SOME ECONOMIC AND ENVIRONMENTAL ISSUES INVOLVED IN THE RECLAMATION OF COAL-MINED LAND IN EASTERN OKLAHOMA*

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Primary data from a survey of four eastern Oklahoma counties were combined with some secondary data to formulate an environmental impact matrix. Four different strategies for coal mining and reclamation served as the framework for analyzing coal mining and reclamation efforts. The results indicate significant environmental benefits of reclamation to society based on a $958 per acre reclamation cost. Assuming an 18-inch thick seam of coal, reclamation costs would be $0.44 per ton of coal mined. These benefits expressed as tons of soil per acre saved annually from water and wind erosion would cost $0.27 per ton per acre over a 50-year period. The complete reclamation strategy concurrent with strip-mining reflected maximum net benefits to society.

INTRODUCTION

The national Surface Mining Control and Reclamation Act became public law on August 3, 1977. Its purposes are to "establish a nationwide program to protect society and the environment from the adverse effects of surface coal mining operations", . . . , and to "promote the reclamation of mined areas left without adequate reclamation" . . . (8, Sec 102 (a) . . . m). Coal company operators are required to deposit into a fund a reclamation fee of 35 cents per ton of coal produced by surface mining; these funds are to be used to reclaim "abandoned lands", "orphan lands", or "spoil banks". Coal company operators also are required to comply with a complex set of regulations to reclaim land currently being mined.

The imposition of vigorous coal reclamation guidelines and standards at the State and Federal levels has challenged the conscience of coal operators and endorsed the societal concept of nonmonetary land value. While returning the land to its pre-mining state or better, these enforcements are bound to exert upward pressure on reclamation costs and land values in the coal regions of the country. Average reclamation costs per acre continue to outstrip average market value of the land. The widening margin between these two values has become a matter of concern. Hertsgaard *et al*. (3) and Brooks (2) have attempted to justify the wide divergence between reclamation cost and land values by considering some related economic and environmental issues. However, any justification is predicated on the dollar valuation of external benefits and disbenefits, which often is subjective and difficult.

The objective of this report is to provide a framework for the evaluation of the economic and environmental parameters useful in analyzing the justification of increased reclamation efforts in the coal region of eastern Oklahoma. Another aspect of the report is to compare the results obtained from four different reclamation alternatives or strategies that have been used at different times in the study area.

The impact of strip-mining of coal and reclamation is a function of the geographical location of the coal region, government legislation, and economic conditions. Oklahoma falls within the Western Region of the Interior Coal Province and bears bituminous coal beds of Middle and Late Pennsylvanian age. This coal-bearing region spans the northeastern and east-central portions of the state and is confined in an area of about 185 miles in the north-to-south direction. The total coal area is estimated at about one-fifth of the total land area of Oklahoma (2).

The coal in the counties selected for the study has relatively low sulfur and low ash content and is relatively high in heating value – British Thermal Units (BTU) per ton. The climate is variable or change-

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able, with average minimum and maximum temperature between 0°F and 105°F. The average annual precipitation varies between 38 and 43 inches. The topography is noticeably gently sloping or nearly level. The soil is mainly of class III type and the major enterprise is cattle ranching.

METHODS

Data on quantitative and qualitative factors were assembled from a survey of four eastern Oklahoma counties (Rogers, Craig, Nowata, and Okmulgee) during the months of August, September, and October, 1978. Interviewed were: (a) professionals (county extension directors, soil conservationists, bankers, school superintendents); (b) local government officials (district commissioners, county treasurers, county assessors, and excise board members); (c) land owners; and (d) coal company operators.

The survey form were different for each category of interviewees, with varying degrees of emphasis placed on economic and environmental questions. Using some period of little or no strip-mining and no reclamation (abandoned lands or spoil banks exist) as the bench-mark period, economic and environmental factors were compared for stages which included periods[†] of partial strip-mining reclamation and complete reclamation. Alternative reclamation strategies considered were: (a) partial reclamation after strip-mining[§], (b) complete reclamation several months after strip-mining, (c) complete reclamation concurrent with strip-mining (present strategy), and (d) no reclamation after strip-mining, which is a direct opposite of strategy 3.

The quantitative and qualitative approach is in accordance with the principles and standards established by the Water Resources Council. In its final adopted guidelines, the use of an environmental impact matrix is emphasized (7). The Soil Conservation Service of USDA has prepared a Draft Environmental Impact Statement for the Rural Abandoned Coal Mine program where the impacts of alternative funding strategies for reclamation are analyzed (6). Richardson and Badger (5) have developed an environmental impact matrix for analyzing alternative pest control strategies in cotton production for Southwestern Oklahoma, and identifying the socially preferred one.

