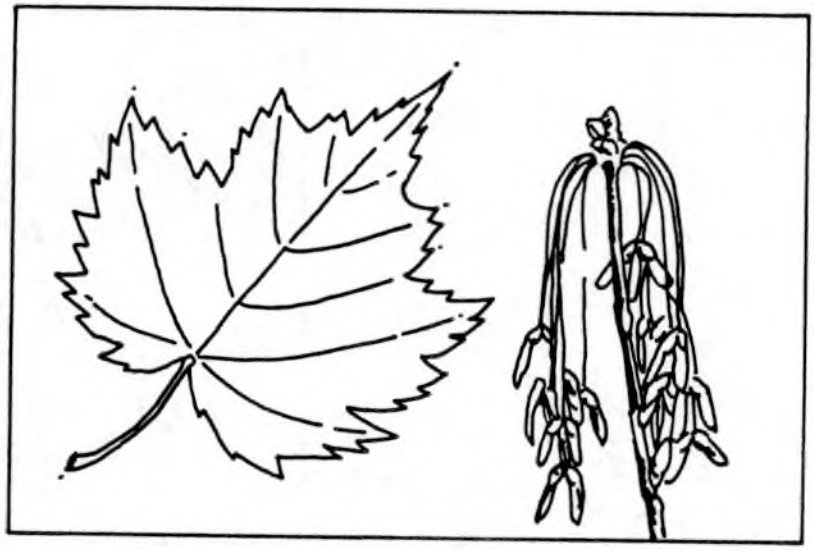
(Pinus rigida)

Type of plant: tree-conifer
Size: medium
Intolerant to shade
Origin: native
Lower pH limit: 4.0
Elevation limit: not above 3,000 feet
Planting materials: seedlings (1-0)
Major uses: esthetics and screening; wildlife cover and food; forest products (pulp, structural timber, lumber, and millwork)

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.

Red maple

(Acer rubrum)

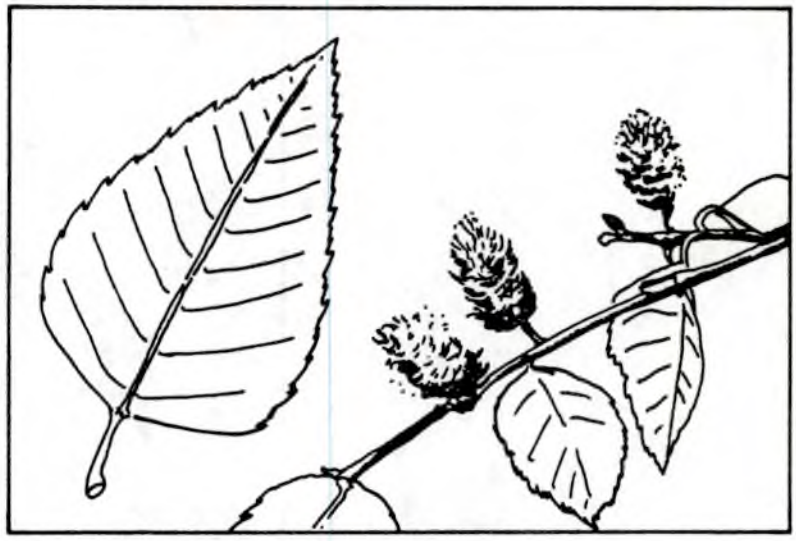


Type of plant: tree-hardwood
Size: medium
Intermediate tolerance to shade
Origin: native
Lower pH limit: 4.5
Planting materials: seedlings (1-0)
Major uses: forest products (pulp, core stock, veneer, crates, and planning-mill products); wildlife food

A fairly fast-growing, short-lived tree. Adapted to a range of mine soil conditions-from quite wet to dry sites, both fine- and course-textured mine soils, 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.

River birch

(Betula nigra)

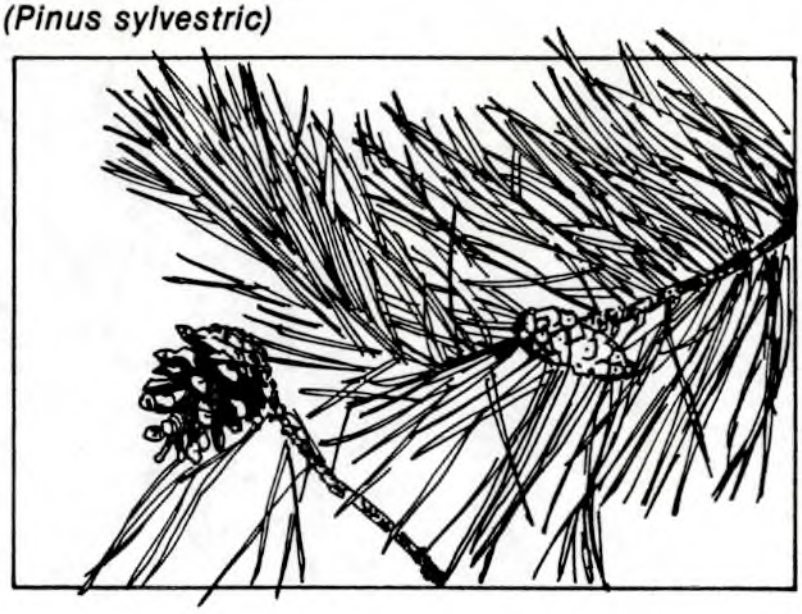


Type of plant: tree-hardwood
Size: medium
Intolerance to shade
Origin: native
Lower pH limit: 4.0
Elevation limit: not above 2,000 feet
Planting materials: seedlings (1-0)
Major uses: esthetics and screening; wildlife food and cover; forest products (furniture, cabinets, crates)

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.

