Hedonic Price and Travel Cost Estimation of Stripmine Impacts on Lake-Based Property and Recreation Values

by

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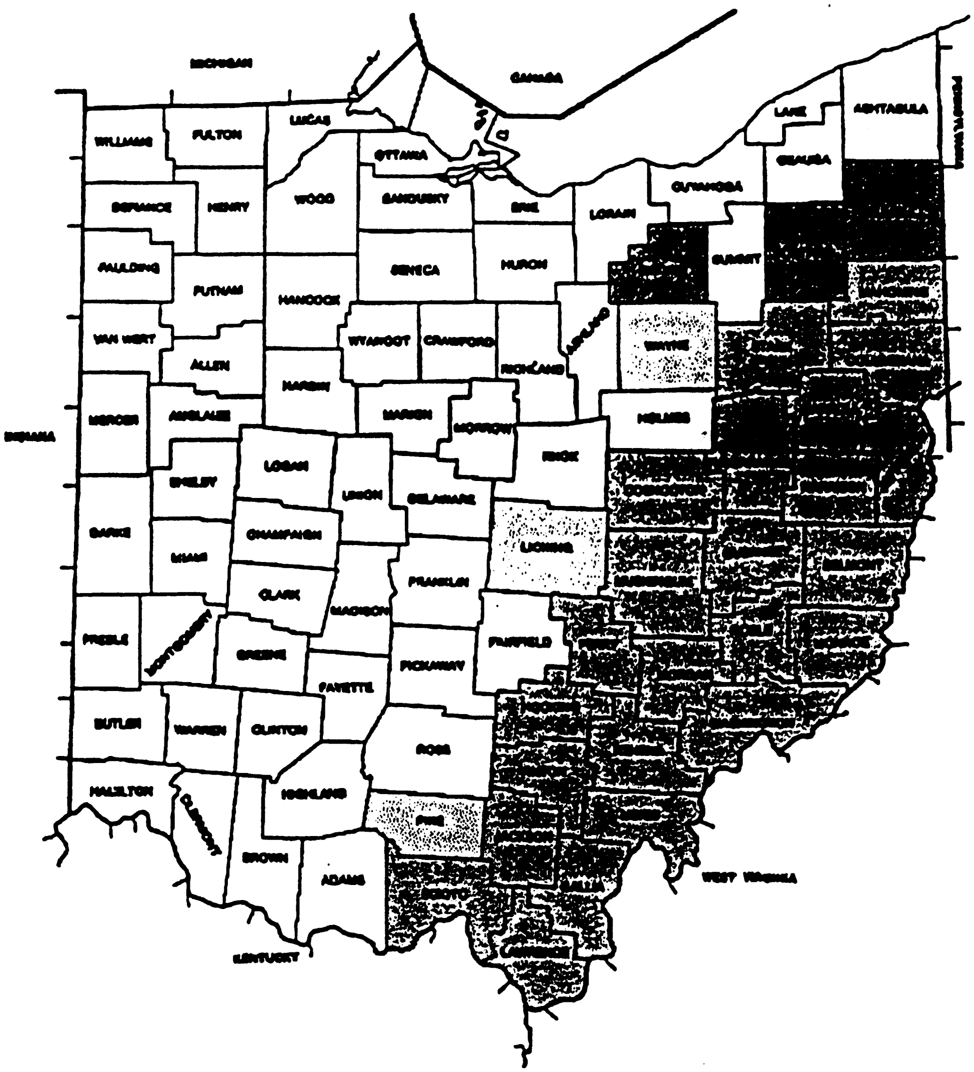
Introduction

The purpose of this study is twofold: (1) estimation of upstream stripmine activity on downstream lakeside property and lake-based recreation, values utilizing hedonic pricing and travel cost methods, respectively, and (2) estimation of the potential property and recreation benefits from increased reclamation of existing stripmines with fluidized gas desulfurization by-product (FGD) from scrubbers on coal burning power installations. This is an important research activity in terms of policy implications for stripmine reclamation and benefits to coal burning power plant by-products that can be accrued by utilization of smokestack scrubbers in the reclamation process.

