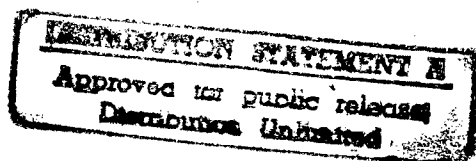


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MARCH 1983

PRACTICES FOR PROTECTING AND ENHANCING FISH AND WILDLIFE ON COAL SURFACE-MINED LAND IN THE SOUTHCENTRAL U.S.



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Fish and Wildlife Service

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There are five manuals in this series:

Practices for protecting and enhancing fish and wildlife on coal surface-mined land in Central and Southern Appalachia. FWS/OBS-83/08.

Practices for protecting and enhancing fish and wildlife on coal surface-mined land in the Green River-Ham's Fork region. FWS/OBS-83/09.

Practices for protecting and enhancing fish and wildlife on coal surface-mined land in the Powder River-Fort Union region. FWS/OBS-83/10.

Practices for protecting and enhancing fish and wildlife on coal surface-mined land in the Southcentral U.S. FWS/OBS-83/11.

Practices for protecting and enhancing fish and wildlife on coal mined land in the Uinta-Southwestern Utah region. FWS/OBS-83/12.

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March 1983

PRACTICES FOR PROTECTING AND ENHANCING
FISH AND WILDLIFE ON COAL SURFACE-MINED LAND
IN THE SOUTHCENTRAL U.S.

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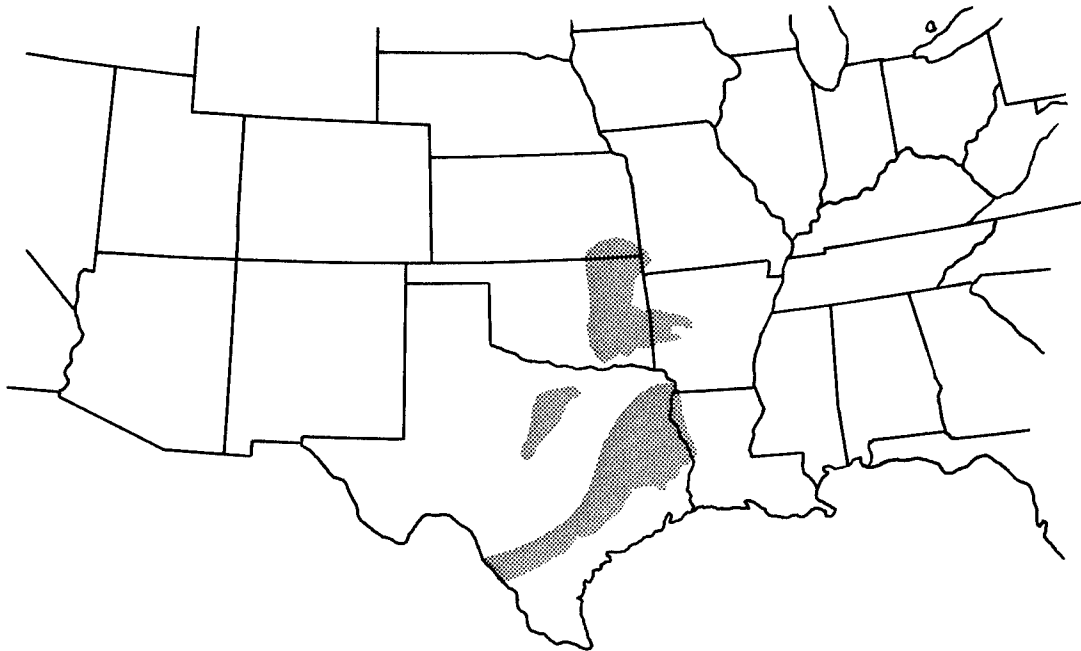
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PREFACE

This handbook contains information on the "Best Current Practices" to protect and enhance fish and wildlife resources on surface mined land in the Southcentral U.S. Current State and Federal legislation was reviewed to determine those practices which were most compatible with the performance standards related to Best Technology Currently Available, Fish and Wildlife Plans, and Reclamation Plans. The information presented in the handbook is region specific, mentioning the risks and limitations, the approximate cost, and the maintenance and management requirements of each practice. Reclamation plans are also included, which integrate the best current practices with the restoration of specific habitats in the region.

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The geographical area included in the handbook (Southcentral U.S.) is illustrated by the map below.



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1. INTRODUCTION

Numerous techniques and methods are being used during surface mine and reclamation operations throughout the country to minimize disturbances and adverse impacts to fish and wildlife. Some of these methods are accepted or recognized as state-of-the-art technology, whereas others may be inappropriate or even detrimental. This handbook is presented as a "first approximation" of design specifications, to document effective field techniques being used, and to highlight sources of information for techniques that are now in use. This review also considers equipment, devices, systems, and methods that have proven useful in special cases. At a later date, and as more information becomes available, this handbook will be revised and updated to reflect the best current practices state-of-the-art.

To facilitate the transfer of information, the term "Best Current Practices" (BCP) has been used to present the field techniques that have been successful, or that have shown definite promise of being successful, on surface-mined land. The Surface Mining Control and Reclamation Act of 1977 states that "to the extent possible using the best technology currently available (BTCA), [the operator is required to] minimize disturbances and adverse impacts of the operation on fish, wildlife, and related environmental values, and achieve enhancement of such resources where practicable" (Section 515 [b] [24]). Furthermore, the Surface Coal Mining and Reclamation Operations Permanent Regulatory Program states that "within the constraints of the permanent program, the regulatory authority shall have the discretion to determine the best technology currently available (BTCA) on a case-by-case basis" (Section 701.5). The BCP's presented in this handbook are offered as guidelines to the mining community and regulatory agencies for use not only when an environmental problem arises, but also when an operator wishes to initiate a wildlife management program.

IN ALL CASES, THE BCP'S IN THIS HANDBOOK, WHICH ARE SELECTED FOR USE ON A PARTICULAR SITE, MUST BE APPROVED FOR USE BY THE STATE REGULATORY AUTHORITY. IN SOME INSTANCES, A BCP MAY NOT CONFORM TO THE LATEST STATE REGULATORY PROGRAM.

1.1 USE OF THE HANDBOOK

This handbook is one of several informational guides developed by the U.S. Fish and Wildlife Service to aid mid-level managers, field inspectors, and mine reclamation specialists in the coal regions. Its purpose is to identify methods by which fish and wildlife resources can be protected and

enhanced during the various phases of mine development and reclamation. Some of the techniques and practices are more applicable in the Southcentral U.S. region, while others can be used in more than one geographic region or coal basin.

The handbook has been arranged to first present a section (Chapter 2) on the planning needs for fish and wildlife resources during the mining process. Regional problems are identified and the specific needs that individual sites might have are highlighted. Planning needs which are discussed include gathering baseline data, the evaluation of site potential, the preparation of a fish and wildlife plan, and reclamation planning.

Next, BCP's for protection and enhancement of fish and wildlife resources are presented (Chapter 3). The format for each BCP generally follows the topical outline below:

Purpose: The usefulness of each BCP is explained, giving its geographic and habitat applicability.

Development: The steps for implementing each BCP are given, emphasizing the BCP's relationship to postmining land uses and compatibility with other BCP's.

Maintenance and Management: Considerations of the long-term upkeep requirements of some BCP's are identified.

Labor and Materials: To give some idea of the cost of implementing a BCP, levels of effort are given in terms of man-hours, types of personnel, and dollar values (where costs could be estimated). Equipment and construction materials are itemized where applicable.

Sources of Information: For further assistance, the following information has been provided where it was available: the company or agency who used or proposed the BCP; government contacts; and useful literature, such as books, journal articles, technical publications, and studies.

Finally, reclamation alternatives are given for specific habitats in the Southcentral U.S. (Chapter 4). For a typical site within a habitat, appropriate BCP's are presented which are compatible with the terrain and indigenous fish and wildlife resources. These reclamation alternatives are designed to be used as an example of what could be done for fish and wildlife under a certain set of environmental conditions in the region. As a guide, they can offer ideas and suggestions to aid an operator with the preparation of a site-specific reclamation plan.

The BCP's described in this handbook were chosen because of their applicability to the Southcentral U.S. Considerations in their choice included the

habitats to be reclaimed, major fish and wildlife species in the area, the postmining land use, and the objectives of the reclamation plan.

With the above considerations in mind, the BCP's are somewhat regionally specific. However, many of the BCP's can also be used in other areas that have similar combinations of habitats, species, postmining land uses, and objectives in the reclamation plan.

1.2 FACTORS AFFECTING PROTECTION AND ENHANCEMENT PRACTICES

In the past, the environmental problems associated with area mining in the Southcentral U.S. involved a general depletion of soil fertility and an alteration of natural drainages. During regrading, the best soils were oftentimes buried and unusable to cover crops planted later. Fertilizing was also done sporadically, if at all, with inadequate quantities of amendments being added. Because of the large size of area mining operations, waterways were often rerouted, producing unanticipated and detrimental offsite impacts. Current Federal and State surface mining laws have addressed these concerns and have created regulations to help eliminate most of the problems.

Today, the single most important factor affecting fish and wildlife resources during surface mining operations is the failure to consider these resources during reclamation. Often, postmining land use plans contain few proposed practices which will enhance wildlife habitat on the site, and this, in turn, creates a situation where wildlife populations take considerable time in recovering from the impact of mining. However, it should be realized that fish and wildlife resources are a valuable asset which the landowner and operator, with a little preplanning, can easily incorporate into any postmining land use objective. For example, a small investment in appropriate reclamation plantings and planting patterns can bring long-term benefits in terms of increased wildlife production. Money may actually be saved in some cases by designing sediment ponds so that they can be left on site for waterfowl or fishery use. The landowner will benefit from the recreational aspects of wildlife on his land, while the operator will profit from the favorable public relations from the maintenance of wildlife areas. Sport fishing and hunting is a big business, and development of areas conducive to this industry certainly provides a stimulus to the local economy.

Once initiated, some wildlife protection and enhancement practices require little maintenance, whereas others may require periodic upkeep. Ordinarily, an area which is reclaimed for a diversity of wildlife will require no maintenance. The area is fertilized and planted, and then allowed to regrow, providing benefits to many different wildlife species as regrowth continues. On the other hand, if a long-term management program for white-tailed deer is begun, certain practices will periodically have to be undertaken to ensure that the management goal is accomplished. These include such activities as periodic thinning of cover to create browse areas and replanting of grassy openings to provide high-quality food.

Ultimately, the question arises as to how much additional cost, if any, would be associated with providing protection and enhancement to fish and wildlife. An effort was made to answer this question to the extent that it could be done without knowing the site-specific characteristics of a particular mine. After reading the sections on Labor and Materials in Chapter 3, the operator should then seek the advice of local surface mining regulatory offices, fish and wildlife agencies, and Soil Conservation Service officials, who can help "fine-tune" the cost information. In most cases, overall costs will be minimal and, as mentioned earlier, may actually save money compared to other land use options. The final cost, however, will depend on the combination of techniques the operator and landowner wish to use to satisfy the land use objective at their particular mine site.

2. PLANNING

2.1 FISH AND WILDLIFE NEEDS

Fish and wildlife have certain basic habitat needs which must be met. These needs include the presence of food, cover, and water within the home range of the animal. These elements also have to be arranged in a particular pattern (interspersed) to ensure accessibility. A successful reclamation plan to enhance fish and wildlife resources must consider all these factors. If one or more of the elements is missing, no amount of effort can achieve the desired enhancement objective. For example, the properly-sized food plots, cover patches, and water resources for cottontail rabbit management might be incorporated into a reclamation plan, but if some of the escape cover is not located near enough to the food plots, predation and high mortality will more than likely cause the management effort to fail.

Not all animals have the same habitat requirements. In fact, even closely related species may have important differences in their habitat needs. It is these differences, when considered in a wildlife management plan, that will ultimately determine the success or failure of the plan. Following are general discussions on the habitat requirements of selected species in the Southcentral U.S. region. This information has been compiled primarily from Dickson and Vance (1981), U.S. Forest Service (1969, 1971), Rafail and Vogel (1978), U.S. Soil Conservation Service (1979a, b), and Hinkle et al. (1981). References containing information on habitat requirements and management of wildlife are listed in Additional references on page 12.

2.1.1 Bobwhite Quail

Quail prefer areas with a good mix of open woodlands, brush, grass, and cultivated land. Their food consists of about 15 percent animal matter and 85 percent plant material. The animal food which adult birds feed on is composed predominantly of insects, such as beetles, weevils, caterpillars, and crickets. Young birds feed almost exclusively on these insects. The plant material is composed mainly of seeds and fruits, although some green vegetation is taken. Plants which produce a smooth, hard seed, such as ragweed, goatweed, and partridge pea, are important food items. Agricultural crops, such as corn, grain sorghum, legumes, soybeans, and small grains, are utilized. High protein green forage is important during winter periods. In this region, bobwhite quail are not dependent on free water and can meet their requirements through dew, rain, snow, succulent herbs, flesh, fruits, and insects.

Quail are often found along the borders or edge of habitats. Here, they can obtain nesting, loafing, escape, and protective cover. Loafing or nesting

cover, composed of low growing woody plants, such as sumac and hackberry, is used during the middle of the day between feeding periods. The previous year's growth of herbaceous cover provides the most ideal nesting sites. In many cases, the edge of roads, fence rows, or firelanes are favorite spots selected for nesting. Escape cover is provided by shrub thickets, while roosting cover is usually at ground level, allowing unrestricted flight in any direction.

Generally, the closer together the required food and cover are, the smaller the home range will be. In most instances, the average home range of a covey is about 16 hectares (40 acres).

2.1.2 Cottontail Rabbit

Cottontail rabbits are found in areas where grassland, cropland, woodland, or mixtures of these habitat types are interspersed with brushy areas. Cotton-tails eat a variety of plants, both herbaceous and woody, depending on the season. Preferred foods are clovers, alfalfa, blackberries, dewberries, grain sorghum, and apples. Woody plants, such as sumac, sassafras, and orchard trees, are eaten more in the winter, when herbaceous plants are not as available due to dormancy and snow cover. These food sources are often adjacent to low, relatively dense ground cover, which provides escape cover. Nesting cover is usually in low vegetation, such as grasses, grass-forb mixtures, vines, or shrubs. Thickets composed of blackberry, sumac, and broomsedge are favorite nest sites. Like bobwhite quail, most water requirements can be met by moisture from succulent plants and dew. Where all the above habitat requirements are met, the home range seldom exceeds 8 hectares (20 acres).

2.1.3 White-tailed Deer

White-tailed deer use a variety of forest, brushy edge, and field habitat types. Favored escape cover is composed of dense woodlands, wood thickets, conifers, and tall weeds. Japanese honeysuckle thickets and other shrubs are preferred concealment locations. During the winter, stands of pine provide cover, while tall grasses are used as resting cover. These areas are often found in draws and along slopes, in places where there is rough topography, in motts or thickets in open areas, or along streams in prairie areas.

Occasionally, deer browse on the same plants that provide their cover. Preferred foods are woody shoots, grasses, forbs, and a variety of fruits and mast. Oak, persimmon, and redcedar are important browse species, along with greenbrier and sorghum. Browse makes up a portion of the diet during all seasons, but is especially important in the winter. Forbs, grasses, seeds, and fruits are important food items in the spring, summer, and early fall. In addition to native plants, deer also feed on many agricultural crops during the warmer months, such as peanuts, corn, vetch, peas, oats, ryegrass, and wheat.

Although deer require a source of open water daily, their water needs are met to some degree by succulent plants. Daily water consumption in most areas will vary from one-half to one gallon. In the dryer parts of Texas and Oklahoma, the availability of water may limit population density.

The area needed to maintain a deer herd depends to a great degree on the accessibility of food, cover, and water. When seasonal food and cover requirements are met, the size of their home range will normally fluctuate between 120 and 260 hectares (300 and 640 acres).

2.1.4 Mourning Doves

These birds are usually found near open areas where grains are present. The cultivated grains, seeds from native grasses, and forbs, such as croton and sunflower, are the major food items. The most popular feeding areas are fields where a crop has been harvested, leaving waste grain. Insects are also occasionally eaten, along with the ingestion of gravel or grit. The seasonal distribution of plant food intake normally consists of the following percentages.

	<u>Spring</u>	<u>Summer</u>	<u>Fall</u>	<u>Winter</u>
Grain	20-50%	10-31%	5-15%	10-25%
Legumes	0-15	5-15	10-30	5-15
Grasses and sedges	5-15	30-50	20-40	30-60
Trees and shrubs	0-5	0	0-10	0-15
Spurges	0-5	5-20	0-10	0-5
Composites, weeds, and herbs	20-50	5-25	15-25	5-15

The mourning dove is one of the most adaptable of all species, as indicated by its wide geographic range. However, they tend to prefer agricultural areas within this range, rather than being widely distributed over several habitat types. Trees, hedgerows, and shrubs around cultivated fields furnish doves with nesting and roosting sites in these areas. Wires between utility poles provide roosting sites.

Water is often a limiting factor since they require a source of open water daily. This need is especially important during the nesting season because of the increased intake during this period.

2.1.5 Waterfowl

During the winter months in the Southcentral U.S., large numbers of waterfowl can be found on lakes, ponds, and rivers where they are provided some degree of protection. A large percentage of these ducks and geese overwinter in the Southern States and provide many enjoyable hours of recreational birdwatching and hunting. Several species, such as the wood duck, are year-round residents and are particularly abundant in hardwood bottomlands.

In general, waterfowl utilize a wide variety of food types consisting mainly of vegetable matter in the form of seeds, leaves, stems, and roots of aquatic plants, in addition to various amounts of animal matter. In Texas, it has been determined that there are basically three plant groups important to ducks. These three groups include plants commonly referred to as smartweeds, millets, and pondweeds. In Texas, over 30 species of smartweed, at least a half dozen millets, and over a dozen species of pondweed are known to be of

importance to ducks. In addition, some ducks, such as the mallard and blue-winged teal, consume domestic grains when they are available.

Diving ducks, such as the canvasback, redhead, and ring-necked duck, utilize a variety of food types, including seeds, stems, leaves, and roots of aquatic plants. Their diving abilities enable them to better utilize many submergent plants to depths of 1.8 m (6 ft). Research data based on stomach analyses reflect the use of such vegetation by diving ducks, although a wide variety of food types are commonly utilized by both divers and surface feeders. The following is a list of food plant groups preferred by divers:

Widgeongrass	Watershield	Bulrush
Pondweed	Coontail	Algae
Waterlily	Duckweed	Musk grass
Smartweed	Spike rush	Wild celery

Each of these plant groups is represented of one or more species. Plant preference depends on the species of duck and varies from region-to-region, and within a given region, from locale-to-locale. It is not uncommon to witness both diving and surface ducks feeding side by side. However, divers do exhibit a food preference unique to this group, and, likewise, habitat requirements for divers vary accordingly.

Geese feed primarily on agricultural grain crops, such as sorghum, corn, and rice, often taking the left-over grains in open fields. Some animal matter, such as insects, crustaceans, and mollusks, are occasionally utilized when geese feed in the aquatic environment.

The term "cover," as it applies to other wildlife species, is not a necessity with waterfowl. Generally, waterfowl prefer more open conditions, relying on eyesight and speed of flight to escape predation. However, the presence of loafing or resting areas, which could be considered as cover, have been found to be a useful, if not essential, element of waterfowl habitat. Such areas provide a place for both resting and preening. Waterfowl do, on occasion, utilize certain types of vegetative cover as shelter during severe weather and/or high winds. Shoreline areas affording protective cover along bays, covers, inlets, backwater areas, and stilling basins are but a few examples. One species which relies heavily on woody cover is the wood duck. Wood ducks require this type of cover for breeding, rearing young, and roosting.

2.1.6 Furbearing Animals

Red and gray fox, raccoon, opossum, skunk, mink, coyote, and bobcat are all important furbearing species that can utilize or inhabit reclaimed surface mines. Although it is not normally practical to develop or manage specific habitats for these species, a reclaimed area could be enhanced to some degree for their use by knowing their habitat requirements.

Raccoons are found primarily in bottomland hardwood forests and marshes, but will use a variety of other habitats, including cultivated areas, tall

weeds, broomsedge, pine-hardwoods, and pine. Ground and tree dens are used for shelter and escape although tree dens are preferred for raising young. Rock outcrops and brush piles can also provide denning cover. Red and gray foxes and skunks use a diversity of cover types. Skunks prefer weedy and brushy fields in semi-open country near water, and foxes and coyotes use similar areas and woodlots. Opossum tend to favor wooded areas along streams, lakes, or swamps. Mink inhabit areas near streams, marshes, lakeshores, and riverbanks. They prefer dense vegetation and small streams with pools that have irregular shorelines. Foxes, skunks, and opossum utilize ground dens.

Furbearing animals generally eat both plant and animal foods, and the availability of desired foods is a major factor in the utilization of an area. Important animal food items include mice, rabbits, frogs, birds, bird eggs, a variety of large insects, and insect larvae. Furbearers also utilize plant material, especially fleshy fruits, such as wild plum, grapes, and persimmon. Raccoons normally live and feed along water courses and swamps in forested areas, but they will seek food on reclaimed surface mines, especially where water is present or nearby.

All of the furbearers require a source of free water daily. However, because they either live near water or tend to travel widely during their search for food, finding water usually does not present a problem.

The home range of furbearers is generally large; therefore, the use of a newly revegetated surface mine by these animals would be due mostly to local animals attracted to it from within a radius of about 1.6 km (1 mi). For example, raccoon will range up to 3.2 km/day (2 mi/day) along shores. Their home range is about 120 hectares (300 acres). Gray foxes, coyotes, and bobcats have home ranges of several thousand acres.

2.1.7 Nongame Birds

The Southcentral U.S. has a great variety of nongame birds (greater than 300 species), reflecting the large number of habitat types in the region. Songbirds, such as cardinals, mockingbirds, thrashers, towhees, and sparrows, are attracted to brushy areas and small clearings, whereas tanagers, warblers, vireos, and thrushes are common woodland species. Shorebirds, such as sandpipers, snipes, rails, and woodcock, prefer marshy or swampy areas, while pastures and hayland attract killdeer, sparrows, blackbirds, meadowlarks, and bluebirds. Open areas around grasslands and scrub growth are ideal habitat for hawks and owls.

Nongame birds vary considerably in their food requirements. In general, insects are taken in the spring and summer when they are most available, while fleshy fruits and seeds are eaten in the fall and winter. Dogwood, wild cherry, pine, and oak are important woody plant species utilized for food, while panicgrass and ragweed are valuable non-woody food producers. Generally, most species will benefit from the management practices instituted for quail and dove. Birds, like owls and hawks, are specialized predators, feeding primarily on rodents.

Many nongame birds get water to meet their metabolic needs from the food they eat. However, stockponds and/or streams are essential for some species. Wading birds, kingfishers, and nongame species of ducks and grebes require water within their habitat.

2.1.8 Threatened and Endangered Species

There are a few species of plants and animals which are presently in danger of becoming extinct or eliminated from an area because of loss of suitable habitat. These species often have very special needs which are met only under certain environmental conditions in a few restricted geographic areas. For this reason, they are highly susceptible to changes in their habitat. In some instances, the Federal Endangered Species Act protects these species, while, in other cases, State regulations are in effect. If it is determined that one of these species occurs on a mine site, the State regulatory authority should be informed of its presence. This will enable the proper authorities to evaluate the impact of mining on the species and to take the steps necessary to minimize the impact.

2.2 MANAGEMENT FOR FISH AND WILDLIFE

Active management for fish and wildlife is a viable part of the surface mining process which can provide long-term benefits to the landowner and society in general. This is an important part of the mining process and should be integrated into all phases of planning.

Long-range planning is necessary because the benefits from managing for fish and wildlife continue beyond the reclamation bonding period. For example, management for reclaimed woodland, riparian habitats would be a long-term goal over several years, realized only after hardwoods, such as cottonwoods and willows, and understory growth, such as alder and buttonbush, were established on the site. In addition, some continued maintenance of the various vegetation phases might be necessary to keep the best habitat for the selected species. Thus, planning for wildlife should begin in the premining planning phase (Hinkle et al. 1981; Schnell et al. 1981).

Certain considerations are necessary to accomplish effective long-range planning that allows for full development of fish and wildlife in the reclamation plan. These considerations include:

- o literature review and synthesis
- o baseline data gathering
- o site potential evaluation
- o goal-setting
- o reclamation planning
- o fish and wildlife planning

The baseline data provide the working foundation for effective management planning. Most of the information gathered in the permitting process can be used to help protect and enhance fish and wildlife resources (Hinkle et al. 1981). After the land use/cover types, wildlife habitat types, aquatic resources, types of fish and wildlife natural to the area, and unique habitat or biological features have been determined, all other planning can be more responsive to fish and wildlife needs.

Knowledge of the premine site characteristics will provide the basis for determining the site potential for fish and wildlife management. The success of species and their habitats naturally occurring in the area gives insight into potential success of managing selected species. The characteristics of the areas around the mine site will indicate the potential for selected species management on the site, particularly in cases where species home ranges extend beyond the reclaimed site proper.

Building from the site characteristics and the site potential, realistic goals may be set for managing fish and wildlife. The landowner and/or operator may have preconceived ideas of the goals for postmining land use. Armed with the knowledge of baseline characteristics and site potential, a wildlife biologist can effectively incorporate fish and wildlife into the goals set for postmining land use. For example, green belts may be interspersed in residential/commercial areas; buffer zones, wind breaks, hedgerows, food plots, and other vegetation patches, as well as impoundments, may be incorporated into grazing land, forest land, agricultural land, or other multiple land use alternatives. Fish and wildlife use is also a viable goal in itself.

Reclamation planning and fish and wildlife planning should be coordinated, whether the proposed postmining land use is solely for fish and wildlife or for some multiple use. After the goals are set, specific measures may be taken to apply the best current technology or practices to achieve fish and wildlife enhancement. Several Federal and State agencies can assist in planning and developing fish and wildlife habitat. Some State regulatory authorities and OSM offices have staff biologists who are experienced in mining technology, as well as wildlife and fisheries management. Other agencies, such as the Agricultural Stabilization and Conservation Service, Soil Conservation Service, State wildlife agency, State forestry service, and the U.S. Fish and Wildlife Service, can provide additional guidance in special planning needs where each agency has a particular expertise. Publications, such as this one and others mentioned throughout this handbook, can provide additional guidance.

References cited:

- Dickson, K. L.; Vance, D. Revegetating surface mined lands for wildlife in Texas and Oklahoma. U.S. Fish and Wildlife Service, FWS/OBS-81/25; 1981.
- Hinkle, C. R.; Ambrose, R. E.; Wenzel, C. R. A handbook for meeting fish and wildlife information needs to surface mine coal, OSM Region IV Washington, DC: U.S. Fish and Wildlife Service, Office of Biological Services, FWS/OBS-79/48.3.4; 1981.

- Rafaill, B.; Vogel, W. A guide for vegetating surface-mined lands for wildlife in eastern Kentucky and West Virginia. Kearneysville, WV: U.S. Fish and Wildlife Service, Office of Biological Service, Eastern Energy and Land Use Team, FWS/OBS-78/84; 1978.
- Schnell, G. D.; Johnson, F. L.; Risser, P. G. Model fish and wildlife plan for a surface coal mine in Oklahoma. Oklahoma City, OK: Oklahoma Dept. of Mines in cooperation with Office of Surface Mining - Region IV; January 1981.
- U.S. Forest Service. Wildlife habitat improvement handbook. Washington, DC: USDA Forest Service, FSH 2609.11; 1969.
- U.S. Forest Service. Wildlife habitat management handbook. Atlanta, GA: USDA Forest Service, FSH 2609.23R; 1971.
- U.S. Soil Conservation Service. Animal guide series. Temple, TX: USDA SCS; 1979a.
- U.S. Soil Conservation Service. Technical standards and specifications for wildlife upland habitat improvement. Temple, TX: USDA SCS; 1979b.
- Additional references:
- DeGraf, R. M. Proceedings of the workshop - Management of southern forests for nongame birds. Ashville, NC: USDA Forest Service, Southeast Forest Experiment Station; 1978.
- Edminster, F. C. American game birds of field and forest. New York: Charles Scribner's Sons; 1954.
- Halls, L. K., ed. Proceedings of the Symposium: White-tailed deer in the southern forest habitat. Nacogdoches, TX: USDA Forest Service and Stephen F. Austin State Univ.; 1969.
- Morrison, J. A.; Lewis, J. C., eds. Proc. 1st Natl. Bobwhite Quail Symp. Stillwater, OK: Oklahoma State Univ. Res. Found.; 1972.
- Sanderson, G. C., ed. Management of migratory shore and upland game birds in North America. Washington, DC: Int. Assoc. Fish Wildlife Agencies; 1977.
- Trippensee, R. E. Wildlife management: upland game and general principles, Volume I, New York: McGraw-Hill; 1948.
- Trippensee, R. E. Wildlife management: fur bearers, waterfowl, and fish, Volume II, New York: McGraw Hill; 1953.

3. BEST CURRENT FISH AND WILDLIFE ENHANCEMENT AND PROTECTION PRACTICES

3.1 PRELIMINARY PRACTICES USED TO ENHANCE AND/OR PROTECT FISH AND WILDLIFE RESOURCES

3.1.1 Roads

PURPOSE

The impacts associated with access and haul roads can be reduced by consideration of fish and wildlife in the design and construction activities. Fish and wildlife resources may be affected over a potentially large area by roads. For example, a haul road with a 6-meter (20-foot) right-of-way covers 1 hectare (2.4 acres) every 1.6 kilometers (1 mile). Destruction of important habitat, wildlife disturbance from vehicles, and the creation of barriers to wildlife travel are negative impacts which can be reduced by proper road location, design and construction. In most cases, there is minimal direct danger to wildlife from vehicle collisions. However, where this is a potential problem, the following techniques coupled with a reduction of speed will minimize the problem.

DEVELOPMENT

Standards and specifications concerning the design and construction of roads are included in State and Federal surface mining regulations. These requirements, along with other engineering aspects dictated by site conditions, must be given first priority when designing and constructing roads. During the planning process, however, fish and wildlife protection and enhancement practices can easily be incorporated into most engineering plans. For example, management practices for sedimentation and siltation control are common elements of most road planning and are extremely important for protection of fish and water resources.

Destruction of wildlife habitat is often unavoidable when building roads, but careful siting can reroute roads to avoid areas of significant value. One way of preserving an area of high-value habitat, such as the edge between a woodland and an open field, is to locate the road a hundred feet or so away from the edge, preferably in the field. This is especially important when critical habitat for an endangered or threatened species has been identified within an area. Adequate buffer zones should be provided for these sites (see Section 3.2.2.a, Buffer Zones).

Roads are sometimes barriers to normal wildlife movements because they separate different habitat types frequented by a species. While roads may not completely prevent movement of wildlife from one area to another, they do create conditions that disrupt normal behavior. Roads carefully located to avoid isolating habitat types and features, such as a watering area, from other wildlife-use areas are preferable in reducing wildlife disruption.

When possible, locate roads below ridgelines (Thomas 1979). This tends to confine any wildlife disturbance created by traffic to one side of the ridge by using the ridgeline as a noise and visual screen. The benefits to be realized in the limiting of disturbance to wildlife must be carefully considered against the additional disturbance caused by having to cut roads into hillsides. Loose dirt cut from the roadway would be pushed downslope, causing additional disturbance in terms of loss of vegetation and siltation.

Direct mortality losses due to vehicle-wildlife collisions are reduced by a number of measures. Animals can be discouraged from frequently using rights-of-way by management techniques that make the rights-of-way unattractive (see Section 3.2.2.c, Rights-of-Way Management). If necessary, fencing can be used to prevent wildlife from entering the roadway (Section 3.1.4, Fences). Fencing can also be used to guide animals to sections of roads where it is safer for them to cross. Sighting distances can be improved for vehicle operators and wildlife by using a larger radius for horizontal and vertical curves and by increasing the right-of-way width on the inside of horizontal curves (Figures 3.1-1 and 3.1-2). This allows more avoidance time for drivers and more escape time for animals.

Roads which are to be removed and reclaimed after mining can be used to enhance wildlife habitat by innovative revegetation. Reclaimed roadbeds can be revegetated to increase habitat diversity by using plants suitable for wildlife and converting them to strip plantings (see Section 3.3.1.1, Planting Patterns). Roadbeds in forested areas can be reclaimed with grasses as open areas, while roads which pass through open fields can be planted with trees and shrubs to create cover and wildlife travel lanes.

MAINTENANCE AND MANAGEMENT

Road design and construction techniques for fish and wildlife protection and enhancement generally do not require any management beyond normal road maintenance except in cases requiring special structures. Fences, for example, would have to be checked periodically for repair.

LABOR/MATERIALS

Most of the effort for including fish and wildlife considerations in the design of roads is required during initial planning. Higher construction costs may be incurred in implementing some techniques, such as increasing a road's length when avoiding important habitat. In this and most other cases, the additional cost can be offset because no other mitigative measures are required.

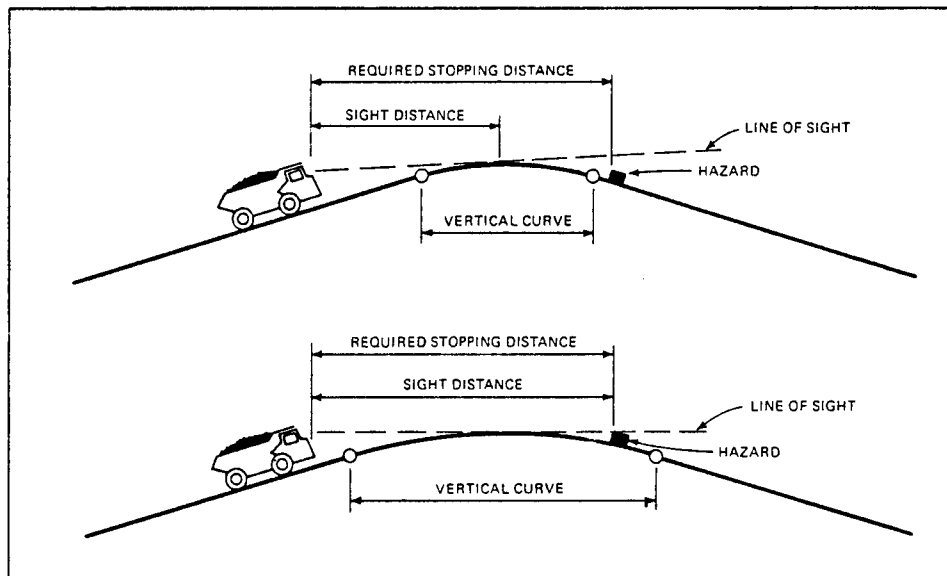


Figure 3.1-1. Sight distance on vertical curves (from Chironis 1978).

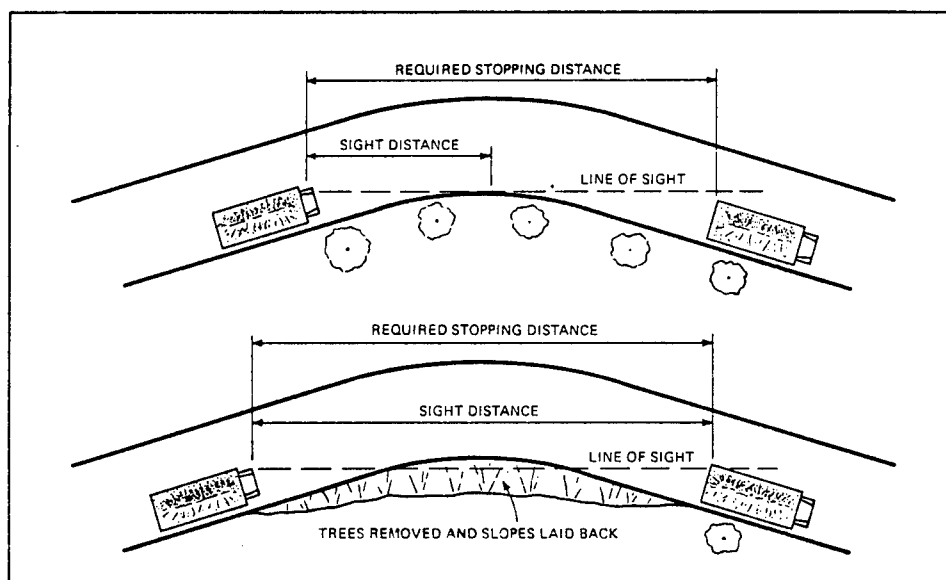


Figure 3.1-2. Sight distance on horizontal curves (from Chironis 1978).

SOURCES OF INFORMATION

Information concerning the location and significance of the fish and wildlife resources within the permit area can be obtained from the fish and wildlife inventory prepared for the permit application. Additional planning information and technical assistance can be requested from:

- o State Regulatory Authority
- o Office of Surface Mining
- o State Fish and Game Agency
- o U.S. Fish and Wildlife Service
- o U.S. Forest Service
- o State Department of Highways/Transportation
- o State Forester
- o Agricultural Extension Service

References cited:

Chironis, N. P., ed. Designing safer and speedier haul roads. In: Coal age operating handbook of coal surface mining and reclamation, vol. 2: McGraw-Hill, New York; 1978.

Thomas, J. W., ed. Wildlife habitats in managed forests: The Blue Mountains of Oregon and Washington. Agriculture Handbook No. 553: U.S. Department of Agriculture, Forest Service; published in cooperation with Wildlife Management Institute and U.S. Department of the Interior, Bureau of Land Management; 1979.

Additional references:

U.S. Forest Service. National forest landscape management. Volume 2, Chapter 4, Roads. Washington, DC; 1977.

3.1.2 Powerlines

PURPOSE

The design and construction of powerlines significantly affect wildlife populations. Impacts to wildlife occur indirectly from design of the powerline and management of the right-of-way and directly from clearing, construction and cleanup activities. In general, the larger the powerline system, the greater the degree of impact.

Because of the importance of powerline considerations in planning, several excellent publications have been made available to aid mine operators and other individuals responsible for installing lines. The information presented in this section is therefore brief and not intended to take the place of other manuals. It is important, however, to highlight the design concerns and planning activities associated with powerlines to emphasize their overall significance in planning.

DESIGN CONSIDERATIONS

- o In areas frequented by large birds (e.g., eagles, hawks, and herons), power poles are favorite perches. Occasionally, the birds come in contact with wiring and fixtures on distribution line poles and are electrocuted. On any given system, relatively inexpensive modifications (i.e., primarily structural design) to frequently used power poles, over relatively short stretches of line, will greatly reduce mortality.
- o Powerline routes should avoid open expanses of water and marshland which are used as flight lanes by migratory waterfowl and other birds. Areas heavily used as nesting and rearing sites by wildlife should be avoided. If construction of the line through wetlands areas is unavoidable, short-term disturbances, such as traumatic dispersal and reduced numbers of offspring, may result, while long-term impacts in the form of injury and mortality from collisions with electrical structures could occur.

CONSTRUCTION CONSIDERATIONS

- o Access and construction roads should be located in a manner that will minimize erosion. Road grades and alignments should follow the contour of the land with smooth, gradual curves when possible. The single greatest impact to most fish and wildlife during powerline construction results from stream degradation due to siltation from improperly sited roads.

- o When clearing for the right-of-way, practices should be used which minimize the amount of cutting and reduce scarring of the landscape and silting of streams. Appropriate clearing techniques and machinery will greatly decrease the amount of time needed for regrowth of the wildlife habitat in the disturbed area.
- o Where replanting of vegetation is required, native plants which have value as food and cover for wildlife should be given priority over introduced species of plants.
- o Brush or small trees which are cut for clearing can be piled in such a way as to provide cover habitat for small game animals and birds.

SOURCES OF INFORMATION

Additional information on powerlines and their effect on wildlife can be obtained from:

- o State Regulatory Authority
- o Office of Surface Mining
- o U.S. Fish and Wildlife Service

Additional references:

Rural Electrification Administration. Powerline contacts by eagles and other large birds. REA Bull. No. 61-10; 1972.*

U.S. Department of Interior and U.S. Department of Agriculture. Environmental criteria for electric transmission systems; 1970.*

U.S. Department of Interior. Management of transmission line rights-of-way for fish and wildlife. Volume 1. Background information. U.S. Fish and Wildlife Service. FWS/OBS-79/22; 1979.

U.S. Department of Interior. Management of transmission line rights-of-way for fish and wildlife. Volume 2. Eastern United States. U.S. Fish and Wildlife Service. FWS/OBS-79/22; 1979.

U.S. Department of Interior. Management of transmission line rights-of-way for fish and wildlife. Volume 3. Western United States. U.S. Fish and Wildlife Service. FWS/OBS-79/22; 1979.

*These guidance manuals are available at any Office of Surface Mining and at the central office of the State regulatory authority.

3.1.3 Stream Crossings

PURPOSE

Activities related to the installation and maintenance of stream crossings can have several adverse impacts on fish and wildlife. The shaping of the streambank and the removal of streambank vegetation not only destroys wildlife habitat cover, but also degrades aquatic habitat by subsequent silting-over of spawning and feeding areas. Improper maintenance of the crossing only aggravates the problem over time.

The crossing of streams by exploration, access, and haul roads should be kept to a minimum. Any stream crossing, whether temporary or permanent, must be approved by the regulatory authority. Where drainage structures are required for stream channel crossings, these structures must not affect the normal flow or gradient of the stream or adversely affect fish movements, aquatic habitat, or related environmental values.

ILLUSTRATION

During the exploration for coal and the construction of access roads, a temporary stream crossing is accomplished by simply fording the stream. Fording has a tremendous impact on the streambank and stream bottom and often can cause silting of downstream habitat. If vegetation is removed from the approaches to the stream, continuous erosion and subsequent siltation can become a major problem, requiring remedial action, such as discussed in Section 3.3.2.b on streambank protection. Temporary fords are an economical way to get over a stream, but if they are abused, remedial action can be costly, approaching the cost of installing temporary culverts or bridges.

If temporary fording is considered a viable option, careful planning can reduce the problems encountered. Several considerations are given below:

- o Place rock or other stabilizing material on the approaches to reduce erosion and sedimentation of aquatic habitat.
- o Align the crossing at right angles to the stream to minimize streambed disturbance.
- o Choose a crossing point with stable bottom materials to prevent erosion.
- o Revegetate the streambank after abandonment of the crossing to reestablish the riparian habitat and stabilize the bank to prevent continued erosion.

In the case of temporary or permanent culverts and/or bridges associated with access roads, the structure needed depends on the class of road and stream characteristics. The three classes of roads are defined as: (1) coal haul roads; (2) access roads, other than coal haul roads, that are to be used 6 months or longer; and (3) access roads, other than coal haul roads, to be used less than 6 months. It is advisable to use culverts and/or bridges with haul roads or access roads to be used longer than six months, and, when a perennial stream is involved, these structures are appropriate for any class of road. Culverts and/or bridges must be designed to handle predicted site specific precipitation events. Specifications should be requested from the regulatory authority.

The size of the culvert, installation specifications, and type of culvert will depend on site-specific considerations. Engineering specifications should be obtained from publications that provide criteria for construction methods that are approved by the regulatory authority.

The type of culvert used will determine, to a large extent, how the natural stream conditions will be altered downstream and whether the culvert will act as a barrier to fish passage. Figure 3.1-3 illustrates three types of metal culverts which are commonly used. In addition to these, cylindrical concrete culverts are also used, but are discouraged because their smooth interior generates very high water velocities compared to corrugated metal culverts of the same diameter and gradient.

Several methods have been demonstrated to provide fish passage through culverts (Watts 1974, Evans and Johnston 1976). An arch culvert or bridge (Figure 3.1-4) has been shown to be effective since "natural" water flow may be maintained. This type of culvert disturbs the stream bed very little, and, since the natural stream width is maintained, the water velocity does not significantly change. This culvert type comes in metal plates that are fabricated on site.

Another culvert which allows fish to pass with a minimum of disturbance is the pipe arch culvert. It can be used in smaller streams where the steel arch culvert cannot be used. Water velocities are a real problem with this type, but near-normal flow conditions can be maintained if the gradient is kept below 1 percent. A major problem with these culverts is that, during periods of low flow, the water level in the culvert bottom is so shallow that fish cannot pass through. This flow problem may be reduced through the use of baffles (Figure 3.1-5). Baffles are also used to reduce water velocity where culvert design and installation features cannot effectively be used for flow reduction. Information on the overall effectiveness of baffle designs is lacking, but is discussed to some extent in McKinley and Webb (1956) and Yee and Roelofs (1980). Normally, baffles are not recommended due to the additional required maintenance and the need to constantly remove debris (Yee and Roelofs 1980).

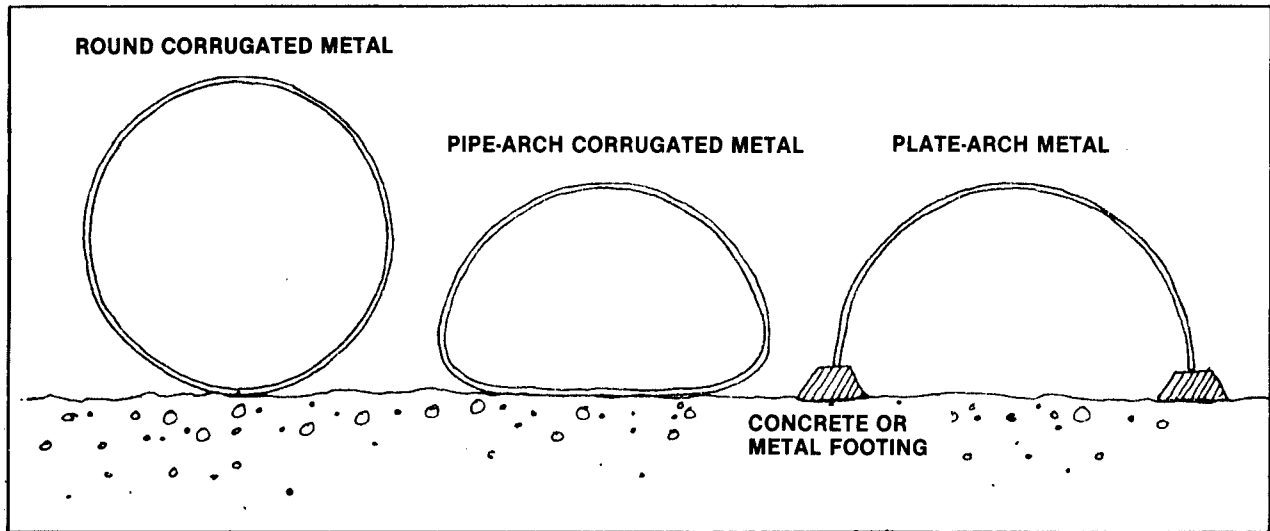


Figure 3.1-3. Cross sections of metal culverts (from Yee and Roelofs 1980).



Figure 3.1-4. The arch bridge, like an arch culvert, provides for fish passage (from Nelson et al. 1978).

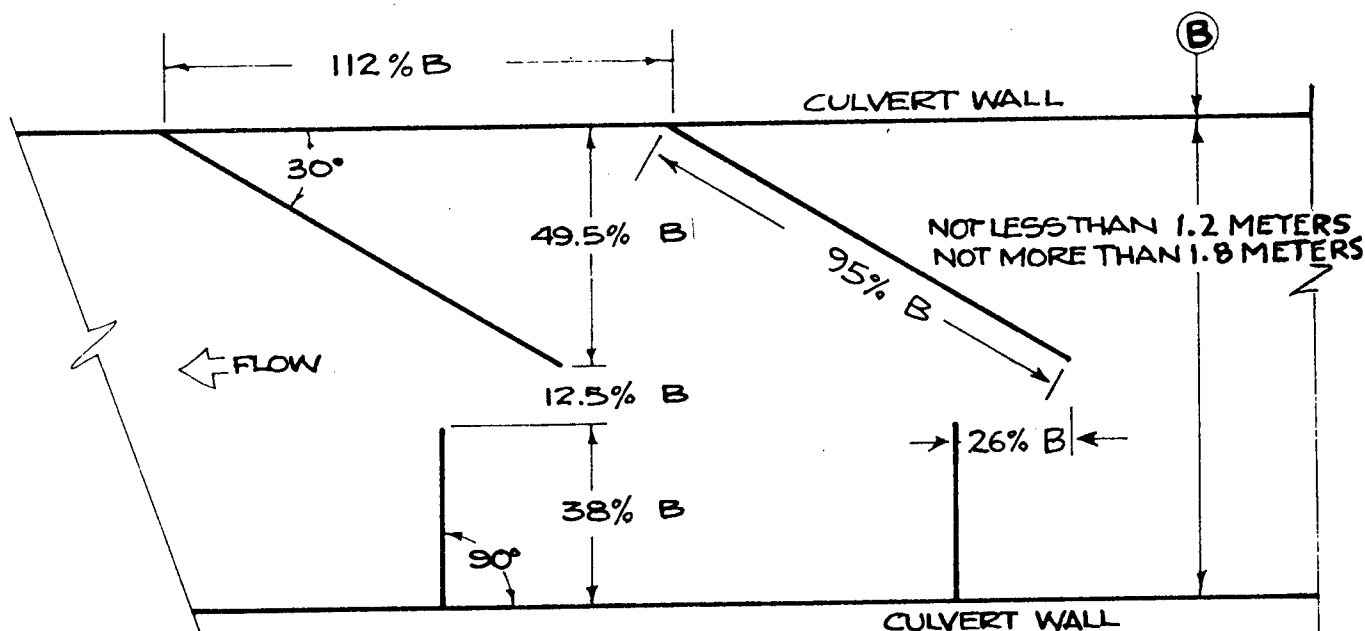


Figure 3.1-5. Baffle placement in a metal culvert (from Yee and Roelofs 1980). Measurements are expressed as percentages of the clear width of the baffled section of culvert (B). Baffles are 0.3 meter (1 foot) high and 13-15 cm (5-6 inches) wide.

The least desirable culvert type with respect to fish passage is the standard, round, corrugated culvert (Figure 3.1-3). Installation of this type of culvert requires narrowing the stream width, which means that to keep water velocity low, the gradient must be near zero. Normal installation of this type of culvert usually leaves an elevated outfall, which creates a barrier to fish passage. However, there are several ways that an outfall barrier associated with a round culvert can be eliminated. One solution is to construct small or low-head dams (Figure 3.1-6) in the tailwater, which will raise the water level to the culvert outfall. Dams create barriers if they are too high [> 0.3 meters (> 1 foot)], and, if dam height becomes a problem, the dam should be notched to prevent it from becoming a barrier. Dams may be constructed from rocks simply laid in the stream, gabions, or other suitable material.

In streams that have a very large fluctuation in water flow, outfall barriers can occur, which can prevent fish passage during low flow periods. This problem is counteracted with stacked culverts (Figure 3.1-7), which are simply multi-culvert installations in which small-sized culverts are placed low to concentrate water at low flow and larger culverts are placed higher to handle high flow (Yee and Roelofs 1980).

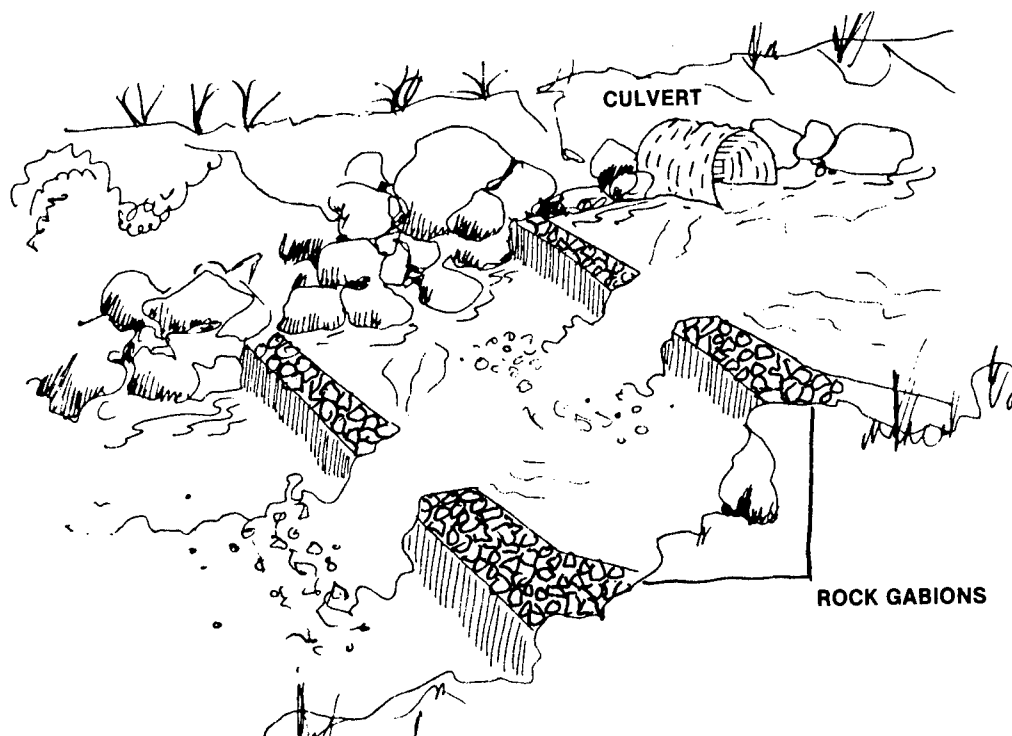


Figure 3.1-6. The use of low-head dams to raise the water level to culvert weight.

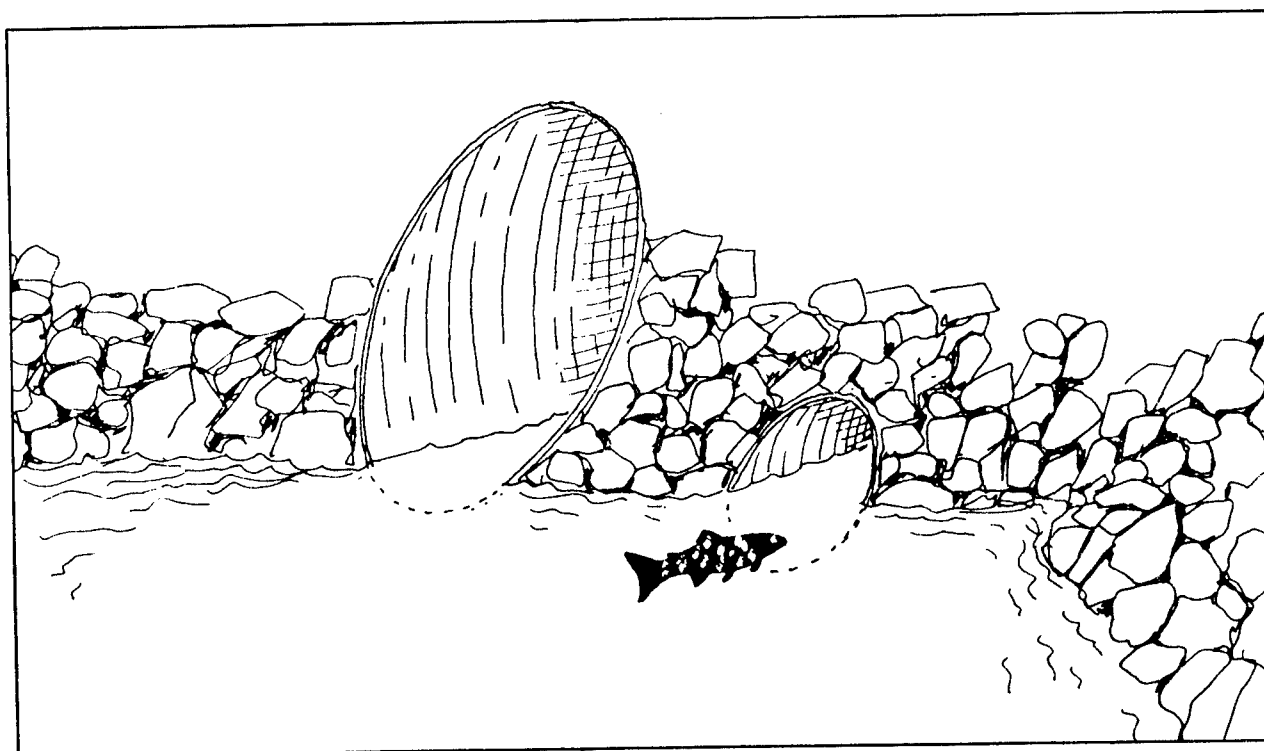


Figure 3.1-7. Multiple or stacked culverts used to compensate for water flow fluctuations. Small culverts concentrate low flow and large culverts handle high flow (after Yee and Roelofs 1980).

