8-1983

Practices for Protecting and Enhancing Fish and Wildlife on Coal Mined Land in the Uinta-Southwestern Utah Region

Bettina R. Proctor

Science Applications, Inc.

Richard W. Thompson

Jane E. Bunin

Kenneth W. Fucik

George R. Tamm

FWS/OBS-83/12
MARCH 1983

PRACTICES FOR PROTECTING AND ENHANCING FISH AND WILDLIFE ON COAL MINED LAND IN THE UINTA-SOUTHWESTERN UTAH REGION

Fish and Wildlife Service

In cooperation with
Bureau of Mines

U.S. Department of the Interior

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.

BEST DOCUMENT AVAILABLE

FWS/OBS-83/12
March 1983

PRACTICES FOR PROTECTING AND ENHANCING FISH AND WILDLIFE ON COAL MINED LAND IN THE UINTA-SOUTHWESTERN UTAH REGION

by

Bettina R. Proctor
Richard W. Thompson
Jane E. Bunin
Kenneth W. Fucik
George R. Tamm
Edward G. Wolf
Science Applications, Inc.
1726 Cole Boulevard, Suite 350
Golden, CO 80401

FWS 14-16-0009-80-075

Project Officer

Phillip L. Dittberner
Western Energy and Land Use Team
Drake Creekside Building One
2627 Redwing Road
Fort Collins, CO 80526

Performed for
Western Energy and Land Use Team
Division of Biological Services
Fish and Wildlife Service
U.S. Department of the Interior
Washington, DC 20240

DISCLAIMER

This report should be cited as:

Proctor, B. P., R. W. Thompson, J. E. Bunin, K. W. Fucik, G. R. Tamm, and E. G. Wolf. 1982. Practices for protecting and enhancing fish and wildlife on coal mined land in the Uinta-Southwestern Utah Region. U.S. Dept. Int., Fish Wildl. Serv. FWS/OBS-83/12. 250 pp.

PREFACE

This handbook contains information on the "Best Current Practices" to protect and enhance fish and wildlife resources on mined land in the Uinta-Southwestern Region of Colorado and Utah. 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, including risks and limitations, approximate cost, and maintenance and management requirements of each practice. Reclamation plans, which integrate the best current practices with the restoration of specific habitats in the region, are also included.

This work was supported by funding from the U.S. Bureau of Mines, Minerals Environmental Technology Program. Chief Project Officer was Tom Brady, Spokane Research Center.

The geographical area included in the handbook (Uinta-Southwestern Utah) is illustrated by the map below.

CONTENTS

CONTENTS (continued)

CONTENTS (concluded)

FIGURES

FIGURES (continued)

FIGURES (concluded)

TABLES

1. INTRODUCTION

Numerous techniques and methods are being used during surface mining 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 outdated or even detrimental. This handbook is written 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 will also consider equipment, devices, systems, and methods that have been 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 field techniques that have been successful, or that show definite promise of being successful, on surface-mined land. The Surface Mining Control and Reclamation Act of 1977 (SMCRA) (applicable to underground as well as surface mines) 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 States of Colorado and Utah, to which this handbook specifically applies, have similar doctrines addressing surface and underground mining. The BCP's presented in this handbook are being 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.

The major emphasis of this handbook is toward BCP's useful on surface-mined lands. However, some of the identified and discussed BCP's are also applicable to surface areas disturbed by underground mining activities. Areas disturbed by these activities may include portals; vent shaft exits; and maintenance, storage, and administrative areas.

IN ALL CASES, THE BCP'S IN THIS HANDBOOK, THAT 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 guides being 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 the points at which fish and wildlife resources can be protected and enhanced during the various phases of mine development and reclamation on a regional basis. Some of the techniques and practices are applicable to more than one geographic region; others are region-specific.

The handbook has been arranged to include a section on the planning needs for fish and wildlife resources during the mining process. Regional problems are identified, and the specific needs that individual sites would have are highlighted. Planning needs, such as baseline data gathering, site potential evaluation, fish and wildlife plan preparation, and reclamation planning are discussed.

BCP's for the protection and enhancement of fish and wildlife resources are presented in Section 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 relationship to postmining land uses and compatibility with other BCP's.

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

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.

Sources of Information: For further assistance, the following information has been provided: the company or agency who used or proposed the BCP; government contacts; and useful literature, such as books, articles, publications, and studies. Addresses and phone numbers of the referenced agencies are listed in Appendix A.

Finally, in Section 4, a regional reclamation plan is given for specific habitat types in the Uinta-Southwestern Utah Coal Region. Within a specific habitat type, 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. As a guide, they can offer ideas and suggestions to aid the operator with site-specific reclamation planning.

The BCP's described in this handbook were chosen because of their applicability to the Uinta-Southwestern Utah Coal Region. 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

Western coal mines often occur on a variety of parcels owned by Federal agencies (such as the U.S. Forest Service and the U.S. Bureau of Land Management), State lands, and privately owned lands. The lease for mineral rights may be obtained from one or all of these entities, depending on surface ownership.

Federal agencies require environmental studies prior to leasing and may exclude certain lands from leasing that are considered environmentally sensitive. Buffer zones may be required as part of the lease to protect a particularly sensitive area. No occupancy requirements may be imposed during certain seasons, for example, when sensitive bird species are nesting.

The operator, with leases secured, must obtain a permit to mine from the Federal Office of Surface Mining and the State regulatory authority. In most cases, disturbed areas are required to be returned to a condition capable of supporting the premining land use. In much of the Uinta-Southwestern Utah Coal Region, the land is used for livestock grazing; croplands are limited to irrigated river valleys. Wildlife needs must be considered in the restoration of both of these types of land use.

The mine permit application and the review process is another chance to evaluate sensitive wildlife areas and propose ways of mitigating impacts. This is a critical time for close contact between the landowner (assuming private ownership) and mineral lessor to cooperate and agree on postmining land use plans If the landowner, Federal or private, does not want sediment ponds or wetlands remaining on his land, they will probably be removed following the performance bond release and will not provide lasting wildlife value. Perhaps the landowner will have suggestions for reclamation projects, such as shelter belts, which will improve the land for both livestock and wildlife. Both the mine operator and landowner can benefit from a mutually agreed-upon plan. The landowner can benefit from the recreational aspects of wildlife on his land, while the operator will profit from favorable public relations

stemming 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.

A significant portion of the coal and/or surface land in this region is Federally owned. Where this is the case, the BLM and Forest Service will negotiate the mitigation measures to be employed. The State regulatory authority, guided by the State game and fish department and the U.S. Fish and Wildlife Service, will also have considerable input.

Ultimately, the question arises as to how much additional cost, if any, would be associated with providing protection and enhancement to fish and wildlife. Efforts were made to answer this question; however, costs will vary with the site-specific characteristics of a particular mine. With this knowledge, the operator should then seek the advice of the local surface mining regulatory authority, fish and wildlife agencies, and U.S. Soil Conservation Service officials, who can help "fine-tune" site-specific cost information. In most cases, overall costs will be minimal, and, as mentioned earlier, may actually save money. The final cost, however, will depend on the combination of techniques the operator and landowner wish to use to satisfy the postmining 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 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 or if they are unavailable, no amount of effort can achieve the desired enhancement objective. For example, pronghorn distribution is restricted by late summer water availability on many ranges. In Wyoming's Red Desert, 95% of 12,465 pronghorn observed were sighted within a 4.8- to 6.4-km (3- to 4-mi) radius of a water source (Sundstrom 1968). Adjacent, suitable areas lacking water sources received low utilization. Utilization of these adjacent ranges could be greatly improved if water sources (the deficient habitat requirement) were more evenly distributed (in this case, every 4 to 5 km [2.5 to 3.1 mi]), or if supplementary wells were provided.

Not all animals have the same habitat requirements. In fact, even closely related species may have important differences in habitat needs. These differences will ultimately determine the success or failure of the reclamation plan. General discussions on the habitat requirements of selected species in the Uinta-Southwestern Utah Coal Region follow.

More detailed descriptions of habitat requirements of many of these species are available in the Habitat Suitability Index (HSI) models. For more information about the HSI models and their availability, contact:

Habitat Evaluation Procedures Group
U.S. Fish and Wildlife Service
2627 Redwing Road
Ft. Collins, CO 80526-2899

2.1.1 Golden Eagle

Golden eagles are often found where escarpments or large trees are available for nesting or roosting and open areas provide adequate hunting habitat. The home range of a pair of golden eagles is about 90 km^2 (35 mi^2). Breeding pairs may use the same nest every year; others use alternate nests in successive years; and some apparently nest only every other year. The same nest site may be used by succeeding generations of eagles. Eagles eat jackrabbits, snakes, ground squirrels, prairie dogs, and some birds, such as magpies and pigeons. Carrion also constitutes a substantial portion of the eagle's diet.

In coal mine areas, increased traffic results in more frequent road kills and, therefore, an elevated prey base. However, traffic also presents a hazard to eagles feeding on carrion along roads. Many eagles are electrocuted every year while landing on, or flying from, high-voltage power lines. Golden eagles, their nests, young, and eggs are protected from disturbance by Federal law. Additional information is provided in Section 3.3.3.h, Building Alternative Nest Sites for Golden Eagles.

2.1.2 Blue Grouse

In the Uinta-Southwestern Utah Coal Region, blue grouse are common in coniferous forests, mountain brush, and aspen habitats. This species is closely associated with Douglas fir forests, which are utilized for food and cover. Fir needles provide the bulk of the diet throughout the year, although the spring and summer diet is mostly forbs. Preferred brood habitat contains a relatively dense herbaceous cover (35-50%) of sufficient height for concealment; a variety of trees, shrubs, forbs, and grasses; and minimal bare ground.

2.1.3 Sage Grouse

As their name implies, sage grouse are closely associated with sagebrush. Sagebrush densities of 20 to 40% are considered optimum, particularly if the distribution is patchy. They are completely dependent on sagebrush for food from October through April. Summer food is mostly forbs, although young sage grouse also feed on insects. Dandelion, clover, common salsify, prickly lettuce, and milkvetch are some of the more important forbs. Water obtained from green vegetation, rain, or dew is apparently adequate to meet sage grouse requirements. Sage grouse require open areas (0.1 to 0.2 ha [0.2 to 0.5 acres]) for strutting grounds (leks) in the spring. A majority of sage grouse nests are found within a 2.4 km (1.5 mi) radius of the lek. Nesting habitat should have a sagebrush density of 20 to 40% and heights should vary between 17 and 79 cm (6.6 and 30.8 in). Wintering areas may be nearby or several kilometers distant. The habitat selected depends on severity of winter weather, local topography, and vegetative cover. Additional habitat requirements and relationships are provided in Section 3.3.3.j, Maintenance of Sage Grouse Habitats.

2.1.4 Chukar Partridge

Chukars are an introduced game bird native to the arid mountainous regions of central and southern Europe and Asia. Their habitat usually consists of steep rugged canyons with talus slopes and rocky outcrops. Scattered juniper and sagebrush are characteristic of their habitats, along with bitterbrush, Indian tea, snakeweed, rabbitbrush, cheatgrass, foxtail chess, and other grasses. Grasses (particularly cheatgrass), including stems, blades, and seeds, are the primary food items in most areas, with seeds of annuals and perennials secondarily important. Rocky outcrops and talus slopes adjacent to feeding areas are important areas for escape cover from predators. During hot, dry summers, birds are not regularly seen more than 1.6 km (1 mile) from water.

2.1.5 Turkey

Wild turkeys prefer pine-oak scrub, ponderosa pine, and riparian forest habitats. Turkeys roost in trees at night. Mature, open-branched ponderosa pine or other suitable trees are preferred. The male has a harem comprised of several females. Following the breeding season, there is a segregation of the sexes. Turkeys are rarely found more than 3 km (2 mi) from water. Food includes seeds, wild fruits, and a wide variety of insects. Specific forage species include ponderosa pine seeds, juniper berries, western ragweed, muhly grass seeds, Gambel oak acorns, and dandelions. Most coal mines in the region are not in turkey habitat.

2.1.6 Waterfowl

Blue-winged teal, mallard, pintail, American wigeon, gadwall, northern shoveler, green-winged teal, cinnamon teal, redhead, ruddy duck, and Canada geese are the most common waterfowl species breeding and rearing their young in these coal regions. Other species occur frequently, particularly in the northern parts of the region. Most common are the first five species listed above. All five are dabbling ducks and require shallow water areas (0.6 m [2 ft] or less) to feed. Small, irregularly shaped ponds with emergent vegetation and islands provide valuable areas for courtship, nesting, and brood rearing.

2.1.7 Raptors

In the Uinta-Southwestern Utah Coal Region, the most common raptors are the sparrow hawk, Swainson's hawk, red-tailed hawk, ferruginous hawk, and golden eagle. Prey range from insects for the sparrow hawk to rodents, jackrabbits, and carrion for the larger species. Nest sites include the cavities of trees, abandoned buildings, or magpie nests (sparrow hawk), or on cliffs, knolls, or in isolated trees (ferruginous hawk, golden eagle). Most are intolerant of human disturbance, which may lead to the abandonment of the nest and/or young.

2.1.8 Nongame Birds

Nongame birds associated with grasslands and sagebrush habitats include horned larks, sage thrashers, and a variety of sparrows, such as black-throated sparrows, sage sparrows, and lark sparrows. Woody draws and riparian areas provide food and/or cover for owls, hawks, woodpeckers, swallows, warblers, vireos, and towhees. Potholes, small stock ponds, and wetlands attract many species of waterfowl, blackbirds, and shorebirds. Rocky outcrops provide important habitat for raptors, swallows, and rock wrens.

2.1.9 Mule Deer

Mule deer are found in the Uinta-Southwestern Utah Coal Region in forested uplands and transition zones, where the occasional escarpments, buttes, draws, and stream bottoms provide adequate forage and cover. In general, three conditions are important for good mule deer habitat: (1) early stages of plant succession are more beneficial than climax vegetation; (2) a mixture of

plant communities provide better habitat than any single community (this is true for most wildlife); and (3) more browse species are preferable. Mule deer can adapt to a wide range of forage types. Browse, particularly sagebrush, is essential on winter ranges. This is not true because sagebrush is highly palatable or desirable to mule deer but because oftentimes it is the only palatable shrub available on ranges heavily used by livestock. The spatial distribution of mule deer habitat requirements is discussed in Section 3.3.3.j, Restoring Big Game Range.

2.1.10 White-tailed Deer

White-tailed deer are less common than mule deer, although they are found throughout the Uinta-Southwestern Utah Coal Region in suitable riparian habitats. They prefer coniferous forests and riparian forests with dense deciduous understory. These habitats are similar to those of the mule deer and, in some areas, the two species crossbreed; however, the whitetail usually prefers denser forests. Like the mule deer, food habits reflect the availability of different forage species in an area.

2.1.11 Elk

Elk are common in the mountainous portions of the coal region considered in this handbook. They occupy semiopen forests, mountain meadows, foothills, and valleys. Elk summer in the mountains or foothills and descend to the more protected lowlands for the winter. They forage primarily on grasses; however, in some areas, forbs comprise the major portion of the summer diet. Shrubs are more important forage species during winter.

2.1.12 Pronghorn

Pronghorn occupy areas typified by low, rolling, wide-open, expansive terrain. They are common on most sagebrush or desert shrub plains in this coal region. Small herds may occupy ranges with sparse stands of ponderosa pine or juniper. Most pronghorn are found within 4.8 to 6.4 km (3 to 4 mi) of water (Sundstrom 1968). Pronghorn prefer succulent plants and thrive best on rangeland with a variety of shrubs, forbs, and grasses. Sagebrush is essential winter forage and is particularly important for cover during the fawning season. Monotypic shrubs or grasslands are not favored pronghorn habitat. Optimum habitat contains 40 to 60% vegetative cover, consisting of 10 to 20% sagebrush, 5 to 15% other browse species, 25 to 35% forbs, and 40 to 60% grass. (For a list of some important forage species, see Section 3.3.3.j, Restoring Big Game Range.) Winter herd concentrations often number 200 to 1,000. When spring approaches, dominant males establish territories with small bands of does, yearlings, and fawns. The range of a pronghorn herd is usually 8 to 16 km (5 to 10 mi) in diameter.

2.1.13 Moose

Moose are generally uncommon throughout the coal region discussed in this handbook. Moose occur in the Uinta and Wasatch Mountain ranges and are common within these areas. Moose are found along mountain streams, in willow bottoms, and in or near water where water plants may be eaten during summer. Willows and other woody plants constitute the majority of their winter diet. Population densities of four animals per 2.59 km^2 (1 mi^2) are high.

2.1.14 Cottontails and Jackrabbits

Cottontail rabbits and whitetail and blacktail jackrabbits inhabit the Uinta-Southwestern Utah Region. These species are active year-round and are primarily nocturnal, although they may be seen at any time during the day. Jackrabbits rest above ground in depressions which they construct at the bases of larger plants. Cottontails seek refuge in shrubs, rocks, or burrows. Both jackrabbits and cottontails feed on grasses and forbs; shrubs are consumed in winter. The home range for cottontails extends from 0.4 ha (1 acre) for females to 6 ha (15 acres) for males. Cottontails and jackrabbits serve as prey for many species of animals, including eagles, hawks, fox, coyotes, owls, and weasels.

2.1.15 Small Furbearers

Skunks, long-tailed weasels, mink, and badgers are common furbearers in the Uinta-Southwestern Utah Coal Region. All of these species eat a wide variety of foods. Weasels and badgers seek small mammals, such as mice and ground squirrels. Mink consume a variety of reptiles, amphibians, fish, and invertebrates associated with stream courses. Raccoons and skunks are omnivores and eat large amounts of plant materials, such as corn and fruit, as well as vertebrates and invertebrates, such as crayfish, birds, insects, and small mammals. Badgers inhabit the open prairie where numerous burrowing rodents are available as food. Raccoons, skunks, and weasels require some type of denning cover, such as rocks, brush piles, or hollow logs. A stream or creek is essential habitat for mink. These furbearers are valuable because of the number of small mammals they consume, but they can also reduce waterfowl nesting success where nesting habitat is easily hunted.

2.1.16 Wild Canids

The major wild canid in the Uinta-Southwestern Utah Coal Region is the coyote; swift fox and red fox also occur. Coyotes prey upon the entire range of small mammals, as well as game birds, waterfowl, reptiles, fish, and occasionally domestic livestock. Coyote dens are usually underground, beneath the roots of larger trees, or dug into a hill or gully. Coyotes are extremely adaptable, and are able to survive on the plains if prey and water are available. Swift fox inhabit open deserts and plains and eat small mammals, small birds, reptiles, amphibians, and insects. Red fox may be found in a mixture of forests and open country and agricultural land associated with river bottoms. Grey fox are found in many of the habitats in this coal region. They are primarily nocturnal and eat small mammals, insects, fruits, birds, and eggs. They den in hollow logs, beneath boulders, or in excavated ground burrows.

2.1.17 Prairie Dogs

Prairie dogs are burrow-dwelling, colonial rodents which can be seen aboveground much of the year. Most of the time aboveground is spent feeding

on grasses and annual forbs. During late fall, winter, and early spring, prairie dogs frequently dig and eat roots of forbs and grasses. Prairie dogs are social animals and live in "towns" which may cover dozens of hectares. Burrowing owls often use prairie dog burrows and can be seen during the day capturing insects. Prairie dog towns are essential habitat of the endangered black-footed ferret. Several ferrets have been sighted recently (November 1981) near Meeteetse, WY.

2.1.18 Sandhill Cranes

The greater sandhill crane can be seen in and west of the mountains and is often confused with the great blue heron. In flight, the heron flies with its head pulled in against the body; whereas, the neck is fully extended in cranes. These birds nest around large marshes or along willow-dominated riparian communities. The habitat in Colorado is declining and a continued loss is possible due to direct and indirect effects of energy development in northwestern Colorado. Since the cranes are protected by law, it is essential that their habitat be protected and, if possible, new nesting habitats created.

2.1.19 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. The Federal Endangered Species Act protects many of these species while, in other cases, State regulations are in effect. If it is determined that one of those 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.

The endangered species of concern to mine operators in this region is the bald eagle. Bald eagles winter in conspicuous numbers along some of the larger creeks and rivers in this region. Breeding populations are much smaller. The peregrine falcon has a range encompassing this region, but probably utilizes the area only during migration. Black-footed ferrets are known from this region, but none have been reported recently (Weaver and Clark 1979). However, ferrets are not extinct and may occur in the region if the habitat is adequate. On 29 October 1981, a black-footed ferret was trapped, radio-collared, and released on a ranch west of Meeteetse, WY. This was the first confirmed sighting of a live ferret in the United States since a 1974 sighting in South Dakota. Several different individuals have been seen in the area since late October 1981. Ferrets feed primarily on prairie dogs and use their burrows for denning and shelter.

Endangered species are fully protected under the Endangered Species Act of 1973, Public Law 93-205, and may be protected under other Federal (Bald Eagle Protection Act of 1969, 16 USC 668, and Migratory Bird Treaties, 16 USC 703, 50 CFR 20.71) and State laws. Operators should contact the U.S. Fish and

Wildlife Service if they suspect a Federally endangered species is inhabiting their lease.

2.2 MANAGEMENT FOR FISH AND WILDLIFE

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

Long-range planning is necessary because the benefits from managing for fish and wildlife continue beyond the reclamation bonding period. For example, management for sage grouse, as mentioned above, would be a long-term goal over several years, realized only after sagebrush stands and other habitat needs were fully established on the site. In addition, some continued maintenance of the various vegetation phases may be necessary to retain the best habitat for a selected species. Thus, planning for wildlife should begin in the premining planning phase and should include consultation with appropriate Federal and State agencies.

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:

- existing data compilation to determine if and what baseline data are needed,
- baseline data gathering,
- site potential evaluation,
- discussions with the postmining landowner,
- goal-setting,
- reclamation planning, and
- 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. After the land use/cover types, wildlife habitat types, aquatic resources, types of fish and wildlife inhabiting the area, and unique habitat or other biological features have been determined, planning can be more responsive to fish and wildlife needs.

Knowledge of the premining site characteristics will provide the basis for determining the potential for fish and wildlife management. The success of species inhabiting the area provides insight into the 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 area.

Based on the site characteristics and the site potential, realistic goals may be set for managing fish and wildlife. It is critical at this time to consult with the postmining landowner so that the proposed reclamation and wildlife enhancement practices are compatible with the landowner's goals. Creating a wetland that will be converted by a private landowner to grazing c agricultural land shortly after bond release will not provide long-term value to wildlife, nor will it be cost-effective for the mining company. This concept is discussed further in Section 1.2, Factors Affecting Protection and Enhancement Practices. With the knowledge of baseline characteristics and site potential, a wildlife biologist can effectively incorporate fish and wildlife needs 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, and agricultural land or other multiple land use alternatives. Areas dedicated solely for use by fish and wildlife are viable and quite reasonable goals.

Reclamation and planning for fish and wildlife 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. Federal and State agencies are required to assist in planning and developing fish and wildlife habitat. Some State regulatory authorities and Office of Surface Mining offices have staff biologists experienced in mining technology, as well as wildlife and fisheries management. Other agencies, such as the U.S. Soil Conservation Service, State wildlife agency, State forestry service, State reclamation service, the U.S. Fish and Wildlife Service, and Federal and State regulatory authorities can provide additional guidance in planning and implementing procedures best suited to a particular site. Publications such as this one and others mentioned throughout this handbook can provide additional guidance.

References Cited:

Sundstrom, C. Water consumption by pronghorn antelope and distribution related to water in Wyoming's Red Desert. Proc. Antelope States Workshop 3:39-46; 1968.

Weaver, J. L.; Clark, T. W. Mammals. Pages 63-76 in Clark, T. W.; Dorn, R. D. eds. Rare and endangered vascular plants and vertebrates of Wyoming; 1979.

3. BEST CURRENT FISH AND WILDLIFE ENHANCEMENT/PROTECTION PRACTICES

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

This group of BCP's is designed to allow the operator to initiate measures to protect wildlife in the design phase of mine development. An additional BCP is provided which can assist the operator in the mitigation of habitat losses by improving the carrying capacity of areas adjacent to the proposed mine. Wildlife displaced from the mined area can move into acceptable habitat. All mitigation should be coordinated with the State regulatory authority.

3.1.1 Design, Location, and Construction

a. Roads.

PURPOSE

Consideration of fish and wildlife in the design and construction of access and haul roads can greatly reduce impacts to animal resources. Loss of habitat, disturbance from vehicles, creation of barriers to wildlife travel, and other negative impacts can be reduced by proper road location, design, construction, and timing to avoid biologically sensitive periods, such as the nesting season. In most instances, there is minimal direct danger to wildlife from vehicle collisions. However, where this is a problem, the following techniques, coupled with a reduction in speed, will minimize the problem.

DEVELOPMENT

Many standards and specifications concerning the design and construction of roads are included in Federal and State surface mining regulations. These requirements, along with other engineering aspects dictated by site-specific conditions, must be given first consideration when designing and constructing roads. However, Federal and State regulations are being abandoned in favor of professional engineering, design, and construction standards whose specifications are applied on a more site-specific basis. Most considerations given fish and wildlife during road development can be initiated during road location and design. Management practices for sedimentation and siltation control are required by the Surface Mining Control and Reclamation Act of 1977 and are extremely important for protection of fish and water resources. Best current practices for stream crossings (Section 3.1.1.c), establishment of buffer

zones (Section 3.2.2.b), fences (Section 3.1.1.d), and rights-of-way management (Section 3.2.2.c) are discussed in separate sections.

When possible, locate roads below ridgelines. This confines any wildlife disturbance created by traffic to one side of the ridge (Thomas 1979). Designing roads with minimum rights-of-way reduces habitat destruction and can also reduce construction costs. 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. Areas of high quality or important habitat should be avoided; specifically, roads should not pass through important nesting or reproduction areas. Wetlands (e.g., marshes, riparian zones) are important wildlife habitat and should be avoided.

Roads sometimes are barriers to animal movements and should not cross important migration routes. The State department of fish and game can give advice on avoiding wildlife migration areas. If bisecting a deer migration route is unavoidable, underpasses should be provided for migrating animals, and the road should be fenced to guide the animals to the underpass (see Section 3.1.1.d, Fences). Underpasses are infrequently used by pronghorn and elk (Ward et al. 1976; Reed et al. 1980).

Sharp curves in roads should be avoided to reduce possible animal-vehicle collisions because of poor visibility. Where a curve is necessary, fences can be provided to keep animals from crossing the road at that point. Sighting distances for vehicle operators and wildlife can be improved 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. One of the most effective means of reducing animal-vehicle collisions is simply to reduce speed limits on mine access roads.

Rights-of-way management practices, such as planting browse species that may attract wildlife, especially elk, deer, and pronghorn, should be avoided along roads with large volumes of high velocity traffic. This can help reduce direct mortality due to animal-vehicle collisions. Where roads are not approved for retention after mining, the roadbeds must be revegetated in accordance with State regulatory authority requirements. Unpalatable vegetation species should be planted along the road right-of-way to discourage grazing and further minimize potential highway mortality.

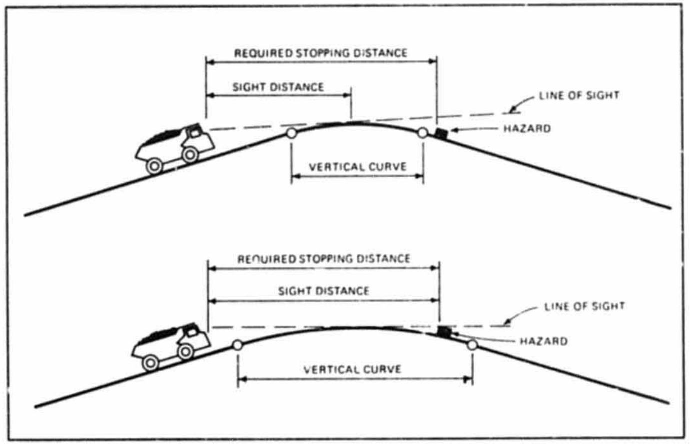

Figure 3.1-1. Sight distance on vertical curves (from Chironis 1978).

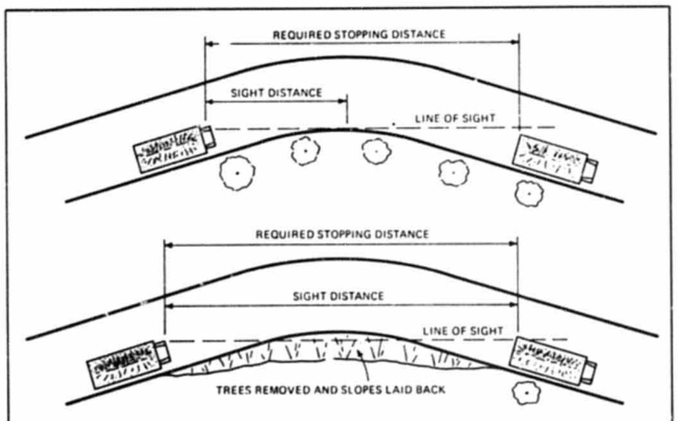

Figure 3.1-2. Sight distance on horizontal curves (from Chironis 1978).

Some basic rules to follow in building roads that could affect permanent and intermittent streams are:

- Do not remove gravel from stream beds.
- Do not operate heavy equipment in any stream except for essential bridge or culvert installation.
- Plan road construction so that sediment eroding from road cuts will not reach streams.
- Build roads in dry weather to reduce the erosion of soils into streams.
- Make provisions to eliminate erosion and prevent drainage waters from entering streams.
- Locate roads on natural benches and ridges well away from stream courses.

The Wyoming Department of Game and Fish (1976) recommends a minimum 152-m (500-ft) undisturbed buffer zone on both sides of large rivers and a 91-m (300-ft) buffer on smaller streams.

Transportation alternatives, such as car pooling, speed limitations, and operating schedules should be considered in the planning of road access.

MAINTENANCE AND MANAGEMENT

Road design and construction techniques for fish and wildlife protection and enhancement generally do not require any maintenance beyond normal road maintenance. Structures that may require maintenance, such as culverts (Section 3.1.1.c), are addressed separately in this handbook (as well as Section 3.2.2.c, Rights-of-way Management).

LABOR/MATERIALS

Incorporation of fish and wildlife considerations in the road design is required during initial planning. Higher construction costs may be incurred while implementing some techniques, such as increasing a road's length when avoiding important habitat.

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:

- State Regulatory Authority
- Office of Surface Mining
- State Game and Fish Agencies
- State Department of Highways/Transportation
- U.S. Fish and Wildlife Service
- U.S. Forest Service

For addresses, see Appendix A.

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.

Reed, D. F.; Giunta, B. C.; Cebula, J. J.; Money, D. L.; Doose, C. A.; Merrell, C. L.; Dillinger, K. C.; Myers, G. T.; Zimmerman, W. B.; Fleming, J. D.; McDonnell, S. L.; Kincaid, K. R.; Pojar, T. M.; Woodard, T. N.; Beck, T. D. I. Deer vehicle accidents Statewide and methods and devices to reduce them. Proj. No. W-125-R. Colorado Division of Wildlife, Dept. Nat. Resour., Denver; 1980. 53 p.

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

Ward, A. L.; Cupal, J. J.; Goodwin, G. A.; Morris, H. D. Effects of highway construction and use on big game populations. Rep. No. FHWA-RD-76-174. Fed. Highway Admin. Washington, D.C.; 1976. 92 p.

Wyoming Department of Game and Fish. Consideration for wildlife in industrial development and reclamation; 1976. 65 p.

Additional Reference:

Virginia State Water Control Board. Best management practices handbook: forestry. Planning Bulletin 317: Virginia State Water Control Board; 1979.

b. Powerlines.

PURPOSE

The design and construction of powerlines can significantly affect wildlife populations. Indirect impacts to wildlife occur from powerline design and management of the right-of-way. Direct impacts result from clearing, construction, and cleanup activities. Collisions, electrocutions, and entanglements are the principal causes of wildlife fatalities at powerline locations.

Several excellent publications are available to aid mine operators and other individuals responsible for planning and installing powerlines. Most newly installed powerlines are built to prevent injury or death to birds coming in contact with the lines. The information presented in this section is therefore brief and not intended to take the place of these other manuals. It is important, however, to highlight the design and construction concerns associated with powerlines and to emphasize their overall significance in planning.

DESIGN CONSIDERATIONS

- In areas frequented by large birds (e.g., eagles and other raptors, herons, and pelicans), power poles are often used for hunting sites and feeding perches. Occasionally, birds are electrocuted when they contact two-phase conductors, or a one-phase conductor and a ground wire while landing or taking off. On any given system, relatively inexpensive modifications can be made to highly frequented power poles that will greatly reduce mortality (Figures 3.1-3, 3.1-4, and 3.1-5) (see Ansell and Smith 1980).

- Powerline routes should avoid open expanses of water and marshlands or waterways, which are used as flight lanes by migratory waterfowl and other birds. Areas heavily used for nesting, rearing, and roosting sites by wildlife should also be avoided. Areas where endangered or threatened species might be affected by the powerline construction and design should be avoided or appropriate mitigation must be considered. The local wildlife agency can advise appropriate measures. (Others are provided in BCP's, such as Section 3.1.2.a, Habitat Improvement on Adjacent Areas to Increase Carrying Capacity; Section 3.2.2.b, Establishment of Buffer Zones; and Section 3.2.2.c, Rights-of-Way Management for Wildlife.)

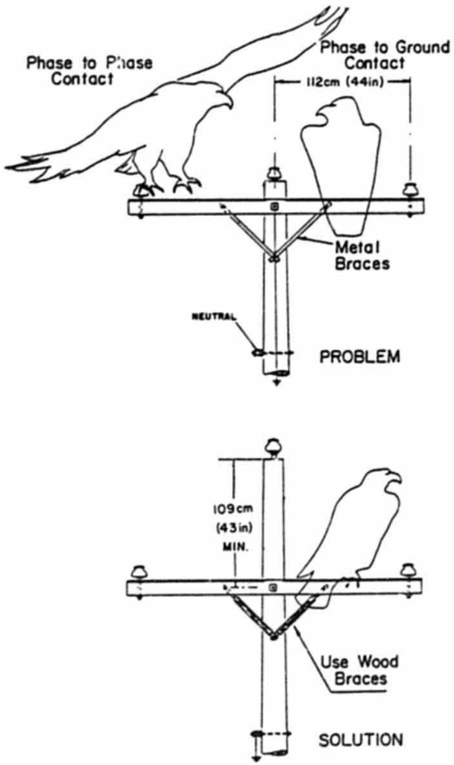

Figure 3.1-3. Vertical separation of the center and two outside conductors precludes the electrocution hazard on one type of pole (after Steenhof 1978).

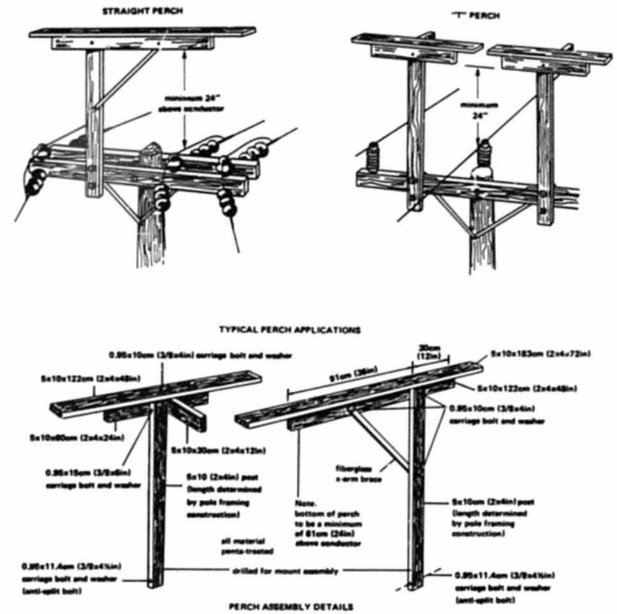

Figure 3.1-4. Artificial perches mounted above existing poles as an alternative to pole modification (suitable primarily for treeless areas) and perch assembly details (after Ansell and Smith 1980).

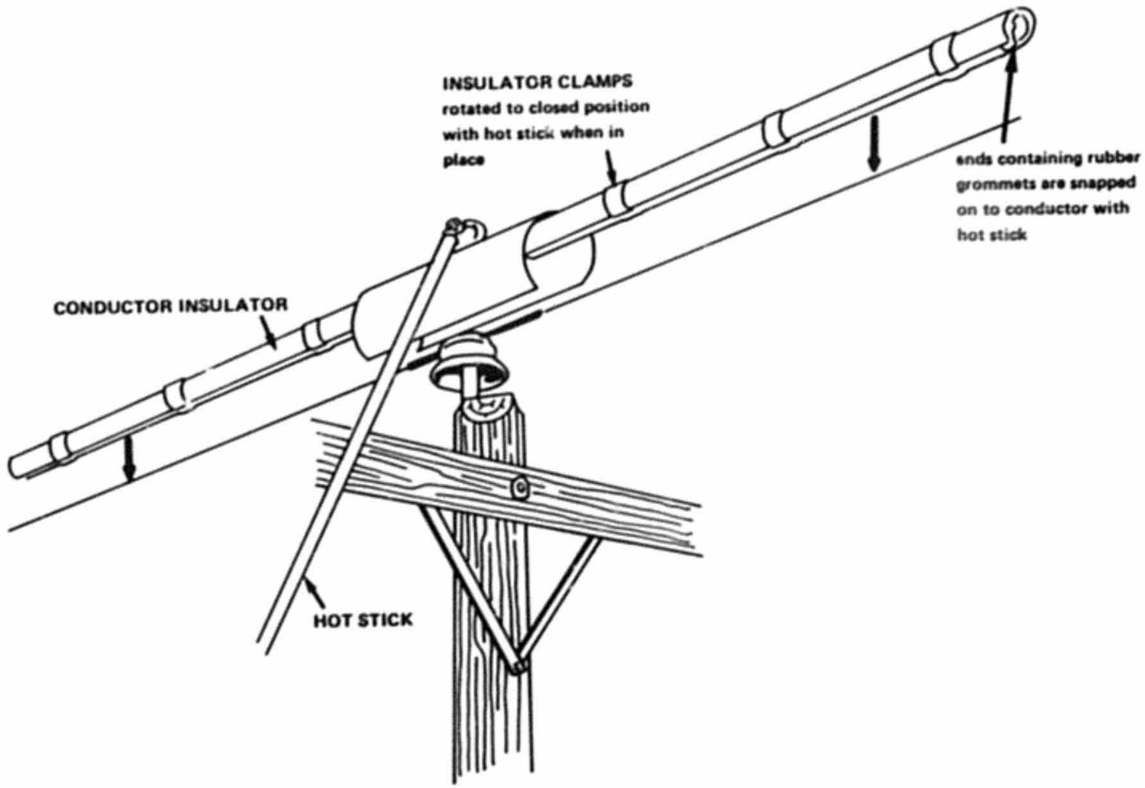

Figure 3.1-5. Protective conductor insulation cover for installation on poles used by raptors as an alternative to pole reconstruction (after Ansell and Smith 1980).

CONSTRUCTION CONSIDERATIONS

- Access, construction, and maintenance roads should be located so erosion will be minimized. When possible, road grades and alignments should follow the contour of the land with smooth, gradual curves. (For additional information concerning roads, see Section 3.1.1.a, Roads.) If it is necessary to use heavy equipment along the path of the power poles, care should be taken to operate such equipment in a manner that does not result in stream degradation. Stringing line with helicopters can be done to avoid damage to other sensitive habitats and avoid road access.

- When clearing rights-of-way, practices should be used which minimize the amount of cutting and reduce marring of the landscape and silting of streams.

- Revegetation and closure of access roads should occur as soon as possible after the power line has been installed. Plants should be used that have value as food and cover for wildlife, if this is compatible with the postmining land use, and if approved by the regulatory authority. Brush or small trees which are cut for clearing can be piled to provide cover habitat for small animals and birds (see Section 3.3.3.e, Brush Piles).

SOURCES OF INFORMATION

References Cited:

Ansell, A. R.; Smith, W. E. Raptor protection activities of the Idaho Power Company. Pages 56-70 in Howard, R. P. and J. F. Gore, eds. Workshop on raptors and energy developments, 1980.

Steenhof, K. Management of wintering bald eagles, U.S. Fish and Wildlife Service, FWS/OBS-78/79; 1978.

Additional References:

Raptor Research Foundation. Suggested practices for raptor protection on powerlines. Provo, UT; 1975.

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

---

*These guidance manuals may be available at the nearest Office of Surface Mining office or the central office of the State regulatory authority. These must be consulted before construction begins and the operator must check with the appropriate State regulatory authority to find out specific criteria for construction and design.

U.S. Department of Interior; 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.

U.S. Department of Interior. Impacts of transmission lines on birds in flight. U.S. Fish and Wildlife Service, FWS/OBS-78/48; 1978.

---

*These guidance manuals may be available at the nearest Office of Surface Mining office or the central office of the State regulatory authority. These must be consulted before construction begins and the operator must check with the appropriate State regulatory authority to find out specific criteria for construction and design.

c. Stream crossings.

PURPOSE

Stream crossings may have several adverse impacts on fish and wildlife. Clearing and shaping stream banks causes temporary stream sedimentation. Removal of stream-bank vegetation not only destroys wildlife cover but increases the chance of erosion and sedimentation and destruction of the aquatic habitat by silting over spawning and feeding areas. In some cases, structures impeding fish movement could significantly affect upstream travel to spawning grounds, resulting in population decline.

Crossing streams for exploration, access, and haul roads should be kept to a minimum. Any stream crossing, whether temporary or permanent, must receive prior approval from the Federal or State regulatory authority. Where drainage structures are required for stream-channel crossings, they must not affect the normal flow or gradient of the stream or adversely affect fish migration, aquatic habitat, or related environmental values.

DEVELOPMENT

The development of buffer zones to protect streams is frequently required by the State Regulatory Authority. The width is established through consultation with the regulatory authority. These areas are set aside for the purpose of preventing erosion of streambanks and sedimentation of streams. In addition, these areas provide "edge" for wildlife; protective cover for terrestrial wildlife; water, shading, and cover for aquatic species; and habitat for nesting and feeding of both terrestrial and aquatic wildlife. In essence, these zones protect many facets of fish and wildlife habitat. For more information, see Section 3.2.2.b, Establishment of Buffer Zones.

Crossings may be accomplished in several ways depending on the type of road and the type of stream. Fords may be used to cross streams on a temporary basis during construction of Class I and Class II roads. In the case of Class III roads (access other than haul roads and are used less than six months), temporary fords may be used to cross ephemeral and intermittent streams. Culverts and/or bridges must be used with Class I and II roads and where Class III roads cross perennial streams.

Fords - Several considerations should be made with respect to temporary stream fords.

- Place rock or other stabilizing material on the approach and exit to reduce erosion and sedimentation of aquatic habitat.
- Align the crossing at right angles to the stream to minimize streambed disturbance.

- Choose a crossing point with stable bottom materials to prevent erosion.
- Revegetate the streambank upon abandonment of the crossing to reestablish the riparian habitat and stabilize the bank to prevent erosion.

Culverts/Bridges - Culverts/bridges must be designed to handle predicted site-specific precipitation events. Since culverts/bridges are subject to regulatory changes, assistance in premining planning should be sought from the regulatory agency or OSM.

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

Certain factors in the design of culverts/bridges must be considered to provide minimal impediment to fish movement. Major factors are:

- Culvert outlets must not be above streambed level, preventing upstream movement of fish.
- Flow through the culvert must not be too fast and shallow, impeding movement of fish.
- Riprap and materials used to stabilize the culverts/bridges must not impede natural channel flow, restricting movement of fish.

Several methods have been demonstrated to provide fish passage through culverts (Watts 1974; Evans and Johnston 1976). However, only the arch culvert (Figure 3.1-6) has been shown to be effective in maintaining "natural" water flow. A pipe culvert may be set below the streambed level to allow passage of fish. This eliminates the problem of a culvert ending above the streambed level. Streambed gravel in the culvert and the slope of the culvert help control the natural rate of flow so that the culvert does not become a barrier.

MAINTENANCE AND MANAGEMENT

Debris that collects in the culvert or against bridge structures can also impede fish movement. Periodic checks should be made and such materials should be removed. Culverts and bridges must be maintained within appropriate standards as required by the Federal and State regulatory agencies.

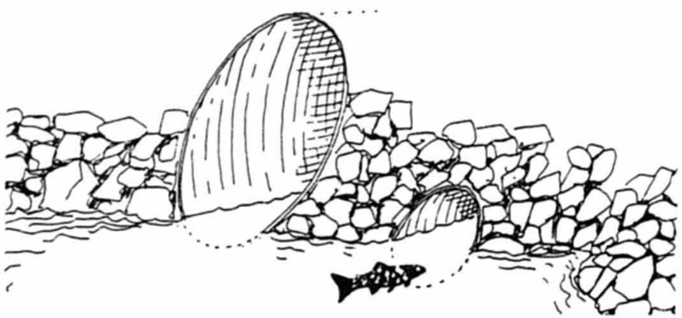

Figure 3.1-6. The arch culvert provides for fish passage (from Nelson et al. 1978).

LABOR/MATERIALS

Culvert or bridge materials, equipment operation, fill haulage, fill placement, and labor cost will vary according to stream width, slope of stream bank, and other site-specific considerations. Most road building contractors and State highway department personnel have ready access to 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 (lin ft)
122 cm (48 in)-14 gauge	34.82 per 0.3 m (lin ft)
183 cm (72 in)-16 gauge	66.43 per 0.3 m (lin ft)
Corrugated Metal Area Culvert	
89 x 61 cm (35 x 24 in)-14 gauge	$ 24.06 per 0.3 m (lin ft)
125 x 84 cm (49 x 33 in)-14 gauge	30.78 per 0.3 m (lin ft)
285 x 191 cm (112 x 75 in)-12 gauge	110.00 per 0.3 m (lin ft)

SOURCES OF INFORMATION

Further guidance and information on stream crossings may be acquired from:

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

For addresses, see Appendix A.

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; 1976.

Nelson, R. W.; Horak, G. C.; Olson, J. E. Western reservoir and stream habitat improvements handbook. Western Energy and Land Use Team, U.S. Fish and Wildlife Service. FWS/OBS-78/56; 1978.

Watts, F. J. Design of culvert fishways. Water Resources Research Institute, University of Idaho, Moscow, ID; 1974.

d. Fences.

PURPOSE

Fencing may be used to exclude pronghorn or deer from areas such as toxic ponds and reclamation areas; to reroute pronghorn or deer around haul roads and similar areas; and to allow pronghorn or deer to pass freely while excluding certain animals, such as cattle. With careful design, fencing can be used to accomplish its purpose on the surface mine area with minimal impact on the big game animals present.

DEVELOPMENT

Antelope (pronghorn)

Several types of fences may be used for various purposes on antelope range. Listed below are some common fencing applications and the specific type of fence which can be used to solve them:

	Problem	Fence Type
o	During winter, fence out cattle in areas of antelope concentration and migration routes.	Three strands barbed wire, barbless bottom wire (Figure 3.1-7A).
o	During winter, fence out sheep in areas of antelope concentration and migration routes.	Four strands barbed wire, barbless bottom wire (Figure 3.1-7B).
o	During winter, fence out cattle and sheep in areas of antelope concentration and migration routes.	Four strands barbed wire, barbless bottom wire (Figure 3.1-7C).
o	Fence out cattle and horses, but allow other wildlife access (no sheep present).	Four barbed strands (Figure 3.1-7D).
o	Fence out sheep, cattle, and horses, as well as deer and other high-jumping wildlife.	Woven wire (Figure 3.1-8A).
o	Fence out all livestock and antelope.	Woven wire (Figure 3.1-8B).

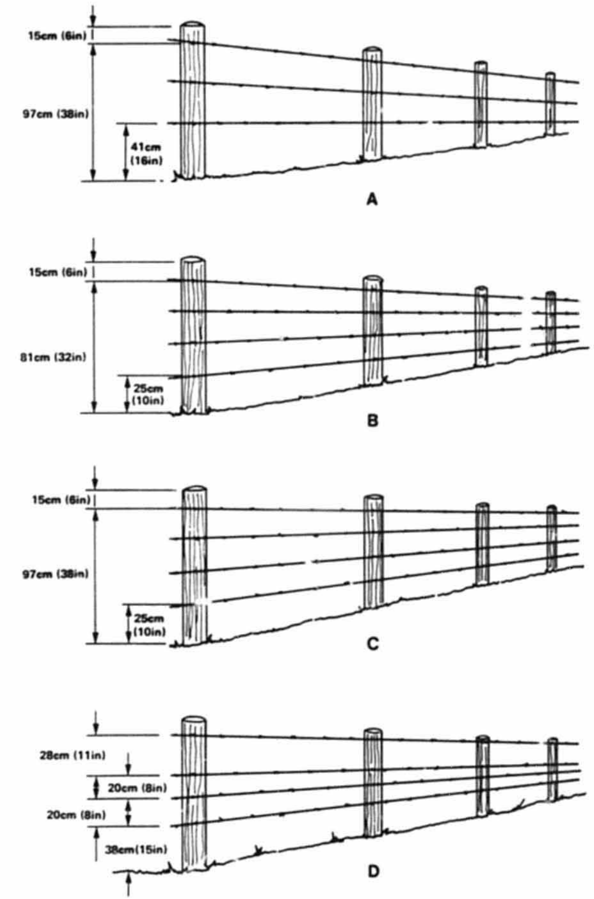

Figure 3.1-7. Fence types including cattle tight (A), sheep tight (B), cattle-sheep tight (C), and cattle-horse tight (D) where deer, elk, and moose are present.

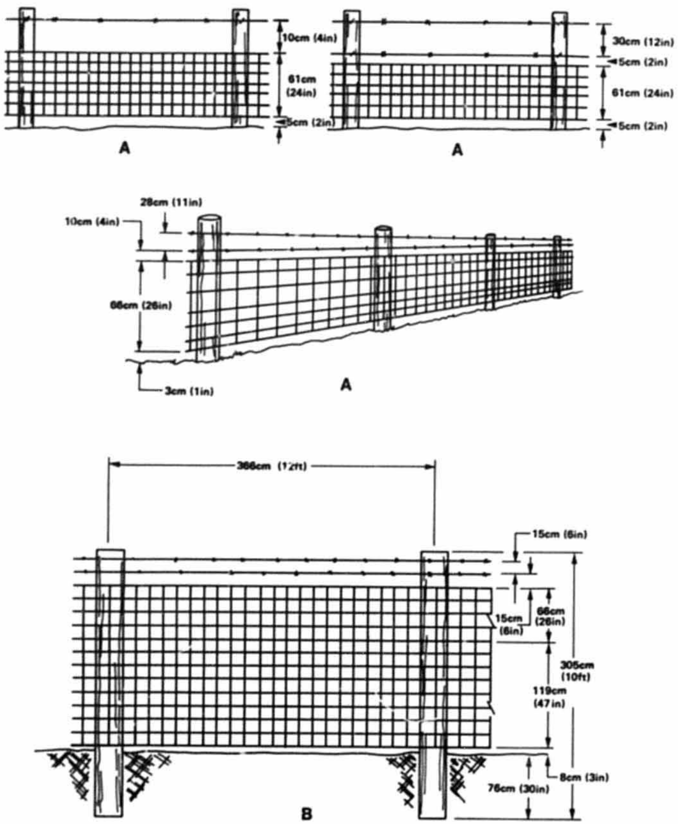

Figure 3.1-8. Woven wire fencing on antelope range including tall sheep tight (A), and cattle-horse tight (B) where deer, elk, and moose are present and sheep are absent. This type of fencing will not selectively allow for antelope movement unless antelope passes or other selective passageways are incorporated in the design.

Since antelope typically will not jump fences, fence type and location must consider antelope. For example, an angle of 90° is very hazardous during blizzards because antelope tend to crowd into corners, causing trampling and suffocation. Several small angles in corners (Figure 3.1-9) will prevent this from happening. Fences should also be angled along migration routes (Figure 3.1-9) rather than at right angles to the path of movement. Such angled fencing will help guide animals around hazardous areas.

Where sheep-tight fencing has to be used (Figure 3.1-8A), underpasses, overpasses, or other passageways should be placed every mile and at natural crossings. Antelope will not normally use an underpass. Passageways, such as cattle guards (Figure 3.1-10), placed at fence corners and other locations will allow antelope movement through fences but should not be used in place of fences that will permit passage of antelope (Mapston and ZoBell 1972).

Standards for constructing fences may vary from State to State and on Federal lands. Check with State authorities and the Bureau of Land Management to ensure that proper standards are met.

Deer

Deer characteristically jump over fences and this often leads to entanglement and death. While the adult deer is jumping, its hind feet can become entangled between the top two wires of range fences. The best fence adapted to allow deer passage should contain the following specifications (Yoakum et al. 1980).

