EFFECTS OF SURFACE MINING ON FISH AND WILDLIFE IN APPALACHIA

UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
BUREAU OF SPORT FISHERIES AND WILDLIFE

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A Special Report by

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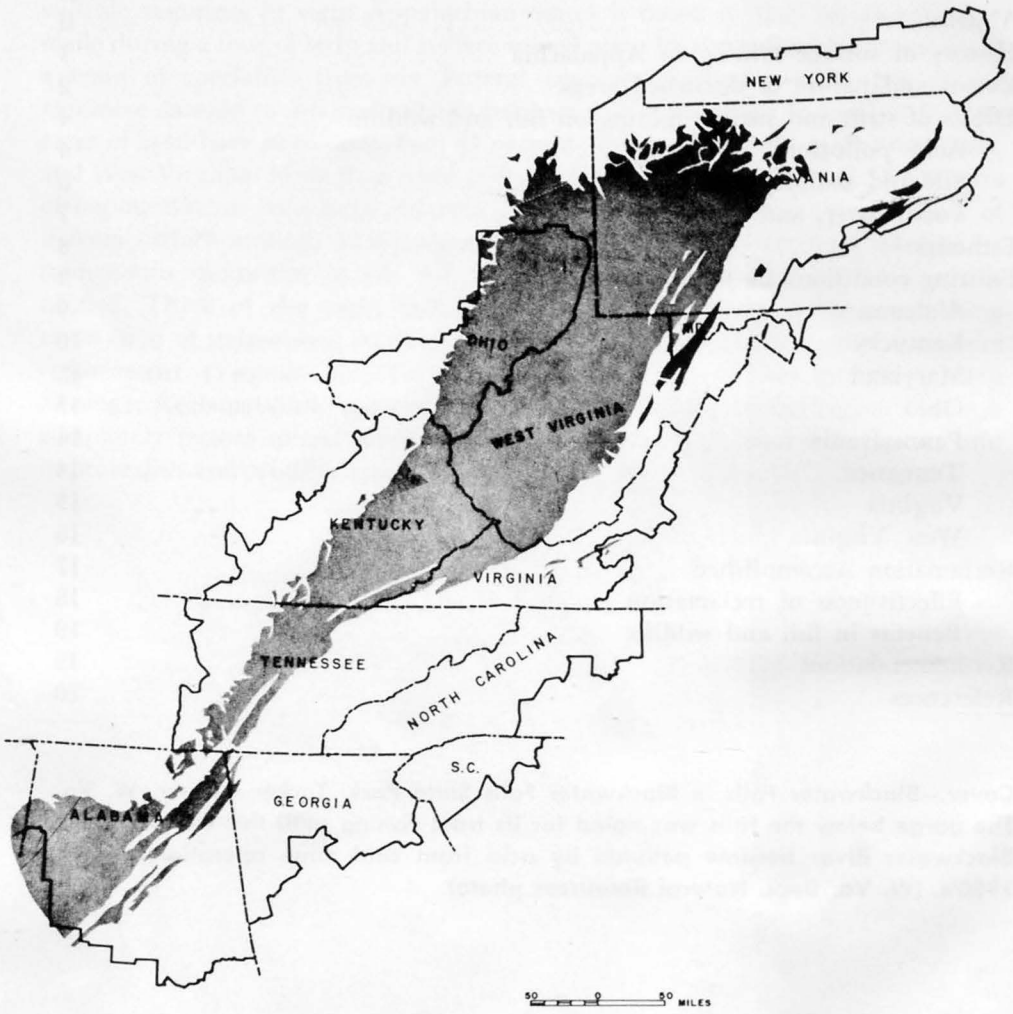
ABSTRACT

This report on the effects of strip and surface mining on the fish and wildlife resources in eight Appalachian States is based in part on observations made during a tour of strip and surface mined areas by the authors, as members of a team of specialists from six Federal agencies. Surface mining has caused extensive damage to fish and wildlife habitats and populations. A total of 832,605 acres of land have been disturbed; 81 percent of these are in Ohio, Pennsylvania, and West Virginia. More than 5,000 miles of Appalachian streams and 13,800 acres of impoundments have been seriously contaminated by acid mine water, some of it from surface mining. Additional water acreage has been adversely affected by tremendous quantities of silt and sediment. Reclamation of mined lands is needed. Three of the eight States visited in 1965-66 had no laws requiring restoration of strip-mined lands, and other States needed stronger laws and more enforcement (Virginia and Tennessee have since passed laws governing strip mining). Reclamation as currently practiced in the Appalachian region does not adequately restore mined lands to minimal standards necessary to protect and improve fish and wildlife resources.

CONTENTS

Cover.—Blackwater Falls in Blackwater Falls State Park, Tucker County, W. Va. The gorge below the falls was noted for its trout fishing until this section of the Blackwater River became polluted by acid from coal mine operations in the 1950's. (W. Va. Dept. Natural Resources photo)



Appalachia—shaded area indicates coal-bearing strata.

EFFECTS OF SURFACE MINING ON FISH AND WILDLIFE IN APPALACHIA

The Appalachian Regional Development Act of 1965 (Public Law 89–4, approved March 9, 1965) provides for public works, economic development programs, and the planning and coordination needed to develop these activities.

The Department of the Interior is concerned particularly with section 205 of the Act, "Mining Area Restoration." The purpose of that section is the rehabilitation of areas damaged by mining. Section 205 directs the Secretary of the Interior to make a national study of strip and surface mining operations and their effects. The first phase of the survey was conducted in the Appalachian region by a field appraisal team from the Bureau of Sport Fisheries and Wildlife, the Bureau of Mines, the Geological Survey, the Forest Service, the Federal Water Pollution Control Administration, and the Soil Conservation Service.

Selected mining areas in Pennsylvania, West Virginia, Virginia, Ohio, Kentucky, Tennessee, Maryland, and Alabama were visited and evaluated by the Field Appraisal Team. The areas included the principal mineral commodities recovered by surface mining in each State, the most important being coal. Thus, this report deals primarily with strip and surface mining for coal in Appalachia and its effects on fish and wildlife.

HISTORY OF SURFACE MINING IN APPALACHIA

Surface mining was probably the earliest form of mineral recovery in the Appalachian region. In the earlier days of the industry, the reserves of minable coal were considered small, and it was anticipated that they would soon be exhausted. As larger machines were produced, reserves of coal theretofore considered impossible to mine became accessible, and the operations were increased (Gillespie, 1964). Extensive strip and surface mining of coal has had a brief history, with the greatest expansion occurring during the last 25 years.

Surface mining of minerals (predominantly coal in Appalachia), is accomplished primarily by two methods: contour stripping and area stripping. These methods may be employed separately or together, depending on topography, past mining operations, and the nature or extent of the deposit.

Contour stripping, as the name implies, is a continuous process of following and removing a coal seam around a hillside or mountain top until the mineral or mineral ownership ends (fig. 1). Power equipment removes the material covering the coal (overburden), which is cast aside or pushed to the outer edge of the cut (fig. 2). The mine pit is a relatively level bench bounded on the inside by a vertical highwall and on the outside by a ridge of spoil which tails off downhill. *An additional one to four acres of land may be disturbed for each acre of coal recovered by this type of mining.* If there is more than one coal seam on the same hillside, multiple cuts are made, and spoil tailings may extend to the next lower strip mine (fig. 3). This situation is common in parts of Kentucky, Tennessee, and West Virginia, where in some areas spoil banks cover entire hillsides.

Area stripping is accomplished in flat to rolling terrain. A long trench is made across the mining area to expose the coal; after the coal is removed, spoil from adjacent workings is deposited in the initial cut. The operation continues until the entire area is mined. This type of mining leaves parallel ridges in rows of varying heights (fig. 4). The last cut is generally left open. These open pits often contribute to pollution.

Figure 1.—Contour strip mine on Bird Mountain in Tennessee. Photograph taken from the same mine half a mile away.