Scotch pine

(Pinus sylvestric)

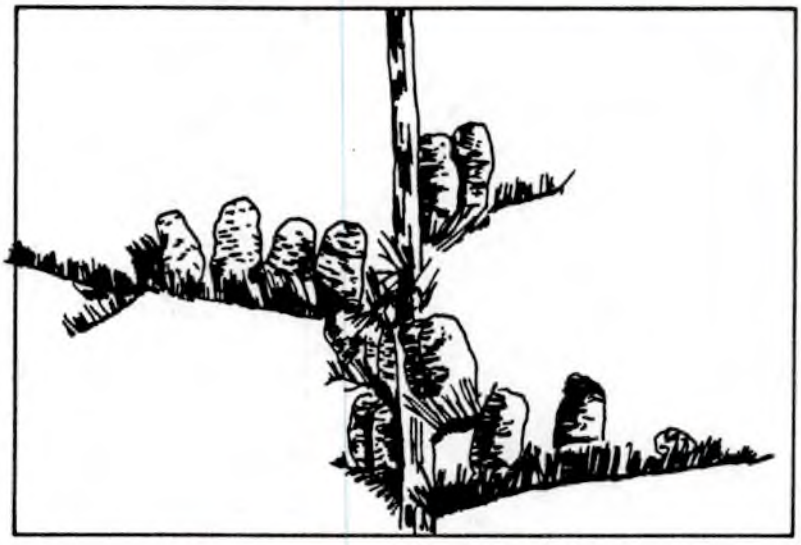


Type of plant: tree-conifer
Size: medium
Intolerant to shade
Origin: introduced
Lower pH limit: 4.0
Planting materials: seedlings (2-0, 3-0)
Seedling spacing: 5 x 5 feet or 6 x 6 feet (for Christmas trees)
Major uses: Christmas trees; esthetics and screening; wildlife cover and food

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.

Shortleaf pine

(Pinus echinata)

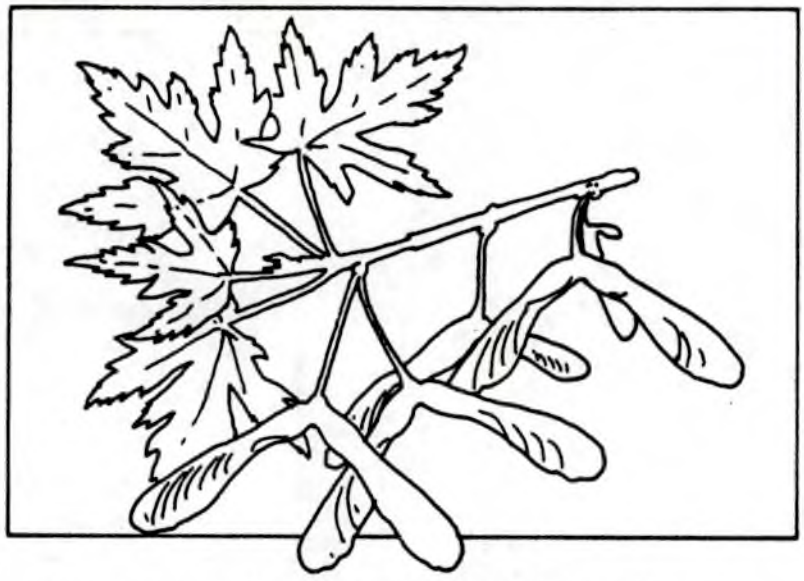


Type of plant: tree-conifer
Size: medium
Intermediate tolerance to shade
Origin: native
Lower pH limit: 4.5
Elevation limit: not above 2,500 feet
Planting materials: seedlings (1-0, 2-0), Seed (stratified, insect and rodent repellent)
Seeding rate: 1/2 to 1 lb/acre
Time of seeding: spring (stratified seed), late fall-early winter (unstratified seed)
Major uses: forest products (pulp, poles, mine timbers, building materials); wildlife cover and food; esthetics and screening

Best performance of this southern pine is mainly within its natural range. Adapted to a wide variety of mine sites, but not in mine soils 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.

Silver maple

(Acer saccharinum)

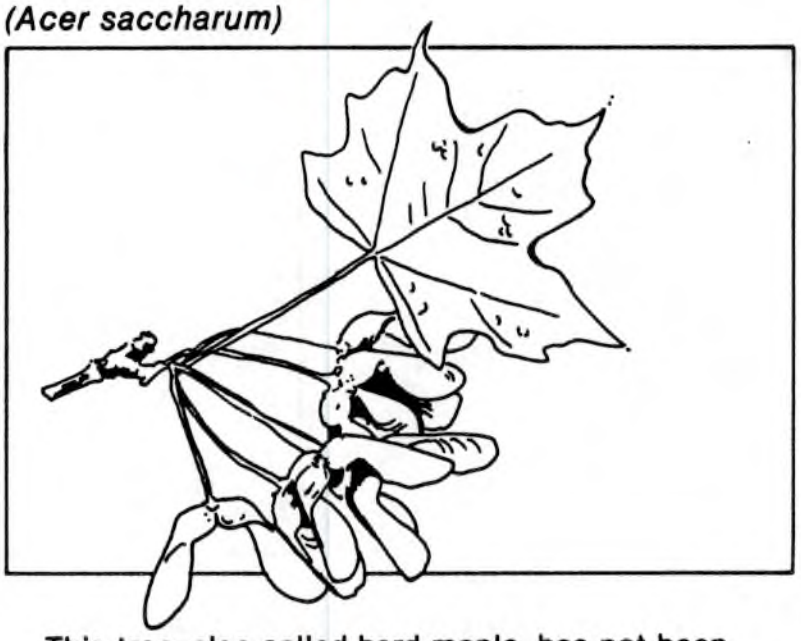


Type of plant: tree-hardwood
Size: medium to large
Intermediate tolerance to shade
Origin: native
Lower pH limit: 4.0
Elevation limit: not above 2,500 feet
Planting materials: seedlings (1-0)
Major uses: forest products (fuel, pulp, corestock, veneer, crates, and planning-mill products); wildlife food

Grows on most mine soil 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.

