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STRIP MINE RECLAMATION AND ECONOMIC ANALYSIS

DAVID B. BROOKS*

It was proved conclusively that the stripping had no near or substantial relationship to the public health, safety, morals or general welfare.

—Edwin R. Phelps¹

With strip mining and its companion, the auger-mining process, the shades of darkness moved close indeed to the Cumberlands.

—Harry M. Caudill²

It has almost become a cliché to describe strip mining for coal as “rape of the land.” Strip mining is a surface method in which large power shovels—some of them the largest in the world—“strip” off the soil and rock overlying coal beds, dump it to one side, and then load the underlying coal onto trucks.³ An extremely productive method of mining,⁴ it nevertheless evokes strong reactions because the unwanted soil and rock are turned into long, successive ridges of unsorted, ugly, and unproductive waste as “strip” after parallel “strip” of earth is mined. These man-made badlands extend over large areas, each ending in a deep pit, the last strip mined out, beside

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1. E. R. Phelps, *Current Practices of Strip Mining Coal*, in Proceedings of Symposium on Surface Mining Practices 8 (Univ. of Ariz. College of Mines 1960).

2. H. M. Caudill, *Night Comes to the Cumberlands* 305 (Atlantic-Little, Brown 1963).

3. The word “strip” is used both as a verb indicating the removal of overburden and as a noun describing the long, thin plan of the areas mined out in each stage of advance. Many discussions of strip mining are available: O. E. Kiessling, F. G. Tryon & L. Mann, *The Economics of Strip-Coal Mining* (Economic Paper No. 11, U.S. Bureau of Mines 1931); H. D. Graham, *The Economics of Strip Coal Mining* (Bull. No. 66, Bureau of Economic and Business Research, Univ. of Ill. 1948); University of Ariz. College of Mines, *Proceedings of Symposium on Surface Mining Practices* (1960), especially E. R. Phelps, *Current Practices of Strip Mining Coal*, *id.* at 1.

4. In 1962 the average productivity at bituminous coal and lignite strip mines in the United States was nearly 27 tons per man per day. The average at underground mines was 12 tons. The absolute difference between the two rates has been increasing. 2 U.S. Bureau of Mines, *Minerals Yearbook, Fuels* 71, 86 (1962) [hereinafter cited as *Minerals Yearbook, Fuels*].

which is a cliff called the highwall. With "area stripping," used in relatively flat terrain, the entire surface area is turned into giant washboards. With "contour stripping," used in mountainous areas, the strips resemble looped shoestrings as they follow the sinuous outcrop of a coal seam, leaving a gash of one hundred feet or so in the hillside. Finally, with "auger mining," a relatively new technique, drills as large as seven feet in diameter bore into a seam (often into a high-wall left by stripping) from the surface, leaving it perforated by a series of holes from which the coal has been removed.⁵ Any of these methods may cause extensive pollution and erosion damage downslope and downstream of the mine site unless the mine is carefully managed.⁶

Strip mining for coal in the United States will be one hundred years old in 1966, but during much of this time it was not an important method. Since the 1930's, however, strip mining has grown to account for one-half of all anthracite and nearly one-third of all bituminous coal and lignite mined in this country.⁷ It has recently been estimated that operating and abandoned strip pits now occupy 500,000 acres in the Appalachian and Midwest coal fields.⁸ Since the 1930's, coal strip mining has been attacked—and defended—in literally hundreds of emotional articles, speeches, and political

5. Minerals Yearbook, Fuels 98-101. See also W. A. Haley & J. J. Dowd, *The Use of Augers in Surface Mining of Bituminous Coal*, in Report of Investigations 5325 (U.S. Bureau of Mines 1957). The average productivity at auger mines in 1962 was about 35 tons per man per day; cf. note 4 *supra*.

6. Among the many descriptions of the effects of strip mining on landforms, watercourses, and land use, the following, which do not agree in all respects, were found particularly useful: G. S. Bergoffen, A Digest: Strip-Mine Reclamation (U.S. Forest Service 1962); C. R. Collier et al., Influences of Strip Mining on the Hydrologic Environment of Parts of Beaver Creek Basin, Kentucky, 1955-1959 (Professional Paper No. 427-B, U.S. Geological Survey 1964); G. F. Deasy & P. R. Griess, *Coal Strip Pits in the Northern Appalachian Landscape*, J. Geography, Feb. 1959, p. 72; A. Doerr & L. Guernsey, *Man as a Geomorphological Agent: The Example of Coal Mining*, Annals of the A. of American Geographers, June 1956, p. 197; L. Guernsey, *Strip Coal Mining: A Problem in Conservation*, J. Geography, April 1955, p. 174; G. A. Limstrom, *Forestation of Strip-Mined Land in the Central States* (Agricultural Handbook No. 166, Central States Forest Experiment Station 1960); Tenn. Dep't of Conservation and Commerce, *Conditions Resulting From Strip Mining for Coal in Tennessee* (1960); TVA, *An Appraisal of Coal Strip Mining* (1963).

7. Minerals Yearbook, Fuels 84-86, 172. A brief history of surface mining is presented by J. W. Feiss, *Surface Mining—Minerals, Men, and Divots*, Paper Delivered to the Conference on Surface Mining conducted by the Council of State Governments, Roanoke, Va., April 13, 1964, p. 6 (mimeo.).

8. TVA, *op. cit. supra* note 6, at 4. An estimate made five years ago concluded that, "on the average, some two acres of every square mile in the Northern Appalachian Coal Fields, and a slightly smaller acreage of every square mile in the Eastern Interior Coal Fields, consist of strip pits." Local concentrations are, of course, much higher. Deasy & Griess, *supra* note 6.

campaigns. During the same period scientific knowledge about the effects of strip mining has been developed from a variety of sources. Both science and emotion are represented in current opinion and in the body of legislation that regulates strip mining in the important producing states.⁹

As yet, however, little effort has been devoted to subjecting these questions to economic analysis.¹⁰ The purpose of this article is to indicate what economics has to say about coal strip mining and attendant efforts to protect other natural resources. More explicitly, I will argue that the private profit signals to which coal stripping firms must and should respond to maximize their profits are not adequate guides for maximizing social welfare. In many situations private market decisions can be relied upon to yield an approach to maximizing social welfare, but this is not the case whenever there is a divergence between private costs and social costs, like the situation presented here. The essence of the strip mining problem is that substantial costs resulting from the process of stripping are imposed on other individuals and are not reflected in the accounts of the coal mining firms.

It will be convenient to use the term "reclamation" to mean efforts devoted to controlling the use of land while it is being stripped as well as efforts devoted to bringing back to use land that was stripped in the past. The term "regulation" will refer to a legal enactment to accomplish one or both of these goals. In popular statements both reclamation and regulation are commonly called "conservation."

I

THE UNIQUENESS OF COAL STRIP MINING

Why has coal strip mining attracted more attention than other mineral commodities mined in open pits? The answer lies in a combination of reasons. First, coal strip pits are common in the wooded and agricultural areas of the populous eastern half of the country, not in the remote and semi-arid West. Second, compared with other non-metallic minerals mined in large quantities in the East, coal

9. In 1962 bituminous coal and lignite stripping was practiced in 22 states. However, six states—Illinois, Indiana, Kentucky, Ohio, Pennsylvania, and West Virginia—accounted for about 85% of the tonnage produced. These states and Maryland have laws regulating strip mining. R. G. Meiners, *Strip Mining Legislation*, 3 *Natural Resources J.* 442, 443 (1964).

10. Bergoffen, *op. cit. supra* note 6, at iii.

stripping requires the production of much larger amounts of waste.¹¹ Third, compared with open pit metal mines, coal strip pits are very short-lived. The coal is mined from an area within a year or a few years, while iron or copper pits often remain in existence for half a century or more. Fourth, coal mines (not only strip mines) present certain problems not common to other mines. Coal, both in place and in dumps, is inflammable. Some 220 fires are burning in underground seams today and about 500 more burn in waste piles.¹² Many coal seams also carry iron sulfide minerals that react with air and water to form sulfuric acid, thus producing the widespread acid mine drainage that is toxic to fish and vegetation and which causes extensive corrosion damage.¹³

Finally, there are factors that are less definable. Coal mining is a symbol of the industrial revolution and carries with it a congeries of impressions for some people: impersonality, monopoly capitalism, absentee ownership, etc. To these, stripping adds the following: wholesale and rapid change in land use; serious deterioration in a familiar landscape; and extensive stream and valley pollution. It has also been suggested that stripping offends most seriously not by creating ugliness per se, but by creating ugliness in areas where one least expects to find it.

Given this complex of issues—partly rational, partly mystical, but always strongly felt—it is more apparent why individuals with otherwise diverse interests—sportsmen, farmers, conservationists, and even underground miners—could unite in their opposition to strip mining.¹⁴ During the past several decades, therefore, strip mining has been generally and popularly regarded as an evil, mitigated

11. Typically the ratio of waste to coal is 12:1. The ratio of waste to usable product is much higher in low-grade metal mines, but the great bulk of the waste is not produced at the mine but at mills and smelters where it can more easily be handled. Feiss presents an outline comparing the physiographic effects of different mining methods; *op. cit. supra* note 7, at Fig. 1.