EXTENT AND NATURE OF DISTURBED AREAS

The extent of strip mining in Appalachia is presented in table 1. The percentage of disturbed area in each State was calculated by dividing the total State area into the strip-mined area. The percentages are rather low, but the aggregate area is more than 830,000 acres, and with increasing needs for coal this will double or triple within the next 25 years. This potential disturbance by surface mining is best demonstrated in West Virginia, where the State reclamation personnel anticipate that about 20 percent of its 3,449,600-acre coal field will eventually be mined. The magnitude of this disturbance will be extremely significant locally, and could have far-reaching effects nationally. Pollution resulting from mining affects thousands of miles of rivers and streams (Kinney, 1964), and the harmful effects on waters are often measurable in areas outside the mining area (fig. 5).

Table 1.—*Extent of surface disturbance in Appalachia*

State	Total acres in State	Acres disturbed	Percent disturbed
Alabama	33,029,760	50,600	0.15
Georgia	37,680,640	300	Trace
Kentucky	25,852,800	48,289	0.19
Maryland	6,769,280	2,200	0.03
Ohio	26,383,080	179,256	0.68
Pennsylvania	29,013,120	302,400	1.04
Tennessee	27,036,160	26,760	0.10
Virginia	26,121,600	30,800	0.12
West Virginia	15,475,840	192,000	1.24
Total	227,362,280	832,605	0.36

Figure 2.—Bulldozer clearing mine pit by pushing spoil over the edge, Campbell County, Tennessee.

A commonly overlooked effect of strip and surface mining is the tremendous acreage of lands made inaccessible to wildlife by contour strip operations. In West Virginia alone there are more than 411,000 acres of land essentially isolated to most animals by highwalls thrown around hilltops during mining (fig. 6). State authorities recognize 192,000 acres of land disturbed by surface mining; to this should be added the 411,000 acres for a total of somewhat more than 603,000 acres which have been disturbed or isolated. Similar conditions prevail, to varying degrees, in at least four other Appalachian States.

In addition to the disturbed areas given in table 1, it is estimated from topographic maps that an additional 700,000 acres of land are left isolated by highwalls, or a total of 1.5 million acres seriously affected by surface mining in Appalachia.

The problems associated with strip and surface mining—acid pollution, sedimentation, siltation, destruction of aesthetic values, etc.—are not new. Relatively few action programs for the alleviation of problems have been undertaken and, except for revegetation of mine spoils in some areas, those undertaken have seldom reclaimed the land (fig. 7). Coal is a valuable mineral, and in mining States it is a significant and essential part of the economy; however, the public is becoming better informed and highly conscious of the need for insuring that utilization of one natural resource shall not result in permanent destruction of or damage to others (U.S. Forest Service, 1962).

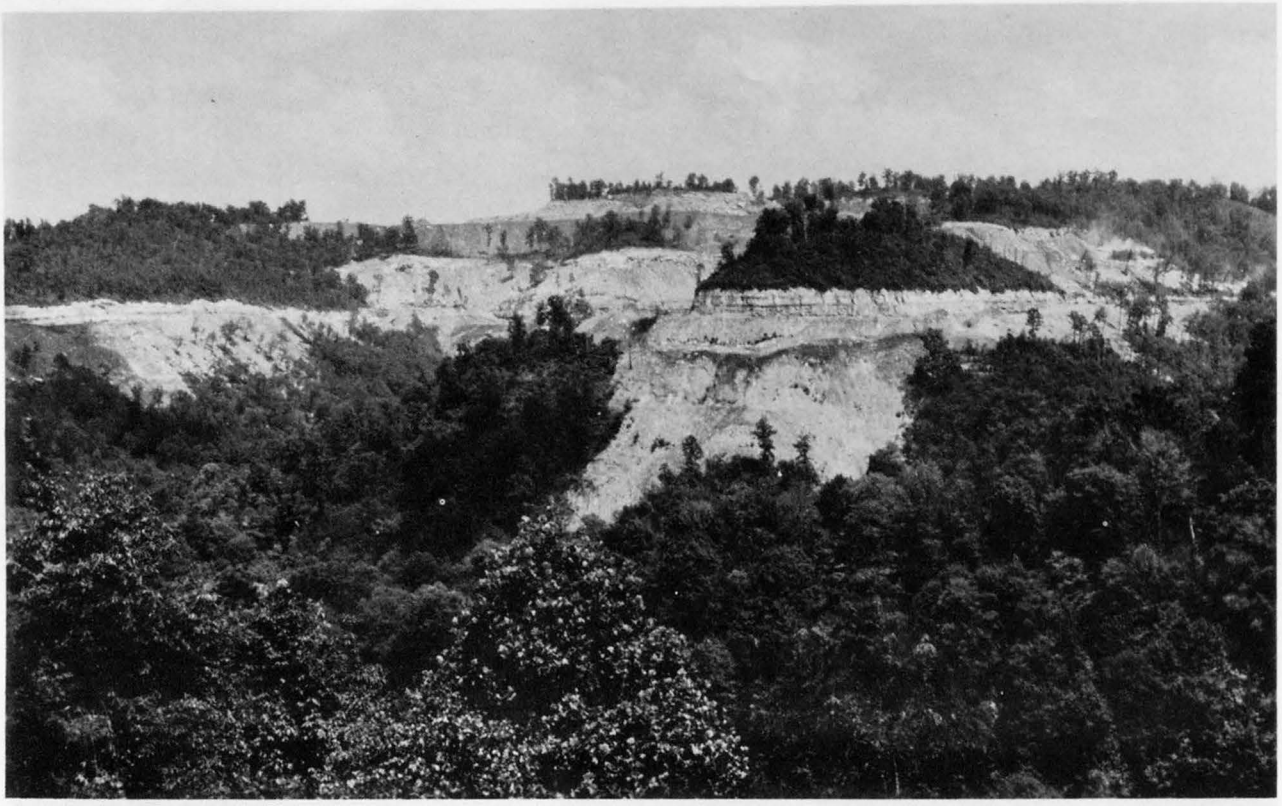


Figure 3.—Multiple contour stripping in northeastern Bell County in Kentucky. Note slides from overloaded spoil banks.

EFFECTS OF STRIP AND SURFACE MINING ON FISH AND WILDLIFE

Strip and surface mining in the Appalachian region is, in most instances, detrimental to both fish and game resources. During active mining there is complete destruction of terrestrial and aquatic habitats at the mining site, and offsite damages can be far reaching. In Appalachia, seven States reported that waters have been polluted by acid mine wastes—see table 2. This table does not separate the sources of acid drainage, but States reported that 10 to 25 percent of this pollution originates in strip mines. Many investigations have been made to document the seriousness of acid pollution, siltation, and sedimentation that result from surface mining. It is perhaps appropriate to summarize the effects of these pollutants on fish and wildlife populations.

Acid pollution

Mine drainage is rendered acid by chemical and possibly biochemical reactions involving water, oxygen, and sulphur in pyrite, marcasite, and other minerals and ores commonly found with coal deposits (Sido and Mackenthun, 1963).

Acids change the water quality of streams into which they are discharged, affecting fish and wildlife in several ways. The acids may be present in such concentrations as to be directly lethal; they may be harmful because of anions of high toxicity, or have marked toxic properties as dissociated molecules; and they may bring about changes in condition of existence and rate of growth of fishes

Table 2.—*Potential fish and wildlife waters deleteriously affected by acid mine pollution*

[Adapted from Kinney, 1964]

State	Miles of stream	Acres of impoundments	Minerals mined
Pennsylvania	2,906	10,100	Coal.
West Virginia	1,150	3,533	Coal.
Kentucky	580	.....	Coal.
Ohio	278	192	Coal.
Tennessee	125	.....	Coal, copper, phosphorus,
Maryland	83	.....	Coal.
Virginia	10	.....	Copper, zinc.
Total	5,132	13,825	4

Figure 4.—Area mining in Pennsylvania. Spoil banks lie in rows parallel with the last cut in the background. (USDA–SCS photo)

(Jones, 1964; Turner, 1958). Acids also depress or prevent reproduction of desirable sport fishes.