Sugar maple

(Acer saccharum)

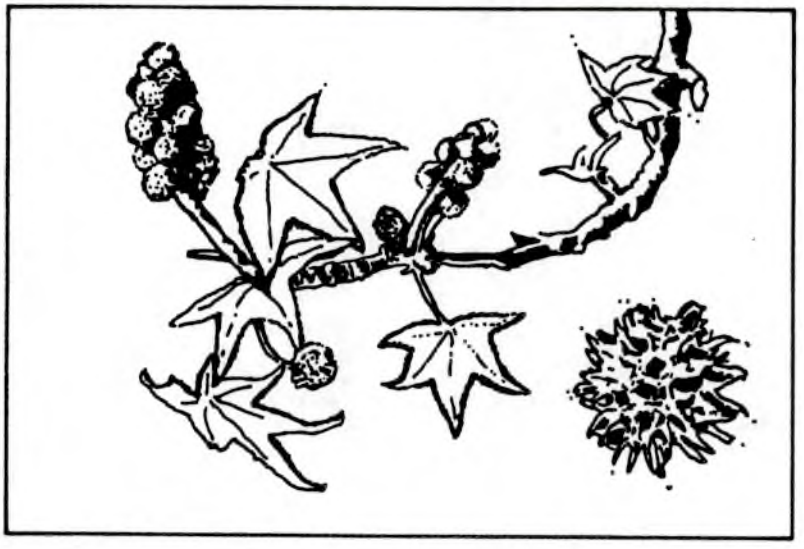


Type of plant: tree-hardwood
Size: medium
Tolerant to shade
Origin: native
Lower pH limit: 4.5
Planting materials: seedlings (1-0, 2-0)
Major uses: forest products (furniture, veneer, gunstocks, and cabinet work); wildlife food and cover

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 mine soils 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.

Sweetgum

(Liquidambar styraciflua)

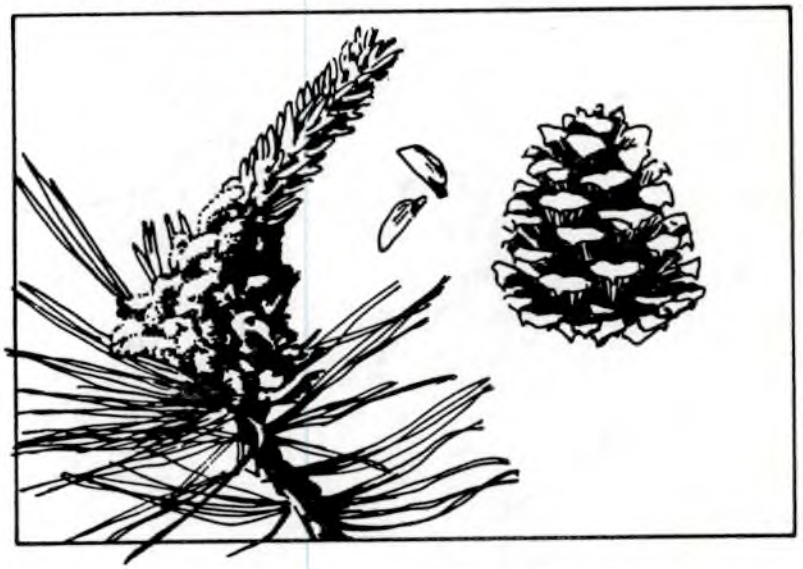


Type of plant: tree-hardwood
Size: large
Intolerant to shade
Origin: native
Lower pH limit: 4.0
Elevation limit: below 2,500 feet
Planting materials: seedlings (1-0)
Major uses: forest products; (pulp, veneer, plywood, interior parts of furniture, lumber); wildlife food and cover

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.

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
Planting materials: 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-every winter (unstratified seed)
Major uses: esthetics and screening; wildlife cover and food; forest products (pulp); Christmas trees

Virginia pine is the most widely planted conifer on mine soils, especially in the Appalachian region. It is adapted to a wide range of mine soil types and is especially useful for vegetating acid and droughty sites. Within its natural range this pine often is a pioneer species on mine soils 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 seedlings. 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.

White ash

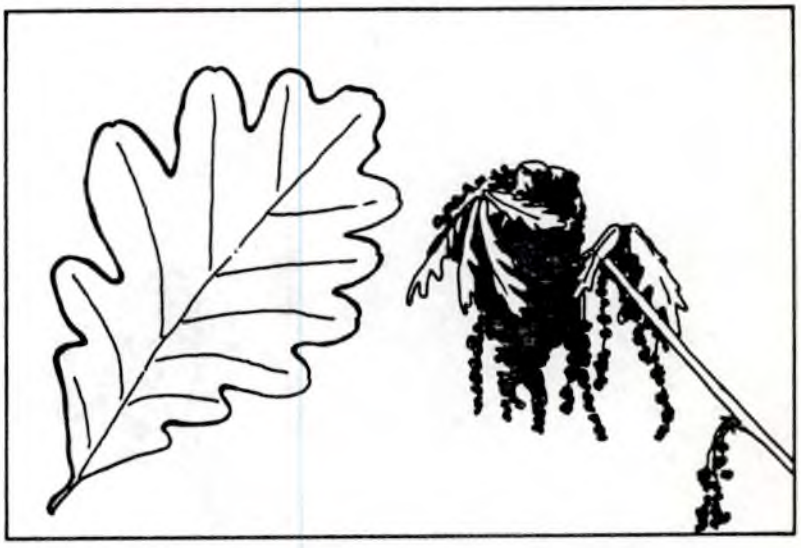
(Fraxinus americana)

Type of plant: tree-hardwood
Size: large
Intermediate tolerance to shade
Origin: native
Lower pH limit: 4.0
Elevation limit: not above 3,000 feet
Planting materials: seedlings (1-0)
Major uses: forest products (pulp, tool handles, furniture, veneer, baseball bats, and tennis rackets); wildlife food and cover

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 as is a valuable forest species. The trunk usually is long, straight, clear and cylindrical. White ash grades much higher than green ash.