12. U.S. Dep't of the Interior, Annual Report of the Secretary for the Fiscal Year 397 (1962); R. W. Stahl, Survey of Burning Coal-Mine Refuse Banks 1 (Information Circ. No. 8209, U.S. Bureau of Mines 1964).

13. The following are useful introductions to the acid mine drainage problem: G. P. Hanna et al., *Acid Mine Drainage Research Potentialities*, 35 *J. Water Pollution Control Federation* 275 (1963); G. D. Beal, *Common Fallacies About Acid Mine Water* (Sanitary Water Bd., Pa. Dep't of Health 1953) (mimeo.); and any of the papers by S. A. Braley appearing in mining journals during the 1950's.

14. Indications of both open and hidden attacks by underground miners on the lower cost strippers can be found scattered through the mining literature. Rather more surprising is the fact that the TVA, once the delight of conservationists, is being cast by them in the villain's role for allegedly ignoring the effects of strip mining to purchase cheap coal for low-cost thermal power.

only in part in its high productivity. But this was not the only dilemma that it posed. Conservationists looked with disgust upon the resulting landscape, yet they had to admit that strip mining recovered a greater proportion of the coal than did underground mining.¹⁵ Agronomists emphasized the loss of arable land to strip pits, yet they had to admit that poor farming practices resulted in a far greater loss.¹⁶ Social scientists worried about effects of stripping on local communities, yet they had to admit that stripping not only provided much needed employment in coal towns but also had a far better safety record than underground mining.¹⁷

Thus, to most people any judgment of the social value of coal strip mining has always been a matter of balance. And it is just this kind of balancing, of choosing among alternatives when there are real and difficult conflicts, that economic analysis is designed to handle.¹⁸ Economic analysis does this by providing a *rational and operational* set of rules for determining whether the benefits from any action outweigh the costs. Moreover, in situations like strip mining, where private costs are not equal to social costs, *all* costs can, at least in principle, be incorporated so that the general goal of public policy, to maximize net social benefits, can be pursued.

The remainder of this paper is divided into three sections. The first is a review of how approaches to strip mine reclamation have changed during the past several decades. The second is a series of conclusions pertinent to economic analysis that I have drawn from the literature, from interviews, and from field observations. Then, in the third section tentative suggestions are made about the application of economic concepts to policy problems.

A final note before proceeding. The emphasis in this paper is on the effects of strip mining on natural resources. There is reason to think that the more immediate problems may relate to the people

15. Strip mines recover 90% or more of the coal in place whereas underground mines seldom recover more than 50%. This conflict is typified in an article by W. C. Bramble, *Strip Mining: Waste or Conservation?*, American Forest, June 1949, pp. 24-25.

16. See, e.g., H. R. Moore & R. C. Headington, *Agricultural Land Use as Affected by Strip Mining of Coal in Eastern Ohio* 34 (Bull. No. 135, Ohio State Univ. Agricultural Experiment Station 1940) (mimeo.).

17. In 1959 the accident frequency rates at underground bituminous mines were 1.02 fatal and 42.71 nonfatal accidents per million man-hours. The rates at strip mines were respectively 0.46 and 20.69. At auger mines the rates were 0 and 21.20. D. Drury, *The Accident Records in Coal Mines of the United States 96-97* (Dep't of Economics, Univ. of Ind. 1964).

18. P. A. Samuelson, *Economics: An Introductory Analysis* 1-7 (5th ed., McGraw-Hill 1961); R. A. Dahl & C. E. Lindbloom, *Politics, Economics and Welfare* 18-28 *passim* (Harper & Bros. 1953).

who live in and move out of strip mined areas. Indeed, a large proportion of strip coal comes from the poverty-stricken region defined as Appalachia.¹⁹ Human resources and natural resources are related, of course, and I could not disagree if it were stated that the first emphasis in these areas should be placed on education rather than on reclamation.²⁰

II

CHANGING APPROACHES TO THE PROBLEM

Beyond noting the few articles in economics journals, the purpose of this section is not to review the extensive literature on strip-mine reclamation and regulation.²¹ Rather, it is to point out the decided change in both tone and content discernible in serious considerations of the subject.

A. Agriculture and Agricultural Journals

Scattered articles on the effects of strip mining and on the minor reclamation efforts of the time began to appear in the 1920's.²² Discussion warmed considerably in the following decade but focused less on the ill-effects themselves than on the amount of land that was taken, probably permanently, out of agricultural production. The arguments were not well supported and tended to reflect agrarian values.

During the late 1930's, two forces initiated a change in the tenor of discussion. The first was the research interest that state agricultural experiment stations and the Central States Forest Experiment Station of the United States Forest Service began to show in strip mine reclamation. (In the case of acid mine drainage, state engineer-

19. President's Appalachian Regional Comm'n, *Appalachia 42-44* (1964).

20. This is surely a major theme of Harry Caudill's book, *Night Comes to the Cumberlandlands* (Atlantic-Little Brown 1963), especially pp. 305-24. It is also the principal conclusion in M. J. Bowman & W. W. Haynes, *Resources and People in East Kentucky 244-46* (Johns Hopkins Press for Resources for the Future, Inc. 1963). These two books should be acknowledged as the source of my interest in these problems.

21. The pamphlets by Limstrom and Bergoffen, note 6 *supra*, include reviews of the literature. Three bibliographies have been prepared: G. A. Limstrom, *A Bibliography of Strip-Mine Reclamation* (Misc. Release No. 8, Central States Forest Experiment Station 1953); K. L. Bowden, *A Bibliography of Strip-Mine Reclamation 1953-1960* (Dep't of Conservation, Univ. of Mich. 1961) (mimeo.); D. T. Funk, *A Revised Bibliography of Strip-Mine Reclamation* (Misc. Release No. 35, Central States Forest Experiment Station 1962).

22. These early activities were usually reported in the *Journal of Forestry*.

ing experiment stations and the United States Public Health Service served in a similar relationship.) The experiment stations viewed problems created by mining like they did those problems created by farming: they saw damages; they analyzed their nature; and they sought ways of coping with them.²³ Moreover, they financed or inspired studies by individuals in related fields—ecologists, fish and wildlife biologists, hydrologists—so that many disciplines have contributed to our present knowledge of strip pits.

Strip mine legislation was the second force. West Virginia passed the first regulatory law in 1939,²⁴ and other states followed suit. As state agencies were established to administer the law and carry out reclamation activities, a demand was created not only for researchers but for foresters and agronomists who could put findings into practice over large areas. But perhaps the main contribution of the state laws was a shift of emphasis from cure to prevention, from post-mining reclamation to regulation designed to avoid damages. Moreover, as the postwar agricultural revolution muted the argument that stripped land was needed for food production, the public-oriented perspective of state agencies encouraged them to further shift their emphasis toward recreational use of stripped land.

B. Mining Industry and Journals

For the most part during the prewar years the strip mining industry denied legal or moral responsibility for the effects of stripping. However, as the first results of reclamation research became available, a few companies did experiment with reforestation. Also, several statewide associations of strip mining firms—usually the larger ones—were formed to carry out reclamation programs.²⁵ Gradually the prevailing attitude shifted from do-nothing to one that could be called “industry *oblige*.” But so long as voluntary reclamation was held to be the appropriate policy, strippers fought every state law.²⁶ Organized efforts were devoted to opposing bills introduced in state legislatures and, when passed, fighting them in the courts. Never-

23. Much of this work was published in the *Proceedings* of the state academies of science rather than in an official publication.

24. W. Va. Acts 1939, ch. 84.

25. A. L. Toenges, *Reclamation of Stripped Coal Land*, in Report of Investigations 3440 (U.S. Bureau of Mines 1939); L. E. Sawyer, *Reclamation and Conservation of Stripped-Over Lands: Indiana*, Mining Congress J., July 1946, pp. 26-28.

26. For a recent statement that reflects the earlier opposition to any compulsory reclamation, see W. H. Schoewe, *Land Reclamation*, Mining Congress J., Sept. 1960, pp. 92-97, and Oct. 1960, pp. 69-73.

theless, some laws were passed and, with the exception of a poorly drafted Illinois statute, upheld by the courts as a legitimate use of the police power to protect the general welfare.²⁷

Today state regulation is no longer opposed by the strip mining industry as a whole. Indeed, one often hears a call for stricter enforcement.²⁸ There remains some opposition to extending legislation to states which do not now regulate strip mining,²⁹ but the more broadly supported industry position is to oppose: (1) federal investigation of any kind,³⁰ and (2) state laws placing responsibility on the industry for lands stripped and abandoned before existing legislation went into effect.³¹

Articles on strip mine reclamation have appeared regularly in the mining press since about 1946.³² Most articles have been written by officials of the now very active reclamation associations set up by the strippers. These organizations, staffed by foresters and agronomists, were better equipped to utilize the techniques developed by the experiment stations than were mining companies. Their professional attitude is probably the source of the most recent shift in the industry attitude. The goal of "industry *oblige*" was to reduce opposition to stripping, much as institutional advertising might improve the public image. But agronomists and foresters, like miners, are interested in production; they shifted the emphasis from public relations to gaining income from mined-out land through commercial forestry, grazing, or (increasingly) charging user fees for recreational use.³³

27. Meiners, *supra* note 9, at 445. G. D. Sullivan, Presentation Before the Mineral and Natural Resources Law Section, American Bar Association, Chicago, Aug. 12, 1963 (mimeo.).

