ECONOMIC AND ENVIRONMENTAL IMPACTS OF COAL MINING AND RECLAMATION IN EASTERN OKLAHOMA

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Preface

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Table of Contents

Economic and Environmental Impacts of Coal Mining and Reclamation in Eastern Oklahoma

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Introduction

Political instability in the Middle East and the action of some members of the Organization of Petroleum Exporting Countries (OPEC) to cut back supplies and increase prices of oil and gas have reduced the reliability on foreign petroleum imports for major energy needs in the United States. The current U.S. government energy policy proposes conservation and development of alternative energy sources such as coal.

The United States has abundant reserves of coal estimated at 483.3 billion tons in 1976, of which 297 billion tons is recoverable by deep (underground) mining, and 141.3 billion tons is recoverable by strip (surface) mining. Recoverability, i.e., that portion of the coal that can be removed, is between 40% and 90% depending on characteristics of coal bed, mining techniques, and environmental constraints (1, p. 21).**

Since the 1973 oil embargo, both the supply of and the demand for coal has increased. Between 1974 and 1975, coal consumption on a British Thermal Unit (BTU) basis declined by 32%, but rebounded in 1977 to contribute 18% to total energy consumption. Coal conversion technology has been intensified. Processes are being developed to desulfurize high sulfur coals, demineralize high ash coals, and depolymerize solid coal into conventionally acceptable liquid and gaseous products (2).

Coal production between 1970 and 1973 had declined by 7%. But this was turned around between 1973 and 1977 when coal production increased by 16.8% with an average annual growth rate of 4.2%. Some of this coal is produced in Oklahoma, which has over three billion tons of known reserves.

Coal production in Oklahoma increased by 54% during the period 1963-1973. That average annual growth rate of 5.4% was surpassed by the average annual growth rate of 36% recorded between 1973 and 1977 (3). Strip mining accounts for nearly all the coal produced in Oklahoma. Commercial production of bituminous coal in Oklahoma

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**Numbers in parentheses refer to sources in the References Section.

dates back to 1880. Coal is found in an area of about 15,000 square miles in the eastern portion of the state with surface coal existing in 17 counties. The thickness of workable coal beds have been estimated to range from two to six feet and in a few locations up to eight feet (4, p.30). The share of underground mining to total production declined from 5.5% in 1963 to a small trickle in 1973. On the other hand, the share of strip mining increased from 95% in 1963 to almost 100% in 1981.

The share of United States coal produced by strip mining increased by 92% between 1963 and 1973. Actually, that share levelled off in 1971 because of environmental constraints. The share of strip mining to total coal output was 50% in 1973 and 60% in 1977 (5, p.344). The sustained shift to strip mining was attributed to the proximity of coal to the surface, economy, safety, and the productivity of inputs per ton of coal mined.

The Problem

Strip mining is a surface technique by which giant power shovels tear up the soil and rock overlying coal beds, place it aside and remove the exposed coal. In 1973, 35,000 acres of farmland were disturbed by strip mining in Oklahoma. Out of this total, 5,000 acres were partly reclaimed and 3,400 acres were fully but not successfully reclaimed.

Successful reclamation is defined as that reclamation effort which restores the land to at least its pre-mining productive potential. In economic terms, the productivity index of that land should be such that it combines with other inputs to facilitate economic production at the point where marginal factor cost (MFC) $\leq$ marginal value product (MVP). The MFC includes the cost of reclaiming the land. Full reclamation refers to reclamation effort that completely restores the physical nature of the land but may not restore fertility.

Most of the 5,000 acres partly reclaimed had not been properly graded and levelled. As a result, the terrain is not suited to working with farm equipment. In addition, many acres of these reclaimed lands had lost most of their top soil from poor soil management and the long lag between mining and reclamation. Strip mining without concurrent reclamation therefore competes with agriculture, pollutes water and air, and threatens the life and safety of man and wildlife.

Strip mining interrupts agricultural production. More than 36,000 acres of abandoned coal mine land (orphan land) existed in Oklahoma in 1977, (6, p.9). It is argued that without reclamation, strip mining is tantamount to trading off food for energy. Another view argues that if the land retirement program of the United States Department of Agriculture is relaxed, no shortages in food production would arise from strip mining (7, p.26).

Many acres of prime agricultural land are lost annually to urbanization, highway construction, and other commercial facilities like airports. Unlike strip mining, such uses involve the conversion of agricultural land into permanent intensive non-agricultural uses. In strip mining without reclamation, the land is usually used for a brief period of time, when it is scarred and finally left desolate and derelict. Reclamation provides a means of increasing the inventory of cropland, pastureland and forestland. Increases in regional income from improved agricultural output may be attained. In addition, the visual quality of the landscape is improved.

Objectives

The general objective of this study is to estimate resource productivity in agriculture before and after strip mining and reclamation, and to formulate an environmental impact matrix for alternative reclamation strategies. The specific objectives are:

1. Develop pasture and livestock budgets for reclaimed land and compare net cash returns to existing pre-mining budgets.
2. Use the developed budgets to formulate static linear programming (LP) models which evaluate the profitability of a cattle ranching operation before and after strip mining and reclamation.
3. Use the developed LP model to estimate and project the wealth and net cash returns under alternative mineral rights transfer strategies.
4. Use the developed LP model to estimate and project the opportunity costs in wealth and net cash returns to ranchers from being locked into unsuccessfully reclaimed land by using the land leasing alternative.
5. Estimate the economic, social, and environmental impacts of strip mining on the region's economy under alternative reclamation strategies.

Selection of Study Area

The bituminous coal producing counties of Craig, Okmulgee, Nowata, and Rogers were selected for the study (Figure 1). Rogers, Nowata, and Craig counties are contiguous to each other in northeastern Oklahoma while Okmulgee is in the eastern portion of Oklahoma. Temperatures in this area range from 0°F to 105°F with an average annual precipitation of 38 to 48 inches.

The major enterprise on the gently sloping, mostly Class III soils is cattle ranching. Most of the cow-calf enterprises are on owner-operated farms; many of the owners are part-time farmers, that is, they also work off the farm. The area laborers are known to prefer higher paying jobs in the coal fields to farm jobs. Even some of the livestock owner-operators who own coal land work in the coal fields.

These four counties were selected for two main reasons. First, they fall within the strip mining coal zone with the desired characteristics in coal seam, coal depth, sulfur content, ash content, and British Thermal Unit requirements. Second, they represent the area with a combination of family owned and company owned active coal companies and differing tonnage of coal produced. In addition, the number of strip mines abandoned, partly reclaimed and completely reclaimed in these counties are representative of the entire region.

Legislation to Control Strip Mining and Reclamation

The 1971 Oklahoma Legislation. The "Mining Lands Reclamation Act" of 1971 was the first attempt by the State to regulate strip mining activity in Oklahoma (8). This act covers many minerals, including coal. It stipulated that reclamation plans must accompany application for mining permits. The mining permit requirements were a fee of $50 and a penalty range of $50 to $1,000 per day for mining without a valid permit. The reclamation provision included a sketchy guideline for handling the soil and a performance bond of $350 to $650 per acre. The penalty for failure to reclaim was forfeiture of the bond and denial of a new mining permit.