White oak

(Quercus alba)

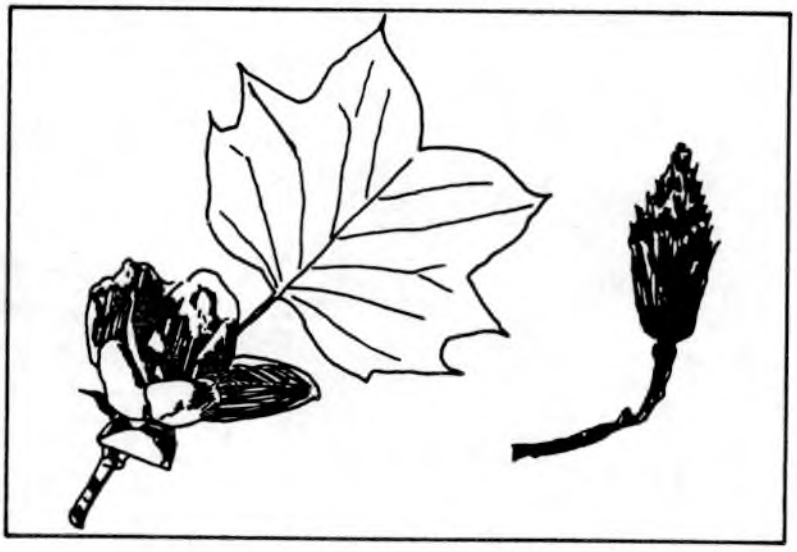


Type of plant: tree-hardwood
Size: large
Intermediate tolerance to shade
Origin: native
Lower pH limit: 5.0
Planting materials: seedlings (1-0)
Major uses: forest products (flooring, cooperage, and furniture); wildlife food

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 success and high value of this species warrant further testing. Seedlings and saplings will persist for many years where overtopped by faster growing trees.

Yellow-poplar

(Liriodendron tulipifera)



Type of plant: tree-hardwood
Size: large
Intolerant to shade
Origin: native
Lower pH limit: 4.5
Elevation limit: not above 3,000 feet
Planting materials: seedlings (1-0)
Major uses: forest products (pulp, lumber, veneer, plywood, furniture mill work); wildlife food and cover

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 mixture 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.

Table III-C
Tree Species of Limited Importance or Use

Common & scientific name	Origin	Tolerance	Lower pH limit	Major uses	Comments
Conifers					
Baldcypress *Taxodium distichum*	N[a]	M[b]	5.0	F, H[c]	Deciduous. Used on poorly to well-drained sites. Often planted near lakes and wet sites.
Hardwoods					
Chestnut oak *Quercus prinus*	N	M	4.5	F, H	Similar site requirements as white oak.
Flowering dogwood *Cornus florida*	N	T	4.5	H, E	Fruit and browse for wildlife. Survival often quite low. Natural seedings sometimes found in established woody vegetation.
Pin oak *Quercus palustris*	N	I	4.0	H, F, E	Use below 1,500 feet. Volunteers on older forested sites.
Royal paulownia *Paulownia tomentosa*	I	M	4.5	F, E	A rapid growing tree with high market value for export to Japan. Has escaped from cultivation but difficult to seed artificially. Nursery seedlings and plantation programs available from American Paulownia Corporation.
Russian olive *Elaeagnus angustifolia*	I	M	5.5	H, E	Small tree or large shrub. Much used for shelterbelts in Midwest.
Sweet birch *Betula lenta*	N	I	4.0	H, F	Value to wildlife greatest in northern Appalachians.

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;

Shrubs

Amur honeysuckle

(Lonicera maackii)

Morrow

(Lonicera morrowii)

Tatarian

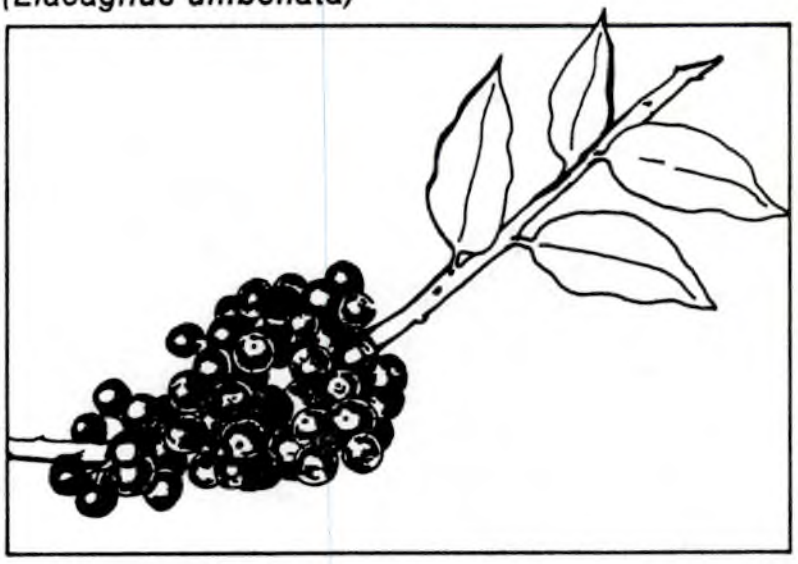
(Lonicera tatarica)

Type of plant: shrub
Intermediate tolerance to shade
Origin: introduced
Lower pH limit: 5.0
Planting materials: Seedlings (1-0, 2-0)
Superior cultivars: 'Rem Red' and 'Cling red' Amur honeysuckle
Major uses: wildlife food and cover; esthetics and screening

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 in 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.

