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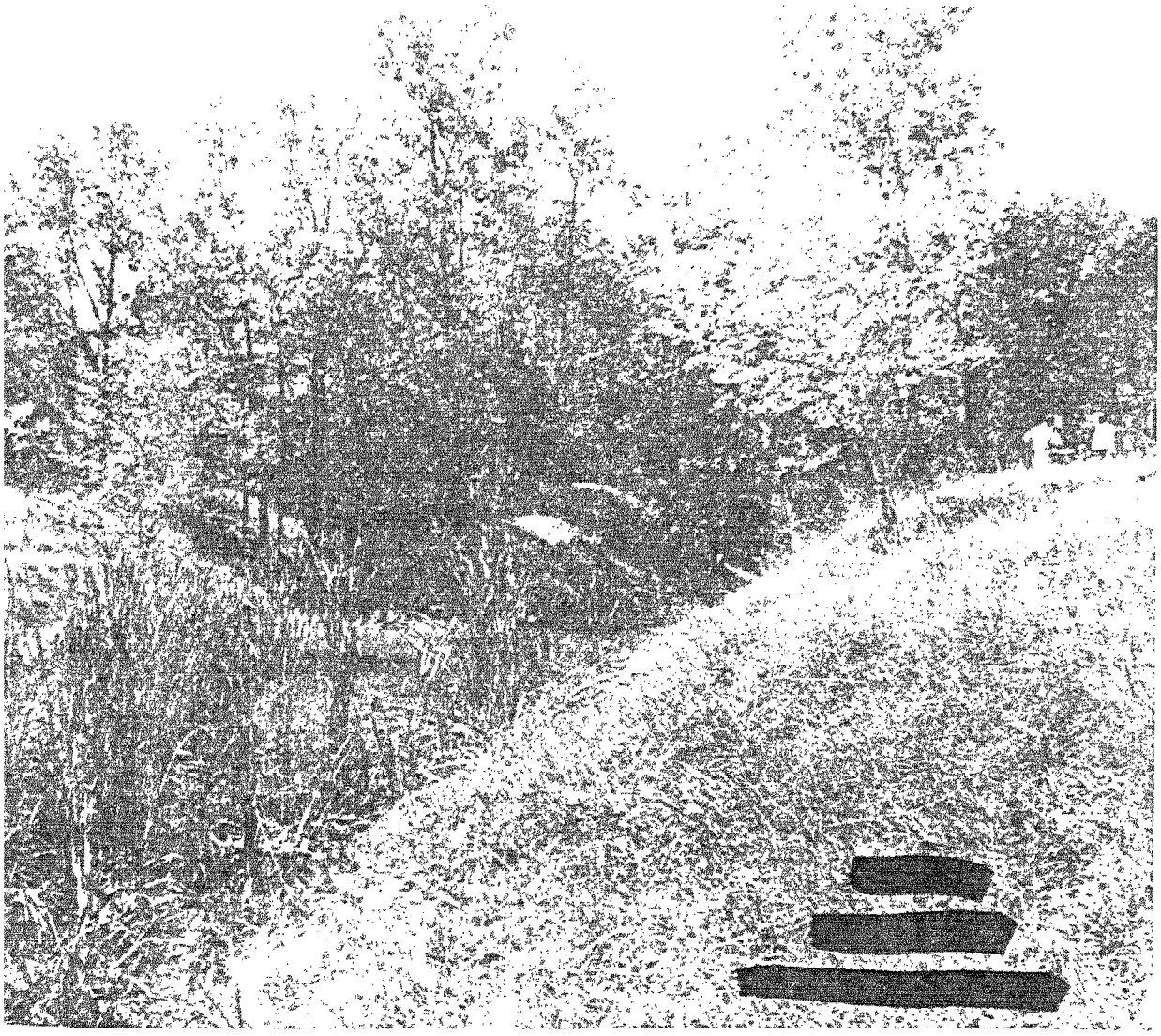
A Guide for Revegetating Coal Minesoils
in the Eastern United States

by Willis G. Vogel



THE AUTHOR

WILLIS G. VOGEL, range scientist, is engaged in research in surfa reclamation research with the USDA Forest Service, Northeastern Forest iment Station, Berea, Ky. He joined the Northeastern Station in 1963 working in range management with the USDA Forest Service in southwest and as a range conservationist with the USDA Soil Conservation Service Idaho. Vogel received a B.S. degree in agriculture in 1952 from the U sity of Nebraska, and an M.S. degree in range management in 1961 from tana State University.

ABSTRACT

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

FOREWORD

The mining of coal, especially surface mining, often is dangerous to en-
ronmental resources. Existing vegetation is destroyed, ecosystems are al-
ered, and unreclaimed areas are visually displeasing. One of the adverse
fects of mining and vegetation removal is the degradation and pollution of
ter resources. Erosion on raw exposed minesoils can contribute large quan-
ties of sediment to streams. Where the overburden contains acid-bearing
cks, streams also are polluted with toxic chemical substances.

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

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

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LAND USES AND SPECIES MIXTURES

Regulations promulgated under the Surface Mining Control and Reclamation Act of 1977 direct that postmining land uses be similar to or higher or better than the premining land uses. Also required is that vegetational productivity be restored to levels similar to productivity levels on unmined lands in the vicinity supporting similar types of vegetation. Land uses concerned primarily with vegetation and defined in the regulations are forest, range, fish and wildlife habitat, pasture, hayland, and cropland. Vegetative cover for protecting the soil surface from erosion is required in conjunction with all land uses.

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

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

Species mixtures and planting patterns for several land uses are discussed in this section. It is not feasible to list all of the species combinations that could be used in the different areas of the East. However, the several examples given may help to illustrate the rationale for mixing species for the various land uses.

EROSION CONTROL

Regardless of the intended use of reclaimed land, the establishment of vegetation is necessary first of all for control of water and wind erosion. Vegetation for watershed protection is especially important in mountainous and sloping areas where erosion caused by runoff is potentially greatest. Herbaceous species especially are important for the quick, initial establishment of a stabilizing vegetative cover.

Herbaceous Mixtures

Examples of seeding mixtures suggested primarily for erosion control are shown in Table 9. These mixtures include an annual or short-lived perennial species that provides quick but temporary cover. One of these should be chosen and added to the permanent mixture that contains at least one perennial grass and one perennial legume. Ideally, the perennial species will succeed and replace the temporary species. 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.