The desirable pH range for fish in the Appalachian region is 6.7 (slightly acid) to 8.6 (alkaline) (U.S. Dept. Interior, 1965). Although fish can live for a short time at a pH of 4.5 (very acid) a pH lower than 6 is unfavorable. Lloyd and Jordan (1964) reported that rainbow trout died at a pH of 4.18 in soft water. Jones (1964) found that trout eggs developed normally between pH 4 and pH 5, but eggs died at levels below pH 4. Other authors have reported failure of fish reproduction in waters having pH values below 5.5.

In addition to undesirable acid and pH in effluents from strip mines, iron hydroxide is precipitated when these waters enter streams. Iron hydroxide or "yellow boy" is only slightly soluble in water; it coats stream bottoms, destroying natural beauty and the habitat suitable for aquatic life (Cordone and Kelly, 1961; Warner, 1965). Acid pollution of a stream may also have effects not generally recognized. If water is too acid, it cannot be used for household purposes, livestock watering, or industrial use, without expensive treatment. Wildlife, unwilling to drink acid water, is usually absent near badly polluted areas. Iron hydroxide deposits in stream channels and lack of desirable fish and wildlife in or near acid streams result in decreased land value (Parsons, 1952).

Silt and sediment

The effects of silt and sediment on aquatic flora and fauna vary with concentrations of pollutants,

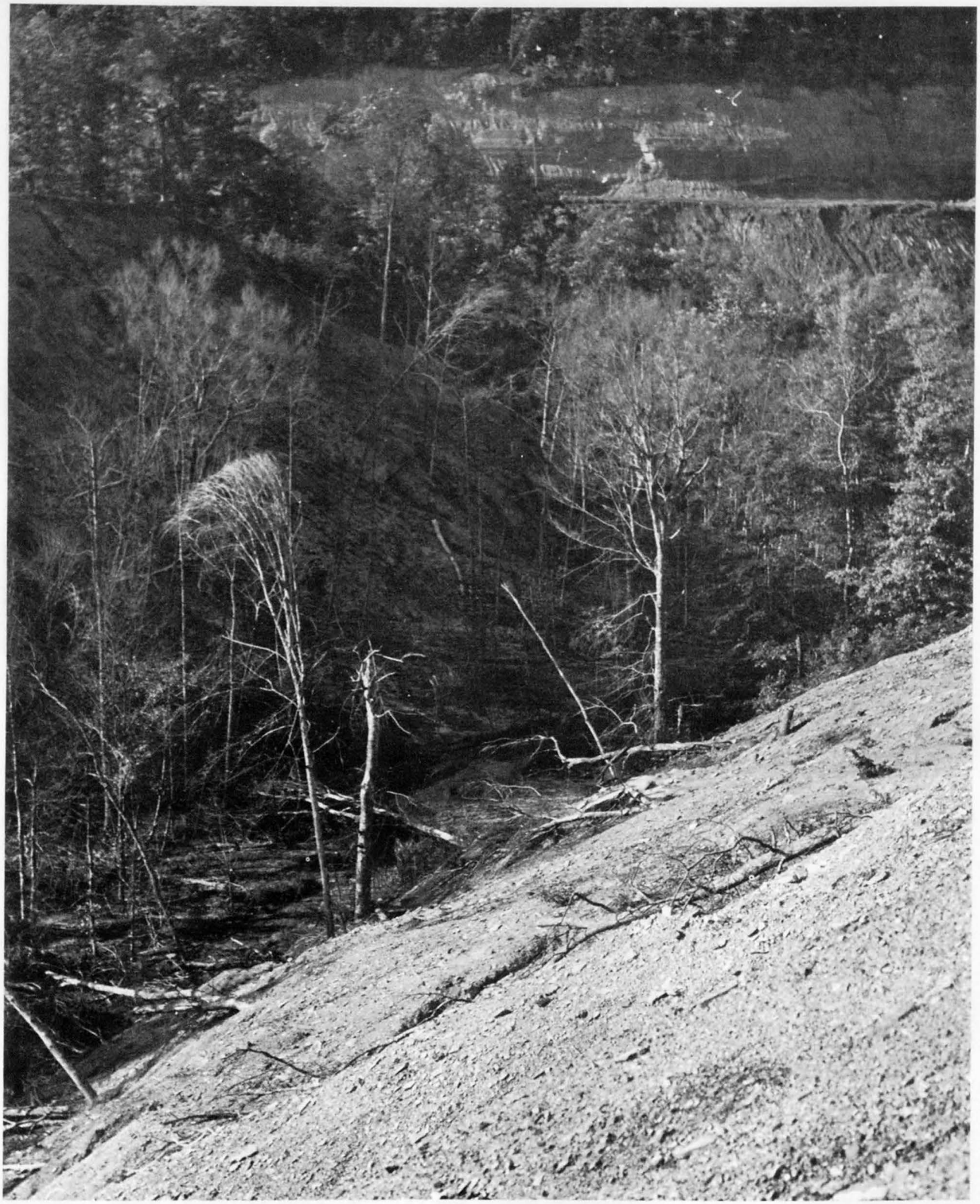


Figure 5.—An active mine on the Hickory Creek Watershed, Campbell County, Tennessee. Acid sediment and silt originating on this mine are measurable miles from the mining area.

Figure 6.—Access to more than 400,000 acres of wildlife habitat is impaired by highwalls in West Virginia. This unscalable highwall is in Randolph County.

and with species affected. Silt results from mining, gravel and coal washeries, limestone sawmills and crushers, and erosion. Fine silt may stay in suspension; larger particles drop, blanketing the stream bottom and smothering desirable aquatic life. Silt and sediment may reduce light transmittance, alter temperature gradients, absorb organic materials and other substances, and cause further deposition (Parsons, 1952; Sido and Mackenthun, 1963).

Food, cover, and access

Contour mining has a deleterious effect on game populations. When large areas of formerly productive lands are denuded, scalped, and pitted, and resultant mine spoils are deposited over additional acreage, the disturbed areas are unproductive until revegetated, usually after mining is completed. On spoil banks in areas of steep terrain, revegetation is very slow. Raw earth is a common sight on old workings where new earth slippage has destroyed ground cover. In general, only the pit, haulage area, and the inner slope of the spoil are planted. At least an equal acreage is left to natural revegetation.

Some mitigation of the destructive features of surface mining will result from increased access, from changes in total cover type, and from replanting with desirable trees and shrubs that produce food and cover for wildlife. Lack of access to many thousands of acres, cut off by unscalable highwalls circumscribing the hills (fig. 8), will reduce the total area available for outdoor recreation. This type of loss occurs in eastern Kentucky, Tennessee, western Virginia, Maryland, and West Virginia.

Figure 7.—New growth on a 4-year-old shortleaf pine plantation on a strip mine area in McCreary County, Kentucky. (USDA–SCS photo)

ESTHETICS

Destroyed beauty is the primary reason for the pressures throughout Appalachia to correct the problems associated with strip mines. Disturbance of land and water by surface mining was accepted in the name of payrolls and progress. As destruction and pollution from strip mines spread, public awareness and concern increased. Many people could no longer accept what had been done to nature, for a raped and gutted hillside is not a thing of beauty. The drive to clean up and repair began in many areas. Attempts at improvement in appearance alone helped quiet public reaction, even though it did not correct the pollution or make the land usable.

In lowland regions with rolling hills, strip mine disturbances are usually less severe and can be corrected. In the mountainous Appalachia, however, damage is greater and repair more difficult. It is in these areas that long-lasting effects of surface disturbances are greatest: complete mountainsides denuded and covered by mine spoil from multiple stripping; miles of streams destroyed by silt and sediment; and natural beauty destroyed (fig. 9). This is wholesale destruction which dulls the senses of anyone forced to live in the area and assaults the senses of persons passing through.