To summarize, several factors must be considered to minimize the impact of stream crossings on fish movement (Yee and Roelofs 1980):

- o Where possible, avoid the use of round culverts if fish passage is a problem. Arch culverts or bridges should be used, especially where culverts would be > 30.5 meters (> 100 feet) in length or the gradient > 2 percent.
- o Design the culverts to handle maximum flow (see above).
- o Single culverts are better than stacked culverts, because debris collection is less likely. Use only multi-culverts in situations of large flow fluctuation.
- o Install culverts with the smallest gradient possible (zero preferable). Reduce fish passage restriction and streambed lowering by placing the culvert just under the normal stream grade.
- o Use larger culverts or reduced gradients to avoid baffling if at all possible.
- o Do not place riprap or materials used to stabilize culverts and bridges where it will impede channel flow.

MAINTENANCE AND MANAGEMENT

In the case of fords, stable stream approaches must be maintained. Periodic checks of riprap or other stabilizing material may be necessary. Revegetation of the streambank is appropriate to maintain the riparian habitat.

Debris that collects in the culvert or against bridge structures can prove to be a barrier to fish movement. Periodic checks should be made to remove such materials. Culverts and bridges would have to be maintained within appropriate standards as specified by the regulatory authority.

LABOR/MATERIALS

Culvert or bridge materials, equipment operation, fill haulage, fill placement, and labor would vary in cost according to site-specific considerations. Most road building contractors and State highway department personnel have ready access to information about the cost of such materials. Some States maintain a Unit Bid Price List that contains costs of these and related activities. Some sample costs of culverts are given below:

Corrugated Metal Pipe Culvert	Average Price
91 cm (36 in)-14 gauge	\$ 27.23 per 0.3 m (1in ft)
122 cm (48 in)-14 gauge	\$ 34.82 per 0.3 m (1in ft)
183 cm (72 in)-16 gauge	\$ 66.43 per 0.3 m (1in ft)

Corrugated Metal Area Culvert	
89 x 61 cm (35 x 24 in)-14 gauge	\$ 24.06 per 0.3 m (1in ft)
125 x 84 cm (49 x 33 in)-14 gauge	\$ 30.78 per 0.3 m (1in ft)
285 x 191 cm (112 x 75 in)-12 gauge	\$110.00 per 0.3 m (1in ft)

SOURCES OF INFORMATION

Additional guidance and information on stream crossings can be obtained from:

- o State Regulatory Agency
- o Office of Surface Mining
- o U.S. Forest Service
- o State Highway Department
- o U.S. Army Corps of Engineers
- o U.S. Soil Conservation Service

References cited:

- Evans, W. A.; Johnston, F. B. Fish migration and fish passage - A practical guide to solving fish passage problems. U.S. Forest Service; June 1976.
- Grim, E. C.; Hill, R. D. Environmental protection in surface mining of Coal. U.S. Environmental Protection Agency, Cincinnati, OH, EPA-670/2-74-093; October 1974.
- McKinley, W. R.; Webb, R. D. A proposed correction of migratory fish problems at box culverts. Washington Department of Fisheries, Fish. Res. Paper 1(4):33-45; 1956.
- Nelson, R. W.; Horak, G. C.; Olson, J. E. Western reservoir and stream habitat improvements handbook. U.S. Fish and Wildlife Service, Western Energy and Land Use Team, FWS/OBS-78/56; October 1978.
- Watts, F. J. Design of culvert fishways. Moscow, Idaho: Water Resources Research Institute, University of Idaho; May 1974.

Yee, C. S.; Roelofs, T. D. Planning forest roads to protect salmonid habitat. USDA, Forest Service, Pacific Northwest Forest and Range Expt. Sta., Gen. Tech. Rept. PNW-109; July, 1980.

Additional references:

U.S. Forest Service. Forest Service general provisions and standard specifications for construction of roads and bridges. U.S. Department of Agriculture, Forest Service; 1977.

U.S. Soil Conservation Service. Engineering field manual for conservation practices. U.S. Department of Agriculture; 1975.

3.1.4 Fences

PURPOSE

In the Southcentral U.S., fencing at mine sites is used primarily for livestock grazing management and to exclude white-tailed deer from newly-reclaimed sites. In many cases, cattle, sheep, or goats will be grazing on land adjoining the mine site, and fencing will keep the animals from wandering into the construction site. The problems caused by white-tailed deer are created by their browsing of woody trees and shrubs planted on the reclamation site. Fencing, in some instances, will be required to protect the plantings. In most cases, the type of fence required will vary with respect to the problems at each mine site.

DEVELOPMENT

Where cattle exclusion is the primary goal, a four-strand barbed wire fence will be sufficient. Figure 3.1-8 gives the dimensions for this type of fence, showing wire and post spacing. If white-tailed deer occur in the same area where cattle are being excluded, deer can still cross over or under the fence, providing certain wire-spacing standards are adhered to. The bottom strand should be about 36-41 cm (14-16 inches) from the ground. This will allow does and some fawns to cross under. The top two wires should be no closer than 31 cm (1 foot) apart. This will keep bucks from getting their hind legs entangled in the strands when they jump the fence. Also, the overall height should be around 117 cm (46 inches).

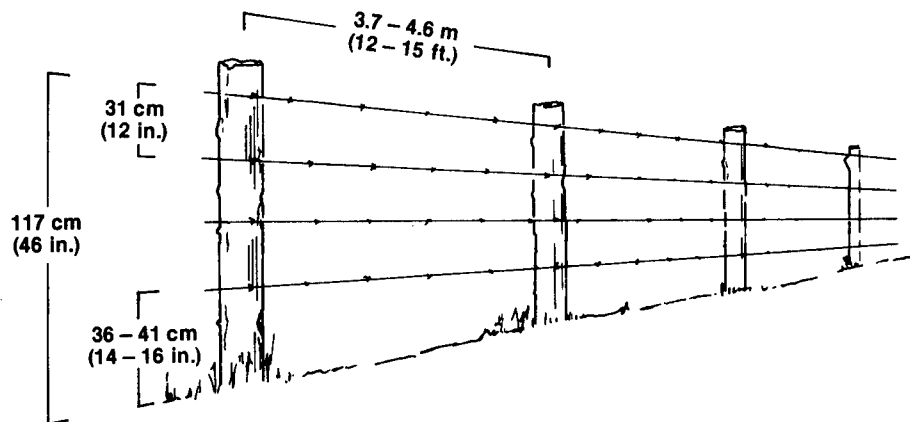


Figure 3.1-8. Four-strand fence for excluding cattle.

Fencing to exclude goats and sheep from an area is a real problem on deer range. Typically, the fence is vertical and made of mesh wire with one strand of barbed wire close to the top of the mesh wire. The mesh wire is usually located so close to the ground that deer cannot pass under, and the distance between the barbed wire and the top of the mesh wire is so small that deer often get entangled in the fence and break their legs when they try to jump it or remain entangled, unable to free themselves.

Currently, the most effective fence in terms of performance and cost for excluding deer from an area is the "slanting" deer fence. Instead of being upright, as most cattle fences are, the slanting fence is inclined at an angle with the high edge pointing in the direction of approach. The angle of slant is approximately 45° and is effective primarily because it acts as a barrier to normal deer movement. Deer often attempt to go under a fence and are discouraged by the fence slanting over their backs. They will not attempt to jump such a fence.

Longhurst et al. (1962) designed a slanting fence suitable for the Southcentral U.S., which consists of mesh wire supported between two guy wires (Figure 3.1-9). Basically, it is constructed in the following manner:

Two guy wires (No. 9 galvanized wire) 1.9 m (6 ft) long are fastened to a vertical post 1.2 m (4 ft) above ground level. The wires form an angle of approximately 45° with the ground and are anchored by 0.6-m (2-ft) long wooden stakes. The 1.8-m (6-ft) line posts are recommended to be set in 0.6-m (2-ft) deep holes, spaced 3.7 m (12 ft) apart.

Starting at ground level and working up, the following fencing materials (as indicated in Figure 3.1-9) are fastened to the guy wires: (1) four strands of barbed wire; and (2) 122-cm-wide (48-in-wide) woven wire. Above the woven wire, two strands of barbed wire are attached to the wooden vertical posts. If desired, an additional 61-cm-wide (24-in-wide) wire mesh can be lain across the barbed wire between the ground level and the woven wire to discourage small mammals from entering between the lower barbed wire strands.

At a point where the fence makes a 90° change in direction, two 2.1-m (7-ft) vertical posts are set 76 cm (30 in) deep and 1.8 m (6 ft) apart on each side of the corner. These are braced with a 1.8-m (6-ft) line post placed horizontally about 0.9 m (3 ft) above ground level. A 2.1-m (10-cm square) [7-ft (4-in square)] sloping post is then inclined from near the top of the vertical corner post to the ground where it is secured with a 20-cm (8-in) spike to a 46-cm (18-in) section of a 10-cm (4-in) diameter post set approximately 30 cm (12 in) deep. The vertical post is notched at the top with a 45° cut to receive the sloping post and hold it against horizontal stress. A pie-shaped wedge of woven wire and several strands of barbed wire are used to close the opening at the corner.

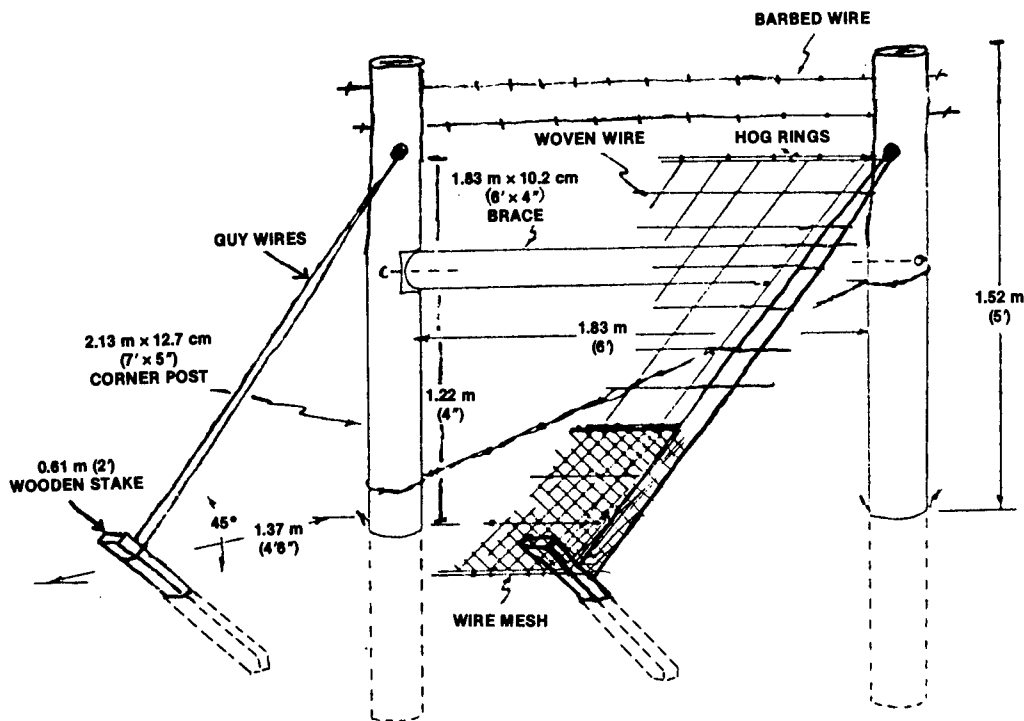


Figure 3.1-9. Diagonal view of slanting deer fence showing guy wire support construction (after Messner et al. 1973).

MAINTENANCE AND MANAGEMENT

Fencing should be checked periodically for broken wire, loose staples, and broken or fallen posts. Replacement or repair is necessary until the need for the fence has passed.

LABOR AND MATERIALS

Cost, man-hours, equipment, and materials needed for fence construction will vary with type of fencing and site-specific characteristics, such as terrain, vegetation types, etc. Average estimates of costs, however, have been calculated for enclosing a 0.13 hectare (0.33 acre) plot [36 x 36 m (120 x 120 ft)] over cleared land for both the cattle-proof (Table 3.1-1) and "slanting" deer fence (Table 3.1-2). Approximately two-man weeks would be required to install the "slanting" deer fence over a 0.13 hectare (0.33 acre) plot; a cattle-proof fence would require one-half this amount of time.

Table 3.1-1. Specifications and costs for a cattle-proof fence [36 x 36 m (120 x 120 ft)].^a

Description	Specification	No.	Unit	Unit Cost	Total
Posts					
Line	1.4 m x 15.2 cm (8 ft x 5 in)	50	ea.	\$5.25	\$262.50
Corner and Brace	1.7 m x 15.2 cm (8 ft x 5 in)	14	ea.	\$5.25	\$ 73.50
Brace Rails	3.7 m x 10.2 cm (8 ft x 5 in)	20	ea.	\$5.25	\$105.00
Barbed Wire	377 m (75 rods) [standard 12.5 gauge]	1 402 (80 rod)	roll m	\$35.45	\$ 35.45
Staples	3.8 cm (1.5 in)	1.6 (3.6)	kg lbs)	\$ 0.60	\$ 2.16
Nails	40 d	3.6 (8)	kg lbs)	\$ 0.50	\$ 4.00
Total cost					\$482.61
Cost per meter					\$ 3.35

^aCosts are base dollars (1981).

Table 3.1-2. Specifications and costs for a slanting deer fence [36 x 36 m (120 x 120 ft)].^a

Description	Specification	No.	Unit	Unit Cost	Total
Posts					
Corner	2.1 m x 12.7 cm (7 ft x 5 in)	16	ea.	\$ 5.00	\$ 80.00
Line	2.1 m x 10.2 cm (7 ft x 4 in)	48	ea.	\$ 4.10	\$185.00
Ground Support					
Post	1.8 m x 10.2 cm (6 ft x 4 in)	4	ea.	\$ 3.90	\$ 15.60
Slanting	2.1 m x 10.2 cm (7 ft x 4 in)	48	ea.	\$ 4.10	\$196.80
Wire (galvanized)					
Smooth	9 gauge 213.4 m (700 ft)	14	rolls	\$ 4.20	\$ 58.80
Woven for main course	12½ gauge mesh, horizontal strands, 10 gauge, 122 cm (48") wide 101 m long	1.5	rolls	\$37.80	\$ 56.70
Barbed, for fence top, bottom and bracing	12½ gauge, 2 pt., 402 m long (79.9 rods)	1 402 m (80 rod)	roll	\$35.45	\$ 35.45
Wire mesh at fence bottom to exclude small animals	45.7 m x 7.3 m with 0.3 cm (150' x 24' with 1") hexagon openings	3.2	rolls	\$13.23	\$ 42.32
Staples	4.4 cm (1 3/4")	4.5 (10	kg lbs)	\$ 0.70	\$ 7.00
Hog Rings					
Join mesh with woven and barbed wires	No. 1	1000	ea.	\$ 0.015	\$ 15.00
Wooden Support					
Stakes	0.6 m (2') long	48	ea.	\$ 1.10	\$ 52.80
Nails	20 cm (8") spike	32	ea.	\$ 0.15	\$ 4.80
Total cost					\$750.27
Cost per meter					\$ 5.21

^aCosts are base dollars (1981).

Upright fences are still being used in some areas of the country to exclude deer, but, to be effective, these fences need to be approximately 2.4 m (8 ft) high. Cost considerations to make when comparing slanted vs. upright fences include the following:

- o The shorter posts of the slanted fence are cheaper than the longer posts of the upright fence, but more posts are needed in the slanted fence.
- o The amount of mesh wire required for the slanting fence is approximately half that required for the upright fence.
- o More barbed wire is needed in a slanting fence. Six strands (two above and four below) are used on the slanting fence, while only two are used (top and bottom) on a 2.4-m (8-ft) high upright fence.
- o Based on material costs, a slanting fence costs \$26.05 per 5 m (rod) compared to \$31.80 per 5 m (rod) for an upright fence.

SOURCES OF INFORMATION

Further guidance and information on fencing can be obtained from:

- o State Regulatory Authority
- o Office of Surface Mining
- o State Fish and Game Agency
- o U.S. Fish and Wildlife Service

References cited:

Longhurst, G. A.; Jones, M. B.; Parks, R. R.; Neubauer, L. W. Fences for controlling deer damage. California Agricultural Experiment Station Service. Circular 514; 1962.

Messner, H. E.; Dietz, D. R.; Garrett, E. C. A modification of the slanting deer fence. J. Range Manage. 26(30):233-235; 1973.

Additional references:

Halls, L. K.; Boyd, C. E.; Lay, D. W.; Goodrum, P. D. Deer fence construction and costs. J. Wildl. Manage. 29(4):885-888; 1965.

U.S. Bureau of Land Management. Fencing. Denver, CO: Bureau of Land Management; BLM Manual Insert 1737; 1975.

U.S. Forest Service. Wildlife habitat improvement handbook. Washington, D.C.: U.S. Forest Service; Forest Service Handbook No. 2609.11; 1969.

3.2 PRACTICES USED DURING MINING TO ENHANCE AND/OR PROTECT FISH AND WILDLIFE RESOURCES

3.2.1 Overburden and Soil Handling

a. General procedures. Incorporating the proper procedures for handling overburden and soil materials into the mine plan is necessary to insure successful reclamation. The decisions on how these materials will be handled will depend in large part on their physical and chemical characteristics, which are determined during the premining analysis of the overburden. The amount of sampling required for the analysis depends on applicable State and Federal regulations, the amount of on-site disturbance, and problems foreseen on the site based on other activities in the area.

The object of the sampling and analysis is to obtain a general knowledge of the soils and overburden and to detect inhibitory zones in the overburden. Site-specific procedures can then be instituted to provide the best situation for counteracting problems in toxicity, salinity-sodicity or acidity, infertility, weatherability, and erodibility. Successful reclamation is dependent on the ability to stabilize a site and to reestablish a good vegetative cover.

Depending on the site-specific situation, mining procedures almost always include:

- o segregation and treatment of toxic materials.
- o segregation and amendment of topsoil, subsoil, and/or soil substitute to be used as a medium for revegetation.

For specific requirements within any one State, the State regulatory authority must be contacted and its regulations followed.

Each mine site will require different procedures, depending on the physical and chemical characteristics of the overburden. It is highly advisable to solicit the help of experts to identify potential problem areas so that mitigative actions can be incorporated into the overall mine plan. The regulatory authority can advise on problems that have occurred in the area, and local soil conservationists can advise on problems related to soil and overburden handling to achieve the best reclamation. General publications, such as the following, provide overviews that can aid in planning:

- o U.S. Forest Service. User Guide to Soils - Mining and Reclamation in the West. Intermountain Forest and Range Experiment Station, U.S. Forest Service, Ogden, UT. Gen. Tech. Rpt. INT-68, SEAM; 1979.
- o U.S. Forest Service. Procedures Recommended for Overburden and Hydrologic Studies on Surface Mines - Thunder Basin Project. Intermountain Forest and Range Experiment Station, U.S. Forest Service, Ogden, UT. Gen. Tech. Rpt. INT-71, SEAM; 1980.

Information provided in the following sections is designed to provide further guidance in handling overburden and soil materials.

b. Selective placement and stabilization of spoils and topsoil.

PURPOSE

In the mining process, it is important to identify problem-producing strata in the overburden so that they can be handled in such a manner that they will not create a spoil that is toxic to plants or contribute acid pollution to streams. Basically, this means separating acid-forming and toxic-forming strata from the neutral or non-acid forming and non-toxic forming strata and burying the acid-forming and toxic-forming strata at the proper depth within the neutral material to prevent leaching, contact with ground water, and contamination of topsoil or soil substitute.

Placement planning and procedures should consider the following:

- o The quantity and characteristics of acid-producing strata that must be dealt with.
- o Potential toxicity and stability problems during storage.
- o Slope and aspect of the storage pile.
- o Access of the mine operator to the storage site.
- o Effect of wind and water on the storage site and the need for erosion control practices.
- o Effects of material storage on adjacent land uses.
- o Treatment, if necessary, to neutralize the material before placement.
- o Location of the stored acid-forming or toxic-forming material within the fill to segregate material from aquifers.
- o Location of fill to segregate it, or runoff from it, from water courses.

DEVELOPMENT

In Texas, topsoil usually is not segregated from other overburden material during the mining operation (Radian Corporation 1978). Various studies have shown that mixed overburdens may provide suitable substrates for vegetation as long as toxic materials, especially pyrites, are buried below the root zone (Angel 1973; Askenasy 1977; Gavande et al. 1979; Brown and Deuel 1980). This is because most of the soil overlaying the lignite deposits consists of a thin sandy to sand-loam surface over a rather dense clayey (i.e., claypan) layer. Sandy to clayey soils do not have good tilth, and the moisture holding capacities are usually not good. Consequently, these characteristics of the soil may be improved by the surface mining disturbances.

An exception to the use of mixed overburdens is required in prime agricultural land or the drier areas of central and south Texas containing unsuitable overburden materials. A mixed overburden in these areas may have greater erosion potential and less desirable soil structure than selectively replaced soil (Gavande et al. 1979).

The overburden materials associated with the bituminous coal deposits of Texas and Oklahoma generally contain more shale than those in the lignite region, creating an undesirable substrate for revegetation (Doerr 1961). Because of this reason, the practice of segregating topsoil during mining to be reapplied during reclamation activities is mandated in Oklahoma (U.S. Soil Conservation Service 1976).

The major problem encountered in the use of mixed overburdens is the formation of acidity. Acidity is caused by the oxidation of pyritic sulfur when exposed to surface conditions. Fortunately, the pyrite content of most soils overlaying the coal seams in Texas is low, and the problem of acidity is not unmanageable. Materials from some overburden may become quite acid, however, and require the application of very large quantities of lime to neutralize them (Maloney 1941). This practice is not only expensive, but it can easily result in marked disturbances in the balance and availability of plant nutrients. Pyrite layers, usually, but not always, found just above the lignite and coal seams, should be analyzed to determine their potential for acidification. If the acidification potential indicates some possible problems, selective placement of the overburden should be made to ensure that pyrites are buried well below the level of root growth.

Acidification of the spoils must be prevented because heavy metals become more soluble in an acid environment and, therefore, reach levels of availability toxic to plants and animals. Concentrations of these metals, such as lead, zinc, chromium, copper, and arsenic, in mixed overburdens are usually within the range and normal concentrations for native soils (Brown and Deuel 1980). So, as long as the spoils are properly limed to prevent acidification, problems with toxicity should not occur.

Chemical analyses have shown that overburden materials in the Southcentral U.S. generally contain adequate concentrations of all essential nutrient elements for plants except phosphorus and nitrogen. The amount of phosphorus and nitrogen required in spoil amendments will depend on their concentration in the spoil and on the plants to be established (see Section 3.3.1.a, Seedbed Preparation).

When segregation and temporary storage of topsoil is required, stabilization of the pile to prevent wind and water erosion can be best accomplished through the planting of coastal bermuda from February to early June. If the early planting season is missed, sudan grass or a summer annual can be used. As temporary winter cover in late fall, different types of clover work well, in addition to rye grass, wheat, or oats.

MAINTENANCE AND MANAGEMENT

Once spoil and topsoil storage areas have been established, they should require no maintenance unless catastrophic rainstorms denude the stockpiles of their vegetation. In this case, the piles will need to be reseeded.

LABOR/MATERIALS

An end dump truck will be required to transport overburden material to an offsite storage location. Later, when the overburden (spoil, topsoil) is being replaced, a front-end loader will be needed to load the overburden on the dump trucks for transport back to the mine. The amount of labor and equipment time will vary significantly with such factors as the size of the operation, the amount of topsoil removed, and the distance to the storage location.

SOURCES OF INFORMATION

Additional information on placement and stabilization of spoils and topsoils can be obtained from:

- o State Regulatory Authority
- o Office of Surface Mining
- o U.S. Soil Conservation Service

References cited:

- Angel, P. N. A soil analysis of the strip mine spoil bank at Fairfield, Texas. Nacogdoches, TX: Stephen F. Austin University; 1973. Thesis.
- Askenasy, P. F. Soil factors influencing row crop production and phosphate adsorption on leveled lignite mine spoil banks. College Station, TX: Texas A&M University; Dept. of Soil and Crop Sciences; 1977. Dissertation.
- Brown, K. W.; Deuel, L. E. Revegetation of drastically disturbed lands. In Proceedings of the Texas A&M University Lignite Symposium; April 17-18. College Station, TX: Coal and Lignite Research Laboratory. 8 pp; 1980.
- Doerr, A. H. Coal mining and landscape modification. Circular 54. Oklahoma Geological Survey. Norman, OK: University of Oklahoma; 1961.
- Gavande, S. A.; Holland, W. F.; Grimshaw, T. W.; Wilson, M. L. Overburden management and revegetation in the Gulf Coast lignite region: problems and solutions, pp. 293-303. In Proceedings of the Symposium on Surface Mining Hydrology, Sedimentology, and Reclamation. Lexington, KY: University of Kentucky; 1979.

Maloney, M. M. Revegetation of coal stripped land near Henryetta, Oklahoma. Proc. Okla. Acad. Sci. 22:123-129; 1941.

Radian Corporation. An environmental overview of future Texas lignite development. Radian Corp. Report to U.S. Environmental Protection Agency, Austin, TX; 1978.

U.S. Soil Conservation Service. State standards and specifications for establishment of vegetation on surface mined areas. Stillwater, OK: USDA SCS; 1976.

Additional references:

Brown, K. W.; Deuel, L. E. The suitability of overburden as a medium for plant growth and characteristics of existing soils at the proposed mine area in Grimes County, Texas. College Station, TX: Texas Agricultural Experiment Station, Texas A&M University; 1977.

Hons, F. M. Physical and chemical properties of lignite spoil material as it influences successful revegetation. In: W. R. Kaiser (ed.), Proceedings of the Gulf Coast Lignite Conference. Austin, TX: Bureau of Economic Geology, University of Texas; 1976.

Hons, F. M. Chemical and physical properties of lignite spoil and their influence upon successful reclamation. College Station, TX; Texas A&M University; Dissertation; 1978.

U.S. Forest Service. User guide to soils. Mining and reclamation in the West. Ogden, UT: Gen. Tech. Rpt. INT-68; 1979.

c. Mycorrhizae and seed inoculum.

PURPOSE

The structural association of living roots and fungi is called mycorrhiza. On some species, such as pines and beeches, fungi live on the outer root surface (ectomycorrhiza) while in others, such as orchids and heaths, the fungi invades the internal root structure (endomycorrhiza). This association aids the roots of the host plant in mineral uptake by providing a greater absorbing surface while the fungi obtains sugar from the host plant. This is a very significant mechanism of soil nutrient absorption in some plants (Jenny 1980). In many cases, timber production is dependent on mycorrhizal fungi since the growth and survival of many forest trees is dependent upon their presence (Maser et al. 1979).

Legumes must be inoculated with the proper bacteria before the seeds are planted. The bacteria are necessary to "fix" or provide nitrogen to the soil. Other bacteria contribute to the cycling of plant nutrients in the soil.

Bacteria and fungi are necessary for the decomposition of biological materials and the formation and improvement of the soil. The addition of these organisms is important to achieving productive soil. Often, in surface mining, the reclaimed areas consist of spoils from deeper geologic layers which may lack microorganisms. Natural inoculation and establishment of microorganisms in these spoils will eventually occur, but several factors can influence the rate and success of the inoculation. Among these are the spoil salinity, acidity, heavy metal content, nutrient levels, handling methods, and spoil storage time (U.S. Forest Service 1979).

ILLUSTRATION

Microorganisms are reestablished in soils by natural processes as well as artificial amendments. Several activities associated with surface mining tend to promote activity of fungi and bacteria. Since these organisms occur in topsoil, the replacement of natural topsoil material, where it is available, is a good method of reestablishing the site.

It is important to realize that microbial activity is greatly influenced by available oxygen and moisture (Alexander 1977); therefore, the storage of topsoil for long periods of time in deep narrow piles can reduce the functional capacity of these organisms (U.S. Forest Service 1979). Shallow, wide piles are preferable. Surface material (soil, litter, forest debris) from other sites may be placed on the mine spoil to introduce microorganisms to the site. There is some reinoculation of newly reclaimed sites by wind-blown dust from adjacent areas.

Soil amendments to adjust pH, salt, trace element, or nutrient problems may be necessary to promote revegetation. Generally, soil quality conducive to revegetation is also conducive to microbial activity. Mulching provides the carbon necessary for microbial activity while fertilizer amendments (e.g., nitrogen, phosphorus) that are necessary for successful revegetation will be adequate for microorganisms.

If there is an indication that poor revegetation success may be related to poor soil conditions (e.g., lack of mycorrhizal fungi, nitrogen-fixing bacteria), tests are available for determining the actual level of microbial soil activity. Direct species counts are prohibitive, but lab analysis for microbially related enzymatic activity in the soil can be accomplished by experts in the subject area. Biomass can be measured by ATP tests, viable counts, and even direct microscopic counts. These tests should be conducted at the advice and under the supervision of an expert and only when absolutely necessary.

Generally, the need for mycorrhizae is known to greenhouse and nurserymen so that seedlings are usually inoculated in the beds (Marx 1980). New equipment is being developed for applying mycorrhizae inoculum (U.S. Forest Service 1980) in nurseries. This equipment is in the final stages of testing so its utility in nurseries or on surface-mined lands is unknown. Dryland sodders and spriggers have been developed for transplanting topsoil and vegetation in clumps during reclamation (U.S. Forest Service 1980). These techniques have potential application for replacing natural microbial populations on mine spoils.

Donald Marx at the U.S. Forest Service Southeastern Forest Experiment Station's Forestry Science Laboratory in Athens, Georgia, has done extensive work on ectomycorrhizae identification and inoculation techniques. Most of the work by the Forestry Science Laboratory so far has been with Pisolithus tinctorius. In addition, Abbott Laboratories, North Chicago, Illinois, has been studying ways of producing a dried, vermiculite-peat moss-based inoculum of P. tinctorius. Results indicate that Abbott Labs inoculum can form ectomycorrhizae on several species of pine, oak, spruce, Douglas fir, and hemlock. Other methods of inoculation include introducing duff, humus, infested soil, crushed sporophores, or excised mycorrhizal roots into the nursery soil or container-growing medium. Although these methods normally ensure ectomycorrhizal development, they also create problems. The inoculum may lack the most desirable fungi for the tree species and planting sites or it can contain various harmful microorganisms and noxious weeds. In addition, sufficient quantities of sporophores or colonized roots may not be available when needed.

According to Aldon (personal communication, E. F. Allen, U.S. Forest Service, 2205 Columbia SE, Albuquerque, NM 87106), the best method for inoculation of endomycorrhizae is to collect soil beneath a native stand of mature plants of the species to be planted. This soil should then be mixed with the soil in which the plants are placed. Although this is a tedious method, it is superior to waiting for the spores to blow in from somewhere else. Although aerial dispersion of spores does occur, the time period may be critical in

ensuring better survival of transplants. If careful removal of the top few inches of topsoil would occur in the mining process so that this soil would again be placed on top of a reclaimed area, enough mycorrhizal spores might be present to make inoculation unnecessary.

MAINTENANCE AND MANAGEMENT

Prolonged storage of topsoil or prolonged wet or dry periods may reduce or inhibit the activity of microorganisms (mycorrhizae and bacteria) in the soil. Reinoculation of a site may be necessary for successful reclamation. The determination of such a need should be made by a soils expert.

Once mycorrhizal fungi and soil bacteria have been established, no maintenance should be necessary

LABOR/MATERIALS

Materials for inoculation of mycorrhizal fungi do not cost anything if soil is taken from around plants that are already infested. The labor costs would be high, however, because of the time involved to find the desired plants, collect the soil, and mix it with the planting medium for the new plants.

According to Dr. Donald Kenney of Abbott Labs (personal communication), *P. tinctorius* ectomycorrhizal inoculum is available commercially in small quantities in the Southern U.S. on a test basis. The inoculum sells for \$16 per liter which, when used with the injection planter developed by the USDA Forest Service, will inoculate approximately 750 seedlings.

SOURCES OF INFORMATION

Additional information on the use of mycorrhizae can be obtained from:

Institute for Mycorrhizal Research and Development
U.S. Forest Service
Southeastern Forest Experiment Station
Athens, GA 30602

USDA, Soil Conservation Service
(Local office in phone book)

Dr. Donald Kenney
Abbott Laboratories
North Chicago
Chicago, Illinois 60064

References cited:

- Alexander, M. Introduction to soil microbiology. New York: John Wiley and Sons; 1977.
- Jenny, H. The soil resource origin and behavior. New York: Springer-Verlag; 1980.
- Marx, D. H. Role of mycorrhizae in forestation of surface mines. Proc. Trees for Reclamation, Lexington, KY, October 27-28, 1980. Interstate Mining Compact Commission and U.S. Forest Service: 109-116; 1980.
- Maser, C.; Anderson, R. G.; Cormack, K., Jr.; Williams, J. T.; Matin, R. E. Dead and down woody material. In: Ward, J. T. ed. Wildlife habitats in managed forests in the Blue Mountains of Oregon and Washington. Portland, OR: U.S. Forest Service, Agr. Handbook No. 553, Pacific Northwest Forest and Range Experiment Station; 1979:78-95.
- U.S. Forest Service. User guide to soils. Ogden, UT: U.S. Dept. Agr., General Tech. Rept. INT-68, Intmtn. Forest and Range Expt. Station; November, 1979.
- U.S. Forest Service. Equipment development and test program. 1979-80 progress and plans. U.S. Dept. of Agr.; September, 1980.

Additional references:

- Aldon, E. F. Endomycorrhizae enhance shrub growth and survival on mine spoils. Wright, R. A., ed. The reclamation of disturbed arid lands. Albuquerque: University of New Mexico Press; 1978.
- Marx, D. H. Mycorrhizal, a type of root infection beneficial to plant growth. Agrichemical Age 15(1):13-14, 16; 1972.
- Parkinson, D. Microbes, mycorrhizal and mine spoil. Wali, M. K., ed. Ecology and coal resource development. Elmsford, NY: Pergamon Press; 1978.
- Ruehle, J. L.; Marx, D. H. Fiber, food, fuel, and fungal symbionts. Science 206:419-422; 1979.

3.2.2 Maintenance and Supplement to Food, Water, and Cover Resources

a. Buffer zones.

PURPOSE

Buffer zones are areas left unmined between the mining operation and areas designated for protection. The zone consists of a band of natural vegetation which "buffers" the effect of the mining activity (Figure 3.2-1).

Buffer zones may be used for a wide variety of purposes, such as:

- o protecting critical habitat, such as the nesting site of threatened and endangered species.
- o protecting unique biological areas.
- o providing a visual screen (e.g., to hide a roadway).
- o protecting streams or other water bodies from sedimentation.

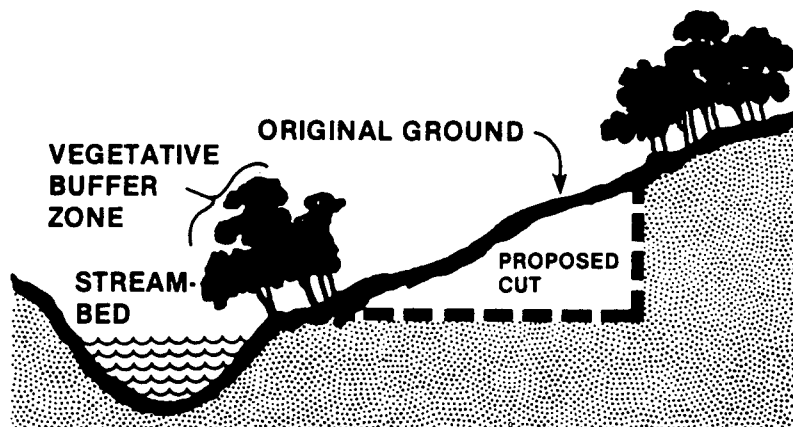


Figure 3.2-1. Vegetative buffer zones used to protect stream water quality (after U.S. Environmental Protection Agency 1976).

DEVELOPMENT

Several important factors should be considered in the utilization of buffer zones for purposes such as those outlined above. Site topography will often determine the size and configuration of the zone, while existing vegetation and type of mining practice will dictate the need for additional protective measures.

The protection of Federally-designated threatened and endangered species and critical habitats may require the establishment of a buffer zone. The size of the area, maintenance requirements, and management considerations should be determined in consultation with the U.S. Fish and Wildlife Service. State fish and game personnel can also provide assistance for protecting unique habitat or high value species as defined by a particular State. Consultation with a professional familiar with the local situation is often needed in the case of extremely unique or rare habitat and/or species. The actual need and configuration of the buffer zone can be difficult to determine because the life history of rare species is not often well known. For example, in a study of golden eagles (Tyus and Lockhart 1979), it was demonstrated that the level, proximity, and exposure of disturbances to nests and use areas (e.g., feeding habitat) are important considerations in mitigating the disturbance of surface mining. That study suggested that factors be assessed on a case-by-case basis, because of the complexity of problems to consider in setting up a buffer zone.

In general, haul and access roads should be designed to go around important wildlife use areas and should be hidden from the view of animals using the areas. The width of the buffer zone needed to screen out roads will vary with site conditions. A "rule of thumb" of 100 meters may be appropriate for the width of the zone (Stubbs and Markham 1979). This will help to protect wildlife from the noise, dust, and other disturbances related to road use.

The requirements related to development of buffer zones to protect streams are variable, depending on the regulatory authority. The width is established through consultation. These areas along streams are set aside for the main purpose of preventing erosion of streambanks and sedimentation of stream beds. In addition, they provide many of the habitat requirements for wildlife, such as protective cover for terrestrial animals, shading and cover for aquatic species, and areas for nesting and feeding. In essence, these zones provide a multifaceted contribution to the protection of fish, wildlife, and habitat.

MAINTENANCE AND MANAGEMENT

Depending upon the regulatory authority, specific steps may have to be taken for delineating, marking, and maintaining stream buffer zones. In most cases, after these areas are set aside, they require little management.

LABOR/MATERIALS

Labor costs depend a great deal on many of the factors already discussed. In a case where the area has to be surveyed and properly marked, the amount of labor depends on the size and configuration of the area and local surveying costs. Where wildlife enhancement is incorporated into the management of a buffer zone, the degree of effort and materials varies on a case-by-case basis.

SOURCES OF INFORMATION

Although the State regulatory authority will ultimately determine the size and type of buffer zone required, the following agencies can provide additional assistance where wildlife protection and enhancement is a concern:

- o U.S. Fish and Wildlife Service
- o State Fish and Game Agency
- o U.S. Soil Conservation Service

References cited:

Stubbs, C. W.; Markham, B. J. Wildlife mitigative measures for oil and gas activity in Alberta. In: Swanson, G. A., technical coordinator. The mitigation symposium: A National workshop on mitigating losses of fish and wildlife habitats; July 16-20, 1979; Colorado State University, Ft. Collins, CO. U.S. Dept. Agr., For. Serv. Rocky Mtn. Forest and Range Expt. Station, GTR RM-65; 1979.

Tyus, H. M.; Lockhart, J. M. Mitigation and research needs for wildlife on western surface mined lands. In: Swanson, G. A., technical coordinator. The mitigation symposium: A National workshop on mitigating losses of fish and wildlife habitats; July 16-20, 1979; Colorado State University, Ft. Collins, CO. U.S. Dept. Agr., For. Serv. Rocky Mtn. Forest and Range Expt. Station, GTR RM-65; 1979:252-255.

U.S. Environmental Protection Agency. Erosion and sediment control -Surface mining in the Eastern U.S. EPA Tech. Seminar Publ., EPA-625/3-76-006; 1976.

b. Use of slash from clearing and grubbing.

PURPOSE

Woody debris left from a clearing or grubbing operation in preparation for mining may represent valuable construction material for developing new wildlife habitat. The material may be used for several purposes, such as:

- o creation of cover and nesting habitat.
- o development of site barriers.
- o creation of temporary erosion control structures.

The logs and downed woody material or slash on the forest floor is often viewed by forest managers as a fire hazard and objects that will attract forest pests which impede reforestation. However, slash materials have real value that justify their salvage during clearing and grubbing prior to mining and incorporation into the reclamation plan. A few of the values include such factors as:

- o Decaying woody material represents a reservoir of slowly released plant nutrients.
- o Elevated areas on logs (e.g., knots, branches) serve as perches and feeding sites for wildlife.
- o The decaying trunk of a tree provides grubs and other insects upon which woodpeckers feed.
- o Root wads are used for dusting and nesting by several species of birds and small mammals.
- o Spaces between the trunk and bark are used for escape and/or thermal cover by invertebrates and small vertebrates.
- o Protected areas under a log are used for escape and thermal cover.
- o Soft decayed wood is used by squirrels for food storage and by mice for burrows.
- o The decaying log becomes colonized by ectomycorrhizal fungi which are necessary for establishment of certain trees.

These factors are discussed in detail with suggestions applicable to a wide range of situations in Thomas (1979).

ILLUSTRATION

Logs

The decision to use slash depends to a large degree on the management objectives of the area. When land is used for wildlife habitat or timber production, the use of slash materials is a viable option for creating micro-habitat on the reclaimed site.

The main value of logs is for cover, feeding sites, and reproduction sites. Several factors, however, need to be considered in the use of logs:

- o A well-distributed pattern of logs provides the most variety of small animal habitat.
- o A clumped, cluttered distribution of logs over an area will impede movement of large animals.
- o Logs placed up- and downslope provide less valuable habitat than those placed along the contour. Orientation along the contour helps check erosion, while soil collected upslope provides a site for natural seedling establishment and provides an improved soil habitat (Ausmus 1977).
- o The utility of the log changes as its structure changes with decay. Logs serve as thermal cover and perches during the early stages of decay and as burrows and reproductive sites in the later stages.
- o The size of the log influences its uses as habitat. Generally, larger logs provide more cover and can accommodate larger animals. Small-diameter logs [10 to 20 cm (4 to 8 inches)] are effective cover for small mammals, such as field mice and shrews, while larger logs can provide cover for animals the size of rabbits and opossums.
- o The use of the log as habitat will depend on the composition of the plant community in which it is located, the successional stage, and the existing wildlife community.
- o Fire-charred logs are less desirable because of the lack of bark and the difficulty that small animals and insects have in excavating charred material.
- o Logs with cavities provide an extra attraction for cover and denning.

Brushpiles

The smaller branches and woody material produced during clearing and grubbing may be used to form brushpiles. This material can provide excellent cover for wildlife. The piled brush along powerline rights-of-way illustrates a good example of how such materials can be used to benefit wildlife. Research from right-of-way studies reveals that:

- o Piles or windrows (long, narrow piles) are most effective if their length and width is less than 12 by 12 meters (40 by 40 feet). Long, narrow piles less than 1.8 meters (6 feet) high are best for general use.
- o Piling downslope from depressions impedes soil erosion.
- o Piles provide food and cover for wildlife, as well as humus to the soil (Ulrich 1976, Hamrick and Bishop 1957).
- o Piling encourages burrowing animals (e.g., woodchucks), which, in turn, provides habitat for other species (Shomon et al. 1966).
- o Upland game birds and rabbits benefit significantly from piles (Yoakum and Dasmann 1971). Game birds prefer loose piles.
- o Rabbit habitat is readily improved by dense brushpiles (Kight 1971) 25 to 38 cm (10 to 15 inches) in diameter and 1.5 to 1.8 meters (5 to 6 feet) high.
- o Turkey have been documented to use piles for nesting, especially around logs (Yoakum and Dasmann 1971).
- o Piles are more effective along the edges of plant communities (e.g., forest-pasture border).
- o Entanglement by grasses, vines, and forbs improve the habitat within the pile.

In addition to providing cover as brushpiles do, windrows may form effective screens. Piles may be used to form temporary breaks in the straight-line-of-sight on level topography until vegetative cover is established (U.S. Fish and Wildlife Service 1979).

MAINTENANCE AND MANAGEMENT

The woody material which composes log and slash piles will decay with time and will need to be replaced, if desired, by the landowner. However, for all practical purposes, the piles will have fulfilled their usefulness by the time decay has significantly reduced the pile. As the reclaimed area around the pile becomes covered with vegetation of varying densities, many micro-habitats will be created, replacing those lost in the decaying piles.

LABOR/MATERIALS

Cost, man-hours, equipment needs, and materials will vary with site specific needs and characteristics. In wooded areas, slash material can be saved from the site-clearing activities and stockpiled. Equipment used in mining (e.g., dozers and dumptrucks) can then be used to move the slash when needed. The degree to which equipment is used versus hand piling will depend, in most cases, on site management activities (e.g., number of piles, size of piles, size of area). A brush pile in the 12 x 12 x 6 meter (40 x 40 x 6 feet) size range would take only 2 to 3 hours of equipment time including loader and dumptruck. Handpiles would take 4 to 6 man hours each.

SOURCES OF INFORMATION

Information on use of slash materials may be obtained from:

- o State Fish and Game Agency.
- o U.S. Forest Service.
- o U.S. Fish and Wildlife Service.
- o U.S. Soil Conservation Service - State Conservationist.

References cited:

- Ausmus, B. S. Regulation of wood decomposition rates by arthropod and annelid populations. In: Soil organisms as components of ecosystems. Proc. 6th Int. Soil Zool. Colloq. U. Lohm and T. Persson, eds. Ecol. Bull. [Stockholm] 25:180-192; 1977.
- Hamrick, A. W.; Bishop, J. S. People, rights-of-way, and game. Proc. Conf. Northeast. Section Wildl. Soc; 1957.
- Kight, J. Cottontail rabbit. In: How to have game on your land: Small game. Atlanta, GA: Ga. Game Fish Comm; 1971:25-28.
- Palmer, W. L.; Ammann, G. A. Ruffed grouse and woodcock populations on several small study units of the Gratiot-Saginaw State Game Area. Mich. Dept. Conserv. Resour. Dev. Rept. 136; 1968.
- Shomon, J. J.; Ashbaugh, B. L.; Tolman, C. D. Wildlife habitat improvement. New York, NY: Natl. Audubon Soc.; 1966.
- Thomas, J. W., ed. Wildlife habitats in managed forests: The Blue Mountains of Oregon and Washington. U.S. Forest Service, Agr. Handbook No. 553; 1979.
- Ulrich, E. S. Selective clearing and maintenance of rights-of-way. In: R. Tillman, ed. Proceedings of the first National symposium on environmental concerns in rights-of-way management. State College, MS: Miss. State Univ.; 1976:206-219.

U.S. Fish and Wildlife Service. Management of transmission line rights-of-way for fish and wildlife. Volume 1. U.S. Dept. of Interior, FWS/OBS-79/22; 1979.

Yoakum, J.; Dasmann, W. P. Habitat manipulation practices. In: R. H. Giles, Jr., ed. Wildlife management techniques, 3rd ed. Wildl. Soc.; 1971:173-231.

c. Rights-of-way management.

PURPOSE

Rights-of-way (ROW) for roads and powerlines often involve large areas of land, which require continual maintenance. The primary purpose of powerline maintenance is to protect the lines from damage and to provide access. Along roadways, maintenance is directed toward improving visibility and removing roadside obstacles.

Maintenance of ROW's along actively used roads should discourage large animals from using the roadsides. High mortality of deer and other grazing animals occurs frequently along roads, where the animals are hit by vehicles. The benefits from providing more food or cover for these animals along well-used roads would, in the long run, be offset by introducing the possibility of injury or death.

ROW management along powerlines, however, should be promoted. Powerline corridors are often located in isolated areas, providing a place where animals can feed and rest undisturbed. In these areas, the wildlife manager can greatly improve wildlife habitat by appropriate initial cutting and/or replanting and periodic maintenance.

DEVELOPMENT

A substantial amount of literature is currently being developed on powerline ROW management for wildlife (Tillman 1976; U.S. Department of Interior 1979a, 1979b, 1979c; Electric Power Research Institute 1981). The art of wildlife management along powerline ROW's is also well developed for many parts of the country. Because of the diverse requirements of wildlife species, the varying terrains in a region, and surrounding land uses, several techniques suitable for a region should be considered during ROW planning and management. The three volume publication, "Management of Transmission Line Rights-of-Way for Fish and Wildlife" (U.S. Department of Interior 1979a, 1979b, 1979c), is an excellent set of manuals, which should be consulted for this purpose. It lists numerous practices which have proven successful. Plant species which are suitable for ROW planting in many geographic areas are included as information. Several important considerations listed in this manual and other publications concerning wildlife habitat management along ROW's are listed below.

Vegetation Management by Mechanical Means

- o Clear-cutting and selective cutting techniques have been widely used to manage wildlife habitat in the Southcentral U.S., but the specific effects of any cutting operation depend on the composition of the vegetation, topography, soil conditions, time of cut, and time since last cutting.

- o Several studies suggest that selective cutting of forested areas creates maximum wildlife diversity. Clumps of shrubs and small trees mixed with sparser vegetation, open grassy cover, and bare ground should be maintained where possible.
- o Snags or den trees should be left when they pose no danger to the powerline. When clearing for the line, an occasional tree could be girdled and left standing rather than felled. This action will allow for the future establishment of snags to serve as hunting perches for birds and as a source of dens for small mammals.
- o "Hinge cutting" or the "cut-and-bend" method of cutting for selected trees in wooded areas eventually produces a low, dense, living brushpile which provides ideal winter cover for small game. This technique involves cutting trees just deep enough so that the tops can be pushed over. The lower branches (no longer shaded) grow vigorously, while the connected tops grow upward again.

Brushpiling

- o In general, piling brush, rather than leaving it on the ground or removing it, provides cover for numerous small animals. Piling brush in natural depressions and gullies also retards erosion.
- o Long, narrow brushpiles, less than 1.8 meters (6 feet) high are preferable to higher rounded piles. They are also most effective when placed near the "edge" of other types of habitat.

(Additional information in Section 3.2.2.b, Use of Slash from Clearing and Grubbing)

Herbicide Application

- o Herbicides are widely used in ROW maintenance and have recently been incorporated into wildlife management programs. Numerous types of herbicides are available for different purposes. Assistance from experienced wildlife managers should be obtained before using them to alter wildlife habitat.

(Additional information in Section 3.2.3.b, Pesticide and Herbicide Use)

Planting and Seeding

- o Wildlife management through planting and seeding has been practiced for many years in the Southcentral U.S. Rights-of-way which have become denuded through bulldozing or excessive

cutting will need to be replanted to prevent erosion. This offers excellent opportunities to create valuable wildlife habitat through the use of proven wildlife plantings.

- o Shrub and tree species planted along rights-of-way for wildlife include autumn olive, Russian olive, Bristly locust, elderberry, and several species of pine and oaks. The berries of autumn and Russian olive are particularly attractive to songbirds, bobwhite quail, and mourning dove; while the oaks, when mature, are intensively used by a wide variety of mammals. Seeding and planting information in Section 3.3.1 will aid in accomplishing the management objective and determining the specific plants useful for a particular site.

(Additional information in Section 3.3.1, Revegetation)

Wetlands

- o Avoiding wetland areas where possible will protect these valuable and fragile resources for wildlife use.
- o In most cases, where the ROW impacts wetland areas, ROW management strategies should be to minimize the impacts rather than to manage the wetlands.
- o During construction, avoid drainage ditches, spoil banks, or access roads that might restrict or prevent normal water movement.

SOURCES OF INFORMATION

Additional information on rights-of-way management and its effects on wildlife can be obtained from:

- o State Regulatory Authority
- o Office of Surface Mining
- o State Fish and Game Agency
- o U.S. Fish and Wildlife Service

References cited:

Electric Power Research Institute. Environmental concerns on right-of-way management. EPRI WS 78-141. Palo Alto, CA; 1981.

Tillman, R., ed. Proceedings of the first National symposium on environmental concerns in right-of-way management. State College, MS: Miss. State Univ.; 1976.

- U.S. Department of Interior. Management of transmission line rights-of-way of fish and wildlife. Volume 1. Background information. U.S. Fish and Wildlife Service. FWS/OBS-79/22; 1979a.
- U.S. Department of Interior. Management of transmission line rights-of-way for fish and wildlife. Volume 2. Eastern United States. U.S. Fish and Wildlife Service. FWS/OBS-79/22; 1979b.
- U.S. Department of Interior. Management of transmission line rights-of-way for fish and wildlife. Volume 3. Western United States. U.S. Fish and Wildlife Service. FWS/OBS-79/22; 1979c.

3.2.3 Protection of Fish and Wildlife Resources During Mining

a. Wildfire control.

PURPOSE

A wildfire is defined as an "unplanned fire which requires suppression action, as contrasted with a prescribed fire burning within prepared lines enclosing a designated area under prescribed conditions" (U.S. Forest Service 1956). Prescribed burning has long been used as a wildlife management tool because it is one of the more economical procedures for removing a stand of vegetation.

Wildfires can result from improper or careless use of machinery or volatile materials, or from such a simple act as tossing a lighted cigarette on dry grass. Potential impacts on wildlife near the mine site from such an accident can be direct mortality and the temporary loss of many acres of valuable wildlife habitat on adjacent land. In addition, long-term degradation of the burned area, such as sheet erosion, can also occur as a result of improper fire-fighting methods.

DEVELOPMENT

Prevention of wildfires is by far the most desirable and economical way to avoid expensive fire-fighting and reclamation costs. Methods for prevention should include such things as:

- o making sure all workmen are aware of the potential dangers of wildfire, particularly at worksites where the probability of occurrence is highest.
- o posting a fire hazard alert whenever surrounding woodlands become extremely dry. This notice should be placed in an area frequented daily by workmen.
- o placing fire extinguishers near or on all heavy machinery and at potential fire locations (e.g. storage sheds, lunch break locations, etc.).

Once a fire breaks out, the first and most important step in fire-fighting procedure is not to panic, but to assess the problem and take appropriate action. Initial actions could be, depending on the severity of the fire, either putting out the fire with available implements (e.g. fire extinguishers, buckets of water, shovels, etc.) or calling for assistance if nearby personnel cannot extinguish the blaze. Clear and decisive action during the early stages of a fire can mean the difference between a minor accident and a disaster.