- Bottom wires up 40.6 cm (16 in) from ground, allowing for movement of fawns.
- Only three strands of wire required. On open rangeland, this is enough to control cattle.
- Top wire is smooth and 91.4 cm (36 in) from ground, thus allowing deer greater ease in jumping over the fence.
- Stays are placed between posts to make a more rigid fence, since deer frequently become entangled when the top two wires twist around the legs.

To keep deer out of an area, such as an area being reclaimed, a woven mesh wire fence of at least 1.8 m (6 ft) in height is required; however, a fence height of 2.4 m (8 ft) is preferred. Since deer will crawl under a fence, the mesh wire should be secured and kept close to ground level. An extra strand of barbed wire stretched along the ground will help prevent deer from crawling under.

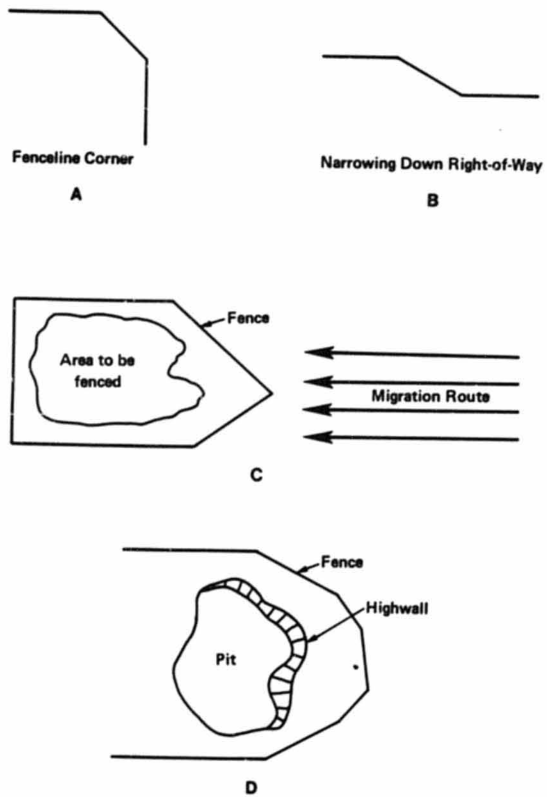

Figure 3.1-9. Fencing layouts for preventing corner pile-up during blizzards (A-B) and for directing animals around reclaimed or hazardous areas (C-D).

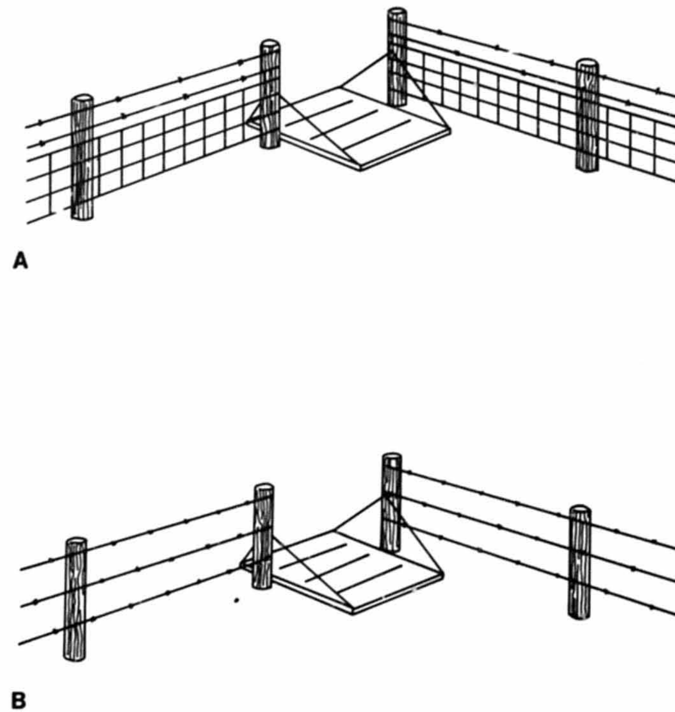

Figure 3.1-10. Antelope passes utilizing cattleguards on woven-wire, sheep tight (A) and barbed wire, cattle tight fencing (B).

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. On BLM land, fencing must be maintained to current BLM standards.

LABOR/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. For example, a square 0.4-ha (1-acre) area on level, cleared land will generally require the following materials and labor in order to enclose the site with livestock-proof fencing, 81 cm (32 in) high (U.S. Forest Service 1969):

Cattle Range	Sheep Range
3 strands of barbed wire spaced at 20, 41, and 61 cm (8, 16, and 24 in), respectively, from the ground up, with top rails.	81-cm (32-in) woven wire, with rails. Woven wire is stapled to the top pole.
14 corner and brace posts (15 cm [6 in] diameter and 1.7 m [5.5 ft] long).	Same.
39 lineposts on 3.7 m (12 ft) centers (15 cm [6 in] diameter and 1.4 m [4 ft 8 in] long).	Same.
54 rails[1], 10 cm [4 in] diameter and 3.7 m [12 ft] long.	Same.
125 rods barbed wire.	None.
None.	200 m (40 rods) woven wire (81 cm [32 in]).
2.3 kg (5 lbs) of staples (3.8 cm [1.5 in]).	2.7 kg (6 lbs) of 3.8-cm (1.5-in) staples.
5.5 kg (12 lbs) of nails (40 d).	Same.

[1]Rails give adequate bracing, so no brace material is needed.

The number of man-hours necessary to construct the fence described above will vary with the equipment used (e.g., mechanical post hole diggers, etc.). However, approximately 60 to 80 man-hours will be needed in most cases.

SOURCES OF INFORMATION

More information on the use and construction of fences may be obtained from:

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

For addresses, see Appendix A.

References Cited:

Mapston, R. D.; ZoBell, R. S. Antelope passes, their value and use. USDI Bur. Land Manage. Tech. Note D-360; 1972. 11 p.

U.S. Forest Service. Wildlife Habitat Improvement Handbook. Washington, DC.: U.S. Forest Service; Forest Service Handbook No. 2609.11; 1969.

Yoakum, J.; Dasmann, W. P.; Sanderson, H. R.; Nixon, C. M.; Crawford, H. S. Habitat improvement techniques. Schemnitz, S. D., et al. Wildlife management techniques manual. Washington, DC.: The Wildlife Society; 1980.

Additional References:

Dorn, R.; Strickland, D. Fencing. Cheyenne, WY: Wyoming Department of Environmental Quality, Land Quality Division; Guideline No. 10; 1979.

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

3.1.2 Habitat Improvement on Adjacent Areas to Increase Carrying Capacity

PURPOSE

Because there is such drastic, long-term disturbance of wildlife habitat during mining, it is possible to compensate for some of these losses by increasing the carrying capacity of adjacent or nearby property. This practice is useful under any of the following conditions:

- The State requires mitigation measures for destruction of wildlife habitat.
- Adjacent land is owned by the mining company.
- Adjacent landowner wishes the land to be improved for wildlife.
- Adjacent land is Federally or State owned and an agreement can be made following multiple use guidelines.

DEVELOPMENT

In all habitats, there is a limited number of animals that can be maintained on a given unit of land. That limitation is known as the carrying capacity (Dasmann 1964). Carrying capacity can be increased by concentrating the needs of a single species (optimally interspersing required habitat components, such as food, cover, and water) or by improving a habitat requirement, such as water, that might be limiting the abundance of several species and the number of individuals of each species.

Food

Food is one requirement that can be enhanced to increase carrying capacity. The amount of food can limit the abundance of a species; however, the nutritional components of the food, although less obvious, may limit the carrying capacity.

For meat-eaters (coyote, bobcat), nutritional requirements are met by consuming other animals. Generally, the carnivores do not suffer nutritional deficiencies, but often the quantity of food is limited. Seed-eating birds and mammals (rodents) obtain most of their dietary requirements from the seeds they eat. Again, food quantity, rather than nutritional quality, is the most likely deficiency.

Seasonally, grazers and browsers (deer, antelope) can suffer from deficiencies in food quality. A shrub may contain 16% protein in its terminal twigs during summer and only 3 to 4% in winter. Grazers thrive on tender young shoots, buds, and leaves, but may encounter nutritional difficulties when forced to eat old, coarse foliage.

Providing a balanced diet for grazers and browsers involves the maintenance of a variety of highly nutritional foods. For example, if the goal is to improve the habitat for pronghorn, the following nutritional conditions and composition (Yoakum 1979) should be incorporated into the reclamation plan:

- Ground cover averaging 50% living vegetation and 50% nonliving vegetation.
- The general composition of vegetation should be 40 to 60% grass, 10 to 30% forbs, and 5 to 20% browse.
- A variety of species should be present, including 5 to 10 species of grasses, 20 to 40 species of forbs, and 5 to 10 species of shrubs.
- Succulent plants are much preferred.
- Vegetation should average 38 cm (15 in) in height.

It should be remembered that other factors, such as water, should also be considered in providing optimum pronghorn habitat.

Soil fertility can also be a factor in providing adequate nutritional components. A general relationship between soil fertility, food quality, and the abundance, size, health, and vigor of wild animals has long been known (Albrecht 1944). One method of improving habitat is to fertilize with soil amendments to provide not only more vegetation, but more nutritious forage (See Section 3.3.1.b, Fertilization). Irrigation of adjacent lands similarly produces a greater quantity of forage, as well as a greater diversity of available succulent vegetation. In many places in the Uinta-Southwestern Utah Coal Region, the availability of water for irrigation is low. (For more information, see Section 3.3.1.i, Irrigation.)

Water

In many areas of the West, water sources may be so far apart that the range between them is poorly utilized, even though the forage and other habitat requirements are entirely adequate. For example, studies in Wyoming disclosed that 95% of 12,465 pronghorn were within a 4.8 to 6.4 km (3 to 4 mi) radius of water (Sundstrom 1968). To increase utilization on such areas, more water must be developed. For a discussion on creating water sources for wildlife, see Section 3.3.2.b, Supplementary Water Resources.

Interspersion

Spatial relationships of habitat components are an important factor in determining habitat utilization. The "edge effect" means that wherever two habitat types come together, the edge between the two types will be more favorable as wildlife habitat than either type considered alone (Odum 1959). It is possible to change a nearby monotypic or low diversity pasture into an area of more value to wildlife by adding "patches" of vegetation of a different species or structure, such as by adding shrubs to a grassland or by planting trees in a natural gully. Besides seeding or planting, it is also possible to reduce competition between desirable browse plants and less desirable species. Four general methods o[illegible]ducing competition are mechanical and manual treatment, chemical sprays [illegible]ee Section 3.3.1.j, Pest Control), and prescribed burning. An additional method to reduce competition on adjacent land may simply involve terminating livestock grazing.

Vegetative manipulation projects, such as chaining, can change the aesthetic and biological values of an area. Consequently, they should be conducted with caution and with a clear idea of the principles and procedures for pretreatment, treatment, and post-treatment.

Chaining is a mechanical method which consists of dragging a heavy chain through vegetation to break off or uproot woody plants (see Figure 3.1-11). The general procedure is for two tractors, one attached to each end of the chain, to travel on parallel courses 18.3 to 30.5 m (20 to 33 yd) apart (Yoakum et al. 1980). The spacing is dependent upon density of vegetation, weight and length of chain, size of tractors, bite of tracks, and slope. The degree of kill desired is dependent upon chain size, number of passes, and direction of passes.

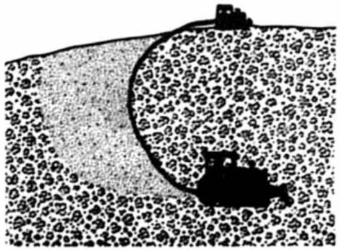

Figure 3.1-11. Chaining to improve wildlife habitat.

Plowing with a heavy offset disc or wheatland plow is used to open up thick strands of nonsprouting plants, such as sagebrush. A brushland plow is best for rough, moderately rocky areas.

Controlled burning is an economical procedure for removing a stand of vegetation but must be done with extreme care to prevent wildfire from starting. Burning may immediately stimulate plant growth, resulting in greater forage yield (Yoakum et al. 1980). On burned areas, soil fertility is usually increased due to the release of nutrients. Most prescribed fires lead to an

increase in protein content and palatability of resprouting plants. For information on the use of fire in land management and the techniques of planning and implementing prescribed burns, see the annual Proceedings of the Tall Timbers Fire Ecology conferences, which have been held since 1962 (Komarek 1962).

MAINTENANCE AND MANAGEMENT

Maintenance and management will depend upon the habitat improvement practice used and the length of time involved.

LABOR/MATERIALS

Most of the habitat improvement practices discussed in this section are labor intensive and expensive. The actual cost involved will vary according to technique and how it is applied. Costs for fertilizing (Section 3.3.1.b), irrigation (Section 3.3.1.i), and creating additional water sources (Section 3.3.2.b) are discussed under the appropriate section. Fire is probably the least expensive of the vegetation manipulation techniques because minimal equipment is required; although the technique is labor intensive. Including labor, water pumpers, and fire line construction, most burns cost \$3-5 per 0.4 ha (1 acre). Chaining, plowing, and other mechanical control methods require the use of heavy equipment (e.g., tractors, bulldozers, etc.) and can treat 7 to 10 ha (17 to 25 acres) of rangeland per hour. Chaining costs approximately \$10-12 per 0.4 ha (1 acre), which includes the operation of two tractors and the operators' labor. The chain can be supplied by the BLM or Forest Service. Equipment and labor costs for plowing run approximately \$15-25 per 0.4 ha (1 acre).

SOURCES OF INFORMATION

- State Regulatory Agency
- Office of Surface Mining
- State game and fish agencies
- U.S. Bureau of Land Management
- U.S. Forest Service
- University wildlife departments

For addresses, see Appendix A.

References Cited:

Albrecht, W. A. Soil fertility and wildlife: cause and effect. Trans. N. Amer. Wildl. Conf. 9:19-28; 1944.

Dasmann, R. F. Wildlife biology. New York, New York: John Wiley & Sons, Inc; 1964.

Komarek, R. Preface. Proc. Tall Timbers Fire Ecol. Conf. 1:v; 1962.

Odum, E. P. Fundamentals of ecology. Philadelphia, Pa.: W. B. Saunders Company; 1959.

Sundstrom, C. Water consumption by pronghorn antelope and distribution related to water in Wyoming's Red Desert. Antelope States Workshop Proc. 3:39-46; 1968.

Yoakum, J. D. Pronghorn. Schmidt, J. L.; Gilbert, D. L. Big game of North America. Harrisburg, Pa.: Stackpole Books; 1979.

Yoakum, J.; Dasman, W. P.; Sanderson, H. R.; Nixon, C. M.; Crawford, H. S. Habitat improvement techniques. Schemnitz, S. D., ed. Wildlife Management techniques manual. Washington, D.C.: The Wildlife Society; 1980.

Additional References:

Green, L. P. Fuelbreaks and other fuel modification for wildland fire control. USDA For. Serv. Agric. Handbook 499; 1977.

Pechanec, J. F.; Plummer, A. P.; Robertson, J. H.; and A. C. Hull, Jr. Sagebrush control on rangelands. USDA Agric. Handbook 277; 1965.

Plummer, A. P.; Hull, A. C.; Stewart, G.; Robertson, J. H. Seeding rangelands in Utah, Nevada, southern Idaho, and western Wyoming. USDA For. Serv. Agric. Handbook. 71; 1955.

U.S. Forest Service. Range seeding equipment handbook. Washington, D.C.; 1965.

Vallentine, J. F. Range development and improvements. Brigham Young Univ. Press, Logan, Utah; 1971.

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

This section provides the operator with a series of BCP's which provide guidance on creating zones that protect wildlife or their habitat or which suggest techniques by which continued disturbance is restricted. It is only through the conservation and rehabilitation of spoils and topsoils that a useful wildlife habitat can be created after mining.

The requirements and procedures of handling topsoil, spoil, and overburden vary between mines, or even between different portions of one mine, due to differences in topsoil and overburden thickness, amount of material to be stockpiled, chemical and physical characteristics of stockpiled material, length of time materials are to be stored, etc. Procedures also differ with individual State regulations. Site-specific requirements should be obtained from the State regulatory authority and OSM.

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 ensure 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 and soils. The amount of sampling required for the analysis depends on applicable Federal and State 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 the following:

- 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:

- USDA 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.

- USDA Forest Service. Procedures Recommended for Overburden and Hydrologic Studies on Surface - Thunder Basin Project. Intermountain Forest and Range Experiment Station, USDA Forest Service, Ogden, UT. Gen. Tech. Rpt. INT-71, 1980.

It is the responsibility of the operator to gather sufficient data to describe soil and overburden characteristics, propose methods to alleviate any problems, and obtain approval from the regulatory agency on the proposed methods. Information provided in the following sections is designed to provide further guidance in handling overburden and soil materials.

b. Selective placement of overburden and topsoil at underground mines.

PURPOSE

In the mining process, it is important to identify problem-producing strata in the overburden so that they can be disposed of in a manner that will ameliorate plant establishment and survival during the reclamation process. Topsoil replacement on top of graded waste rock is required by regulation in Colorado and Utah. Correct handling of overburden and topsoil will minimize potentially adverse environmental effects resulting from waste rock disposal and ultimately lead to a site more valuable as wildlife habitat. 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- and toxic-forming strata at the proper depth within the neutral material to prevent leaching, contact with groundwater, and contamination of topsoil or soil substitute.

[illegible] to consult U.S. Forest Service (1979), which pr[illegible]ssion on this subject.

DEVELOPMENT

Removal, storage, and disposal of overburden (underground development waste, UDW) and topsoil at underground mines is far less involved, quantitatively, than that associated with surface mines. What overburden is extracted is removed to make shafts and tunnels to access the ore. Although most of this section is also applicable to coal-processing waste (CPW), the toxic and acid-forming characteristics of this waste necessitate special disposal procedures. Some of these are discussed in Reclaiming Waste Rock Disposal Piles, Section 3.3.3.f.

The goal of selective placement is to locate and, if possible or required, isolate potentially toxic materials that may adversely affect revegetation efforts. Soils and overburden analysis is a required component of baseline studies prior to mining. These analyses identify potentially toxic zones in the soils and overburden, if and how much topsoil should be stockpiled for redistribution on waste rock piles, etc. Reclamation efforts are based on this premining analysis and include such concerns as how to selectively place potentially toxic strata to ensure that the material most beneficial for plant growth is deposited on the surface and what physical or chemical treatments are required to circumvent foreseen problems (U.S. Forest Service 1979).

Prior to overburden deposition, the disposal area is scalped of topsoil and subsoil with a "cat" or scraper. Topsoil is generally the dark-colored, unconsolidated surface material, containing organic matter which supports plant growth, although the precise definition varies from State to State. Colorado Regulations (Colorado Mined Land Reclamation Board 1978) define topsoil as "the material at the surface of the earth which has been so modified and acted upon by physical, chemical, and biological agents that it will support rooted plants necessary to achieve reclamation goals." Subsoil can be described as the light-colored, unconsolidated, subsurface material found adjacent to the topsoil and within 1.5 m (5 ft) of the surface. Regulations specify that, prior to any major excavation, all surficial materials suitable as a growth/medium shall be removed, segregated, and stockpiled according to its ability to support vegetation, as determined by soil analysis and/or practical revegetation experience. The stockpiles must be protected in such a manner as to minimize or prevent wind and water erosion, unnecessary compaction, and contamination by undesirable materials (State of Utah 1975; Colorado Mined Land Reclamation Board 1978).

"Scalped" topsoil and subsoil is typically stockpiled for later reapplication. Stockpiles are usually graded and seeded if the material is to be stored for any length of time. At many underground mines, topsoils are stored for 30 or more years. Leaching will occur to some extent as rainwater runs off and infiltrates into the stockpile. The major problem associated with leaching is the loss of nutrients and subsequent decrease in topsoil fertility (Moore and Mills 1977). A much more significant problem concerning long-term topsoil stockpiling is that the normal level of microbial activity decreases over 30 years in all areas of the pile except the surface, and the topsoil properties which make it topsoil are lost. This is, at present, a controversial issue. Some workers feel that stockpiled topsoils can be rehabilitated through soil amendments, microbes, etc.; however, most feel that topsoil should not be needlessly stockpiled, but immediately respread.

The taking of topsoil (termed live handling of topsoil) from the area to be disturbed and spreading it on the recontoured area should be conducted whenever possible. This eliminates the leaching of nutrients and reduction in fertility and microbial abundance, which are problems associated with stockpiling. Furthermore, the live soil contains seeds of indigenous species which will sprout immediately or within the next growing season. Such species are already acclimated to the microenvironments and will enhance their survival as compared to introduced native and exotic species. Studies in western Colorado have indicated that this method of soil handling produces greater plant productivity and more rapid recolonization by wildlife (Don Bailey, Reclamation Specialist, Union Oil, Grand Junction, CO., pers. comm.).

Older mines that began mining before topsoil stockpiling was required face special reclamation problems. Without topsoil, revegetation efforts can be greatly hampered. Topsoil can be hauled in to these sites; however, that typically necessitates disturbing some other area. It is possible to establish usable vegetation directly on overburden piles, although some of these species may be exotics. For more information, contact the State Regulatory Authority.

Leaching of stored subsoil or overburden may present greater potential water quality problems than leaching of the stored topsoil layers. Alkaline spoils are found in arid and semiarid regions where precipitation is insufficient to leach out salts (U.S. Forest Service 1979). Part of the rationale for separating and storing subsoil materials is that, when replaced, they will provide a chemically and physically compatible base upon which to place the topsoil material (Moore and Mills 1977). The success of this effort will

depend upon the length of storage of the subsoil material and the care taken to protect it from drastic changes in its physical and chemical properties.

Locating storage and disposal sites is influenced by a host of considerations, such as:

- o Whether storage needs will be permanent or temporary;
- o The quantity and characteristics of the material to be stored;
- o Potential toxicity and stability problems during storage;
- o Slope and aspect of the storage pile;
- o Proximity of the mine operation to the storage site;
- o Effect of wind and water on the storage site and the need for erosion leaching 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 materials from aquifers; and
- o Location of fill to segregate it, or runoff from it, from water courses.

Additional considerations and a summary of the site-selection process are provided by U.S. Forest Service (1979).

Nontoxic overburden is typically graded to approximate premining contours or into a form which blends into the natural topography while minimizing undue disturbances (e.g., the mine operator will disturb far less land if overburden is arranged into gently sloped terraces than if it is spread uniformly over the land. Such terraced areas are also of more value to wildlife) (for additional information, see Creation of Topographic Features, Section 3.3.3.a). The overburden is then compacted by the "cat" while regrading, covered with what topsoil was "scalped" from the disposal site, and revegetated. If stabilization is necessary, contouring to reduce steep slopes and creating small depressions or furrows to increase water filtration will greatly improve the chance for plant establishment (Institute for Land Rehabilitation 1978). Depressions should not be made in toxic waste piles (see Reclaiming Waste Rock Disposal Piles, Section 3.3.3.f).

In Kemmerer, WY, a study on jute netting as a means for spoil bank stabilization (Lang 1971) showed that jute netting, supplemented by barley straw mulch, was quite effective in reducing erosion on spoil banks of various ages. Seedling success was much greater under the jute netting plus straw mulch than with jute netting alone.

The effect of placement and stockpiling waste/rock and topsoil on wildlife is that habitat and less mobile wildlife species are destroyed. Leaching of spoils may also deteriorate water quality. Changes in the chemical and physical nature of the soil over time will affect the kinds of plants that can grow once the mined land is reclaimed and will, therefore, influence the type of habitat that is recreated.

REVEGETATION

Reclaiming waste disposal piles employs the same procedures as those followed on other disturbed areas, including soil redistribution and stabilization, seedbed preparation, fertilization, mulching, seeding and transplanting, irrigation, and management. The procedures are discussed individually under appropriate sections of this handbook and as a total reclamation plan for three important habitat types (Regional Reclamation Plan, Section 4).

LABOR AND MATERIALS

A scraper is needed to scalp the topsoil from the proposed dumpsite. A front-end loader and dump truck are required to load and transport waste rock from the mine processing facility to a storage area or disposal site. At the disposal site, a D9 dozer typically distributes and compacts the rock. The same heavy equipment can be used to redistribute development waste, subsoil, and/or topsoil over the pile. Furrows and depressions can be created with the dozer or a front-end loader. Surface compaction may have to be reduced by ripping, chiseling, etc. (see Water Conservation, Section 3.3.1.g). Labor and equipment costs will vary with the size of the operation. Most surface mines estimate costs of approximately $1,000 per 0.4 ha (1 acre) to remove, store, and replace 0.3 m (1 ft) of topsoil (Barth 1977).

SOURCES OF INFORMATION

- Colorado Mined Land Reclamation Board
- Utah Division of Oil, Gas, and Mining
- U.S. Soil Conservation Service
- Reclamation Consultants
- Office of Surface Mining

For addresses, see Appendix A.

References Cited:

Colorado Mined Land Reclamation Board. Rules and Regulations. Mined Land Reclamation Division. 1978.

Institute for Land Rehabilitation. Rehabilitation of western wildlife habitat: a review. USDI Fish and Wildlife Service. FWS/OBS 78/86; 1978.

Lang, R. Reclamation of strip mine spoil banks in Wyoming. Wyoming Agr. Exp. Stat. Res. J. 51; Univ. of Wyoming, Laramie. 1971. 32 p.

Moore, R.; Mills, T. An environmental guide to western surface mining. Part two: impacts, mitigation and monitoring. USDI Fish and Wildlife Service. FWS/OBS-78/04; 1977.

State of Utah. Mined Land Reclamation Act. Utah Division of Oil, Gas, and Mining. 1975.

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

Additional References:

Barth, R. C. Reclamation practices in the Northern Great Plains coal province. Mining Cong. J. 63:60-64; 1977.

c. Use of mycorrhizae to enhance the establishment of woody plants for wildlife food and cover.

PURPOSE

Most flowering plants are associated with a root-inhabiting fungi (mycorrhizae; fungus-roots). The food exchange between the roots of the host plants and the mycorrhizal fungi is a relationship beneficial both to the plant and to the fungi (Marx 1972). According to Parkinson (1978), mycorrhizae represent one of the most important and complex coupling mechanisms between ecosystem components. The response of roots to stresses, such as drought, disease, and lack of nutrients, and their patterns of growth and death may be controlled by the mycorrhizal association. The success of revegetation of mine spoils will be greatly enhanced by the inoculation of the proper species of mycorrhizae into the roots of newly planted seedlings.

Use of mycorrhizae to enhance plant growth on mine spoils is largely an experimental practice and has not been widely applied in the field at present.

DEVELOPMENT

There are two distinct kinds of mycorrhizae, ectocellular, which do not penetrate the cells of the root tissue, and endocellular, which do penetrate the cells.

Ectomycorrhizal fungi growth is stimulated by root secretions, and dispersion to other plants is primarily through root contact. Reproduction may also occur through airborne spores (Marx 1972).

Mine spoils present harsh conditions for both plant and microbial growth because of low organic content, unfavorable pH, and either coarse structure (low water retention, and, consequently, dry conditions) or compacted structure (poor drainage). For areas strip-mined and being reclaimed, most of these problems will be solved or at least lessened during the replacement of topsoil and preparation for revegetating. Tree or shrub seedlings can be inoculated with ectomycorrhizae species to help increase the chance of survival. It is important to use the ectomycorrhizae which has formed an association with the shrubs and trees to be planted.

Generally, inoculation takes place in the nursery where seedlings were grown (Ruehle and Marx 1979; Marx 1980). Other inoculation methods include introducing duff, humus, infected soil, or excised roots containing mycorrhizae into the growth medium. Although these methods normally ensure ectomycorrhizal development, they may also create undesirable results. The inoculum may lack the most desirable mycorrhizae for the particular woody species and planting site. It usually contains extraneous material, that is expensive to transport, and harmful microorganisms and noxious weeds. In addition, sufficient quantities of sporophores or colonized roots may not be available when needed.

Endomycorrhizal associations have received greatly increased study over recent years (Parkinson 1978). One problem is that endomycorrhizae have not been cultured with much success.

Aldon (1978) has found *Glomus fasiculatus*, an endomycorrhizal fungi, associated with rubber rabbitbrush. *G. fasciculatus* has also been found in association with other western species, including winterfat, mountainmahogany, skunkbush, gambel oak, littleleaf mockorange, and common Apacheplume.

Unfortunately, there is still very little information on the species of endomychorrizal fungus found with many of the major revegetation plants in the Uinta-Southwestern Utah Coal Region. In addition, no commercial inoculum is available. However, according to Aldon (1981, pers. comm. E. F. Aldon, U.S. Forest Service, Rocky Mountain Forest and Range Expt. Stn., 2205 Columbia, S.E., Albuquerque, NM), the best method for inoculation of endomycorrhizae is to collect soil from beneath native stands of mature plants of the particular species to be planted. This soil should 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 occurs in the mining process so that this soil is again placed on top of a reclaimed area, enough mycorrhizal spores may be present and make inoculation unnecessary.

In addition, Ponder (1979) assayed recently graded stripmined coal spoil and found that plants grown in this soil formed abundant endomycorrhizae in the greenhouse. He concluded that grading could be an important means of dispersing endomycorrhizal inoculum in spoil.

MANAGEMENT AND MAINTENANCE

Once the mycorrhizae has been established, it will spread naturally. Maintenance is not required.

LABOR/MATERIALS

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

According to Dr. Donald Kenney of Abbott Laboratories (pers. comm), *Pisolithus tinctorius* ectomycorrhizal inoculum is available commercially in small quantities only in the southern U.S. on a test basis. The inoculum sells for $16 per liter (1.1 quart). This volume, when applied with the injection planter developed by the USDA Forest Service, will inoculate approximately 750 seedlings.

SOURCES OF INFORMATION

U.S. Forest Service
Shrub Science Lab
735 N 500 E
Provo, UT 84601
(801) 377-5717

Rocky Mountain Forest and Range Experiment Station
USDA Forest Service
2205 Columbia SE
Albuquerque, NM 87106
(505) 766-2384

Institute for Mycorrhizal Research and Development
USDA Forest Service
Southeastern Forest Experiment Station
Forestry Sciences Laboratory
Athens, GA 30602
(404) 546-2435

References Cited:

Aldon, E. F. Endomycorrhizae enhance shrub growth and survival on mine spoils. Wright, R. A., ed. The reclamation of disturbed arid lands. Albuquerque: Univ. of New Mexico Press; 1978.

Marx, D. H. Mycorrhizae, a type of root infection beneficial to plant growth. Agrichemical Age 15(1):13-14, 16; 1972.

Marx, D. H. Role of mycorrhizae in forestation of surface mines. Proc. trees for reclamation, Lexington, KY. 1980 October 27-28. Interstate Mining Compact Commission and USDA Forest Service: 109-116; 1980.

Parkinson, D. Microbes, mycorrhizae and mine spoil. Wali, M. K., ed. Ecology and coal resource development. Elmsford, NY: Pergamon Press; 1978.

Ponder, F., Jr. Presence of endomycorrhizal fungi in recently graded coal mine spoil. J. Soil and Water Conserv. 34:186-187; 1979.

Ruehle, J. L.; Marx, D. H. Fiber, food, fuel and fungal symbients. Science 206:419-422; 1979.

Additional References:

Aldon, E. F. Endomycorrhizae enhance survival and growth of fourwing saltbush on coal mine spoils. Fort Collins, Colorado: USDA For. Serv. Res. Note RM-294, Rocky Mtn. For. and Range Exp. Stn.; 1975.

Lindsey, D. L.; Cress, W. A.; Aldon, E. F. Endomycorrhizal (vesicular-arbuscular) associations of some arid zone shrubs. Southwest Natur. 20(4):437-444; 1976.

Miller, M. R. Some occurrences of vesicular-arbuscular mycorrhizae in natural and disturbed ecosystems of the Red Desert. Can. J. Bot. 57:619-623; 1979.

Moorman, T.; Reeves, F. B. The role of endomycorrhizae in revegetation practices in the semi-arid West. II. A bioassay to determine the effect of land disturbance on endomycorrhizal populations. Amer. J. Bot. 66:14-18; 1979.

Williams, S. E.; Aldon, E. F. Endomycorrhizal (vesicular-arbuscular) associations of some arid zone shrubs. Southwest Natur. 20(4):437-444; 1976.

Williams, S. E.; Wollum II, A. G.; Aldon, E. F. Growth of Atriplex canescens (Pursh) Nutt. improved by formation of vesicular-arbuscular mycorrhizae. Soil Sci. Soc. Am. Proc. 38:962-965; 1974.

3.2.2 Wildlife Habitat Improvement and Development

a. Subsidence.

PURPOSE

Subsidence is the failure of the ground surface due to a settling of the subsurface strata. It is a naturally occurring geological phenomenon; however, it is frequently associated with underground mining. Subsidence is dependent on a variety of factors, including the physical characteristics of the site (frequency and orientation of joints and faults, shear and bulk stress potentials and the strata, overburden consolidation, soil characteristics, depth of overburden, etc.), type of mining method (room and pillar vs. block caving vs. longwall, etc.), resource recovery, and stress patterns changed by mining. Subsidence can occur without roof collapse of the mine, even in mines with an overburden thickness of 457 m (1,500 ft) or more. It is the intention of mine operators to prevent or minimize subsidence; however, depressions resulting from subsidence provide microenvironmental diversity. Such areas may be revegetated with important native forage and cover species, thereby enhancing the area's value to wildlife.

DEVELOPMENT

Perhaps the most significant impact of subsidence is its potential for altering surface and groundwater hydrology. Subsidence pits, troughs, and cracks can act as sinks for surface water, increasing infiltration and decreasing surface runoff. This presents the legal issue of surface water rights. A change in the distribution of seeps, springs, and small ponds, which are extremely important wildlife habitats in this region, can alter the distribution of wildlife dependent on these water sources.

In general, subsidence is manifested as cracks or pits, cracks being more common (Dunrud 1976). Subsidence pits (Figure 3.2-1) are frequently found over abandoned underground mines with thin overburden (e.g., 10 to 20 m). Today, such coal deposits would be strip mined. Pits may also be elongated into troughs, on the order of 30 m (100 ft) long. Pits and troughs on slopes present less of a hydrologic problem because of adequate drainage; however, those on relatively flat areas can collect water and act as sinks. Cracks may be either extentional, displaying a 0.3 m wide gap 15 m long, or contractional, which result in an 0.3 to 0.6 m, linear upbuckling of the surface. Both types of cracks are generally thought to "heal" themselves within 5 to 10 years by natural erosion with little or no effects on groundwater hydrology.

Cracks presenting human, livestock, or wildlife hazards are required to be filled in. This is usually accomplished with hand shovels. The small size of these areas presents little potential for improving the habitat for wildlife.

Figure 3.2-1. Subsidence pits over abandoned Old Monarch mine near Sheridan, Wyoming, where approximately 2.7 m of coal was removed, using room and pillar techniques, from a 12 m thick seam, under a thin, weak claystone overbuden (after Riddle 1980). Photo courtesy of Frank W. Osterwald, USGS.

Pits or troughs on slopes that have adequate drainage may simply be revegetated with proper seedbed preparation, etc. The process is discussed below. These pits will have different slopes and aspects than that of the surrounding area, which may lead to additional vegetative diversity beneficial to wildlife. The downhill side of pits with inadequate drainage may be scooped out to allow for drainage. Slope steepness may preclude the use of heavy equipment, thereby necessitating manual labor. It should be noted that, in many cases where subsidence pits occupy only a small area, more damage would be caused by using heavy equipment to recontour the pits, than the damage caused by the pits themselves. In addition, caution should be exercised when using heavy equipment on unstable subsidence areas.

The control, management, and mitigation of subsidence is governed by the State regulatory agency and the Surface Mining Control and Reclamation Act, which applies to any coal operation exhibiting surface effects. The subsidence permitting process is reviewed by Riddle (1980). As stated above, it is in the best interest of mine operators to prevent subsidence, particularly where it could be hazardous or cause "material damage" or diminished future use of structures or renewable resource lands (such lands include farmland, grazing land, silvicultural areas, aquifers, and areas for recharging aquifers and other underground waters). Practices for reclaiming subsidence cracks and pits are discussed below.

Pits on renewable resource land are required to be backfilled. Here the operator would simply use a "cat" or front-end loader, depending upon pit size, fill the pit in, and revegetate. Such areas, if revegetated with important cover and forage species, could greatly increase "edge" and the area's value to wildlife (see Planting Patterns to Increase Wildlife Diversity, Section 3.3.3.b).

Below is a possible scheme for reclaiming subsidence pits.

Seedbed Preparation

Small pit size or steep slopes may preclude the use of heavy equipment during most phases of the reclamation process. Pit slopes may need to be scarified to prepare a proper seedbed and to minimize erosion. If terraces, ledges, and pockets are created, this will allow for better water and soil retention and better vegetative establishment. Rakes, shovels, and picks may be used. Mulch, mulch with tackifying agent, burlap, soil-retaining matting, or hydromulch may be used to enhance moisture and soil retention. For more information, see Mulching, Section 3.3.1.h.

Fertilizing

Pit slopes may require soil amendments if nutrient-poor subsoil is exposed. These are discussed under Fertilization, Section 3.3.1.b. Assessment of soil characteristics will also aid in the determination of possible revegetation species.

Revegetating

Plants chosen to revegetate the pits should be based on soil type, vegetation type, revegetation potential on that site, and value to wildlife. The Plant Information Network (PIN) (Section 3.3.1.a) is a computer-based service available to the public for selecting potential revegetation species base on the above and additional parameters. See Seeding (Section 3.3.1.c), Transplanting Native Vegetation (Section 3.3.1.d), Transplanting Nursery Grown Plants (Section 3.3.1.e), Cover Crops/Preparatory Crops (Section 3.3.1.f), Restoring Big Game Range (Section 3.3.3.j), Brush Piles (Section 3.3.3.e), and other BCP's for specific techniques and practices for enhancing wildlife habitat.

MAINTENANCE AND MANAGEMENT

BCP's, such as Irrigation (Section 3.3.1.i), Pest Control (Section 3.3.1.j), and Grazing Management to Allow Vegetative Recovery (Section 3.3.1.k), may be useful for reclamation management. Additional management recommendations are provided under specific reclamation or enhancement practices.

LABOR AND MATERIALS

Costs and level of effort required are listed individually under the specific BCP's. Estimated total cost per 0.4 ha (acre) of pits may range from $500 to $5,500, depending upon size of individual pits, applicability of heavy equipment, need for soil fill material and amendments, method of revegetation (hand-broadcast seeding vs. planting bareroot shrubs, etc.), level of reclamation required, and management.

Overall, reclamation of subsidence pits employs the same practices as used on other disturbed areas inaccessible to heavy equipment, although pit reclamation is more labor intensive because of the relatively small size of the disturbed areas.

SOURCES OF INFORMATION

- Colorado Mined Land Reclamation Board
- Utah Division of Oil, Gas, and Mining
- U.S. Soil Conservation Service
- Reclamation Consultants
- Colorado School of Mines
- Office of Surface Mining

References Cited:

Dunrud, R. C. Some engineering geologic factors controlling coal mine subsidence in Utah and Colorado. U.S.G.S. Prof. Pap. 969, U.S. Gov't Printing Off., Washington, D.C.; 1976.

Riddle, J. M. Dealing with subsidence and SMCRA. Mining Engineering. pp. 1702-1705; December 1980.

b. Establishment of buffer zones.

PURPOSE

Buffer zones may be used for a wide variety of purposes, such as protecting the nesting sites of threatened and endangered species, protecting critical habitat, providing a visual screen (e.g., to hide a roadway or isolate a migration corridor), and protecting streams or other bodies of water from sedimentation and other disturbances.

DEVELOPMENT

Several important factors should be considered in utilizing buffer zones for the purposes outlined above. However, it must be emphasized that different wildlife species have different buffering needs, and zones must be established on a site-specific basis. The specific species involved and the surrounding topography will often determine the time of year a buffer zone is needed and the size and configuration of the zone. Existing vegetation and type of mining practice will dictate the need for additional protective measures.

The protection of nesting sites of threatened, endangered, and otherwise protected 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 and State wildlife agency. In the case of extremely unique or rare habitat and/or species, a professional familiar with the local situation may be needed.

In some cases, the actual need and configuration of the buffer zone may be hard to determine. In the case of golden eagles, Tyus and Lockhart (1979) found that the level and proximity of disturbances to eagle nests and other habitats (e.g., hunting perches and feeding areas) are important considerations in mitigating surface mining disturbances (see Section 3.3.3.h, Building Alternative Nest Sites for Golden Eagles). In open country, a zone of 0.8 km (0.5 mi) or more may be required around an eagle nest; whereas, 0.4 km (0.25 mi) may be sufficient if the nest is obstructed from the disturbance by a visual barrier. Because of the complexity of site-specific factors needed to determine the size of the buffer zone, Tyus and Lockhart (1979) suggest that situations be assessed on a case-by-case basis. Protection may be needed not only for nesting but also for perching and foraging habitat. (Refer to the State game and fish department, U.S. Fish and Wildlife Service, and/or the State regulatory authority for species- and site-specific guidance.)

Buffer zones may be used to screen out haul and access roads. In general, roads should be designed to go around important wildlife use areas and be hidden from view by animals using the areas. The width of the buffer zone will vary with the species of concern and site conditions.

Complete or partial fencing of stockponds or permanent impoundments with an appropriate design to allow big game access (see Section 3.1.1.d Fences) will improve shoreline cover and water quality. This practice should be compatible with postmining land use.

The development of riparian buffer zones to protect streams must be determined through consultation with the regulatory authority. These areas are set aside for the purpose of preventing erosion of streambanks and sedimentation of streams (Figure 3.2-2). In addition, these areas provide "edge" for wildlife, protective cover and a source of terrestrial wildlife water, shading and cover for aquatic species, and habitat for nesting and feeding. In essence, these zones provide many facets of fish and wildlife habitat.

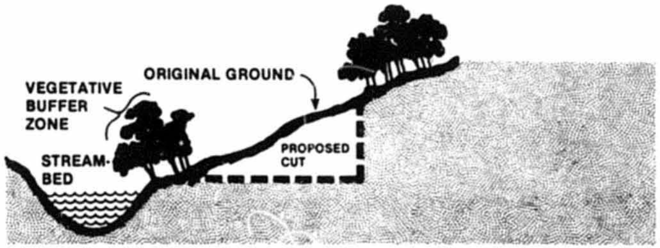

Figure 3.2-2. Vegetative buffer zones to protect stream water quality (after U.S. Environmental Protection Agency 1976).

MAINTENANCE AND MANAGEMENT

The State regulatory authority will provide guidance on specific steps to be taken for delineating, marking, and maintaining stream buffer zones. Maintenance will depend on the specific needs of a site, but, for the most part, once set aside, these areas require little management. However, they could provide an opportunity for adding food plots, planting cover, or producing clearings in such a way as to enhance the buffer zone for wildlife use (see Section 3.3.3.b, Planting Patterns to Increase Wildlife Diversity).

LABOR/MATERIALS

Labor costs will depend largely on many of the factors already discussed. Ordinarily, low or minimal costs are involved since buffer zones are largely precautionary, non-use zones around a sensitive area. Where enhancement for wildlife is incorporated into the management of a buffer zone, the degree of effort and materials will vary with each area.

SOURCES OF INFORMATION

- o State Regulatory Agency
- o Office of Surface Mining
- o State Game and Fish Department
- o U.S. Fish and Wildlife Service
- o Land Management Agencies

References Cited:

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; 1979 July 16-20; Colorado State University, Fort Collins, CO. General Tech. Rept. RM-65. Rocky Mtn. Forest and Range Expt. Station, U.S. Dept. Agr., For. Serv., 1979. p. 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.

Additional References:

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. General Tech. Rept. RM-65. Rocky Mtn. For. and Range Expt. Sta., U.S. Dept. Agr., For. Serv.; 1979. p. 264-269.

c. Rights-of-way management for wildlife.

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.

Along heavily used roads, maintenance activities of ROW should not encourage use by large animals. Deer, antelope, and elk road kills are most common along highways constructed through habitats where big game are concentrated or where highways cross migration routes (Reed et al. 1980). In addition to wildlife losses, there is often considerable damage to personal property and significant risk to personal safety (Woodard and Reed 1974). Vegetation unpalatable to wildlife should be planted to discourage grazing by big game, such as deer, elk, and antelope, and further minimize potential vehicle/ wildlife encounters. The benefits from providing more food or cover for these animals along well-used roads would be offset by increasing the chance of injury or death. Animal/vehicle collisions can also be minimized by reducing speed limits.

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

DEVELOPMENT

A substantial amount of literature is being developed on powerline ROW management for wildlife (Tillman 1976; U.S. Department of Interior 1979; Electric Power Research Institute, in press). The art of powerline ROW management for wildlife is also well-developed for many parts of the country. However, because of the diverse requirements of wildlife species, the variable terrain in a region, and surrounding land uses, all techniques suitable for a region should be considered during ROW planning and management. The publication entitled Management of Transmission Line Rights-of-Way for Fish and Wildlife (U.S. Department of Interior 1979) is an excellent manual and should be consulted. It lists practices which have been successful, as well as plant species suitable for ROW planting in many geographic areas. Several important considerations found in this manual and other publications concerning wildlife habitat management along ROW's are listed below.

Vegetation Management by Mechanical Means

Clear- and selective-cutting techniques have been widely used to manage wildlife habitat, but the specific effects of any method depend on the composition of the vegetation, climate, topography, soil conditions, time of cut, and the interval since last cutting.

For areas where trees are numerous, "hinge cutting" or the "cut-and-bend" method of cutting selected trees eventually produces a low, dense, living brush pile. This provides ideal winter cover for small game. The 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.

Bulldozing is a popular way to initially clear a ROW. Typically, seeding and replanting is necessary after the bulldozing to prevent erosion and to improve wildlife habitat (see Section 3.3.1.c, Seeding).

Brush Piling

In general, piling brush, rather than leaving cut brush on the ground or removing it, provides cover for numerous small animals. Piling brush in the downslope of natural depressions and gullies also prevents erosion (see Section 3.3.3.e, Brush Piles).

Long, narrow brush piles, less than 2 m (6 ft) high are preferable to higher rounded piles. They are most effective when placed near the "edge" of other types of habitat.

Planting and Seeding

Wildlife management through planting and seeding has been practiced for many years in the mid-Atlantic and Southeastern States. It is a relatively newer science in the West and Southwest.

Sagebrush, saltbush, bitterbush, and snowberry are some of the shrub species planted for reclaiming wildlife habitat in the West (see Section 3.3.1.c, Seeding; Section 3.3.1.d, Transplanting Native Vegetation; Section 3.3.1.e, Transplanting Nursery Grown Plants; and all the BCP's listed under Wildlife Habitat Improvement and Development).

Wetlands

Avoiding wetland areas where possible will protect these valuable and fragile resources for wildlife use. In addition, Executive Orders (Nos. 11990 and 11988) require the protection of wetlands and floodplains that may be impacted by a significant Federal action, such as a strip mine.

Where the ROW impacts wetland areas, management should concentrate on minimizing the impacts, rather than managing the wetlands.

During construction, avoid drainage ditches, spoil banks, or access roads that might restrict or prevent normal water movement.

SOURCES OF INFORMATION

References Cited:

Electric Power Research Institute. Proceedings of the second National symposium on environmental concerns in right-of-way management. Palo Alto, CA; in press.

Reed, D. F.; Giunta, B. C.; Cebula, J. J.; Money, D. L.; Doose, C. A.; Merrell, C. L.; Dillinger, K. C.; Myers, G. T.; Zimmerman, W. B.; Fleming, J. D.; McDonnell, S. L.; Kincaid, K. R.; Pojar, T. M.; Woodard, T. N.; Beck, T. D. I. Deer vehicle accidents Statewide and methods and devices to reduce them. Proj. No. W-125-R. Colorado Division of Wildlife, Dept. Nat. Resour., Denver; 1980. 53 p.

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

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.

Woodard, T. N.; Reed, D. F. Economic considerations in reduction of deer-vehicle accidents. Trans. Central Mtn. Plains Sect. Wildl. Soc. Conf. 19:18 (Abstr.); 1974.

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

In this section, the operator will find a number of BCP's which facilitate restoration of disturbed areas for wildlife use as soon as possible following completion of mining. Other BCP's provide alternate reclamation approaches to enhance or provide new habitat for a desired wildlife group, e.g., fish, waterfowl.

3.3.1 Revegetation

a. Use of the Plant Information Network (PIN) to aid in selection of revegetation plants.

PURPOSE

The Plant Information Network (PIN) is a computer-based service, available to the public, developed to store, organize, and rapidly retrieve information on the native and naturalized vascular plants of several Western States. The PIN system data bank currently contains ecological and economic information on approximately 5,000 plants found in Colorado, Montana, North Dakota, Wyoming, and Utah. The system also contains taxonomic, biological, and geographic distribution data for approximately 5,000 species in the region.

DESCRIPTION OF THE SYSTEM

The information in the PIN data bank is in the form of "descriptors" and "descriptor states". Descriptors correspond to the attributes of the plants included in the system. Descriptor states represent the possible ratings a plant may have for a given descriptor. For example: high, medium, and low are the descriptor states for the descriptor LONG-TERM REVEGETATION POTENTIAL. PIN currently lists information on over 500 descriptors under the general headings of taxonomic, geographic, biologic, ecologic, and economic plant attributes. The taxonomic, geographic, and biologic descriptors have been stored for all plants in the data bank. Many of the ecologic and economic descriptors, however, have been examined only for plants identified as important for reclamation, rangeland, wildlife habitat, legal status, or other resource management concerns. These plants are referred to as "priority species."

The list of descriptors and descriptor states under the "economic" heading shown in Table 3.3-1 indicates PIN's value in being able to identify potential plants for use in revegetating wildlife habitat and rangeland. Descriptors and descriptor states under the "ecologic" heading are also valuable as indicators of the growth requirements of each species.

Table 3.3-1. List of descriptor and descriptor states under the general heading of "Economic Attributes" in the PIN data bank.*

Human Health and Food Value

HAYFEVER CAUSING (yes, maybe, no)

EDIBLE (yes, yes-qualified, no, poisonous)

Reclamation Planting

CULTURE (a text on planting requirements of a species)

EROSION CONTROL POTENTIAL (high, medium, low)[a]

ESTABLISHMENT REQUIREMENTS (high, medium, low)[a]

SHORT-TERM REVEGETATION POTENTIAL (high, medium, low)[a]

LONG-TERM REVEGETATION POTENTIAL (high, medium, low)[a]

WEEDINESS (noxious-CO, noxious-CO/MT, noxious-CO/MT/ND, noxious-CO/MT/ND/WY, noxious-CO/MT/WY, noxious-CO/ND, noxious-CO/ND/WY, noxious-CO/WY, noxious-MT, noxious-MT/WY, noxious-CO/WY, noxious-ND, noxious-WY, economic, colonizing, non-weedy)

Wildlife Values

Cover

ELK COVER VALUE (good, fair, poor)[a]

MULE DEER COVER VALUE (good, fair, poor)[a]

WHITETAIL DEER COVER VALUE (good, fair, poor)[a]

ANTELOPE COVER VALUE (good, fair, poor)[a]

UPLAND GAME BIRD COVER VALUE (good, fair, poor)[a]

WATERFOWL COVER VALUE (good, fair, poor)[a]

SMALL NON-GAME BIRD COVER VALUE (good, fair, poor)[a]

SMALL MAMMAL COVER VALUE (good, fair, poor)[a]

Table 3.3-1 (concluded)

Food Value

ELK FOOD VALUE (good, fair, poor)[a]

MULE DEER FOOD VALUE (good, fair, poor)[a]

WHITETAIL DEER FOOD VALUE (good, fair, poor)[a]

ANTELOPE FOOD VALUE (good, fair, poor)[a]

UPLAND GAME BIRD FOOD VALUE (good, fair, poor)[a]

WATERFOWL FOOD VALUE (good, fair, poor)[a]

SMALL NON-GAME BIRD FOOD VALUE (good, fair, poor)[a]

SMALL MAMMAL FOOD VALUE (good, fair, poor)[a]

<u>Livestock Values</u>

Palatability

CATTLE FORAGE PALATABILITY (good, fair, poor)[a]

SHEEP FORAGE PALATABILITY (good, fair, poor)[a]

HORSE FORAGE PALATABILITY (good, fair, poor)[a]

Nutrition

ENERGY VALUE (good, fair, poor)

PROTEIN VALUE (good, fair, poor)

Toxicity

POISONOUS-LIVESTOCK (major, minor, mechanical injury, suspected, no)

---

*Descriptors are printed in capital letters, descriptor states in parenthesis.

[a]Descriptors provide a separate rating for each of the five States in the system. For example, erosion control potential ratings can be obtained for a given plant that are specific to Colorado, Montana, North Dakota, Utah, or Wyoming.

USE AND AVAILABILITY

An example of the type of information that can be obtained by using the PIN system is shown in Table 3.3-2. The example in Table 3.3-2 is a response to the question, "What are some possible revegetation species for livestock forage in Moffat County, Colorado." Numerous other questions can be asked by selecting appropriate combinations of the descriptors and descriptor states listed in Table 3.3-1. Staff members who handle PIN inquiries can help format these questions so that only the information specifically requested is received, eliminating the need for sorting through unnecessary data.