The problem that must be solved is to allow recovery of a natural resource without destruction of other renewable resources and to provide for the repair and replacement of damaged lands coincident with the recovery process. Cordone and Kelly (1961) have aptly stated that—

> More than anything else we need to develop a philosophy of land husbandry that will avoid the creation of untreated and running sores of the earth's surface. Man must acquire a responsibility to future generations that matches the power he has gained through the development of heavy machinery.

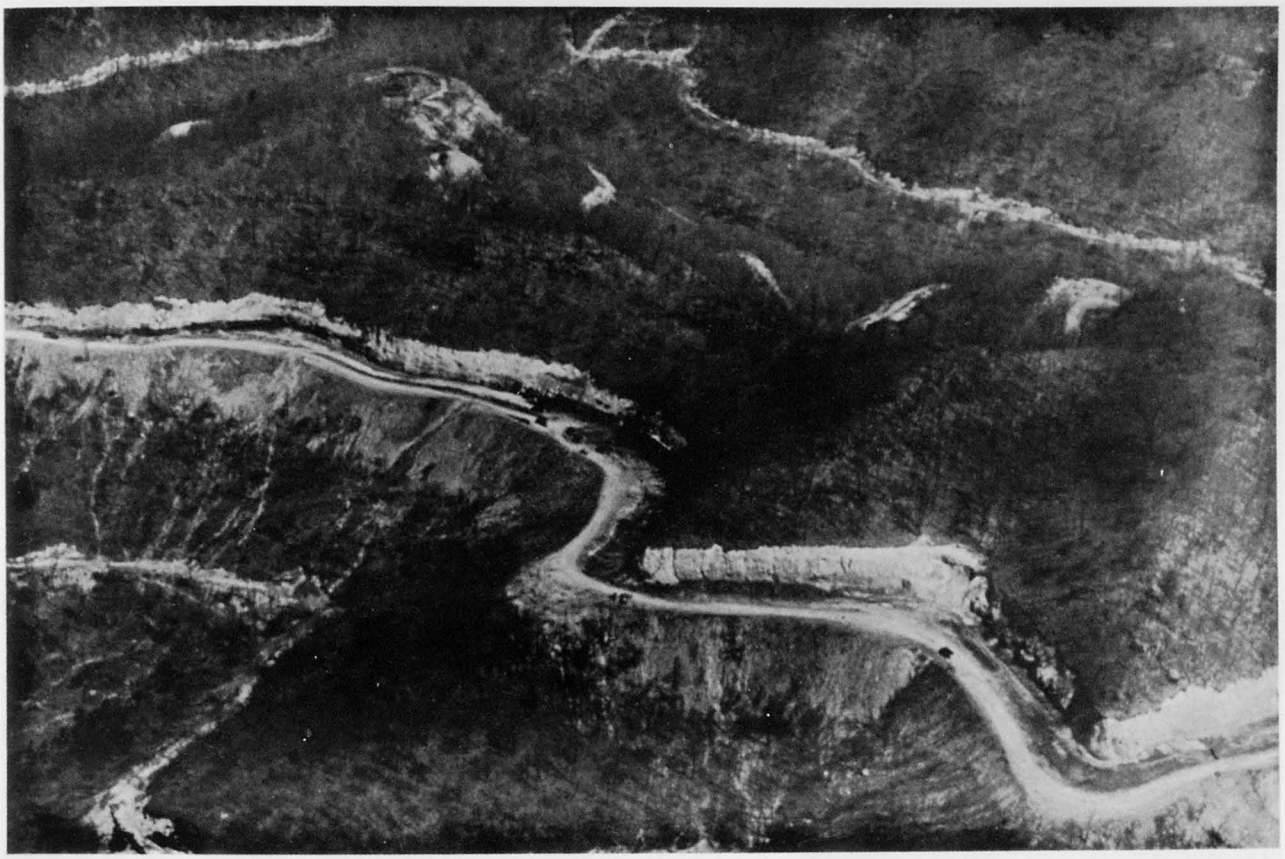


Figure 8.—An indication of how land is isolated by inaccessible highwalls circumscribing hills. (USDI–BM photo)

Existing Conditions by States

The following sections deal with the conditions existing in each of the eight Appalachian States. The effects of surface mining on fish and game resources, current restoration programs, and measures necessary to protect and improve conditions for fish and wildlife are discussed.

ALABAMA

Existing conditions

Strip and surface mining in Alabama has not been fully developed. Current surface disturbance, for coal and iron ore, is estimated to exceed 50,600 acres. This is less than 1 percent of the mineral acreage accessible to surface mining for these minerals.

Alabama authorities do not consider strip and surface mining a problem at this time, and the legislature has not enacted regulatory legislation requiring reclamation. Unless regulated, further exploitation of minerals may create adverse conditions of an appreciable magnitude.

Importance of strip and surface mining to fish and wildlife resources

Inspection of selected iron and coal mining areas by the Field Appraisal Team during March 1966 disclosed that recognizable damage to fish and wildlife resources has occurred. Although in Alabama only small amounts of acidic material are associated with coal and iron deposits, there is some acid pollution of stream systems. The Alabama Water Improvement Commission reported in 1949 that only one small stream (in Walker County) was affected by acid mine drainage. The Alabama Geological Survey now reports that at least five streams are affected by this pollutant.

Figure 9.—A panorama of destruction. (USDI–BM photo)

The denuding of 50,600 acres of land and their subsequent reforestation as single-purpose forest production units has eliminated some desirable wildlife habitat. Reduction of wildlife populations will probably occur with additional mining.

To avoid destruction of fish and wildlife habitats by surface mining, particular attention should be given to measures designed to maintain water quality, by controlling acid wastes, by preventing silt and sediment pollution, and by revegetating the mined areas to meet a variety of planned uses. Benefits rather than losses should then result to fish and wildlife.

Accomplishment in restoration programs

Lacking legislative rules and regulations, reclamation of disturbed areas has been very limited in Alabama. Reforestation for forest products production apparently is the major reclamation objective. In all areas visited by the Field Appraisal Team, this type of reclamation has not adequately compensated for adverse effects on fish and wildlife resulting from mining.

The conditions resulting from strip and surface mining in Alabama point to a need for adequate State legislation that will protect other natural resources. The potential disturbance of over two million acres indicates widespread reduction of fish and game habitat unless adequate safeguards are provided.

KENTUCKY

Existing conditions

Strip and surface mining has expanded rapidly in eastern Kentucy during the past 15 years; estimates made from aerial photographs and on-the-ground inspections indicate more than 48,000 acres of strip-mined lands in eastern Kentucky. Personnel of the State Division of Reclamation estimate that 4,000 new acres are disturbed each year.

