

## SECTION 6

### 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 <sup>a/</sup><br>(Use one with permanent mix) |                   | Permanent (Long-lived) Species             |    |
|---|----------------------------------|---|-------------------|--|----|
| Northern<br>Appalachia  | Early Spring<br>to<br>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<br>to<br>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<br>to<br>Early Fall  | Rye                              | 40  | Ky-31 tall fescue | 20   |    |
|   | Winter wheat                     | 40  | Birdsfoot trefoil | 8  |    |
|   | Annual ryegrass                  | 5   | or                |  |    |
|   |                                  |   | Crownvetch        | 20   |    |
| Mid and<br>Southern<br>Appalachia,<br>Western<br>Kentucky,<br>Arkansas,<br>Oklahoma | Early Spring<br>to<br>Mid Spring | Perennial ryegrass  | 10                | Ky-31 tall fescue                          | 15 |
|   |                                  | Oats  | 48                | Korean and/or Kobe lespedeza <sup>b/</sup> | 10 |
|   |                                  | Weeping lovegrass   | 2-1/2             | Sericea lespedeza                          | 10 |
|   |                                  | Annual ryegrass   | 5                 | or   |    |
|   |                                  |   |                   | Crownvetch                                 | 10 |
|   | Mid Summer<br>to<br>Early Fall   | Rye   | 40                | Ky-31 tall fescue                          | 20 |
|   |                                  | Winter wheat  | 40                | Sericea lespedeza                          |    |
|   |                                  | Annual ryegrass   | 5                 | (1/2 unhulled seed) <sup>c/</sup>          | 20 |
| Perennial ryegrass  |                                  | 10  | or                |  |    |
|   |                                  |   | Crownvetch        | 10   |    |

(continued)

TABLE 9. SUGGESTED HERBACEOUS MIXTURES (CONTINUED)

| Region                                     | Seeding Time               | Temporary (Quick Cover) Species <sup>a/</sup><br>(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 |
|  | Mid Summer                 | Pearl millet  | 10                             | Korean and/or Kobe lespedeza <sup>b/</sup> | 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   |    |
|  | Mid Spring                 | 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  |
|  | Mid Spring                 |   |                                |  | or |
| Crownvetch                                 |                            |   |                                |  | 8  |
| Late Summer to Early Fall                  |                            | Winter wheat  | 60                             | Tall fescue                                | 20 |
|  |                            | Rye   | 56                             | Alfalfa                                    | 6  |

<sup>a/</sup> 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.

<sup>b/</sup> These annual lespedezas usually reseed each year and may become a permanent component of the vegetative cover.

<sup>c/</sup> 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 brome grass 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:

| <u>Species</u>        | <u>Pounds per acre (PLS)</u> |
|-----------------------|------------------------------|
| 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 tulip-poplar 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 mine-soil characteristics. The forestry objective can range from short-term crops such as Christmas trees to long-term crops for timber production. Levels of



Figure 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 big-tooth 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 natural 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 in Table 10. Obviously, many combinations of species besides those suggested are possible, and the choice of species should be influenced by factors such as the natural range of the species, mine-soil characteristics, availability of planting stock, market preferences, potential commercial value and the character of the surrounding landscape. For a given locality, consult appropriate 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 planting of trees nearly always is required for preventing erosion. But the herbaceous 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 trees by planting them concurrent with the seeding of herbaceous species.

The success or failure of trees planted concurrent with herbaceous seedlings appears to be partly, if not largely, related to the amount and distribution of precipitation during the growing season. Results of limited research also suggest that some herbaceous species are more compatible than others with woody species planted at the same time. For example, ryegrass and Ky-31 tall 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 cover 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 large and dense that the tree seedlings are smothered before they can grow above the legume plants. Low-growing legume species and varieties, therefore, are preferred for combination plantings with trees. In southern Appalachia, for example, Kobe and Korean lespedezas are frequently used as a ground cover with newly planted pine. Tall and aggressive legumes such as common sericea lespedeza, crownvetch, and flatpea are least recommended for combination plantings with trees. Where climatically adapted, the following herbaceous mixture is suggested for a ground cover with trees.

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

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

| <u>Species</u>                  | <u>Pounds per acre (PLS)</u> |
|---------------------------------|------------------------------|
| 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 interspersions. 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 interspersed of planted vegetation; and the type and interspersed 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, reedtop, 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 conifers, 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, disking, or controlled burning and reseedling 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.