Mixtures for spring, summer, and fall seeding are suggested for the Appalachian Region. For other regions, mixtures are for spring or fall seedings. 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 other 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. See Section 4 for descriptive information on individual plant species.

Woody Species

Seedlings of most tree and shrub species provide little or no erosion control when newly planted and during their first few years of growth. But once they are large enough to achieve crown closure and litter begins to accumulate on the soil, trees and shrubs contribute significantly to site protection. Obviously, rapid-growing trees and shrubs are the ones that will most readily contribute to erosion control. Black locust, planted or direct seeded, is a rapid-growing tree that is especially useful for providing site protection on steep slopes. Other relatively fast-growing tree species include European alder, hybrid poplars, cottonwood, and sycamore. Autumn olive, a fast-growing plant, and bristly locust, a prolific sprouter, are shrub species that provide reasonably rapid erosion control.

TABLE 9. SUGGESTED HERBACEOUS MIXTURES FOR EROSION CONTROL

(Seeding rates: pounds per acre PLS)

Region	Seeding Time	Temporary (Quick Cover) Species[a/] (Use one with permanent mix)		Permanent (Long-lived) Species	
Northern Appalachia	Early Spring to Mid Spring	Annual ryegrass	5	Ky-31 tall fescue	15
		Perennial ryegrass	10	Birdsfoot trefoil	6
		Oats	48	or	
		Weeping lovegrass	2-1/2	Crownvetch	10
				or	
				Flatpea	20
	Mid Spring to Mid Summer	Foxtail millet	12	Ky-31 tall fescue	15
		Japanese millet	15	Birdsfoot trefoil	8
		Weeping lovegrass	2-1/2	or	
				Crownvetch	10
				or	
				Flatpea	20
	Mid Summer to Early Fall	Rye	40	Ky-31 tall fescue	20
		Winter wheat	40	Birdsfoot trefoil	8
		Annual ryegrass	5	or	
				Crownvetch	20
Mid and Southern Appalachia, Western Kentucky, Arkansas, Oklahoma	Early Spring to Mid Spring	Perennial ryegrass	10	Ky-31 tall fescue	15
		Oats	48	Korean and/or Kobe lespedeza[b/]	10
		Weeping lovegrass	2-1/2	Sericea lespedeza	10
		Annual ryegrass	5	or	
				Crownvetch	10
	Mid Summer to Early Fall	Rye	40	Ky-31 tall fescue	20
		Winter wheat	40	Sericea lespedeza	
		Annual ryegrass	5	(1/2 unhulled seed)[c/]	20
		Perennial ryegrass	10	or	
		Crimson clover	12	Crownvetch	10

(continued)

TABLE 9. SUGGESTED HERBACEOUS MIXTURES (CONTINUED)

Region	Seeding Time	Temporary (Quick Cover) Species[a] (Use one with permanent mix)		Permanent (Long-lived) Species	
Mid and Southern Appalachia	Mid Spring to Mid Summer	Weeping lovegrass	2-1/2	Ky-31 tall fescue	15
		Sorghums	18	Sericea lespedeza	10
		Pearl millet	10	Korean and/or Kobe lespedeza[b]	12
		Foxtail millet	12		
		Browntop millet	15		
Illinois, Indiana, Iowa, Northern Missouri	Early Spring to Mid Spring	Oats	40	Tall fescue	15
		Annual ryegrass	5	or	
		Perennial ryegrass	10	Smooth bromegrass	15
				Alfalfa	10
				or	
				Birdsfoot trefoil	8
				or	
				Crownvetch	10
Missouri, Kansas, Oklahoma	Early Spring to Mid Spring	Oats	32	Tall fescue	18
				Alfalfa	5
				or	
				Crownvetch	8
	Late Summer to Early Fall	Winter wheat	60	Tall fescue	20
		Rye	56	Alfalfa	6

[a] Use only one of the temporary species at rates shown. If more than one is used, reduce seeding rate of each species in proportion to number used, 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.

AGRICULTURE

Except for steeply sloping areas, most reclaimed surface mines have potential for agricultural uses. The type of agricultural use depends on the characteristics of overburden and soil materials, the intensity of the restoration procedures, the land use before mining, the presence of an agricultural economy in the area, and legal requirements. Areas developed for row crops and truck or vegetable crops generally require intensive restoration procedures such as removal of stones and replacement of A and B soil horizons. Areas reclaimed for pasture normally require the least intensive restoration procedures.

Forage Production

Pasture, hayland, and range are the land uses concerned with the production of forage crops. Herbaceous mixtures useful for pasture are similar to those suggested for erosion control. However, because they are more palatable to livestock, grass species such as orchardgrass and timothy can be substituted for Ky-31 tall fescue. In the South, Bermudagrass and Bahiagrass are desirable pasture species for summer grazing, as is perennial ryegrass for fall and spring grazing. Similarly, legumes such as red clover, Ladino clover, and alfalfa are more suitable than sericea lespedeza and flatpea for forage.

Often, the species that are better choices for livestock forage are relatively short lived or require a higher level of management for maintenance than those species recommended primarily for erosion control. A seeding mixture for the establishment of pasture may not require quick-cover companion species, especially on level to gently sloping areas where accelerated erosion will not be a problem. On the other hand, annuals for temporary cover can also provide a temporary forage crop. However, early or premature grazing by livestock on any new seeding will be injurious to the successful establishment of a desirable pasture.

Seedings for hayland often include fewer species than for other uses. For example, alfalfa often is sown alone or with one grass species such as smooth bromegrass or orchardgrass. In much of the Appalachian Region, Ky-31 tall fescue is used for hay, either alone or in mixture with red clover or white clover. Timothy and red clover have long been a popular combination for hay in the Northeastern United States.

