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ESTIMATING ENVIRONMENTAL DAMAGES FROM SURFACE MINING OF COAL IN APPALACHIA: A Case Study

Industrial Environmental Research Laboratory
Office of Research and Development
U.S. Environmental Protection Agency
Cincinnati, Ohio 45268

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ESTIMATING ENVIRONMENTAL DAMAGES FROM SURFACE MINING OF COAL IN APPALACHIA: A CASE STUDY

by

Alan Randall, Orlen Grunewald, Angelos Pagoulatos,
Richard Ausness, and Sue Johnson
The University of Kentucky
Lexington, Kentucky 40506

Contract No. 68-01-3586

Project Officer

John F. Martin
Extraction Technology Branch
Industrial Environmental Research Laboratory
Cincinnati, Ohio 45268

INDUSTRIAL ENVIRONMENTAL RESEARCH LABORATORY
OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
CINCINNATI, OHIO 45268

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FOREWORD

When energy and material resources are extracted, processed, converted, and used, the related pollutional impacts on our environment and even on our health often require that new and increasingly more efficient pollution control methods be used. The Industrial Environmental Research Laboratory-Cincinnati (IERL-CI) assists in developing and demonstrating new and improved methodologies that will meet these needs both efficiently and economically.

This report presents the results of a case study to determine the costs of environmental damage from strip mining in Appalachia. Its conclusions show that various regulatory frameworks, such as federal legislation or an economic incentive program, can reduce the value of environmental damage. This information should prove useful to those interested in formulating or enforcing surface mining laws, and to those individuals charged with evaluating environmental concerns and conducting similar economic case studies. For further information, contact the Extraction Technology Branch of the Resource Extraction and Handling Division.

David G. Stephan
Director
Industrial Environmental Research Laboratory
Cincinnati

ABSTRACT

The major objectives of this research were to develop a methodology for valuation, in economic terms, of the environmental damage from surface mining; to apply that methodology in an empirical case study of the environmental damage associated with surface mining of coal in Appalachia; and to estimate, in economic terms, the value of the environmental damage from surface mining of coal in the case study region, under four alternative regulatory frameworks.

A coherent methodology for economic valuation of the environmental damage from surface mining is presented in this report. This methodology is entirely consistent with economic theory and the principles of benefit/cost analysis, and incorporates market and non-market goods and private and public goods into the analysis. It is consistent with a framework appropriate to many problems in natural resource economics: an activity (in this case, surface mining) changes resource quantity and/or quality attributes, which in turn affects the net value of those resources in later uses.

The empirical case study was conducted in the watershed of the North Fork of the Kentucky River, a mountainous region which includes parts of six counties, four of which have been heavily impacted by surface mining of coal. The value of environmental damage from surface mining for coal in the study region was estimated under four alternative regulatory regimes: (1) the existing regulations, (2) a "no regulations" regime, (3) a regulatory regime similar to that which would be established by a Federal surface mining and reclamation bill, and (4) an alternative regulatory framework, generated by the research team, which relies more heavily on economic incentives for damage prevention and reclamation. In this case study, legal, economic and sociological analyses were integrated.

Estimates of five categories of damage were presented: aesthetic damage; deterioration of water quality for domestic, commercial and industrial uses; damages from increased flooding; damage to land and buildings; and damage to fish, wildlife and recreation related activities.

Findings were that (1) surface mining in the study region generates environmental damage of substantial economic magnitude; (2) existing Kentucky regulations reduce the value of that damage; (3) a Federal bill, similar to that introduced in the 1977 Congress would further reduce the value of damage; (4) a regulatory alternative which places more emphasis on economic incentives is worthy of further study; and (5) given current reclamation technology some of the environmental damage from surface mining in the mountainous study region is irreversible.

This report was submitted in fulfillment of Contract No. 68-01-3586 by the University of Kentucky under the sponsorship of the U.S. Environmental Protection Agency. This report covers the period January 25, 1976, to June 17, 1977.

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SECTION 1

INTRODUCTION AND SUMMARY

The research project reported herein had the following objectives:

1. To review the scientific literature pertaining to the environmental damage associated with the various surface mining industries in America.

2. To review the literature on valuation of the economic costs of environmental damage.

3. To select a region in Appalachia in which to conduct an empirical case study.

4. To develop a methodology for the estimation of the economic costs of environmental damage from surface mining of coal in the case study region.

5. To estimate the economic costs of environmental damage from surface mining of coal in the study region, under the existing regulatory framework, a "no regulations" framework, and two alternative regulatory frameworks.

6. To evaluate the methodology developed under objective 4, and applied in the case study, to determine its adequacy in this use and the feasibility of its application to problems involving surface mining for coal in other regions and surface mining for other minerals throughout the United States.

The study region selected was the watershed of the North Fork of the Kentucky River, which includes parts of Breathitt, Knott, Lee, Letcher, Perry and Wolfe counties, in eastern Kentucky. Coal extraction, using surface mining and deep mining methods, is the major basic industry in the region, which has a relatively undiversified economy. Thus, economic dependence on the coal industry and the government sector characterizes the regional economy. It is a mountainous region, where surface mining for coal is performed using the contour mining and mountaintop removal techniques.

Regional population declined rapidly throughout the 1950's and 1960's as outmigration proceeded apace. However, population stabilized and, in some counties, grew during the 1970's, when improved economic conditions in the coalfields in a period of nationwide economic stagnation led to return migration. By many socioeconomic criteria, the population remains of

relatively low income, poorly educated, and poorly housed and provided with medical services. The dependency ratio is relatively high.

Surface mining in the study region causes disturbance of soil and vegetation, erosion, sedimentation, and increased run-off. These phenomena lead to flooding, landslides, impairment of water quality, disturbance of the land and water ecosystems, and aesthetic damage. Almost every facet of daily life, economic and social, is affected by the impacts of surface mining.

The methodology developed and applied in estimating the economic value of the environmental costs of surface mining in the study region is based upon a relatively simple concept. Surface mining affects resource quality which, in turn, affects the values which people obtain from later uses of those resources. In concept, surface mining may affect resource quality favorably or unfavorably and may have beneficial or adverse affects on the net present value of later uses. In this study, it was found that most, but not all, of the environmental affects of surface mining were adverse.

A variety of techniques are used to estimate the change in net value of particular later uses as a result of mining-induced changes in resource quality. No one technique is applicable for all of these tasks. For most valuational purposes, well-known and accepted techniques are used. In the case of aesthetic damages, the bidding game technique, which has been used previously in a relatively few pioneering studies, is used with notable success.

Thorough legal analysis of all four regulatory alternatives were completed (Appendix A). Then, the impacts of these regulatory alternatives were calculated, using accepted techniques of economic analysis consistent with the methodological framework developed in Section 3. The regulatory alternatives were examined to determine which particular mining and reclamation practices each would mandate or necessitate. The impact that the practices mandated or necessitated by each regulatory alternative would have on the physicial effects of mining on resource quality were determined in consultation with a highly qualified expert on surface mine reclamation. Then, economic analyses were performed, to calculate the estimated economic costs of environmental damage in the study region under each regulatory regime.

Finally, the methodology used in this case study was evaluated, and its general applicability to the valuation of the environmental costs of surface mining was considered.

Conclusions

Major findings and conclusions of the research are summarized below.

1. The research methodology and valuation techniques used in this study are conceptually valid and appropriate for the valuation of

the economic costs of surface mining.

2. Major inadequacies in economic information and data from the physical and natural sciences were faced in this case study.

3. In spite of the data limitations encountered in this case study, the case study region is probably better served with basic data than many other surface mining regions. Therefore, increased knowledge of the social costs of surface mining is dependent on increased research in the physical, natural, and economic sciences.

4. It is desirable that sociological studies accompany economic analysis. In this case study, it was found that (a) sociological studies shed additional light, beyond that shed by purely economic analysis, on some of the human dimensions of the environmental impacts of surface mining, and (b) the sociological analyses tended to corroborate the results of economic analysis.

5. Regulatory frameworks are superimposed upon an existing body of private law and, in application, may perform somewhat differently than was intended by those who passed the enabling legislation. Thus, economic evaluation of regulatory alternatives should be based on careful legal analyses.

6. The total economic costs of environmental damage from surface mining in the study region under the existing regulatory framework were estimated as follows:

a) Regional willingness to pay (R.W.P.) for relief from the environmental impacts of surface mining was estimated, in 1976 dollars, to be $3,556,000 annually, for the whole study region, given the current pattern of mining. The present value of R.W.P. amounted to $1,910 per hectare mined, or $0.40 per metric ton of coal mined.

b) Total consumer payment (T.C.P.) was estimated at $58,995,000 annually for the whole region, $45,030 per hectare mined and $9.14 per ton of coal mined.

The logical bases for the RWP and TCP estimates of the total environmental costs of surface mining in the study region are explained in detail in section 4. It is clear that RWP provides an underestimate of the lower bound of these total costs. On the other hand, the TCP estimate is based upon specific assumptions which ensure that it is an upper bound estimate of the total costs.

It should be noted that data limitations encountered in this case study ensured underestimation of some categories of environmental damage.

7. If there were no regulations pertaining to surface mining and reclamation in the study region, the present value of the environmental

costs of surface mining would be $101,825 (TCP) and $9,472 (RWP) per hectare mined, and $20.64 (TCP) and $1.92 (RWP) per metric ton of coal mined.

The social benefits of reclamation occuring under existing regulations are estimated at $11.50 (TCP) and $1.52 (RWP) per metric ton of coal mined. For purposes of illustration, note that the costs to coal operators of achieving reclamation under existing regulations are about $0.90 per metric ton of coal mined.

8. The costs of environmental damage under regulatory alternative 3, which is similar to recently proposed Federal surface mining and reclamation legislation, are estimated to be $27,016 (TCP) and $1,076 (RWP) per hectare mined, and $5.48 (TCP) and $0.22 (RWP) per metric ton of coal mined.

The social benefits of reclamation under regulatory alternative 3 exceed those under alternative 1 by $3.66 (TCP) and $0.18 (RWP) per ton of coal mined. For the purposes of illustration, note that the costs to coal operators of achieving reclamation under alternative 3 exceed those under alternative 1 by about $1.90 per metric ton of coal mined.

9. A quite different form of regulation, based on flexible bond and bond return provisions, is considered. This form of regulation has certain inherent economic advantages. This alternative is explained and its economic impacts estimated (section 6).

10. This study generated strong evidence that some of the aesthetic impacts of surface mining in the mountainous environment of the study region are irreversible, given current reclamation technology. In other words, the best reclamation practices available do not eliminate all of the aesthetic damage caused by surface mining.

SECTION 2

THE STUDY REGION

The watershed of the North Fork of the Kentucky River was selected as the study region for the empirical case study performed as a part of the project.

REGIONAL CHARACTERISTICS

General Physical Characteristics

The watershed of the North Fork of the Kentucky River is wholly contained in the Commonwealth of Kentucky. It embraces portions of Breathitt, Knott, Lee, Letcher, Perry, and Wolfe counties in the southeastern section of the state. The North Fork is the largest of the three major branches that form the Kentucky River. It starts near the Virginia border, and meets the Middlefork to form the main branch of the River about 6.5 kilometers above Beattyville. A drainage area of 487,694 hectares surrounds the 238 kilometer length of the North Fork. The elevation of the River varies from a maximum height of 340 meters to 190 meters at the lowest point. The average slope of the river is 0.6 meters per kilometer with a range from 0 to 4 meters per kilometer [21].

The North Fork lies entirely within the Mountains and Eastern Coal Field Region. Stretching along the Western edge of the Appalachian Plateau, this area is referred to as the Cumberland Plateau and is subdivided into the Plateau Area and the Mountain and Creek Bottom Area. The Plateau forms the small Northern portion of the watershed and is less rugged than the Mountain and Creek Bottom area. Sandstone, siltstone, shale and coal underlie the Plateau area with occasional limestone outcrops in some of the valleys. Coal mining is not a significant activity in the Plateau. Most of the watershed is in the rugged Mountain and Creek Bottom area, which is a true mountain area with high and sharp-crested peaks, narrow valleys and very little flat land except in the floodplains. The ridges generally run in a Northeast-Southwest direction and become more rugged as one moves southwestward. Abundant coal reserves exist in this more mountainous area [21].

Elevations of ridgetops in the Mountain and Creek Bottom Area typically range from 430 meters to 490 meters above sea level. Comparative elevations in the Plateau Area range from 275 meters to 335 meters. The saw-toothed crests of the extremely rugged southern portions of the watershed reach as high as 990 meters. The generally steep slopes vary from 20 to 60 degrees. Stream slopes of the North Fork vary from 2.5 meters per kilometer in the headwaters to little more than zero where it meets the Middle Fork [21].

Map 1

TOPOGRAPHIC MAP

SCALE IN MILES
WOLFE
WEST BREATHITT
KNOTT
PERRY
LESLIE
HELCHER
Jackson
Hazard
Viper
Cornettsville
Daisy
Slemp
Blackey
Carcassonne
Jeremiah
Mayking
Millstone
Thornton
Isom
Happy
Roxana
Skyline
Flint
Partridge
Delbarton
Gilley
Green
Sauk
Avawam
Christopher
Lothair
Bloomfield
Cordia
Dwarf
Ritchie
Ivis
Maflie
Spider
Redfoot
Sackett
Carbon
Glade
Poly
Neon
Fleming
Seco
Kona
Hopkins
Dorton
Garrard
Tayo
Butcher
Kingston
Bowlingtown
Gayes Creek
Talcum
Garner
Cebum
Blindman
Pippa Passes
Hollybush
Sheilwa
Elite
Puncheon
Omaha
Beaver
Deane
Mine
Ambulgey
Anco
Wisconsin
Cassatras
Littcarr
Boyd
Bolyn
Mousie
Yellow Mtn
Vest
Soft Shell
Rayes
Elmstock
Handshoe
Gray Horse Hill
Deboy
Evanston
Vail
Wilstacy
Cherokee
Sassafras
Talbert
Crockettville
Beech
Wolf Coal
Astro
Manuel
Eagle
Blue Diamond
Harveyton
Pardourly
Dorton
Lost Creek
Hard Rock
Noble
Rockcastle
Little
Rockcastle
Rockcastle
Stevenson
Rouseau
Kesk
Malverde
Elkhorn
Lovall
Kenton
Oneida
Rockcastle
Malaga
Rosefork
Lee City
Gillmore
Stillwater
Trent
Bastista
Campton
Ravenna
Kerby Knob
Pebble
Crestmont
Hazelbaya
Pebble
Sebastian
Hollybush
Campbell
Valley
Rock Lake
Eastbed
Yahatan
Burbank
Ball
Alpine
Ewan
Valena
Dalton
Gatewood
Tilda
Ridge
Bethelridge
Rockcastle
Pebble
Mt Way
Lena
Wolfe
Pebble
Sebastian
Sebastian
Lee
Wolfe
Wolfe
Wolfe

The Breathitt Formation of Middle Pennsylvanian Age is the dominant geologic formation. It varies in thickness from about 300 meters in the northeast to over 600 meters in the southwest. Most of the coal seams are less than 120 centimeters thick though some outcrops of 300 centimeters occur locally. Upland soils, reflecting their parent rock formation and topography, are primarily residual soils composed of weathered limestone, shale, siltstone or sandstone with some loess and wind-blown silt in the surface layers. Soils are generally thin on hill and mountain sides whereas thick, younger alluvial soils are found in the narrow valleys along river and stream bottoms [21].

Climate and Hydrology

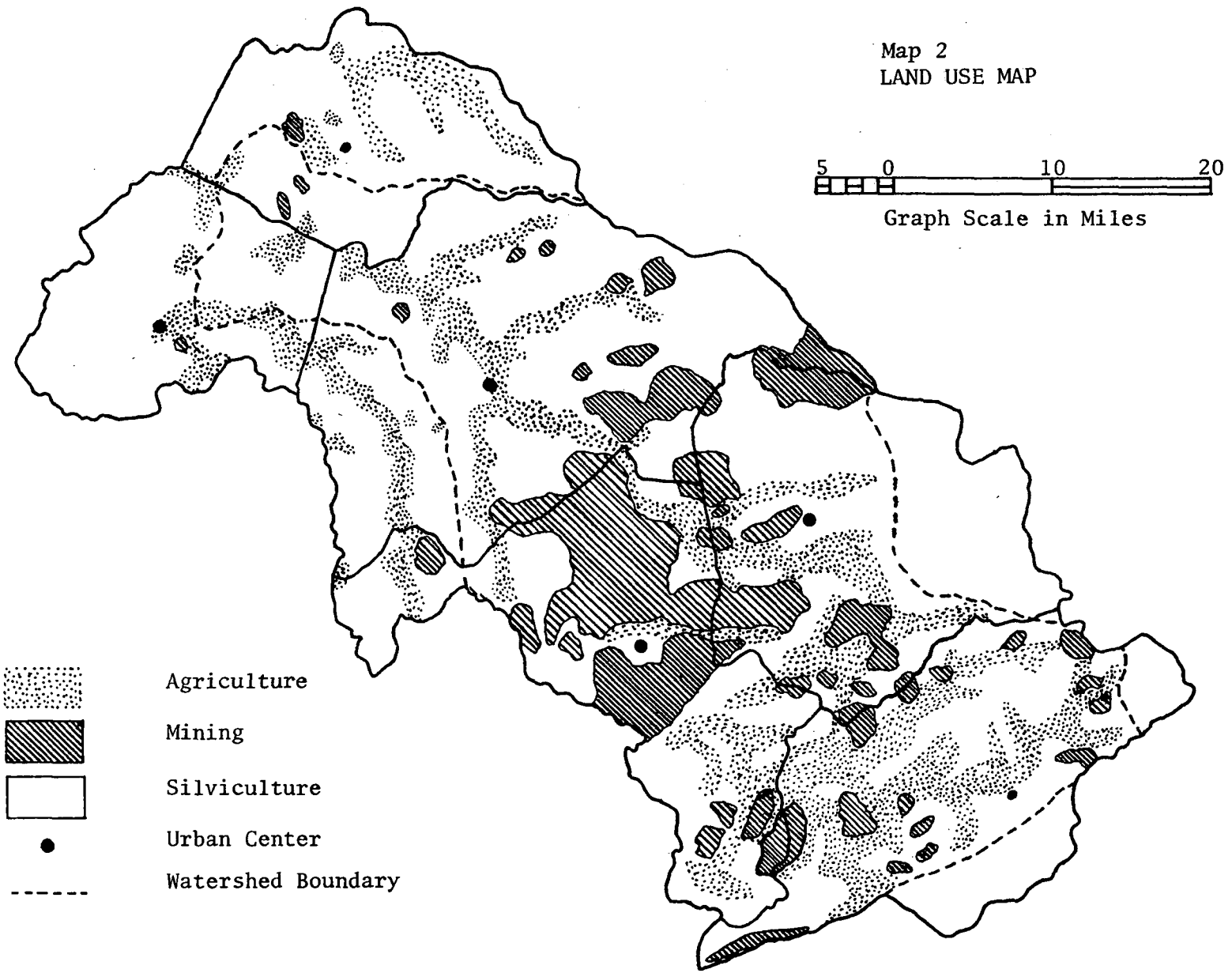
The climate of the region is relatively mild; average yearly temperature is 14° C with average summer highs of 23° C and average winter lows of 2° C. Temperature extremes and heavy snowfall are generally infrequent and of short duration. Prevailing winds are from the west-southwest. Precipitation in the North Fork Area averages about 117 centimeters a year. It is generally evenly distributed throughout the year. Flooding, mostly in the smaller mountain streams, is most likely to occur in the spring. The maximum rainfall which can be expected in a 48 hour period once in 25 years is about 14.3 centimeters; once in 100 years a 17.6 centimeter fall can be expected [22]. While these maximum rainfalls are similar to the rest of Kentucky, the topography of the North Fork Area results in a relatively high frequency of severe flash floods of rather short duration, especially in the narrow valleys surrounding small streams and tributaries[21].

There are no natural lakes in the North Fork area. To help meet water supply needs and provide flood protection, two lakes have been constructed in Letcher and Knott counties. Carr Fork Lake in Knott County is a Federally-funded installation with a 287 hectare surface area and a 799 hectare meter capacity. The smaller state-funded Fishpond Lake in Letcher County has a 12.55 hectare surface area and a 127 hectare meter capacity [21].

Potable groundwater can be found in the region from 60 meters to more than 600 meters below the surface. Groundwater flow is among joint systems, fractures and bedding planes of the sandstone, siltstone, shale and coal strata. Moderately-soft groundwater from valley wells of 60 meters or less usually provides enough water for household consumption in the area. The numerous small springs in the area usually dry up in the summer [21].

Vegetation, Wildlife and Land Use

Originally, the North Fork Area was covered by mostly deciduous trees with scattered patches of conifers. Valleys were cleared by early settlers and the virgin forest was selectively logged for timber. The non-commercially valuable trees and successional growth contributed to the current diverse, degraded and unmanaged nature of much of the forests. Red maple, American birch, sweet maple and flowering dogwood are common species. Rhododendron and mountain laurel shrubs are also commonly found. Bottom land vegetation is generally riparian,e.g. box elder, black willow, and


Map 2
LAND USE MAP
5
0
10
20
Graph Scale in Miles
Agriculture
Mining
Silviculture
Urban Center
Watershed Boundary

sycamore. Wildlife resources in the area include deer, raccoons, squirrels, grouse and quail. Common species of fish include smallmouth bass, rockbass, muskellunge and suckers [2,5,29].

Most land in the study region remains in forests or unmanaged woodlots. In 1970, the percentage of land classified as forest-woodland ranged from sixty-four percent in Wolfe County to eighty-eight percent in Breathitt County [table 1]. Federal land use in Lee and Wolfe counties is primarily National Forest, though there are no National Forests within the watershed study area [17]. Pasture and crops use accounts for twenty-three percent of the land in Wolfe county and sixteen percent in Lee county. The average figure for the North Fork area is ten percent. Use of the land for growing crops has generally been declining in the North Fork area; land used for pasture has increased. The 1969 Census of Agriculture put the average value of agricultural production at 100 dollars per hectare or less and the average value of farm land and buildings at 500 dollars/hectare [30]. Urban use which now accounts for two percent of the land in the area, is generally on the increase, especially in Knott and Wolfe Counties. Land surrounding Carr Fork Reservoir, recently completed, will provide the major developed outdoor recreation site in the watershed [23]. Of the 29,000 hectares devoted to public and private recreation in the study area, less than two percent has been developed and only two percent is currently available for water related activities.

Mining currently uses 2.6 percent of the land in the region. Perry and Letcher Counties are heavily surface mined: almost 6 percent of land in Perry and more than 3 percent in Letcher County has been mined. In Lee and Wolfe counties, mining uses less than 1 percent of the total land.

Transportation

The topography of the North Fork area limits the construction of transportation arteries. Kentucky Route 15 is the major road in the area and it is a two-lane highway linking the northern and southern portions. Other internal roads are generally narrow and winding. Linking the North Fork area to the urban areas of Kentucky is the Mountain Parkway, which collects traffic from Route 15. The Daniel Boone Parkway provides transportation from the center of the area to the western part of the state. Railroad lines run along the North Fork of the Kentucky River primarily to haul coal. Hazard and Whitesburg have airports but have no commercial traffic [23].

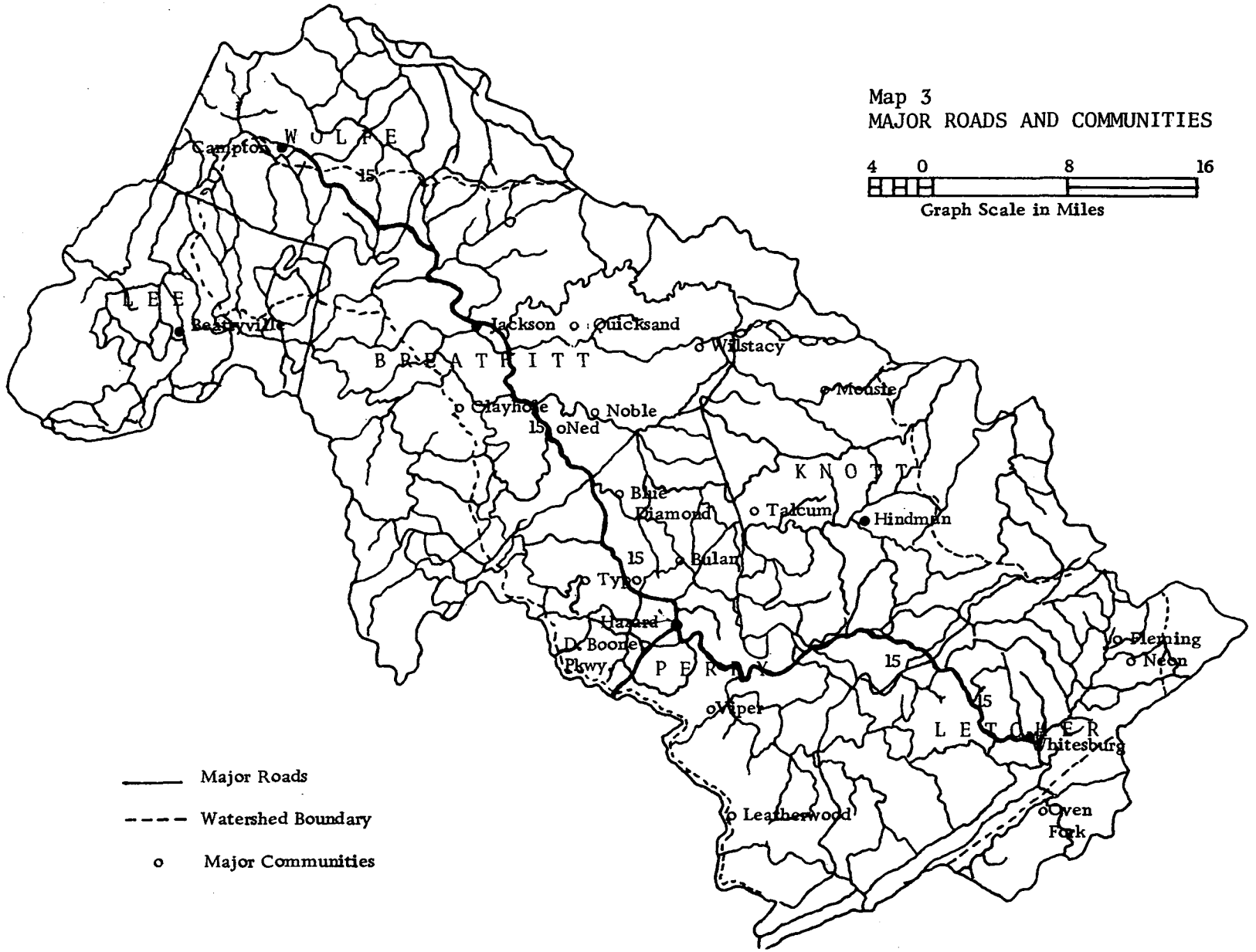
Socioeconomic Data

The population of the North Fork area is, for the most part, rural. Houses are scattered throughout the countryside, or clustered in small settlements along the valleys. Hazard and Whitesburg, small cities, are the largest urban places in the region [19]. Of the cities and towns in the region, only Hazard shows any sizeable population growth over the 1960-1970 decade. In the same period Seco lost eighty-three percent of its population, Whitesburg lost thirty-six percent and Fleming lost twenty-nine

Table 1
LAND USE: PERCENTAGE OF TOTAL LAND IN EACH USE 1958 AND 1967

County*	Year	Cropland	Pasture-Land	Forest Woodland	Federal (Non-Crop)	Urban-Built-Up	Water	Other
Breathitt	1958	11.4	2.5	81.7	0.0	1.2	0.5	2.7
	1967	4.4	2.6	88.4	0.0	1.5	0.6	2.5
Knott	1958	3.5	0.7	81.6	0.0	1.5	0.0	12.7
	1967	3.1	3.3	86.7	0.0	2.4	0.0	4.5
Lee	1958	7.2	4.5	74.9	5.0	1.8	0.0	6.6
	1967	4.5	11.0	76.1	5.1	1.9	0.2	1.2
Letcher	1958	2.0	0.8	89.3	0.0	1.9	0.4	5.6
	1967	2.5	6.3	86.2	0.0	2.0	0.4	2.6
Perry	1958	2.3	1.5	78.6	0.0	2.0	0.6	15.0
	1967	2.9	1.6	85.3	0.0	2.1	0.6	7.5
Wolfe	1958	7.5	6.8	56.7	9.7	2.0	0.0	17.3
	1967	8.0	14.7	63.8	9.8	2.5	0.0	1.2
TOTAL	1958	5.9	2.4	78.9	1.6	1.7	0.3	9.2
	1967	4.0	5.5	83.0	1.7	2.0	0.3	3.5

Figures are computed from base data total acres.
Source: Kentucky Soil and Water Conservation Needs Inventory, 1970.


Map 3
MAJOR ROADS AND COMMUNITIES
4 0 8 16
Graph Scale in Miles
WOLFE
LEE
BREATHITT
KNOTT
PERRY
LETCHER
Campton
Beattyville
Jackson
Quicksand
Willstacy
Mousie
Clayhole
Noble
Ned
Blue Diamond
Talcum
Hindman
Bulan
Typo
Hazard
D. Boone Pkwy
Viper
Leatherwood
Fleming
Neon
Whitesburg
Oven Fork
15
Major Roads
Watershed Boundary
Major Communities

percent (32).

Compared to the national population, the study area population tends to be concentrated in the young and elderly age groups. Young and middle-aged adult groups are under represented. Households in the study area have relatively high dependency ratios and the "productive" age group (18-64) forms a smaller proportion of the population than is characteristic of either Kentucky or the U.S. (table 2). The population aged over the 1960-70 decade, showing both a decline and fertility and outmigration of the young, though this latter trend may now be in the process of revising.

The typical level of educational attainment among the residents is low, about eight years, with a sizeable proportion of young people not completing high school (table 3). Over seventy-five percent of the adult population did not complete high school. Median family income is far below the U.S. median and some $3-4,000 below the Kentucky median (table 4). Letcher and Perry counties are the most prosperous counties and Wolfe county is the poorest in terms of the median family income. Approximately one-half to one-third of a typical poor family's income comes from transfer payments in all but Perry county. About half the area's families fall below the poverty line compared with a U.S. average of about ten percent. (26).

Housing generally reflects the poverty that characterizes the area. A majority of houses are at least twenty years old, and often older than thirty. Proportionally, there are more crowded households than is typical in the U.S. or Kentucky. Over ten percent of the housing units in Perry and Wolfe counties are vacant and the other counties also show a high proportion vacant, in part due to the high outmigration from the region. About half the houses lack at least one standard plumbing facility. The median value of houses in the area is $5000 as contrasted with $12,600 for Kentucky and $17,100 for the U.S., again reflecting the poverty of the residents (26).