Autumn olive

(Elaeagnus umbellata)

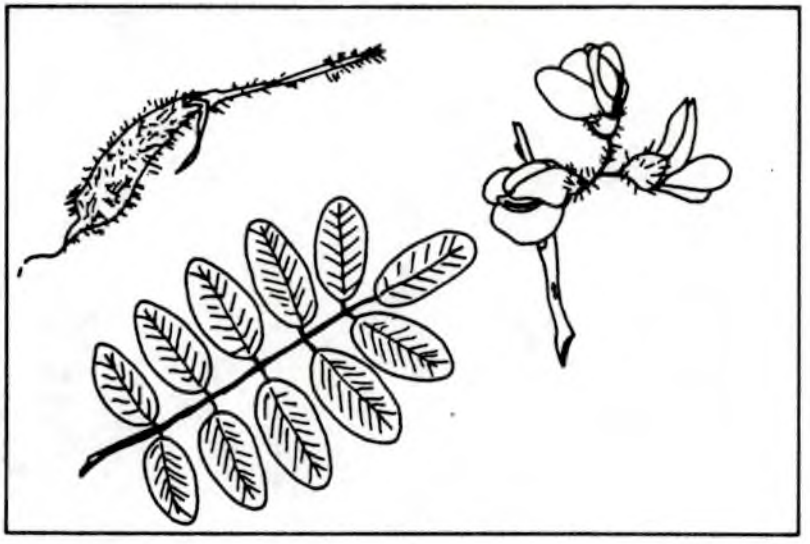


Type of plant: shrub
(Nitrogen-fixer)
Intermediate tolerance to shade
Origin: introduced
Lower pH limit: 4.0
Planting materials: seedlings (1-0)
Superior cultivars: 'Cardinal', 'Elsberry'
Major uses: wildlife food and cover; watershed protection; esthetics and screening

This nonleguminous nitrogen-fixing species is adapted in all of the eastern coal regions. It is easily established on a wide range of mine soil types and conditions. Initial survival and growth usually is good even where planted in 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.

Bristly locust

(Robinia fertilis)

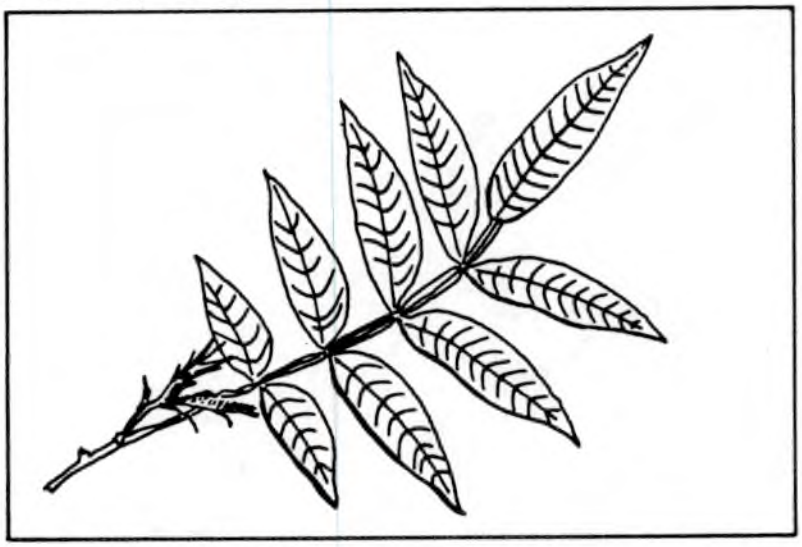


Type of plant: shrub-legume (Nitrogen-fixer) Intolerant to shade
Origin: native
Lower pH limit: 3.5
Planting materials: seedlings (1-0), Seed (scarified, special inoculum)
Seeding rate: 2 to 5 lb/acre
Time of seeding: spring, fall, winter
Superior cultivars: 'Arnot'
Major uses: erosion control; wildlife cover and food

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.

Shining sumac

(Rhus copallina)



Fragrant sumac

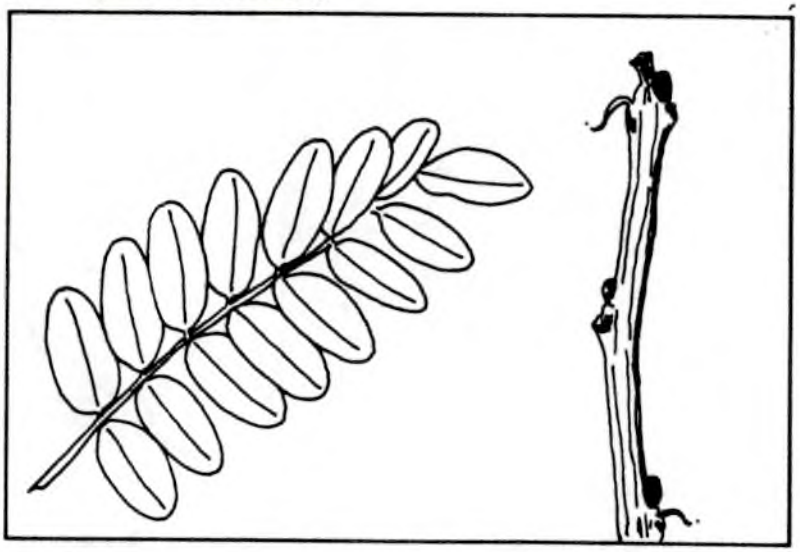
(Rhus aromatica)

Type of plant: shrub
Shade tolerance:
Shining—intermediate
Fragrant—tolerant
Origin: native
Lower pH limit: shining—4.0
fragrant—4.5
Planting materials: seedlings (1-0, 2-0); root cuttings
Major uses: wildlife food and cover; esthetics

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 mine soils 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 have not been 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.

Indigobush

(Amorpha fruiticosa)