PIN is now available for public use. Charges for the use of the system are minimal and can be obtained by contacting the PIN staff at the address below.

U.S. Fish and Wildlife Service
Office of Biological Services
Western Energy and Land Use Team
2627 Redwing Road, Drake Creekside One
Ft. Collins, Colorado 80526
phone: (303) 226-9389, FTS 323-5389

SOURCES OF INFORMATION

Additional References:

Evans, G.; Vories, K. C. The plant information network: volume IV. A subject guide and annotated bibliography to selected literature on land reclamation and rehabilitation in the western United States. Ft. Collins, CO: Western Energy and Land Use Team, Off. of Bio. Serv. USDI Fish and Wildlife Serv.; 1977.

Vories, D. C.; Sims, P. L. The plant information network: volume I. A user's guide. Ft. Collins, CO: Western Energy and Land Use Team, Off. of Bio. Serv. USDI Fish and Wildlife Serv.; 1977a.

Vories, K. C.; Sims, P. L. The plant information network: volume II. Reclamation and PIN in northwestern Colorado. Ft. Collins, CO: Western Energy and Land Use Team, Off. of Bio. Serv. USDI Fish and Wildlife Serv.; 1977b.

Vories, K. C.; Sims, P. L. The plant information network: volume III. Reclamation and PIN in Powder River Basin of Montana and Wyoming. Ft. Collins, CO: Western Energy and Land Use Team, Off. of Bio. Serv. USDI Fish and Wildlife Serv ; 1977c.

Table 3.3-2. Possible revegetation species for livestock forage in Moffat Co., Colorado.

MEMO Infraspecific--
Infraspecific names refer to subspecies, varieties, or forms. When a plant has an infraspecific name, it is printed immediately after the species name. If no infraspecific name is recognized, the word "None" is printed. Occasionally PIN obtains County records for plants which have not been keyed out to variety or subspecies. In such instances, the word "Unknown" is printed after the species name, indicating we are uncertain which infraspecies the record should be tied to.

MEMO Abbreviations used for origin descriptor states--
Austral = Australia-Pacific
North A = North America
South A = South America

MEMO Abbreviations used for potential biomass production, erosion control potential, establishment requirements, short-term revegetation potential, and long-term revegetation potential descriptor states--
H = High
M = Medium
L = Low
V = Very Low

MEMO Abbreviations used for poisonous-livestock descriptor states--
Mechani = Mechanical Injury
Suspect = Suspected

COLUMNS 10,-2,38=3,-1,32,-1,7,-2,13,-2,1,-1,1,-2,7

Print, habit, genus, species, infraspecific, common name, origin, habitat, establishment requirements-CO, long-term revegetation potential-CO, poisonous-livestock for plants with Moffat-CO, present or reported and minimum elevation-Co, less than or equal to 8,000 and maximum elevation-CO, greater than or equal to 7,000 and establishment requirements-CO, low or medium and long-term revegetation potential-CO, high or medium and cattle forage palatability-CO, good or fair and weediness, or colonizing and not poisonous-livestock, major.

Table 3.3-2 (continued)

Column Descriptors
A = Habit
B = Genus
Species
Infraspecific
C = Common name
D = Origin
E = Habitat
F = Establishment requirements-CO
G = Long-term revegetation potential-CO
H = Poisonous-livestock

List 36

Response

A	B	C	D	E	F	G	H
Forb	Hedysarum boreale None	Northern sweetvetch	Native	Dry-Moist	M	M	No
Forb	Linum lewisii None	Lewis flax	Native	Dry	M	M	Suspect
Forb	Medicago sativa None	Alfalfa	Europe	Moist	M	M	Minor
Forb	Monarda fistulosa menthaefolia	Mintleaf beebalm	Native	Moist	M	M	No
Forb	Penstemon strictus strictus	Rocky Mountain penstemon	Native	Dry	M	M	
Forb	Trifolium repens None	White clover	Europe	Moist	M	M	Minor
Grasslike	Agropyron cristatum None	Fairway wheatgrass	Asia	Dry-Moist	M	H	No
Grasslike	Agropyron dasystachyum riparium	Streambank wheatgrass	Native	Moist	M	H	No
Grasslike	Agropyron dasystachyum dasystachyum	Thickspike wheatgrass	Native	Dry	M	H	No
Grasslike	Agropyron intermedium intermedium	Intermediate wheatgrass	Europe	Dry-Moist	M	M	No
Grasslike	Agropyron smithii None	Western wheatgrass	Native	Dry-Moist	M	H	No
Grasslike	Agropyron spicatum inerme	Beardless bluebunch wheatgrass	Native	Dry	M	H	No

Table 3.3-2 (concluded)

A	B	C	D	E	F	G	H
Grasslike	Agropryon spicatum spicatum	Bearded bluebunch wheatgrass	Native	Dry	M	H	No
Grasslike	Agropyron trachycaulum unilaterale	Bearded slender wheatgrass	Eurasia	Dry-Moist	L	M	No
Grasslike	Agrostis stolonifera None	Carpet bentgrass	Europe	Moist	M	H	No
Grasslike	Bromus inermis inermis	Smooth brome	Eurasia	Dry-Moist	L	H	No
Grasslike	Bromus marginatus None	Big mountain brome	Native	Dry-Moist	L	M	No
Grasslike	Elymus canadensis None	Canada wildrye	Native	Dry-Moist-Wet	M	M	No
Grasslike	Elymus cinereus None	Great basin wildrye	Native	Dry-Moist	M	H	No
Grasslike	Eragrostis trichodes trichodes	Sand lovegrass	Native	Dry	M	M	No
Grasslike	Festuca idahoensis None	Idaho fescue	Native	Dry-Moist	M	M	No
Grasslike	Phleum pratense None	Timothy	Europe	Moist	M	M	No
Grasslike	Poa ampla None	Big bluegrass	Native	Dry-Moist	M	H	No
Grasslike	Poa pratensis None	Kentucky bluegrass	Eurasia	Dry-Moist	L	M	No
Grasslike	Puccinellia airoides None	Nuttall alkaligrass	Native	Moist-Wet	M	M	No
Grasslike	Sporobolus airoides None	Alkali sacaton	Native	Dry-Moist	M	H	No
Grasslike	Sporobolus cryptandrus None	Sand dropseed	Native	Dry	M	M	No
Grasslike	Stipa viridula None	Green needlegrass	Native	Dry	M	H	Mechani
Shrub	Atriplex canescens None	Fourwing saltbush	Native	Dry	M	H	Minor
Shrub	Ceratoides lanata None	Common winterfat	Native	Dry-Moist	M	M	Minor
Shrub	Ephedra viridis viridis	Green ephedra	Native	Dry	M	M	Suspect
Shrub	Rosa woodsii None	Wood's rose	Native	Dry-Moist	M	M	No
Shrub	Symphoricarpos oreophilus None	Mountain snowberry	Native	Dry-Moist	M	H	No
Shrub-tree	Cercocarpus montanus None	True mountainmahogany	Native	Dry	M	M	Minor
Shrub-tree	Salix amygdaloides None	Peachleaf willow	Native	Wet	M	M	No
Shrub-tree	Salix interior None	Sandbar willow	Native	Moist-Wet	M	H	No

No. of items in query response = 36
No. of items in the data bank = 4,297
Percentage of response/total data bank = .838

68

b. Fertilization.

PURPOSE

Fertilizers are added to the soil to supply one or more elements essential for plant growth. If the soil material contains less of a certain nutrient than is required for the initial establishment and maintenance of vegetation, fertilizers or other soil amendments are needed.

DEVELOPMENT

In semiarid regions, such as the Uinta-Southwestern Utah Coal Region, nitrogen and phosphorus are the nutrients most often found deficient (Tucker and Day 1980). The typical method of fertilizing at these mines is by broadcasting, followed by disking, chisel plowing, harrowing, or some other treatment designed to incorporate fertilizer into the top 10 to 15 cm (4 to 6 in) of soil.

Deficiencies of other essential plant nutrients have seldom been recognized in mine spoils in this region; however, research on this subject is limited. Power et al. (1978) reports that, in some areas, exchangeable magnesium levels may be high enough to restrict calcium uptake, even from soils containing 10% free calcium carbonate. Also, molybdenum levels in plants may occasionally be high enough to interfere with copper metabolism in livestock.

Two other problems should be considered before proceeding with fertilization:

- o The use of fertilizer may reduce the amount of water available for plant absorption, especially during the critical period of seed germination.
- o Fertilization at the time of seeding often benefits the annuals or weeds more than the seeded species.

The first problem can be solved by either not fertilizing or by deciding that the benefits of fertilizing outweigh the disadvantages of decreased water absorption. Delaying fertilization for one year may help solve the latter problem.

Researchers have shown that tests developed over the last 25 years to determine soil nutrient deficiencies on unmined lands have proven useful on reclaimed mine soils also, whether the proposed land use is grazing or crop production. Before a fertilization plan, which includes rate and timing, can be formulated, a soil test should be made. In addition, the following factors should be considered:

- o what species of grasses, forbs, or shrubs are to be planted;

- o the available water supply in the rooting zone at seeding;
- o the thickness of the topsoil; and
- o whether an organic mulch will be used.

The use of native plants for revegetation has increased over the past five years. Native plants have evolved under conditions of infertile soils, often do not have high nutrient requirements, and may not require the amount of fertilizer of introduced species. Another influence on amount of fertilizer is the water supply. What is the expected precipitation? Will supplementary water be used? Thickness of topsoil influences the potential yield of grasses (U.S. Agricultural Research Service and North Dakota Agricultural Experiment Station 1977) and should be considered when determining fertilization rate (see Section 3.2.1.a, General Procedures). In other words, topsoil of 4.7 cm (12 in) would generally require less fertilizer than topsoil of 1.6 cm (4 in). In addition, if organic mulch is used, nitrogen fertilization must be increased because 9.1 kg (20 lb) or more of nitrogen per 0.9 MT (ton) of mulch may be consumed or "tied up" by microbial metabolism as the mulch decomposes.

To correct a phosphorus deficiency, P_2O_5 (phosphorus pentoxide) is added at a recommended rate of 89.1 kg/ha (100 lb/acre) on coarse-textured soils and 178.2 kg/ha (200 lb/acre) on fine-textured clay soils (U.S. Forest Service 1979). (This is a general figure, and specific rates should be determined by laboratory analyses of soil material from the site in question.) Because phosphate-phosphorus is not water soluble, it must be incorporated into the root zone to be effective. In semiarid regions, the best results are obtained if the soil is treated prior to seeding. Phosphorus fertilization has a long-lasting effect and the soil/ spoil may need only one application.

Nitrogen fertilizer, applied at 35.6 to 44.5 kg/ha (40 to 50 lb/acre), may be necessary to correct a nitrogen deficiency. With straw mulch, this amount would have to be doubled (U.S. Forest Service 1979). If seeding is done in the late fall, nitrogen should be applied after germination in the spring. In spring, nitrogen can be applied at the time of seeding before expected moisture, if possible. As mentioned above, if annual weeds are a problem, nitrogen may be applied at the beginning of the second growing season to avoid fertilizing the weeds. Nitrogen is water soluble and can be spread on the soil surface. Nitrogen availability is more short-term than phosphorus, and more than one initial application may be required.

Nutrient deficiencies can be corrected by the application of fertilizer in the form of ammonium nitrate, phosphoric acid, and potash. These compounds provide nitrogen, phosphorus, and potassium, respectively. These compounds can be obtained as a straight fertilizer containing 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. An analysis of 0-46-0 indicates that this fertilizer is concentrated superphosphate and provides only phosphorus at a percentage of 46% by weight (100 kg [220 lbs] of fertilizer contains 46 kg [101 lbs] of phosphorus).

Likewise, a fertilizer with an analysis of 10-10-10 provides 10 kg (22 lbs) each of nitrogen, phosphorus, and potassium per 100 kg (220 lbs) of fertilizer. Minimum rates of fertilizer are required by some State regulatory agencies.

For more information on types of fertilizers, rates, and methods of fertilization, see the publications under "Additional References."

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. Refertilization may be necessary to correct these conditions.

Nitrogen may have to be added every two or three years on certain nitrogen-deficient soils. If the vegetation on reclaimed areas is a light green color and/or there is a substantial reduction in ground cover, nitrogen fertilization should be considered.

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 the type of equipment and the number of hours of equipment time required for tilling.

Soil amendments can be performed by a number of methods. Application costs vary depending upon method and terrain. A particularly rough area may require many man-hours of hand labor, but only one hour of aircraft time. Combining the application of fertilizer with seeding by using a hydroseeder or dry-application blower can reduce costs considerably.

Phosphorus is added prior to seeding, while nitrogen may be added during seeding, which reduces labor costs. A spreader can be mounted on a trailer or a truck and driven or pulled near the area to be treated. For steep, rough terrain or a confined area, a fertilizer blasting gun may be used. The blasting gun is hand-held and connected to a portable air compressor which should allow fertilizer granules to be sprayed up to 23 m (75 ft) if maintained at a pressure of 1,278 to 1,420 kg/cm^2 (90 to 100 lb/in^2). For more information on equipment for fertilization, see the catalog of revegetation equipment by Larson (1980).

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.

The cost of a 22.7 kg (50 lb) bag of phosphorus (0-46-0), which contains 10.4 kg (23 lbs) of phosphorus, is approximately $15. To apply 89.1 kg phosphorus/ha (100 lb/acre) would require 194 kg (430 lbs) of 0-46-0 fertilizer at a cost of $129/ha ($52/acre). Nitrogen applied as ammonium nitrate (33-0-0) costs $12/22.7 kg (50 lb). An application of 44.5 kg/ha (50 lb/acre) would require 134 kg (295 lbs) of 33-0-0 fertilizer at a cost of $70.80/ha ($28.66/acre).

SOURCES OF INFORMATION

- State Regulatory Authority
- Office of Surface Mining
- North Dakota Agricultural Experiment Station
- USDA Northern Great Plains Research Center
- U.S. Soil Conservation Service
- Colorado Agricultural Experiment Station
- Utah Agricultural Experiment Station

For addresses, see Appendix A.

References Cited:

Larson, J. E. Revegetation equipment catalog. USDA Forest Service Equipment Development Center, Missoula, MT 59801; 1980. p. 83-87.

Power, J. F.; Ries, R. E.; Sandoval, F. M. Reclamation of coal-mined land in the Northern Great Plains. J. of Soil and Water Conservation 33(2):69-74; 1978.

Tucker, T. C.; Day, A. D. Vegetative reclamation of mine wastes and tailings in the Southwest. Brittain, R. G.; Myhman, M. A., eds. 1980 April 23-25; Mine Reclamation Center, U. of Arizona, Tucson, AZ; 1980. p. 7-1 to 7-3.

U.S. Agricultural Research Service and North Dakota Agricultural Experiment Station. North Dakota progress report on research on reclamation of strip-mined lands - update 1977; 1977. p. 17-19.

U.S. Forest Service. User guide to soils. USDA For. Serv. Gen. Tech. Rep. INT-68. Intermt. For. and Range Exp. Stn., Ogden, UT 84401; 1979. 85 p.

Additional References:

Barth, R. C. Reclamation practices in the Northern Great Plains coal province. Mining Cong. J. 63(5):60-64; 1977.

Soil Improvement Committee, Calif. Fertilizer Assn. Western fertilizer handbook. Danville, IL: Interstate Printers and Publishers, Inc.; 1975.

Tisdal, S. L.; Nelson, W. L. Soil fertility and fertilizers. New York, NY: MacMillan Publications; 1975.

c. Seeding.

PURPOSE

For the Uinta-Southwestern Utah Coal Region, the major post-mining land uses will be livestock grazing and wildlife habitat. In considering wildlife habitat as an important land use, the primary revegetation goal is to produce hardy, drought resistant plants which will provide food and cover for various wildlife species.

DEVELOPMENT

Much consideration is being given to the use of native species in designing seed mixtures. Native species are adapted to local climatic conditions, and introduced species, in general, possess a wider range of adaptation to soils and climate. When mixtures of native and introduced species are used, the plant community is dominated by a small number of vigorous, highly productive introduced species, even if these varieties comprise only a small percentage of the seed mixture (DePuit et al. 1980). Berg (1975) recognized that communities on reclaimed mined lands, when dominated by certain introduced species, would be best used for grazing pastures; whereas, lands reclaimed with more diverse, native plant species would be better for more general grazing and diversified wildlife habitat. In any case, the State regulatory authority will be the final decision maker on the adequacy of the operator's proposed seed mixture.

Producing a climax community from seed may not be realistic. A more attainable goal would be to produce a successional stage that is easier to establish, which can then gradually change toward the expected climax community. Because the soil has been altered to some degree in a reclamation project (it is impossible to replace the soil profile exactly as it was), the suitability of the area to preexisting plant species may be radically affected (Moore et al. 1977). The best adapted inhabitants of these disturbed environments are annual grasses and forbs, including introduced species. Few of the original native species are capable of reestablishing themselves because they belong to a more advanced successional stage than a newly disturbed mine site can support.

In developing a seed mixture for a specific site, the following considerations are important: soil conditions; micro-climate; slope; aspect; and water availability. To prepare a mixture of predominantly native species, seed availability, successional stages of surrounding plant communities, and wildlife and livestock food and cover values are all important factors. Seed mixtures can be site specific or can be used for a certain ecotype, such as woody draws or steep uplands.

Selection of native species for seeding is dependent upon availability of seeds that are adapted to the soil and climate of the mine site. Seeds of many species are available commercially from collectors and seed companies.

Seeds of some native plant species must be collected from native stands, since reliable commercial seed production techniques have not been developed for some species.

Seed production from wildland populations can be unpredictable from year to year (Institute for Land Rehabilitation 1979). Low precipitation, frost, insect damage, disease, and grazing can lower seed quality or even prevent production. Thus, most native species produce abundant seed crops only in favorable years.

Methods of Seeding

An important problem in reclaiming western coal lands is that both native and introduced species may require amounts of water beyond natural precipitation (see Section 3.3.1.g, Water Conservation). The method of seeding is also important. Seeds need to be planted at proper depths with as much conservation of moisture as possible.

Drilling and broadcasting are the two most commonly used methods in the West. Both drilling and broadcasting can be done by machines or by hand. Drilling is considered the superior method of seeding where site conditions permit; however, in some cases, the site may be accessible only to a specific type of broadcast seeding. In the Uinta-Southwestern Utah region, most mines drill seed when possible and broadcast on slopes inacessible for drilling. Seeding depths range from 1.3 to 3.8cm (0.5 to 1.5 in).

The following table (Table 3.3-3) lists the advantages and disadvantages of broadcasting and drilling.

Table 3.3-3. Seeding methods - advantages and disadvantages (from Cook et al. 1974; Depuit and Dollhopf 1978; Frischknecht and Ferguson 1979; Benally 1980).

	Advantage	Disadvantage
Broadcasting	Lower cost	Seed desiccation if seed is inadequately covered with soil
	Applicable to small, rough or steep sites	Uneven soil coverage
	Useful for seed mixtures with variable size, weight, structures	More seed per unit area
	Faster method of seeding	Loss of seed to rodents can be great

Table 3.3-3 (concluded)

	Advantage	Disadvantage
		Seed planting very variable and loss of seed to wind can be great
Drilling	Applicable to mulched surfaces	Restricted to smooth sites with gradual slopes
	More uniform planting depth and resultant stands of seeded plants	Slower Higher cost
	More rapid production of seeded plants	Requires more intensive seed-bed preparation
	Less seed per unit area	All seeds planted at same depth regardless of requirements

In general, broadcast seeding has traditionally taken twice the amount of seed as drilling (Cook et al. 1974). In a recent study by DePuit et al. (1980), which compared both methods of seeding native species, initial establishment of seedlings was somewhat slower under broadcasting than drilling, but the ultimate (2 to 3 years) plant densities were similar under equal seeding rates.

As more complex mixtures of seeds of many different sizes are developed, drilling has become less efficient. Broadcast seeding, when preceded by a chisel plow (see Section 3.3.1.g, Water Conservation) and followed by a culti-packer, chain, drag bar, or spike tooth harrow to cover the seed (ideally with 0.6 to 1.3 cm [0.25 to 0.5 in] of soil), or when broadcasting follows a land imprinter, is an economical and productive alternative to drilling. The Colowyo Coal Company has had success broadcasting seed at rates equal to drilling when seeding in the fall following seed bed chiseling (R. Adkinson, pers. comm.).

A hydroseeder is an alternative broadcast method that applies seed and mulch by means of a high-pressure stream of water and is an especially fast, efficient method of seeding steep, hard-to-reach areas. Disadvantages are that large amounts of water must be available, the seed may be held off the ground by the mulch fibers, many seeds may be damaged by the agitators and pump, and seed may germinate due to water in mulch but die before the root system can be established in the soil. For more information on types of broadcast and drill seeders, consult the USDA Forest Service Revegetation Equipment Catalog (Larson 1980).

Seeding of Shrubs

The seeding of shrubs, although an economical practice, has been limited in the past by unavailability of seed and a lack of understanding of seeding techniques. Crofts and McKell (1977) can be consulted for a list of seed and planting material sources in the Western States. Most States have a similar list which is usually available from the U.S. Soil Conservation Service field offices and/or the regulatory authority. Plummer et al. (1968) provides data on the establishment requirements of shrubs, particularly for species important to big game (see Section 3.3.3.j, Restoring Big Game Range).

Shrub seeds usually require a longer period of stratification (exposure to moisture and low temperature) than do seeds of most herbs. Consequently, shrub seedling growth is often suppressed by the more robust herbs. According to Crofts and Parkin (1979), an acceptable shrub seedling density can be obtained when planted at a rate of about six to ten seeds per 0.093 m^2 (1 ft^2), even when seeded with highly competitive grasses and forbs.

Seeding Rates

Rate of seeding depends on seed quality. To account for quality, seeding rates should be expressed as pure live seed (PLS). PLS refers to the amount of live seed of the desired species in a bulk lot. An example given by Cook et al. (1974) is that if an order for 147.7 kg (325 lbs) of grass seed had a 90% germination and 95% purity rates, the PLS would be 85.5% or 126.3 kg (278 lbs) pure live seed (.90 x .95 x 147.7 = 126.3).

There are several other factors that influence the rate of seeding. As discussed, broadcasting usually requires more seed than drilling. The general rule is to broadcast at twice the drilled rate. Drier sites generally require 1.5 to 2.0 times more seed than wetter sites (U.S. Soil Conservation Service 1976). West and south slopes should have the quantity of seed increased by 50 to 100%. Different species also have different seeding rates. For a small-seeded species, fewer pounds per acre are required because of the greater number of seeds per pound.

Season of Planting

In the Uinta-Southwestern Utah Coal Region, either mixtures of grasses and legumes or cool season grasses alone are suited to late summer seeding (National Academy of Sciences 1974). Warm season species should be seeded in the spring just prior to the period of the most favorable growing conditions, usually April. However, it is often too wet to seed in the spring.

Seeding a mixture of both cool and warm season species presents a problem. The decision on when seeding is most appropriate for this kind of mixture should be based on the dominant species being planted and the preceding and current climatic conditions. Late fall seedings (after a killing frost and before the ground freezes) are best when mixtures of grasses, forbs, and shrubs are used because the winter period provides stratification of the seed (Cook et al. 1974).

MAINTENANCE AND MANAGEMENT

Management of seeded areas may require fertilization or supplemental watering depending on the site conditions. Choosing species with self-generating, long-lived, disease-resistant, and pest-resistant characteristics will lessen the amount of maintenance required.

LABOR/MATERIALS

There is a wide range of seeding equipment on the market from aircraft spreaders to seed dribblers to rangeland drills. Space does not allow even a brief description of all the possible seeders, but more information is available from the USDA Forest Service Revegetation Equipment Catalog (Larson 1980).

Seed sources are listed in Hinkle et al. (1981) and Everett (1981) or can be obtained from the State regulatory authority.

The cost of seeding mixtures will vary tremendously depending on availability of seed, amount of seed used, and species selected. Crofts and Parkin (1979) compared costs of seeding and transplanting shrubs by extrapolating data from the Colowyo Mine and the Energy Fuels Mines. The cost of each shrub established from seeding ranged from $0.001 to $0.031 per plant while transplanting one shrub using modified front end loaders, based on an expected 70% survival rate, was $9.89 per surviving seedling. Projected costs for reestablishing shrub densities on surface-mined land using different planting methods are summarized in Section 3.3.1.d, Transplanting Native Vegetation. The cost variation for transplanting is tremendous; this makes seeding an attractive method of shrub propagation.

SOURCES OF INFORMATION

- State Regulatory Authority
- Office of Surface Mining
- U.S. Forest Service, Rocky Mtn. Forest and Range Experiment Station
- U.S. Forest Service, Intermountain Forest and Range Experiment Station
- U.S. Forest Service - Equipment Development Center
- U.S. Soil Conservation Service
- USDA High Plains Grasslands Research Center
- State Agricultural Research Stations

For addresses, see Appendix A.

References Cited:

Benally, R. Seed drilling and broadcasting. Brittain, R. G.; Myhrman, M. A., eds. Vegetative reclamation of mine wastes and tailings in the Southwest; 1980 April 23-25, Tucson, AZ. Mine Reclamation Center. Arizona Mining and Mineral Resources Research Institute; 1980. p. 13-1 to 13-5.

Berg, W. A. Revegetation of land disturbed by surface mining in Colorado. Wali, M. K., ed. Practices and problems of land reclamation in western North America. Fargo, ND; University of North Dakota Press; 1975.

Cook, C. W.; Hyde, R. M.; Sims, P. L. Revegetation guidelines for surface mined areas. Colorado State University Science Series No. [illegible]; 1974.

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

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

DePuit, E. J., Coenenberg, J. G.; Skilbred, C. L. Establishment of diverse native plant communities on coal surface-mined lands in Montana as influenced by seeding method, mixture and rate. Montana Agr. Exp. Sta., Bozeman; Research Report 163; 1980.

DePuit, E. J.; Dollhopf, D. J. Revegetation research on coal surface-mined lands at West Decker Mine, Decker, MT: Progress Report 1975. Montana Agr. Exp. Sta., Bozeman; Research Report 133; 1978.

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

Frischknecht, N. C.; Ferguson, R. B. Revegetating processed oil shale and coal spoils on semi-arid lands; interim report. Office of Research and Development, U.S. Environ. Protection Agency; EPA-600/7-79-068; 1979.

Hinkle, C. R.; Ambrose, R. E.; Wenzel, C. R. A handbook for meeting fish and wildlife information needs to surface mine coal. OSM Region 5, Washington, D.C.; USDI Fish and Wildlife Service. FWS/OBS-79/48.3.5; 1981.

Institute for Land Rehabilitation. Selection, propagation, & field establishment of native plant species on disturbed arid lands. Utah Agricultural Exp. Sta. Bull. 500; 1979.

Larson, J. E. Revegetation equipment catalog. USDA Forest Service Equipment Development Center, Missoula, MT; 1980.

Moore, R. T.; Ellis, S. L.; Duba, D. R. Advantages of natural successional processes on western reclaimed lands. Paper presented at the 5th Symposium on surface mining and reclamation. Louisville, KY; 1977.

National Academy of Sciences. Rehabilitation potential of western coal lands. Study Committee on the potential for rehabilitating lands surface mined for coal in the western United States. Cambridge, MA: Bullinger Publishing Company; 1974.

Plummer, A. P.; Christensen, D. R.; Monsen, S. B. Restoring big game range in Utah. Utah Div. of Fish and Game Publ. 68-3; 1968.

U.S. Soil Conservation Service. Critical area planting. Technical Guide Sec. IV, No. 342; 1976.

d. Transplanting native vegetation.

PURPOSE

In addition to being valuable in a situation where seeding is likely to fail, the transfer of existing vegetation from an area not yet mined to a location ready for planting offers the following advantages:

- The vegetation is growing in the area and is already adapted to the site-specific environmental factors.
- The soil-vegetation unit contains a portion of the soil profile and community, including the varied soil microorganisms (e.g., mycorrhizae) that enhance the health of the plants.
- Food and cover for wildlife are provided.
- The mature plants immediately provide seed sources and centers for vegetative reproduction, which hasten the revegetation of the surrounding area.
- Species that cannot be effectively seeded or planted as nursery stock can be transplanted.
- Patches of native vegetation can enhance the aesthetic value of the site.

DEVELOPMENT

Woody Vegetation

Two different methods are being used for transplanting native woody vegetation in the arid West. One is a tree spade which is mounted on a front-end loader (FEL). This can be used with a transport trailer (Larson and Knudson 1978,; U.S. Forest Service 1980b). The tree spade has been tried at the Glenharold, Edna, Energy, Trapper, and Western Energy Mines, but is in regular use only at the Western Energy Mine. The other method is to use a FEL, for which two modified transplant buckets have been developed (Frizzell et al. 1980; Larson 1980; U.S. Forest Service 1980a; Carlson et al. 1981). Use of a FEL with a transplant bucket has a large advantage over other methods because FEL's are widely used at all western surface mines and operate effectively on rocky soils where tree spades do not.

Tree Spade

The tree spade is designed to dig and transplant trees and shrubs with a minimum of root damage and is widely used in the nursery business. The plants are transplanted in a ball of soil that remains undisturbed and keeps the roots intact. Tree spades are available in three- or four-blade models, the former usually operating faster and the latter able to dig deeper. The blades are lowered into the ground hydraulically to form a soil ball which can be transported in the spade or loaded onto a truck or trailer. Trees up to 7.6 cm (3 in) in diameter have been transplanted on mined lands. Leveling devices ensure that the tree is upright in the transplant hole. For use on mined lands, the spade can be mounted on trucks, tractors, trailers, or FEL's. Limitations include:

- Use of the tree spade is restricted to slopes of less than 15% to ensure adequate depth of the soil ball and adequate roots on the downhill side.
- The tree spade can be used only on sites with few rocks so that the spade can dig effectively.
- The spade cannot be used on species with long tap roots.
- Transportation distance should be less than 1.6 km (1 mi) due to the travel time needed; if distances are greater than 1.6 km (1 mi), then a transport trailer should be used.
- Tree spades are more expensive than the use of FEL's (see Table 3.3-4).

Table 3.3-4. Projected costs required to reestablish shrub densities on surface-mined lands in northwestern Colorado (modified from Crofts 1981).

Cost/0.4 ha (acre) of various shrub planting methods				
Seeding	FEL	Bareroot	Tree spade	Containerized
$0.031/plant	$3.37/plant	$8.91/plant	$28.14/plant	$42.35/plant

The restriction of use to sites with virtually no rocks poses severe limitations on utility of the tree spade.

More information on the use of the tree spade for transplanting woody plants on disturbed western lands can be found in Dressler and Knudson (1976), Larson (1980), Larson and Knudson (1978), Jensen and Hodder (1979), and U.S. Forest Service (1980b).

An experimental transplant system using a FEL mounted tree spade plus a transport trailer has been developed and tested by the U.S. Forest Service Equipment Development Center in Missoula, MT (Figure 3.3-1). A Vermeer Model TS-44A Tree Spade (four-blades) mounted on an articulated FEL was developed and used along with a specially built trailer that carries eight trees or shrubs. The tree transport truck consists of two rows of four cone-shaped pods. A crew of three is required, one to operate the FEL-spade, one working on the ground, and one driving the truck-trailer. Detailed information can be found in Larson (1980), Larson and Knudson (1978), U.S. Forest Service (1980b), and Missoula Equipment Development Center Drawings No. 602 (transport trailer) and No. 604 (buckets).

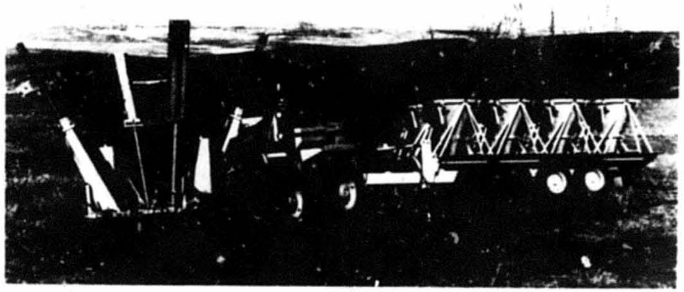

Figure 3.3-1. Tree spade and transporter (photo courtesy of USDA Forest Service).

Front End Loader

Three kinds of FEL buckets are used for transplanting shrub and tree pads on western mined lands. Coal buckets have been used successfully for several years in northwest Colorado (Crofts and Parkin 1979) and near Colstrip, MT (Sindelar et al. 1973; Jensen and Hodder 1979). Two buckets have been developed specifically for transplanting mature vegetation. An experimental unit was developed by the Missoula Equipment Development Center with funds from the Bureau of Land Management (Larson 1980; U.S. Forest Service 1980a) (Figure 3.3-2), and the other bucket was designed by Colorado State University (CSU) in cooperation with Energy Fuels Corporation (funded by the Bureau of Mines) (Frizzell et al. 1980; Carlson et al. 1981). The CSU bucket is used regularly at the Energy Fuels mine in northwest Colorado. The two transplant buckets have several characteristics in common.

Figure 3.3-2. Front end loader and transplant bucket (photo courtesy of U.S. Forest Service).

- o Each bucket has straight rear and side walls so that tall plants can stand upright without being injured.
- o The load-carrying surface area of the bucket has been increased as compared to coal buckets.
- o A friction-reducing material has been applied to the bottom of the bucket so that the soil pad will slide smoothly and not break.
- o Each bucket is capable of picking up a soil pad at least 30 cm (12 in) thick.
- o Excavation is done by removing a "slice" parallel to the ground surface.

- o The bucket is unloaded by tilting it forward while the loader backs up.
- o They can move large shrubs as well as small trees (the CSU bucket, for instance, moves trees well over 15 cm [6 in] in diameter and up to 12 m [40 ft] high when operated by an experienced person).
- o Each unit is attachable to a variety of FEL's. (The Missoula Equipment Development Center, for instance, has drawings for adaptors for four FEL's.)

The two buckets differ in surface area, shape, and method of control.

A FEL used for transplanting is most effective when operated over short distances (less than one mile). At greater distances, travel times are excessive and wear and tear on the machine is great. In order to overcome this limitation, a transporter has been designed and used with the FEL bucket developed at CSU. The transporter moves the soil-vegetation pads more efficiently than the FEL and cuts down on the total time needed for the transplanting operation. Thus, the FEL would be used for a short time to remove a large number of clumps of vegetation from the undisturbed premined land and would then be free to again be used in mine production work. The transporter is a modified Hesston haystack mover that can pick up the stored vegetation clumps, move them to the planting site, and place them on the ground. The transporter is less expensive to operate and lower in initial cost than the FEL and can be pulled by a variety of equipment (Frizzell et al. 1980).

The success of the transplants depends upon a variety of factors, the most important one being the lag time between transplanting and topsoiling around the exposed roots. To maximize survival, the exposed root pad must be backfilled as soon as possible after transplanting. Other factors include the species, size of the plants, soil moisture, distance travelled, experience of the operator, and location of the transplant. Guidelines for locating the transplant pads are discussed in Carlson et al. (1981). Considerations include plant species characteristics, site characteristics (e.g., topography, wind, and snow accumulation), and clump configuration and size (e.g., a number of pads placed together protect the inner plants from drying winds and damage due to wildlife use).

In general, shrubs should be planted in patches rather than uniformly, and the open areas (between patches) should be seeded with a shrub mix. A revegetation pattern of shrub patches interspersed with grass and forb stands will provide an area far more valuable as wildlife habitat (see Section 3.3.3.b, Planting Patterns to Increase Wildlife Diversity, and Section 3.3.3.a, Creating Topographic Features). Sites, such as lowlands, drainages, depressions, north-facing slopes, and sheltered sides of topographic features, are preferred for reestablishing shrub patches.

Sprigger

The sprigger developed by the Missoula Equipment Development Center is designed to gather bareroot, rhizomatous (i.e., with spreading, underground, horizontal stems) shrubs for transplanting. The shrubs are first mowed and then the sprigs are gathered, separated from the soil, and carefully spread and covered with soil in the reclamation area. The sprigger can quickly gather a large number of shrubs for transplanting. In preliminary tests, it planted one quarter acre per day. Since mature, entire plants are not moved, sprigging does not provide the six advantages cited in the purpose section. A severe limitation on the use of the sprigger is its inability to separate roots from soil in heavy textured soils. It is still in the experimental stage.

More information is available from the Missoula Equipment Development Center, Larson (1980), and U.S. Forest Service (1980c).

Herbaceous Vegetation

Transplanting of native herbaceous vegetation may be accomplished with the Missoula Equipment Development Center Dryland Sodder (i.e., a FEL with a modified bucket). Equipment and techniques specifically designed for transplanting grasses and herbs have been used on various disturbed western lands over the last 75 years (see Bunin et al. 1980 for a review of dry land sodding in the Northern Great Plains). A commercial sod cutter has been successfully used for several years at the Rosebud Mine in Colstrip, MT (Chris Cull, Western Energy, pers. comm., March 31, 1980) to revegetate reconstructed drainages where erosion is a potential problem. In order to ensure integrity of the relatively thin soil pad cut by commercial sod cutters, the vegetation must form a dense root mat in the top few centimeters (inches) of soil and the soil must be relatively rock-free.

At the Rosebud Mine, sod is cut into pieces 5 to 6 cm (2 to 2.5 in) deep, 45 cm (18 in) wide, and up to 8 m (25 ft) long with a commercial cutter. The pieces are rolled, transported immediately on a flatbed truck, and laid down with their long axes parallel to the contours. In critical areas, continuous rows of sod are laid with small overlaps 3 to 4 cm (1.5 to 2 in), facing downhill, which aids the survival of the sod. Critical areas are identified by observations of runoff during a storm. Patches of sod are also used in other parts of drainages and are spaced 30 to 60 m (100 to 200 ft) apart. Sodding, done as early in the spring as possible, usually starts mid-April to May and ends by July 1. If the sod is dry, a hydroseeder is used to wet the sod the night before cutting. The sod takes approximately three weeks to bind to the soil sufficiently to withstand a normal runoff event. During this early period, a commercial product, Roll-lite, should be laid over the sod to protect the turf from water erosion.

MAINTENANCE AND MANAGEMENT

None of these methods of transplanting native vegetation depend upon supplemental watering or other care for their success. However, an initial watering immediately after transplanting is important for transplant survival.

Protection from grazing and rodent damage is advisable (see Section 3.3.1.j, Pest Control, and Section 3.3.1.k, Grazing Management to Allow Vegetative Recovery).

The survival rate of the transplants depends upon a number of factors such as: rooting characteristics; environmental tolerances; soil moisture; precipitation and temperatures following transplanting; distance between sites; similarity of sites; and management practices.

Equipment maintenance is simplest in the case of the FEL since it is normally used as a part of routine mining activities. If a new piece of equipment is being used at a mine, additional maintenance is necessary. The tree spade-transport trailer system, the transporter used with a FEL, the sprigger, the commercial sod cutter, and additional pieces of equipment would require additional maintenance time and expense.

LABOR/MATERIALS

All methods of transplanting native vegetation are far more expensive than seeding. In 1980, the use of a commercial sodder for transplanting small areas of grassy vegetation cost the equivalent of about $54,340/ha ($22,000/acre) (Chris Cull, Western Energy, pers. comm., March 31, 1980). A cost comparison for use of five methods of establishing woody plants is presented in Table 3.3-4. These figures are based upon the cost of the plant stock, equipment, and labor and survival rate of the transplants.

SOURCES OF INFORMATION

- State Regulatory Authority
- Office of Surface Mining
- State Agricultural Experiment Stations
- USDA Forest Service Equipment Development Center

For addresses, see Appendix A.

References Cited:

Bunin, J.; Hackos, J.; Harthill, M. The feasibility of dry land sodding for mined land reclamation. Prepared for U.S. Bureau of Mines, Denver, CO; 1980.

Carlson, K.; Smith, J.; Crofts, K. Transplanting mature vegetation in mine reclamation. Presented before the American Society of Agricultural Engineers; 1981 March 20-21; Laramie, WY. St. Joseph, MO: American Society of Agricultural Engineers; 1981.

Crofts, K. The nonconcept of species diversity and woody plant density as revegetation success standards. Proceedings of the Northwest Colorado Land Reclamation Seminar II. 1981. In press. To be published by Colorado State University Extension Service.

Crofts, K.; Parkin, C. Methods of shrub and tree establishment on strip mined lands in northwest Colorado. Papers presented before the symposium on surface coal mining and reclamation. Coal Conference & Expo V: Louisville, KY. McGraw-Hill, NY; 1979.

Dressler, R.; Knudson, R. Evaluation of Vermeer Model TS-44A Tree Spade for transplanting trees on surface mined land. Missoula, MT. USDA Forest Service Equipment Development Center; 1976. Available from: USDA Forest Service, MEDC, Missoula, MT.

Frizzell, E.; Smith, J.; Crofts, K. Transplanting native vegetation. Staff-US Bureau of Mines. Proceedings of Bureau of Mine technology transfer seminars, surface coal mining reclamation equipment and techniques. 1980 June 3-5; Evansville, IN, and Denver, CO. U.S. Bureau of Mines Information Circular 8823; 1980.

Jensen, I.; Hodder, R. Tubelings, condensation traps, native tree transplanting and root sprigging techniques for tree and shrub establishment in semiarid areas. Montana Agricultural Experiment Station Research Report 141; 1979. 105 p.

Larson, J. Revegetation Equipment Catalog. Missoula, MT. USDA Forest Service Equipment Development Center; 1980.

Larson, J.; Knudson, R. A transplant system for revegetating surface mined land. Missoula, MT. USDA Forest Service Equipment Development Center; 1978. Available from: USDA Forest Service, MEDC, Missoula, MT.

Sindelar, B.; Hodder, R.; Majcrus, M. Surface mined land reclamation research in Montana. Montana Agricultural Experiment Station Research Report 40; 1973. 122 p.

U.S. Forest Service. Dryland sodder. Missoula, MT. USDA Forest Service Equipment Development Center; 1980a.

U.S. Forest Service. Transplanting system. Missoula, MT. USDA Forest Service Equipment Development Center; 1980b.

U.S. Forest Service. Sprigger. Missoula, MT. USDA Forest Service Equipment Development Center; 1980c.

e. Transplanting nursery grown plants.

PURPOSE

The use of young woody plants that have already germinated in the controlled conditions of a nursery can greatly increase the chances for successful mined land revegetation in situations where seeding is likely to fail. Seeding may be unsatisfactory for one or more of the following reasons:

- The site is so dry that germination and establishment are poor.
- Soil erosion or slope instability is critical.
- Rapid vegetation establishment is required.
- Seeds for desired species are not available.
- A desired species will not reproduce satisfactorily by seed at the mine site but may reproduce by seed or by vegetative propagation in the controlled conditions of a nursery.

From the perspective of wildlife habitat enhancement, any procedure that recreates desirable food and cover rapidly and reliably is advantageous.

DEVELOPMENT

A comparison of seeding and transplanting is shown in Table 3.3-5. Although transplanting is far more expensive than seeding, transplanting offers several substantial advantages in terms of wildlife habitat restoration.

Nursery grown transplants may be obtained in two forms, containerized or bare root stock. Containerized stock refers to young plants grown in a container that may range from a narrow tube to a milk carton to a 3.8 ℓ (1 gal) plastic can. In general, the larger vessels hold older and larger plants, and such plants usually have better survival although they are more expensive. Container stock is typically grown in a greenhouse. Bare root stock is produced by digging up nursery plants and shaking the soil from the roots after they have been grown in beds for one to two years. Bare root plants are typically cultivated in outdoor beds and grow more slowly than containerized stock. They are planted in the same dormant season in which they were dug. Cold storage can maintain the bare root plants until the appropriate planting time. Early spring planting is best so that roots are established before top growth starts. A comparison of the two forms of nursery grown transplants is provided in Table 3.3-6.

Table 3.3-5. Comparison of seeding and transplanting nursery grown stock.

Seeding	Transplanting
Probability of success is lower due to the vulnerability of the young seedlings to frost and drought.	Likelihood of higher survival rates, especially on arid sites or where erosion is a potential problem.
	Makes possible establishment of species for which abundant seed is not available.
	Improves probability of successful establishment for species with low germination rates and poor establishment characteristics.
Techniques have been relatively well worked out and are usually simpler.	Preparatory storage and planting of stock is more laborious.
Far less expensive.	In northwest Colorado, each established shrub plant costs on the order of 25 to 50 times the seeding cost (Crofts and Parkin 1979).

Table 3.3-6. Comparison of nursery grown planting stocks (compiled from Institute for Land Rehabilitation 1979 and U.S. Forest Service 1979.).

Container grown	Bare root
<u>Species</u> Some species are difficult to cultivate. In the northern Great Plains, recommended for evergreens by Orr (1977) and Bjugstad et al. (1980) and for general use by Jensen and Hodder (1979).	Most native shrubs and trees can be successfully grown and field planted. A few woody plants perform better in containers. Recommended for deciduous species by Orr (1977) and Bjugstad et al. (1980) and for general use by Crofts and Parkin (1979).
<u>Availability</u> Available from Federal, State, and private nurseries during all seasons.	Available from Federal, State, and private nurseries. Not available at certain seasons, but may be stored in coolers for up to one year.
<u>Growth Time</u> Can be grown quickly by suppliers. most cases, should not be field planted when very young (i.e., less than about 10 weeks old) if frost is probable.	Usually field grown for one to two In years.
<u>Roots</u> Root system is better protected during planting. Nutrients and moisture are intact in containers. Roots may stagnate in the container after field planting (Stevens 1980).	Advisable for roots to be at least 15 to 20 cm (6 to 8 in) long, except on rocky sites where shorter lengths may be advantageous.
<u>Preparation for Planting</u> Plants must be hardened before planting; i.e., exposed to cool temperatures and less watering, so that they resist cold, heat, and desiccation.	Dig up plants while dormant and plant in the same dormant season.
<u>Ease of Handling</u> Heavier and bulkier. Many operations in the greenhouse can be mechanized.	Packages compactly in moist peat moss, but must be protected from wind and heat so that roots stay moist.

Table 3.3-6 (concluded)

Container grown	Bare root
Maintenance before Planting	
Difficult to maintain from delivery to field planting time because watering and daily care are needed.	Must be taken out of cold storage one day ahead of time to acclimate the stock. Roots must be kept moist.
Season to Plant	
Spring best.	Early spring best so that new roots are established before top growth starts.
Cost	
In northwest Colorado, from about 2 to 5 times more expensive per established plant (Crofts and Parkin 1979).	Less expensive.

In the last decade, a number of plantings utilizing both containerized and bare root stock have been carried out in the West. Based on the results of 11 plantings in which the two stocks were directly compared, Crofts (1981) concluded that bare root nursery stock is clearly superior to containerized material. At best, containerized nursery stock is only half as cost-effective as bare root stock (using costs in Crofts and Parkin 1979).

In any particular case, there is substantial variability in the performance of bare root stock. Factors contributing to the unpredictability in performance include seed source and ecotype variability; nursery propagation techniques; handling, storage, and shipping; and destination storage, handling, and planting techniques (Orr 1977; Draves and Berg 1979; Institute for Land Rehabilitation 1979). In summary, bare root stock is less expensive and is easier to handle but takes more advance planning than container grown stock.

MAINTENANCE AND MANAGEMENT

Usually, supplemental watering after planting or other treatments are not necessary to ensure survival of most of the transplants. An initial watering immediately after planting is important for transplant survival. Protection from grazing and rodent damage is advisable (see Section 3.3.1.j, Pest Control, and Section 3.3.1.k, Grazing Management to Allow Vegetative Recovery). The degree of success depends on the particular seedling stock, its handling, the

particular species, site characteristics, and the precipitation pattern and amount in the period immediately following the transplanting.

LABOR/MATERIALS

Three aspects of transplanting nursery grown stock will be discussed here: containers,; holes to receive the stock; and costs.

Containers

Containers are important not only because they influence costs and techniques for transplanting, but also because the container size and shape can cause a deformed root system which reduces plant survival and growth after outplanting. For instance, rectangular containers direct the roots to the corners and then downward. Or, a bottom on a container causes roots to become twisted and netted (Institute for Land Rehabilitation 1979). A study near Billings, MT demonstrated that tubelings with a polyethylene mesh sleeve can influence root growth, depending on the species rooting characteristics. Species with small diameter primary and secondary roots were not restricted in growth; whereas, species with enlarged primary and secondary roots were adversely affected by the mesh (Jensen and Hodder 1979).

A variety of containers has been used, including "tubelings" (Jensen and Hodder 1979), small plastic tubes, cardboard tubes, milk cartons, and one-gallon plastic and metal food cans (Gass 1980). Much useful information can be obtained from Tinus et al. (1974).

Planting Stock

Below are some considerations for planting nursery grown stock (U.S. Soil Conservation Service 1979):

- Roots should be kept moist at all times before planting by covering with moist burlap or submersing in a container of water.
- Roots should be spread out as close to natural position as possible during planting.
- Holes should be deep enough to accommodate seedlings without bending roots.
- Stock should be set the same depth as in the nursery or slightly deeper. In no case should a plant be set shallower than it was in the nursery.
- Soil should be packed well around roots until seedling cannot be easily pulled from the ground. Care should be taken to eliminate <u>all</u> air pockets in the soil around the roots.
- Stock should be watered at planting time.

Most planting is done by hand (Figure 3.3-3) or with planting augers. The hand tools most commonly used are planting hoes and planting bars. Other specialized tools are used for container stock. Planting augers are portable powered tools that dig holes for bare root or containerized seedlings. More information on the use and availability of hand planting tools and planting augers is in Larson (1980). Larson's Revegetation Equipment Catalog also describes and presents capabilities and limitations for a tractor drawn implement for planting bare root seedlings. In addition, the USDA Forest Service Equipment Development Center in Missoula (1980) is working on a dryland plug planter prototype for mechanized planting of containerized seedlings.

Costs

Crofts (in press) has calculated the comparative costs of obtaining a surviving plant from bare root and containerized stock.

Table 3.3-7. Cost required to establish one surviving nursery transplant.*

Method	Cost per surviving seedling by year					
	1	2	3	4	5	6
Bare root	$0.44	$0.63	$0.64	$0.51	$0.75	$1.04
Containerized	$0.88	$1.62	$1.34	$1.17	$5.00	$6.11

*Based upon acquisition and planting cost of $0.27 per bare root seedling and $0.55 per containerized seedling from Crofts and Parkin (1979).

In short, bare root transplants are from 2.3 to 4.9 times more cost effective than containerized transplants (Crofts and Parkin 1979).

Sources of nursery grown stock are listed in Hinkle et al. (1981) or can be obtained from the State regulatory authority.

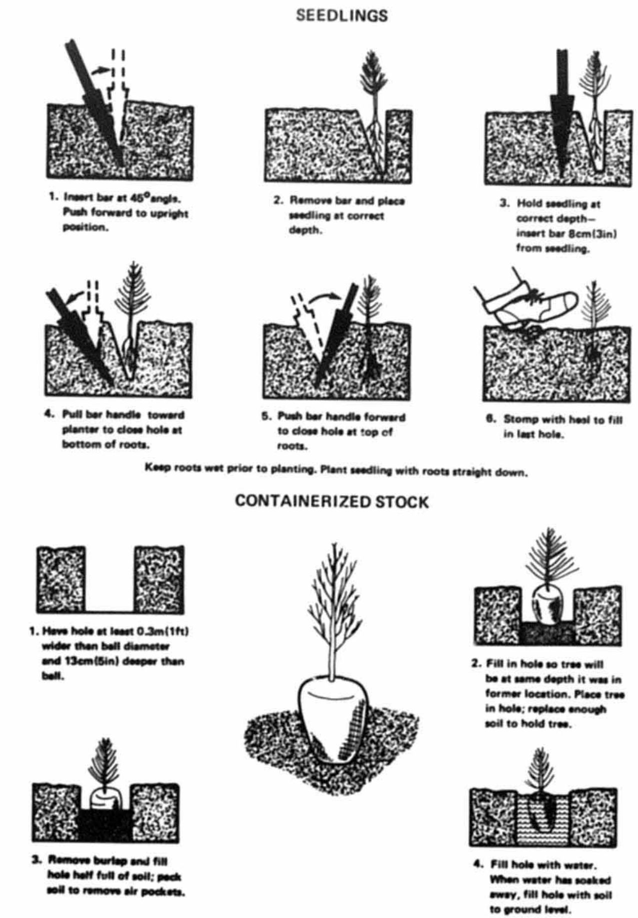

Figure 3.3-3. General procedure for planting seedlings and containerized (including bare root) stock (after Johnson and Anderson 1980).

SOURCES OF INFORMATION

- State Regulatory Authority
- Office of Surface Mining
- Nurseries: Federal, State, and private
- State Agricultural Experiment Stations
- State Forest Service
- U.S. Soil Conservation Service
- U.S. Forest Service Equipment Development Center

For addresses, see Appendix A.

References Cited:

Bjugstad, A.; Yamamoto, T.; Uresk, D. Upland shrub establishment on coal and bentonite clay mine spoils. Proceedings of the Shrub Establishment Symposium; 1980 December 2-3; Laramie, WY; 1980.