28. A. E. Lamm, *Surface Mine Reclamation—Why and How*, Mining Congress J., March 1964, p. 25; D. Jackson, *Strip Mining, Reclamation, and the Public*, Coal Age, May 1963, p. 94. Interstate groups like ORSANCO are also favored over federal regulation; see W. A. Raleigh, *Acid-Drainage Curbs Are Here*, Coal Age, April 1960, pp. 80-84. There are two "ulterior purposes" that are at times alleged to be of influence in the call for stricter enforcement: (1) an attempt to take the steam out of efforts to strengthen existing laws, and (2) an attempt to force the smaller stripping concerns out of business.

29. Schoewe, *supra* note 26.

30. Lamm, *supra* note 28; Meiners, *supra* note 9, at 460. This position is somewhat inconsistent with complaints that reclamation requirements in one state are more expensive than those in another.

31. West Virginia is alone in having a fund into which strip miners pay a fee for reclamation of land mined in the past. Meiners, *supra* note 9, at 458. The ORSANCO rules for control of acid drainage define no responsibility for abandoned mines.

32. Most of these articles appear in *Coal Age* or *Mining Congress Journal*.

33. L. Cook, *A New Approach to Strip Land Reclamation*, Mining Congress J., Aug. 1963, p. 68, and *Reclaiming Land for Profit*, Coal Age, Oct. 1963, p. 94; Jackson, *supra*

C. Economics Journals

It is surprising that during three decades of widespread interest only four articles on strip mining have appeared in economics journals.³⁴ Of these, only one considers strip mining in a framework explicitly separating private and social values.³⁵ Another essentially proposes application of a social rate of discount to strippable farm land to retain it in agriculture.³⁶ A third presents a useful critique of strip mine legislation.³⁷ And the fourth, written by a geographer, describes the effects of strip mining in a semi-arid region.³⁸ As a matter of fact, the work of several geographers deserves substantial credit for today's more rational climate of opinion and comes close to providing, albeit qualitatively, the kind of analysis urged in this paper.³⁹

The comments above should not be taken to imply that economic considerations are absent in other studies, for information on reclamation cost is given in many articles. However, the data presented are typically very general or very specific. More important, cost is reported as if reclamation were a production process in which private costs could be simply tabulated against private returns. In short, economic data have sometimes been reported, but economics has not been used as a decision framework incorporating social as well as private values.

III

ECONOMIC OBSERVATIONS

To formulate public policy for strip mining with the objective of increasing the net benefits to society, the place of strip mining in our

note 28. In 1963 a national organization, the Mined-Land Conservation Conference, was formed in Washington, D.C., to coordinate and publicize the work of state associations. The "Voluntary Industry Program for Surface Mined-Land Conservation" of the Conference would be ideal if it were actually practiced. See Mined-Land Conservation Conference, *Surface Mine Land Conservation 1-4* (undated) (mimeo.).

34. In addition, strip mining in the context of establishing "safe minimum standards" for conservation practice has been discussed by S. V. Ciriacy-Wantrup, *Resource Conservation: Economics and Policies 264-65* (Univ. of Cal. 1952).

35. H. W. Hannah & B. Vandervliet, *Effects of Strip Mining on Agricultural Areas in Illinois and Suggested Remedial Measures*, 15 *J. Land & P.U. Econ.* 296 (1939).

36. C. L. Stewart, *Strategy in Protecting the Public's Interest in Land with Special Reference to Strip Mining*, *id.* at 312.

37. Meiners, *supra* note 9.

38. A. H. Doerr, *Coal Mining and Changing Land Patterns in Oklahoma*, 38 *Land Econ.* 51 (1962).

39. See especially G. F. Deasy & P. R. Griess, *Coal Strip Mine Reclamation*, Mineral Industries, Oct. 1963, p. 1; Guernsey, *Strip Coal Mining: A Problem in Conservation*, *supra* note 6.

socio-economic system must be described. The following conclusions, drawn from a variety of sources, seem relevant to an analysis of strip mining in this context.

(1) The day of depletion of the coal minable by surface methods is not at hand, as some have suggested. Technologic advances, manifested in the pit by mammoth shovels, are making it possible to move larger and larger amounts of overburden to reach underlying coal. Furthermore, in thermal generation of electricity, the most important use of coal today, the lower quality coal usually produced at strip mines can be burned as efficiently as the more expensive, higher quality coal produced at underground mines.

(2) Under existing economic arrangements coal strip mining is the highest use of most land stripped or sought by strippers. That is, the present value of the time stream of private net revenues from coal production is greater, usually considerably greater, than the market price of that land for any other use.⁴⁰ Not only are the per acre returns from coal higher than from other commodities, but they accrue within such a short time that their present value is not greatly diminished by discounting the future. The difference in capital values is indicated by the active market existing for stripable land.

In other words, both strip mining firms and land owners appear to be making appropriate decisions in terms of the private costs and returns that each must consider.⁴¹ In this framework the long standing argument whether or not strip mines consume land of good, average, or marginal agricultural quality is irrelevant.⁴² The same analysis applies whatever the quality of land is involved, though coal companies will presumably have to pay more for higher quality.

(3) By private standards the strip mining industry is acting in an

40. Graham, *op. cit. supra* note 3, at 29-31, 46-51; Guernsey, *Strip Coal Mining: A Problem in Conservation*, *supra* note 6, at 178.

41. This is not to say the market is working in ideal fashion. First, the bargaining advantage lies with the coal companies because they have the drilling records. Graham, *op. cit. supra* note 3, at 50; Guernsey, *Strip Coal Mining: A Problem in Conservation*, *supra* note 6, at 178. Moreover, while some farmers may welcome stripping as a way to get their capital out of the farm, others who would prefer to continue farming may be forced to sell because the area loses economies, perhaps in marketing or in the supply of factors, when too much land is withdrawn from farming. Fear of such diseconomies could set up a chain reaction that in effect lowers property values. Guernsey casts some light on these possibilities; *id.* at 179-81. See also G. H. Walter, *Agriculture and Strip Coal Mining*, Agricultural Economics Research, Jan. 1949, pp. 26-28.

42. Coal operators have generally held that the land stripped was of marginal quality, whereas others have held that it was of higher quality. Evidence indicates that land stripped is neither largely good nor largely poor land for agricultural purposes. Graham, *op. cit. supra* note 3, at 43-44; TVA, *op. cit. supra* note 6, at 5.

efficient manner. Like the exploitation of many other natural resources, the difficulty with coal strip mining is that private standards are not sufficient to define social efficiency. This market failure results because the decisions of strip miners impinge upon other individuals in the economy and affect the miners' production and consumption decisions in ways that are not reflected in their cost calculations. These effects are what economists call technical externalities or external costs. They are of interest not only because they are tangible or intangible costs imposed on others by the mining operation, but more importantly because there is no compensation for such costs and, therefore, no need for the coal operator to control them. They are outside his market calculations—hence the name, external costs—even though they are significant costs to society.

Through the years an almost endless number of ill-effects have been attributed to strip and auger mining. Upon closer examination many of these accusations have been found to be untrue. Other damages, those affecting the sales value of land held by coal companies, should come to be reflected in private decisions. But there are external costs that are real enough, and they form the heart of the strip mining problem. Inasmuch as these costs have been the subject of most of the nontechnical articles about stripping, they need not be discussed here in any detail,⁴³ but they should be reviewed briefly.

(a) Air pollution is a relatively minor problem, confined to dust at some pits and to smoke from burning waste piles or coal seams.⁴⁴

(b) Water pollution, resulting from acid drainage or sedimentation, or both, is much more serious than air pollution. Acid drainage (actually a greater problem with deep mining) occurs as direct runoff from pits and as seepage from auger holes. It is responsible for caking in boilers and for corrosion of boats and bridges at considerable distances downstream from its point of origin. Acid drainage is also responsible for long reaches of some streams that are permanently devoid of fishlife or vegetation and for occasional fish kills in other reaches. Sedimentation, a more serious problem with contour stripping, results from the erosion of spoil banks, denuded hillsides,

43. For varying appraisals of the importance of these costs, see references cited note 6 *supra*; also Hannah & Vandervliet, *supra* note 35. Graham, *op. cit. supra* note 3, at 52-61, emphasizes the effect of strip mining on tax collections. Several admittedly biased but nevertheless vivid pictorial reviews have also been published. See, e.g., *Kentucky's Ravaged Land*, Louisville Courier-Journal, Jan. 5, 1964 (special supplement).