Coal stripmining in the United States, particularly in the Ohio River Valley and the Appalachian Regions, has contributed to many environmental problems. Currently in Ohio, high sulfur coal is being mined extensively in the eastern part of the state (See Figure 1). Combustion of high sulfur coal for electric generation results in levels of SO_2 emissions that contribute to acid rain and other environmental problems. Scrubbers promoted by the Clean Air Act of 1990 that remove the SO_2 create a by-product, fluidized gas desulfurization (FGD) waste, that may have the potential to neutralize acid spoils at mine sites. However, it may also create an environmental disamenity if it is landfilled, which is currently the most common means of disposal (Hitzhusen and Hite et al.).

This study addresses a specific problem associated with unreclaimed strip-mines, i.e., the impact on nearby lakes. The impact usually involves a severe discoloration of the water, due to acid mine drainage, and an odor problem due to excess hydrogen sulfide in the water and increased acidity of lakes that can potentially harm fish and other wildlife.

In this study, values of cottages and recreation on two lakes in the Eastern Ohio mining region, Piedmont Lake and Leesville Lake, are examined. The cottages on both lakes



Coun:ies with both active and abandoned mines:

Coun:ies with active mines:

Coun:ies with a:andoned mines:

Figure 1: Ohio Counties with Active and Abandoned Mines

Source: Ohio Department of Natural Resources Division of Reclamation, 1996 are more often used as summer vacation homes rather than as permanent residences. Piedmont Lake has been impacted by abandoned strip-mines while leesville remains relatively unaffected. U.S. Geological Survey mapping in 1976 showed that one-third of the Piedmont Lake drainage basin had been stip-mined, with two thirds of the strip-mined area reclaimed. The primary cause of mining impacts are concentrated at one end of the lake and include reclamation failures as well as other direct problems caused by unreclaimed land. These impacts were present before the dam was built and the cottages constructed. Leesville Lake has not been impacted by strip-mining. U.S.G.S. mapping in 1978 showed that less than 0.5% of this drainage basin has had strip-mining activity.

The two lakes are close in geographical area and have homogeneous features (See Figure 2). Both are used for boating, fishing, swimming, camping, and vacation home sites. Both have the same restrictions on horsepower for boating (10 hp max). Individuals have privately built and owned homes on lots leased from the Muskingum Water Conservancy District (MWCD). The leases are for 14 year periods. Certain specifications on the homes are required under the leases. For example, guidelines regarding color, landscape, and roof style are specified in the lease. Plans must be submitted to MWCD for any new cottages or major renovations.

Hedonic Pricing Method

Hedonic pricing method (HPM) is the basic method utilized in the analysis of environmental amenities or disamenities related to property values. Hedonic pricing asserts that the implicit price of each characteristic of a property, such as number of rooms, square footage, etc., is embedded in the price of a composite good, in this case, a lakeside property. Thus, the hedonic technique provides a method for estimating the price of components not