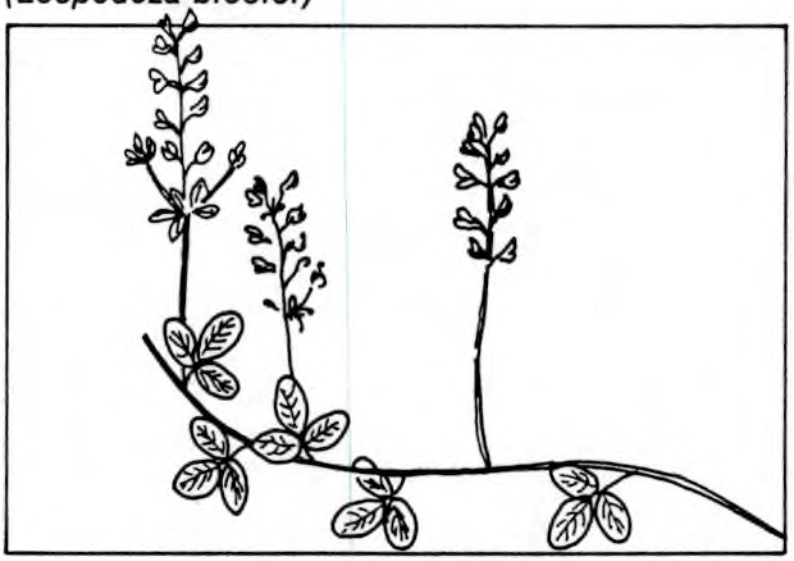


Type of plant: shrub-legume (Nitrogen-fixer) Intermediate tolerance to shade
Origin: native
Lower pH limit: 4.0
Planting materials: seedlings (1-0); seed (special inoculum)
Seeding rate: 1/2 to 1 lb/acre (seed in pods)
Time of seeding: spring, fall, winter
Major uses: wildlife food and cover; watershed protection

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 mine soils. 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.

Shrub lespedeza

(Lespedeza bicolor)



Japan

(Lespedeza japonica)

Thunberg

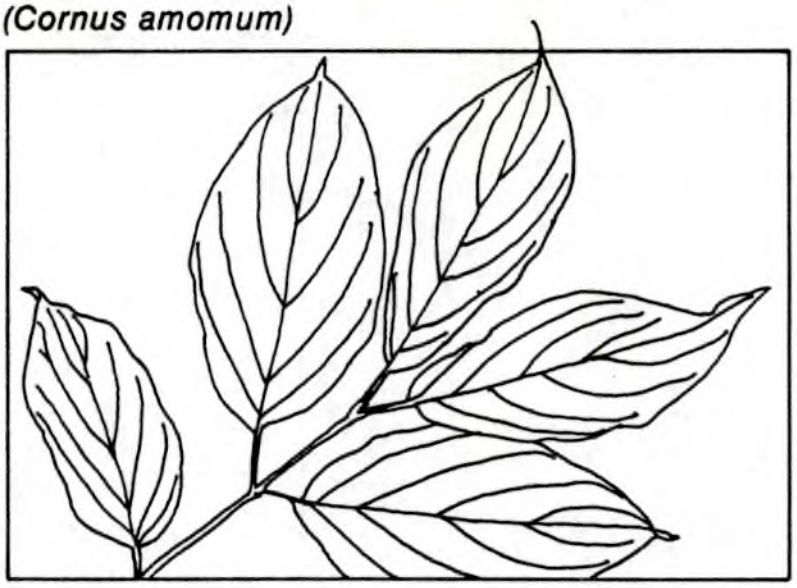
(Lespedeza thunbergii)

Type of plant: shrub-legume (Nitrogen-fixer) Intolerant to shade
Origin: introduced
Lower pH limit: 4.5
Elevation limit: not above 2,500 feet
Planting materials: seedlings (1-0); seed (scarified)
Seeding rate: 1 to 3 lb/acre
Time of seeding: spring, late winter
Superior cultivars: 'Natob' bicolor
Major uses: wildlife food and cover; esthetics and screening

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.

Silky dogwood

(Cornus amomum)



Type of plant: shrub
Tolerant to shade
Origin: native
Lower pH limit: 4.0
Planting materials: seedlings (1-0)
Major uses: wildlife food and cover

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.

Table III-D
Shrub Species of Limited Importance or Use

Common & scientific name	Origin	Lower pH limit	Major uses	Comments
American elder *Sambucus canadensis*	N[a]	5.0	H, E[b]	Excellent food and cover plant for wildlife, especially songbirds. Establish with 1-0 seedlings.
Amur privet *Ligustrum amurense*	I	4.5	H, E	Naturalized in southeastern United States. Medium-size shrub. Field plant 1-0 or 2-0 seedlings. Tolerant.
Arrowwood *Viburnum dentatum*	N	4.5	H, E	Field plant 1-0 or 2-0 seedlings. Also propagated by cuttings or layering. Tolerant. Other species of *Viburnum* may be useful.
Chokecherry *Prunus virginiana*	N	5.0	H	Tall shrub, 8-18 feet, widely adaptable. Excellent food and cover plant for wildlife. Spreads from root sprouts. Easily established from 1-0 seedlings.
Gray dogwood *Cornus racemosa*	N	5.0	H, E	Similar to silky dogwood. Produces fruit in 4 to 5 years. Intermediate shade tolerance.
Hawthorn *Crateagus* spp.	N	5.5	H, E	Tall shrubs; there are many hybrids and varieties. Washington hawthorn *(C. phaenopyrum)* is the most widely used and available. Field plant 1-0 seedlings. Intolerant.
Japanese honeysuckle *Lonicera japonica*	I	4.5	H	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.

Shrub Species of Limited Importance or Use (continued)

Common & scientific name	Origin	Lower pH limit	Major uses	Comments
Korean barberry *Berberis koreana*	I	4.0	H, E	Small shrub. Field plant 2-0 seedlings.
Memorial rose *Rosa wichuraiana*	I	5.5	H, W	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.
Multiflora rose *Rosa multiflora*	I	5.0	H, W	Has become "pest" plant in many agricultural areas and now is seldom planted. An excellent food for providing food and cover for game birds and small mammals.
Purpleosier willow *Salix purpurea*	I	5.0	H	Useful along ponds, seepage areas. Grows best in pH range 5.0 to 6.0.
Red-osier dogwood *Cornus stolonifera*	N	4.5	H, W, E	Suited for seepage areas and along ponds. Spreads by underground shoots. Dense root system protection against overland flow.
Rose-acacia locust *Robinia hispida*	N	3.5-4.0	W, H, E	Similar to bristly locust *(R. fertilis)*. Plant 1-0 seedings or seed. Intolerant.

a] I = introduced; N = native

b] H = habitat (food and cover) for wildlife; E = esthetics and screening; W = watershed protection (erosion control)

Appendix

Miscellaneous Tables

What follows is a collection of tables which may be of some value to the revegetation of mined lands.