44. E. Hall, *Air Pollution From Coal Refuse Piles*, Mining Congress J., Dec. 1962, p. 37.

and access roads. Sediment in streams destroys fish habitat, erodes bridges and roadways, clogs culverts, and aids in undercutting stream banks. It shortens the life of flood control and water storage projects. Both acid drainage and sediment contribute to increased treatment costs for downstream users.

(c) Land problems go hand-in-hand with those of watercourses. The land downslope or downstream of a strip mine may receive eroded material from the mine area. It may become devegetated. In some cases sediment and coal fines have choked stream valleys until the fields become swampy and useless for agriculture. There is some evidence that choked stream beds and the bursting of sediment-built dams are responsible for increased flood damages.⁴⁵ Forest development is often altered and wildlife habitat destroyed; stagnant pools commonly develop in old strip pits, and there are cases in which coal fires have set forest fires.

(d) Intangible or less measurable effects derive from aesthetic and cultural values that are not directly tied to markets. Important aesthetic effects result from the loss of a natural environment, whatever its original character. Other aesthetic effects result from the absence of vegetation for years on some spoil banks and from the debris remaining after mining. Aesthetically speaking, the small proportion of land actually consumed by strip pits is of less importance than the much larger area over which its effects are visible.⁴⁶ Such intangible costs are imposed not only on residents but on visitors traveling through the area. Equally important are the effects on communities near stripping areas. The character of many may be adversely affected by the transient nature of coal strip mining. Tax burdens for those who remain in the area may rise while the level of, or access to, public services declines because people move away or routes of communication are disrupted. Finally, the high-wall itself presents a safety problem near built-up areas.

Some of the external costs discussed above are incurred directly by existing producers of products other than coal and by consumers.

45. Collier, *op. cit. supra* note 6, at B-1, B-18. However, W. G. Jones argues that presently used methods of backfilling after strip mining contribute to flood control. He claims that the strip pits themselves act as terraces to prevent rapid runoff and that the backfill is more porous than natural soils and holds more water. Jones, *Land Conservation in Pennsylvania Open Pit Mines*, Mining Congress J., Oct. 1963, p. 53.

46. The point that stripping consumes a small proportion of the total land surface was relevant when the community was worried about the destruction of agricultural land. It obviously has no relevance when the effects in question occur away from the site of mining. And it is almost equally irrelevant when many recreational uses of land are considered.

The remainder are represented by local income lost because additional productive opportunities are reduced by stripping.⁴⁷ There is no question that income from fishing, tourism, and other recreational activities is reduced while stripping is in progress, and that such income may remain low for years after abandonment of the mine. More questionable are the effects of strip mining on potential industrial development. It is considered important by the Area Re-development Administration,⁴⁸ and at least one power company has engaged in a reclamation program in the hope of increasing industrial development within its market area.⁴⁹

(4) Less widely recognized than the external costs of coal strip mining are certain external benefits. That is, in some cases stripping confers benefits on individuals or on the community at large for which the coal company is not recompensed. For example, it has been claimed that men employed in strip mines learn skills more widely used in other industries than are those learned in timbering or in underground mining.⁵⁰ Other effects are more tangible. When stripping occurs over old underground mines, the process often collapses the roofs and seals openings so that the flow of acid mine water from the deep mines is reduced or eliminated.⁵¹ It has already been noted that some flood control benefits are claimed. In other cases, strip mining can be an effective way of extinguishing fires in coal seams.⁵²

(5) It is now rather widely held that technologic problems associated with reclaiming strip-mined land have been solved, and that today's problems relate to managing land and making it more pro-

47. It is not necessarily true that local income losses are net losses to the economy. They may simply be transfers from one region to another. However, given the depressed conditions in many strip mining areas, a case can be made for considering them as net losses.

48. The same approach is implicit in the Appalachia program. The less optimistic side of the argument is carefully presented by Bowman & Haynes, *op. cit. supra* note 20, at 135-59.

49. *Program Drawn To Enhance Landscape*, *Electical World*, Sept. 17, 1962, p. 94. No doubt this motive also underlies in part the TVA's recent interest in strip mine reclamation.

50. Graham, *op. cit. supra* note 3, at 41-42.

51. Jones, *supra* note 45, at 54, states that strip mining in areas once mined by underground methods has been the greatest single factor in controlling acid drainage in Pennsylvania; see also Jackson, *supra* note 28, at 89.

52. The Carbondale, Pennsylvania, program is the best known example of controlling a fire by strip mining. However, this case does not qualify as an external benefit because the purpose of fire control was fully recognized in the contract signed between the city and the coal companies. *Towns Built Over a Furnace*, *Business Week*, May 4, 1963, p. 98.

ductive.⁵³ As a general statement, this is no doubt true. However, there are areas in which further technical research would probably significantly lower the cost of reclamation. Most of our reclamation knowledge pertains to the relatively flat terrain stripped in Indiana, Illinois, western Kentucky, and elsewhere. Smaller but still large amounts of strip coal come from the contour mines in the hills of West Virginia, Pennsylvania, eastern Kentucky, and eastern Ohio. These areas are also the home of the auger mine. But there is little research and still less experience to guide reclamation efforts in mountainous terrain.⁵⁴

Additionally, only a small part of the research on reclamation has treated the method of mining as a variable. It has been shown that the tandem system—a method in which a dragline on the edge of the pit removes and segregates the soil and overburden while a shovel in the pit digs the coal—produces better reclamation results but raises the direct cost of mining.⁵⁵ However, there have been no systematic studies of the relationships existing between mining methods, reclamation results, and total costs. This probably results from thinking of mining and reclamation as separate stages of production. In contrast, German coal operators have for years incorporated reclamation practices directly into their mining methods.⁵⁶ The same approach is being followed at phosphate mines in Florida.⁵⁷ In both cases substantial costs savings are claimed over procedures that divorce reclamation from mining.

(6) Useful information on the cost of strip mine reclamation and control of acid drainage is not readily available. What has been published is often of little meaning because there is no indication of what is included in the cost figures. Such reported “costs of reclamation” may include anything from piles of spoil bulldozed against the

53. G. S. Bergoffen, *A Digest: Strip-Mine Reclamation 22* (U.S. Forest Service 1962); R. F. May, *Surface-Mine Reclamation: Continuing Research Challenge*, *Coal Age*, March 1964, p. 98.

54. Bergoffen, *op. cit. supra* note 53, at iv, 12; Feiss, *op. cit. supra* note 7, at 9. Actually, much the same statement might be made about reclamation in semi-arid areas, which is not a problem today, though it might become one if lignite is ever mined in large amounts. See Doerr, *supra* note 38.

55. Bergoffen, *op. cit. supra* note 53, at 26; Limstrom, *Forestation of Strip-Mined Land in the Central States 26* (Agricultural Handbook No. 166, Central States Forest Experiment Station 1960).

56. W. Knabe, *Methods and Results of Strip-Mine Reclamation in Germany*, 64 *Ohio J. Science* 75 (1964).

57. U. K. Custred, *New Mining Methods Rehabilitate Florida's Strip Mines*, *Mining Engineering*, April 1963, p. 50; *Land Reclaimers Plan for '68*, *Chemical Week*, Nov. 14, 1964, p. 55. Of course, reclamation in level and semi-tropical Florida is simpler than in the Appalachian or Midwest coal fields.

highwall to the development of fields and forests. Moreover, costs vary with the nature of the terrain, with local employment conditions, and with the purpose for which the land is being reclaimed. Grading costs, perhaps the major variable, are reported to range from $1\frac{1}{4}$ cents per ton to 43 cents per ton (over \$1000 per acre).⁵⁸ Nor is it always clear whether "per acre" figures refer to acres actually stripped or acres affected in other ways. Finally, it is impossible to dissociate costs of mining from costs of reclamation in many reported instances.

Despite the problems of generalizing about reclamation costs, it is nevertheless useful to have some idea of the magnitude of the costs involved. The most frequently cited cost figure is fifty dollars per acre. This amount is supposed to include a very little grading, some soil preparation, simple erosion control, and planting of tree seedlings; it presumes reasonably flat terrain. In rougher terrain the same figure may be used with the understanding that no grading or soil preparation is included but that greater precautions are taken to ensure correct drainage. Reclamation for purposes other than reforestation is generally more expensive.

It is likely that the figure of fifty dollars per acre represents a minimum program serving to avoid the worst effects, rather than an average cost of reclamation. The other extreme is represented in the estimates prepared by a special committee appointed by the Secretary of Agriculture when it was proposed to open a wooded, mountainous area of a national forest to stripping. The committee estimated that the cost of "restoring" mined land to something like its original contour and original forest cover would be \$1800 to \$3000 per acre, plus \$800 to \$1500 per acre for land that was disturbed but not actually mined.⁵⁹

The minimum figure can apparently be borne by the coal industry, but the higher figure—assuming the full costs are to be paid by the coal company—would preclude mining. Between these extremes one can find cited almost any cost figure that he considers more repre-

58. TVA, *An Appraisal of Coal Strip Mining* 9 (1963). Cost figures for strip mine reclamation are usually reported in terms of cents per ton or in terms of dollars per acre. One can be converted to the other by assuming that coal weighs 75 pounds per cubic foot, so that one acre of coal one foot thick (one acre-foot) contains 1600 short tons of coal. If a stripping seam is 3 feet thick, a reclamation cost of \$50 per acre is roughly equivalent to 1 cent per ton. Typically divergent views on costs in relatively flat terrain can be found in L. Guernsey, *The Reclamation of Strip Mined Lands in Western Kentucky*, *J. Geography*, Jan. 1960, p. 11, and in J. Hyslop, *Some Present Day Reclamation Problems: An Industrialist's Viewpoint*, 64 *Ohio J. Science* 157, 159-64 (1964).