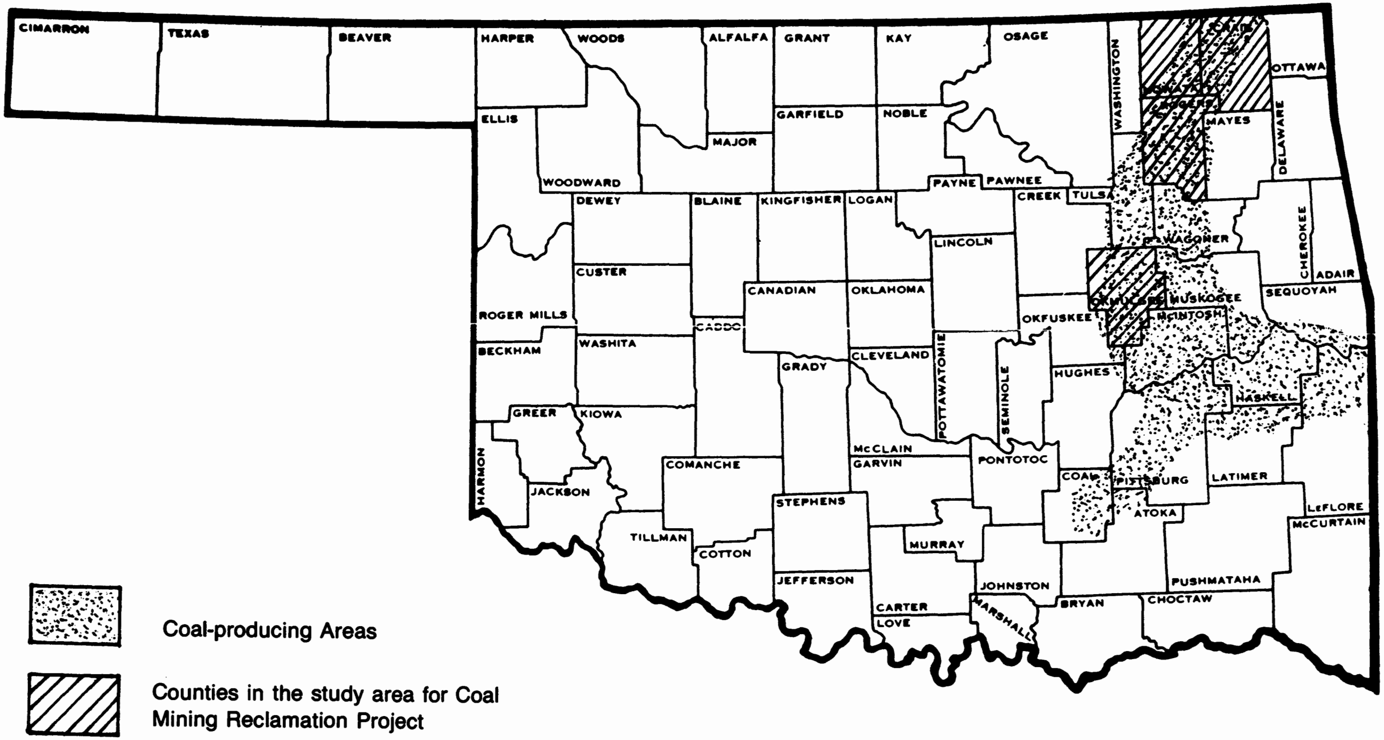

Figure 1. Study Area and All Coal Producing Counties in Oklahoma

The reclamation guidelines specified grading to reduce peaks, dam construction, covering of acid forming material with earth to a depth of three feet, and different revegetation methods for specified land uses. Other stipulations were: 1) where feasible, grading shall be completed not later than one year following cessation of mining and initial seeding should follow thereafter; and 2) reclamation bonds shall not be released until the office of the Chief Mining Inspector has approved and released the disturbed areas as completely graded and satisfactorily reclaimed. This release comes at least two years after completion of reclamation, during which time cattle are kept off the land to let the soil set and the pasture become established.

Sections of the 1971 Oklahoma Reclamation Act regarding definition of surface mining, bond setting, and mining maps were amended in 1972. Despite these efforts the regulations were not comprehensive and enforcement was haphazard.

The 1977 Federal Law. In 1977, a federal act, the "Surface Mining Control and Reclamation Act" (PL 95-87) was passed to assist, complement, and where necessary replace state programs of surface mining and reclamation control (9). The law provided for an Office of Surface Mining Reclamation and Enforcement in the U.S. Department of Interior to work in close cooperation with state regulatory agencies. The 1978 Amendment of the Oklahoma Law coincided with the detailed standards and enforcement frame-work of PL 95-87.

Under the new federal law, the planning process, progress and eventual success of reclamation is supervised by a regulating agency, the Office of Surface Mining (OSM). Any landowners' alternatives to the reclamation program must be approved by OSM.

The key items of the new law include: 1) separation of soil layers, preservation and replacement of top soil; 2) reclamation concurrent with strip mining; 3) retention of hydrologic balance in water quality and quantity; 4) use of fertilizer and other soil amendments through soil tests to promote revegetation and soil productivity; 5) return of land to its pre-mining highest and best use or other use approved by OSM; 6) posting of a performance bond of no less than $10,000 per permit, in the event of failure to complete the reclamation plan; 7) provide ponds and fences as required; and 8) hold land out of production for at least five years after revegetation/reclamation, before released to landowner (10, pp. 15311-15463).

The new mining and reclamation regulation provides for a detailed timetable of mining engineering techniques and considerations to meet local, state, and national applicable environmental protection performance standards.

The current status of many of these enforcement regulations is unclear due to lawsuits by both coal companies and environmental groups challenging some of the specific provisions of the regulations.

Social Cost and Shift in the Coal Supply Curve

Strip coal mining without reclamation generates some external costs. Strip mines may discharge chemicals which pollute streams and lakes. Strip mining without reclamation also lowers the quality of agricultural land and destroys the beauty of the landscape. To incorporate these social costs, laws regulating strip coal mining have been enforced. The impact of these laws shift the industry supply curve for coal upward and to the left, reflecting increased costs of mining. This reduces the quantity of coal produced and increases the equilibrium price for coal, *ceteris paribus.* Regulation will not eliminate the deterioration of the environment completely, but does ensure a more responsible use of coal land.

Regulation Costs and Qualities of Reclaimed Land

Regulation costs vary according to the individual producer's ability to comply with higher strip mining and reclamation standards. As a result, we have reclaimed lands which differ in productive and esthetic qualities.

Two qualities of reclaimed land, lands C and D were identified. Land C has been mined for coal and completely reclaimed but, is below its pre-mining productivity potential. It has intermediate use capacity. Land D has been mined for coal and completely reclaimed to its pre-mining productive potential. It has the highest use-capacity. Each quality of land has an intensive margin indicating the economic point beyond which it is unprofitable to use additional variable inputs. In product curve analysis, this is where the marginal factor cost (MFC) equals the marginal value product (MVP).

Past Research

Strip mining and reclamation research has been done in two general areas: revegetation and socio-economic effects. The revegetation process on abandoned and reclaimed mines is determined by soil age, conditions of soil formation, the controlling substrate and climatic conditions. The probability of revegetation success hinges on a good knowledge of the seasonal dynamics of soil moisture, nutrient availability, mineral weathering process, and plant-soil interaction in a given geographical region. Spess's (11) study of the strip mined spoils of Haskell county in eastern Oklahoma showed that suitable grass and legumes can be successfully grown with fertilizer treatments.

Socio-economic studies have centered on land use changes and socio-economic impacts on rural communities. The success of the preplanned concurrent mining and reclamation program completed in the Centralia (Washington) coal area has been reported by McCarthy (12). The pre-mining land use was forestry and marginal valley farms on poorly drained soils. Families had to rely on off-farm employment to supplement their income. However, the reclamation project resulted in improved water quality and volume, self sustaining vegetation, better topography and more productive land use. The potential was greater for forestry, Christmas tree plantations, wildlife preserves, cattle grazing and farm crops. Thus, the reclaimed land showed improvements over its natural state prior to mining.

Callahan and Callahan (13) applied survey data to a linear programming model to estimate the socio-economic effects of strip mining on communities and natural resources. Using some adjacent non-coal producing counties in Indiana as control, it was concluded that although tax revenues increased, strip mining had not been crucial in inducing the economic development of the coal producing counties. As strip mining increased, land use was shifted from more intensive to less intensive uses. Rural populations and communities in the coal areas were adversely affected by new farming technology, farm consolidation and corporate farming.

Procedure

Personal interviews with farmers and ranchers who owned coal land in the four-county study area provided background data on use of the land before and after strip mining, stocking rates and animal unit months (AUM's) grazing. Information from these interviews plus interviews with coal company operators provided information on leasing arrangements, reclamation costs, and some of the environmental considerations. We also interviewed other informed personnel in the four counties to obtain community data on social, economic and environmental considerations where coal mining and reclamation has occurred.

Costs and returns budgets for the ranching enterprises were developed, as a basis for the linear programming model. The linear programming (LP) model was used to determine the economic impact of changes in land quality, and the impact of coal mining reclamation on the monetary position of land owners. Estimates were developed for wealth and discounted net cash returns. More details of the procedure used are presented in the results.

Finally, data obtained from all the local groups interviewed were used to develop an environmental impact matrix. This matrix included parameters on economic, environmental and social well-being impacts of coal mining and reclamation in this four-county area.

Survey Results and Development of Budgets

The Sample Survey

Most of the data used in this study were obtained by personal interviews conducted in the summers of 1978 and 1979 in four eastern Oklahoma counties (Rogers, Craig, Nowata and Okmulgee). Survey forms were designed and pre-tested after consultations with area extension specialists. The survey forms were different for each category of interviewees, with varying degrees of emphasis placed on economic and environmental questions.

Four groups of people were interviewed:

(a) professionals, including county extension directors, soil conservationists, bankers and school superintendents;

(b) local government officials, including county commissioners, county treasurers, county assessors and county excise board members;

(c) landowners whose land has been leased for strip mining; and,

(d) coal company operators.

Randomness of data was assumed to the extent that interviews were limited to those present at the time of the visit and who were willing to be interviewed. It also was assumed that the interviews of professionals, government officials, coal land owners and coal company operators were unbiased samples and represented a cross-section of the population. The survey data was therefore expected to represent parent population characteristics.