If a fire has the potential for being uncontrollable, fire control lines can be installed with crawler tractors. Although fire control lines are an

excellent first-line defense for large wildfires, they have the disadvantage of promoting erosion after the fire unless preventive measures are taken. Usually, when lines are being built rapidly, little can be done to prevent erosion. However, if given the choice, good judgment with respect to line location, such as placing the line along the contour, will save time and effort in post-fire reclamation. Also, where a control line is being constructed near a slow-moving fire, diversion ditches can be installed if necessary as the line is being built. Diversion ditches will definitely be required on those control lines which cross the contour or drainageways.

Hot fires consume organic material from the soil surface, and subsequent rapid oxidation of the remaining organic matter bares the soil. This creates a situation very conducive to sheet erosion. After diversion ditches are in place, the area should be reclaimed by reseeding or replanting. Section 3.3.1 (Revegetation) presents methods of establishing vegetative cover that will not only promote soil stabilization, but also benefit wildlife. Additional methods for preventing erosion on problem areas include the placement of logs or poles, tree tops, and/or stumps in actively eroding gullies.

MAINTENANCE AND MANAGEMENT

Wildfire prevention is a continuing need. It is insurance against an accident which could potentially be devastating, not only in terms of loss of natural resources (i.e., timber, wildlife), but also in loss of property and human life. Fire prevention equipment should be periodically checked for readiness, and workmen should be reminded of the need for concern for wildfires.

LABOR/MATERIALS

The number of fire extinguishers and other devices for fire protection will vary with the size of the mining operation and the particular needs at each site. The number of fire-fighters will also vary, depending on the severity and potential danger of the fire. In general, the final cost of stopping a wildfire will probably depend more on the speed with which it is extinguished, than any other factor.

SOURCES OF INFORMATION

The following agencies welcome consultation on methods for preventing and fighting wildfires.

- o U.S. Forest Service
- o State Forest Agency

Reference cited:

U.S. Forest Service. Glossary of terms used in forest fire control. U.S. Dep. Agric. Handb. 104. Washington, DC; 1956.

b. Pesticide and herbicide use.

PURPOSE

Occasionally, it may be necessary to use pesticides or herbicides to control pests or weeds. These chemical agents vary widely in toxicity and persistence. These compounds should be used with great caution and according to manufacturer's label and EPA and State criteria. On a reclamation site, pesticides are sometimes used to discourage birds and mammals from eating germinating seeds or browsing on tender shoots. Insect populations can also increase to the point where pesticides are required to prevent undue damage to vegetation. Herbicides, on the other hand, are less frequently used at mine sites. When they are used, they are usually applied along roadsides and around buildings to kill unwanted vegetation.

DEVELOPMENT

When the mine operator has a problem requiring the use of either pesticides or herbicides, he should first contact the State surface mining regulatory authority for advice. There are many chemical agents available, and experts recommended by the State regulatory authority will be able to assist in determining the best control measures available.

Excessive applications and misuse are the most prevalent problems associated with pesticides and herbicides. On the premise that more of anything is better, the widespread tendency is to use an excess. When this happens, the end result is often the death of unintended species, the overkill of the intended species, undesirable toxic effects off site, or human contamination. It is important that personnel who are applying herbicides or pesticides follow the directions for use indicated for that specific chemical agent. Because of the potential danger from some pesticides, most States require that certain compounds only be used by or under the supervision of a State Certified Pesticide Applicator.

MAINTENANCE AND MANAGEMENT

Most herbicides currently in domestic use must be applied during the early growing season to be effective. Depending on the vegetation to be controlled, reapplication throughout the growing season may or may not be required.

Pesticide reuse is also highly dependent on several factors, such as the frequency and type of pest outbreaks, the toxicity and persistency of the pesticide, and the environmental conditions on site. For example, one application of a pesticide to young plants may be enough to protect them from caterpillar damage, while repeated applications of a rodenticide may be required to protect a young pine plantation from vole damage.

LABOR/MATERIALS

The costs of using herbicides or pesticides will vary depending on the chemical used and the recommended rate of application. Cost estimates can be obtained by contacting a local agricultural products distributor.

SOURCES OF INFORMATION

Additional information on the use of pesticides and herbicides can be obtained from:

- o State Regulatory Authority
- o Office of Surface Mining
- o State Departments of Agriculture
- o State Extension Services

Additional references:

U.S. Department of Interior. Management of transmission line rights-of-way for fish and wildlife. Volume 1. Background information. U.S. Fish and Wildlife Service. FWS/OBS-79/22; 1979.

U.S. Forest Service. Wildlife habitat improvements handbook. FSH 2609.11; 1969.

c. Drilled holes.

PURPOSE

Drill holes include exploration holes, boreholes, monitoring wells, or other exposed underground openings associated with the exploration and surface mining activity. These holes may be a planned part of the surface mining operation or they may be uncovered during the operation. These holes can have direct impacts to wildlife, resulting in physical injury, while at the same time indirectly affecting habitat quality through surface water and/or ground water contamination.

They should be barricaded, fenced off, or protected until they are permanently sealed after abandonment or transferred to water well use. Some wells may be maintained for monitoring groundwater quality.

ILLUSTRATION

Three major considerations need to be addressed: casing; protecting; and sealing of wells or drilled holes.

Casing

The main concern in casing drilled holes is the protection of ground water. Toxic materials generated by the mining operation sometimes enter uncased wells. If groundwater containing these materials surfaces in springs or streams, significant deterioration of wildlife and fish habitat can occur. Proper casing of wells will prevent such an occurrence.

Borehole wells can cave in and sometimes contaminate water aquifers. Casing pipe can be used to prevent such problems. Proper mining techniques in the drilling of wells has been described in several studies (Campbell and Lehr 1973; Moran et al. 1978; Anderson 1979).

Casing pipe varies in size, weight, and the ability to resist corrosion. Stainless steel and carbon steel are resistant to corrosion and are quite durable. Polyvinyl chloride (PVC) and epoxy reinforced by fiberglass do not have the strength of steel piping, but are useful in lengths of up to 61 meters and 91.4 meters (200 ft and 300 ft), respectively. Plastic casing is the cheapest and least durable of all piping and is satisfactory for many casing uses. A disadvantage, however, is that plastic casing does not come in sizes larger than 15 cm (6 in) in diameter. When installing any of these pipes, gravel or other inert packing material is used to fill in space around the casing. In addition, grouting with materials such as Portland cement, bentonite, perlite, Gilsonite, or diatomaceous earth is also necessary to seal the space around the casing to prevent surface contamination of the well and subsequent aquifer contamination (Barrett et al. 1980).

Drilling practices accepted by State or local standards should be adequate if followed. However, the State regulatory authority should be consulted for specific criteria which will meet their regulations and guidelines.

Protecting

Drilled hole openings present a safety hazard not only to the human population but also to wildlife. Fences can be used to exclude large animals and people from the area, while temporary caps can be used to seal the openings.

Sealing

Permanent plugs may be used to seal openings. These must be water-tight in order to prevent water table contamination from surface drainage. The methods used must meet local health and safety standards.

MAINTENANCE AND MANAGEMENT

In the case of barricades, temporary caps, and plugs, periodic checks need to be made to ensure continued protection of people and wildlife. After final plugging or sealing and approval by regulatory inspectors, maintenance is no longer required.

LABOR/MATERIALS

Local well drilling companies can provide estimates of costs associated with casing and sealing wells or boreholes. If barricades or fencing are required, the additional expense will depend on the type and amount of fencing used. Fencing costs are discussed in Section 3.1.4 (Fences).

SOURCES OF INFORMATION

Specifications and guidance on the requirements associated with the maintenance and management of drilled holes can be obtained from:

- o State Regulatory Authority
- o Office of Surface Mining

References cited:

Anderson, K. E. Water well handbook. 4th ed. Missouri Water Well and Pump Contractors Association; 1979.

- Barrett, J.; Deutsch, P. C.; Ethridge, F. G.; Franklin, W. T.; Heil, R. D.; McWhorter, D. B.; Youngberg, A. D. Procedures recommended for overburden and hydrologic studies of surface mines. Ogden, UT: U.S. Dept. Agr., For. Serv. Int. Forest and Range Expt. Station; 1980.
- Campbell, M. D.; Lehr, J. H. Water well technology. New York: McGraw-Hill Book Co.; 1973.
- Moran, S. R.; Groenewold, G. H.; Cherry, J. A. Geologic, hydrologic and geochemical concepts and techniques in overburden characterization for mined land reclamation. Rep. Invest. No. 63, North Dakota Geol. Surv.; 1978.

d. Dust control.

PURPOSE

Fugitive dust can result from several activities associated with surface mining. These include, in order of intensity: (1) haul road usage; (2) dragline operation; (3) use of exposed areas; (4) front-end loader operation; (5) topsoil removal; (6) blasting; (7) dump truck traffic; (8) drilling; (9) shovel/truck loading; and (10) train loading (Moore and Mills 1978). Haul and access roads are by far the worst dust producers and need specific control measures developed into the mine plan to reduce the environmental impact.

Specific problems associated with fugitive dust vary, but include such items as:

- o inhibited plant growth due to coating of leaves.
- o reduced palatability of vegetation to wildlife and domestic animals.
- o detrimental effects on mucous membranes of animals exposed to high levels of dust.

ILLUSTRATION

Dust may be controlled on haul and access roads by using water and/or chemical binders. Advantages and disadvantages of using either or a combination of these materials depend on several factors.

Watering, where there is a readily available source, is a common practice. Water is generally spread by such equipment as Wabco water trucks or Caterpillar 30,000- to 38,000-liter (8,000- to 10,000-gallon) spreaders. The number of water trucks needed depends on the length of roads to cover as well as the drying conditions. Water is a very temporary retardant and, as such, has to be constantly applied at a rate that retards dust without creating hazardous, slick roads. Surfacing with gravel, "Red Dog," or a chemical binder will help reduce dust as well as reduce the hazard of muddy roads.

Chemical binders may be used to provide longer-term dust control. These include such materials as polymer solutions, latex solutions, and asphalt emulsions. Although more expensive than water, the cost of these chemical binders must be weighed against very frequent watering and the cost of extra trucks in very dry situations, where dust is a major problem. Chemical binders can generally be applied with the same type of truck used for watering, and the longer-term dust reduction, in turn, reduces the number of applications necessary. These chemical binders can also effectively be used to "tie down" topsoil or spoil storage piles to minimize wind-blown dust.

There is good evidence that road paving is a viable option in long-term operations. The purpose of paving, when it is done, however, is generally

oriented toward improving the haul operation. Dust reduction, in this case, would be a significant added benefit (Chironis 1978).

MAINTENANCE AND MANAGEMENT

The rate and frequency of application of control measures depends entirely on specific road conditions, such as roadbed material, number and size of trucks, length of road, the projected length of time of use of the road, and the type of material applied. In the case of chemicals, manufacturer's specifications will serve as a guide, but the real test is the amount of dust generated. Watering need only be frequent enough to keep the dust down, which will vary with temperature, relative humidity, and other factors.

Ripping of the road surface to a depth of an inch and application of dust retardant may be necessary to reduce rutting in chemically treated roads (Chironis 1978).

LABOR/MATERIALS

Chemical binders may be purchased from regional distributors of asphalt and other road-building materials. A sample cost on a 21-meter (70-foot) wide haul road at a 15 percent dilution rate has been cited as \$3500 per mile, with annual upkeep at a dilution of 1:10 at about \$2000 per mile. These prices include the cost of the retardant only, which is about 11 cents per liter (Chironis 1978).

The number of trucks required for watering depends on the amount of road and the frequency of watering. Factors, such as distance from a suitable water source, enter into the costing.

SOURCES OF INFORMATION

Additional information on dust control needs may be obtained from:

- o State Regulatory Authority
- o Office of Surface Mining
- o U.S. Forest Service
- o State Highway Department

References cited:

Chironis, N. P., ed. Coal age operating handbook of coal surface mining and reclamation. New York: Vol. 2 - Coal Age Library of Operating Handbooks, McGraw-Hill, Inc.; 1978.

Moore, R.; Mills, T. An environmental guide to western surface mining. Part Two: Impacts, mitigation and monitoring. U.S. Fish and Wildlife Service, FWS/OBS-78/04; 1978.

e. Sediment ponds.

PURPOSE

Surface mining operations, like other large-scale earth-moving operations, have the potential to produce large amounts of sediment. If the sediment is contained on site, the problem is minimized; however, if it washes into adjacent waterways, it can become a serious pollutant. With respect to fish and wildlife, sediment can clog stream channels, act as a carrier for other pollutants (insecticides, herbicides, plant nutrients, etc.), and fill lakes and ponds, resulting in degradation of aquatic habitats. In some areas, acid drainage from mines can also be a serious problem which can significantly harm productive streams and lakes. Sediment ponds (Figure 3.2-2) are often the final line of defense in controlling these offsite environmental problems.

Sediment ponds are, by definition, holding areas at the periphery of a mine site to detain runoff for a short period of time and to trap heavier sediment particles. Regulations will vary from State to State with respect to the design criteria and number of sediment ponds needed on a particular type of site. In most States, an engineer is required to design these pond systems.

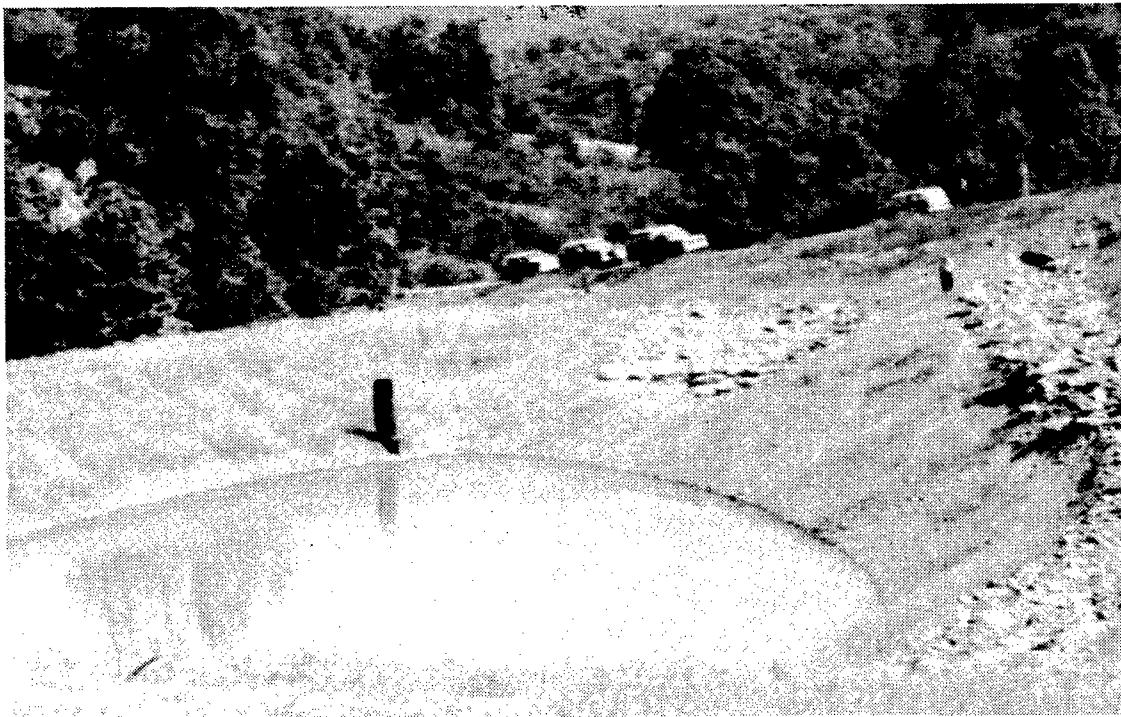


Figure 3.2-2. A well constructed sediment pond (from U.S. Environmental Protection Agency 1976a).

DEVELOPMENT

Basically, the sediment pond must be designed to accomplish two functions: (1) it must effectively remove a certain percentage of suspended sediment; and (2) it must provide sufficient storage capacity for the sediment removed from suspension. In order to accomplish these objectives, the location and number of ponds must first be determined. The pond should be located to obtain maximum storage benefit from the terrain and for ease of cleanout of trapped sediment. Some agencies recommend it be placed in the main drainway, while others prefer it to be placed out of main drainways to facilitate maintenance and removal. In some areas, several small ponds may also be required, primarily because the topography is not suited to one large pond. Large ponds, however, have the advantage that they can often be designed to function for the life of a mine without cleaning.

Other design factors of sediment ponds to consider are the following:

- o Spillways should consist of a principal and emergency spillway. The combined capacities of both spillways should exceed the peak rate of runoff from a predetermined storm intensity.
- o Points where surface runoff enter a sediment basin should be protected to prevent erosion. The point of exit from the pool should also be located as far as practical from the "point of entry." This will allow maximum settling time for particles in suspension to settle out before the water exits the basin.
- o If sediment is to be removed from the pond, the mine plan should indicate the proposed method of removal. The sediment should not be placed in a location where it will eventually reach a stream. The mine plan should also outline the methods for removing or abandoning the sediment pond after mining is completed.
- o The embankment should be formed from clean mineral soil, free of woody vegetation, large rocks, and other objectionable material. Pervious material, such as sand and gravel, should not be used.
- o Immediately following construction, the embankment and spillways should be stabilized with vegetation approved by the regulatory authority.
- o State and local laws must be met concerning fencing and posting of hazardous areas around the pond.

MAINTENANCE AND MANAGEMENT

Sediment ponds should be checked frequently and routinely after high-intensity or major rainstorms. Corrective measures taken during the early stages of a problem, such as spillway stoppage or dam breaching, can help prevent costly repairs later.

Sediment must be removed from the pond when it reaches a predetermined depth below the top of the riser on the exit spillway. Many States have established criteria for sediment removal, but a rule of thumb is that a cleanout is required when the pond has reached 50% of its sediment storage capacity, or 6 months after the mining operation was started, whichever comes first (U.S. Environmental Protection Agency 1976a).

If the sediment pond is designed as a temporary structure, it can be disposed of after mining is completed and all disturbed areas are stabilized. If accumulated sediment is to be left in the pond, it should be covered with fill, topsoiled, compacted and revegetated to prevent the sediment from leaving the site. If the sediment is to be disposed of on another location on the mine site, it should be spread in layers, dewatered, covered with earth, and revegetated. In situations where the embankment is built across a natural drainageway, the embankment and all accumulated sediment should be removed and the area returned to its original profile. Where the embankment is built adjacent to the natural drainage, the embankment, in some situations, can be left in place and the entrance channel diverted to the natural drainageway.

LABOR/MATERIALS

The costs of sediment ponds can vary considerably, depending on the size of the mine site, the general terrain, and the number of ponds required. Generally, no more than 3-4 days of dozer time would be required per sediment pond and 1-2 days of end dump truck time to transport embankment material to the site.

SOURCES OF INFORMATION

State surface mining regulations are specific with respect to the design criteria necessary for sediment ponds. Once these criteria are obtained, engineers can then design ponds which will meet the needs of specific mine sites. Additional information on ponds can be obtained from:

- o State Regulatory Authority
- o Office of Surface Mining
- o U.S. Soil Conservation Service

Reference cited:

U.S. Environmental Protection Agency. Erosion and sediment control. Surface mining in the Eastern U.S. Vol. 1, Planning. EPA-625/3-76-006; 1976a.

Additional references:

Grim, E. C.; Hill, R. D. Environmental protection in surface mining of coal. U.S. Environmental Protection Agency. Cincinnati, OH: EPA-670/2-74-093; 1974.

U.S. Environmental Protection Agency. Erosion and sediment control. Surface mining in the Eastern U.S. Vol. 2, Design. EPA-626/3-76-006; 1976b.

U.S. Soil Conservation Service. Engineering field manual for conservation practices. NTIS PB-244 668. Vol. I and II; April, 1975.

West Virginia Dept. of Natural Resour. Drainage handbook for surface mining. Charleston, WV: Div. Planning Develop. and Div. Reclam.; 1975 (Revised).

f. Diversion ditches.

PURPOSE

Diversion ditches are a class of structures designed to intercept surface runoff and divert it to a safe disposal location. Typically, they are permanent or temporary structures constructed by digging a shallow ditch along a hillside and then building a soil dike along the downhill edge of the ditch with the removed soil. In most cases, permanent diversions are installed on long slopes of 15 percent or less which are subject to heavy runoff. They can also be used on abandoned haul roads as water bars to intercept runoff flowing down the roadway.

Diversion ditches can be of considerable value in preventing offsite siltation of waterways. Siltation of streams and lakes from surface mines can often be a serious problem, resulting in aquatic habitats being of marginal value to fish and wildlife. Erosion prevention in the form of diversion ditches, sediment ponds (Section 3.2.3.e), and stabilizing vegetation (Section 3.3.1) are, in many cases, essential to fish, wildlife, and environmental protection following surface mining.

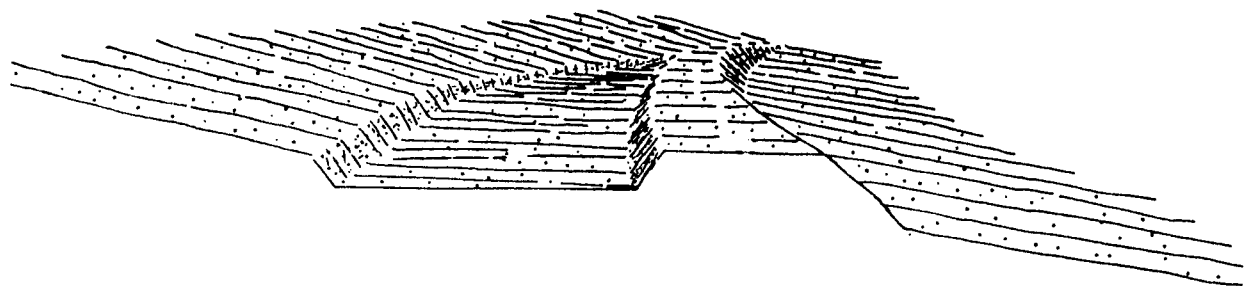
Permanent diversion ditches left as grassy waterways can provide good upland game cover sites in areas of relatively level terrain. In many instances, these waterways can provide winter cover and protection from predators for numerous species of small birds and mammals.

DEVELOPMENT

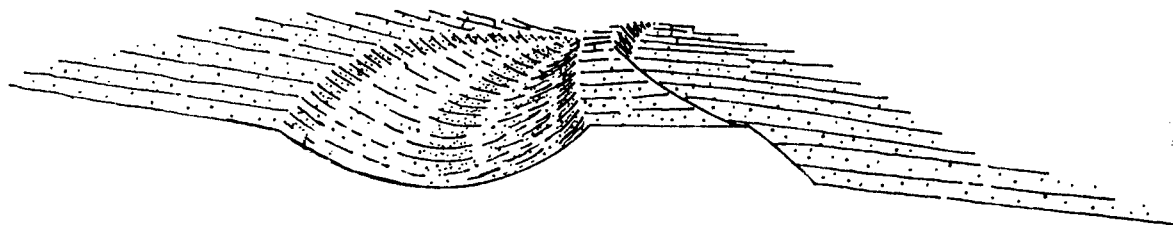
If diversion ditches are designed to be permanent on-site structures, they require certain design considerations. Standards and specifications for such structures should include the following:

- o Location of ditches must consider outlet conditions, topography, land use, soil type, length of slope, seep planes, and mine layout.
- o Construction specification requirements include:
 - The diversion to be constructed must meet the State's performance specifications.
 - The removal of all woody material and other objectionable material (i.e., large rocks, trash, etc.) from the ditch and dike.
 - The capacity and grade of the diversion will be specified by the regulatory authority.

- The cross-section of the channel should be either parabolic, V-shaped, or trapezoidal, as shown in Figure 3.2-3, with stable sides flat enough to insure ease of maintenance.
- All excess earth not needed in construction should be placed so that it will not interfere with the functioning of the diversion.
- o Vegetative stabilization should follow the State's standards and specifications for time of seeding, sprigging or sodding, liming and fertilizing, and site and seedbed preparation.
- o Stone center diversions, as shown in Figure 3.2-4, or paved diversions should be considered in instances where heavy runoff is anticipated.



Trapezoidal cross-section



Parabolic cross-section

Figure 3.2-3. Effective cross-section shapes for diversion ditches (after U.S. Environmental Protection Agency 1976).

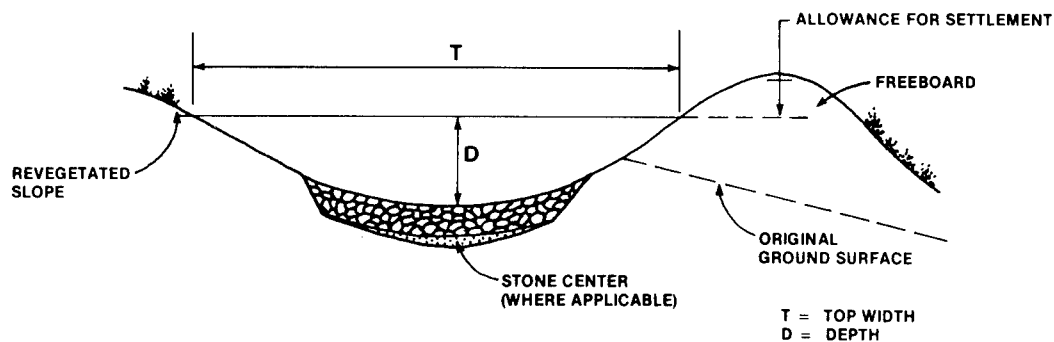


Figure 3.2-4. Stone center diversion for use in areas with heavy runoff.

MAINTENANCE AND MANAGEMENT

Ditches, like sediment ponds (Section 3.2.3.e), need to be checked routinely for accumulations of sediment, debris, and other obstructions that keep them from accomplishing their purpose. This is particularly important after heavy rainfalls, when there is the greatest possibility of blockage of runoff channels. Hillsides which have well-established vegetation will be less susceptible to diversion ditch failure, but nonetheless should be checked periodically during the bonding period.

LABOR AND MATERIALS

Once the slope has been graded to the required angle, diversion ditches can be installed with a minimum of personnel and equipment time. Subsequent compaction with roller graders also requires relatively little equipment time. Approximately 1 hour of equipment time would be required to construct and compact 305 linear meters (1000 linear feet) of a typical parabolic-shaped ditch. An additional 6 to 8 man days, in addition to the use of a dumptruck, would be required to lay a stone center.

The cost for 5-cm (2-in) stone, suitable for laying a stone center in a diversion ditch, is currently \$4.30 per ton. A ditch 61 meters (200 feet) long and 0.9 meters (one yard) wide, lined with 10 centimeters (4 inches) of stone, would require 5.4 cubic meters (7 cubic yards) or 9080 kg (10 tons) of 5-cm (2-in) stone. Total cost lining a ditch of this size would be \$43.00.

SOURCES OF INFORMATION

Additional information on the design and placement of diversion ditches can be obtained from:

- o State Regulatory Authority
- o Office of Surface Mining
- o U.S. Soil Conservation Service

References cited:

Environmental Protection Agency. Erosion and sediment control. Surface mining in the Eastern U.S. Vol. 2, Design. EPA-625/3-76-006; 1976.

Additional references:

Grim, E. C.; Hill, R. D. Environmental protection in surface mining of coal. Cincinnati, OH: Environmental Protection Agency; EPA-670/ 2-74-093; 1974.

U.S. Environmental Protection Agency. Erosion and sediment control. Surface mining in the Eastern U.S. Vol. 1, Planning. EPA-625/3-76-006; 1976.

U.S. Soil Conservation Service. Field office technical guide: Diversion ditches: Available in each county SCS office.

U.S. Soil Conservation Service. Field office technical guide: Grass waterways: Available in each county SCS office.

g. Access control.

PURPOSE

Access control may be necessary to protect critical wildlife areas which are opened up by mine support roads. New access to once remote areas has both advantages and disadvantages in terms of wildlife management. One advantage is that legal hunting and fishing activities may be expanded into once little-used areas, taking pressure off areas more frequently used. A disadvantage is that, along with legitimate resource utilization, illegal activities may put heavy pressure on a reserve of fish and wildlife that was formerly little utilized and unmanaged. These activities can create problems for the landowner, as well as the State game and fish management agency.

In addition to the direct effect of hunting pressure are the potential problems brought about by recreational vehicles. Noise, soil erosion, and wildfires, which are associated with uncontrolled off-road vehicle activities, can contribute to direct harassment of wildlife, as well as habitat destruction. It is important to remember that access roads associated with surface mines can lead to abuse if they are left open without any control. For example, while normal use may not be a problem, during times of high fire risk, strict control may be appropriate.

ILLUSTRATION

Access roadways can be closed with a locked gate to prevent casual traffic. "No hunting," "no trespassing," or "controlled access" signs can then be posted on the gate, indicating that the area behind the sign is off limits to unauthorized persons. The degree of access freedom may depend to a large degree on the desires of the landowner, who may coordinate recreational access with the mine operator.

The number of roads can be reduced significantly if companies operating adjacent or nearby mines can share road use. In addition, shared costs can result in cheaper operation with better roads.

MAINTENANCE AND MANAGEMENT

Periodic checks are necessary to ensure that the gate and signs are maintained. Also, the occurrence of illegal access should be ascertained, and, if security becomes a problem, patrols by fish and game agents or private security agents may be necessary. Consultation with local foresters to determine times of high fire risk and the need for tight control during these periods is an important consideration.

LABOR/MATERIALS

The major costs are associated with the gate, gate posts, and installation costs. Security gate and post installation can run from \$100 to \$150, including approximately a half day for installation. If private security patrols are required, then labor costs are an additional item.

SOURCES OF INFORMATION

Additional information on types of access control structures can be obtained from:

- o State Regulatory Authority
- o Office of Surface Mining
- o State Fish and Game Agency

3.3 PRACTICES OR RECLAMATION TECHNIQUES USED TO ENHANCE AND/OR PROTECT FISH AND WILDLIFE RESOURCES

3.3.1 Revegetation

a. Seedbed preparation.

PURPOSE

Seedbed preparation, both mechanical and chemical, is necessary to ensure the timely establishment of vegetative cover. Mechanical preparation is generally limited to scarifying the soil surface immediately before seeding. Some postmining land uses may also require the removal of large rocks from the soil surface and immediate subsurface. Chemical preparation usually consists of liming to correct acid conditions (low pH) and fertilization to correct inadequate nutrient levels.

It is also assumed that all revegetation programs will be within the specifications as detailed for Texas (U.S. Soil Conservation Service 1977) and Oklahoma (U.S. Soil Conservation Service 1976). These publications include valuable information on species selection, establishment, and use.

DEVELOPMENT

Surface Preparation

When soil surface preparation is necessary, tilling or scarifying the soil can be performed by one of several methods. On areas that are not too steep (not over 20°) or rocky, tractor-drawn farm implements, such as a disc, bog harrow, spring-loaded chisel plow, or spring-tooth, spike-tooth or flexible harrow can be used. Heavy-duty implements should be used since some breakage and excessive wear can be expected. For rougher, rockier areas, extra-heavy-duty equipment should be used, such as offset disc harrows and brush harrows designed to be drawn by crawler tractors. Preparation of extremely rough, rocky areas will require chisel plows or ripper teeth mounted behind a crawler tractor or grader. These implements leave a pronounced furrow and should be operated along the contour on slopes. Ripper teeth may also tend to drag large rocks to the surface where they may create a problem. Regrading with a bulldozer can also be used for seedbed preparation, but is generally much slower than drawing an implement and leaves a much poorer seedbed. Steep slopes are often limited to tracking-in with a bulldozer.

No matter what method is used to prepare the soil for planting, the major objective is to provide a suitable environment for seed germination and root growth. A loose surface is needed to allow moisture penetration and provide a good environment for seeds to germinate and establish root systems. The material under the seed should be firm enough (usually accomplished with cultipackers) to eliminate air pockets that affect plant establishment. However, material that is too firm may prevent good water movement through the

soil. Generally, after final grading, a combination of ripping, disking, harrowing, and seeding with a seeder-packer provides the necessary treatment to get good coverage. Local agricultural practices or proven successful practices on mines in the local area will generally be adequate for good seedbed preparation.

Treatment of Acid Soils

The major problem encountered in the use of mixed overburden is the formation of acidity. Acidity is caused by the oxidation of pyritic sulfur that has been exposed to surface conditions. Fortunately, the pyrite content of most soils overlaying the coal seams in Texas and Oklahoma is low, and the problem of acidity is not unmanageable. Materials from some overburden may become quite acid, however, and require the application of very large quantities of lime to neutralize them. This practice is not only expensive, but it can easily result in marked disturbances in the balance and availability of plant nutrients. Pyrite layers, usually, but not always, found just above the coal seams, should be analyzed to determine their potential for acidification. If the acidification potential indicates some possible problems, selective placement of the overburden should be made to ensure that pyrites are buried well below the level of root growth.

Few plants can tolerate a pH of 4.0 or lower. While vegetation can be established at a pH level of 5.0-5.5, certain trace metals, such as aluminum and manganese, are soluble at this and lower levels. These metals are toxic to most plants, when soluble, and limit their survival and growth. By raising the pH value of the soil to a minimum of 5.5, these metals are rendered insoluble while plant nutrients become more available. Concentration of heavy metals, such as lead, zinc, chromium, copper, and arsenic, in the mixed overburden are well within the range and normal concentrations for native soils (Brown and Deuel 1980). Mixed overburden in the Texas-Oklahoma area is slightly alkaline (Gavande et al. 1979); therefore, as long as the spoils are properly limed to prevent acidification, no problems with plant or animal toxicity should occur.

Liming rates are best determined by testing soil samples. These tests can be performed by the State Testing Laboratory through a County Extension Agent. Private laboratories are also located in many of the coal fields. Liming rate recommendations from these tests normally specify the amount of lime required to neutralize the acidity in the top 6 inches of soil. After application, the lime should then be turned into the soil to a depth of 6 inches. Extremely acid soils that may slow revegetation should be limed at twice the recommended rate and turned to a depth of 12 inches. Turning of the lime into the soil can be accomplished during mechanical seedbed preparation, but the accepted agricultural practice is to apply lime 6 months before seeding. This allows the lime sufficient time to neutralize the acid, but requires scarifying the soil before seeding.

Agricultural limestone can be spread with a conventional lime-spreading truck in accessible areas. An Estes spreader or similar one-way blower mounted on a lime-spreading truck can be used to reach areas on steep slopes. Hydrated lime can be applied with a hydroseeder and has a higher neutralizing value than agricultural limestone. Rock phosphate, high in calcium and phosphorus, is applied in the same manner as agricultural limestone. Use of rock phosphate is best limited to marginal soils (pH 3.9-4.5), because it is not as effective as lime in neutralizing acidity, or where rock phosphate is considerably cheaper or easier to obtain than lime. Other materials that may be used to neutralize soil acidity include marl, calcium, silicate slag, and some types of fly ash. Technical advice should be obtained when these lime substitutes are considered for use.

Correction of Nutrient Deficiencies

Prior to sowing or planting on a reclamation site, adequate soil tests should be made to determine what must be done to the soil so that it meets the requirements of the desired plants. Obviously, these tests will indicate conditions unfavorable for many plants, thereby narrowing the selection of plants for the site. Most agricultural schools, such as Texas A&M University and Oklahoma State University, will analyze soil samples for a modest fee; several commercial companies also analyze soils.

Newly prepared seedbeds of surface mined soils have virtually no organic matter and have little, if any, nitrogen. Consequently, the establishment of a vegetative cover will necessitate the application of nitrogen. Whenever logistics and costs permit, nitrogen should be applied in split applications. Three to five species of legumes should be included in reclamation plantings as a nitrogen source and to aid in the addition of organic matter to the soil.

Phosphorus tests should indicate both available and residual phosphorus. Since little information is available concerning the amount of phosphorus required on spoils, yields from plots fertilized according to recommended levels should be measured over several years to determine if single or multiple applications are needed to support the plants being grown (Barnhisel 1977). Phosphorus may pose particular problems in a spoil because of varying pH conditions. Residual phosphorus may be much more readily released in some areas than in others; therefore, monitoring available phosphorus levels over time is required.

Potassium may be deficient in sandy soils. Limited data indicate that the more shaly soils contain adequate amounts of available potassium. Soil tests indicate how much, if any, potassium should be added to the soil.

Nutrient deficiencies can be corrected by the application of fertilizer in the form of ammonium nitrate, phosphoric acid, and potash. These compounds provide nitrogen (N), phosphorus (P), and potassium (K), respectively. These compounds can be obtained as a straight fertilizer which contains only one compound or as a mixed fertilizer which contains two or all three nutrients. Fertilizers are identified by percentage analysis of the three major nutrients.

This percentage is always listed in the order N-P-K. An analysis of 0-46-0 indicates that this fertilizer, concentrated superphosphate, provides only phosphorus at a percentage of 46 percent by weight [100 kg (220 pounds) of fertilizer contains 46 kg (101 pounds) of phosphorus].

Likewise, a fertilizer with an analysis of 10-10-10 provides 10 kg (22 pounds) each of nitrogen, phosphorus, and potassium per 100 kg (220 pounds) of fertilizer. Minimum rates of fertilizer are required by State regulations. To ensure revegetation success, soil samples can be tested to determine whether the minimum requirements are sufficient. This is most important where phosphorus may be critically deficient. In most cases, the addition of potassium is not needed.

Fertilizer can be applied at the same time seeding is performed or a few days before or after seeding. When seeding is done during winter when seeds are dormant, application of fertilizer should be delayed until the expected germination date in the spring.

Fertilizer can be applied by cyclone spreaders, tractor-drawn spreaders, lime trucks, or aircraft. Application of fertilizer with a hydroseeder is effective, but two problems may be encountered with this method. When mixed with water, fertilizer forms a salt solution that may damage seeds, especially grass seeds. Damage may occur if the seed-water-fertilizer slurry is allowed to stand for more than a few hours. The second problem arises when seeding legumes that require inoculating bacteria; the addition of fertilizer to the slurry lowers the pH (increases the acidity) of the mixture. A pH of 5.0 or lower can kill 75% of the inoculating bacteria within 2 hours. To maintain a viable inoculant, the following recommendations can be used:

Neutralize the acidity of the mixture by adding 45.4 kg (100 pounds) of hydrated lime for every 3,785 liters (1,000 gallons) of water. Add the inoculating bacteria at least 15 minutes after the hydrated lime has been added to the seed-water-fertilizer slurry.

Use larger amounts of inoculant; 1.5 to 2 times the recommended rate should prove effective.

A fresh supply of inoculating bacteria should be added if the seeding slurry is allowed to stand more than 2 hours.

MAINTENANCE AND MANAGEMENT

Proper seedbed preparation greatly increases the chances of successful revegetation. If vegetation begins to fail during the bonding period, the affected areas should be checked for nutrient deficiencies or an acid condition. Refertilization and reliming may be necessary to correct these conditions.

LABOR/MATERIALS

The amount of effort required to prepare a seedbed depends on site conditions, such as soil compaction, size and quantity of rocks, slope, and length of time since final grading. These conditions, in addition to the size of the area, will dictate what type of equipment and the number of hours of equipment time that will be required for tilling. On relatively level terrain, with most rocks removed, a tractor with a spike-tooth harrow can prepare an 8.1-hectare (20-acre) seedbed in an 8-hour day.

The application of soil amendments can be performed by a number of methods. A particularly rough area may require many man-hours of hand labor, but only one hour of aircraft time. Application costs vary depending upon method and terrain. Combining the application of fertilizer with seeding by using a hydroseeder or dry-application blower can reduce costs considerably. A typical 14,000-16,000 kg (15-18 ton) limestone dry spreader with no special attachments will cost approximately \$22,000. An optional attachment, a belt-over chain converter which will allow seed and fertilizer spraying, will cost an additional \$700. Costs for hydroseeders will vary from \$17,000 for a 57,000 liter (15,000 gallon) capacity machine to \$22,000-\$25,000 for a 95,000 liter (25,000 gallon) capacity machine.

Material and labor costs for fertilization can be reduced by using fertilizers with high nutrient analyses. This reduces unnecessary handling of often unneeded bulk by allowing specific fertilizer requirements to be fulfilled.

SOURCES OF INFORMATION

Additional information on seedbed preparation can be obtained from:

- o State Regulatory Authority
- o U.S. Soil Conservation Service
- o State and County Extension Services

References cited:

- Barnhisel, R. L. Reclamation of surface mined spoils. Cincinnati, OH: Interagency Energy-Environment Research and Development Program Report, U.S. Environmental Protection Agency; EPA-600/7-77-093; 1977.
- Brown, K. W.; Deuel, L. E. Revegetation of drastically disturbed lands. Proceedings of the Texas A&M University Lignite Symposium; April 17-18, 1980; Coal and Lignite Research Laboratory, College Station, TX. 8 p.
- Gavande, S. A.; Holland, W. F.; Grimshaw, T. W.; Wilson, M. L. Overburden management and revegetation in the Gulf Coast lignite region: problems and solutions. Proceedings of the symposium on surface mining hydrology, sedimentology and reclamation; 1979; University of Kentucky, Lexington, KY; 292-303.

U.S. Soil Conservation Service. State standards and specifications for establishment of vegetation on surface mined areas. Stillwater, OK: U.S. Soil Conservation Service State Office, Area 5, Section IV; 1976.

U.S. Soil Conservation Service. Technical standard and specification for reclamation of surface mined land. Temple, TX: U.S. Soil Conservation Service State Office, Area 5, Section IV; April 1977.

Additional references:

Angel, P. N. A soil analysis of the stripmine spoil bank at Fairfield, Texas. Nacogdoches, TX: Stephen F. Austin University; 1973; Master's thesis.

Ashby, W. C.; Baker, M. B., Jr. Soil nutrients and tree growth under black locust and shortleaf pine overstories in strip-mine plantings. J. Forestry 66:67-71; 1968.

Askenasy, P. F. Soil factors influencing row crop production and phosphate adsorption on leveled lignite mine spoil banks. College Station, TX: Texas A&M University, Dept. of Soil and Crop Science; 1977; Dissertation.

Chapman, A. G. Effects of spoil grading on tree growth. Mining Congr. J. 53:93-100; 1967.

Davis, H., ed. Specialized tools for final touches. In: Chironis, N. P., ed. Coal age operating handbook of coal surface mining and reclamation. New York: McGraw-Hill; 1978.

Hons, F. M. Physical and chemical properties of lignite spoil material as it influences successful revegetation. Kaiser, W. R., ed. Proceedings of the Gulf Coast lignite conference; 1976. Univ. of Texas at Austin, Bureau of Economic Geology; Austin, TX.

Howland, J. W. New tools and techniques for reclaiming land. Proceedings of the first research and applied technology symposium on mined-land reclamation; 1973; Bituminous Coal Research Institute, Monroeville, PA. 39-64 p.

Larson, J. E. Revegetation equipment catalog. Washington, DC: U.S. Forest Service; 1980.

Rafaill, B. L.; Vogel, W. G. A guide for vegetating surface-mined lands for wildlife in eastern Kentucky and West Virginia. U.S. Fish and Wildlife Service. FWS/OBS-78/84; 1978.

Smith, R. M.; Sohek, A. A., Jr.; Sencindiver, J. C.; Freeman, J. R. Extensive overburden potentials for soil and water quality. Washington, D.C.: U.S. Environmental Protection Agency; EPA-600/2-76-184; 1976.

U.S. Bureau of Mines. Economic engineering analysis of U.S. surface coal mines and effective land reclamation. U.S.B.M. 50241049, U.S. Department of the Interior; 1975.

- U.S. Forest Service. Research and demonstration of improved surface mining techniques for the eastern Kentucky coal fields. ARC 71-66-T4: Appalachian Regional Commission; 1975.
- U.S. Forest Service. User guide to soils--mining and reclamation in the West. General Technical Report INT-68. Ogden, UT: USDA Forest Service, Intermountain Forest and Range Experiment Station; 1979.

b. Seeding techniques.

PURPOSE

Herbaceous Species

Seeds are sown by broadcasting and/or drilling. Each method has advantages and disadvantages, and each is more applicable to certain situations than others. Consequently, one method is not necessarily more effective or desirable than the other; local conditions will dictate the method of choice. Appendix C provides a list of herbaceous species that are considered good for wildlife use as food and cover.

Woody Species

Seeds of most woody plants recommended for wildlife habitats in Texas and Oklahoma can be obtained from commercial dealers. In most cases, seed is the least expensive plant material available. However, the attractive initial cost often is counterbalanced by the fact that the seeds must be germinated into seedlings, which are then planted, or they must be direct-seeded on the site.

Direct-seeding of trees and shrubs has become more popular in recent years, especially on steep slopes and areas of limited accessibility. Unfortunately, only a few data are available to suggest the best procedures to follow to ensure maximum success. Nevertheless, a number of species have been successfully established through direct-seeding on diverse sites. Rafaill and Vogel (1978) list several species that have been successfully established by direct-seeding, especially in the South and Southeast. Species that may be successfully established by direct-seeding in the Southcentral U.S. include black locust, loblolly pine, shortleaf pine, Virginia pine, green ash, shrub lespedeza, indigobush, and autumn olive. Appendix C provides a list of trees, shrubs, and vines that are considered good for wildlife use as food and cover.

Seed treatment with bird, rodent, and insect repellants has markedly increased the success of direct-seeding (Chandler 1980). The addition of a mycorrhizal inoculant, especially for pines, is advised. Since the success of direct-seeding depends on so many variables, and since the effects of most variables are poorly understood, it is imperative to work closely with experienced direct-seeders, as suggested by Chandler.

DEVELOPMENT

Herbaceous Species

Drilling is common practice on those areas that are readily accessible by farm machinery. Various types and sizes of drills are available. On spoils that are relatively free of rocks, grain drills or grassland drills are used. Rangeland drills are used on rocky, rough spoils. For very fine, small grass seeds, the Brillion seeder and culti-packer are exceptionally useful. Because

drilled seeds are placed in the soil and covered, they are exposed to a micro-environment favorable to germination and early seedling growth. Also, fewer seeds are required when drilling is used, as opposed to broadcasting.

Broadcasting seeds is necessary on those areas where drills cannot be used and is the method of choice in many other situations. Seeds can be sown dry by various kinds and sizes of broadcast seeders. Such seeders range from small, hand-operated broadcasters to large, tractor-powered machines. Other equipment, such as fertilizer or lime spreaders, may be used to broadcast seeds, but it is difficult to accurately calibrate the dispersal of seeds from these spreaders. Broadcast seeding is much faster than drilling, and one can broadcast seed over a wide range of soil conditions. Broadcast seeding should be done on well-prepared seedbeds if results comparable to drill-seeding are to be expected.

In those areas where steep slopes are prevalent, the use of hydroseeders is quite advantageous. A major advantage of using a hydroseeder is that seed, fertilizer, hydrated lime, and mulch are mixed to form a slurry that is applied in a single operation. Major disadvantages of a hydroseeder are that a water source is required, a considerable amount of time is needed to refill the tank, and it is expensive. Also, the abrasive action of the slurry agitation system may damage some soft-coated seeds; of course, the germination of some hard-coated legume seeds may be enhanced due to scarification.

Aircraft (especially helicopters) are very useful, but expensive, in seeding large acreages and those areas not accessible by ground equipment. Commercial contractors for aerial seeding can be located through local seed dealers.

Regardless of how seeds are sown, they must be covered to ensure maximum germination and subsequent establishment of the seedlings. This process can be time consuming, expensive, and, on very rocky soil or steep slopes, almost impossible. Therefore, the reclamation planner must have a thorough understanding of all pertinent factors before deciding on the seeding methods to be used.

Woody Species

Planting schemes that call for rows or strips of woody vegetation can be hand-broadcast, drilled, or applied with a seed dribbler. Hand-broadcasting requires a well-prepared seedbed and covering of the seeds after sowing. Hand-broadcasting produces an uneven pattern of vegetation that is suitable for most plants, especially smaller shrubs.

A deep-furrow seed drill can be used to plant evenly spaced rows of plants. Most deep-furrow drills produce furrows 5 to 7.6 cm (2 to 3 inches) deep. The spacing of furrows can be adjusted, usually in increments of 31 cm (12 inches), to properly space the seeds according to plant species requirements. Most deep-furrow drills can be pulled by a farm tractor.

Seed dribblers, developed in the West, make use of the soil disturbed by the tracks of crawler tractors. Mounted in pairs, one over each track, the dribblers drop seed from a hopper onto each track as it rides over the front idler. Seeds fall from the tracks and are embedded in the soil by the tracks. Driven by a rubber-tired wheel riding against a track, seed dribblers can be adjusted for various seeds and seeding rates.

Area seeding of woody species can be performed with cyclone seeders, hydroseeders, and aircraft. Tree and shrub seeds can be seeded along with herbaceous species, but the herbaceous seeding should be reduced because competition from the faster-growing forbs and grasses may inhibit development of woody seedlings. Pines are especially sensitive to competition. To reduce competition, low-growing grasses and legumes should be used at seeding rates which will not produce too dense a stand. Recommended seeding rates for pure live seed (PLS) are listed in Table 3.3-1.

Table 3.3-1. Pure live seed seeding rates for selected woody species (from Rafaill and Vogel 1978).

Species	kg/hectare	(lb/acre)
Black locust	2.5-3.75	(2-3)
Bicolor lespedeza	1.25-2.5	(1-2)
Indigobush (pods)	0.6	(0.5)
Shortleaf pine	0.6-1.25	(0.5-1)
Virginia pine	0.3-0.6	(0.25-0.5)
Green ash	2.5	(2)

Direct seeding should be performed during late fall, late winter, or early spring.

MAINTENANCE AND MANAGEMENT

Clearing a small area around each seedling during the first two or three growing seasons would greatly increase seedling survival, but may be impractical on large areas. This treatment would be feasible for strip and row plantings. Reseeding of woody species is not recommended in areas with established herbaceous cover.

LABOR/MATERIALS

Direct seeding of trees and shrubs can be very economical. A study comparing the costs of direct seeding versus transplanting of shrubs shows a significant cost difference (Crofts and Parkin 1979). The cost of shrubs

established from direct seeding range from \$0.001 to \$0.031 per plant, while the cost of transplanted shrubs average \$0.20 per plant.

Seed can be hand-broadcast at a rate of 3 hectares (8 acres) per man-day when seeding at a rate of 15 kg/hr (12 pounds/hr) of seed (Rafaill and Vogel 1978).

SOURCES OF INFORMATION

Additional information on seeding techniques can be obtained from:

- o State Regulatory Authority
- o U.S. Forest Service Forest Experiment Station
- o U.S. Soil Conservation Service
- o State Forestry Commission
- o State Agricultural Research Stations

References cited:

Chandler, J. W. Seedling development and availability. Proceedings of the conference on reforestation of disturbed sites. College Station, TX: Texas A&M University, Texas Agricultural Extension Service; 1980.

Crofts, K. A.; Parkin, C. A. Methods of shrub and tree establishment on strip mined lands in northwest Colorado. In: Symposium on surface coal mining and reclamation. Coal Conference and Expo V; 1979, October 23-25; Louisville, KY: McGraw-Hill, New York; 1979.

Rafaill, B. L.; Vogel, W. G. A guide for vegetating surface-mined lands for wildlife in eastern Kentucky and West Virginia. U.S. Fish and Wildlife Service; FWS/OBS-78/84. 1978.

Additional references:

Dickson, K. L.; Vance, D. Revegetating surface mined lands for wildlife in Texas and Oklahoma. Washington, DC: U.S. Fish and Wildlife Service, FWS/OBS-81/25; August, 1981.

Larson, J. E. Revegetation equipment catalog. Washington, DC: U.S. Forest Service; 1980.

Plass, W. T. Preliminary recommendations for seeding pine on surface mine spoils. Charleston, WV: Green Lands 5(1); 1975.

U.S. Forest Service. Wildlife habitat improvement handbook. FSH2609.11: Washington, DC; 1969.

Zarger, T. G.; Curry, J. A.; Allen, J. C. Seeding of pine in coal spoil banks in the Tennessee Valley. In: Hatnik, R. J.; Davis, G., eds. Ecology and reclamation of devastated land. New York: Gordon and Breach; 1973.

c. Seed mixtures.

PURPOSE

The primary purposes of revegetation of surface mined land are to limit the erosion and subsequent amount of sediment in nearby streams and to develop a productive revegetation cover to fulfill the postmining land use objectives. Therefore, most areas are revegetated with herbaceous species (e.g., grasses) to provide quick ground cover in minimum time to meet Federal and State regulations. There are a number of species or mixtures of species available for revegetation in the Southcentral U.S. region. Many are good for wildlife as well as for stabilization of the site (Dickson and Vance 1981).

DEVELOPMENT

According to the U.S. Soil Conservation Service (1981), mixtures for wildlife should consist of three to five perennial legumes and two forbs. Favorable grasses commonly selected include those that grow well and need little maintenance. Legumes provide nitrogen, thus assisting the growth of other species and lessening the need for continually adding nitrogen to the soil by fertilizer.

The selection of the seed mixture is very important since local conditions and owner preferences greatly influence the types needed. It is highly advisable to consult with a local SCS plant materials center specialist (to find out the best suited varieties and mixes for a local area) and a wildlife management biologist (to find out the best species for wildlife of the plant materials suitable for a local area).

Seeding rates are often expressed in terms of kg/ha (lbs/acre) of Pure Live Seed (PLS) or kg/ha (lbs/acre) of commercial seed. The PLS rate is determined by multiplying the percent germination of the seed times the percent purity. These values can be found on the seed tag or label. For example, a batch of seed with a germination of 91% and a purity of 82% would be: $91\% \times 82\% = 75\%$ PLS. This indicates that a 45.4 kg (100 lb) bag of this seed would only contain 34 kg (74.9 lbs) of viable seed. It would then be necessary to apply commercial seed bulk mixtures at $1 \frac{1}{3}$ times the suggested PLS rate to achieve the desired PLS seeding rate. To calculate how much bulk seed must be sown to satisfy PLS requirements, divide the recommended PLS seeding rate by the percent PLS and multiply by 100.

Example: If a Bahiagrass seed mix has an 80% PLS and a recommended PLS seeding rate of 22.5 kg/ha (20 lbs/acre):

$$\frac{22.5 \text{ kg}}{80} \times 100 = 28 \text{ kg/ha bulk seeding rate}$$

or

$$\frac{20 \text{ lbs}}{80} \times 100 = 25 \text{ lbs/acre bulk seeding rate}$$

Using PLS seeding rates instead of bulk seeding rates will help ensure that enough viable seed is applied to obtain a good stand of vegetation. This is especially important when using native grass seed, which often has relatively low germination and purity.

Dickson and Vance (1981) have recommended seeding rates for the revegetation of surface mined lands for wildlife in Texas and Oklahoma. Tables 3.3-2 through 3.3-5 are reproduced here from their publication to demonstrate the wide variety of species suitable for revegetation in three major vegetation types common to the Southcentral U.S.

LABOR/MATERIALS

A seed mixture, such as switchgrass, Indiangrass, big bluestem, little bluestem, and clover (red or white), has been estimated to cost \$124/ha (\$50/acre). That cost, without considering wildlife, would be incurred in addition to \$54/ha (\$22/acre) for seedbed preparation, \$14/ha (\$6.00/acre) for seeding operation and soil amendments, and \$99/ha (\$40/acre) for fertilizer and lime (Dickson and Vance 1981).