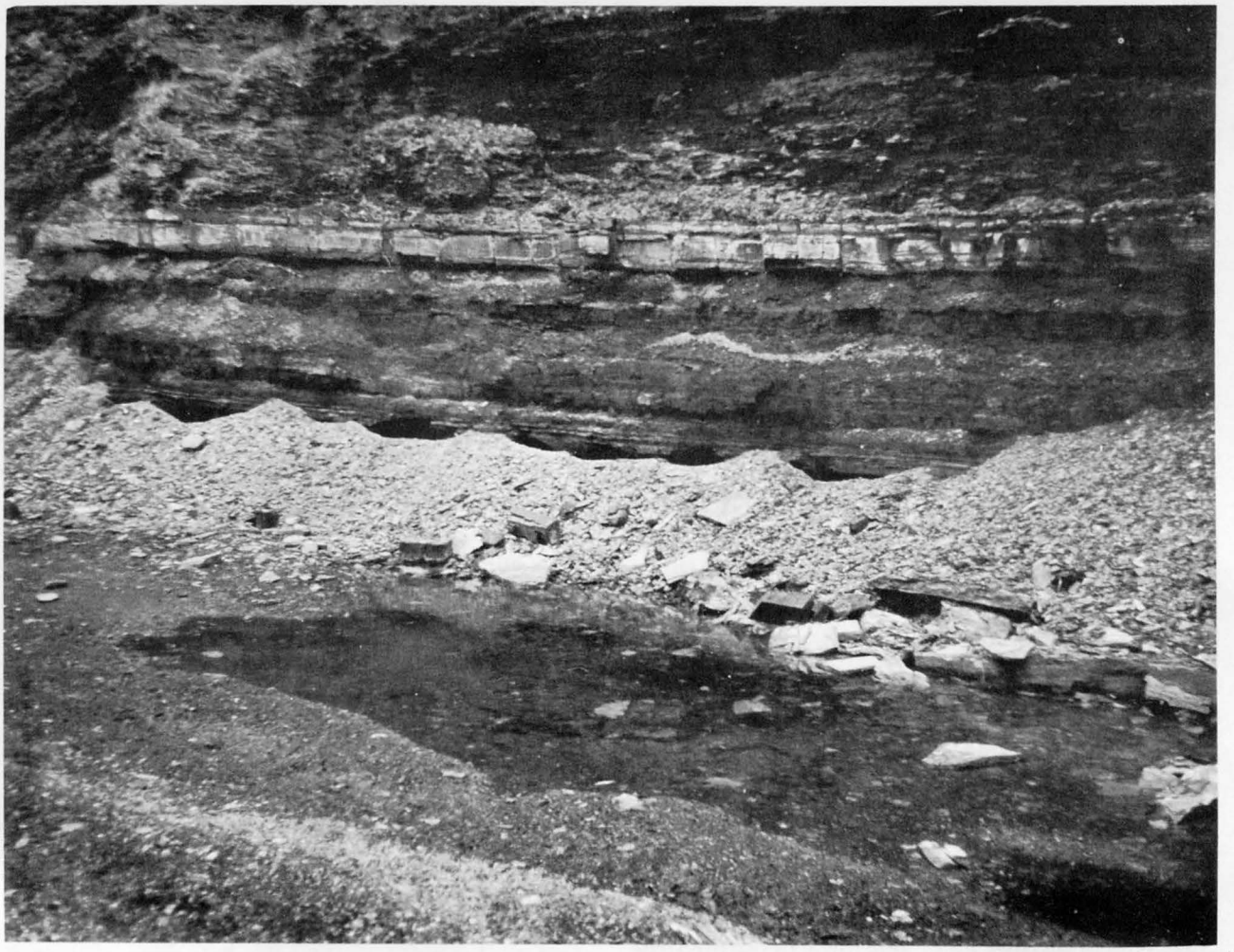


Figure 10.—Evidence of auger-mining in exposed coal seam is readily visible after 20 years of natural slumpage, Randolph County, West Virginia.

In the mountains of eastern Kentucky, coal seams are generally found at the upper levels of the hills, rather like the meat in a sandwich. Strip miners in this area characteristically bulldoze a "haul road" up to the seam and carve a long, broad "bench" at the level of the seam. The coal is stripped from the exposed seam. Overburden and coal often have to be blasted loose. In past mining, much of the dirt, stone, and debris dug out by power shovel from the face of the hill cascaded down the hillside. The development of rotary drilling equipment, better explosives, and excavators has contributed to the increased scale and efficiency of such contour stripping operations (Walsh, 1965).

Pollution of streams by acid, silt, and sediment and massive erosion are a direct result of surface mining. Thousands of acres of land have been buried under constantly moving spoil, and additional acres have been cut off from use by wildlife by continuous unbroken highwalls. These highwalls, unscalable by man and beast, are characteristic of many mountainous areas being mined.

Reclamation laws originated in 1954 and were amended in 1956, 1960, 1962, 1964, 1965, and 1966. Prior to surface mining for coal, operators must obtain a permit and post a bond, which is subject to forfeiture if reclamation does not meet State specifications. They must report on reclamation progress which requires grading and planting of disturbed areas.

Importance of strip and surface mining to fish and wildlife resources

Onsite and offsite effects of strip mining have been harmful to both wildlife and fish populations

endemic to the coal fields. The Kentucky Department of Fish and Wildlife Resources reports that about 580 miles of fishable streams and rivers in Kentucky are harmed by mine acid drainage (Kinney, 1964). State estimates show that at least 25 percent of these, or 145 miles, are harmed by strip mining (Walsh, 1965). In addition there are thousands of miles of small headwater tributaries and main streams in which numbers of fish and their foods are suppressed or greatly reduced as the result of sedimentation, siltation, or sublethal amounts of acid water entering drainages directly from surface mining operations. It is generally agreed that most mine acid comes from deep mines, but surface drainage enters these mines from surface disturbed strip-mined lands. Every strip-mined area visited by the Field Appraisal Team in Kentucky had exposed acidic material or acid-polluted water somewhere on the strip.

The detrimental effects of turbidity and siltation on aquatic organisms were evident in all permanent streams visited by the Appraisal Team. Although adult fishes can withstand large amounts of sediment, their eggs and fry can be destroyed by small amounts.

Before mining began, the eastern coal fields were largely timbered with second and third growth hardwoods in unbroken stands. Huntable populations of squirrel, ruffed grouse, rabbit, raccoon, turkey, white-tailed deer, and dove frequented the area. At least a 25-percent reduction in wildlife has occurred in mined areas. Large tracts of forest have been despoiled by surface mining and construction of haul roads. Den trees, food, cover, and territorial ranges have been greatly reduced if not eliminated. Fish and wildlife resources which have been historically important in the State of Kentucky are rapidly disappearing in mining areas.

Accomplishment in restoration programs

Reclamation programs until recently have been directed at restoring surface conditions. In December 1965, new State legislation was passed. This increases bond requirements, regulates the width of bench allowable by degree of slope, and specifies the type of surface restoration by degree of slope. It also regulates, by other basic instructions, the handling of toxic materials, construction of haul roads, and methods of revegetation.

MARYLAND

Existing conditions

Strip mining in Maryland is restricted to Allegany and Garrett Counties in the western part of the State. This area is mountainous, confining surface mining to contour stripping methods. None of the mines are large; most are 10 to 100 acres and are worked with small equipment, principally bulldozers, shovels, and draglines with buckets holding less than 18 cubic yards. Strip mine operations have increased land erosion and have polluted streams with acid, silt, and sediment.

The problem of strip and surface mining in Maryland is confined to a small part of the State. At present only 2,200 acres, less than 1 percent of Maryland's total area, have been disturbed. An additional 400 acres of new mining occurs each year, and this is not expected to increase substantially. The coal mining region of Maryland, like that of neighboring Pennsylvania and West Virginia, is predominately underlain with shale and sandstone. Since only minor amounts of limestone occur, there is little buffering ability to neutralize acid.

It is estimated that 115 miles of fishable streams, with 500 surface acres of water, are polluted to a moderate or severe degree (Reppert, 1964). The extent to which strip mining contributes to this pollution has not been determined, but it is thought to be a substantial portion of the total acid load carried by Maryland's waters.

Maryland law requires that all surface mine operators post a minimum bond of $2,000 per tract, or $500 per acre, based on the number of acres of coal expected to be mined. The reclamation law requires back filling over the coal seam to a depth of 3 feet and a surface slope of not over 45 degrees. This must be accomplished at the conclusion of mining or use of the pit area as a haul road.

Importance of strip and surface mining to fish and wildlife resources

From visits to selected areas in the coal mining region of Maryland, the Field Appraisal Team concluded that there has been a general decline in fish and wildlife habitat on the stripped areas. Evidence of acid mine drainage was observed throughout the tour. There were few instances of onsite effects, but there were many indications of offsite pollution. A large percentage of pollution

observed occurred directly from deep mine drainage with an unknown contribution to this discharge from surface mining. As is the case in other coal producing areas, the two types of pollution cannot be readily separated. Conservative calculations indicate that the absence of a productive fishery in the acid-polluted streams of Garrett and Allegany Counties represents a loss of more than $100,000 a year to the economy of the two counties (Reppert, 1964). With increased attention to acid pollution problems associated with strip mine reclamation and proper planning, benefits rather than losses should result.