Crofts, K. The nonconcept of species diversity and woody plant density as revegetation success standards. Proceedings of the Northwest Colorado Land Reclamation Seminar II; 1981. To be published by Colorado State University Extension Service. (In press)

Crofts, K.; Parkin, C. Methods of shrub and tree establishment on strip mined lands in Northwest Colorado. Paper presented before the symposium on surface coal mining and reclamation. Coal Conference Expo V; 1979 October 23-25; Louisville, KY. New York: McGraw-Hill; 1979.

Draves, R.; Berg, W. Establishment of native shrubs on disturbed lands in the mountain shrub vegetation type. Ft. Collins, CO: Colorado State University Department of Agronomy; 1979.

Gass, R. Options for transplanting. Brittain, R.; Myrhman, M., eds. Vegetative reclamation of mine wastes and tailings in the Southwest; 1980 April 23-25; Tucson, AZ. Mine Reclamation Center. Arizona Mining and Mineral Resources Research Institute; 1980.

Hinkle, C. R.; Ambrose, R. E.; Wenzel, C. R. A handbook for meeting fish and wildlife information needs to surface mine coal. OSM Region 5, Washington, D.C.; USDI Fish and Wildlife Service. FWS/OBS-79/48.3.5; 1981.

Institute for Land Rehabilitation. Selecting, propagation and field establishment of native plant species on disturbed arid lands. Utah Agricultural Experiment Station Bulletin 500: Logan, UT; 1979. 49 p.

Jensen, I.; Hodder, R. Tubelings, condensation traps, mature tree transplanting and root sprigging techniques for tree and shrub establishment in semiarid areas. Montana Agricultural Experiment Station Research Report 141: Missoula, MT; 1979. 105 p.

Johnson, K. L.; Anderson, E. S., editors. Conservation planting handbook for Wyoming and Colorado. Agricultural Extension Service, University of Wyoming, Laramie, Wyoming 82071. 1980.

Larson, J. Revegetation equipment catalog. USDA Forest Service Equipment Development Center, Missoula, MT; 1980.

Orr, H. K. Reestablishment of wooded waterways and associated upland shrub communites in surface coal mining areas of the northwestern Great Plains. Fifth symposium surface mining and reclamation NCA/BCR coal conference and expo IV; October 18-20; Louisville, KY; 1977.

Stevens, R. Shrubs can be transplanted successfully with a tree transplanter. Russell, T. V., chairman. 34th Annual Report. Vegetative Rehabilitation and Equipment Workshop; 1980 February 10-11; San Diego, CA. USDA Forest Service, Washington, D.C. 20013; 1980.

Tinus, R. W.; Stein, W. I.; Balmer, W. E., editors. Proceedings of the North American Containerized Forest Tree Seedling Symposium. Great Plains Agricultural Council Publication 68; 1974. 458 p.

U.S. Forest Service. User guide to vegetation. Mining and Reclamation in the West. USDA Forest Service Gen. Tech. Rep. INT-64: Intermountain For. and Range Exp. St., Ogden, UT; 1979. 85 p.

U.S. Forest Service. Dryland plug planter. Missoula, MT. USDA Forest Service Equipment Development Center; 1980.

U.S. Soil Conservation Service. Standards and specifications: tree planting. Technical Guide, Section IV, Code 612; 1979.

Additional Reference:

Hartman, H. T.; Kester, D. E. Plant propagation. 3rd ed. Englewood Cliffs, NJ: Prentice Hall, Inc.; 1975.

f. Cover crops/preparatory crops.

PURPOSE

Cover crops and preparatory crops are species planted to act as temporary stabilizers of the site until permanent vegetation can be established. Even though their functions are similar, there are important differences in the two crop systems. Cover crops (sometimes called companion or nurse crops) are annual crops, such as peas, barley, sorghum, rye, sudan-grass, or oats, that are seeded with perennial species to modify microenvironmental conditions until the perennial species can become established. Preparatory crops are seeded before the perennial forage; the crop is mowed, and the perennial species are seeded directly into the stubble (U.S. Forest Service 1979). These crops can be used to stabilize the site, as well as provide a cleaner (weed-free) seedbed.

DEVELOPMENT

Cover crops are not recommended for semiarid regions where moisture shortages are likely during the establishment period, or on soils of low fertility (U.S. Forest Service 1979). The cover crop will compete with perennial grasses for nutrients, light, and especially water, resulting in poor establishment of the perennial species. If irrigated, cover crops will not compete as severely with the desired permanent vegetation.

Preparatory crops have been more successful in the West. Advantages of using a preparatory crop are that it may:

- protect topsoil until a permanent species can be established;
- control wind and water erosion;
- reduce evaporation from around seeds and establishing plants;
- smother out germinating weeds;
- reduce or prevent a new crop of weeds; and
- provide food or cover for small mammals, birds, and waterfowl.

In the Uinta-Southwestern Utah Coal Region, many mines plant barley or wheat in the spring as preparatory crops. At Peabody Coal's Seneca Mine, barley or wheat are cover cropped in the fall if the reclaimed area is ready for seeding at that time. Since each site has different environmental influences, the decision to use a nurse or preparatory crop depends on rainfall, steepness of slope, and the time of year revegetation will be conducted. The local U.S. Soil Conservation Service office can advise what species to use and the best time to plant according to local conditions.

Schuman et al. (1980) compared the effectiveness of crimped straw or hay residue used as a mulch with the use of a small grain planted in the spring and a grass mixture fall-seeded into the stubble. The stubble mulch or preparatory crop proved to be statistically as good as the straw mulch for establishment of perennial grasses, showed slight benefit in effects on soil

moisture and temperature, and significantly increased the infiltration. Ten percent more native grass was established by the preparatory crop method.

In selecting species for use as preparatory crops, consideration should be given to quickness of germination, growth rate, water and temperature requirements, canopy cover produced, herbage and root production, and seed availability and cost.

MAINTENANCE AND MANAGEMENT

Preparatory crops should be mowed before they produce seed to prevent competition with the perennial species to be established.

LABOR/MATERIALS

Use of preparatory crops will increase the labor and other costs involved in reclamation but, in the long run, it may also increase the survival of the perennial species, so that seeding would not have to be repeated.

Items listed in Table 3.3-8 are adapted from Schuman et al. (1980), who compared the cost of preparatory crop treatments with crimped straw mulch at two locations in Wyoming.

Table 3.3-8. Comparative cost of preparatory crops and crimped straw mulch.

Location	Crimped straw (5 MT/ha)	Cost of planted stubble
Northern Energy Resources Co., Glenrock Coal Co., WY	$803/ha ($326/acre)	$ 40/ha (millet) ($ 16/acre)
Pathfinder Mines Corp., Shirley Basin, WY	$618/ha ($251/acre)	$148/ha (barley) ($ 60/acre)

SOURCES OF INFORMATION

- State Regulatory Authority
- Office of Surface Mining
- State Agricultural Experiment Stations
- County Agricultural Extension Agents
- University Agriculture Departments
- Seed Suppliers

For addresses, see Appendix A.

References Cited:

Schuman, G. E.; Taylor, E. M., Jr.; Rauzi, F.; Howard, G. S. Standing stubble on mined lands. J. of Soil and Water Cons. 35(1):25-27; 1980.

U.S. Forest Service. A user guide to vegetation. USDA For. Serv. Gen. Tech. Rep. INT-64; Intermt. For. and Range Exp. Stn.: Ogden, UT; 1979.

g. Water conservation.

PURPOSE

In the arid West, conserving water for use by vegetation is extremely important. Increasing the amount of water stored in the soil for use by plants during the growing season may allow establishment and growth of seeded vegetation even in years of subnormal precipitation. Snow fences, windbreaks, and rock and brush piles allow a buildup of snow in specified areas which then is available to the soil as it melts. Surface manipulation, such as gouging or chiseling, also may restrict wind and water erosion, as well as conserve rainfall and provide suitable sites for vegetation establishment.

DEVELOPMENT

Snow Fences

Much of the precipitation in the northern and eastern portions of these two coal regions occurs as snow that may be lost through wind and sublimation. Usually, snow fences are used to keep an area free of deep snow, but the same type of barrier can be used to increase snow depth and, thus, the amount of available water to newly planted vegetation.

General topography limits the effectiveness of snow fences and not all locations are suitable. In a study near Kemmerer, WY (May and Lang 1971), it was determined that snow fences were effective only when placed on the leeward side of large, open level areas and at right angles to the prevailing wind.

Additional benefits of snow fences include the accumulation of natural mulch and windblown seed and versatility as either a permanent or temporary treatment that can eventually be replaced by "living" snow fences (see Section 3.3.3.c, Creating Wind and Snowbreaks for Winter Wildlife Protection). The most effective fence design includes 50% porosity (open area between the slats), a bottom-gap of one-tenth the fence height, and the use of horizontal slats having widths less than 20.3 cm (8 in). Tabler (1980) studied drifts which accumulated behind snow fences of both the horizontal and vertical slat varieties and found the vertical slat drifts to contain 26% less water-equivalent volume. A fence 3.7 m (12 ft) high would be very useful for drift prevention, but snow fences for protecting transplanted shrubs and augmenting soil water should be shorter or more porous (U.S. Forest Service 1979). Fences that are 0.6 m (2 ft) high, spaced 18.6 m (60 ft) apart, will provide a relatively uniform snow cover on level terrain. Fencing that is 1.2 m (4 ft) high, having about 75% porosity, will also result in a sufficiently shallow, uniform deposit on level terrain. Spacing should be about 30 x H (height of the fence), which is the maximum length of the drift behind a fence.

To determine the volume of water stored behind a fence, a single equation - $10 \times H^2$ per linear foot of fence can be used (U.S. Forest Service 1980). For engineering drawings for effective snow fences, see Tabler (1975).

Tabler has conducted extensive research on snow fences at the Rocky Mountain Forest and Range Experiment Station in Laramie, WY. Contact the Experiment Station for more information on snow fence construction for increased water supply (see Appendix A).

Surface Manipulation

Compaction of the spoils by heavy equipment used in shaping and topsoiling processes can reduce infiltration and storage of precipitation. Consequently, soil, seed, and fertilizer could be washed from slopes before the stablizing vegetation becomes established. Scarification before topsoiling or freeze-thaw periods can offset the compaction problem. In addition, mulching (see Section 3.3.1.h) can minimize the loss of topsoil, seed, and fertilizer.

Surface manipulation is the modification of the surface lands into configurations which reduce the rate of runoff by intercepting, storing, and encouraging infiltration. Four commonly used methods are gouging, deep chiseling, dozer basins, and land imprinters. Gouging is accomplished with a specially constructed machine having hydraulically operated 61.3 cm (25 in) scoops that are raised and lowered while being drawn by a tractor, creating elongated basins 30 to 40 cm (14 to 16 in) wide, 1.0 to 1.3 m (3 to 4 ft) long, and 15 to 20 cm (6 to 8 in) deep (Figure 3.3-4). Gouging is most effective on the slope contour.

Dozer basins are created by dropping the bulldozer blade at an angle to form elongated basins 3 to 5 m (10 to 16 ft) long and 0.6 to 1.0 m (2 to 3 ft) deep. Basins are constructed in parallel rows with about 6.2 m (20 ft) between rows, depending on the gradient of the slope, and are used for stabilization of steeper slopes (Sindelar et al. 1974).

Deep chiseling can be done with a modified Graham-Hoeme plow with 12 chisels to break up compacted surfaces to a depth of 20 to 30 cm (8 to 12 in). Improved infiltration rates are a major feature of deep chiseling.

The land imprinter creates a series of geometric patterns on the ground surface to control erosion and increase infiltration. The imprinter is essentially a towed chopper with two interchangeable drums, mounted on a common axle, which crushes and chops brush, mixes and imbeds surface debris or seed, and forms stable, complex impressions on the ground. The resulting closed V-shaped furrows can collect up to 5 cm (2 in) of rainfall and displace concentrated runoff (Larson 1980).

The advantages and disadvantages of these surface manipulation techniques are presented in Table 3.3-9.

In a study done on surface manipulation that compared gouging, chiseling, and dozer basins at the Western Energy Company Rosebud Mine at Colstrip, MT, Sindelar et al. (1974) found that the most efficient treatment, in terms of soil moisture storage in the upper 1.3 m (4 ft) of soil, was gouging. Gouging greatly reduced the number of moisture stress days for vegetation and resulted in slightly increased seedling survival.

Figure 3.3-4. Tractor-drawn modified Hodder Gouger (Photo courtesy of U.S. Forest Service Equipment Development Center, Missoula, MT).

Dozer basins did not appear to store significantly more moisture in the upper 1.2 m (4 ft) of soil than did chiseling. Although vegetation growing within dozer basins was profuse and resulted in high plant densities, areas between basins supported only sparse vegetation. While chiseling did not provide good soil moisture conditions and improved erosion control, it did produce a good seedbed which resulted in a satisfactory vegetation cover.

The benefits of erosion control and increased moisture storage must be weighed against the drawbacks of producing a pitted hillside that might prove dangerous to large herbivores, such as deer and pronghorn, as well as cattle. The land imprinter operates satisfactorily on rough, rocky, or brush-covered terrain and on most soil conditions. It can treat slopes up to 45% but cannot treat dense stands of sprouting brush.

Table 3.3-9. Advantages and disadvantages of surface manipulation techniques

Techniques	Advantages	Disadvantages
Gouging	Most efficient in storing soil moisture in 1.3 m (4 ft) of soil Increases infiltration Improves erosion control	Pitted hillside produced Designed for slopes of 20% or less
Dozer Basins	Effective on hillsides High plant densities found in dozer basins Increases infiltration Improves erosion control	Not suited for level ground Sparse vegetation survival surrounding basins Deeply pitted hillsides produced Clay soils inhibit infiltration; water may evaporate without benefiting plants
Deep Chiseling	Good seedbed produced Can be used on level ground or hillsides Well suited to rocky land	Low ground clearance prevents effective brush control No improved soil moisture conditions
Land Imprinter	Improves erosion control Increases infiltration Can operate on rough, rocky, or brush-covered terrain on slopes up to 45%	Cannot treat dense stands of sprouting brush

MAINTENANCE AND MANAGEMENT

Snow fences require very little maintenance beyond occasional repair or replacement of weather damaged portions. Maintenance for surface manipulation would only apply to the equipment used. As the vegetation matures, no management should be necessary as the natural successional patterns take over.

LABOR/MATERIALS

Standard 1.2 m (4 ft) high snow fence is approximately $3.75 to $4 per running 0.3 m (foot), including fencing, T-bars, wire, and installation.

Surface manipulation devices can all be attached to crawler or standard tractors which most mines would use for other operations. The gouger implement costs $12,000 and the land imprinter is slightly over $11,000. A chisel plow can be obtained from most farm implement dealers for approximately $1,000. Dozer basins are formed by standard dozer blades. A "D9" can bulldoze out a dozer basin over a 4- to 6-ha (10- to 15-acre) area in about 8 hours at a cost of around $900 for the operation of the machine and the driver's labor. A basin blade that can be mounted on the rear of a crawler tractor to scoop out large basins would cost approximately $9,000 to $10,000, using the specifications of the USDA Forest Service Equipment Development Center in Missoula, MT.

SOURCES OF INFORMATION

General:
- State Regulatory Authority
- Office of Surface Mining

Snow fences:
- State Department of Highways
- Fencing suppliers
- State Agricultural Research Stations
- U.S. Forest Service, Rocky Mountain Forest and Range Experiment Station, Laramie, WY

Surface manipulation:
- Reclamation Equipment manufacturers
- State Agricultural Research Stations

For addresses, see Appendix A.

References Cited:

Larson, J. E. Revegetation equipment catalog. U.S. Forest Service Equipment Development Center, Missoula, MT; 1980.

May, M.; Lang, R. Reclamation of strip mine spoil banks in Wyoming. Research Journal 51, Ag. Exp. Sta., Univ. of Wyoming, Laramie; 1971.

Sindelar, B. W.; Atkinson, R.; Majerus, M.; Proctor, K. Surface mined land reclamation research at Colstrip, Montana. Montana Ag. Exp. Sta. Res. Report 69. Montana State Univ., Bozeman; 1974.

Tabler, Ronald D. Estimating the transport and evaporation of blowing snow. Snow manage. on Great Plains symp. 1975 July, Bismarck, ND. Proc. Great Plains Agric. Counc. Publ. 73; 1975.

Tabler, R. D. Geometry and density of drifts formed by snow fences. J. Glaciol. 26:405-419. 1980.

U.S. Forest Service. User guide to vegetation. Gen. Tech. Report INT-64: Intermt. For. and Range Exp. Stn., Ogden, UT; 1979. 85 p.

U.S. Forest Service. User guide to hydrology. Gen. Tech. Report INT-74: Intermt. For. and Range Exp. Stn., Ogden, UT; 1980. 64 p.

h. Mulching.

PURPOSE

A mulch is defined as any nonliving material placed or left on or near the soil surface for the purpose of protecting it from erosion or protecting plants from heat, cold, or drought. Mulches are effective in modifying environmental factors to improve soil properties, soil moisture availability, and temperature conditions. Stabilizing an area can be done by establishing plant growth as quickly as possible. Mulching can be used to protect the site until plants become established and will often shorten the time for adequate plant growth. Mulching is a reclamation practice required by most regulatory authorities.

DEVELOPMENT

Both organic and inorganic mulches can be used and include asphalt mulches, jute or excelsior netting, straw, sawdust, and chemical mulches; however, organic mulches have a relatively short effect, decomposing within about a year. In addition, organic mulches with a high carbon to nitrogen ratio (>25:1) can potentially cause nitrogen deficiencies because the micro-organisms decomposing the organic matter are more efficient in using any inorganic nitrogen than are the plants. As a result, these microorganisms decrease the availability of inorganic nitrogen and leave a deficiency for a short time. Included among mulches that have a high carbon to nitrogen ratio are straw and wood waste.

Another problem associated with mulches is germination inhibition. Mulches high in nitrogen can produce ammonium concentrations that are toxic to germinating seedlings. Light colored mulches can lower soil temperatures and, at certain times, this may have an inhibiting effect on plant growth.

Some mulches may contain weed seeds that could compete with the desired seedlings. Insects, fungi, and diseases can also be transported to the site via mulch. Rodents can be attracted to a mulch and then eat seeds or seedlings.

For mulching, the modified StakProcessor uses a flail device to distribute straw mulch from 680 kg (1,500 lb) round bales. The StakProcessor is not suited for steep terrain, and the mulch should be incorporated into the ground in some fashion. Power mulchers blow dry fiber mulch, mostly straw and hay, onto treatment areas. These mulchers can cover inaccessible areas with self-attaching mulches blown from a nearby bench or road. Another blower, the Estes spreader, can blow up or down a slope but is limited to accessible areas.

The advantages and disadvantages of commonly used mulches are listed in Table 3.3-10 (U.S. Forest Service 1979). Factors to be considered when choosing a mulch are cost, type of vegetation to be planted, and characteristics of the site.

Table 3.3-10. Advantages and disadvantages of different types of mulches (from U.S. Forest Service 1979).

Type of Mulch	Advantages	Disadvantages	Comments
Hydraulic mulching	Typical green color allows operator to get uniform distribution Hydromulching and hydroseeding can be done at the same time	Labor and maintenance costs high Of little value unless it adheres to the soil surface and remains intact during rainstorms, wind Hydromulch with fiber improves germination, not production When hydromulch and hydroseeding are done together, seeds may not have adequate soil contact	Application rate of 1,685 kg/ha (1,500 lb/acre) adequate for most situations; may need more for steep slopes May need to add N to hydromulch to compensate for C:N ratio of mulch chosen
Fabric or mats: jute; excelsior; woven; paper; plastics; nets	Especially useful on steep slopes Nets good in high wind areas	Expensive: 4-5 times more than tacked straw High labor input for anchoring Not effective on rough surfaces or rocky areas Erosion from beneath may be a problem	Used only on limited critical areas because of cost
Manure and sewage sludge	Can protect soil surface and adds nutrients, such as N, P, K, and S	When used alone, it desiccates and can lose much of the N through volatilization of ammonia	Needs 4.5 to 13.6 MT/0.4 ha (5 to 15 tons/acre) in order to protect soil

Table 3.3-10 (continued)

Type of Mulch	Advantages	Disadvantages	Comments
Asphalt	Rapid-curing asphalt keeps straw and other materials in place	Nonporous, causes surface water to run off	11,219 ℓ/ha (1,200 gal/acre) an average application
	Slow-curing asphalt allows for growth of seedlings before it cures	Some plants react negatively to it	Typically, heated and spread by spraying
	Coats surface, remains intact 4 to 10 weeks		Apply from top of slope down
Resin emulsion in water	More porous than asphalt		5,609 ℓ/ha (600 gal/acre) good against wind erosion
	Insoluble in water		Often considered superior to asphalt
	Resistant to weathering		
Latex emulsion	Resistant to erosion	Limits water penetration	
		Some studies indicate it is less effective than other mulches	
Crop residues; straw or hay	Generally most economical	Weed seeds usually present; even hay seeds may be considered a weed on a particular site	Anchor mulch, especially on slopes, by crimping or using plastic meshes, jute, or chemical tackifiers
	Usually satisfactory under many circumstances		
		Straw may "wick-out" moisture from soils in very dry conditions, resulting in poor germination and seeding establishment	Uniform application important
			Generally, 0.91 MT/0.4 ha (1 ton/acre) adequate
Native grasses; prairie hay	Adds desirable native species seeds to area and mulches at same time	May harvest weeds along with native species	

108

Table 3.3-10 (concluded)

Type of Mulch	Advantages	Disadvantages	Comments
Wood residues; sawdust, woodchips, bark, shavings	Protects surface Adds organic matter No weed seeds More fire resistant than straw Long lasting Easy to apply	Shavings and sawdust blow Nitrogen deficiency Packing may occur resulting in less aeration May float on running water May prevent precipitation from reaching spoil	Chips: 1.8 MT/0.4 ha (2 tons/acre) usually adequate; chip size, 13 to 0.5 mm (0.5 to 1/50 in)
Plastic film	Excellent vapor barrier Good weed control	Labor intensive High cost	Information on temperature effect varies Color is important because of reflection, absorption
Fiber tackifiers and soil binders	SBR Styrenebutadiene and SS Super Slurper have been found to be very absorbent and help provide water	Quite expensive Must be applied correctly for maximum effectiveness In high wind areas, it can solidify, break into pieces, and blow away	Typically added into water carriers; can also be added with seed slurries 227 to 455 kg (500 to 1,000 lb) of solids/0.4 ha (1 acre) usually sufficient, dilution rates of 5:1 to 7:1 optimum
Rocks, gravel, pebbles	Effective at specific sites Are permanent--do not disintegrate	Smaller than 2.1 mm (1/12 in) diameter poor for wind erosion	Must nearly cover entire ground surface; 2.5 to 5 cm (1 to 2 in) thick is effective control (123 MT [135 tons]/0.4 ha (1 acre) = about 2.5 cm (in) depth)

MAINTENANCE AND MANAGEMENT

Mulching is a one-time application and therefore requires no further maintenance. As the vegetation matures, no management should be necessary as the natural successional patterns take over.

LABOR/MATERIALS

Mulching equipment costs are extremely variable. The StakProcessor costs slightly over $7,000 and can be attached to a tractor. Finn power mulchers are towed and vary from $8,000 for the smaller models to $17,300 ($20,300 for diesel) for the larger models (freight charges included). The Estes Blower Spreader is mounted on a truck and costs $20,540 for a 3-m (10-ft) hopper and $22,185 for a 4.9-m (16-ft) hopper.

Material and application costs will vary with the type of mulch used. At the Kemmerer Coal Fields, material and labor costs (excluding seed costs and adjusted to approximate 1982 dollars) of comparative treatments ranged from $550/0.4 ha (1 acre) for straw mulch held in place by a wire netting, to $2,750/0.4 ha (1 acre) for jute netting, to $3,200/0.4 ha (1 acre) for jute netting underlain with straw (Jacoby 1969).

SOURCES OF INFORMATION

- o State Regulatory Authority
- o Office of Surface Mining
- o U.S. Soil Conservation Service
- o County Agricultural Extension Agents
- o State Agricultural Research Stations
- o University Agriculture Departments

For addresses, see Appendix A.

References Cited:

Jacoby, P. W. Revegetation treatments for stand establishment on coal spoil banks. J. Range Manage. 22:94-97; 1969.

U.S. Forest Service. User guide to vegetation. Gen. Tech. Report INT-64: Intermt. For. and Range Exp. Stn., Ogden, UT; 1979. 85 p.

Additional References:

Larson, J. E. Revegetation equipment catalog. U.S. Forest Service Equipment Development Center, Missoula, MT; 1980.

U.S. Forest Service. User guide to hydrology. Gen. Tech. Report INT-74: Intermt. For. and Range Exp. Stn., Ogden, UT; 1980. 64 p.

i. Irrigation.

PURPOSE

The precipitation regime in the Uinta-Southwestern Utah Coal Region is characterized by high intensity seasonal storms, long periods of drought, and unpredictable precipitation patterns. Although native vegetation survives under these conditions, the germination of many species is limited to the few years when soil moisture is sufficient (Sherman et al. 1980). During the intervening years, the result can be a near monoculture of vegetation best suited to prevailing moisture conditions. As a tool for use during the germination and initial growth stage, irrigation can be very useful for improving reclamation success.

DEVELOPMENT

Only one mine in the Uinta-Southwestern Utah region is currently (1982) irrigating. Most mines in this region irrigate only if initial revegetation attempts fail or if irrigation is considered a major factor in successful revegetation. However, the use of irrigation to supplement natural precipitation can help ensure rapid and successful perennial plant establishment, especially when annual natural precipitation is less than 20 cm (8 in) (Aldon et al. 1976; Aldon 1978; Ries 1980). Irrigation is generally used for the first year or two. Once vegetation is established, plants require less water and the irrigation system is usually removed. Water suitable for irrigation is available in many of the mine pits or from wells that furnish water for various mining activities (May 1975).

The two most frequently used irrigation systems for reclaiming mine sites are drip and sprinkler irrigation. The advantages and disadvantages of these two systems are outlined in Table 3.3-11.

Drip (trickle) irrigation is the process by which water is slowly delivered to a plant (at a rate of approximately 3.8 to 38 ℓ/hr [1 to 10 gph]) from a point source called an emitter (Aldon et al. 1977). The application rate should not exceed the soil's intake rate. Drip irrigation is usually not a full coverage system; perhaps as little as 25 to 30% of the total field is watered. This system is most frequently used where water is in short supply and where high plant densities are not critical.

The laterals which supply water to the emitters are usually polyethelene hose of diameters varying between 1.37 and 1.47 cm (0.50 and 0.58 in) in diameter. Several laterals may be joined by a manifold and connected to a water supply line through a common valve. This practice allows repairs to be made without shutting the entire system down. An extensive filtration system may be required for the drip system, depending upon water quality. Water must be as clean as tap water to prevent clogging problems. Generally, the lower the water quality, the greater the filtration system cost, complexity, and labor requirement.

Table 3.3-11. Advantages and disadvantages of drip and sprinkler irrigation systems (from U.S. Forest Service 1979; Bengson 1980).

Type of irrigation system	Advantages	Disadvantages	Comments
Drip irrigation	Uses 1/3 less water than sprinkler systems Evaporation is minimal Amounts of water can be placed directly where wanted Especially wanted on steep slopes, under power lines (because it is safer), between buildings, on critical areas Moves salts away from plant roots Well suited for woody vegetation	If water contains high sediment level, it will clog the lines, unless well filtered If water is high in salt, deposits can build up around the emitter openings Requires more maintenance than sprinklers because the filtering system must be periodically inspected Labor intensive Less portable Shorter life span than sprinkler More easily damaged; e.g., rodents can chew holes in hoses	Also called trickle irrigation Plant densities will be less; this can be a disadvantage, but not always Adequate filtering system crucial Quality of water (sediment, salinity) a factor Three types of emitters; spitter (puts out a spray); single (puts small amount in local place); and bi-wall (plastic tubing with pinprick opening to emit water)
Sprinkler	Less filtering needed	More evaporation will occur	High plant densities possible

112

Table 3.3-11 (concluded)

Type of irrigation system	Advantages	Disadvantages	Comments
Sprinkler (continued)	Less expensive than drip	Need larger water supply	
	Less labor intensive	Frequency of application higher than drip	
	Longer life	Can cause erosion problems	
	Easier to move, more flexible		
	Gentle on friable or easily crusted soils		
	Adaptable to most fields and terrains		

Water soluble fertilizer may be applied through drip systems. Precautions should be taken so that precipitates do not form, which tend to coat the pipeline and clog the emitters.

Drip systems usually operate at an emitter pressure of approximately 10 to 40 psi. An appropriate pumping unit should be selected to supply an adequate quantity of water at this pressure.

After a survey of the general irrigation methods of surface, subsurface, drip, and sprinkler, Sherman et al. (1980) determined that, in the West, sprinkler irrigation in the form of above ground, portable, solid set is the most feasible and practical approach where rangeland or wildlife habitat is considered to be the final land use.

The solid set sprinkler fits the needs of native vegetation because it can supply a steady, moist environment in a timely fashion, without disturbing the seed or the soil around it. Solid set is a network of pipes and sprinklers typically spaced 10 or 12 m (30 or 40 ft) apart. An entire field can be irrigated by opening and closing valves, either automatically or manually.

The hardware used in solid set systems consists of five basic components:

- o Sprinklers
- o Laterals
- o Manifolds
- o Water Supply Lines
- o Water Source

Impact or rotary sprinklers, which typically emit 3.8 to 75.7 ℓ (1 to 20 gal)/min at pressures of 30 to 80 psi, are generally used for irrigation. Risers connect the sprinklers to the water supply line, or lateral. Risers are required to provide proper clearance between the sprinkler and the crop and may benefit uniformity of application when windy conditions prevail. The assembly of sprinklers, laterals, risers, and the automatic or manual valves which direct water flow are illustrated in Figure 3.3-5.

Principal advantages of solid set systems are the ability to irrigate and fertilize the entire field, regardless of configuration (see Figure 3.3-6), at low application rates and yet have flexibility in irrigation duration and frequencies. Reclamation irrigation is supplemental and temporary in concept and should be used on a given field for only one or two seasons. The vegetation should then be capable of surviving on its own, and the system can be moved to new areas as mining and reclamation progresses.

The Cottonwood Portal Project (Emory Mining Co.) is the only mining operation in the Uinta-Southwestern Utah Coal Region currently using irrigation. They are using a solid-set system with oscillatin sprinklers to irrigate 1 ha (2.5 acres) of a slope planted with 4,000, 15-20 cm (6-8 in) containerized serviceberry, sagebrush, pinyon pine, rabbitbrush, and shadscale seedlings and a grass mixture. The area is watered every other day. The most successful vegetation establishment is associated with hand-dug trenches contouring the slope which enhance moisture retention.

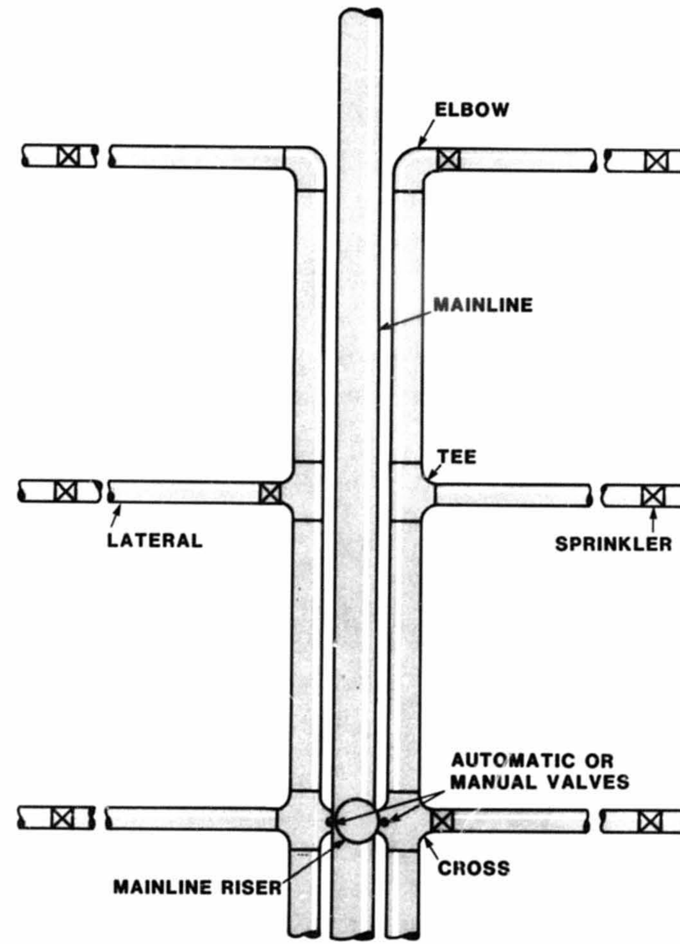

Figure 3.3-5. Manifold detail.

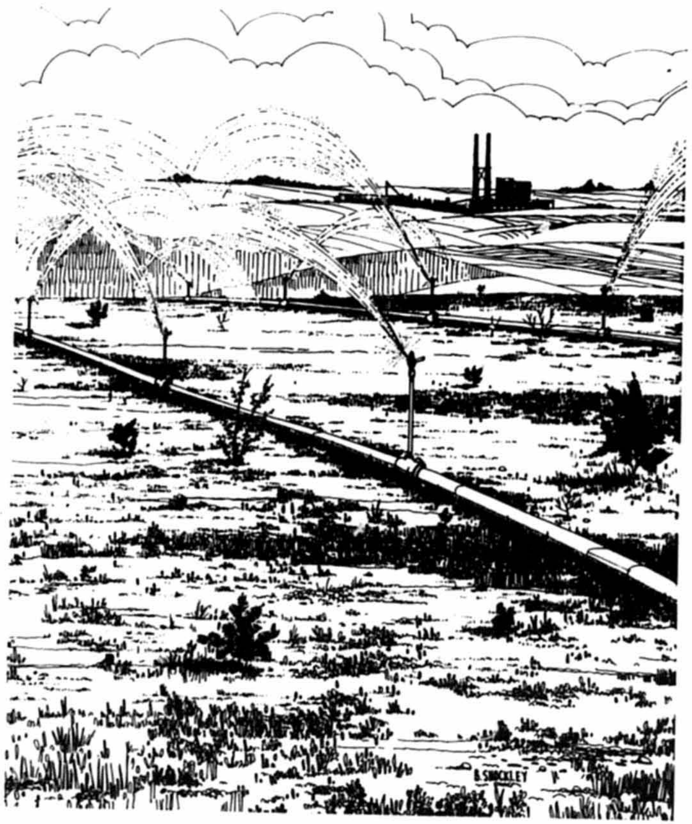

Figure 3.3-6. Artist's representation of a solid set irrigation system operating on a reclaimed mine site (after Sherman et al. 1980).

Water resources are usually very limited in the Uinta-Southwestern Utah region. Often a 152.4 to 304.8 m (500- to 1,000-ft) well will yield no more than 37.9 to 75.7 ℓ (10 to 20 gallons)/min (Sherman et al. 1980). The limited surface water resources are often fully allocated to downstream agricultural users. Sediment ponds and pit water are potential sources, depending upon the quality. Ries (1980) researched the use of supplemental water, including the use of poor quality water, for the establishment of perennial vegetation on strip-mined lands. Initial results from the study revealed that stands established with good or poor quality water have been equal. Where natural precipitation plus poor quality water was used for two seasons, the stands of seeded species established produced more than the stand of seeded established with only natural precipitation. Increases in salt, soluble sodium, and SAR were moderate where poor quality water (EC of 3.0 to 4.0 mmhos/cm²) was used.

The use of irrigation is dependent upon the availability and cost of water and the anticipated success of establishing plant growth without supplemental water.

MAINTENANCE AND MANAGEMENT

Irrigation systems require a great deal of maintenance. The drip system often becomes clogged by sediment unless well filtered. Salt deposits can also build up around the emitter openings. The filtration system and the laterals must be periodically flushed to prevent buildup of fouling material. Corrosion of pipelines may occur in sprinkler systems where the water or soil quality is poor. If the system is automated, management is lower, except for increases in set-up time.

LABOR/MATERIALS

Both drip and solid-set systems have a high equipment cost. The Bridger Coal Company in Rock Springs, WY, is using a solid-set sprinkler system on the Jim Bridger Mine. The set-up cost was $1 million to irrigate 97 ha (240 acres) at one time. The solid-set system irrigating 1 ha (2.5 acres) at the Cottonwood Portal project cost approximately $5,000. The system is manually operated every other day. Operation costs include the expense of running the pump and 0.5 man/days labor every other day. Drip system costs are generally higher on a per-acre basis than sprinkler systems. Comparative cost data are unavailable.

The labor required to maintain and operate a drip system must be available throughout the season. Since, in most cases, emitters operate silently, they must be checked frequently by inspecting each device. The filtration system must also be flushed regularly and requires skilled labor. The use of automatic valves and a controller allows sprinkler systems to operate with a minimal labor requirement.

SOURCES OF INFORMATION

- State Regulatory Authority
- Office of Surface Mining
- U.S. Soil Conservation Service
- County Agricultural Extension Agents
- State Agricultural Research Stations
- Irrigation Systems Manufacturers
- USDA Northern Great Plains Research Center

For addresses, see Appendix A.

References Cited:

Aldon, E. F. Reclamation of coal-mined land in the Southwest. J. Soil Water Cons. 33:75-79; 1978.

Aldon, E. F.; Cable, D.; Scholl, D. Plastic drip irrigation systems for establishing vegetation on steep slopes in arid climates. Pages 107-112 In Proc. Seventh Intl. Agric. Plastics Congr. 1977.

Aldon, E. F.; Springfield, H. W.; Sowards, W. E. Demonstration test of two irrigation systems for plant establishment on coal mine spoils. Pages 201-214 In Fourth Symp. on Surface Mining and Reclamation NCA/BCR. Coal Conf. and Expo III. Natl. Coal Assoc., Wash., D.C.; 1976.

Bengson, S. A. Irrigation techniques for mine revegetation in the arid Southwest. Brittain, R. G.; Myhrman, M. A. eds. Vegetative reclamation of mine wastes and tailings in the Southwest; 1980 April 23-25; Tucson, AZ. Mine Reclamation Center. Arizona Mining and Mineral Resources Research Institute; 1980.

May, M. Moisture relationships and treatments in revegetating strip mines in the arid West. J. Range Manage. 28:334-335; 1975.

Ries, R. E. Supplemental water for the establishment of perennial vegetation on strip-mined lands. North Dakota Farm Research 37(6):21-23; 1980.

Sherman, R. M.; Kinkead, J. A.; Campbell, G. J.; Alder, G. M. Irrigation for reclamation of strip mined lands (draft). Prepared for USDI Bureau of Mines; 1980.

U.S. Forest Service. User guide to vegetation. U.S. For. Serv. Gen. Tech. Report INT-64; Intermt. For. and Range Exp. Stn., Odgen, UT 84401; 1979. 85 p.

Additional References:

Hagen, R. M.; Haise, H. R.; Edminster, T. W., editors. Irrigation of agricultural lands. Agronomy No. 11. Madison, WI: American Society of Agronomy; 1967.

Israelson, O. W.; Hansen, V. E. Irrigation principles and practices. New York, NY: John Wiley and Sons, Inc.; 1962.

Merriam, J. L.; Keller, J. Farm irrigation system evaluation: a guide for management. Department of Agricultural and Irrigation Engineering, Logan, UT; 1978.

Ries, R. E.; Day, A. D. Use of irrigation in reclamation in dry regions. Schaller, F. W.; Sulton, P., editors. Reclamation of drastically disturbed lands; 1978.

j. Pest control.

PURPOSE

Grazing by wildlife and competition by weeds are two factors that contribute to seeding failures. Rodents, birds, and ants are common seed-eaters (granivores) in the Uinta-Southwestern Utah Coal Region which can greatly affect the survival rate of seeds that are not covered by soil. Large herbivores, rabbits, hares, and rodents all can take their toll on transplanted or seeded forbs, shrubs, and trees. Since fencing out all of these wildlife species is impossible, other methods are available to substantially decrease the loss of seeds and plantings. Weeds, too, can affect germination success and compete with seedlings for moisture and nutrients and, therefore, must be controlled either through mechanical or chemical means or by proper timing of planting.

Wildlife Predation on Seeds

Seeds planted by broadcasting (see Section 3.3.1.c, Seeding) are often vulnerable to predation. Studies on rangelands and forests in the northwestern United States have shown that over 90% of the seeds are lost to rodents after broadcast seeding (Nelson et al. 1970; Spencer 1954) even after all rodents were previously removed from the site (Sullivan 1979). Goebel and Berry (1976), also working in the Northwest, showed that birds may significantly add to the degradation of a range site because of the preference for seed produced by native bunchgrass or other desirable forage species. Krementz et al. (1981, unpublished manuscript) and others have studied ant consumption of seeds with results varying by region. Krementz et al. found that ants consumed less seed than rodents at the Bridger coal mines in Wyoming's Red Desert, while Pulliam and Brand (1975) found ants consuming 50% more seeds than did rodents in southeastern Arizona.

It is clear from Sullivan's study (1979) in coastal British Columbia that actual removal (poisoning) of rodents has little effect on the amount of depredation because colonization from surrounding areas occurs very quickly. In addition, Reichman (1979), working near Tucson, AZ, found that seed predators adjust their predation levels depending on the population of other seed predators.

Methods of granivore control that can be used on a reclamation site, if necessary, include decreasing seed exposure time through spring sowing, drilling instead of broadcasting or, if broadcasting is essential, covering the seed with a cultipacker. Sowing the seed at a greater depth will help prevent predation but it might also interfere with seedling survival.

If it is not possible to cover the seed soon after sowing, other techniques to reduce predation include using unpalatable seed (once grown, the plants themselves are palatable) or including a sacrifice species of preferred foods. Through feeding trials, Everett et al. (1978) studied deer mouse seed preference in western Nevada. They concluded that selecting species less

preferred by deer mice, such as flowering saltbush, bulbous bluegrass, sheep fescue, and smooth brome, should reduce the rate of predation of planted seed. Coating preferred seeds with an aversive chemical is another way to reduce predation. Everett et al. (1978) found that coating bitterbrush seeds with alpha-naphthylthiourea (ANTU) reduced their desirability markedly. Marsh et al. (1974) found that Douglas fir seeds treated with 4.0%, by weight, ANTU adhered to the seed with a solution of Rhoplex AC-33 prepared at a dilution ratio of 1:7 with water and then dried, repelled deer mice.

Bird predation is a more difficult problem to identify because people do not normally observe bird activity at its peak (Goebel and Berry 1976). Since the numbers of birds are generally low in the Uinta-Southwestern Utah Coal Region, bird predation may not be as great a problem unless seeding occurs when a migrating flock is passing through the area. This is likely to occur in the fall when granivorous birds travel in large flocks. Again, covering the seed would lessen the possibility of predation since birds feed by sighting their food.

Wildlife Depredation on Seedlings and Transplants

Herbivore damage to seedlings and transplants can be a significant source of failure and increase the cost of reclamation. Taste repellants or aversives, seedling protectors, and scaring are methods to reduce damage.

The Missoula Equipment Development Center (MEDC) has studied ways to prevent wildlife damage to seedlings. Methods evaluated were fences, noise barriers, special hunting seasons, chemical treatments, habitat manipulation, and individual seedling protectors (Knudson 1972). MEDC investigators found that individual seedling protectors were far superior to any of the other protection methods.

Vexar seedling protectors are manufactured by DuPont and are available in diamond, twill, or mesh patterns. Recommended tube lengths are 0.5 m (1.5 ft) for established stock and 1.5 m (5 ft) for hardwoods (Larson et al. 1979). Plastic tube seedling protectors are photodegradable and eventually break down when exposed to sunlight. The time required for breakdown is determined by the color of the plastic. Translucent green tubes with 5.0% ultraviolet inhibitor will provide 3.5 to 4.5 years of protection.

MEDC also did tests on support mechanisms for Vexar tubes (Larson et al. 1979). They evaluated wooden laths, spiral pins, straight pins, plastic stakes, short wooden stakes with locking nails, and wooden dowels. Results showed that two straight wires with hooks or two spiral wires provide sufficient support if the ground is not rocky or steep. Short wood stakes with locking nails should be used on areas that are rocky, steep, under heavy snowpack, or extensively used by elk.

Vexar seedling protectors are being used in North Dakota. This method has been tested and used with success in reforestation in the Pacific Northwest.

Thiram (Arasan) is a taste repellant which can be applied to trees, seedlings, and shrubs for protection from rabbits, mice, ground squirrels, and large ungulates (Hawthorne 1980). This product is available in aerosol sprays, a 20% solution to be diluted with water, and in a 42% concentrate to make a mixture of water and sticker. The plant should be sprayed thoroughly before damage begins. This product cannot be used on plant parts that will be eaten by humans or domestic animals. Livestock would have to be fenced from an area where Thiram was being used.

Deer-Away Big Game Repellant protects seedlings from browsing by deer and elk. This is a two-part product and must be mixed together before use at the rate of one part Concentrate 2103, one part Formula 2104, and six parts water, and must be used the same day of mixing. To protect against winter browsing, the repellant should be applied as close as possible to onset of browsing, but after seedlings are dormant and frost-hardy. For protection of new growth against spring browsing, treatment should start as soon as buds have fully opened and begun to elongate. One gallon of diluted repellant, applied from a pressurized hand sprayer to the point of run-off of repellant from the foliage, will treat about 400 seedlings that are 0.5 to 1 m (1.5 to 3 ft) tall.

Noise makers, flashing lights or other visual repellants have been used to frighten deer away from plantings. Such devices provide fair success when first used, but prove ineffective as long-term repellants. Animals become accustomed to the noise or light and eventually ignore it unless a combination of devices are used. Woven wire fences 2.4 m (8 ft) high are recommended to exclude antelope, deer, and elk (see Section 3.1.1.d, Fences).

It has been suggested that providing habitat for predators, such as roosts, nest boxes, and rock piles, may provide a rodent control mechanism. Because of the high reproductive rate of rodents and their ability to move in quickly from elsewhere, it is unlikely that predators, such as kestrels, can actually provide adequate population control. However, some success has been reported. Rodent damage in a grassland habitat was significantly reduced by planting a snag (dead tree) in the middle of the area, which served as a hunting perch for raptors (Dick Hodder, Montana State University, pers. comm.). Such snags may also enhance the value of the area for perching birds. Peter Kiewit Son's in Sheridan, WY, and Pittsburg-Midway near Steamboat Springs, CO, are experimenting with kestrel nest boxes on some of their reclamation areas and should have more information on the success of this technique.

A variety or a combination of methods to control predation on both seeds and seedlings may have to be tried before success is achieved. The results of the described techniques are often unpredictable and may be expensive, but may be worth trying if predation is threatening to destroy the reclamation program.

Weed Control

Fall seeding is a common practice in the reclamation of many surface coal mines and may be applicable in the Uinta-Southwestern Utah Coal Region. If land shaping is finished in the late fall or spring and seeding is not done until the following fall, weedy growth can be abundant. The control of weeds

during the summer growing season or summer "fallowing" prevents weeds from going to seed, thereby reducing the likelihood of thick stands of weeds competing with the newly emerged seedlings.

Summer fallowing can be done by tilling the soil or through the application of preemergence and/or postemergence herbicides. Neither burning nor mowing is an effective means of summer fallowing (Cook et al. 1974). Preemergence herbicides are effective for annual grasses, while postemergence herbicides affect broad-leaved plants and should not be used where shrubs and trees are transplanted or must be saved. The application of herbicides as a summer fallow practice gives significantly better stands of seeded vegetation than untreated areas where the seed is drilled directly into the weedy growth of annuals.

Tillage is difficult and costly on steep or rocky slopes and the effectiveness would be reduced. However, the advantage of tillage on level ground is that working with chemicals can be avoided.

Common problem weeds in the Uinta-Southwestern Utah Coal Region are Canada thistle, whitetop, prickly lettuce, Russian thistle, and leafy spurge. The U.S. Soil Conservation Service recommends aerial or hand spray treatment with 2,4-D (2,4-dichlorophenoxyacetic acid) or other appropriate herbicides. For information on current recommended application rates, contact the U.S. Soil Conservation Service, U.S. Environmental Protection Agency, and/or State Regulatory Authority.

The U.S. Environmental Protection Agency keeps a registry of legal pesticides, which have an EPA registration number on the label, as well as a list of uses. To use EPA-restricted-use pesticides, State certification is required. For information on restricted-use pesticides and on obtaining a commercial applicator's license, contact the appropriate State agriculture agencies.

LABOR/MATERIALS

Many of the granivore control techniques would not increase the cost of seeding appreciably. Sowing seed in the spring instead of fall, making sure the seed is covered, and using less palatable species are inexpensive changes that could be made if seed predation is a problem. Rolled barley at $6/22.7 kg (50 lbs) and Lab Chow at $15/22.7 kg (50 lbs) can be mixed with seed. The number of pounds per ha (acre) to use would have to be derived experimentally, but the cost is minimal.

Taste repellants to protect shrubs, trees, and seedlings cost approximately $20 to $35/3.8 ℓ (gal). Approximately 400 seedlings can be treated with 3.8 ℓ (1 gal). Labor time for 400 seedlings would be approximately five hours (Jack Terry, International Reforestation Suppliers, pers. comm.).

Plastic mesh tubes to protect seedlings can be obtained for $0.20 to $0.36 per tube, depending on the manufacturer, quantity, diameter, and freight charges. Application rate for each tube, stakes, and tie would be approximately two to three minutes. For 400 seedlings, the labor time would be 13 to 20 hours.

SOURCES OF INFORMATION

- State Regulatory Authority
- Office of Surface Mining
- State Game and Fish agencies
- U.S. Forest Service
- U.S. Bureau of Land Management
- County Agricultural Extension Agents
- U.S. Soil Conservation Service
- State Agricultural Experiment Stations

For addresses, see Appendix A.

References Cited:

Cook, C. W.; Hyde, R. M.; Sims, P. L. Revegetation guidelines for surface mined areas. Colorado State Univ. Science Series No. 16; 1974. 74 p.

Everett, R. L.; Meenwig, R. O.; Stevens, R. Deer mouse preference for seed of commonly planted species, indigenous weed seed, and sacrifice foods. J. Range Manage. 31(1):70-73; 1978.

Goebel, C. J.; Berry, G. Selectivity of range grass seed by local birds. J. Range Manage. 29(5):393-395; 1976.

Hawthorne, D. W. Wildlife damage and control techniques. Pages 411-440 in Schemnitz, S. D. ed. Wildlife management techniques manual. Washington, D.C.: The Wildlife Society; 1980.

Knudson, R. S. Survey of current methods for seedling protection. USDA Forest Service, MEDC Project Record; 1972.

Krementz, D. G.; Stanton, N. L.; Pentecost, E. D. Granivore communities on reclaimed mine spoils of northern desert shrub-steppe. Unpublished manuscript available from Dept. of Zoology, U. of Western Ontario, London, Ontario, Canada; 1981.

Larson, J. E.; Campbell, D. L.; Evans, J.; Lindsey, G. D. Plastic tubes for protecting seedlings from browsing wildlife. Report on Equipment Development and Test Project 2217-Plastic Tube Seedling Protectors. USDA Forest Service; 1979.

Marsh, R. E.; Passof, P. C.; Howard, W. E. Anticoagulants and alpha-napthylthiourea to protect conifer seeds. Black, H. E., ed. Wildlife and forest management in the Pacific Northwest. Oregon State Univ.; 1974.

Nelson, J. R.; Wilson, A. M.; Goebel, J. Factors influencing broadcast seeding in bunchgrass range. J. Range Manage. 23; 1970.

Pulliam, H. R.; Brand, M. R. The production and utilization of seeds in plains grassland of southeastern Arizona. Ecology 56; 1975.

Reichman, O. J. Desert granivore foraging and its impact on seed densities and distributions. Ecology 60(6); 1979.

Spencer, D. A. Rodents and direct seeding. J. For. 52; 1954.

Sullivan, T. P. Repopulation of clear-cut habitat and conifer seed predation by deer mice. J. Wildl. Manage. 43(4); 1979.

k. Grazing management to allow vegetation recovery.

PURPOSE

Grazing is the primary land use on much of the reclaimed mined lands in the western United States, but without some follow-up level of management, even the best plant stands can be destroyed by excessive or improper grazing (Institute for Land Rehabilitation 1978). The ultimate success of revegetation depends upon post-revegetation management. However, until the operator's bond is released on a given parcel of land, the State regulatory authority will determine what grazing practices should be used. The mining company should, therefore, work with the State regulatory agency and the Office of Surface Mining to determine the need for, and level of, post-revegetation management.