Dickson and Vance (1981) indicate an additional \$11/ha (\$4.50/acre) would be required to add a mixture of herbs along with rangeland grasses and clover. This cost includes only cost of seeds at a rate of 1.1 kg/ha (1 lb/ac) for sunflower, sesbania, partridge pea, sericea lespedeza, and common lespedeza. It was assumed that these wildlife species would be mixed in the original mixture so no extra cost would be incurred for seeding. The cost of the seed is the only extra cost.

Table 3.3-2. Permanent herbaceous mixtures and planting dates recommended for the establishment of wildlife habitat in the Pineywoods vegetation region of East Texas (from Dickson and Vance 1981).

Species	Bulk seeding rates (lb/ac) ^a	Planting dates ^b
<u>Grasses</u>		
Bahiagrass	20.0 PLS ^c	10/1 - 5/15
Bluestem mixture	6.8 PLS	2/1 - 4/30
Dallisgrass	7.0 PLS	2/1 - 4/30
Indiangrass	9.0 PLS	2/1 - 4/30
Kleingrass	4.0 PLS	3/1 - 5/31
Switchgrass	7.0 PLS	2/15 - 5/15
Tall fescue	12.0 PLS	9/15 - 11/30
Weeping lovegrass	4.0 PLS	3/1 - 5/31
<u>Forbs</u>		
Common sunflower	3.0 CM ^c	3/15 - 6/1
Maximilian sunflower	16.0 PLS	3/1 - 4/30
<u>Legumes</u>		
Arrowleaf clover	6.0 CM	9/15 - 11/30
Crimson clover	20.0 CM	9/15 - 11/30
Partridge pea	20.0 CM	3/1 - 4/30
Sericea lespedeza	30.0 CM	3/1 - 4/15
Sesbania	30.0 CM	3/1 - 4/30
Singletary pea	25.0 CM	9/15 - 11/30
Vetch	10.0 CM	9/1 - 11/30

^aWhere mixtures of species are seeded, rates should be adjusted proportionately.

^bPlanting dates fluctuate based on weather, elevation, and latitude.

^cPLS = Pure Live Seed.
CM = Commercial Seed.

Table 3.3-3. Permanent herbaceous mixtures and planting dates recommended for the establishment of wildlife habitat in the Post Oak Savannah vegetation region of Texas (from Dickson and Vance 1981).

Species	Bulk seeding rates (lb/ac) ^a	Planting dates ^b
<u>Grasses</u>		
Bahiagrass	20.0 PLS ^c	9/15 - 5/15
Bluestem mixture	6.8 PLS	2/1 - 5/15
Buffalograss	20.0 PLS	2/1 - 5/15
Dallisgrass	7.0 PLS	2/1 - 4/30
Green sprangletop	3.4 PLS	3/1 - 5/15
Indiangrass	9.0 PLS	3/1 - 5/15
Kleingrass	4.0 PLS	3/1 - 5/15
Sideoats grama	11.0 PLS	3/15 - 5/15
Switchgrass	7.0 PLS	3/1 - 5/15
Vine mesquite	12.0 PLS	3/15 - 5/15
Weeping lovegrass	4.0 PLS	4/1 - 5/15
<u>Forbs</u>		
Bush sunflower	10.0 PLS	3/15 - 5/30
Common sunflower	3.0 CM ^c	3/15 - 6/1
Engelmann daisy	1.0 PLS	9/1 - 2/30
Maximilian sunflower	16.0 PLS	3/1 - 4/30
<u>Legumes</u>		
Arrowleaf clover	6.0 CM	9/15 - 11/30
Crimson clover	20.0 CM	9/15 - 11/30
Partridge pea	20.0 CM	3/1 - 4/30
Sericea lespedeza	30.0 CM	3/1 - 4/15
Sesbania	30.0 CM	4/15 - 6/15
Singletary pea	25.0 CM	9/15 - 11/30
Sweetclover	15.0 CM	9/1 - 10/31
Vetch	10.0 CM	9/1 - 11/30

^aWhere mixtures of species are seeded, rates should be adjusted proportionately.

^bPlanting dates fluctuate based on weather, elevation, and latitude.

^cPLS = Pure Live Seed.
CM = Commercial Seed.

Table 3.3-4. Permanent herbaceous mixtures and planting dates recommended for the establishment of wildlife habitat in the Post Oak Savannah vegetation region of Oklahoma (from Dickson and Vance 1981).

Species	Bulk seeding rates (lb/ac) ^a	Planting dates ^b
<u>Grasses</u>		
Bahiagrass	20.0 PLS ^c	3/1 - 6/30
Big bluestem	10.0 PLS	8/1 - 9/30
Indiangrass	10.0 PLS	12/1 - 5/15
Little bluestem	10.0 PLS	12/1 - 5/15
Smooth bromegrass	25.0 PLS	9/1 - 10/31
Switchgrass	8.0 PLS	12/1 - 5/15
Tall fescue	20.0 PLS	9/1 - 10/31
Weeping lovegrass	6.0 PLS	4/1 - 6/15
<u>Forbs</u>		
Common sunflower	3.0 CM ^c	3/15 - 6/1
Maximilian sunflower	2.0 PLS	3/1 - 6/15
<u>Legumes</u>		
Arrowleaf clover	5.0 PLS	9/1 - 10/31
Crimson clover	15.0 PLS	9/1 - 10/31
Crownvetch	5.0 PLS	9/1 - 10/31
Red clover	5.0 PLS	9/1 - 10/31
Sericea lespedeza	30.0 PLS	3/1 - 5/15
Sweetclover	15.0 PLS	9/1 - 10/31
Vetch	15.0 PLS	9/1 - 10/31

^aWhere mixtures of species are seeded, rates should be adjusted proportionately.

^bPlanting dates fluctuate based on weather, elevation, and latitude.

^cPLS = Pure Live Seed.

CM = Commercial Seed.

Table 3.3-5. Permanent herbaceous mixtures and planting dates recommended for the establishment of wildlife habitat in the South Texas Plains vegetation region (from Dickson and Vance 1981).

Species	Bulk seeding rates (lb/ac) ^a	Planting dates ^b
<u>Grasses</u>		
Alakli sacaton	2.0 PLS ^c	2/15 - 3/15, 8/15 - 9/15
Big bluestem	12.0 PLS	2/15 - 3/15
Buffalograss	4.0 PLS	2/15 - 3/15, 8/15 - 9/15
Green sprangletop	3.4 PLS	2/15 - 3/15, 8/15 - 9/15
Indiangrass	9.0 PLS	2/15 - 3/15
Kleberg bluestem	2.4 PLS	2/15 - 3/15, 8/15 - 9/15
Kleingrass	4.0 PLS	2/15 - 3/15, 8/15 - 9/15
Lehmann lovegrass	4.0 PLS	2/15 - 3/15, 8/15 - 9/15
Plains bristlegrass	6.0 PLS	2/15 - 3/15, 8/15 - 9/15
Sideoats grama	11.0 PLS	2/15 - 3/15, 8/15 - 9/15
Switchgrass	7.0 PLS	2/15 - 3/15, 8/15 - 9/15
Trichloris	2.4 PLS	2/15 - 3/15, 8/15 - 9/15
<u>Forbs</u>		
Bush sunflower	1.0 CM ^c	3/15 - 6/1
Common sunflower	3.0 CM	3/15 - 6/1
Engelmann daisy	1.0 PLS	3/1 - 5/15, 9/1 - 2/30
Maximilian sunflower	16.0 PLS	3/15 - 6/1
<u>Legumes</u>		
Sesbania	30.0 CM	4/15 - 6/15
Sweetclover	15.0 CM	2/15 - 3/15, 9/1 - 11/30
White clover	5.0 CM	9/1 - 11/30

^aWhere mixtures of species are seeded, rates should be adjusted proportionately.

^bPlanting dates fluctuate based on weather, elevation, and latitude.

^cPLS = Pure Live Seed.
CM = Commercial Seed.

SOURCES OF INFORMATION

Lists of seed distributors can be found in the following publications:

Everett, W. Sources of seed and planting stock. Vegetative Rehabilitation and Equipment Workshop. Missoula, MT: USDA Forest Service, Equipment Development Center; 1981.

Hinkle, C. R.; Ambrose, R. E.; Wenzel, C. R. A handbook for meeting fish and wildlife information needs to surface mine coal - OSM Region IV. Washington, DC: U.S. Fish and Wildlife Service. FWS/OBS-79/48.3.4; 1981.

Dickson, K. L.; Vance, D. Revegetating surface mined lands for wildlife in Texas and Oklahoma. Washington, DC: U.S. Fish and Wildlife Service. FWS/OBS-81/25; July 1981.

Additional information to help determine the most appropriate seed mixtures can be obtained from:

Arkansas -	Game and Fish Commission #2 National Resources Drive Little Rock, AR 72205 (501) 223-6300 Field Supervisor U.S. Fish and Wildlife Service Ecological Services 820 South Street, Room 409 Vicksburg, MS 39180 (601) 638-1891	U.S. Soil Conservation Service P.O. Box 2323 Little Rock, AR 72203 (501) 378-5445
Louisiana -	Department of Wildlife and Fisheries 400 Royal Street New Orleans, LA 70130 (504) 586-5665 Field Supervisor U.S. Fish and Wildlife Service Ecological Services P.O. Box 4305 Lafayette, LA 70502 (318) 234-7478	U.S. Soil Conservation Service 3737 Government Street Alexandria, LA 71301 (318) 473-7856

Oklahoma - Department of Wildlife
Conservation
1801 N. Lincoln
P.O. Box 53465
Oklahoma City, OK 73105
(405) 521-3851

Regional Plant Materials
Specialist
SCS, Southern Region
P.O. Box 6567
Ft. Worth, TX 76115
(817) 334-5282

Coal Coordinator
U.S. Fish and Wildlife Service
Ecological Services
222 S. Houston, Suite A
Tulsa, OK 74127
(918) 581-7458

Texas - Texas Parks and Wildlife
Department
4200 Smith School Road
Austin, TX 78744
(512) 479-4977

Regional Plant Materials
Specialist
SCS, Southern Region
P.O. Box 6567
Ft. Worth, TX 76115
(817) 334-5282

Coal Coordinator
U.S. Fish and Wildlife Service
Ecological Services
819 Taylor Street, Room 9A33
Fort Worth, TX 76102
(817) 334-2961

References cited:

Dickson, K. L.; Vance, D. Revegetating surface mined lands for wildlife in Texas and Oklahoma. Washington, DC: U.S. Fish and Wildlife Service. FWS/OBS-81/25; July 1981.

U.S. Soil Conservation Service. Guidelines for establishing vegetation on surface mined lands. Temple, TX: Unpublished technical guidance prepared for the Texas Railroad Commission, Surface Mining and Reclamation Division. USDA SCS; 1981.

Additional references:

Frentress, C.; Spain, R. Reclamation efforts for wildlife resources. College Station, TX: Paper presented at the Surface Mine Reclamation Workshop; Texas A&M University; Oct. 7, 1980.

Frizzell, E. M.; Smith, J. L.; Crofts, K. A. Transplanting native vegetation, pp. 48-53. In Surface Coal Mining Reclamation Equipment and Techniques. Washington, DC: Information Circular 8823, U.S. Bureau of Mines; 1980.

- Garner, R. V. Revegetation of strip-mined areas in Oklahoma. *Proc. Oklahoma Acad. Sci.* 34:208-209; 1953.
- Gill, J. D.; Healy, W. M. Shrubs and vines for northeastern wildlife. Washington, D.C.: USDA Forest Service, Technical Report NE-9. (Available from Supt. Documents, GPO, Washington, DC; 1974-706-049/711); 1973.
- Gould, F. W. Texas plants: a checklist and ecological summary. College Station, TX: Texas Agricultural Experiment Station, Texas A&M University; 1975.
- Grandt, A. F. Species trials on strip-mine areas, pp. 347-352. In J. Thomas (ed.), *Reclamation and Use of Disturbed Land in the Southwest*, Tucson, AZ: University of Arizona Press; 1977.
- Hinkle, C. R.; Ambrose, R. E.; Wenzel, C. R. A handbook for meeting fish and wildlife information needs to surface mine coal, OSM Region IV. Washington, DC: U.S. Fish and Wildlife Service. FWS/OBS-79/48.3.4; 1981.
- Rafaill, B.; Vogel, W. A guide for vegetating surface-mined lands for wildlife in eastern Kentucky and West Virginia. Kearneysville, WV: U.S. Fish and Wildlife Service. FWS/OBS-78/84; 1978.
- Schnell, G. D.; Johnson, F. L.; Risser, P. G. Model fish and wildlife plan for a surface coal mine in Oklahoma. Norman, OK: Prepared for the Oklahoma Department of Mines by the Oklahoma Biological Survey, University of Oklahoma; 1981.
- U.S. Forest Service. User guide to vegetation--mining and reclamation in the West. Ogden, UT: USDA Forest Service, Intermountain Forest and Range Experiment Station, General Technical Report INT-64; 1979.
- U.S. Soil Conservation Service, Technical standards and specifications for wildlife upland habitat management. Temple, TX: USDA SCS; 1979.
- U.S. Soil Conservation Service. Standard and specifications for critical area plantings. Temple, TX: USDA SCS; 1980.

d. Seedlings.

PURPOSE

The most common means of establishing woody plants is through the use of seedlings. Desired seedlings can be grown in on-site nurseries or purchased from commercial nurseries. It is often necessary to order seedlings a year or more in advance of the planting date; therefore, thorough advance planning is required.

Planting of tree and shrub seedlings and wildlings for wildlife allows more control of planting density and species composition than direct seeding (Section 3.3.1.b, Seeding Techniques) and decreases the time necessary to establish woody vegetation.

DEVELOPMENT

Seedlings

Seedlings shipped from commercial nurseries are perishable and must be carefully handled upon receipt. If seedlings must be stored, they should be placed in refrigeration at a temperature of 35-40°F (2-5°C). Prior to refrigeration, roots must be wrapped in a mulch and well watered. When seedlings are removed from refrigeration, it is imperative that they be protected from desiccation. They should be kept moist, shaded, and out of the wind. Never allow the roots to become dry.

An alternative method of holding seedlings until they can be outplanted is by "heeling-in." When space is available, this method usually is more feasible than refrigeration. To heel-in seedlings, a V-shaped trench is dug in a shaded piece of land. Seedlings are spread out in the trench and covered with loose soil to a depth sufficient to cover the stems a little higher than the root system. The loosely-filled trench is watered, and the process is completed by filling in soil and tamping it down to firm it and remove large air spaces that may have formed. It is imperative to keep the seedlings moist, not wet, until they are planted in the field.

Planting Methods

Both hand- and machine-planting methods can be used to plant seedlings. Hand planting is necessary on steep slopes and is more cost-effective for small areas than machine planting. Tractor-drawn planting machines are used on large, level to gently sloping areas that are free of stones. The maximum safe slope for planting on the contour with a machine is 20%. Slopes of up to 25% can be planted up- and downslope.

Seedlings can be planted by hand by using a mattock or planting bar. Planting bars (dibbles) are usually easier and faster to use for most seedlings. Seedlings with spreading root systems may require the use of a mattock

to provide a planting hole of adequate size. Planting holes for all seedlings must be large enough to allow the roots to spread out without being crooked or doubled under.

For either planting method, the soil should be packed firmly around the root system. When planting by machine, it is wise to have someone on foot follow the machine to reset any loose seedlings.

Planting Densities

State regulations require successful establishment of a certain number of stems per 0.4 hectare (1 acre). Expected survival rates of seedlings can be determined so that a sufficient number of seedlings can be planted to allow for loss. Table 3.3-6 lists the number of seedlings per 0.4 hectare (1 acre) when planted on different spacings.

Table 3.3-6. Seedlings per 0.4 hectare (1 acre)
at various spacing distances.

Spacing [meters (feet)]	Seedlings per 0.4 hectare (1 acre)
1.8 x 1.8 (6 x 6)	1200
1.8 x 2.1 (6 x 7)	1037
1.8 x 2.4 (6 x 8)	907
2.1 x 2.1 (7 x 7)	890
2.4 x 2.4 (8 x 8)	680

MAINTENANCE AND MANAGEMENT

Although clearing around each seedling can increase the survival rate of a planting in areas with dense herbaceous cover, competition from herbaceous species is often a limiting factor in establishing woody vegetation, especially conifers. Unfortunately, additional fertilization has proven to be of little value in helping establish woody species. Uncontrolled grazing of revegetated areas should not be permitted until the plants are well established--usually the third or fourth growing season.

LABOR/MATERIALS

Seedlings can be planted by hand at a normal rate of 500 to 800 seedlings per man-day. Tractor-drawn seedling planters can plant about 5,000 seedlings per day.

Bare-root stock tree seedlings are available from State and private nurseries. Commonly used species, such as black locust, loblolly pine, Virginia pine, and shortleaf pine, cost about \$10.00 per 500 seedlings.

SOURCES OF INFORMATION

Lists of seedling distributors can be found in the following publications:

Dickson, K. L.; Vance, D. Revegetating surface mined lands for wildlife in Texas and Oklahoma. Washington, DC: U.S. Fish and Wildlife Service. FWS/OBS-81/25; July 1981.

Everett, W. Sources of seed and planting stock. Vegetative Rehabilitation and Equipment Workshop. Missoula, MT: USDA Forest Service, Equipment Development Center; 1981.

Hinkle, C. R.; Ambrose, R. E.; Wenzel, C. R. A handbook for meeting fish and wildlife information needs to surface mine coal - OSM Region IV. Washington, DC: U.S. Fish and Wildlife Service. FWS/OBS-79/48.3.4; 1981.

Additional information on seedlings and planting methods can be obtained from:

- o State Regulatory Authority
- o State Forester
- o State Forest Extension Service
- o U.S. Forest Service
- o U.S. Soil Conservation Service

References cited:

Rafaill, B. L.; Vogel, W. G. A guide for vegetating surface-mined lands for wildlife in eastern Kentucky and West Virginia. FWS/OBS-78/84. Washington, DC: U.S. Fish and Wildlife Service; 1978.

Virginia State Water Control Board. Best management practices handbook-- surface mining. Draft Planning Bulletin. Richmond; 1978.

Additional references:

Barnett, J. P. Containerized pine seedlings for difficult sites. In: Proceedings of the Conference on Reforestation of Disturbed Sites. College Station, TX: Texas Agricultural Extension Service, Texas A&M University; 1980.

- Bryson, H. L., Jr. Early survival and total height and foliar analyses of 11 tree species grown on strip-mine spoils in Freestone County, Texas. Nacogdoches, TX: Stephen F. Austin University; 1973; Master's thesis.
- Chandler, J. W. Seedling development and availability. In: Proceedings of the Conference on Reforestation of Disturbed Sites. College Station, TX: Texas Agricultural Extension Service, Texas A&M University; 1980.
- Clark, F. B. Forest planting on strip-mined land in Kansas, Missouri, and Oklahoma. Technical paper 141. Columbus, OH: USDA Forest Service and Central States Forestry Experiment Station; 1954.
- Fowler, D. K.; Adkisson, L. F. Survival and growth of wildlife shrubs and trees on acid mine soil. Technical Note B37. Norris, TN: Tennessee Valley Authority; 1980.
- Hons, F. M. Land preparation for reforestation. In: Proceedings of the Conference on Reforestation of Disturbed Sites. College Station, TX: Texas Agricultural Extension Service, Texas A&M University; 1980.
- Texas Agricultural Extension Service. Reforestation of disturbed sites: proceedings. College Station, TX: Texas A&M University; 1980.

e. Cuttings.

PURPOSE

Most trees, shrubs, and vines can be propagated by stem or root cuttings. This type of propagation is used mostly in those areas in which large acreages are being reforested, but the method has value for revegetating surface mined areas with woody species for wildlife habitats (McKnight 1970).

DEVELOPMENT

Evergreen cuttings should be made in late summer following the flush of new growth. The success rate of rooting pine cuttings usually is low; therefore, many more cuttings must be made than normal to ensure the desired quantity of rooted cuttings. Cuttings should be 5.1-15.2 cm (4-6 inches) long, and the leaves should be carefully cut off the butt end, leaving two to four leaves at the top end.

Cuttings of hardwood deciduous trees should be made in late fall when the trees are dormant. The cuttings should be bundled and buried upside down in moist sand and refrigerated. By spring, callus tissue will have formed on the exposed butt ends of the cuttings. Plant the callused cuttings in a rooting medium consisting of sharp sand and peat moss (3:1). Prior to planting, the cuttings should be treated with a rooting hormone according to label directions. The rooting medium should be about 6 inches deep so that cuttings can be inserted two-thirds of their length. The surface of the rooting medium must be watered well following the insertion of the cuttings to flush out all air pockets. Keep the cuttings in a greenhouse or covered with glass or plastic. Protect cuttings from direct sunlight and wind, and keep the rooting medium moist. When done properly, propagation by cuttings is an attractive alternative to seedlings since cuttings survive and grow well in comparison to seedlings, and they are less expensive to procure.

MAINTENANCE AND MANAGEMENT

Once established, planted cuttings need no additional maintenance than that required for rooted stock.

LABOR/MATERIALS

Most of the expense in propagating cuttings will be in labor in obtaining the cuttings and burying them in the fall for use the following spring. If the area to be mined has a forest cover, the cuttings can be obtained prior to clearing of the area. Approximately one man-day would be required to obtain and temporarily root (in sand) 500 cuttings. The sand pit [3.1 m long, 3.1 m wide, and 0.2 m deep (10 ft long, 10 ft wide, and 0.5 ft deep)] would cost \$30.00, with the advantage that the sand can be reused. The root hormone,

suitable for propagation of approximately 500 hardwood cuttings, would cost \$3.25.

SOURCES OF INFORMATION

Additional information on the success of cuttings of different types can be obtained from:

- o U.S. Forest Service
- o U.S. Soil Conservation Service

Reference cited:

McKnight, J. S. Planting cottonwood cuttings for timber production in the South. Res. Paper SO-60. New Orleans, LA: USDA Forest Service, Southern Forest Experiment Station; 1970.

Additional references:

Crofts, K; McKell, C. M. Sources of seeds and planting materials in the Western States for land rehabilitation projects. Utah Agricultural Station Land Rehabilitation Series No. 4; 1977.

Institute for Land Rehabilitation. Selection, propagation and field establishment of native species on disturbed arid lands. Utah State Agricultural Experiment Station Bulletin 500; 1979.

U.S. Forest Service. User guide to vegetation--mining and reclamation in the West. Ogden, UT: USDA Forest Service, Intermountain Forest and Range Experiment Station, General Technical Report INT-64; 1979.

U.S. Soil Conservation Service. Plant materials for use on surface mined lands in arid and semi-arid regions. Lincoln, NE: USDA SCS-TP 157; no date.

f. Mulching.

PURPOSE

Mulching is the application of plant residues or other suitable materials to the soil surface. It is usually performed after a seeding operation to aid the establishment of vegetation. Mulching reduces erosion, conserves soil moisture, and reduces surface compaction or crusting of the soil. It is especially beneficial on sites with adverse growing conditions, such as dark-colored soils, south-facing slopes, highly erodible soils, and acid soils that have been limed.

DEVELOPMENT

There are many materials suitable for use as mulch, each with its own advantages and disadvantages. The most commonly used materials in the South-central U.S. are discussed below.

- o Hay and straw are two of the better mulching materials, especially when they are anchored chemically or mechanically. Hay, composed mainly of grasses, often contains seeds that can also aid revegetation. Hay and straw should be applied at the rate of 1400 kg per 0.4 hectare (1.5 tons per acre), either by hand or with a mulch blower.
- o Shredded bark is an excellent mulching material because it remains in place without tacking, even on steep slopes. Shredded bark can also be a source for introducing mycorrhizal fungi into the soil. Bark can be applied with an Estes or manure spreader at a rate of 34.4 cubic meters per 0.4 hectare (45 cubic yards per acre).
- o Processed wood fibers and reprocessed paper materials can be mixed with seed and fertilizer for application by hydroseeder. High rates of application are necessary for effective erosion control, requiring a minimum of 681 kg per 0.4 hectare (1500 pounds per acre).
- o Leaves of deciduous trees are useful as a mulch and as an organic soil additive on level areas. This type of mulch is usually available only in the fall, unless collected and stored for later use. Leaves can be applied with a mulch blower or manure spreader at a rate of approximately 1,800 to 2,700 kg per 0.4 hectare (2 to 3 tons per acre), followed by light disking to hold them in place.
- o Processed garbage and dewatered sewage sludge are also being used to a limited extent on some mine sites. Wide application of these mulches, however, is limited primarily because they are not readily available.

Most mulches require mechanical or chemical anchoring immediately after application to retard loss by wind or water. Mechanical anchoring can be accomplished with commercially available mulch nettings, a tractor-drawn mulch-anchoring tool, or by tracking-in with a crawler tractor. Chemical anchoring, or tacking, is performed by applying emulsified asphalt or a synthetic tacking agent. The emulsified asphalt is applied at a rate of 750 to 1,300 liters per 0.4 hectare (200 to 348 gallons per acre), depending on slope. Specifications for emulsified asphalt use are available from The Asphalt Institute (see Sources of Information). Commercially available synthetic tacking agents should be applied at the rates recommended by the manufacturers. Both emulsified asphalt and synthetic tacking agents are applied by spraying.

MAINTENANCE AND MANAGEMENT

Mulched areas should be checked periodically, and places where mulch has been removed by wind or water should be remulched until vegetation has stabilized the area.

LABOR/MATERIALS

Mulch material, application method, and anchoring requirements all determine the final cost per acre for mulching. Site conditions, availability of mulch, and compatibility of equipment for application are important considerations in selecting a mulch for efficiency in cost and performance. Mulch netting and synthetic tacking agents are usually used in small areas with special problems because of their cost.

SOURCES OF INFORMATION

Additional information on mulching can be obtained from:

- o State Regulatory Authority
- o U.S. Soil Conservation Service
- o State Department of Agriculture
- o State Highway Department
- o The Asphalt Institute
Asphalt Institute Building
College Park, MD 20740
(301) 277-4258

Additional references:

Rafaill, B. L.; Vogel, W. G. A guide for vegetating surface-mined lands for wildlife in eastern Kentucky and West Virginia. FWS/OBS-78/84. Washington, DC: U.S. Fish and Wildlife Service; 1978.

The Asphalt Institute. Asphalt mulch treatment. Information Series No. 161; 1973.

The Asphalt Institute. Specification for paving and industrial asphalts. Specification Series No. 2; 1977 (revised biennially).

g. Maintenance practices.

PURPOSE

The success of reclamation plantings can depend to a large degree on the appropriate maintenance practices which are instituted. This is particularly true of the more western and arid land in the Southcentral U.S.

DEVELOPMENT

Watering

Some means of watering newly planted bare-rooted stock is essential to achieve high survival in arid areas. If watering is not feasible, then the planting rate should be increased or repeat plantings made, so that enough plants will survive to establish adequate habitat. Small-area plantings or widely-spaced plants may be watered from a truck-mounted water tank. However, the installation of an irrigation system using surface-laid pipes and appropriate sprinkler heads may prove to be more economically feasible in some situations.

Two types of piped-irrigation systems have been used with success on surface mine sites in the Southcentral U.S.: a portable aluminum piping system and a "traveling gun" system. The former is more labor intensive, but can be used on areas with rolling terrain, while the latter uses less manpower to establish, but has to be used on relatively level sites. The aluminum piping comes in 6-, 9-, and 12-m (20-, 30-, and 40-ft) lengths with terminal sprinkler heads that will cover a 12 x 12-m (40 x 40-ft) area. A number of sprinkler heads can be used on a main distribution line. The "traveling gun" system uses a flexible hose and is designed for a 6 to 8 hectare (15 to 20 acre) maximum-size irrigation area. Both types of systems require a readily available source of water (e.g., stream, pond, or well), from which water can be pumped using centrifugal pumps. In addition, the pumps will require a nearby electrical hookup, either in the form of an electrical distribution line or diesel generator.

Temporary Exclusion of Grazing Animals
(Additional information in Section 3.1.4, Fences)

Cattle, sheep, and goats must be excluded from newly-planted areas. Fencing is quite expensive, but is necessary to ensure the successful establishment of woody plants. Cattle not only browse on small seedlings, but they also trample them into the ground. Deer will also browse on newly planted seedlings, but the cost/benefit ratio of installing a deer-proof fence to protect seedlings is considered too low to recommend its use.

Seeding Protection

(Additional information in Section 3.2.3.b, Pesticide and Herbicide Use)

Small woody plants must be protected from other plants that might grow so rapidly that they smother the seedlings (Vogel 1981). Grasses and legumes may grow so thick and/or tall that they interfere with the growth of young tree and shrub seedlings by shading them severely and/or outcompeting them for water and mineral nutrients. Therefore, woody plants should be protected by prohibiting the growth of herbaceous plants near them. This can be accomplished manually or with herbicides. When herbicides are used, care must be taken that desirable plants are not damaged.

It is important to observe seedlings for insect damage regularly. If an insect infestation is noted, treatment with an appropriate insecticide is usually needed. Management personnel are advised to consult appropriate authorities before using any pesticide.

MANAGEMENT

Maintenance practices will need to be continued until plantings are well enough established to be able to survive on their own (usually by the end of the second growing season).

LABOR/MATERIALS

An irrigation system suitable for a 20-acre site using either the portable aluminum piping or the traveling-gun system would cost approximately \$12,000 to \$14,000. This system is portable and can be moved from 20-acre site to 20-acre site.

Costs will increase, however, depending on the distance of the reclamation site from an available source of water or electrical power supply. Costs of fencing and pesticides and herbicides are discussed in Sections 3.1.4 and 3.2.3.b.

SOURCES OF INFORMATION

Additional information on maintenance practices can be obtained from:

- o State Regulatory Authority

Reference cited:

Vogel, W. G. A guide for revegetating coal mine soils in the Eastern United States. IERL-Ci-778. Cincinnati, OH: U.S. Environmental Protection Agency, Industrial Environmental Research Laboratory; 1981. Draft report.

h. Vegetation clump transplanting system.

PURPOSE

Transplanting of native vegetation (trees, shrubs, and other species) can provide mature growing plants immediately to the reclaimed area and create a nucleus from which seeds and other organisms can re-invade the area. Other advantages include immediate cover for wildlife, erosion control, and improved landscape aesthetics. This system, as described below, is more effective and efficient than current mechanized transplanting systems and compares favorably in cost with reseeding or planting of nursery stock. It also has wide geographic adaptability because it can be used in virtually any location where the machinery can be transported.

ILLUSTRATION

The transplant system consists of a front-end loader (FEL) and a transporter. The FEL bucket should be designed to maximize the area of material (soil plus vegetation) that can be removed. Because of operating costs and production efficiency, the FEL should be used only for removing clumps of vegetation from undisturbed soil and transferring them short distances. If the distance which an FEL has to move is greater than 274 meters (300 yards), or if there is limited availability of the FEL, a separate transporter makes the operation more efficient. The transporter currently modified for this use is a Hesston stack mover (see Labor/Materials section). In the transplanting operation, the transporter is used to pick up clumps of vegetation removed by an FEL and transport the clumps either to a holding area or to the transplant site.

The operation of the FEL bucket for transplanting, which differs markedly from typical FEL operation, is as follows:

1. A vertical bank or step, approximately 0.6 meter (2 feet high), is cut around the source of trees and shrubs.
2. With the bucket bottom parallel to the ground surface and between 0.3 and 0.6 meter (1 to 2 feet) below the top of the vertical bank, the bucket is pushed into the bank.
3. When the bucket is full, it is lifted vertically, thereby removing a clump of vegetation and soil.
4. The bucket is tilted back (towards the loader) about 10° to 15°, and the clump is transported by the loader to a nearby location.
5. At the unloading point, the bucket is tilted forward (30° to 45° or more) and the loader is reversed, leaving the clump on the ground.

6. The loader is returned to the source of vegetation and the cycle is repeated. Any access roads that may be required for unloading are constructed prior to picking up the next clump, and any necessary surface leveling is done. All roadbuilding and leveling operations must be done with the reclamation bucket.

At this point, if a transporter is utilized, it should have the following characteristics:

1. Capable of picking up clumps of vegetation, each having an area of 6.97 square hectares (75 square feet), and including small trees.
2. Capable of transporting vegetation loads in excess of 13.9 square meters (150 square feet) per load at speeds up to 32 kilometers (20 miles) per hour.
3. Capable of placing the vegetation clumps in the transplant area.

MAINTENANCE AND MANAGEMENT

As a conventional piece of mine production equipment, the FEL would be readily available, but as mentioned earlier, should only be used to transport clumps of vegetation short distances. This would tend to maximize the efficiency of the FEL, compared to the higher operating costs that would be incurred if the FEL had to transport vegetation long distances. The use of a separate transporter would also enable large areas to be transplanted in less time than with an FEL alone. Maintenance of equipment, such as FEL's and transporters, is standard practice during mining operations.

LABOR/MATERIALS

Specifications for equipment are as follows:

Reclamation Bucket

1. Recommended bucket size is 4.6 meters (15 feet) wide, 1.5 meters (5 feet) deep, and 0.9 meter (3 feet) high.
2. Lucite should be used to line the inside bottom of the reclamation bucket. This material proved superior in field tests and will significantly reduce the sticking problem and problems of soil freezing to the bucket.

3. The front cutting edge of the reclamation bucket should be straight and balanced (the cutting edge will have an equal angle and length bevel on top and bottom). This will help control the depth of cutting and help confine soil in the clump.

Transporter

The modified Hesston stack mover, presently being used for transporting operations, was originally manufactured to load, transport, and unload haystacks. It consists of the following mechanical elements:

1. A tilt-bed trailer having a surface area of approximately 15.8 square meters (170 square feet).
2. A chain conveying system capable of sliding the stack across the top of the trailer.
3. A pickup roller for separating the stack from the ground.
4. A set of tracks located at the rear of the trailer to pull the trailer under the stacks.

The rear tracks are synchronized with the conveyor so that the stack is pulled up into the trailer at the same rate that the tracks pull the trailer under the stack. When unloading, the stack is moved off the trailer at the same rate that the rear tracks push the trailer forward. The maximum tilt angle of the trailer is approximately 15° (about 20 percent of the angle used between the FEL transplant bucket and the ground surface when unloading). When the clumps of vegetation are handled by the transporter, they are subjected to minimal bending.

The stack mover was converted to a vegetation transporter by the following modifications:

1. The subframe and tilt bed were strengthened for increased load-carrying capability.
2. The pickup roller was removed, and a short incline was located on the tail of the trailer to slide the vegetation clumps up on the conveyor chain.
3. The tilt-bed trailer was covered with Lucite to reduce friction and facilitate moving vegetation clumps across the top of the trailer.
4. Because a self-contained hydraulic system was mounted on the trailer, only a prime mover (truck or farm tractor) was required for operation of the transporter.

It should be noted that, although the converted stack mover is narrower than the transplant bucket [2.7 meters compared to 4.6 meters (9 feet compared to 15 feet)], it is possible to move clumps having the full 1.5-meter (5-foot) lateral dimension of the transplant bucket. This is the critical dimension because it represents the length over which the clumps are subjected to bending as they are moved on and off the transporter.

SOURCES OF INFORMATION

The U.S. Bureau of Mines, Spokane, Washington, is currently funding a study to evaluate transplanting native vegetation and the mobile transporter system. The prime contractor for the field test is Colorado State University, Fort Collins, Colorado. Energy Fuels Corporation is the cost-sharing cooperator, providing senior staff, machinery, equipment, and facilities.

Additional reference:

Frizzel, E. M.; Smith, J. L.; Crofts, K. A. Transplanting native vegetation. In: Surface Coal Mining Reclamation Equipment and Techniques. U.S. Bureau of Mines Information Circular 8823; 1980: 48-53.

i. Nurse crops and preparatory crops.

PURPOSE

The purpose of nurse and preparatory crops is to provide rapid stabilization of the site and to provide for site modification in favor of establishing permanent cover. Even though their functions are similar, there are important differences in the two crop systems. A preparatory crop is one that is sown and harvested prior to the permanent crop. The permanent crop is then seeded directly into the stubble of the preparatory crop. On the other hand, a nurse crop is seeded with the permanent crop. Nurse crop species are generally annual, quick-cover species that are mixed with the more permanent perennials. The nurse crop is quickly established, thus providing suitable habitat modification for the target species. Nurse crops are sometimes called cover crops or companion crops (green mulch).

Nurse and preparatory crops are not always required for a successful reclamation program. Advantages or disadvantages depend on reclamation objectives and site-specific factors. Some of the major considerations are discussed below.

RECOMMENDATIONS

Since erosion control is a high priority objective on surface-mined areas, seeding mixtures often contain a mix of at least one annual grass and one perennial legume species. The annual grass provides quick cover while the legume provides long-term cover and a source of nitrogen. Some annuals reseed themselves (e.g., Common and Korean lespedeza), while others (e.g., oats, wheat, rye) only provide adequate cover for a single season. Biennials (e.g., crimson and sweet clover) last two seasons, while perennials (e.g., Indian-grass, switchgrass, bluestem) last three seasons or more (Rafaill and Vogel 1978).

There are several advantages to the use of nurse or preparatory crops. Nurse crops tend to reduce wind and water erosion and reduce the germination of weed species that compete with the permanent cover. Nurse crops, such as oats and wheat, may also be harvested for a return on investment prior to the establishment of permanent cover. Seeds harvested from a preparatory crop of wheat can be used to reseed other newly reclaimed areas. Preparatory crops also protect the soil from wind and water erosion, while the stubble reduces water loss, thus aiding the establishment of permanent species. As an added benefit, weed growth is reduced by competition from the preparatory crop.

A disadvantage of nurse crops is that they compete with the desired permanent species for moisture. Preparatory crops leave a thick residue that can inhibit seed germination of the permanent species. Second-year germinating seeds of the preparatory crop will compete with the permanent cover. In a few cases, residue from the preparatory crop may contain substances toxic to the permanent cover. These disadvantages can be reduced to some extent by reducing the seeding rate of the nurse crop species.

In general, nurse crops are not recommended in areas with limited moisture availability due to competition for water. Irrigation may be required for successful establishment in such a case. Preparatory crops have a greater benefit on dry sites, where the reduction in surface temperature and water loss is promoted by the stubble (U.S. Forest Service 1979).

MAINTENANCE AND MANAGEMENT

Preparatory crops should be mowed before they seed in order to prevent competition with the target perennial species.

Where the vegetation fails or cover is poor, replanting, refertilizing, and/or reliming may be necessary. Once perennial legumes are established, refertilization of established vegetation is usually not necessary. Grazing, where it is allowed, has to be controlled. Grazing will damage most cover vegetation if the cover has not been established for at least 2 years; a 3- to 4-year interval of "no grazing" is preferable (Rafaill and Vogel 1978). Overgrazing destroys the vegetation cover, reducing its value to wildlife; continued monitoring of grazing is necessary to prevent this from occurring.

LABOR/MATERIALS

Seeding costs for the nurse crop will vary with seed mixture used and local conditions. Generally, a mixture of annual grasses, annual legumes and grain crops can run approximately \$124/hectare (\$50/acre) for seed mixtures. Added to that is \$54/hectare (\$22/acre) for seedbed preparation, \$15/hectare (\$6.00/acre) seeding, and \$99/hectare (\$40/acre) soil amendments.

SOURCES OF INFORMATION

Additional information on the use of nurse crops and preparatory crops can be obtained from:

- o State Regulatory Authority
- o U.S. Soil Conservation Service
- o State Fish and Game Agency

References cited:

- Rafaill, B. L.; Vogel, W. G. A guide for vegetating surface-mined lands for wildlife in eastern Kentucky and West Virginia. U.S. Fish and Wildlife Service, FWS/OBS-78/84; July, 1978.
- U.S. Forest Service. User guide to vegetation. Ogden, UT: Forest Service Tech. Rept. INT-64, Intmtn. Forest and Range Expt. Sta.; 1979.

j. Stabilization of critical areas with fabric netting.

PURPOSE

Fabric netting is a coarse, open-mesh material woven of natural or synthetic fibers that is used as a mechanical aid to reduce erosion of critical areas during the time necessary to establish vegetative cover. A critical area may be a very steep bank, a diversion ditch, a surface with highly erodible soil, or other area that presents erosion or stabilization problems. Used in place of mulch (Section 3.3.1.f, Mulching), fabric netting provides exceptional protection against wind and water erosion.

DEVELOPMENT (Virginia State Water Control Board 1978)

Fabric netting must make full contact with the soil surface to be effective. After final shaping or grading of an area, all rocks and clods larger than 3.8 cm (1.5 inches) in diameter must be removed. Sticks and other materials that could prevent the netting from contacting the surface must also be removed.

Liming, fertilizing (Section 3.3.1.a, Seedbed Preparation), and seeding should be performed before placing the netting. If desired, half of the required amount of seed can be applied before the netting is placed and the other half after the netting is down. This may help prevent seed loss if there is a delay between seeding and placing of the netting.

Fabric netting is supplied in rolls. The netting is placed at the top of the slope and is unrolled downgrade. The top edge of the netting is buried in a narrow trench that is 10 cm (4 inches) or more deep (Figure 3.3-1). The filled trench should be well-tamped and the edge secured with a row of U-staples about 10 cm (4 inches) downhill from the trench. These staples should be spaced about 25 cm (10 inches) apart. Outside edges are stapled 0.9 to 1.2 meters (3 to 4 feet) apart.

Where more than one roll is necessary to cover an area, a 5-cm (2-inch) overlap is allowed along the outside edges of each roll. The overlapped netting is then stapled to the ground together. When netting ends are joined to extend the netting down the slope, a 10-cm (4-inch) overlap is allowed and buried in a trench. Again, staples are placed along the overlap at 25-cm (10-inch) intervals. After securing the netting, use a roller at a right angle to the slope to ensure good contact between the soil and netting. Perfect contact is essential for the netting to be effective.

For added effectiveness, erosion stops may be made at any place along the length of the netting. Erosion stops check water flow and erosion that may occur underneath the netting. A 10-cm (4-inch) fold is made in the netting, buried, and secured with a double row of staples. Erosion stops can be spaced from 7.6 to 30.5 m (25 to 100 feet) apart.

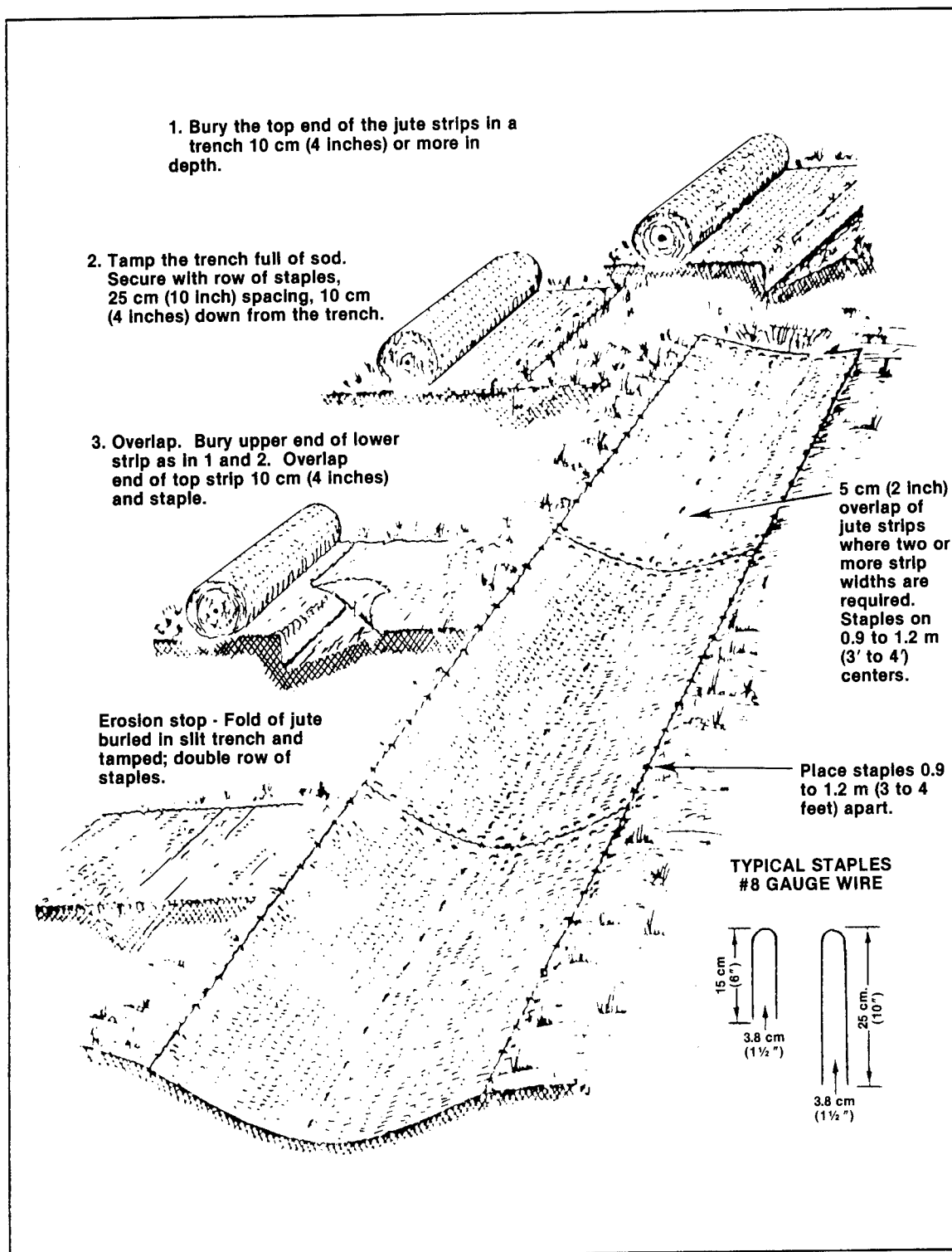


Figure 3.3-1. Installation of fabric netting for stabilization of critical areas (after Virginia State Water Control Board 1978).

MAINTENANCE AND MANAGEMENT

Properly installed fabric netting will not require any maintenance. Runoff flows over well-secured netting with full soil surface contact prevent erosion of the soil underneath the netting.

LABOR/MATERIALS

Netting and wire staples are available commercially. Netting made of natural fibers, such as jute and cellulose, are not as readily available as in the past. Synthetic fiber netting, such as fiberglass and plastic, are available from a number of manufacturers. When choosing a material, special attention should be given to the fact that some of these nettings will not deteriorate and will require removal by hand. Most synthetic nettings range in cost from \$0.08 to \$0.12 per 0.84 square meter (1 square yard). Staples can also be made from 8-gauge wire according to the dimensions in Figure 3.3-1. Proper installation of 93 square meters (1000 square feet) of netting and two erosion stops takes about 3 to 4 man-hours.

SOURCES OF INFORMATION

Additional information on the stabilization of critical areas can be obtained from:

- o State Regulatory Authority
- o U.S. Soil Conservation Service
- o State Highway Department

Reference cited:

Virginia State Water Control Board. Best management practices handbook--agriculture. Richmond, VA; 1978.

k. Food patches.

PURPOSE

A food patch is, by definition, any plot of domestic food plants (usually small grains) reserved for use by wild animals. If leguminous or woody plants are also included in the planting, the patches can be a source of wildlife cover. Food plots can easily be incorporated into almost any postmining land use objective because the size of the plots are relatively small and can be placed in areas where they will not interfere with other land use activities.

Food patches can either be planted for a specific species, or they can be general-purpose plantings, providing food for a variety of animals. The literature on plantings for specific species is well-documented and readily available and, for this reason, will not be repeated here. (See Shomon et al. 1966; Hinkle et al. 1981; and several excellent State publications listed in the references following Section 3.3.1.1, Planting Patterns.) General-purpose food patches, on the other hand, are less well-documented, but are very important because of the number and variety of wildlife served by them.

The success of food patches and the volume of food materials produced is sometimes dramatic. In a study in New Hampshire, where nine food patches were planted for pheasants, 339 kg of seed were produced per 0.4 hectare (746 pounds of seed per acre) (Gould no date). Costs averaged \$3.38 per 45.4 kg (100 pounds) of seed produced and \$25.24 per 0.4 hectare (1 acre). The most productive plot yielded 634 kg per 0.4 hectare (1,396 pounds per acre) at a cost of \$1.86 per 45.4 kg (100 pounds); corresponding values for the least productive plot were 107 kg (235 pounds) and \$10.70. Results of the study indicated that the pheasant population where the food patches were planted increased from 19 in September to 50 in November.

DEVELOPMENT

Most general-purpose food patches should be no smaller than 0.05 hectare (0.1 acre) in size and not larger than 0.4 hectare (1 acre). Several scattered plots are also better than grouped plots; long narrow patches are the best shape. Plots will be more readily used if they are located close to protective cover, such as a woods edge or a rock or brushpile. The attractiveness of the patch will be further enhanced if strip plantings connect the food patches and cover. These strip plantings need be nothing more than a few rows of tall-growing legumes or a double row of woody shrubs or trees.

Several general-purpose food patch mixtures have been developed for various areas of the country and for locations where the seeds are available. Table 3.3-7 lists three mixtures suitable for east Texas, Oklahoma, Arkansas, and north Louisiana (Shomon et al. 1966). Each should be planted in the spring in patches that are 0.2 to 0.4 hectare (0.5 to 1 acre) in size. Liming may be necessary to bring the pH of the soil to the preferred 6-6.5 range, and fertilizer is recommended at an application rate of 136-182 kg per 0.4 hectare

(300-400 pounds per acre) of 5-10-10. Each of the mixtures was developed to group certain types of plants that grow well together and provide wildlife benefits over an extended period of time.

Table 3.3-7. Food patch mixtures for planting in spring for the Southcentral U.S. (from Shomon et al. 1966).

Species	Kilograms	(Pounds)
<u>Mixture #1 for 2.02 hectares (5 acres)</u>		
Buckwheat	4.5	(10.0)
Grain sorghum	4.1	(9.0)
Foxtail millet	6.8	(15.0)
Proso millet	6.8	(15.0)
Kaffir	4.1	(9.0)
Sudangrass	2.3	(5.0)
Soybeans	6.8	(15.0)
Cowpeas	5.9	(13.0)
Vetch	4.1	(9.0)
Total kilograms (total pounds)	45.4	(100.0)
<u>Mixture #2 for 2.02 hectares (5 acres)</u>		
Buckwheat	6.8	(15.0)
Foxtail millet	6.8	(15.0)
Sudangrass	6.8	(15.0)
Soybeans	11.4	(25.0)
Cowpeas	13.6	(30.0)
Total kilograms (total pounds)	45.4	(100.0)
<u>Mixture #3 for 2.02 hectares (5 acres)</u>		
Proso millet	8.0	(17.5)
Grain sorghum	11.4	(25.0)
Sunflower	3.4	(7.5)
Total kilograms (total pounds)	22.8	(50.0)

In choosing a seed mixture to plant, the greater the variety of seeds in the mix, the greater the potential number of species that will use the planting. However, the availability of certain seeds from suppliers may limit the use of certain mixtures.

MAINTENANCE AND MANAGEMENT

Most of the plants listed in Table 3.3-7 are annuals, which means that they rapidly establish vegetative growth, flower, and die within one growing season. They reproduce only from the seed they produce during their life cycle and will rarely produce successful food patches during the second season without assistance.

Plots will essentially have to be retilled and sown each spring to be effective. Bushes and herbaceous growth will quickly cover a plot during the second growing season unless they are removed manually by tilling and/or controlled burning.

LABOR/MATERIALS

See Section 3.3.1 for appropriate equipment and labor estimates for establishing vegetative plantings.

SOURCES OF INFORMATION

Additional information on food patches for wildlife can be obtained from:

- o State Fish and Game Agency
- o U.S. Fish and Wildlife Service
- o U.S. Soil Conservation Service
- o State Forestry Agency
- o U.S. Forest Service

References cited:

Gould, E. W. Progress report of the southern New Hampshire pheasant demonstration and research project. New Hampshire Fish and Game Dept. Tech. Cir. 5; no date.

Hinkle, C. R.; Ambrose, R. E.; Wenzel, C. R. A handbook for meeting fish and wildlife information needs to surface mine coal - OSM Region IV. U.S. Fish and Wildlife Service. FWS/OBS-79/48.3.4; 1981.

Shomon, J. J.; Ashbaugh, B. L.; Toman, C. C. Wildlife habitat improvement. New York: Nat. Audubon Society; 1966.

Additional references:

Missouri Department of Conservation. Plant annual food plots for wildlife. Jefferson City, MO: Missouri Department of Conservation; 1973.

Missouri Department of Conservation. Green browse food plots. Jefferson City, MO: Missouri Department of Conservation; no date.

1. Planting patterns.

PURPOSE

The distribution of habitat types in a community can be a key determinant of the area's value to wildlife. Since use of an area is largely determined by the mobility of a species and the relative availability of food, water, cover, and other habitat requirements, the greater the interspersed of these habitat components (the more patchiness or diversity that exists in the community), the more valuable the area is to wildlife. Reclamation of surface-mined coal lands incorporating the interspersed of different vegetation types invariably increases the diversity and overall abundance of wildlife.

After determining what to plant, the next most important questions are "how" and "where" to plant. The planting pattern in many cases can be as important, if not more so, than what is planted. A food plot located in the middle of an open field will not receive nearly as much use as a similar plot located near a woods edge. The placement of food plots near cover will further increase the attractiveness of the planting to wildlife.

With careful placement of wildlife plantings, food and shelter plots can easily be incorporated into almost any postmining land use scheme. Suggestions offered later in this section indicate planting schemes which would be compatible with several of the more common land use objectives and special areas in the Southcentral U.S.

DEVELOPMENT

Different types of vegetation have different values for wildlife. Trees and shrubs typically provide nesting habitat, cover, fawning areas, escape terrain, and foraging areas. Grasses and forbs generally provide food, but may also provide cover, nesting habitat, and escape terrain for smaller wildlife species. A wildlife biologist can determine those habitat requirements most needed by single target species or groups of target species. Those requirements can be provided through the spatial arrangement of selected vegetation types. Several excellent State and Federal publications which discuss regional planting patterns for wildlife are given at the end of this section.

In most cases, when trying to maximize diversity, strip plantings are highly successful. Variety results from having bands of different types of vegetation (e.g., different growth forms, foliage retention periods, fruit retaining dates) planted in alternate rows. Some of the strips will be used by wildlife as travel lanes and runways. A random planting pattern may be more pleasing to the eye, but it creates gaps in the cover that some ground-dwelling birds and mammals are unwilling to cross. Some game species, such as cottontail rabbits and bobwhite quail, will benefit significantly from such planting patterns. Travel lanes of bristly locust, alternating with two rows of shrubs, such as autumn olive or sumac, are recommended as general-purpose strip plantings.

Specific guidelines for wildlife planting patterns to promote diversity on special sites can be summarized as follows (Hinkle et al. 1981):

In Areas with Steep Slopes

- o Plant two or three rows of trees above the top of the original highwall.
- o Plant benches to alternating strips or blocks of herbaceous species and shrubs.
- o Plant the edge of the bench near the outslope to a few rows of conifers.
- o Plant the outslope to strips of herbs and woody plants that will also ensure quick erosion control.

In Flat Areas

- o Plant strips of grasses and legumes that are 30 to 46 meters (100 to 150 feet) wide, with alternating strips of shrubs and/or trees that are 9 to 15 meters (30 to 50 feet) wide.
- o In land reclaimed for forest, provide open areas that are at least 0.2 hectare (0.5 acre) in size, with a minimum of one patch per 16 hectares (40 acres). Seed to grass and/or legume species.