Range usually implies the use of native species for forage. Customarily, most of the range-type seedings have been done in the Western Interior Coal Region, namely in Kansas, Oklahoma, and western Missouri. Restoration of the tall grass prairie that is native in that region is virtually impossible because some 200 to 300 species of grasses, forbs, and shrubs are known components of the tall grass prairie. Most range-seeding mixtures used on mined lands in this area include several species of native warm-season grasses. When available, seed of prairie forb species can be included. A suggested range seeding mixture is as follows:

Species	Pounds per acre (PLS)
Switchgrass	2
Big bluestem	3
Little bluestem	3
Indiangrass	4
Side-oats grama	4
Illinois bundleflower	5

These native species also can be sown and used for pasture on mined lands in most of the Eastern Interior and Appalachian Regions. However, establishment of these species normally is slow compared with most of the introduced warm- and cool-season species used in the East. Two or three years are required for establishment of an acceptable stand; but once established, these native species will gradually increase in density and may require little or no maintenance fertilization. However, grazing management practices usually applied to the exotic cool-season grass pastures in the East are not appropriate for the native warm-season grasses. Excessive and season-long grazing by livestock will limit or prevent the successful establishment of these grasses.

Cropland and Horticulture

These uses include plant species, cultural practices, and management systems beyond the scope of this guide. Generally, these uses pertain to the growing of one species under intensive management similar to that practiced on unmined agricultural land. Crops that have been grown successfully on reclaimed land include corn, oats, wheat, soybeans, and buckwheat. Apple orchards and vineyards also have been established, and vegetable crops have been grown experimentally. Technical advice on developing these uses should be sought from agronomic and horticultural specialists in each area.

FORESTRY

Forestry is a logical land use for many areas currently being mined, as well as for many abandoned or orphan mine sites. However, reforestation efforts have been minimal in recent years due to changing economic, political, legal, and social pressures. Previously, the planting of trees often was considered the most expeditious way to revegetate mined lands. Recent evaluations of 25- to 50-year-old forest plantings throughout the Eastern United States show that on many of the mined sites the combination of planted and natural vegetation is producing young forests that appear similar to forests on adjacent unmined sites (Figure 15). Many of the trees now are approaching or have reached marketable size. Some species such as black walnut and tulippoplar show promise for producing a favorable economic return.

Factors to consider in selecting tree species include: the forest management objective, species preferences in current markets, predicted preferences in future markets, the proposed level of management, and site and minesoil characteristics. The forestry objective can range from short-term crops such as Christmas trees to long-term crops for timber production. Levels of

ure 15. A 30-year-old mixed hardwood forest on surface-mined land in Ohio that has developed from planted and naturally established vegetation.

management can be intensive, requiring regular care and treatment, or extensive, requiring little care or treatment. Obviously, markets for the harvested crop should be within a hauling distance that is economical.

Where feasible, species should be matched with site and minesoil quality. For example, preference should be given to planting high-value hardwoods such as black walnut, yellow-poplar, and sugar maple on slightly acid to neutral loam and silt loam minesoils that are well drained but not drouthy. Conversely, some of the pine species are a better choice for sandy acid soils on warm (south-facing), moderately drouthy sites.

Christmas Tree Production

Planting and management for Christmas trees is an intensive forestry practice. Species should be selected that are marketable in the region. For example, Scotch pine is very popular in the Eastern States and can be grown in all but the southernmost coal producing areas. Other pines used for Christmas trees are red, eastern white, Austrian, ponderosa, and jack. Norway and white spruce also are used, but generally do not reach marketable size as quickly as pine. Pure plantings of a proven species usually are recommended, but mixed plantings of two or three species may reduce the risk of loss from insects and disease or from a change in market demand. Low-growing herbaceous species are recommended as a ground cover. Mowing and the use of herbicides may be needed to reduce competition by herbaceous plants.

Management needs include a road system for maintenance, harvest, and fire protection. Fencing may be needed to protect the plantings from livestock, theft, and vandalism. Care of Christmas trees also includes shearing to shape trees for market; application of fertilizer; and protection from insects, disease, and fire. Specific information on Christmas tree production is available from State universities, agricultural extension agents, and Christmas tree growers associations.

Pulpwood Production

Revegetating mined land for pulpwood production can include either intensive or extensive management. Intensive management usually entails the planting of one fast-growing pulp species such as shortleaf, loblolly, or longleaf pine, European alder, hybrid poplars, cottonwood, sycamore, or bigtooth aspen. Management practices may include periodic inspections for detection and control of insects and diseases, thinning, control of competing vegetation, and fertilization. With hybrid poplars and some of the other hardwoods, two or more rotations of pulp may be obtained from sprouts that originate after the first cutting.

Extensive management for pulpwood can be accomplished with pure or mixed plantings. Trees cut for pulpwood may consist mainly of those removed when thinning stands designated for timber production or when creating openings for wildlife habitat. Only selected trees would be left uncut to develop into veneer or sawlogs.

Timber Production

This management objective implies a long-term commitment. The overall level of management is extensive but it can become periodically intensive when trees would benefit from thinning, pruning, and other cultural practices. Access for periodic inspection, cultural treatments, and fire protection is desirable. Due to the long time span until timber harvest, interim benefits such as wildlife habitat and recreational use also can be considered.

For some timber production programs, especially with pine, planting of only one or two tree species may be desired. With hardwoods, mixtures of species more often are preferred. Herbaceous and shrubby species can be included to provide initial site protection and to add vegetational variety for esthetic values and for the enhancement of wildlife habitat as an interim land use. However, shrubs should be limited to 25 percent or less of the total planting because Federal standards require that, where commercial forest is the approved postmining land use, at least 75 percent of the countable trees and shrubs shall be commercial tree species at the end of the 5-year period of responsibility.

Pure vs. Mixed Plantings

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

1. Pure plantings of pine usually are favored over pine mixtures. Where two or more pine species are desired, a block or group of several rows of one species should be alternated with blocks of the other species. A block or group should consist of at least five rows. An exception may be a mixture of species with similar growth rates such as pitch and shortleaf pines.

2. Mixing hardwoods with intolerant pine species is not recommended. Hardwoods usually shade out the pine. Mixing groups or blocks of pine and hardwoods are acceptable, especially where diversity in cover types are desired for esthetic purposes and wildlife habitat. Intimate mixing of tolerant conifers such as spruce and white pine with tolerant hardwoods and slow-growing hardwoods is acceptable.

3. Hardwood species, such as hybrid poplar and European alder, that will produce a quick crop (pulpwood) may be planted in alternate rows with conifers (except larch with hybrid poplar). A coniferous stand will follow after the hardwoods are harvested.