A total of 21 professionals, 16 local government officials, 36 coal land owners and 11 coal company operators were interviewed in the four counties. Between 1978, when the survey was started and 1979, when it was completed, the estimated total number of coal company operators had shrunk from 33 to 12 in these four counties. This represents a decline of 64% for all counties combined. This decline was caused partly

Table 1. Summary of Mineral Transfers, Acres Involved and Royalty for Oklahoma Coal Mining Operations, 1970-1979

Mineral Transfer	Percent of Total	Royalty or Price	Tons/Acre	Trade Ratio
Lease Land A	72.0	$1.00/ton	2,000	——
Trade Land A for Land B	17.0	——	——	1:2.5
Trade Land A for Land C		——	——	1:4.0
Sell Land A[1]	11.0	$2,000/acre	——	——
Sell Land C[2]		$400/acre	——	——

Source: Data obtained from 1978 and 1979 surveys of land owners and coal company operators
[1]Sold by landowner to coal company
[2]Sold by coal company to landowner

by the financial burden of the more stringent strip mining and reclamation regulations of PL 95-87 which forced many coal company operators to cease operations. The high foreclosure rate was accentuated by the fact that 80% of the coal company operators were small family operations.

Survey Results

A summary of the survey of landowners is presented in Table 1. Since this is a regional study, the aggregated county data were considered to be representative of the area. Land A is coal-bearing land in native pasture that will be leased or sold. Land B is non-coal-bearing land in improved pasture. Excluding coal land sizes of larger than 300 acres, the representative size for coal-mined land on a typical farm (Land A) was estimated at 100 acres. Non-coal land on the same farm (Land B) which has good quality pasture was estimated at a representative size of 197 acres. After excluding all reclaimed coal land sizes of 240 acres and above, reclaimed land was estimated at 35 acres. Land C is land which has been mined for coal and reclaimed, but not reclaimed as it should be by the 1977 federal reclamation regulations. Land D is land which has been mined and reclaimed according to the 1977 federal reclamation regulations. Thus, it is more productive land than Land C and has the same productivity coefficients as Land B.

The data included all coal strip mining and reclamation that occurred on those lands between 1970 and 1979. Under the 1971 Oklahoma "Mining Lands Reclamation Act", all lands reclaimed in 1977 were released in 1979 for grazing cattle (a two-year "hold back" requirement). All land reclaimed in 1978, after PL 95-87 was passed in 1977, would be released for grazing cattle in 1983 due to a five-year "hold back" requirement. The implications of these "hold back" requirements were that the post reclamation carrying capacity of such lands could not be determined in this study.

The soil structure of reclaimed land was described as stony or non-stony. Stony soils bore large deposits of limestone usually with zero to four inches of top soil. The absence of limestone and a top soil layer of four inches and above depicts the non-stony soils which could be loamy or clayey. Reclamation effort was described as complete or incomplete depending on the quality and progress of the effort. Complete reclamation indicates that all stages of the reclamation process were completed. However, the resulting pasture may fall short of its expected productivity. Incomplete reclamation resulted from hazard grading, levelling and revegetation, or reclamation efforts that were abandoned before being completed. The resulting terrain lacks the top soil to support pasture and is difficult to work.

Three types of mineral right transfers between coal company operators and land owners are practiced. About 72% of those interviewed leased their land for two years to the coal company; 17% traded one acre of coal bearing land (Land A) for 2.5 acres of non-coal land (Land B) or one acre of coal land (Land A) for 4 acres of low quality reclaimed land (Land C); and 11% had an outright sale of the surface and mineral rights to the coal operators (Table 1). Coal output was estimated at 2,000 tons per acre at a royalty payment of one dollar per ton. This coincides with an average coal seam of 18 inches. One of every three acres was reclaimed. The market or dollar value of trading depends on the bargaining skill of the mineral rights owner. An acre of coal land (Land A) sells for $2,000 while an acre of reclaimed land (Land C) sells for $400.

A summary of the results of the survey of professional, coal company operators, and local government officials is presented in the Appendix. These responses concerning economic, environmental, and social well-being impacts of coal mining and reclamation were used to develop an environmental impact matrix.

Secondary Data

Secondary (published) data were used to show the dramatic changes in Oklahoma coal production and changes in number of coal operators since 1975. The decrease in output in 1979 was caused mainly by the foreclosure of coal company operators (Table 2). The number of coal company operators reached a peak in May 1978, with the large companies operating multiple mines in more than one county. In 1979 many small family-owned operators closed due to the intensified reclamation regulations. As a result, the number of active coal operators operating in Oklahoma declined from 55 in 1978 to 31 in 1979. Nine coal companies went out of business in Rogers county alone between 1978 and 1979.

Enterprise Budgets

Costs and returns estimated for all farm enterprises require budgeting. The enterprise budget is a tool for measuring costs and returns for each unit of a given enterprise. In this study, pasture is estimated on per acre basis and livestock in cow units. These budgets are statements of expected revenues, and expenses incurred, from the production of hay/pasture and cattle for a specified period. As a result, the information relating particular input combinations to output is incomplete. However, the budgets are useful in farm planning and analysis for the study area. Representative cow-calf and pasture production budgets for lands A, B, and D based on regional (area) data have been developed by the Agricultural Economics Department at Oklahoma State University. The cow-calf and production budgets for land C are the modified versions of land B budgets. These revised budgets were accomplished with the assistance of agronomists, animal scientists, area extension specialists and agricultural economists. All budgets present the per unit return to land, capital, overhead, operator's labor, risk and management used in a linear programming model to estimate and project the organization of an optimum ranching enterprise.

Table 2. Changes in Oklahoma Coal Production and Number of Active Coal Companies, by Selected County and State Totals, 1974-1980

	Coal Output (Million Short Tons)							% Change in Output			Number of Active Coal Operators				
County	1974	1975	1976	1977	1978	1979	1980	1975-78	1978-79	1979-80	1974	1975	1978	1979	1980
Craig	0.88	1.25	2.14	2.50	2.30	1.70	1.80	+84	−26	+ 6	3	5	6	3	4
Okmulgee	0.00	0.09	0.22	0.37	0.46	0.33	0.59	+411	−28	+78	0	1	9	3	3
Nowata	0.01	0.04	0.10	0.26	0.14	0.42	0.23	+250	+200	−45	1	1	4	1	1
Rogers	1.00	0.67	0.50	0.84	1.05	0.63	1.10	+57	−40	+75	4	8	14	5	7
State	2.40	2.90	3.60	5.30	5.40	4.78	5.36	+86	−11	+12	12	29	55	31	25

Source: Department of Mines, Chief Mines Inspector, *Annual Reports,* and *Newsletters,* 1974-1980. Oklahoma City.

Table 3: Comparative Productivity Coeffiecients and Changes in Land Quality

					AUM Supply			AUM Demand		
Land Class (1)	Acres/ Head (2)	Number of Units[1] (3)	Hay Supply (Tons) (4)	Pasture Type (5)	Oct.- March (6)	April- Sept. (7)	Total (8)	Oct.- March (9)	April- Sept. (10)	Total[2] (11)
Land A	8.0	1.12	—	Native	0.46	0.75	1.21	7.80	6.45	15.96
Land B	3.0	1.12	0.50	Fescue/Bermuda	2.40	5.50	7.90	6.00	6.00	13.44
Land C	5.0	1.12	0.28	Fescue/Bermuda	1.34	3.07	4.41	6.00	6.00	13.44
Land D[3]	3.0	1.12	0.50	Fescue/Bermuda	2.40	5.50	7.90	6.00	6.00	13.44
Δ Land D[4]	−2.0	—	0.22	—	1.06	2.43	3.49	0	0	0

[1]The 1.12 represents one cow plus .12 replacement heifer as shown in the cow-calf budget for northeastern Oklahoma. This figure is used in computing the input-output coefficient of the linear programming model.

[2]Total Demand = Col 3 × (Col. 9 + Col. 10).

[3]Land D is formerly coal-bearing land A reclaimed to its full productive potential and has the same productivity coefficients as land B.

[4]ΔLand D = Land D minus Land C coefficients.

Pasture and Hay Budgets. The costs and returns for pasture production are based on input levels and machinery/equipment operations specified by the area extension specialists. The inputs used represent those used by efficient producers in the area. Fertilizer usage, timely harvest of hay, rotation of grazing, and above average management are assumed.

For improved pasture on land B, the establishment cost is usually pro-rated over ten years. However, the establishment cost has been deleted from this budget to achieve comparability with the improved pasture on lands C and D (reclaimed lands) where pasture is established at no cost to the landowner. The quality of the pasture is established at no cost to the landowner. The quality of the pasture has been estimated by the amount of hay produced in the summer months and the Animal Unit Months (AUM's) of pasture provided in the winter and summer months.

Cow-Calf Budgets. Data for designated areas provided by the area extension specialists are used to calculate costs and returns based on livestock investment, production, and operating inputs including pasture charges and machinery/equipment operations. Since the farm organization would produce and use its own hay and pasture, such charges have been deleted. Protein supplement and crude protein equivalent for hay are inclusive in the operating inputs. A 90% calf crop is assumed. The carrying capacity for pasture on lands B and D is three acres per cow; carrying capacity for pastures on land C is five acres per cow (Table 3). Pastures on lands B and D could be rented at $16.00 above operating costs per acre. This level of input management also is above average.