The range of services and amenities provided in the North Fork region is rather meager. Elementary and secondary education tends to be poorly financed. The area is served by three junior colleses and one small, four-year institution (23). Health facilities are also inadequate. There is a severe shortage of doctors and other medical personnel (26). One doctor serves an average of over 2,000 people, compared to a national average of one doctor per thousand persons. There is a total of 276 hospital beds in the region. Fewer than twenty dentists work in the North Fork area. All the counties maintain a health department and, except in Wolfe County, services are also provided by a regional Home Health Agency. An anbulance service in Hazard serves the area (23).

Water and sewer facilities are generally poor throughout the area Approximately seventy-five percent of the residents have no public water or sewer system serving their homes. This can be compared to the seventy-five percent of the U.S. population who do have such facilities (24). County seats, however, are served by city water and sewer systems. Except for urban areas, little exists in the way of garbage collection. Dumping in unauthorized sites is quite common in the area (23).

Table 2
POPULATION AND AGE CHARACTERISTICS 1970

County	Total Population	Age: Under 6 %	6-17 %	18-64 %	65 & Over %	Median Age of Population
United States (000)	203,166	10.3	24.1	55.7	9.9	28.1
Kentucky (000)	3,218	10.3	24.3	54.9	10.4	27.5
Breathitt	14,221	11.1	30.0	48.8	10.1	23.6
Knott	14,698	11.4	29.1	49.8	9.7	24.0
Lee	6,587	9.9	27.1	48.8	14.1	29.4
Letcher	23,165	10.5	27.3	51.6	10.6	27.4
Perry	26,259	12.0	26.9	49.1	9.9	25.3
Wolfe	5,669	8.9	29.4	48.3	13.5	27.9

Sources:

U.S. Bureau of the Census, Census of Population, 1960, General Population Characteristics, Kentucky, PC (1) - 19B.

U.S. Bureau of the Census, Census of Population, 1970, General Population Characteristics, Kentucky, PC (1) - B19.

Table 3
YEARS OF SCHOOL COMPLETED BY THE ADULT POPULATION

County	Less Than 8 %	Less Than 12 %	12 Years %	Over 12 %
Breathitt	48.0	78.8	10.2	11.0
Knott	44.8	81.2	9.6	9.2
Lee	44.6	83.4	9.5	7.1
Letcher	40.8	80.7	12.4	6.9
Perry	39.6	75.8	14.5	9.7
Wolfe	48.4	83.4	8.8	7.8
Total				
Kentucky	23.6	61.5	24.1	14.4
United States	15.5	47.6	31.1	21.3

Sources:

U.S. Bureau of the Census, Census of Population, 1960, General Population Characteristics, Kentucky, PC (1) - 19B.

U.S. Bureau of the Census, Census of Population, 1970, General Population Characteristics, Kentucky, PC (1) - B19.

Table 4
PERSONAL INCOME BY SOURCE, 1960 AND 1970, KENTUCKY COUNTIES

	United States ($ Billions)	Kentucky ($ Millions)	Breathitt	Knott	Lee	Letcher	Perry	Wolfe
WAGES								
1970	541.4	6,633.3	9.4	9.8	5.3	42.2	38.6	3.2
1960	270.8	3,139.0	5.9	5.9	3.5	28.9	30.4	1.3
PROPRIETORS								
FARM								
1970	15.5	425.6	1.0	0.0	0.3	0.1	0.0	1.2
1960	12.0	298.0	0.8	0.5	0.3	0.0	0.2	0.9
NON-FARM								
1970	51.0	729.1	1.0	1.6	1.2	4.3	4.9	0.6
1960	36.2	393.0	0.5	0.3	0.3	1.6	2.8	0.2
PROPERTY								
1970	113.0	1,121.0	0.9	1.8	1.1	3.9	3.4	0.3
1960	52.6	514.0	0.3	0.3	0.3	1.2	2.0	0.1
TRANSFER PAYMENTS								
1970	79.6	1,136.0	6.5	6.4	3.3	11.2	12.5	2.6
1960	28.5	438.0	2.4	2.4	1.1	4.8	5.7	0.9
TOTAL PERSONAL INCOME								
1970	800.5	9,719.6	18.3	19.2	10.8	59.7	57.4	7.8
1960	400.1	4,702.0	9.9	8.9	5.5	36.6	41.1	1.3
GOVERNMENT INITIATED								
1970		1,428.2	3.5	4.6	1.8	5.6	8.1	1.5
MEDIAN FAMILY INCOME								
1970	9,590	7,441	3,176	3,279	3,390	4,407	4,607	2,694
1960	5,660	4,051	1,432	1,876	1,847	2,615	2,689	1,455

Source: Ralph J. Ramsey and Paul D. Warner, Kentucky County Data Book, Univ. of Ky. Cooperative Extension Service and Department of Sociology, Lexington, 1974.

There are library facilities in every North Fork county with the exception of Knott County. Perry and Letcher counties have quite modern libraries. Each county has a weekly newspaper as well as access to regional daily newspapers. Radio and television are available, the latter often through cable service. There are numerous churches. Each county has at least one small bank and the more populous counties have two. Motel and motel rooms and private recreational facilities are quite limited. (18)

Labor Force Composition and Employment

The North Fork area has historically suffered from chronic unemployment and underemployment in spite of the recent upsurge in the coal industry, unemployment rates remain high (table 5). The economy of the area is relatively undiversified and heavily dependent on the coal industry. Mining alone accounts for forty percent of all employment in Letcher county (table 6). The proportion of the labor force engaged in agricultural pursuits has been steadily dropping. Trade and government sources of employment are growing in importance (table 6). There is very little manufacturing activity.

Women account for less than one-third of the labor force in all the study counties.* Three-quarters of the women in Breathitt, Letcher and Wolfe counties are not in the labor force.

Table 5
RATE OF UNEMPLOYMENT BY BOUNTY, 1975

County	Rate of Unemployment (%)
KENTUCKY	7.3
Breathitt	8.9
Knott	9.0
Lee	13.3
Perry	7.5
Wolfe	10.9

Source: Kentucky Department for Human Resources, Kentucky Labor Force Estimates, Annual Averages, Frankfort, Ky. 1975.

THE COAL INDUSTRY

Eastern Kentucky produced 80,047,850 metric tons of coal and employed 36,759 men in coal mining in 1975 (table 7). There were 6,776 men employed in coal mining in the study region, producing 22 percent of eastern Kentucky's coal output. In the North Fork region, 95 firms engaged in surface mining in 1975 (table 8). Approximately half of these firms produced only

*Calculated from tables in Industrial Sources, Kentucky Department of Commerce, for each county.

Table 6
CIVILIAN EMPLOYMENT BY INDUSTRY, 1970 KENTUCKY COUNTIES
IN PERCENTAGES

	United States (000)	Kentucky	Breathitt	Knott	Lee	Letcher	Perry	Wolfe
Agriculture	3.7	7.3	6.4	0.2	0.4	0.1	2.7	19.2
Mining	0.8	2.8	5.9	18.4	15.4	41.4	19.9	3.1
Construction	6.0	7.6	10.6	13.6	12.6	5.1	6.2	6.1
Manufacturing	25.9	27.6	7.3	5.0	11.9	4.6	3.8	17.6
Transportation Communication Utilities	6.8	7.1	4.3	6.9	6.5		8.4	3.8
Trade	20.1	20.2	15.7	13.9	18.2		21.9	9.7
Personal Service	4.6	5.3	3.7	3.2	6.7	4.1	4.3	3.0
Health Service	5.5	5.3	0.7	2.8	2.3	5.8	4.3	2.4
Education	8.0	8.7	26.5	20.0	10.8	9.0	9.4	16.3
Public Administration	5.5	5.1	9.3	7.0	6.1	4.5	8.7	9.8
All Other	8.0	7.1	6.8	7.4	5.3	5.8	8.0	9.1
Total	76,554	1,008,758	2,944	2,823	1,368	5,095	5,805	1,056

Sources:

U.S. Bureau of the Census, Census of Population, 1970 General Social-Economic Characteristics, Kentucky. PC (1)-19C.

Table 7
NUMBER OF MINES, COAL PRODUCTION, AND EMPLOYMENT IN EASTERN KENTUCKY, 1975

Counties	Number of Mines			Production (metric tons)			Men Employed		
	Total	Underground	Surface	Total	Underground	Surface	Total	Underground	Surface
Eastern Kentucky Total	3356	1120 1720 ?	1636	80,047,850	38,953,770	41,094,080	36,759	20,857	15,902
Six Hazard District Counties*	720	370	350	17,881,441	5,794,209	12,087,232	6,776	3,713	3,063
Breathitt	73	1	72	5,605,827	50,503	5,555,324	708	17	691
Knott*	124	76	48	1,751,389	818,538	932,851	874	569	305
Lee	24	4	20	198,610	8,890	189,720	117	17	100
Letcher	303	222	81	4,418,116	3,094,997	1,323,119	2,740	2,249	491
Perry*	182	67	115	5,742,092	1,821,281	3,920,811	2,266	861	1,405
Wolfe	14		14	165,407		165,407	71		71

Source: Annual Report, Kentucky Department of Mines and Minerals, 1975. *Data For Perry and Knott Counties pertain to the sections of these counties which are in the Hazard District as defined by the Department. The Hazard District includes all of the North Fork Area.

three percent of the output while the largest six firms produced 59 percent. Surface mining has steadily been increasing in importance and in 1975 accounted for 68 percent of the regional coal production [table 9]. Surface mining output surpassed underground mining production in every study area county except Letcher.

Surface mining occurs throughout the region but is concentrated in several intensively mined areas. These include the head waters of Quicksand Creek in Breathitt county; the watersheds of Troublesome, Lost, Buckhorn, and Grapevine Creeks centered near the boundary between Breathitt and Perry counties; the North Fork itself near Hazard; Leatherwood Creek in Perry county; the stream valleys of Lotts Creek, Balls Fork, Troublesome Creek and Carr Fork close to the county bondary between Perry and Knott counties; and substantial portions of Line Fork, Rockhouse Creek, and the North Fork in Letcher County.

Table 8
COAL PRODUCTION IN THE NORTH FORK WATERSHED, BY SIZE OF FIRM

Coal Production Class (Metric Tons)	No. of firms	Percent of total Production
Below 22,678	47	3.3
22,679 to 45,358	13	3.5
45,359 to 90,717	11	5.8
90,718 to 226,795	12	15.8
226,796 to 453,591	6	13.0
453,592 to 907,184	5	25.6
907,185 and above	1	33.0
	95	

Source: Annual Report, Department of Mines and Minerals.

Environmental Impacts of Surface Mining

Prior to the enactment of surface mine reclamation legislation in Kentucky in 1966, surface mining in the region was conducted under minimal legal restraint (see Section 6 and Appendix A). The conventional method of contour mining was commonly used. This method involves removal of the stratum above the outcrop of coal until the coal is exposed. In the crudest form of contour mining, the overburden is simply pushed down the outslope. After the coal is removed, a bench is left. The width of the bench depends on economic and topographical factors. The slope of the hill determines the rate at which the overburden becomes deeper as the mining operation moves toward the center of the hill. The cost of mining and the price of coal determines the maximum depth of overburden which can profitably be removed. When this maximum depth of overburden has been removed, a vertical highwall remains exposed. Some additional coal may then be

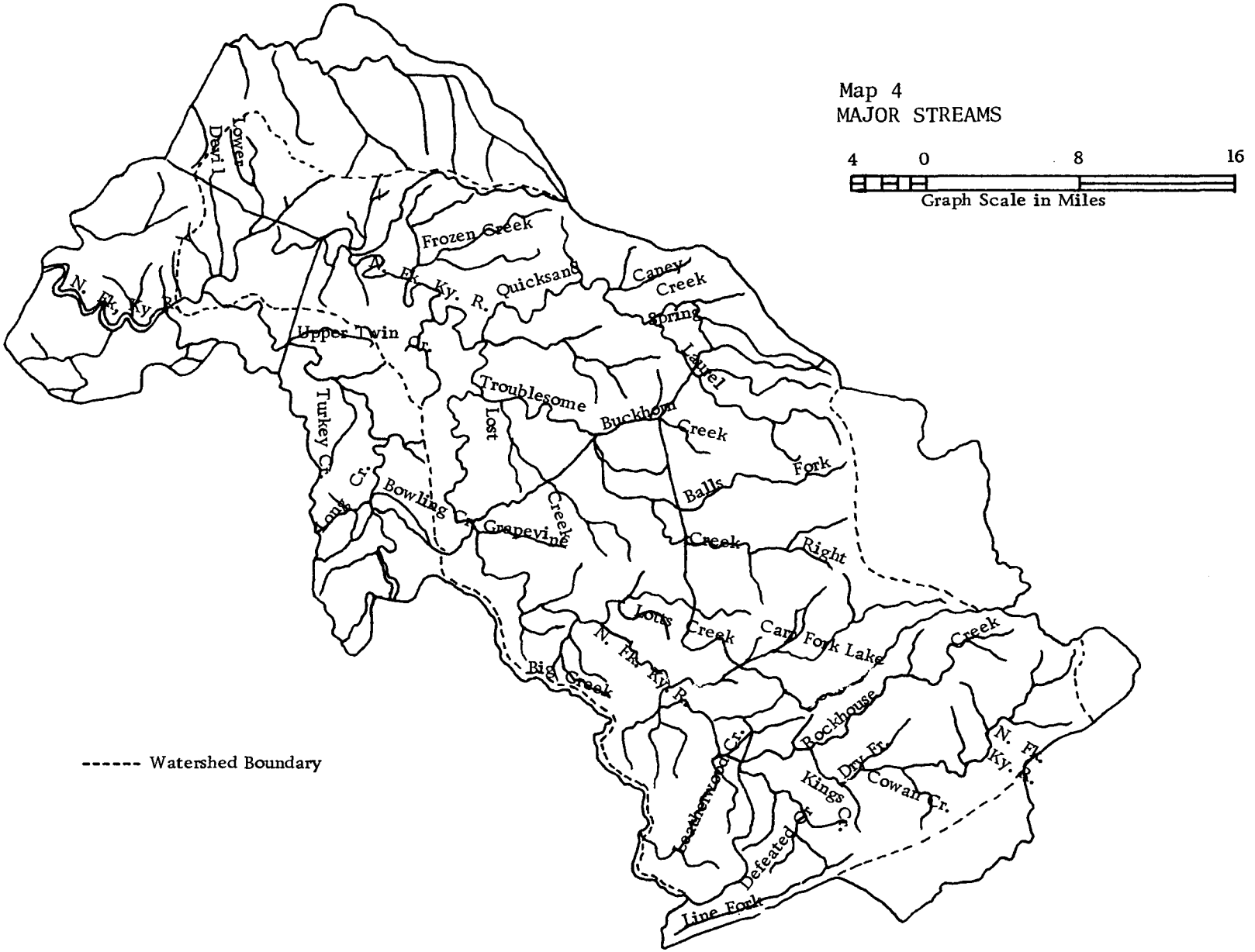
Table 9

COAL PRODUCTION IN METRIC TONS, HAZARD MINING DISTRICT COUNTIES
1961-1975

Year	Type of Mine	Breathitt	Knott	Lee	Letcher	Perry	Wolfe	Total
1975	Surface	5,555,324	932,851	189,720	1,323,119	3,920,811	165,407	12,087,232
	Underground	50,503	818,538	8,890	3,094,997	1,821,281		5,794,209
1974	Surface	3,727,784	1,113,287	204,215	1,724,208	3,092,899	12,648	9,875,041
	Underground	51,066	1,179,769	18,416	3,239,519	1,939,775		6,428,545
1973	Surface	4,298,738	786,751		1,432,236	2,835,928		9,353,653
	Underground		835,503	16,012	2,819,320	2,275,352		5,966,187
1972	Surface	4,146,222	567,323		2,141,802	2,238,428		9,093,775
	Underground	726	864,875	15,127	2,617,107	2,239,478		5,737,313
1971	Surface	2,355,649	1,444,064	9,783	2,436,133	3,880,014	14,572	10,140,215
	Underground	23,614	951,630	18,523	3,111,792	2,611,400		6,716,959
1970	Surface	1,617,343	1,297,258	113	2,851,647	4,427,920	9,337	10,203,618
	Underground	21,355	1,496,962	24,526	3,853,022	2,773,541		8,169,406
1969	Surface	1,358,963	982,070	91	1,462,492	3,051,765		6,855,381
	Underground	14,923	1,258,430	17,627	4,132,246	2,447,676		7,870,902
1968	Surface	426,445	495,854	54	882,602	1,885,705		3,690,660
	Underground	21,319	1,174,104	24,240	4,590,627	2,096,065	91	7,906,446
1967	Surface	879,969	597,174	454	909,661	1,934,585		4,321,843
	Underground	89,475	1,340,542	18,434	5,061,799	2,424,792	635	8,935,677
1966	Surface	519,913	903,859		766,988	1,638,094		3,828,854
	Underground	72,303	1,747,453	21,228	5,222,502	2,651,294		9,714,780
1965	Surface	331,765	663,565		840,976	1,567,370		3,403,676
	Underground	71,115	1,201,081	431,313	5,010,223	2,101,053	4,890	8,819,675
1964	Surface	18,144	350,109		584,532	1,588,286		2,541,071
	Underground	96,013	1,363,153	104,767	4,933,067	1,905,134	7,979	8,410,113
1963	Surface	62,653	797,920		472,142	1,136,865		2,469,580
	Underground	166,869	1,442,058	75,276	4,396,723	2,184,748	8,849	8,275,523
1962	Surface	86,183	620,845		496,575	739,635	272	1,943,510
	Underground	507,775	1,244,283	45,777	3,948,009	2,470,348	10,363	8,226,555
1961	Surface	415,971	364,901		276,878	508,171	837	1,566,758
	Underground	494,570	1,295,160	40,311	3,797,899	2,612,770	11,394	8,247,104
	Total:	27,482,692	30,151,372	1,284,897	78,425,843	69,001,183	248,274	206,594,261

Source: Annual Report, Kentucky Department of Mines and Minerals, 1961-75.

*See Footnote, Table 7.


Map 4
MAJOR STREAMS
4 0 8 16
Graph Scale in Miles
Lower Devil
N. Fk. Ky. R.
Frozen Creek
N. Fk. Ky. R.
Quicksand
Caney Creek
Spring
Upper Twin Cr.
Isabel
Troublesome
Buckhorn
Creek
Turkey Cr.
Lost
Fork
Balls
Bowling Cr.
Creek
Grapevine
Creek
Right
Lonts Cr.
Lotts Creek
Carr Fork Lake
Creek
N. Fk. Ky. R.
Big Creek
Rockhouse
Dry Fr.
N. Fk. Ky. R.
Kings Cr.
Cowan Cr.
Leatherwood Cr.
Defeated Cr.
Line Fork
------ Watershed Boundary

extracted by the use of augers inserted into the exposed vertical face of the coal seam. Conventional contour mining thus leaves substantial coal, under relatively deep overburden, unexploited. Augering allows only about a 35 percent recovery rate of reserves within reach of the augers. When the mining operation was completed, it was common practice to simply abandon the site.

Unregulated contour mining in mountainous terrain caused very substantial off-site environmental damage during and after mining, in addition to despoiling the mining site and leaving it in a condition which discouraged productive post-mining land uses. Types of off-site environmental damage include:

- landslides, resulting from failure to properly stabilize overburden deposits;
- increased run-off which results from soil disturbance and removal of the vegetative cover and causes increased flooding, soil erosion, siltation of streams and water impoundments, and sediment load in streams
- deterioration in water quality which results when soil disturbance and exposure of coal and toxic materials in layers near the seam increase the sediment load and the content of certain chemicals in run-off waters[3].

On-site and off-site damage resulting from surface mining may include aesthetic damage, disturbance to ecosystems and noise pollution from explosions and operation of mining equipment [3].

The pattern of mining in the mountainous terrain is much influenced by the economic conditions prevailing in the market for coal. Mining sites may be temporarily abandoned when prospects for profitable mining become less favorable. During the period of abandonment, the mine site is left in a disturbed state which results in continued off-site damages. Mine sites may be re-opened some years after reclamation, in times of highly favorable coal market conditions, in order to either mine further toward the center of the hill or mine a deeper seam. Since stabilization and re-vegetation of a mine site after regrading takes many years, the interruption of the process increases off-site damage.

There have been several research projects on the environmental impacts of surface mining conducted in the study region. The Southeastern Forest Experiment Station has engaged in research in the Breathitt county area for many years. Numerous studies have been conducted by this group in the areas of geology, hydrology, forestry, soils, range and wildlife and engineering. Curtis has done numerous studies on the hydrologic effects of surface mining [9,10,11,12,13]. His studies of six small watersheds indicate that surface mining has a pronounced impact on suspended sediment levels, peak discharge levels, and chemical pollutants; especially sulfate, calcium, and magnesium in the streams. These studies generally indicate that acid mine drainage is not a major problem in the North Fork Watershed. A water quality study of 415 locations in the North Fork supported the contention that acid mine drainage is not a major problem [14]. Branson and Batch found that suspended sediment in the same Breathitt county area

reduced fish populations in the streams [4]. Weigle found that slides are a common occurence from contour mining in Eastern Kentucky [34]. In another study, Weigle found that erosion from abandoned coal haul roads in Eastern Kentucky represents an important environmental impact [33].

A major study which has documented the impact that surface mining has on water quality and land disturbance has been completed in the Quicksand Watershed in Breathitt county [2]. In that study water quality samples were taken from several sites within the watershed during a one year period. In general, surface mined areas were shown to have higher levels of various chemical constituents. Another major purpose of the study was to identify and map land use, including land used for surface mining, for the entire Quicksand Watershed.

Before the building of the Carr Fork Dam in the southeastern portion of the watershed, the U.S. Army Corps of Engineers conducted a study of surface mining in the Carr Fork Watershed [28]. The study focused on the potential effects that surface mining would have on the proposed lake project. In the study, various land disturbance analyses and water quality analyses were conducted. In general, it was found that acid drainage was was not a serious water problem but sedimentation affected every stream in the basin.

One of the most complete studies of the environmental impacts of surface mining in Eastern Kentucky was conducted by the U.S. Geological Survey on the Beaver Creek Basin [7]. Findings indicated that strip mining of coal in the Beaver Creek basin has significantly increased the acidity and mineralization of surface and ground water and increased the sediment content of streams. These factors in turn reduced or eliminated aquatic life in streams.

A major study of the techniques of surface mining in Eastern Kentucky [1] concluded in 1975 that the environmentally damaging impacts of contour mining can be reduced through the use of various modified mining techniques and reclamation practices. Unfortunately, the study noted, these techniques were not being used as frequently as desirable. Nevertheless, the enactment of more stringent surface mining and reclamation regulations and improved enforcement of regulations have resulted in a progressive improvement in the environmental performance of the surface mining industry in Kentucky since 1966. Abandonment of unreclaimed mine sites is no longer permissible and the deposition of overburden on the outslope is restricted. Sedimentation structures to control run-off from surface mines are required.

Two relatively new mining methods, head-of-hollow fill and mountain-top removal, are becoming more common in the region [2, 15]. Both methods were designed to improve reclamation and resource extraction efficiency. Using the head-of-hollow method an operator would place the spoil in a hollow which has been scalped of vegetative cover and provided an internal drain. The surface of the head-of-hollow is graded and revegetated. With mountain-top removal the first cut is made along the contour line as in contour mining. The spoil from the first cut is placed on the slope or in a hollow

fill and in subsequent cuts spoil is placed on the previously mined bench. These two methods alter the area by providing relatively flat land in a generally mountainous area.

The Area of Land Disturbed by Surface Mining in the Study Region

During surface mining, the total area of land disturbed is substantially more than the area mined. The additional land is used for spoil deposition, access and haul roads, etc. Howard [16] has calculated that in Eastern Kentucky, 4932 metric tons of coal are produced for each hectare of land disturbed.

For the purposes of this study, it was necessary to estimate for the study region (1)the area of land currently in a disturbed state due to mining and reclamation in progress, (2) the area which has been previously mined and is now reclaimed, and (3) the area of mined and abandoned lands called "orphan lands".

The area of land currently disturbed was calculated under the assumption that land remains disturbed for approximately three years after the initiation of mining. Production records for the six counties for 1973 through 1975 were obtained [20]. The proportion of total production from surface mines in the six counties which falls inside the North Fork watershed boundaries was estimated using land use maps. Total study area production was then divided by 4932 to estimate the number of acres currently disturbed in the study area. It was found that 6,000 hectares of land was in a disturbed state due to surface mining, at the end of 1975. Of that area, mining had been initiated on 2,142 hectares during 1975.

Estimates of the area of reclaimed land and orphan land were derived from a study [2] which used high and medium altitude aerial photography. For these purposes, the estimates from aerial photographs are preferred to estimates derived from production data, because the former method eliminates the possibility of double counting areas which have been mined more than once while the latter method does not. It was estimated that, in the study area, there were 7,393 hectares of mined-and-reclaimed land and 671 hectares of orphan mine lands in 1975.

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SECTION 3

THEORY, METHODOLOGY AND RESEARCH TECHNIQUES

VALUE AND VALUATION

The Simplest Case

For bundles of goods which represent small increments in the total stock of a given commodity, the price established in unregulated competitive markets is taken as the value of each unit. To arrive at the value of the bundle, the quantity of units in the bundle is multiplied by the parametric price. The competitive price is taken as the measure of value since it is freely arrived at in a process of voluntary exchange. The amount of money that buyers are willing to pay is equated with the amount which will induce sellers to voluntarily relinquish the goods.

Thus, for bundles of goods which represent small increments in the total stock of a given commodity which is frequently traded in unregulated markets, valuation presents few conceptual difficulties. The relevant quantity is determined, and is multiplied by the observed market price.

Valuation is often performed in a comparative framework where alternative situations or courses of action are being compared, and information on the economic consequences of the alternatives is sought. The alternatives under consideration may result in differing kinds and amounts of outputs being produced, outputs of differing quality and thus differing unit prices being produced, and/or the use of differing kinds and amounts of inputs. For valuation of each alternative, the task is to determine the relevant quantities and prices, and calculate the net value of output,

$$\sum^{n} p_i q_i - \sum^{m} p_j x_j$$

where

p_i = price of output i; i=1,....,n.
q_i = quantity of output i
p_j = price (cost) of input j,j=1,....,m.
x_j = quantity of input j.

For comparative valuation exercises for short-run decisions, the net value of output under each alternative is compared. If one alternative is the existing situation (ie. no change) and another involves a change from the existing situation, the net benefits (positive or negative) of the change are equal to

$$(\Sigma p_i q_i - \Sigma p_j x_j)_p - (\Sigma p_i q_i - \Sigma p_j x_j)_{\bar{p}}$$

where the subscripts, p and $\bar{p}$ signify "with the proposed change" and "without the proposed change" respectively.

If the decision-maker faces a cost constraint, then the quantities of inputs and outputs should be chosen so as to maximize the net value of output, subject to the cost constraint, for each alternative under consideration.

For decision involving comparisons of long term investments, the net present value of output from each alternative should be compared. Present value of a stream of revenue, R, is

$$P.V.(R) = \sum^{n} \frac{R_t}{(1+i)^t}$$

where R_t = revenue in year t; t = 1,....,n.

i = the rate of interest, commonly called the discount rate.

Where projects involving large capital investments are to evaluated, a benefit/cost ratio may be calculated. A commonly used form of benefit/cost ratio is

$$\frac{B}{C}$$

where B = benefits, defined as net present value of outputs, which is equal to:

$$P.V.[(\Sigma p_i q_i - \Sigma p_j x_j)_p - (\Sigma p_i q_i - \Sigma p_j x_j)_{\bar{p}}], \text{ and}$$

C = costs, defined as net present value of project costs, which is equal to:

$$P.V.(C_p - C_{\bar{p}})$$

A proposed project is judged to be efficient if

$\frac{B}{C} > 1.0$, that is, net benefits are in excess of costs.

While several projects are being considered by an agency or firm with a limited budget, efficiency is served when projects are selected in decreasing order of the size of the benefit/cost ratio, selecting no further projects when the budget is exhausted, or the benefit/cost ratio of the highest ranked remaining project is less than 1.0, whichever occurs first.

The foregoing has been a concise statement of the conceptual framework

in which the economic value of goods is determined and the economic merits of alternative situations, courses of action, and long-term investment projects may be estimated. For many decisions of major social consequence, valuation is complicated because one or more of the assumptions of the above-stated conceptual framework are violated in significant ways. Of particular concern in the study are violations of the following two assumptions: (1) that the bundle of goods represents a small increment in the total stock of the commodity, and (2) that prices may be observed which were generated in unregulated, competitive markets.

Economic Surplus and Related Concepts

It is recognized that, when two parties who are rational and well-informed consummate a voluntary exchange, both realize some gains from the trade. Focusing on the buyer, his gains from trade may be defined as the integral below his demand curve and above the competitive price line. This has been called his consumer's surplus [24]. The logic of the concept is that the consumer who has a negatively sloped demand curve for the commodity and who buys n units at a parametric price p would have been willing to pay more than p for each of the first through n-1 units. The seller, too, experiences gains from the trade, if he is operating on a positively sloped supply curve for the commodity. He would have been willing to supply fewer than n units at prices lower than p. The integral above his supply curve and below the competitive price line is called his producer's surplus, which has been equated with economic rent [25]. The total economic surplus from the production, exchange and consumption processes is the sum of consumer's and producer's surplus.

For valuation, the consumers' surplus should be included in the total value of a bundle of goods. For bundles of goods which represent small increments in the total stock of a commodity, which has many close substitutes, consumers' surplus may safely be ignored since it will be small and approaching zero. In other cases, consumers' surplus must be considered. Where, for example, the bundle of goods represents a substantial proportion of the stock of a commodity which has no close substitutes, in a given and relatively isolated market, consumers' surplus will be a major component of total value. Where such a good is unpriced, consumers' surplus will represent the total value of the bundle of goods.

Unfortunately, the concept of consumers' surplus is not as simple as the foregoing comments might suggest. Hicks [18] reformulated the concept of consumers' surplus to define four consumers' surpluses, each appropriate to a particular set of circumstances and each different under the most likely set of assumptions. Compensating variation (C.V.) is appropriate to analyses which leave the consumer in his initial welfare position following a price change. Equivalent variation (E.V.) leaves the consumer in his subsequent welfare position in the absence of the price change. Compensating surplus (C.S.) and equivalent surplus (E.S.) are similar to C.V. and E.V., respectively, except that the consumer is constrained from making quantity adjustments to price changes [18].

The Hicks reformulation of the concept of consumers' surplus

contributed to the current relatively widespread acceptance of the concept in empirical analyses, and spawned a voluminous theoretical literature. Machlup [22], for example, identified not just four but ten measures analogous to consumer surplus in particular situations. Recent articles by Currie et al [9], Harberger [15], Willig [39], Broadway [5] and Hause[16] are especially helpful in understanding the theoretical construct and empirical application of consumers' surplus.