Accomplishment in restoration programs

Maryland law does not recognize mine acid as an industrial pollutant; therefore, water quality control is not considered a primary objective in reclamation, which consists in limited earth moving to achieve minimal coverage of exposed minerals. Sloping to the highwall may increase surface drainage into the deep mines with a resultant increase in acid water discharge. It is apparent that until the discharge of acid water is identified by law as a pollutant and water quality control is recognized as the major problem, damage to the aquatic environment will continue.

OHIO

Existing conditions

The topography and geology of the coal producing region of Ohio make area strip mining possible. Limited contour stripping is practiced in the hilly southeastern section of the State. Limestone deposits are associated with most of the overburden found with the coal measures in the region, and these deposits effectively buffer most of the acid drainage waters associated with surface mining. Acid pollution has affected 392 miles of streams in Ohio (Kinney, 1964), however, no distinction is made between surface and deep mining in this report.

Strip mining in Ohio has affected 179,256 acres, of which 137,503 have been reclaimed according to State law. This law requires that all new strip mines (an estimated 10,000 acres annually) shall be reclaimed to the following minimal requirements:

1. Spoil piles will be graded to flattened top surface of not under 20 feet in width.

2. Slopes shall be short and not exceed an angle of 45 degrees.

3. Long uninterrupted slopes shall be terraced to minimize erosion.

4. Earth dams will be constructed, where feasible or practical, in the last cut of an operation. When ponding is not feasible other procedures are required in grading to control water pollution. Consideration of inundation of all acidic materials is included in this regulation (Section 1513.04, Administrative Regulations, Revised Code of Ohio).

Importance of strip and surface mining to fish and wildlife resources

Strip mining in Ohio has destroyed considerable fish and wildlife habitat during the active operations, but favorable topography and reclamation methods have created or improved hunting and fishing opportunities in many mined areas.

There has been an increase in fishable water in Ohio as a direct result of surface mining. Approximately 690 acres of these impoundments, ranging in size from 0.5 to 50 acres (average 31 acres), are managed for public fishing by the Ohio Department of Natural Resources on lands mined by the Ohio Power Company. It was estimated from the number of permits issued and from spot checks by company personnel that these areas provide more than that 10,000 man-days of fishing per year (14 man-days per acre). An estimated 100 small ponds, ranging from 0.25 to 15 acres, have been created as the result of surface mining on Wayne National Forest, Lawrence County, Ohio. These areas were devoid of impoundments before mining operations.

Wildlife of interest to the hunter has benefited from reclamation of strip-mined lands through the development of habitat conditions, sometimes better than those formerly found on the area. Other strip-mined areas are being reclaimed for agricultural or forest crop production, and these areas may not support the game species and numbers that they did before mining.

Accomplishment in restoration programs

Under present regulations, Ohio strip mine reclamation meets minimal requirements to improve and protect the fish and wildlife resources in most areas of the State. Recovery of water quality is aided largely by limestone formations in the coal

producing region. Reclamation for water quality control on a watershed basis could result in physical and biological conditions equal to, or better than, those that existed before mining.

PENNSYLVANIA

Existing conditions

Strip and surface mining for coal in Pennsylvania includes both the anthracite and the bituminous coal fields. Frank (1964) estimated that 112,000 acres of surface disturbances from mining existed in the 487-square-mile anthracite coal field. The total disturbance in the bituminous coal region is over 300,000 acres.

Essentially there are two problems in strip mining operations in Pennsylvania: (1) Acid and sediment resulting from mining pollutes streams and ponds; and (2) increased water production from deep mines occurs as a result of directing surface drainage underground. Pennsylvania has in excess of 2,900 miles of acid-destroyed streams. This total does not include hundreds of miles of small headwater streams considered to have little fishery potential (Kinney, 1964). In addition to acid pollution, large amounts of suspended silt and sediment adversely affect fish and other aquatic life.

In 1965 Pennsylvania enacted strong laws for the regulation of strip mining. All new, or reworked old, stripped areas must be restored to contour, and acidic materials must be separated and buried under clean fill material. Mined areas must be graded to achieve adequate drainage. The Pennsylvania law has all the elements needed for a successful reclamation program.

These active strip mine reclamation programs are currently in progress: (1) Joint Federal-Commonwealth projects, cost shared on a 50-percent basis, and (2) Commonwealth of Pennsylvania projects. To date, 84 strip mine reclamation projects have been completed under both programs. The cost of reclaiming such areas varies tremendously from project to project. Straight backfilling of abandoned strip pits generated a range of per acre costs of $43.50 to $2,375 in Luzerne and Lackawanna Counties. The average cost per acre for 1,490.2 acres reclaimed under the State program was $424, whereas the average cost per acre for the joint Federal-State projects was $744. It is possible that the higher average cost may reflect costs for items other than backfilling, such as depth of pit, accessibility, etc.

Importance of strip and surface mining to fish and wildlife resources

Most of Pennsylvania's strip mining areas were forested. It is estimated that 80 percent of the deer and 95 percent of the bear killed by hunters are harvested in the bituminous coal region. The Field Appraisal Team concluded that wildlife populations have declined at least 15 percent in unreclaimed strip mine areas in Pennsylvania. Squirrel and turkey ranges have been destroyed through the loss of den and mast trees and through changes from open-stand hardwood forests to densely mixed species. On reclaimed areas some small-game populations such as the cottontail rabbit, snowshoe hare, and ruffed grouse have increased through creation of openings and vegetative diversification which followed the disruption of solid even-aged stands of hardwoods.

Acid, silt, and sediment pollution of 2,906 miles of streams in Pennsylvania has destroyed an extremely valuable fishery resource. A third of the Nation's population resides within 200 miles of Pennsylvania's coal fields. With the increase in leisure time and the improvement of highway systems, a large percentage of this population would utilize the fish and wildlife resources in the area (ORRRC Study Report 7, 1962).

Accomplishment in restoration programs

Pennsylvania's legislation governing strip mine reclamation is the strictest in the Nation. Reclamation has been directed toward restoring the surface contours and revegetating the land. Much effort went into grading and backfilling. Section 5, Article 700, Rules and Regulations of the State's Sanitary Water Board, states that in order to protect the waters of the Commonwealth from pollution all acid forming materials disturbed during each cut of the operation shall be buried in the pit under an impervious layer of clean fill (Pennsylvania Amendment Article 700, 1965).

Enforcement of the present State law with full recognition of the significance of water quality control on a watershed basis is tantamount to successful reclamation of strip-mined areas.

TENNESSEE

Existing conditions

Tennessee has over 25,000 acres of strip-mined coal land in 16 counties. This acreage increases annually by approximately 8,500 acres. Only 2,000

of these acres have been reclaimed by private and Federal agencies. With the exception of the Tennessee Valley Authority, which included grading and pond construction in its reclamation projects, most reclamation has been single-purpose planting for future timber production.

Tennessee now has strip mine legislation; also, the Tennessee Valley Authority requires strip mine reclamation as a part of all new coal contracts.

In areas visited by the Field Appraisal Team most water found in the vicinity of the mines was acid. It was reported by TVA (Elmore. 1961) that "It can be stated confidently that the acid mine drainage of this region will not develop into a pollution problem of major proportion," because of the occurrence of calcareous material (limestone and dolomite) in the overburden of much of the Tennessee Valley. It should be noted, however, that whenever total acid loads in a water system exceed the buffering capacity of that system, deleterious acid conditions can result.

Importance of strip and surface mining to fish and wildlife resources

The Game and Fish Commission reports that fish habitat in over 125 miles of stream has been destroyed. These streams formerly contained an abundance of smallmouth bass and muskelunge (Parsons, 1952). Additional miles of stream have been degraded by large amounts of silt and sediment which blanket the bottom and smother desirable aquatic organisms. With additional mining these forms of pollution will increase, and their effects will become more evident.

Desirable wildlife habitat has been reduced in mining areas. Isolated hilltops of little value to wildlife or hunters are created by unscalable highwalls. Where toxic spoil conditions have resulted from mining, use by wildlife is limited. Burial of toxic spoil material can create good habitat for wildlife.