4. A few hardwoods--cottonwood, sycamore, and hybrid poplar--preferably should be planted in pure stands or block mixtures. Most other hardwoods also may be planted in pure stands or blocks, but mixtures generally are recommended.

5. Black locust, European alder, or autumn olive may be beneficial as "nurse" species in hardwood mixtures. Red oak, white oak, chestnut oak, yellow-poplar, black walnut, sweetgum, green and white ash, and sugar maple are some of the most promising species for planting with a nurse crop. The nurse species should generally make up no more than one-fourth to one-third of a hardwood mix.

6. The presence of black locust and European alder will encourage the natura establishment of indigenous forest species. Thus, planting mixtures of numerous tree species may, in the long run, offer little advantage over simple mixes that include these nurse species.

Examples of several hardwood mixtures for timber production are shown i Table 10. Obviously, many combinations of species besides those suggested ar possible, and the choice of species should be influenced by factors such as the natural range of the species, minesoil characteristics, availability of planting stock, market preferences, potential commercial value and the character of the surrounding landscape. For a given locality, consult appropriat natural resource agencies or services and State revegetation guides for additional advice on forestry procedures and species selection.

Tree-Herbaceous Combinations

The seeding of herbaceous species before or concurrent with the plantir of trees nearly always is required for preventing erosion. But the herbaceou cover also may slow or prevent establishment of the trees. Where herbaceous cover is established first, it may be necessary to kill or suppress it with herbicides or cultivation before planting trees. But in the more humid regions of the East, especially in Appalachia, it is possible to establish tre by planting them concurrent with the seeding of herbaceous species.

The success or failure of trees planted concurrent with herbaceous see ings appears to be partly, if not largely, related to the amount and distrib ution of precipitation during the growing season. Results of limited resear also suggest that some herbaceous species are more compatible than others wi woody species planted at the same time. For example, ryegrass and Ky-31 tal fescue are more suppressive than weeping lovegrass to the survival and early growth of direct-seeded black locust.

In eastern Kentucky, where Ky-31 tall fescue, sericea lespedeza, and Korean lespedeza were planted with trees, the growth of trees was suppressed in cover that was predominantly fescue but after 3 years was favored in cove that was predominantly lespedeza. Thus, legumes seem to be a better choice than grasses for use with trees, providing the legume plants are not so larg and dense that the tree seedlings are smothered before they can grow above t legume plants. Low-growing legume species and varieties, therefore, are pr ferred for combination plantings with trees. In southern Appalachia, for e ample, Kobe and Korean lespedezas are frequently used as a ground cover wit newly planted pine. Tall and aggressive legumes such as common sericea les pedeza, crownvetch, and flatpea are least recommended for combination plant ings with trees. Where climatically adapted, the following herbaceous mixt is suggested for a ground cover with trees.

TABLE 10. SUGGESTED HARDWOOD MIXTURES FOR PLANTING ON SURFACE-MINED LANDS

Location	Species	Composition (percent)
Northern Appalachia	Northern red oak	25
	Green or white ash	25
	European white birch	25
	Black locust or European alder	20
	Autumn olive	5
Central and Southern Appalachia	Yellow-poplar	20
	Northern red oak	20
	White or green ash	15
	Sycamore	20
	Black locust or European alder	25
Lower Midwest (Southern Illinois, Southern Indiana, and Western Kentucky)	Black walnut	15
	Yellow-poplar	15
	Sweetgum	15
	Northern red oak	15
	Silver maple	15
	European alder	25
Western Interior Region	Bur oak	15
	Green ash	15
	Black walnut	15
	Black cherry	15
	Sycamore	15
	Black locust	25

Species	Pounds per acre (PLS)
Weeping lovegrass	2
Orchardgrass	5
Korean or Kobe lespedeza	10
Sericea lespedeza (cv. Appalow)	8

Temporary Cover--

Annual species may be used effectively in tree planting programs where a temporary cover is established one year and trees are planted the following spring. A heavy seeding rate of oats, barley, wheat, or rye could be used where early spring seeding is required. Where adapted, Korean or Kobe lespedeza seed could be included. For late spring and early summer seedings, summer annuals such as sorghum, pearl millet, and Japanese millet are useful.

Late summer and fall seeding of winter annuals such as wheat, rye, annual ryegrass, and hairy vetch poses an additional problem for tree planting in that these species will be established and actively growing in the spring when the newly planted tree seedlings are trying to become established. Herbicides or tillage in spots or strips may be required to suppress the fall-planted cover before the tree seedlings are planted.

Seeding and Planting in Alternate Strips--

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

Alternate strip planting will work best on areas that can be traversed with farm equipment, because a grain or grass seeding drill and a pull-type fertilizer spreader would be most useful for establishing strips that are uniform in width. On sloping land the strips should run on contour.

WILDLIFE HABITAT

The place where a wildlife species usually lives is called its habitat. The basic components of habitat are food, cover, water, home range, and interspersion. All are essential for the success of wildlife. Food provided by a variety of plants must be available during all seasons and within foraging range of protective cover. Different types of plant cover are required for different purposes such as brooding and nesting, escape, and shelter. Some species of wildlife require open water; others obtain moisture from succulent plants, dew, or their own metabolic processes. The home range of a species is the size of its habitat or living area. The required size varies for different species. Interspersion is the arrangement of food, cover, and water within the living area of a species. Food and cover that otherwise meet the needs of a species may be of little value where they are not properly interspersed.

Habitat for wildlife can be developed either as the primary land use or in association with other land uses. However, it should not be assumed that every revegetation effort will automatically develop or improve wildlife habitat. Most any vegetational community will in some degree contribute to habitat, but the best habitat is developed by planning and providing for the needs of the desired wildlife species. In revegetating surface-mined areas, the maximum benefit for wildlife usually is obtained by establishing vegetational communities that are not presently available or that are in short supply in the vicinity. For example, in a region that is predominantly deciduous forest, communities of coniferous trees where established will provide greater diversity of food and cover than plantings of mixed hardwoods. Because they

often are lacking in forested and agricultural areas, shrub communities are especially beneficial to wildlife.