Which measures of consumers' surplus are appropriate and in what circumstances? For goods which are divisible and additive (i.e. the most commonly observed type of goods, which Samuelson [31] has called "private goods", the argument of Mishan [26] that E.V. and C.V. are the appropriate measures has been widely accepted. But, in what circumstances should each of these measures be used? For analyzing the impact of a price rise, E.V. answers the question: "how much would you be willing to pay to reserve your right to buy at the old price?", while C.V. answers the question: "how much would I have to bribe you, in order to induce you to accept the new price (assuming you retained the right to buy at the old price)?". Both E.V. and C.V. provide an answer to the question: "What is your welfare loss, as a result of the price rise?", but the answer given assumes a different distribution of rights at the outset. In positive analyses, E.V. assumes that the consumer is powerless to prevent the price rise, while C.V. assumes that the consumer has the power to prevent the price increase. For positive empirical analysis, it is appropriate to use the measure of consumer surplus relevant to the actual initial position of the consumer. In normative analyses, the use of E.V. assumes the consumer should be expected to pay the going price to buy those things he wants, while C.V. assumes the consumer should be compensated for changes in economic conditions which adversely affect him.

The problem of selection of the appropriate measure of consumers' surplus is empirically relevant only if the alternative measures yield different quantitative results. In most cases of practical concern, they do. For a price rise, C.V. is greater than E.V., in all cases where the Slutsky income effect [35] is positive, as it usually is. How much greater is C.V. than E.V.? If the commodity bundle concerned is a small part of the total consumption set, and if the income effect is small, the difference between C.V. and E.V. will be small [39]. Conversely, it the commodity bundle is a substantial part of the consumption set and/or the income effect is large, the difference between C.V. and E.V. is relatively large, and the selection of the appropriate measure of consumers' surplus remains an important consideration in empirical research.

There are some circumstances in which some authors have argued consumers' surplus does not capture all of the value of a good or resource. Consider a resource which is literally unique, for example, a plant or animal species or a natural phenomenon like the Grand Canyon or Kentucky's Red River Gorge. There are no perfect substitutes, and perhaps even no close substitute for these resources and the amenities they provide for people. Now, consider a course of action which may result in the loss, or the significant permanent modification, of a resource of this kind. Such a

change would be literally irreversible or reversible only at an immense cost in time and money.

The theory of valuation is not yet fully developed to handle irreversible changes. It is clear that the "reversible-irreversible" dichotomy is not particularly serviceable. The Second Law of Thermodynamics implies that, in a closed system, no change is reversible at zero cost. On the other hand, many changes loosely called "irreversible" may perhaps be reversed at less than infinite cost. Rather than attempt to conceptualize and develop a more adequate terminology, we will use the term "irreversible" to describe changes which can be reversed only at prohibitive expense (given current and expected technology).

When a change is determined to be irreversible, it does not follow automatically that the change is undesirable. The thing to be lost may have little value, relative to the benefits generated by the irreversible change. However, the possibility of irreversible change confronts the economist with some special problems in valuation. Valuation must be approached with great caution. Perhaps the present generation may be willing to permit the irreversible change in order to enjoy the benefits accompanying the change, but future generations (who are, of course, not party to current decisions) may have good reasons to wish the change had never been made. Tastes and preferences may change in the future. Technologies may develop which would permit future valuable uses to be made of resources which seem to have little value today. In either case, an irreversible change which seems to be of little consequence to the present generation may represent a significant loss to future generations. Economics has little ability to predict the future course of technological development or the tastes and preferences of generations yet unborn. In the context of intergenerational conflict, about all that economics can offer is a sound argument for caution in making irreversible change [20].

Irreversibility is not only of concern in the intergenerational context. People who are not presently using a particular resource, have never done so in the past, and who are uncertain as to whether they ever will in the future, may derive utility from the maintenance of resource quality because that would keep open their option for later use. The value of this source of utility has been defined as option value [7,20, 21,27,33]. Recent articles have considered whether option value is conceptually different from expected consumer surplus and have defined conditions under which option value, as distinct from expected consumer surplus, is positive or negative [7,27,33]. Regardless of the final resolution of this controversy, expected consumers surplus and option value (where it has a distinct existence) should be measured empirically. This logically implies that the total value of a unique resource of good which is threatened with irreversible change must be determined by aggregation of the values placed upon it by both its users and non-users.

Non-users may place another kind of value, distinct from option value or expected consumers' surplus, on a unique resource. This kind of value is independent of any possibility that the non-user may ever use the resource personally, in order to enjoy the amenities it provides. The

non-user may derive utility from the knowledge that the unique resource continues to exist (perhaps at a given level of quality). The value of this utility has been called preservation value or existence value [20]. This value, too, should be determined and is additive to the other kinds of value discussed above.

Market Imperfections

A second generic source of valuation problems arises from violations of the assumption that prices may be observed which were generated in unregulated, competitive markets.

For analyses which are based on a strict concept of economic efficiency, any deviation from efficient prices, such as may result from non-competitive market influences and direct or indirect price regulation, is a cause for concern. However, observed market prices of importance in this study are, for the most part, generated by markets which are reasonably competitive. The most significant pricing problem confronted in this study are the result of the absence of observable market prices.

Let us consider some characteristics of goods which are important in determining, first, whether a market in a particular good may exist and, second, whether the market, if it exists, is likely to generate efficient prices. Goods may be classified as private or public goods [30]. Private goods are additive and divisible, such that the total amount of a commodity consumed is equal to the sum of the amounts consumed by each consumer. Pure public goods, on the other hand, are neither additive nor divisible: the total amount, once made available, is equally available to all consumers and additional consumers can be added without diminishing the amount available to any consumer. It is difficult to find examples of pure public goods; among the best examples are T.V. and radio signals [10]. However, there are many examples of congestible public goods, which possess the following characteristics. Over some range, additional consumers may be added without effectively diminishing the amount available to any other consumers. Yet, eventually congestion begins to occur and the addition of consumers reduces the amount or quality of the good available to the original consumers. In other words, additional consumers may no longer be added at zero marginal cost. Then, as more consumers are added, the marginal cost of adding each one rises until it eventually becomes asymptotic to the vertical, at the point where an inflexible capacity constraint is reached [10]. Many goods and amenities associated with community facilities, recreational opportunities and outdoor environments have the characteristics of congestible public goods.

In order to consider the prospects for an efficient market in a commodity, one must also consider the rights associated with the goods. If a good is exclusive, that is, payment is associated with exclusive rights of use, a market can exist. A market in a non-exclusive good will not exist, since there is little reason to pay if payment does not ensure exclusive rights of use and, conversely, the good can be used without payment.

Goods may be produced and distributed in the following ways: (1) private production and voluntary exchange (the market system); (2) public sector production and distribution to buyers on a price (user charge or fee for service) basis, and the price may be arbitrarily set at greater than, equal to, or less than the average unit cost of production; and (3) production by the public sector or philanthropic organizations, and distribution at a zero price.

At long last, the punchline. All exclusive goods can be produced and distributed by methods (1) and (2). Exclusive, private goods can be produced efficiently in competitive market economies. Exclusive, public goods may be produced and distributed by methods (1) and (2), but in neither case is Pareto-efficiency possible [10]. Non-exclusive goods, both public and private, may be produced and distributed only by method (3), and Pareto-efficiency is impossible [10]. It should be pointed out that many non-exclusive goods are non-exclusive only as a result of legislative decisions. In these cases, exclusion requires that the law be changed to establish exclusive rights over these goods. Exclusion, however, is not cost -free activity, and some non-exclusive goods remain that way, even in economies oriented toward private enterprise, because the high cost of exclusion makes it economically infeasible.

Any good which is not produced and exchanged in the market may be called a non-market good. One category of non-market goods may have observable prices (those goods produced by the public sector and exchanged for a price, charge, or fee), yet it is uncertain a priori whether or not the observed price is efficient and thus an acceptable measure of unit value. Other categories of non-market goods have no observable prices. Non-market goods must be valued by other methods; usually by techniques designed to elicit value information from respondents, or by indirect observation based on information about the demand for closely related market goods. These techniques will be discussed later in this section. The foregoing discussion has aimed to place the concept of non-market goods in theoretical perspective and to demonstrate that non-market goods may include goods with many different kinds of economic characteristics.

A GENERAL MODEL FOR VALUATION OF THE COSTS OF ENVIRONMENTAL DAMAGE FROM SURFACE MINING

The environmental impacts from surface mining are expressed in terms of changes in resources quality. Mining has direct and indirect impacts on the quality of the resources of the Appalachian coal producing region. These resources have alternative later uses. The economic value of the environmental impacts of surface mining is conceptualized as the change, attributable to mining, in the net value of later uses of the impacted resources.

Since there are many conceivable uses for the natural and environmental resources of the Appalachian coal producing region, it is appropriate to focus on relationships between uses. Three kinds of relationships can be identified [11,19,36,37]: (a) neutral relationships between uses,

when one use has no effect on other uses; (b) complementary relationships, when one use increases the availability and/or improves the quality of resources for another use; and (c) competitive relationships, when one use adversely affects the quantity and/or quality of resources available for uses.

Resource supplies and demands are differentiated in terms of quality, as well as quantity, location and time. Resource quality is affected by a set of physical, chemical and/or biological parameters, and resource demands are expressed in terms of quality dimensions. Thus, a resource supply of a particular quality may not serve different sources of demand equally well.

It is in this context that we conceptualize environmental damage. Damage occurs when waste constituents from one use affect the quantity and/or quality of a resource supply so as to (1) preclude, (2) increase the costs, or (3) reduce the benefits of a later use of the resource. Thus, not all changes in resource quality are damaging; some changes may be beneficial to later uses. In empirical estimation of the economic value of environmental damage due to surface mining, it is appropriate to identify and evaluate, in addition to damages, any beneficial changes in resource quality that may be created.

In ascribing dollar values to the impacts of surface mining on environmental quality, later uses of affected resources are traced, and net economic values placed on the preclusion of later uses, losses of productivity of later uses and increased costs of treatments to restore or improve resource quality for later uses.

In the following pages, a model for determining the economic value of impacts of mining on environmental quality will be developed. This model provides a framework for identifying, first, the impacts of surface mining on resource quality and, then, the impacts of changes in resource quality on later uses. The model will permit the conceptualization of functional relationships among identified variables and will provide the logical basis for quantification of changes in resource quality and in the value of later uses.

The General Model

Surface mining changes resource quality and, thus, the net social benefits of later uses of these resources.

Let C_t denote the present value at time t of the future net value of environmental impacts of surface mining which takes place in time period t. It is hypothesized that the net economic value of the environmental impacts of surface mining will be negative, thus C denotes "net costs" of that damage.

$$\text{Then } C_t = \sum^{I} \sum^{J} \sum^{K} C_{ijkt} \qquad \ldots.(1)$$

where

C_{ijkt} = the present value of the net loss in social benefits of later resource use k (where k = 1,....,K), resulting from resource quality change j (where j = 1,....,J) which occured as a result of mining hectare i (where i = 1, ...,I) in time t.

For notational convenience, equations (2), (3), (4) and (6) are specified in present value terms, with a time horizon sufficiently long to capture all of the costs of damage stemming from surface mining of the hectare i. Thus, the subscript t may be omitted.

Now, let Π_k denote the net social benefits of later resource using activity A_k.

$$\text{Then } \Pi_k = \Sigma^{N} p_{kn} Y_{kn} - \Sigma^{M} p_{km} Y_{km} + V_k^* \qquad \ldots.(2)$$

where

P_{kn} = price of commodity n (where n = 1,....,N) produced in later use k.

Y_{kn} = quantity of commodity n produced in later use k.

p_{km} = price of input m (where m = 1,....,M) used in later use k.

X_{km} = quantity of input m used in later use k.

$V_k^* = V_{ko} - V_{kw}$

V_{kw} = value of capital stock associated with resource use k, given Q_{ijw}.

V_{ko} = value of capital stock associated with resource use k, given Q_{ijo}.

The terms Q_{ijw} and Q_{ijo} refer to the quantity and quality of resource attribute j when the hectare 1 is mined, and when it is not mined, respectively. Difference between Q_{ijw} and Q_{ijo} indicates the net impact of mining on resource attribute j, that is, Q_{ij}^*,

where

$$Q_{ij}^* = |Q_{ijw} - Q_{ijo}| \qquad \ldots.(3)$$

For each of the outputs Y_{kn} produced by resource using activity A_k, a production function can be specified which defines the impacts of resource

quality changes on both output and input levels:

$$Y_{kn} = f[\vec{X}_{km}, \vec{X}_{km}(\vec{Q^*_{ij}}),\ \vec{Q^*_{ij}}, V^*_k(\vec{Q^*_{ij}})] \qquad \ldots.(4)$$

where the superscript, $\rightarrow$, indicates a vector

Equations (2) and (4), together, specify the manner in which resource quality changes Q^*_{ij}, as a result of mining hectare i, influence the net value of later uses, A_k.

The total dollar reduction in the net social benefits of later resource use k, resulting from resource quality change j, which occurred as a result of mining hectare i is determined by equation (5).

$$C_{ijkt} = -\int_{Q_{ijo}}^{Q_{ijw}} \Pi_k dQ_{ij} \qquad \ldots.(5)$$

where

$$\Pi'_k = \sum^{N} p_{kn} \frac{\partial Y_{kn}}{\partial Q_{ij}} - \sum^{M} p_{km} \frac{\partial X_{km}}{\partial Q_{ij}} + \frac{\partial (V_k)}{\partial Q_{ij}} \quad , \qquad \ldots.(6)$$

That is, the marginal change in the net social value of resource use k, with respect to a change in Q_{ij}.

Taking equations (5) and (1), together, we obtain the total economic cost of damages from mining which occurs in time period 1.

This general model can be adapted to the estimation of the economic costs of environmental damage from surface mining. All that is required is the specification of relevant relationships, one by one, and the incorporation of these relevant relationships into the general model.

Mining of hectare i causes resource quality changes $\vec{Q^*_{ij}}$

where any $Q^*_{ij} = f(\vec{S_u};\ \vec{P_v})$ $\qquad \ldots.(7)$

where

$\vec{S_u}$ = a vector of variables describing mine site characteristics

$\vec{P_v}$ = a vector of variables describing mining process characteristics

A substantial but non-exhaustive list of these variables includes:

Site variables, S_u

S = slope of hillside mined below bench
D = distance to nearest stream from bench (meters)
OD = depth of overburden at highwall (meters)
OPH = overburden pH

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OFE = overburden Fe content (ppb)
OMN =     "      Mn    "    ( " )
OZN =     "      Zn    "    ( " )
OPB =     "      Pb    "    ( " )
OCL =     "   chloride "    (mils. per liter)
OSO =     "   sulfate  "    (mgs.   "    " )
ONO =     "   nitrate  "    ( "     "    " )
OCO =     "   carbonates and bicarbonates content mgs. per liter)
  V = vegetative cover of mine site, as a series of dummy vari-
      ables:
 V1 = 1:  site vegetation is a managed forest
    = 0:   "       "      is not a managed forest
 V2 = 1:   "       "      is an unmanaged woodlot
    = 0:   "       "      is not an unmanaged woodlot
 V3 = 1:   "       "      is grassland
    = 0:   "       "      is not grassland
    :
    :
    :
    :

RHL = length of haul road (meters)
RHD = average distance of haul road to stream (meters)
RHS = slope below haul road
RHG = gradient of haul road
P   = annual mean precipation (centimeters)
PI  = rainfall intensity (maximum expected rainfall in centimeters,
      in 24 hour period in 10 years)
DS  = stream mean discharge, when no mining is occurring in catch-
      ment basin
DSX = variables indicating discharge characteristics, flood
      stages, etc., when no mining......
    :
    :
    :
    :

  L = location of site, with respect to population concentrations
```

Mining Process Variables, P_V