In Pasture or Hay Fields

- o Plant a strip of shrubs (bristly locust, autumn olive, or sumac), not over 6 meters (20 feet) in width, around the field.
- o Plant a clump of trees and shrubs at random locations on every 2 hectares (5 acres) of field to provide food and cover.
- o Fence special-use wildlife food plots.

In Forest Plantations

- o In forest plantations, leave open areas (e.g., fire breaks) to provide more food and cover.
- o Mixed forest populations are best for wildlife in providing diversity of habitats. Hardwood and coniferous rows can also be separated from each other by grass and legume strips to give more edge and open areas.
- o Plant a single or double row of shrubs at the forest edge.

- o Plant a double or single row of shrubs, spaced 2 meters (6 feet) apart, between rows of trees on pine tree plantations.

In Industrial Areas

- o Plant shrubbery around office buildings. Emphasize those species with high wildlife food value.

In Unplanted Areas

- o Locate escape cover of boulders, logs, slash, and brush.

In Streams

- o Establish grasses or sedges on the bank as a food source.
- o Establish trees and/or shrubs at intervals along the streambank for cover for wildlife and for shade for fish.
- o Establish clump plantings of shrubs on moist low-lying areas paralleling the stream to protect these areas from overuse by large animals.

In and Around Impoundments

- o Establish shoreline grasses, shrubs, and/or trees to provide food and cover.
- o In shallow areas, establish aquatic plants for waterfowl cover and food. Some aquatic plantings may cause poor fish production if they are too dense. Plantings must be compatible with objectives; fish or wildlife production.
- o Establish a mixture of grass and shrub patches on shorelines to encourage waterfowl breeding.

MAINTENANCE AND MANAGEMENT

It should be remembered that vegetation changes with time; therefore, the quality and quantity of food and cover will, in time, be affected. If the landowner so desires, he can counteract this process of change to a great degree by initiating some maintenance practices. For example, open areas will become overgrown, thus requiring cutting, disking or controlled burning to preserve the cover type. Practices such as these for maintaining open areas should be undertaken only after the broods of ground-nesting birds, such as bobwhite quail, have left the nest, generally in late summer. Recommendations for the best maintenance procedures can be obtained from professional wildlife biologists, conservationists, and foresters.

LABOR/MATERIALS

Once the decision has been made to utilize a variety of wildlife plantings for reclamation, an appropriate planting pattern can be implemented at no substantial additional cost. Strip wildlife planting, as opposed to random planting, can even reduce costs, by allowing personnel and machinery to concentrate their efforts in one area.

SOURCES OF INFORMATION

Additional information on planting patterns for wildlife plants can be obtained from:

- o State Regulatory Authority
- o Office of Surface Mining
- o State Fish and Game Agencies
- o U.S. Bureau of Land Management
- o U.S. Fish and Wildlife Service
- o U.S. Forest Service
- o U.S. Soil Conservation Service

Reference cited:

Hinkle, C. R.; Ambrose, R. E.; Wenzel, C. R. A handbook for meeting fish and wildlife information needs to surface mine coal-OSM Region IV. U.S. Fish and Wildlife Service. FWS/OBS-79/48.3.4; 1981.

Additional references:

Alexander, B. G. Movements of deer in northeast Texas. J. Wildl. Manage. 32(3):618-620; 1968.

Alexander, B. G. Fox squirrel management in east Texas. PWD Booklet 7000-28. Austin, TX: Texas Parks and Wildlife Department; 1979.

Allaire, P. N. Reclaimed surface mines: New potential for some North American birds. Am. Birds 32(1):3-5; 1978.

Allan, P. F.; Steiner, W. W. Autumn olive for wildlife and other conservation uses. USDA leaflet No. 458. U.S. Government Printing Office. Washington, DC; 1972.

Alverson, K. Cattle and fish on surface-mined land. Soil Conservationist 34(4):4-6; 1973.

Anderson, W. L. Making land produce useful wildlife. USDA Farmers' Bull. No. 2035. U.S. Govt. Printing Office, Washington DC; 1969.

- Anonymous. Reclamation under semiarid conditions. Coal Mining Process 7(11):34-37; 1970.
- Arner, D. H.; Davison, V. E. Wild turkeys on southeastern farms and woodlands. USDA Leaflet No. 526. Washington, DC: U.S. Government Printing Office; 1976.
- Baxter, W. L.; Wolfe, C. W. The interspersation index as a technique for evaluation of bobwhite quail habitat. In: Morrison, J. A.; Lewis, J. C., eds. Proceedings first bobwhite quail symposium. Stillwater, OK: Oklahoma St. University; 1972:158-165.
- Baxter, W. L.; Wolfe, C. W. Life history and ecology of the ring-necked pheasant in Nebraska. Lincoln, NE: Nebraska Game and Parks Comm.; 1973.
- Brenner, F. J. Food and cover evaluation of strip mine plants as related to wildlife management. In: Surface Mining and Fish and Wildlife Needs in the Eastern U.S. U.S. Fish and Wildlife Service. FWS/OBS-78/81; 1978.
- Brakhage, G. K. Waterfowl management. Jefferson City, MO: Missouri Department of Conservation; no date.
- Christisen, D. M. Dens for squirrels. Jefferson City, MO: Missouri Conservation Commission; no date.
- Cottam, C.; Trefethen, J. B., eds. Whitewings: the life history, status, and management of the whitewinged dove. Princeton, NJ: D. Van Nostrand Co., Inc.; 1968.
- Davis, B. D. Effects of brush control on quail populations. FA Series No. 19. Austin, TX: Texas Parks and Wildlife Department; 1979.
- Davis, R. B.; Winkler, R. B. Brush versus cleared range for deer habitat in southern Texas. J. Wildl. Manage. 32(2):321-329; 1968.
- Evans, K. E. Forest management opportunities for songbirds. In: Proceedings of Forty-Third North American Wildlife Conference.; 1978:69-77.
- Evans, K. E. Oak-pine and oak-hickory forest bird communities and management options. In: Proceedings of the Workshop: Management of Southern Forests for Nongame Birds, Atlanta, GA. January 24-26. USDA Forest Service General Technical Report SE-14. U.S. Forest Service. Southeastern Forest Experiment Station; 1978:76-89.
- Giles, R. H., Jr., ed. Wildlife management techniques. Washington, DC: The Wildl. Soc.; 1969.
- Goodrum, P. D. The gray squirrel in Texas. Bulletin No. 42. Austin, TX: Texas Parks and Wildlife Department; 1967.

- Hailey, T. L. Basics of brush management for white-tailed deer production. PWO Booklet 7000-35. Austin, TX: Texas Parks and Wildlife Department; 1979.
- Halls, L. K.; Ripley, T. H., eds. Deer browse plants of southern forests. U.S. Forest Service. Southern and Southeastern For. Exp. Stns.; 1961.
- Hewitt, O. H. The wild turkey and its management. Washington, DC: The Wildl. Soc.; 1967.
- Hosley, N. W. Selected references on management of white-tailed deer 1910 to 1966. U.S. Fish Wildl. Serv. Bureau Sport Fish. Wildl. Spec. Sci. Rep. 112; 1968.
- Hubbard, R. L. The place of browse seeding in game range management, pp. 394-401. In North American Wildlife Conference Transactions; 1962.
- Jackson, A. S. Quail management handbook for west Texas rolling plains. Bulletin No. 48. Austin, TX: Texas Parks and Wildlife Department; no date.
- Jackson, A. S.; Holt, C.; Lay, D. W. Bobwhite quail in Texas. Brochure No. 101. Austin, TX: Texas Parks and Wildlife Department; no date.
- Kolar, C.; Ashby, W. C. Potential for woodland habitat from surface mine tree plantings. Volume VII, pp. 323-330. In Sabol, K., ed., Transactions of the forty-third North American wildlife and natural resources conference, Phoenix, AZ, March 18-22. Washington, DC: Wildlife Management Institute; 1978.
- Korschgen, L. J. Food habits of the mourning dove in Missouri. Missouri Cons. Comm. Fish and Game Division P-R Series 12; 1955.
- Korschgen, L. J. Feeding habits and food. In: Hewitt, O. W., ed., The wild turkey and its management. Washington, DC: The Wildl. Soc.; 1967:137-199.
- Korschgen, L. J. Principal year-round foods of cottontails in Missouri. Missouri Dept. Conserv. P.R. Proj. W13-R-27. Job 1; 1973.
- Lay, D. W. Brief summary of turkey range management. In: Proc. First Natl. Wild Turkey Mgmt. Symp.; 1959:79-100.
- Lay, D. W. The importance of variety to southern deer. Presented to Southeastern Association, Clearwater, FL: Game and Fish Commissioners Meeting. October 19-21; 1964.
- Lay, D. W. Deer range appraisal in eastern Texas. J. Wildl. Manage. 31(3):426-432; 1967.

- Lay, D. W. Quail: a management handbook for east Texas. Bulletin No. 34. Austin, TX: Texas Parks and Wildlife Department; 1969.
- Lennartz, M. R.; Bjugstad, A. J. Information needs to manage forest and range habitats for nongame birds, pp. 328-333. In Proceedings: A symposium on management of forest and range habitats for nongame birds; Tucson, AZ, May 5-9, 1975. Washington, DC: USDA Forest Service, General Technical Report WO-1.
- Lewis, J. C. The world of the wild turkey. New York: J. B. Lippincott Co.; 1973.
- Lindzey, J. S. Highlights of management. In: Hewitt, O. W., ed. The wild turkey and its management. Washington, DC: The Wildl. Soc.; 1967:245-260.
- Louisiana Department of Wildlife and Fisheries. Mourning dove in Louisiana. Wildlife Education Bulletin No. 94. Baton Rouge, LA: Louisiana Department of Wildlife and Fisheries; 1974.
- Markley, M. H. Limiting factors. In: Hewitt, O. W., ed. The wild turkey and its management. Washington, DC: The Wildl. Soc.; 1967:199-244.
- McAtee, W. L., ed. The ring-necked pheasant and its management in North America. Washington, D.C.: Am. Wildl. Inst.; 1945.
- McKell, C. M.; Blaisdell, J. P.; Goodin, J. R.; eds. Wildlife shrubs: their biology and utilization. USDA Forest Service General Technical Report ITN-1. Ogden, UT: Intermountain Forest and Range Exp. Station; 1972.
- McMahan, C. A.; Inglis, J. M. Use of Rio Grande Plain brush types by white-tailed deer. J. Range Manage. 27(5):369-374; 1974.
- Missouri Department of Conservation. Make non-crop areas produce. Jefferson City, MO: Missouri Department of Conservation; 1967.
- Missouri Department of Conservation. Plant sericea lespedeza for wildlife cover. Jefferson City, MO: Missouri Department of Conservation; 1967.
- Missouri Department of Conservation. Native prairie grasses: self-guided tour. Montrose Wildlife Area. Jefferson City, MO: Missouri Department of Conservation; 1974.
- Missouri Department of Conservation. An introduction to bird study in Missouri. Jefferson City, MO: Missouri Department of Conservation; no date.
- Moore, G. M. The Louisiana deer story. Wildlife Education Bulletin No. 108. Baton Rouge, LA: Louisiana Department of Wildlife and Fisheries; 1979.

- Murphy, D. A. Missouri deer hunting. Jefferson City, MO: Missouri Department of Conservation; 1976.
- Nelson, R. W.; Horak, G.; Olson, J. E. Western reservoir and stream habitat improvements handbook. FWS/OBS-78/56. U.S. Fish and Wildlife Service; 1978.
- Patton, D. R. A diversity index for quantifying habitat "edge." Wildl. Soc. Bull. 3:171-173; 1975.
- Plummer, A. P. Research in game forage restoration in Utah, pp. 159-166. In Proceedings of 39th Annual Conference of Western Association of State Game and Fish Commissioners, Portland, OR: 1959.
- Prickett, T. Louisiana bobwhite basics. Wildlife Education Bulletin No. 113. Baton Rouge, LA: Louisiana Department of Wildlife and Fisheries; no date.
- Rafaill, B. L.; Vogel, W. G. A guide for vegetating surface-mined lands for wildlife in eastern Kentucky and West Virginia. U.S. Fish and Wildlife Service. FWS/OBS-78/84; 1978.
- Riley, C. V. Reclamation of coal strip-mine lands with reference to wildlife plantings. J. Wildl. Manage. 21:402-413; 1957.
- Riley, C. V. Revegetation and management of critical sites for wildlife. In: J. B. Treethen, ed. Transactions of the 28th North American wildlife and natural resources conference. Washington, DC: Wildl. Manage. Inst. Also in Wildl. Rev. 112:17 (Abstr.); 1963:269-283.
- Rosene, W., Jr. The bobwhite quail: its life and management. New Brunswick, NJ: Rutgers University Press; 1969.
- Sadler, K. C. Rabbit management. Jefferson City, MO: Missouri Conservation Commission; no date.
- Sadler, K. C. Dove management. Jefferson City, MO: Missouri Department of Conservation; no date.
- Samuel, D. E.; Stauffer, J. R.; Hocutt, C. H.; Mason, W. T., eds. Surface mining and fish/wildlife needs in the eastern United States. Proceedings of a symposium, FWS/OBS-78/81. West Virginia University. U.S. Fish and Wildlife Service; 1978.
- Sanderson, G. C., ed. Management of migratory shore and upland game birds in North America. Washington, DC: Int. Assoc. Fish and Wildlife Agencies; 1977.
- Scott, V. E. Cavity-nesting birds of North American forests. U.S. Forest Service Handbook 511. U.S. Government Printing Office; 1977.

- Smith, R. J.; Townsend, J. E., eds. Improving fish and wildlife benefits in range management. U.S. Fish and Wildlife publ. FWS/OBS-77/01; 1977.
- Stanford, J. A. Quail management. Jefferson City, MO: Missouri Department of Conservation; no date.
- Stoddard, H. L. The bobwhite quail: its habits, preservation and increase. New York: Charles Scribner's Sons; 1931.
- Texas Forest Service. Managing your Texas forest. Circular 217. College Station, TX: Texas Forest Service; 1976.
- Texas Forest Service. Improving your woodland for wildlife. Circular 222. College Station, TX: Texas Forest Service; no date.
- Trippensee, R. E. Wildlife mangagement: upland game and general principles. Volume I. New York: McGraw-Hill; 1948.
- U.S. Agriculture Research Service. Report 9--game range improvement in New Mexico. Las Cruces, NM: U.S. Department of Agriculture, Agricultural Research Service; 1971.
- U.S. Forest Service. How to manage woodlands for birds. NE-INF-31-76; no date.
- U.S. Forest Service. Wildlife habitat improvement handbook. FSH 2609.11; 1969.
- U.S. Soil Conservation Service. Plants for a purpose. Coffeeville, MS: U.S. Department of Agriculture; 1978.
- U.S. Soil Conservation Service. Landowner information job sheet: wildlife borders and planting in odd places (LA-Biol-2). Alexandria, LA: U.S. Department of Agriculture, Soil Conservation Service; various dates.
- U.S. Soil Conservation Service. Field office technical guide handbook: pond (Sec. IV, 378). Alexandria, LA: U.S. Department of Agriculture; various dates.
- U.S. Soil Conservation Service. Land management guide: a supplement to biology standard and specifications for Louisiana. Alexandria, LA: U.S. Department of Agriculture; no date.
- U.S. Soil Conservation Service. State standard and specifications for wildlife upland habitat management. Stillwater, OK. U.S. Department of Agriculture; 1974.
- Yoakum, J.; Dasmann, W. P; Sanderson, H. R.; Mixon, C. M.; Crawford, H. S. Habitat improvement techniques. In: Schemnitz, S. D., ed. Wildlife management techniques manual. Washington, DC: The Wildlife Society; 1980:329-403.

m. Grazing management.

PURPOSE

Livestock production is a viable and profitable postmining land use option in the Southcentral U.S. This is shown by the fact that surface mine operators have made "improved grassland" the dominant postmining land use after mining and subsequently use the area to graze cattle. The grazing management program which is instituted on these lands can have a significant effect on wildlife in the area. The most important concerns should be how, when, and to what extent a pasture is grazed. Also, where fields adjoin wooded areas, the restriction of woodland grazing should be considered. Studies have shown that, where moderate grazing of pastures is practiced, certain habitats may be improved for wildlife (Weatherill and Keith 1969). On the other hand, overgrazing, which sometimes occurs in woodlands, can remove 50% or more of the bird species on an area (Dambach and Good 1940).

Grazing systems currently in practice include year-long, continuous, deferred rotation/rest rotation, common use, and alternate use by different kinds of livestock (Buttery and Shields 1975). The management system chosen can potentially result in many long-term benefits, not only in terms of increased productivity of the land to support grazing, but also by increasing wildlife populations which otherwise would be depressed.

DEVELOPMENT

Year-long Grazing

This is probably the most detrimental form of grazing management to wildlife. The pasture is often overgrazed to the point where range plants are never given the opportunity to develop adequate food and cover to support birds and small mammals. Stock may also denude certain areas of vegetation to the point where erosion can cause siltation of streams and degrade fish habitat.

Continuous Grazing

Although year-long grazing is continuous, not all continuous grazing is year-long. If the season of grazing of an area can be selected, spring and early summer grazing would probably rank as the most detrimental to wildlife. It is during these times that birds and small mammals are raising young and have the greatest need for high-quality food. Heavy grazing during these times can trample nests and remove the most tender vegetation preferred by wildlife. The remaining seasons, in order of importance to wildlife, would be (from most important to least) late summer, fall, and winter.

Deferred Rotation/Rest Rotation Grazing

Deferred grazing is the discontinuance of grazing on an area for a specified time. As indicated under Continuous Grazing, an area can be allowed to recover from intense grazing pressure by allowing cattle to graze elsewhere for a certain period of time, preferably during the growing season. However, as the deferred pasture is recovering, the grazed pasture is nearly always placed under heavy use. This can be offset by placing a limit on the number of cattle allowed to graze within a given area.

Common Use Grazing

Common use grazing is the use of an area by more than one kind of animal, either at the same time or at different times. Since cattle and horses prefer grasses, sheep prefer forbs, and goats prefer shrubs, almost all of the vegetation on an area could potentially be cut back, depending on the variety and number of animals which use the area. Common use grazing, in this regard, can be very detrimental to wildlife habitat because of the variety of vegetation types which might be affected.

Alternate Use Grazing

Alternating the kinds of grazing animals that utilize a pasture in different years can often be extremely beneficial to wildlife. It has been used to improve areas that have deteriorated to the point where the vegetative cover is largely forbs. In this management scheme, certain vegetation types on an area are allowed to recover, while others are alternately used. This, in turn, allows wildlife groups which were depressed a chance to recover on an area. A commonly used alternate use grazing system allows cattle to graze a pasture for 2-3 years and then be replaced for 1-2 years by horses or sheep.

Restriction of Grazing

One of the most detrimental grazing management practices to wildlife is allowing livestock to roam freely from pastureland into surrounding wooded areas. When livestock are not restricted by fencing, they wander into woods to seek shade and consume woodland ground cover. Plants are then trampled as well as eaten. In a study in Ohio, it was found that protected woods supported more than twice the bird population--both in terms of individuals and species--than did grazed woods (Dambach and Good 1940). Furthermore, none of the species which nested on the ground in the protected woods were found in the grazed woods.

SOURCES OF INFORMATION

References cited:

Buttery, R. F.; Shields, P. W. Range management practices and bird habitat values. In: Proceedings of the symposium on management of forest and range habitats for nongame birds. Tucson, AZ: U.S. Forest Service General Tech. Rpt. WO-1; 1975.

Dambach, C. A.; Good, E. E. The effect of certain land use practices on populations of breeding birds in southwestern Ohio. J. Wildl. Manage. 4(1):63-76; 1940.

Weatherill, R. G.; Keith, L. B. The effects of livestock grazing on an aspen forest community. Alberta Dept. Lands and Forests. Fish and Wildlife Division. Tech. Bull. 1; 1969.

Additional references:

Hamilton, W. Range management for quality wildlife. Rangelands 1(4):149-151; 1979.

3.3.2 Water Resources Improvement and Development

a. Stream improvements: Mitigation and restoration techniques.

PURPOSE

Stream improvements can be required by the regulatory authority on sites where aquatic habitats are disturbed by mining activities. Mitigation of unavoidable damage to an aquatic habitat often takes the form of improving remaining aquatic resources. Restoration, on the other hand, is necessary when a stream is directly affected by being mined through or diverted. Restoration and mitigation techniques which should prove useful in the South-central U.S. are the construction of artificial channels and meanders, the development of pools and riffles, and the creation of fish shelters. Artificial channels and meanders create new aquatic habitat, while the development of pools, riffles, and other shelters enhances or restores existing aquatic resources.

DEVELOPMENT

Fish Shelters

Simple techniques can provide useful fish shelters in wide, shallow streams with fast currents and limited natural shelter. Anchored logs provide excellent cover (Section 3.3.2.f, Fish Shelters in Ponds and Lakes), but should be placed where they will not catch trash and create an unwanted dam. Large boulders, 0.5 cubic meters (two-thirds of a cubic yard) or larger, also make effective fish shelters. They should be placed with a front-end loader or other suitable machinery in areas with gravel bottoms to prevent the boulders from becoming buried in finer materials. One boulder for every 38 square meters (300 square feet) of channel surface can be considered a maximum (U.S. Forest Service 1969). In all cases, soft erodible banks should be protected by careful choice of equipment access and proper placement of in-stream structures to avoid excessive current deflection.

Dams

Pools provide deepwater cover, feeding, resting, and spawning habitat and riffles are used for spawning by many fish species. In most cases, they are created by placing a low check dam across a stream. Experience with most check dams shows that, after dam completion and upstream pool formation, a pool is formed below the dam by scouring during floods, while above the dam, the upstream pool fills with gravel and becomes a riffle area. Check dams, which need be no more than 0.3 meter (12 inches) above the stream bottom to be effective, can be constructed of logs, boards, rocks, posts and wire, and gabions (for details of gabion construction, see Section 3.3.2.b, Streambank Protection).

Dams should never be built so high that floodwaters will be forced over the bank at either end. It is extremely important to keep this fact in mind because dams reduce the gradient of the stream channel, thus increasing the cross section of the flow.

The width of dams is an important consideration. Restrict log-type dams to channel widths of 6.1 meters (20 feet) or less. Simple rock dams frequently fail when constructed wider than 3.1 or 3.7 meters (10 or 12 feet). Rock and wire dams may be used to span wider streams when maximum flood volumes are less than 2.8 cubic meters (100 cubic feet) per second.

Location of dams is important. Sites along straight sections of narrow channels reduce costs and possible damage to the stream channel and dam.

Directing the flow through wide notches, greater than one-fourth the total width of the dam, may be desirable. This will help provide the scouring action needed during low-flow periods. Other structures, such as opposing deflectors, can be used where increased scouring is desired.

K-Dams. The K-dam obtains its name from the knee braces used at each end of the dam which, when viewed from above, give the dam the shape of the letter K. The K-dam (Figures 3.3-2 and 3.3-3) is highly reliable when properly installed. Installation costs are generally less than those for log and board dams. As with all log dams, streams with narrow channel widths, low gradients, and low-volume flows are most suitable for these structures. Logs, called mudsills, are placed beneath the dam parallel to the streamflow and furnish the base on which the upstream face of the dam is constructed.

Construction should start with excavations for the ends of the dam and the mudsills. Place the ends of the dam 1.8 meters (6 feet) or more into the bank; the excavation for the mudsills should be at least one-half of their diameter. Mudsills should not be spaced farther than 0.9 meter (3 feet) from center to center.

In streams with low flow, it is possible to place the mudsills in position first and then lower the main dam on top of them. However, if there is a sizable volume of water to work in, it is easier to place the main dam log in position first and then slide the ends of the mudsills underneath the log. Drift pins, as shown in Figure 3.3-2, hold the mudsills in place.

After the mudsills and dam log are in place, woven wire is stapled to the top of the log and pressed into place against the mudsills to which it is also stapled. The woven wire extends up the banks at least 0.9 to 1.2 meters (3 to 4 feet) and into the bank excavations at the ends of the dam. A layer of rocks of a larger diameter than the openings in the woven wire is carefully laid on the woven wire. This layer of rocks is covered with a thick seal of water-washed gravel, which is carefully tamped in around the ends of the log extending into the bank excavation. The application of this gravel seal should start at the ends of the dam and progress toward the center of the stream. The gravel seal is finally given a protective covering of large rocks to prevent its being swept away in high water. Figure 3.3-3 shows in detail how the dam is sealed.

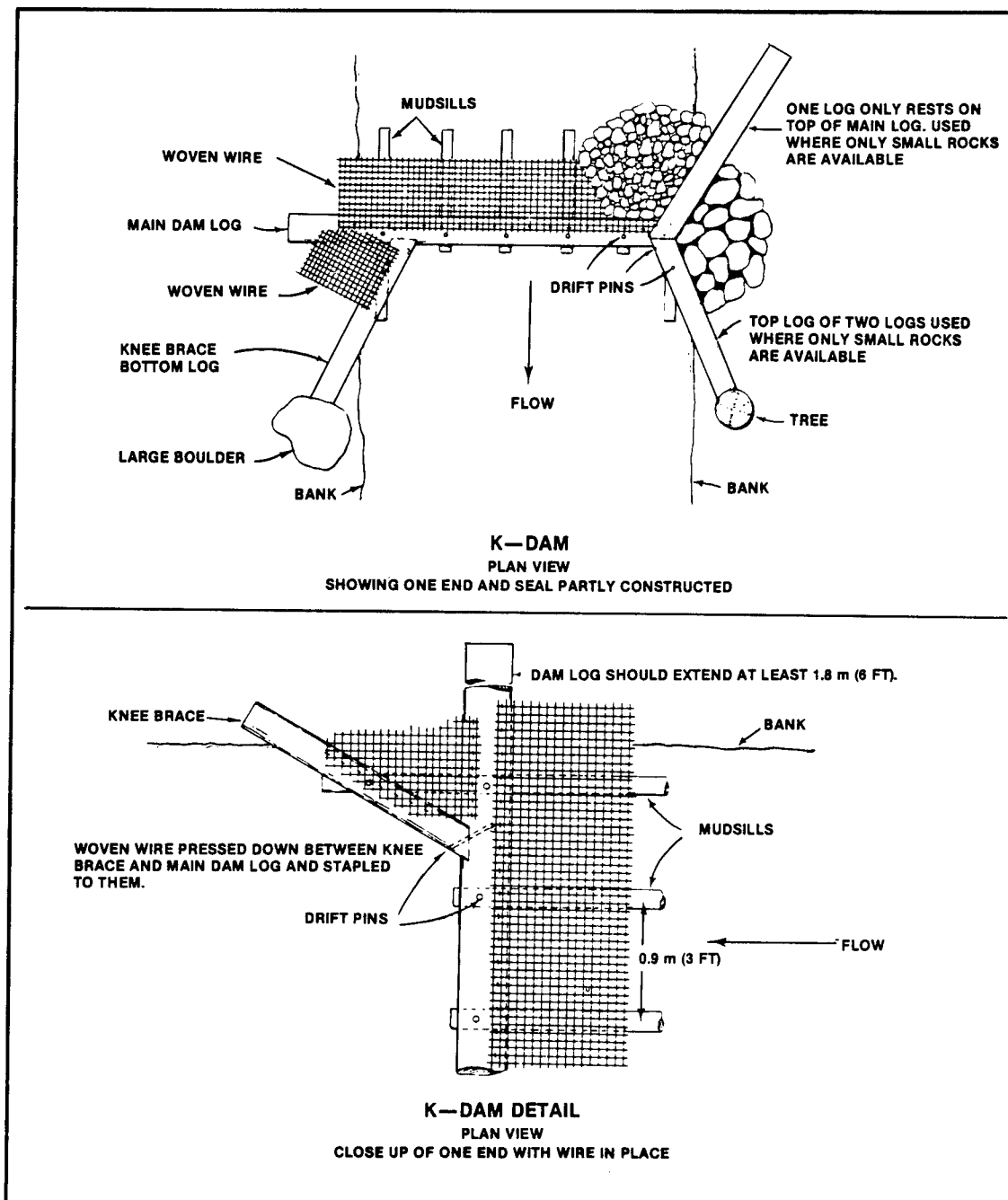


Figure 3.3-2. K-dams (U.S. Forest Service 1969).

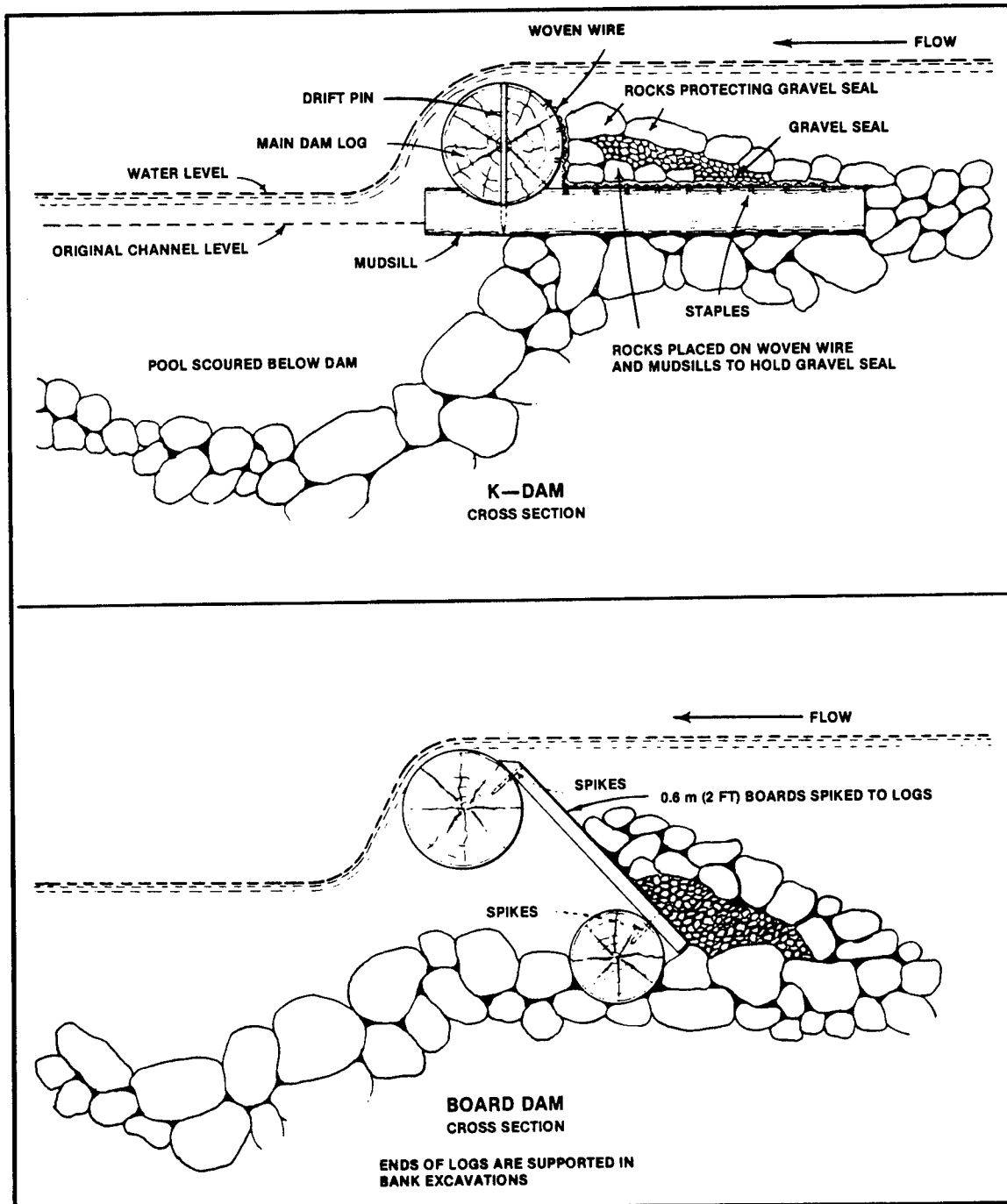


Figure 3.3-3. K-dams and board dams (from U.S. Forest Service 1969).

Knee braces are installed as shown in Figure 3.3-2. These are unnecessary where the main log is braced behind trees or large boulders. The knee braces are securely drift-pinned to the main log and extend into the banks for good sound footing. Woven wire is next stapled to the knee brace and forced down into the opening between it and the streambank. One edge of the wire is stapled to the main dam log, and the pocket thus created is filled with carefully laid large rocks. The floor of this pocket may be given additional strength by extending the mudsill forward at the end of the dam. Rock work starts with the knee brace as a toe and extends up and over the end of the dam.

Where only small rocks are available, it is often desirable to build up the knee brace with another log and construct a cribbing by extending a log upstream, as shown at the right end of the dam in Figure 3.3-2. Rock work at the ends of the dam should extend up the banks above the high-water level.

When the dam fills, the water should pour over the full length of the log between the knee braces. This keeps the entire log wet and less subject to rotting.

Board Dams. Boards in place of mudsills and woven wire are sometimes used in the construction of log dams. This is a more expensive method of construction, but is very effective on streams where there is little flow. Construction costs may be reduced where heavy equipment, such as a backhoe, can be used to do the excavation work. Under these circumstances, it is much easier to make dams watertight by the use of boards. Board dams require special construction, as shown in Figure 3.3-3. The main dam log is held slightly above the channel level of the stream by keeping the bottom of the bank excavations higher than the channel level. Boards are nailed flush with the top of the main log and are supported on the lower end by a log placed on the stream bottom. This bottom log also extends into excavations in the banks similar to the main dam log, but dug to the same level as the channel. Boards also extend into the excavations in the banks for a short distance. The bottom end of the boards are cut to conform to the unevenness of the stream bottom. Construction at the ends of the dam is the same as for the K-dam.

Board dams are best suited to rocky streams, where the banks can be excavated to expose strata which are solid enough to support the weight of the dam. Very short spans are also recommended because there is no support to the main dam log except at the ends.

Green, rough lumber, at least 5 cm (2 inches) thick, is satisfactory for board dams. Soak dry lumber before use so that it will not expand and buckle after being nailed in place. Almost any species of wood is suitable as it will be continually immersed and thus subject to little rot. However, poplar, aspen, and related species should be avoided because they lack strength when wet.

Simple Log Dams. Where flooding is not severe and the bottom materials are not subject to excessive scouring, dams may be constructed by spanning the stream with two logs, as shown in Figure 3.3-4. The construction differs from the K-dam because the woven wire and mudsills in the seal are eliminated and replaced with a log placed upstream from the main dam log and flush with the streambed. Other features of the simple log dam are essentially the same as those for the K-dam, although the knee braces may also be eliminated if the banks are hard and large rocks are available for the construction at the ends of the dam.

Use simple log dams only where excessive undercutting will not result in loss of the seal. Where there is doubt, standard K-dam construction using mudsills and woven wire or boards is usually the best guarantee against undercutting.

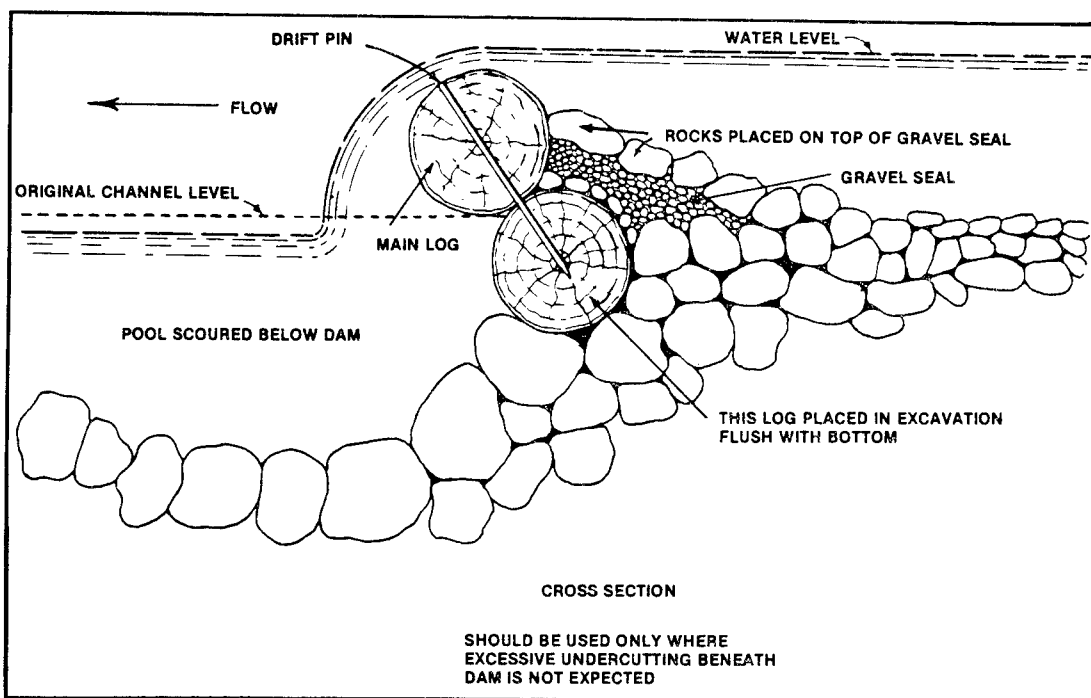


Figure 3.3-4. Cross section of log dam
(from U.S. Forest Service 1969).

Rock Dams. Rock dams are most useful on small streams, 3.1 to 3.7 meters (10 to 12 feet) wide, that are not subject to severe flooding. Large oblong rocks about 1.2 meters (4 feet) long are arranged in an upstream arch for strength and sealed with small rocks and gravel as with other dams (Figure 3.3-5). Naturally occurring boulders in the streambed can often be used as keystones for additional strength. Rock construction should be extended onto the banks to prevent the dam from washing out. Smaller rocks can be used for this purpose.

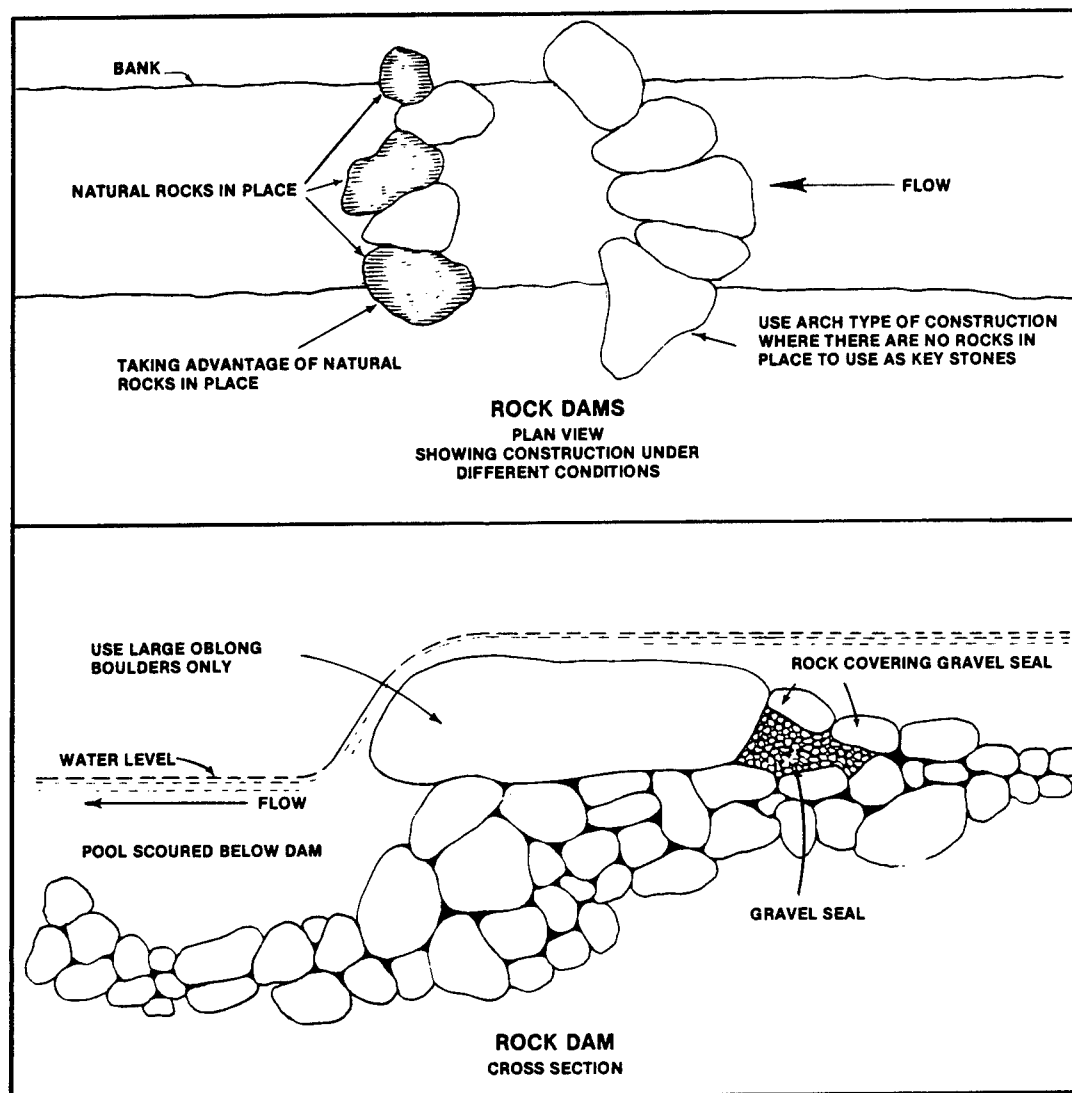


Figure 3.3-5. Rock dams (from U.S. Forest Service 1969).

Current Deflectors

Current deflectors are used to maintain a deep channel with a swift current by redirecting existing currents. Built at an angle to the flow and only part of the way across the channel, deflectors can be of log, rock, or gabion construction almost identical to check dams. Placement of the deflector is very important because deflectors can cause severe bank erosion or pool siltation if improperly installed. In an ideal situation, a series of current deflectors would alternate from bank to bank, creating a natural, twisting stream pattern (Figure 3.3-6). This configuration has been shown to be effective in restoring habitat in channelized streams (Barton and Winger 1973). Deflectors can also be constructed in opposing pairs to form a 'V', but these tend to increase current velocities too much and easily catch debris which blocks the channel. As with check dams, deflectors need not be high to be effective. Low deflectors are less susceptible to flood damage.

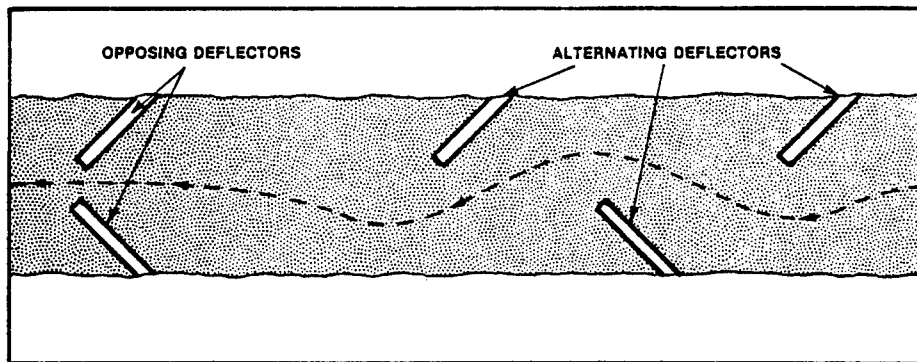


Figure 3.3-6. Current deflectors (after U.S. Fish and Wildlife Service 1978).

Artificial Channels and Meanders

Artificial channels and meanders are used to restore or replace aquatic habitat in severely disturbed or diverted streams. They are used to reduce the stream gradient and increase the stream length. Artificial channels and meanders should be developed under the guidance of a fisheries biologist and a civil engineer in order to satisfy necessary biological and engineering requirements. Assistance should be enlisted when possible from the State fish and game and other agencies or from the U.S. Soil Conservation Service, which has considerable experience in stream channel development. Minimum flows, bottom materials, pool-riffle ratio, depth, width, gradient, and streambank vegetation must all be considered when planning an artificial channel or

channel restoration (Hinkle et al. 1981). Design and construction of an artificial channel is very site-specific, depending on region, water quality, geology and soils, and existing aquatic communities.

MAINTENANCE AND MANAGEMENT

Most in-stream improvement structures require no maintenance under normal conditions. Extreme floods, however, can damage any structure or bury it under sediment or debris. Repair or clearing of structures may not always be desirable or beneficial because the disturbance caused by maintenance activities may weaken the structure or cause extreme siltation downstream.

LABOR/MATERIALS

Construction of log, board, and rock check dams requires 1 to 4 man-days to complete, depending upon channel width, soil conditions, and access to needed materials. Materials for these structures are generally available on most mine sites, although some hauling may be necessary. Heavy equipment is generally not needed for constructing these structures; however, boulder placement may require the use of machinery, depending on the size of the materials used.

SOURCES OF INFORMATION

Additional information on stream improvements can be obtained from:

- o State Regulatory Authority
- o Office of Surface Mining
- o State Fish and Game Agency
- o U.S. Soil Conservation Service
- o U.S. Fish and Wildlife Service

References cited:

- Barton, J. R.; Winger, P. V. A study of the channelization of the Weber River, Summit County, Utah. Utah Division of Wildlife Resources and Utah State Department of Highways: Final report; 1973.
- Hinkle, C. R.; Ambrose, R. E.; Wenzel, C. R. A handbook for meeting fish and wildlife information needs to surface mine coal - OSM Region IV. Washington, DC: U.S. Fish and Wildlife Service, FWS/OBS-79/48.3.4; February 1981.
- U.S. Fish and Wildlife Service. Western reservoir and stream habitat improvement handbook. FWS/OBS-78/56; 1978.
- U.S. Forest Service. Wildlife habitat improvement handbook. FSH 2609.11; 1969.

Additional references:

- Bennett, A. C. Management of relocated streams and ditches in surface-mined areas. Paper presented at Texas A&M University, Surface Mine Reclamation Workshop, Oct. 24-25, 1979.
- Corning, R. V. (ed.). Symposium on stream channel modification, Proceedings of a symposium. Harrisonburg, VA: 1975.
- Federal Highway Administration. Restoration of fish habitat in relocated streams. Implementation package FHWA-IP-79-3. Washington, DC: Supt. of Documents, GPO, Stock #050-001-00167-5; 1979.
- McClellan, T. J. Ecological recovery of realigned stream channels. Federal Highway Administration, Rpt. No. FHWA-CR-74-1. NTIS No. PB 266-657; 1974.
- Swales, S.; Ohara, K. Instream habitat improvement devices and their use in freshwater fisheries management. Jour. Env. Mgmt. 10(2); 1980.
- Wildlife Management Institute. Stream renovation: A necessary management practice for "208" programs. Washington, DC: Wildl. Mgmt. Institute; 1980.
- Wydoski, R. S.; Duff, D. A. Indexed bibliography on stream habitat improvement. Washington, DC: Bureau of Land Management, Technical Note No. 322; 1978.

b. Streambank protection.

PURPOSE

The purpose of streambank protection is to:

- o prevent bank erosion and subsequent sedimentation.
- o prevent the destruction of riparian (streambank) habitat.

Aquatic habitat can easily be destroyed as a result of streambank undercutting and sloughing off of bank material into the stream. When this occurs, riparian vegetation is often washed away, resulting in the loss of valuable wildlife cover for land animals and shading for aquatic animals. Three common structures used to stabilize streambanks are gabion mats, gabion deflectors, and riprap. They all have drawbacks because they provide poor hiding places for fish and tend to speed up the water velocity. However, bank erosion can be a very serious problem, and these structures should be used if revegetation or other methods to protect the bank do not work. The ultimate goal is to establish and/or maintain the streambank vegetation.

DEVELOPMENT

The basic elements of a gabion structure are rectangular wire-mesh cages and rock. Standard gabion mat sizes are given below:

Dimensions (meters)	Approximate equivalents (U.S. units)	No. of diaphragms (partitions)	Capacity	
			Cubic meters	Cubic yards
2 X 1 X 1	6'6" X 3'3" X 3'3"	1	2	2.6
3 X 1 X 1	9'9" X 3'3" X 3'3"	2	3	3.9
4 X 1 X 1	13'1" X 3'3" X 3'3"	3	4	5.2
2 X 1 X 0.5	6'6" X 3'3" X 1'8"	1	1	1.3
3 X 1 X 0.5	9'9" X 3'3" X 1'8"	2	1.5	2.0
4 X 1 X 0.5	13'1" X 3'3" X 1'8"	3	2	2.6
2 X 1 X 0.3	6'6" X 3'3" X 1'	1	0.6	0.8
3 X 1 X 0.3	9'9" X 3'3" X 1'	2	0.9	1.2
4 X 1 X 0.3	13'1" X 3'3" X 1'	3	1.2	1.6

Fractional size mats may be placed along the slope of a streambank (Figure 3.3-7) to prevent erosion. It is recommended that the wire baskets used to build the mats be assembled in place, formed, and stretched out prior to filling them with rock. Where more than one mat needs tying together, it is easier to accomplish this prior to filling the mat with rock. Placing the rock in the basket by hand is preferable to machine filling because sagging is less likely to occur in hand-filled baskets. The top of the basket or lid should be closed and fastened on the downstream side to prevent debris from ripping it off. In addition to these gabion mats, tire mats made from discarded tires bound together with nylon or wire may be used (West Virginia Department of Natural Resources no date).

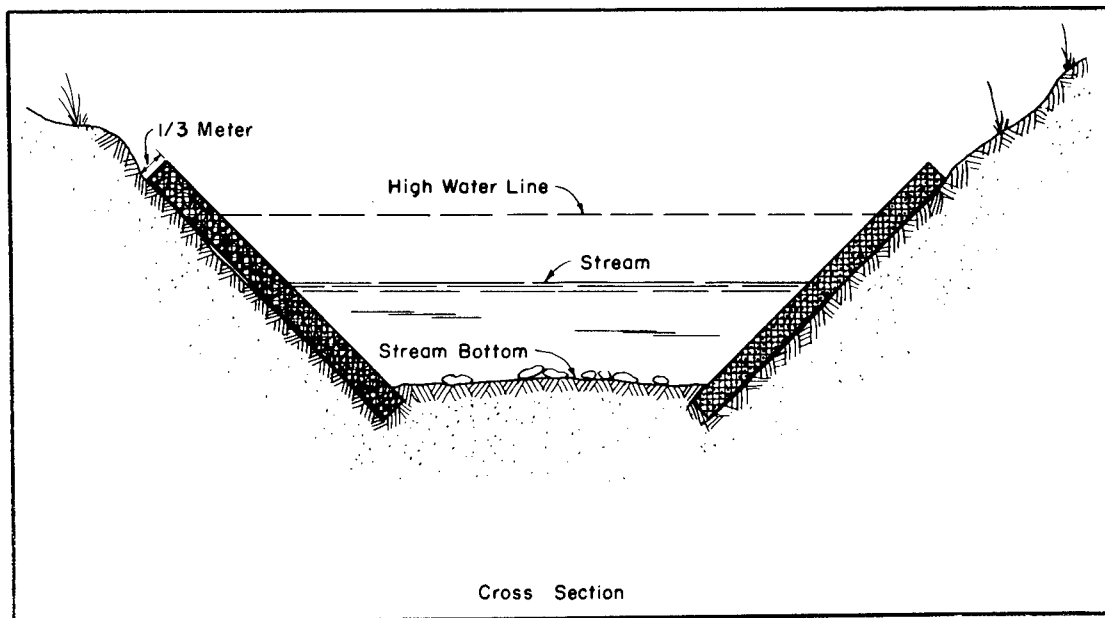
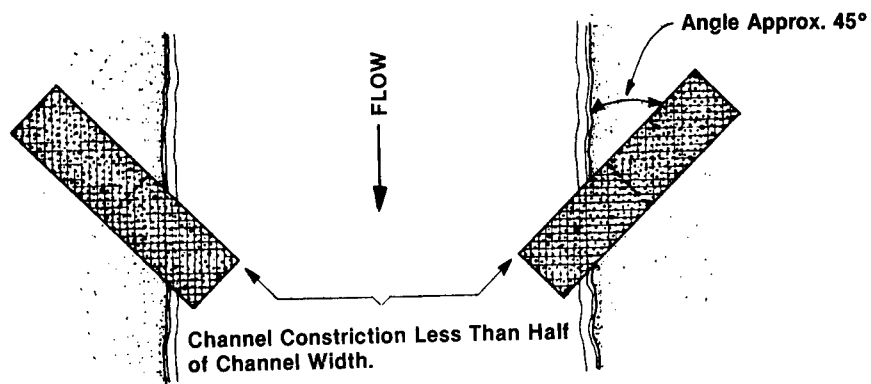


Figure 3.3-7. Stream cross section showing the use of gabion mats on a sloping streambank (from Nelson et al. 1978).

Stream deflectors may be constructed by using gabion baskets (Figure 3.3-8). These deflectors direct water flow toward the center of the stream, deepening and cleaning stream channels which have sand or gravel bottoms and protecting streambanks by directing the current away. Combinations of deflectors may be used (Figure 3.3-9) to form pools, build bars, or protect the banks of a stream. One problem with the double (V) deflector system is that trash often collects in the narrowed channel, creating an obstruction in the stream. This can be prevented to some extent by keeping the distance between opposing deflectors equal to or greater than half the width of the stream.



Figure 3.3-8. Placement of stone gabions to protect a streambank (from U.S. Forest Service 1969).



DOUBLE DEFLECTORS

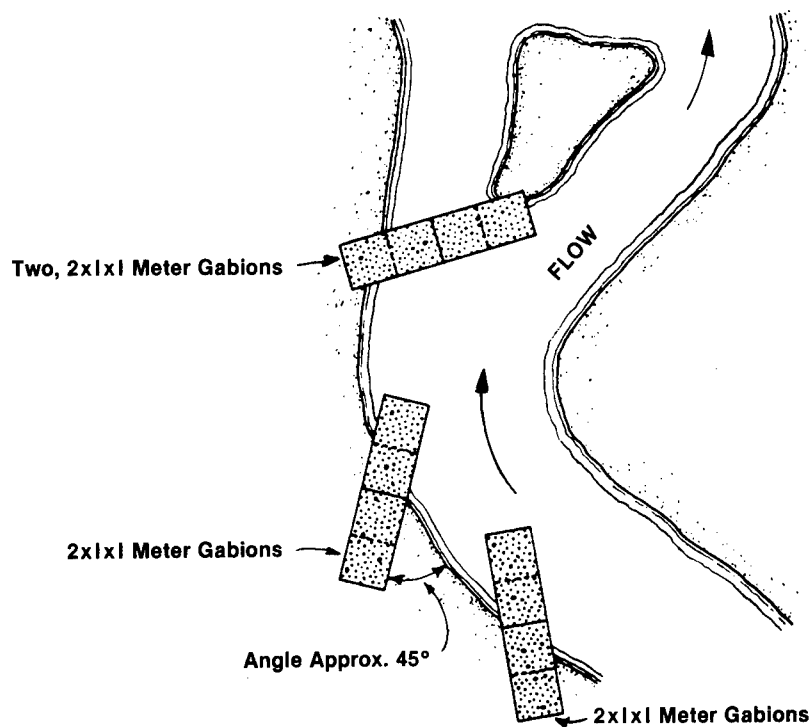


Figure 3.3-9. Examples of the use of a combination of gabion deflectors (from U.S. Forest Service 1969).