Each species of wildlife has different habitat requirements. Thus, the vegetation established for different land uses will affect the diversity and productivity of wildlife populations. For example, bird populations in the East are most diverse and productive in a mixed hardwood forest. Different species of birds are attracted to and inhabit open grasslands; others prefer edges between forest and grassland that are partially vegetated with shrubs and small trees. Thus, even in a forested region, the overall diversity of bird species is increased by developing shrub and grassland vegetational types on surface-mined areas. Similarly, the planting of tree and shrub communities in grassland and agricultural regions will increase the diversity of birds and mammals.

Habitat can be developed on mined land to favor one or two species, several species, or wildlife in general. But newly revegetated surface mines should not be expected to provide habitat for all resident species of wildlife. For example, squirrels inhabit forests in advanced stages of succession. Ruffed grouse and wild turkey may derive benefit only from those newly revegetated sites that are adjacent to or interspersed with natural undisturbed forest or woodland. For bobwhite quail, cottontail rabbit, white-tail deer, and other species, how little or how much of the habitat requirement is derived from the early stages of revegetation depends on the size of the area; type, age, and interspersion of planted vegetation; and the type and interspersion of land uses in the surrounding unmined areas. Thus, habitat requirements should be determined before attempting to establish habitat for particular species of wildlife.

Herbaceous Mixtures

Grass-legume mixtures similar to those listed in Table 9 are suggested for seeding on steep slopes and other areas subject to severe erosion. For other sites, grasses such as orchardgrass, timothy, deertongue, Kentucky and Canada bluegrasses, and smooth bromegrass are recommended in place of Ky-31 tall fescue in seed mixtures for wildlife habitat. Similarly, limited use should be made of common sericea lespedeza, crownvetch, and flatpea because these legumes usually dominate the vegetational cover and limit the diversity in food and cover. Also, the dense persistent cover of these legumes may retard or prevent the invasion and establishment of indigenous plant species that contribute to habitat diversity. Herbaceous legumes that are desirable food plants but less aggressive and persistent than the three mentioned previously should be used. These include red clover, white clover, alsike clover, alfalfa, birdsfoot trefoil, partridge pea, prostrate lespedeza, and the annual lespedeza species.

Mixtures of native warm-season grasses--switchgrass, Indiangrass, big bluestem, and little bluestem--are useful for providing nesting cover for certain game birds and cottontail rabbit. Mixtures containing Japanese millet, redtop, reed canarygrass, and alsike clover are suggested for wet or poorly

drained areas and pond borders. Mixtures seeded in food patches for game and song birds could include common sunflower, cowpea, soybean, broomcorn millet, foxtail millet, browntop millet, or buckwheat.

Woody Plant Mixtures

Trees and shrubs are important components of wildlife habitat. In fact, development of wildlife habitat is a major reason for planting shrubs on reclaimed surface mines (Figure 16). For wildlife plantings, shrubs and trees usually are planted in rows, clumps, or blocks of a single species. Adjacent rows of different shrub or tree species can be employed to develop a "tepee" effect; that is, the tallest species are planted in the center row of a strip and shorter species are planted in the outer rows.

Figure 16. An informal planting of bicolor lespedeza that provides cover and food for wildlife.

Many woody plants provide both food and cover, but the relative importance of these values varies with different species of wildlife. Time of fruit or seed maturity and the duration of fruit or seed retention on the

plant differ among tree and shrub species. Planting several species that differ in time of maturity and retention of fruit will extend the period that food is available to wildlife.

The benefits of woody plants to wildlife do not occur as quickly after planting as they do with some herbaceous plants. For most woody species, 3 or more years of growth are required before they contribute effective amounts of cover and food to the wildlife habitat. Some tree species, such as some of the oaks, may require many years before they contribute mast to the habitat. Thus, wildlife plantings should include a variety of woody plants that will provide food continuously for a relatively long period.

Planting Patterns

Diversity is the basic principle in developing habitat for wildlife. Planting patterns that provide variety and diversity in types and arrangement of vegetation are the most beneficial when all species of wildlife are considered as a group. For example, the planting of trees and shrubs in rows, strips, clumps, and blocks in and around open areas seeded to herbs creates a desirable interspersion of food and cover types and provides for better distribution of wildlife (Figure 17).

Habitat can be improved on any reclaimed site by alternate rather than solid plantings of trees, shrubs, and herbs. For example, where contour mining creates a highwall, bench, and outslope, a basic planting pattern in the Appalachian hardwood forest region could be as follows: (1) plant several rows of conifers parallel and adjacent to the highwall; (2) plant strips, blocks, or clumps of shrubs alternating with strips or blocks of herbs on the bench; (3) plant several rows of conifers along the edge of the bench adjacent to the outslope; and (4) plant the entire outslope with herbs and several strips of shrubs or black locust trees.

A suggested pattern for expansive sites such as leveled off ridgetops would include strips of grass-legume mixtures 100 to 150 feet wide alternating with strips of shrubs and trees 30 to 50 feet wide. In some of the woody plant strips, the inner rows should be trees and the outer rows shrubs. Clumps of fruit-producing trees also can be placed randomly throughout the open areas. Where an area is less than 150 feet wide, one to three rows of woody vegetation through the middle, or scattered clumps of woody plants, may create sufficient diversity in habitat. The open areas, seeded to grasses and legumes, should be at least 1/2 acre but no more than 5 acres.

Wildlife habitat can be incorporated with other land uses chosen for the reclaimed mine. Single rows of dense shrubs between small pastures and crop fields can provide escape cover, shelter, and variety in food for game birds and small mammals. Extensive tracts revegetated for pasture, hay, or range can be diversified with occasional strips (up to 20 feet wide) of shrubs such as autumn olive, amur privet, shrub lespedeza, shrub honeysuckles, arrowwood, or rose-acacia. Similar plantings may also serve as woodland-field borders at the edge of pastures or cropland. Several rows of conifers and shrubs or small, fruit-producing trees planted at right angles to the direction of the

Figure 17. Interspersion of trees, shrubs, herbs, water, and landform provides habitat diversity that is essential for wildlife.

prevailing winds can provide windbreaks for cropland or pasture while improving nesting, escape, and winter cover for game birds

The boundaries or edges of plantings need not be uniform or exacting. Ragged, irregular edges increase the value of a planting to wildlife, and they also may add esthetic interest to a site.