59. S. T. Dana, *The Stearns Case: An Analysis*, *American Forests*, Sept. 1955, p. 44.

sentative. My own impressions are that costs of \$50 to \$250 per acre are appropriate for reforestation and pollution control on relatively level land; and that costs in the mountains are unlikely to be less than several hundred dollars per acre, despite claims to the contrary.⁶⁰

(7) Although time has provided considerable experience, it does not appear that strip mine reclamation has been privately profitable.⁶¹ In the majority of cases the net monetary return to a coal company would be greater if the company could avoid performing any reclamation activities at all. This does not mean that the returns (from harvesting timber, leasing, charging user fees, etc.) are insufficient to recoup the direct costs of maintaining and paying taxes on the land. But it does mean that the private returns are insufficient to recoup these costs plus the initial investment in reclamation if any reasonable interest rate is charged for the funds. In short, granting that for one reason or another coal companies have decided to reclaim land, they have made the best of the situation;⁶² but the costs and returns are not usually such that an outside investor would look at strip mine reclamation as an attractive venture.

This is in contrast to the position of the reclamation associations and the large coal companies that reclamation is privately profitable.⁶³ No doubt in special sets of circumstances it is profitable. How-

60. This impression is corroborated by experiments carried out in Pennsylvania. See H. B. Montgomery, *Conscientious Coal Stripping*, *Coal Age*, July 1962, p. 87. Additional evidence is found in the fact that costs of establishing timber stands in California after burns or harvesting run close to \$100 per acre. See J. R. McGuire, *What Are All the Costs of Stand Establishment?*, in *Economics of Reforestation 3* (Proceedings of the Annual Meeting of the Western Reforestation Coordinating Comm. 1963). The costs reported by the TVA are much lower, but there seems to be an inconsistency between the amount of coal produced and the acreage mined. TVA, *op. cit. supra* note 58, at 10.

61. As a generalization this conclusion is not common. However, it is supported by many studies on particular projects: G. H. Deitschman & R. D. Land, *How Strip-Mined Lands Grow Trees Profitably*, *Coal Age*, Dec. 1951, p. 95; P. N. Seastrom, *United Electric Coal Companies Land-Use Program*, *Mining Congress J.*, Dec. 1963, p. 27; H. Kohnke, *The Reclamation of Coal Mine Spoils*, in *Advances in Agronomy*, vol. 2, at 341 (1950); *Symposium of Strip-Mine Reclamation*, 64 *Ohio J. Science* 98, 146 *passim* (1964).

62. Thus, recognizing that coal strip mining is a land use generally incompatible with farming, the companies have turned in most instances to commercial forestry or commercial grazing. In England, where a very different land situation exists, reclamation of open pit mines has been directed toward the production of cereals. See the series of three articles by W. M. Davies, *Bringing Back the Acres*, *Agriculture*, March, April, May 1963.

63. See Mined-Land Conservation Conference, *op. cit. supra* note 33, at 3. In support of the industry position, it is often pointed out that reclaimed strip land is worth more, or is more productive, than adjacent non-stripped land. Such statements are evidence of successful physical reclamation but are irrelevant economically because

ever, most statements about the "profits" are found on closer examination to include only a comparison of revenue and direct cost, not revenue and total cost. In other cases hidden subsidies are involved, as when a company "loans" the use of its earthmoving equipment to the reclamation project or charges off costs for the replacement of soil as an expense of mining. Rarely is reclamation recognized as an investment process on which discounted net returns should amount to at least a normal profit if reclamation is to be regarded as privately profitable. In the few cases for which there are sufficient data to roughly compute and discount net returns, the results run to less than three per cent per year.⁶⁴

(8) Although it is likely that the net private returns from strip mine reclamation are less than a firm could earn from other investments, there is good evidence that over some range the net social returns are high. Social returns include all the benefits from some action, no matter to whom they accrue, whether or not they can be marketed (as social costs include all the costs of some action, no matter who pays them or whether there is a market for them). To restate my conclusion, the direct returns from reclamation, which could be collected by a public body rather than by a private one, *plus* the tangible and the intangible returns accruing to others will often considerably exceed the costs of reclamation. Because these latter, non-direct returns—largely but not entirely represented by external costs avoided—are not collectible in the ordinary sense, strip mine reclamation can be socially, but not privately profitable. However, like private investment, social investment must be justified in incremental amounts. It is not enough to know merely that investment in strip mine reclamation is worthwhile in an overall sense. The benefits and the costs of reclamation vary from place to place—and not always in the same direction. Before investing, one should also know where and in what amount investment will yield the greatest net return. The problem presented by comparison of the social benefits of reclamation with the social costs of reclamation is discussed in the next section.

considerable money was spent on the stripped parcel of land, whereas none was spent on the other parcel. Therefore, the time stream of costs as well as of returns is different, and it is not immediately obvious that the stripped land is the more profitable.

64. But one much-quoted figure of \$3.71 profit per year from reforestation implies a return of 6 or 6½%. The figure was apparently estimated by Professor L. A. Holmes and first published in Strip Mine Investigation Comm'n, Report to the 63rd General Assembly of Illinois 24 (1942).

IV

THE APPLICATION OF ECONOMICS

A. Benefit-Cost Analysis

The main burden of this paper is that benefit-cost analysis offers the most useful framework for making decisions about strip mine reclamation. Benefit-cost analysis is essentially the same sort of decision-making process that is used in ordinary market calculations. However, it can be used in situations in which for one reason or another private market calculations do not produce good results, *e.g.*, external costs in strip or auger mining. In either benefit-cost or private market calculations a comparison is made, in monetary measures, between (1) the gains to be realized if some action is taken, and (2) the things that have to be given up in order to take that action. The action is justified if the benefits exceed the costs or, more accurately, if the benefits exceed the costs by a greater amount than for any alternative action.

The same benefit-cost principles apply whether operating strip mines are being regulated or abandoned pits are being reclaimed. However, it is simpler to illustrate the latter case. Consider a limited budget of, say \$1000 available for recreational development at three pits. Pit *A* is near a city; pit *B* is on rolling farmland well out from the city; and pit *C* is in the mountains. Because of differences in the availability of construction equipment, in terrain, and in the types of development proposed (playgrounds in the city park, trails in the mountains, etc.), the costs of reclamation, assumed constant at each pit, vary among the pits as follows:

Pit *A*—\$200/acre, Pit *B*—\$100/acre, Pit *C*—\$300/acre.

Benefits do not remain constant but vary with the amount of land developed. Ignoring for the moment how gross benefits are determined, assume that for three successive acres in each case they are:

	<i>Pit A</i>	<i>Pit B</i>	<i>Pit C</i>
1st acre	\$600	\$250	\$600
2nd acre	550	150	400
3rd acre	300	100	200

By subtracting the per acre reclamation cost for each of the three acres at each pit, the net benefits are :

	<i>Pit A</i>	<i>Pit B</i>	<i>Pit C</i>
1st acre	\$400	\$150	\$300
2nd acre	350	50	100
3rd acre	100	0	-100

Costs are lowest for pit *B*. The "three-acre benefit-cost ratio" is highest for pit *A*. Neither is a sufficient criterion for optimizing investment. The greatest net social gain can be won by developing the first acre at pit *A*, the second also at pit *A*, the third at pit *C*, and so forth. Thus, some pits may receive extra reclamation funds while others are not reclaimed at all.

What are the benefits, and what are the costs of strip mine reclamation? As emphasized above, the main benefits of both regulation and post-mining reclamation are represented by external costs avoided. When corrosion of boats or silting of ponds and streams can be reduced, this is a benefit. In addition, there are benefits from making the land productive. Represented by profits from grazing or tree harvesting, and in recent years, from orchards, homesite construction, or recreation fees, these benefits have often been captured by private owners. Other productive uses are likely to lie within the public sector. Use of strip pits for sanitary dumps is among these.⁶⁵ Also with the public sector are certain recreational uses and the production of fish and wildlife, particularly when they are treated as primary products of reclamation, rather than by-products.⁶⁶ It has even been suggested that strip pits themselves be used as tourist attractions.⁶⁷

The costs of strip mine reclamation appear in two stages. Some are incurred after mining is completed and are clearly associated

65. G. F. Deasy & P. R. Griess, *Strip Pits and the Sanitary Landfill Process*, Mineral Industries, Nov. 1960, p. 1.

66. The best example of the use of strip mined land for public recreation is Kickapoo State Park in Indiana, part of which was built on strip land. (Indeed, almost every brochure on strip mine reclamation carries a picture of people fishing at Kickapoo Park.) Charles V. Riley of Kent State University has conducted pioneering studies on the use of strip land for wildlife production.