Accomplishment in restoration programs

Voluntary reclamation of mined lands in Tennessee has been very limited. The strip mine problem is manifested in many ways: acid water discharge; loss in beauty; sedimentation; siltation; unstable terrain; and unusable land. Recently passed legislation should help remedy these conditions.

VIRGINIA

Existing conditions

In Virginia, strip and surface mining for coal and manganese is in nine southwestern counties, where 30,000 acres of land have been disturbed. Of these, all but 1,000 acres are confined to coal extraction; the 1,000 acres of manganese mining are principally in Smythe County, where 500 acres have been mined in the Jefferson National Forest. The State has recently enacted legislation on strip mining.

Serious erosion and siltation were found at all surface mining areas visited by the Field Appraisal Team. Although acid pollution has not been reported as a problem in Virginia (Kinney, 1964), acid water and acidic materials were found on most areas inspected.

Importance of strip and surface mining to fish and wildlife resources

To date, fish and game resources in Virginia have not been severely affected by surface mining. This can be accounted for by the abundance of calcareous subsurface material and the relatively small amount of disturbance by mining.

Vegetative growth on mined lands generally exceeds that of unmined areas. Strip mining can be considered deep plowing by which minerals are made available to plants for additional growth. Wildlife food and cover result rapidly on mined lands in most areas in this State.

Major stream systems in the mining regions of Virginia have not been adversely affected by acid pollution. All major stream systems effectively neutralize mine acid but neutralization makes "hard" water and increases iron precipitate. Although these effects have not yet had an adverse effect on fishing they are danger signals. Extreme hardness associated with neutralized acid mine water can be as harmful to aquatic life as the acid itself.

An additional hazard to fishery resources is the lessening of stream flows. Many miles of stream are now intermittent in flow, as a direct result surface mining (Martin, personal communication, 1966). A State hatchery located on a drainage in the manganese mining area was closed because of offsite effects of mining.

Accomplishment in restoration programs

Restoration of strip-mined lands in Virginia was not required by law until 1966 and was not done unless specifically requested by the mineral owner or a public agency. When reclamation was undertaken, minimal wildlife habitat resulted. Adverse effects on aquatic habitats have been alleviated in areas of manganese mining where soil erosion has been controlled.

WEST VIRGINIA

Existing conditions

Strip mining, probably the earliest form of coal mining practiced in the State, has been an industry in West Virginia since 1916. In 1922 and 1923 this form of mining accounted for about 0.3 percent of the total coal production in the State. It rose steadily until 1947, when a production of 21,937,542 tons amounted to 12.5 percent of the coal mined in the State. Recent production has fluctuated, but it normally amounts to 6,000,000 tons for regular stripping and 3,000,000 tons for augering, or approximately 8 percent of the total State production (Gillespie, 1964).

Numerous estimates have been made in the last 20 years of the amount of land affected by strip mining in West Virginia. The passage of legislation in 1945, 1958, and 1963, with amendments in 1964, established regulations which required mining permits, bonds, and reclamation procedures. The 1963 amendment (substitute for House Bill 296) to State strip mine regulations provides for the industry assessment of $30 per acre for all new strip mining operations. These monies were to finance the reclamation of an estimated 30,000 acres of unreclaimed lands not covered by earlier stripping regulations. This amendment made it imperative that a reliable estimate of disturbed lands be obtained.

Dr. William H. Gillespie, West Virginia University, contracted to design and carry out such an inventory. The survey, completed in 1963, located 4,689 miles of strip mines on 71 quadrangles in 37 counties. These mines represent an estimated disturbed acreage totalling 192,000 acres which Dr. Gillespie reduced to 179,172 acres as a conservative estimate. He further reported in September 1965 that strip mining has disturbed in excess of 5.2 percent of the 5,390 square miles of area overlying the known coal reserves in West Virginia. If strip mining should ultimately affect four times the present acreage, a commonly quoted figure, it will involve 4.6 percent of the total area of the State, or 20.8 percent of the area in which the industry will be concentrated.

Table 3.—*Strip mines in West Virginia*

[As reported by Gillespie (1964)]

County	Number of stripped areas	Miles of strip mines	Acres distributed [1]	Acres isolated by highwalls [2]
Barbour	129	151	8,607	1,330
Boone	93	206	9,413	12,517
Braxton	13	19	451	1,815
Brooke	56	99	5,040	7,571
Clay	28	35	980	2,930
Fayette	245	526	14,728	51,136
Gilmer	25	32	1,080	13,014
Grant	23	14	550	1,421
Greenbrier	114	186	6,290	20,611
Hancock	15	9	302	411
Harrison	188	370	25,384	24,955
Kanawha	195	406	20,250	32,524
Lewis	180	174	9,918	11,306
Lincoln	5	3	61	258
Logan	37	181	4,140	18,984
McDowell	192	329	9,158	25,813
Marion	32	12	406	644
Mason	17	14	342	1,342
Mercer	29	174	4,872	13,894
Mineral	39	26	714	2,575
Mingo	92	255	6,462	18,825
Monongalia	140	125	4,974	4,150
Nicholas	128	217	6,048	27,524
Ohio	4	3	61	417
Pleasants	6	2	46	67
Pocahontas	9	21	1,014	2,342
Preston	322	235	10,664	14,056
Putnam	15	22	665	2,047
Raleigh	109	281	9,521	39,436
Randolph	73	114	3,774	13,118
Summers	1	2	45	115
Taylor	58	71	2,500	4,948
Tucker	36	57	1,879	7,554
Upshur	92	65	2,138	4,965
Wayne	3	2	37	184
Webster	44	59	1,310	12,266
Wyoming	102	192	5,348	13,718
Total	2,889	4,689	179,172	410,783

[1] Reflects a 15 percent decrease from measured acreage of strip mines by Gillespie to insure conservative data. Other reports show 192,000 acres disturbed.

[2] 1965 data.

Importance of strip and surface mining to fish and wildlife resources

Strip mining has been detrimental to fish and wildlife in West Virginia. Kinney (1964), reported that approximately 1,150 miles of potential fishing streams and 3,533 surface acres of reservoirs and ponds contained mine acid pollution. Acid water discharge results from both deep and surface mining of bituminous coal with an estimated 25 percent of this discharge resulting from strip mining.

Mountain tops are rendered inaccessible by unbroken 20- to 70-foot highwalls as stripping operations circumscribe the hills (Gillespie, 1964). A recent calculation plotted from topographic maps identified more than 411,000 acres of land in West Virginia that are essentially isolated to most ground-dwelling animals.

It is conceivable that certain rare and endangered fauna and flora indigenous to the State could be eliminated by continued strip mining. The Cheat Mountain salamander (*Plethoden nettingi*) is an example of a unique species found in restricted areas within the coal fields. (Collins, 1959).

Accomplishment in restoration programs

Reclamation in West Virginia, except for a few isolated cases, has been directed primarily toward reforestation. Tree planting has been primarily (an estimated 90 percent) black locust; however, sheet and gully erosion, siltation, and sedimentation were found associated with these plantings in many instances. Changes in revegetation practices must be initiated before stabilization of spoil is realized and detrimental effects of mining eliminated.

With minor changes in current reclamation practices, better enforcement powers, and establishment of water quality control as the main reclamation objective, most detrimental effects of active strip and surface mining operations could be eliminated. It will require higher bonding, preplanning, greater reclamation expenditures, and in some areas new techniques for coal extraction.

Most West Virginia streams have little to no buffering capacity, and small amounts of acid can destroy entire stream systems.

A large pollution problem exists in the abandoned mines of this State. Although deep mine discharge is commonly blamed for the bulk of acid pollution, as much as 75 percent of this water may have originated from surface mines (USPHS, unpublished report; Dierks et al., 1964). With more stringent laws and better enforcement, West Virginia could lessen the deleterious effects of surface mining and improve the fish and wildlife resources of the State.

Reclamation Accomplished

Appalachian States have differing legislation designed to correct problems which are direct results of surface mining. Reclamation measures are presently directed at segments of the total problem i.e., revegetation of spoil banks, control of erosion, and treatment of exposed highwalls, and various degrees of surface restoration. These efforts contribute, only in part to the primary objective, control of water quality.