Log cribbing may also be used as an effective means of protecting the streambank (Figure 3.3-10). Here, rock backfilling is used for added support. Water is prevented from getting behind the cribbing by securely anchoring and protecting the upstream end (West Virginia Department of Natural Resources no date).

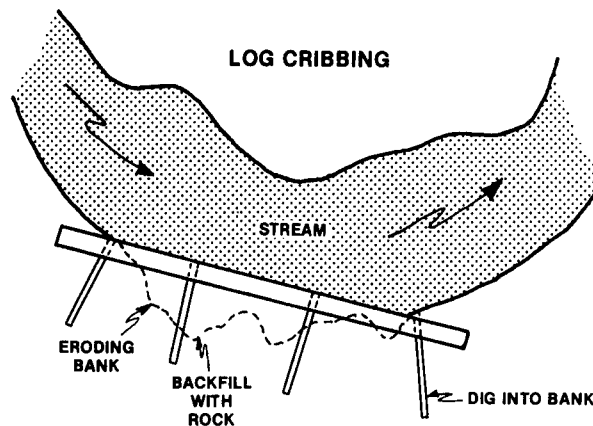


Figure 3.3-10. A diagram demonstrating the use of log cribbing for streambank protection (from West Virginia Department of Natural Resources no date).

Riprap is less expensive than gabion matting. In this case, large rocks are piled along the bank to help prevent erosion (Figure 3.3-11). The rocks should be large enough to prevent silting of intervening spaces which provide fish habitat. Use of riprap is common along roads, and specifications should comply with road building codes.

In addition to artificial protective structures, the planting of additional vegetation will provide increased stabilization of the shoreline. Various species of willow are commonly used (U.S. Forest Service 1969). Grasses and shrubs provide additional stability. As a general rule, native species are best used since they are adapted to the area. Proven exotic species may be beneficial in some cases to provide added food and cover, but local experts in agencies such as the U.S. Soil Conservation Service should be consulted to determine the most suitable species and their availability.



Figure 3.3-11. Use of riprap to protect a streambank from erosion (U.S. Environmental Protection Agency 1976).

MAINTENANCE AND MANAGEMENT

Gabion mats, deflectors, and riprap are considered temporary and should not be expected to replace the need for revegetation of a streambank. In cases where bank stabilization is a serious problem, however, these techniques can provide the additional protection necessary for vegetation to become reestablished. Depending on the site, stream size, and degree of erosion, the need for replacement of gabions or riprap will vary.

LABOR/MATERIALS

Cost, man-hours, equipment needs, and materials will vary with site-specific characteristics. Use of riprap is cheaper than gabions, but depends on the availability of the proper-sized stone. Hauling stone long distances can significantly affect the price. Gabions require the use of wire mesh and therefore require the added cost of the construction labor. Placing the rocks in the wire cages by hand (as recommended) may also incur labor cost.

Generally, prices of stone riprap averages \$24 per 0.8 cubic meter (cubic yard) dumped. Stone filler for gabion mats runs approximately \$24 per 0.8 cubic meter (cubic yard) but can range from \$14 to \$45 per 0.8 cubic meter (cubic yard). Wire mesh for constructing gabions varies in price based on mesh size and wire gauge but can range from \$1.50 to \$5.00 per 0.3 meters (linear foot).

The cost of revegetation will vary according to the size of the area, the species used, and local labor costs.

SOURCES OF INFORMATION

More information on the protection and maintenance of streambanks can be obtained from:

- o State Regulatory Authority
- o Office of Surface Mining
- o State Fish and Game Agency
- o State Highway Department
- o U.S. Forest Service
- o U.S. Army Corps of Engineers

References cited:

- Nelson, R. W.; Horak, G. C.; Olson, J. E. Western reservoir and stream habitat improvements handbook. U.S. Fish and Wildlife Service. FWS/OBS-78/56; October 1978.
- U.S. Forest Service. Wildlife habitat improvement handbook. FSH 2609.11; August 1969.

U.S. Environmental Protection Agency. Erosion and sediment control -surface mining in the Eastern U.S. Technology Transfer, EPA-625/3-76-006; October 1976.

West Virginia Department of Natural Resources. Stream improvement guide. Charleston, WV: Division of Wildlife Pamphlet; no date.

Additional references:

Keown, M. P.; Oswalt, N. R.; Perry, E. B.; Dardeau, E. A., Jr. Literature survey and preliminary evaluation of streambank protection methods. U.S. Army Engineer Waterways Experiment Station, Hydraulics Laboratory, Mobility and Environmental Systems Laboratory, Soils and Pavement Laboratory, Technical Report H-77-9; May 1977.

U.S. Soil Conservation Service. Streambank protection and stream channel stabilization. In: Soil Conservation Service. National handbook of conservation practices: Washington, DC. U.S. Government Printing Office. Stock No. 001-007-00903-1.

c. Final cut lakes as permanent impoundments.

All of the States in the Southcentral U.S., with the exception of Louisiana and Texas, have historically had final cut lakes left as permanent impoundments. Final cut lakes in the other States (Oklahoma, Arkansas, Missouri, Kansas, and Iowa) are still commonplace, as shown in the State of Oklahoma, where, at the present time, every other mining and reclamation permit submitted contains a plan for a mine lake cut. However, with the enactment of SMCRA and some State regulations, the retention of this type of impoundment on reclaimed surface mines was limited to some extent. The objective of the final cut regulations were to return the cut to its approximate original contour with all highwalls, spoil piles, and depressions eliminated. There is, however, a provision in the law allowing the mine operator a variance from this requirement if a proposed alternative postmining land use of the lake is deemed an equal or better economic or public use of the land compared to its premine utilization.

Various uses of final cut lakes have been proposed, including recreation, livestock watering, irrigation or community water supply, and fish and wildlife use. Problems arise when trying to determine the design criteria which should be met in order for the final cut lake to be practical in its postmining land use objective. A study has recently been completed, funded by the Office of Surface Mining, to assist operators with these and other problems associated with final cut lakes (Nelson et al. 1982). This manual is expected to address many of the problems associated with final cut lakes and set recommendations on design criteria and management of proposed permanent impoundments. Because of the comprehensive and definitive nature of this study, it is recommended that operators obtain a copy of this publication prior to considering the use of final cut lakes as permanent impoundments. Information on this manual can be obtained by writing the following address:

Asst. Director for Technical Standards and Research
Office of Surface Mining
1951 Constitution Ave., NW
Washington, D.C. 20240

SOURCES OF INFORMATION

Reference cited:

Nelson, R. W.; Osborn, J. F.; Logan, W. J. Planning and management of mine cut lakes at surface coal mines. USDI Office of Surface Mining, Washington, DC; OSM TR-82/1; 1982.

d. Fish stocking.

PURPOSE

A well-stocked permanent fish pond is a valuable asset to any landowner. Even if the pond is managed primarily for fish production, these ponds can also provide recreational swimming, picnicking along the shore, and water for wildlife. Sale of fishing rights can also provide an added source of income. Stocking, however, is more than just putting fish in a pond. Several factors are discussed below which can lead to very successful fish production.

DEVELOPMENT

Warm-water fisheries are successful where the summer water temperature reaches between 27°C (80°F) and 32°C (90°F) (Dillon et al. 1977). The preferred kinds, combinations, and number of fish for stocking in such ponds are discussed below.

Warm-Water Fishery

Warm-water ponds can be managed for largemouth bass, bluegill and redear sunfish, catfish (channel or bullhead), or bait minnows. The pond to be stocked should be clear of wild fish prior to stocking. This can be accomplished by either draining the pond or using chemical killing agents. The supervision of a State game and fish agent or U.S. Soil Conservation Service (SCS) State conservationist is highly advised during the removal of wild fish.

The size and number of fish will depend on the combination of species and the surface area of the pond. It is very important to know the correct pond size [preferably within 0.04 hectare (0.1 acre)]. If the size of the pond is underestimated, too many fish will be ordered and very few will grow to desirable sizes. On the other hand, if the size of the pond is overestimated, a few fish will grow large and, in the case of bass and bluegill, bluegill will overpopulate in a short time.

Stocking rates of fertilized and unfertilized ponds differ; therefore, this should be considered when determining the number of fingerling (i.e., young fish) needed for stocking a pond. It is not good practice to stock mature fish from other ponds in the area. Always stock the number, type, and size of fish and perform the stocking in the season recommended by local, State and/or Federal hatcheries. In many cases, free fish are available from these hatcheries, and applications may be obtained from offices of the game and fish agency or from the SCS.

When the fish are available to be picked up, follow hatchery directions as closely as possible in transporting the fingerlings. A clean container is an absolute must for transporting.

Some special considerations are in order for certain species or species groups:

Bass and bluegills - Ponds with average fertility can be stocked at a rate of 50 bass and 500 bluegills per 0.4 hectare of surface area (per surface acre), while ponds with high fertility can be stocked with 100 to 150 bass and 1000 to 1500 bluegills per 0.4 hectare (1 acre). Redears may be included at the above rates as a substitute for one-third of the bluegills. If water is overflowing during the time of stocking, a temporary screen will prevent fingerling loss. However, the screen should be removed 10 days after stocking (Dillon et al. 1977).

Channel catfish - In a bass-bluegill pond, 100 to 200 catfish per 0.4 hectare of surface area (per surface acre) may be used if they are about the same size as the bass and are stocked at the same time (Dillon et al. 1977). Basically, the number of fish stocked depends on the size desired at the end of the growing season. Fingerlings that measure 10 to 15 cm (4 to 6 inches) reach 0.5 kg (1 pound) average weight in 210 days when stocked at 1500 per 0.4 hectare of surface area (surface acre). Larger fingerlings [25 cm (10 inches)] stocked at 1200 per 0.4 hectare of surface area (surface acre) average 0.9 kg (2 pounds) at the end of the growing season. Rates vary considerably, but some rules of thumb are:

- o 750 to 1000 fish per 0.4 hectare of surface area (surface acre) [10 to 15 cm (4 to 6 inches)] in runoff impoundments where aeration is not practiced.
- o 1500 to 2000 fish [10 to 15 cm (4 to 6 inches)] per 0.4 hectare of surface area (surface acre) in ponds with constant water supply.
- o 1200 fish [25 cm (10 inches)] per 0.4 hectare of surface area (surface acre) in ponds with constant water supply.
- o 700 to 800 fish [2 years old or 0.22 kg (0.5 pound)] per 0.4 hectare of surface area (surface acre) in ponds with constant water supply.
- o 3500 to 5000 fish [10 to 15 cm (4 to 6 inches)] per 0.4 hectare of surface area (surface acre) where water flows through at the rate of approximately 570 liters (150 gallons) per minute (Grizzell et al. 1975).

Channel catfish rarely spawn in fish ponds without proper facilities. Periodic restocking is necessary and generally easier than preparing the spawning facilities.

Bullhead catfish - These fish spawn well in bass-bluegill ponds, but need cover for escape. If they are too well protected, they may overpopulate the pond. In heavily managed ponds, bullheads may be stocked after the spawning season, fed during the winter, and harvested the following spring (Dillon et al. 1977).

Israeli carp - Carp stocking may be prohibited by some States, but they can successfully be used to control algae growth where permitted. Fingerlings placed in bass ponds should be greater than 13 cm (5 inches) to prevent predation by bass and should be stocked at 25 to 50 per 0.4 hectare of surface area (surface acre) (Dillon et al. 1977).

Crappie - Low summer water levels and high winter levels are necessary for production of this species. They are stocked at a rate of 25 fingerlings of crappie with 50 to 100 largemouth bass per 0.4 hectare of surface area (surface acre) (Dillon et al. 1977). They are not often recommended for farm ponds due to the need to manage the water level.

Bait fish - Expert consultation is needed for production methods here. The SCS fisheries biologist can provide assistance.

MAINTENANCE AND MANAGEMENT

Restocking depends on the fish species, pond characteristics, fishing pressure, and fish health. Pond management, including fertilization and pest control, are discussed in other sections. It is best to discuss your plans with a State Conservationist who can help you set up a management plan.

LABOR/MATERIALS

Although free fish for stocking are no longer available from government agencies, the State Parks and Wildlife Departments can provide a list of commercial hatcheries where fingerlings can be purchased.

SOURCES OF INFORMATION

In many cases, free information on fish stocking is available through government agencies within a State. Below is a list of appropriate contacts to make within the States covered by this handbook:

Arkansas - Game and Fish Commission
#2 National Resources Drive
Little Rock, AR 72205
(501) 223-6300

Regional Biologist
South Technical Service Center
U.S. Soil Conservation Service
P.O. Box 6567
Ft. Worth, TX 76115
(817) 334-5282

Louisiana - Department of Wildlife and
Fisheries
400 Royal Street
New Orleans, LA 70130
(504) 568-5665

Regional Biologist
South Technical Service Center
U.S. Soil Conservation Service
P.O. Box 6567
Ft. Worth, TX 76115
(817) 334-5282

Oklahoma - Department of Wildlife
Conservation
1801 N. Lincoln
P.O. Box 53465
Oklahoma City, OK 73105
(405) 521-3851

Regional Biologist
South Technical Service Center
U.S. Soil Conservation Service
P.O. Box 6567
Ft. Worth, TX 76115
(817) 334-5282

U.S. Soil Conservation Service*
P.O. Box 2323
Little Rock, AR 72203
(501) 378-5445

U.S. Soil Conservation Service*
3737 Government Street
Alexandria, LA 71301
(318) 473-7856

U.S. Soil Conservation Service*
Agricultural Center Office
Bldg.
Farm Road and Brumley St.
Stillwater, OK 74074
(405) 624-4360

*In addition to regional offices, local SCS offices, listed in the telephone directory, can provide guidance on fish pond development and stocking.

Texas - Parks and Wildlife Department
Inland Fisheries Division
4200 Smith School Road
Austin, TX 78744
(512) 479-4860

Regional Biologist
South Technical Service Center
U.S. Soil Conservation Service
P.O. Box 6567
Ft. Worth, TX 76115
(817) 334-5282

U.S. Soil Conservation Service*
101 South Main Street
P.O. Box 648
Temple, TX 76501
(817) 774-1711

*In addition to regional offices, local SCS offices, listed in the telephone directory, can provide guidance on fish pond development and stocking.

References cited:

Dillon, O. W., Jr.; Neely, W. W.; Davison, V. E.; Compton, L. V. Warm-water fish ponds. Washington, DC: USDA Farmers Bulletin No. 2250. U.S. Gov't. Printing Office; 1977.

Grizzell, R. A., Jr.; Dillon, O. W., Jr.; Sullivan, E. G.; Compton, L. V. Catfish farming. Washington, DC: USDA Farmers Bulletin No. 2260. U.S. Gov't. Printing Office; 1975.

Additional references:

Alverson, K. Cattle and fish on surface-mined land. Soil Conservationist 34(4):4-6; 1973.

Borell, A. E.; Scheffer, P. M. Trout in farm and ranch ponds. Washington, DC: USDA Farmers Bulletin No. 2154; 1961.

Burner, C. C. Fishery management in strip-mine lakes. In: Research and Applied Tech. Symposium on Mined Land Reclamation. Pittsburgh, PA; 1973:304-318.

Davies, W. D. Managing small impoundments and community lakes. In: Proceedings of the 27th Annual Conference of the Southeastern Association of Game and Fish Commissioners (reprint); 1973:347-355.

Fox, A. C. Development and impoundment of drastically disturbed surface-mined land for fishing. In: Symposium on Rehabilitation of Drastically Disturbed Surface Mined Land. Georgia Surface Mined Land Use Board. Macon, GA; 1971:109-111.

- Inman, C. R. Construction hints and preliminary management practices for new ponds and lakes. Austin, TX: Texas Parks and Wildlife Department; October 1976.
- Nelson, R. W.; Horak, G.; Olson, J. E. Western reservoir and stream habitat improvements handbook. Ft. Collins, CO: U.S. Fish and Wildlife Service, FWS/OBS-78/56; October 1978.
- Swingle, H. S. Biological means of increasing productivity in ponds. Auburn University Agricultural Experiment Station. In: Proceedings FAO World Symposium on Warm-Water Pond Fish Culture. Rome, Italy; 1966.
- U.S. Fish and Wildlife Service. Farm fish ponds and their management. Washington, DC: Fishery Leaflet No. 27; no date.
- U.S. Soil Conservation Service. State standard and specifications for fish pond management. Stillwater, OK: USDA, SCS; August 1974.
- U.S. Soil Conservation Service. Landowner information job sheet: fish pond management. Alexandria, LA: USDA, SCS; LA-BIOL-6; various dates.
- U.S. Soil Conservation Service. Field office technical guide handbook: fish pond management (Sect. IV-E.399). Alexandria, LA: USDA, SCS; various dates.
- Whitwell, T.; Bayne, D. R. Weed control in lakes and farm ponds. Circular ANR-48. Alabama Cooperative Extension Service; no date.

e. Pond fertilization for fish management.

PURPOSE

Pond fertilization with commercial fertilizers (N-P-K) is a technique used to increase fish production and to control aquatic weeds. Fertilizer added to a pond increases algae production, ultimately increasing the food base available to the fish. This desirable algae growth does not include the troublesome filamentous algae. Increased algae growth shades out most types of submerged aquatic weeds and suppresses the growth of many emergent plants. Weed control provides easier feeding for game fish and easier fishing and fish management for the pond owner. Fertilizer may also cause clay particles to settle out of muddy water.

DEVELOPMENT

New ponds should be fertilized as soon as they fill with water. This will develop a good food base for fish and control the growth of aquatic weeds. Once started, fertilization of a pond should be continued as long as the pond is managed for fish. A pond with low total water hardness (below 10 to 15 ppm) or an acid condition should be treated with lime before fertilizer is added (U.S. Forest Service 1969). These conditions inhibit the fertilizer from being fully utilized in a pond. To increase water hardness, hydrated lime can be applied at 45.4 kg per 0.4 hectare of surface area (100 pounds per surface acre), or agricultural lime may be used at 450 to 900 kg per 0.4 hectare (1,000 to 2,000 pounds per acre). Acidic water should be treated with lime until the pH is at a level suitable for the species of fish to be stocked.

Most ponds require about 10 or less applications of fertilizer each year. In the Gulf States of Southcentral U.S., fertilizer can generally be applied year around. Use a fertilizer such as 8-8-2 and apply when the water temperature is about 60°F. After the first application of 45.4 kg per 0.4 ha (100 lbs 8-8-2 per acre), wait two weeks. If a "bloom" or change in water color does not occur, apply 45.4 kg (100 lbs) more. Continue until a bloom starts (USDA 1978).

Determination of how often to fertilize a pond after the first bloom can be made with the aid of a simple measuring instrument (Dillon et al. 1971). A white disk (coffee can lid or larger) a few centimeters in diameter is fastened to the end of a 0.9-meter-long (3-foot-long) stick marked at 0.3- and 0.5-meter (12- and 18-inch) intervals above the disk (Figure 3.3-12). To check pond fertility, the disk is placed in the water with the stick held upright. If the disk is visible at a depth of 0.5 meter (18 inches) or more (marked on the stick), an application of fertilizer is needed. A color change in the water should be detectable in 3 to 7 days after fertilizer is added. Water color may be any shade of green or brown, depending on the types and number of algae present. When the disk is out of sight, between 0.3 and 0.5 meter (12 and 18 inches) deep, the pond is productive enough to support up to 180 kg of fish

per 0.4 hectare of surface area (400 pounds per surface acre) and needs no fertilizer at that time. In the spring, applications may be needed as often as every 10 days (USDA 1978, Dillon et al. 1971).



Figure 3.3-12. Determination of the need to fertilize using a testing stick (from Dillon et al. 1971).

Mineral fertilizers are the best for fish ponds because organic materials (e.g., cottonseed meal, blood meal, manure, or leaves) lead to the growth of pond scum (filamentous algae). A fertilizer, such as 8-8-2 at 45.4 kg (100 lbs) per acre, may be substituted with 22.7 kg (50 lbs) of 16-16-4 or 18.2 kg (40 lbs) of 20-20-5. The important ratio to remember is 3.6 kg (8 lbs) nitrogen: 3.6 kg (8 lbs) phosphate: 0.9 kg (2 lbs) potash per 0.4 ha (acre). Be sure to apply as much nitrogen as phosphorus; if a mixed fertilizer with less nitrogen is used, add enough nitrogen to equal the phosphate. Ponds that have been completely fertilized over 3 to 5 years may be maintained by phosphate alone. In such a case, 18.2 kg (40 lbs) of superphosphate or 8.2 kg (18 lbs) of triple superphosphate per 0.4 ha (acre) should be used. This is attractive since it lowers the cost of fertilization, but it should be done on a trial basis. If the response is not positive, immediately return to a complete fertilizer (Dillon et al. 1971).

A popular way to apply fertilizer is from a pallet-like platform placed about 0.3 hectare (12 inches) below the water surface near the pond edge (Figure 3.3-13). Fertilizer sacks are placed on the platform and slit open, letting wave and current action mix the fertilizer into the pond. One platform can be used to treat up to 6.1 hectares (15 acres) of surface area. A floating platform can be used in ponds with fluctuating water levels. Fertilizer can also be applied by broadcasting it from the bank or from a boat in areas not deeper than 0.9 or 1.2 meters (3 or 4 feet) (Dillon et al. 1971).

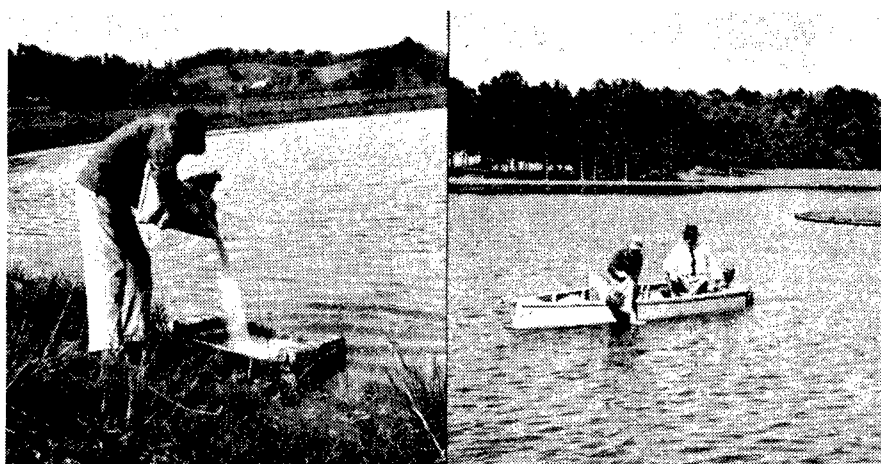


Figure 3.3-13. Fertilizer application by floating platform or boat (from Dillon et al. 1971).

MAINTENANCE AND MANAGEMENT

Fertilization of a pond does not always improve fishing. Proper fish population management techniques should be used together with fertilization to maintain a healthy, productive pond. Fertilization of an overpopulated pond will produce more pounds of fish, but generally the average size of the fish will not increase appreciably. Management recommendations should be obtained from a local fisheries biologist.

Aquatic weed and filamentous algae control may become necessary if these plants begin to crowd the pond. Submerged and emergent vegetation can be controlled with commercial herbicides. Since many herbicides are extremely toxic to fish even in very small amounts, they must be used under the direction of a fisheries biologist. Manual removal of vegetation is usually not effective, especially in large ponds. Ponds with most areas at least 0.9 meter (3 feet) deep have fewer weed problems than ponds with extensive shallow areas. Filamentous algae can be controlled by applying copper sulfate crystals directly on the algal mats at a rate of 1.4 kg per 93 square meters (3 pounds per 1000 square feet).

LABOR/MATERIALS

The labor and materials necessary to fertilize a pond for improved fish production are minimal. The fertilizer itself is the only essential material and costs vary based on size of fertilizer package and the analysis. If platforms are used for application, scrap hardwood lumber from a pallet or crate can provide the needed material. The labor involved in building and

placing a platform should be no more than a few hours. The labor required for fertilizing a pond includes about 12 visits to a pond each year. The length of time necessary for each visit depends on the size of the pond and the need for weed control activities. For ease of application, the amount of fertilizer necessary for a pond for one year can be stored near the pond, either on pallets under a plastic sheet or in a small shed.

SOURCES OF INFORMATION

Recommendations and advice on pond fertilization can be obtained from a fisheries biologist. These wildlife specialists can be contacted in private industry or at one of the following State or Federal agencies:

- o State Fish and Game Agency
- o U.S. Fish and Wildlife Service
- o U.S. Soil Conservation Service

References cited:

Dillon, O. W., Jr.; Neely, W. W.; Davison, V. E.; Compton, L. V. Warm-water fishponds. U.S. Soil Conservation Service. Farmers' Bulletin No. 2250; 1971.

U.S. Department of Agriculture. Fish pond management. Alexandria, LA: U.S. Soil Conservation Service, Job Sheet LA-BIOL-1; November 1978.

U.S. Forest Service. Wildlife habitat improvement handbook. FSH 2609.11; 1969.

Additional references:

Davies, W. D. Managing small impoundments and community lakes. In: Proceedings of the 27th Annual Conference of the Southeastern Association of Game and Fish Commissioners; 1973.

Klussman, W. G.; Lowman, F. G.; Davis, J. T. Common aquatic plants of Texas - identification and control. College Station, TX: Texas Agr. Extension Service, Bull. B-1018; 1980.

Oklahoma Department of Wildlife Conservation. Farm pond fertilization (Pamphlet). Oklahoma City, OK: undated.

Oklahoma Department of Wildlife Conservation. Rid your pond of weeds. (Pamphlet). Oklahoma City, OK; undated.

Smith, D. Q.; Mitchell, J. M. The ecology of farm pond fertilization. (Pamphlet). Austin, TX: Texas Parks and Wildlife Department; 1975.

Swingle, H. S. Fertilizing farm fish ponds. Agricultural Experiment Station of Auburn University. Highlights of Agricultural Research 12(1):11; 1965.

f. Fish shelters in ponds and lakes.

PURPOSE

Fish shelters provide cover, feeding habitat, and spawning areas for game and forage fish. In warm-water ponds and lakes, they tend to attract and concentrate fish, making recreational fishing more productive. Brush shelters, tire shelters, and culvert shelters (Figure 3.3-14) are considered most effective by fisheries biologists (U.S. Fish and Wildlife Service 1978). Other structures are available for use, but they are, in most cases, more expensive to construct.

DEVELOPMENT

Brush Shelters

Brush shelters range in structure from something as simple as a single tree pushed over into the water (Figure 3.3-14) to a complicated small log house (Figure 3.3-15). A single tree, pushed over into the water, provides excellent cover for bass. Most of the top should be removed, and the tree should be left anchored by its roots (Figure 3.3-14).

Small, submerged brushpiles are most easily constructed before a pond is filled or during a drawdown. Brush is gathered into a 3.1- to 6.2-meter (10- to 20-foot) diameter pile, tied together with wire or cable, and anchored or weighted to keep it in place. Screw-type power pole cable anchors make excellent tie-downs. Brushpiles should be placed in 3.1 to 6.2 meters (10 to 20 feet) of water and about 45.7 meters (150 feet) apart (U.S. Forest Service 1969).

In large ponds or final-cut lakes, large brushpiles 9.1 to 12.2 meters (30 to 40 feet) in diameter or long windrows can be created from slash (U.S. Fish and Wildlife Service 1978). While effective and easy to build with heavy equipment, large brushpiles and windrows are difficult and time-consuming to anchor. The water depth and distance recommendations, however, are the same as for smaller brush shelters.

Tire Shelters

Discarded tires, bound together with wire or cable, weighted, and sunk, make excellent, long-lasting shelters. For small ponds, three tires wired together in a triangle produce effective shelters (Figure 3.3-14). The tires are weighted with rocks so the structure will remain upright when sunk. Slashing the tires prevents air from being trapped. Structures as large as desired can be formed by adding more tires in any configuration that maximizes the size and number of spaces between tires (Figure 3.3-16).

On pond and lake bottoms that lack sand or gravel beds, tires can be used to create spawning beds for largemouth bass (Figure 3.3-14). Before the pond or lake is filled, tires are placed on their side in areas where the water will be 0.6 to 1.2 meters (2 to 4 feet) deep and then filled with sand or gravel. Large-diameter equipment tires are best for this purpose. Although spawning beds can also be constructed by creating gravel beds [3.1 to 4.6 meters in diameter (10 to 15 feet)], the use of tires prevents the gravel from silting over.

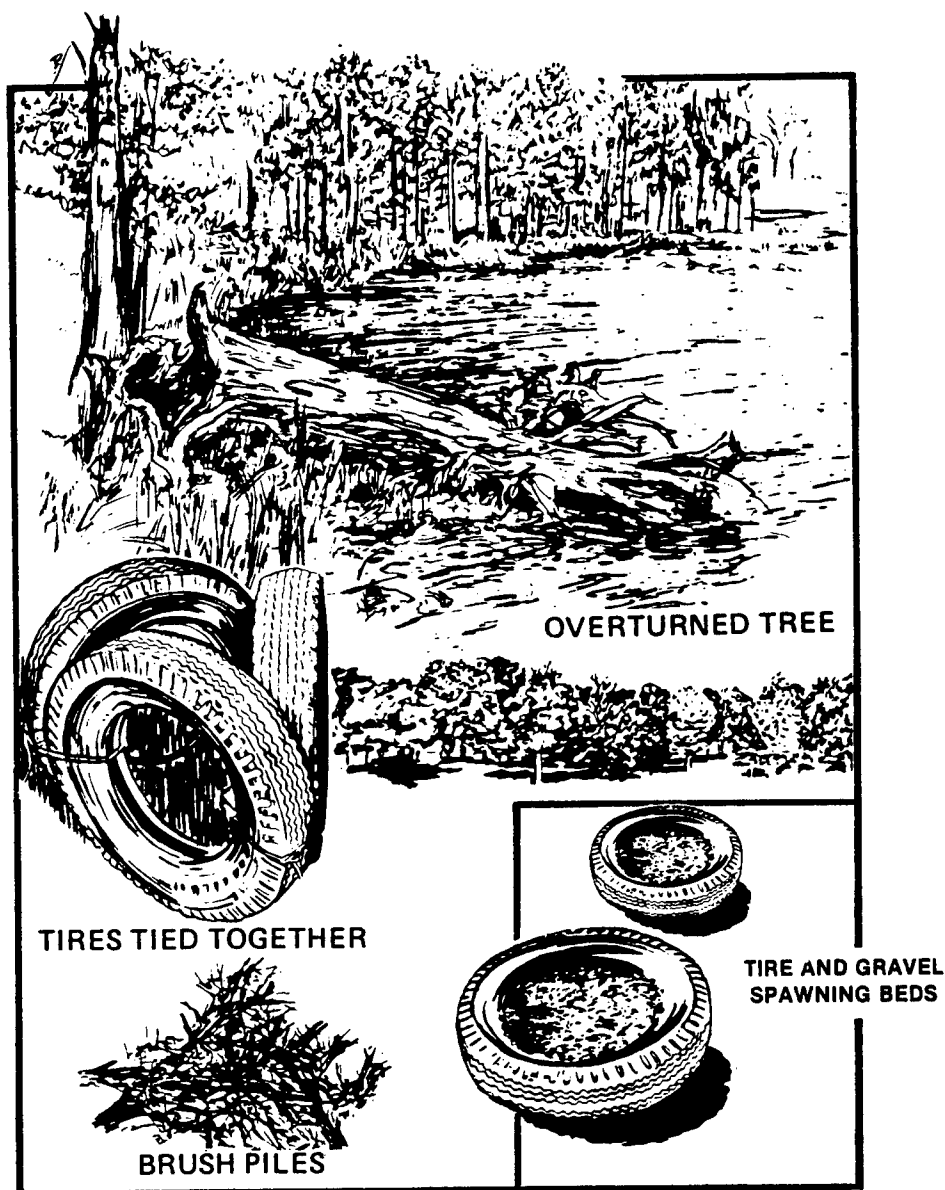


Figure 3.3-14. Simple, effective types of fish shelters (from Inman 1976).



Figure 3.3-15. Brush shelter under construction (from Cobb 1980).

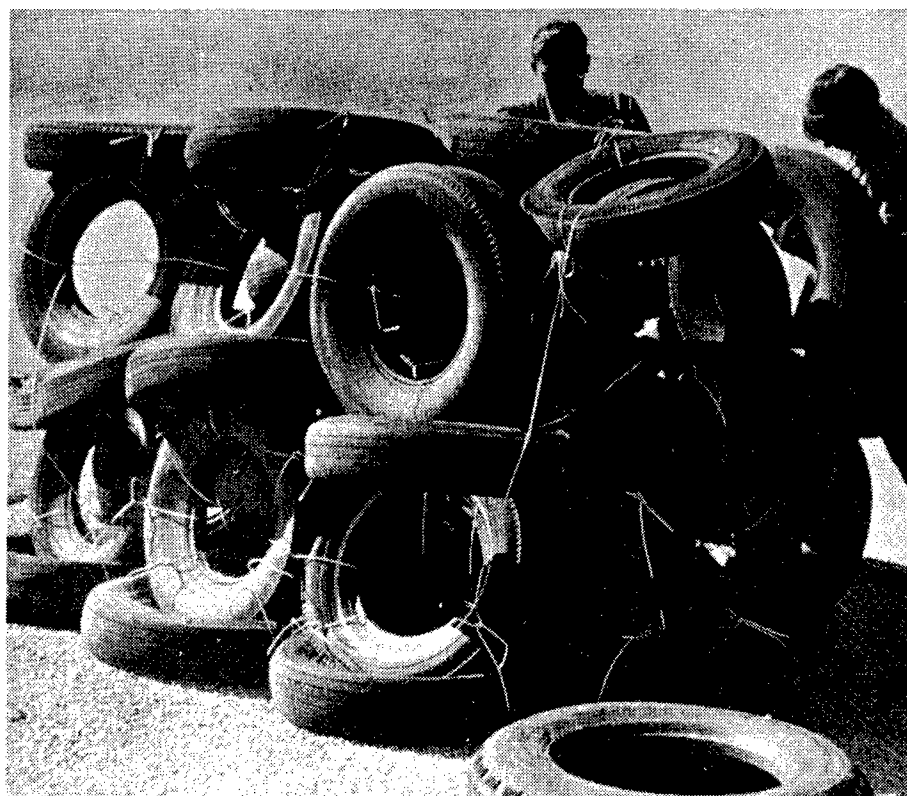


Figure 3.3-16. A large tire shelter (from U.S. Fish and Wildlife Service 1978).

Culvert Shelters

Natural reproduction of channel and other catfish can be encouraged by providing artificial spawning structures in the form of culvert shelters. Small-diameter [20- to 30-cm (6- to 12-inch)] concrete or corrugated metal culverts or clay drain tiles are suitable as shelters when placed in 2 to 4 feet of water (Figure 3.3-17). Best results are obtained when one end of the culvert is closed by filling with 8 to 10 cm (3 to 4 inches) of concrete or by burying one end in the pond bottom. The open end should then be placed at a slight upward angle to avoid trapping air inside the culvert. On steep bottoms, the culverts should be half-buried, leaving the open end protruding from the sloping bottom.

Figure 3.3-18 shows the placement of several types of fish shelters in a pond approximately 2 hectares (5 acres) in size. Relocating or changing the number or types of shelters in a pond would depend on the size, shape, and depth of the impoundment. Assistance on the placement of these structures can be obtained from agencies listed under Sources of Information below.

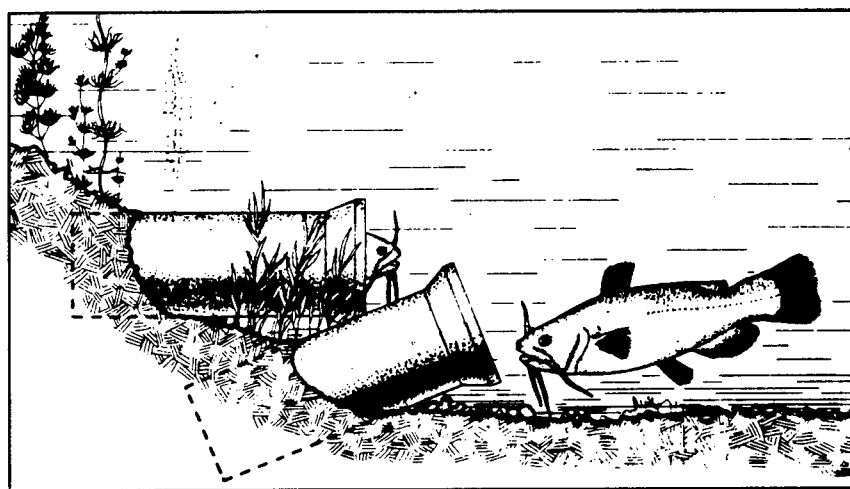


Figure 3.3-17. Catfish spawning shelters (from U.S. Fish and Wildlife Service 1978).

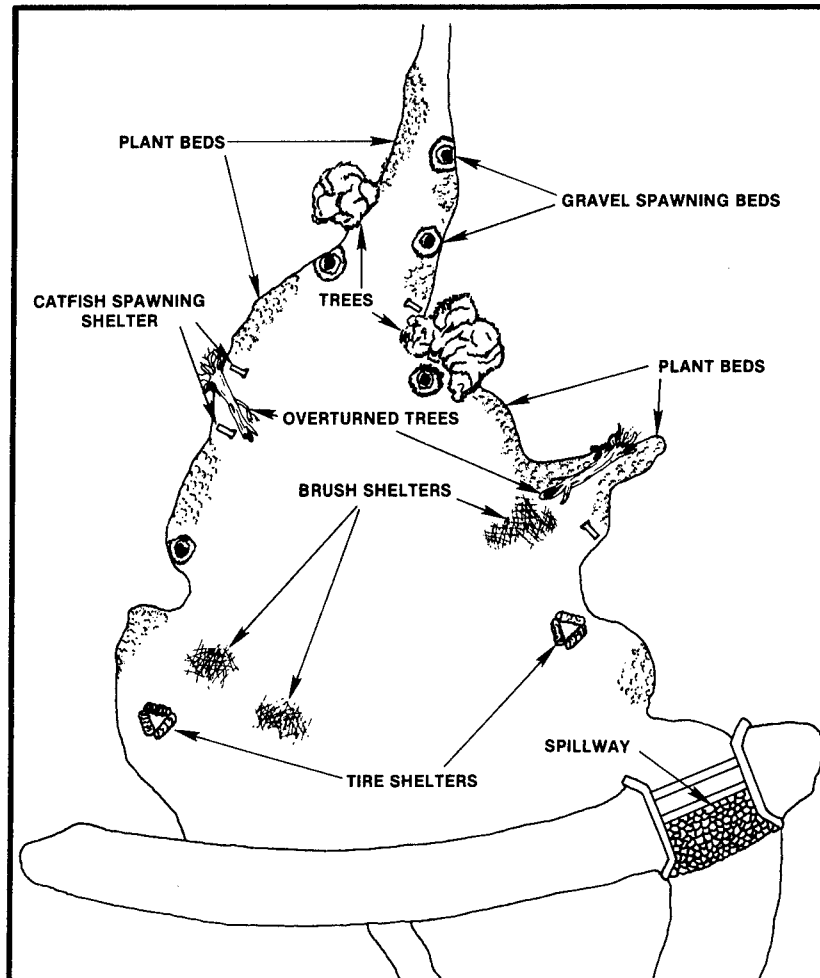


Figure 3.3-18. Placement of fish shelters in a pond (after Inman 1976).

MAINTENANCE AND MANAGEMENT

Once constructed, fish shelters require no maintenance. Replacement of brushpiles and other wooden structures may become necessary after a number of years due to deterioration.

LABOR/MATERIALS

Most simple fish shelters will require about two man-hours or less to construct and install. More elaborate structures will require considerably more time. All the materials needed for constructing fish shelters are readily available as salvage material from most mining operations. Logs, brush, discarded tires, bits of wire and cable, and cracked or broken culverts can be

used as excellent fish shelters with proper planning and construction. Although these materials are sometimes discarded after a mining operation, a pond should not be used as an indiscriminate dumping ground. Shelter materials should be placed within the pond with careful consideration of the fisheries management objectives.

SOURCES OF INFORMATION

A fisheries biologist can provide assistance in determining the fish shelter needs for a specific pond or lake. The following agencies can provide personnel for assistance:

- o State Fish and Game Agency
- o U.S. Fish and Wildlife Service
- o U.S. Soil Conservation Service
- o State University Extension Service

References cited:

- Cobb, E. S. The management of Tennessee farm ponds. Nashville, TN: Tennessee Wildlife Resources Agency; 1980.
- Inman, C. R. Construction and preliminary management practices for new ponds and lakes. Austin, TX: Texas Parks and Wildlife Department; 1976.
- U.S. Fish and Wildlife Service. Western reservoir and stream habitat improvement handbook. FWS/OBS-78/56; 1978.
- U.S. Forest Service. Wildlife habitat improvement handbook. FSH 2609.11; 1969.

g. Creation of impoundments for waterfowl.

PURPOSE

A great number of waterfowl of many species migrate through the South-central U.S. and Midwest in the fall to overwinter further south and then return in the spring to establish breeding territories further north. The wood duck and the American coot are the only ducks which nest regularly in the Southcentral U.S., while some 14 other species, such as the mallard, blue-winged teal, lesser scaup, and ring-necked duck, are common winter residents. The areas which these ducks need for feeding, nesting, and for cover is rapidly disappearing due to channelization of waterways, filling of wetlands, and clearing of hardwood swamps. Small impoundments on strip-mined sites can offer significant benefits to local waterfowl populations by providing the food, cover, and shelter which otherwise may be unavailable.

DEVELOPMENT

Most State surface mine regulations require that impoundments constructed on the permit area be removed if designed as temporary structures, or they can be allowed to remain if designed as permanent structures where no hazards exist. The overall structural design of an impoundment which is allowed to remain on a mine site after mining will have to be approved by the regulatory authority. Several factors, listed below, will influence their decision:

- o the potential safety hazard of an impoundment dam failing during a heavy rainfall. This could result in the flooding of downstream communities and/or the release of sediments or toxic materials.
- o the postmining land use objective. If an impoundment for waterfowl use is proposed for a reclaimed area, then the impoundment should be compatible with the postmining land use. For example, some types of industrial development are not very compatible with wildlife use.
- o the appropriate measures taken to make the impoundment attractive to fish and wildlife. An impoundment which is not "enhanced" by suitable plantings or which is not designed properly will also be of marginal value to wildlife.

Several publications have been written which discuss the use of impoundments for waterfowl in the southcentral U.S. (Almand 1971; Anderson 1975; Ouchley 1976; Hobough and Teer 1981). They emphasize the use of beaver ponds, "green-tree" reservoirs, and seasonal feeding ponds as waterfowl use areas. Seasonal feeding ponds (Figure 3.3-19) come the closest of all three types to the kind of impoundment most appropriate for waterfowl on reclaimed surface-mined areas.



Figure 3.3-19. A seasonal pond of the type suitable for attracting wood ducks and other waterfowl (from Beshears 1974).

Seasonal feeding ponds are characterized as being impoundments located in open drainage areas which are adequately supplied with water and have good soil nearby to support the growth of food plants (Beshears 1974). Open water areas should be at least 0.1 hectare (0.25 acre) in size, and preferably 4.1 hectares (10 acres) or more. In general, the larger the impoundment, the better the opportunity for attracting waterfowl. Depths of the impoundment should also be no greater than 0.5 meters (18 inches) to allow dabbling ducks (e.g., mallard and teal) access to food.

Seasonal feeding ponds, as implied, will serve primarily to provide food for waterfowl only during certain seasons. Additional benefits will be resting and loafing areas on the open water and on islands (Sect. 3.3.2.h) and the increased attractiveness of nearby wooded areas as wood duck nesting sites.

Planting of waterfowl food can be accomplished in different ways, depending on the management objectives of the site:

Method 1 - Objective: Basic Waterfowl Food Production

- o Japanese millet is sown on exposed mud bottoms immediately after drawdown in the spring without seedbed preparation (Figure 3.3-20).
- o Drawdown can be delayed until mid-summer for millet plantings. This decreases blackbird depredation, but often necessitates the clearing of summer weed species from the seedbed.
- o In some areas, the original seeding of millet will provide enough seed so that further seeding may not be necessary for three years. However, for best results, some seeding each year is recommended.



Figure 3.3-20. Sowing Japanese millet on an exposed moist mud flat immediately after drawdown (from Beshears 1974).

Method 2 - Objective: Enhanced Waterfowl Food Production

- o Drain the impoundment in the early spring and use standard farming methods (fertilization, planting, cultivation, etc.) to plant crops, such as corn and sorghum.
- o A combination of farm grain crops and millet can be planted where the farm grains are grown after early drawdown and Japanese millet is grown after late drawdown. Millet would be sown in the shallow parts of the impoundments, while the farm grains would be sown in the deeper areas. This combination, because of the variety of foods, is often more attractive to waterfowl than single-crop plantings.

Method 3 - Objective: Waterfowl Food Production and Fish Management

- o Useful for 2-hectare (5-acre) or larger impoundments which have extensive shallow areas, good cover, and brushy edges at the upper end.
- o The impoundment is drawn down at the upper end in mid-July and sown in Japanese millet. A late summer drawdown is generally not detrimental to fishing.

- o After maturity, the standing grain is flooded in late October-early November.

MAINTENANCE AND MANAGEMENT

Management of an impoundment for waterfowl can be accomplished by one individual doing a variety of tasks (i.e., seedbed preparation, planting, water level manipulation). These various jobs will also need to be performed at different times of the year, depending on the objectives of the management (see Development above). A relaxed management or cessation of maintenance can only result in an impoundment having little or no value to waterfowl.

LABOR/MATERIALS

Labor requirements are small, amounting to a day per year each for seeding, fertilizing (if needed), and drawdown maintenance. Recommended seed amounts are 9.1 to 11.4 kg (20 to 25 pounds) of Japanese millet per 0.4 hectare (1 acre) and standard regional planting rates for corn and sorghum. Current costs for seeds are as follows: Japanese millet [23 kg (50 lb) bag] - \$27.50; yellow seed corn [23 kg (50 lb) bag] - \$42.00; and low-growing sorghum [23 kg (50 lb) bag] - \$29.25.

SOURCES OF INFORMATION

Additional information on impoundment design suitable for waterfowl can be obtained from:

- o State Regulatory Authority
- o State Fish and Game Agency
- o U.S. Soil Conservation Service

References cited:

- Almand, J. D. Wood duck. In: How to have small game on your land ... Small game management in Georgia. Georgia Game and Fish Commission; 1971:13-20.
- Anderson, W. L. Making land produce useful wildlife. USDA Farmers' Bulletin No. 2035; 1975.
- Beshears, W. W., Jr. Wood ducks in Alabama. Alabama Department of Conservation and Natural Resources, Division of Game and Fish. Special Report No. 4; 1974.
- Hobaugh, W. C.; Teer, J. G. Waterfowl use characteristics of flood-prevention lakes in north-central Texas. J. Wildl. Manage. 45(1):16-26; 1981.
- Ouchley, J. K. Waterfowl food and habitat utilization on a southern reservoir. College Station, TX: Texas A and M Univ.; 1976. Thesis.

Additional references:

- Atlantic Waterfowl Council. Technique handbook of waterfowl habitat development and management. 2nd edition, Bethany Beach, DE: Atlantic Waterfowl Council; 1972.
- Bateman, H. A. The wood duck in Louisiana. Wildlife Education Bulletin No. 29. Baton Rouge, LA: Louisiana Department of Wildlife and Fisheries; 1977.
- Burger, G. W. Practical wildlife management. New York, NY: Winchester Press; 1973.
- Davison, V. E.; Neeley, W. W. Managing farm fields, wetlands and waters for wild ducks in the South. U.S. Soil Conservation Service Bull. 2144; 1939.
- Environmental Laboratory. Preliminary guide to wetlands of the Gulf Coastal Plain. Vicksburg, MS: U.S. Army Engineer Waterways Experiment Station, Tech. Rpt. Y-78-5; 1978.
- Hall, L. C. Bibliography of freshwater wetlands ecology and management. Madison, WI: Wisconsin Dept. of Natural Resources, Research Rpt. No. 33; 1968.
- Johnson, R. R.; McCormick, J. F. (Tech. Coord.). Strategies for the protection and management of floodplain wetlands and other riparian ecosystems. Washington, DC: U.S. Forest Service. Gen. Tech. Rpt. WO-12; 1978.
- Linde, A. F. Techniques for wetland management. Madison, WI: Wisconsin Dept. of Natural Resources. Technical Rpt. No. 45; 1969.
- Martin, A. C.; Wiler, F. M. Food of game ducks in the United States and Canada. U.S. Fish and Wildlife Service Rpt. 30; 1951.
- McGillvrey, F. B., ed. A guide to wood duck production habitat requirements. U.S. Fish and Wildlife Service Res. Pub. 60; 1968.
- Neely, W. W.; Davison, V. E. Wild ducks on farmland in the South. USDA Farmers' Bulletin 2218. Washington, DC: U.S. Government Printing Office; 1971.
- Ocean Data Systems, Inc. Handbook for terrestrial wildlife habitat development on dredged material. Vicksburg, MS: U.S. Army Engineer Waterways Experiment Station. Tech. Rpt. D-78-37; 1978.
- Singleton, J. R. Waterfowl habitat management in Texas. Texas Parks and Wildlife Dept. Bull. 47; 1965.
- Spohrer, Mary L. Marsh management for wildlife: A bibliography with abstracts. La. Coop. Wildlife Research Unit, Publication No. 1; 1975.

- Trippensee, R. E. Wildlife management: fur bearers, waterfowl, and fish. Volume II. New York: McGraw-Hill; 1953.
- U.S. Forest Service. Wildlife habitat improvement handbook. Washington, DC: U.S. Forest Service. FSH 2609.11; 1969.
- U.S. Forest Service. Wildlife habitat management handbook. Atlanta, GA: U.S. Forest Service. FSH 2609.23R; 1971.
- U.S. Soil Conservation Service. Gulf Coast wetlands handbook. Alexandria, LA: U.S. Soil Conservation Service; undated.
- U.S. Soil Conservation Service. Technical standard and specifications for wildlife wetland habitat management. Temple, TX: U.S. Soil Conservation Service State Office; 1980.
- U.S. Soil Conservation Service. Landowner information job sheet: wood ducks (LA-Biol-5). Alexandria, LA: U.S. Department of Agriculture; various dates.
- Yoakum, J., Dasmann, W. P.; Sanderson, H. R.; Nixon, C. M.; Crawford, H. S. Habitat improvement techniques. pp. 329-403, In: Wildlife management techniques manual, 4th edition (S. D. Schemnitz, editor), Washington, DC: The Wildlife Society; 1980.

h. Island development for waterfowl.

PURPOSE

Small islands in permanent impoundments can provide an effective means of reducing terrestrial mammalian predation on waterfowl and their nests by providing protected nesting and loafing sites near open water (Figure 3.3-21). Many predators, such as raccoons and snakes, which may account for 50 to 90 percent of wood duck nest failure, will avoid swimming large stretches of water to gain access to a nest (Beshears 1974). The open water surrounding an island will also allow resting ducks to see foxes or feral dogs which may try to gain access to the island. Several species of migrant waterfowl which will benefit in this regard are mallards, lesser scaup, ring-neck duck, blue-winged and green-wing teal, shovelers, pintails, American coot, and pied-billed grebe.



Figure 3.3-21. Aerial view of an island created for waterfowl on a surface mine reservoir (photo courtesy of North American Coal Corporation).

DEVELOPMENT

Islands can be easily and inexpensively incorporated into the construction of a permanent impoundment. The islands should be 0.02 hectare (0.05 acre) or larger, with their distance from the mainland depending on each individual situation. In Alberta, it was found that channels 0.5 to 0.6 meter (1.5 to 2 feet) deep and approximately 9.1 meters (30 feet) wide between the island and

the mainland were adequate (Keith 1961). Another study recommended long, narrow islands at least 15.2 meters (50 feet) from the shore on impoundments larger than 0.81 hectares (2 acres) (McCarthy 1973). Hook (1973) found that, on large water areas, a minimum of 45.7 meters (150 feet) between islands minimizes territorial strife and encourages nesting in Canada geese. Most studies documenting the benefits of islands to waterfowl have been performed in the prairie pothole regions of the West. Because of this fact, little information is available on island size or the recommended distances islands should be from the shore in the eastern United States. However, considering all known information, it is recommended that islands be no closer than 9.1 meters (30 feet) to any impoundment shoreline.

During impoundment construction, potential high points or deltas within the reservoir can be built up, while land which would have been a peninsula can be separated from the mainland (Figure 3.3-22). The location of islands with respect to the prevailing wind direction can present special problems. Here, islands should be protected from strong wave action, which encourages erosion. Plantings on the mainland can reduce winds, while plantings on the island or in the shallow areas around the island can reduce wave erosion. Placement of rock or riprap on the exposed side of the island will also substantially reduce erosion. Islands at least 0.9 meter (3 feet) high are recommended to avoid nest destruction due to flooding and eventual settling of the ground.

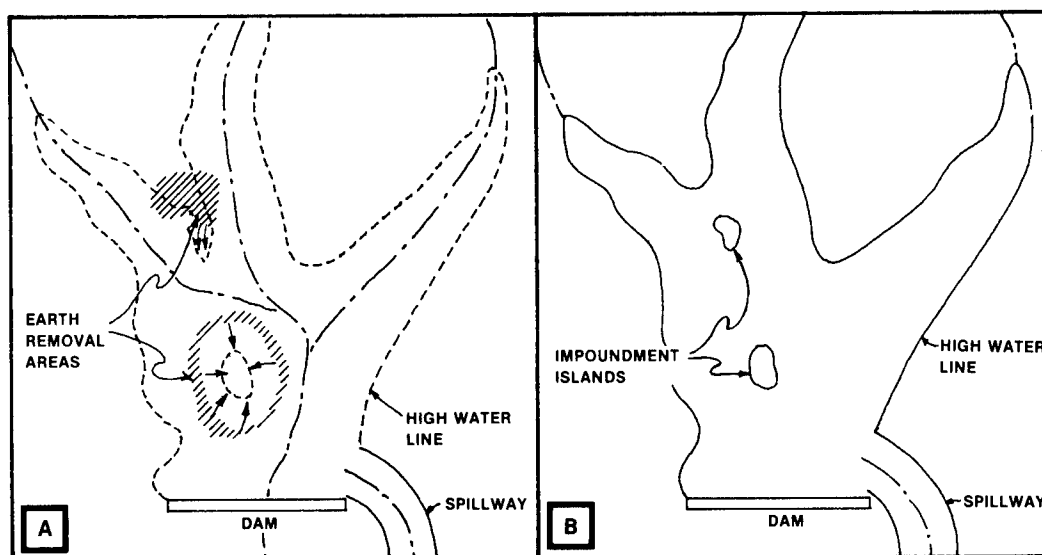


Figure 3.3-22. Schematic showing (A) possible areas of earth removal and (B) areas of placement to create post-impoundment islands (from Jones 1975).