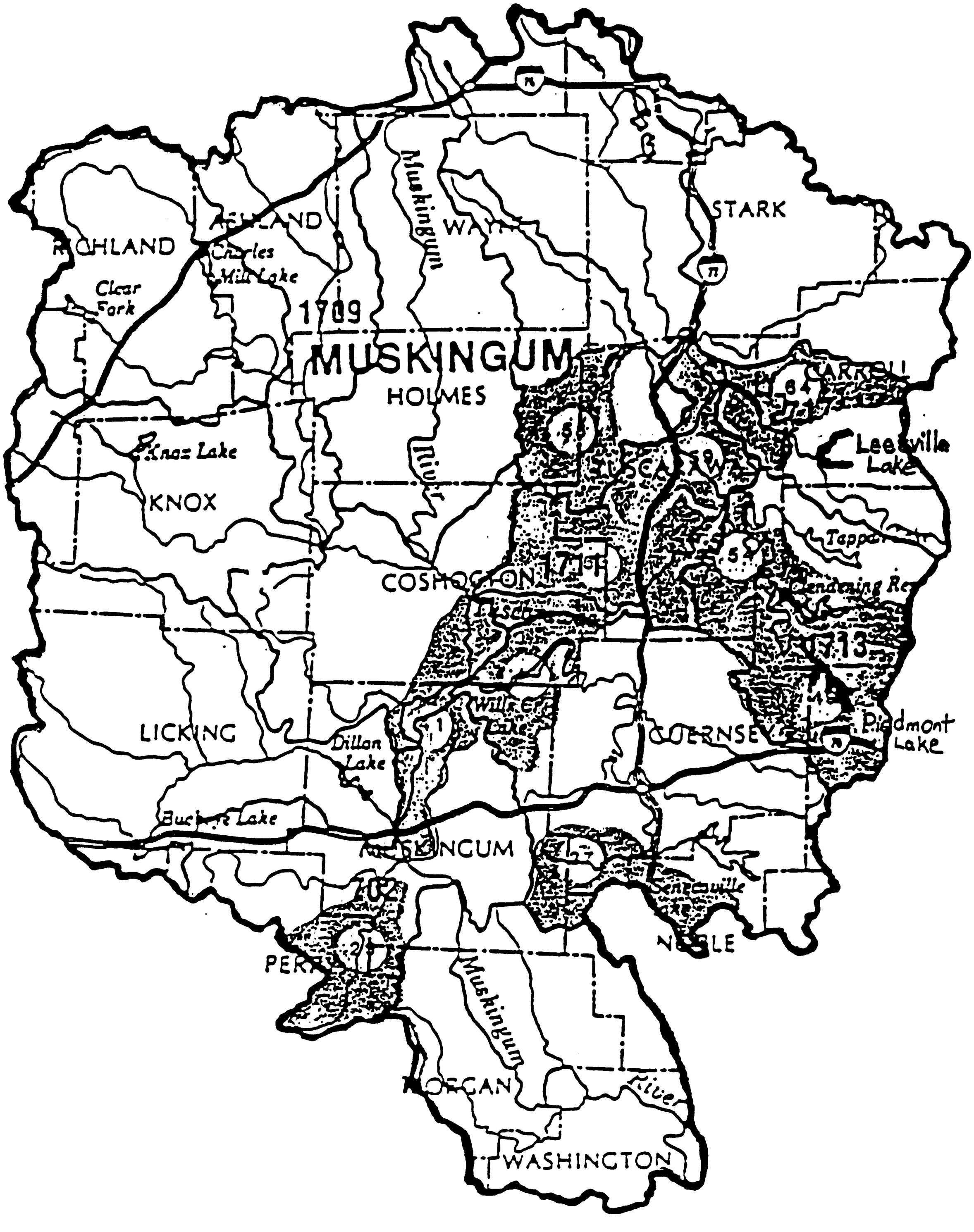


Figure 2: Muskingum Watershed Conservancy District

Shaded areas show mining impacted watersheds.

explicitly offered in the marketplace. This is particularly true of goods that have public good characteristics such as environmental attributes.

Griliches (1961) was the first to use a hedonic pricing model to value quality changes in automobiles. A pioneering study on the relationship between lakeshore property values, water quality and other lake characteristics, including steep sloped and swampy banks, was conducted by David (1968). Another early example of the use of property values to estimate willingness to pay for environmental quality improvements is the Ridker and Henning (1967) study. Their work was aimed at the measurement of the value of clean air for neighborhoods in St. Louis. They used a regression of a hedonic equation to estimate marginal implicit prices and from these prices determined willingness to pay for air quality improvements.

Freeman (1971) contends that willingness to pay can be estimated from marginal implicit prices for marginal changes, but that changes in implicit prices are an inappropriate measure for non-marginal changes. Rosen (1974) developed a more complex two-stage procedure to estimate demand for a characteristic. Described in a general way, the first stage is the estimation of marginal implicit prices, and the second stage incorporates other variables to estimate demand. This analysis will focus on the first stage of this hedonic price procedure.