67. P. R. Griess & G. F. Deasy, *Economic Impact of a New Pennsylvania Tourist Facility*, 40 *Land Econ.* 213 (1964); K. L. Bowden & R. L. Meier, *Should We Design New "Badlands"?*, *Landscape Architecture*, July 1961, p. 226. Use of the unique character of pits is contemplated in Sweden where architects are making long range redevelopment plans for the iron mines; *id.* at 228. Similar proposals have been made but never implemented for the Lake Superior iron district of the United States.

with the reclamation program. When abandoned pits are being reclaimed, all costs are of this type. But operating pits also incur costs because of strip mine regulations and anticipated reclamation activities. Such hidden but, nevertheless, additional costs must also be counted against the benefits of strip mine reclamation.

By moving directly into illustrations of benefits and costs, an important step has been omitted. It has been implicitly assumed that by evaluating social benefits and social costs in terms of dollars, the social value of proposed actions may be approximated. It is not possible to justify this step here. It is sufficient to say that there is broad agreement that market prices or information on willingness-to-pay (which may consist of surrogate measures in the absence of markets) are socially valid indications of the desires of the members of a community for certain quantities of goods and services.⁶⁸ Moreover, prices and willingness-to-pay data provide rational and operational guidelines for investment decisions that will maximize society's gain from the use of its resources. By the same token, public intervention in the market is justified when something interferes with the maximization process. This implies that intervention is costless, which is of course not true; however, in the case of strip mining the costs are probably not excessive when compared with the costs imposed by unregulated market operation. As reflected in benefit-cost analysis, prices provide the tools for making public decisions about strip and auger mining that cannot be provided by such nonoperational slogans as "full reclamation."

B. The Role of Public Policy

The first requirement for the systematic use of benefit-cost analysis in public policy toward strip mining is an explicit statement of the social optimum being sought. The appropriate criterion for a social optimum involving strip mining activities is that all costs associated with an optimum level of mining be minimized. This criterion will not be satisfied whenever strip mining imposes costs that are not included in the coal operator's calculations, nor will it be satisfied if

68. An extended discussion of the theory underlying benefit-cost analysis can be found in J. V. Krutilla & O. Eckstein, *Multiple Purpose River Development* 3-77 (Johns Hopkins Press for Resources for the Future, Inc. 1958). A shorter treatment is presented by Allen V. Kneese, *Water Pollution: Economic Aspects and Research Needs* 18-20 (Resources for the Future, Inc. 1962). R. K. Davis offers a useful discussion of some "conceptual weeds," such as the notion that economic valuation implies commercialization, which can readily be expanded from recreation planning to strip mine reclamation. Davis, *Recreation Planning as an Economic Problem*, 3 *Natural Resources J.* 239, 241-44 (1963).

cheaper solutions to some problems are feasible but are not open to individual operators. These two conditions, external costs and economies of scale, to use the economist's terms, are the most important general rationales for public intervention.⁶⁹

Given the criterion for a social optimum, what is the role of public policy when there are uncompensated externalities? Its main role is redistribution of costs in a manner ensuring that those who are responsible for external costs have an incentive to take them into account. Only when costs can no longer be shifted to others in the economy will private costs correspond with social costs and the social optimum be realized. For example, in many areas strip mine operators have no incentive to prevent mine wastes from being picked up and carried off by streams. Because the miner has free use of the water, a valuable resource, his costs are understated. Simultaneously, a farmer downstream has lower profit from his land because acid and sediment are in the stream. Hence, the farmer's costs are overstated. If the downstream losses are greater than the costs of control at the strip mine, there is a net social loss and society is receiving less from the use of its resources than it could. But if costs are redistributed so that the mine operator must pay compensation to the farmer for damages, this net loss cannot occur.⁷⁰ The operator will have an incentive to control the release of sediment and acid to the point at which the added benefits from further control are no longer worth the added expense. If damages remain, it will be cheaper (and socially appropriate) for him simply to compensate the farmer. Once again, net social returns are being maximized. Moreover, they are being maximized by the normal market process in which a private resource owner attempts to minimize his costs. The only difference is that social costs are now made equal and are reflected in his private costs.⁷¹

There are several things about this process of cost redistribution that deserve further attention. First, not all external effects are eliminated. To do so would be as much a waste of society's resources

69. F. M. Bator, *The Question of Government Spending* 76-120 (Harper & Bros. 1960); see also Kneese, *op. cit. supra* note 68, at 29-32.

70. In some states, notably Kentucky, there are legal qualifications to the responsibility of coal operators to pay for damages. *Kentucky's Ravaged Land*, *supra* note 43, at 8-9; H. M. Caudill, *Night Comes to the Cumberlands* 74-75, 305-09 (Atlantic-Little, Brown 1963). These qualifications, upheld by the courts, derive from the contracts by which coal companies obtained mineral rights to the land around the turn of the century. This legal principle does not invalidate the economic principle stated in the text.

71. This process of "internalizing" external effects is discussed at greater length and with more attention to the theoretical underpinnings by Kneese, *op. cit. supra* note 68, at 20-27.

as controlling none of them. The social costs of moderate control measures plus some damages will usually be less than the social costs of eliminating all external effects. Similarly, there will be some abandoned pits for which the external costs avoided plus the potential net returns with reclamation will amount to less than the cost of reclamation at that location, and such pits would not optimally be reclaimed. On the other hand, with cost redistribution the scale of mining activities, the "optimum level of mining," will also differ from what it would be with an unregulated market. There are some lands that can be strip mined profitably now because certain costs need not be considered by miners. If the miners of these lands had to bear all the costs of strip mining, the operation would not be profitable and the land would probably remain in its natural state. Finally, social benefits and costs must be computed in net terms. In the example above the social cost of crops lost by pollution is the profit expected from those crops, not their gross value. Similarly, the social benefits of a reclamation program include the profit from the crops saved plus any profit that can be earned from the reclaimed land itself.

Redistribution of costs is the major role that public policy can play in the strip mining problem, but that is not the only role of public policy. It also has a role whenever regional or multipurpose approaches to reclamation can capture economies of scale and thus yield cheaper solutions than could be obtained with mine-by-mine approaches. For instance, it has been shown that large multipurpose dams often achieve a significant reduction in damages from acid drainage through dilution of the acid,⁷² though it is an open question whether this method is preferable to mine-by-mine methods. Again, better reclamation results can often be achieved by coordinated work in larger parcels of land than may be controlled by one operator. The importance of such economies of scale is indicated by the success of coal operators' conservation associations and local soil conservation districts in West Virginia, where the strip mine law permits the miner to contract with them to do his required reclamation.⁷³ Regional or multipurpose projects introduce additional questions about sharing the costs of the program. For example, it is not obvious how the costs of a regional program for replanting strip

72. C. S. Clark, *Mine Acid Formation and Mine Acid Pollution Control*, Paper Delivered to the Fifth Annual Symposium on Industrial Waste Control, Frostburg State College, Frostburg, Md., May 7, 1964 (to be published in the *Proceedings* of the Symposium).

73. E. Leadbetter, *There Oughta Be a Law*, Soil Conservation, Sept. 1957, p. 36.

land in a depressed area should be distributed among mining firms, direct beneficiaries, and the general public.

Finally, the time dimension of strip mine reclamation deserves mention. Many of the damages from strip mining are temporary. An important aspect of benefit-cost analysis is to determine when the costs imposed by temporary losses or temporary ugliness are greater than benefits that may become negligible in a fairly short time. If a strip mine will reforest itself in five or ten years, it would no longer be correct to assign benefits to the reclamation program after that time. Should reclamation be left to nature in such a case? In some cases this might be appropriate action, but if this were the only area near a city for fishing or hiking, then even a temporary loss might impose large costs. Acid mine drainage presents a particular problem in this regard because its effects are so persistent. It has been reported that a stream may require thirty months for restoration after concentrated acid has flowed for barely one hour.⁷⁴ That is, the damages are much less reversible than are damages from other pollutants. Consequently, the importance of keeping acid out of streams or of maintaining adequate dilution flows at all seasons of the year becomes critical.

The reclamation program can also be designed to serve varying purposes during the passage of time. It has been persuasively argued, for example, that too much emphasis has been placed on reclaiming land in ways that lead directly to marketable products. A socially preferable procedure may be to make the initial goal one of obtaining cover on the bare soil and eliminating the ugliest aspects of the scar. Later phases of the program may then be devoted to commercial forestry or other profitable pursuits.⁷⁵ In any event, the sequence of reclamation activities is another variant in the search for the optimal reclamation program.