The combination of iron- and sulphur-bearing materials with air and moisture creates many compounds, including sulphuric acid. If any one of the three components is missing, acid cannot be formed (Moulton, 1957; Pennsylvania Sanitary Water Board, 1965). This concept is recognized by legislation in most States. The laws and regulations state that exposed pyritic materials shall be covered with clean soil following mining. The depth they shall be buried varies considerably State by State.

Restoration of mined lands to contour requires the moving of spoil into pits and surface grading to near original conditions. No grades are left steeper than those originally found on the area, and no depressions are left that will accumulate water. This type of reclamation is most easily accomplished in areas of moderate relief such as found in parts of Pennsylvania and Ohio.

McKee and Wolf (1963) state that although a moderate amount of silt may have a beneficial effect on aquatic life by increasing the available amount of mineral nutrients, excessive quantities are deleterious to all desirable uses of water.

Erosion and silting hinder fish populations (Peters, 1962), smother food organisms, and destroy spawning areas and aquatic habitat (Bullard, 1962; Warner, 1960). Smith (1940) reported that silting reduced the bottom fauna of the Rogue River by 25 to 50 percent.

The effluents from coal washing operations are both directly and indirectly harmful to fish. Evidence has been advanced which indicates that silt particles cause abrasive injuries to delicate gill filaments of fishes and other aquatic fauna. Indirectly the absence of fish from waters receiving these effluents is due to lack of food. The suspended coal dust prevents light transmittance through the water, making plant photosynthesis impossible. Without plants there can be no invertebrates and without plants and invertebrates there can be no fish (Jones, 1964).

In hilly and mountainous areas, partial or terrace backfilling is used. Backfilling is accomplished so that no slope exceeds 45 degrees, but it may not be sloped away from the highwall, as specified in Pennsylvania's regulations (P.L. 1198, 1963). In many instances grading directs surface drainage into the highwall and is permissible under most State laws.

Five of the eight States visited in 1966 had regulations requiring exposed coal measures to be covered with earth as a reclamation requirement. Maryland requires the exposed face of coal measures to be covered to a depth of at least 3 ft. (Article 66C, Md. 1965). Coal seams exposed by augering in West Virginia, Kentucky, and Maryland were not covered as specified in regulations. Coal operators and reclamation officers felt that in time natural subsidence or slumpage from the highwalls would adequately cover exposed coal, although comparable areas are not generally covered by natural slumpage (fig. 10).

Water entrapment along the highwall, or construction of ponds and lakes in strip-mined areas, is allowed in only five of the six States having strip mine regulations. But such action is encouraged in Ohio which requires that earth dams be constructed in the last cut of an operation, for increasing available water and for control of floods, erosion, and pollution (Sec. 1513.6, Reg. No. 20, 1960).

Pond and lake construction is recognized as a reclamaiton method by West Virginia and Pennsylvania, but requires separate approval under present regulations. Considerable effort is made to discourage impoundment construction if the mine is located below drainage. Toxic waste or spoil materials are sorted and buried under an impervious layer of soil in Pennsylvania, Maryland, and Ohio, a relatively new regulation that requires strict onsite investigations to be effective. If pyritic or toxic materials are properly buried, no acid should be generated.

Methods used to revegetate mined lands differ among States and with reclamation purposes. Assortments of grasses and legumes are used for pasture; black locust, black alder, white pine, Scotch pine, aspen, and others are used for forest product plantings. Excluding areas of extreme toxicity, methods and species are available to vegetate most disturbed areas. Stabilization of spoil and sediment is generally adequate within 10 years of planting. In only a few isolated areas was immediate plant cover part of the reclamation plan, nor is it required under current strip mining regulations.

Water quality control as the primary objective of reclamation could result in adequate restoration to meet minimum fish and game requirements along with other water uses. Reclamation regulations of Ohio, West Virginia, Pennsylvania, and the Tennessee Valley Authority specifically mention water control; however, this basic approach has not been taken by any State until recently. Pennsylvania has passed legislation which does recognize water quality and sets standards for mine drainage. Grading, filling, and planting are separate facets of this concept and would be undertaken to fulfill this program.

EFFECTIVENESS OF RECLAMATION

Past attempts to restore surface mining disturbances have been concerned with minor facets of the reclamation effort. Mine reclamation is a watershed problem, and any restorative measures should be conducted under a watershed management plan. Past strip mine reclamation programs have made a piecemeal approach to the problem and have failed with the exception of those in which the goal was control of water quality.

Ohio was the only State that mentioned water quality in its statutes, but even there it is not the primary objective of reclamation. Recent legislative actions in Pennsylvania recognize the water quality concept, and rigid control on the discharge of mine pollutants will soon begin. Three other Appalachian States have reclamation laws, but basic objectives and provisions of these laws differ considerably in detail. Water quality has only recently been considered of major importance in remedial programs.

BENEFITS IN FISH AND WILDLIFE

Reclaimed strip mine areas have a large potential for fish and wildlife. Restored and revegetated strip mines, combined with impoundments, could provide hunting and fishing opportunities on thousands of acres. An indication of the fish and wildlife values which accrue from strip mine reclamation in Appalachia is found in table 4. These values reflect only the benefits observed by the Appraisal Team at selected reclamation projects and are derived by assigning monetary values to man-days of hunting or fishing per acre for the species which responded to the reclamation. Resulting tables would be higher if all reclaimed areas in a State were evaluated.

Benefits to fish and game from strip mine reclamation in most cases have been indirect, i.e., the projects were designed for other purposes. Had the project design stipulated reclamation for these resources, the benefits would likely have been much higher.

Reclamation which produced clean water would restore productivity to a significant portion of 6,000 miles of fishable streams and over 14,000 acres of lakes and impoundments. It would be possible in many watersheds to justify the cost of reclamation with benefits derived from fish and game. The economics of fish and game should be carefully weighed and included in all reclamation plans.

Unreclaimed strip mine lands, in most areas, have smaller fish and wildlife populations than they had before mining. Exceptions to this rule are in gently rolling terrain underlain with calcareous materials. Shallow water tables in these areas have produced ponds of good quality water, and newly exposed minerals have benefited plant growth.

Table 4.—*An indication of the economic values of reclamation (one-time values)*

State	Selected reclamation projects	Total acres	Estimated total wildlife value	Estimated total fishery value
Ohio	4	2,491	$18,250	$ 85,250
West Virginia	8	1,132	7,432	186,980
Pennsylvania	11	1,270	5,475	9,561
Kentucky	7	3,175	1,070	125
Total	30	8,068	32,227	281,916

Mining in these areas has resulted in improved wildlife habitat capable of supporting greater numbers and species than before.

Few Appalachian States have geologic formations which alleviate the deleterious effects of surface mining. Extensive deposits of calcareous materials aid in the neutralization of acid and promote plant growth on raw spoil. West Virginia, Pennsylvania, Maryland, and minor areas of other Appalachian States are underlain with noncalcareous materials which offer little buffering capacity to acid conditions, and exposure of acidic material produces conditions detrimental to biological communities. The reclamation of disturbed lands in these areas requires more intensive treatment (and is more expensive) than in States and regions with gently rolling topography and favorable geology.

Unreclaimed strip mines in most of Appalachia are poor fish and game habitat; their damaging effects are long lasting and not easily modified. Existing economic conditions in the Appalachian region vividly indicate the loss that will occur by exploitation of one resource without regard for others.

Recommendations

It is recommended that—

1. All strip mining should be controlled by adequate legislation which provides for wise use of all natural resources.

2. All reclamation should be preplanned to insure the primary objective of water quality control.

3. Prior to the extractive process, fish and wildlife must be fully considered and measures for their protection and enhancement included as an integral part of reclamation plans.

4. Other natural resources, particularly water, should be protected from deleterious effects attributable to the mineral extractive process.

5. All mined lands should be restored to a condition which will support their best use, and considering the natural beauty of the area.

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