The success of reclamation is reflected in pasture productivity which can be determined by vegetative production, animal performance, vegetative composition and diversity and plant and canopy cover (14). Vegetative production and animal performance have been combined to provide comparative productivity coeffiecients for the four land classes (Table 3). The change in land D (Δ land D) shows improved carrying capacity (40% fewer acres per head), and a 79% increase in hay and AUM supply over land C. This also implies that land D would sell at a higher price.

Additional data obtained from publications of the Soil Conservation Service, USDA, and the Office of the Chief Mine Inspector for the State of Oklahoma were combined with some aspects of the survey results to develop an environmental impact matrix.

Coal Land Transfer Arrangements: Benefits and Costs to Landowners

Trading one acre of land A or 2.5 acres of land B, yields a cash balance of $750. This value is derived from the difference between the $2,000 value of land A and the $1,250 value of land B ($500 per acre). By the same token, a cash balance of $400 results by trading one acre of land A for 4 acres of land C. The cash balance is obtained by subtracting the $1,600 value of land C ($400 per acre) from the $2,000 value of land A. By selling one acre of land A, a cash balance of $2,000 is realized. Leasing out one acre of land A brings in $2,000 in the first year and an additional $400 in the fifth year after reclamation, when that land is used as land C.

The Coal Lease

For many years, leasing has been the major option for transferring coal extraction rights from the landowner to the coal company operator. Important considerations in this process are the title of the land and the primary term of the lease.

The Title . Current coal leases require that the landowner has the lawful right to lease his land. The owner must prove that the land to be leased is free of all liens and furnish an abstract of the title. If the title is defective in any way, the coal company will require the owner to cure the defects at his expense.

An alternative to the general warranty provision is to permit or require the coal company to examine the title prior to consummation of the lease. In this instance, the landowner would not be required to warrant title of encumbrances and would be relieved of the burden of possible substantial financial responsibility that may arise from a general warranty.

If the surface and all of the mineral rights are not owned, it becomes important for the landowner to understand and distinguish between royalty paid to the mineral owner and surface damage paid to the surface owner. In the normal lease no distinction is made between these two items and compensation is made in the form of a royalty payment that is defined to cover everything.

Primary Term . The primary term is defined as the period of time in which production must be initiated. Regardless of whether or not bonus payments are paid for the execution of the lease, the typical lease will require that the coal company either 1) actually commence mining of the property or 2) pay an annual delay rental to continue the lease throughout the remainder of the primary term. The length of the primary term is usually negotiated between the coal company and the landowner and varies from a few months to fifty years.

From the landowner's point of view, several questions should be answered relative to the primary term. In addition to the length of the primary term, the timing of the disruption should be estimated. Planning agricultural operations would be easier if the producer had some general indication of when mining operations would begin. The lease should provide for some kind of notice to the landowner prior to the commencement of mining operations so that no new crops would be planted on the property to be mined. This would also provide an opportunity to move or dispose of the cattle grazing on the land.

Another important consideration relative to the primary term is what actually constitutes the initiation of coal production. Most leases stipulate that coal production must begin prior to the end of the primary term. Once begun, however, the land can be tied up until production activities are completed. The landowner needs to know what constitutes the initiation of production and should have it spelled out in the lease. For example, does production begin with the presence of machinery or with the first actual recovery of coal reserves?

The question arises as to the relative importance of the length of the primary term. By using techniques of discounting, the present value of the annual rentals can be estimated. The result is the present value of the lease in the absence of actual mining operations. Ideally, the producer should estimate the present value of a lease with several different lengths of primary term.

Leasing Arrangment

The lease is a legal contract between the lessor (landowner) and the lessee (coal company). The benefits of the lease to the lessor depend on the terms or obligations of the lease. If the lessee does not meet the lease obligations, the lessor has a strong legal right to seek redress. Some coal companies provide ready made lease forms which may not contain all obligations to the best interest of the landowner. Lease forms originating from landowners are more likely to include terms that are of mutual interest to the lessor and lessee. The following are some of the important obligations to include in the lease:

1. Specific location of the coal
2. Quality of coal
3. Estimated quantity of coal recoverable
4. Depth of coal
5. Primary term (time to start mining)
6. Length of mining
7. Easement rights
8. Default Provisions: royalty payment schedule, approved reclamation plans, etc.
9. Royalty with price escalator
10. Written guarantees

Results from personal interviews of thirty-seven landowners conducted in 1978 and 1979 in Rogers, Craig, Nowata, and Okmulgee counties showed most leases do not contain all important obligations. Verbal promises were given but often not kept. Landowner complaints during the interview suggest that all promises be written in the lease. A similar interview of eleven coal company operators indicated that the coal companies are willing to cooperate with informed landowners in forming a mutually beneficial coal lease.

The royalty payment per ton of coal mined is designed to compensate for (a) the purchase of the coal, (b) permanent damage done to real estate as a result of strip mining, (c) temporary damage and inconvenience caused by the strip mining operations, (d) haul road easements, (e) top soil loss, and (f) other considerations in the lease. Royalty payments in the survey are estimated to range from $1.00 to $2.50 per ton of coal mined. The spread in royalty payments has been attributed to differences in coal seam, coal quality and bargaining skill of landowners. A landowner's bargaining skill is strengthened by the foreknowledge he has about the quality and potential demand for his coal.

Trading Arrangement

Land is exchanged on a market or dollar value basis. One acre of coal land is exchanged for a given number of acres of non-coal land, which may include reclaimed land. For example, if one acre of coal land is worth exactly X acres of a given quality of non-coal land, than no cash payments accompany the trade. In other words, cash payments are used to equalize dollar or market value of the trade only where there is not sufficient land to make an even trade.

The owner of the coal land may exercise the right of choosing the quality and location of the land he wants in exchange. Often when reclaimed land is involved in the trade, the land owner has limited choice of land quality and location. Therefore, more acres of land are exchanged than when trading for non-reclaimed, non-coal land.

Outright Sale Arrangement

This arrangement implies the exchange of coal land for cash only. This transaction may be accompanied by a "buy back" provision, and in some cases, a "first refusal" provision to the seller. A "buy back" provision in the sale agreement legally binds the land owner to buy back the land after reclamation at some specified price per acre. This "buy back" price is usually lower than the sale price established by the coal company after reclamation of land it has acquired through other means.

This concept also is used as the basis for the "first refusal" right. A "first refusal" right guarantees the original landowner the first offer to buy back the land after reclamation. This offer by the original landowner may be refused by the coal company. The reclaimed land price depends on the quality of reclamation, demand for reclaimed land, and the personal relationship between the coal company and the original landowner.

Opportunity Costs of Transfer Arrangements

An important concept in transferring coal rights is opportunity cost. The landowner must compare the value of the chosen transfer arrangement (lease, trade, sell) against expected revenues and expenses of a particular arrangement that is not chosen. For example, leasing must be matched by expected revenue from agricultural production, while trading and selling must be matched by the replacement value of the land.

Most information provided by a lease arrangement may be used to evaluate the coal and land to be traded or sold. Courthouse records, resident farmers and real estate brokers are good sources for valuation of the land to be received in exchange. Without such information, trading or selling could be risky. The risk posed by leasing occurs when reclamation is incomplete or improperly completed as specified by the Oklahoma Mining Lands Reclamation Act of 1971. The Federal Surface Mining Control and Reclamation Act of 1977 (PL 95-87), which replaced the Oklahoma Law, is intended to eliminate incomplete and improper reclamation.

The long term opportunity cost of leasing is low under the Federal government law if proper reclamation can be achieved. If the land is out of production for seven years (two years of mining and reclamation plus five years past reclamation holdback), the landowner must earn enough income in royalty payments and pasture establishment benefits to stay ahead. Under the old Oklahoma law, the landowner may have been locked into improperly reclaimed land. As a result, the present value of his future net income stream is reduced. The new federal law provides the opportunity both to sell the coal and increase long-run net returns to the agricultural enterprise.

The risk of incomplete reclamation will always exist. Reclamation efforts may be abandoned at various stages of completion if the coal company is foreclosed. When this happens, future royalty payments may not be received and the disturbed land cannot be put to productive use as previously planned. Although a bond is set aside for defaults of this nature, the landowner has to wait for a longer time to have his land reclaimed by some government agency. To avoid this risk, it is advisable that landowners deal with the reputable and financially sound coal companies in the coal region.

Landowners may use the trading arrangement to improve the quality of their land and buildings so that a reduction in physical deterioration, functional and locational obsolescence can be attained. Some landowners have been known to combine two of the three transfer arrangements in one land deal. In this way, they have been able to enjoy the best advantage of each option.

Reclamation

Strip mining of coal is not a permanent use of agricultural land as in urban development or highway construction. It predisposes the land to soil erosion and sedimentation. The landscape is disfigured and landowners forego potential wealth and cash income. Government agencies, landowners and other interest groups have therefore supported the reclamation of mined land to its highest and best use.