C. Evaluation

Thus far statements about benefits and costs have been made as though it were possible to evaluate them simply and accurately. This is, of course, far from the truth. They can be exceedingly difficult to evaluate. However, there are many benefits and costs whose market prices can be directly incorporated into the analysis. Value of timber

74. G. D. Beal, Common Fallacies About Acid Mine Water 4 (Sanitary Water Bd., Pa. Dep't of Health 1953) (mimeo.).

75. Bergoffen, *op. cit. supra* note 53, at 21-22; F. W. Collins, Triple-Phase Strip-Mine Reclamation (Div. of Strip Mine Reclamation, Ky. Dep't of Conservation) (undated).

produced, cost of seedlings, and fees collected are a few of those regularly used in evaluating government projects. There are other benefits and costs that can be evaluated indirectly, though no market exists for the particular benefit or cost in question.⁷⁶ In these cases values can be imputed by substituting market prices that do exist. For example, in a Public Health Service study, the amount of money spent each year because of mine acid-induced corrosion of boats and marine structures, caking of boilers, and added treatment by industries downstream was calculated. The annual value imputed to acid drainage control was then the amount of these costs that would be avoided each year.⁷⁷ Flood damages, erosion damages, and other costs imposed by strip mining could be evaluated in the same way. Moreover, there are still other costs and benefits, once thought to be unmeasurable, that are proving at least partly tractable to analysis. Recreation is the most important of these.⁷⁸ It would seem entirely feasible today to use one of these techniques and the information available on the costs of different types of recreational sites to make a benefit-cost calculation of the net benefits of reclaiming strip land for recreational use.

There will remain, however, benefits and costs that are presently unmeasurable, and whose absolute values may be in principle unmeasurable. But this does not mean that these effects must be completely excluded from benefit-cost analysis. Kneese has suggested that the best way of handling "socially valid goals for which for one or another reason there are no values commensurable with the values pertaining to other elements of the system" is to treat them as explicit requirements in any proposed program.⁷⁹ Referring to water pollution control programs, he states:

This can be done by initially treating these goals, expressed in physical terms, as limits or constraints upon the cost minimization objective Conceivably this would require a very different combination of units with different operating procedures than a system designed without the constraints. Presuming the constraints are effective, *i.e.*, not automatically met if costs are minimized, they would result in a

76. A. V. Kneese, *Socio-Economic Aspects of Water Quality Management*, 36 J. Water Pollution Control Federation 257 (1964).

77. U.S. Public Health Service, *Acid Mine Drainage Studies*, in Ohio River Pollution Control 973-1023 (Supplement C to Part II, 1944).

78. J. L. Knetsch, *Outdoor Recreation Demands and Benefits*, 39 Land Econ. 387 (1963); Davis, *supra* note 68.

79. Kneese, *Socio-Economic Aspects of Water Quality Management*, *supra* note 76, at 258.

higher cost system than could otherwise have been achieved. The extra cost represents the limitation which the constraint places upon the objective.⁸⁰

For example, it might be decided that for aesthetic reasons stripped land will remain denuded for no longer than one year. To accomplish this it may be necessary to save and replace topsoil, to do more soil preparation, or to avoid mining in certain sites. All of these procedures would increase the cost of the mining-reclamation process.

This method of making social goals explicit has the further advantage that it permits us to calculate their minimum value. It has been stated by Kneese:

One useful way of stating the results of variation of constraints which represent goals . . . not valued directly by, or imputable from, the market . . . is in terms of what they must 'at least be worth.' . . . [By] comparing the optimum system with and without the constraint, it is possible to indicate what the *least* value is that must be attached to the increment of pleasure in order to make that level of control procedures worth while.⁸¹

In short, we are in fact putting a monetary valuation on aesthetic or social goals whether or not we like to think of it that way.

Actually this point is quite general and worth emphasizing. Any restriction or regulation that is placed on the processes of strip and auger mining (or anything else) implies an evaluation. Each has an economic cost that can be made explicit, and one must be able to argue that the social benefits to be gained by imposition of the requirement are worth *at least* this much.

D. Methods and Techniques

In the two preceding sections some principles of benefit-cost analysis and its application to strip and auger mining have been discussed in general terms. The final step in this preliminary assessment of the role of economics is to offer suggestions about how one might actually base decisions on benefits and costs. At this point it becomes convenient to separate the problem of regulating existing strip mines from that of reclaiming abandoned ones.

80. Kneese, *Water Pollution: Economic Aspects and Research Needs*, *op. cit. supra* note 68, at 32-33, 42-44.

81. *Id.* at 34-35.

What methods are available for making benefit-cost calculations for reclamation of abandoned strip pits? The most promising approach is the method now coming into use for determining the social value of soil conservation projects.⁸² These techniques require careful estimation of expected returns over time and clear recognition of the principle that reclamation must be justified on investment criteria. The data needed, but not presently available, to make these analyses include expected returns from different types and different sequences of reclamation activities on strip mined land of varying qualities and different locations. (Changes in land values may be a clue here.) Additionally, it would be essential to systematically collect data on the external costs of strip mining and to estimate the present value of future damages avoided. Some information of this type may come out of the cooperative study on acid drainage in several river basins in the northern coal fields of West Virginia recently begun by the United States Public Health Service and the West Virginia Bureau of Mines. In the same project various methods of coping with acid drainage will be compared, careful cost accounts being kept for each. The same approach could be fruitfully applied to an area in which the whole set of problems associated with strip mining is at issue.

With such data in hand it would be possible to adapt the techniques applied in soil conservation projects (which already include both direct returns and external costs avoided as benefits) to strip mine reclamation proposals. The problem is essentially no different. Moreover, the method is flexible. It would be possible to use a lower rate of interest for funds loaned in a depressed area; in areas where aesthetic values are high, limits on the depth or location of strip mining could be imposed as constraints on cost minimization.

When one turns to the more difficult problem of regulating existing mines, he finds that none of the seven state laws presently in force are adequate to handle the range of problems presented by strip and auger mining.⁸³ Most laws do not recognize that condi-

82. A. J. Coutu, W. W. McPherson & L. R. Martin, *Methods for an Economic Evaluation of Soil Conservation Practices* (Tech. Bull. No. 137, N.C. Agricultural Experiment Station 1959); R. N. S. Harris, G. S. Tolley & A. J. Coutu, *Cropland Reversion in the South* 61-69 (Agricultural Economics Information Series No. 100, N.C. State College 1963). See also certain of the papers in *Economics of Reforestation*, *op. cit. supra* note 60.

83. Detailed comment on these laws is given by Meiners, *Strip Mining Legislation*, 3 *Natural Resources J.* 442 (1964), and a summary of their provisions is given by Bergoffen, *op. cit. supra* note 53, at 26-42. The laws of individual states are generally reviewed in detail in law journals shortly after passage or amendment.

tions vary, hence that external costs vary, within the state. Nor do these laws recognize that both reclamation costs and potential benefits vary with location and terrain conditions. The differences between area stripping and contour stripping are usually ignored. Regulations are applied across-the-board. For example, almost all of the laws impose a single standard for the grading of stripped land and spoil piles. Actually, the appropriate kind and degree of grading depends upon the terrain, adjacent land use, and proposed use of the reclaimed land. Professors Deasy and Griess have specifically urged laws designed to foster

selective and local modification of the terrain, without major remodeling of the entire surface, [thereby permitting] development, at reasonable cost, of the widest variety, frequently aesthetically most pleasing, and on the whole economically most profitable types of highly specialized land usage—recreation, education, water conservation and waste disposal.⁸⁴

On the other hand, a useful feature of some laws is their provision for substitution of land. Rather than reclaim land now being mined, an operator may elect to reclaim an equal number of acres of land not previously reclaimed. Although open to possible abuse, substitution does permit the reclamation effort to be concentrated on land that will return greater net benefits. It is not difficult to think of other techniques for concentrating the effort, possibly making it more efficient physically as well as economically.⁸⁵

There is no need to belabor the point. The few instances cited indicate that much could be done to make existing strip mine legislation and its enforcement a more effective tool for reducing social costs by requiring certain practices of strip miners and by creating conditions under which socially more profitable reclamation procedures can be followed.

Perhaps there has been altogether too much reliance on control of strip and auger mining by legislative regulations. For existing

84. Deasy & Griess, *Coal Strip Mine Reclamation*, *supra* note 39, at 1. On the other hand, Meiners, *supra* note 83, at 449 *passim*, attacks the laws for being too flexible. He seems to view every permissible relaxation of regulation as an unwarranted gift to the strip miner. But in economic terms rigid restrictions, rigidly enforced, may have no more to offer than administrative simplicity. However, Meiners is certainly correct when he argues that whatever the flexibility permitted by law, it is poor practice to allow the mining company alone to determine the degree to which the law will be applied, as is done in some states.