Hedonic pricing in this study is used as a method to determine willingness to pay for environmental goods. A basic concept of the hedonic method is that the value of an asset (in this case a home) is a function of the set of its characteristics. This can be expressed as:

(1) $\mathbf{P = f(S,C,Q)}$,

where P = price of value of the house, S = structural characteristics, C = community characteristics, and Q = environmental quality characteristics. This is called the hedonic price function. Each of these variables represent the various contributors toward the value of the house.

The econometric estimation of hedonic pricing function consists of property value as the dependent variable and all of the individual characteristics as independent variables. Using this function, the change in property value with a change in an environmental characteristic holding all other characteristics constant can be measured by taking the derivative with respect to the environmental quality characteristic. This gives the marginal implicit price of the individual characteristics.

There are several considerations when developing an empirical hedonic model, one of which is the functional form that is to be used. Various functional forms may be estimated and compared for best fit, including, linear, log-linear, log-log, quadratic, etc. Anderson and Bishop (1986) state that although economic theory offers very little information to suggest choice of functional form, the linear form can probably be rejected. Linearizing assumes that the implicit price is constant regardless of the amount of the attribute. This assumption can be rejected because we know that the current level of an environmental quality attribute will influence the willingness to pay for more of the attribute. Based on diminishing marginal utility, if an individual already has a great deal of an attribute, he/she is probably not willing to pay much for more, while if an individual has very little of an attribute, he/she will likely be willing to pay more for an additional unit. Therefore, it follows that the linear specification can be eliminated from the choices.

It seems most reasonable to choose the form that features the appropriate attributes of the variables such as diminishing marginal utility. In this study, the double-log form is used based on superior econometric performance.

There is some discussion in the literature regarding the most appropriate way to specify property value. The most readily available data is the tax assessed value. The tax assessed value of property is available from any county auditors' office. ***The Dictionary of Real Estate Appraisal*** (Appraisal Institute, 1993) defines the difference between property price and value. Price refers to "the amount a particular purchaser agrees to pay and a particular seller agrees to accept....". Value is defined as "the present worth of the future benefits that accrue to real property ownership." Since with complete markers, price reflects the full value of a property, price is used in this study as a proxy for value. This is usually measured by examining the structural characteristics of the house, as well as observing recent sales of similar, close-by houses. Both are used to predict what the market value of the home would be. It is commonly agreed that the use of assessed values causes a potential problem. Assessors in different counties may use different methods to value a home. Also there may be amenities or disamenities that are difficult for assessors to value, such as views, and may be left out.

The most theoretically correct dependent variable to specify would be sale values. The problem is data availability. In a small study area, it is sometimes difficult to find enough sales observations because each home will not sell each year. Some researchers have solved this problem by developing predictive models to estimate sale values based on assessed value and other locational specific characteristics.

A predictive model for property values was developed for this study because the subject cottages were very rarely sold and when they were, they typically were not arms-length transactions. This model is as follows:

$$\text{lnsale} = \alpha_o + \alpha_1 \text{ lnApp} + \alpha_2 \text{ Sba} + \alpha_3 \text{ years} + e,$$

where,

lnsale = log of sale price.

lnApp = log of appraisal value.

Sba = 1 if sale was before appraisal,

0 if sale was after appraisal.

Including these variables in the predictive model accounts for improvements or deterioration that occurred between the sale and the appraisal. A more detailed description of this model will not be presented in this paper due to length considerations, but may be found in Friedman (1996). All of the variables in the model were statistically significant and there was a significant difference in the regression results when assessed values were used versus when predicted sale values (based on a subset of actual values) were used for the dependent variable. It was assumed that the predicted sale values were more accurate and were used in the final model specification.

Because the lots are leased from MWCD by the homeowners, the value of the home refers only to the value of the structure. In order to incorporate the lease price into the property value, the home values are converted into a yearly rental equivalent. Assuming a mortgage rate of 8%, the rental equivalent can be calculated as follows:

rent equivalent = (house value) (0.08) + lease rate.