```
 AD = number of hectares disturbed per hectare mined.
 TE = time elapsed from initiation of clearing for mining, until
      backfilling and grading is completed (months)
 TV = time elapsed from completion of backfilling and grading
      until establishment of satisfactory vegetative cover (months)
 M  = mining method, as a series of dummy variables:
 M1 = 1:  mining method 1
  2 = 0:  not mining method 1
 M2 = 1:  mining method 2
    = 0:  not mining method 2
```

:
:
:
:

R = reclamation method, as a series of dummy variables:
R1 = 1: reclamation method 1
= 0: not reclamation method 1
R2 = 1: reclamation method 2
= 0: not reclamation method 2
:
:
:
:

In table 10, those resource quality changes, Q^*_{ij}, which are hypothesized to be significant impacts of surface mining in the study area are listed as row titles. The sites and mining process variables, S_u and P_v, are listed as column titles. The cells of table 10 indicate the hypothesized direction of the impact of each mining site and process variable on Q^*_{ij}. An empty cell indicates that no significant impacts are expected. A + sign indicates that an increase in the value of the variable (S_u or P_v) is expected to increase the extent of the resource quality change. A negative sign indicates the opposite effect. The notation -, +, for example, indicates that both positive and negative impacts are hypothesized, but the negative effects are expected to be of greater magnitude. Where the site or process variable is discontinuous and therefore expressed as a series of dummy variables, a √ sign is used in all cells where some impact is expected.

Each row, therefore, can be read as a general form function,

$$Q^*_{ij} = f(\vec{S_u}; \vec{P_v})$$

and the + and - signs can be read as the hypothesized signs of the partial derivatives $\frac{\partial Q_{ij}}{\partial S_u}$ and $\frac{\partial Q_{ij}}{\partial P_v}$.

Having specified the relationships between site and process variables and resource quality changes, it is now appropriate to consider relationships between net value of later resource uses, Π_k, and resource quality. Table 11 shows the relationships which we have hypothesized. Row titles are A_k, resource using activities, and column titles are Q^*_{ij}, resource quality changes. The cells of table 11 indicate the hypothesized impacts of each Q^*_{ij} on Π_k, the net social benefits of resource using activity A_k. Notation in the cells is consistent with that in table 10.

Each row, therefore, can be read as a partial function,

$$\Pi_k = f(\vec{Q^*_{ij}}), \ldots\ldots),$$

Table 10.
HYPOTHESIZED IMPACTS OF MINE SITE AND MINING PROCESS VARIABLES ON RESOURCE QUALITY

Q_{ij} for j=1,.....,23 \ S_u, P_v	S	D	OD	OPH	OSO	OCL	ONO	OCO	OMN	OFE	OZN	OPB	V	RHL	RHD	RHS	RHG	P	PI	DS	DSX	L	AD	TE	TV	M	R
LAND																											
1. Vegetation Disturbance	+		+										✓	+		+			+				+	+	+	✓	✓
2. Soil Disturbance	+		+										✓	+		+	+	+	+				+	+	+	✓	✓
3. Erosion	+	+-	+										✓	+		+	+	+	+				+	+	+	✓	✓
4. Slides	+		+										✓	+		+		+	+				+	+	+	✓	✓
5. Damage to Roads	+		+										✓	+		+		+	+			+	+	+	+	✓	✓
6. Damage to Buildings	+		+										✓	+		+		+	+			+	+	+	+	✓	✓
7. Noise			+										✓									+	+			✓	✓
8. Flooding	+		+										✓	+	-	+	+	+	+	+-	✓		+	+	+	✓	✓
WATER																											
9. Discharge	+	-	+										✓	+	-	+	+	+	+	+	✓		+	+	+	✓	✓
10. Turbidity	+	-	+										✓	+	-	+	+	+-	+	-+	✓		+	+	+	✓	✓
11. Eutrophication	+	-	+										✓	+	-	+	+	+-	+-	-+	✓		+	+	+	✓	✓
12. pH	-+	-+	-+	+	-	-	-	-	+	+	+	+	✓	-+	-+	-+	-+	-+	-+	-+	✓		-+	-+	-+	✓	✓
13. Conductivity	+	-	+		+	+	+	+	+	+	+	+	✓	+	-	+	+	+-	+-	-+	✓		+	+	+	✓	✓
14. Hardness	+	-	+						+	+	+	+	✓	+	-	+	+	+-	+-	-+	✓		+	+	+	✓	✓
15. Sulfates	+	-	+		+								✓	+	-	+	+	+-	+-	-+	✓		+	+	+	✓	✓
16. Chlorides	+	-	+			+							✓	+	-	+	+	+-	+-	-+	✓		-+	-+	-+	✓	✓
17. Nitrates	+	-	+				+						✓	+	-	+	+	+-	+-	-+	✓		+	+	+	✓	✓
18. Mn	+	-	+		+				+				✓	+	-	+	+	+-	+-	-+	✓		+	+	+	✓	✓
19. Fe	+	-	+							+			✓	+	-	+	+	+-	+-	-+	✓		+	+	+	✓	✓
20. Zn	+	-	+				+				+		✓	+	-	+	+	+-	+-	-+	✓		+	+	+	✓	✓
21. Pb								+				+	✓	+	-	+	+	+-	+-	-+	✓		+	+	+	✓	✓
22. Sediment	+	-	+										✓	+	-	+	+	+-	+-	-+			+	+	+		
AIR																											
23. Dust			+										✓	+								+	+	+	+	✓	✓

Table 11

HYPOTHESIZED IMPACTS OF RESOURCE QUALITY CHANGES ON THE VALUE OF LATER RESOURCE USES

Resource Quality Changes Q_{ij} / Activities, A_k	Disturbance		LAND									WATER										AIR	
	Veg.	Soil	Soil Erosion	Slides	Damage To Roads	Damage to Buildings	Noise	Flooding	Discharge	Turbidity	Eutroph-ication	pH	Conduct-ivity	Hardness	Sulphates	Chlorides	Nitrates	M_D	F_e	Z_n	P_b	Sediment	Dust
k= j=	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1. Agriculture, crops	-+	-+	-	-	-	-		-+															
2. Agriculture, Livestock	-+	-+	-	-	-	-	-	-+				-	-	-	-	-	-	-	-	-	-		
3. Foresty	-+	-+	-	-	-	-		-															
4. Woodlots	-+	-+	-	-	-	-		-															
5. Minerals	+-	-+		-	-	-		-															
6. Oil & Gas	+-	-+		-	-	-		-															
7. Transportation	+-	-+		-	-	-		-															
8. Residential	-+	-+	-	-	-	-	-	-		-		-	-	-	-	-	-	-	-	-	-	-	-
9. Commercial	-+	-+	-	-	-	-	-	-		-		-	-	-	-	-	-	-	-	-	-	-	-
10. Industrial	+	-+	-	-	-	-		-		-		-	-	-	-	-	-	-	-	-	-	-	-
11. Aesthetic uses	-	-	-	-	-		-	-	-	-	-	-			-		-					-	-
12. Hunting	-	-	-	-	-		-	-															-
13. Hiking	-	-	-	-	-		-	-															-
14. Camping	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15. Nature Study	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
16. Fishing (Recreational)				-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
17. Swimming				-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
18. Boating				-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19. Fishing (Commercial)				-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

which is a partial representation of equation (4), and the + and - signs can be read as indicating the hypothesized sign of the partial derivative,

$$\partial \Pi_k / \partial Q_{ij}$$

This completes the general model for conceptualizing the economic costs of environmental damage from surface mining of coal in the study region. This model provides the conceptual basis for the empirical valuation which is performed in this case study. The model has several attributes which are worthy of some discussion.

Attributes of the General Model

The model is totally consistent with a conceptual framework widely used in natural resource economics: a resource using activity (in this case, surface mining) affects the quality of resources, thus affecting the net benefits derived from later resource uses. In many studies, this framework is implicit. In this study, the framework is explicitly presented in a concise and rigorous model which serves as a basis for empirical analysis.

The model is totally consistent with the concept of value, as presented at the beginning of this chapter.

The concept of the total net costs of environmental damage from surface mining in the study region, as used in the general model, is entirely consistent with the framework of benefit/cost analysis. However, it provides a part, but not all, of the information required for benefit/cost analysis. If it were desired to determine the social, as distinct from private, benefit/cost ratio of surface mining in the study region, the net total costs of environmental damage could readily be incorporated into the analysis. If it were desired to determine the social benefit/cost ratio of certain procedures for reducing environmental damage and reclaiming land subsequent to mining, the change (attributable to the procedures under consideration) in net total costs of environmental damage could be calculated and treated as a benefit of those procedures.

The model is conceptually able to handle resource quality changes which are reversible or irreversible. However, it has no intrinsic power to solve the problems of valuation of irreversible changes. Since some of these problems are relatively intractable, some aspects of the irreversibility question will be addressed independently of the analyses based on this model.

The model, as presented above is strictly applicable only to private goods. It can be modified, with relative ease, to incorporate the net collective benefits or costs of changes in the quantity or quality of public goods provided. Then, it can conceptually handle all market and non-market goods. Once again, this model is essentially an accounting tool, and the problems encountered in valuation of non-market goods must be solved prior to incorporation of non-market goods in the model.

While the model is designed to permit calculation of the economic costs of environmental damage from surface mining in the study region, no conceptual problem is presented by the accrual of some of these costs outside the study region. The empirical application of this model explicitly includes costs which are visited upon users of water in, or downstream from, the Kentucky River downstream from the study area.

VALUATION TECHNIQUES

As previously indicated, valuation of market goods is conceptually a relatively simple matter, if sometimes laborious and time consuming in practice. On the other hand, valuation of non-market goods requires that procedures be used which are often relatively ingenious but nevertheless not totally satisfactory.

Market Goods

In this study, market goods will be valued at their observed market prices. Thus, valuation, itself will not pose serious problems. However, the task of determining C_{ijkt}, where the activity A_k produces only market goods is not necessarily easy. The difficulty lies not in pricing inputs and outputs, but in determining the changes in inputs and outputs which result from the resource quality change, Q^*_{ij}. This requires substantial inputs from the natural and physical sciences, in order to establish the underlying relationships between surface mining and resource quality changes, and resource quality changes in the physical productivity of later uses. The procedures used for these purposes in the empirical case study are reported and the results presented in Section 4.

Non-Market Goods

The techniques which are designed for valuation in money terms of non-market goods fall into two broad categories, (1) those which attempt to infer the value of non-market goods by analysis of the revealed demand for closely related market goods, and (2) those which seek to generate information on value through processes which involve questioning of users.

The revealed techniques have the advantage that they are based on what economists like to call "hard data", that is, data which record actions that people have actually taken and decisions that people have actually made. The hard data are actual market data for some good(s) which is closely related to the non-market good of concern. Two well-known and much studied examples involve the use of data on travel expenses to infer the demand for outdoor recreation (for example, see [8]) and the use of data on sales of residential land in metropolitan areas to infer the value of air pollution abatement (for example, see [1]). A recent example involves the use of data on wage rates for jobs involving varying degrees of risk to life and limb to infer the value that people place on human

life.* These techniques are necessarily quite ingenious and a substantial literature reporting careful research has been built up. Nevertheless, conceptual problems remain [23]. These problems include difficulties in both the economic logic and statistical methods on which these techniques are based. This is not to imply that the present authors reject revealed demand techniques in all uses. Their basis in "hard data" is, in itself, a good reason for the attractiveness of these techniques in certain research situations. Nevertheless, these techniques are clearly imperfect.

There is another, more pragmatic, reason to reject revealed techniques for the valuation of many non-market goods. In many cases, it is not possible to identify a market good, the value of which can be determined by market observation, and which is related closely enough to the non-market good to allow inference of the value of the non-market good.

Several quite different techniques, which generate information on the value of non-market goods through processes which involve questioning of users, have been developed and applied. The "household production function" approach involves questioning of respondents to determine in great detail (a) household budgets, in terms of money and time and (b) the mix of consumption activities, (including the activities which use non-market goods, e.g. outdoor recreation, enjoyment of nature and environmental aesthetics, etc.) which are undertaken of the household. Then an iterative series of questions are asked, designed to determine how household budgets might be reallocated in response to changes in the price, availability and/or time requirements of these activities. From these data, using a well accepted framework of economic analysis, economic value of the non-market good (s) in question can be calculated.**

An alternative valuation technique uses an iterative procedure based on the Ramsey method of utility estimation to fit indifference curves between two non-market goods (or, conceivably, a market good and a non-market good). From this data, individual demand curves are calculated and may be aggregated to estimate community demand curves for the non-market good [34].

A third technique which uses data gathered by interviewing respondents is known as the bidding game method. This method has been used to value outdoor recreation, which may be a private good or a congestible public good and may be exclusive or non-exclusive [12]. It has also been used to value the outdoor environment of a region, which exhibits most of the characteristics of a non-exclusive, public good [6,29,30].

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*Report by Sherwin Rosen and Richard Thaler to the EPRI/Sigma workshop on Valuation of Non-Market Goods, Pacific Grove, Ca., August 2-5, 1976. (Proceedings in press)

**Report by Thomas D. Crocker to the EPRI/Sigma Workshop on Valuation of Non-Market Goods, Pacific Grove, Ca., August 2-5, 1976. (Proceedings in press).

Through an iterative bidding procedure, indifference curves passing through a given initial state, with dollar values on the vertical axis and the non-market good on the horizontal axis, are fitted. If the non-market good is a public good, individual bid curves are summed vertically to generate the aggregate bid curve. The aggregate bid curve provides estimates of value which are exactly equivalent to benefits in the context of benefit/cost analysis [4]. The first derivative of the aggregate bid curve, which may be called the marginal aggregate bid curve, is analogous to the demand curve; there are theoretical differences between the demand curve, which is appropriate for private goods and the marginal aggregate bid curve, which is appropriate for public goods [4]. In a collective sense, the efficient amount of a public good may be determined by the intersection of the marginal aggregate bid curve with the marginal cost curve for providing the good.*

The three methods of valuation of non-market goods using questioning techniques, discussed above, are all conceptually superior to the techniques based on indirect inference using revealed demand data [12,6,28,29]. However, they suffer from a difficulty which can conceivably present significant problems. Preference information is not the "hard data" variety. Rather, respondents, usually in a personal interview situation, provide answers to hypothetical questions posed in a "what if ....." context. This is not necessarily a fatal flaw. Sociologists and social psychologists have built up an impressive literature detailing methods by which such surveys may be designed to generate reliable responses. In addition, some evidence of the efficiency of bidding games is available. In one interesting experiment, it was found that results exhibited an impressive degree of consistency when a series of different bidding-type games, all well-designed, were played by groups of experimental subjects [3]. Two bidding game studies, designed to value the same non-market good in the same study area, but performed three years apart, showed a very high degree of consistency in the results obtained [7,29]. Thus, bidding game results are replicable.

All of this suggests that questioning techniques such as those discussed above can be useful and reliable research tools for valuation of non-market goods. However, it is essential that the data collection instrument be designed very carefully and pre-tested thoroughly to ensure that it is consistent with both the relevent economic theory and the principles of designing effective instruments to produce reliable data.

Bidding games are used in the empirical case study for the very important purpose of valuing the aesthetic damage caused by surface mining in the study area. The conceptual basis of these bidding games and the design of the data collection instrument are discussed in detail in Section 4.

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*Efficiency in the collective sense is not synonymous with Pareto-efficiency. Pareto-efficiency in the provision of a public good is impossible.

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SECTION 4

ESTIMATES OF THE VALUE OF ENVIRONMENTAL DAMAGE FROM SURFACE MINING IN THE STUDY REGION

The general damage model developed in Section 3 provides the conceptual basis for empirical estimation of the costs of environmental damage from surface mining in the study region. However, limitations in data have necessitated the aggregation of the twenty-three categories of resource quantity/quality changes and the nineteen categories of affected later uses into five general categories of damage: aesthetic damage; degradation of water quality; flooding; damage to land and buildings; and losses to fish, wildlife and recreation related activities.

AESTHETIC DAMAGES

Surface mining in the study area, and throughout the western slopes of the central Appalachian mountains, has major aesthetic impacts including the removal of vegetation, the removal and deposition of overburden leaving exposed benches and highwalls, the discoloration of water and increased turbidity of streams. These aesthetic impacts are observable to resident and visitor alike, and have been much photographed, written about, and discussed. However, there has been relatively little serious study of the human and social response to these changed aesthetic conditions.

A number of studies, in various study areas throughout the U.S., have demonstrated that individuals have clear preferences with respect to the aesthetic environment [9,11,13,14,16,21,26, and 32]. In general, people perceive environmental aesthetics visually, although the sense of smell may be a source of positive and negative stimuli[11]. The aesthetic environmental damage of concern in this study is almost entirely visual. Studies indicate that respondents are able to consistently rank landscapes according to their preferences. Purely visual methods [13,14] and methods combining visual techniques and a semantic differential rating [9] have been used for this purpose. In general, it has been found that people prefer more complex visual patterns to simple ones (i.e. they prefer a landscape with greater visual variety) [2]. Stark landscapes are not perceived as beautiful. However, the presence of flowing water improves the perceived attractiveness of almost any landscape [9,16.32]. Among outdoor and rural scenes, the natural landscape is usually preferred to the man-made [2]]. People often combine recreational uses of land with aesthetic uses such as sightseeing and nature study. Thus, an environment which is less pleasing visually, is less attractive to outdoor

recreationists [26].

While these studies have not directly addressed surface mined mountain landscapes, they do provide a basis for the hypotheses that citizens in the study region may perceive the surface mined environment negatively, and that citizens' perceptions of the mined environment may be measurable.

Several studies [8,20,22] have shown that citizens can make rational trade-offs among aesthetic environments and other goods (or money, the medium of exchange). These studies have shown that, in aggregate, citizens are willing to pay substantial amounts of money in order to obtain specified levels of improvement in the aesthetic environment [8, 22]. In one study of the environmental impacts of a single, huge coal-burning electric power plant and its captive strip mine, it was estimated that citizens and recreational users of the regional environment were willing to pay approximately $24 million annually to ensure complete abatement of visual pollution [22]. The package of environmental insults considered in that study included unreclaimed spoil banks from an area surface mine in an arid region. However, air pollution from the generating plant was considered the most serious and pervasive of the negative visual impacts.

These economic valuation studies were not addressed specifically to the aesthetic impacts of surface mining in mountainous areas. However, they do provide a basis for the hypotheses that visual environmental impacts, in general, are amenable to economic valuation, and the value of the aesthetic impacts of surface mining in our study region are non-zero and negative . Conversely, the value of aesthetic benefits from surface mine reclamation are non-zero and positive.

In this case study, the economic value of the aesthetic impacts of surface mining was determined in a public goods framework, using data gathered using bidding games. In addition to data placing money values on aesthetic impacts, citizens' perceptions of environmental quality and preferences among alternative levels of environmental quality were determined.

The Design of the Bidding Games

a) The Conceptual Basis of the Bidding Game Technique

The aesthetic environment of the study region is conceptualized as a public good, in the sense of Davis and Whinston [12], since it is inexhaustible over at least a wide range. Over this range, additional users can be added with minimal diminution of the visibility and scenic beauty available to each. Damage to that environment is a public discommodity, and abatement of that damage, in this case by the use of techniques to prevent offsite damages during mining and subsequently reclaim the land, is a public good.

Bradford [7] has presented a theoretical framework for the valuation of public goods. Traditional demand curves are inappropriate for the

analysis of demand for public goods, since the situation is not one of people responding to a parametric price per unit by choosing an appropriate number of units. Rather, each person directly arrives at the total value to himself of a given package. With a public good, one person cannot exercise any choice over the quantity provided him, except as a member of the collective which makes a collective choice. Further, the nature of a public good like aesthetic environmental improvements is such that increases in the quantity provided are not purely quantitative increases, but are more in the nature of improvements in quality.*

Bradford proposes the concept of an aggregate bid curve for public goods. Individual bid curves are simply indifference curves passing through a given initial state, with the numeraire good (i.e., the measure of value, which can be money) on the vertical axis and the public good on the horizontal axis. The aggregate bid curve is the algebraic or vertical, summation of individual bids over the relevant population.

The aggregate bid curve provides an accurate measure of the total benefits, including consumers' surplus, of provision of the public good. The Samuelson equilibrium [24,25], a level of provision which is efficient in the collective sense but not Pareto-efficient, is that level of provision which maximizes the excess of aggregate bid over total costs of provision. Alternatively, it can be found by equating the first derivative of the aggregate bid curve with the marginal cost of provision. The efficient level of provision of a public good maximizes the surplus of benefits over costs. Thus, the aggregate bid methodology is entirely consistent with the theory and method of benefit/cost analysis.

The bidding game technique is directly applicable to the derivation of individual, and aggregate, bid curves for public goods. Individual bid curves can be generated directly from bidding game results, and can be aggregated by vertical summation to generate aggregate bid curves. The basic data gathered through bidding games are responses to hypothetical questions about the respondent's willingness to trade money for environmental amenities (i.e. to pay for environmental improvements, or to accept compensation in exchange for environmental amenities).

Given the hypothetical nature of bidding games substantial effort should be expended to minimize bias through sound design of the games and to test the results for evidence of any bias that may remain. In a previous study by the senior author [22], there is considerable discussion of the design of bidding games to minimize bias. All of the desirable design features identified in that discussion were incorporated in the bidding games used in this study. These bidding games were also designed to permit statistical tests for: (1) enumerator bias; (2) starting point

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*Bradford [7] notes that these considerations of the nature of the process of demanding a public good mean that the usual restraints placed on the slope of demand curves may not be relevant for public goods. A priori, nothing can be said about the slope of the "demand" curve for a public good.

bias, which occurs when the final bid in any game is influenced by the money amount chosen as a starting point; (3) vehicle bias, where the specific methods by which money is to be (hypothetically) collected influences the amount of money bid; and (4) strategic behavior on the part of respondents. In addition, information, in non-monetary terms, about preferences with respect to the same environmental packages used in the bidding games was collected to allow test for consistency among monetary and non-monetary indicators of environmental preferences.

b) The Bidding Games

Four groups of color photographs were used to represent four levels of the visual quality of the study region environment. Photographs in each set were comparable in all respects, except for the level of environmental quality depicted: one photograph showed a long distance view, two showed intermediate views, and one focused on a flowing stream. Environment A was a surface mined but unreclaimed environment (a condition currently illegal, but represented by orphan lands in the region); Environment B was surface mined with a partial, or intermediate level of reclamation; Environment C was surface mined with full reclamation in accordance with current feasible technology; and D had never been mined. Environment D, for some purposes, served to depict an environment surface mined and reclaimed to its precise original condition (if that were possible).

Respondents, first, examined each set of photographs and ranked each environment on two scales indicating (1) whether the environment is liked or disliked and (2) how important is each environment to the respondent's sense of wellbeing (i.e. how strongly does he care about the condition of the environment). Analysis and results of this section are reported in Section 5.

Then, three bidding games were used with each respondent: (1) asking what increase in the price of coal would be acceptable if environmental improvements, as shown, were guaranteed to result; (2) asking what percentage increase in the respondent's electricity bill....; and (3) asking how much would the respondent be willing to pay into an "environmental improvement fund"..... Each game assumed environment A, mined but unreclaimed, as the starting point. Games were played considering improvements from A to D, A to C, and A to B, in that order. The enumerator nominated a starting point, by phrasing his opening question in terms of: "would you pay X if ...?"* The answer, yes or no, was recorded and the amount was varied, iteratively, by the enumerator until the highest amount which elicited a "yes" answer was discovered and recorded.

If in response to any one of the games, a respondent's maximum bid was zero, he was questioned to determine whether his zero bid represented his "true" valuation of the environmental improvement, or was a protest

*To provide data with which to test for starting point bias, three different starting points were specified for each game. Each respondent faced one given set of starting points, selected randomly from the three available sets.

against one or more of the assumptions implicit in the format of the games. "Protest" bids were counted, and then eliminated from those analyses designed to calculate values. True zero bids were included in all analyses.

The Conduct of the Survey

The survey was conducted by the Kentucky Agricultural Experiment Station* under the direction of Alan Randall and Sue Johnson. A pilot survey was conducted in Bell County, Ky., during the week of June 21, 1976. The pilot survey permitted field training of the three enumerators (graduate students in the social sciences who had undergone intensive training prior to this field experience), and the redesign of certain sections of the survey schedule.

The survey was conducted in the study region, by three enumerators with on-site supervision by Randall and Johnson during the period July 5 to 21, 1976. The sample was selected in a manner designed to approximate a random sample, while economizing a little on travel costs in this very rural region with many poor roads. It was desired to interview an adult representative of approximately one percent of all households in the region. Forty-four houses were selected randomly, so that each house in the region had an equal probability of being selected, to serve as starting points for systematic cluster sampling. Five schedules were completed in each systematically sampled cluster. Households which refused (13 percent of households refused), and where no one was found at home on the initial visit and one call-back, were systematically replaced within the cluster. Interviews were taken during working hours, and also at night and on weekends to ensure that regularly employed adults were well represented in the sample. Sixty percent of respondents were heads of households and thirty percent were spouse-of-heads. The remainder were responsible adults. Of the 220 attempted schedules,16 were rejected because they were incomplete or because the enumerator reported that the respondent exhibited a low degree of cooperation or understanding, or a high degree of suspicion or evasion. The 204 remaining schedules provided the data base for analysis.

Bidding Game Results

a) The Economic Meaning of the Bids

Individual bids for alternative levels of environmental quality represent points on individual bid curves which, as Bradford [7] demonstrates, are indifference curves passing through a given initial state. In each of three games and for every respondent, the initial state is taken to be A, the zero level of reclamation, which is attainable at a zero cost. Bids for situations B,C, and D assume the respondent has a right to the starting point and determine his maximum willingness to pay for environmental improvements. Thus, the final bids for situations B,C, and D leave the respondent at his initial level of utility. All estimates of willingness to pay obtained in this study are, therefore, compensating variation measures of the consumer's surplus generated by environmental improvement.

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*Under project H-43

The three different bidding games assume a different distribution of the burden of the costs of reclamation and damage prevention in the North Fork watershed.

Game 1 assumes that all users of products derived from coal produced in the region will contribute. Game 2 assumes that all users of electricity generated from coal produced in the region will contribute. Game 3 assumes that households in the region will bear the burden alone. Thus, it would be expected that the total sum of money generated by multiplying the mean bid by the relevant population would be quite different across games: game 1 would generate more money than game 2, and game 2 would generate more money than game 3. However, the aggregate willingness of regional residents to pay for environmental improvements should be exactly the same for all three games. This is demonstrated by the following analysis.

Let the utility level of any respondent at the starting point be represented by

$$U(E^\circ, m^\circ)$$

where

E° = initial level of environmental quality , and
m° = initial level of money income

This initial level of utility can be expressed alternatively as

$$U(E^\circ, m^\circ) = U(E^\circ, M^\circ + C^\circ + P_c^\circ q_c^\circ + P_e^\circ q_e^\circ) \qquad \ldots\ldots(1)$$

where the superscript $^\circ$ refers to initial values and ' refers to final values

C = money value of compensation received
$C^\circ = 0$
p_c = price of coal
q_c = quantity of coal which the individual consumes (perhaps indirectly)

p_e = price of electricity

q_e = quantity of electricity consumed
M = individuals adjusted income; $M^\circ = m^\circ - (C^\circ + P_c^\circ q_c^\circ + p_e^\circ q_e^\circ)$

Thus, $m^\circ = M^\circ + C^\circ + p_c^\circ q_c^\circ + p_e^\circ q_e^\circ \qquad \ldots\ldots(2)$

Now, the respondent's willingness to pay for an environmental improvement to E' will be given by the following equalities (since a bid curve is an indifference curve):

For the "coal price" game

$$U(E^\circ, M^\circ + C^\circ + p_c^\circ q_c^\circ + p_e^\circ q_e^\circ) = U\{E', M^\circ + C^\circ + [p_c^\circ q_c^\circ + (p_c^\circ q_c^\circ - p_c' q_c')] + p_e^\circ q_e^\circ\} \quad \ldots\ldots\ldots(3)$$

and, since $E' > E^\circ$, $(p_c^\circ q_c^\circ - p_c' q_c') < 0$

For the "electricity bill" game

$$U(E^\circ, M^\circ + C^\circ + p_c^\circ q_c^\circ + p_e^\circ q_e^\circ) = U\{E', M^\circ + C^\circ + p_c^\circ q_c^\circ + [p_e^\circ q_e^\circ + (p_e^\circ q_e^\circ - p_e' q_e')]\} \quad \ldots\ldots\ldots(4)$$

and, since $E' > E^\circ$, $(p_e^\circ q_e^\circ - p_e' q_e') < 0$

and for the direct payment game

$$U(E^\circ, M^\circ + C^\circ + p_c^\circ q_c^\circ + p_e^\circ q_e^\circ) = U(E', M^\circ + C' + p_c^\circ q_c^\circ + p_e^\circ q_e^\circ) \quad \ldots\ldots\ldots(5)$$

and, since $E' > E$, $C' < 0$

Given equations (1) and (2), we can rewrite equations (3), (4), and (5) thus:

$$(3)\ldots\ldots U(E^\circ, m^\circ) = U[E', m^\circ + (p_c^\circ q_c^\circ - p_c' q_c')]$$

$$(4)\ldots\ldots U(E^\circ, m^\circ) = U[E', m^\circ + (p_e^\circ q_e^\circ - p_e' q_e')]$$

$$(5)\ldots\ldots U(E^\circ, m^\circ) = U(E', m^\circ + C')$$

Thus,

$$(p_c^\circ q_c^\circ - p_c' q_c') = (p_e^\circ q_e^\circ - p_e' q_e') = C' \quad \ldots\ldots\ldots(6)$$

This analysis indicates that the total amount of money bid by any individual should be equal for all three games, and thus total willingness of regional residents to pay should be the same for all three games. Thus, the use of these games should provide an adequate test of vehicle bias.

It should also be noted that each individual bid (and, therefore, each estimate of aggregate willingness of regional residents to pay) should provide a conservative estimate of the value of environmental improvements. Willig [31] has shown that the empirical difference between compensating and equivalent measures of consumers' surplus, given certain plausible assumptions about the magnitude of income effects, should be relatively small. However, the measure derived from willingness to pay always gives the smaller estimate and the measure derived from willingness to accept compensation always gives the larger estimate of consumers' surplus. Willingness to pay is strictly limited by the budget constraints of regional residents, while willingness to accept compensation is not.

Aggregation of the bids generated by game 3 can only be performed in one way: mean household bid is converted to an annual measure and aggregated over all households in the region, giving a measure of regional willingness to pay (R.W.P.). Aggregation of the bids from games 1 and 2, however, can proceed in two ways. R.W.P. can be calculated after determining the amount of coal used to make products consumed by regional residents, or the amount of electricity consumed by regional residents, respectively. Alternatively, the bids can be aggregated over all surface-mined coal produced in the region, or all electricity generated from surface-mined coal produced in the region, respectively. These latter aggregates have been called total consumer payment (T.C.P.). If, as hypothesized, R.W.P. is of the same order of magnitude for all three games, TCP will be substantially greater than RWP for games one and two.

Which of these provides the more accurate measure of the social costs of aesthetic environmental damage from surface mining in the study region? Both are based on specific ethical assumptions. RWP assumes first that willingness to pay, rather than willingness to accept compensation, is the appropriate measure of consumers' surplus; and second, that the total burden of payment should fall on the residents of the region in which mining takes place. On the other hand, TCP assumes that all consumers of products made from surface-mined coal produced in the region either would be willing to contribute, or should contribute toward the costs of reclamation and off-site damage prevention at the same rate as the regional residents. Thus, it is clear that RWP and TCP are not two different estimates of the same quantity, but estimates of two fundamentally different quantities.

Further, observe that RWP does not include any measures for the following, all of which can be expected to be greater than zero: (1) the willingness of visitors to the region to pay for aesthetic environmental improvements, (2) the option value, or expected consumers' surplus, of people who might one day live in, or visit, the region, and (3) the preservation value which non-residents and non-visitors would place on the mountain environment. Thus, RWP is clearly an underestimate of the social costs of aesthetic environmental damage in the region. An aggregate of RWP plus bids representing the willingness of visitors and non-residents to pay would provide a lower bound estimate of these social costs.

On the other hand, TCP is a reasonable upper bound estimate of the social costs of aesthetic damage from surface mining in the study region.

In this report, RWP and TCP measures are presented for all estimates of the costs of environmental damage attributable to surface mining of coal in the study region. Interpretation of these results is left to the reader, who may find the above discussion of assistance.

b) The Empirical Results

Mean individual bids and median individual bids were significantly greater than zero (table 12). Mean bids were all greater than median bids, which is to be expected since no one could bid less than zero, but a small number of individuals who are intensely concerned about the aesthetic

Table 12
BIDDING GAME AND ENVIRONMENTAL PREFERENCE
RESULTS (NORTH FORK OF THE KENTUCKY RIVER REGION, 1976)*

Game 1. An acceptable increase in the price of coal

Level of Reclamation	Mean ($/ton)**	S.E. (mean)***	Median ($/ton)
Back to original	8.97	1.27	2.00
State-of-the-art	6.39	0.94	1.50
Partial	3.51	0.70	0.75

Game 2. An acceptable increase in the household electricity bill

Level of Reclamation	Mean (% increase)	S.E. (mean)	Median (% increase)
Back to original	15.32	1.35	10.00
State-of-the-art	11.33	1.01	8.00
Partial	6.87	0.71	5.00

Game 3. An acceptable monthly payment per household

Level of Reclamation	Mean ($/mo.)	S.E. (mean)	Median ($/mo)
Back to original	5.90	0.45	5.00
State-of-the-art	4.76	0.41	3.00
Partial	3.06	0.37	2.00

Environmental Preference Scores
[Scale: Offends me greatly -12.....+12, pleases me greatly.]

Environment	Mean Score*	S.E. (mean)
Mined, no reclamation	-9.95	0.29
Mined, partial reclamation	-2.54	0.46
Mined, Full reclamation	7.84	0.29
Never Mined	11.52	0.12

*All mean bids were significantly different from zero, at the 0.01 level of confidence. All mean preference scores were significally different from each other at the 0.01 level of confidence.