Three main parameters, economic, environmental, and social well-being, were developed with special reference to strip-coal mining. The components of each of the three main parameters were developed from the review of relevant coal mining reclamation literature and the Draft Environmental Impact Statement cited above. The phrase "change in" used in the parameter elements (Table 1) indicates the change in the parameter element from the bench-mark period to the present required strategy (complete reclamation concurrent with strip-mining). For example, the parameter element "change in land value" evaluates the land values for each alternative from the bench-mark, if only coal activity is considered to influence land values. Following the guidelines of the Water Resources Council in policy decisions regarding resource use (7), equal weights of 10.0 were assigned to each of the main parameters. The weight of 10.0 was then distributed to each of the *elements* of the parameters according to average aggregate scores arrived at from analyzing the responses from the survey. Weights for each of the parameter elements were assigned to qualitative and quantitative issues as follows:

Negligible impact = 0.05 Slight impact = 0.05-0.70 Average impact = 0.71-1.35 Major impact = 1.35-2.00

This assignment of weights, compiled from surveying a cross-section of land owners, coal company operators, local government officials, conservationists, and professionals, is considered to reflect society's values. The bench-mark was assigned a value of zero.

The qualitative weights (raw score) assigned to parameter elements were mainly obtained from survey results and secondary

†These periods differed by the lag between the actual date of enactment of state law and the enforcement of the state reclamation laws. The first state law, the Mining Lands Reclamation Act, was enacted June 12, 1971. It was amended on April 7, 1972 and on May 3, 1978. Better enforcement of state law through complete reclamation occurred after 1972. The federal law, PL 95-87, was enacted August 3, 1977.

§A survey indicated displaced top-soil, terrain difficult to work, very poor grading and leveling low-quality vegetation, but deceptively good-looking land from a distance.

TABLE 1. *Impact Analysis of Alternative Strip Coal Mining and Reclamation Strategies in Eastern Oklahoma.*

Parameter	Parameter Weight	Strategies: 1) Partial Reclamation and Active Strip Mining — Raw Score	1) Weighted Score	2) Complete Reclamation Following Strip Mining — Raw Score	2) Weighted Score	3) Complete Reclamation Concurrent with Strip Mining — Raw Score	3) Weighted Score	4) No Reclamation After Strip Mining — Raw Score	4) Weighted Score
1. *Economic Impact*[a]	10.00								
a. Change in School Enrollment	0.05	0	0	0	0	0	0	0	0
b. Change in Land Values	2.00	0.50	1.00	0.60	1.20	0.60	1.20	0.50	1.00
c. Change in Land Tax Rate	0.05	0	0	0	0	0	0	0	0
d. Change in Farm Employment	0.50	0	0	0	0	0	0	0	0
e. Change in Regional Employment	1.30	ϵ[b]	ϵ	ϵ	ϵ	ϵ	ϵ	ϵ	ϵ
f. Change in Valuation of Coal Equipment	1.50	0.24	0.36	0.72	1.08	1.20	1.80	0.24	0.36
g. Change in Acreage Farmed	1.65	0	0	0	0	0	0	0	0
h. Change in Population Mix	0.20	−0.30	−0.06	−0.30	−0.06	−0.30	−0.06	−0.30	−0.05
i. Change in Roads	1.30	−1.50	−1.95	−1.50	−1.95	−1.50	−1.95	−1.50	−1.95
j. Change in Public Services	0.05	0.10	0.005	0.10	0.005	0.10	0.005	0.10	0.005
k. Change in Regional Income Distribution	1.40	0.50	0.70	0.50	0.70	0.50	0.70	0.50	0.70
Net Economic Impact			0.05+ϵ		0.97+ϵ		1.69+ϵ		0.05+ϵ
2. *Environmental Impact*[c]	10.00								
Pollution									
a. Change in Stream and Lake Pollution from									
i) acid mine drainage	0.75	−1.56	−1.17	−1.12	−0.84	−1.12	−0.84	−2.00	−1.50
ii) spoil bank erosion	0.75	−0.20	−0.15	−0.08	−0.06	−0.08	−0.06	−1.50	−1.13
b. Change in Dust Pollution	1.70	−1.0	−1.70	−1.0	−1.70	−1.00	−1.70	−1.0	−1.70
c. Change in Noise Pollution	0.80	0	0	0	0	0	0	0	0
Terrestrial and Aquatic Habitat									
d. Change in Acres of Vegetation for Wildlife	1.35	1.50	2.03	1.74	2.35	1.74+	2.35+	0.74	1.00
e. Change in Safety for Wildlife	0.60	ϵ	ϵ	ϵ	ϵ	ϵ	ϵ	ϵ	ϵ
f. Change in Number of Streams and Lakes for Aquatic Habitat	1.35	ϵ	ϵ	ϵ	ϵ	ϵ	ϵ	ϵ	ϵ
g. Change in Safety of Aquatic Habitat	1.00	0	0	0	0	0	0	0	0
h. Change in Food and Cover	0.60	−ϵ	−ϵ	−ϵ	−ϵ	−ϵ	−ϵ	−ϵ	−ϵ
j. Change in Grazing Livestock	1.10	−0.65	−0.72	0	0	0	0	−2.00	−2.20
Net Environmental Impact			−1.71+ϵ		−0.25+ϵ		—0.25+2ϵ		−5.53+ϵ
3. *Social Well-Being Impact*[d]									
a. Safety of Human Life and Health	10.00								
i) Change in car wrecks from coal trucks, bad roads, dust	0.40	0	0	0	0	0	0	0	0