Table IV-A
Pounds of Grass Seed Material Required to Yield One Pound of Pure Live Seed

% Purity	Percent Germination												
	100	95	90	85	80	75	70	65	60	55	50	45	40
100	1.0	1.1	1.2	1.2	1.3	1.4	1.5	1.6	1.7	1.9	2.0	2.3	2.5
95	1.1	1.2	1.2	1.3	1.4	1.5	1.6	1.7	1.8	2.0	2.2	2.4	2.7
90	1.2	1.2	1.3	1.4	1.4	1.5	1.6	1.8	1.9	2.1	2.3	2.5	2.8
85	1.2	1.3	1.4	1.4	1.5	1.6	1.7	1.9	2.0	2.2	2.4	2.7	3.0
80	1.3	1.4	1.4	1.5	1.6	1.7	1.8	2.0	2.1	2.3	2.5	2.8	3.2
75	1.4	1.5	1.5	1.6	1.7	1.8	2.0	2.1	2.3	2.5	2.7	3.0	3.4
70	1.5	1.6	1.6	1.7	1.8	2.0	2.1	2.2	2.4	2.6	2.9	3.2	3.6
65	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.4	2.6	2.8	3.1	3.5	3.9
60	1.7	1.8	1.9	2.0	2.1	2.2	2.4	2.6	2.8	3.1	3.4	3.8	4.2
55	1.9	2.0	2.1	2.2	2.3	2.5	2.6	2.8	3.1	3.4	3.7	4.1	4.6
50	2.0	2.2	2.3	2.4	2.5	2.7	2.9	3.1	3.4	3.7	4.0	4.5	5.0
45	2.3	2.4	2.5	2.7	2.8	3.0	3.2	3.5	3.8	4.1	4.5	5.0	5.6
40	2.5	2.7	2.8	3.0	3.2	3.4	3.6	3.9	4.2	4.6	5.0	5.6	6.3
35	2.9	3.1	3.2	3.4	3.6	3.9	4.1	4.4	4.8	5.7	5.8	6.4	7.2
30	3.4	3.6	3.8	4.0	4.2	4.5	4.8	5.2	5.6	6.1	6.7	7.5	8.4
25	4.0	4.3	4.5	4.8	5.0	5.4	5.8	6.2	6.7	7.3	8.0	8.9	10.0
20	5.0	5.3	5.6	5.9	6.3	6.7	7.2	7.7	8.4	9.1	10.0	11.2	12.5
15	6.7	7.1	7.5	7.9	8.4	8.9	9.6	10.3	11.2	12.2	13.4	14.9	16.7
10	10.0	10.6	11.2	11.8	12.5	13.4	14.3	15.4	16.7	18.2	20.0	22.3	25.0

Table IV-B
Area of Large Circles with Equivalent Square Dimensions

Area in Acres	Square dimension/feet	Radius of circle/feet	Radius of circle/chains
1/1,000	6′7.2″	3′8.7″	0.056
1/100	20′10.5″	11′9.3″	0.18
1/20	46′8.0″	26′4.0″	0.40
1/10	66′0″	37′2.8″	0.56
1/5	93′4.1″	52′7.9″	0.80
1/4	104′4.3″	58′10.5″	0.89
1	208′8.5″	117′9.0″	1.78

Table IV-C
Map Scales and Equivalents

Fractional scale	Inches per mile	Acres per square inch	Dot grid factor*
1: 7,920	8.00	10.000	0.156
1: 9,600	6.60	14.692	0.230
1: 15,840	4.00	40.000	0.625
1: 20,000	3.168	63.769	0.996
1: 24,000	2.64	91.82	1.43
1: 31,680	2.00	160.000	2.500
1: 63,360	1.00	640.000	10.000
1:125,000	0.507	2,490.980	38.922
1:250,000	0.253	9,963.906	155.686
1:500,000	0.127	39,855.627	622.744

**Multiply by converting factor to get total acreage using Modified Acreage Grid (64 dots per square inch).*

List of Plant Species for Revegetating Coal Surface Mined Lands in Kentucky

Common Name	Scientific Name and Authority #	Table
Grasses		
*Annual ryegrass	*Lolium multiflorum* Lam.	
*Bermudagrass	*Cynodon dactylon* (L.) Pers.	
*Big bluestem & Little bluestem	*Andropogon gerardi* Vitm. *Schizachyrium scoparium* (Michx.) Nash	
Broomcorn millet	*Panicum miliaceum* L.	III-A
Caucasian bluestem	*Bothriochloa caucasica* (Trin.) C. E. Hubb.	III-A
*Deertongue	*Panicum clandestinum* L.	
Eastern gamagrass	*Tripsacum dactyloides* (L.) L.	III-A
*Foxtail millet	*Setaria italica* (L.) Beauv.	
*Indiangrass	*Sorghastrum nutans* (L.) Nash	
Oats	*Avena sativa* L.	III-A
*Orchardgrass	*Dactylis glomerata* L.	
*Pearl millet	*Pennisetum americanum* (L.) Leeke	
*Perennial ryegrass	*Lolium perenne* L.	
Red fescue	*Festuca rubra* L. (Eastern Kentucky only)	III-A
*Redtop	*Agrostis gigantea* Roth	
*Reed canarygrass	*Phalaris arundinacea* L.	
*Rye	*Secale cereale* L.	
*Sorghum	*Sorghum bicolor* (L.) Moench	
*Sudangrass	*Sorghum sudanense* (Piper) Stapf	
*Switchgrass	*Panicum virgatum* L.	
*Tall fescue 'Kentucky-31'	*Festuca arundinacea* Schreb., selection Ky-31	
*Timothy	*Phleum pratense* L.	
*Weeping lovegrass	*Eragrostis curvula* (Schrad.) Nees	
*Winter wheat	*Triticum aestivum* L.	
Forbs-legumes		
*Alfalfa	*Medicago sativa* L.	
Alsike clover	*Trifolium hybridum* L.	III-B
Bigflower vetch	*Vicia grandiflora* Scop.	III-B
*Birdsfoot trefoil	*Lotus corniculatus* L.	
*Common lespedeza	*Lespedeza striata* (Thunb. ex Murr.) Hook. & Arn.	
Cowpea, Black-eyed pea	*Vigna unguiculata* (L.) Walp. subsp.	III-B
*Crownvetch	*Coronilla varia* L.	
*Flatpea	*Lathyrus sylvestris* L.	
Hairy vetch	*Vicia villosa* Roth	III-B
*Kobe lespedeza	*Lespedeza striata* var. Kobe	
*Korean lespedeza	*Lespedeza stipulacea* Maxim.	
*Ladino clover	*Trifolium repens* L.	