Topsoils should comprise the upper soils on the island, and reseeding with native grass species and low-growing legumes is recommended. In general, extensive woody growth should be prevented because brushy areas that would develop are not desirable for most waterfowl. While establishing vegetation, hay should be spread on the surface of the island to encourage plant growth and to aid in stabilizing the island against wind and wave action.

To encourage wood duck nesting, some areas on an island should be planted in bushes and small trees. Once the height of this vegetation reaches 1.8 to 3.1 meters (6 to 10 feet), a nest box can be placed along the brushy edge with the opening of the box situated so that the bird can have an unobstructed access. Design specifications for a wood duck nesting box are given in Section 3.3.3.d.

MAINTENANCE AND MANAGEMENT

If properly designed, the type of island discussed in this paper will be relatively maintenance-free. Eventually, however, woody vegetation will invade the island and begin to grow. Since plants of this type are undesirable for waterfowl habitat, they should be removed, preferably by hand-thinning, to reduce disturbance of other vegetation.

LABOR/MATERIALS

Small islands can be created in a relatively few hours of equipment time (approximately 2 hours/island). Draglines [0.4-0.6 cu. meter (0.5-0.75 cu. yard) capacity], scrapers, and bulldozers are among the types of equipment that can be used. The actual choice of machinery is often dictated by what is being used to create the impoundment (Figure 3.3-23). An advantage of the use of heavy equipment is that compaction, resulting from operation of the machinery, will result in a more stable, erosion-resistant island.

SOURCES OF INFORMATION

Additional information on island development for waterfowl can be obtained from:

- o State Regulatory Authority
- o Office of Surface Mining
- o State Fish and Game Agency
- o U.S. Fish and Wildlife Service
- o U.S. Soil Conservation Service
- o U.S. Forest Service

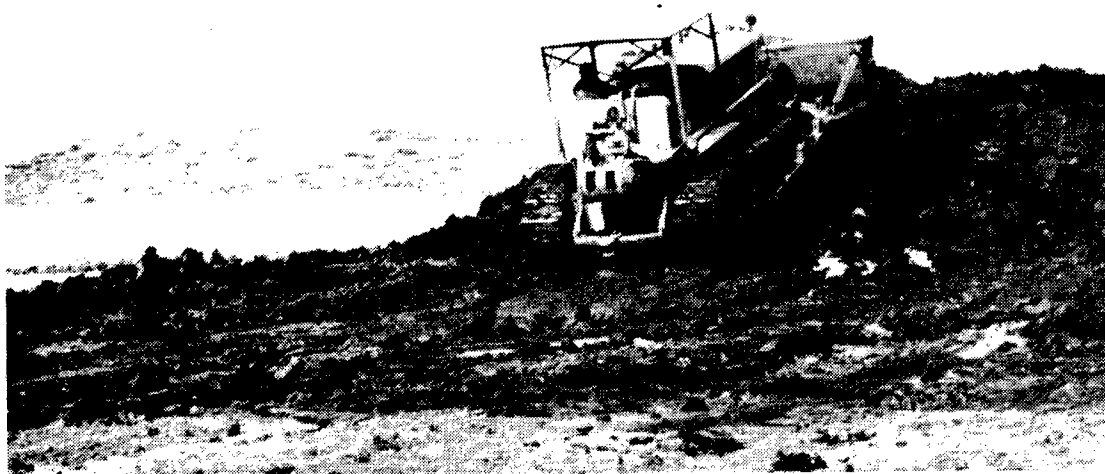


Figure 3.3-23. Earthen-mound islands can easily be constructed with a bull-dozer during impoundment construction (from Jones 1975).

References cited:

- Beshears, W. W., Jr. Wood ducks in Alabama. Special Report No. 4. Alabama Department of Conservation and Natural Resource. Division of Game and Fish. Montgomery, AL. 1974.
- Hook, D. L. Production and habitat use by Canada geese at Freezeout Lake, Montana. Bozeman, MT: Montana State Univ.; 1973. Thesis. 1-53.
- Keith, L. B. A study of waterfowl ecology on impoundments in southeastern Alberta. Wildl. Mono. No. 6. The Wildlife Society; 1961.
- Jones, J. D. Waterfowl nesting island development. Denver, CO: Technical note 260. Bureau of Land Management; 1975.
- McCarthy, J. J. Response of nesting Canada geese (*Branta canadensis*) to islands in stockdams in northcentral Montana. Bozeman, MT: Montana State University; 1973. Thesis. 1-34.

Additional references:

- Hammond, M. C.; Mann, G. E. Waterfowl nesting islands. J. Wildl. Mgmt. 20(4):345-352; 1956.
- Noble, R. L.; Teer, J. E.; Steinbach, D. W. Fish populations and waterfowl utilization characteristics of flood water retarding structures. Summary Report to U.S. Soil Conservation Service; October 17, 1978.

3.3.3 Other Habitat Improvements

- a. Creation of topographic features for maximum habitat diversity.

PURPOSE

In general, where topographic diversity exists, microhabitats will be created which will benefit a great variety of wildlife. Microhabitats are small or restricted sets of distinctive environmental conditions that constitute a small habitat. For example, a rock or brushpile could be thought of as a microhabitat that provides shelter and cover for rabbits and other small mammals that otherwise may not occur in the area if the piles were not there. Recontouring to leave an undulating terrain is another example because a microhabitat can be created in the lee of a small hillock. In the winter, these areas act as windbreaks, protecting wildlife from storms and exposure. These and other topographic modifications can significantly increase the variety of wildlife on an area and are recommended wherever conflicts with postmining land use do not occur.

DEVELOPMENT

The creation of topographic features to promote habitat diversity can be most successful following area mining operations. Richard Kerr (Bureau of Land Management, unpublished manuscript) has described some of the options that are available during regrading of area mined land. These are presented below.

One technique is the contouring of overburden or spoil materials into a form Kerr calls a "poppy seed roll" (Figure 3.3-24). The advantages of such a form over uniform or flat areas is that it allows different sun exposures, provides various air or wind flows, and creates a variety of plant habitats. Varying sun exposures create different conditions of humidity, air, and soil temperatures. Where similar topographic shaping has been tried in the West, mule deer will congregate on the warm dry areas on south-facing slopes in winter. The windbreak effect of these land forms is also an important feature (Figure 3.3-25). Many animals can find protection on the lee sides of the slopes during storms. Deer will also congregate on the upper half of the south-facing slope in winter. To enhance the windbreak effect, vegetation can be planted to provide shelter.

Another option is contouring to create several parallel, low, rolling hills at right angles to the prevailing wind direction. This takes maximum advantage of the windbreak effect that can be created during final contouring. To be effective and practical, these hills should be no more than 10 feet in height and should be spaced at intervals of 91.4 to 152.4 meters (300 to 500 feet). Breaks at intervals in the ridges and randomly placed open areas [1.2 to 2 hectares (3 to 5 acres) in size] will also make the parallel contouring more visually appealing. After being planted to grasses and legumes interspersed with small shrubs and trees, this type of area would be extremely attractive to white-tailed deer.



Figure 3.3-24. Contouring to create wildlife habitat.

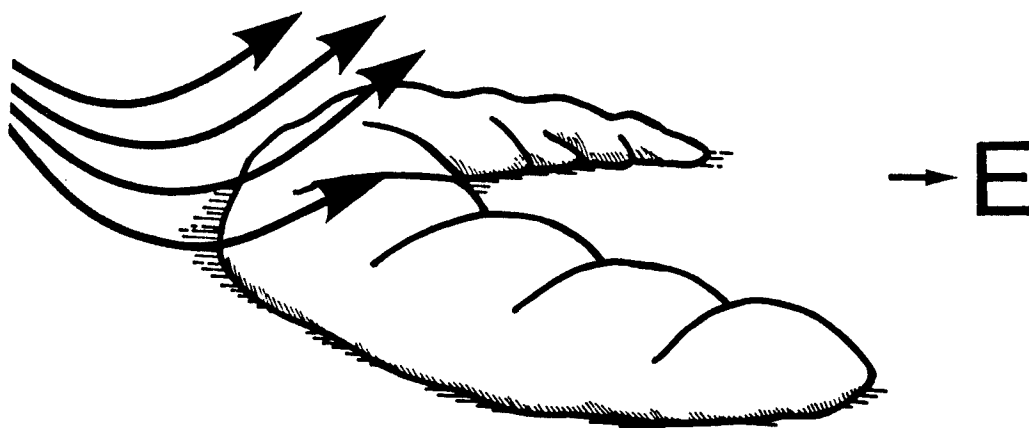


Figure 3.3-25. Windbreak effect of land contouring.

Allowing small pools of water to form in the low areas associated with parallel ridges and poppy seed roll forms will provide temporary water sources which are badly needed in some locations. These low areas would collect rainwater and should not be located where runoff would create erosion or acid drainage problems.

Rock- and brushpiles are features which can be used to create a more diverse habitat on a localized basis. They can be constructed following contour or area mining operations after final grading has been completed. On reclaimed areas, where protective cover is often lacking, rock- or brushpiles can be valuable assets in a wildlife enhancement program. Construction of rock- and brushpiles is discussed in Sections 3.3.3.b and 3.3.3.c.

MAINTENANCE AND MANAGEMENT

For most of these features, maintenance would be restricted to ensuring successful growth of vegetation after the structure has been completed.

LABOR/MATERIALS

Costs would be a function of engineering requirements and heavy equipment use. These costs would have to be balanced against the costs for reclaiming the land to its original contours.

SOURCES OF INFORMATION

Additional information on the creation of topographic features to enhance wildlife habitat can be obtained from:

- o State Regulatory Authority
- o Office of Surface Mining
- o U.S. Fish and Wildlife Service

Reference cited:

Kerr, R. Ideas about reclaiming western mined lands for wildlife. Denver, CO: Unpublished manuscript, Bureau of Land Management, Denver Service Center.

b. Brushpiles.

PURPOSE

Brushpiles provide several benefits to wildlife, such as:

- o Concealment and protection from predators
- o Protection from the elements
- o Nesting habitat

These structures are especially beneficial in areas of limited small game habitat, such as newly reclaimed areas.

ILLUSTRATION

There are many methods for constructing brushpiles. Depending upon the situation and availability of materials, construction may be accomplished in several ways. Residual brush materials, logs, or boulders may be utilized together or separately to provide a general habitat for small animals, as shown in Figure 3.3-26 (Gutiérrez et al. 1979). When scattered throughout an area, these piles provide valuable habitat for many different types of small animals. The number and location of brushpiles can be determined in consultation with a local wildlife biologist or soil conservationist.

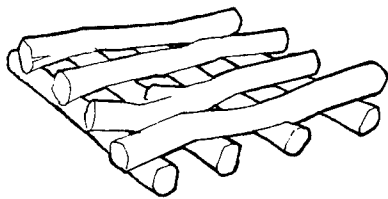
Construction with a combination of brush and rocks, as shown in Figure 3.3-26 (D, E, and F), provides cover with escape cavities for small mammals. Living piles can provide excellent winter cover for birds and mammals. Piles may be constructed, as shown, from rock and brush materials or exclusively from slash (see Section 3.2.2.b, Use of Slash from Clearing and Grubbing for specifications on pile shape, size, and utility).

MAINTENANCE AND MANAGEMENT

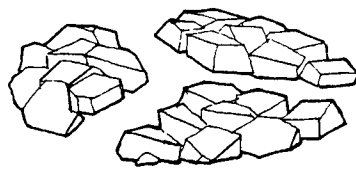
The brushpiles provide benefits to wildlife for many years with very little maintenance requirement. In time, the brushpiles may develop into a mass of living vegetation through sprouting of the original twigs (especially in wetland areas) or from germination of seeds that are caught in the material used to construct the piles.

LABOR/MATERIALS

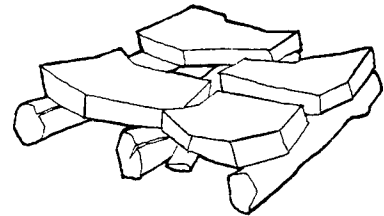
Materials can generally be picked up free or stockpiled from strip mine clearing operations and hauled to the reclamation sites. An individual can construct one of these structures in 20-30 minutes.



A



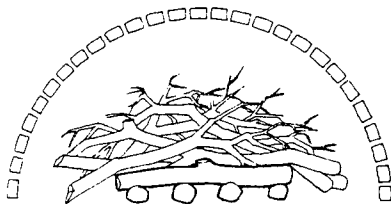
B



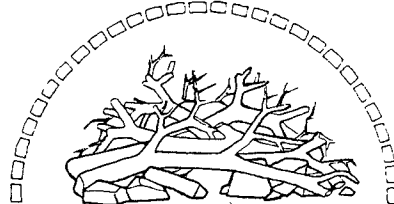
C

Build up with small brush

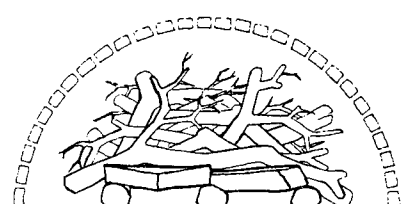
Dotted lines indicate additional brush



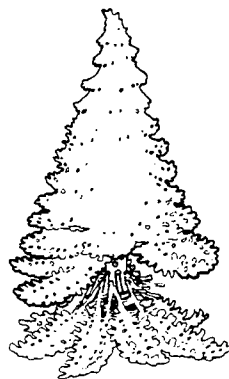
D



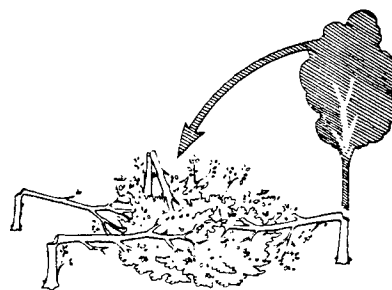
E



F



G



H

Figure 3.3-26. Construction of brushpile shelters demonstrating base construction methods (A-logs, B-boulders, C-log/boulder combination), dead brush construction (D-F), and living brush construction utilizing conifers (G) or hardwoods (H) (from Gutiérrez et al. 1979).

SOURCES OF INFORMATION

More information on the use of brushpiles may be obtained from:

- o State Regulatory Authority
- o Office of Surface Mining
- o State Fish and Game Agency
- o State Soil Conservationist
- o U.S. Fish and Wildlife Service
- o U.S. Forest Service

Reference cited:

Gutiérrez, R. J.; Decker, D. J.; Howard, R. A., Jr.; Lassoie, J. P. Managing small woodlands for wildlife. Extension Publication, Info. Bull. No. 157. Ithaca, NY: New York State College of Agriculture and Life Sciences at Cornell University; 1979.

Additional references:

U.S. Forest Service. Wildlife habitat improvement handbook. FSH No. 2609.11; 1969.

Warrick, C. W. Artificial brushpiles. Denver, CO: Bureau of Land Management, Tech. Note 290; 1976.

c. Rock piles.

PURPOSE

Rock piles provide wildlife with denning areas, protection from the elements, and concealment and protection from predators. They are most beneficial to smaller game and nongame animals. On newly reclaimed areas where cover may not exist, they are especially valuable. Rock piles are also useful for enhancement of wildlife habitat in the undisturbed areas adjacent to mining activities. Rock piles can be used to mitigate the loss of similar types of habitat structure (e.g., rock outcrops) during mining.

DEVELOPMENT

Coarse, angular rocks no smaller than 15 cm (6 inches) across are ideal for constructing rock piles (Figure 3.3-27). Less subject to weathering and scattering, rocks of this size provide large interior spaces within a pile. The size of these interior spaces influences, to a large degree, the animals likely to use the structure. Rodents and cottontail rabbits will utilize small spaces, whereas woodchucks, opossums, and raccoons prefer larger spaces.



Figure 3.3-27. Rock piles are ideal shelters for small wildlife (from Johnson 1978).

Rock piles should be large enough to provide an interior climate with a fairly stable temperature and humidity. A pile roughly 4.3 meters (14 feet) in diameter and 1.2 meters (4 feet) deep should be considered a minimum size for equipment-placed rock piles, allowing for some scattering of rocks around the edge. Smaller structures, about 1.8 meters (6 feet) across and 0.6 to 0.9 meters (2 to 3 feet) deep, may be constructed by hand.

One or two rock piles can be constructed per 0.4 hectare (1 acre) and should be placed near other habitat, such as feeding areas, water, or other cover, depending on the animals expected to utilize the structure. Rock piles placed along ridgelines can provide perches for birds of prey. Specific recommendations on rock pile sizes, placement, and number can be made by a local wildlife biologist.

Rocks are most easily gathered when their removal from topsoil material is necessary for proper reclamation. Suitable material for building rock piles can then be stockpiled for later use or placed in piles directly on regraded areas during rock removal operations.

MAINTENANCE AND MANAGEMENT

Rock piles require no maintenance. With proper placement and selection of materials, rock piles can be expected to indefinitely provide benefits to wildlife.

LABOR/MATERIALS

Suitable material should be readily available at some stage of the mining operation. Lifting equipment, such as a front end loader or high-lift, can be used for material handling, while the placement of rocks can be performed most economically by dump truck. When rock removal is necessary for reclamation, the creation of rock piles can reduce disposal costs by reducing haulage. The loading and placement of rocks for a pile 3 meters (10 feet) in diameter by 1 meter (3 feet) high should require 1-2 man-hours of time and 1-2 hours of front end loader and dump truck time.

SOURCES OF INFORMATION

Information on the usefulness, placement, and size requirements of rock piles to benefit wildlife can be obtained from:

- o State Regulatory Authority
- o Office of Surface Mining
- o State Fish and Game Agency
- o U.S. Fish and Wildlife Service
- o U.S. Forest Service

Reference cited:

Johnson, T. R. Tips on the management of amphibians and reptiles on private lands. Jefferson City, MO: Missouri Department of Conservation; 1978.

Additional reference:

Thomas, J. W., ed. Wildlife habitats in managed forests: The Blue Mountains of Oregon and Washington. U.S. Dept. of Agriculture, Forest Service, Agriculture Handbook No. 553: published in cooperation with Wildlife Management Institute and U.S. Bureau of Land Management; 1979.

d. Nest structures.

PURPOSE

A deficiency of natural nest sites can limit wildlife success and distribution in an otherwise suitable habitat. Artificial nest structures provide substitute nest sites in areas where natural sites have been destroyed or are lacking. The advantage to attracting bird species to a site is not only aesthetic. For example, raptors and owls consume rodents and small mammals that prey upon seeds and seedlings, while other birds consume insect pests.

DEVELOPMENT

Graul (1980) presents some excellent general guidelines concerning the application of artificial nesting structures:

The primary use of the [artificial nest] structures should be to temporarily replace lost habitat elements, i.e., the main emphasis should be upon replacing the natural habitat element. For instance, an artificial nest structure might be necessary in the interim between when a tree is lost and a new one grown.

Artificial structures might also be used for the relocation of a nesting pair of a high-value species whose natural nest site is jeopardized by mining activities.

Nest Boxes

Nest boxes ("birdhouses") benefit a wide variety of the region's birds, including songbirds and other perching birds, woodpeckers, owls, and kestrels. They can be placed on trees, utility poles, fence posts or abandoned buildings. These structures must meet the requirements of the target species and be properly designed, located, erected, and maintained for beneficial results (Yoakum et al. 1980). Furthermore, they must be durable, predator-proof, weathertight, lightweight, and economical to build (Yoakum 1971). Table 3.3-8 provides nest box dimensions for a variety of birds in the Southcentral U.S. Figures 3.3-28, 3.3-29, and 3.3-30 show typical nest box construction layouts and examples of other nesting structures.

Nest Baskets

Conical nest baskets have been constructed for ducks out of 0.6-cm (0.25-inch) hardware cloth, reinforcing rods, and a galvanized pipe support for placement in shallow water. For more information on these structures, including a complete list of materials, construction procedures, and placement considerations, see Yoakum et al. (1980).

Table 3.3-8. Nest box dimensions and placement height for selected species of birds.

Species	Floor		Depth		Entrance Diameter		Entrance Height Above Floor		Box Height Above Ground ^a	
	cm	(inches)	cm	(inches)	cm	(inches)	cm	(inches)	meters	(feet)
Eastern Bluebird	13 x 13	(5 x 5)	20 - 25	(8 - 10)	3.8	(1.5)	15 - 20	(6 - 8)	1.5 - 3.1	(5 - 10)
Carolina Chickadee	10 x 10	(4 x 4)	20 - 25	(8 - 10)	2.8	(1.1)	15 - 20	(6 - 8)	1.8 - 4.6	(6 - 15)
Yellow-shafted Flicker	18 x 18	(7 x 7)	41 - 61	(16 - 24)	6.4	(2.5)		(14 - 16)	1.8 - 6.1	(6 - 20)
Crested Flycatcher	15 x 15	(6 x 6)	20 - 25	(8 - 10)	5.1	(2.0)	15 - 20	(6 - 8)	2.4 - 6.1	(8 - 20)
American Kestrel	20 x 20	(8 x 8)	31 - 38	(12 - 15)	7.6	(3.0)	22 - 31	(9 - 12)	3.1 - 9.1	(10 - 30)
Purple Martin ^b	15 x 15	(6 x 6)	15	(6)	6.4	(2.5)	3	(1)	4.6 - 6.1	(15 - 20)
White-breasted Nuthatch	10 x 10	(4 x 4)	20 - 25	(8 - 10)	5.7	(2.25)	15 - 20	(6 - 8)	3.7 - 6.1	(12 - 20)
Barn Owl	25 x 25-	(10 x 10-)								
	46 x 46	(18 x 18)	38 - 46	(15 - 18)	15.2	(6.0)	10	(4)	3.7 - 5.5	(12 - 18)
Screech Owl	20 x 20	(8 x 8)	31 - 38	(12 - 15)	7.6	(3.0)	23 - 31	(9 - 12)	3.1 - 9.1	(10 - 30)
Tufted Titmouse	10 x 10	(4 x 4)	20 - 25	(8 - 10)	5.7	(1.25)	15 - 20	(6 - 8)	1.8 - 4.6	(6 - 15)
Carolina Wren	10 x 10	(4 x 4)	10 - 15	(4 - 6)	5.7	(1.25)	15 - 20	(6 - 8)	1.5 - 3.1	(5 - 10)
House Wren	10 x 10	(4 x 4)	20 - 25	(8 - 10)	2.8	(1.1)	15 - 20	(6 - 8)	1.5 - 3.1	(5 - 10)
Downy Woodpecker	10 x 10	(4 x 4)	20 - 25	(8 - 10)	5.7	(1.25)	15 - 20	(6 - 8)	1.8 - 6.1	(6 - 20)
Red-bellied Woodpecker	15 x 15	(6 x 6)	31 - 36	(12 - 14)	6.4	(2.5)	25 - 31	(10 - 12)	3.7 - 6.1	(12 - 20)
Red-headed Woodpecker	15 x 15	(6 x 6)	31 - 38	(12 - 15)	5.1	(2.0)	23 - 31	(9 - 12)	3.7 - 6.1	(12 - 20)
Wood Duck										
(wooden box)	31 x 31	(12 x 12)	61	(24)	7.6 x 10.2	(3 x 4)	46	(18)	2.4 - 4.6 ^c	(8 - 15) ^c
(metal cylinder)	31 dia.	(12 dia.)	61	(24)	10.2	(4.0)	46	(18)	2.4 - 4.6 ^c	(8 - 15) ^c

^aData indicate that boxes at moderate heights, mostly within reach of a man on the ground, are readily accepted by many birds.

^bDimensions for one compartment.

^c1.5 meters (5 feet) when placed on pole or tree in water.

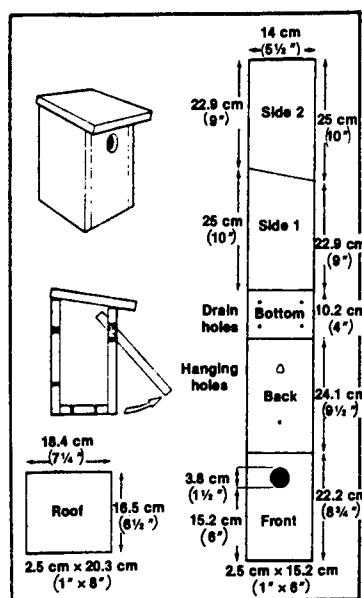


Figure 3.3-28. Eastern bluebird box (from Gutiérrez et al. 1979).

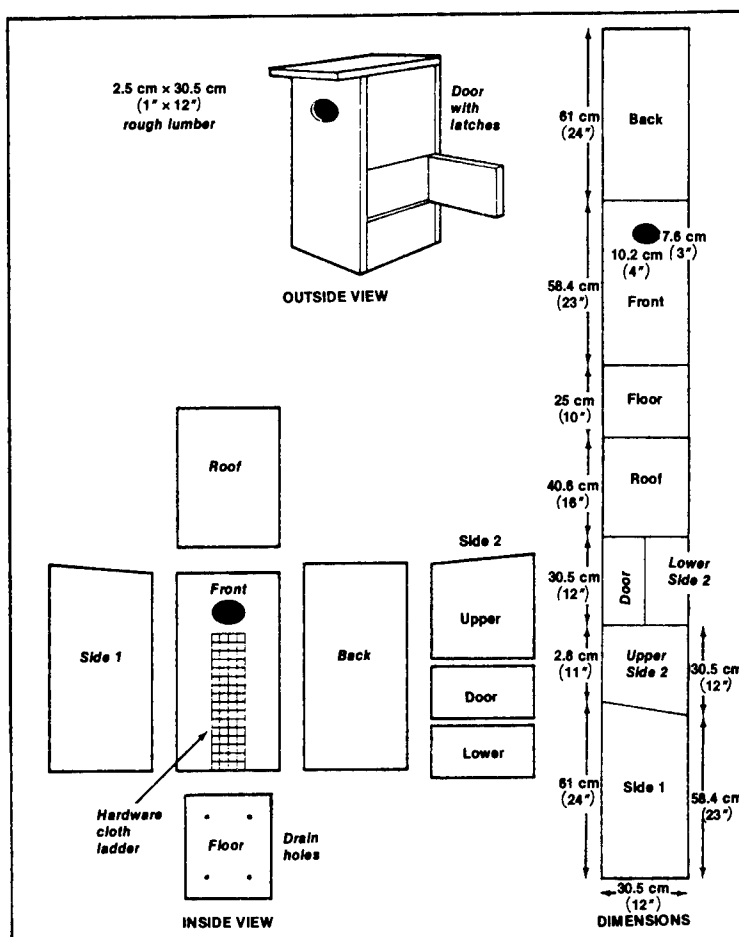


Figure 3.3-29. Wood duck nest box (from Gutiérrez et al. 1979).

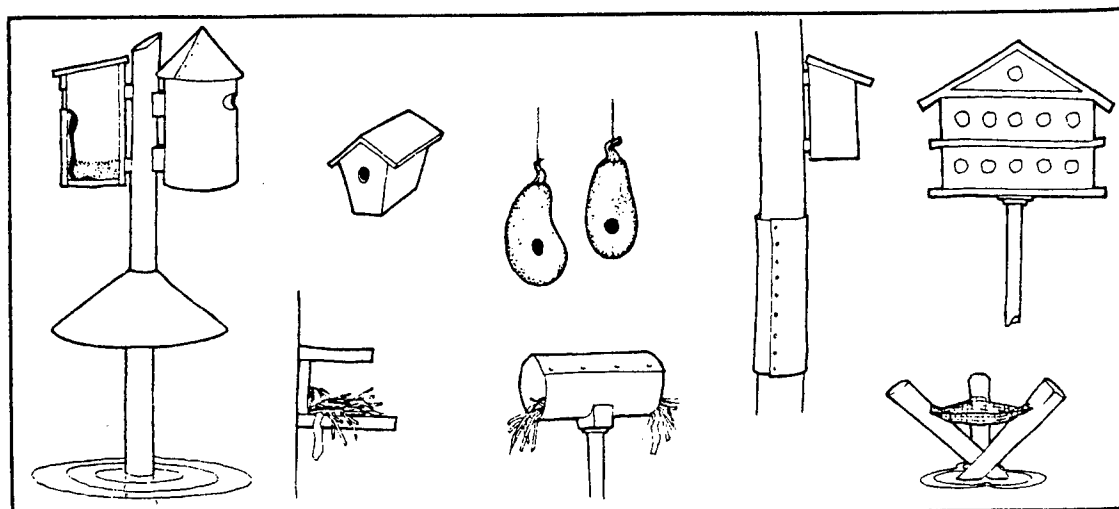


Figure 3.3-30. Examples of bird nest structures (from Gutiérrez et al. 1979).

Nest Cones

Because of the likelihood for the loosely constructed twig nests of mourning doves to be destroyed during storms, artificial nest cones can be used to improve nesting survival (Ohio Department of Natural Resources no date). The cones are easily constructed out of a 31-cm (12-inch) square of 0.6- or 1.0-cm (0.25- or 0.38-inch) hardware cloth and can be installed with nails or staples in the forks of tree branches. Recommended sites must command good visibility, provide adequate clearance for the birds to easily escape danger, and occur in modest shade, 1.8-4.9 meters (6-16 feet) above the ground.

Nest Cover

Normal revegetation procedures during reclamation produce suitable nesting cover for a variety of grassland nesting birds and other wildlife. Shomon et al. (1966) provide suggestions for maintaining and enhancing nest cover for wildlife.

1. Maintain permanent, undisturbed cover whenever possible along fences, roads, and unused areas.
2. Fence nesting cover where possible to prevent grazing by livestock.
3. Plant shrubby thickets for use as cover in areas unused for other purposes.
4. Refrain from dryland fallowing operations during the nesting season to enable ground nesting birds to raise their brood in these important stubble habitats.
5. Use flushing devices on mowers to save nesting females during the first cutting of the crop.

Raptor Nesting Tripod

Grubb (1980) has developed a tripod nesting structure for bald eagles which supports a nest more than 35 feet above the ground. The stability and ease of relocating this structure makes it ideal for relocating eagle nests or simply providing additional nest sites for several types of raptors. The construction is discussed below. Table 3.3-9 provides a complete list of all materials needed.

Table 3.3-9. Material list for constructing basic bald eagle nesting tripod (from Grubb 1980).

Item	Quantity
Aluminum pipe, 0.6-cm (0.25-in) wall thickness	
10.2-cm (4.0-in) inner diameter x 6.1 m (20 ft)	7
8.9-cm (3.5-in) inner diameter x 6.1 m (20 ft)	1
Railroad ties, 15 cm x 20 cm x 2.4 m (6 in x 8 in x 8 ft)	3
Steel bolts, 1.3-cm (0.5-in) diameter x 15.2 cm (6 in)	24
compatible nuts	48
compatible flat washers	48
Steel all-thread, 1.9-cm (0.75-in) diameter x 35.6 cm (14 in)	5
compatible nuts	20
compatible flat washers	10
Paint	
zinc-chromate aluminum primer	3.8 l (1 gal)
base paint (brown, green, or gray)	3.8 l (1 gal)
green spray paint	2 cans
brown spray paint	2 cans
Chicken wire, 2.5-cm (1-in) mesh, 1.8-m (6-ft) width	6.1 m (20 ft)
Tie wire, 14 gauge	1 roll
All-thread, 0.6-cm (0.25-in) diameter x 45.7 cm (18 in)	6
compatible nuts	12
compatible locking washers	12
Flat metal plates, 2.5 cm (1 in) x 20 cm (8 in)	6
Optional 2 by 4 framework, cedar or redwood	
3-m (10-ft) length	1
1.8-m (6-ft) length	2
bolts, 1.3-cm (0.5-in) diameter x 17.8 cm (7 in)	4
bolts, 1.3-cm (0.5-in) diameter x 10.2 cm (4 in)	2
compatible nuts	12
compatible flat washers	12

Seven sections of aluminum pipe [10.2 cm (4 in) with 0.6 cm (.25 in) walls in 6.1 m (20 ft) sections are required to make the tripod (Figure 3.3-31). Each tripod leg is comprised of one short length [made from cutting one 6.1 m (20 ft) section into three equal 203.2 cm (80 in) sections] and two 6.1 m (20 ft) lengths. The short length extends above the apex, forming the seat for the nest. Special equipment includes a portable generator for drilling footing holes in the field, a 11 m (36 ft) extension ladder, and post hole diggers. Inner sleeves for the joints are made by cutting a 6.1 m (20 ft) length of 8.9 cm (3.5 in) diameter aluminum pipe into six equal pieces. These 101.6 cm (40 in) sleeves fit inside the 10.2 cm (4 in) pipe. They are inserted equidistant in the two pieces joined together and bolted in place using two steel machine bolts at 15.2 cm (6 in) and 30.5 cm (12 in) from the center [Figure 3.3-31(b)]. Bolts used should be 1.3 cm (0.5 in) diameter by 15.2 cm (6 in) long. Stress points at the footing and apex should be attached with 1.9 cm (0.75 in) steel all-thread cut into 35.6 cm (14 in) lengths. Washers are used on all bolts, and two nuts are used for locking.

Railroad ties may be used for the tripod footing. Ties that are 2.4 m (8 ft) long should be buried up to 1.5 m (5 ft) [Figure 3.3-31(c)]. The uprights above the apex may be used for attaching a simple framework for raising the nest, attaching branches, or shade screens (Figure 3.3-32). Redwood or cedar 2x4's (5.1x10.2 cm) may be predrilled and bolted to form these structures. Perch branches may be attached by two u-bolts made from 0.6 cm (0.25 in) all-threads. The nest base plate may be made by boring holes in a 2.5 cm by 45.7 cm (1 in x 8 in) metal plate.

Chicken wire [2.5 cm (1 in) mesh] can be used for bundling nest material. The aluminum pipe should be treated with zinc chromate primer and painted to camouflage into the landscape.

Most all of the drilling, fitting, and painting should be done in a shop. Footing bolt holes are drilled in the field. The footings are buried forming an equilateral triangle with 12.2 m (40 ft) sides. The triangle is oriented so that the complete structure will have two upward extensions forming a plane facing the sun (south/southwest), allowing for sunshade installation if needed.

Since the assembled tripod weighs about 306 kg (675 lbs), a helicopter makes placing it upright a simple matter. However, it can be done using winches and booms. Legs should be spread exactly as shown in Figure 3.3-31(a). Apex bolts are tightened after the footings are secured.

If a helicopter is used to raise the tripod into place, it can also be used to place nesting material into the apex. Otherwise, pulley and ropes can be used in conjunction with a 2x4 cross arm (Figure 3.3-32). The finished nest structure is shown in Figure 3.3-33.

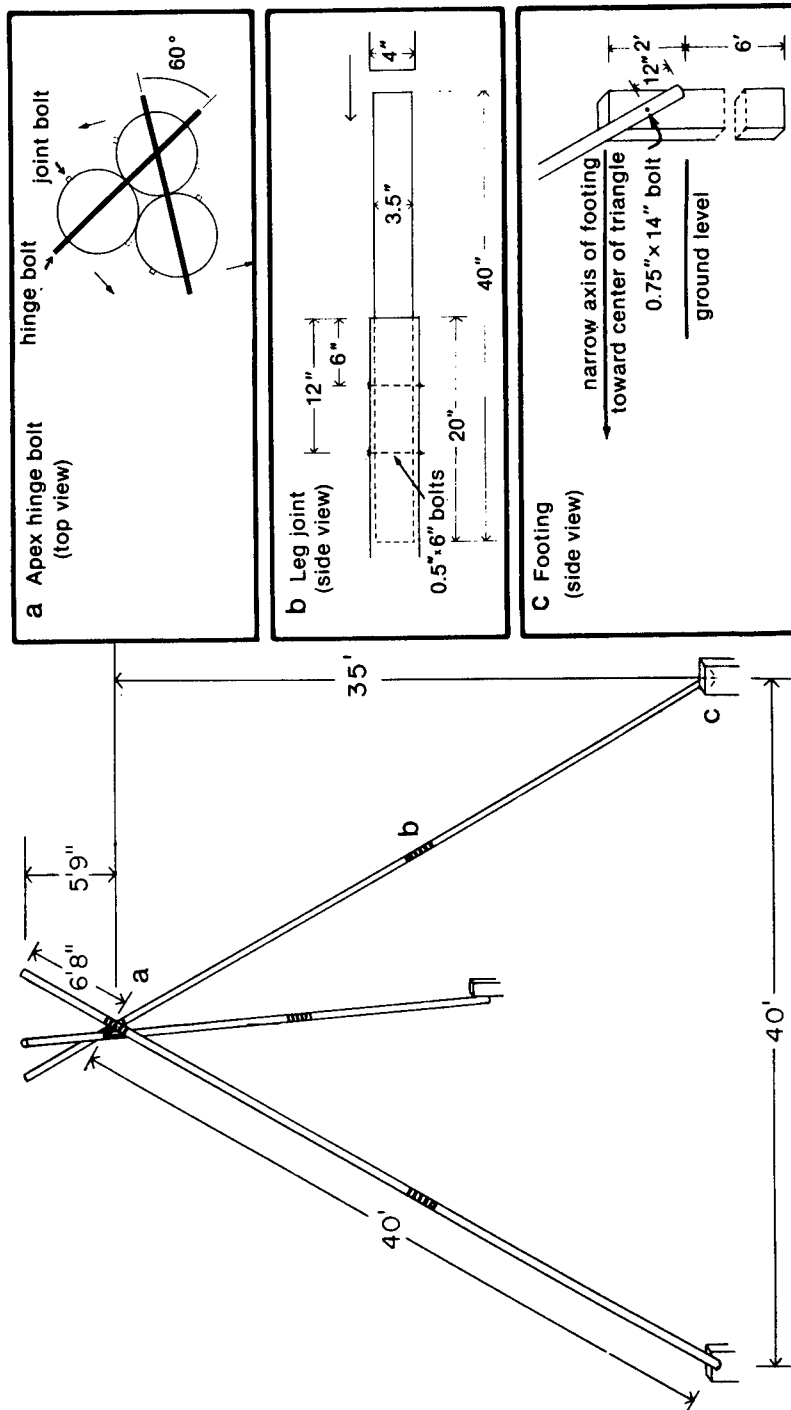


Figure 3.3-31. Diagram of nesting platform construction. (a) Top view of tripod. Note hinge bolt placement and joint bolt placement to allow free spreading of the legs in the direction of the arrows, (b) leg joint construction and (c) footing attachment (from Grubb 1980).

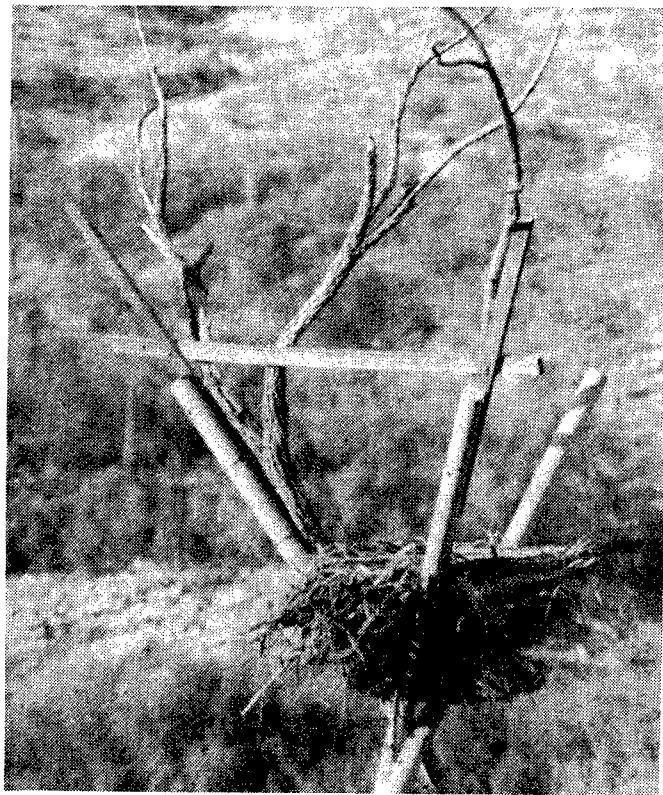


Figure 3.3-32. Finished tripod apex with attachments (from Grubb 1980).

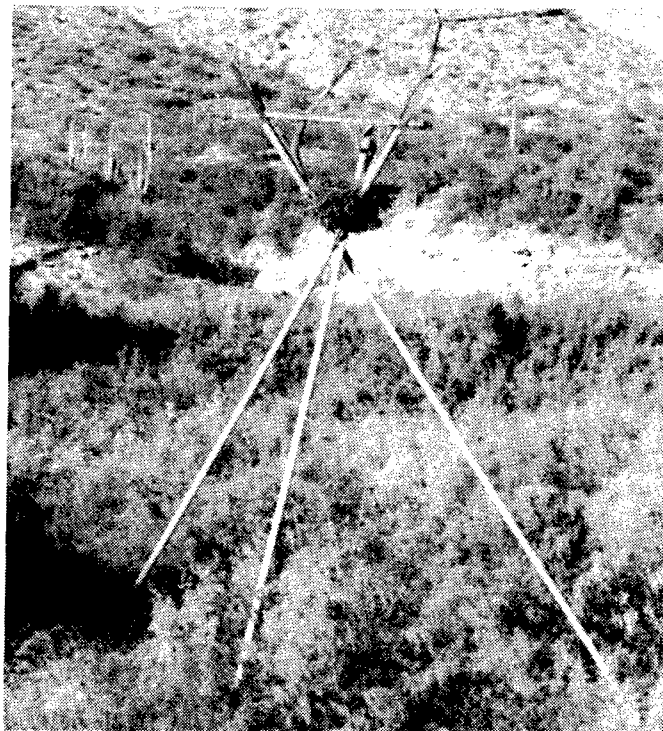


Figure 3.3-33. Overview of finished tripod (from Grubb 1980).

MAINTENANCE AND MANAGEMENT

Nest structures should be checked before each breeding season and repaired if necessary. Nest cones for mourning doves should be cleaned out after each nesting season. Generally, nest boxes do not need to be cleaned out yearly.

LABOR/MATERIALS

Nest boxes and other nesting structures can be constructed using mass production techniques to reduce labor costs. Correctly placing nest structures requires more time than manufacturing them. As an example, bluebird boxes average approximately \$5.00 for materials and one man hour per box to build.

Rough-sawn hardwood lumber, especially white oak, will produce long-lived structures. Mill-run lumber can be purchased inexpensively from a local sawmill. If pine is used, it should be treated with a preservative. A nest box for bluebirds requires about 4,720 cc (2 board-feet) of lumber, while a wood duck nest box requires about 23,600 cc (10 board-feet).

A nesting tripod for raptors, such as described by Grubb (1980), is estimated to cost approximately \$1200, including 1 hour of helicopter time. In addition, 150 man hours of labor are used.

SOURCES OF INFORMATION

Additional information on nesting structures can be obtained from:

- o State Regulatory Authority
- o Office of Surface Mining
- o U.S. Fish and Wildlife Service
- o U.S. Forest Service
- o State Fish and Game Agencies

References cited:

- Graul, W. D. Grassland management practices and bird communities. Proceedings of management of western forests and grasslands for nongame birds. U.S. Forest Service Tech. Rep. INT-86. Intermountain Forest and Range Exp. Sta., Ogden, UT 84401; 1980:38-47.
- Grubb, T. G. An artificial bald eagle nest. Ft. Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Research Note RM-383; March 1980.
- Ohio Department of Natural Resources. Attracting birds in Ohio. Division of Wildlife; no date.

Shomon, V. V.; Ashbaugh, B. L.; Tolmon, C. D. Wildlife habitat improvement. New York: Natl. Audubon Soc.; 1966.

Yoakum, J.; Dasmann, W. P.; Sanderson, H. R.; Nixon, C. M.; Crawford, H. S. Habitat improvement techniques. In: Schemnitz, S. D., ed. Wildlife management techniques manual. Washington, DC: The Wildlife Society; 1980.

Additional references:

Gutiérrez, R. J.; Decker, D. J.; Howard, R. A., Jr.; Lassoie, J. P. Managing small woodlands for wildlife. Extension Services Info. Bull. 157. Ithaca, New York: New York State College of Agriculture and Life Sciences at Cornell University; 1979.

U.S. Fish and Wildlife Service. Nest boxes for wood ducks. Washington, DC: U.S.D.I., Fish and Wildlife Service, Wildlife Leaflet 510; 1976.

Yoakum, J. Habitat improvement. In: Teague, R. D., ed. A manual of wildlife conservation. Washington, DC: The Wildlife Society; 1971.

4. REGIONAL RECLAMATION PLANNING

4.1 INTRODUCTION

Coal deposits in the Southcentral U.S. encompass parts of four States, which includes eastern Oklahoma, westcentral and southcentral Arkansas, northwestern Louisiana, and a large part of Texas. The major coal resource in Texas, southcentral Arkansas, and northwestern Louisiana is lignite deposits. However, eastern Oklahoma, westcentral Arkansas, and northcentral Texas have deposits of bituminous coal.

The lignite beds lie within three major vegetation types in Texas. These types include Pineywoods, Post Oak Savannah, and South Texas Plains [comparable to Bailey's ecoregions 2320, 2510, and 2520, respectively (Bailey 1978)]. In the bituminous regions of northcentral Texas, the Cross Timbers and Prairie vegetation types are predominant (Gould 1975). Oak-hickory, oak-pine, and tallgrass prairie vegetation occur in the Oklahoma bituminous coal region (Duck and Fletcher 1943). A detailed discussion of factors (e.g., climatic, edaphic, and biotic) in Texas and Oklahoma that affect reclamation for wildlife is contained in Dickson and Vance (1981).

Most of the lignite in northwestern Louisiana and southcentral Arkansas and the bituminous coal in westcentral Arkansas coincide with Bailey's ecoregion 2320 Southeastern Mixed Forest (Bailey 1978). The area represented by the coal regions includes a variety of climatic, edaphic, and biotic characteristics. Reclamation programs must be written for each specific area so that these local factors can be incorporated into the plans.

Habitats associated with streams are highly important to wildlife throughout the region. Floodplains of perennial streams represent a year-round moisture source and, consequently, harbor bottomland forests. These forests vary from narrow strips of willows and cottonwoods to, on broader floodplains, bottomland hardwood forests with well-developed canopy, shrub, and herbaceous layers. Intermittent streams are dry during some part of the year, but still represent a moister environment than the surrounding uplands and have vegetation similar to the bottomland forest. Ephemereral streams are dry most of the year except during rain events so that vegetation associated with these habitats varies little from the surrounding upland.

A wide variety of game and nongame wildlife inhabit the region, and the species vary with regional habitat types. Species, such as white-tailed deer and cottontail rabbit, are widespread. Fox squirrel, gray squirrel, raccoon, and fox occur throughout the region. Bobwhite quail and mourning dove are common game birds.

4.2 EXAMPLE RECLAMATION PLAN

The Cloud Mine is presented in the following pages as an example of the reclamation of a hypothetical site in the Southcentral U.S. region. The site is typical of one in which area mining would be used. The topography is flat to rolling (Figure 4.2-1), and most slopes are shallow.

The current land use of the area is fish and wildlife habitat. Four major vegetation types which occur on the premine site include bottomland hardwood forest, bluestem prairie, oak-hickory forest, and marsh (Figure 4.2-2).

The bottomland hardwood forest which occurs in the permit area is dominated by American elm and hackberry. Associate species include Shumard's oak, bur oak, black walnut, bitternut hickory, sycamore, green ash, and cottonwood. Coralberry, rough-leaf dogwood, and poison ivy occur in the understory. In wet areas, willows are common, especially along streambanks. Coralberry is the most common understory shrub. Wild rye is conspicuous throughout the forest area.

The marsh area represents a low, permanently wet area dominated by grasses and sedges. Species include sedges, rushes, smartweed, and cattails. Small pools of water occur throughout the area. Many of the ponded areas are dominated by cattails.

Oak-hickory forest is common in the area. Species of trees in this forest type include Chinquapin oak, white oak, Shumard's oak, post oak, black-jack oak, black oak, black hickory, mockernut hickory, sugar maple, winged elm, and American elm. A woody understory and herbaceous ground cover occurs also.

The Bluestem Prairie is dominated by tall grasses and forbs, including big bluestem, little bluestem, switchgrass, Indiangrass, tall dropseed, wooly croton, and false wild indigo.

The mine site area supports a variety of wildlife species. White-tailed deer are common, as well as striped skunks, raccoons, Virginia opossums and eastern cottontails. Based on general distributional patterns, some 55 mammal species can occur on this site.

Although over 200 bird species can occur on the site, most of these would be infrequent visitors. Commonly seen species include red-tailed hawk, mourning dove, starling, common yellowthroat, house sparrow, red-winged blackbird, brown-headed cowbird, and cardinal.

A brief reconnaissance of the Cloud Mine site, prior to mining, revealed that the forest harbored the fox squirrel and eastern woodrat. Birds in this habitat included the yellow-billed cuckoo, red bellied woodpecker, blue jay, common crow, Carolina chickadee, tufted titmouse, and blue-gray gnatcatcher. The prairie harbored the deer mouse and large numbers of eastern meadowlarks. The muskrat and a variety of ducks and geese were common in the marsh area.

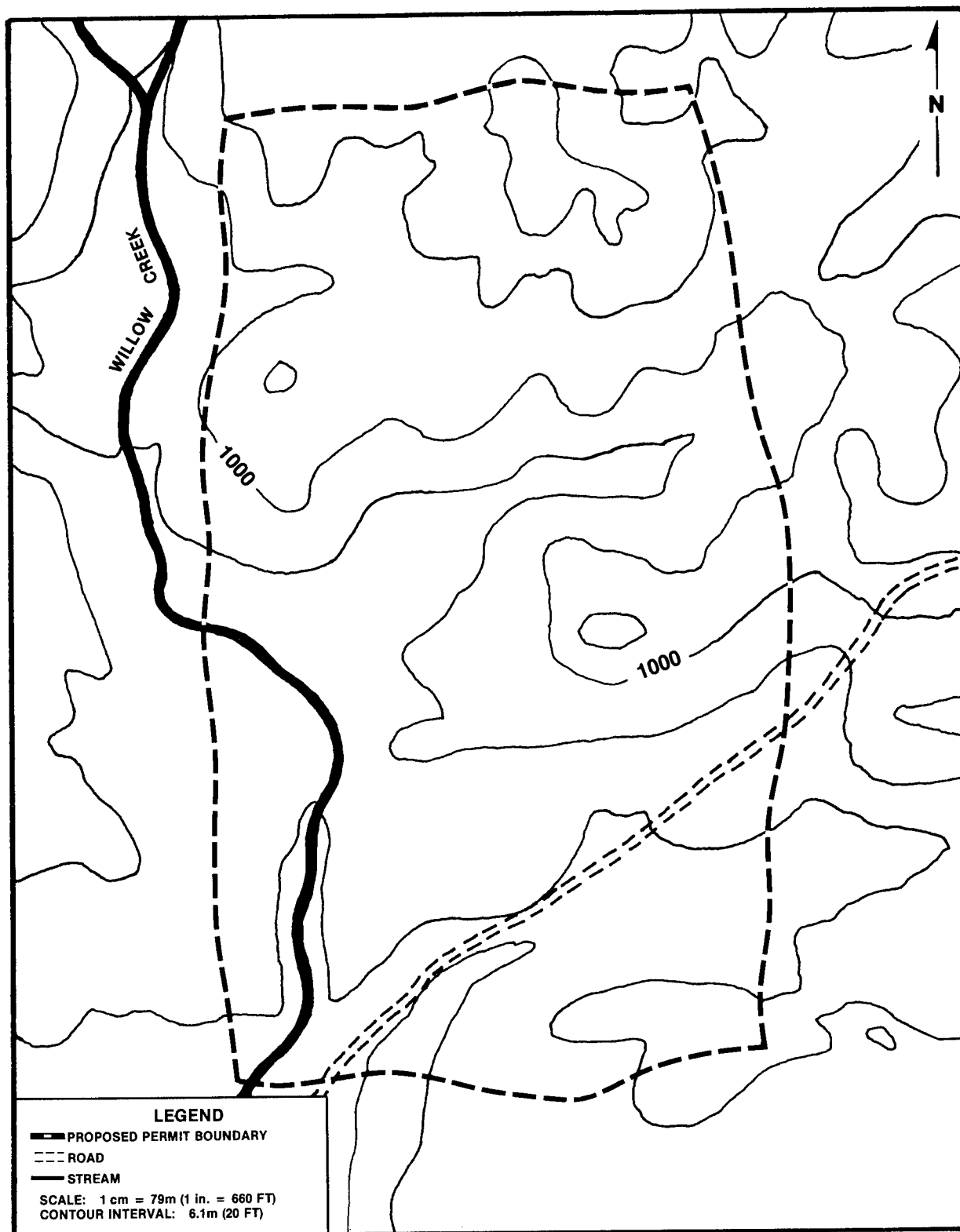


Figure 4.2-1. Topography of the Cloud Mine permit area.

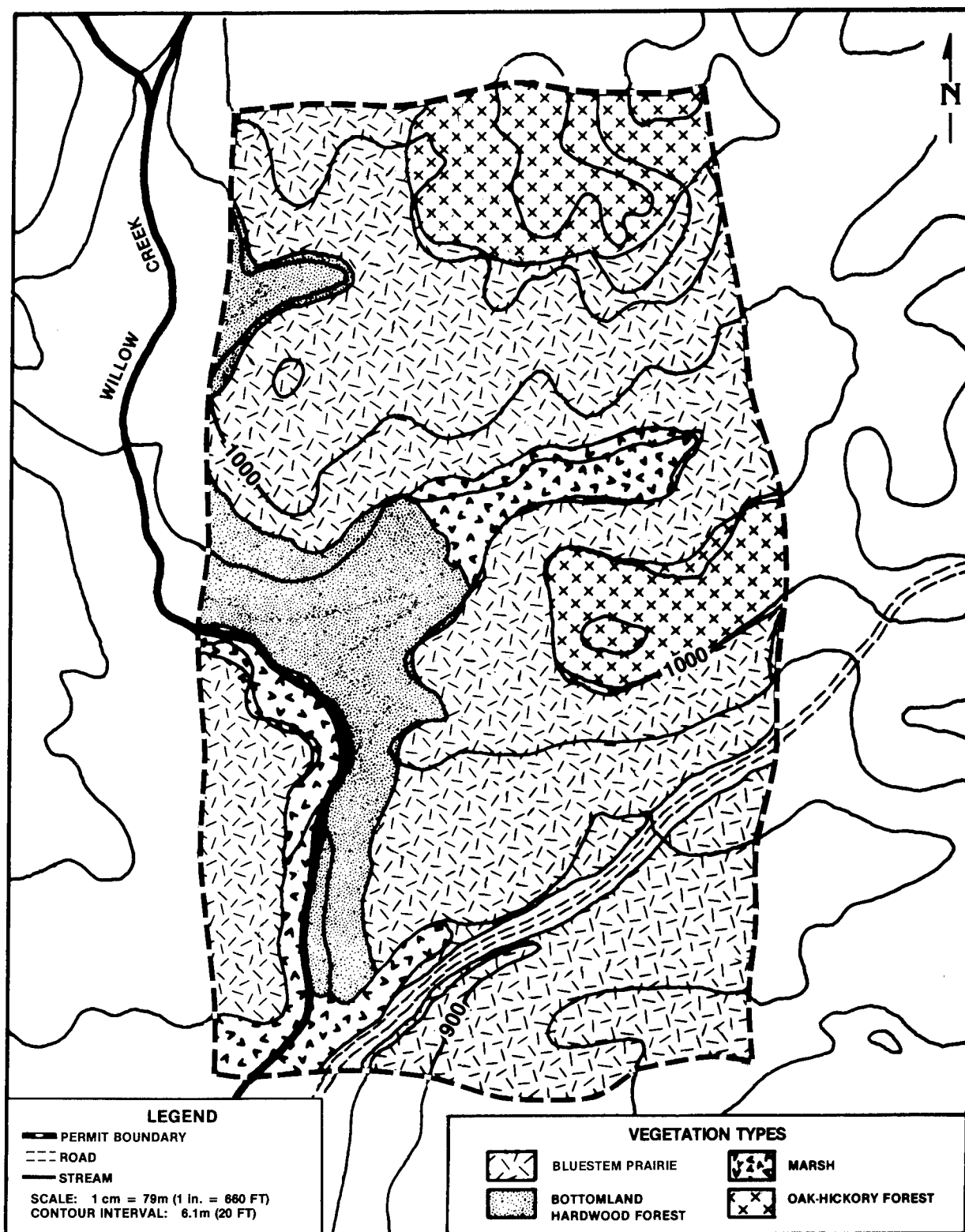


Figure 4.2-2. Vegetation types on the Cloud Mine permit area.