DEVELOPMENT

The immediate goal of a reclamation program should be to reestablish vegetation growth for site stabilization and soil cover before allowing grazing to commence. Young plants and seedlings do not develop well when cropped or trampled by large or small animals (Yoakum and Dasmann 1971). In seeded stands, the best rule to follow is to exclude grazing animals until the plants have become sufficiently established to withstand grazing (Institute for Land Rehabilitation 1978). Vallentine (1971) suggests that seeded or planted areas should not be grazed until after the second full growing season following seeding. Fencing to exclude large grazers and repellants to deter small mammals are some of the measures that can be employed to protect newly established vegetation (see Section 3.1.1.d, Fences, and Section 3.3.1.j, Pest Control).

In designing a grazing management program, it is important to understand that forage competition between domestic and native animals can be a major factor in both livestock and wildlife production. The degree of this competition depends upon the similarity in diets, the kind and amount of forage present, the relative size and numbers of domestic and wild herbivores, the intensity of grazing, and the degree to which the animals use the same part of the range (Stoddart et al. 1975). To minimize competition and to help ensure the success of the reclamation program for both wildlife and cattle, grazing management programs should be concerned not only with plant productivity but also with diversity. Furthermore, any grazing system must be tailored to characteristics of the range to be grazed and the type and number of animals to be managed. In this context, the four basic rules of range management are:

- graze the proper number of animals;
- graze the proper kind of animals;
- graze animals that are properly distributed; and
- graze at the proper season or time of year.

Berg (1975) recognized three grazing-forage management alternatives, which he suggested be adopted in reclamation plans. These three alternatives are:

- Use of revegetated areas for special use pastures, with emphasis on establishment of a limited number of highly productive, probably introduced plant species (this alternative would rarely be implemented on Federal land but may be a viable practice on private land, although it may require land use change approval by OSM or the State regulatory authority);
- pastures of more general livestock use, primarily composed of native plant species; and
- special use areas for wildlife, emphasizing establishment of suitable browse species.

Grazing management systems include season or yearlong grazing, deferred grazing, rotation grazing, deferred rotation grazing, and rest rotation grazing (Stoddart et al. 1975).

In a yearlong grazing system, the entire range is available to grazing yearround. This system usually results in undesirable successional changes in range forage and should generally be avoided.

Deferred grazing involves delaying grazing for some period of time during the growing season. In this system, a pasture receives no use for at least one entire growing season. This system is generally applied to land that has been disturbed or overgrazed. An example of a three-pasture (unit) deferred grazing system, in which units are ungrazed during winter is (Stoddart et al. 1975):

Year	Unit 1	Unit 2	Unit 3
1	Spring	Summer	Fall
2	Spring	Summer	Fall
3	Summer	Fall	Spring
4	Summer	Fall	Spring
5	Fall	Spring	Summer
6	Fall	Spring	Summer

Deferred grazing has some theoretical advantage in that forage plants are given a better opportunity to reproduce. Delaying grazing until after the seed matures causes less injury to plants, and animals scatter and trample the seeds into the soil, promoting establishment.

Rotation grazing involves subdividing the area to be grazed into units and grazing one unit, then another, in regular succession so that any one unit is not grazed the same season in consecutive years. This system assumes that a larger number of animals forage more uniformly, and that a rest from grazing is beneficial to the plants, even though it must support more animals during the shorter time it is grazed (Stoddard et al. 1975).

With the deferred rotation system, grazing is deferred on one part of the range during one or more years. By rotation, other areas are successively deferred until all have been deferred. The system consists of dividing a given range into two subunits, A and B. Animals are placed on unit A for the first half of the season to allow seed to mature on unit B. No animals are placed on B. This pattern is followed for two years. During the third year, Unit B is grazed during the first half of the year and A is allowed to mature seed. After two more years, the original order is followed. Three pastures are commonly used in this system, but there may be as many as ten.

The deferred part of the range is given complete rest for an entire year in the rest rotation system. The system has been widely used in areas where seasonal grazing is practiced and cool-season grasses make up most of the vegetation (Stoddart et al. 1975).

Another system developed for large, arid areas places all grazing animals into one unit. All other units are deferred. Animals are moved to another unit when 50% of the forage has been utilized.

Variations of the rotation grazing system are most commonly used in the Uinta-Southwestern Utah region. While most mine permit areas in this region are relatively small, they do compose portions of larger grazing allotments. Allotments are subdivided into seasonal units. For example, cattle may be grazed in a lower elevation unit during the winter and spring, then moved to a higher elevation pasture during the summer and fall. In this example the allotment is divided into two pastures. Three and four seasonal pastures are also common. All cattle allotments in the region are fenced; sheep allotments are not usually fenced. The maximum number of livestock that can be carried on any unit of land is the number that can be supported during a poor season (Stoddart et al. 1975). Ranges in most western states can support one animal unit on 10 to 32 ha (25 to 80 acres) per year. Each of the described grazing systems assumes that fencing will be used to control livestock. These systems also require a distribution of water sufficient to support the herd.

A variety of methods are available for keeping livestock away from a particular site. Indirect methods for accomplishing this are less costly than direct methods and include (Bjugstad 1979):

- adding less palatable species to the seed mixture,
- salting at least 0.4 km (0.25 mi) from the seeded area, and
- providing permanent water away from the seeded area and fencing out nearby water.

Direct methods include the use of barriers, either of metal or wood, and ranging from barbed-wire fences to brush piles. Repellents have been developed for wild ungulates and are sometimes effective for sheep and cattle. Repellents specifically for livestock have not been fully developed. Herding may also be tried although this requires the use of herders to keep the animals contained.

MAINTENANCE AND MANAGEMENT

Management to control grazing will require a concerted effort. However, the effort involved should be no more than would be expected on unmined lands. The procedures which have been described are those that would be required for any successful grazing operation. Costs should be expected to equal those of any other similar operation.

SOURCES OF INFORMATION

- State Regulatory Agency
- Office of Surface Mining
- U.S. Soil Conservation Service
- County Agricultural Extension Agents
- U.S. Forest Service
- U.S. Bureau of Land Management

For addresses, see Appendix A.

References Cited:

Berg, W. A. Revegetation of land disturbed by surface mining in Colorado. Wali, M. K., ed. Practices and problems of land reclamation in western North America. Univ. North Dakota Press: Grand Forks, ND; 1975.

Bjugstad, A. J. Management plan and monitoring. User guide to vegetation. Mining and reclamation in the West. USDA Forest Service Gen. Tech. Rep. INT-64: Intermtn. For. and Range Exp. Stn., Ogden, UT; 1979. 85 p.

Institute for Land Rehabilitation. Rehabilitation of western wildlife habitat: A review. Washington, D.C.: U.S. Fish and Wildlife Service, FWS/OBS-78/86; 1978.

Stoddart, L. A.; Smith, A. D.; Box, T.W. Range management. New York: McGraw-Hill; 1975.

Vallentine, J. F. Range development and improvements. Brigham Young University Press: Provo, UT; 1971.

Yoakum, J.; Dasmann, W. P. Habitat manipulation practices. Giles, R. H., ed. Wildlife management techniques. Washington, D.C.: The Wildlife Society; 1971.

3.3.2 Water Resource Improvement and Development

a. Final cut lakes as permanent impoundments. Recently, Federal and State regulations began limiting the retention of this type of impoundment on reclaimed surface mines. 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 publication, entitled Manual for Planning and Management of Mine-Cut Lakes at Surface Coal Mines (Nelson et al. 1982), is the result of a recently completed Office of Surface Mining study to assist operators with problems associated with final cut lakes. This manual also presents 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 to the following address:

Asst. Director for Technical Standards and Research
Office of Surface Mining
1951 Constitution Ave., N.W.
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. U.S. Dept. Int., Office of Surface Mining, Washington, DC; OSM TR-82/1; 1982.

b. Supplementary water resources.

PURPOSE

Water is an essential requirement of most wildlife and, in some areas of the Uinta-Southwestern Utah region, is the key component dictating habitat use and population levels. Water holes in the semiarid West are often the center of wildlife activities, but the paucity of natural water impoundments on the unglaciated portion of this xeric region has placed the value of water for wildlife at a premium. Thousands of man-made ponds constructed for livestock use have alleviated this problem somewhat; however, water in this region is still locally limited.

Water developments extend the ranges of many species. Yoakum et al. (1980) provide an example of an area, formerly void of natural surface waters, where wildlife managers channeled water from an artesian well into a small excavated pond. The pond ultimately supported over 155 different species of wild mammals, birds, fishes, and amphibians. Such areas not only provide an animal's water requirements, but also create additional habitat and increase local species diversity. Creating supplementary water impoundments in the semiarid coal regions of Utah and Colorado may greatly enhance the distribution, numbers, and diversity of wildlife in an otherwise hostile habitat.

DEVELOPMENT

The design and specifications below represent those of a basic embankment pond, the versatility of which promotes maximum utilization by a broad variety of wildlife species. Modifications for enhancing individual species are provided elsewhere in this publication (see Section 3.3.2.c, Creating Impoundments for Waterfowl, and Section 3.3.2.e, Creating Impoundments for Fish) or in the references cited in this section. General considerations for wildlife needs are:

- Water sources should be present year-round to optimize benefits to wildlife. Ponds should be designed for at least a 20-year lifetime.
- Several small, irregularly shaped ponds are more desirable than one large, uniformly shaped pond, particularly if they are dispersed.
- Wildlife should have easy access to the water. Shoreline slopes should pitch at a gradient of 5 to 1 or less. Shorelines with gentle slopes also have minimal erosion problems.

The following are site/design considerations which should be incorporated into the selection of water impoundment sites:

- Surface runoff and snowmelt are the primary water sources for these ponds. Ponds must be sited so that the watershed supporting them is of adequate area to provide sufficient water to replenish the reservoir annually, yet not so large that peak runoff damages the spillway or the dam. The characteristics determining the amount of annual runoff are numerous and highly variable; however, 20.2 to 24.3 ha (50 to 60 acres) per acre foot of pond storage are generally required for this region (U.S. Soil Conservation Service 1971).

- To facilitate revegetation and to comply with regulatory requirements, reclamation efforts often reestablish a moderate overall topography. If the reclaimed area is too flat, too high above groundwater aquifers, or lies in a drainage area inadequate to yield the required runoff to fill the reservoir annually, then the impoundment may be built on suitable, adjacent, undisturbed lands. Even with siting on undisturbed lands, areas disturbed during pond construction should be immediately revegetated to prevent excessive sediment loading. Proper planning should also mitigate runoff leaching and the transportation of toxic substances into the reservoir from tailings, overburden, and waste rock disposal and soil storage sites.

- Water depths in some portion of the pond (33% is recommended by the U.S. Soil Conservation Service) should be at least 3 to 3.7 m (10 to 12 ft) in this region, to ensure the presence of surface water year-round (U.S. Soil Conservation Service 1971). Deeper portions are required if a permanent water supply is essential or where seepage exceeds three inches per month (U.S. Soil Conservation Service 1971). This deep pool will provide the last remnant of water when the rest of the pond has dried up. In the wetter months, the pool should overflow and provide shallow water habitat. Surface area of the deep pool should be minimized to reduce evaporative losses. A moderate slope should be retained around some portion of the deep pool to allow access by wildlife at all water levels. Pond size will vary with runoff accumulation.

- Proper impoundment siting is the most important step in pond construction from a wildlife and economic standpoint. Prior to construction, the topography, surface hydrology, geochemistry, vegetation, wildlife use patterns, and construction costs should be reviewed. Catchment basins along ephemeral streams are often the best sites for impoundment siting, especially in areas where the surrounding vegetation is comprised of bluegrasses, sedges, asters, or other wet meadow flora indicative of periodic flooding. Furthermore, construction costs can be lowered by using natural drainage systems where use of earth-moving equipment can be minimized.

The value of sedimentation ponds to wildlife varies greatly, depending on the level of toxic effluents present. These ponds may offer a great potential for wildlife enhancement to the mine company. If the design of such ponds, intended for less toxic pollutants, also considers wildlife needs, the company can provide a highly beneficial postmining habitat with little additional cost, indeed, a negligible cost relative to the cost involved in building a new postmining pond specifically for wildlife.

ENGINEERING CONSIDERATIONS

Ponds can be excavated with tractor-pulled wheeled scrapers, bulldozers, or draglines. Prior to compacting the pond bottom, soil composition should be checked to ensure a minimum composition of 20% clay or other impervious material. If soils are too porous, a sealer, such as bentonite, can be mixed into the soil with a disk. A sheepsfoot roller can be used to compact the pond bottom. The deep portion of the pond can be excavated immediately upstream of the dam and the excavated material used in dam construction. Dam construction and engineering specifications for the materials used in the dam and spillway, the dimensions of each, the associated valves and instrumentation, and appropriate methods of excavation are described in Agriculture Handbook No. 387 (U.S. Soil Conservation Service 1971) and Technical Guide No. 378 (U.S. Soil Conservation Service 1980). Other related engineering standards and specifications for impoundment creation are available from the Soil Conservation Service and are identified below.

Creating supplementary water resources on or adjacent to coal lands, like all reclamation practices discussed in this publication, is obviously contingent upon the surface owner's land-use goals and the State regulatory program. Reclamation efforts would be possible under any of the following conditions:

- adjacent or reclaimed land is owned by the mining company;
- the owner of reclaimed or adjacent land wishes his or her land to be improved for wildlife; or
- reclaimed or adjacent land is Federal or State-owned and an agreement is made following multiple use guidelines.

REGULATORY SPECIFICATIONS FOR PERMANENT IMPOUNDMENTS

The first step for a coal mine operator planning to retain a permanent impoundment is to consult with the State regulatory agency. In Colorado, the Mined Land Reclamation Division is the regulatory authority. This agency grants the permit to create an impoundment and also the National Pollutant Discharge Elimination System (NPDES) permit. The State Engineer's office must be consulted if the impoundments are larger than 2.2 ha-m (20 acre-ft), if reservoir capacity is greater than 100 ha-m (1,000 acre-ft), if dam height is 3 m (10 ft) or greater, or if water rights are in question. The primary concern is that the impoundments have geotechnically stable dams, sealed and relatively inert pond bottoms, protection from excessive erosional products, pond water quality that will support a postmining land use equivalent to or greater than the premining land use, and discharge of water from the impoundment that will not degrade the quality of the receiving waters. The Utah Division of Oil, Gas, and Mining have comparable rules and regulations. Both states refer the mine operator to several publications of the U.S. Soil Conservation Service (1971, 1976, 1980) for the engineering specifications to be followed in the design, construction, and maintenance of permanent impoundment structures. In light of the fact that techniques and procedures for the creation of supplemental water resources have yet to be tested with respect to enhanced wildlife use in the Uinta-Southwestern Utah region, the guidelines presented in the Soil Conservation Service Technical Guide No. 378, Ponds, are considered the best way to proceed for the present. In the future, some of the standards and specifications may be modified when the planned land use is primarily for wildlife (including livestock). Pond siting and construction criteria that are relevant to wildlife use are listed below:

- Minimum distance between ponds in undulating prairie land should be 1.2 to 1.6 km (0.75 to 1 mi); in the foothills or on rolling land, the distance between ponds should be no less than 0.6 to 1.2 km (0.38 to 0.75 mi).
- Ponds must have an effective life of 25 years. The drainage area should be large enough to ensure adequate water storage.
- Water quality should be suitable for the intended land use.
- Ponds should have a minimum size of 0.1 surface ha (0.25 surface acres).
- No more than 20% of the pond surface should have a depth less than 0.6 m (2 ft) when the pond is full.
- The side slopes of the embankments should be no steeper than 5 horizontal : 1 vertical, averaged over upstream and downstream sections.
- Slopes should be of stable material.
- The embankment dam should have an emergency spillway to prevent flood damage to the pond.

LABOR/MATERIALS

Construction and reclamation costs are estimated in the bonding section of the mine permit application that each operator submits to the State regulatory agency. Costs are quite variable, depending on the mine site, geology, availability of equipment, the size of the ponds, etc. Cost of most "average" 0.4 to 0.81 ha (1- to 2-acre) ponds in this region run between $35,000 and $50,000 (Sam Scott, Peter Kiewit Son's, pers. comm.); however, ponds beneficial to wildlife can be built far less expensively. Energy Development Co. excavated a 0.7 ha-m (6 acre-ft) pond in about 8 hours with a "D9", at a cost of about $1,000 for the operation of the machine and labor. If the equipment had been rented, the price would have doubled. Engineering and permitting costs add significantly to the final cost.

Many operators simply convert sediment control ponds to permanent impoundments. In these cases, most costs are absorbed as part of normal mine operations, and the only additional cost is that of cleaning up the impoundments and converting them.

The major cost of most impoundments is incurred from permitting requirements. The applicant must guarantee dam stability quantity and quality of water, etc. (as described above) for the proposed use. Water quality must be monitored, which often includes expensive laboratory procedures.

It is expensive to create water impoundments and later destroy the reservoir to reclaim the land. For this reason, operators appear interested in working with regulatory agencies to develop a set of procedures and methods that would allow sediment ponds to be cleaned, modified, and left as final impoundments that wildlife and livestock could use.

SOURCES OF INFORMATION

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

For addresses, see Appendix A.

References Cited:

U.S. Soil Conservation Service. Ponds for water supply and recreation. Agricultural Handbook No. 387; 1971.

U.S. Soil Conservation Service. Earth, dams and reservoirs. Tech. Release No. 60; 1976.

U.S. Soil Conservation Service. Ponds. Practice Standard 378. SCS Denver, CO; 1980.

Yoakum, J.; Dasmann, W. P.; Sanderson, H. R.; Nixon, C. M.; Crawford, H. S. Habitat improvement techniques. Schemnitz, S. D. ed. Wildlife management techniques manual. The Wildlife Society, Washington, D.C.; 1980.

Additional References:

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; 1977.

Wyoming Department of Environmental Quality. Rules and Regulations. Cheyenne, WY; 1981.

c. Creating impoundments for waterfowl.

PURPOSE

Portions of the Uinta-Southwestern Utah Coal Region of Colorado and Utah are located in the semidesert where the surface water acreage is low. These coal regions are along the western border of the Central Flyway (major migration route) and the eastern border of the Pacific Flyway. Waterfowl make temporary use of playas, catchment basins along ephemeral streams, and stock ponds. Relatively small numbers of mallards, pintails, blue-winged teal, American wigeon, and other waterfowl remain in the region, to breed and rear their young. The densities of waterfowl are limited by the extent and type of water bodies available. Lokemoen (1973), Ruwaldt et al. (1979), and others have shown that waterfowl, particularly mallards and gadwalls, will readily make use of new, man-made impoundments, provided they have the appropriate habitat features (Flake et al. 1977). By creating more permanent impoundments with suitable cover and food resources, waterfowl production will be enhanced in the Uinta and Southwestern Utah Region (Brewster et al. 1976).

DEVELOPMENT

Adequacy of Habitat

Blue-winged teal, mallard, pintail, American wigeon, gadwall, northern shoveler, green-winged teal, cinnamon teal, redhead, lesser scaup, canvasback, ruddy duck, and Canada geese breed and rear their young in this coal region. The most common are the first five species listed above. Newly constructed impoundments designed for waterfowl should particularly consider habitat needs of these species first. All five are dabbling ducks and require shallow (0.6 m; 2 feet or less) areas to feed in. Small, irregularly shaped ponds with emergent vegetation and islands provide areas for courtship, nesting, and brood raising. Flake et al. (1977) examined 28 habitat variables and found that pond size and distance between ponds were positively correlated with the presence of breeding pairs of mallards and gadwalls. The areal extent of emergent vegetation and percent of semi-open marsh were key features that attracted blue-winged teal and American wigeon. In addition to differences in species habitat preferences, ducks sought different environmental conditions as they aged. Patterson (1976) showed that the number of breeding pairs of ducks was most closely correlated with pond size, the number of broods correlated with the suitability of escape cover and food, and fledgling numbers were positively correlated with wetland fertility. As a result, a small group of ponds is more advantageous to waterfowl production than one large one.

Design Features

Impoundment design should follow that suggested in Section 3.3.2.b (see especially the regulatory specifications), with the exceptions that 50 to 75% of the pond should consist of water less than 0.6 m (2 ft) deep, the pond should be irregularly shaped, and contain islands and side channels. The shallow areas suited for waterfowl feeding and emergent plant growth in turn

make the pond more attractive for waterfowl nesting and brood rearing. A deep basin may attract diving ducks and serve as a prairie oasis in times of drought. Ideally, several ponds are excavated within 0.4 km (0.25 mi) of the reservoir.

Specific design features of ponds that appear most suitable for waterfowl production have been reviewed by Lokemoen (1973), Patterson (1976), Flake et al. (1977), and Eng et al. (1979). These include:

- Pond density: 2 to 3 ponds/2.59 km² (1 mi²).
- Pond size: 0.4 to 4.0 ha (1 to 10 acres); 0.4 to 2.0 ha (1 to 5 acres) optimal.
- Pond depth: Eng et al. (1979) recommend that 50 to 75% of the pond be less than 0.6 m (2 ft) deep; the Wyoming Game and Fish Department (1977) suggests that no more than 30% of the pond be less than 0.9 m (3 ft) deep.
- Pond configuration: Irregular with islands and side channels.
- Islands: 0.009 to 0.06 ha (0.01 to 0.15 acres) in size, vegetated, at least 9.1 m (30 ft) from shore, with a greater than 0.46 m (1.5 ft) channel depth between island and mainland (see Section 3.3.2.d, Island Development for Waterfowl).
- Vegetation: Sedges, spikerush, smartweed, rushes, and duckweed are most likely pioneer species, but can be transplanted (rootstock, entire plant); emergents require water depths greater than 0.9 m (3 ft) to develop.
- Fencing: Not required, provided some shoreline areas (e.g., islands) are kept free from excessive grazing pressure.

Engineering Considerations

If several satellite ponds are created in addition to damming the drainage system, they should be constructed first. The excavated material can be used in constructing the dam and islands of the main reservoir. When complete, these ponds should resemble playas and should be filled seasonally with surface drainage. To ensure a maximal water supply, annual runoff must be accurately estimated and pond size adjusted accordingly. The dam construction procedures and engineering specifications outlined in Agriculture Handbook No. 387 (U.S. Soil Conservation Service 1971) may be recommended, but it is essential that the operator consult with the State regulatory authority before beginning construction of any impoundments on the mine permit area.

MAINTENANCE AND MANAGEMENT

Impoundment maintenance is required, and the State regulatory authority will provide guidance as appropriate.

LABOR/MATERIALS

The number of man-hours required depends upon the size, complexity, and location of the impoundment. Construction can be accomplished with heavy equipment normally used during mining and/or reclamation activities. Cost of most 0.4- to 0.81-ha (1- to 2-acre) ponds in this region averages between $35,000 and $50,000 (Sam Scott, Peter Kiewitt Son's, pers. comm.). Additional cost and labor estimates are provided in Supplementary Water Resources, Section 3.3.2.b.

SOURCES OF INFORMATION

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

For addresses, see Appendix A.

References Cited:

Brewster, W. G.; Gates, J. M.; Flake, L. D. Breeding waterfowl populations and their distribution in South Dakota. J. Wildl. Manage. 40(1):50-59; 1976.

Eng, R. L.; Jones, J. D.; Gjersling, F. M. Construction and management of stockponds for waterfowl. U.S. Dept. Interior, Bureau of Land Management Tech. Note No. 327; 1979.

Flake, L. D.; Peterson, G. L.; Tucker, W. L. Habitat relationships of breeding waterfowl on stockponds in northwestern South Dakota. Proc. S. Dak. Acad. Sci. 56:135-151; 1977.

Lokemoen, J. T. Waterfowl production on stockwatering ponds in the northern plains. J. Range Manage. 26(3):179-184; 1973.

Patterson, J. N. The role of environmental heterogeneity in the regulation of duck populations. J. Wildl. Manage. 40(1):22-32; 1976.

Ruwaldt, J. J., Jr.; Flake, L. D.; Gates, J. M.: Waterfowl pair use of natural and man-made wetlands in South Dakota. J. Wildl. Manage. 42(3):375-383; 1979.

U.S. Soil Conservation Service. Ponds for water supply and recreation. Agricultural Handbook No. 387; 1971.

Wyoming Game and Fish Department. Considerations for wildlife in industrial development and reclamation. Wyoming Game and Fish Dept., Cheyenne; 1977.

Additional Reference:

Bellrose, F. C. Ducks, geese and swans of North America. Stackpole Books, Harrisburg, Pa.; 1976.

d. 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 sites which are relatively inaccessible (Figure 3.3-7). A number of species of waterfowl and shorebirds will benefit from such development. It has been shown from several studies that nesting success as high as 90% has been recorded for islands, compared to 20% for mainland-nesting individuals. Islands are also attractive to waterfowl because they represent places where general disturbance is minimized and the birds can rest undisturbed.

Figure 3.3-7. 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. Islands should be 0.02 ha (10 x 20 m) 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 m (1.5 to 2 ft) deep and approximately 9 m (30 ft) wide between the island and the mainland were adequate (Keith 1961). Another study recommended long, narrow islands at least 15 m (50 ft) from the shore in impoundments larger than 0.8 ha (2 acres) (McCarthy 1973). Hook (1973) found that, on large water bodies, a minimum of 33 m (150 ft) between islands minimized territorial strife and encouraged nesting in Canada geese.

During impoundment construction, potential high points and deltas within the reservoir can be built up, while land which was previously a peninsula can be separated from the mainland (Figure 3.3-8). The location of islands with respect to the prevailing wind direction on large bodies of water represent special problems. 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 (see Section 3.3.3.c, Creating Wind and Snowbreaks for Winter Wildlife Protection, and Section 3.3.1.c, Seeding). Islands at least one meter (3 ft) high are recommended to avoid nest destruction due to flooding and eventual settling of the ground.

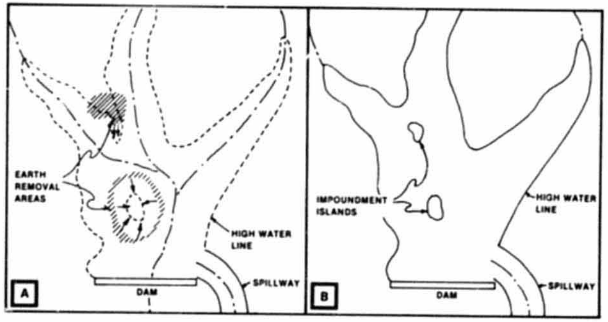

Figure 3.3-8. Schematic showing (A) possible areas of earth removal and (B) areas of placement to create postimpoundment islands (after Jones 1975).

Top soils should comprise the upper soils on the island, and reseeding with native grass species is recommended (see Section 3.3.1.a, Use of the Plant Information Network (PIN) to Aid in Selection of Revegetation Plants). In general, woody growth should be avoided because brushy areas that would develop are not desirable for waterfowl use. While establishing vegetation, hay or other suitable material 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 (see Section 3.3.1.c, Seeding; Section 3.3.1.f, Cover Crops/Preparatory Crops); and Section 3.3.2.h, Streambank Protection-Gabion Matting and Riprap).

MAINTENANCE AND MANAGEMENT

If properly designed, the type of island discussed in this section 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 to other vegetation (see Section 3.3.1.j, Pest Control).

LABOR/MATERIALS

Small islands can be created with a few hours of equipment time (~ 2 hours/island). Draglines (0.38 to 0.57 m^3 capacity [0.5 to 0.75 yd^3]), scrapers, and bulldozers are among the types of equipment that can be used (Figure 3.3-9). 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.

Figure 3.3-9. Earthen-mound islands can easily be constructed with a bulldozer during impoundment construction (Jones 1975).

SOURCES OF INFORMATION

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

For addresses, see Appendix A.

References Cited:

Hook, D. L. Production and habitat use by Canada geese at Freezeout Lake, Montana. M.S. Thesis, Montana State Univ.; 1973. 53 p.

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. Technical note 260; 1975. 17 p. (Available from Bureau of Land Management, Denver, CO.)

McCarthy, J. J. Response of nesting Canada geese (Branta canadensis) to islands in stockdams in northcentral Montana. M.S. Thesis, Montana State University, Bozeman; 1973. 34 p.

Additional Reference:

Hammond, M. C.; Mann, G. E. Waterfowl nesting islands. J. Wildl. Mgmt. 20(4):345-352; 1956.

e. Creating impoundments for fish.

PURPOSE

Impoundments supporting fish populations add complexity to the food web, enrich local wildlife diversity, and provide water for wildlife and livestock. Ponds further provide recreational opportunities. Most State regulatory authorities encourage the retention of such impoundments as enhancement features, provided water rights, long-term water quality, and other similar regulatory requirements are met.

DEVELOPMENT

Pre-Construction Considerations

While ponds supporting a fish population offer a potential habitat improvement because of increased diversity, there are several constraints inherently imposed by the characteristics associated with reclaimed coal lands in the semiarid Uinta-Southwestern Utah Coal Region. These constraints are the availability of a permanent water supply and acceptable water quality. Thus, it is difficult to establish a viable fishery in this region. Furthermore, "building a dam, impounding water, and stocking with fingerling fish does not assure satisfactory fish production" or even fish survival (Marriage and Davison 1971). Ponds supporting fish must be managed to some degree at least for the first few years. Therefore, when considering if the development of such a resource is feasible, the landowner or land management agency should also evaluate the level of postconstruction management required.

The following is a sequence of potential problems to consider before constructing an impoundment for fish:

- Permanent water and adequate water quality are essential to fish production. Site selection, soil suitability, and a variety of other considerations are discussed under "Supplementary Water Resources" (Section 3.3.2.b). Water quality characteristics as they relate to fish species suitable for stocking, are discussed in "Stocking Impoundments with Fish" (Section 3.3.2.f). The U.S. Soil Conservation Service (1971) states that ponds from 0.1 ha (0.25 acre) to several hectares can be managed for good fish production and that ponds greater than 0.8 ha (2 acres) are not as difficult to manage as smaller ones. However, Marriage and Davison (1971) contend that ponds less than 0.4 surface ha (1 acre) will not support enough fish, without supplementary feeding, to furnish much food or sport. Whatever size pond is constructed, it should be planned for the average annual runoff expected: 12 to 40 ha (30 to 100 acres)/acre foot of pond storage are generally required for this region (U.S. Department of Agriculture 1971). Recommended minimum water depths in the ponds are 3 to 3.7 m (10 to 12 ft) (U.S. Soil Conservation Service 1971). At least one-fourth of the pond's area must be this

deep to provide adequate fish habitat during all seasons (U.S. Department of Agriculture 1971), although deep areas are generally less productive than shallower areas. Deeper ponds should be excavated to guard against the ponds drying up following successive drought years. Final cut lakes and ponds (see Section 3.3.2.a, Final Cut Lakes as Permanent Impoundments) supplied groundwater by aquifers would probably require considerably less surface drainage area, depending upon flow rates from the aquifer.

- Water quality is much more critical to fish than to terrestrial wildlife. The following parameters substantially influence fish production: water temperature; dissolved oxygen; pH; turbidity; nutrient levels (NO_3, PO_4, SO_4); concentration of metals; and permanent toxic materials (i.e., pesticides, hydrocarbons) (selected references on this subject are listed under Additional References at the end of this section). Prior to impoundment construction, an assessment of anticipated year-round water characteristics should be conducted and compared with the tolerance limits of fishes selected.

- Even if the above problems are solved, it takes a relatively long time for a pond to evolve to where it can support a perennial fish population. It may take several years for adequate water to be impounded. Once the impoundment is full, 2 to 5 years are required until aquatic plants are well established (Bue et al. 1964). It may take even longer for adequate numbers of plankton and benthic fauna to be produced which serve as food for fishes. Minnows (Cyprinidae) or other nongame fish could be stocked to provide forage for piscivorous game species. In general, natural waters have low or moderate fertility. Good fish production usually necessitates the addition of commercial fertilizer, which increases the growth of microscopic plants supporting the entire food chain. Fertilizer typically decreases the amount of time required before a pond can support a fish population and increases the number and size of fish a pond can produce.

Many habitat improvement programs are conducted by State game and fish agencies in conjunction with private groups. The State game and fish agency may actually help build the reservoir, supply submerged artificial breeding structures, and stock the impoundment in exchange for public access and use as a fishing area. While the impoundment is developing into a habitat supporting a self-sustaining fish population, the landowner might consider annual stocking with State-reared hatchery fish for the public. Such programs have not yet been conducted on surface mined lands; however, they would be beneficial both to the State and the mine operator if the program could be worked out with the regulatory authority.

State laws on water storage and water rights vary greatly. Consult with the State engineer or water authority prior to construction.

Design Features

As stated in the previous sections, the State regulatory authority must be consulted prior to any impoundment construction. Many of the design features and regulatory specifications for fish impoundments have been previously addressed either in this or the "Supplementary Water Resources" Section (3.3.2.b). Specific features reviewed by the U.S. Soil Conservation Service (1971) and Marriage and Davison (1971) relevant to wildlife use are as follows:

- Pond size: At least 0.4 ha (1 acre), if no supplemental feeding is intended.
- Pond depth: A minimum depth of at least 3 to 3.7 m (10 to 12 ft) over one-fourth of the pond's area.
- Drainage area: 12 to 40 ha (30 to 100 acres) per acre foot of water impounded (e.g., for a 0.4-ha [1-acre] pond with an average depth of 2.1 m [7 ft], 85 to 283 ha [210 to 700 acres] are required to provide sufficient water if the pond is filled only by runoff).

Ponds designed exclusively for fish and fishing should have at least some shores which slope as abruptly as possible to a 1-m (3-ft) depth. This makes fishing easier, discourages growth of emergent aquatics and pond weeds (potentially interfering with fishing and fish production), and decreases the number of fish lost to wading birds (U.S. Department of Agriculture 1971). The steep slope also may provide shelter for fish from high winds and may act as a sink in which the density of benthic organisms increases.

In ponds intended primarily for sport fishing, trees, stumps, shrubs, cattails, and debris may be removed from some areas of the pond site; however, this vegetation and debris provides important habitat diversity for many fish and wildlife species. The disturbed slopes of newly created ponds should be seeded with sod-forming grasses or woody plants (depending upon management objectives) to stabilize soil and reduce erosion and silting. Managers should avoid planting willows or deciduous trees within 9 m (30 ft) of a pond designed exclusively for fishing. These trees may interfere with fishing and their decomposing leaves deposited in the pond utilize valuable oxygen. Additional shoreline protection to minimize the effects of wave action, trampling by livestock, and other sources of damage may include berms, booms, riprap, or fencing. These methods are discussed in detail in U.S. Soil Conservation Service (1971).

Many of the figures and data given in this section apply to a broad geographical area and are generalized. For more detailed and site-specific design specifications, consult with local engineers and State authorities.

Engineering Considerations

As discussed in preceding sections, ponds can be excavated with bulldozers, scrapers, land planes, and/or draglines. Detailed construction procedures and engineering specifications are discussed in Agriculture Handbook No. 387 (U.S. Soil Conservation Service 1971), which should be consulted before construction activities begin.

MAINTENANCE

Impoundment maintenance must be carried out as required by the State regulatory authority.

LABOR/MATERIALS

The number of man-hours required obviously depends upon the size, specifications, and site of the impoundment. Construction can be accomplished with the heavy equipment normally used during mining and/or reclamation activities. Costs and labor are discussed under Supplementary Water Resources, Section 3.3.2.b. Many operators simply convert sediment control ponds to permanent impoundments. In these cases, most costs are absorbed as part of normal mine operations, and the only additional cost is that of cleaning the impoundments and converting them.

At the North Antelope Mine in Wyoming, Peabody Coal Company proposes to leave the final pit as a permanent impoundment (S. Tessman, Wyoming Department of Environmental Quality, pers. comm.). In this case, the cost of leaving the pit as an impoundment will probably be less than recontouring and revegetating.

SOURCES OF INFORMATION

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

For addresses, see Appendix A.

References Cited:

Bue, I. G.; Uhlig, H. G.; Smith, D. J. Stock ponds and dug-outs. Linduska, J. P., ed. Waterfowl tomorrow; 1964. 770 p. (Available from the U.S. Government Printing Office, Washington, D.C.)

Marriage, L. D.; Davison, V. E. Fish ponds--construction and management. Teague, R. D., ed. A manual of wildlife conservation. Washington, DC.: The Wildlife Society; 1971.

U.S. Department of Agriculture. Trout ponds for recreation. Farmers' Bull. No. 2249; 1971. 13 p. (Available from the U.S. Government Printing Office, Washington, DC.)

U.S. Soil Conservation Service. Ponds for water supply and recreation. Agricultural Handbook No. 387; 1971.

Additional References:

Baxter, G. T.; Simon, J. R. Wyoming fishes. Bull. No. 4, Wyoming Game and Fish Dep., Cheyenne; 1970. 168 p.

Burnham, B. L.; Peterka, J. J. Effects of saline water from North Dakota lakes on the survival of fathead minnow (Pimephales promelas) embryos and sac fry. J. Fish. Res. Board Can. 32:809-812; 1975.

Chipman, R. K. Studies of tolerance of certain freshwater fishes to brine water from oil wells. Ecology 40:229-302; 1959.

Everhart, W. H.; May, B. E. Effects of chemical variations in aquatic environments. Vol. I. Biota and chemistry of Piceance Creek. Ecol. Res. Ser. No. EPA-R3-73-011a, Environmental Protection Agency, Washington, D.C.; 1973. 117 p.

Foster, M. A. Ionic and osmotic regulation in three species of Cottus (Cottidae, teleost). Comp. Biochem. Physiol. 30:751-759; 1969.

Goettl, J. P.; Edde, J. W. Environmental effects of western coal surface mining. Part I - The fishes of Trout Creek, Colorado. Ecol. Res. Ser., Office of Research and Development, U.S. Environmental Protection Agency, Duluth, MN. (In Prep.)

Grande, M. Effect of copper and zinc on salmonid fishes. Proc. 3rd Int. Conf. Water Pollut. Res. Munich, 1966. 1:96-111; 1967.

McCormick, J. H.; Hokanson, E. F.; Jones, B. R. Effects of temperature on growth and survival of young brook trout, Salvelinus fontinalis. J. Fish. Res. Board Can. 29(8):1107-1112; 1972.

McKim, J. M.; Christensen, G. M.; Tucker, J. H.; Lewis, M. J. Effects of pollution on freshwater fish. J. Water Pollut. Control Fed. 45(6):1370-1407; 1973.

Peterka, J. J. Effects of saline waters upon survival of fish eggs and larvae and upon the ecology of the fathead minnow in North Dakota. PB-223 017, Natl. Tech. Inf. Serv., Springfield, VA 22161; 1972.

f. Stocking of impoundments with fish.

PURPOSE

Impoundments in the Uinta-Southwestern Utah Coal Region are stocked with fish to:

- establish fish populations where there formerly were none;
- increase local wildlife diversity;
- enhance a preexisting population; and
- introduce a species more desirable for recreation.

Ponds also provide valuable water for wildlife and may allow fishing, boating, and swimming while aesthetically enhancing the landscape (Marriage and Davison 1971).

DEVELOPMENT

Fish production is affected by water temperature, average annual water depth, dissolved oxygen, pH, turbidity, nutrient levels, food supply, concentration of metals, and the presence of toxic materials. Each species has a range of tolerance for each parameter. Therefore, it is essential that, prior to stocking, water quality parameters be determined so appropriate fishes can be selected. For example, while the warm temperatures characteristic of most ponds and small impoundments in the southern and western segments of the Uinta-Southwestern Utah Coal Region are generally unsuitable for perennial populations of trout and other cold-water species, trout may thrive in the colder, higher altitude ponds in the northeast and eastern portions of the region. The analyses required to evaluate water quality and the interpretation of the results can be arranged through Soil Conservation Service conservationists, county agents, private consultants, and Federal or State fishery biologists.

Ponds should be stocked only after they are judged suitable for sustaining a perennial population. Impoundment design specifications required to sustain a perennial fishery are discussed under "Creating Impoundments for Fish" (Section 3.3.2.e) and "Supplementary Water Resources" (Section 3.3.2.b). The sunfish, minnows, catfish, and trout, species which are most suitable for stocking in the warm- and cold-water ponds of this region, are generally stocked as fry or fingerlings, although some catchable size fish can be maintained by stocking (Butler and Borgeson 1966). Ponds should be stocked with the proper species and number of individuals, according to the size of the pond, its food supply, water characteristics, and the intended level of management (Dillon et al. 1971).

The stocking rate for a pond is related to its surface area, the amount of food available to the fish or fishes stocked, and the size of fish desired (Marriage and Davison 1971; Marriage et al. 1971). The surface area determines the amount of sunlight available for the photosynthetic production of food

(Marriage and Davison 1971). Recommended stocking rates in warm-water ponds of average fertility are 125 bass and 1,235 bluegills per surface hectare (50 and 500 per surface acre, respectively (Dillon et al. 1971). In cold-water ponds with average food supplies, spring stocking a 0.4-ha (1-acre) pond with 500 5- to 10-cm (2- to 4-inch) trout fingerlings will yield 18- or 20-cm (7- or 8-inch) trout the first year. Stocking 250 fingerlings in the fall should produce 25-cm (10-inch) trout the first year (Marriage et al. 1971). Under normal fishing pressure, 10- to 13-cm (4- to 5-inch) trout fingerlings are restocked every two years to maintain the catchable population since trout generally do not reproduce in impoundments. For more specific stocking rates of other species and stocking combinations under different fertility levels, see Dillon et al. (1971) and Grizzell et al. (1975), or consult with fishery biologists from Federal or State game and fish agencies or the local Soil Conservation Service office.

Since summer water temperatures of most lower elevation ponds in the Uinta-Southwestern Utah Coal Region reach 27° to 32°C (80° to 90°F) or higher (measured 15.2 cm [6 in] below the surface), they must be stocked with fish species adapted to this thermal environment. Species, such as largemouth bass, bluegill, and other sunfish ("bream"), channel catfish, and black bullhead, are suitable for warm-water ponds where summer temperatures exceed 21°C (70°F) for four or more months per year (Baxter and Simon 1970; Marriage and Davison 1971; Dillon et al. 1971; Grizzel et al. 1975; Woodling 1980).

Trout can live in ponds containing water between 1° and 24°C (33° and 75°F), but grow most rapidly in water between 10° and 18°C (50° and 65°F). Trout die if the water temperature reaches 30°C (86°F). Rainbow trout are most frequently stocked in ponds because they ive under a wide range of conditions and are widely available from hatcheries. Brook trout are also suitable for stocking and are often stocked with rainbows. Brown and cutthroat trout are not recommended for stocking in ponds (Marriage et al. 1971).

Fish may be obtained from Federal (U.S. Fish and Wildlife Service), State (game and fish agencies), or commercial hatcheries, or from fish farmers. However, prior to stocking, the State game and fish agency should be contacted for approval of any permit that may be required. Often an agreement can be reached between the landowner and the fish and wildlife agency whereby the landowner's impoundment is stocked with fish in exchange for public access and use. In this case, Federal or State personnel transport and stock the pond with suitable fishes. Most likely, whether fish are obtained from a Federal, State, or private hatchery, the hatchery can arrange delivery in an insulated tank truck with mechanical refrigeration, oxygen, and a fish pump. For more information on the transportation of live fish and the factors influencing this, see Johnson (1979).

MAINTENANCE AND MANAGEMENT

The key to maintaining a viable fish population is the perpetuation of a suitable environment, specifically adequate water quality. However, maintenance of such water characteristics as fertility, turbidity, acidity, dissolved

oxygen, and temperature in a range tolerated by fish, and fish management practices, such as supplemental feeding, fencing from livestock, pond depth, and fishing, are too complex to discuss in detail here. For more information on these factors and practices, see Marriage and Davison (1971), Marriage et al. (1971), Dillon et al. (1971), Grizzell et al. (1975), Martin (1978), Johnson (1979), and Boyd (1980), or contact your local Soil Conservation Service office.

LABOR AND MATERIALS

Without assistance from Federal or State agencies, fish stocking costs are a composite of production, transportation, and personnel costs. The costs of raising fish at hatcheries varies between $1.65 and $2.73 per kg ($0.75 and $1.24 per lb) of fish released (1977 dollars) (Bell 1973; Nelson et al. 1978). Cost per kg to the landowner will be higher. Transportation costs vary with the type of equipment used, the transport distance, and the accessibility of the release site. Operating costs for a modern insulated tank truck with mechanical refrigeration and oxgyen are around $1.86 per km ($3.00 per mi) (after Bell 1973, adjusted to 1981 dollars). Once at the release site, stocking should take approximately an hour while the fish are acclimated to the water characteristics of the pond (see Marriage et al. 1971).

SOURCES OF INFORMATION

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

For addresses, see Appendix A.

References Cited:

Baxter, G. T.; Simon, J. R. Wyoming fishes. Wyoming Game and Fish Department Bull. No. 4. Cheyenne; 1970. 168 p.

Bell, M. C. Fisheries handbook of engineering requirements and biological criteria. Fisheries Engineering Research Program, U.S. Army Corps of Engineers; 1973.

Boyd, C. E. Water quality in catfish ponds. Aquaculture 6(6):39; 1980.

Butler, R. L.; Borgeson, D. P. "Catchable" trout fisheries. Calhoun, A., ed. Inland fisheries management. California Department of Fish and Game; 1966.

Dillon, O. W.; Neely, W. W.; Davison, V. E.; Compton, L. V. Warm-water fish-ponds. USDA Soil Conservation Service, Farmers' Bull. No. 2250. U.S. Govt. Printing Office, Washington, D.C.; 1971. 14 p.*

Grizzell, R. A.; Dillon, O. W.; Sullivan, E. G.; Compton, L. V. Catfish farming. USDA Soil Conservation Service, Farmers' Bull. No. 2260. U.S. Govt. Printing Office, Washington, D.C.; 1975. 21 p.*

Johnson, S. K. Transport of live fish. Aquaculture 5(6):20-24; 1979.

Marriage, L. D.; Davison, V. E. Fish ponds--construction and management. Teague, R. D., ed. A manual of wildlife conservation. The Wildlife Society, Washington, D.C.; 1971. 100-102 pp.

Marriage, L. D.; Borell, A. E.; Scheffer, P. M. Trout ponds for recreation. USDA Soil Conservation Service, Farmers' Bull. No. 2249. U.S. Govt. Printing Office, Washington, D.C.; 1971. 13 p.*

Martin, M. Fish farmer must know what to do when turbidity becomes a problem in his ponds. The Commercial Fish Farmer 4(5):19-21; 1978.

Nelson, R. W.; Horak, G. C.; Olson, J. E. Western reservoir and stream habitat improvements handbook. USDI Fish and Wildlife Service, Office of Biological Services, Fort Collins, CO. FWS/OBS-78/56; 1978.

Woodling, J. Game fish of Colorado: an identification guide for sport fish commonly caught in Colorado. Denver: Colorado Division of Wildlife; 1980. 40 p.

*Publications often available from local Soil Conservation Service and County Agent offices.

g. Reclaiming sediment ponds.

PURPOSE

Water resources in many portions of the Uinta - Southwestern Utah region are limited to small, isolated wetlands that contain surface runoff on a seasonal basis, intermittent streams, and scattered stockponds. These water sources are important feeding, drinking, nesting, and rearing sites for waterfowl (Bellrose 1976), raptors (Olendorff 1972, 1973), pronghorn (Sundstrom 1968), mule deer (Wyoming Game and Fish Department 1978), and other wildlife species. From the wildlife literature, there is ample evidence that providing additional water resources in the semiarid and arid regions of Colorado and Utah benefits wildlife populations. Reclaiming sediment ponds following mining will cost the mine operator about the same amount as grading the impoundment back to premining contours.

DEVELOPMENT

Sediment ponds are required at mines to minimize contributions of suspended solids to streamflow or runoff outside the permit area as a result of mining operations. Mining activities must deposit no more suspended solids to streams than would normally exist in streams off the permit area (see applicable State and Federal laws). Sediment ponds are typically built prior to any mining activities and are the last structures removed. After all disturbed areas are revegetated and stabilized and all regulatory requirements are met, the standard reclamation procedure is to bulldoze the impoundment dam into the pond (generally in late summer or fall when all the water has evaporated), grade the area to its approximate premining contours, cover the area with topsoil, and revegetate in accordance with the approved reclamation plan. However, the Colorado Division of Mined Land Reclamation may approve the retention of sediment ponds as permanent impoundments when it is adequately demonstrated that:

- The size of the impoundment is adequate for its intended purposes.
- The impoundment dam construction will be so designed as to achieve necessary stability with an adequate margin of safety compatible with that of structures constructed under Public Law 83-566, 16 U.S.C. 1006.
- The quality of impounded water will be suitable on a permanent basis for its intended use and that discharges from the impoundment will not degrade the water quality below water quality standards established pursuant to applicable Federal and State law in the receiving stream.
- The level of water will be sufficiently stable for its intended use.

- Final grading will provide adequate safety and access for proposed water users.

- Such water impoundments will not result in the diminution of the quality of water or the quantity of water available to water right holders for agricultural, industrial, recreational, or domestic uses (Colorado Mined Land Reclamation Board 1978).

Utah's Board of Oil, Gas, and Mining has a similar policy. The minimum design standards referred to above follow those of the U.S. Soil Conservation Service's (1971) publication, Ponds. (These are discussed briefly under Supplementary Water Resources, Section 3.3.2.b.) In addition, impoundments with dam heights > 3 m (10 ft), or with a reservoir capacity > 110 ha-m (1,000 acre-feet), or with a surface area in excess of 8.1 ha (20 acres) must receive approval from the State engineer's office.

To date, the creation of new impoundments, or the reclamation and modification of existing ponds, for wildlife and livestock use has received little attention. There is no "after-the-fact" experience with pond creation or restoration on coal lands in Utah and Colorado (Shirley Lindsey, Office of Surface Mining, Denver, pers. comm.). Some mine operators have proposed modifying and leaving sediment ponds as final impoundments. but this approach has not yet been widely supported by the States' regulatory agencies. The operator is encouraged to consult with the Colorado Division of Wildlife and the Utah Division of Wildlife Resources when the intended final land use is for fish and wildlife.

Reclamation of sediment ponds is basically a four-step process:

1. clean out sediment and debris;

2. install desired enhancement features;

3. establish appropriate vegetation; and

4. provide soil stabilization.

Temporary impoundments being retained as permanent water sources can be cleaned out with a backhoe or small bulldozer when they have dried up. Permanent ponds being renovated prior to abandonment or temporary ponds containing water year-round can be cleaned out with a dragline.

Enhancement features include islands for waterfowl, bottom contours providing more diverse habitat, etc. These are discussed in detail under Supplementary Water Resources (Section 3.3.2.b), Creating Impoundments for Waterfowl (Section 3.3.2.c), Island Development for Waterfow (Section 3.3.2.d), and Creating Impoundments for Fish (Section 3.3.2.e).

Establishing appropriate vegetation is discussed in Creating Impoundments for Waterfowl (Section 3.3.2.c), Island Development for Waterfowl (Section 3.3.2.d), and in other Revegetation BCP's. Selection of potential revegetation

species will depend on the intended use of the pond. The local Soil Conservation Service office and the Plant Information Network (Section 3.3.1.a), available from the U.S. Fish and Wildlife Service, can assist in the selection process.

LABOR/MATERIALS

Construction and reclamation costs are estimated in the bonding section of the mine permit application that each operator submits to the Colorado Mined Land Reclamation Division or Utah Board of Oil, Gas, and Mining. Costs are quite variable depending on the mine site, geology, availability of equipment, the size of the ponds, etc.

Including the development of enhancement features, the removal of sediment and debris, soil stabilization, and establishment of vegetation at ponds intended for wildlife and/or livestock use would cost approximately the same amount as the standard reclamation practice of grading the dam back into the pond to premining contours, replacing topsoil, stabilizing soil, and revegetating. For this reason, operators may be eager to work with regulatory agencies in developing a set of procedures and methods that would allow sediment ponds to be cleaned, modified, and left as final impoundments that wildlife and livestock could use. The cost range for this process may run from $2,000 to $4,500 per 0.4 ha (1 acre) depending upon the complexity of the revegetation plan.

SOURCES OF INFORMATION

- Colorado Mined Land Reclamation Division
- Utah Board of Oil, Gas, and Mining
- U.S. Soil Conservation Service
- Office of Surface Mining
- State Game and Fish Agencies
- U.S. Fish and Wildlife Service

For addresses, see Appendix A.

References Cited:

Bellrose, F. C. Ducks, geese and swans of North America. Stackpole Books, Harrisburg, PA; 1976. 540 p.

Colorado Mined Land Reclamation Board. Rules and Regulations. Mined Land Reclamation Division. 1978.

Olendorff, R. R. The large birds of prey of the Pawnee National Grassland: nesting habits and productivity, 1969-1971. US/IBP Grassland Biome Tech. Rep. No. 151. Colorado State University, Fort Collins; 1972. 59 p.

Olendorff, R. R. The ecology of the nesting birds of prey of northeastern Colorado. US/IBF Grassland Biome Tech. Rep. No. 211. Colorado State University, Fort Collins; 1973. 59 p.

Sundstrom, C. Water consumption by pronghorn antelope and distribution related to water in Wyoming's Red Desert. In: Antelope States Workshop Proc. 3:39-46; 1968.