** Short tons. ***Standard error of the mean.

effects of surface mining could be expected to bid many times higher than the median. It is interesting, however, that the median bid was closer to the mean bid in Game 3 and furthest from the mean in Game 1. Game 3 places all the costs of aesthetic environmental improvements directly on the receptors of damage, while Game 1 spreads that cost over the broad range of consumers of coal products.

Prior to calculation of aggregate bids, all bids greater than the mean plus one standard deviation were arbitrarily set equal to that amount. This has the effect of limiting the influence of a small number of usually high bids, and thus, arbitrarily introduces a conservative element into the analysis.

Regional willingness to pay (R.W.P.), determined by translating individual bids into annual dollar amounts and aggregating them across the regional population, were very similar for all three games (table 13). When compared to regional effective buying income (an indicator of total personal disposable income in the region), all estimates of RWP were quite small (table 14). Total consumer payment (TCP), calculated by applying the results of game 1 to all coal produced in the study region generated substantial amounts of money (table 15).

There was no conclusive evidence of any kind of bias in the bidding game results. Using the test developed by Brookshire, et al [8], no evidence of strategic bias was found. Tests for enumerator bias, starting point bias and vehicle bias were conducted using analysis of variance. Visual inspection of the data suggested that bids generated using the electricity bill game at environmental quality levels D and C were somewhat lower than the bids using the other two games. Perhaps, there was some resistance to the idea of increased electricity bills at a time when consumers had just suffered sudden and major increases in these charges. However, at the 5 per cent level of statistical significance, the hypothesis that none of these biases (i.e. enumerator, starting point, and vehicle bias) existed could not be rejected.

The general consistency of the results of all three bidding games and the non-monetary preference scale (table 12) provides evidence, by way of replication, that the bidding games generated valid results.

Relationship of Bids to Income

The relationship of willingness to pay and household income is of interest. However, since the aesthetic environmental improvements under consideration here are public goods, the concept of income elasticity of demand, which pertains to private goods, is inappropriate. The calculation of an income elasticity of demand would require consideration of the relationship between income and the quantity of homogeneous units of environmental improvement demanded at a given parametric price. However, in a study of willingness to pay for public goods, the quantity is fixed for the individual by the predefined environmental quality levels A, B, C, and D, while the amount bid varied for each individual.

Table 13

ANNUAL RWP FOR AESTHETIC ENVIRONMENTAL IMPROVEMENT
(10% confidence limits in parentheses)

Environmental Improvement	Game 1 $ millions	Game 2 $ millions	Game 3 $ millions
From A to D	1.230 (±0.117)	0.906 (±0.063)	1.328 (±0.070)
A to C	0.918 (±0.086)	0.675 (±0.048)	1.070 (±0.061)
A to B	0.509 (±0.055	0.452 (±0.040)	0.655 (±0.045)

Table 14

RWP, AS A PERCENTAGE OF REGIONAL
EFFECTIVE BUYING INCOME*

Environmental Improvement	Game 1 %	Game 2 %	Game 3 %
From A to D	0.66	0.59	0.71
A to C	0.52	0.37	0.57
A to B	0.27	0.24	0.35

* Source of effective buying income data: Survey of Buying Power 1976, Sales and Marketing Management, Inc.

Table 15

ANNUAL TCP FOR AESTHETIC ENVIRONMENTAL IMPROVEMENT, GAME 1
(10% confidence limits in parentheses)

Environmental Improvement	Game 1 $ Millions
From A to D	84.307 (±8.114)
A to C	61.304 (±5.937)
A to B	34.854 (±3.739)

Income elasticity of bid, defined as $\frac{dB}{dY} \cdot \frac{Y}{B}$, or the percent change in bid resulting from a one percent change in income, is a concept appropriate to public goods. Income elasticity of bid was calculated for each game and each level of abatement. In all cases, income elasticity of bid was positive, and in five of the nine cases was significantly greater than zero at the 95 percent level of statistical confidence (table 16). We conclude that the amount bid tends to rise as income increases, but at a slower rate.

Table 16
INCOME ELASTICITY OF BID

Environmental Improvement	Game 1	Game 2	Game 3
From A to D	0.20	0.41*	0.29*
A to C	0.15	0.37*	0.20*
A to B	0.03	0.41*	0.15

* Significantly different from zero at the .05 percent level.

Who Should Bear the Cost?

Respondents, after having played each bidding game under the assumption that the framework of that particular game represented the only feasible way to collect money to pay the costs of environmental improvements, were provided the opportunity to answer the normative question: "who should bear the costs of surface mine reclamation"? The answers were almost unanimous: 65 percent thought the cost should be borne entirely by the surface mining industry, while an additional 26 percent thought the industry should bear the major proportion of those costs (table 17). There was unanimous rejection of the idea that the costs should be borne by the residents of the affected region.

DEGRADATION OF THE QUALITY OF WATER FOR DOMESTIC, COMMERCIAL AND INDUSTRIAL USES

In order to estimate the economic costs of surface mine related degradation in the quality of water for domestic, commercial and industrial uses, it is necessary first to determine the influence of surface mining activity on water quality in the study region.

The Impact of Surface Mining on Water Quality

To determine the impacts of mining on water quality, sophisticated statistical techniques were applied using monitoring data collected in the Quicksand watershed, a sub-region of our study region. On eight days between June 1974 and June 1975, measurements of 18 parameters of water quality were taken at each of 26 locations on second through fifth order streams in the Quicksand watershed [3]. These time series and cross-

Table 17
RESPONSES TO "WHO SHOULD BEAR THE COST OF SURFACE MINE RECLAMATION?"

Response*	% of Respondents
1	65
2	2
3	0
4	4
1,2	7
1,3	1
1,4	9
4,1	2
1,2, -,- Combinations	3
1,4, -,- Combinations	6
Other combinations	1

* Response code: 1 = the surface mining industry
2 = the final consumers of coal products
3 = the residents of the affected region
4 = the government

More than one entry indicates a combination, listed in order of the contribution of each.

sectional data were pooled. Eighteen simultaneous equations, one for each water quality parameter, were estimated using seemingly unrelated regression techniques.

Each equation for a water quality parameter Y had the general form:

$$Y_{t,i} = f[YU_{t,i}, (YU_{t,i})^2, MINE_{t,i}, SLPE_i, DIST_i, D_2, D_3, D_4, D_5, D_6, D_7, D_8]$$

where

t = time of monitoring
i = location of monitoring
YU = concentration of the dependent variable at the monitoring point immediately upstream
MINE = % mined for catchment immediately above monitoring site
SLPE = the slope of the overburden
DIST = the distance of the stream from the location where surface mining is taking place
D = dummy variable, where
D_1 = 1, if data collected on first monitoring date.
D_1 = 0, if not.
etc.

This form is conceptually consistent with the general damage model (section 3, note especially table 10). However, due to data limitations, not all of the mining site and process variables indentified in table 10 could be included in this analysis.

The only mining process variable used was $MINE_i$, the proportion of the surface of the catchment immediately above monitoring location i, which is in a disturbed state due to surface mining. The values for this variable were calculated from topographical maps showing disturbed land [3]. Since individual catchments may include several mining operations, it was not possible to include other process variables such as mining and reclamation techniques.

The mine site variables included were $DIST_i$, average distance of mines in catchment i from the nearest stream; and $SLPE_i$, average slope, within catchment i, of mine site. Since these variables are average data across catchments which are quite homogeneous with respect to topography, variability in the data was very limited and it was hypothesized a priori that coefficients for these variables would be insignificant. Due to the aggregate nature of the data, no other site variables could be considered.

Some comment on the variables YU and $(YU)^2$ seems appropriate. Consider the 26 catchments. For each catchment, $Y_{t,i}$, is a function of mining activity in the catchment, SLPE, DIST, the dummy variables and the quality of the water when it enters the catchment, YU. The term

$(YU)^2$ is introduced to depict possible non-linear relationships between Y and YU.

One would expect stream discharge to be an important variable. However, stream discharge data were unavailable. The dummy variables, D, through D_8, were used to identify the monitoring date for each water quality observation. In the relatively small Quicksand watershed, relative discharge should be fairly constant on a given date. That is, when the discharge level is high at one monitoring location, it will be high at all locations. Thus, the dummy variables, which serve to segregate the data according to monitoring date, should pick up the effects of relative discharge levels. Interpretation of the dummy variables, however, is not easy since, in addition to discharge effects, the coefficients for the dummy variables are also influenced by other time-related effects, e.g. time of year, and seasonal patterns of mining activity.

The hypothesized signs of the estimated coefficients for the independent variables were: +MINE, +YU and $-(YU)^2$. Due to the limited variation and the aggregate nature of the data, it was hypothesized that the coefficients for SLPE and DIST would be insignificant. No a priori hypotheses were formed with respect to D_1 through D_8 for reasons explained in the preceding paragraph.

The empirical results obtained in this analysis are presented in table 18. Each row of table 18 can be read as one equation (of the set of 18 simultaneous equations), relating an endogenous water quality parameter to a set of exogenous variables. Most of the estimated coefficients were significant and their signs as hypothesized in advance. Strip-mining activity in the region appears consistently as the most important variable in explaining increased concentrations of the particular quality parameter in the water. The upstream concentration of each quality parameter contributed to an increased concentration downstream (at the monitoring point). Only in the case of pH and chloride (Cl), was there a significant dilution effect from upstream to downstream.

As expected, slope and distance were insignificant in explaining the variation in the concentration of water quality parameter, due to the similarity of the topography of different locations within the study region.

The hypothesis of curvilinear relationships of upstream concentrations to downstream concentrations was confirmed in the cases of pH, conductivity, hardness, sulfate, chloride, potassium, magnesium, and strontium.

The significance of the dummy variables was generally low, as expected. No apparent pattern of seasonal variations in the values of dependent variables was detected. Further data plots indicated no significant correlation between rainfall prior to monitoring and the dummy variables.

The Economic Costs of Degraded Water Quality

Table 18
ESTIMATES OF WATER QUALITY PARAMETERS*

Endogenous Variables	Exogenous Variables												
	Intercept	Dependent Variable Upstream	Dependent Variable Upstream Squarred	Mine	Slope	Distance	D_2	D_3	D_4	D_5	D_6	D_7	D_8
Sediment	135.851	0.2585	0.00005	14.525	-1.805	-0.39994	32.483	174.180	-71.161	195.012	-43.714	-54.679	46.724
	(148.209)	(0.1258)	(0.00004)	(1.787)	(2.266)	(0.3535)	(83.834)	(83.755)	(84.659)	(89.044)	(83.752)	(84.613)	(87.958)
pH	7.267	-0.0547	0.0007	0.0114	0.0018	-0.00003	0.1439	0.0943	-0.1005	-0.0153	-0.1165	-0.1402	-0.0439
	(0.113)	(0.0053)	(0.00006)	(0.0013)	(0.0016)	(0.0002)	(0.0612)	(0.0604)	(0.0618)	(0.0630	(0.0611)	(0.0617)	(0.0639)
Conductivity	104.733	0.1210	0.0001	14.024	-1.907	0.0203	60.897	68.197	-53.894	-13.629	-14.797	-7.547	14.173
	(39.484)	(0.0341)	(0.00003)	(0.496)	(0.623)	(0.0942)	(23.224)	(22.998)	(23.460)	(23.460)	(23.215)	(23.471)	(24.305)
Alkalinity	9.876	0.2839	0.0001	2.564	-0.2107	0.0161	9.534	15.778	-5.725	1.026	-1.433	-0.847	11.061
	(9.923)	(0.0501)	(0.0002)	(0.124)	(0.1560)	(0.0235)	(5.830)	(5.778)	(5.888)	(6.023)	(5.828)	(5.917)	(6.112)
Hardness	30.678	0.1648	0.0002	7.409	-1.017	0.0337	25.105	29.888	-18.332	0.8554	-3.578	-5.266	23.843
	(19.664)	(0.0333)	(0.00006)	(0.248)	(0.311)	(0.0469)	(11.616)	(11.505)	(11.733)	(12.0006)	(11.612)	(11.735)	(12.174)
SO_4	35.580	-0.0094	0.0004	5.281	-0.9094	-0.0181	16.969	15.509	-18.154	-2.789	0.923	8.053	4.432
	(15.338)	(0.0494)	(0.0001)	(0.191)	(0.2423)	(0.0366)	(8.961)	(8.873)	(9.052)	(9.255)	(8.966)	(9.065)	(9.377)
Cl	1.852	-0.0271	0.0009	0.0047	0.0025	0.0009	0.4600	0.3512	0.3985	1.068	0.9527	0.6495	0.6279
	(0.342)	(0.0121)	(0.0003)	(0.0039)	(0.0048)	(0.0008)	(0.1826)	(0.1812)	(0.1848)	(0.2078)	(0.1887)	(0.1860)	(0.1936)
K	1.627	-0.0080	0.0002	0.1286	-0.0153	0.0007	0.4795	0.7003	-0.7495	-0.0512	-0.4735	-1.201	0.3654
	(0.446)	(0.0047)	(0.00005)	(0.0055)	(0.0069)	(0.0010)	(0.2575)	(0.2551)	(0.2604)	(0.2661)	(0.2580)	(0.261)	(0.2697)
Na	3.093	-0.0029	0.00008	0.0351	-0.0231	0.0016	1.728	1.678	-0.7569	-0.1745	1.225	-0.3343	-0.3023
	(0.865)	(0.0167)	(0.0003)	(0.0098)	(0.0122)	(0.0020)	(0.469)	(0.465)	(0.4644)	(0.4740)	(0.464)	(0.4636)	(0.4804)
Mg	3.111	0.0140	0.00002	1.104	-0.1349	0.0064	2.355	2.563	-3.226	-0.6561	0.0397	-0.1930	3.138
	(2.817)	(0.0035)	(0.000004)	(0.035)	(0.0447)	(0.0067)	(1.662)	(1.646)	(1.680)	(1.7183)	(1.6630)	(1.6807)	(1.742)
Ca	6.311	0.0220	0.000009	1.143	-0.1854	0.0047	5.642	7.782	-1.924	1.027	-1.452	-1.543	4.845
	(3.605)	(0.0040)	(0.000005)	(0.045)	(0.0570)	(0.0086)	(2.131)	(2.112)	(2.151)	(2.201)	(2.129)	(2.152)	(2.233)
Al	32.331	-0.1054	0.0029	-0.2040	0.1676	-0.0131	-3.496	-0.1974	-7.457	12.893	12.374	8.531	-8.582
	(11.891)	(0.2212)	(0.0034)	(0.1432)	(0.1764)	(0.0280)	(6.646)	(6.601)	(6.698)	(6.968)	(6.832)	(6.766)	(6.953)
Sr	237.894	-0.0876	0.0002	13.082	-1.492	0.0307	265.035	188.588	18.948	218.459	209.049	15.997	14.249
	(59.136)	(0.0600)	(0.00005)	(0.742)	(0.905)	(0.1413)	(33.717)	(33.028)	(33.570)	(34.510)	(33.401)	(33.602)	(34.827)
Mn	-159.889	0.4700	-0.0001	3.103	1.961	0.5018	-8.596	-49.351	25.497	-0.9082	112.432	107.054	55.508
	(30.243)	(0.2628)	(0.0004)	(1.006)	(1.269)	(0.1949)	(47.824)	(47.517)	(48.583)	(49.726)	(48.460)	(48.992)	(50.584)
Fe	24.045	0.1968	-0.0003	-0.9497	0.4070	0.0025	20.229	-3.489	28.898	8.105	-7.257	24.019	9.153
	(15.431)	(0.1999)	(0.0019)	(0.1924)	(0.2287)	(0.0366)	(8.587)	(8.490)	(8.775)	(8.865)	(8.580)	(8.744)	(9.028)
Zn	-3.698	0.2602	-0.0035	0.1809	0.1376	0.0205	2.624	6.034	-0.5764	-1.885	-6.927	-7.291	-5.186
	(9.566)	(0.3422)	(0.0037)	(0.1140)	(0.1447)	(0.0222)	(5.408)	(5.348)	(5.378)	(5.586)	(5.513)	(5.566)	(5.659)
Cd	0.0603	0.1132	-0.0255	-0.0052	0.0051	-0.0004	0.1112	0.2084	0.7162	0.2638	0.5217	0.3176	-0.0637
	(0.1899)	(0.0826)	(0.0188)	(0.0024)	(0.0030)	(0.0004)	(0.1114)	(0.1138)	(0.1193)	(0.1190)	(0.1172)	(0.1166)	(0.1202)
Pb	1.340	0.2398	-0.1347	-0.0001	-0.0067	0.0021	-0.9849	-0.3622	-1.385	-1.419	-1.386	-1.467	0.8666
	(0.436)	(0.2136)	(0.0760)	(0.0052)	(0.0067)	(0.0010)	(0.2546)	(0.2495)	(0.260)	(0.266)	(0.259)	(0.262)	(0.2650)

* Values in parenthesis are standard errors.

The degradation in water quality in the study region due to surface mining results in economic losses by increasing the costs of water treatment prior to domestic, commercial and industrial use. Water is treated by water companies, local public sector water facilities, and some firms which draw water directly from the river. It was found that a total of 59,100 million liters of water were withdrawn from the North Fork and the main Kentucky River in 1975.*

A telephone survey of major water companies and specialized users of water (eg. distillers, food processors, laundries, etc.) discovered no cases where a user found it necessary to treat water, beyond the treatment provided by the diverter. Thus, treatment costs accrued by water companies, water services and private diverters are assumed to account for all treatment costs.

The relationship between surface mining and water treatment costs has been determined by Smathers [27]. It was found that water diverters treated raw water with alum, lime, chlorine, and fluoride. Surface mining affects the amounts of alum and lime used, but not the amounts of chlorine and fluoride [27]. The use of lime and alum is related to the turbidity of the water, which in turn is related to the concentration of suspended solids. The effect of alum and lime treatment is to cause flocculation which allows particulate matter to form a bond which enables removal of the particulate matter by settling or clarification. The flocculation process also results in removal of some of the metal ions in the raw water, and lime is used to adjust pH. This water treatment process may increase hardness of the water.

While the regression analysis (table 18) indicated that surface mining has significant impacts on many water quality parameters, it appears that, given current requirements for quality of delivered water and current treatment technology, only suspended sediment has a direct relationship to water treatment costs in our study region.**

The model developed by Smathers [27], which relates alum and lime use to turbidity, stream temperature and rainfall, was developed through multiple regression analysis. The fitted model is presented in equations (1) and (2).

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*Unpublished data, Engineering Division, Kentucky Department of Natural Resources and Environmental Protection.

**This has two implications: (1) if more stringent requirements for quality of delivered water were enacted, water treatment costs attributable to surface mining may be greater than estimated here, and (2) if there are any losses borne by domestic, commercial and industrial water users, other than increased costs of alum and lime, these losses are not quantified here.

$$Y_A = 0.17934 + 0.0004\ X_{1A} + 0.00036\ X_{2A} + 0.00723\ X_{3A} \quad .....(1)$$

$$Y_L = 0.06784 + 0.00002\ X_{1L} + 0.00039\ X_{2L} + 0.00364\ X_{3L} \quad .....(2)$$

where

Y_A = Alum (in pounds) per thousand gallons of water treated

$X_{1A,L}$ = turbidity (J.T.U.). One J.T.U. is equivalent to 2.2 mg/liter of suspended sediment

$X_{2A,L}$ = stream temperature (in Fahrenheit)

$X_{3A,L}$ = rainfall (in inches)

Y_L = Lime (in pounds) per thousand gallons of water treated

Using this model, and the mean values of the dependent variables for our study region, the amounts of alum and lime used were calculated. In the North Fork region, estimated useage was 45.4 kilograms of alum and 21.6 kilograms of lime per million liters of water treated. Downstream, in the main Kentucky River, estimated use was 33.0 kg. of alum and 15.2 kilograms of lime per million gallons. Given the average price of alum and lime in our study region ($0.181 per kilogram of alum and $0.095 per kilogram of lime), the total costs of alum and lime used for water treatment was calculated. It was assumed, correctly, that the incremental costs of water treatment attributable to surface mining would be equal to the costs of additional alum and lime needed. The costs of maintaining and operating water treatment facilities would need to be met even if mining activity was zero.

Our regression equation for suspended sediment allows the calculation that an annual average of 72 percent of the suspended sediment in the water in the North Fork of the Kentucky River can be attributed to surface mining. Thus, it was calculated that the total costs of water treatment (attributable to surface mining) in the North Fork was $30,500 annually (in 1976 dollars).

In order to determine the proportion of water treatment costs in the main Kentucky River which are attributable to mining in the North Fork, it is first necessary to determine the proportion of the total sediment in the Kentucky River which came from the North Fork. The average discharge from the North Fork was calculated to be 59 percent of the average discharge at Lock 14 and 23 percent of the average discharge at Lock 1 on the Kentucky River. Thus, an average of 41 percent of the water in the main Kentucky River was attributed to discharge from the North Fork. It was assumed, in the absence of scientific data, that one half of the suspended sediment discharged from the North Fork settles out by the time the water reaches Lock 1. At the mid-point between the end of the North Fork and Lock 1, 75 percent of the suspended sediment load discharged from the North Fork would remain in suspension. Thus, an average of 31 percent of the suspended sediment in the Kentucky River is calculated to have come from the North Fork. Since 72 percent of that amount is

attributable to surface mining within the North Fork watershed, 22 percent of the averages suspended sediment in the main Kentucky River is attributed to surface mining the North Fork watershed.

Twenty-two percent of the annual costs of alum and lime for treating main Kentucky River water is equal to $94,400 annually.

Thus, the total water treatment cost attributable to North Fork area surface mining is estimated to be $125,000 annually (in 1976 dollars).

FLOODING

The disturbance of the overburden during surface mining processes generates higher levels of sediment load in streams draining the mined watershed. Erosion from the mined area and spoil deposits continues for some time after cessation of mining. The increased sediment load in streams results in siltation, which reduces the capacity of streams to provide drainage. This effect may be exacerbated when mining on steep slopes causes land slides, which increase erosion and, in some cases, may block stream channels [19]. Additionally, the removal of vegetation and disturbance of soil increases run-off during periods of intense rainfall. Together, these two effects of surface mining (i.e. siltation and increased run-off) result in increased severity of floods.

Existing studies of the characteristics of stream flow as a result of sediment deposition indicate that strip mining significantly affects storm runoff during peak flow periods and low flows during dry periods [10,18]. Strip mining activities have been directly related to the peak flood state and these damages appear to represent substantial portions of the tangible economic effects of strip mining.

In a 1962 study, the U.S. Army Corps of Engineers estimated that the average annual value of flood damages in the North Fork below Carr Fork was $780,000, and in the Kentucky River downstream it was $2,016,000 (in 1958 dollars). Since the North Fork provides approximately 41 percent of the total water in the mainstream, it is assumed that flooding in the North Fork causes $980,000 plus 41 percent of $2,016,000, that is $1,807,000 worth of average annual damages (in 1958 dollars). That is $3,627,000 in 1976 dollars.

A study in eastern Kentucky indicates that surface mining of coal causes peak flow rates to increase by a factor of 3 to 5 in small Appalachian watershed [10]. Also, retention time is reduced, thus effecting an increase in the rate at which flood peaks move downstream. Peak flow was found to be directly and positively correlated with the percent of area disturbed during surface mining. Flood peaks increased by 73.3 percent after surface mining had disturbed about thirty percent of the land in the catchment [10].

Approximately 1.5 percent of the land in our study area is currently in a disturbed state due to surface mining (that is, disturbed for mining

and not yet properly revegetated following grading and back filling). Assuming a linear relationship between flood peaks and proportion of the area mined, and a linear relationship between marginal changes in the flood peak and marginal changes in the average annual value of flood damages, it was calculated that 3.7 percent of the average annual value of flood damages can be attributed to surface mining in the study region. This amounts to $134,500 annually.

Now, the Corps of Engineers study [28] does not include flood damage in the North Fork watershed from the following sources: the North Fork above Carr Fork, and all North Fork tributaries other than Carr Fork. For want of a better assumption, we conservatively assume that total annual average damage from flooding in the study region is two times the amount captured in the Corps of Engineers study. Total annual value of flood drainage attributable by surface mining in the North Fork region is estimated to be $269,000.

The reader will observe that, due to serious data limitations, several undocumented assumptions were necessary in order to derive this estimate. The assumption of a linear relationship between marginal changes in flood peak and marginal changes in the average annual value of flood damage is especially unsatisfying, since the relationship between flood peak and the area of land inundated is clearly non-linear. On a flat floodplain, small increases in flood peak may cause large increases in the area flooded. Thus, our assumed linear relationship results inevitably in underestimation of the flood damage attributable to surface mining.

DAMAGE TO LAND AND BUILDINGS

The surface mining industry may cause two categories of damage to land and buildings: on-site and off-site damage. On-site damage occurs when land is disturbed and structures are destroyed in the process of removal and deposition of overburden. Off-site damage occurs when mining activity results in slides, rockfalls, erosion, etc. which damage land and buildings away from the immediate mining site.

Much of the damage occuring to land falls into several categories, aesthetic damage, damage to wildlife and recreational uses and land-water interactions such as sedimentation and flooding, which are being considered in this study under other sub-headings. Here, we are concerned with damage to land and buildings which is reflected in market values: e.g. changes in the market value of land or the net value of its productivity in uses such as agriculture and forestry which are integrated into the market, and changes in the market value of structures or the cost of restoring damaged structures for productive use.

On-site Damage to Land

During January, 1977, a telephone survey of realtors in the study area, in which all major realtors were called, yielded the following results. There are relatively few transactions involving the surface estate

of land which overlies coal reserves in the study region. This may be explained by two factors: (1) most of such land in the study region is unmanaged forests and woodlots of little immediate productive potential and (2) "broad-form" mineral deeds (section 6) are common in the study region, and thus the surface holder's use and enjoyment of his land is to a high degree subject to decisions which are made by the mineral holder. Accordingly, estimates of surface land values in the study region are based on limited market information. With that caveat, the mean values obtained through the survey of realtors are:

value of unmined land:	$300 per hectare
value of mined but unreclaimed land:	$150 per hectare
value of land contour mined and reclaimed:	$500 per hectare
value of land mined by mountaintop removal technique and reclaimed:	$850 per hectare

In 1975, 2,141 hectares were disturbed by surface mining, and 30% of this area by the mountaintop removal method. Assuming that, in accordance with the current Kentucky reclamation law, all of this area was reclaimed, the disturbance and subsequent reclamation of land resulted in an annual net gain of $653,000.

This gain may require some explanation. In the study area, most of the land overlying coal reserves is currently used as unmanaged forests and woodlots and is of steep slopes. Mining and subsequent reclamation produces some grassed areas of flat to gently sloped land which may have a variety of alternative uses including rangeland for domestic animals, wildlife or game. It is conceivable that reclaimed land may have residential, commercial and industrial uses. Thus, reclaimed land may have a higher market value than unmined land. Reclaimed land mined by the mountaintop removal technique may have higher value than land which had been contour mined, since larger contiguous areas of flat to gentle slopes are created.

Nevertheless, it must be noted that surveys conducted by the study team found that more than ninety percent of surface mined land in the region was unmanaged forest or woodlot prior to mining and remained in that status after reclamation. Thus, the potential beneficial land use impacts of surface mining and reclamation are mostly unrealized.

It should be noted that if reclamation was not performed, a total annual loss of $321,150 would be incurred.

Off-site Damage to Land

Off-site damage to land occurs when the productive uses of land, other than at the mining site, are rendered less valuable, for example, by slides, rock falls, erosion, or by damage related to mining and coal transportation

operations. During the survey of regional residents, data on the value of off-site damages were collected. Respondents indicated first whether they had suffered off-site damages to land they owned and, then, their estimate of the dollar value of damages. Thus, the estimates of the value of off-site damages presented below are based on respondents' personal estimates of financial losses they had suffered.

In the fiscal years 1975 and 1976, of 204 respondents, 22 respondents suffered damage to land. The smallest reported loss in the two year period was $50 while the largest was $2,500. The total annual value of damage to land in the study region was $845,000 ± $253,000 (10% confidence limit).

Damage to Buildings and Structures

The value of damage to buildings was calculated from survey data in fiscal years 1975 and 1976. A total of 18 respondents reported damage to structures they owned. The smallest reported loss in the two year period was $10 while the largest was $16,000. The annual damage to buildings and structures in the study region was $1,684,000 plus or minus $925,000 (10% confidence limits). The confidence limit is rather wide, because one respondent reported damage many times in excess of that reported by other respondents.

Total Annual Damages to Land and Buildings

The total annual value of damages to land and buildings in the study region was estimated at $1,837,000.

DAMAGE TO FISH, WILDLIFE AND RECREATION-RELATED

It is hypothesized that surface mining in the study, through its impacts on the land and water resources, causes economic losses in fishing, hunting and water-based recreation activities within the study region, and in fishing and water-based recreation activities in the Kentucky River downstream from the region. Economic estimates of the value of some categories of losses are presented below; in other categories, the losses remain unquantified.

Commercial Fishing Losses (In-region and Downstream)

A small commercial fishing industry exists in the Kentucky River. A study [30] indicates that surface mining has negatively affected mussel beds, and probably had minor effects on populations of commercially valuable fishes. Due to the lack of statistical data on the economics of commercial fishing in Kentucky, these losses must remain unquantified.

In-region Recreational Fishing Losses

It has been determined that surface mining through its impacts in increasing erosion and sedimentation of streams and, in some instances,

reducing the pH of streams, results in reduced fish populations in the streams of the study region [4].

Unfortunately there are no reliable estimates of fishing activity in the region, (in terms of angler days of use, for example).

The survey of area residents does yield some qualitative information. Of 204 respondents, 81 indicated that "reduced opportunities for fishing" was an environmental problem in the region. Of these 81, 75% indicated that the problem was "serious", 71% that the problem was "important to them", and 87% that it had become worse in the last ten years.

It can be concluded that surface mining has caused an economic loss in the value of recreational fishing in the region. That loss remains unquantified.

A study by Professor Donald Batch calculated that fish with a replacement cost of $410,000 have been lost from streams in the region, as a result of surface mining [4]. In order to annualize this replacement cost, we make the following assumption: if all surface mining in the region were to cease at some time, it would take five years until water quality improved sufficiently to justify replacement of the fish [4]. Thus, the replacement cost of $410,000 is annualized over five years. The present value of the annual loss was calculated to be $65,300.

In-region Hunting Losses

Some information is available on the impacts of surface mining on hunting opportunities [5]. A study in Perry County, Ohio, reports that reclaimed surface mined areas support a less diverse population of game species and attract fewer hunters than unmined lands [6].

Unfortunately, there are no reliable estimates of hunting activity (in terms of hunter days of use, for example) for the study region.

The survey of area residents does yield some qualitative information. Of the 204 respondents, 105 reported that "reduced opportunities for hunting" was an environmental problem in the region. Of these 105, 87% said that the problem was serious, 83% that the problem was "important to them", and 79% that it had become worse in the last ten years. It is known, of course, that surface mining and its cumulative environmental impacts have increased in the region in the last ten years.

It is reasonable to conclude that some economic losses in hunting activity can be attributed to surface mining. These losses remain unquantified.

Downstream Recreational Losses

Increased suspended sediment and turbidity in the Kentucky River, downstream from the confluence of the North and Middle Forks, is hypoth-

esized to result in diminished recreational value of the rivers. The method by which an economic value is placed on this loss is as follows:

1. Recreational use of the main stream is estimated, assuming the fourteen locks are equally desirable for water-based recreation as other slack water areas in the recreation market area.

2. Estimated recreational use is compared with actual use, as recorded by the U.S. Army Corps of Engineers.

3. The difference between estimated and actual use, in visitor days, is calculated. The total value of the "lost" visitor days is calculated.

4. One half of this difference is attributed to the "muddy" turbid condition of the water in the Kentucky River locks. The other half of this difference is attributed to other disadvantages of the locks for recreational purposes, e.g., relatively narrow expanse of water, relatively poor access to some sections of the river.

5. Of the one half of the "lost" recreational value of visitor days, twenty-two percent is attributed to suspended sediment and turbidity due to surface mining in the North Fork region (see sub-section on water treatment costs for the derivation of the 22% figure).

6. Given the above assumptions, the value of downstream recreational losses due to surface mining in the North Fork is calculated.

Downstream recreational losses were determined for the approximately 400 river kilometers of the Kentucky River below Beattyville to the confluence with the Ohio River. A market area with a radius of 160 kilometers around Frankfort, Ky., was defined as a potential market area for recreation on the Kentucky River. Regression equations as reported in a study of recreation potential commissioned by the Appalachian Regional Commission [2] were used to estimate the conditional probability of an individual's participation in three types of water based recreation activities: swimming, fishing and boating. The equations estimated using Bureau of Outdoor Recreation data are (t values in parentheses):

$$S = \underset{(23.124)}{.0119A} + \underset{(6.222)}{.2536R} + \underset{(5.109)}{.2554Y} - \underset{(2.424)}{.0425Y^2} - \underset{(2.446)}{.0546U} - 6809$$

$$B = \underset{(8.234)}{-.00414A} + \underset{(5.691)}{2277R} + \underset{(4.261)}{.0901Y} + \underset{(3.755)}{.0681E} + \underset{(2.964)}{.0662Re}$$

$$F = \underset{(6.694)}{-.0033A} + \underset{(3.202)}{.0583Y} + \underset{(5.271)}{.1060Re} + .2509$$

where

A= age of respondent, in years

R= Race: 0 = nonwhite
1 = white
Y= Family income
U= Urbanization: 0 = if respondent lives in area over 25,000 population
1 = if respondent lives in area less than 25,000 population
E= Education: 1 = if no response or less than six years
2 = if high school or less
3 = if more than high school
Re= Residence: 0 = if lives in an SMSA
1 = if does not live in an SMSA
S= Swimming
B= Boating
F= Fishing

Conditional probabilities were calculated for each ethnic and demographic classification and multiplied by the population in that classification. The resultant number of persons participating in each of the three recreation classifications was then multiplied by the average number of activity days per participant as reported [2]. The results of these calculations are the total number of recreation days for boating , swimming and fishing demanded annually in the market area.

The surface area of water available for recreation in the market area, and in the Kentucky River below Beattyville, was calculated. Assuming that the Kentucky River is equally desirable for water-based recreation, compared to other recreation sites, expected recreational use of the Kentucky River, was calculated by dividing total recreation days demanded by the percentage of surface acres in the market area which are in the Kentucky River.

These expected recreation days were compared with 1975 actual recreation days recorded by the Corps of Engineers. Table 19 is a summary and comparison of expected and actual recreation in the Kentucky River.

The economic value of the expected and annual recreational days of use was calculated using a value of $1.50 per day, which is the midrange of the current Water Resources Council estimates of the value of slack water recreation. The shortfall in recreational use on the Kentucky River amounts to about $1,922,000 annually. Of this, one half ($961,000) may be attributed to suspended sediment. Of that, an annual loss of $115,000 may be attributed to impairment of water quality due to surface mining in the North Fork basin.

Total Annual Losses in the Value of Fish, Wildlife and Recreational Activities

The annual economic losses in downstream recreational activities and the annualized replacement cost of fish in the region, attributable to surface mining in the region, amount to $180,300. Commercial fishing

Table 19
PREDICTED AND ACTUAL RECREATION, KENTUCKY RIVER BELOW BEATTYVILLE

	Predicted Recreation Days	Actual Recreation Days (1975	Difference in Actual and Predicted	Actual As % of Predicted	Predicted $ Value of Recreation	Actual $ Value of Recreation	Difference In $ Values
Swimming	778,440	100,388	678,052	12.896	$1,167,660	$150,582	$1,017,078
Boating	508,934	13,107	495,827	02.575	$ 763,401	$ 19,661	$ 743,740
Fishing	128,756	21,524	157,232	16.717	$ 193,134	$ 32,286	$ 160,848

losses, in-region hunting losses, and in-region recreational fishing losses remain unquantified. It is quite possible that the annual value of the unquantified losses exceeds the value of those losses which could be quantified.

THE TOTAL ECONOMIC COSTS OF ENVIRONMENTAL DAMAGE

It now remains to determine the total economic costs of environmental damage from surface mining for coal in this study region, under the existing regulatory framework. Presented below are estimates of the total annual costs of damage in the study region, the costs of damage per hectare mined and per metric ton of coal surface mined (all in 1976 dollars).

For each of these calculations, total costs are determined by addition of the costs for the five identified and quantified categories of environmental damage: aesthetic damage; water treatment costs; flood damages; damage to land and buildings; and losses in fish, wildlife and recreation related activities. These estimates of total damage are systematic underestimates, to the extent that flood damage is underestimated and additional sources of damage remain unquantified and therefore are omitted from these calculations. Unquantified sources of damage include: in-region recreational fishing and hunting losses; in-region and downstream commercial fishing losses; downstream aesthetic losses (other than recreational); and the option and preservation value of the mountain enviroment.