ii) Change in land slides	0.05	0	0	0	0	0	0	0	0
iii) Change in soil subsidence	0.05	0	0	0	0	0	0	0	0
iv) Change in fatal explosions	0.05	0	0	0	0	0	0	0	0
v) Change in fire outbreaks from coal refuse	0.05	0	0	0	0	0	0	0	0
vi) Change in anxiety from coal traffic on roads	0.80	$-\epsilon$	$-\epsilon$	$-\epsilon$	$-\epsilon$	$-\epsilon$	$-\epsilon$	$-\epsilon$	$-\epsilon$
b. Recreation									
i) Change in land-based recreation	0.50	0.05	0.03	0.05	0.03	0.05	0.03	0.05	0.03
ii) Change in water-based recreation	1.00	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
c. Conservation									
i) Change in green space	1.00	ϵ	ϵ	ϵ	ϵ	ϵ	ϵ	ϵ	ϵ
ii) Change in archeological and historical sites	0.05	0	0	0	0	0	0	0	0
d. Tourism									
i) Change in tourism	0.05	0	0	0	0	0	0	0	0
e. Other Social Well-Being Considerations									
i) Change in aesthetic value of the land	2.00	$-\epsilon$	$-\epsilon$	$-\epsilon$	$-\epsilon$	$-\epsilon$	$-\epsilon$	$-\epsilon$	$-\epsilon$
ii) Change in land ownership through trading	2.00	ϵ	ϵ	ϵ	ϵ	ϵ	ϵ	ϵ	ϵ
iii) Change in option demand on land use	2.00	$-\epsilon$	$-\epsilon$	$-\epsilon$	$-\epsilon$	$-\epsilon$	$-\epsilon$	$-\epsilon$	$-\epsilon$
Net Well-Being Impact			$0.08-\epsilon$		$0.08-\epsilon$		$0.08-\epsilon$		$0.08-\epsilon$
TOTAL IMPACT			$-1.57+\epsilon$		$0.80+\epsilon$		$1.52+2\epsilon$		$-5.40+\epsilon$

[a] Raw scores for economic impact compiled from the survey data as follows:
b) Δ in real estate tax assessment
f) Δ in the size of coal equipment (assessed value as a function of size)
h) Δ in age composition
i) Δ in quality of the roads
j) Δ in quality of public services
k) Δ in income redistribution to the poor

[b] indicates some positive value that is not estimated or is difficult to attribute solely to the strategies; — is some negative value of a similar description.

[c] Raw scores for environmental impact compiled from secondary and primary data as follows:
a) (i) SCS representative data for annual rate of erosion (RAMP study (6))
(ii) same data from RAMP (6) for surface run-off
b) Δ in number of coal operators and method of hauling coal (from survey)
d) proportion of unreclaimed, partly reclaimed, and completely reclaimed land to total distributed land (OK. Dept. of Mines; Chief Mines Inspector)
j) Δ in carrying capacity of the land (from survey)

[d] Raw scores for social well-being impact computed from the survey as follows:
b) (i) Δ in quality of land-based recreation
(ii) Δ in quality of water-based recreation

data. Coefficients used for this study were representative annual soil erosion and water run-off estimates made by the Soil Conservation Service (SCS) of USDA in the Rural Abandoned Mine Program (RAMP). The estimates are as follows:

	Annual erosion rate (tons per acre)
Post-reclamation land use (rangeland, cropland, and pasture land)	4 (average)
Partially reclaimed mine spoil	10
Unreclaimed mine spoil (unprotected and unvegetated)	75
Land intensively disturbed by strip mining including haul road, tipple sites, dumps, etc.	110 (Midwest)

The study also estimated that storm runoff would be reduced by 40 percent after reclamation, from a rainfall event of 2.5 inches (6, p. 30).