U.S. Soil Conservation Service. Ponds for water supply and recreation. Agricultural Handbook No. 387; 1971.

U.S. Soil Conservation Service. Ponds. Practice Standard 378: SCS; Denver, CO. April; 1980.

Utah Board of Oil, Gas, and Mining. Mined land and reclamation. General rules and regulations and rules of practice and procedure. Utah Divison of Oil, Gas, and Mining; 1975.

Wyoming Department Game and Fish. The mule deer of Wyoming. Bull. No. 15. Cheyenne, WY; 1978. p. 149.

Additional Reference:

Eng, R. L.; J. D. Jones; F. M. Gjersing. Construction and management of stock ponds for waterfowl. U. S. Dept. Interior, BLM Tech. Note No. 327; 1979. 39 p.

h. Streambank protection-gabion matting and riprap.

PURPOSE

The purpose of streambank protection is to:

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

Two common methods used to stabilize streambanks until vegetation is reestablished are gabion mats and riprap. Problems with these structures are that they provide poor hiding places for fish and tend to increase 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 are not feasible or are unsuccessful.

DEVELOPMENT

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

Dimensions in meters	Approximate equivalents in feet	No. of diaphragms (partitions)	Capacity Cubic meters	Capacity Cubic yards
2 x 1 x 1	6' 6" x 3' 3" x 3' 3"	1	2	2.616
3 x 1 x 1	9' 9" x 3' 3" x 3' 3"	2	3	3.924
4 x 1 x 1	13' 1" x 3' 3" x 3' 3"	3	4	5.232
2 x 1 x .5	6' 6" x 3' 3" x 1' 8"	1	1	1.308
3 x 1 x .5	9' 9" x 3' 3" x 1' 8"	2	1.5	1.962
4 x 1 x .5	13' 1" x 3' 3" x 1' 8"	3	2	2.616
2 x 1 x .3	6' 6" x 3' 3" x 1'	1	0.6	0.785
3 x 1 x .3	9' 9" x 3' 3" x 1'	2	0.9	1.177
4 x 1 x .3	13' 1" x 3' 3" x 1'	3	1.2	1.570

Fractional size mats may be placed along the slope of a streambank (Figures 3.3-10 and 3.3-11) to effectively 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 with rock. Where more than one mat needs tying together, it is easier to do prior to filling with rock. Hand placement of rock in the basket is suggested over machine fill since 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.

Riprap may be less expensive to use than gabion matting. Large rocks may be piled along the bank to help prevent its eroding away (Figure 3.3-12). The rock should be large enough to prevent silting of the intervening spaces. These intervening spaces may actually provide fish habitat. Use of riprap is common along roads and specifications should comply with road building codes.

MAINTENANCE AND MANAGEMENT

These techniques of erosion control are 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 protection to allow for reestablishing vegetative cover. 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 cost. Gabions require the use of wire mesh and, therefore, have the added cost of construction labor. If the rocks are placed in the wire cages by hand (as recommended), labor cost will be incurred there, also.

Generally, prices of stone riprap average $24.00/0.77 m³ (1 yd³) dumped. Stone filler for gabion mats runs approximately $24.00/0.77 m³ (1 yd³) but can range from $14.00 to $45.00/0.77 m³ (1 yd³). Wire mesh for constructing gabions varies in price, based on mesh size and wire gauge, but can range from $4.64 to $15.47 per linear meter (1.09 yd).

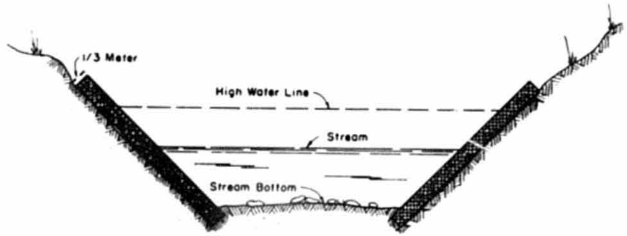

Figure 3.3-10. Stream cross section showing the use of gabion mats on a sloping streambank (from Nelson et al. 1978).

Figure 3.3-11. Placement of stone gabion to protect a streambank (from U.S. Forest Service 1969).

Figure 3.3-12. Use of riprap to protect a streambank from erosion (from U.S. Environmental Protection Agency 1976).

SOURCES OF INFORMATION

More information on the use and construction of gabions and riprap may be obtained from:

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

For addresses, see Appendix A.

References Cited:

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; 1978.

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

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

Additional Reference:

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.

3.3.3 Wildlife Habitat Improvement and Development

a. Creating topographic features.

PURPOSE

The Uinta-Southwestern Utah Coal Region is primarily in mountainous terrain. However, creating additional topography variability, particularly in relatively flat areas, could increase habitat diversity and enhance the value of the area for wildlife. Approaches to create topographic diversity range from a minimal effort for maintaining existing topographic features to large scale habitat creation. The overall purpose of each of these projects is to create an environment that can support a greater diversity of organisms.

Because mine reclamation has primarily focused on recontouring the land to the original topography, almost no information is available concerning structuring the land with wildlife habitat as the focus. The enhancement measures in this chapter consider general ecological requirements of wildlife in the Uinta-Southwestern Utah Coal Region. As stated in previous sections, all topographic features on coal mined lands will have to be approved by the State regulatory authority.

DEVELOPMENT

Dry stream beds or gullies can provide seasonal wetlands, as well as corridors for wildlife movement. These features should be maintained whenever possible. Planting of hedgerows along these features can improve and diversify wildlife habitat for escape, refuge, or travel lanes.

Rock piles are another feature which can be used to create a more diverse habitat. Rock piles are useful to small mammals and rodents, which nest among the rocks. Construction of the rock piles is discussed in Section 3.3.3.d, Rock Piles.

For larger wildlife species, such as antelope, creation of land forms will require greater effort. The features that the land form takes will vary according to the amount of overburden available, rainfall, etc. Richard Kerr (Bureau of Land Management, Denver, unpublished manuscript) described some options that are available. These are presented below and may be used by the operator if the State regulatory authority finds that they fall within the "approximate original contour" requirements or if they are compatible with the surrounding topography.

One experimental technique is to contour overburden or spoil materials to a form reminiscent of what Kerr calls a "poppy seed roll" (Figure 3.3-13). The advantages of such a form over uniform or flat areas is that it allows different sun exposures, provides various air or wind flows, creates a variety of plant habitats, and allows a varied elevation and topographic variety for viewing, hiding, and resting. Implementation of these forms will probably require a variance from the State regulatory authority because it does not conform to the "approximate original contour" concept.

Figure 3.3-13. Contouring to create wildlife habitat (after Kerr, no date).

Figure 3.3-14. Windbreak effect of land contouring (after Kerr, no date).

Varying sun exposures create different conditions of humidity, air, and soil temperatures. The windbreak effect of these forms is also an important feature (Figure 3.3-14). Antelope will escape blizzard-like conditions on the lee sides of the slopes. Deer and elk 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 and habitat (for a discussion of windbreaks, see Section 3.3.3.c, Creating Wind and Snowbreaks for Wildlife Protection). Timber growth may be possible on north facing slopes. This would provide for different small mammal and rodent habitats and increase hunting and roosting areas for raptors. A rolling hill with a downward view may enchance antelope fawning, while escape is also offered to game animals from one side of a hill to the other.

The Thunder Basin Coal Co. in Wright, WY, has created promontories for eagles by building hills approximately 6 to 7.5 m (20 to 25 ft) high. On one corner of the hill is an even more elevated portion, approximately 9 m by 12 m (30 ft by 40 ft), littered with rocks. The hill has been situated so that it overlooks a valley, providing a viewing area for eagles.

MAINTENANCE AND MANAGEMENT

For most of these features, maintenance would be restricted to ensuring vegetation establishment and slope stabilization once the structure has been completed.

LABOR AND MATERIALS

Costs would be a function of engineering requirements and heavy equipment use. These costs would have to be balanced against those for reclaiming the land to its original contours.

SOURCES OF INFORMATION:

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

For addresses, see Appendix A.

References Cited:

Kerr, R. Ideas about reclaiming western mined lands for wildlife. Unpublished manuscript, Bureau of Land Management, Denver Service Center, Denver, CO.

Additional References:

Arch Minerals Corp. Permit to mine application, Seminoe No. 1 Mine. Hanna, Wyoming, 1981.

Wyoming Game and Fish Department. Considerations for wildlife in industrial development and reclamation. Cheyenne, WY; 1976. 65 p.

b. Planting patterns to increase wildlife diversity.

PURPOSE

The spatial arrangement of habitat requirements in a community is a key determinant of the area's value to, and use by, wildlife. Use is largely determined by the mobility of a species and the relative availability of food, water, cover, and other habitat requirements. The greater the interspersion of these habitat components, or the more patchiness or diversity that exists in the community, the more valuable the area is to wildlife, in general. For example, pronghorn distribution is restricted by late summer water availability on many ranges. Sundstrom (1968) found 95% of 12,465 pronghorn in Wyoming's Red Desert within a 4.8- to 6.4-km (3- to 4-mi) radius of a water source. Adjacent areas lacking water sources received low utilization. Utilization of adjacent ranges could be greatly improved if the habitat components (in this case, water sources) were more evenly distributed (in this case, every 4 to 5 km. 2.5 to 3 mi), or if supplementary wells were provided. Reclamation of mined coal lands, which incorporate the interspersion of vegetation types to increase habitat diversity and provide additional food and cover, potentially increase wildlife diversity. In all cases, the State regulatory authority will determine the acceptability of proposed revegetation species and the selective placement of such species.

DEVELOPMENT

"Edge" occurs where two habitat types come together, such as grasslands and mountain shrub. A measure of total linear "edge" per unit area is a good general indicator of total (all species) wildlife production potential. Patton (1975), relating "edge" to diversity, proposed a means of measuring this diversity through an index using the circumference to area ratio of a circle (the geometric figure with the least perimeter for a given area) as the base value. He calculated that, compared to a circle of the same area, a square and a rectangle have 13 and 41% more "edge", respectively (Figure 3.3-15). Subdividing these figures into different vegetation types additionally increases the diversity index. Figure 3.3-15 is an example illustrating that long narrow strips divided into different vegetation types provide the greatest diversity index value. However, PATTERNS OF VEGETATION TYPES ON RECLAIMED LANDS MUST BE DESIGNED TO FOLLOW NATURAL TOPOGRAPHIC FEATURES (such as drainages, toe slopes, knolls, etc.) AS OPPOSED TO GEOMETRICAL STRIPS (Yoakum et al. 1980). In most situations, this will actually further increase "edge." The goal for spatially arranging vegetation types is to maximize the interspersion of a variety of wildlife habitat requirements relative to their mobility (as measured by the home range). For example, the interspersion of habitat requirements for a deer mouse with a home range of 2 ha (5 acres) must be on a much smaller scale than for a highly mobile, far ranging golden eagle with a home range of 25,900 ha (100 mi²). (This, perhaps unrealistically, assumes the same number and proportionate area of habitat requirements for each species.)

Although increasing "edge" through habitat manipulation benefits the great majority of wildlife, some species will do best where diversity is lowest. Therefore, as with all environmental manipulations, the wildlife biologist must evaluate the effectiveness of the proposed alterations beforehand and assess any potentially detrimental effects to sensitive species or species of special concern caused by the proposed practice.

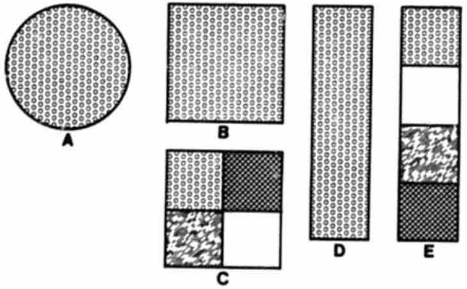

Figure 3.3-15. Comparison of diversity indices for various geometrical shapes, all with an area of 0.4 ha (1 acre). A = 1.0, B = 1.13, C = 1.69, D = 1.41, E = 1.83 (Index values and figure after Patton [1975]). NOTE: The geometrical shapes used above serve only as examples to convey the concept of edge and interspersion. Patches of vegetation on reclaimed areas should have irregular shapes and vary with the topography.

What to Plant

Different types of vegetation yield different values for wildlife. They may provide food, cover, escape terrain, nesting habitat, and/or other habitat requirements. Trees and shrubs typically provide nesting habitat, cover, fawning areas, escape terrain, security, and foraging areas. Grasses and forbs generally provide food, but may also provide cover, nesting habitat, and escape terrain for smaller wildlife. A wildlife biologist can determine those habitat requirements, most needed by a single or a group of species, that can be provided through the spatial arrangement of selected vegetation types.

Once the desired life forms (trees, shrubs, grasses, or forbs) are determined, native or introduced species can be planted in a spatial arrangement best suited to the site. The land management agency and Soil Conservation Service are good sources of information on plants adapted to a particular area. An additional source of information on suitable revegetation species is available through the Plant Information Network (PIN) (Section 3.3.1.a), a computer-based service available for public use at a minimal charge through the U.S. Fish and Wildlife Service. It provides relative importance values of food and cover for certain wildlife species or groups. For more information on this system, see "Use of the Plant Information Network (PIN) to Aid in Selection of Revegetation Plants" (Section 3.3.1.a).

Where to Plant

Microenvironmental site selection, site preparation, planting depth, and soil moisture are the most important considerations leading to successful revegetation (Yoakum et al. 1980). Sites which formerly supported the species of concern offer the greatest probability for successful reestablishment.

The leeward sides of hills are relatively protected areas which can be used to increase habitat diversity. Lee slopes generally have more soil moisture, potentially produce more succulent and vigorous vegetation, and have lower wind velocities. Such areas, when revegetated, provide ideal habitat for food, cover, and a variety of other wildlife requirements. At the Thunder Basin Coal Mine near Wright, WY, the broadscale planting of shrubs has been replaced by transplanting 0.4 to 0.8 ha (one to two acres) of shrub patterns on the lee side of hills (George Larson, pers. comm.).

The microclimate on north-facing slopes is generally cooler, moister, and shadier than other slopes and, as such, is more conducive to the establishment of trees and shrubs, such as ponderosa pine, juniper, curlleaf mountain-mahogany, antelope bitterbrush, big sagebrush, and rubber rabbitbrush. South-facing slopes, while drier during summer, have greater snow-shedding characteristics, making them important winter range and resting areas in the winter for big game.

"Odd areas" may also provide useful wildlife habitat. Such areas include eroded features in agricultural fields, bare knobs, sinkholes, blowouts, gullies, abandoned roads, railroad rights-of-way, borrow pits, hedgerows, fencerows, and areas cut off from the rest of a field by a stream, drainage ditch, or gully. Ditchbanks, when covered with grasses and legumes, provide ideal habitat for small mammals, passerines, and some game birds (Anderson 1969). During dry seasons, ditchbanks may provide escape corridors for larger wildlife. Plantings in the odd areas may include clumps of evergreens centrally located to provide cover. Shrubs, grasses, and forbs may be planted about the trees so as to intersperse the area with other wildlife requirements and provide additional habitat for small mammals and ground-nesting birds.

MAINTENANCE AND MANAGEMENT

Maintenance and management is generally restricted to the initial establishment of vegetation. Depending upon objectives, some areas may require

biennial mowing to suppress woody plants. Mowing should occur only after the broods of ground-nesting birds have left the nest, generally in late summer.

LABOR/MATERIALS

Costs involved in modifying planting patterns for the benefit of wildlife include:

- additional species to be used for reclamation; and
- additional labor and materials costs for revegetating areas in a larger number of smaller, more diverse vegetation types rather than a single, extensive homogeneous stand.

For more information on revegetating procedures and costs, see the appropriate practices under "Revegetation" (Sections 3.3.1.a through 3.3.1.k).

SOURCES OF INFORMATION

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

For addresses, see Appendix A.

References Cited:

Anderson, W. L. Making land produce useful wildlife. USDA Farmers' Bull. No. 2035. U.S. Govt. Printing Office, Washington, D.C.; 1969. 29 p.

Patton, D. R. A diversity index for quantifying habitat "edge." Wildl. Soc. Bull. 3:171-173; 1975.

Sundstrom, C. Water consumption by pronghorn antelope and distribution related to water in Wyoming's Red Desert. Antelope States Workshop Proc. 3:39-46; 1968.

Yoakum, J.; W. P. Dasmann; H. R. Sanderson; C. M. Mixon; H. S. Crawford. Habitat improvement techniques. Pages 329-403 in Schemnitz, S.D., ed. Wildlife management techniques manual. Washington, D.C.: The Wildlife Society; 1980.

Additional Reference:

Ward, A. L. Multiple use of timbered areas: views of a wildlife manager specifically for elk and mule deer. Proc. Rocky Mountain Forest Industries Conf., May 7-10, Jackson, WY; 1980. 24 p.

c. Creating wind and snowbreaks for winter wildlife protection.

PURPOSE

The construction of wind and snowbreaks can be classified under the general heading of cover improvement. Specifically, breaks provide protection for both wildlife and livestock during severe weather, as well as escape refuge for wildlife. They also provide cover and food for birds. The absence of cover, its sparseness, or its poor distribution can limit the use of an area by wildlife (Yoakum and Dasmann 1971). Windbreaks and snowbreaks also help to reduce soil erosion, the drying effects of wind on soil and plants, and the abrasive action of rapidly moving soil particles on young seedlings. During the winter, windbreaks trap snow that provides moisture for plants in spring and summer.

Species selection and location of plantings on coal mined lands must be approved by the State regulatory authority.

DEVELOPMENT

When planting windbreaks to enhance wildlife habitat, there are a few generalizations that should be remembered during planning:

- Tighter barriers are better than more porous ones. Tighter windbreaks can be ensured by multirow plantings.
- Plants selected for wildlife use should be planted in the correct location in the windbreak, generally on the leeward side. Middle or windward locations provide little use during the winter.
- With multirow plantings, the windward rows should provide as tight a barrier as possible to prevent snow drifting across the entire break.
- When in doubt, plant shrubs rather than trees for wildlife; plant suckering rather than nonsuckering shrubs.
- Plant tall trees a few rows from the shrubs to prevent overtopping or a high-wall effect.

Windbreaks should be planted at right angles to prevailing winds and should follow the contour in sloping fields (Ferber 1969). Where damaging winds come from several directions, it is necessary to plant the windbreaks in patterns forming squares or two-direction combinations. For livestock, plantings should be in the form of an L, U, or E design and placed to protect feed and water supplies.

Windbreak designs can take several forms (Figures 3.3-16 to 3.3-18). In areas where blizzards are common, 10- to 15-row windbreaks are recommended. At a minimum, no less than five to seven rows should be planted. Shrubs are planted approximately 0.9 to 1.2 m (3 to 4 ft) apart, medium trees 1.2 to 1.8 m (6 to 8 ft) apart, and tall trees 2.7 to 3.6 m (8 to 10 ft) apart. In dry land areas, a 6-m (20-ft) spacing between rows should be established. Yoakum and Dasmann (1971) suggest a windbreak for each 9 to 10 ha (20 to 25 acres) in open country.

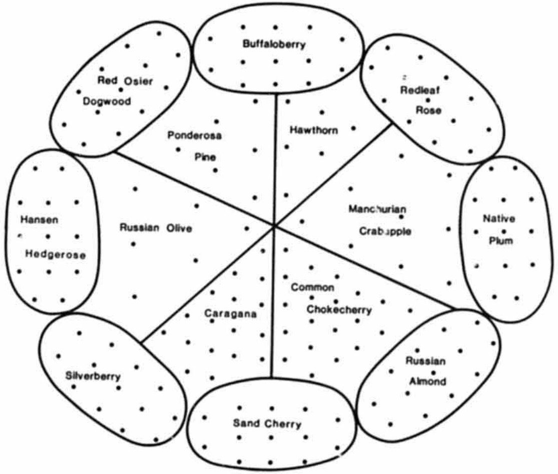

Figure 3.3-16. Suggested wildlife planting for an open area (after Heintz et al. no date).

Size: The size of the planting will depend on the area available. The number of wildlife species and individuals using the planting will increase with increasing size and diversity of the planting.

Spacing: Shrubs: 1 to 1.2 m (3 to 4 ft) by 3.7 to 4.6 m (12 to 15 ft). Low to medium trees: 1.8 to 1.4 m (6 to 8 ft) by 3.7 to 5.5 m (12 to 18 ft). Tall and bushy trees: 2.4 to 3.0 m (8 to 10 ft) by 3.7 to 6.1 m (12 to 20 ft). If cultivation is to take place, the size of the cultivator will dictate the width between rows.

Row								
1								
2								
3	Blue spruce		Silverberry		Red osier dogwood		Rocky Mt. juniper	
4								
5								
6								
7	Bur oak			American elm			Ponderosa pine	
8								
9								
10								
11	Chokecherry		Hawthorn		"Midwest" crabapple		Buffaloberry	
12								
	Optional Herbaceous Cover Strip (9.1 to 30.5 m 030 to 100 fto wide)							
13								
14								
15	H. hedgerose	R. almond	N. cherry	Caragana	Sand cherry	Plum	Juneberry	Redleaf rose
16								

Figure 3.3-17. Multirow wildlife plantings with single species planted in blocks (from Heintz, no date).

Example species are listed for a 16-row belt, but this planting in blocks can be applied to any width of belt. Openings of about one rod between blocks is advantageous. Blocks of single species provide more advantages to wildlife than single species rows. Let wildlife reap the benefits of a little extra planning at planting time.

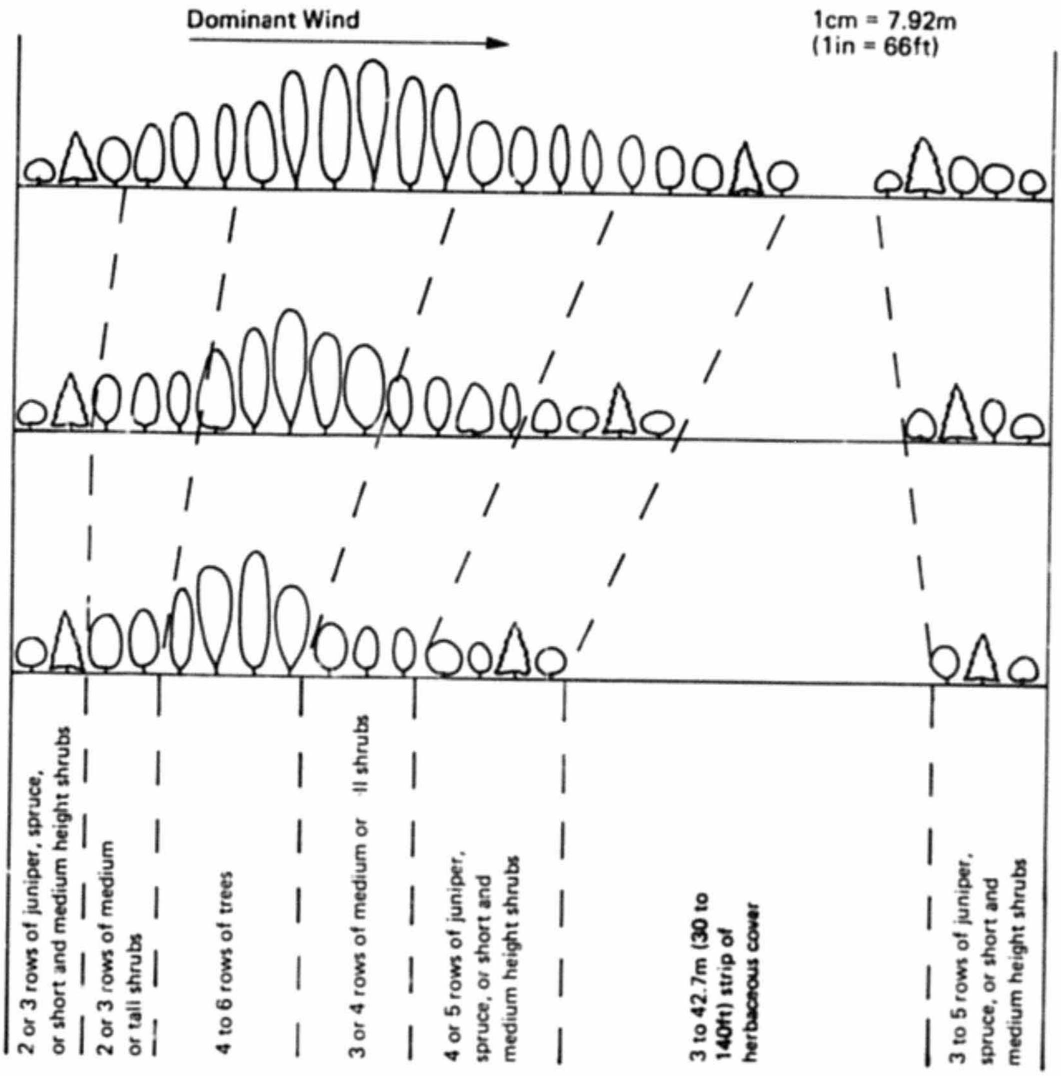

Figure 3.3-18. Suggested design for large multirow wildlife plantings (end view) (from Heintz et al. no date).

The list below, which has been taken from The Conservation Planting Handbook for Wyoming and Colorado (Johnson and Anderson 1980) and the Tree Planting Handbook for the Dakotas (Heintz et al. no date), gives suggested arrangements of tree and shrub species of high value to wildlife. Other similar species may be substituted as necessary. State regulatory authorities are encouraging the use of native species in revegetation to the maximum extent possible, but some introduced species may be approved. The above mentioned books are available from the agricultural extension services in the representative States.

The numbers on the right suggest which species should be included in a planting of the size needed. (Consult the above reports for instructions on the selection of species for various planting dimensions.) The numbers in parentheses behind the names give the relative position of that species within a planting. These parenthetical numbers should be arranged in ascending order from north to south, but may not be consecutive.

Species and Location[1]	Index of Species to Include
Redleaf rose (1)[1]	1
Silverberry (2)	12
Caragana (3)	14
Buffaloberry (4)	4
Chokecherry (5)	10
Russian olive (6)	2
Siberian elm (7)	15
American elm (8)	11
Green ash (9)	13
Boxelder (10)	6
"Midwest" crabapple (11)	7
Hawthorn (12)	5
9.1 to 30.5 m (30 to 100 ft) of herbaceous cover may be included here	
Mixed[2] (13)	3
Mixed[2] (14)	8
Mixed[2] (15)	9

[1]Relative position of row in planting.

[2]These rows should be identical so they form blocks of species when planted together. They may include Hansen hedgerose, red osier dogwood, and fruit, like Nanking cherry, sand cherry, juneberry, plum, or others.

Example: To create a five-row belt, include all species numbered 5 or less in the right column and arrange them according to the relative position number in the parentheses behind the species name; i.e.,

Redleaf rose(1)	1
Buffaloberry (4)	4
Russian olive (6)	2
Hawthorn (12)	5
Mixed (13)	3

Species planted on the windward side should form the most dense barrier practical to block snow and wind.

The herbaceous cover strip should be as wide as possible to maximize wildlife food and cover uses. Legume and grass combinations are best. Acceptable species include alfalfa, sweetclover, tall wheatgrass, intermediate wheatgrass, pubescent wheatgrass, or similar species.

MAINTENANCE AND MANAGEMENT

Care of windbreaks does not end with the planting of trees. Windbreaks must be cultivated, weeds and grass kept out, insects controlled, and water conserved or diverted to their use. Livestock must be kept out of windbreaks at all times and cultivation maintained for at least five years. In dry areas, it may be necessary to cultivate for the life of the windbreak.

In planting the windbreak, the soil should be fallowed at least one year prior to planting (Johnson and Anderson 1980). In the fall, trees should be planted in strips and cultivated to protect against blowing soil and to catch snow during winter.

LABOR/MATERIALS

The Soil Conservation Service and the U.S. Forest Service conduct programs that make trees and shrubs available to land owners specifically to plant as windbreaks. Such programs minimize the costs of obtaining the windbreak species. The costs for these trees vary, depending on the size of the windbreak and the species planted. Most young (0.6 to 0.9 m [2 to 3 ft]) trees cost $20 to $30 per 100. The major cost for this action will be cultivating the soils to establish the windbreaks and then, on a yearly basis, to maintain the breaks. These costs will involve labor, equipment usage, and maintenance.

SOURCES OF INFORMATION

- State Regulatory Agency
- U.S. Soil Conservation Service
- County Extension Agent
- State Game and Fish Agency
- U.S. Bureau of Land Management
- U.S. Forest Service

For addresses, see Appendix A.

References Cited:

Ferber, A. E. Windbreaks for conservation. USDA Soil Conservation Serv. Agr. Information Bull. 339; 1969. 29 p.

Heintz, R.; Helwig, L.; Hinds, L.; Hintz, D.; Umland, E. Undated. Tree planting handbook for the Dakotas. This document can be obtained from the North Dakota Extension Service, State University Station, Fargo, ND 58102.

Johnson, R. L.; Anderson, E. S. (eds.). Conservation planting handbook for Wyoming and Colorado. Ag. Ext. Serv., Univ. of Wyoming; 1980.

Yoakum, J.; Dasmann, W. P. Habitat manipulation practices. Giles, Robert H., ed. Wildlife management techniques. Washington, D.C.: The Wildlife Society; 1971:173-232; 1971.

d. Rock piles.

PURPOSE

Rock piles provide several benefits to wildlife, such as:

- perching sites;
- protection from the elements;
- concealment and protection of small mammals from predators;
- nest sites; and
- may enhance snow catchment and encourage vegetative development.

Rock piles are most beneficial to small game and nongame animals, especially on newly reclaimed areas where cover is minimal. Development of rock piles is also useful for enhancement of wildlife habitat in undisturbed areas adjacent to mining activities. As a mitigative measure, rock piles can be used to replace certain types of habitat lost during mining. Single boulders or clusters also provide useful wildlife habitat.

DEVELOPMENT

Rock piles are most easily constructed when the removal of rocks from topsoil is necessary for reclamation. Suitable rock can be stockpiled for placement after final grading or disposed of directly on regraded areas.

Coarse material (rocks > 0.5 m in diameter) should be used for building rock piles (Figure 3.3-19). Coarse rocks provide more space and openings within a pile, are more stable, and are less subject to weathering than fine material. Rock piles intended as denning sites should be large enough to provide a relatively stable interior environment. Piles greater than 4 m (L) x 4 m (W) x 2 m (H) are usually sufficient to meet this criterion. Both the size of the material and the pile itself can influence what species of wildlife will utilize the rock structures and what they will use them for. Rock piles intended primarily for raptor perches or nest sites should be placed on the leeward side of hills, near (but not on) ridgetops (Phillips 1981; Tessman 1982). Such piles should consist of two or three boulders propped together that are as large as equipment can handle. Rock piles intended for small mammal use are more desirable along bottoms and in other protected areas (Tessman 1982). Rock piles are most advantageous in areas where such natural habitat does not exist. Recommendations on rock pile sizes, placement, and number can be made by a local wildlife biologist. There are no formal guidelines to follow for constructing rock piles, and almost any rockpile will benefit wildlife. Some general design criteria include:

- Several smaller (e.g., 4 m x 6 m x 2 m), interspersed rock piles will be more beneficial than one large pile.

- Boulders should be large enough so that, once piled, there is a maze of spaces within the pile.

o In general, the greater "edge" (see Section 3.3.3.b, Planting Patterns to Increase Wildlife Diversity) the rock pile has (i.e., the more irregular the configuration), the more value it will have for wildlife.

o Rock piles do not have to be neatly arranged. Several dump truck loads piled next to or on top of each other will be adequate.

MAINTENANCE AND MANAGEMENT

Rock piles require no maintenance. With proper stable placement and selection of durable materials, rock piles can be expected to provide benefits to wildlife for a considerable time.

LABOR/MATERIALS

Large rocks and boulders are readily available at some stage of the mining operation. Proper planning such as stockpiling suitable boulders, can keep equipment usage to a minimum. When rock removal is necessary for reclamation, the creation of rock piles can reduce disposal costs. Any lifting equipment (high-lift front end loader) can be used for material handling. Placement of rocks is performed most economically by dump truck when long distance hauls are involved. The loading and placement of rocks for a pile 3 m (10 ft) in diameter by 1 m (3 ft) high should require 1-2 man-hours of labor and similar front-end loader and dump truck time.

Figure 3.3-19. A rock pile for use by amphibians and reptiles (from Johnson 1978).

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 Game and Fish Agency
- o U.S. Fish and Wildlife Service
- o U.S. Forest Service

For addresses, see Appendix A.

References Cited:

Johnson, T. R. Tips on the management of amphibians and reptiles on private lands. Jefferson City, MO; Missouri Department of Conservation; 1978.

Phillips, R. Personal communication; 1981. (As cited in Tessman [1982])

Tessmann, S. Measures for restoring wildlife habitat on reclaimed mine lands. Wyoming Game and Fish Department; 1982.

Additional Reference:

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

e. Brush piles.

PURPOSE

Brush piles provide several benefits to wildlife, such as:

- o concealment and protection from predators;
- o protection from the elements; and
- o nesting habitat.

These structures are especially beneficial in areas of limited small mammal and bird habitat, such as newly reclaimed areas or wetlands.

DEVELOPMENT

There are many methods of constructing brush piles. Depending on 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 (Figure 3.3-20) (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 brush piles can be determined by consulting with a local wildlife biologist or soil conservationist.

In the West, brush piles can often be made with woody materials, such as mature sage, placed parallel to the prevailing winds. Cables should be placed over the top of the brush piles and secured with stakes. Several small brush piles are more useful to small mammals and birds than one large pile.

Brush piles may be constructed specifically for duck nesting sites on or near newly-constructed wetlands or impoundments. Brush piles for ducks should be located on islands surrounded by water, but shorelines or open wetlands may be selected. The location should be protected from erosion and prevailing winds and should be 0.3 to 1 m (1 to 3 ft) from the water's edge. The distance from the water will vary with species and can be determined by consulting with a local wildlife biologist or soil conservationist. Construction should include the following steps (Warrick 1976).

- o Collect brush (0.6 to 5 cm [¼ to 2 in] diameter twigs, which are 0.3 to 1.2 m [1 to 4 ft] in length) and a bundle of native grass.

- o Dig a bowl-shaped depression (15.2 cm [6 in] deep and 30.5 cm [12 in] in diameter).

- o Build a canopy over the depression by pushing twigs (45.7 to 61 cm long [18 to 24 in] 20 cm (8 in) into the soil, at an angle of 60°, leaving a 15.2 x 15.2 cm (6 x 6 in) opening at ground level.

- o Put native grass throughout the inside of the canopy and depression.

- o Weave more twigs into the canopy and place a layer of dense brush over the entire pile. Be sure that the 15.2 x 15.2 cm (6 x 6 in) opening remains free.

The brush should be weighted at one end or pushed into the soil to provide stability. Construction should be completed prior to the arrival of migratory species in the spring.

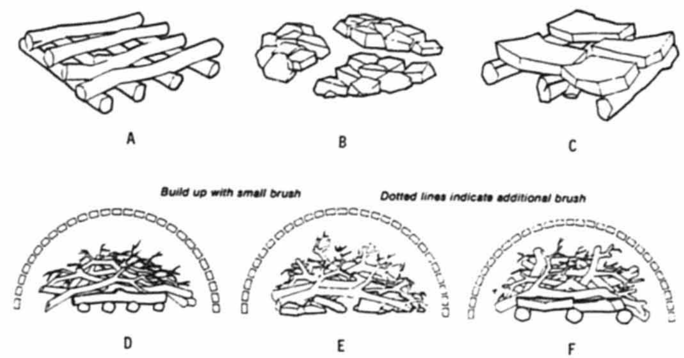

Figure 3.3-20. Construction of brush pile shelters demonstrating base construction methods and construction with dead brush (D-F) (A-Logs, B-Boulders, C-Log/Boulder Combination) (from Gutiérrez et al. 1979).

MAINTENANCE AND MANAGEMENT

The brush piles will provide benefits to wildlife for several years with very little maintenance. The materials may eventually blow away but will provide shelter for a few years until natural shelter can be established.

LABOR/MATERIALS

Materials are generally available from stripmine clearing operations. These can be hauled to the reclamation sites in dump trucks or front end loaders. An individual can construct one of these structures in 20 to 30 minutes.

SOURCES OF INFORMATION

More information on the use of brush piles may be obtained from:

- State Regulatory Authority
- State Game and Fish Agencies
- State Soil Conservation Offices
- U.S. Fish and Wildlife Service
- U.S. Forest Service
- U.S. Bureau of Land Management
- Other wildlife management agencies
- Office of Surface Mining

For addresses, see Appendix A.

References 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. New York State College of Agriculture and Life Sciences at Cornell University, Ithaca; 1979.

Warrick, C. W. Artificial brush piles. USDI, Bureau of Land Management, Tech. Note 290. Denver, CO; 1976.

Additional Reference:

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

f. Reclaiming waste rock disposal piles.

PURPOSE

Identification, proper handling, and placement of toxic waste rock can minimize potentially adverse environmental effects and ultimately provide valuable wildlife habitat from unproductive areas otherwise worthless to wildlife.

DEVELOPMENT

Waste rock from underground mines generally falls into two categories: coal processing waste (CPW) or underground development waste (UDW). CPW is the residue of processed ore. It is typically high in coal fines and sulfides and, as such, is generally toxic and acid-forming. UDW is equivalent to the overburden of surface mines. It is the substrate removed to obtain access to the ore deposit.

Disposal of waste rock depends upon the characteristics of the material. Toxic or acid-forming waste are buried in a manner that precludes or minimizes the spread of these toxins out of the pile. UDW, which is relatively inert, is generally piled, compacted, covered with topsoil, and revegetated.

Disposal of Toxic or Acid-Forming Waste

Complete testing of waste rock using standard EPA testing schemes is required to determine its chemical properties. If the material is toxic or acid-forming, it must be disposed of accordingly. Extreme cases employ underdrains and impermeable membranes to prevent water infiltration and loss of toxins via subsequent leaching. Groundwater is generally monitored uphill, downhill, and in some cases, in the pile. Effluents from underdrains (when used) are also monitored. Tests are conducted to assess permeability through the pile, because the longer water is associated with toxic materials, the more toxins potentially leach out. Regulations require that piles be sealed on top, so as to be impermeable, with at least 1.2 m (4 ft) of the best available material (typically development waste or subsoil, then topsoil).

If disposal of waste rock at underground mines does not meet the original contour concept, as specified in the regulations, the regulatory agencies generally allow the operator to create a topography which blends into the natural topography while minimizing undue disturbances. Disposal piles should be graded evenly to prevent ponding.

A much more comprehensive discussion of factors influencing toxic waste rock disposal and the treatments is found in U.S. Forest Service (1979).

Disposal of Development Waste

Being relatively nontoxic, development waste is typically piled, compacted by the dozer, covered with what topsoil was "scalped" from the disposal site, and revegetated. If stabilization is necessary, contouring to reduce steep slopes and creating small depressions or furrows to increase infiltration may greatly enhance the probability of plant establishment (Institute for Land Rehabilitation 1978); however, because of this infiltration potential, depressions should not be made in toxic waste piles. See Selective Placement of Overburden and Topsoil at Underground Mines, Section 3.2.1.b, for additional information.

Revegetation

Reclaiming waste disposal piles employs the same procedures as those followed on other disturbed areas, including soil redistribution and stabilization, seedbed preparation, fertilization, mulching, seeding and transplanting, irrigation, and management. The procedures are discussed individually under appropriate sections of this handbook and as a total reclamation plan for sagebrush-grasslands, mixed mountain brush habitats, and aspen/coniferous forests (Regional Reclamation Plan, Section 4.0).

LABOR AND MATERIALS

A landplane is needed to scalp the topsoil from the proposed dumpsite. Front-end loaders and dump trucks are required to load and transport waste rock from the mine processing facility to a storage area or disposal site. At the disposal site, a "D9" dozer typically distributes and compacts the rock. The same heavy equipment can be used to redistribute development waste, subsoil, and/or topsoil over the pile. Furrows and depressions can be created with the dozer or front-end loader. Surface compaction may have to be reduced by gouging, chiseling, etc. (see Water Conservation, Section 3.3.1.g). Labor and equipment costs will vary with the size of the operation. Most surface mines estimate costs of approximately $1,000 per 0.4 ha (1 acre) to remove, store, and replace 0.3 m (1 ft) of topsoil (Barth 1977).

Depending upon the amount of soil amendments, mulching, irrigation, and management required, and the revegetation plan (seeding vs. transplanting mature vegetation, etc.), total reclamation costs can vary from $1,500 to $4,000 per 0.4 ha (1 acre). Cost estimates for seeding, mulching, fertilization, irrigation, etc., are provided under the appropriate BCP.

SOURCES OF INFORMATION

- Colorado Mined Lands Reclamation Board
- Utah Division of Oil, Gas, and Mining
- U.S. Soil Conservation Service
- Reclamation Consultants
- Office of Surface Mining

References Cited:

Barth, R. C. Reclamation practices in the Northern Great Plains coal province. Mining Cong. J. 63:60-64; 1977.

Institute for Land Rehabilitation. Rehabilitation of western wildlife habitat: a review. USDI Fish and Wildlife Service, FWS/OBS 78/86; 1978.

U.S. Forest Service. User guide to soils: mining and reclamation in the West. Intermountain Forest and Range Exp. Stn. Gen. Tech. Rep. INT-68. Ogden, UT; 1979.

g. Construction of nesting structures for birds.

PURPOSE

A lack of natural nest sites, food, water, or any other habitat requirement can limit wildlife success and distribution in an otherwise suitable habitat. Artificial nest structures provide substitute nest sites in areas where former sites have been destroyed, are naturally lacking, and/or have not reached the required successional stage.

DEVELOPMENT

Graul (1980) stresses that the use of artificial structures is a species-specific management objective and may not be compatible with the habitat needs of the wildlife community. Management practices should be directed towards restoring or maintaining natural relationships between the various wildlife species of the area. Any artificial nesting structure should be carefully evaluated prior to its use. As a result, a detailed analysis of the specific site under construction and all species present in the area should precede any development. For example, placement of a golden eagle nesting platform on a powerline tower adjacent to a sage grouse lek (courting grounds) would not benefit the overall wildlife community. When artificial nest structures are employed, a follow-up evaluation should be conducted to determine if the structure achieved the intended goal (Graul 1980).

Nest Boxes

Nest boxes ("bird houses") benefit a wide variety birds, including songbirds, various perching birds, woodpeckers, owls, and kestrels. These can be placed on trees, utility poles, fence posts, or on abandoned buildings. The structures must meet the requirements of the desired 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). Nest-box dimensions are listed in Table 3.3-12 for a variety of bird species in the Uinta-Southwestern Utah Coal Region. For more information, see Kalmbach et al. (1969) and Shomon et al. (1966).

Table 3.3-12. Nest box dimensions and placement height (adapted from Kalmbach et al. 1969).

Species	Floor of cavity cm	Depth of cavity cm	Entrance above floor cm	Diameter of entrance cm	Height above ground[1] m
Bluebird	13 x 13	20	15	4	1.5-3
Robin	15 x 20	20	([2])	([2])	1.8-4.5
Chickadee	10 x 10	20-25	15-20	3	1.8-4.5
Nuthatch	10 x 10	20-25	15-20	3	3.7-6
Wrens	10 x 10	15-20	3-15	2.5-3	1.8-3
Swallows	15 x 15	15	3-13	4	2.4-4.5
Phoebe	15 x 15	15	([2])	([2])	2.4-3.7
Flycatchers	15 x 15	20-25	15-20	6.5	1.8-6
Flicker	18 x 18	41-46	36-41	6.5	1.8-6
Downy woodpecker	10 x 10	23-30	15-20	3	1.8-6
Hairy woodpecker	15 x 15	30-38	23-30	4	3.7-6
Screech owl	20 x 20	30-38	23-30	7.5	3 -8
Saw-whet owl	15 x 15	25-30	20-25	6.5	3.7-6
Barn owl	25 x 46	38-46	10	15	3.7-5.5
Sparrow hawk	20 x 20	30-38	23-30	7.5	3 -9

[1]Data indicate that boxes at moderate heights, mostly within reach of a man on the ground, are readily accepted by many birds.

[2]One or more sides open.

Nest Platforms

Nesting platforms are constructed to benefit raptors and geese. For raptors, platforms (Figures 3.3-21, 3.3-22, and 3.3-23) can be mounted on top of trees (living or dead) or on utility poles. Such structures serve a number of species, including eagles, ferruginous hawks, and great horned owls (Yoakum et al. 1980) (see Section 3.3.3.h, Building Alternative Nest Sites for Golden Eagles). An excellent review of a variety of raptor nest structures is contained in Olendorff et al. (1980).

The nest platform should provide:

- o shade for the young birds;
- o a large platform for nest construction; and
- o a base high enough to prevent dangling nesting materials from contacting wires (Nelson and Nelson 1976).

Figure 3.3-21. Diagram of artificial raptor nest platform with sunshade and perch mounted on utility pole (after Yoakum et al. 1980, modified from Olendorff and Stoddart 1974).

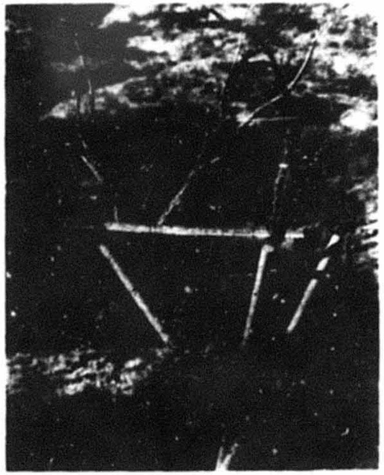

Figure 3.3-22. Finished tripod apex with attachments (from Grubb 1980).

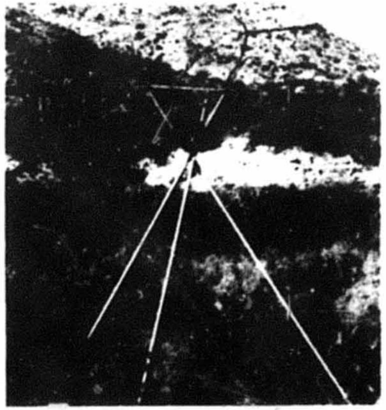

Figure 3.3-23. Overview of raptor nesting tripod (from Grubb 1980).

These platforms have been used successfully by nesting golden eagles, ferruginous hawks, red-tailed hawks, and ravens. Utilities should be consulted prior to any construction of nesting structures on power poles.

Grubb (1980) developed a tripod-teepee nesting structure (Figures 3.3-22 and 3.3-23) for bald eagles, which supports a nest more than 10.6 m (35 ft) above the ground. The stability and ease of locating this structure has made it ideal for relocating eagle nests or simply providing additional nest sites for a variety of raptors. Grubb has also provided a detailed discussion of construction, materials, and manpower needs. The estimated cost of materials, including an hour of helicopter time, was $1,200. Approximately 150 man-hours were required for site preparation, construction prior to field assembly, and setting the structure.

A variety of artificial structures (wooden nest boxes, wash tubs, 55 gallon barrels cut lengthwise, tires, and floating rafts) have been used successfully by nesting Canada geese. These structures are either a floating raft type anchored in water or some type of platform supported off the ground (2.1-m [7-ft]). Both types provide security from predators; on islands within impoundments, these structures can be placed on the ground. Nesting materials composed of hay, wood shavings, or natural vegetation are tightly packed on or in the structure to form a nest. Because of the numerous variations of these platforms, the cost and effort involved in construction varies widely. For more information on the design and placement of these structures, see Saake (1968), Will and Crawford (1970), Bone (1972), and Yoakum et al. (1980).

Nest Baskets

Conical nest baskets for ducks have been constructed out of 0.6 cm (1/4 in) 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).

Brush piles (see Section 3.3.3.e, Brush Piles) also provide nesting sites for ducks when installed near newly-constructed wetlands or aquatic habitat.

Nest Cones

Because the loosely constructed twig nests of mourning doves are easily destroyed during storms, Cowan (1959) developed artificial nest cones to improve nestling survival. The cones are constructed out of a 30.5-cm (12-in) square of 0.6-cm (1/4-in) or 1-cm (3/8-in) mesh hardware cloth and can be installed with nails in the forks of tree branches. Recommended sites must have good visibility, provide adequate clearance for the birds to easily escape danger, and occur in modest shade, 1.8 to 4.9 m (6 to 16 ft) above the ground. The best results will be obtained by installing the cones in late winter or early spring prior to nesting territory selection. Annual maintenance is required to clean out old nesting materials and ensure that the cones are securely fastened.

Nest Burrows

The decline of burrowing owls throughout much of their historic range is primarily due to the loss of burrows, caused by control of burrowing mammals, and the loss of habitat to urban, industrial, and agricultural development (Zarn 1974). Collins and Landry (1977) were able to enhance a local burrowing owl population through the use of artificial nest burrows (Figure 3.3-24). These were constructed out of exterior plywood with a natural dirt floor. The tunnel was 1.8 m (6 ft) long, with an opening of 10 x 10 cm (4 x 4 in), and one right angle turn, approximately 1.2 m (4 ft) from the entrance to maintain darkness. The tunnel complex was attached to a 30.5 x 30.5 x 20 cm (12 x 12 x 8 in) nesting chamber. The entire structure was covered with 15 cm (6 in) of soil to provide thermal stability in the chamber.

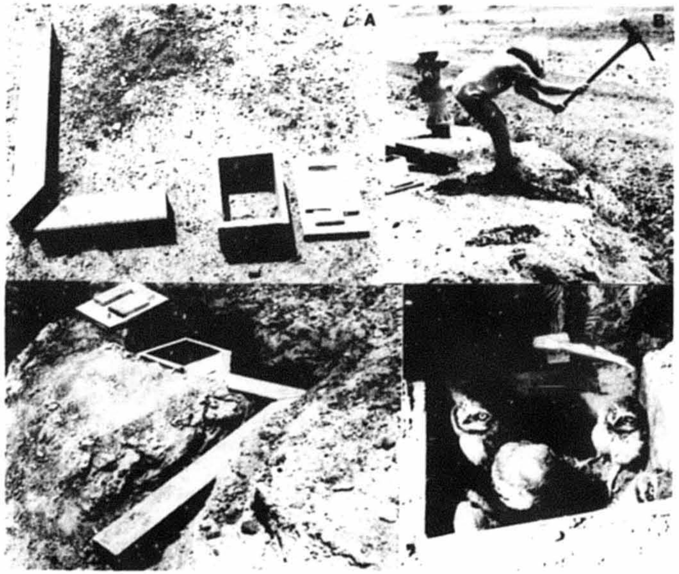

Figure 3.3-24. Installation and operation of artificial burrowing owl nest burrows: (A) the unassembled burrow components; (B) excavation; (C) artificial burrow ready for burial; and (D) burrowing owls in excavated burrow (Modified from Collins and Landry 1977) (Reprinted with permission from North American Bird Bander 2:152).

Nest Cover

Normal revegetation during reclamation will produce suitable nesting cover for a variety of grassland nesting birds and other small mammals. Shomon et al. (1966) provide suggestions for maintaining and enhancing nest cover for wildlife:

- Maintain permanent, undisturbed cover along fences, roads, railroad rights-of-way, and wherever possible.
- Fence nesting cover to prevent damage by livestock grazing.
- Plant shrubby thickets along gulleys and draws for wildlife.
- Refrain from dryland fallowing operations during the nesting season so that ground nesting birds can raise their brood in the stubble habitats.
- Use devices on mowers to flush nesting females during crop cutting.

SOURCES OF INFORMATION

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

For addresses, see Appendix A.

References Cited:

Bone, T. Ecology of Canada geese. Influence of artificial nesting structures on Canada goose population. Wyo. Game and Fish Job Completion Rep., W-71-R-8; 1972.

Collins, C. T.; Landry, R. E. Artificial nest burrows for burrowing owls. N. Amer. Bird Bander 2(4):151-154; 1977.

Cowan, J. "Pre-fab" wire mesh cones give doves better nest than they can build themselves. Outdoor Calif. 20(1):10-11; 1959.

Graul, W. D. Grassland management practices and bird communities. Proceedings of management of western forests and grasslands for nongame birds. USDA Forest Service Tech. Rep. INT-86; 1980:38-47. Intermountain Forest and Range Exp. Sta., Ogden, UT; 1980.

Grubb, T. G. An artificial bald eagle nest structure. USDA Forest Service Res. Note RM-383: Rocky Mountain Forest and Range Exp. Stn., Fort Collins, CO; 1980. 4 p.

Kalmbach, E. R.; McAtee, W. L.; Courtsal, F. R.; Ivers, R. E. Homes for birds. U.S. Fish and Wildl. Serv. Conserv. Bull. 14; 1969.

Nelson, M. W.; Nelson, P. Power lines and birds of prey. Idaho Wildl. Rev. 28(5):3-7; 1976.

Olendorff, R. R.; Stoddart, J. W. The potential for management of raptor populations in western grasslands. Hammerstown, F. N.; Harrell, B. E.; Olendorff, R. R. eds. Management of raptors. Raptor Res. Rep. No. 2, Raptor Res. Found., Inc., Vermillion, SD; 1974.