The first government act to enforce the reclamation of Oklahoma mined land was in 1971 (8). Although it established certain guidelines for reclamation, it was neither complete nor effectively enforced. The 1978 Amendment coincided with the detailed performance standards and enforcement framework instituted by the federal government in 1977 (9). Under the new federal law, the plan, process, progress and eventual success of reclamation is supervised by a regulating agency, the Office of Surface Mining (OSM). Any landowner's alterations to the reclamation program must be approved by OSM. The following highlights of the new law (10) are of special interest to landowners: 1) separation of soil layers, preservation and replacement of top soil; 2) reclamation concurrent with strip mining, 3) retention of hydrologic balance in water quality and quantity, 4) use of fertilizer and other soil amendments through soil tests to promote revegetation and soil productivity, 5) return of land to its premining highest and best use or other use approved by OSM, 6) provide ponds and fences as required, and 7) keep land out of production for at least five years after revegetation/reclamation, before released to landowner.

Reclamation provisions are no longer dependent on negotiations between the landowner and the coal company. The inclusion of reclamation terms in the typical coal lease is no longer a necessity. However, the ability of each coal company to comply with the new regulations varies. To insure against mishandling of top soil, our survey shows that many new coal leases include a surcharge of $.50-$.70 per ton of coal mined. The decision of this arrangement generally is based on the company's reclamation record and the "felt presence" of the enforcement agency in the area.

The coal company is required to pay a bond and obtain a mining permit prior to mining. The firm also must complete all reclamation if it plans to cease operation. However, if the coal company is foreclosed, the landowner must wait for other alternative arrangements to reclaim the land. This will affect the productivity of the land and expected income from agricultural production.

Some Thoughts for the Landowner

Leasing, trading and outright sale of land for coal mining can be profitable but also complex. Presented below is a summary of the key items in negotiating with the coal companies:

1. Determine why the coal company is interested in your land.
2. Know the location, acreage, quantity, and quality of coal reserves.
3. Consider alternative land uses (present and future) and calculate the present value of the land for each alternative use up to 40 years. (21)
4. Understand the primary term of the lease and negotiate for a suitable term.
5. Know the value of your property in exchange before trading or selling.
6. Make certain that default provisions are included in writing in the lease.
7. Consider an attorney's advice on title requirements.

In the final analysis, the stability and success of any arrangement depends on the bargaining skill of the landowner.

Application of the Analytical Model

Static and Dynamic LP Models

Static and "Dynamic" versions of the model were used to evaluate (compare) the profitability of cattle ranching on different qualities of coal land and to project the monetary impact of coal mining reclamation, respectively.

The static (one period) linear programming model was set to maximize net cash returns from a ranching enterprise. The ranch had two land classes, initially comprised of 100 acres of land A and 197 acres of land B. Three identical models were developed. OBJ 1, the baseline strategy, maximized the net cash income in the pre-mining state of lands A and B. OBJ 2, the present strategy, maximized the net cash income on lands B and C. Net cash income from operating lands B and D is maximized in OBJ 3, the future strategy.

The major activities in the model are cow-calf and pasture/hay production. Hay is produced on lands B, C, and D and may be bought, sold and/or transferred between the summer and winter months. The resource restrictions are land, labor, pasture, and hay. It is assumed that all land A was reclaimed by law and that additonal labor was hired to achieve full utilization of all available land. The three OBJ values are then compared for differences in cash return attributable to the quality of reclamation.

Two (dynamic) multi-period linear programming models were used to estimate optimal strategies for monetary benefits associated with leasing, selling, or trading coal land. The introduction of the three alternatives to surface and mineral right transfers necessitated the use of a model with a 40-year planning horizon. The planning horizon was divided into five periods - years 1,2,3,4, and 5-40. The first four years are required to incorporate a four-year mining lease that consists of two years' mining plus a two-year required "hold back" period before reclaimed land can be utilized for grazing.

One model (OBJ 4) maximizes the total wealth. It was assumed that land A appreciates at 10 percent, lands B, C and D appreciate at 12 percent, and surplus cash can be invested at 8 percent annually. The differences in the annual appreciation rates have been used to reflect the differences in expected net cash returns and the opportunity cost of unsuccessful reclamation. The second model (OBJ 5) maximizes the present value of discounted net cash returns from the ranch business.

Six broad categories of resource restrictions are used in each period of the model, namely land, wealth, cash, labor, pasture and hay. The wealth and cash restrictions are the special features in OBJ 4 designed to estimate wealth (WLTH). WLTH A, B and C are attributed to land A, B and C. Cash is defined as CASH (cash at hand) and CFMLVG (cash for family living). CASH represents the net cash returns to the different activities in the model. CFMLVG starts at \$8,000 and is increased by 8% per year. Similarly the activities in each period include family living expenses and transfer columns for accumulated wealth and cash. In OBJ 5, the WLTH and CASH features are deleted. The values for OBJ 5 are discounted net cash returns. CFMLVG is calculated period by period as follows:

$$PV = C + \frac{C(1.08)}{1.1} + \frac{C(1.08)^2}{(1.1)^2} + \frac{C(1.08)^3}{(1.1)^3} + \sum_{t=4}^{39} \frac{C(1.08)^t}{(1.1)^t}$$

where:

PV = present value of cash for family living
C = \$8,000 (starting cash) for current period
t = 4,5,6,7 . . . 39 years

Modeling for Land D and Quality Changes in Reclaimed Coal Lands

Four objective functions, OBJ 6, OBJ 7, OBJ 8, and OBJ 9 are maximized. Models for OBJ 6 and OBJ 7 estimate and project expected wealth from unsuccessful and successful reclamation, respectively. Both models are obtained by deleting all the mineral rights transfer strategies but leasing from model OBJ 4 such that model OBJ 6 had land C values, and land D values are substituted for land C values in model OBJ 7.

Models for OBJ 8 and OBJ 9 estimate and project the present value of net cash returns from unsuccessful and successful reclamation, respectively. By deleting all the mineral rights transfer strategies but leasing from model OBJ 5, two models are developed. The first model, OBJ 8, has land C values and the latter model, OBJ 9, has land D values in place of the land C values. The difference in objective function values between OBJ 6 and OBJ 7 is the projected loss in land value (wealth), while the difference between OBJ 8 and OBJ 9 values represent the projected loss in net cash return. This opportunity cost in wealth and cash income indicates the impact of quality changes in reclaimed coal lands.

Objective Function Values

The net cash returns in OBJ 1, OBJ 2, and OBJ 3 are obtained by subtracting value of operating inputs, capital costs, ownership costs and labor costs from total receipts. Thus the return to land, overhead, risk and management is being maximized. In OBJ 5, OBJ 8, and OBJ 9, the net cash returns are obtained from total receipts less operating inputs costs and ownership costs. These returns are then discounted into the future at an annual rate of 10%. Thus the model is set to maximize the present value of net returns to land, capital, overhead, operator's labor, risk and management.

Limitations of the Model

Multi-period linear programming provides cost-minimizing or profit-maximizing solutions which are useful for long-run predictions because farmers may overcome inertia, lack of knowledge, risk and uncertainty or other restrictions as time progresses. However, it is unable to estimate intermediate-run response or the actual process of adjustment. (15) Risk and uncertainty, and non-economic considerations are not specifically recognized to the extent that linear programming solutions are more normative than positive. In linear programming, confidence intervals of predicted levels of net returns and wealth cannot be estimated. As a result, the error of prediction is unknown.

Despite its shortcomings, linear programming is beneficial in allowing many sections of the ranching enterprise and their interaction to be considered simultaneously.

Table 4. Summary of Net Cash Returns, Activities, and Resources from the Models Solutions for Coal Mining Reclamation in Eastern Oklahoma

	Unit	OBJ 1 (Cash)	OBJ 2 (Cash)	OBJ 3 (Cash)
Period	Year	one	one	one
OBJ Value	dollars	13,224	13,936	18,771
Activity				
Livestock A	head	6	—	—
Livestock B	head	70	70	70
Livestock C	head	—	20	—
Livestock D	head	—	—	36
Resource Use				
Land D	acre	100	—	—
Pasture A	acre	100	—	—
Land B	acre	197	197	197
Pasture B	acre	197	197	197
Land C	acre	—	100	—
Pasture C	acre	—	100	—
Land D	acre	—	—	100
Pasture D	acre	—	—	100
Family Labor	hours	443	443	443
Hire Labor	hours	315	449	594
Total Labor	hours	758	942	1,037
Total Livestock	head	76	90	106
Total Land	acres	297	297	297

This avoids the problems of other approaches that consider each section separately and thereby isolate the interaction between sections. Moreover, linear programming is relatively easy, flexible and less expensive in data requirements and computer time than such methods as integer programming or recursive programming.