Two estimates of the total economic costs of environmental damage attributable to surface mining in the study region are reported: total consumer payment (TCP) and regional willingness to pay (RWP). These estimates differ only with respect to aesthetic damages, and their interpretation is discussed in that subsection. To calculate total R.W.P., the estimates of aesthetic damage derived from game 3 are used.

Total Annual Environment Costs in the Study Region

Aesthetic costs can be determined from the bidding game results by calculating the difference in value between the unmined environment, D, and the existing regional environment. Of the land in the study region which has been mined, mining of 42.9% has commenced within the last three years, and so this land has not yet been revegetated. Also, 4.8% is orphan, or unreclaimed land. These two categories of land are currently in state A, mined but unreclaimed. The remainder of the mined land has been reclaimed fully or partially. After considering the pattern of mining activity in this study region over time and the time of enactment of existing reclamation laws, we estimate that one third is now partially reclaimed and two-thirds is now fully reclaimed. Thus, of the total area of land which has been mined, 17.4% is now in state B and 34.9% is in state C.

The other categories of environmental costs were initially calculated for existing conditions. Thus, we calculate annual environmental costs of

surface mining in the study region to be:

Category of Costs	T.C.P. $ Millions	R.W.P. $ Millions
Aesthetic	56.487	1.048
Water Treatment	0.125	0.125
Flooding	0.269	0.269
Land and Buildings	1.837	1.837
Fish, Wildlife and Recreation	0.277	0.277
Total	58.995	3.556

Present Value of the Environmental Costs of Disturbing One Hectare by Surface Mining

It is assumed that almost all of the erosion and sedimentation which result from mining occur in the first three years. After that time, revegetation will stabilize the soil and result in very substantial reduction in run-off, erosion and sedimentation. Thus, the flooding, water treatment and water-based recreational costs will occur in years 1 through 3 following mining. The damage to land and buildings will occur, in very large part, during years 1 and 2, the years when substantial earth moving activity is under way. This assumes compliance with regulations designed to eliminate slides which result from improper deposition of overburden. Aesthetic damage occurs as follows: the environment is in state A, unreclaimed, for three years after the initiation of mining; it is in state B, partially reclaimed for the next 5 years; and in state C, fully reclaimed thereafter (again, assuming compliance with reclamation regulations).

The present value of the environmental damages from mining one hectare in the study region, discounted at six percent per year, are presented below.

Category of Costs	T.C.P. $/hectare	R.W.P. $/hectare
Aesthetic	43,890	770
Water treatment	58	58
Flooding	122	122
Land and Buildings	834	834
Fish, Wildlife and Recreation	126	126
Total	45,030	1,910

Present Value of the Environmental Costs of Producing One Metric Ton of Coal by Surface Mining

Given that the disturbance of one hectare in the study region yields 4932 metric tons of coal, the present value of environmental costs per metric ton is:

Category of Costs	T.C.P. $/Metric Ton	R.W.P. $/Metric Ton
Aesthetic	8.90	0.16
Water treatment	0.01	0.01
Flooding	0.03	0.03
Land and Buildings	0.17	0.17
Fish, Wildlife and Recreation	0.03	0.03
Total	9.14	0.40

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SECTION 5

NON-MONETARY INDICATORS OF THE HUMAN AND SOCIAL IMPACTS OF ENVIRONMENTAL DAMAGE FROM SURFACE MINING

Characteristics of the Sample

In addition to the estimates of the economic value of aesthetic environmental damage from surface mining (reported in Section 4), the survey of residents in the study region yielded additional valuable information about their lifestyles and how they felt about their environment and what they perceived the impacts of surface mining to be on their lives.

The 204 households sampled exhibited the following characteristics. Reflecting the extreme rurality of the study area, 164 respondents were located in rural areas, and 40 in the small town characteristic of the North Fork region. The majority of respondents were heads of households (132) or the spouse of the head (62). One hundred fifteen of the respondents were male and 89 were female. The age distribution of the sample is representative of the population of the North Fork area. The mean age of respondents was 46, reflecting the elderliness of many of the respondents. Sixteen were over 70 years old. Almost one-third of the respondents were age 36 and under. Their mean educational attainment was 9.67 years of schooling, with 45 percent having an eighth grade or less education. Fifteen percent had some college and 40 percent held high school diplomas.

Of heads of households, 24 percent were retired which again reflects the elderliness of many of the respondents. Nineteen percent of heads of households were employed in the coal mining industry. This number tends to underestimate the economic dependence of study area households on the coal industry; many retirees had retired from coal industry work. Sixteen percent were employed in service industries and 7 percent in construction. Nine percent were unemployed. While the mean household income of the sample was a fairly high $10,265, the median is $9,156. Ten percent of sample households had incomes exceeding $25,000. A quarter of the sample had incomes of $5,200 or less.

Household size ranged from one person (27 observations) to fourteen persons (1). The largest number of households (47) were composed of four persons and three person households were the next most common (39). Fifty households contained five or six people. Eleven households had from seven to fourteen persons in them.

Spouses (all but four were women) had characteristics similar to the

household head. Their mean age was 43 and they averaged almost ten years of education. Most spouses (129) were not employed outside the home.

Attachment to Place

The sample reveals a remarkably stable population with 93 percent of respondents having been born in Eastern Kentucky and having lived there an average of forty years. Ninety-five percent of the sample had lived in the same residence for fifteen years or more. Sixty-four percent traced their family's residence in the region back for more than 100 years. More than one-third could trace their family roots in the region back for 150 years or more. Only five percent said they or their families had lived in Eastern Kentucky for thirty years or less. Nonetheless, a little over half the respondents had lived outside of Eastern Kentucky at some time; they stayed away for a median of five years. Respondents who had lived outside the region had a variety of reasons for doing so. Some had fulfilled military obligations or participated in depression-era work programs. Others had sought employment primarily in manufacturing and service industries. The reason for the vast majority (72 percent) returning was simple personal preference for living in their present place. Only eight percent of the respondents indicated a desire to reside elsewhere. Eighty-nine percent said they wanted to be buried in the area. Eighty percent of them also strongly agreed to the statement, "This is the only place I consider home". Moreover, 56 percent said they would not consider moving away even if it became a little harder to earn a living. Obviously, these people have a strong attachment to their part of Kentucky.

Environmental Awareness

Twelve categories of potential environmental problems were listed. Respondents were shown a map of the study region, and asked (1) whether the problem exists in the region, (2) if it is a serious or minor problem (3) whether it has become less or more serious in the last ten years, and (4) whether the problem is of major, minor, or no personal importance to the respondent. (See table 20).

Litter, stream pollution and deterioration of roads were considered the most obvious and important environmental problems by a large majority of respondents (table 20). A slight majority also saw air pollution, soil erosion and reduction in wildlife as problems. Traffic noise was a problem on which opinion was evenly divided. Deterioration in scenery, other kinds of noise, crowded recreational sites and reduced fishing opportunities were not regarded as problems in the North Fork area by a majority of respondents. Many said the fishing had been poor for as long as they could remember. Generally, most of the people who perceived that an environmental problem existed in the area, also considered it serious, important, and to have become worse over the past decade.

Attitudes Toward Surface Mining and the Environment

Attitudes toward the study area environment and toward the surface mining industry were measured. Respondents were presented with statements,

Table 20
ENVIRONMENTAL AWARENESS RESPONSES
(In percentages, N=204)

Problem	Present?		How Serious?			In the last 10 yrs, has it gotten?			How Important to You?		
Column	Yes	No*	Very	Somewhat	Not Serious	Better	Worse	No Change	Very	Somewhat	Not Important
1. Stream Pollution	84	16	69	26	5	20	61	19	72	17	11
2. Lake Pollution	28	72	45	39	16	29	47	24	71	18	11
3. Air Pollution (include dust)	57	43	52	29	19	15	63	22	76	15	9
4. Traffic Noise	50	50	46	38	16	3	79	18	58	27	15
5. Other Noise	15	85	39	36	25	17	66	17	52	28	20
6. Litter	85	15	75	20	5	18	66	16	82	12	6
7. Soil Erosion	66	34	70	20	10	13	61	26	79	13	8
8. Deterioration of Scenery	47	53	53	40	7	16	74	10	77	20	3
9. Reduction of Wildlife	52	48	70	24	6	7	85	8	79	10	11
10. Reduced Opportunities for Hunting	52	48	59	29	12	6	79	15	67	16	17
11. Reduced Opportunities for fishing	40	60	72	24	4	5	89	6	72	20	8
12. Crowding in Recreation Sites	42	58	60	26	14	0	92	8	55	23	22
13. Deterioration of Roads and Highways	72	28	85	12	3	13	78	9	91	8	1

*"No" respondents are included from percentages in remainder of each row.

and asked to indicate strong agreement, agreement, no opinion, disagreement, or strong disagreement. Table 21 shows the responses.

There is a strong sentiment for conservation of the natural beauty of the mountain environment. To better interpret the depth of these feelings, recall the very strong attachment to place, as demonstrated by length of residence in the region and length of family history in the region and the very strong affirmation of attachment to the region which was elicited by attitudinal questions. This sentiment for conservation of the mountain environment seems to be a deeply held belief among a population strongly attached to an environment and a way of life which is different from national norms.

These people had a very strong perception that surface mining is causing irreversible damage to the mountain environment. This perception, among a population with strong sentiments toward conservation and strong attachment to place, indicates a deep sadness about the effects that surface mining is having. This, however, must not be taken as evidence of hostility toward the surface mining industry. The industry is the major basic industry in the region and 27 percent of the households had members who worked in the industry, while 64 percent had close relatives (non-members of the household) who worked in the industry. Our survey was not designed to determine attitudes toward the mining industry in general (just those attitudes closely related to environmental aspects). However, it is apparent that many respondents feel a deep sense of helplessness, due to their economic dependence on an industry of whose negative impacts they are very conscious.

In this context, it is notable that, when asked who should bear the costs of restoring the environment after surface mining (the coal industry, consumers of coal and coal products, citizens in coal producing regions, or the government), 65 percent indicated that the coal industry should bear these costs alone and an additional 17 percent that the coal industry should bear the major portion of these costs.

The strong assent to the statement that operators should get the consent of landowners before surface mining provides evidence of the unpopularity in the region of the manner in which Kentucky courts have interpreted the "broad-form" mineral deed (see Section 6).

Personal Experience of Impacts of Surface Mining

Respondents were asked whether they had personally felt the impacts of surface mining in their immediate living environments, within the past two years. If so, was the damage caused to them serious or minor? If they had not come into personal contact with surface mining impacts in the past 2 years, had they ever experienced such impacts? Table 22 provides the responses.

Damage to roads and noise from coal trucks are rather common impacts of mining affecting a majority of respondents as they conduct their daily affairs. Road damage is considered more serious by those affected. Visible mines, either active or abandoned, are present in the daily lives of about

Table 21
ATTITUDES TOWARD THE MOUNTAIN AND SURFACE MINING ENVIRONMENT
(Percentages, N= 204)

	% Strongly Disagree	% Disagree	% No Opinion	% Agree	% Agree Strongly
1. In the North Fork region, there are some places where the environment should never be disturbed.	1	7	2	38	52
2. There is no need to preserve the natural beauty of the mountain environment for future generations.	0	5	10	35	50
3. Sometimes, land surface mined and then reclaimed is more productive than it was before mining.	9	20	4	38	29
4. Once surface mining has taken place, no matter how good are the efforts at reclamation, the land will never be exactly as it used to be.	2	10	16	38	34
5. Once the headwaters of a stream have been disturbed, the stream will never again be as good as it used to be.	67	24	3	2	4
6. Mining operators should be required to restore surface mined land to its original contour.	13	21	18	40	8
7. Mining operators should have to get permission from the landowner before surface mining.	0	1	0	18	81

Table 22
RESPONSES TO QUESTIONS CONCERNING
SURFACE MINING AND RESIDENTIAL QUALITY OF LIFE
(Percentages, N= 204)

In your immediate living environment (i.e. your home and the places where you shop, attend school, church and/or regular social activities, but not including your work environment) have you noticed any of the following impacts of surface mining?

Impacts	In the last 2 years? *			Ever?		
	Serious	Minor	None	Serious	Minor	None
Active surface mine visible	26	22	52	29	13	58
Abandoned surface mine visible	33	26	41	1	8	91
Noise from blasting	28	33	39	20	7	63
Noise from operating surface mining equipment	12	22	66	14	14	72
Noise from coal trucks	26	33	41	29	11	60
Damage to public roads that you use	71	18	11	50	9	41
Drinking water tastes or looks unpleasant	16	8	76	6	2	92

*If answered affirmatively, respondent was not asked "Ever?" questions. These columns, "last 2 years?", represent proportions of the total respondent sample... "Ever?" percentages are the proportion of those saying "None" to "in the last 2 years" and thus form a sub-proportion of the respondent sample.

half the respondents and from a quarter to a third of all respondents consider this to be a serious impact. Noise from blasting was considered a serious impact by 28 percent of the respondents but only 12 percent felt noise from mining equipment to be of serious impact.

We also asked if respondents had never experienced any damage to personal property due to surface mining. Eighteen did report some damage to buildings and structures they owned in the past two years with ten of them terming the impact as serious. Eight other respondents had sustained similar damage in the past, and five of them considered it serious. Twenty-two respondents experienced damage to land they owned in the past two years, with thirteen characterizing the damage as serious. Those who had experienced serious damage to their land in the past but not in the most recent two years numbered eighteen, while four had suffered minor damage in the past.

When asked about other kinds of damage, nineteen had experienced various environmental impacts that did not fall in our predetermined categories, including eight who experienced flooding due to surface mining. Other complaints included coal dust, damages from blasting, silt dam problems, erosion, coal truck traffic and negative effects on their underground water supply.

Environmental Perceptions and Surface Mining

Respondent's aesthetic preferences among four alternative environments, each represented by four photographs, were recorded. The packages of photographs were the same as were used with the bidding games (Section 4). The mined but not reclaimed, mined and partially reclaimed, mined and fully reclaimed, and never mined environments were represented. Each respondent indicated whether he liked or disliked the environments represented on a scale of (dislike greatly -3, -2, -1, 0,1,2,3,4 like very much). He also indicated how important each environment was to his sense of well-being on a scale of (not important 0,1.2,3,4 very important). Multiplication of the responses on these two scale allowed the development of a composite scale (offends me greatly -12, -11,....., 11, 12 pleases me greatly).

Table 23
ENVIRONMENTAL PERCEPTIONS AND PREFERENCES
(North Fork of Kentucky River Region, 1976)

Scale: Offends me greatly -12.....+12, pleases me greatly.

Environment	Mean Score*	SE (mean)
Mined, no reclamation	-9.95	0.29
Mined, partial reclamation	-2.54	0.46
Mined, full reclamation	7.84	0.29
Never mined	11.52	0.12

*All mean scores significantly different from each other at the .01 level of significance. N=204.

The respondents showed a remarkable degree of unanimity in their responses. Each environment was ranked differently from the others, at the .01 level of statistical significance. The unreclaimed environment was perceived very negatively, the partially reclaimed environment slightly negatively, the fully reclaimed environment quite positively, and the never mined environment very positively (table 23). It is very important to note that the fully reclaimed environment was perceived as aesthetically inferior, at a very high level of statistical significance, to the never mined environment.

As reported in Section 4, the respondents to the bidding games expressed a positive and substantial willingness to pay for aesthetic environmental improvements in the context of damage from surface mining. Partial reclamation was ranked lower than full reclamation, which was ranked lower than reclamation to return the land to a condition indistinguishable from the original (if that were possible), in terms of the dollar amounts respondents were willing to pay. These differences were highly significant (table 12 Section 4).

These data recording the environmental perceptions of a sample of regional residents and their willingness to pay for environmental improvements are most interesting. Environments are perceived differently, by ordinary citizens, most of whom would reject the "environmentalist" label. Further, citizens are willing to pay to obtain a higher level of aesthetic environmental quality. Reclaimed environments were perceived as preferable to unreclaimed environments and the never mined environment as preferable to the environment reclaimed with the best current practices. These data provide further strong evidence that citizens in the study region see the environmental damage from surface mining as irreversible.

Summary

The result of a survey of residents in the study area show:

1. The population is a little older, poorer and less well educated than the national population.

2. Respondents are aware of environmental problems in the study region and many believe that, if anything, these problems are getting worse as time goes on.

3. The lives of many respondents have been touched by surface mining for coal: many by one or more of its environmental impacts and many by its economic impacts in the region. This results in an ambivalence toward the industry. Its environmental impacts are strongly disliked, while its economic impacts provide the basis for the material aspirations of some.

4. The population has a very strong attachment to its home in the mountains, and a strong positive sentiment for conservation of the beauty of the mountain environment.

5. The aesthetic impacts of surface mining are seen as strongly

negative, with reclamation ameliorating some of the damage.

6. The citizens are willing to undergo some economic sacrifice if they were assured of aesthetic environmental improvements.

7. The aesthetic damage caused by surface mining in the mountains is seen as irreversible. Reclamation improves, but cannot fully restore, the surface-mined landscape.

SECTION 6
THE ECONOMIC VALUE OF DAMAGE UNDER ALTERNATIVE REGULATORY REGIMES

In Appendix A, a detailed analysis of existing and alternative regimes for the regulation of surface mining activities is presented. The alternatives considered include:

1. the existing regime which consists of state regulations superimposed on a structure of private law property rights,

2. a "no regulation" regime, which consists only of the existing private law property rights as they pertain to land, minerals and water,

3. a federal surface mining law superimposed on state law and private law, and

4. a modified state law, superimposed on the existing structure of private law. The state law would be modified by the introduction of a flexible bonding schedule based on a priori estimates of the social costs of surface mining, in place of the existing, less flexible, bonding schedule based on a priori estimates of reclamation costs.

Below, the salient legal features of each of the four regimes are discussed. For convenience, alternative 2 is discussed first. The other alternatives build upon the private law basis of alternative 2. Then, the impact of each regime on the economic cost of environmental damage from surface mining is estimated.

Alternative 2.

The second alternative is one of "no regulation". By that we mean a legal and economic environment in which there are no statutory or administrative regulations by federal, state or local government affecting surface mining activities. The types of public regulation thus suspended would include those dealing with water pollution and reclamation, as well as with the mining operation itself. Under this approach, rights and liabilities would be determined solely by reference to the principles of private law. In Kentucky, property law doctrines would govern the relationship between mineral and surface interests on the same tract of land, while the law of nuisance would control in the case of conflicts between the coal mine operator and other landowners.

Although various legal interests can be created with respect to subsurface minerals such as coal, in Kentucky the mineral interest is usually regarded as a separate estate of equal dignity to the surface interest. Thus we typically speak of a mineral estate and a surface estate. In much of eastern Kentucky mineral estates were created by means of "broad form" deeds. By their express terms these instruments made the surface estates completely subordinate to the mineral estates. Furthermore, these deeds often contained provisions by which the surface owner and his successors in title waived any claims they might have against the mineral owner for damage to the surface as a result of mining operations.

According to the Kentucky courts, the broad-form deed, with its waiver-of damages provisions, applies to strip mining activities and makes the coal mine operator liable only for oppressive, arbitrary, wanton or malicious conduct. If necessary, the surface estate may be entirely destroyed in order to remove the coal.

Private nuisance principles apply when the mine operator does not have any property interest in the tract which is damaged, as in the case of downstream landowners injured by water pollution from upstream surface mining operations. Liability is ascertained by examining the reasonableness of the defendant's activity and the gravity of the harm to the injured landowner. This involves a balancing of the social utility of the defendant's conduct against the harm to the plaintiff's land. If a nuisance is found to exist, the court may grant injunctive relief or award damages to the injured party. Under the balancing test described above, strip mining activities which cause substantial harm to nearby property would probably be regarded as private nuisances. However, the expense and uncertainties of litigation apparently have discouraged many landowners from asserting their rights under private law doctrines.

Alternative 1.

In addition to the limitations of private law described in our discussion of the second alternative, surface mining is presently subject to regulation by agencies of federal, state and local government. Therefore, our first alternative, the "status quo", must take account of these various forms of public regulation.

At the federal level, the Federal Water Pollution Control Act Amendments of 1972 (FWPCAA) are potentially the most significant form of existing governmental regulation. The goal of this legislation is to eliminate all discharges of pollutants into the navigable waters of the United States by 1985. Effluent limitations which are implemented by means of a National Pollution Discharge Elimination System (NPDES), will require the application of the "best practicable" control technology by 1977 and the "best available" technology by 1983. FWPCA is administered by the Federal Environmental Protection Agency (EPA), but the states will eventually run the NPDES permit programs once they

meet EPA approval. At the present time it is unclear to what extent FWPCA will apply to surface mining activities since many of the Act's regulatory provisions are limited to "point sources". Federal law also regulates strip mining operations in both national parks and national forests. Mining is not permitted in most national parks, but may be allowed in national forests, subject to strict regulation, where environmental damage is not expected to be serious.

At the state level, the Kentucky Department for Natural Resources and Environmental Protection, operating under the authority of KRS Chapter 350, has general regulatory responsibility for surface mining in Kentucky. The Department's basic tool is a permit system which applies to all private strip mining operations. To strip mine coal in Kentucky, an operator must first obtain a permit, pay a fee, and post a reclamation bond. The permit application must contain a variety of information along with detailed plans indicating the proposed method of operation, the manner, time and distance for backfilling and grading work, along with a reclamation plan for the affected area. KRS 350 and Department regulations impose limitations on solid bench width and highwall slope and prohibit contour mining on slopes of more than 28 degrees. In addition, the state act requires the coal operator to reclaim the land in a manner approved by the Department.

Strip mining is at least potentially subject to regulation at the local level as well. Kentucky's zoning enabling act, KRS Chapter 100, authorizes cities and counties to exercise a variety of land use controls, including zoning. The enabling act specifically mentions the "filling or excavation of land, and the removal of natural resources....". Through the use of this delegated power units of local government could probably restrict strip mining activities in populated areas. However, to date, few if any cities and counties have attempted to do so.

Alternative 3.

The third alternative is based on a possible federal regulatory program. It should be noted that a federal strip mine bill, if enacted, would not displace other existing federal, state, or local regulations, although it would require some modification of KRS Chapter 350. Therefore, in addition to the features discussed below, the third alternative would include most of the elements of alternatives one and two described earlier.

A proposed Federal bill would probably differ from the present Kentucky statute, KRS Chapter 350, with respect to permit applications, bonding procedures, public hearings and enforcement measures, and would impose stricter and more comprehensive regulations on both the mining operation itself and subsequent reclamation efforts than existing state legislation. A proposed federal bill would require segregation of topsoil, plugging of auger holes and better reclamation practices. In addition, where mining takes place on steep slopes, a proposed Federal act would prohibit disturbance of land above the highwall, limit pushing

spoil material over the outslope, and generally require the operator to restore the land to its approximate original contour. Furthermore, a proposed federal act might ban strip mining entirely in some areas.

Alternative 4.

The fourth alternative is aimed at confronting the coal mine operator with the full social costs of surface mining. Under this approach, most of the regulatory provisions discussed in Alternative 2 would be retained, but a more flexible performance bond technique would be used instead of that currently found in KRS Chapter 350.

Under Alternative 4, the performance bond would be set by the regulatory agency at an amount equal to (or perhaps greater than) the estimated social costs that would result if no reclamation was performed. Social costs would be estimated on a case-by-case basis, taking all relevant considerations into account. A matrix relating the estimated social costs to the physical environment in the area of proposed mining operation could be developed and used for this purpose. The operator could question the amount of the proposed bond in an administrative hearing if he chose prior to the issuance of the strip mining permit.

Upon satisfactory compliance with all requirements for the prevention of off-site damage during mining and subsequent reclamation the full amount of the bond would be returned. This is the present procedure under KRS Chapter 350. However, under Alternative 4, the operator, after posting bond and obtaining his permit, could elect to abandon the site at any time. If he did so he would forfeit either (1) the total amount of the bond, or (2) the costs to the state of completely reclaiming the land plus a fixed penalty per acre abandoned, whichever amount was less. If the operator reclaimed the land properly, but failed to prevent off-site damages during mining, as required, the prescribed penalties could be assessed and subtracted from the bond prior to its return.

This approach may be contrasted with the performance bond provisions of both the present Kentucky Statutes, KRS Chapter 350, and the proposed federal strip mine bill.

At present, KRS 350.151 authorizes the state regulatory agency to require the operator to post a performance bond of $500-$3,000 per acre in order to obtain a strip mining permit. This bond may not be less than $5,000. If the operator fails to comply with the terms of his permit, provisions of the statute or agency regulations, the Department, under KRS 350.130, may suspend and eventually revoke the permit. Revocation also results in forfeiture of the performance bond. KRS 350.093 (6) provides for a partial release of the bond when the backfilling and grading have been completed by the operator and approved by the agency and the required soil pH level has been achieved. However, the Department must retain $300 per acre until the required planting and revegetation work is completed. According to KRS 350.113 (3), the remainder of the operator's performance bond is released after the agency has determined

that a satisfactory revegetative cover has been established on the reclaimed area.

If the operator fails to reclaim the land in accordance with his permit obligations, the agency may cause his bond to be forfeited pursuant to the provisions of KRS 350.130. However, KRS 350.130 (3) states that no operator who has forfeited a bond may receive another permit unless the land involved has been reclaimed without cost to the state. An operator who does not meet the planting requirements but does not want his bond forfeited may instead pay the department a sufficient sum to cover the remaining reclamation costs.

According to KRS 350.139, all funds from the forfeiture of bonds are to be expended insofar as possible upon the lands for which the bonds were originally given.

The provisions of the proposed federal strip mining statute (Alternative 3) with respect to performance bonds are similar in many respects to those of the Kentucky Act discussed above.

A proposed federal bill would provide that after a surface mining permit is approved, but before it is issued, the applicant must post a performance bond. The amount of the bond will depend upon the reclamation requirements of the approved permit and would be determined by the regulatory agency on the basis of independent estimates. Under the proposed Federal bill, part of the bond would be released after completion of backfilling, and drainage control for a bonded area in accordance with the approved mining and reclamation plan. The remainder of the bond would be released after completion of revegetation.

In a comparison with the performance bond provisions of KRS 350 and the proposed federal act, Alternative 4 vests a good deal more discretion in the coal operator. For any particular site, he would have to decide whether or not to mine. If the operator decided to mine, he would then determine his optimal expenditure on reclamation on the basis of economic incentives. On the other hand, the public would be fully compensated for any shortfall in reclamation performance.

Alternative 4 would involve comparatively minor changes in the text of KRS Chapter 350. The upper and lower bond limits of KRS 350.060 (9) and KRS 350.151 (2) would have to be removed. In addition, KRS 350.110 and 350.130, which deals with performance bond forfeitures, would have to be revised. The only serious legal problem concerns the method by which the amount of the performance bond would be determined by the regulatory agency. Ideally, the statute should provide a comprehensive list of the sorts of damages the Legislature considers to be social costs of surface mining. The declaration of policy contained in KRS 350.020 does this to some extent, but a more specific enumeration would be desirable. Secondly, the agency should be directed to formulate by rule or administrative regulation a specific procedure or methodology by which prospective social costs can be identified and quantified in monetary terms for particular tracts of land so that performance bonds will be determined on an objective

basis. It is necessary to provide some standards to guide the agency in such matters. Otherwise, it might be argued that the statute vests too much discretion in the agency and thus amounts to an unlawful delegation of legislative authority. Of course absolute precision would not be needed to satisfy this constitutional requirement, and the methodology developed in this study for identifying and quantifying the social costs of strip mining might very well serve as a basis for these suggested administrative guidelines. Another approach, the use of estimates by outside sources as provided for in the proposed federal strip mining act, might also be considered. In either event, the permit applicant (and possibly other interested parties), should be provided with an opportunity to challenge both the amount of the performance bond and the manner by which it is calculated.

THE ECONOMIC COSTS OF ENVIRONMENTAL DAMAGE

Alternative 1

Alternative 1 is the existing regulatory regime, as currently enforced. The economic value of environmental damage from surface mining in the study region under alternative 1 is equal to the amounts calculated in section 4. These estimates are presented in table 24.

Table 24

COSTS OF ENVIRONMENTAL DAMAGE, UNDER REGULATORY ALTERNATIVE 1

Cost of Environmental Damage	TCP	RWP
For the study region ($ million, annual)	58.995	3.556
Per hectare mined ($, present value)	45,030	1,910
Per metric ton of coal mined ($, present value)	9.14	0.40

Alternative 2

Alternative 2 is a "no regulations" regime, in which the existing private law property rights as they pertain to land, minerals and water constitute the complete legal framework within which surface mining would take place. The economic costs of environmental damage per hectare mined, and per metric ton of coal mined, were calculated on the basis of the following assumptions about physical damage.*

*Assumptions about the extent of physical damage to the environment under regulatory alternatives 2, 3 and 4 were made by the study team in consultation with Mr. J.D. Brackenrich, P.E. of Brackenrich and Associates, consulting engineers, Lewisburg, W.V. Mr. Brackenrich is a noted expert on surface mining and reclamation.

1. Due to the absence of regulations concerning the deposition of overburden, the incidence of slides would increase sixfold.

2. Sediment run-off from mine sites (which accounts for about 60 percent of total sediment under alternative 1) would increase fourfold, due to unregulated deposition of overburden and water management. Sediment runoff from haul roads (which accounts for about 40 percent of the total sediment under alternative 1) would increase at least eightfold. Unregulated haul roads would most likely run adjacent to stream beds and, in some cases, along stream beds since that would allow cost savings to operators. As sediment entering streams increases, the suspended sediment in streams increases, but at a decreasing rate. Thus, total suspended sediment due to surface mining in the study region would increase fourfold.

3. Total land disturbance would increase by a factor of 1/3, as a result of unregulated deposition of overburden.

4. Flooding, due to increased peak run-off and siltation of stream beds would increase by 50 percent.

5. For estimation of aesthetic costs and on-site damage to land, the land is assumed to remain unreclaimed.

Estimates of the economic costs of environmental damage under alternative 2 are presented in tables 25 and 26.

Table 25

COSTS OF ENVIRONMENTAL DAMAGE PER HECTARE MINED, ALTERNATIVE 2

Cost Item	TCP ($)	RWP ($)
Aesthetic	94,071	1,716
Water treatment	232	232
Flooding	189	189
Land and buildings	6,918	6,918
Fish, wildlife and recreation	415	415
Total	101,825	9,472

Table 26

COSTS OF ENVIRONMENTAL DAMAGE PER METRIC TON OF COAL MINED, ALTERNATIVE 2

Cost Item	TCP ($)	RWP ($)
Aesthetic	19.07	0.35
Water treatment	0.05	0.05
Flooding	0.04	0.04
Land and buildings	1.40	1.40
Fish, wildlife and recreation	0.08	0.08
Total	20.64	1.92

By comparing the environmental costs under alternatives 1 and 2, it is possible to estimate the net economic benefits from the reduction in environmental damages attributable to the existing Kentucky regulations. Per metric ton of coal mined, the benefits attributable to existing regulations amount of $11.50 (TCP) or $1.52 (RWP).

The contract under which the study was performed does not call for formal benefit/cost analysis of reclamation. However, for the purposes of illustration, the best available estimates of the cost of reclamation suggest that in order to meet existing standards, the total costs of mining are increased by about $0.90 per metric ton of coal mined.*

Alternative 3

Alternative 3 is the Federal surface mining regulatory bill, as introduced into Congress in the 1977 session. Compared with alternative 1, the existing Kentucky regulations, alternative 3 would make the following substantive changes in regulations (only those changes which are likely to have major impacts on environmental damage are listed):

1. Mined land would be returned to its approximate original contour.

2. On steep slopes (i.e. slopes greater than 20°), which predominate in our region, only spoil from the initial cut may be deposited down the outslope providing such spoil is properly stabilized. Otherwise, no spoil materials may be deposited down the outslope.

3. Access roads will be more strictly regulated.

*This cost estimate for reclamation was derived by adaptation of the estimates presented in Table 12, Appendix E, of reference [1]. The estimates presented in [1] are adapted from these in [2], and make use of information presented in [3].