Olendorff, R. R.; Motroni, R. S.; Call, M. W. Raptor management - the state of the art in 1980. Proceedings of management of western forests and grasslands for nongame birds: USDA Forest Service Tech. Rep. INT-86, Ogden, UT; 1980.

Saake, N. Nevada's Canada geese. Nev. Wildl. 2(2):24-25; 1968.

Shomon, V. V.; Ashbaugh, B. L.; Tolmon, C. D. Wildlife habitat improvement. New York: Natl. Audubon Soc.; 1966.

Will, G. C.; Crawford, G. I. Elevated and floating nest structures for Canada geese. J. Wildl. Manage. 34(3):583-586; 1970.

Yoakum, J. Habitat improvement. Teague, R. D. ed. A manual of wildlife conservation. Washington, D.C.: The Wildlife Society; 1971.

Yoakum, J.; Dasmann, W. P.; Sanderson, H. R.; Nixon, C .M.; Crawford, H .S. Habitat improvement techniques. Schemnitz, S.D. ed. Wildlife management techniques manual. Washington, D.C.: The Wildlife Society; 1980.

Zarn, M. Burrowing owl, Speotyto cunicularia hypugaea. Endangered species Rep. No. 11, Habitat management series for unique or endangered species. Denver, CO: USDI Bureau of Land Management; 1974.

h. Building alternative nest sites for golden eagles.

PURPOSE

The golden eagle is not on the Federal Endangered Species List, yet golden eagles and their nests are afforded protection by amendment to the Bald Eagle Protection Act of 1940 and the Wildlife Improvement Act of 1978. The Bald Eagle Protection Act authorizes only the Secretary of the Interior to issue permits for the capture and relocation of golden eagles that interfere with resource development or recovery operations. When cliff nesting raptor aeries are identified that would be impacted by mining operations, contact should be initiated with the State game and fish agency and the U.S. Fish and Wildlife Service. After field examination, an acceptable course of action to resolve this problem will be developed by those agencies, in consultation with representatives of the mining operation. These actions could include modified mining schedules, modification of planned development, alternative nest site development, and possibly the physical movement of the nest.

DEVELOPMENT

The technique described below for building an alternative nest site for a golden eagle has been tested by Jim Grier, Howard Postovic, and Jim Tate on ARCO's Coal Creek lease in Wyoming's Powder River Basin. The project was begun in May 1979 and was continuing as of Spring 1982. To conduct the project, the investigators received approval from the U.S. Fish and Wildlife Service, the Wyoming Department of Game and Fish, and the Land Quality Division of the Wyoming Department of Environmental Quality. (The Colorado Division of Wildlife and the Utah Division of Wildlife Resources must be consulted for similar proposals.)

The nesting structure used consists of an oval wooden platform large enough to hold a nest 0.6 m (2 ft) or more in diameter. The platform is attached to a 12-m (40-ft) pole that runs through one end. Short pegs are attached to the pole to support shading material, while a steel collar around the pole prevents theft of eggs by raccoons.

One month after hatching, the investigators mov[illegible] chick from the original nest to the platform that had been built 165 [illegible] ([illegible]50 ft) away. After 45 hours, the female began to feed the chick. A week after the adults accepted the new nest, the chick was again moved to another platform 705 m (2,350 ft) from the original nest. The second site was accepted by the parents within 23 hours. Six days later, the chick was again moved 1,305 m (4,350 ft) from the original nest site. This time, the male accepted the new site within six hours, the female the next morning. The chick fledged before being moved again.

All platforms were removed in 1981 except the one from which the chick had fledged in 1980 and another platform 2.3 km (1.4 mi) from the original nest. This latter platform was the desired site for relocating the eagle

nest. While the platforms were being removed, the original nest (1980) was moved 2.3 km (1.4 mi) from the tree to the preferred new site. This gave the eagle pair three choices in 1981: (1) build a new nest in the tree; (2) build a new nest at the 1980 fledging platform; or (3) occupy the nest at 2.3 km (1.4 mi). Observations during 1981 showed that the latter choice was selected. A single egg hatched, and the young eagle eventually fledged.

The investigators recommended that, before moving nesting eagles, one should first get to know the habits and movements of the adult eagles. Moves should be made within the adults' existing home range and, if possible, the move should be towards the center of the range. Chicks and adults should be intensively monitored both prior to, during, and after moves. On the ARCO site, the investigators sometimes had to replace the eaglet in the original nest to protect it from adverse weather.

The U.S. Fish and Wildlife Service (FWS) has cooperated in moving four eagle nests in the Powder River region (Phillips and Beske 1981). The first nest moved was on the Caballo Mine site. The company, in cooperation with the FWS, erected a nesting platform 150 m (500 ft) from the original nest in January 1980. A makeshift nest was installed on the platform and, by March, the adult eagles were incubating two eggs in the platform nest after abandoning their original nest in a cottonwood tree. One eaglet hatched from the platform site in early May.

A permanent site was selected 0.5 km (0.3 mi) from the original nest, and a platform with a nest was erected. The adults refused to accept this nest even after the 4-week-old eaglet was moved to the new site. The eaglet was returned to its original nest after severe weather became a threat. An alternate approach was to construct a nest on a manlift, and the eaglet was moved in successive stages over seven days to the permanent relocation. The original cottonwood tree was cut down to prevent the return of the adult pair.

In a second nest move (at Kerr-McGee's Jacobs Ranch Mine), a nest was built among some ponderosa pines which were regularly used for perching and roosting. This pine stand was 1 km (0.6 mi) from a nest site. A nesting platform was then constructed halfway between the occupied nest and the desired nest site. When four weeks old, the eaglet was moved to the platform. The parents were feeding the young eagle at the new site within 24 hours. Six days later, the eaglet was moved to the nest in the pine trees, and the adult eagles again accepted the chick at this site.

Two young eagles have been successfully moved 100 m (330 ft) to a platform nest at Arco Coal's Black Thunder Mine. The adult pair will be monitored to see if they continue to accept the platform nest. At the Wyodak Resources Mine, the entire tree used for nesting by an eagle pair was cut off at the base and moved with heavy equipment to a site 0.8 km (0.5 mi) from the old location. The success of this move is being monitored.

Fyfe and Olendorff (1976) have discussed some of the dangers to eggs or young as a result of these nesting studies. To minimize the chances of the adult deserting the nest, it is suggested that long nest visits be delayed until late in the nesting season and preferably until after hatching. Howard

Postovic also strongly suggests that the nest be avoided during courtship through a couple weeks into incubation to avoid abandonment of the nest by the parents. He also recommends that trees be planted at the new nest site early in the move process so that there will be nesting structures available for future generations. The nests of birds that have been consistently unsuccessful in fledging young in the past should be avoided. It is also suggested that, when conducting aerial surveys, approaches to nest sites should be avoided. When approaching a nest, care should also be taken to eliminate the element of surprise whenever possible. This is to avoid startling the parent and causing the egg or the hatchling to be crushed or puncturing of the eaglet with a talon. If a parent bird is reluctant to fly, an investigator should retreat and visit the nest after hatching is completed.

When parents are frightened from a nest, eggs and young are exposed to the dangers of overheating, cooling, or loss of moisture. Dehydration can be especially critical at hatching. In general, visits to the nest should be kept short, and factors, such as weather, sun position, and time of day, noted. In unshaded areas, visits should be restricted to the cooler parts of the day. For extended visits, eggs should be covered with a soft cloth to slow down the loss of heat and moisture.

Several missed feedings in a row are not likely to kill young raptors, except for hatchlings only a few days of age. Eagles can survive extended periods of fasting (Fyfe and Olendorff 1976).

As fledging approaches, young eagles and other raptors are ready to leave the nest or ledge (Grier 1969). Therefore, movements around a nest should be slow and deliberate to prevent startling the young and causing them to leave the nest prematurely. When a young bird does jump from a nest, it should be immediately retrieved, checked for injury, and returned to the nest.

Predators can be attracted to nests by scent trai. laid down by humans. The proper way to approach a nest is to walk past it at . distance, retrace a portion of the path, and then walk along a single right-angled side trail to the nest. Sprinkling the side trail with naphthalene crystals during the exit covers the human scent and decreases the chance of nest predation.

Young birds should only be handled when necessary; handling may lead to injury. Only when necessary, the birds should be picked up with both hands. Very young birds can be cradled in one hand and held firmly with the thumb. Medium-sized chicks should be held by both legs and stabilized against the body. If the bird falls over in one's hand, it should be laid on its back. For large birds, such as golden eagles, it is best to pin the bird to the nest with one hand while the other hand searches underneath for the feet.

For additional information on building alternative nest sites, see Section 3.3.3.g, Construction of Nesting Structures for Birds.

MAINTENANCE AND MANAGEMENT

Overall maintenance of the structure should be minimal and may require little if any follow-up costs once a permanent location has been selected. Monitoring the success of renesting would involve some cost, depending upon the level of effort.

LABOR/MATERIALS

Materials for constructing the artificial nests consist mainly of a large diameter pole and wooden materials for constructing the nest platform. Costs for material and labor for constructing the structure should be minimal; however, some equipment may be needed to erect the structure. A liberal estimate of the costs involved would be $1,000 per nesting structure, including costs for materials, construction, and labor.

SOURCES OF INFORMATION:

- State Regulatory Agency
- Office of Surface Mining
- ARCO Coal
- U.S. Fish and Wildlife Service
- State Fish and Game Agencies
- U.S. Bureau of Land Management

For addresses, see Appendix A.

References Cited

Fyfe, R. W.; Olendorff, R. R. Minimizing the dangers of nesting studies to raptors and other sensitive species. Can. Wildl. Serv. Occ. Paper No. 23; 1976.

Grier, J. W. Bald eagle behavior and productivity responses to climbing to nests. J. Wildl. Manage. 33:961-966; 1969.

Phillips, R. L.; Beske, A. E. Resolving conflicts between nesting golden eagles and energy development. Paper presented at 43rd Midwest Fish and Wildlife Conference. Wichita, KS; 1981.

i. Maintenance of sage grouse habitat.

PURPOSE

Sage grouse are gallinaceous birds which occur in select areas of the Uinta-Southwestern Utah Coal Region. As game species, they have economic value and are managed by wildlife departments of the States where they occur. This species has specific habitat requirements, and plans should be made for the maintenance of resident populations before their habitat is impacted.

Mine operators should consult with the State regulatory authority and the game and fish department before any critical habitat component (identified during baseline studies) is disturbed and before any habitat restoration is attempted.

DEVELOPMENT

Recent sage grouse studies have concentrated on moving leks (display grounds) which will be destroyed by mining (James Tate, ARCO Coal; John Monarch, Pittsburgh-Midway; Robert Eng, Montana State University, pers. comm.). The technique has been to create a new lek, usually a clearing on a high point, and then attempting to induce birds to use it by playing tapes of male sage grouse "booming" and by setting out decoys.

Variable success has been achieved in getting the birds to move their display grounds. The most recent research suggests that, although a lek may be destroyed by mining, if adequate habitat is available nearby, hens may still produce the same number of chicks (H. Harju, Wyoming Game and Fish Department; J. Tate, ARCO Coal Co., pers. comm.). The current emphasis (Tate et al. 1979; Colenso et al. 1980) is on developing standards for all habitat components, such as winter habitat, nesting cover, and brood habitat, so that reclamation can focus on any portion of sage grouse habitat that will be impacted or is naturally limiting. The following is a brief summary of sage grouse habitat requirements to be considered where mitigation is planned.

Breeding and Nesting Areas

Open areas surrounded by sagebrush serve as strutting grounds (leks) (Figure 3.3-25). Most sage grouse movements during the breeding season occur within 1 km (0.6 mi) of the lek (Wallestad and Schladweiler 1974).

Most nesting occurs under sagebrush within a few kilometers (miles) of the lek (Braun et al. 1977). Sagebrush commonly used for nesting varies between 17 and 79 cm (6.6 to 30.8 in) in height. Most nests are located under the tallest bushes available. Areas where the canopy coverage is 20 to 40% are most frequently used for nesting. Colenso et al. (1980) found that, in northwest Wyoming, the favored nesting habitat consisted of sagebrush with a mean height of 27 cm (10.5 in) with 25% cover.

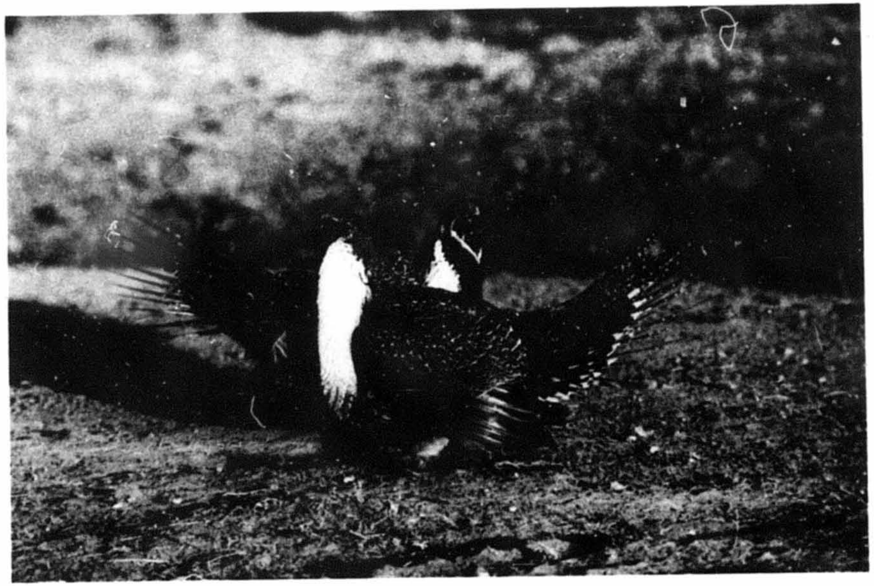

Figure 3.3-25. Male sage grouse on strutting ground (photo courtesy of Colorado Division of Wildlife).

Brood Rearing

Johnsgard (1973) summarized studies that found that young broods use areas having a lower plant density and crown cover (23 to 38 cm [9 to 14.8 in]) than older broods or adults (18 to 64 cm [7 to 25 in]). Martin (1970) found most broods in areas having an average canopy cover of 14%, while adults occupied sites averaging 25% cover.

Wintering Areas

The extent of seasonal movements of sage grouse vary with the severity of winter weather, topography, and vegetative cover. Braun et al. (1977) reported studies showing that most sagebrush use in winter is in the "greater than 20%" canopy coverage class. However, during winter, the grouse may be restricted to less than 10% of the sagebrush-dominated lands. Wintering areas hold some of the highest densities of sage grouse and may be used on an annual basis by birds from several leks (Eng et al. 1979). These areas, therefore, have considerable influence on the area-wide grouse population.

Recommended Guidelines

- Although sagebrush is essential to the sage grouse, homogeneous stands do not receive highest use (Colenso et al. 1980); sagebrush intermixed with forbs should be provided. Habitat patchiness will increase the edge-effect, which will not only benefit sage grouse, but will increase the diversity and abundance of other game and nongame wildlife.

- Nesting stands should have a sagebrush canopy coverage of 20 to 40% and heights should vary between 17 and 79 cm (6.6 and 30.8 in) (Braun et al. 1977).

- Open areas, 0.1 to 0.2 ha (0.25 to 0.5 acre) in size, surrounded by sagebrush, should be available for strutting grounds (Johnsgard 1973).

- For brood rearing, less dense stands with lower canopy cover should be available. Average canopy cover of 14% (Martin 1970) and height of 23 to 38 cm (9 to 14.8 in) (Johnsgard 1973) are used by young broods.

- Wintering areas may be a limiting habitat component. Baseline studies before mining should define these areas, which can then be preserved.

- Available water for sage grouse is very often a limiting factor in the region. Therefore, development of alternative water sources to make water available to sage grouse and other species is often beneficial. Water resource development might include water holes, springs or seeps, catchments (guzzlers, dugouts), tanks, troughs, or wells. For additional information see Yoakum et al. (1980).

In summary, it must be remembered that a sagebrush habitat is a climax community; to replace a stand to usable proportions from seed may take 30 years (Clait Braun, pers. comm., Colorado Division of Wildlife, 317 W. Prospect Road, Ft. Collins, CO 80526). Mitigation and/or reclamation of this important habitat for sage grouse should include transplanting sagebrush clumps (see Section 3.3.1.d, Transplanting Native Vegetation, and Section 3.3.1.e, Transplanting Nursery Grown Plants).

It is important not to concentrate totally on one component, but to consider all components of a necessary habitat when designing a mitigation plan. Local conditions and sage grouse habitat needs will vary.

SOURCES OF INFORMATION

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

References Cited:

Braun, C. E.; Britt, T.; Wallestad, R. D. Guidelines for maintenance of sage grouse habitats. Wildl. Soc. Bull. 5(3):99-106; 1977.

Colenso, B. E.; Boyce, M. S.; Tate. S. Developing criteria for reclamation of sage grouse habitat on a surface coal mine in northeastern Wyoming. Symp. on surface mining hydrology, sedimentology and reclamation; 1980 Dec 1-5; Univ. of Kentucky, Lexington, KY; 1980.

Eng, R. L.; Pitcher, E. J.; Scott, S. J.; Greene, R. J. Minimizing the effect of surface coal mining on a sage grouse population by a directed shift of breeding activities. The Mitigation Symposium; 1979 July 16-20; Colorado State University, Fort Collins, CO. USDA Forest Service, Rocky Mountain Forest and Range Exp. Sta. Gen. Tech. Rep. RM-65; 1979.

Johnsgard, P. A. Grouse and quail of North America. University of Nebraska Press, Lincoln and London; 1973.

Martin, N. S. Sagebrush control related to habitat and sage grouse occurrence. J. Wildl. Manage. 34:313-320; 1970.

Tate, J., Jr.; Boyce, M. S.; Smith, T. R. Response of sage grouse to artifically created display ground. The Mitigation Symposium; 1979 July 16-20; Colorado State University, Fort Collins, CO. USDA Forest Service, Rocky Mountain Forest and Range Exp. Sta. Gen. Tech. Rep. RM-65; 1979.

Wallestad, R. O.; Schladweiler, P. Breeding season movements and habitat selection of male sage grouse. J. Wildl. Manage. 38:634-637; 1974.

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. The Wildlife Society, Washington, D.C. 686 pp. 1980.

j. Restoring big game range.

PURPOSE

Restoration of mined lands can greatly increase production of forage for game and livestock and improve soil stability. Reclamation directed towards big game, an ecologically, aesthetically, and economically important wildlife group, actually involves the restoration of a community, which includes and benefits a wide variety of plant and wildlife species.

Active coal mine areas in the Uinta-Southwestern Utah Coal Region are inhabited primarily by mule deer, elk, moose, and pronghorn. Restoration practices in this section will be oriented toward their specific habitat requirements.

DEVELOPMENT

Development of a reclamation plan for big game range requires the evaluation of two criteria:

- o Did a particular big game species inhabit the area prior to mining or, with the development of a certain habitat requirement, could they have?
- o Would the species be suited to the area if the present habitat were adequately improved? (This assumes the animal would recolonize the area on its own.)

If, for some reason, the former range never supported a given species and likely will not when the range is restored (e.g., a situation where the restored range is 16 km [10 mi] from the closest population of deer and is too small to constitute a yearlong range), then perhaps the reclamation effort should be oriented to benefit another group of wildlife. If the restored range could support deer, elk, or moose, a determination must be made regarding whether the range could support the group year-round or seasonally. This distinction is important because the distribution of habitat requirements (food, water, cover) depends upon the type of range being reclaimed. For example, water is much more critical on a late summer and fall deer range than on a winter range. Once the determination is made, it is essential that all habitat requirements are included. When reclaiming year-round range, all requirements must be abundant enough and properly interspersed to meet the species' yearlong needs.

At most coal mines, the area to be reclaimed is of inadequate size to support a year-round big game population. In such areas, the reclamation goals should be to establish seasonally important habitat components, limited or lacking on adjacent, undisturbed range. Important components often limited include late summer and fall water sources, winter cover, and shrublands which provide food, thermal and escape cover, and fawning/ calving areas. These habitat components are addressed below.

Habitat Requirements

Mule deer are remarkably adaptable animals and are ubiquitously distributed throughout a variety of habitats in the western United States. Because of this attribute and the diversity of habitats which exist in the Uinta-Southwestern Utah Coal Region, only generalizations can be made that are applicable on a region-wide basis.

- o Early stages of plant succession are more beneficial than climax vegetation.
- o A mixture of vegetation types provides better habitat than a monotypic community.
- o Browse is essential to winter survival and ranges with more browse are preferable to ranges with less browse.
- o It must be emphasized that optimum habitat for mule deer, as with elk, moose, pronghorn, and most other wildlife species, is directly related to the quantity, quality, and interspersion of all essential requirements (see Section 3.3.3.b, Planting Patterns to Increase Wildlife Diversity).

Additional habitat requirements for mule deer are discussed in the following sections.

Because of the elk's altitudinal migrations between summer and winter ranges, they occupy a variety of habitats in the Uinta-Southwestern Utah region including, but not limited to, valley meadows, sagebrush slopes, mixed mountain brush, aspen/coniferous forests, parks, and alpine meadows. Around October, the cows, calves, and most bulls begin to descend to the more protected lowland where they spend the winter. Around March and April, they gradually begin migrating back up to their summer ranges (Boyd 1978).

Food habits vary in relation to season, location, and elevation. Elk are primarily grazers. Grasses and grasslike plants compose the bulk of their annual diet, followed by browse and forbs. As with most big game, forbs constitute a greater portion of the diet in summer and shrubs a greater proportion in winter (Boyd 1970, 1978; Kufeld 1973).

Moose inhabit the Uinta and Wasatch Mountain ranges in the Uinta-Southwestern Utah Coal Region and are common within these areas. Their habitats in this region are generally restricted to stream and river bottoms with access to cooler forested areas (Kelsall and Telfer 1974). Moose utilize willows, forbs, and aquatic plants in many areas during summer (Franzmann 1978). Willow communities are probably the most important moose habitat in this region, particularly during winter (Harry 1957; Wilson 1971; Peek 1974). Wilson (1971) found that Drummond's and Geyer's willow made up 92.0 and 4.7%, respectively, of all winter browse on the north side of the Uinta Mountains. Aspen, conifer, and mountain brush habitats are also locally important (Denniston 1956; Peek 1974). Some characteristics of moose habitat include:

- Preferred habitats are willow communities along streams, rivers, and lakes with adjacent aspen, conifer, and/or mountain brush habitats.

- Early successional woody browse species (such as those following fire, logging, mining, or other disturbances) are preferred over climax vegetation.

- Moose are primarily browsers (particularly in winter), and willows are the preferred browse species in this region, although aspen, Saskatoon serviceberry, redosier dogwood, chokecherry, currant, and subalpine fir are also locally important.

Pronghorn occupy ranges characterized by low, rolling, expansive terrain. Their zone of maximum abundance and productivity is closely associated with the distribution of big sagebrush and silver sagebrush (Sundstrom et al. 1973) and the general environmental factors associated with these plant communities. Characteristics of optimum pronghorn habitat listed below are based on studies (Sundstrom 1968, 1979; Beale and Smith 1970; Sundstrom et al. 1973; Yoakum 1974, 1978) conducted over several sites, including the Uinta-Southwestern Utah Coal Region.

- Vegetative cover is relatively open, ranging between 40 and 60%.

- Height of vegetation averages 38 cm (15 in) above ground level. Range with vegetation exceeding 61 cm (24 in) is less preferred, and ranges with vegetation over 76 cm (30 in) are used infrequently.

- The general vegetative composition of the range is 40 to 60% grass, 10 to 30% forbs, and 5 to 20% sagebrush or other browse species.

- The vegetative community contains a variety of species, which include 5 to 10 species of grasses, 20 to 40 species of forbs, and 5 to 10 species of shrubs.

- Preferred species of browse are big sagebrush, fringed sagewort, silver sagebrush, and Douglas rabbitbrush.

- Open ranges supporting a variety of vegetative types are preferred to monotypic stands. Such areas provide grass sprouts and an abundance of succulent forbs.

- Water sources must be available during hot, dry periods and able to supply 3 to 5 ℓ (0.8 to 1.3 gal) of water/animal/day. Permanent water sources should not be more than 4.8 to 8 km (3 to 5 mi) apart for proper distribution of animals across the total available range.

- Landscape irregularities that provide shelter from cold, winter winds and produce microclimates which increase the availability of forage should be present.

Water Sources

Big game distribution, forage utilization, fawn/calf survival, and herd productivity can be improved through the development of small, strategically located water sources. Because of their arid habitat, water is more critical to antelope than to other big game; although late summer water sources are important to deer as well. Water is generally available in most elk and moose ranges and much of their moisture needs are obtained from the vegetation they consume, especially during the summer months. The availability of water sources is most critical during mid and late summer.

Some considerations of water development for big game are listed below.

- It is more beneficial to provide a number of small, strategically located ponds rather than one or two large lakes.

- The availability of water is most critical during mid to late summer.

- Antelope and deer will drink from most facilities designed for livestock use. Such facilities should be available during critical periods.

- Responsible planning can not only protect and enhance existing water sources but also provide additional ones.

- Ponds should have some permanent source of water to avoid water quality deterioration.

- Water quality should be periodically monitored.

- The best way to insure adequate water on big game range is to maintain existing sources and wildlife access to them.

- Toxic sediment ponds should be fenced with net wire to prevent animals from ingesting contaminated water (see Section 3.1.1.d, Fences).

For information on the construction of water sources, see Supplementary Water Resources (Section 3.3.2.b).

Cover

Cover is required for predator evasion, fawning areas, shelter from the heat and cold, and psychological security; although what constitutes "cover" differs between big game species. For example, cover for mule deer may be a draw of tall, dense sagebrush; a pile of rocks; or a thicket of large shrubs or trees. The lee sides of rolling hills or a tall stand of sagebrush along an intermittent stream may constitute cover for pronghorn.

If at all possible, mining operations should avoid critical habitat components. Recontouring should be oriented towards developing a variable topography (see Section 3.3.3.a, Creating Topographic Features), as well as a variety of microenvironments which promote a mixture of vegetation types. Ridges, draws, boulder piles, and steep slopes are examples of topographic features which can provide cover.

Reclamation practices suggested for mule deer and elk (Wyoming Game and Fish Department 1976) include:

- o Where possible, avoid the destruction of rimrocks, rock piles, and dense shrub stands important as winter cover and fawning areas.
- o During recontouring, minimize leveling disturbed areas. Topographic undulations provide environmental variability that encourages the establishment of a mixture of vegetation types. Modify slopes, boulder piles, and gullies only to enhance revegetation efforts. In this region, deer could not survive critical winter periods without utilizing exposed, southerly slopes and bare, windblown ridges for foraging.
- o Minimize, eliminate, or mitigate the effects of construction/operation activities on elk calving grounds in early June.
- o Limit activities precluding migrations between seasonal ranges.

Some general enhancement practices for moose include:

- o Avoid the destruction of riparian habitats and existing moose ranges.
- o Limit activities that restrict or prevent migrations and movements between and within seasonal ranges (Franzmann 1978).
- o The early successional stage of vegetation on reclaimed areas of mines will benefit moose, provided preferred browse species, such as willows, serviceberry, chokecherry, and redosier dogwood, are established.
- o Willows are an important habitat component for food and cover. Willow stands should be adjacent to streams, ponds, and aspen, conifer, and/or mountain brush habitats.

For information on the development of these reclamation practices, refer to applicable BCP's listed in the Table of Contents.

Forage

Big game feeding areas should be protected from development. Where development is unavoidable, the following considerations are suggested when reclaiming disturbed lands (Wyoming Game and Fish Department 1976):

- o Evaluate the area's revegetation potential. Mining will alter the biological, physical, and chemical properties of the affected soil and substrata, potentially changing the natural vegetation suitable for the site.
- o Based on the site evaluation, identify species and varieties that establish readily and yield forage of satisfactory quality and quantity not only for big game, but all local wildlife. Pronghorn and mule deer generally consume approximately 75% shrubs, 20% forbs, and 5% grasses, annually (Wyoming Game and Fish Department 1976). These figures vary seasonally with weather conditions, plant composition, and availability. Elk primarily consume grasses and grasslike plants, but also browse on shrubs during winter. Willows and other woody plants are some of the most important forage species of moose.

  Browse is essential on all big game winter ranges.
- o Select a mixture of species, including browse, forbs, and grasses. Plant good quality seed in well prepared sites using adequate rates and/or numbers of seedlings and satisfactory planting techniques. Frequently, seed collected from the area is better adapted to the site-specific conditions than seed of the same species obtained from other areas.

Refer to appropriate BCP's in this handbook for the technical procedures.

A partial list of forage species, readily utilized by mule deer in Wyoming includes (Wyoming Game and Fish Department 1976):

Browse	Forbs	Graminoids
true mountainmahogany	red clover	Idaho fescue
curlleaf mountainmahogany	yellow sweetclover	bluebunch wheatgrass
antelope bitterbrush	dandelion	sedges
Wyoming big sagebrush	buckwheat	
black sagebrush	fireweed willowherb	
rubber rabbitbrush		
serviceberry		
currant		

A partial list of forage species readily utilized by pronghorn in Wyoming includes (Wyoming Game and Fish Department 1976):

Browse	Forbs	Graminoids
Wyoming big sagebrush	alfalfa	Sandberg bluegrass
black sagebrush	chickpea milk vetch	prairie Junegrass
saltbush (Atriplex)	dandelion	bluebunch wheatgrass
Douglas rabbitbrush	buckwheat	western wheatgrass
rubber rabbitbrush	yellow sweetclover	dryland sedge
fringed sagewort	woody aster	Indian ricegrass
birdfoot sagewort	penstemon	
greasewood		

Many of the same species are listed by Plummer et al. (1968) as major species for restoring big game range in Utah.

Forage species selected by elk include (Boyd 1970; Kufeld 1973):

Browse	Forbs	Graminoids
snowberry	peavine	western wheatgrass
currant	penstemon	Kentucky bluegrass
huckleberry	vetch	timothy
oakbrush	arrowleaf balsamroot	elk sedge
aspen	western hedysarum	pine reedgrass
serviceberry	mountain arnica	bluebunch wheatgrass
big sagebrush	agoseris	cheatgrass
red elderberry	shootingstar	mountain muhly
	buttercup	tufted hairgrass
	dandelion	

Additional species, perhaps more compatible with local mine sites than those listed above, may be found in Kufeld's (1973) review of foods eaten by Rocky Mountain elk.

Browse species eaten by moose in this region include Dummond's, Geyer's, and other willow species; redosier dogwood; Saskatoon serviceberry; aspen; chokecherry; currant; and river birch.

MAINTENANCE AND MANAGEMENT

Considerations for the long-term upkeep of practices suggested in this section are generally minor. Refer to the appropriate BCP for the specific maintenance needs.

LABOR AND MATERIALS

Costs involved in the implementation of those practices recommended in this section are discussed in detail under the specific BCP.

SOURCES OF INFORMATION

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

For addresses, see Appendix A.

References Cited:

Beale, D.; Smith, A. Forage use, water consumption and productivity of pronghorn antelope in western Utah. J. Wildl. Manage. 34:570-582; 1970.

Boyd, R. J. Elk of the White River Plateau, Colorado. Colo. Div. Game, Fish and Parks, Denver. Tech. Publ. No. 25; 1970. 126 p.

Boyd, R. J. American elk. Pages 11-29 In Schmidt, J. L.; Gilbert, D. L., eds. Big game of North America, ecology and management. Wildlife Management Institute, Washington, D.C.; 1978. 494 p.

Denniston, R. H. Ecology, behavior and population dynamics of the Wyoming or Rocky Mountain moose, Alces alces shirasi. Zoologica. 41:105-118; 1956.

Franzmann, A. W. Moose. Pages 67-81 In Schmidt, J. L.; Gilbert, D. L., eds. Big game of North America, ecology and management, Wildlife Management Institute, Washington, D.C.; 1978. 494 p.

Harry, G. B. Winter food habits of moose in Jackson Hole, Wyoming. J. Wildl. Manage. 21:53-57; 1957.

Kelsall, J. P.; Telfer, E. S. Biogeography of moose with particular reference to western North America. Can. Nat. 101:117-130; 1974.

Kufeld, R. C. Foods eaten by the Rocky Mountain elk. J. Range Manage. 26:106-113; 1973.

Peek, J. M. A review of moose food habit studies in North America. Can. Nat. 101:195-215; 1974.

Plummer, A. P.; Christensen, D. R.; Monson, S. B. Restoring big game range in Utah. Publ. No 68-3: Utah Div. of Fish and Game, Salt Lake City; 1968. 183 p.

Sundstrom, C. Water consumption by pronghorn antelope and distribution related to water in Wyoming's Red Desert. Proc. Antelope States Workshop 3:39-46; 1968.

Sundstrom, C. Effects of livestock fences on antelope. Fed. Aid Rept. FW-3-R-16: Wyoming Game and Fish Comm., Cheyenne; 1979. 14 p.

Sundstrom, C.; Hepworth, W. G.; Diem, K. L. Abundance, distribution and food habits of the pronghorn. Wyoming Game and Fish Comm. Cheyenne: Bull. No. 12; 1973. 61 p.

Wilson, D. E. Carrying capacity of the key browse species for moose on the north slopes of the Uinta Mountains, Utah. Utah Div. Wildl. Resourc. Publ. No. 71-9, pp. 1-57; 1971.

Wyoming Game and Fish Department. Considerations for wildlife in industrial development and reclamation. Cheyenne, WY; 1976. 65 p.

Yoakum, J. Pronghorn habitat requirements for sagebrush-grasslands. Proc. Biennial Antelope States Workshop 6:16-25; 1974.

Yoakum, J. D. Pronghorn. Pages 102-121 In Schmidt, J. L.; Gilbert, D. L., eds. Big game of North America, ecology and management. Wildlife Management Institute, Washington, D. C.; 1978. 494 p.

Additional Reference:

Robinette, W. L.; Julander, O.; Gashwiler, J. S.; Smith, J. G. Winter mortality of mule deer in Utah in relation to range condition. J. Wildl. Manage. 16:289-299; 1952.

k. Management of feral horses.

PURPOSE

Bands of feral horses can be found in several areas of the Uinta-Southwestern Utah Coal Region (Zarn and Collins 1977); however, according to the Colorado and Utah Bureau of Land Management (BLM) offices, there are no feral horses in the northwest portion of Colorado, except in the Piceance Basin (D. Kaplan, pers. comm.), and none in Utah that would conflict with coal mining (K. Boyer, pers. comm.).

The Public Rangelands Improvement Act of 1978 (Public Law 95-514) requires that feral horses (and burros) be considered comparably with other resource values in the development of resource management plans by the BLM and that the animals be allocated an appropriate portion of the available forage. Any feral horse territory that will be affected by coal surface mining should be addressed in the mine reclamation plan.

DEVELOPMENT

If a band of feral horses is discovered on proposed mined lands, the following State BLM offices should be contacted:

Colorado	Utah
Bureau of Land Management 1600 Broadway Denver, Colorado 80101 (303) 837-3264	Bureau of Land Management University Club Building 136 E. South Temple Salt Lake City, Utah 84111 (801) 524-4033

If the herd is determined by the BLM to be part of an excess population, the BLM will allow removal and adoption of horses. The BLM has initiated an Adopt-a-Horse program where feral horses can be adopted by private individuals, who, after a trial period of one year, may obtain title to the horse or horses. If the horse herd is within the population limits set for it, other management practices will have to be considered.

BLM offices recommend that existing water sources be preserved or alternate water be provided for feral horses (see Section 3.3.2.b, Supplementary Water Resources). Lack of water is the most important limiting factor on the use of an area by horses. Feral horses are sometimes reluctant to cross oiled roads. If haul roads are to be oiled, they should be oiled in sections to allow horses access to regular water holes.

Protection of newly revegetated areas from grazing by feral horses is important because horses are very efficient at eating short new growth. Horses and cattle use the same areas and forage plants in summer and compete for resources (Seals 1972). Hansen et al. (1977) studied the foods of feral horses, deer, and cattle in the Douglas Mountains, northwest of Craig, CO. Both horses and cattle fed on needlegrasses, wheatgrasses, and brome; mule deer preferred sagebrush and mountainmahogany. The dietary overlap for horses and cattle was 77%. A seed mixture designed to benefit cattle would also benefit horses.

Although diets of cattle and feral horses were similar in the Piceance Basin, CO, those of feral horses and mule deer were not (Hubbard and Hanson 1976). Similarities in diets of feral horses and cattle in the Red Desert, WY, were greatest (45%), but less for elk (40%) and domestic sheep (27%) (Olsen and Hansen 1977). When feral horses and elk occur on a mine property, competition for food may be a problem. State game and fish departments should be contacted for advice.

Feral horses are not territorial (Hall and Kirkpatrick 1975) and are more easily managed than animals which are defending a specific area. If it is necessary to fence horses out of some mined lands, they can be moved to another suitable habitat. The major food items of the horses in the Pryor Mountains of Wyoming and Montana are bluebunch wheatgrass and Sandberg bluegrass. In winter, saltbush, rabbitbrush, and big sagebrush are the preferred foods (Hall and Kirkpatrick 1975). Feist (1971), studying the same herd, noted that grass was preferred, but it was in short supply and animals were forced to supplement their diet with other types of vegetation. He observed horses also grazing on the new growth of saltbrush, greasewood, black sagebrush, and, on rare occasions, Utah juniper and mountainmahogany.

MAINTENANCE AND MANAGEMENT

Fences should be constructed to keep horses away from newly revegetated areas. If existing water sources are destroyed, alternative water should be provided. Oiled roads should be built so that horses are not blocked from traditional watering areas.

LABOR/MATERIALS

See Section 3.1.1.d on Fences for detailed information on costs of horse-tight fences. Section 3.3.2.b on Supplementary Water Resources has a discussion on costs for developing ponds.

References Cited:

Feist, J. D. Behavior of feral horses in the Pryor Mountain wild horse range. M.S. Thesis, University of Michigan, Ann Arbor, MI; 1971.

Hall, R.; Kirkpatrick, J. F. Biology of the Pryor Mountain wild horse. Bureau of Land Management, Salt Lake City, UT; 1975.

Hansen, R. M.; Clark, R. C.; Lawhorn, W. Foods of wild horses, deer and cattle in the Douglas Mountain area, Colorado. J. Range Manage. 30:116-119; 1977.

Hubbard, R. E.; Hansen, R. M. Diets of wild horses, cattle, and mule deer in the Piceance Basin, Colorado. J. Range Manage. 29:389-392; 1976.

Olsen, F. W.; Hansen, R. M. Food relations of wild free-roaming horses to livestock and big game, Red Desert, Wyoming. J. Range Manage. 30:17-20; 1977.

Seals, S. J. Murderers Creek wild horse area, biological unit management plan, Malheur National Forest; proposed final draft. USDA Forest Service; 1972.

Zarn, M.; Collins, K. Wild, free-roaming horses--status of present knowledge. USDI Bureau of Land Management/USDA Forest Service. Tech. Note No. 2?4; 1977.

4. REGIONAL RECLAMATION PLAN

This section discusses needs and procedures for reclaiming sagebrush-grasslands, mixed mountain brush or mountain shrub habitats, and aspen/coniferous forests on a hypothetical mine site in the Uinta - Southwestern Utah region. These habitats are some of the more important communities for wildlife in this region. The plan illustrates how an operator may incorporate the BCP's contained in this handbook into a sound reclamation program.

Other major vegetation types in this region are the pinyon-juniper and shadscale-saltbrush types. These types are somewhat difficult to revegetate. Because of this, the complexity of this sample reclamation plan, and the need for additional research, we have not addressed reclamation of pinyon-juniper and shadscale-saltbrush types in this sample plan.

A reclamation plan submitted to a regulatory agency requires a set of maps of the proposed mine site, including maps showing the premining topography, predisturbance vegetation, predisturbance soil inventory, recontoured (postmining) topography, and the revegetation plan. Figures 4.1-1 to 4.1-4, 4.3.1, and 4.6-1 are examples of the types of maps contained in reclamation plans. Technical requirements of reclamation plans vary between States, and the operator should consult with the specific State regulatory agency for their particular requirements. The mine site illustrated supports all three habitats listed above.

4.1 INTRODUCTION

The Buzzard Creek Mine is presented on the following pages as an example of the reclamation of selected portions of a hypothetical site in the Uinta - Southwestern Utah region. The site is physiognomically representative of this region and typical of one on which surface mining would be employed (Figure 4.1-1). The only surface portions of the Buzzard Creek Mine permit area (delineated in Figure 4.1-1) to be disturbed by mining are portions of Sections 17 and 18. Access to coal seams (Figure 4.1-2) in the permit area will be through two portals in Sections 17 and 18.

Current land uses on the area are wildlife habitat and limited cattle grazing. Soils on Sections 17 and 18 (Colorado and Utah require baseline soils inventories only on those portions of an underground mine's permit area that will be disturbed during mining) range from alluvial loamy soils and silty clay loams along the intermittent streambed to Shinler soils and shale outcrops (Figure 4.1-3). Four major habitat types occur on the proposed mine site, including cottonwood drainages, sagebrush-grasslands, mixed mountain brush habitats, and aspen/coniferous forest (Figure 4.1-4). Postmining restoration of the latter three types will be discussed below.

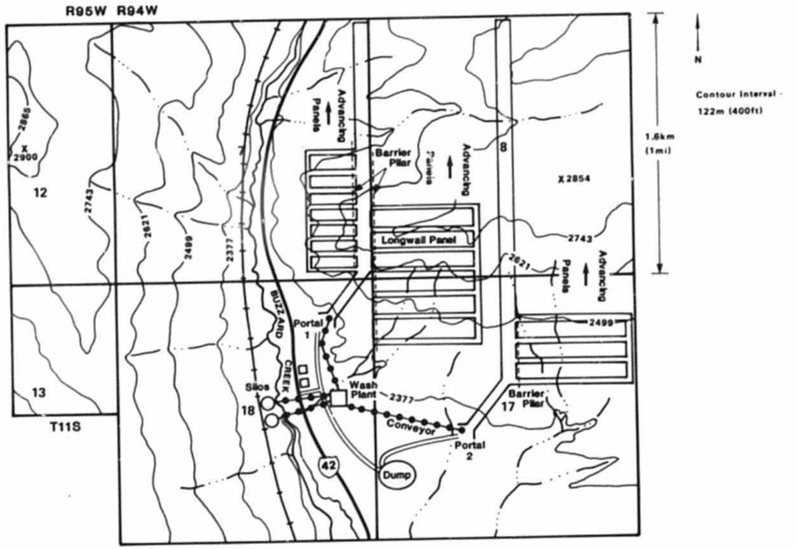

Figure 4.1-1. Original topography on the Buzzard Creek Mine permit area and proposed mine layout, including areas of surface disturbance.

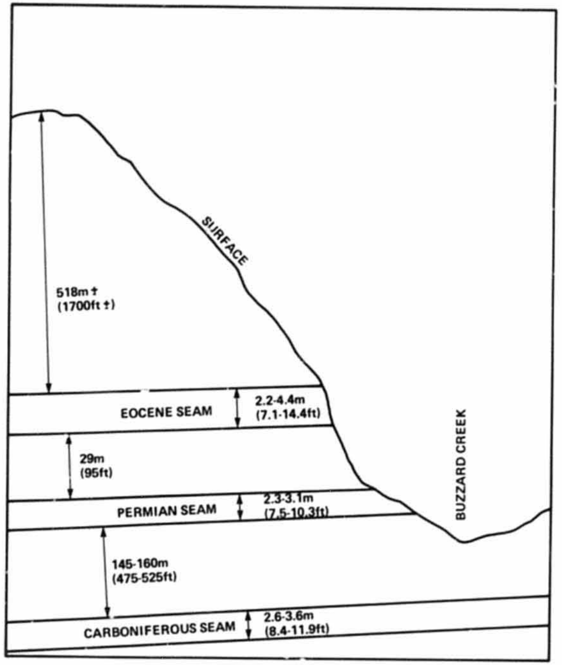

Figure 4.1-2. Schematic of coal seams at the proposed Buzzard Creek Mine.

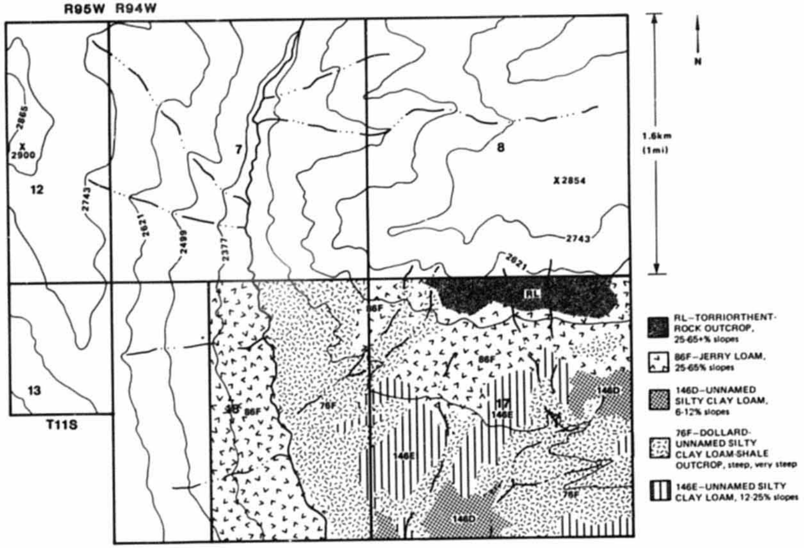

Figure 4.1-3. Premining soils inventory on those portions of the Buzzard Creek Mine to be disturbed during mining.

BEST DOCUMENT AVAILABLE 219

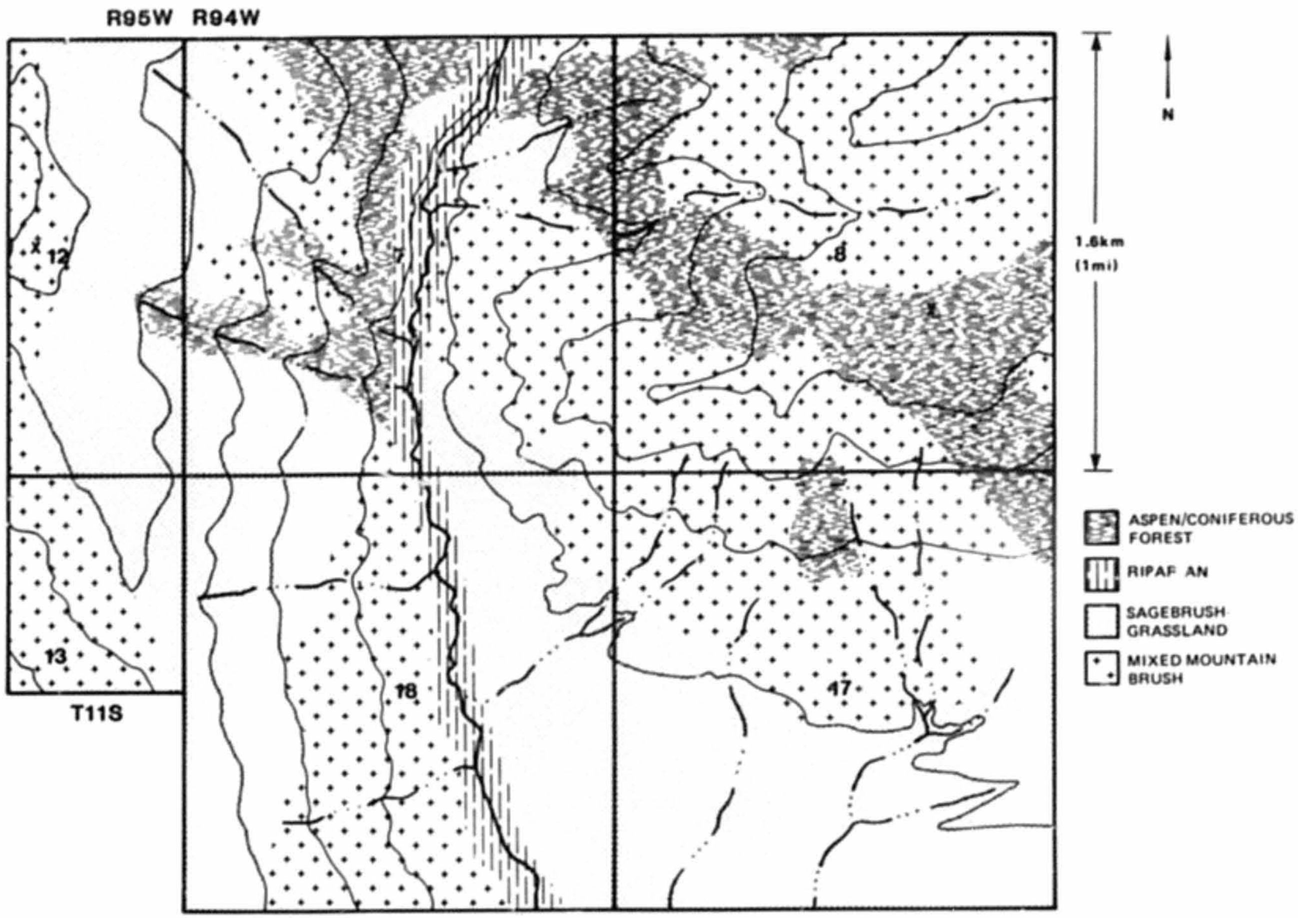

Figure 4.1-4. Premining vegetation types on the Buzzard Creek Mine permit area.

The postmining land use on the Buzzard Creek Mine site will be wildlife habitat and livestock grazing. The riparian zone adjacent to Buzzard Creek and the creek itself will not be disturbed during mining. Emphasis will be placed on restoring the original habitat types in patches that will enhance the value of the area for wildlife. The goal of the reclamation and revegetation activities will be to establish landforms, shrub patches, important forage species, cover, and other precursors of diverse wildlife vegetative communities that will develop into an optimum wildlife habitat in 20 to 50 years following bond release.

4.1.1 Sagebrush-Grasslands

Thousands of acres in the Uinta-Southwestern Utah region support dense stands of big sagebrush with various herbaceous understory plants. In some areas, bunchgrasses are abundant enough to classify the vegetation as a sagebrush grassland or sagebrush steppe community. Sagebrush is the climax community on semidesert areas where annual precipitation is usually greater than 18 cm (7 in) (Cronquist et al. 1972). Sagebrush communities are best developed on deep, permeable, moderately alkaline to neutral soils of well-drained valleys and the bases of mountain ranges (Costello 1954; Cronquist et al. 1972). This type is most prominent below 2,134 m (7,000 ft) in the region, although it extends above 3,048 m (10,000 ft) in many areas. Such high elevation communities, however, are not characteristic of the semidesert zone.

Costello (1954) provides a good account of the spatial relationship between sagebrush and those communities adjacent to it:

> At its lower border the type merges with the saltbush and greasewood communities. The transition at the upper limits is variable. The boundary between sagebrush and mountain shrub is usually clear-cut. The contact with pinon-juniper is frequently diffusive, with indications in many localities..., that the junipers are invading the sagebrush from above....[The transition commonly forms a mosaic] where ponderosa pine, oak, and sagebrush occupy the same zone. With increase in altitude the sagebrush patches decrease in size and number until the forest associations become completely dominant.

Big sagebrush is typically the dominant species. Other important shrubs include low sagebrush, rubber and Douglas rabbitbrush, common blackbrush, torrey and green mormontea, spiny hopsage, granite pricklygilia, antelope bitterbrush, desert gooseberry, snowberry, and littleleaf horsebrush (Costello 1954; Cronquist et al. 1972).

Bluebunch wheatgrass and Sandberg bluegrass dominate in some areas; however, they generally co-dominate with sagebrush or play a less important role. Other important perennial grasses in this type include thickspike and western wheatgrass, red threeawn, basin wildrye, prairie junegrass, Indian ricegrass, mutton and Nevada bluegrass, bottlebrush squirreltail, alkali sacaton, and needle-and-thread (Costello 1954; Cronquist et al. 1972).

Common perennial forbs in this habitat include agoseris, tapertip onion, milkvetch, arrowleaf balsamroot, sego mariposalily, desert indianpaintbrush, hairy goldenaster, tapertip hawksbeard, Anderson larkspur, wildbuckwheat, pinque actinea, biscuitroot, tailcup and silky lupine, Hoods and longleaf phlox, Great Basin violet, mulesear wyethia, and foothill deathcamus (Costello 1954; Cronquist et al. 1972).

The sagebrush-grass complex, generally found immediately below mountain shrub habitats, provides highly important habitat for many wildlife species. The importance of these communities to mule deer, antelope, and grouse has been well documented (see Restoring Big Game Range, Section 3.3.3.j, and Maintenance of Sage Grouse Habitats, Section 3.3.3.i). Elk, coyotes, fox, numerous raptors and many small mammals, birds, and reptiles are associated with this community. Birds characteristic of this habitat are horned larks, sage thrashers, and Brewer's, vesper, sage, and black-throated sparrows (Hayward et al. 1976).