Impact of Coal Mining Reclamation on Monetary Position of Land Owners

Maximized Net Cash Income

The maximum net cash returns obtained from solutions to models OBJ 1, OBJ 2, and OBJ 3 are shown in Table 4. The results indicate that the contribution to net income from land A and land C are almost the same in models OBJ 1 (no law) and OBJ 2 (old law). In both cases the returns to land, overhead, risk and management are $13,224 and $13,936, respectively. This represents a difference of $712 in cash returns. On the other hand, the impact of the new law, as shown in model OBJ 3 (new law), maximized net cash income at $18,771. This represents a difference of $4,835 over the old law in model OBJ 2.

While using the same total acreage of land, differences in the quality of reclamation enabled the rancher to keep 76 head of cow-calf units in model OBJ 1, 90 head of cow-calf units in model OBJ 2, and 106 head in model OBJ 3. The family labor requirement was the same in all cases, but additional hired labor was required as the productivity of land increased. In each case, family labor was 443 hours while hired labor increased from 315 hours in model OBJ 1 to 499 hours and 594 hours in models OBJ 2 and OBJ 3, respectively.

Projected Wealth and Discounted Net Cash Returns

The optimal wealth and discounted net cash return including selected activities and resources obtained from the solutions to the linear programming models are presented in Table 5. Total increase in wealth from land and cattle was $19.5 million. In OBJ 4, 30 head of cow-calf units were grazed on 84 acres of the best pasture (land B). All land A was either traded or leased out in year one. Thus land C increased by 263 acres in year one and by 34 acres in the period 5-40 (years). Total land increased from 332 acres to 529 at the end of the planning horizon. However, 445 acres of this total land was not grazed.

The present value of net cash return from operating land and cattle was $319,000. This represents a return to land, capital, overhead, operator's labor, risk and management. In model OBJ 5, 30 head of cow-calf units were grazed on 84 acres of pasture on land B, during each year. However, all 100 acres of land A were leased out in the first period and received back as land C but not grazed in year 5-40. The leasing of land A to a coal company represents a transfer of land between land classes but does not increase total acres owned.

Projected Opportunity Cost in Wealth and Discounted Net Cash Returns

The optimal projected wealth obtained from solutions to models OBJ 6 and OBJ 7 are reported in Table 6. The wealth for land C (sells for $400 per acre) was $15.254 million while that for land D (sells for $450 per acre) was $15.596 million. This represents an opportunity cost of $0.342 million. This loss in value of land wealth was due to unsuccessful reclamation under the old law. Included in the solution were 30 head of cow-calf which grazed on 84 acres of pasture B each year period. Forty-seven acres of the original 100 acres of land A were leased out in year one and received back in year 5-40 as land C (land D). This land transfer increased land C (land D) from 35 acres to 82 acres and reduced land A to 53 acres in the year 5-40. Two hundred and forty-seven acres of all land classes were not used due to labor limitation.

The optimal projected present value of net cash returns and associated opportunity cost from solutions to models OBJ 8 and OBJ 9 are presented in Table 7. Net cash returns for land C and land D are $317,510 and $324,390, respectively. The opportunity cost is thus $6,780. This represents a loss in net cash returns to land, capital, overhead, operator's labor, risk and management. The configuration of activities and resources is identical to Table 6 except that 100 acres of land A are leased out in year one. Land C (land D) therefore increased to 135 acres in year 5-40. The non-use of 247 acres of all land classes was attributed to labor shortage.

Table 5. Summary of Wealth and Discounted Net Cash Returns from Solutions to Models OBJ 4 and OBJ 5

	Unit	Initial Resource	OBJ 4 Wealth					OBJ 5 Discounted Net Cash Return				
Period	Year		1	2	3	4	5-40	1	2	3	4	5-40
OBJ Value	dol(000)						19,518.42					319.30
Accumulated With	dol(000)		339.43	375.20	414.25	456.94	19,518.42					
Disc. Net Cash Return	dol(000)											319.30
Activity:												
Livestock	head		30.17	30.17	30.17	30.17	30.17	30.17	30.17	30.17	30.17	30.17
Resource Use:												
Land A	ac	100.00										
Pasture	ac		—	—	—	—	—	—	—	—	—	—
Trade A for B	ac		—	—	—	—	—	—	—	—	—	—
Trade A for C	ac		65.85	—	—	—	—	—	—	—	—	—
Lease out A	ac		34.15	34.15	34.15	34.15	—	100.00	100.00	100.00	100.00	—
Sell A	ac		—	—	—	—	—	—	—	—	—	—
Total	ac		100.00	34.15	34.15	34.15	—	100.00	100.00	100.00	100.00	—

Table 5. Summary of Wealth and Discounted Net Cash Returns from Solutions to Models OBJ 4 and OBJ 5 (Cont.)

	Unit	Initial Resource	OBJ 4 Wealth					OBJ 5 Discounted Net Cash Return				
Period	Year		1	2	3	4	5-40	1	2	3	4	5-40
Land B	ac	197.00										
Pasture	ac		84.47	84.47	84.47	84.47	84.47	84.47	84.47	84.47	84.47	84.47
Trade A for B	ac		—	—	—	—	—	—	—	—	—	—
Rent in B	ac		—	—	—	—	—	—	—	—	—	—
Non-Use	ac		112.53	112.53	112.53	112.53	112.53	112.53	112.53	112.53	112.53	112.53
Total	ac		197.00	197.00	197.00	197.00	197.00	197.00	197.00	197.00	197.00	197.00
Land C	ac	35.00										
Pasture	ac		—	—	—	—	—	—	—	—	—	—
Trade A for C	ac		263.38	—	—	—	—	—	—	—	—	—
Non-Use	ac		35.00	298.38	298.38	298.38	332.53	35.00	35.00	35.00	35.00	135.00
Total	ac		298.38	298.38	298.38	298.38	332.53	35.00	35.00	35.00	35.00	135.00
Land Summary												
Grazed	ac		84.47	84.47	84.47	84.47	84.47	84.47	84.47	84.47	84.47	84.47
Non-Grazed	ac		445.06	445.06	445.06	445.06	445.06	247.53	247.53	247.53	247.53	247.53
Total	ac	332.00	529.53	529.53	529.53	529.53	529.53	332.00	332.00	332.00	332.00	332.00

Table 6. Summary of Projected Wealth and Opportunity Cost from Solutions to Models OBJ 6 and OBJ 7

	Unit	Initial Resource	OBJ 6 Wealth/Land C					OBJ 7 Wealth/Land D					OBJ 7-OBJ 6
Period	Year		1	2	3	4	5-40	1	2	3	4	5-40	40 Years
OBJ Value	(000)dol						15,254					15,596	
Accumulated Wealth	(000)dol		341.28	375.16	411.90	451.77	15,254	345.40	379.77	417.10	457.55	15,596	
Opportunity Cost	(000)dol												342.00
Activity:													
Livestock	head		30.17	30.17	30.17	30.17	30.17	30.17	30.17	30.17	30.17	30.17	
Resource Use:													
Land A	ac	100.00											
Pasture	ac		—	—	—	—	—	—	—	—	—	—	
Lease Out A	ac		47.32	47.32	47.32	47.32	—	47.32	47.32	47.32	47.32	—	
Non-Use	ac		52.68	52.68	52.68	52.68	52.68	52.68	52.68	52.68	52.68	52.68	
Total	ac		100.00	100.00	100.00	100.00	52.68	100.00	100.00	100.00	100.00	52.68	

Table 6. Summary of Projected Wealth and Opportunity Cost from Solutions to Models OBJ 6 and OBJ 7 (Cont.)

	Unit	Initial Resource	OBJ 6 Wealth/Land C					OBJ 7 Wealth/Land D					OBJ 7-OBJ 6
Period	Year		1	2	3	4	5-40	1	2	3	4	5-40	40 Years
Land B	ac	197.00											
Pasture	ac		84.47	84.47	84.47	84.47	84.47	84.47	84.47	84.47	84.47	84.47	
Rent in B	ac		—	—	—	—	—	—	—	—	—	—	
Non-Use	ac		112.53	112.53	112.53	112.53	112.53	112.53	112.53	112.53	112.53	112.53	
Total	ac		197.00	197.00	197.00	197.00	197.00	197.00	197.00	197.00	197.00	197.00	
Land C (Land D)	ac	35.00											
Pasture	ac		—	—	—	—	—	—	—	—	—	—	
Non-Use	ac		35.00	35.00	35.00	35.00	82.32	35.00	35.00	35.00	35.00	82.32	
Total	ac		35.00	35.00	35.00	35.00	82.32	35.00	35.00	35.00	35.00	82.32	
Land Summary:													
Grazed	ac		84.47	84.47	84.47	84.47	84.47	84.47	84.47	84.47	84.47	84.47	
Non-Grazed	ac		247.53	247.53	247.53	247.53	247.53	247.53	247.53	247.53	247.53	247.53	
Total	ac	332.00	332.00	332.00	332.00	332.00	332.00	332.00	332.00	332.00	332.00	332.00	

Table 7. Summary of Present Value of Net Cash Returns and Opportunity Cost from Solutions to Models OBJ 8 and OBJ 9

	Unit	Initial Resource	OBJ 8: PV Cash Returns/Land C					OBJ 9: PV Cash Returns/Land D					OBJ 9-OBJ 8
Period	Year		1	2	3	4	5-40	1	2	3	4	5-40	40 Years
OBJ Value	(000)dol						317.51					324.29	
Opportunity Cost	(000)dol												6.78
Activity:													
Livestock	Head		30.17	30.17	30.17	30.17	30.17	30.17	30.17	30.17	30.17	30.17	
Resource Use:													
Land A	ac	100.00	—	—	—	—	—	—	—	—	—	—	
Pasture	ac		—	—	—	—	—	—	—	—	—	—	
Lease Out A	ac		100.00	100.00	100.00	100.00	—	100.00	100.00	100.00	100.00	—	
Non-Use	ac		—	—	—	—	—	—	—	—	—	—	
Total	ac		100.00	100.00	100.00	100.00	—	100.00	100.00	100.00	100.00	—	

Table 7. Summary of Present Value of Net Cash Returns and Opportunity Cost from Solutions to Models OBJ 8 and OBJ 9 (Cont.)