4. The operator will assume responsibility for five full growing seasons after the last seeding.

The economic costs of environmental damage under alternative 3 were calculated under the following assumptions with respect to physical damage (in each case the damage under alternative 3 is compared with that under alternative 1):

1. Due to strict regulation of the deposition of overburden on the outslope, the incidence of slides would be reduced by 50 percent.

2. Total sediment run-off is reduced by 44 percent. This would occur as a result of (a) better design of haul roads (which would reduce sediment run-off from haul roads by 80 percent), and (b) the reduction of deposition of overburden on the outslope and the stricter revegetation requirements (which would reduce sediment run-off from the mine site by 20 percent).

3. Flooding would be reduced by 20 percent.

4. On-site damage to land would be affected as follows. Contour mine sites, following reclamation, would be valued in the market similarly to unmined land (section 4). Mountaintop removal sites, following reclamation, would be valued at the amounts reported in (section 4).

5. In order to estimate aesthetic damages, it is assumed that the mined land is in state A for three years following the initiation of mining. For the next five years, the land will be a state of similar value to state C. It will be returned to its approximate original contour, and planted with trees. For the next 15 years, as the trees grow, it will be in a state of aesthetic value midway between C and D. After that time, it will be aesthetically indistinguishable from D, the never mined state.

Estimates of the economic costs of environmental damage under alternative 3 are presented in tables 27 and 28.

Table 27

COSTS OF ENVIRONMENTAL DAMAGE PER HECTARE MINED, ALTERNATIVE 3

Cost Item	TCP ($)	RWP ($)
Aesthetic	26,393	451
Water treatment	32	32
Flooding	107	107
Land and buildings	414	414
Fish, wildlife and recreation	71	71
Total	27,016	1,076

Table 28

COSTS OF ENVIRONMENTAL DAMAGE PER METRIC TON OF COAL MINED, ALTERNATIVE 3

Cost Item	TCP ($)	RWP ($)
Aesthetic	5.35	0.09
Water treatment	0.01	0.01
Flooding	0.02	0.02
Land and buildings	0.09	0.09
Fish, wildlife and recreation	0.01	0.01
Total	5.48	0.22

Per metric ton of coal mined, the incremental environmental benefits of alternative 3 (compared with existing regulations, alternative 1) amount to $3.66 (TCP, or $0.18 (RWP).

For the purpose of illustration only, we note that the best available estimate of the additional costs of reclamation under alternative 3 (compared with alternative 1), adapted from (1,2,3) is about $1.90 per metric ton of coal mined.

Alternative 4.

Alternative 4 would set the operator's bond equal to the estimated costs of environmental damage which would occur in the absence of environmentally sound practices to prevent off-site damage during mining and reclaim the land following mining. The amount of the bond would necessarily be set on a case by case basis. For a typical mine in our study region, the bond would be on the order of $102,000 per hectare if TCP were used as the measure of environmental costs, or $9,500 per hectare if RWP were used. Note that even the bond based on RWP exceeds the current maximum bond under KRS 350, which is $3,000 per acre, or $7,426 per hectare.

Now, we estimate the amount of reclamation which would take place under alternative 4, and the amount of bond which would be forfeited by an economically rational operator of a typical mine in the study region. Figure 1 presents the total environmental cost curves derived from the TCP and RWP. Note that, no matter how great are the efforts at reclamation, some environmental damage remains. This damage is the aesthetic damage which occurs between the time of the initial cut and the time when revegetation is complete (i.e. when trees planted on the restored hillside are of mature appearance). These unpreventable environmental costs amount to $5.35 (TCP) or $0.09 (RWP), per metric ton of coal mined. In figure 2, the marginal benefits from reclamation are shown. Reclamation would proceed until the marginal benefits (which, from the perspective of the operator, are equal to the marginal savings in bond forfeiture) just equal the marginal costs (see points A and B on figure 2). Thus, the total investment

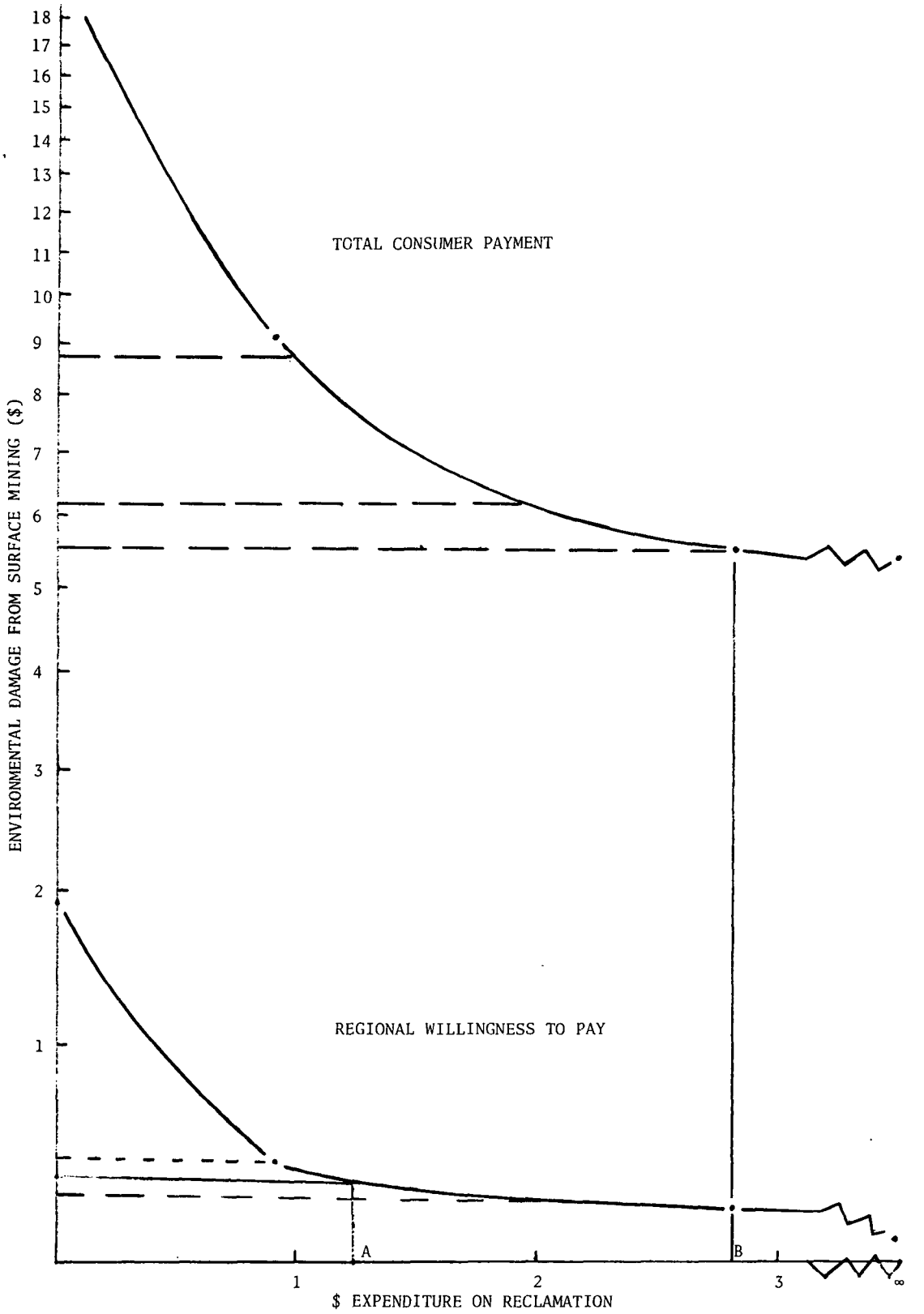

FIGURE 1. ENVIRONMENTAL DAMAGE FROM SURFACE MINING, AS A FUNCTION OF RECLAMATION EXPENDITURE.

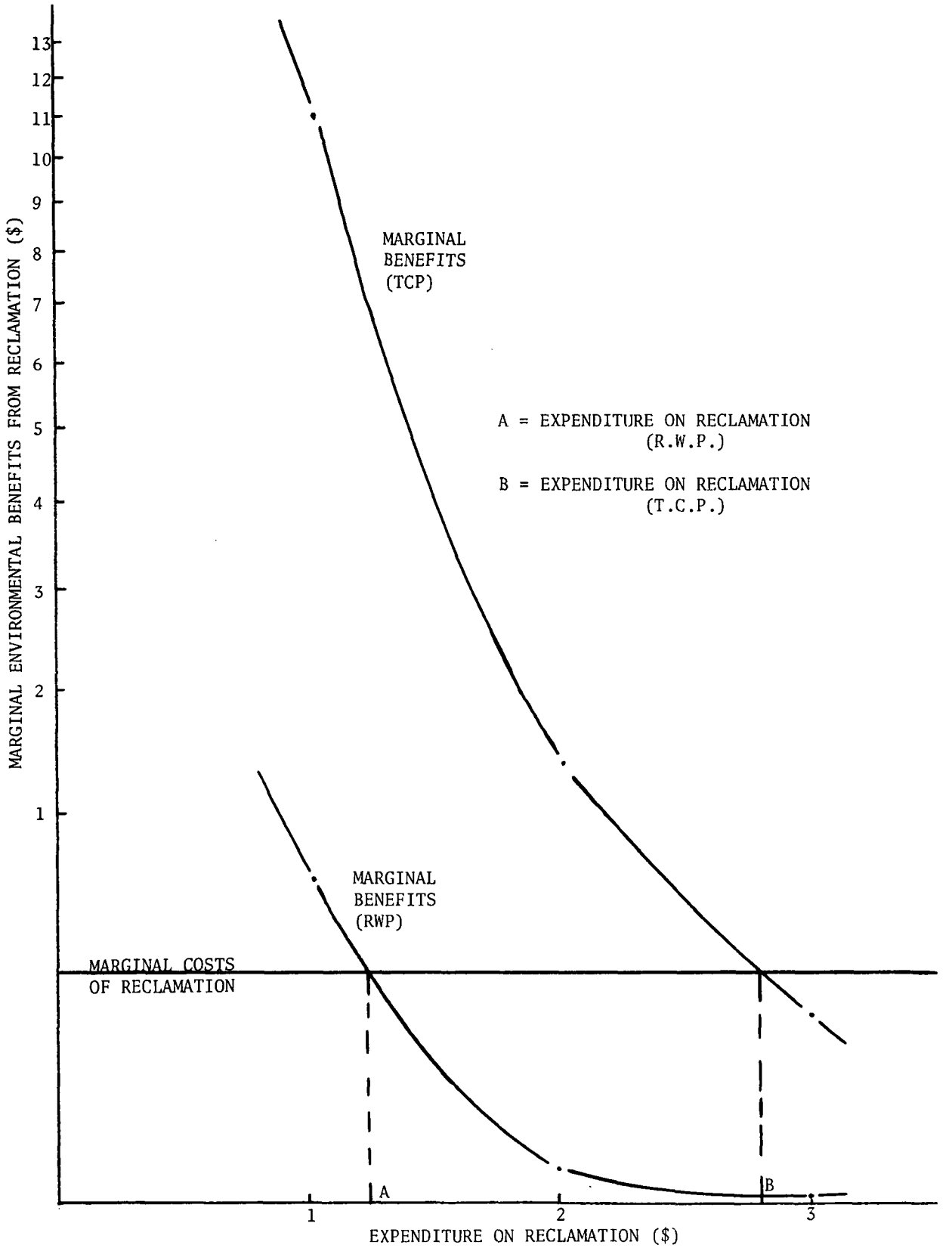

FIGURE 2. MARGINAL COSTS AND ENVIRONMENTAL BENEFITS OF RECLAMATION.

in reclamation would amount to $2.80 per metric ton of coal produced (TCP), or $1.25 per metric ton (RWP). Now the points A and B (figure 2) may be identified on the horizontal axis of figure 1. By drawing perpendicular lines from A and B to their respective damage curves, and then to the horizontal axis, bond forfeiture may be determined. An economically rational operator would forfeit $5.48 (TCP) or $0.30 (RWP). Total environmentally related costs faced by operators (i.e. reclamation costs plus bond forfeiture) would be $8.28 (TCP or $1.55 (RWP), per metric ton of coal mined. The degree of reclamation achieved would be about equal to that under alternative 3 (TCP), or perhaps 30 percent greater than under alternative 1 (RWP).

While the answers are beyond the scope of this study, some questions must be raised. Under alternative 4, if TCP was used as the measure of environmental costs of surface mining, bonds would customarily exceed $100,000 per hectare mined, and the operator's mining costs would be $8.28 per ton greater than under the "no regulation" alternative. What would be the impact of these cost increases on the price of coal, production of coal, and employment in surface mining? Clearly, surface mining in the steep, mountainous environments typical of our study area would decline.

On the other hand, if RWP was used as the measure of the environmental costs of surface mining, compared to the current regulatory regime, the increase in operator's costs would be quite reasonable, reclamation performance would improve somewhat, and the public treasury would receive approximately 30 cents per ton of coal mined as compensation for the environmental damage suffered by the public.

We are convinced that alternative 4 is worthy of additional study compared with existing and proposed regulatory approaches, it has the following potential advantages.

1. The decisions where and how to mine would be made on economic grounds by mining operators faced with the full environmental costs of their actions.

2. The decision as to reclamation would be made on economic grounds by mining operators faced with the full environmental costs of their actions.

3. The public would be compensated, through bond forfeiture, for the full economic value of damage which remains unmitigated.

4. The provision that unpaid fines for violation of regulations during mining are automatically deducted from the amount of the bond returned would allow stricter enforcement than is presently obtained under KRS 350.

A number of additional, fascinating possibilities are raised by alternative 4. For example, it might be possible to provide for "negative bond forfeiture" in the case where an operator re-opens an orphan mine for

a second cut or to exploit a deeper seam. If the operator reclaimed the site very well, his operation may result in a net environmental gain and he could be returned more than the amount of his bond.

Given these various considerations, we recommend that serious, in-depth analyses of the environmental, economic and energy impacts of alternative 4 be undertaken.

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SECTION 7

AN EVALUATION OF THE METHODS USED FOR ESTIMATING THE ECONOMIC VALUE OF THE ENVIRONMENTAL COSTS OF SURFACE MINING

The methods used in this case study must be evaluated by three criteria: (1) their conceptual validity, (2) the feasibility of their empirical application, and (3) their applicability to other empirical problems involving the evaluation of the social costs of surface mining.

Conceptual Validity and Feasibility of Empirical Application

The basic methodology of valuing the environmental costs of surface mining, as used in this study is in accord with sound and accepted economic theory. It is consistent with the conceptual basis of benefit/cost analysis, and adaptable to the special problems associated with non-market goods. The basic economic methodology recognizes the problems introduced by the prospect of irreversible change in man's environment, but provides no new insights into the problems of valuation in the context of irreversibility.

In summary, the methodology used in this study (that is, the logical framework of the general model presented in section 3) is conceptually valid, and consistent with the state of the art in economic valuation of external costs.

Within this coherent methodological framework falls a large number of specific valuation problems which are handled pragmatically on a problem by problem basis.

The valuation of aesthetic costs of surface mining is carried out using the bidding game technique. This technique has been used successfully in several recent studies [1,2], but nevertheless faces a skeptical reception by some economists who distrust data derived from other than the recorded outcomes of actual decisions. The basic data of bidding game studies, individual bids, are the responses of individuals to questions based upon hypothetical situations. This is the one serious objections to the bidding game technique. Otherwise, it is theoretically impeccable. The problems introduced by the hypothetical nature of the data are attacked in several ways: by the careful design of data collection instruments to incorporate the results of research in the social sciences on methods to make attitude surveys more accurate; by the replication, by other researchers at later times, of bidding game results [1.2]; and by the internal replication of results, by using several comparable games. This study has used the first and third of these approaches and, in addition, a device believed to

be used here for the first time: the direct comparison of results obtained using bidding games and non-monetary environmental preference scales with the same test environments and the same respondent population. The degree of consistency found among the results obtained using three different bidding games and the non-monetary preference ranking scale was most impressive and exceeded the prior expectations of the research team. Thus, substantial validation of the research is provided.

The use of sociological analyses in this study provided a valuable complement to the economic valuation analyses. The examination of non-monetary preference rankings for consistency with bidding game results provided a degree of validation of the latter. The sociological study demonstrated that residents of the study region perceive some of the adverse effects of surface mining to be irreversible, and thus provided useful information which could not be provided using traditional economic analyses.

The valuation of damage suffered to land and buildings was based on the results of survey: personal interview surveys to determine the value of damage to buildings and land off the mining site; and a telephone survey of realtors to determine the value of land unmined, mined and reclaimed, and mined but not reclaimed. The data collection technique relies on the knowledge and the honesty of respondents, or, on the assumption that errors and prevarications (to the extent that they exist) are normally distributed about the "true" mean.

The valuation of damages from increased flooding and impairment of water quality was undertaken using conceptually valid techniques. However, serious limitations in the data available forced the research team to undertake various shortcuts in empirical valuation. In the case of flood damage, it was necessary to assume that the relationship between the proportion of the catchment area surface mined and stream discharge was linear regardless of the size of the catchment area; and that the 1962 Corps of Engineers study of flood damages in the North Fork below Carr Fork, and the main Kentucky River, accounted for one half of the flood damages in our study region and downstream. Access to better data would permit future studies the use of actual data instead of such precarious assumptions. In the evaluation of downstream damages from impairment of water quality, it was necessary to make some heroic assumptions in order to calculate the impact of mining in the North Fork region on the concentration of suspended sediment in the Kentucky River. Access to more reliable data on the behavior of sediment loads in rivers would permit more reliable calculations.

The valuation of recreational losses was undertaken using conceptually valid techniques. However, data limitations were so serious that this was the least reliable facet of our empirical case study. No responsible agency collected reliable data on hunting and fishing activity in the study region, thus there was no empirical basis for either time series or inferential estimation of the impact of increased surface mining on the economic value of hunting and fishing in the region. The estimation of losses in the value of water-based recreation downstream from the region was based on a valid technique but required two assumptions: (1) the assumption (discussed

above) about the impact of mining in the study region on the concentration of sediment in the Kentucky River downstream, and (2) an assumption that one half of the shortfall in recorded recreation on the Kentucky River was due to poor water-quality while the other half was due to disadvantages of the river in terms of access and facilities for recreationists.

More complete information about wildlife and fish populations, and recreational use would have allowed much greater accuracy in our empirical analysis of losses related to fish, wildlife and outdoor recreation. We are certain that the empirical estimate of the value of these losses, presented in the study is a substantial underestimate.

In aggregate, we believe our estimates of the total value of the damages from surface mining in the study region, under the various regulatory regions, are underestimated, since we know of no items which have been overestimated but several which have been underestimated.

At this point, let us return to the general model for valuation of the costs of environmental damage from surface mining (presented in section 3, note equations 1 through 6 and tables 10 and 11). The observant reader will have noticed that in our empirical case study while we were faithful to the concepts of the model, we did not follow its dictates literally. The nineteen activities, A_k, and twenty-three resource quality changes, Q^*_{ij}, were compressed into five major categories of damage; aesthetic damage, damage to land and structures, water treatment costs, damage from flooding, and losses in fishing, hunting, and recreational activity. This compression is defensible in that it omitted no major categories of damage while on the other hand, double-counting was assiduously avoided. Further, it was rendered totally essential by major limitations in the data, both economic and physical, which were available to us.

However, it would be desirable if, in future such empirical investigations, the general model (as expressed in equations 1 through 6 and tables 10 and 11) was followed more closely. Examination of tables 10 and 11 provides the basis for identifying the kinds of data which would be needed from the natural and physical sciences in order to permit that approach.

Finally, it must be noted that there are some problems which our economic approach did not permit us to analyze thoroughly. Among these are; the question of irreversible change in the mined environment, the complete human dimensions of the tragic dilemma faced by a population economically dependent on an industry which changes irreversibly its beloved mountain environment and culture, and the option demand and preservation demand which non-use of the Appalachian environment may have. We feel strongly that future studies of the environmental costs of surface mining should include sociological studies of the regional population as we have done (section 5) and, in addition, should determine option demand and preservation demand for the environment which may be irreversibly changed by mining.

The Economic Analysis of
Regulatory Alternatives

The technique used for the analysis of the impacts of alternative regulatory regimes on the economic value of damage from surface mining is conceptually sound. The specific requirements of each regulatory alternative were identified following careful legal analysis. The research team, in consultation with a highly qualified expert on surface mining reclamation, estimated the changes in physical damage to the environment which would result from enforcement of the alternative regulatory requirements. Then, using the techniques which had been used to estimate the economic costs of environmental damage under the existing regulatory framework, these costs were estimated under the three alternative regulatory frameworks.

Again, the analytical and empirical technique of economic investigation which were used in this work are conceptually valid. However, limitations in the availability of essential physical data handicapped the economic analysis. In particular, we relied on the opinions of a highly qualified, experienced expert, rather than the results of careful scientific studies, to estimate the impacts of alternative regulatory requirements on the physical extent of environmental damage from surface mining in the region.

Feasibility of Application of These Research Techniques to Other Empirical Problems

Conceptually, the research methodology developed in this case study is applicable to the estimation of the economic costs of environmental damage from surface mining of coal in other regions, and from surface mining for minerals other than coal. As explained (section 3), these techniques used can be incorporated into the analysis of the social benefits and costs of surface mining, or the social benefits and costs of reclamation. However, limitations in economic data and research results from the natural and physical sciences limit the empirical applicability of the research technique and the reliability of the results obtained.

While we have noted repeatedly the data limitations which have afflicted our empirical case study, we believe that our study region is rather favorably situated with respect to data, compared with many other surface mining regions, at the present time. We had access to the following, highly valuable, localized studies of our region: (1) the "Surface Mine Pollution Abatement and Land Use Impact Investigation" study performed at Eastern Kentucky University for the Department of Natural Resources and Environmental Protection, and the Appalachian Regional Comission, 1975, report ARC 71-66-T2; (2) the long series of studies conducted by W.R. Curtis and his associates at the Southeastern Forest Experiment Station, Berea, Ky*; and (3) the "Kentucky River and Tributaries" study

*In the context, it should be noted that we had access to reports based on data collected prior to 1970. Reports based on more recent data are in the draft stage, but were unavailable to this research team. It should also be noted that in 1976 substantially increased funding at the Berea station resulted in the installation of much newer research equipment. Future research reports from the Berea station will be very helpful in this kind of analysis.

by the U.S. Army Corps of Engineers, 87/2 H. Doc. 423, 1962. We doubt that data of this quality is available for most surface mined regions.

Conclusion

This empirical case study has been a valuable exercise. Its value lies in two dimensions: (1) the development and refinment of a methodology for estimating the economic costs of environmental damage from surface mining, and (2) the development of empirical estimates of these costs for a case study area. While these empirical estimates are subject to data limitations, the research team believes they are of an acceptable order of reliability, and are demonstrably conservative estimates since areas of underestimation but not of overestimation can be identified. In spite of the imperfect nature of these empirical estimates, they represent a substantial increment to knowledge, where little knowledge previously existed.

Accordingly, it would be highly valuable to carry out several more such studies in a variety of different mining environments, and considering each of the major minerals which are surface mined. The information which would result is essential for the benefit/cost analysis of existing and proposed surface mining legislation and regulations. In order that progress be made in this direction, a two-pronged research attack is necessary: (1) continued research in the physical and natural sciences to elucidate the relationships between mining and resource quality changes, and between resource quality changes and the physical productivity of later uses; and (2) continued economic analyses to provide a broader base of economic information on the costs of environmental damage form surface mining, to allow replication of the results of this case study, and to further refine the relevant techniques of economic analysis.

Finally, it is noted (in section 6) that the fourth regulatory alternative which involves a flexible bonding schedule based on the social costs of non-reclamation (rather than the private costs of reclamation) has certain inherent economic advantages. In order to implement such a regulatory shceme, if that were desired, a substantial investment in research such as performed in this empirical case study would be necessary. Nevertheless, that it is possible that the social benefits from such an undertaking may exceed the costs.

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APPENDIX

LEGAL ANALYSIS OF SURFACE MINING REGULATION

PRIVATE LAW CONCEPTS

The areas of private law we call contract, tort and property have always played an important role in the ordering of human activities. Even today, while governmental regulations often supplement this private law framework rarely do they displace it entirely. This is certainly true of the coal mining industry. If all legislative and administrative controls were removed from coal mining operations, in most cases private law doctrines would still allow the various elements of the coal production process to adjust relationships among themselves.

While the law of contracts has a significant role in the dynamics of coal production, tort and property law doctrines are more important in the land use aspects of mining operations. Each of these bodies of substantive law will be briefly examined. Within the law of real property there is a specialized area, known as mineral law, which deals with the relationship between the holder of the mineral rights and the owner of the surface estate. The discussion below will concentrate on this area. In the case of tort law, nuisance is most important, although trespass cases sometimes occur in the context of strip mining. As a general rule, the law of nuisance seeks to protect the use and enjoyment of land from externalities caused by other landowners. Where the plaintiff and defendant each have an interest in the same tract of land as in the case of a severance of the surface and mineral ownership, principles of both property and tort law may be applicable.

A. Mineral Law

1. The Ownership Theory Versus the Profit Theory

There are two theories in the United States concerning severed interests in real property such as mineral rights: the ownership theory and the profit theory. Under the ownership theory the mineral interest is regarded as a separate estate of equal dignity with the surface interest. Title to the minerals underground is vested in the mineral estate and severed entirely from that of the surface owner. According to the profit theory, the surface owner continues to own the minerals in the ground while the holder of the mineral lease or profit a prendre, has the right to take and remove the minerals. In the latter instance, title to the minerals passes to the lessee only when they have been extracted from the ground. Although Kentucky favors the

ownership theory, either type of interest can be created, depending on the instrument by which the rights are granted.

As a general rule, the mineral owner or lessee has certain rights at common law over the surface estate in order that he may extract the subsurface minerals. These include the right to sink shafts and drill through the surface to reach the mineral, the right to cut timber for use in the mining operation and the right to pump water from the mine onto the surface. On the other hand, mineral interests must normally provide lateral and subjacent support for the surface estate.

2. The Broad Form Deed

In Kentucky the relationship between the mineral and surface estate is often complicated by the existence of a broad form deed. Much of Kentucky's mineral wealth was sold years ago under sweeping broad form deeds drafted by coal and land companies. By their express terms these instruments made the surface estates almost totally subservient to the mineral estates. Moreover, the Kentucky courts have held that the right to "mine" under such conveyances, refers not only to deep mining techniques, but also includes strip mining. A number of court decisions in this state have upheld the right of mineral owners under broad form deeds to remove their minerals regardless of damage to the surface estate. In most of these cases, the deeds contained waiver-of-damages provisions that prevented surface owners from obtaining any compensation for their losses.

The leading case is Buchanan v. Watson 290 S.W. 2d 40 (Ky. 1956). The Kentucky Court of Appeals in Buchanan held that the conveyance of a mineral estate by means of a broad form deed was sufficient to permit removal of the coal by surface mining methods, regardless of the intent of the original parties. Moreover, since the broad form deed contained a waiver of damages clause, the court declared that "the owner of the mineral has the paramount right to the use of the surface in the prosecution of its business for any purpose of necessity or convenience, unless this power is exercised oppressively, arbitrarily, wantonly, or maliciously, in which event the surface owner may recover for damages so occasioned." The surface estate in the Buchanan case was unimproved land. Four years later, however, in Blue Diamond Coal Co. v. Neace, the court held that the mineral owner under a broad form deed was not required to compensate the surface estate for damage to improvements on the property either. Applying the Buchanan rationale the court stated that the use of surface mining techniques, instead of those associated with deep mining, was not in and of itself sufficient to constitute arbitrary, wanton, or malicious conduct.

Since 1960 the Kentucky Supreme Court has steadfastly refused to alter in any significant manner the legal relationship between the mineral owner and the surface owner. The issue was thoroughly

re-examined in Martin v. Kentucky Oak Mining Co. involving a 10-acre tract of land in Knott County. Most of the parcel was on a hillside, but there was also a small area of bottom land occupied by the plaintiff's dwelling house, outbuildings and garden. The plaintiff sought to prevent the mineral owner from removing the coal by auger or strip mining operations. The trial court ruled that mineral owner could strip mine the area but must pay damages to the surface owner for any destruction of the surface. Both parties appealed the trial court's decision. Amicus curiae briefs were submitted to the State Supreme Court (then known as the Court of Appeals) by environmentalist and civil libertarian organizations as well as by representatives of the coal industry. A closely divided court (4-3) upheld the rights of the mineral owner and refused to modify the holding of the Buchanan decision.

Some years later, in 1974, the Kentucky Legislature attempted to circumvent the effect of the Buchanan and Martin cases by amending the state's strip mining regulations. This legislation, known as "House Bill 9," required applicants for strip mining permits under KRS Chapter 350 to obtain the written consent of the surface owner. This would have prevented a mineral owner from strip mining without securing the permission of the present surface owner. House Bill 9, however, was declared unconstitutional as an invalid exercise of the state's police power by the Court in Dept. for Natural Resources v. No. 8 Limited of Virginia, 528 S.W. 2d 684 (Ky. 1975).

B. Nuisance

The courts often distinguish between public nuisance and private nuisance. Normally a public nuisance affects the public at large, or those members of the public who come into contact with it, while a private nuisance affects only a limited number of individuals. However, the categories are not mutually exclusive: some conditions or activities may be characterized as both public and private nuisances where public and individual interests are simultaneously invaded. Mining activities which cause water pollution, soil erosion, or mudslides may often be treated as both public and private nuisances.

1. Public Nuisance

Public or common nuisances are diverse groups of minor criminal offenses which involve some interference with the interests of the community or the comfort and safety of the general public. The entire community need not be affected, however, as long as the condition interferes with the exercise of a public right. Although a public nuisance is normally treated as a criminal offense, the government may also pursue a civil remedy.

In addition, private individuals can maintain tort actions when they suffer damage from a public nuisance which differs from that suffered by the general public. When a public nuisance affects the use and enjoyment of one's land, the property owner meets the

requirements of the "special damage" rule. Not only is each tract of land considered unique in the eyes of the law, but in most cases the number of landowners affected by the nuisance will be limited and their interest different from that of the general public. For example, in Hancock v. Terry Elkhorn Mining Co., 503 S.W. 2d 710 (Ky. 1973), residents of Johnson County sued to enjoin the use of overweight coal trucks on state roads. The plaintiffs alleged that they suffered special injuries because their homes were damaged by vibrations and dust from the trucks. The court held that the landowner's complaint stated a cause of action in public nuisance.

2. Private Nuisance

A private nuisance may be anything which unreasonably annoys or disturbs the free use of one's property or which renders ordinary use or physical occupation of the property uncomfortable. Liability must be ascertained by examining the reasonableness of the defendant's conduct against the harm to the plaintiff's land. According to the Restatement of Torts, any intentional invasion is considered unreasonable unless the utility of the defendant's conduct outweighs the gravity of the harm. Factors that determine the gravity of the harm are its extent and character, the suitability of the invaded interest, and the burden on the injured party of avoiding harm. These factors must be balanced against the social value of the invading conduct, its suitability to the locality, and the ease by which it may be modified to prevent the harm.

3. Remedies

A variety of remedies are potentially available to the successful plaintiff in a nuisance case. The choice of remedies, however, may depend on the nature of the defendant's activity, whether the action is one of public or private nuisance, and whether the suit is brought by the state or by a private party. Since public nuisance is both a civil wrong and a crime, the government may institute a civil suit to enjoin the maintenance of the nuisance or it may bring criminal proceedings against the defendant. Depending on the circumstances, a private individual, whether suing in private nuisance or under the special damage rule in public nuisance, may seek either damages or injunctive relief.

4. Strip Mining and Nuisance Law

It appears that neither public nor private nuisance theories have been used very often against surface mining operations in Kentucky. Mining activities which cause water pollution, endanger public safety, or damage public highways would normally be considered as public nuisances. Apparently state officials are reluctant to bring public nuisances actions against mine operators when such conditions occur or prefer to deal with these problems under Kentucky's strip mine regulatory statutes.

Private nuisance actions are also fairly uncommon. When speaking of private nuisance it is necessary to distinguish between suits by surface owners against mineral owners within the same tract of property and suits by nearby landowners against surface mine operators. As we mentioned earlier, where a tract has been divided into a surface and a mineral estate under a broad-form deed, the surface owner is usually barred from suing the mineral owner under private nuisance unless the surface damage is caused by oppressive, arbitrary, wanton or malicious conduct. The usual principles of private nuisance apply where the mine operator does not possess any rights to the plaintiff's land under a broad form deed or some other conveyance. However, even though the law provides some protection from the effects of strip mining, it seems that the expense and uncertainties of litigation discourage many landowners from asserting their rights by means of private nuisance actions.

EXISTING PUBLIC REGULATIONS

A. Sources of Regulatory Authority

Although all levels of government, federal, state, and local, engage in regulatory activities, each derives its regulatory authority from a different source. In theory, the federal government has no inherent powers, but may exercise only those powers granted to it under the federal constitution. Among the more important of these are the commerce power, the property power, the tax power, and the war power. These constitutional provisions have been liberally construed by the United States Supreme Court and, therefore, generally provide ample support for federal regulatory legislation.

State regulatory legislation, on the other hand, is based on the state's police power. This power can be defined as an exercise of the sovereign right of the state to enact laws for the protection of the lives, health, morals, comfort and general welfare of the people. Institutions of local government, such as cities, counties and special districts have no inherent regulatory powers, but the state, through legislation, may delegate some of its police power to these local governmental bodies. A regulation by local government, however, will be deemed ultra vires and invalid if it exceeds the scope of the authority delegated to it by the state. The state or federal government may also delegate a portion of its legislative power to administrative agencies. Local governmental bodies may also subdelegate their own delegated powers in the same manner. Thus one can speak of a state or local administrative agency as having "rulemaking" powers. Such delegation is lawful as long as the delegating body provides the agency with adequate standards to control the exercise of administrative discretion.

B. Constitutional Limits on the Exercise of Regulatory Power

Various constitutional provisions impose constraints upon federal,

state and local governmental regulatory powers. The most important of these are the due process and equal protection clauses of the federal constitution. Both the United States Constitution and many state constitutions also prohibit regulations which impair the obligation of contracts, but this doctrine has largely been incorporated into the concept of due process and will not be discussed further.

1. Equal Protection

The equal protection clause of the fourteenth amendment of the federal constitution provides that no state shall deny to any person within its jurisdiction the equal protection of the laws. Federal regulatory activities are also subject to equal protection requirements through the application of the due process clause of the fifth amendment. In addition, the principle of equal protection is part of state constitutional law in virtually every jurisdiction.

Although the concept of equal protection is perhaps better known for its use by the federal courts in racial discrimination cases, it is also important where state and local economic or land use regulations are involved. When governmental regulations differentiate among various classes, such classifications are valid only where there are real differences between the classes, and the system of classification is reasonably related to the regulatory objectives of the statute or ordinance.

2. Due Process

The concept of due process is perhaps the most significant restriction on governmental regulatory authority. The due process clause of the fifth amendment to the United States Constitution applies to the federal government, while the due process clause of the fourteenth amendment to the Constitution is applicable to the states, and by implication, to local governmental bodies to which regulatory powers have been delegated by a state. In addition, most state constitutions have their own due process provisions.

Due process may be divided for analytical purposes into procedural and substantive aspects. The concept of procedural due process applies to both civil and criminal proceedings of an adjudicatory nature. It provides that before life, liberty or property can be taken by administrative or judicial action, those affected must be notified and given the opportunity for a hearing before an impartial tribunal.

Substantive due process imposes a two-fold limitation on governmental power. First, the regulation must have a reasonable relation to public safety, health, morals or general welfare. Legislative findings that a regulation promotes one of these interests, while not conclusive, are usually very persuasive. Second, governmental regulations must be reasonable and not arbitrary, capricious or oppressive. Property and individual rights may be impaired by the

government only in a manner and to the extent reasonably necessary to protect a legitimate public interest. This is sometimes referred to as the "taking issue." Moreover, a regulation which is generally valid, may be held invalid when applied to a particular individual or class of persons. For example, a restriction which destroys substantially all of the value of a particular piece of property will often be held unconstitutional unless compensation is paid. This implies a balancing process: the greater the public benefit, the more burdensome the regulation may become. Nevertheless, there is always a point beyond which the value of the affected property may not be diminished, no matter how great the public benefit. This approach is known as the "diminution-in-value" theory. Other solutions to the taking problem have also found favor with courts or commentators, but unfortunately, none of them, including the diminution test, can be applied with any precision in a specific case.

C. Federal Regualtion

1. Federal Water Pollution Control Legislation

Strip mines are a major source of water pollution in Kentucky. Sediment, iron compounds, and a variety of other substances are often discharged into streams as a result of nearby surface mining operations. Sediment is composed of both suspended solids and rapidly settleable material. Suspended solids, made up largely of fine particles of dirt and coal, block light for plant growth, clog fishes' gills and fill the watercourse with mud. Rapidly settleable materials, though not as harmful in the short run as suspended solids, also contribute to the silting up of lakes and reservoirs. Iron pyrite is often uncovered with strip-mined coal. When exposed, this material reacts with oxygen in the air and moisture from rainfall or in the stream itself to produce ferrous sulfate and sulfuric acid. These substances harm fish and other organisms by lowering the pH level of the stream. Other harmful compounds containing manganese, aluminum, nickel, zinc, sulfates, ammonia, fluoride, strontium, chloride, arsenic, lead, mercury, oils, and cyanide may also be discharged into streams by strip mining activities.