4.1.2 Mixed Mountain Brush Habitats

In the Uinta-Southwestern Utah region, mixed mountain brush habitats are dominant in the transitions between grassland and semidesert at their lower limits and woodland or coniferous forest at their upper borders. The lower contact is usually with sagebrush, while the upper border frequently meets the aspen and lodgepole pine. These habitats are generally characterized by Gambel oak, mountain snowberry, Saskatoon serviceberry, bitterbrush, and Douglas rabbitbrush. Other shrubs common in these habitats include big sagebrush, common chokecherry, and true mountainmahogany.

The understory on mesophytic slopes in this zone usually consist of Kentucky bluegrass, needle-and-thread, letterman needlegrass, yellow owlclover, ceanothus, goldenrod, showy goldeneye, branchy groundsmoke, curruth sagewort, trailing fleabane, mulesear wyethia, and scarlet gaura. On drier slopes, common understory species include Scribner needlegrass, Indian ricegrass, broom snakeweed, Torrey beadlip penstemon, tasselflower brickellbush, common gaillardia, and flowery phlox (Costello 1954).

The mountain shrub community is an extremely important habitat to a number of wildlife species, especially deer. Numerous studies have demonstrated the importance of browse, particularly that of the preferred species (for a review of food habits, see Kufeld et al. 1973), to the overwinter survival of mule deer, although a diet consisting entirely of browse cannot maintain deer for long (Robinette et al. 1952; Ammann et al. 1973; Mautz et al. 1976; Wallmo et al. 1977; Short 1981). The quantity and quality of browse in mountain shrub habitat is, therefore, critical to a deer population, especially during severe winters.

This habitat is important to other species, including elk, black bear, coyotes, fox, and several raptors. The most characteristic birds are the rufous-sided towhee, Virginia's warbler, orange crowned warbler, and scrub jay (Hayward et al. 1976). Other birds include the poor-will, gray flycatcher, Pinyon jay, plain titmouse, common bushtit, Bewick's wren, and blue-grey gnatcatcher.

4.1.3 Aspen/Coniferous Forest

The aspen/coniferous forest is composed of diverse vegetative communities found between 2,195 to 3,353 m (7,200 to 11,000 ft) in the Uinta-Southwestern Utah region. This association may be dominated by aspen, lodgepole pine, Douglas-fir or subalpine fir, and Engelmann spruce, depending on the site characteristics and seral stage. Both aspen and lodgepole pine are typically successional species in this region (Daubenmire 1943), although some stands may be the climax type (Alexander 1974; Hoffman and Alexander 1980). Aspen and lodgepole are generally succeeded by Douglas-fir at lower elevations and the Engelmann spruce-subalpine fir associations at higher altitudes.

Common understory species in these communities include American vetch, common dandelion, arnica, mulesear wyethia, western yarrow, elk sedge, pine reedgrass, Letterman needlegrass, blue wildrye, whortleberry, snowberry, rubber rabbitbrush, and common juniper (Severson 1963).

Interactions between elevation, soil characteristics, aspect, and seral stage result in a diverse association composed of a number of habitats important to wildlife. This association provides important seasonal forage and cover for deer and elk (Compton 1975), and important nesting sites for bluebirds, woodpeckers, and several species of raptors. Other species inhabiting aspen/conifer forests include black bears, martens, weasels, porcupines, red squirrels, Gapper's red-backed voles, blue grouse, chickadees, nuthatches, purple martins, and Steller's and gray jays.

4.2 RECLAMATION TIMETABLE

Buzzard Creek Mine, Inc. has coal reserves projected to last 35-70 years and is pursuing additional reserves. Reclamation of disturbed lands will be initiated as soon as possible after cessation of mining activities. Most facilities are scheduled to be used until at least the year 2011. Final reclamation will occur immediately or shortly after abandonment.

Revegetation efforts on all disturbed areas will commence the first appropriate season following grading and topsoil redistribution. As necessary, this will include the use of soil amendments (see Use of Mycorrhizae to Enhance Plant Growth on Mine Spoils, Section 3.2.1.c, and Fertilization, Section 3.3.1.b). A suitable, permanent, diverse vegetative cover, selected in consultation with various governmental and private agencies, will be established on all reclaimed areas. The following subsections describe the major aspects of the proposed revegetation plan.

4.3 REGRADING

During and following mining operations, disturbed areas will be backfilled to the approximate original contour (Figure 4.3-1), as specified by regulations. Contemporaneous reclamation will be instituted to provide protection to exposed soils on the site. The goal of the backfilling, soil stabilization, compacting, and grading processes is to provide a reclaimed

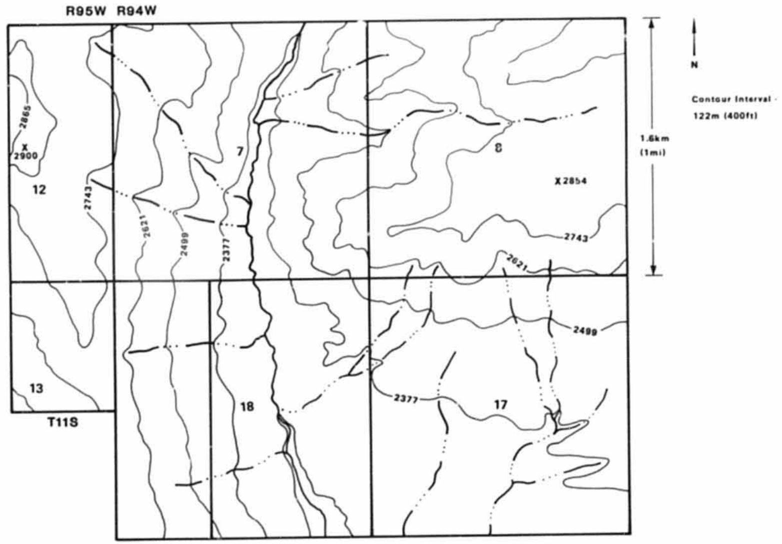

Figure 4.3-1. Postmining topography on the Buzzard Creek Mine permit area.

surface with topographic features resembling the surrounding topography and enhancing postmining land uses. Increasing the topographic relief and irregularity of an area over pre-mine conditions (while staying within the guidelines of the original contour concept) will create additional microhabitat diversity and provides wildlife topographic cover while the vegetation recovers from mining. (The small undulations, knolls, ridges, etc., resulting from "roughening" the landscape are not discernible in Figure 4.3-1 due to their small size relative to the contour intervals. See Creating Topographic Features, Section 3.3.3.a, and Planting Patterns to Increase Wildlife Diversity, Section 3.3.3.b.) All mine portals, air intake shafts, and other mine openings will be sealed. All surface structures, including roadbeds, will be removed. Solid waste generated from debris removal will be collected and removed from areas to be reclaimed. Backfilling operations will be conducted in depressions created by cut and fill operations. Solid wastes, debris, and surface foundations will be buried under at least 1.2 m (4 ft) of subsoil and topsoil. Stockpiled subsoil will augment fill material. A dozer and front end loader will be used to fill all depressions. Filled depressions will be compacted and stabilized by heavy equipment. Grading will return the disturbed areas to their approximate original contours.

Prior to redistribution, the topsoil stockpiles will be broken up with a dozer and disk or similar equipment, thereby ensuring a more uniform topsoil layer throughout selected portions of the disturbed area. Live handling of topsoil will be instituted whenever possible. The advantages of this procedure are discussed in Section 3.2.1.b, Selective Placement of Overburden and Topsoil at Underground Mines. If needed, regraded lands will be scarified to a depth of 20 to 30 cm (8 to 12 in) by a ripper-equipped tractor to reduce surface compaction, provide a roughened surface to encourage topsoil adherence, and promote vegetational root penetration. To minimize excessive compaction of the redistributed topsoil, travel on topsoiled areas will be restricted.

Within a suitable time period prior to revegetating, topsoil will be distributed on all areas to be reclaimed. During this time, the topsoil will be allowed to settle. Topsoil redistribution procedures will ensure a thickness consistent with the proposed reclamation plan and will be redistributed at a time of the year suitable for establishing permanent vegetation. Topsoil depth will vary from 20 to 46 cm (8 to 18 in) throughout the area, depending upon the vegetative community to be reclaimed and the plant community and quantity of topsoil originally on the site. (For more specific information on soil handling, consult General Procedures, Section 3.2.1.a, and Selective Placement of Overburden and Topsoil at Underground Mines, Section 3.2.1.b.)

4.4 INTERMITTENT STREAMBED RESTORATION

The intermittent streambeds originally running through Sections 17 and 18 (Figure 4.1-1) will be recut along their former courses with a dozer following all mining operations on this area (Figure 4.3-1). The reclaimed streambeds will simulate the original slope, width, depth, natural meanders, and vegetative cover. Log and rock deflectors, large instream rocks, and other structures (see Streambed Protection -Gabion Matting and Riprap, Section 3.3.2.h) will be used as needed to stabilize banks and control erosion during streamflow periods.

4.5 SOIL AND SEEDBED PREPARATION

Soil tests will be made to determine the amount and types (ratios) of fertilizer needed, if any. If phosphorus is needed, it will be broadcast onto the plowed ground and then disked into the soil before seeding. Nitrogen, if needed, will be applied at the time of seeding in the spring, or if fall seeding is done, nitrogen application will occur after germination in the spring. (The Fertilization BCP, Section 3.3.1.b, elaborates on these procedures.)

4.5.1 Mulching

On all but the steeper slopes, a weed-free straw mulch will be used to enhance the moisture retention required for seed germination. The straw mulch will be disced or crimped into the soil using a coulter disc or standard farming equipment following seeding. The steeper slopes may require a hydro-mulch and/or the addition of burlap or soil-retaining matting. Mulch with tackifying agent may be used on steep banks. (More information is available on this subject under Mulching, Section 3.3.1.h).

4.6 REVEGETATION AND MANAGEMENT

4.6.1 Sagebrush-Grasslands

Portions of Sections 7 and 18 to be reclaimed as sagebrush-grassland habitats (Figure 4.6-1) will be reclaimed by seeding, planting nursery grown stock, and transplanting more mature plants from the immediate area with a modified front end loader. Mature shrubs will serve as seed sources for further shrub establishment and as cover for many wildlife species before the seeded plants can attain adequate height. The goal in this habitat will be to establish a minimum of 2000 stems (a plant at least 20 cm [8 in] tall) per 0.4 ha (1 acre) (A. Whitaker, Wildlife Program Specialist, Colorado Division of Wildlife, pers. comm.).

Seeding and Transplanting

Seeding will occur in the fall after a killing frost and before the ground freezes. Gently sloping areas will be seeded with a drill followed by a cultipacker to pack the soil. Steeper slopes will be seeded with a cyclone spreader or hydroseeded at twice the drill rate. While transplanting mature shrubs may be the most dependable method of shrub establishment, adequate stands of shrubs can be obtained from direct seeding when firming the seedbed and mulching (Draves and Berg 1978). As stated above, the Buzzard Creek Mine will employ these practices to enhance revegetation efforts. (Additional methods of seeding, periods for seeding, and the amount of seed required are discussed in Seeding, Section 3.3.1.c. Techniques for increasing reclamation success have also been discussed in the Fertilization Section, 3.3.1.b, and the Water Conservation Section, 3.3.1.g).

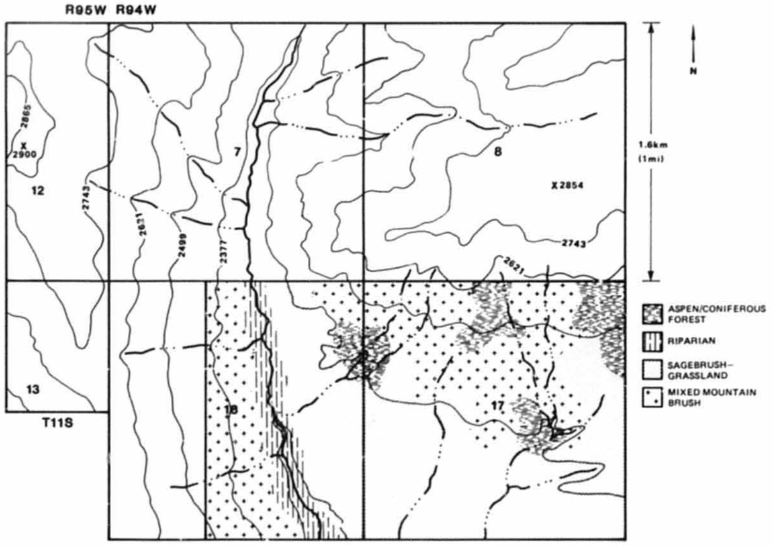

Figure 4.6-1. Postmining vegetation on the Buzzard Creek Mine permit area.

BEST DOCUMENT AVAILABLE 227

Shrubs that are not seeded will be established by planting nursery grown stock and by using a modified front end loader to transplant established, more mature vegetation. Transplanted and nursery grown stock will be planted in clumps in microhabitats conducive to survival. (For transplanting information, see Transplanting Native Vegetation, Section 3.3.1.d, and Transplanting Nursery Grown Plants, Section 3.3.1.e.)

Species Selection

Plants used to revegetate disturbed sites were selected specifically for the vegetative community to be established. The dominant species used for each vegetative type were chosen on the basis of premining vegetative cover, available seed source, and utilization by wildlife and livestock. The Plant Information Network (PIN) and the Soil Conservation Service were useful in the selection of revegetation plants.

The seed mixture to be used for reclaiming sagebrush-grassland habitats is listed in Table 4.6-1. Dates and method of seeding are discussed above. The large percentage of sagebrush seed in the mixture should provide the minimum standard of 2000 stems (a plant at least 20 cm [8 in] tall) per 0.4 ha (1 acre) even with competition from the grasses. Microhabitats particularly conducive to sagebrush establishment should meet or exceed the performance standard of 3000 stems (here a stem is defined as a plant at least 30 cm [12 in] tall) per 0.4 ha (1 acre) which is recommended for sage grouse winter range (A. Whitaker, pers. comm.).

Table 4.6-1. Seed mixture for revegetating sagebrush-grassland habitats on the Buzzard Creek Mine site.

Common name		Seeding rate[1] in kg PLS/ha (lbs PLS/acre)
Big sagebrush		0.9 (1)
Woods rose		0.9 (1)
Rubber rabbitbrush		0.4 (0.5)
Douglas rabbitbrush		0.4 (0.5)
Green ephedra		0.9 (1)
Winterfat		0.9 (1)
Thickspike wheatgrass		1.8 (2)
Orchard grass		1.8 (2)
Yellow sweetclover		1.8 (2)
	Total	9.8 (11)

[1]Rate for drilled seed. Hand-broadcast rates will be doubled.

In addition to planting shrubs, grasses, and forbs from seed, shrubs and some clumps of large grasses will be transplanted using a modified front end loader. This will provide wildlife a source of browse, cover, and perching areas which would normally take several years to develop using seedlings. To facilitate survival, the transplants will be selectively matched as closely as possible to slope, direction, and spacing as they were in their original habitat. The most common transplants will be big sagebrush, rabbitbrush, and clumps of the native grasses and forbs.

Any recoverable trees and shrubs that are not transplanted, but reusable as snags or deadfalls, will be placed on reclaimed areas to improve wildlife habitat.

Irrigation

Irrigation will not be used unless initial revegetation attempts fail due to inadequate moisture or if it is considered a major factor in successful revegetation. If irrigation is necessary, it will be used to supplement natural precipitation. Water will be obtained from Buzzard Creek and sampled as required by the State regulatory agency. (For details on the best current irrigation practices, see Irrigation, Section 3.3.1.b.)

Protection of Newly Seeded Areas

All newly seeded areas will be protected by a five-strand barbed wire fence which surrounds the permit area. The construction of the fence and the type of fence received approval from both the State Game and Fish Department and the local Bureau of Land Management. This fence design limits sheep and cattle from the mine area while allowing wildlife movement. (For fence specifications, see Fences, Section 3.1.1.d.)

4.6.2 Mixed Mountain Brush Habitats

Seeding and Transplanting

Slopes will be seeded using the procedures and techniques for revegetating the sagebrush-grassland habitats. Most shrubs that are not seeded will be established by hand-setting seedlings, or with the use of a front end loader to transplant established, more mature, vegetation. The goal in this habitat will be to establish a minimum of 1000 shrub stems per 0.4 ha (1 acre) (A. Whitaker, Wildlife Program Specialist, Colorado Division of Wildlife, pers. comm.). (For more information, see Transplanting Native Vegetation, Section 3.3.1.d, and Transplanting Nursery Grown Plants, Section 3.3.1.e.)

Species Selection

Plants used to revegetate disturbed sites were selected specifically for the vegetative community to be established in the given area. The dominant species used for each vegetative type were chosen on the basis of premining vegetative cover, available seed source, and utilization by wildlife and livestock. The Plant Information Network (PIN) (Section 3.3.1.a) and the Soil Conservation Service were useful in the selection of revegetation plants.

The seed mixtures to be used for reclaiming mountain shrub habitats are provided in Tables 4.6-2 and 4.6-3. The shrub seed mixture (Table 4.6-2) will be planted in a mosaic of 0.4- to 1.6-ha (1- to 4-acre) patches. Surrounding these shrub patches, the grass and forb seed mixture (Table 4.6-3) will be planted. Shrub seedlings and transplants (discussed below) will also be planted in clumps throughout the area to provide immediate habitat for wildlife. The goal is to create a shrub habitat interspersed with openings - a diverse habitat more valuable to wildlife.

Table 4.6-2. Shrub seed mixture for revegetating mixed mountain brush habitats on the Buzzard Creek Mine site.

Common name		Seeding rate in kg PLS/ha (lbs PLS/acre)
Big sagebrush		0.4 (0.5)
Bitterbrush		0.9 (1)
Woods rose		2.7 (3)
Douglas rabbitbrush		0.9 (1)
Mountain snowberry		1.8 (2)
Chokecherry		0.9 (1)
	Total	7.6 (8.5)

Table 4.6-3. Grass and forb seed mixture for revegetating mixed mountain brush habitats on the Buzzard Creek Mine site.

Common name		Seeding rate in kg PLS/ha (lbs PLS/acre)
Intermediate wheatgrass		1.8 (2)
Russian wildrye		1.8 (2)
Yellow blossom sweetclover		1.8 (2)
Nomad alfalfa		0.9 (1)
Big bluegrass		1.8 (2)
Mountain brome		1.8 (2)
Orchard grass		1.8 (2)
Western wheatgrass		1.8 (2)
	Total	13.5 (15)

[1]For drilled seed. Hand-broadcast rates will be doubled.

In addition to planting shrubs, grasses, and forbs from seed, shrubs and some clumps of large grasses will be transplanted using a modified front end loader. This will provide wildlife a source of browse, cover, and perching areas which would normally take several years to develop using seedlings. To facilitate survival, the transplants will be selectively matched as closely as possible to the slope, direction, and spacing of their original microhabitat. The most common transplants will be Utah serviceberry, big sagebrush, quaking aspen, chokecherry, bitterbrush, snowberry, and Gambel oak. Shrub and aspen transplants will be set in a peat slurry with root stimulant.

Any recoverable trees and shrubs that are not transplanted, but are usable as snags or deadfall, will be placed on reclaimed areas to improve wildlife habitat.

Irrigation

Irrigation is discussed above under Sagebrush-Grassland Habitats (Section 4.6.1).

Weed Control

Weed control will be aimed at reducing competition from grasses. For problem grasslike weeds, such as wild oats, a rotary mower may be used. Since these annuals grow faster than the desirable perennials, they can be mowed without harming the grasses underneath.

In addition, hand-held gasoline-powered weed eaters or machetes may be used to clip weeds around shrubs if this becomes necessary. Care will be taken to avoid damage to shrubs and trees. Weeding in this manner may be done twice during the growing season, mid-June and late July. Other methods of weed control are discussed in Pest Control, Section 3.3.1.j.

Protection of Newly Seeded Areas

Protection of newly seeded areas will follow that discussed above under Sagebrush-Grassland Habitats (Section 4.6.1).

4.6.3 <u>Aspen/Coniferous Forest</u>

Areas to be revegetated as aspen/lodgepole habitats (Figure 4.6-1) will be reclaimed by transplanting nursery grown stock and by transplanting native trees, shrubs, and clumps of grasses from adjacent areas using a modified front end loader. Like the mountain shrub habitat, this will provide wildlife a source of browse, cover, and perching areas which would normally take several years to establish from seed or seedlings. The seed mixture in Table 4.6-4 will be used between transplants to provide cover and increase soil stability. The short-term revegetation goal in this habitat will be to establish 1000 stems per 0.4 ha (1 acre) (A. Whitaker, Wildlife Program Specialist, Colorado Division of Wildlife, pers. comm.). Aspen/lodgepole habitats will be interspersed in large patches (Figure 4.6-1) of mixed mountain shrub to provide a more diverse and valuable wildlife habitat.

Table 4.6-4. Seed mixture for use between transplanted clumps of native aspen/lodgepole vegetation on the Buzzard Creek Mine site.

Common name	Seeding rate in kg PLS/ha (lbs PLS/acre)
Rubber rabbitbrush	0.9 (1)
Pine reedgrass	1.8 (2)
Nomad alfalfa	0.9 (1)
Big bluegrass	1.8 (2)
Intermediate wheatgrass	1.8 (2)
Mountain brome	1.8 (2)
Yellow sweetclover	1.8 (2)
Spreading sweetroot	0.9 (1)
Heart-leaf arnica	1.8 (2)
Total	13.5 (15)

Mulching, irrigation, and weed control practices will be applied as specified under Sagebrush-Grassland and Mixed Mountain Brush Habitats (Sections 4.6.1 and 4.6.2).

Animal Damage Control

If rodent damage to the roots of the young trees becomes apparent, an EPA-approved rodenticide may be used. (For more details and other methods of control, see Pest Control, Section 3.3.1.j.)

4.7 ADDITIONAL ENHANCEMENT FOR WILDLIFE

4.7.1 Brushpiles and Rock Piles

Brush which had been stockpiled during the clearing operation for the mine or obtained during reclamation 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 three piles/ha (one pile/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, sagebrush, and debris cuttings. It is expected that these piles will provide cover for small wildlife, both game and nongame species (Gutierrez et al. 1979). Rock piles will also be formed from rock gathered after the final grading. These piles will be no more than 3 m (10 ft) high and 6 m (20 ft) in diameter. Approximately one pile/ha (one pile/2.5 acres) will be created.

4.7.2 Nest Boxes

Ten passerine nest boxes will be erected systematically throughout the area. Nest box dimensions will vary to account for different species identified during the baseline studies. (Dimensions for different species are provided in Construction of Nesting Structures for Birds, Section 3.3.3.g). Boxes will be checked periodically through the bonding period to determine if repairs are needed.

One raptor nesting tripod or elevated platform will be placed in the sagebrush-grassland habitat on the northeast quarter of Section 17. Due to the isolation of the reclaimed mine site from populated areas, it is anticipated that a raptor nesting structure could be utilized successfully on the area by either hawks or golden eagles (Grubb 1980).

4.7.3 Access Restriction

Access to the reclamation site will be prohibited to encourage reclamation development and wildlife protection. Locked gates will be erected at access points off the main roads to the site, and signs posted as follows: Buzzard Mine; Private Property; Access by Permission Only; Inquire John Doe, 1214 Temple St., Salt Lake City, UT.

4.8 REFERENCES

Alexander, R. R. Silviculture of central and southern Rocky Mountain forests. USDA For. Serv. Res. Pap. RM-120. Rocky Mtn. For. and Range Exp. Stn., Fort Collins, Colo; 1974. 36 p.

Ammann, A. P.; Cowan, R. L.; Mothershead, C. L.; Baumgardt, B. R. Dry matter and energy intake in relation to digestibility in white-tailed deer. J. Wildl. Manage. 37:195-201; 1973.

Compton, T. Mule deer-elk relationships in the western Sierra Madre area of southcentral Wyoming. Wildl. Techn. Rept. No. 1. Wyoming Game and Fish Dept., Cheyenne; 1975.

Costello, D. F. Vegetation zones in Colorado. Pages iii-x in Harrington, H. D. Manual of the plants of Colorado; Swallow Press, Chicago; 1954. 666 p.

Cronquist, A.; Holmgren, A. H.; Holmgren, N. H.; Reveal, J. L. Intermountain flora: vascular plants of the intermountain West. U.S.A. Vol. 1. Hafner Publishing Co., Inc., New York; 1972. 270 p.

Daubenmire, R. F. Vegetational zonation in the Rocky Mountains. Bot. Rev. 9:325-393; 1943.

Draves, R. W.; Berg, W. A. Establishment of native shrubs on disturbed lands in the mountain shrub vegetation type. Dept. of Agronomy, Colorado State Univ. and Colorado State Univ. Exp. Sta.; 1978. 97 p.

Grubb, T. G. An artificial bald eagle nest structure. USDA Forest Service Res. Note RM-383: Rocky Mountain Forest and Range Exp. Stn., Fort Collins, CO; 1980. 4 p.

Gutierrez, 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, Ithaca; 1979.

Hayward, C. L.; Cottam, C.; Woodbury, A. M.; Frost, H. H. Birds of Utah. Great Basin Nat. Mem. No. 1; 1976.

Hoffman, G. R.; Alexander, R. R. Forest vegetation of the Routt National Forest in northwestern Colorado: a habitat type classification. USDA For. Serv. Res. Pap. RM-221. Rocky Mtn. For. and Range Exp. Stn., Fort Collins, CO; 1980.

Kufeld, R. C.; Wallmo, O. C.; Feddema, C. Foods of the Rocky Mountain mule deer. USDA Forest Service Res. Pap. Rm-111; 1973. 31 p.

Mautz, W. W.; Silver, H.; Holter, J. B.; Hayes, H. H.; Urban, W. E., Jr. Digestibility and related nutritional data for seven northern deer browse species. J. Wildl. Manage. 40:630-638; 1976.

Robinette, W. L.; O. Julander; J. S. Gashwiler; J. G. Smith. Winter mortality of mule deer in Utah in relation to range condition. J. Wildl. Manage. 16:289-299; 1952.

Severson, K. E. A description and classification by composition of the aspen stands in the Sierra Madre Mountains, Wyoming. M. S. Thesis, Univ. Wyo., Laramie; 1963.

Short, H. L. Nutrition and Metabolism. Pages 98-127 in Wallmo, O. C., ed. Mule and black-tailed deer of North America. Wildl. Manage. Institut., Univ. Nebraska Press, Lincoln; 181. 605 p.

Walmo, O. C.; Carpenter, L. H.; Regelin, W. L.; Gill, R. B.; Baker, D. L. Evaluation of deer habitat on a nutritional basis. J. Range Manage. 30:122-127; 1977.

Additional Reference:

Tucker, T. C.; Day, A. D. Vegetative reclamation of mine wastes and tailings in the Southwest. Brittain, R. G.; Myhman, M. A., eds. 1980 April 23-25; Mine Reclamation Center, U. of Arizona, Tucson, AZ; 1980; 7-1 to 7-3.

APPENDIX A
SOURCES OF INFORMATION

This list includes only public agencies and institutions. States covered in this handbook are listed alphabetically. Categories under each state are Federal and State agencies, universities, and agricultural experiment stations. Listings under these categories are alphabetically arranged.

COLORADO

State Agencies

Surface and Underground Mining Regulatory Authority

Division of Mined Land Reclamation
1313 Sherman
Denver, CO 80203
(303)-839-3567

Natural Resources

Division of Administrative Services
6060 Broadway
Denver, CO 80216
(303)-839-3101

Fish and Wildlife

Division of Wildlife
6360 Broadway
Denver, CO 80216
(303)-825-1192

Mining

Division of Mines
1313 Sherman
Denver, CO 80203
(303)-839-3351

Soils

Soil Conservation Board
618A State Centennial Bldg.
1313 Sherman Street
Denver, CO 80203
(303)-839-3351

Water

Water Conservation Board
823 State Centennial Bldg.
1313 Sherman Street
Denver, CO 80203
(303)-839-3441

State Department of Agriculture

Animal Industry Division
1525 Sherman Street
Denver, CO 80203
Predatory Animal (303)-839-3028
Rodent Control (303)-839-3562

Cooperative Research Units

Cooperative Fishery Research Unit, USDI
Room 102, Cooperative Units Building
Colorado State University
Ft. Collins, CO 80523
(303)-491-6942

Cooperative Wildlife Research Unit, USDI
Room 103, Cooperative Units Building
Colorado State University
Ft. Collins, CO 80523
(303)-491-5396

Extension Services

State Extension Services (Agriculture)
Colorado State University
Fort Collins, CO 80523
(303)-491-6251

State Extension Services
Extension Wildlife Specialist, Animal Damage Control
Dept. of Fishery and Wildlife Biology
Colorado State University
Ft. Collins, CO 80523
(303)-491-7093

State Extension Services
Extension Wildlife Specialist, Wildlife Management
Dept. of Fishery and Wildlife Biology
Colorado State University
Ft. Collins, CO 80523
(303)-491-6411

Forestry

State Forest Service
Colorado State University
Ft. Collins, CO 80523
(303)-482-8185

Federal Agencies

Department of Agriculture

U.S. Forest Service
Rocky Mountain Regional Office
11177 W. 8th Ave.
Box 25127
Lakewood, CO 80225
(303)-234-4185, -3711

U.S. Forest Service
Rocky Mountain Forest and Range Experiment Station
240 W. Prospect Street
Ft. Collins, CO 80521
(303)-221-1270

U.S. Soil Conservation Service
2490 W. 26th Avenue
P. O. Box 17107
Denver, CO 80217
(303)-837-4275

Department of Army

U.S. Army Engr., District, Sacramento
650 Capital Mall
Sacramento, CA 95814
(916)-440-2232

Department of the Interior

Office of Surface Mining, Reclamation and Enforcement
Region V
Brooks Towers
1020 15th Street
Denver, CO 80202
(303)-837-4731

U.S. Bureau of Land Management
Denver Federal Center
Building 50
Denver, CO 80225
(303)-234-4560, -2329, or -837-3165

Bureau of Mines
Intermountain Field Operations Center
Bldg. 20, Denver Federal Center
Denver, CO 80225
(303)-234-6866

Bureau of Mines
Denver Mining Research Center
Denver Federal Center
Denver, CO 80225
(303)-234-4144

U.S. Fish and Wildlife Service
Region 6
P. O.Box 25486
Denver, CO 80225
(303)-234-3990

Office of Endangered Species
U.S. Fish and Wildlife Service
P. O. Box 25486
Denver Federal Center
Denver, CO 80225
(303)-234-2496

U.S. Fish and Wildlife Service
Western Energy and Land Use Team
Drake Creekside Building One
2627 Redwing Road
Ft. Collins, CO 80526
(303)-226-9100

COLORADO (continued)

U.S. Fish and Wildlife Service
Denver Wildlife Research Center
Building 16, Denver Federal Center
Denver, CO 80225
(303)-234-2283

Bureau of Reclamation
Lower Missouri Region
Bldg. 20, Denver Federal Center
Denver, CO 80225
(303)-234-4441

Bureau of Reclamation
Upper Colorado Region
P. O. Box 11568
Salt Lake City, UT 84111
(801)-524-5592

Univers ties

rado State University
Coop rative Wildlife Research Unit
Fort llins, CO 80523
(303, 91-1101

Colorado State University
Department of Fisheries and Wildlife
Fort Collins, CO 80523
(303)-491-1101

University of Colorado
Environmental, Population, and Organismal Biology
Boulder, CO 80309
(303)-492-0111

UTAH

State Agencies

Fish and Wildlife

Division of Wildlife Resources
1596 W. N. Temple
Salt Lake City, UT 84116
(801) 533-9333

UTAH (continued)

Mining Authority

Oil, Gas, and Mining Division
1588 West North Temple
Salt Lake City, UT 84116

Water Resources

Division of Water Resources
Empire Building
Suite 300
231 East 4th South
Salt Lake City, UT 84111
(801) 533-5401

Natural Resources

State Department of Natural Resources
400 Empire Building
231 East Fourth South
Salt Lake City, UT 84111
(801) 533-5356

Federal Agencies

Department of the Interior

Bureau of Land Management
University Club Building
136 East South Temple
Salt Lake City, UT 84111
(801) 524-5311

Office of Surface Mining, Reclamation and Enforcement
Region V
Brooks Towers
1020 15th Street
Denver, CO 80202

U.S. Fish and Wildlife Service
Region 6
134 Union Blvd.
Denver, CO 80225
(303) 234-2209

U.S. Fish and Wildlife Service
Area Manager
125 S. State Street
Salt Lake City, UT 84138
(801) 524-5630

Water and Power Resources Service
Upper Colorado Region
P.O. Box 11568
Salt Lake City, UT 84111
(801) 524-5592

Department of the Army

U.S. Army Engr. District, Sacramento
650 Capital Mall
Sacramento, CA 95814
(916) 440-2232

Department of Agriculture

U.S. Forest Service
Intermountain Region
Federal Office Bldg.
324 25th Street
Ogden, UT 84401
(801) 399-6201

Soil Conservation Service
4012 Federal Bldg.
Salt Lake City, UT 84138
(801) 524-5051

Universities

Utah State University
Wildlife Sciences
Logan, UT 84322
(801) 752-4100

APPENDIX B
NAMES OF PLANTS MENTIONED IN THE TEXT

COMMON NAME	SCIENTIFIC NAME
Actinea, pingue	Hymenoxys richardsoni
Agoseris	Agoseris glauca
Alfalfa	Medicago sativa
Alkaligrass, Nuttall	Puccinellia airoides
Apacheplume, common	Fallugia paradoxa
Arnica, heartleaf	Arnica cordifolia
Arnica, mountain	Arnica montana
Arnica	Arnica spp.
Ash, green	Fraxinus pennsylvanica lanceolata
Aspen, quaking	Populus tremuloides
Aster, woody	Aster xylorrhiza
Aster	Aster spp.
Balsamroot, arrowleaf	Balsamorhiza sagittata
Barley	Hordeum spp.
Beebalm, mintleaf	Monarda fistulosa menthaefolia
Bentgrass, carpet	Agrostis stolonifera
Birch, river	Betula occidentalis
Biscuitroot	Lomatium spp.
Bitterbrush, antelope	Purshia tridentata
Bitterbrush	Purshia spp.
Blackbrush, common	Coleogyne ramosissima
Bluegrass, big	Poa ampla
Bluegrass, bulbous	Poa bulbosa
Bluegrass, Kentucky	Poa pratensis
Bluegrass, mutton	Poa fendleriana
Bluegrass, Nevada	Poa nevadaensis
Bluegrass, Sandberg	Poa secunda
Bluegrass	Poa spp.
Brickellbush, tasselflower	Brickellia grandiflora
Brome, fringe	Bromus ciliatus
Brome, mountain (big)	Bromus marginatus
Brome, smooth	Bromus inermus
Brome	Bromus spp.
Buckbrush	Ceanothus intergerrimus
Buffaloberry, silver	Shepherdi argentea
Buffaloberry	Shepherdi spp.
Buttercup	Ranunculus spp.

COMMON NAME	SCIENTIFIC NAME
Cattail	Typha spp.
Ceanothus	Ceanothus spp.
Cheatgrass	Bromus tectorum
Cherry, Nanking	Prunus tomentosa
Cherry, sand	Prunus besseyi
Chess, foxtail	Bromus rubens
Chokecherry, (common)	Prunus virginiaria
Clover, red	Trifolium pratense
Clover, white	Trifolium repens
Clover	Trifolium spp.
Cottonwood, plains	Populus sargentii
Cowparsnip, common	Heracleum lanatum
Crabapple, midwest	Malus ioensis
Currant, wax	Ribes cereum
Currant	Ribes spp.
Dandelion, common	Taraxacum officinale
Dandelion	Taraxacum officinale
Deathcamus, foothill	Zygadenus paniculatus
Dogwood, redosier	Cornus stolonifera
Dropseed, sand	Sporobolus cryptandrus
Dropseed, hairgrass (Alkali sacaton)	Sporobolus alroides
Duckweed	Lemna spp.
Elderberry, red	Sambucus racemosa
Elm, American	Ulmus americana
Elm, Siberian	Ulmus pumila
Ephedra, green	Ephedra viridis
Fescue, Idaho	Festuca idahoensis
Fescue, sheep	Festuca ovina
Flax, Lewis	Linum lewisi
Fir, Douglas	Pseudotsuga menziesii
Fir, subalpine	Abies lasiocarpa
Fleabane, trailing	Erigeron flagellaris
Foxtail, meadow	Alopecurus pratensis
Gaillardia, common	Gaillardia aristata
Gaura, scarlet	Gaura coccinea
Globemallow, scarlet	Sphaeralcea coccinea
Goldenaster, hairy	Chrysopsis viscida
Goldeneye, showy	Viguiera multiflora
Goldenrod	Solidago spp.
Gooseberry, desert	Ribes velutinum
Grama, blue	Bouteloua gracilis
Greasewood	Sarcobatus vermiculatus
Groundsmoke, branchy	Gayophytum ramosissimum

COMMON NAME	SCIENTIFIC NAME
Hairgrass, tufted	Deschampsia caespitosa
Hawksbeard, tapertip	Crepis acuminata
Hawthorn, fleshy	Crataegus succulenta
Hawthorn	Crataegus spp.
Hedgerose, Hansen	Rosa spp.
Hedysarum, western	Hedysarum cccidentale
Hemlock	Tsuga spp.
Hopsage, spiny	Grayia spinosa
Horsebrush, littleleaf	Tetradymia glabrata
Huckleberry	Gaylusacia spp.
Indianpaintbrush, desert	Castilleja chromosa
Juneberry (Saskatoon serviceberry)	Amelanchier alnifolia
Junegrass, prairie	Koeleria cristata
Juniper, common	Juniperus communis
Juniper, Rocky Mountain	Juniperus scopulorum
Juniper, Utah	Juniperus osteosperma
Juniper	Juniperus spp.
Larkspur, Anderson	Delphinium andersoni
Lettuce, prickly	Lactuca serriola
Lovegrass, sand	Eragrostis trichodes
Lupine, mountain	Lupinus alpestris
Lupine, silky	Lupinus sericeus
Lupine, tailcup	Lupinus caudatus
Maple, boxelder	Acer negundo
Mariposalily, sego	Calochortus nuttalli
Milkvetch, chickpea	Astragalus cicer
Milkvetch	Astragalus spp.
Millet	Milium spp.
Mockorange, littleleaf	Philadelphus microphyllus
Mormontea, green	Ephedra viridis
Mormontea, torrey	Ephedra torreyana
Mountainmahogany, curlleaf	Cercocarpus ledifolius
Mountainmahogany, true	Cercocarpus montanus
Mountainmahogany	Cercocarpus spp.
Muhly, mountain	Muhlenbergia montana
Needle-and-thread	Stipa comata
Needlegrass, green	Stipa viridula
Needlegrass, Letterman	Stipa lettermanii
Needlegrass, Scribner	Stipa scribneri

COMMON NAME	SCIENTIFIC NAME
Oak, bur	Quercus macroparpa
Oak, Gambel	Quercus gambelii
Oak	Quercus spp.
Oakbrush	Quercus spp.
Oat, wild	Avena fatua
Oat	Avena spp.
Oatgrass, African	Helictotrichon elongatum
Olive, Russian	Elaeagnus augustifolia
Onion, tapertip	Allium acuminatum
Orchardgrass	Dactylis glomerata
Owlclover, yellow	Orthocarpus luteus
Pea	Pisum spp.
Peashrub	Caragana spp.
Peavine	Lathyus spp.
Penstemon, Rocky Mountain	Penstemon strictus strictus
Penstemon, Torrey beadlip	Penstemon barbatus torreyi
Penstemon	Penstemon spp.
Phlox, flowery	Phlox multiflora
Phlox, Hoods	Phlox hoodii
Phlox, longleaf	Phlox longifolia
Pine, lodgepole	Pinus contorta
Pine, pinyon	Pinus edulis
Pine, ponderosa	Pinus ponderosa
Pine	Pinus spp.
Plum	Prunus spp.
Prairieconeflower	Ratibica spp.
Pricklygilia, granite	Leptodactylon pungens
Rabbitbrush, Douglas	Chrysothamnus viscidiflorus
Rabbitbrush, rubber	Chrysothamnus nauseosus
Rabbitbrush	Chrysothamnus spp.
Reedgrass, pine	Calamagrostis rubescens
Ricegrass, Indian	Oryzopsis hymenoides
Rose, redleaf	Rosa rubrifolia
Rose, Wood's	Rosa woodsii
Rush	Juncus spp.
Rye	Secale spp.
Sacaton, alkali	Sporobolus airoides
Sagebrush, big	Artemisia tridentata
Sagebrush, black	Artemisia nova
Sagebrush, fringed (sagewort)	Artemisia frigida
Sagebrush, low	Artemisia arbuscola
Sagebrush, sand	Artemisia filifolia
Sagebrush, silver	Artemisia cana
Sagebrush, Wyoming big	Artemisia tridentata wyomingensis
Sagebrush	Artemisia spp.

COMMON NAME	SCIENTIFIC NAME
Sagewort, birdfoot	Artemisia pedatifida
Sagewort, curruth	Artemisia carruthi
Salsify, common	Tragopogon dubius
Saltbush, fourwing	Atriplex canescens
Saltbush, Nuttall	Atriplex gardneri
Saltbush	Atriplex spp.
Sedge, dryland	Carex filifolia
Sedge, elk	Carex geyeri
Sedge	Carex spp.
Serviceberry, Saskatoon	Amelanchier alnifolia
Serviceberry, Utah	Amelanchier utahensis
Serviceberry	Amelanchier spp.
Shootingstar, Jeffrey	Dodecatheon jeffreyi
Silverberry	Elaeagnus commutata
Smartweed	Polygonum spp.
Snakeweed, broom	Gutierrezia sarothrae
Snakeweed	Gutierrezia spp.
Snowberry, mountain	Symphoricarpos orephilus
Snowberry, western	Symphoricarpos occidentalis
Snowberry	Symphoricarpos spp.
Sorghum	Sorghum vulgare
Spikerush	Eleocharis spp.
Spurge, leafy	Euphorbia esula
Spruce, blue	Picea pungens
Spruce, Engelman	Picea engelmannii
Squirreltail, bottlebrush	Sitanion hystrix
Spruce	Picea spp.
Sudan-grass	Sorghum halepense
Sumac, skunkbrush	Rhus trilobata
Sweetclover, yellow	Melilotus officinalis
Sweetclover	Melilotus spp.
Sweetroot, spreading	Osmorhiza chileusis
Sweetvetch, northern	Hedysarum boreale
Sweetvetch, Utah	Hedysarum utahense
Tea, Indian	Ephedra spp.
Thermopsis, prairie	Thermopsis rhombifolia
Thistle, Canada	Cirsium arvense
Thistle, Russian	Salsola kali
Threeawn, red	Aristida longiseta
Timothy	Phleum pratense
Vetch, American	Vicia americana
Vetch	Vicia spp.
Violet, Great Basin	Viola beckwithi

COMMON NAME	SCIENTIFIC NAME
Wheat	Triticum spp.
Wheatgrass, bluebunch	Agropyron spicatum
Wheatgrass, beardless bluebunch	Agropyron spicatum inerme
Wheatgrass, bearded bluebunch	Agropyron spicatum spicatum
Wheatgrass, bearded slender	Agropyron trachycaulum unilaterale
Wheatgrass, fairway	Agropyron cristatum
Wheatgrass, intermediate	Agropyron intermedium intermedium
Wheatgrass, pubescent	Agropyron trichophorum
Wheatgrass, slender	Apropyron trachycaulum
Wheatgrass, bearded slender	Agropyron trachycaulum unilaterale
Wheatgrass, streambank	Agropyron dasyctachyum riparium
Wheatgrass, tall	Agropyron elongatum
Wheatgrass, thickspike	Agropyron dasystachyum dasystachyum
Wheatgrass, western	Agropyron smithii
Whitetop	Cardaria spp.
Whortleberry	Vaccinium spp.
Wildbuckwheat	Eriogonum spp.
Wildrye, Great basin	Elymus cinereus
Wildrye, blue	Elymus glaucus
Wildrye, Canada	Elymus canadensis
Wildrye, Salina	Elymus salina
Wildrye, Russian	Elymus junceus
Willow	Salix spp.
Willow, Drummond's	Salix drummondiana
Willow, Geyer's	Salix geyeriana
Willow, peachleaf	Salix amygdaloides
Willow, sandbar	Salix interior
Willowherb, fireweed	Epilobium angostifolium
Winterfat, common	Ceratoides lanata
Wyethia, mulesear	Wyethia amplexicaulis
Yarrow, western	Achillea lanulosa

Nomenclature follows Beetle (1970. Recommended plant names. Univ. of Wyoming Agric. Exp. Stn. Res. J. 31. Laramie. 124 p.) and Weber (1976. Rocky Mountain flora. Colorado Assoc. Press, Boulder. 479 p.).

APPENDIX C
NAMES OF ANIMALS MENTIONED IN THE TEXT

COMMON NAME	SCIENTIFIC NAME
Antelope (pronghorn)	Antilocapra americana
Badger	Taxidea taxus
Bass, largemouth	Micropterus salmoides
Bear, black	Ursus americanus
Bluebird	Sialia spp.
Bluegill	Lepomis macrochirus
Bullhead, black	Ictalurus melas
Bunting, lark	Calamospiza melanocorys
Burro, feral	Equus asinus
Bushtit, common	Psaltriparus minimus
Canvasback	Aythya valisineria
Catfish, channel	Ictalurus punctatus
Catfish	Ictalurus spp.
Chickadee	Parus spp.
Cottontail, desert	Sylvilagus auduboni
Cottontail, Nuttal's	Sylvilagus nuttalli
Coyote	Canis latrans
Crane, sandhill	Grus canadensis
Deer, mule	Odocoileus heminous
Deer, white-tailed	Odocoileus virginianus
Deer	Odocoileus spp.
Dove, rock (pigeon)	Columba livia
Duck, ruddy	Oxyura jamaicensis
Eagle, bald	Haliaeetus leucocephalus
Eagle, golden	Aquila chrysaetos
Elk	Cervus elaphus
Ferret, black-footed	Mustela nigripes
Flicker	Colaptes auratus
Flycatcher, gray	Empidonax wrightii
Flycatcher	Empidonax spp.
Fox, red	Vulpes vulpes
Fox, swift	Vulpes velox
Fox	Vulpes spp.

COMMON NAME	SCIENTIFIC NAME
Gadwall	Anas strepera
Gnatcatcher, blue-gray	Polioptila caerulea
Goose, Canada	Branta canadensis
Ground squirrels	Citellus spp.
Grouse, blue	Dendragapus obscurus
Grouse, Columbian (mountain) sharp-tailed	Pediocetes phasianellus columbianus
Grouse, sharp-tailed (plains)	Pedioecetes phasianellus jamesi
Grouse, sage	Centrocercus urophasianus
Hawk, ferruginous	Buteo regalis
Hawk, marsh	Circus cyaneus
Hawk, red-tailed	Buteo jamaicensis
Hawk, sparrow	Falco sparverius
Hawk, Swainson's	Buteo swainsoni
Heron	Ardea spp.
Horse, feral	Equus caballus
Jackrabbit, blacktail	Lepus californicus
Jackrabbit, whitetail	Lepus towsendi
Jay, gray	Perisoreus canadensis
Jay, Pinyon	Gymnorhinus cyanocephalus
Jay, scrub	Aphelocoma coerulescens
Jay, Steller's	Cyanocitta stelleri
Kestrel	Falco spp.
Lark, horned	Eremophilia alpestris
Lark, meadow	Sturwella neglecta
Longspur	Calcarius spp.
Magpie	Pica pica
Mallard	Anas platyrhynchos
Marten	Martes americana
Martin, purple	Progne subis
Mink	Mustela nigripes
Minnows	Cyprinidae
Moose	Alces alces
Mouse, deer	Peromyscus maniculatus
Nuthatch	Sitta spp.
Owl, barn	Tyto alba
Owl, burrowing	Speotyto cunicularia
Owl, great horned	Bubo virginianus
Owl, saw-whet	Aegolius acadicus
Owl, screech	Otus asio

COMMON NAME	SCIENTIFIC NAME
Pelican	Pelecanus spp.
Phoebe	Sayornis spp.
Pintail	Anas acuta
Poor-will	Phalaenoptilus nuttallii
Porcupine	Erethizon dorsatum
Prairie dog, blacktail	Cynomys gunnisoni
Prairie dog, whitetailed	Cynomys leucurus
Pronghorn	Antilocapra americana
Raccoon	Procyon lotor
Raven	Corvus corax
Redhead	Aythya americana
Robin	Turdus migratorius
Scaup, lesser	Aythya affinis
Shoveler, northern	Spatula clypeata
Skunk, spotted	Spilogale putorius
Skunk, striped	Mephitis mephitis
Sparrow, black-throated	Amphispiza bilineata
Sparrow, Brewer's	Spizella breweri
Sparrow, sage	Amphispiza belli
Sparrow, vesper	Pocecetes gramineus
Squirrel, red	Tamiasciurua hudsonicus
Sunfish	Lepomis spp.
Swallow	Petrochelidon pyrrhonotea
Teal, blue-winged	Anas discors
Teal, cinnamon	Anas cyanoptera
Teal, green-winged	Anas carolinensis
Thrasher, sage	Oreoscoptes montanus
Titmouse, plain	Parus inornatus
Towhee, rufous-sided	Pipilo erythrophthalmus
Trout, brook	Salvelinus fontinalis
Trout, brown	Salmo trutta
Trout, cutthroat	Salmo clarki
Turkey	Meleagris gallopavo
Vole, Gapper's red-backed	Clethrionomys gapperi
Warbler, orange-crowned	Vermivora celata
Warbler, Virginia's	Vermivora virginiae
Weasel, long-tailed	Mustela frenata
Weasel	Mustela spp.
Wigeon, American	Anas americana
Woodpecker, downy	Dendrocopos pubescens
Woodpecker, hairy	Dendrocopos villosus
Wren, Bewick's	Thryomanes bewickii
Wren, house	Troglodytes aedon
Wren, rock	Salpinotes obsoletus

50272-101

REPORT DOCUMENTATION PAGE

1. Report No.: FWS/OBS-83/12
2.
3. Recipient's Accession No.:

4. Title and Subtitle: Practices for protecting and enhancing fish and wildlife on coal mined land in the Uinta-Southwestern Utah region.
5. Report Date: March 1983
6.

7. Author(s): Bettina R. Proctor et al.
8. Performing Organization Rept. No.:

9. Performing Organization Name and Address:
Science Applications, Inc.
1726 Cole Boulevard, Suite 350
Golden, CO 80401

10. Project/Task/Work Unit No.:
11. Contract(C) or Grant(G) No.:
(C) 14-16-0009-80-075
(G)

12. Sponsoring Organization Name and Address:
Western Energy and Land Use Team
Division of Biological Services
Research and Development
Fish and Wildlife Service
Washington, D.C. 20240

13. Type of Report & Period Covered:
14.

15. Supplementary Notes

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 Uinta-Southwestern 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.

17. Document Analysis a. Descriptors
Surface mining
Coal mining
Reclamation
Wildlife
Fishes

b. Identifiers/Open-Ended Terms
Revegetation
Wildlife management
Mitigation
Habitat improvement
Uinta
Southwest
Utah
Colorado
Arizona

c. COSATI Field/Group

18. Availability Statement: Release Unlimited
19. Security Class (This Report): Unclassified
20. Security Class (This Page): Unclassified
21. No. of Pages: 250
22. Price

(See ANSI–Z39.18) See Instructions on Reverse OPTIONAL FORM 272 (4–77) (Formerly NTIS–35) Department of Commerce

*U.S. Government Printing Office 1983 – 679-763/328 Reg. 8

BEST DOCUMENT AVAILABLE

REGION 1
Regional Director
U.S. Fish and Wildlife Service
Lloyd Five Hundred Building, Suite 1692
500 N.E. Multnomah Street
Portland, Oregon 97232

REGION 2
Regional Director
U.S. Fish and Wildlife Service
P.O. Box 1306
Albuquerque, New Mexico 87103

REGION 3
Regional Director
U.S. Fish and Wildlife Service
Federal Building, Fort Snelling
Twin Cities, Minnesota 55111

REGION 4
Regional Director
U.S. Fish and Wildlife Service
Richard B. Russell Building
75 Spring Street, S.W.
Atlanta, Georgia 30303

REGION 5
Regional Director
U.S. Fish and Wildlife Service
One Gateway Center
Newton Corner, Massachusetts 02158

REGION 6
Regional Director
U.S. Fish and Wildlife Service
P.O. Box 25486
Denver Federal Center
Denver, Colorado 80225

REG[illegible] 7
Regional Director
U.S. Fish and Wildlife Service
1011 E. Tudor Road
Anchorage, Alaska 99503

DEPARTMENT OF THE INTERIOR
U.S. FISH AND WILDLIFE SERVICE

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering the wisest use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to assure that their development is in the best interests of all our people. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.