Mixed forest plantations will provide good habitat for most species of wildlife that naturally inhabit forest land. Establishing blocks of conifer up to 1 acre in size, within larger plantations of mixed hardwoods increases the variety of available food and cover types while providing potential wood products. Blocks of hardwoods may be separated from the conifers by grass-legume strips to provide more edge and open areas. Food patches of 1/8 to 1/2 acre seeded to species such as cowpea, partridge pea, soybean, wheat, white clover, or orchardgrass will benefit some species of wildlife in a forest area. One food patch in about 40 acres is suggested. Prescribed harvesting of pulpwood and timber also may create diversity in wildlife habitat.

Vegetation, especially forest vegetation, changes with time; in turn, the quality and quantity of food and cover available for wildlife will be

altered as the forest canopy closes in. To counteract this natural process of change, maintenance procedures are necessary. For example, open areas that become overgrown with woody plants may require cutting, discing, or controlled burning and reseeding to extend the longevity of the desired type of habitat.

The preceding discussion focuses on planting patterns for habitat for wildlife in general. Obviously, where habitat is desired primarily for one or two species of wildlife, variations in planting patterns must be provided that are most beneficial to those species. Additional recommendations on habitat requirements, management of the wildlife, and maintenance of habitat should be obtained from professional wildlife biologists and other reference sources.

ESTHETICS

Esthetic values should be considered in plans for revegetating surface-mined lands. The concept of esthetics involves all of the senses, but it is most often equated with the visual sense to denote quality and attractiveness or "visual appeal" of the landscape scene or scenes being viewed. The major components of the characteristic landscape are landform, vegetation, water forms, and structures.

Vegetation removal during mining and reestablishment during reclamation create significant changes in the visual relationships of cover types, patterns, and open spaces. This is especially noticeable in landscapes with continuous forest cover as found in Appalachia. Revegetation for esthetic purposes is concerned with reestablishing the visual character of the landscape by integrating the postmining land use or uses of the reclaimed area with the surrounding area.

Land use objectives and an evaluation of the characteristic landscape should guide revegetation treatments and esthetic design. Revegetation plans should include the following design considerations.

Selection. Species that have visual similarity to those in surrounding unmined areas should be used to minimize contrasts in color and texture. The use of mixtures of shrubs and trees will avoid a monoculture effect; herbaceous material alone will not always make a reclaimed site visually compatible.

Function. Introduce vegetation of varying height and configuration to define space, separate incompatible uses, blend and soften the impact of structures, and mask or screen visually objectionable or undesirable objects and views which have visual contrast.

Arrangement. Visual interest in the landscape depends on the composition and patterns of openings in forested lands, or plantings of trees and shrubs in open, nonforested lands. The physical arrangement and location of plants should be related to the natural pattern of existing vegetation to complement surroundings.

Variety. Landscapes rich in variety are desirable. Vegetation can enhance an area where there is little variety. For example, species can be introduced to provide spring color, to highlight fall color, and to create contrast (conifer with deciduous) in form, foliage, growth habit, and size. Openings can add variety to a forested landscape that otherwise might be a monotonous cover of trees.

Viewing Distance. The distances from which reclaimed areas are viewed may differ greatly. As these distances differ, the observer's impression of the visual contrast will change. For example, the size and shape of a reclaimed area appears larger where the key viewing point is relatively close, and smaller where it is far away.

Size and shape. For esthetic improvement, the size and shape of openings or plantings should be varied according to the viewing distance. Geometric-shaped openings usually are unnatural forms. Irregular and free-form shapes expose less area to view, soften the visual contrast between plantings and openings, and simulate natural conditions. Strategically located islands, clumps, and groups of vegetation help to alter the apparent size or shape of openings.

Edge. Changes in vegetational types often create abrupt visual contrast due to differences in soil or vegetation color and types. For example, in Appalachia, many contour surface mines are located in forests. Reclamation with herbaceous material creates an abrupt, sharp edge between the opening and surrounding undisturbed woods. This unnatural configuration can be modified by planting shrubs and small trees to undulate or feather the edge between the openings and undisturbed forest.

Spacing. Openings and plantings that are uniform and regimented in size, shape, and spacing seldom are visually pleasing and lead to monotony and lack of unity in the landscape. Dispersal and irregular spacing can be used to minimize contrast.

Vistas. Where there are worthwhile opportunities, select individual or groups of trees, such as conifers and flowering trees, to accentuate, focus, frame, and give scale and dimension to views of outstanding physical features (rock outcrops, lakes, streams, falls, etc.) and panoramas of the landscape.

Additional recommendations on planning and designing visual quality requirements, landscape management, and maintenance of the landscape character should be obtained through the services of a landscape architect.

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GLOSSARY

ACID-PRODUCING MATERIAL: Geologic material (rock strata) containing sufficient pyrite of a reactive form that when exposed to air and water will cause the formation of sulfuric acid.

AMENDMENT: Material such as lime, fertilizer, and manure added to minesoil to make it productive or more productive of vegetation.

ARTIFICIAL PASTURE: Grazing lands under relatively intensive management, usually supporting introduced forage species and receiving periodic cultural treatments, such as tillage, fertilization, mowing, and irrigation.

ARTIFICIAL REVEGETATION: The establishment of vegetation by mechanical or unnatural methods.

AVAILABLE NUTRIENT: The part of the supply of a plant nutrient in the soil that can be taken up by plants.

BROADCAST SEEDING: Spreading or scattering seed on the soil surface.

BROWSE: That part of current leaf and twig growth of shrubs, woody vines, a trees available for animal consumption.

BRUNCHGRASS: Grasses so called because their growth characteristic is a distinct tuft, clump, or bunch.

CANOPY: The cover formed by the aerial portion of trees and shrubs. Measur as the vertical projection downward of the leaves and branches. Simila to overstory.

CATION: An ion carrying a positive charge of electricity. The most common cations in eastern minesoils are calcium, magnesium, potassium, hydrog aluminum, iron, and manganese.

CATION EXCHANGE CAPACITY: A measure of the total amount of exchangeable cations that can be held by the soil. It is expressed in terms of mil equivalents per 100 grams of soil (meq/100 g).

CLAY: Mineral soil particles less than .002 mm in diameter. As a textural class, soil that contains 40 percent or more clay-size particles, less than 45 percent sand, and less than 40 percent silt.

COMPACTION: The closing of pore spaces among the particles of soil and rock; most often caused by repeated running of heavy equipment over an area or by excessive trampling by livestock. At lower depths, caused by weight of soil above.