Since 1948, the Federal Water Pollution Control Act has been the major federal statute dealing with water quality. This legislation has been amended many times. The 1972 Amendments completely overhauled the existing statute and represent a significant federal commitment to water quality regulation. These Amendments require that all discharges of pollutants into the navigable waters of America be eliminated by 1985. Under its provisions, the Environmental Protection Agency (EPA) is required to conduct an extensive research into waste treatment methods. In addition, the federal government has subsidized a large construction program for municipal waste treatment facilities. Finally, the 1972 Amendments utilize a variety of enforcement devices in order to attain the 1985 goal.

Effluent limitation standards are an important feature of the new Federal Act. An effluent limitation is a restriction which limits quantities, rates and concentrations of chemical, physical, biological or other constituents which are discharged into the water from a particular point source. The Act provides that effluent limitations must require the application of "best practicable" control technology by July 1, 1977, and by July 1, 1983, effluent limitations must require use of the "best available" technology. In addition, point sources in certain categories, if constructed after 1972, must meet national performance standards--effluent limitations equivalent to the 1983 requirements. These categories include such operations as steel plants, textile mills, paper mills, and feed lots. Finally, EPA is required to establish separate effluent limitations for toxic substances.

Effluent limitations are implemented under the Federal Act by the National Pollution Discharge Elimination System (NPDES). A discharge permit will be issued only if all applicable effluent limitations are met. In cases where the applicant cannot meet the 1977 or 1983 requirements, the permit must include an enforceable schedule of compliance to meet those goals, and the permit may be modified or revoked if any condition is violated. The 1972 Amendments authorize the EPA to place the permit program under state control provided certain conditions are met.

First, each state must submit to the EPA for approval a proposed plan for implementing the new Act. This plan must provide for effluent limitations and schedules of compliance sufficient to meet the 1977 and 1983 requirements. The state implementation plan must also contain new source and toxic standards which are strict enough to meet the Federal requirements. Second, a state program must comply with a variety of substantive and procedural requirements. For example, state programs must provide for a monitoring and reporting system, enforcement procedures, and adequate state funding. Once approved, the state permit program must remain in compliance with the Federal Act and the EPA may revoke its approval if a state, after proper notice, fails to remedy the alleged defect.

When the provisions of a federal discharge permit are violated, the EPA must either issue a compliance order or institute a civil action. If a state-issued permit is violated, the EPA may also issue a compliance order or initiate a civil action. Moreover, under a separate section of the Act, the EPA may seek injunctive relief even when no permit has been violated, in cases where an imminent danger to public health exists. Also, private citizens may sue to enforce effluent limitations contained in state or federal permits and may also bring suit to compel the EPA to perform any nondiscretionary duty. Finally, there are criminal penalties for those who willfully or negligently violate the Act's provisions.

At the present time it is unclear whether these strict Federal

regulations apply to strip mining operations. Most of the Federal Act's provisions, including NPDES, are applicable only to point sources. The 1972 Amendments define a "point source" as "any discernible, confined and discrete conveyance, including but not limited to, any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock concentrated animal feeding operation, or vessel or other floating craft, from which pollutants are or may be discharged."

Federal officials in the EPA's Region IV, which includes the state of Kentucky, have declared that the 1972 Amendments, including NPDES extend to "pumped or gravity drainage from the bench, . . . discharges from silt basins (settlement ponds) . . . . [and] discharges from other treatment facilities associated with coal operations." The EPA appears to take the position that sheet runoff into a stream does not constitute a "discrete conveyance" and that a strip mine would not be considered a point source, unless the operator placed silt traps or some other treatment facilities into the stream in question. However, settling ponds, silt traps, pump hoses or ditches, if manmade, might also be regarded as "discrete conveyances" within the meaning of the Federal Act. Kentucky's existing strip mine regulations require strip miners to construct drainage ditches above high walls and use collection basins, water retarding structures and silt traps to reduce the effects of runoff from their operations. Arguably, if a strip mine constructs such facilities in order to comply with state law, it will also be subject to the federal government's NPDES program.

The EPA's intention to treat some strip mines as point sources is further evidenced by the fact that Region IV has already prepared NPDES permit applications for strip mining. Similarly, the agency has proposed some effluent limitations for strip mining. Although a pH parameter of 6.0 to 9.0 is the only final limitation in effect at the present time, final limitations for iron, dissolved iron and suspended solids were announced on April 26, 1977 (40CFR434).

If either EPA or the courts finally determine that all or most strip mining operations must comply with the provisions of the 1972 Federal Act, there will be a significant economic impact on the mining industry in Kentucky. On the substantive level, the 1972 Amendments require that the discharge of pollutants from point sources be eliminated by 1985. This goal is to be met by requiring all operations to emply the "best practicable" control techniques by 1977 and the "best available" techniques by 1983. A determination of what "best practicable" means must include consideration of the total cost of the technology, relative to the amount of effluent reduction, age of equipment, type of facility and process involved, as well as any nonwater quality environmental impact. In the case of strip mining, the 1977 standards would probably require the use of settlement basins and acid neutralization in conjunction with drainage ditches and effluent pumpage from the bench. Determination of "best available" is similar to that of "best practicable" except that cost

relative to effluent reduction is not a relevant consideration. It would appear that in some cases the costs of meeting this standard would exceed the economic benefit of extracting the coal by surface mining methods.

There are a number of procedural provisions in the new Federal Water Pollution Control Act that would insure better enforcement of strip mining regulations. For example, section 402 (b) (3) requires adequate notice to the public and the opportunity for a public hearing before any NPDES discharge permit is granted. In addition, where administration of NPDES has been delegated to the states, the state agency must give the EPA notice of each application and provide it with a 90-day period within which to contest the permit application. This means that each discharge permit would undergo a minimum three-month review period instead of the two weeks that is common in Kentucky at the present time. The Act not only provides for citizen input in the permit application process, but also requires that the public be given the opportunity to participate in the development of regulations, programs and standards.

Another provision requires that in some cases, permit applicants must also provide an environmental impact statement before their NPDES permit can be granted. The applicant will have to balance the social costs of extracting the coal by means of strip mining against the expected economic benefits. Alternatives, such as deep mining methods, must also be evaluated. Thus, it will be difficult for the state agency to allow strip mining in areas where the social or environmental costs greatly exceed economic or other benefits. This requirement, however, extends only to "new sources." These are operations which will become subject to NPDES regulation after EPA establishes performance standards for them under section 304.

Regulation under the Federal Water Pollution Control Act is much more limited in the case of nonpoint sources. The Act requires the EPA to identify and study nonpoint sources of water pollution and to develop alternative guidelines for their control. In addition, the states must identify areas with substantial nonpoint source pollution problems, and then, with EPA grants, the states must develop methods of control for nonpoint sources. The Act, however, is not very specific about the mechanics of this approach. It appears, therefore, that the Federal Act would have little immediate effect on strip mining operations if they are treated as nonpoint sources.

2. Mining in National Parks and Forests

National parks are operated by the Department of the Interior through the National Park Service. Prospecting, mining, and the staking of mining claims are prohibited in national park areas except where specifically provided by a particular park's authorizing legislation.

The only national park located in Kentucky is Mammoth Cave. There is no provision allowing prospecting or mining in the authorizing legislation for Mammoth Cave, and thus mining in the park is outlawed.

National forests were established to conserve natural resources and to furnish a continuous supply of timber for the citizens of the United States. Moreover, Congress has declared that the designation of land as national forest is not to interfere with the exploitation of the mineral and timber resources of the land so designated. Nevertheless, there are regulations designed to minimize the adverse environmental effects of such operations that must be adhered to by anybody desiring to so utilize the land. To conduct mining operations on national forest land one must submit a notice of intent to the District Ranger having jurisdiction over the area in which the operations will be conducted. If the District Ranger determines that the operation is likely to cause a significant disturbance of the surface resources, he will, within fifteen days after receiving the notice of intent, require the operator to submit a proposed plan of operations.

A notice of intent should provide information sufficient to identify the area involved, the nature of the proposed operation, the route of access to the operation, and the method of transport to be used. The Forest Service may require the operator to submit a modification of the plan detailing the means of minimizing unforeseen significant disturbances of surface resources. Finally, the authorized officer must perform an environmental analysis for each proposed plan, and if necessary, may require the operator to prepare an environmental impact statement.

All mining operations must be conducted in compliance with the provisions of the Clean Air Act and the Federal Water Pollution Control Act, and must comply with applicable federal and state standards regarding the disposal of solid wastes. Operators must harmonize their operations with the landscape, and take "all habitats." Operators must also reclaim the surface disturbed in their operations in such a way as to control erosion and landslides, control water runoff, isolate or remove toxic materials, reshape and revegetate disturbed areas where "reasonably practicable," and rehabilitate fisheries and wildlife habitats. Operators must file reports with the District Ranger upon completion of mining activities, and this includes temporary cessations. Operators may also be required to post reclamation bonds when this is considered appropriate by the authorized Forest Service officer.

In 1964 Congress passed the Wilderness Act which designated certain national forest areas as wilderness areas. These wilderness areas were meant to be more primitive than forest areas, and the act stipulates that no one may acquire rights to any mineral desposits in designated wilderness areas after 1984. Rights acquired in wilderness areas prior to 1984, however, are preserved and may

be exercised under the same controls that exist for ordinary national forest lands. There is a provision in the Wilderness Act requiring that any mining done on wilderness areas must be carried out in a manner compatible with the preservation of the wilderness environment.

D. State Strip Mining Regulatory Legislation

The Kentucky Department for Natural Resources and Environmental Protection (hereinafter referred to as "the Department") has general regulatory powers over strip mining activities in Kentucky. The agency's basic regulatory tool is a permit system which applies to all private strip mining operations. The Department is expressly authorized to promulgate rules and regulations for strip mining; to conduct investigations and hearings; to levy sanctions or require remedial measures forcing an operator to comply with the law; and to direct its Division of Reclamation to revoke a permit when other sanctions are inadequate. In addition, the Department has broad discretion to adopt whatever regulations it deems necessary to "minimize or prevent injurious effects on the people and resources of the Commonwealth." If an operator fails to meet the burden of proving that the operation for which a permit is sought can and will be run and reclaimed according to the law, the Department may deny, withhold, suspend, or modify the terms of the permit application accordingly.

Within the Department, the Division of Reclamation supervises the enforcement of Kentucky's strip mine laws and has seven specific duties: (1) to enforce the state strip mining laws, rules, and regulations; (2) to conduct investigations and research relating to strip mining and reclamation; (3) to adopt administrative and procedural rules and regulations; (4) to examine all reclamation and backfilling plans submitted by operators in permit applications before approving them; (5) to make any investigations or inspections needed to insure compliance with state laws; (6) to order permits suspended when an operator is not complying; and (7) to stop any operation for which no permit was obtained. Some 75 inspectors are charged with the field work of discovering violations.

To strip mine in Kentucky at the present time, an operator must first obtain a permit, pay a strip mining fee, and post a reclamation bond. He must identify his operation site by posting signs, and comply with safety regulations issued by the state Department of Mines and Minerals, and at the cessation of production at a particular site the operator must file a report with the state. To obtain a permit, the operator must file an application with the Department stating the location and area of the land that will be affected by the mining operation, including a description of the routes of ingress and egress to the affected area from the nearest public highways; the identity of the owners of the surface of all land within 500 feet of the affected area; the source of operator's legal right to mine the coal; the permanent and temporary post office addresses of the applicant; and whether the applicant, or any person, partnership or corporation associated with the applicant, has ever previously held a permit to mine coal in the state, and if so, where and when. An operator

who has had a previous permit in any part of the state revoked or suspended is not eligible to receive another permit until he has rectified those deficiencies in his previous operation which led to his permit being revoked or suspended.

The application for a permit must be accompanied by two copies of a United States Geological Survey topographic map identifying the area to correspond with the application, to be prepared and certified by a professional engineer registered in the state. In addition to showing the specific operation for which a permit is sought, the maps must show any adjacent deep mining operations; the boundaries of the surface properties; the names of the owners of the affected area and the area within 500 feet of any part of the affected area; the names and locations of all streams, creeks or other bodies of public water, roads, buildings, cemeteries, oil and gas wells, and utility lines on the affected area and within 500 feet thereof; the boundaries of the area of land to be affected, the cropline of the coal deposit that is to be removed; the total number of acres involved in the area of land to be affected; the drainage plan on and away from the area of land to be affected, with the directional flow of water, constructed drainways, natural waterways to be used for drainage, and the bodies of water receiving the drainage to be indicated. The map must be dated and state the name of the applicant and the name of the person who located the operation on the map.

The permit application must be accompanied by a transportation plan indicating any parts of the state primary road system over which the applicant intends to transport coal or other minerals extracted by his operation. This transportation plan should specify the legal weight limits for each portion of state highway or bridge over which the applicant proposes to transport extracted minerals, and should indicate whether or not the applicant intends to obtain a special permit from the state to exceed the weight limits on any highway or bridge. The transportation plan must contain a certification by an authorized state Department of Transportation official attesting to its accuracy. The permit application must be accompanied by detailed plans indicating the method of operation; the manner, time and distance for backfilling and grading work; and a reclamation plan for the affected area.

The applicant must pay a fee of $150 plus $35 per acre or fraction of an acre of land to be affected by the operation, and also post a reclamation bond with the Department of between $500 and $3,000 for each acre or fraction thereof to be affected, with a minimum amount set at $5,000. Both fee and bond must be provided before the operation may commence.

A permittee may apply to the Department for a modification of the permit so as to entitle him to mine a larger area than originally applied for. To obtain such a permit modification the operator must follow the same procedure as that for acquiring the original permit--that is, he must file an application accompanied by topographic maps of the modified project, pay the mining fees for the additional acreage, and post

reclamation bond for the new area. An operator may also apply to have his permit modified to reduce the area he is entitled to strip. If an operator's permit area is reduced, the reclamation bond posted for the eliminated acres is returned to him (although the bond must not be reduced to less than the $5,000 minimum), and the fees the operator paid for those acres will be credited to any fees he may have to pay in applying for future permits. A modified permit is not effective for a full new year, but expires when the original permit would have expired.

An operator must prepare and carry out a method of operation, a plan of grading and backfilling, and a reclamation plan for the affected area. In developing such plans, all measures shall be taken to eliminate damages to private citizens and their property, public roads, public streams and all other public property from soil erosion, rolling stones, and overburden, water pollution and "hazards dangerous to life and property." Such plans must be submitted to the Department and it must notify the applicant within twenty days as to whether or not such plans were approved. If not, the Department shall give the operator the reasons why and may suggest modifications which will make the plans acceptable. The operator may request a hearing concerning any adverse decisions. An operator is specifically required to cover the face of the coal with compacted nonacid-bearing and nontoxic materials to a distance of at least four feet above the seam being strip-mined, or by a permanent water impoundment; bury all the toxic acid-producing or fire-hazardous materials, including roof coal and pyritic coal or shale; seal off any break through of acid water creating a fire hazard; impound, drain or treat all runoff water so as to reduce soil erosion, damage to agricultural lands and pollution of water bodies; and remove or bury all metal, lumber and other refuse from the operation. Any dumping or placing of any materials of debris from the operation beyond the boundaries of the area described in the permit is prohibited. This prohibition extends to placing any such materials in such a way that they will be carried from the permit site by normal erosion or slides brought about by natural physical causes.

There are also specific backfilling and grading requirements. On lands where area stripping is done, complete backfilling is required, "beginning at or beyond the top of the highwall and sloped to the top of the spoil back at a maximum angle not to exceed the approximate original contour of the land with no depressions to accumulate water." All highwalls and spoil peaks are to be eliminated, and the Department can order the operator to construct ditches or terraces to control water runoff from the site or other restoration work if it deems such to be necessary. Reclamation is relatively successful on lands stripped by the area method, both because it is easier to reclaim flat land than hills and because the flat western part of the state is mined primarily by large, multistate corporations which must be concerned with their reputations. Reclamation is much harder in the contour mined hills of eastern Kentucky, which is primarily mined by smaller independent operators.

Because a mountain cannot be put together again once it has been cut apart, contour mined areas have much more specific backfilling requirements. For example, all highwalls must be reduced or backfilled, and the steepest slope of the reduced highwall may be no greater than 45°, although the Department is authorized to waive this requirement if there is not sufficient soil from backfilling; the restored area shall have a minimum depth of four feet of fill over the floor of the pit from which the coal has been removed; the restored area must leave no depressions which might accumulate water, and the Department may require the operator to construct lateral drainage ditches connected to larger watercourses when it thinks they are needed. Backfilling and grading requirements are specified and, in addition, the operator's method of operation on steep slopes may be regulated and controlled. Such regulations may limit bench widths, control the amount of overburden placed beyond the solid bench, and prohibit any overburden being placed beyond the solid bench on precipitous slopes. The Department may also require the operator to take any other reclamation steps that might be needed, and may establish special regulations for any operations conducted on steep slopes. Operators may propose alternate reclamation plans which the Department may approve in appropriate circumstances. Normally the backfilling must be done promptly upon the completion of actual mining, "before necessary equipment is moved from the operation," but there are some exceptions to these requirements. For example, if any other bona fide mining is to be done on the stripped land, the operator may supply the Department with a map and the details of the additional mining, and reclamation may be deferred until all mining of all types is finished. Similarly, if the operator desires to use the mine openings for haulageways or other lawful purposes, he may designate the openings to be so used and defer reclamation of that part of the stripped land until it is no longer used for those purposes. However, the reclamation bond posted by the operator will not be returned to him for the portions of the site on which reclamation is to be deferred until after the reclamation is actually done. The reclamation bond is returned to the operator in two steps after reclamation. The bulk of the bond is returned after the grading and backfilling is completed, but with $200 per acre held until after the operator has complied with the vegetative cover requirements. The vegetative cover requirements for each site are to be defined by regulations of the Department. Reclamation is to be completed within one year of the expiration of the operator's permit, unless the Department has approved an alternate plan of reclamation for the affected area. The Department may authorize the operator to defer replanting until a later time if it determines that the soil conditions of the stripped area will not support plant cover at the time of reclamation. In more extreme cases where the stripped land may never support vegetation, the Department may allow the operator to substitute for reclamation an equal area of orphan land previously stripped but never reclaimed.

While the mining operation is in progress, the operator must post signs identifying the operator at the points of access to the operation from the nearest public highways and place monuments outlining the permit area. The operator must also file two reports. The first

report must be filed within sixty days after the expiration of the permit, stating the exact number of acres of land affected by the operation and the amount of the reclamation work already accomplished. This report must be accompanied by a copy of the topographic map filed with the original application revised to reflect any changes in the original plan made necessary by results of the operation. The second report must be filed once the planting of a permit area is completed. This report should include a description of the type of planting done, the date of planting, and the area planted. The Department then waits at least until the completion of the first growing season and inspects the vegetative cover of the reclaimed area. If the cover is sufficient, the remainder of the reclamation bond is returned to the operator.

Compared with strip mining legislation in other states, the Kentucky statute provides a fairly comprehensive regulatory framework. However, the Act's enforcement provisions are weak. When an inspector detects a violation, he reports it to the Department. If the violation is serious, a notice of noncompliance is issued or an order of suspension may be made. If the violations are not remedied, the operator's permit can be revoked and his reclamation bond forfeited. However, the Department has no enforcement power of its own, but must rely on the courts to enforce its orders. The Department can fine operators between $100 and $1,000 for a violation, with the fine to be repeated for every day the violation continues. To collect the fines, however, the director has to request the Attorney General to sue the operator. Usually the Department levies the fine, then threatens to go to the Attorney General, whereupon the operator and the Department settle the fine out of court. The Department can also ask the Attorney General to seek restraining orders and temporary or permanent injunctions against recalcitrant operators. For willful violations, an operator can be prosecuted for a misdemeanor and fined between $500 and $5,000 for each day the violation continues.

The penalties are not stiff enough. Coal operators make their biggest money by operating fast. To be unable to operate on any given day may easily cost an operator $50,000. Thus, a fine of $1,000, or even of $5,000 for a willful violation, is of small deterrent value. The sanctions of suspension or revocation of a permit, on the other hand, are of very great deterrent value. In Kentucky, however, these remedies are very seldom used. Once an operator receives a notice of noncompliance, he is to have a hearing with Department officials at which a scheme of compliance is to be devised. If the violations persist, suspension or revocation may be authorized.

Enforcement in the field is often inadequate. There are not enough inspectors to cover all of the mining sites. Many of these inspectors are not properly trained; some are corrupt; and others are often hired away from the Department by the coal companies with large raises once they have developed sufficient expertise to be troublesome to the coal companies as inspectors. Threats and assaults upon inspectors efficiently performing their duties are also not uncommon. Thus, it is likely that many violations never get reported at all. Of the violations that did

get reported to the Department during the last half of 1974, only 11% resulted in issuance of noncompliance notices, with only 84 ultimately resulting in suspension.

Another weakness of the Kentucky law is that it does not provide adequate remedies from citizens aggrieved by strip mining operations. If a citizen has some complaint he may report it to the Department. If the agency decides not to take action on the matter, the citizen is then entitled to a hearing before a hearing examiner. But the Secretary of the Department is authorized to block the citizen from going to the hearing examiner if the claim is groundless, and even if the hearing examiner finds grounds for the complainant, the opinion of the hearing examiner is merely advisory. The Departmen can thus ignore the opinion if it desires. This leaves the citizen taking his appeal to court, which results in delay. Considering that an area can be completely ruined by strip mining in a very short time, the loss of time is crucial. Restraining orders and injuctions thus become necessary, but before a citizen will be granted an injunction, he must post an injunction bond which few Appalachian strip mining victims can afford.

The Kentucky law also does not require that notice be given to residents before strip mining begins on their land. The Kentucky Supreme Court's recognition of the broad form deed means that no compensation need be paid to farmers before plowing up their crops, although coal companies now as a practice provide such notice and pay token consideration.

E. Local Land Use Controls

Local governments utilize a number of regulatory devices to control land use. Zoning is no doubt the most important of these techniques, but subdivision controls, official maps and other types of regulation are also used.

1. Enabling Legislation

Cities and counties have no inherent power to zone or otherwise control land use activities. They are usually authorized to do so by state legislation commonly known as state zoning enabling acts which represent a delegation of the state's police power. As a general rule, enabling acts do not require local governments to regulate land use; they merely allow cities and counties to exercise such power if they wish. Those units of local government which desire to regulate land use within their boundaries must then enact the appropriate ordinances. State-enabling legislation, however, not only authorizes land use controls by local governments, but often sets limits on such regulation or imposes conditions that must be met before such power may be exercised. Therefore local land use controls that go beyond the provisions of the enabling act or are contrary to them will be held invalid as ultra vires by the court. Kentucky's enabling act, KRS Chapter 100, has vested extensive land use control

authority in cities and counties, but also imposes strict standards on the exercise of this power.

2. Local Zoning Ordinances

The conventional zoning ordinance consists of a text and a map. The text lists a number of zone categories and describes the types of land use that is permitted in each category. The zoning map shows the geographical boundaries of each zone within the city or county. The zoning ordinance must, of course, be enacted by the local legislative body. Kentucky's zoning enabling act, however, requires that a planning commission must be established and a comprehensive land use plan adopted by it before a city or county can exercise its power to zone. In addition, all proposed revisions or amendments to the text or map of the zoning ordinance must be reviewed by the planning commission before submission to the local legislative body.

Occasionally, the text of the zoning ordinance will allow a use in a particular zone only if a conditional use permit is obtained from a local agency known as the board of adjustment. In addition to granting conditional use permits, the board may issue a variance, waiving the restriction of the ordinance for a particular applicant, when it can be shown that strict application of the zoning restrictions would cause the landowner "unnecessary hardship".

3. Local Land Use Controls and Strip Mining

It seems that local governments in Kentucky could restrict strip mining in some cases by zoning. Kentucky's zoning enabling act provides that "the city or county may regulate...activity on the land, including filling or excavation of land, and the removal of natural resources...." Local zoning of strip mining was also approved in an Attorney General's Opinion: "Cities and counties have the power under planning and zoning statues to reasonably regulate strip mining in the public interest and to prohibit such activity as long as it is not completely arbitrary and unreasonable." Moreover, it appears that the state has not pre-empted the field by regulatory strip mining under KRS Chapter 350. The Kentucky Supreme Court in an analogous case held that local regulation of oil and gas activities by means of zoning was not pre-empted by state statutory authority to control the exploration and recovery of oil or gas.

Even if regulation of strip mines is authorized by the state zoning enabling act, particular zoning ordinances may be considered invalid if they constitute a taking of property without due process of law. As we mentioned earlier, all exercise of the police power is subject to the constitutional limitations of substantive due process. There are cases in other states which have overturned

local mining restrictions on due process grounds. On the other hand, such zoning regulations have also been upheld. In determining the validity of strip mine regulations of this sort the courts must weigh the economic interests of the coal mine operator against the health, safety and environmental concerns of the local community. On this basis it is likely that municipalities could prohibit strip mining activities within the corporate boundaries.

At the present time several Kentucky coal counties are considering the enactment of zoning regulations that will restrict the extraction of coal by surface mining techniques. Zoning by counties may be less effective because county zoning regulation usually apply only to unincorporated areas within the county. Attempts to restrict strip mining in rural or lightly populated areas of a county may create a taking problem particularly in cases where the land involved is not suitable for other purposes.

PROPOSED FEDERAL STRIP MINING LEGISLATION

Alternative 3, discussed in Section 6, is based on the proposed Federal strip mining bill, H.R. 13950, as it stood in August of 1976. We believe that any Federal bill, when enacted, will have most of the features described herein. The proposed Federal Act would probably be administered by the Department of the Interior. The Act would make money available to each participating state for research and would establish a national reclamation fund. Money for the fund would be derived from the sale or lease of federal coal deposits, user charges imposed on the leased federal lands, and reclamation fees assessed from operators of coal mining operations. The Act would be administered by the individual states; the federal government, however, would oversee all operations within a state until the state submitted a regulatory scheme approved by the Secretary of the Interior.

The primary regulatory device of the Act would be to require all strip mine operators to obtain a permit--either from the state involved or, if a particular state had no approved permit program, from the Secretary of the Interior--before commencing operations. Permits would be issued for a maximum of five years and would be renewable, but not transferable. The proposed Federal Act would require certain information to be included in a permit application, and a state operating its own approval program could require additional information. Each permit application would have to include reclamation plans for the area to be mined. If a proposed mining area was not suitable for reclamation, no mining permit would be issued. Reclamation would have to be achieved in a manner consistent with the local environment and climatological conditions and applicable state and local land use plans, with measures taken to assure the protection of both on- and off-site surface water and insure the maximum practicable recovery of the mineral resources. The regulatory agency with jurisdiction may also prescribe by regulation any other requirements it deems appropriate. Unlike the strip mining laws of some states, including Kentucky, the proposed Federal Act would require that notice be given to and a hearing provided for all holders of interests in the land to be affected before a permit is

issued. After a permit application and reclamation plan was approved, a performance bond would have to be posted by the operator before his permit will be issued. The amount required for the bond would depend upon the reclamation requirements of the affected area as determined by the regulatory agency on the basis of independent estimates. The amount would have to be sufficient to assure the completion of the reclamation plan if the work had to be performed by a third party.

The Secretary of the Interior and the regulatory agencies of states with approved plans would have joint responsibility for enforcing the Act. All permittees would be required to establish and maintain appropriate records during their operations, install monitoring equipment, and make periodic reports to the appropriate regulatory agency. The state regulatory agency would also inspect mining sites at irregular intervals.

The Secretary could request the Attorney General to initiate civil proceedings against operators violating the Act, and seek injunctions or fines. Criminal sanctions and imprisonment would be authorized for any operator convicted of willfully and knowingly violating a permit condition or of refusing to comply with an order issued by the Secretary. If the Secretary found that violations of an approved state program appeared to result from the state's failure to enforce its program effectively, he could, after notice, assume the enforcement of the state program until satisfied that the state would effectively enforce its own program. In addition, citizens would be authorized to bring suit against either the Secretary or the state regulatory agency to compel them to enforce the Act.

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16. ABSTRACT

The major objectives of this research were to develop a methodology for valuation, in economic terms, of the environmental damage from surface mining; to apply that methodology in an empirical case study of the environmental damage associated with surface mining of coal in Appalachia; and to estimate, in economic terms, the value of the environmental damage from surface mining of coal in the case study region, under four alternative regulatory frameworks.

The empirical case study was conducted in the watershed of the North Fork of the Kentucky River, a mountainous region which includes parts of six counties, four of which have been heavily impacted by surface mining of coal. Findings were that (1) surface mining in the study region generates environmental damage of substantial economic magnitude; (2) existing Kentucky regulations reduce the value of that damage; (3) a Federal bill, similar to that introduced in the 1977 Congress would further reduce the value of damage; (4) a regulatory alternative which places more emphasis on economic incentives is worthy of further study; and (5) given current reclamation technology some of the environmental damage from surface mining in the mountainous study region is irreversible.

17. KEY WORDS AND DOCUMENT ANALYSIS

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