HPM Model Specification

The hedonic price function for the model developed for this study can be expressed as:

$$(2) \quad \mathbf{renteq = a + B_1 lnlot + B_2 lnsqft + B_3 age + B_4 elev + B_5 baths + B_6 firepl + B_7 base + B_8 porch + B_9 rooms + B_{10} \#homes + B_{11} lakev + B_{12} lndistlk + B_{13} lnunim + B_{14} 1/lnd + e}$$

where,

renteq = value of the property in yearly rent equivalent.

a = intercept term

lnlot = size of lot in square feet

lnsqft = square footage of the cottage

age = age of the cottage in years

elev = elevation in feet above lake

baths = number of bathrooms

firepl = 1 if fireplace, otherwise 0

base = 1 if basement, otherwise 0

porch = 1 if porch, otherwise 0

rooms = number of rooms

#homes = number of homes in the development

lakev = 1 if view is of lake, otherwise 0

lndistlk = distance to the lake in feet

lnunim = distance to the highway that is unimproved

lnd = distance to the impacted part of the lake in feet

e = stochastic disturbance term

Some of the variables may require further explanation regarding their meaning. "#homes" refers to number of homes in a development. Each lake has four developments, each having varying numbers of cottages. This variable was hypothesized to be negatively related to price because homeowners are interested in privacy and quiet. The variable named "lakev", refers to whether the cottage has a view of the lake or an inlet. A few of the developments have cottages which only face an inlet. "invlnd" is the environmental quality variable and will be clarified in the next section.

Due to the nature of the market for summer homes versus permanent residences, some of the community characteristics which are generally found in hedonic analyses are not relevant here. Some of these, for example, crime, are assumed to be consistent between the two lakes. Demographic variables such as quality of schools, race, and education while relevant in a normal housing market, are assumed to be unimportant factors regarding decisions to buy a summer home.

Distance to the impacted part of the lake is the environmental quality variable in this model. This distance variable is utilized instead of using paired comparisons between the impacted and unimpacted lakes. This is because the underlying hypothesis is that there is a difference in house values that is due to the impact and this is not only a difference between the two lakes but also within the impacted lake, according to the amount of distance between the cottages and the impact.

In order to account for both differences in homes between the two lakes and differences in homes within the impacted lake, a dummy variable was set up according to $d=0$ for the unimpacted lake and $d=1$ for the impacted lake. Then the product $d*1/\text{distance}$ was calculated with distance equaling the distance to the impacted part of the lake. Inverse distance is used here because a value of zero represents zero impact. As the effect of the impact (distance) increases, the value increases. The result of this interaction is used in the equation as the environmental quality variable. The values for all of the Leesville Lake observations will be zero. The Piedmont Lake observations will be the inverse of the distance to the impact. This value will consequently be negatively related to price. As the distance to the impact gets smaller, the inverse distance increases and the price decreases.

Data on prices and structural characteristics was collected from the county auditors offices and from the MWCD offices. Auditors' records were from 1988 and 1989. Data on distances was obtained by measuring straight line distances on maps of the lakes provided by MWCD.

HPM RESULTS

The model was estimated using the predicted sale values (in the form of a rental equivalent) as the dependent variable. The results are presented in Table 1.

All of the coefficients had the expected signs except for distance to the lake. It was hypothesized that this would be negatively related to price. The reasoning was that people would prefer to be closer to the lake because of better view and lake access. However, there are potentially confounding factors. It could be that properties located closer to the lake have more flooding problems, and contrary to expectations, homes further from the lake may have better views due to higher elevation. Elevation was included in the model and thought to be important ex-ante because there is variability in elevation among the lots. However elevation was not significant.

These unexpected results may be due to the limitations of the data available. Distance to the lake and elevation alone do not explain all of the differences in the quality of the lots. Some of the homes are located at high elevations and have clear views of the lake, and others are lower with clear views. Others have less of a view due to tree density, but these also occur at various elevations and distances from the lake. To correct for these differences, a careful, individual assessment of the lots would have to be done.