The soils of the upland rolling area are shallow to deep loam, silt loam, and silty clay loam of the Collinsville-Vinita, Dennis, and Summit Series. On the lower slopes in the areas with deep, moderately well drained alluvial soils, Verdigris Silty Clay Loam is present (U.S. Department of Agriculture 1973). The Bates-Collinsville Complex is the common prairie soil in the area. Figure 4.2-3 shows the soils on the Cloud Mine permit area.

The mine site area is characterized by hot, dry summers. The midsummer temperature averages approximately 28°C (82.4°F) but may reach up to 44.5°C (112°F). Moderately cold, dry winters prevail with midwinter temperatures averaging 3.0°C (37.4°F) but reaching -33°C (-27.4°F). The effective growing season is approximately 200 days. Generally, the area is wet from April to June; May averages 15.6 cm (6.2 in) of rain. Rainfall in January is 4.9 cm (1.9 in). The precipitation/evaporation ratio is relatively high (0.70), using pan evaporation.

The postmining land use on the Cloud Mine Site will be fish and wildlife habitat. Emphasis will be placed on restoring the original forest types, prairie, and marsh. In this respect, the reclamation and revegetation activities will be planned to stabilize the site and encourage return to the premine cover. Several practices will be utilized to enhance the area for wildlife.

4.2.1 Soil Preparation

a. Grading and shaping. During the area mining operation, the mined area will be backfilled to approximately the original contour, as shown in Figure 4.2-4. Contemporaneous reclamation will be instituted in order to provide protection to exposed soils on the site. The backfilling will be done in 1.2 m (4-ft) lifts to insure the necessary stability and compaction, and the grading will be done to allow for natural drainage patterns. A diversion ditch will be located next to the vegetation buffer zone (on the north and east sides) to provide additional protection to Willow Creek from sediment runoff. The ditch will terminate in a sediment pond located in the southeast corner of the permit area. Due to the readily available supply of water for wildlife in Willow Creek, the sediment pond will not be retained on the site, but rather will be cleaned out and graded over during final shaping. Dozers and graders will perform the grading and shaping for this operation.

b. Soil amendments. Because of the nature of the subsoils in the area (i.e., mildly acidic), lime will be added to the mixed overburden to bring the spoil to a pH of 5.5 or higher. This will be done to reduce the acidification of the resulting topsoil layer from the thin, but evident, pyrite layer overlying the coal seam. Hydrated lime will be applied with a hydroseeder and disced into place. The lime will be mixed with the surface soils to a depth of at least 15 cm (6 in), at a rate of 8,970 kg/hectare (4 tons/acre).

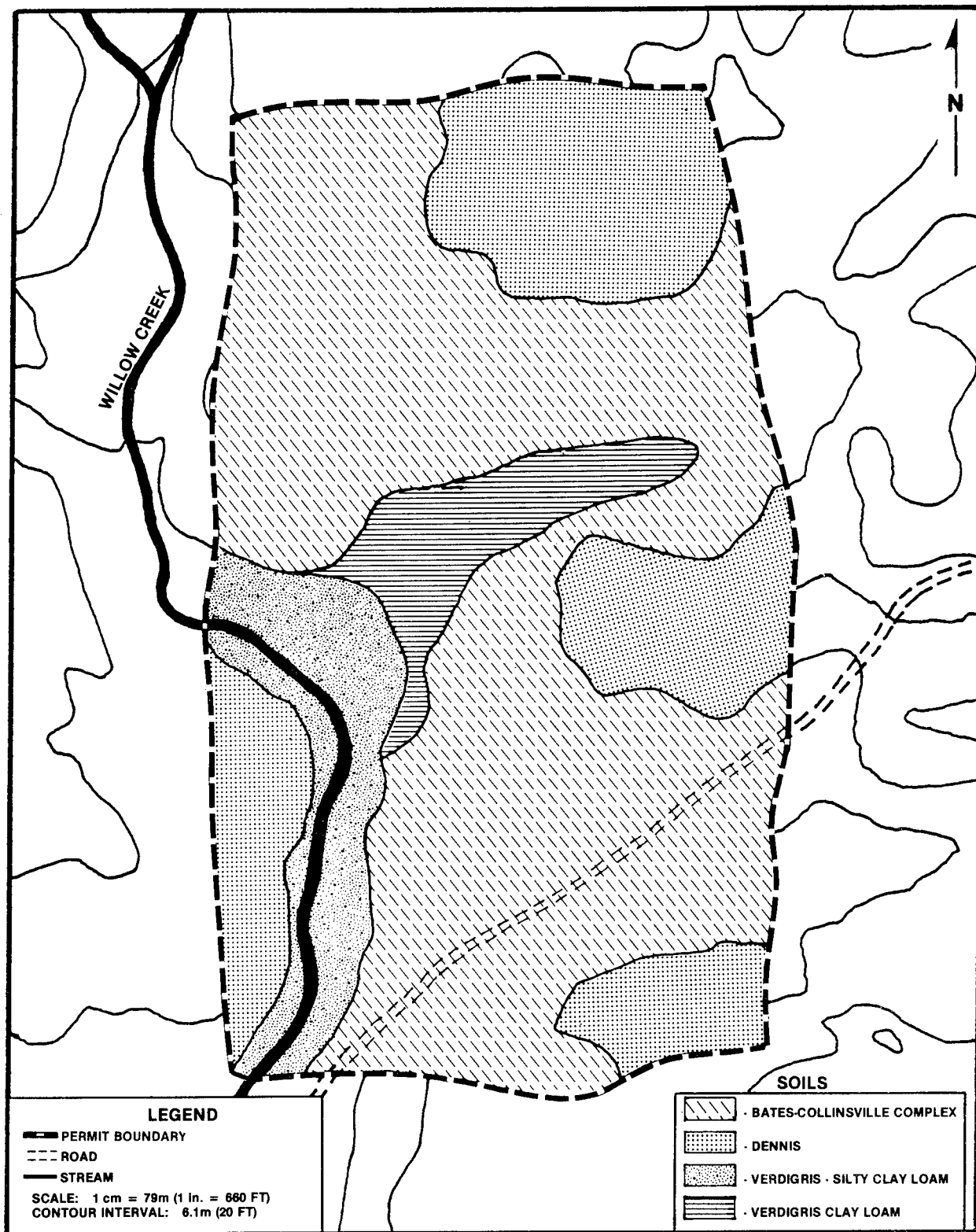


Figure 4.2-3. Soils on the Cloud Mine permit area.

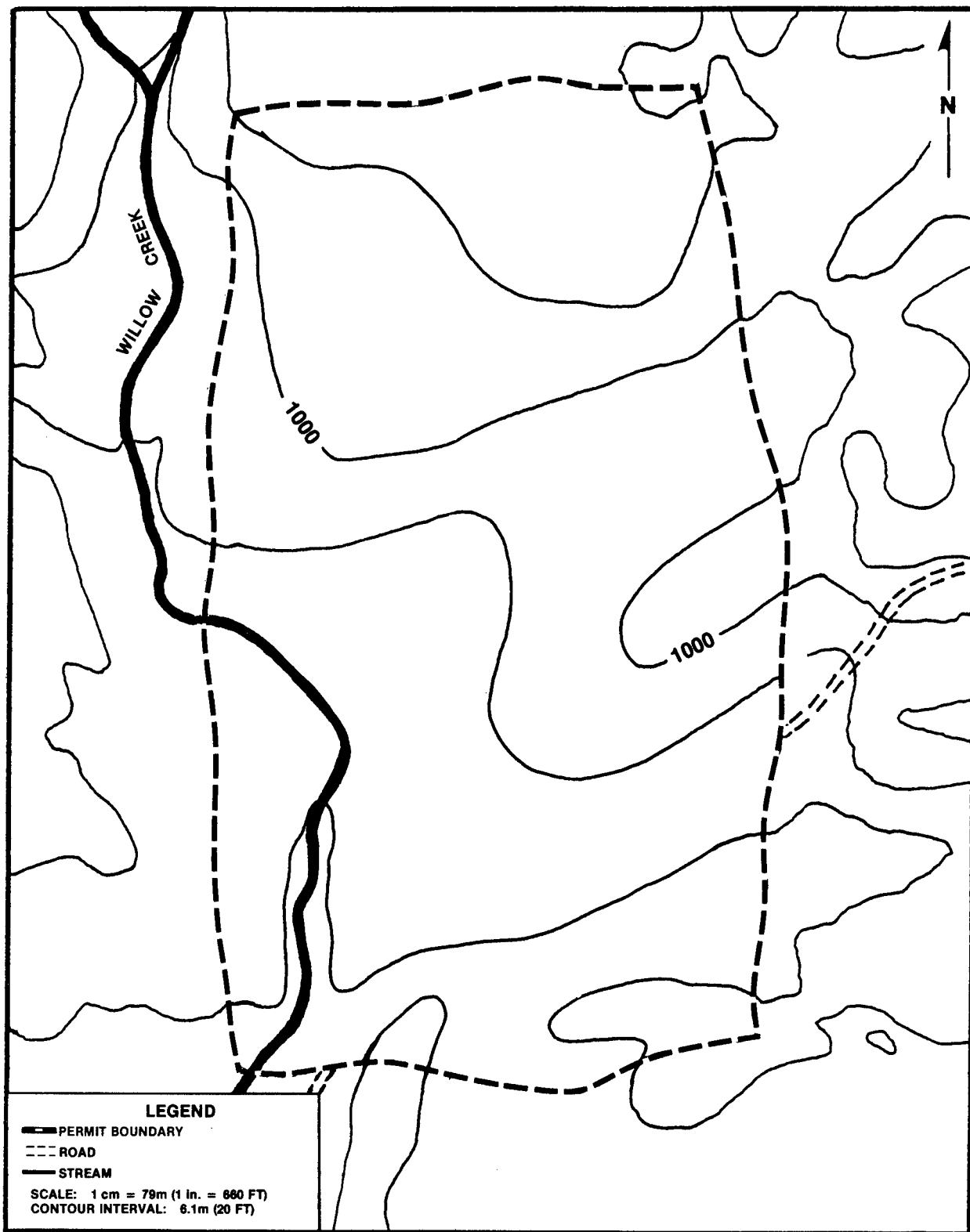


Figure 4.2-4. Recontoured topography of the mine site and adjacent areas.

The following rates of fertilizer application will be used: nitrogen [67 kg/hectare (60 lbs/acre)]; phosphorous [67 kg/hectare (60 lbs/acre)]; and potassium [67 kg/hectare (60 lbs/acre)]. A standard fertilizer mix of 12-12-12 will be used at a rate of 560 kg/hectare (500 lbs/acre). Application will be by hydroseeder, spread with the seed mixture soon after grading and liming.

Mulching

Mulching will be performed to hold soil moisture, which could potentially be low during the early regrowth period. Small grain straw will be applied with an Estes Spreader at a rate of 3,360 kg of straw per hectare (1.5 tons of straw per acre). Following the mulch application, the surface will be crimped with a light tractor to minimize mulch blow-away by the wind.

4.2.2 Reclamation Plantings

a. Revegetation. The reclamation plan for the Cloud Mine site includes the revegetation plan shown in Figure 4.2-5. Table 4.2-1 summarizes the proposed planting scheme.

Area 1 will be mechanically seeded in April prior to the spring rains. The grass species are used to stabilize the site, which will be planted in tree species one year later. Tree species will be planted in alternating double rows using a mechanical planter and spaced as shown in Table 4.2-1.

The bottomland forest will be restored in Area 2. The site will first be stabilized by permanent grass cover; the trees will be planted a year later. Trees will be mechanically planted in alternating rows by species and spaced as shown in Table 4.2-1. The marshy area (Area 3) adjacent to the bottomland forest will be restored and seeded with appropriate species. Wildlife habitat will be enhanced by scattered plantings of buttonbush and indigobush. These shrubs will be planted randomly by hand over the area.

Areas 3a, 4a, and 6 were left undisturbed during mining to protect Willow Creek. Area 4a is native prairie, Area 3a is natural wetland marsh, and Area 6 is a buffer zone of bottomland hardwood forest. Wildlife habitat was enhanced during mining by planting a double row of shrubs between Areas 3a and 4a. Shrubs will be spaced as shown in Table 4.2-1.

Most of the acreage in the permit area will be reseeded to grasses (Area 4). Species that are native to the prairie will be used as a basis for returning it to native prairie cover. Throughout Area 4, food plots (Area 5), containing several species useful to wildlife, will be placed in a regular manner. Food plots will be mechanically sown as will all of Area 4. Eight rectangular plots of approximately 0.8 ha (2.0 ac) will be used.

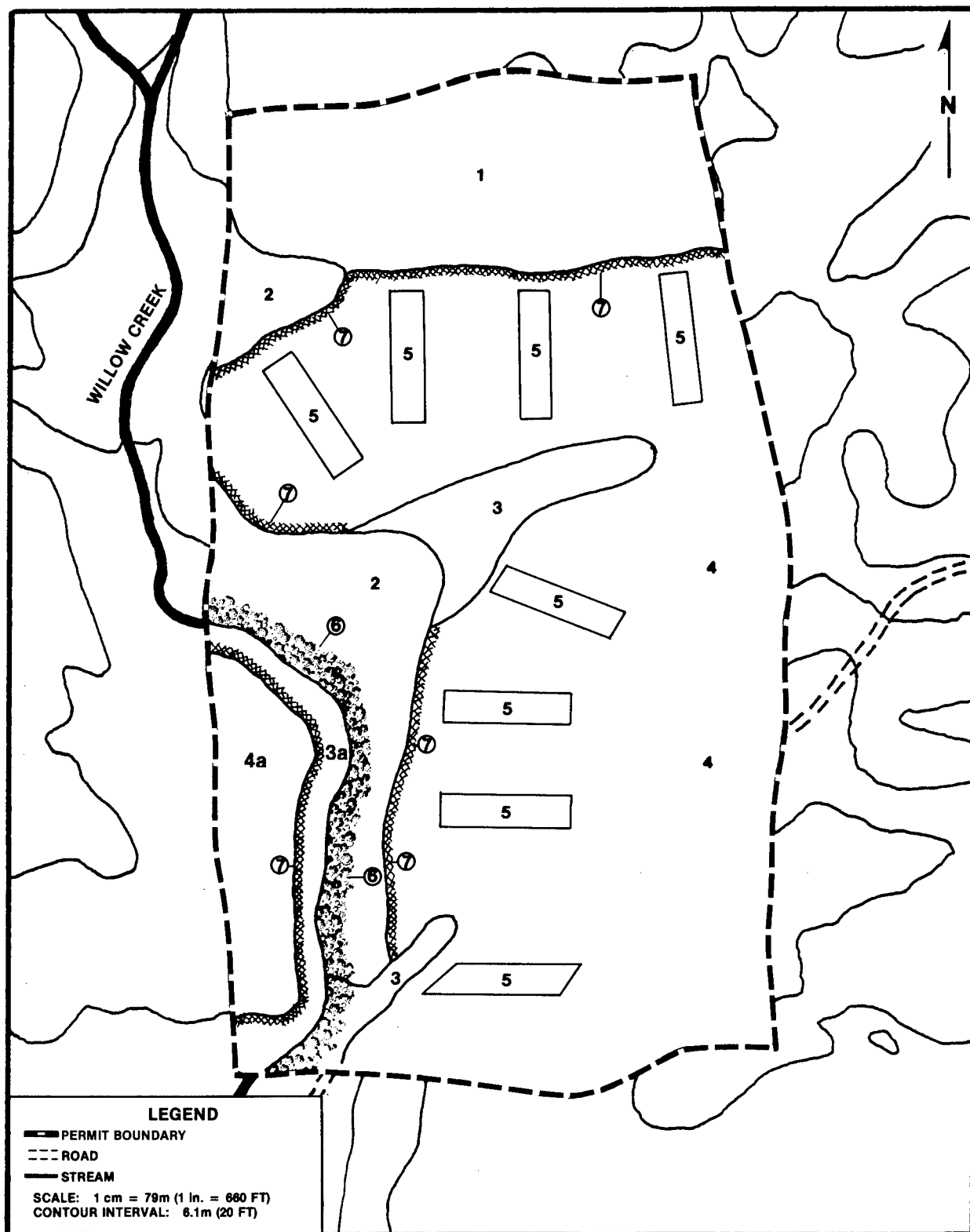


Figure 4.2-5. Revegetation scheme of the Cloud Mine site.
(See text for explanation of numbered areas.)

Table 4.2-1. Key to proposed plantings on the Cloud Mine site shown in Figure 4.2-5.

Area	Size	Planting ^a	Rate ^b
1	16.2 ha (40 ac)	Herbaceous: Tall fescue Bluestem mixture Red clover Trees: Shortleaf pine Black locust Bur oak Red oak	22.4 kg/ha (20 lbs/ac) 7.9 kg/ha (7 lbs/ac) 5.6 kg/ha (5 lbs/ac) 1.8 m x 3.1 m (6 ft x 10 ft) Rows 2.4 m x 3.1 m (8 ft x 10 ft) Rows 2.4 m x 3.1 m (8 ft x 10 ft) Rows 2.4 m x 3.1 m (8 ft x 10 ft) Rows
2	11.3 ha (27.9 ac)	Herbaceous: Bluestem mixture Red clover Trees: American elm Cottonwood Hackberry Shumard's Oak Sycamore Green ash	7.9 kg/ha (7 lbs/ac) 5.6 kg/ha (5 lbs/ac) 2.4 m x 3.1 m (8 ft x 10 ft) Rows 2.4 m x 3.1 m (8 ft x 10 ft) Rows 2.4 m x 3.1 m (8 ft x 10 ft) Rows 2.4 m x 3.1 m (8 ft x 10 ft) Rows 2.4 m x 3.1 m (8 ft x 10 ft) Rows 2.4 m x 3.1 m (8 ft x 10 ft) Rows
3a	3.1 ha (7.8 ac)	Marsh area left undisturbed during mining	
3	3.8 ha (9.3 ac)	Herbaceous: Sedges Smartweed Rushes Shrubs: Buttonbush Indigobush	5.6 kg/ha (5 lbs/ac) 5.6 kg/ha (5 lbs/ac) 5.6 kg/ha (5 lbs/ac) 988 per ha (400 per ac) 988 per ha (400 per ac)
4a	5.6 ha (13.9 ac)	Native prairie left undisturbed during mining	

Table 4.2-1. (concluded)

Area	Size	Planting ^a	Rate ^b
4	54.9 ha (135.6 ac)	Herbaceous: Big bluestem Little bluestem Indiangrass Tall fescue Red clover Sweetclover	 11.2 kg/ha (10 lbs/ac) 11.2 kg/ha (10 lbs/ac) 11.2 kg/ha (10 lbs/ac) 22.4 kg/ha (20 lbs/ac) 5.6 kg/ha (5 lbs/ac) 16.8 kg/ha (15 lbs/ac)
5	6.7 ha (16.5 ac)	Herbaceous: Indiangrass Bluestem mixture Bush sunflower Maximilian sunflower Engelmann daisy Partridge pea Singletary pea Vetch	 10.1 kg/ha (9 lbs/ac) 7.6 kg/ha (6.8 lbs/ac) 11.2 kg/ha (10 lbs/ac) 17.9 kg/ha (16 lbs/ac) 1.1 kg/ha (1 lb/ac) 22.4 kg/ha (20 lbs/ac) 28.0 kg/ha (25 lbs/ac) 11.2 kg/ha (10 lbs/ac)
6	3.3 ha (8.3 ac)	Native bottomland forest left undisturbed during mining	
7	4.7 ha (11.6 ac)	Shrubs: Autumn olive Fragrant sumac Russian olive	 1.2 m x 1.8 m (4 ft x 6 ft) Rows .3 m x 1.2 m (1 ft x 4 ft) Rows 1.2 m x 1.8 m (4 ft x 6 ft) Rows

^aSpecies mixes were adapted from Schnell et al. (1981) and Dickson and Vance (1981).

^bRates for herbaceous species are bulk rates.

As shown in Figure 4.2-5, borders between Areas 1 and 4 and Areas 2 and 4 will be planted with shrubs. This edge between habitat types will consist of double rows of shrubs. Autumn olive, Russian olive, and fragrant sumac will be alternated in 30.5 m (100 ft) long sections and spaced as indicated in Table 4.2-1.

4.2.3 Additional Enhancement for Wildlife

a. Brushpiles and rock piles. Brush which had been stockpiled during the clearing operation for the mine will be trucked to regraded areas and placed in piles approximately 1.5 m (5 ft) high and 3.1 m (10 ft) in diameter. No more than 3 piles per hectare (one pile per acre) will be created. The piles will contain a variety of woody material varying from logs not more than 20 cm (8 in) in diameter to small saplings and debris cuttings. It is expected that these piles will provide cover for small wildlife, both game and nongame species (Gutiérrez et al. 1979). Rock piles will also be formed from rock gathered after the final grading. These piles will be no more than 1 m (3 ft) high and 2 m (6 ft) in diameter. Approximately 3 piles per hectare (one pile per acre) will be created.

b. Nest boxes. Ten bluebird boxes will be erected on the area, placed no closer than 30.5 m (100 ft) apart to reduce bluebird territorial competition. The dimensions of the boxes will also be specifically designed for bluebirds to keep other more aggressive and undesirable birds (i.e., starlings) from occupying the box. Boxes will be checked periodically through the bonding period to determine if repairs are needed.

One raptor nesting tripod will be placed on the area in a location which will be revegetated with native prairie grasses. Due to the isolation of the reclaimed mine site from populated areas, it is anticipated that a raptor nesting tripod could be utilized successfully on the area through several nestings by either hawks or golden eagles (Grubb 1980).

c. Access restriction. Access to the reclamation site will be prohibited to encourage reclamation growth and wildlife protection. Locked gates will be erected at access points off the main roads to the site and signs posted as follows: Cloud Mine; Private Property; Access by Permission Only; Inquire T. Cloud, 1814 Waycross Road, Coal City, Texas.

SOURCES OF INFORMATION

References cited:

Bailey, R. G. Ecoregions of the United States. Washington, D.C.: USDA Forest Service in cooperation with the U.S. Fish and Wildlife Service; 1978.

- Dickson, K. L.; Vance, D. Revegetating surface mined lands for wildlife in Texas and Oklahoma. FWS/OBS-81/25. Kearneysville, WV: U.S. Fish and Wildlife Service; 1981.
- Duck, L. G.; Fletcher, J. B. A game map of Oklahoma. Oklahoma City, OK: Dept. of Wildlife Conservation, Division of Wildlife Conservation; 1943.
- Gould, F. W. Texas plants: a checklist and ecological summary. College Station, TX: Texas Agr. Expt. Station, Texas A&M Univ.; 1975.
- Grubb, T. G. An artificial bald eagle nest. Ft. Collins, CO: USDA Forest Service. Rocky Mountain Forest and Range Experiment Station. Research Note RM-383; March 1980.
- Gutierrez, R. J.; Decker, D. J.; Howard, R. A., Jr.; Lassoie, J. P. Managing small woodlands for wildlife. Extension Services Info. Bull 157. Ithaca, New York: New York State College of Agriculture and Life Sciences at Cornell University; 1979.
- Schnell, G. D.; Johnson, F. L.; Risser, P. G. Model fish and wildlife plan for a surface coal mine in Oklahoma. Oklahoma City, OK: Oklahoma Dept. of Mines in cooperation with Office of Surface Mining - Region IV; 1981.
- U.S. Department of Agriculture. Soil survey, Craig County, Oklahoma. Washington, D.C.: U.S. Government Printing Office; 1973.

APPENDIX A
CONSULTATION AND COORDINATION DIRECTORY

ARKANSAS

State Agencies

Surface Mining Regulatory Authority

Surface Mining and Reclamation Section
Department of Pollution Control and Ecology
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Fish and Wildlife

Game and Fish Commission
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Heritage and Conservation Service
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Forestry

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ARKANSAS

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TEXAS

Federal Agencies

Department of Agriculture

U.S. Forest Service
Region 8, Southern Region
Suite 800
1720 Peachtree Road, N.W.
Atlanta, GA 30367
(404) 881-4191

U.S. Soil Conservation Service
101 South Main Street
P.O. Box 648
Temple, TX 76503
(817) 774-1214

Plant Materials Center
Route 1, Box 155
Knox City, TX 79529
(817) 658-3922

Regional Biologist
South Technical Service Center
U.S. Soil Conservation Service
P.O. Box 6567
Fort Worth, TX 76115
(817) 334-5282

Regional Plant Materials Specialist
U.S. Soil Conservation Service, Southern Region
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Department of the Army

U.S. Army Corps of Engineers
Ft. Worth District
P.O. Box 17300
Ft. Worth, TX 76102
(817) 334-2150

U.S. Army Corps of Engineers
Galveston District
P.O. Box 1229
Galveston, TX 77550
(713) 766-3899

TEXAS

Department of the Interior

Office of Surface Mining
Reclamation and Enforcement, Region IV
5th Floor
Scarritt Building
818 Grand Avenue
Kansas City, MO 64106
(816) 374-2618

U.S. Bureau of Land Management
New Mexico State Office
P.O. Box 1449
Santa Fe, NM 87501
(505) 988-6227

U.S. Fish and Wildlife Service
Southwest Region
Dennis Chaves Building
U.S. Court House
500 Gold Avenue, S.W.
Albuquerque, NM 87103
(505) 766-2321

Office of Endangered Species
U.S. Fish and Wildlife Service
Southwest Region
P.O. Box 1306
Albuquerque, NM 87103
(505) 766-3972

Coal Coordinator
U.S. Fish and Wildlife Service
819 Taylor Street, Room 9A33
Fort Worth, TX 76102
(817) 334-2961

U.S. Bureau of Reclamation
Southwest Region
714 South Tyler, Suite 201
Amarillo, TX 79101
(806) 378-5400

U.S. Bureau of Mines
Department of the Interior
2401 E. St. NW
Washington, DC 20241
(202) 634-1004

APPENDIX B

B.1 LIST OF COMMON AND SCIENTIFIC NAMES OF PLANT SPECIES REFERENCED IN THE TEXT (ARRANGED ALPHABETICALLY BY COMMON NAME).

Common Name	Latin Name
<u>Trees - Conifers</u>	
Douglas-fir	<u>Pseudotsuga menziesii</u> (Mirb.) Franco var. <u>menziesii</u>
Hemlock	<u>Tsuga canadensis</u> (L.) Carr.
Loblolly pine	<u>Pinus taeda</u> L.
Shortleaf pine	<u>Pinus echinata</u> Miller
Spruce	<u>Picea</u> spp.
Virginia pine	<u>Pinus virginiana</u> Miller
<u>Trees - Hardwoods</u>	
American elm	<u>Ulmus americana</u> L.
Black hickory	<u>Carya texana</u> Buckl.
Black locust	<u>Robinia pseudo-acacia</u> L.
Black oak	<u>Quercus velutina</u> Lam.
Black walnut	<u>Juglans nigra</u> L.
Blackjack oak	<u>Quercus marilandica</u> Muenehh.
Bur oak	<u>Quercus macrocarpa</u> Michx.
Bitternut hickory	<u>Carya cordiformis</u> (Wangenh.) K. Koch
Chinquapin oak	<u>Quercus muehlenbergii</u> Engelm.
Cottonwood	<u>Populus</u> spp.
Green ash	<u>Fraxinus pennsylvanica</u> Marshall
Hackberry	<u>Celtis occidentalis</u> L.
Mockernut hickory	<u>Carya tomentosa</u> Nutt.
Persimmon	<u>Diospyros virginiana</u> L.
Post oak	<u>Quercus stellata</u> Wang.
Red oak	<u>Quercus</u> spp.
Shumard's oak	<u>Quercus shumardii</u> Buckle.
Sugar maple	<u>Acer saccharum</u> Marsh.
Sycamore	<u>Platanus occidentalis</u> L.
White oak	<u>Quercus alba</u> L.
Willow	<u>Salix</u> spp.
Winged elm	<u>Ulmus alata</u> Michx.

B.1 (Continued)

Common Name	Latin Name
<u>Shrubs - Vines</u>	
Autumn olive	<u>Elaeagnus umbellata</u> Thumb.
Bristly locust	<u>Robinia fertilis</u> Ashe
Buttonbush	<u>Cephalanthus occidentalis</u> L.
Coral berry	<u>Symphoricarpos orbiculatus</u> Moench
Elderberry	<u>Sambucus canadensis</u> L.
Fragrant sumac	<u>Rhus aromatica</u> Ait.
Grapes	<u>Vitis</u> spp.
Indigobush	<u>Amorpha fruticosa</u> L.
Plum	<u>Prunus</u> spp.
Poison ivy	<u>Rhus radicans</u> L.
Rough-leaf dogwood	<u>Cornus drummondii</u> C. A. May
Russian olive	<u>Elaeagnus angustifolia</u> L.
Sumac	<u>Rhus</u> spp.
<u>Herbs - Leguminous Forbs</u>	
Arrowleaf clover	<u>Trifolium vesiculosum</u>
Common lespedeza	<u>Lespedeza striata</u> Thumb. ex J. Man
Cowpea	<u>Vigna unguiculata</u> (L.) Walp.
Crimson clover	<u>Trifolium incarnatum</u> L.
Crownvetch	<u>Coronilla varia</u> L.
False wild indigo	<u>Baptisia tinctoria</u> (L.) R. Br.
Partridge pea	<u>Cassia fasciculata</u> Michx.
Pea (wild)	<u>Lathyrus hirsutus</u> L.
Red clover	<u>Trifolium pratense</u> L.
Sericea lespedeza	<u>Lespedeza cuneata</u> (Dumont) G. Don
Sesbania	<u>Sesbania exaltata</u> (Raf.) Cory.
Soybean	<u>Glycine max</u> (L.) Merrill
Sweet clover	<u>Melilotus</u> spp.
Vetch	<u>Vicia</u> spp.
White clover	<u>Trifolium repens</u> L.
<u>Herbs - Nonleguminous Forbs</u>	
Buckwheat	<u>Fagopyrum</u> spp.
Bulrush	<u>Scirpus</u> spp.
Bush sunflower	<u>Simsia calva</u> Engelm. and Gray
Cattail	<u>Typha</u> spp.
Coontail	<u>Ceratophyllum demersum</u>
Croton	<u>Croton</u> spp.
Duckweed	<u>Lemna</u> spp.
Engelmann daisy	<u>Engelmannia pinnatifida</u> Nutt.
Maximilian sunflower	<u>Helianthus maximiliani</u>

B.1 (Continued)

Common Name	Latin Name
Pondweed	<u>Potamogeton</u> spp.
Ragweed	<u>Ambrosia</u> spp.
Rush	<u>Juncus</u> spp.
Sedge	<u>Carex</u> spp.
Smartweed	<u>Polygonum pensylvanicum</u> L.
Spike rush	<u>Eleocharis</u> spp.
Spurge	<u>Euphorbia</u> spp.
Sunflower	<u>Helianthus annuus</u> L.
Waterlily	<u>Nymphaea</u> spp.
Water-shield	<u>Brasenia schreberi</u> Gmel.
Wild celery	<u>Vallisneria americana</u> Michx.
Wooly croton	<u>Croton capitatus</u> Michx.
<u>Grasses</u>	
Alakli sacaton	<u>Sporobolus airoides</u>
Bahiagrass	<u>Paspalum notatum</u> Flugge
Bluestem, big	<u>Andropogon gerardii</u> Vitm.
Bluestem, little	<u>Andropogon scoparius</u> L.
Broomsedge	<u>Andropogon</u> spp.
Buffalograss	<u>Buchloe dactyloides</u> Nutt. Engelm.
Corn	<u>Zea mays</u> L.
Dallisgrass	<u>Paspalum dilatatum</u> Poir
Field brome grass	<u>Bromus japonicus</u> Thunberg.
Foxtail (German) millet	<u>Setaria italica</u> (L.) Beauvois
Grain sorghum	<u>Sorghum bicolor</u> (L.) Moench
Green sprangletop	<u>Leptochloa dubia</u> (H.B.K.) Nees
Indiangrass	<u>Sorghastrum nutans</u> (L.) Nash.
Japanese millet	<u>Echinochloa crusgalli</u> (L.) Beauv
Kafir	<u>Sorghum vulgare</u> var. <u>caffrorum</u> (Retz.) Hubb. and Rehder
Kleberg bluestem	<u>Andropogon</u> sp.
Kleingrass	<u>Panicum coloratum</u> L.
Lehmann lovegrass	<u>Eragrostis lehmanniana</u> Nees.
Millet	<u>Panicum</u> spp.
Oats	<u>Avena sativa</u> (L.) Thell.
Plains bristlegrass	<u>Setaria leucophila</u> Scribn. and Merr.
Proso millet	<u>Panicum miliaceum</u> L.
Rice	<u>Oryza sativa</u> L.
Ryegrass	<u>Lolium perenne</u> L.
Sideoats grama	<u>Bouteloua curtipendula</u> Michx.
Smooth brome grass	<u>Bromus</u> sp.
Sudangrass	<u>Sorghum sudanense</u> (Piper) Staph.
Switchgrass	<u>Panicum virgatum</u> L.

B.1 (Concluded)

Common Name	Latin Name
Tall dropseed	<u>Sporobolus</u> sp.
Tall fescue ('K-31')	<u>Festuca arundinacea</u> (Sreb.)
Trichloris	<u>Trichloris</u> sp.
Vine-mesquite	<u>Panicum obtusum</u> H.S.K.
Weeping lovegrass	<u>Eragrostis curvula</u> (Shrad.) Neew
Wheat	<u>Triticum</u> spp.
Widgeongrass	<u>Ruppia occidentalis</u> S. Wats.
Wild rye	<u>Elymus</u> spp.
Witchgrass	<u>Panicum capillare</u> L.

B.2 LIST OF COMMON AND SCIENTIFIC NAMES OF ANIMAL SPECIES
REFERENCED IN THE TEXT (ARRANGED ALPHABETICALLY BY
COMMON NAME).

Common Name	Latin Name
<u>Birds</u>	
American coot	<u>Fulica americana</u>
Bald eagle	<u>Haliaeetus leucocephalus</u>
Barn owl	<u>Tyto alba</u>
Blue-gray gnatcatcher	<u>Polioptila caerulea</u>
Blue jay	<u>Cyanocitta cristata</u>
Blue-winged teal	<u>Anas discors</u>
Bobwhite quail	<u>Colinus virginianus</u>
Brown-headed cowbird	<u>Molothrus ater</u>
Canvasback	<u>Athya valisineria</u>
Cardinal	<u>Cardinalis cardinalis</u>
Carolina chickadee	<u>Parus carolinensis</u>
Carolina wren	<u>Thryothorus ludovicianus</u>
Canada goose	<u>Branta canadensis</u>
Common crow (American)	<u>Corvus brachyrhynchos</u>
Common yellowthroat	<u>Geothlypis trichas</u>
Crested flycatcher (Great)	<u>Myiarchus crinitus</u>
Downy woodpecker	<u>Picoides pubescens</u>
Eastern bluebird	<u>Sialia sialis</u>
Golden eagle	<u>Aquila chrysaetos</u>
Green-winged teal	<u>Anas crecca</u>
House sparrow	<u>Passer domesticus</u>
House wren	<u>Troglodytes aedon</u>
Kestrel (American)	<u>Falco sparverius</u>
Killdeer	<u>Charadrius vociferous</u>
Kingfisher (Belted)	<u>Megaceryle alcyon</u>
Lesser scaup	<u>Athya affinis</u>
Mallard	<u>Anas platyrhynchos</u>
Meadowlark (Eastern)	<u>Sturnella magna</u>
Mockingbird (Northern)	<u>Mimus polyglottos</u>
Mourning dove	<u>Zenaida macroura</u>
Pheasant (Ring-necked)	<u>Phasianus colchicus</u>
Pied-billed grebe	<u>Podilymbus podiceps</u>
Pintail (Common)	<u>Anas acuta</u>
Purple martin	<u>Progne subis</u>
Red-bellied woodpecker	<u>Melanerpes carolinus</u>
Redhead	<u>Athya americana</u>
Red-headed woodpecker	<u>Melanerpes erythrocephalus</u>
Red-tailed hawk	<u>Buteo jamaicensis</u>
Red-winged blackbird	<u>Agelaius phoeniceus</u>
Ring-necked duck	<u>Athya collaris</u>
Ruffed grouse	<u>Benasa umbellus</u>

B.2 (Concluded)

Common Name	Latin Name
Screech owl (Common)	<u>Otus asio</u>
Shoveler (Northern)	<u>Anas clypeata</u>
Starling (European)	<u>Sturnus vulgaris</u>
Thrasher (Brown)	<u>Toxostoma rufum</u>
Towhee (Rufous-sided)	<u>Pipilo erythrophthalmus</u>
Tree swallow	<u>Iridoprocne bicolor</u>
Tufted titmouse	<u>Parus bicolor</u>
White-breasted nuthatch	<u>Sitta carolinensis</u>
Wild turkey	<u>Meleagris gallopavo</u>
Woodcock (American)	<u>Philohela minor</u>
Wood duck	<u>Aix sponsa</u>
Yellow-billed cuckoo	<u>Coccyzus americanus</u>
Yellow-bellied sapsucker	<u>Sphyrapicus varius</u>
Yellow-shafted flicker (Common)	<u>Colaptes auratus</u>
<u>Fish</u>	
Bluegill	<u>Lepomis macrochirus</u>
Catfish (bullhead)	<u>Ictalurus spp.</u>
Catfish (channel)	<u>Ictalurus punctatus</u>
Crappie	<u>Pomoxis spp.</u>
Israeli carp	<u>Cyprinus sp.</u>
Largemouth bass	<u>Micropterus salmoides</u>
Redear sunfish	<u>Lepomis microlophus</u>
<u>Mammals</u>	
Beaver	<u>Castor canadensis</u>
Bobcat	<u>Lynx rufus</u>
Coyote	<u>Canis latrans</u>
Deer mouse	<u>Peromyscus maniculatus</u>
Eastern woodrat	<u>Neotoma floridana</u>
Fox squirrel (eastern)	<u>Sciurus niger</u>
Gray fox	<u>Urocyon cinereoargenteus</u>
Gray squirrel (eastern)	<u>Sciurus carolinensis</u>
Mink	<u>Mustela vison</u>
Mule deer	<u>Odocoileus hemionus</u>
Muskrat	<u>Ondatra zibethica</u>
Opposum	<u>Didelphis marsupialis</u>
Rabbit (cottontail)	<u>Sylvilagus floridanus</u>
Raccoon	<u>Procyon lotor</u>
Red fox	<u>Vulpes fulva</u>
Skunk (striped)	<u>Mephitis mephitis</u>
White-tailed deer	<u>Odocoileus virginianus</u>
Woodchuck	<u>Marmota monax</u>

APPENDIX C

LIST OF PLANT SPECIES AND THEIR USES FOR WILDLIFE IN THE SOUTHCENTRAL U.S. REGION

Plant Name	Use ^a	
	Food	Cover
<u>Coniferous Trees:</u>		
Chinese arborvitae - <u>Thuja arborvitae</u>	2	1
Eastern red cedar - <u>Juniperus virginiana</u>	1	1
Loblolly pine - <u>Pinus taeda</u>	1	1
Shortleaf pine - <u>Pinus echinata</u>	1	1
Slash pine - <u>Pinus elliottii</u>	1	1
Virginia pine - <u>Pinus virginiana</u>	1	1
<u>Hardwood Trees:</u>		
American beech - <u>Fagus grandifolia</u>	2	2
American elm - <u>Ulmus americana</u>	2	2
Apricot - <u>Prunus armeniaca</u>	1	1
Black cherry - <u>Prunus serotina</u>	1	1
Black locust - <u>Robinia pseudoacacia</u>	3	1
Black walnut - <u>Juglans nigra</u>	1	2
Black willow - <u>Salix nigra</u>	4	1
Blackjack oak - <u>Quercus marilandica</u>	1	1
Boxelder - <u>Acer negundo</u>	3	2
Bur oak - <u>Quercus macrocarpa</u>	1	1
Cedar elm - <u>Ulmus crassifolia</u>	2	1
Chinese date, jujube - <u>Ziziphus jujuba</u>	1	1
Cottonwood - <u>Populus deltoides</u>	3	2
Crabapple - <u>Pyrus ioensis</u>	1	2
Green ash - <u>Fraxinus pennsylvanica</u>	2	2
Hackberry - <u>Celtis occidentalis</u>	1	2
Hickory - <u>Carya spp.</u>	1	2
Honey locust - <u>Gleditsia triacanthos</u>	2	2
Live oak - <u>Quercus virginiana</u>	1	1
Osage-orange, Bois d'Arc, horseapple - <u>Maclura pomifera</u>	3	1
Pecan - <u>Carya illinoensis</u>	1	2
Persimmon - <u>Diospyros virginiana</u>	1	2
Pin oak - <u>Quercus palustris</u>	1	1
Post oak - <u>Quercus stellata</u>	1	1

APPENDIX C (Continued)

Plant Name	Use ^a	
	Food	Cover
Red maple - <u>Acer rubrum</u>	3	3
Red mulberry - <u>Morus rubra</u>	1	2
Redbud - <u>Cercis canadensis</u>	2	2
River birch - <u>Betula nigra</u>	3	2
Sassafras - <u>Sassafras albidum</u>	1	1
Shumard oak - <u>Quercus shumardii</u>	1	1
Silver maple - <u>Acer saccharinum</u>	3	2
Southern red oak - <u>Quercus falcata</u>	1	1
Sugarberry - <u>Celtis laevigata</u>	1	2
Sweetgum - <u>Liquidambar styraciflua</u>	2	2
Sycamore - <u>Platanus occidentalis</u>	3	2
Water oak - <u>Quercus nigra</u>	1	1
Western soapberry - <u>Sapindus saponaria</u> var. <u>drummondii</u>	3	2
Willow oak - <u>Quercus phellos</u>	1	1
Yellow poplar, tulip tree - <u>Liriodendron tulipifera</u>	2	2
<u>Shrubs:</u>		
American beautyberry - <u>Callicarpa americana</u>	1	2
American holly - <u>Ilex opaca</u>	1	1
Amur privet - <u>Ligustrum amurense</u>	3	2
Arrow-wood - <u>Viburnum dentatum</u>	1	2
Autumn olive - <u>Elaeagnus umbellata</u>	1	1
Bayberry, waxmyrtle - <u>Myrica cerifera</u>	1	1
Bristly locust - <u>Robinia fertilis</u>	2	1
Buttonbush - <u>Cephalanthus occidentalis</u>	1	1
Carolina buckthorn - <u>Rhamnus caroliniana</u>	1	1
Cherry laurel - <u>Prunus caroliniana</u>	2	1
Coral berry, snowberry - <u>Symphoricarpos orbiculatus</u>	1	1
Elbowbush - <u>Forestiera pubescens</u>	2	1
Elderberry - <u>Sambucus canadensis</u>	1	1
Euonymus - <u>Euonymus bungeanus</u>	1	1
Flameleaf, shining sumac - <u>Rhus copallina</u>	1	1
Flowering dogwood - <u>Cornus florida</u>	1	1
Fourwing saltbush - <u>Atriplex canescens</u>	2	1
Hawthorn - <u>Crataegus</u> spp.	1	1
Indigobush - <u>Amorpha fruticosa</u>	1	1
Multiflora rose - <u>Rosa multiflora</u>	1	1
Pfitzer juniper - <u>Juniperus chinensis</u>	3	1
Possumhaw, deciduous holly - <u>Ilex decidua</u>	1	1
Pyracantha, firethorn - <u>Pyracantha angustifolia</u>	1	1
Rough-leaf dogwood - <u>Cornus drummondii</u>	1	1
Russian olive - <u>Elaeagnus angustifolia</u>	1	1
Serviceberry - <u>Amelanchier</u> spp.	1	1

APPENDIX C (Continued)

Plant Name	Use ^a	
	Food	Cover
Shrub lespedeza - <u>Lespedeza bicolor</u>	2	1
Silky dogwood - <u>Cornus amomum</u>	1	1
Skunkbush, fragrant sumac - <u>Rhus aromatica</u>	1	1
Texas kidneywood - <u>Eysenhardtia texana</u>	2	2
Wild cherry, chokecherry - <u>Prunus virginiana</u>	1	1
Wild plum - <u>Prunus americana</u>	1	1
Winterberry - <u>Ilex verticillata</u>	1	1
Yaupon - <u>Ilex vomitoria</u>	1	1
<u>Vines:</u>		
American bittersweet - <u>Celastrus scandens</u>	1	1
Carolina jessamine - <u>Gelsemium sempervirens</u>	2	1
Dewberry, blackberry - <u>Rubus</u> spp.	1	1
Japanese honeysuckle - <u>Lonicera japonica</u>	1	1
Matrimony vine - <u>Lycium halimifolium</u>	2	1
Peppervine - <u>Ampelopsis arborea</u>	1	3
Tatarian honeysuckle - <u>Lonicera tatarica</u>	1	1
Trumpet creeper - <u>Bignonia radicans</u>	2	1
Virginia creeper - <u>Parthenocissus quinquefolia</u>	1	1
Wild grape - <u>Vitis</u> spp.	1	1
<u>Leguminous Forbs:</u>		
Arrowleaf clover - <u>Trifolium vesiculosum</u>	2	2
Birdsfoot trefoil, deervetch - <u>Lotus corniculatus</u>	2	2
Bundleflower - <u>Desmanthus illinoensis</u>	2	2
Common lespedeza - <u>Lespedeza striata</u>	2	2
Crimson clover - <u>Trifolium incarnatum</u>	2	2
Crownvetch - <u>Coronilla varia</u>	2	3
Hairy vetch - <u>Vicia villosa</u>	3	2
Korean lespedeza - <u>Lespedeza stipulacea</u>	2	2
Partridge pea, prairie senna - <u>Cassia fasciculata</u>	1	3
Purple prairieclover - <u>Petalostemum purpureum</u>	3	2
Sericea lespedeza - <u>Lespedeza cuneata</u>	2	2
Sesbania - <u>Sesbania exaltata</u>	2	3
Sweetclover - <u>Melilotus</u> spp.	2	2
Trailing wildbean - <u>Strophostyles helvola</u>	1	2
White clover - <u>Trifolium repens</u>	2	3
Wild pea - <u>Lathyrus hirsutus</u>	2	1

APPENDIX C (Continued)

Plant Name	Use ^a	
	Food	Cover
<u>Non-Leguminous Forbs:</u>		
Bush sunflower - <u>Simsia calva</u>	2	1
Common sunflower - <u>Helianthus annuus</u>	1	1
Engelmann daisy - <u>Engelmannia pinnatifida</u>	2	3
Firewheel, Indian blanket - <u>Gaillardia pulchella</u>	2	3
Goldeneye - <u>Viguiera dentata</u>	2	3
Maximilian sunflower - <u>Helianthus maximiliani</u>	1	1
<u>Grasses:</u>		
Bahiagrass - <u>Paspalum notatum</u>	2	3
Bermuda grass - <u>Cynodon dactylon</u>	4	3
Big bluestem - <u>Andropogon gerardii</u>	3	2
Blue grama - <u>Bouteloua gracilis</u>	3	4
Buffalograss - <u>Buchloe dactyloides</u>	3	4
Buffelgrass - <u>Cenchrus ciliaris</u>	3	2
Dallisgrass - <u>Paspalum dilatatum</u>	2	3
Eastern gamagrass - <u>Tripsacum dactyloides</u>	3	3
Green sprangletop - <u>Leptochloa dubia</u>	3	3
Indiangrass - <u>Sorghastrum nutans</u>	2	2
Johnsongrass - <u>Sorghum halepense</u>	3	2
Kleingrass - <u>Panicum coloratum</u>	2	3
Little bluestem - <u>Andropogon scoparius</u>	3	2
Perennial ryegrass - <u>Lolium perenne</u>	3	3
Plains bristlegrass - <u>Setaria leucopila</u>	2	3
Rescuegrass, bromegrass - <u>Bromus unioloides</u>	2	3
Sand dropseed - <u>Sporobolus cryptandrus</u>	2	3
Sideoats grama - <u>Bouteloua curtipendula</u>	2	3
Switchgrass - <u>Panicum virgatum</u>	1	2
Tall fescue - <u>Festuca arundinacea</u>	3	2
Vine-mesquite - <u>Panicum obtusum</u>	2	2
Weeping lovegrass - <u>Eragrostis curvula</u>	3	2
<u>Marsh and Aquatic Plants:</u>		
Bulrush - <u>Scirpus spp.</u>	3	1
Cattail - <u>Typha spp.</u>	4	1
Common reed - <u>Phragmites communis</u>	4	1
Giant reed - <u>Arundo donax</u>	4	1
Japanese millet - <u>Echinochloa crusgalli</u>	1	2
Nutgrass, chufa - <u>Cyperus esculentus</u>	2	3
Pondweed - <u>Potamogeton spp.</u>	1	4
Prairie cordgrass - <u>Spartina pectinata</u>	4	1
Reed canarygrass - <u>Phalaris arundinacea</u>	3	2
Smartweed - <u>Polygonum pennsylvanicum</u>	1	1
Wild rice - <u>Zizania aquatica</u>	1	2

APPENDIX C (Concluded)

Plant Name	Use ^a	
	Food	Cover
<u>Cultivated Food and Cover Crops:</u>		
Alfalfa - <u>Medicago sativa</u>	2	2
Barley - <u>Hordeum vulgare</u>	1	2
Corn - <u>Zea mays</u>	1	2
Cowpeas - <u>Vigna unguiculata</u>	2	2
Millet - <u>Panicum</u> spp.	1	2
Milo, grain sorghum - <u>Sorghum vulgare</u>	1	2
Oats - <u>Avena sativa</u>	1	2
Rice - <u>Oryza sativa</u>	1	2
Sudangrass, forage sorghum - <u>Sorghum sudanense</u>	3	2
Wheat - <u>Triticum</u> spp.	1	3
Wildflowers and native plants	Variable	
Winter rye - <u>Secale cereale</u>	2	2

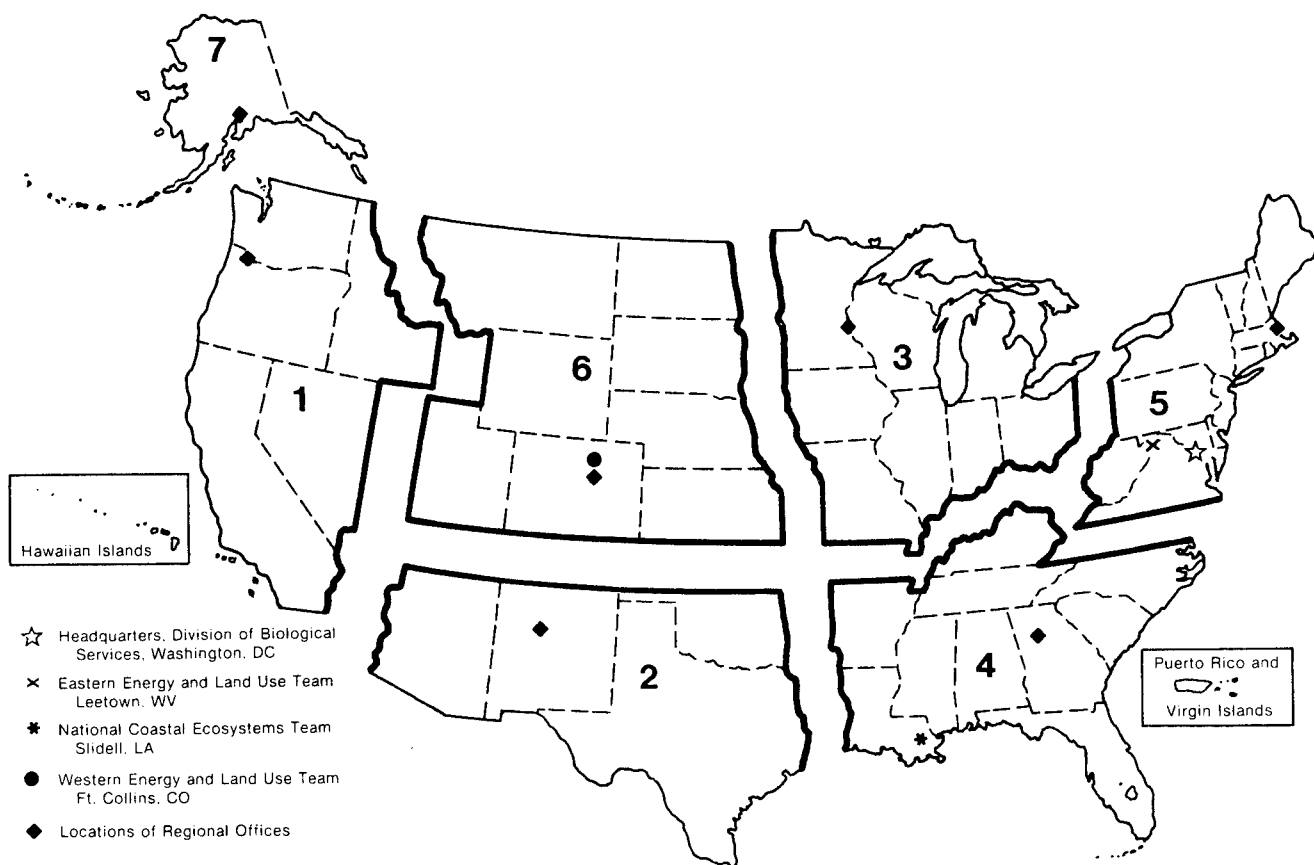
^aUsefulness rated as 1 = Excellent; 2 = Good; 3 = Fair; 4 = Limited (Dickson, K. L.; Vance, D. Revegetating surface mined lands for wildlife in Texas and Oklahoma. FWS/OBS-81/25. Kearneysville, WV: U.S. Fish and Wildlife Service; 1981).

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16. Abstract (Limit: 200 words) This handbook contains information on the best current practices to minimize disturbances and adverse impacts of surface mining on fish and wildlife resources. Current state and federal legislation was reviewed to determine those practices which were most compatible with the best technology currently available, fish and wildlife plans, and reclamation plans for the Southcentral region of the U.S. The information presented includes risks, limitations, approximate costs, and maintenance and management requirements of each practice. Plans for the restoration of specific habitats, according to the best current practices, are also included.				
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See Instructions on Reverse

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