	Unit	Initial Resource	OBJ 8: PV Cash Returns/Land C					OBJ 9: PV Cash Returns/Land D					OBJ 9-OBJ 8
Period	Year		1	2	3	4	5-40	1	2	3	4	5-40	40 Years
Land B	ac	197.00											
Pasture	ac		84.47	84.47	84.47	84.47	84.47	84.47	84.47	84.47	84.47	84.47	
Rent in B	ac		—	—	—	—	—	—	—	—	—	—	
Non-Use	ac		112.53	112.53	112.53	112.53	112.53	112.53	112.53	112.53	112.53	112.53	
Total	ac		197.00	197.00	197.00	197.00	197.00	197.00	197.00	197.00	197.00	197.00	
Land C (Land D)	ac	35.00											
Pasture	ac		—	—	—	—	—	—	—	—	—	—	
Non-Use	ac		35.00	35.00	35.00	35.00	135.00	35.00	35.00	35.00	35.00	135.00	
Total	ac		35.00	35.00	35.00	35.00	135.00	35.00	35.00	35.00	35.00	135.00	
Land Summary:													
Grazed	ac		84.47	84.47	84.47	84.47	84.47	84.47	84.47	84.47	84.47	84.47	
Non-Grazed	ac		247.53	247.53	247.53	247.53	247.53	247.53	247.53	247.53	247.53	247.53	
Total	ac	332.00	332.00	332.00	332.00	332.00	332.00	332.00	332.00	332.00	332.00	332.00	

Benefits and Costs of Reclamation

A comparison of land values and reclamation costs may be used to estimate the cost of complete and successful reclamation to society. If the average value of land and cost are known, then societal cost can be calculated as follows:

$$C = \bar{P} - \bar{V}$$

where C = the cost of reclamation to society,
$\bar{P}$ = the average cost of reclamation per acre, and
$\bar{V}$ = the average value of land and buildings per acre.

In 1979, the average value of land and buildings was estimated to be $400 per acre in the study area. On the other hand, based on the survey of the active coal operators during the same period, the average reclamation cost per acre was estimated at $958 (16). Thus, it is estimated that the cost to society amounts to:

$$C = \$958 - \$400$$
$$C = \$558$$

This dollar difference, $558, between the average cost of reclamation and the average market value of land represents the cost to society, if the society places this value on reclaimed land.

Alternatively, if the coal recovery rate per acre is known, the actual cost of reclamation can be determined by:

$$K = \bar{P}/S$$

where K = the actual cost of reclamation per ton of coal mined, and
S = the coal recovery rate.

The Oklahoma Department of Mines has used a recovery rate of 80% of the original coal or 1,440 tons of coal per foot of seam per acre. Thus a coal seam thickness of 18 inches average would yield 2,160 tons of coal per acre. K may then be estimated:

$K = \$958/2{,}160$ tons
$K = \$.44$

This indicates that K, the actual cost of reclamation for the land was $.44 per ton of coal mined. This represents only about 2% of the f.o.b. value of coal which averaged $22.00 per ton in 1980. K is expected to increase under the new reclamation law.

Another method of estimating the advantage of complete and successful reclamation is the cost of top soil lost to erosion. The Soil Conservation Service in its Rural Abandoned Coal Mine Program (RAMP) has estimated that 75 tons of soil is lost per year if the land was unreclaimed while only 4 tons was lost per year from completely and successfully reclaimed land. The reclamation cost per ton of soil saved can be estimated as follows:

$$R = \bar{P}/([L_m - L_n] \times T)$$

where R = the cost per ton of soil saved,
$\bar{P}$ = the average cost of reclamation per acre,
L_m = the tons of soil lost per year, if no reclamation,
L_n = the tons of soil lost per year, if reclamation, and
T = the total number of years the soil is saved.

Applying the data, it is estimated that:

R = \$958/([75 - 4] X 50)

R = \$958/(71 X 50)

R = \$.27/ton of soil saved per acre

To the extent that erosion is a major burden to society from strip mining of coal, the cost for preventing soil from water and wind erosion is \$.27 per ton of saved soil 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.

Analysis of the Region With an Environmental Impact Matrix

Assumptions, Strategies, and Considerations

A benchmark period of sometime before and including 1970, when a lull in coal mining activity prevailed, was assumed. This was based on the dwindling output of coal and the limited economic and environmental impacts of abandoned mines (orphan lands) which resulted from strip mining some decades ago. The survey data included quantitative and qualitative answers on economic and environmental factors. Using the benchmark period as control these factors were compared for periods which included partial reclamation and complete reclamation. The alternative strategies in the reclamation continuum were: 1) partial reclamation after strip mining, 2) complete reclamation following strip mining, 3) complete reclamation concurrent with strip mining, and 4) no reclamation after strip mining.

Under the 1971 Oklahoma law, many acres of strip mines were *partially reclaimed* either by the coal company or by the land owner several months after strip mining was completed. Economic and environmental damage was at their peak during this lag period before reclamation. The extent of this damage was only reduced but not eliminated by partial reclamation associated with poor soil handling and scanty vegetation. Complete reclamation following strip mining also was accomplished several months after strip mining. While the damage was at its peak during the lag period, the intensity was greatly reduced by good soil management, good vegetation and level terrain resulting from complete reclamation. Complete reclamation concurrent with strip mining requires immediate reclamation. As a result, the peak damage accompanying a lag period was avoided. In addition the timing of reclamation, the retention of top soil and overall soil management provided the terrain and vegetation for a successful reclamation.

No reclamation after strip mining is a state occurring when coal companies foreclose before reclamation commences, or unreclaimed land that was mined before 1971. It exposes the land to intense or peak economic and environmental damage.

The quantitative and qualitative approach used 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 (17). The Water Resources Council, in its proposed water resource development guidelines to replace Senate Document No. 97 and in the Final Rule for National Economic Development (NED), has strongly endorsed the environmental impact matrix (18). The Soil Conservation Service of USDA has prepared a Draft Environmental Impact Statement for the Rural Abandoned Coal

Mine Program (RAMP) where the impacts of alternative funding strategies for reclamation are analyzed (19). Studying cotton production in Southwestern Oklahoma, Richardson and Badger developed an environmental impact matrix to analyze alternative pest control strategies. The matrix was used to determine the socially desireable pest control strategy for cotton production (20).

Parameter Framework

Three main parameters, economic, environmental, and social well-being, were developed for the alternative strip mining and reclamation strategies. The economic impact parameter included all the components considered to affect economic well-being. The environmental impact parameter encompasses those components that could impinge on the social life of residents of the area. The components of each of the three main parameters were developed from the review of relevant coal mining reclamation literature, the survey format, and the Draft Environmental Impact Statements mentioned above.

The phrase "change in" used in the parameter elements indicates the change in the parameter element from the benchmark 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 strategy from the benchmark, if only coal activity is considered to influence land values.

Following the guidelines of the Water Resources Council in policy decisions regarding resource use, equal weights of 10.0 points were assigned to each of the main parameters because Federal Government regulations generally require that each parameter be given equal weight in making decisions on resource use. 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 all survey categories. Weights for each of the parameter elements were assigned to qualitative and quantitative issues as follows:

Negligible impact	=	0.05
Slight impact	=	0.06 - 0.70
Average impact	=	0.71 - 1.35
Major impact	=	1.36 - 2.00

The benchmark of 1970 was assigned a value of zero.

The qualitative weights (raw scores) assigned to parameter elements were mainly obtained from qualitative portions of the surveys and other sources of published data. Annual representative soil erosion and water run-off estimates made by the Soil Conservation Service (SCS) of USDA in RAMP, were used as follows:

	Annual erosion rate tons per acre
Post reclamation land use (rangeland, cropland, and pastureland)	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)

RAMP also estimated that storm run-off could be reduced by 40% after reclamation from a rainfall event of 2.5 inches. Zero was assigned as an alternative's raw score if no change from the benchmark period to the present situation in the parameter element was expected.