A score range of –2.0 to +2.0 was used according to whether the parameter element was a cost (–) or benefit (+) to residents from the bench-mark value. For example, a weighted score of –0.06 for "change in population mix" indicates that the net impact of population change attributed to coal activity was slightly negative.

RESULTS

A weighted score for each strategy was obtained by multiplying the weights of the parameter elements by their respective raw scores. By summing the weighted scores in each strategy within the three main parameters (economic, environmental, and social well being) the net impact of the alternative on each parameter was obtained. The net *economic* impact of the alternative strategies ranges from $0.05+\varepsilon$ for strategies 1 and 4 to $1.69+\varepsilon$ for strategy 3. The net environmental impact ranges from $–5.53+\varepsilon$ for strategy 4 to $–0.25+\varepsilon$ for strategies 2 and 3. The net social well-being impacts is about the same for all the strategies. The total net rankings from greatest benefit (positive value) to greatest cost (negative value) are as follows: strategy 3, complete reclamation concurrent with strip-mining with a total weight of $+1.52+2\varepsilon$; strategy 2, complete reclamation following strip-mining with a total weight of $+0.80+\varepsilon$; strategy 1, partial reclamation and active strip-mining with a total weight of $–1.57+\varepsilon$, and strategy 4, no reclamation after strip-mining with a total weight of $–5.40+\varepsilon$.

It is pertinent at this point to compare average land value and average reclamation cost in Eastern Oklahoma. The average value of land and buildings in 1977 is estimated to range from $318.00 to $387.00 per acre in the study area (4). On the other hand, based on a survey of 10 active coal operators in the study area, the average reclamation cost per acre is estimated to range from $750 to $1,166 per acre. Thus, the difference between the average cost of reclamation per acre and the average market value of land is $605.50 per reclaimed acre ($958.00-$352.50). This dollar difference is the cost to society if the society places this value on reclaimed land.

Alternatively, assuming a recovery rate of 80 percent of the original coal, or 1,440 tons per foot (Oklahoma, Department of Mines, Chief Mining Inspector), it is estimated that a coal seam of 18-inch average thickness will yield 2,160 tons of coal per acre. If the average reclamation cost of $958 per acre is divided by the 2,160 tons, then the actual cost of reclamation for that land is $0.44 per ton of coal mined. This represents only about two percent of the f.o.b. value of the coal, which averaged $20.00 per ton in 1978.

Water and wind erosion are the major determinants of the many costs to society from strip-mining of coal. Periods of precipitation lead to the exposure of iron sulfide minerals which produce pollutants in the form of acid mine drainage. These acid mine discharges damage surface water quality.

In addition, stream sedimentation is caused by erosion. The costs of sedimentation are reduced carrying capacity; clogged reservoirs; increased water treatment cost; and destruction of habitat for fish and other aquatic life. Top soil on arable land is gradually lost to erosion. This loss gradually lowers the productivity of the soil.

To the extent that erosion is a major cost to society from strip-mining of coal, the cost for preventing soil erosion from water and wind is estimated at $0.27 per ton of soil saved per acre, if computed for 50 years.‡ If this cost is evaluated in perpetuity, then it would cost virtually nothing to provide the benefits of reduced erosion to society.

The Soil Conservation Service (SCS) of USDA has estimated that society stands to gain from reclamation of rural abandoned mines. The study indicates that under a given funding strategy, reclamation will increase cropland by 2 percent, pasture land by 5 percent, rangeland by 0 percent, and forest land by 3 percent and will decrease all other land use by 10 percent for every 10 acres reclaimed in the Midwest which includes Oklahoma. In addition, soil erosion, surface run-off, and sedimentation would be reduced by reclamation.

DISCUSSION

Three major problems encountered in preparing this matrix are the choice of a bench-mark period, treatment of qualitative factors under different strategies, and the fact that some of the strategies do indeed overlap in the coal mining activity. The bench-mark period was some period before and including 1970, when a lull in local activity was present. Moreover, it was felt that the impacts of abandoned lands (spoil banks), which resulted from strip-mining some decades ago, are minimized.

Caution is suggested in interpreting the implication of these results. For example, the ratio of weights between one parameter element and another may not be synonymous with the weight society places on those elements. The weights provide a "modus operandi" for assigning merit and demerit values to rank the alternative reclamation strategies. Society and the coal operators stand to gain immensely from pre-planning reclamation and opting for strategy 3 rather than strategy 2. Strategy 3 thus is the best alternative, as it recognizes the value or benefits that society derives from an undisturbed and peacefully green landscape.

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‡This assumes loss of 75 tons of soil per year if the land is unreclaimed and only four tons of soil per year if the land is completely reclaimed (6). Then 75 – 4 = 71 tons difference. $958 ÷ (50 years × 71 tons per acre difference) = $0.27 reclamation cost per ton of soil saved.