Common Name	Scientific Name and Authority #	Table
Partridge pea	*Cassia fasciculata* Michx.	III-B
*Red clover	*Trifolium pratense* L.	
*Sericea lespedeza	*Lespedeza cuneata* (Dum.) G. Don	
Soybean	*Glycine max* (L.) Merr.	III-B
*White clover	*Trifolium repens* L.	
*White sweetclover	*Melilotus alba* Medik.	
*Yellow sweetclover	*Melilotus officinalis* Lam.	
Forbs-Non legumes		
*Buckwheat	*Fagopyrum esculentum* Moench	
*Common sunflower	*Helianthus annuus* L.	
*Japanese fleeceflower	*Polygonum cuspidatum* Sieb. & Zucc.	
Trees-Conifers		
*Austrian pine	*Pinus nigra* Arnold (Eastern Kentucky only)	
Baldcypress	*Taxodium distichum* (L.) L. Rich	III-C
*Eastern white pine	*Pinus strobus* L.	
*Loblolly pine	*Pinus taeda* L.	
*Pitch pine	*Pinus rigida* Mill	
Pitch x loblolly hybrid	*Pinus rigida* x *P. taeda* P. *xrigitaeda*	
*Scotch pine	*Pinus sylvestris* L.	III-C
*Shortleaf pine	*Pinus echinata* Mill.	
*Virginia pine	*Pinus virginiana* Mill.	
Trees-Hardwoods		
*American sycamore	*Platanus occidentalis* L.	
*Black cherry	*Prunus serotina* Ehrh (Eastern Kentucky only)	
*Black locust	*Robinia pseudoacacia* L.	
*Black walnut	*Juglans nigra* L.	
*Bur oak	*Quercus macrocarpa* Michx. (Eastern Kentucky only)	
Chestnut Oak	*Quercus prinus* L.	III-C
*Chinese chestnut	*Castanea mollissima* Blume	
*Crab apple	*Malus* Mill. spp. (Eastern Kentucky only)	
*Eastern cottonwood	*Populus deltoides* Bartr. ex Marsh.	
*European black alder	*Alnus glutinosa* (L.) Gaertn.	
Flowering dogwood	*Cornus florida* L.	III-C
*Green ash	*Fraxinus pennsylvanica* Marsh.	
*Hybrid poplars	*Populus L. sp.*	
*Northern red oak	*Quercus rubra* L.	
*Osage-orange	*Maclura pomifera* (Raf.) Schneid. (Western Kentucky only)	
Pin oak	*Quercus palustris* Muenchh.	III-C
*Red maple	*Acer rubrum* L.	
*River birch	*Betula nigra* L.	

Common Name	Scientific Name and Authority #	Table
Royal paulownia	*Paulownia tomentosa* (Thunb.) Steud.	III-C
Russian-olive	*Elaegnus angustifolia* L.	III-C
*Silver maple	*Acer saccharinum* L.	
*Sugar maple	*Acer saccharum* Marsh. (Western Kentucky only)	
Sweet birch	*Betula lenta* L.	III-C
*Sweetgum	*Liquidambar styraciflua* L.	
*White ash	*Fraxinus americana* L.	
*White oak	*Quercus alba* L. (Western Kentucky only)	
*Yellow-poplar	*Liriodendron tulipifera* L.	
Shrubs		
American elder	*Sambucus canadensis* L.	III-D
*Amur honeysuckle	*Lonicera maackii* (Rupr.) Maxim.	
Amur privet	*Ligustrum amurense* Carr.	III-D
Arrowwood	*Virburnum dentatum* L.	III-D
*Autumn olive	*Elaeagnus umbellata* Thunb.	
*Bristly locust	*Robinia fertilis* Ashe	
Chokecherry	*Prunus virginiana* L.	III-D
*Fragrant sumac	*Rhus aromatica* Ait. (Eastern Kentucky only)	
Gray dogwood	*Cornus racemosa* Lam.	III-D
Hawthorn	*Crataegus sp.* L.	III-D
*Indigobush	*Amorpha fruticosa* L. (Eastern Kentucky only)	
Japanese honeysuckle	*Lonicera japonica* Thunb.	III-D
*Japan lespedeza	*Lespedeza japonica* L. H. Bailey	
Korean barberry	*Berberis koreana* Palib.	III-D
Memorial Rose	*Rosa wichuraiana* Crep.	III-D
*Morrow honeysuckle	*Lonicera morrowii* A. Gray	
Multiflora rose	*Rosa multiflora* Thunb. ex Murr	III-D
Purple osier willow	*Salix purpurea* L.	III-D
Red-osier dogwood	*Cornus stolonifera* Michx.	III-D
Rose-acacia locust	*Robinia hispida* L.	III-D
Rugosa rose	*Rosa rugosa* Thunb. (Eastern Kentucky only)	III-D
*Shining sumac	*Rhus copallina* L. (Eastern Kentucky only)	
*Shrub lespedeza	*Lespedeza bicolor* Turcz.	
Siberian peashrub	*Caragana arborescens* Lam.	III-D
*Silky dogwood	*Cornus amomum* Mill. (Eastern Kentucky only)	
*Tatarian honeysuckle	*Lonicera tatarica* L.	
*Thunberg lespedeza	*Lespedeza thunbergii* (DC.) Nakai	
Western sandcherry	*Prunus besseyi* L. H. Bailey	III-D

**Detailed information is given on individual description sheets in this section. The other species are briefly described in Tables III, A-D.*

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