85. The West Virginia practice of allowing soil conservation districts to contract with coal operators to perform required reclamation is one such technique.

operations other techniques may be applicable. In the field of water quality management, techniques such as zoning, effluent standards, and effluent charges have been successfully used to redistribute external costs.⁸⁶ Effluent standards are implied by Pennsylvania's "Experimental Rules and Regulations for the Operation and Maintenance of Strip Mines."⁸⁷ The rules provide that acid in drainage shall be reduced as close to zero as possible in the outflow and that the iron content shall not be so high that it precipitates as "yellow boy" on the stream bottom. The rules also suggest that hillsides be zoned so that certain areas, notably water courses, be left unstripped. Similarly, the *Stearns* case decision, in which a specially convened board refused to permit stripping in Cumberland National Forest, was a zoning decision.⁸⁸ The *Stearns* decision was based not on the fact that the land was public land, but upon the hilly and forested character of that land. It was pointed out that the social costs of stripping would be much greater than the net value of the coal produced. And there was no reason to think that the coal under this land was of any greater value than coal that could be mined without such large social costs. Thus, this decision is not in conflict with other decisions permitting stripping in other national forests where conditions differ. Although rather broadbrush zoning to prevent stripping has been held unconstitutional,⁸⁹ there is no reason to think that zoning based on an evaluation of social costs would be so held.

The bonding system, common to all seven state laws, shows great promise as a device to redistribute costs to bring private and social costs in line. These bonds are required of strip miners before they begin operations and are released upon the completion of specified reclamation activities. Unfortunately, there is little evidence that the bonding system is being used as a device to direct reclamation along the socially most efficient path. Rather it is viewed only as a

86. A. V. Kneese, *Water Quality Management by Regional Authorities in the Ruhr Area, with Special Emphasis on the Role of Cost Assessment*, in Proceedings of the 1962 Meeting of the Regional Science Association (in press). See also other papers by Kneese for elaboration on the use of these techniques.

87. Sanitary Water Bd., Pa. Dep't of Health, *Experimental Rules and Regulations for the Operation and Maintenance of Strip Mines to Prevent Pollution of Waters of the Commonwealth* (1952) (mimeo.). The ORSANCO acid drainage control program is similar; see Raleigh, *Acid-Drainage Curbs Are Here*, *Coal Age*, April 1960, p. 80.

88. Dana, *supra* note 59. There was an additional legal question in this case involving mineral rights reserved when the land was taken into the national forest. However, the board was instructed not to consider this question but only to evaluate the long term public interest.

89. G. D. Sullivan, Presentation before the Mineral and Natural Resources Law Section, American Bar Association, Chicago, Aug. 12, 1963, pp. 11-12 (mimeo.).

club over the heads of the operators, and with lax administration it need not be a very heavy club. First, the amount of the bond is usually fixed by law. It is not varied with the character of the land, the proposed method of mining, the nature of the reclamation problem, or the past performance of the coal operator. Second, there is no attempt to use the bonds as a device to gather blocks of land into planned reclamation areas. One strip pit could be reclaimed for forest, the adjacent pit for meadow. Third, in many cases the bonds are set so low that it is cheaper to forfeit than to perform any reclamation. Finally, the bond is usually returned on the basis of certain activities, not on the basis of certain accomplishments. The fact of seeding, not of growth, is sufficient to have the bond released. In short, there is little economic rationale for the amount of the bonds or for their terms as they are used today. If, instead, the bonds were set according to some benefit-cost guidelines taking into account the nature and beauty of the terrain, proximity to urban areas, the time required for natural revegetation, and alternative uses of the land, among other things, the net benefits to society from the whole strip mining process would be significantly increased.

All of the methods suggested to achieve a socially preferable allocation of resources would require more complex administrative procedures than do the current across-the-board rules. Public intervention is never costless. The justification for the added administrative costs lies in the social gains that can justifiably be expected from the application of economic concepts to the problems created by strip and auger mining. Finally, there is every reason to think that the strip mining industry could accommodate itself to a new regime. It is a remarkably resilient industry that has taken many other problems in its stride. With further research it may appear that the socially optimal position is not so privately expensive after all.

CONCLUSION

This is an opportune time to review the problems associated with strip and auger mining for coal. Public concern is high, and this concern derives increasingly from the desires of numerous individuals and groups residing in urban areas, rather than from those few whose interests are directly affected. The legislatures of a number of states have considered new or amended strip mine laws in the past year or two. Such legislative proposals invariably generate

even broader public interest. The chairman of the mineral law section of the Pennsylvania Bar Association noted that the 1963 amendments to the strip mine laws of that state were "the single, most controversial piece of legislation of the past decade."⁹⁰

With passage of the Appalachian Region Development Act of 1965,⁹¹ strip mining has become for the first time an explicit concern of the federal government. This federal concern is potentially the most important development for solution of the problems of strip and auger mining. The act authorizes the spending of funds to cope with the effects of both surface and deep mining. Indeed, President Johnson, upon the insistence of Governor Scranton, agreed to substantially more funds than had originally been proposed.⁹² Additionally, Senator Lausche's perennial bill to authorize a federal study of strip mining, which in other years had aroused vehement opposition and had never passed out of committee, was incorporated almost completely in the act as one of the few sections made applicable to the entire country rather than solely to Appalachia.⁹³ The importance of this new federal involvement in relating the problems of local and Appalachia is reflected in the strong positions taken outside of government. At one end are those who see an expanding coal industry, largely by means of strip and auger mining, as the key to Appalachian redevelopment. At the other end are those, like Harry Caudill, who claim that the social costs of strip mining in the mountains are so high that it should be completely prohibited.⁹⁴

With interest focused on strip mining from a number of sources, there is danger that the desire for action will foster uneconomic or

90. D. B. Dixon, *Report of the Mineral Law Section*, 34 Pa. Bar Ass'n Q. 456, 457 (1963).

91. 79 Stat. 5 (1965) [Pub. L. No. 89-4, 89th Cong., 1st Sess. (March 9, 1965)].

92. *Washington Post*, April 23, 1964, p. A-6, col. 1, and April 29, 1964, p. A-11, col. 1.

93. Pub. L. No. 89-4, § 205(c), U.S. Code Cong. & Ad. News, March 20, 1965, pp. 100-01.

Struck by the inconsistency of proceeding simultaneously with reclamation and with a study of how best to go about it, Senator Lausche succeeded in having the Appalachian Bill amended to provide that no federal funds be spent to restore privately owned strip land, pending completion of the study. Immediate reclamation of public land is permitted. Pub. L. No. 89-4, § 205(d), *id.* at 102. (This amendment to the bill was one of two passed on the floor of Congress. *Washington Post*, Feb 2, 1965, p. A-4, col. 2.)

Some work on the application of benefit-cost analysis had already been started in the Department of the Interior. Interview With E. H. Montgomery, Resources Program Staff, Dep't of the Interior, June 3, 1964.

94. H. M. Caudill, *Appalachia: Path From Disaster*, *The Nation*, March 9, 1964, p. 240. The special supplement to *The Courier-Journal* stated that such a prohibition would be ideal, but that it was unattainable. *Kentucky's Ravaged Land*, *Louisville Courier-Journal*, Jan. 5, 1964, p. 13 (special supplement). See also Knabe, *supra* note 56, at 141-42.

inconsistent programs. The problem is basically one of allocation of resources. An unregulated market will not produce a socially optimal allocation because of technical externalities. The purpose of this paper has been to indicate that a rational public approach to this problem, based on benefit-cost analysis, is within the capabilities of our analytic methods. Three different but interrelated goals have been implied, goals that may complement or oppose the others.⁹⁵ The first goal is national productivity, maximization of the net value of output from the resources that society puts into production. This goal is presumably approached by firms operating through the market system in response to free consumer choice. However, it is also this goal that requires government intervention to minimize the total of all costs associated with an optimum level of strip and auger mining whenever (1) costs associated with mining need not be considered by miners, or (2) a regional or multipurpose reclamation program would be more efficient than a mine-by-mine approach.

The second goal includes cultural and aesthetic values that cannot, for one reason or another, be put directly into the cost minimizing calculation. They are represented by constraints on the system forcing it away from the minimum cost point. The implication is that added benefits received are greater than added costs incurred. The importance of this quality of the environment goal is increasing. A substantial proportion of the public seems to be opting for beauty, or at least for the absence of ugliness.

The third goal for programs of strip mine reclamation is redistribution of income to individuals in stripped areas whenever these areas fall within the scope of the poverty program. For our purposes, this goal can be narrowed to local employment. If local employment in certain areas is accepted as a benefit, it follows that the "cost" of certain reclamation projects will be reduced to the extent that men who would otherwise be unemployed will secure jobs. On the other hand, if action directed to other goals reduces the amount of mining in some areas, an important conflict that must be resolved develops among the goals. Again, this goal of redistribution of income is real because the public seems to be opting for the elevation of poverty stricken areas.

The three goals of national productivity, quality of the environment, and local employment together represent a rationale for pub-

95. Bowman and Haynes outline policy criteria for eastern Kentucky in terms of a set of goals, and I have drawn upon their formulation. Bowman & Haynes, *Resources and People in East Kentucky 259-66* (Johns Hopkins Press for Resources for the Future, Inc. 1963).

lic policy on strip and auger mining. By the use of benefit-cost analysis conducted under constraints, an explicit and flexible framework becomes available for considering both regulation of existing surface mines and reclamation of the "orphan pits" abandoned in earlier years. Unfortunately, we are still a long way from having the data necessary to make such analyses. If the primary purpose of this paper is to emphasize the applicability of economic analysis to strip and auger mining, its secondary purpose is to indicate the lack of appropriate data and to stimulate the collection of it.