CONTOUR: An imaginary or measured line that is kept at the same elevation (level) for its entire length, usually in reference to tillage or terracing at right angles to the direction of slope.

DENSITY: The number of plants or specific plant parts per unit area of ground surface.

DOMINANT SPECIES: The major constituent of a plant or animal community.

DRILL SEEDING: Planting seed in rows with an implement called a drill.

ENVIRONMENT: Sum of all external forces, conditions, and substances that affect organisms in any way.

EROSION: The wearing away of the land surface by detachment and transport of soil and rock materials caused by the action of moving water, ice, wind, and other geological agents.

GULLY EROSION: Caused by water accumulating or concentrating in channels; soil is removed to considerable depths.

RILL EROSION: The formation of numerous small channels only several inches deep.

SHEET EROSION: The removal of a fairly uniform layer of soil from the surface by runoff.

SPLASH EROSION: The spattering of soil particles caused by the impact of raindrops or water dripping from tall vegetation. On slopes, the soil particles are moved down slope by the repeated spattering of raindrops; also may be removed by surface runoff. A dense cover of herbaceous vegetation prevents splash and sheet erosion and retards or slows rill and gully erosion but may not prevent it.

EXCHANGEABLE: Describes the ions in the absorbing complex of soil that can be exchanged with other ions. For example, when acid soils are limed, calcium ions exchange for hydrogen ions in the complex.

EXCHANGEABLE ACIDITY: The amount of ions, mostly hydrogen, aluminum, and iron that, brought into the soil solution by ion exchange, can react with basic materials such as lime; measured as acidity.

EXOTIC: An organism that is not native to the area where it is found.

FERTILIZER: Any natural or manufactured material added to soil to provide one or more plant nutrients.

FIELD CAPACITY: The amount of water held in the soil after the excess or gravitational water has drained away.

FORAGE: All browse and herbaceous plant material that can be used as food by domestic livestock or wildlife. Forage may be either grazed or harvested for feeding.

FORAGE PRODUCTION OR YIELD: The weight of forage produced in a designated period on a given area. May be expressed as green, air dry, or oven-dry weight.

GERMINATION: Beginning of growth or sprouting as from a seed.

GRAZING CAPACITY: The maximum stocking rate possible without inducing damage to vegetation and related resources.

GROUND COVER (OF VEGETATION): The total area of live aerial and basal parts of plants, or the combined parts of plants and plant litter that, projected vertically downward, provides cover to the ground. Usually expressed as percent of ground surface that is covered by vegetation when viewed or measured directly from above. Also called vegetative cover.

HERB: Any flowering plant except those developing persistent woody stems above ground.

HERBAGE: Herbs taken collectively, often used in the same sense as forage, except that it may include plant material not acceptable to animals.

HORIZON, SOIL: A layer of soil, approximately parallel to the soil surface, with distinct characteristics produced by soil-forming processes.

A HORIZON: The surface horizon of a mineral soil having maximum biological activity, or eluviation (removal of materials dissolved or suspended in water), or both. See TOPSOIL.

B HORIZON: A soil horizon beneath the A horizon, or surface soil, in which clay, iron, and aluminum, with accessory organic matter, have accumulated by receiving suspended material from the horizon above it. In soils with distinct profiles, the B horizon is roughly equivalent to the term "subsoil."

C HORIZON: The unconsolidated rock material in the lower part of the soil profile like that material from which the upper horizons, or part of them, have developed. See PARENT MATERIAL.

HUMUS: The decomposed organic fraction of soil.

HUMID CLIMATE: A climate with a high average relative humidity and enough precipitation to support predominantly forest vegetation. The precipitation effectiveness index ranges from 64 to 128.

INTERPLANTING: Anyone of several ways of planting one species or type of plant in association with another species or type of plant.

INTRODUCED SPECIES: A species not a part of the original plant or animal communities in a given area.

INVADERS: Plant species that move into an area, usually a disturbed area, by natural seeding from surrounding areas.

INVASION: The migration of organisms from one area to another in which they become established.

ION: As used in soils, refers to an electrically charged element or combination of elements resulting from the breaking up of an electrolyte in solution. Since most soil solutions are highly dilute, many of the salts exist as ions. For example, potassium chloride in most soils exists as potassium ions (cation) and chloride ions (anions). Cations are positively charged, anions negatively charged.

LANDSCAPE: The combination of characteristics that give an area a distinguishing appearance in contrast to other areas.

LEACHING: The removal of soluble materials by the passing of water through soil.

LIME: In common usage, the term applied to all limestone-derived materials used as amendments to reduce acidity in acid soils.

LITTER: Undecomposed plant residuum on the soil surface.

LOAM: In general terms, a soil of intermediate texture between the coarse-textured or sandy soils and the fine-textured or clayey soils.

LOESS: Geologic deposits of fine-grained, predominantly silt-size material, presumably transported by wind.

MAST: Nuts and acorns that are consumed by animals.

MICROORGANISMS: Forms of life that are microscopic or submicroscopic.

MINESOIL: The mixture of earth and rock materials left on the mined area to serve as the growth medium for plants after shaping and grading is completed and the area is ready for planting. Generally, does not include replaced topsoil. Similar to spoil.

MYCORRHIZAE: The morphological association, usually symbiotic, of fungi and roots of seed plants.

NATIVE SPECIES: A species that is part of the original flora or fauna of an area.

NATURAL REVEGETATION: The reestablishment of plants, or propagation of new plants over an area by natural processes.

NITROGEN FIXATION: The conversion of atmospheric (free) nitrogen to nitrogen compounds that are eventually usable by plants. Nitrogen-fixing organisms associated with plants such as legumes are called symbiotic, i.e., the plants and organisms each contribute to the benefit of the other.

NUTRIENT: Any element or compound taken into a plant or animal that is essential to its growth.

ORGANIC MATERIAL: Nonmineral matter composed of compounds consisting primarily of carbon, hydrogen, and oxygen, and derived from living organisms.

OVERBURDEN: The earth and rock materials that lie above the coal seam.

OVERSTORY: The taller vegetation growing above vegetation with a lower growt form, e.g., trees are an overstory to herbs and shrubs.