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 benchmark value. Each alternative's weighted score was obtained by multiplying the raw scores by their respective parameter weights. To obtain the net impact of each alternative, the weighted scores were summed for each parameter (economic, environmental, and social well-being). The sum of parameter net impacts for each alternative indicates the overall (total) impact on society. The alternative was then considered beneficial to society if the overall impact was positive. Conversely, an alternative with a negative overall impact was regarded as detrimental to society. All alternatives could then be ranked from highest to lowest or from greatest benefit to greatest cost.

Summary of the Environmental Impacts

An analysis of the environmental impact matrix of alternative reclamation strategies evaluates the economic and environmental consequences of strip coal mining on residents of the area (Table 8). The net economic impact of the four alternative strategies ranged from $0.05+\epsilon$ for strategies 1 and 4, to $1.69+\epsilon$ for strategy 3. The net environmental impact ranged from $-5.53+\epsilon$ for strategy 4, to $-0.25+\epsilon$ for strategies 2 and 3. The net social well-being impact was about the same for each of the strategies.

The total net rankings from greatest benefit (positive value) to greatest cost (negative value) were as follows: strategy 3, complete reclamation concurrent with strip mining with a total weight of $+1.52+2\epsilon$; strategy 2, complete reclamation following strip mining with a total weight of $+0.80+\epsilon$; strategy 1, partial reclamation and active strip mining with a total weight of $-1.57+\epsilon$; and strategy 4, no reclamation after strip mining with a total weight of $-5.40+\epsilon$. The ϵ values could not be obtained because the specific parameter element is impacted by non-coal factors or the data are unavailable. As a result, the coal mining impact could not be isolated or estimated.

Table 8. Impact Analysis of Alternative Strip Coal Mining and Reclamation Strategies in Eastern Oklahoma

		Strategies							
		1) Partial Reclamation and Active Strip Mining		2) Complete Reclamation Following Strip Mining		3) Complete Reclamation Concurrent with Strip Mining		4) No Reclamation After Strip Mining	
Parameter	Parameter Weight	Raw Score	Weighted Score	Raw Score	Weighted Score	Raw Score	Weighted Score	Raw Score	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			$0.05+\epsilon$		$0.97+\epsilon$		$1.69+\epsilon$		$0.05+\epsilon$
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

Parameter	Parameter Weight	1) Partial Reclamation and Active Strip Mining: Raw Score	1) Partial Reclamation and Active Strip Mining: Weighted Score	2) Complete Reclamation Following Strip Mining: Raw Score	2) Complete Reclamation Following Strip Mining: Weighted Score	3) Complete Reclamation Concurrent with Strip Mining: Raw Score	3) Complete Reclamation Concurrent with Strip Mining: Weighted Score	4) No Reclamation After Strip Mining: Raw Score	4) No Reclamation After Strip Mining: Weighted Score
Terrestrial and Aquatic Habitat									
d. Change in Acres of Vegetation for Wildlife	1.35	1.50	2.03	1.74	2.35	$1.74+\epsilon$	$2.35+\epsilon$	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	$-\epsilon$	$-\epsilon$	$-\epsilon$	$-\epsilon$	$-\epsilon$	$-\epsilon$	$-\epsilon$	$-\epsilon$
j. Change in Grazing Livestock	1.10	−0.65	−0.72	0	0	0	0	−2.00	−2.20
Net Environmental Impact			$-1.71+\epsilon$		$-0.25+\epsilon$		$-0.25+2\epsilon$		$-5.53+\epsilon$
3. Social Well-Being Impact[d]	10.00								
a. Safety of Human Life and Health									
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

Table 8. Impact Analysis of Alternative Strip Coal Mining and Reclamation Strategies in Eastern Oklahoma (Cont.)

		Strategies							
		1) Partial Reclamation and Active Strip Mining		2) Complete Reclamation Following Strip Mining		3) Complete Reclamation Concurrent with Strip Mining		4) No Reclamation After Strip Mining	
Parameter	Parameter Weight	Raw Score	Weighted Score	Raw Score	Weighted Score	Raw Score	Weighted Score	Raw Score	Weighted Score
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 was 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]ϵ indicates some positive value that is not estimated or is difficult to attribute solely to the strategies. $-\epsilon$ is some negative value of a similar description.

[c]Raw scores for environmental impact was 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 # of coal operators and method of hauling coal (from survey)
- d) proportion of unreclaimed, partly reclaimed and completely reclaimed land to total disturbed 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 was computed from the survey as follows:
- b) (i) Δ in quality of land-based recreation
  (ii) Δ in quality of water-based recreation

Summary and Conclusions

The results of the static linear programming analysis showed that the application of the new law would increase net cash income by $4,835 over the old law. The results of the dynamic linear programming model to project intertemporal monetary benefits to coal land owners indicate a substantial gain in wealth and net cash returns for a 332-acre ranch. These substantial monetary benefits are realized if the land transaction was made with a reliable and financially sound coal company. Reclamation regulations which lead to restoration of land A to its former productive capacity enhances this personal monetary benefit. Such improved reclaimed land may sell for as much as land B per acre.

However, a high foreclosure rate for the smaller coal companies unable to cope with the new reclamation laws and unsuccessful/incomplete reclamation could jeopardize the basic livelihood of mineral right owners if the land was leased. A great advantage of trading over leasing and selling is the avoidance of capital gains tax and the higher price of replacing the land sold to the coal company. Land prices in the coal producing areas have been found to be higher than in the surrounding non-coal areas. As long as the larger coal companies have a backlog of their own reclaimed land to be traded, trading may be to the mutual benefit of buyer and seller.

The results of the analysis to project opportunity costs of quality changes in reclaimed land show that a landowner could lose several thousand dollars in foregone net cash returns and land wealth if his land was unsuccessfully reclaimed. If coal lease royalties are paid up and the land is unsuccessfully reclaimed, the erosion of the landowners' land wealth still exists. While the 1977 federal reclamation law may prevent economic losses in new coal leases, it does not provide any compensation for landowners with pre-1977 coal leases. The bad experiences of landowners with the old coal leases have set in motion a growing trend of alternative mineral rights transfer strategies (trading coal land for non-coal land and outright sale of coal land to coal companies) aimed at minimizing these economic losses.

Although the 1977 federal reclamation law minimizes the risk of unsuccessful reclamation, it does not eliminate other risks such as defaults in royalty payment and incomplete reclamation arising from the foreclosure of coal companies. As a result, the alternative transfer strategies with their liquidity advantages may undercut the effectiveness of supervising reclamation efforts on coal lands which are owned, mined, and reclaimed by some coal companies.

The results of environmental impact matrix analysis indicate that strategy 3, reclamation concurrent with strip mining, was the best with a total positive impact of $1.52 + 2^{\epsilon}$. Strategy 4, no reclamation after strip mining, was the worst with a total negative impact of $-5.40 + {}^{\epsilon}$. 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 these elements. The weights provide a "modus operandi" for assigning merit and demerit value to rank the alternative reclamation strategies.

This study has shortcomings which could be traced to the conceptualization of the land ownership survey and the assumptions on the quality of reclaimed land and the labor requirements. The data on landowners were collected from a population of landowners who allowed their cattle to graze on reclaimed and unreclaimed land concurrently. It would have been ideal to collect the data from landowners who fenced their cattle to graze on reclaimed lands. The non-use of all reclaimed lands had omitted some expected foregone cash returns associated with quality differences of reclaimed lands. To reflect these returns, a labor hire activity would have sufficed. However, this was not used since the preference of the area labor for off-farm jobs exclude the effective utilization of the rancher's land-holdings.

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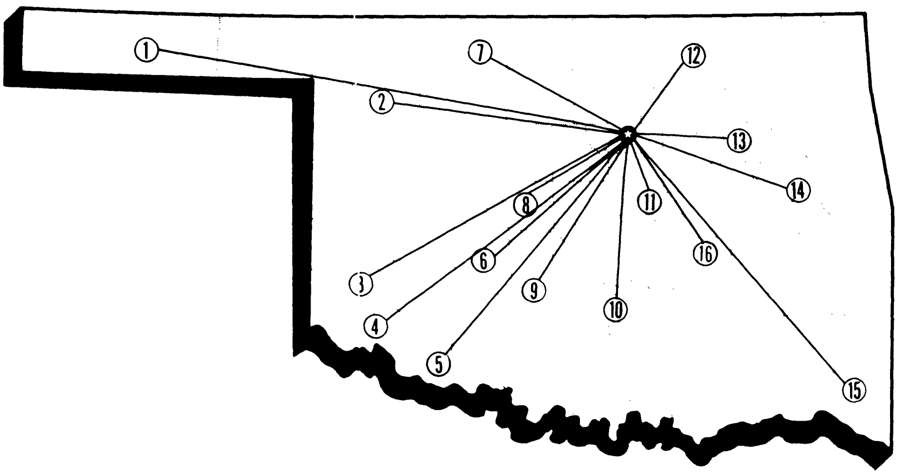

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