OXIDATION: A chemical change of an element or compound involving the additio of oxygen or its chemical equivalent. In the weathering of pyritic materials, sulfur is oxidized to form sulfuric acid.

PARENT MATERIAL: The unconsolidated mass of rock material from which the soi profile develops. Usually synonymous with C horizon.

PASTURE: Grass or other growing plants used as food by grazing animals.

PERMANENT VEGETATION: Communities of vegetation consisting mostly of plant species that are long lived and that regenerate themselves indefinitely under appropriate management.

PLANT COMMUNITY: An aggregation of plant species within a specific area.

PLANT SUCCESSION: The natural process of vegetational development whereby a area becomes occupied successively by different plant communities of higher ecological order.

PRAIRIE: A tract of land that was originally treeless and covered predominantly with grasses and forbs.

PRECIPITATION EFFECTIVENESS (P-E) INDEX: The sum of the 12 monthly quotient of precipitation divided by evaporation.

PROPER GRAZING: The degree and time of grazing of current year's growth th if continued, will either maintain or improve the condition of pasture or range consistent with conservation of associated natural resources.

PYRITE: A mineral compound of iron and sulfur, most forms of which produce acidic conditions when exposed to water and oxygen.

RANGE: Land producing native forage for animal consumption and lands that are revegetated naturally or artificially to produce a plant cover that is managed as native vegetation.

REFORESTATION: The natural or artificial restocking of an area with trees.

REVEGETATION: The reestablishment of vegetation by either natural or mechanical means.

RHIZOBIA: The bacteria that live symbiotically with leguminous plants within nodules on their roots.

RHIZOME: A horizontal undergound stem, usually sending out roots and aboveground shoots at the nodes (joints).

ROOT ZONE: The part of the soil inhabitated by the roots of plants.

SAMPLE: A part of a population taken to estimate the quantity or quality of the whole.

SAND: Soil particles with diameters between 0.05 and 2.00 mm. The textural class name of any soil containing 85 percent or more of sand and not more than 10 percent clay.

SANDSTONE: A cemented or otherwise compacted sedimentary rock composed predominantly of sand-size grains.

SCARIFY: Abrasion of the hard seedcoat, mostly of legume seeds, to decrease time required for germination. Also, to scratch or loosen the soil surface as for seedbed preparation.

SEEDBED: Soil prepared by natural or artificial means to promote the germination of seed and the growth of seedlings.

SEEDLING: In forestry, a plant at least 1 year old that is dug from a nursery bed for transplanting. May also refer to young plants less than 1 year old that are grown indoors in containers. With herbaceous species, a small plant from time of initial emergence of root and shoot from the germinating seed until initial development of the secondary root system.

SHALE: Sedimentary rocks generally formed by consolidation of clay or clay-like material, and exhibiting distinct cleavage parallel to the bedding. Similar rocks without cleavage are claystones.

SILT: Soil particles ranging in diameter from 0.05 to 0.002 mm. Also, the textural class name of soil containing 80 percent or more silt and less than 12 percent clay. Loosely applied to sediments deposited from water.

SOD GRASSES: Grasses with stolons or rhizomes that form a sod or turf.

SOIL: The unconsolidated mineral and organic material on the immediate surface of the earth that serves as a natural medium for the growth of land plants.

SOIL TEXTURE: Refers to the relative proportions of groups of soil particles of various size in a mass of soil. Specifically, the relative proportions of sand, silt, and clay in the fine-earth portion of minesoils.

SPECIES COMPOSITION: The relative proportions of various plant species in th total cover or yield of vegetation on a given area.

SPOIL: The overburden materials removed from above the coal and placed near the excavation or back in it after the coal is removed. Similar to minesoil.

SPOIL BANK: The deposited pile of ungraded spoil or overburden.

STAND: An effective number of one or more plant species of the same life fo

STOLON: A stem growing horizontally on the surface of the soil and that for roots and shoots at the nodes.

SUBSOIL: Generally, similar or synonymous to the B horizon of soils with distinct profiles. Cannot be accurately defined in soils with weak profile development.

SYMBIOTIC: Refers to the living together of two different organisms with a resulting mutual benefit.

TILLAGE: The operation of implements through the soil to prepare seedbeds rooting beds.

TOPSOIL: The original or present dark-colored upper soil; or the original present A horizon; also synonymous with surface soil or surface plow layer. Applied to soils in the field, the term has no precise meaning unless defined as to depth or productivity in relation to a specific kind of soil.

TOXIC SPOIL (MINESOIL): Spoils (minesoils) with levels of aluminum, mangan or other elements that adversely affect plant growth. Broadly, spoils with pH below 4.0.

UNDERSTORY: Vegetation growing beneath the canopy of taller vegetation, e. herbs and shrubs growing beneath a canopy of overstory of forest trees

VEGETATION: Vascular plants in general including grasses, forbs, trees, a shrubs occurring naturally or planted intentionally.

VEGETATIONAL: Concerned with vegetation. Not synonymous with vegetative.

VEGETATIONAL COVER: See Ground Cover.

VEGETATIVE: In a strict sense, the nutritive and growth function of plants in contrast to sexual reproductive functions. Although often done so in common usage, this term should not be confused with vegetation or vegetational.

VEGETATIVE REPRODUCTION: Propagation of new plants by any asexual method.

VOLUNTEER PLANTS: Vegetation springing up spontaneously without having been planted artificially.

WATERSHED: Total land area above a point on a stream that contributes water to the stream flow at that point.

WEATHERING: The physical and chemical changes, disintegration, and decomposition of rocks and minerals resulting from the effects of weather, climate, and microorganisms.

Vogel, Willis G. A guide for revegetating coal minesoils in the Eastern United States. Broomall, PA : Northeast. For. Exp. Stn.; 1981; USDA For. Serv. Gen. Tech. Rep. NE-68. 190 p.

Provides information, recommendations, and guidelines for revegetating land in the Eastern United States that has been disturbed by coal mining. Includes brief descriptions of major coal mining regions in the East, and a discussion of minesoil properties and procedures for sampling, testing, and amending minesoils. Plant species used in revegetating surface-mined lands are identified. Selection criteria for plant species and methods and requirements for seeding and planting are explained.

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Headquarters of the Northeastern Forest Experiment Station are in Broomall, Pa. Field laboratories and research units are maintained at:

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