The variable of greatest importance in this study is distance to the impact. As hypothesized, the inverse distance is negatively related to price. This can be interpreted as a positive relationship between distance and property value.

To derive the marginal implicit price for the environmental quality variable, the first derivative of $\ln P = a_{14}(1/(\ln d))$ is computed.

(3) $$\frac{d\ln P}{d\ln d} = -a_{14}(\ln d)^{-2} = -a_{14}(1/(\ln d)^2)$$

dlnP/dlnd is by definition the elasticity, therefore

(4) $$\frac{d\ln P}{d\ln d} = \frac{dP}{dd}\frac{d}{P} .$$

Rearrange to find marginal implicit price(MIP) for distance to the impact:

(5) $dP/dd = -P/d*a_{14}(1/(\ln d)^2)$.

Marginal implicit prices (MIP) were calculated for each observation on the impacted lake. The average MIP is 9.48. The average distance to the impact is 25,800 feet. Keeping in mind that distance to the impact is measured in 1,000 ft. units, the average MIP, 9.48 can be interpreted as a $9.48 increase in property value per year for a one thousand foot increase in distance from the impact for cottages which are 25,800 feet away.

The marginal implicit price is different for each observation since each house has a different price and is located at a different distance from the impact. The theory of diminishing marginal returns states that an incremental increase in distance from impact for a home close to the impact has a larger effect on price than an increase for a home further away. Using an average yearly rental equivalent of $3519.00, marginal implicit prices were calculated for the average house at various distances from the impact.

As Table 2 illustrates, the MIP is different for cottages located at different distances. The MIP's represent the average house in terms of value. For homes of different value, the MIP will be different.

Table 1. Regression results

variable	**coefficient**	**t-statistic**	**probability of committing a Type I error**
lot size	0.0097	0.1312	0.448
square feet	0.2199	4.0581	0.000054
elevation	-0.00035	-0.4016	0.344
age	-0.00042	-0.2483	.402
distance to lake	0.0497	1.5914	0.058
# of homes	0.0021	0.9043	0.184
lake view	0.0872	1.6240	0.054
# of rooms	0.0541	3.4232	0.00047
# of baths	0.0988	1.4777	0.072
fireplace	0.0278	0.7087	0.240
basement	0.0655	1.8696	0.032
porch	0.0740	1.7550	0.041
distance unimproved	0.0001	0.0037	0.499
inv. dist. to impact	-0.18297	-1.700	0.046

$R^2 = 0.513$ adjusted $R^2 = 0.435$

$F = 5.27$ $n = 104$

Table 2. Marginal Implicit Prices

distance to the impact	marginal implicit price
5 units (5,000 feet)	$49.71
10 units (10,000 feet)	$12.14
30 units (30,000 feet)	$1.86
50 units (50,000 feet)	$0.84

The aggregate benefits to property owners of any future reclamation of mines in the Piedmont Lake Watershed can be estimated. Two assumptions that will be made are that reclamation results in complete remediation of stripmine impacts on the lake and that these reductions represent marginal changes. Accordingly, the aggregate benefits are estimated by integrating under the hedonic price function. Although this method may overstate aggregate benefits, particularly if changes are non-marginal, it does provide a reasonable upper bound value.

There are four housing developments that are located at different distances from the impact. The total benefit of reclamation to homeowners can be estimated by summing the marginal implicit prices for each incremental increase in distance until the effect is negligible. This is done for the population of homes in each housing development. Again, the total population can be used because it is assumed that the sample is random. Therefore, the estimated marginal implicit prices are appropriate for all of the homes. For example, homes in development A are 5,000 feet from the impact. If a home in this development were 1,000 feet further away, or 6,000 feet from the impact, the cottage would increase in annual rent value by $50.59. Then if the cottage were moved from 6,000 feet to 7,000 feet, it would increase in annual value by $34.01. These increments are summed for all marginal implicit prices that are greater than $1.00. The assumption necessary here is that an observation that is far enough away from the impact that the marginal implicit price is less than $1.00 is equivalent to having no impact from stripmining. Therefore, this is equivalent to the status of the home if reclamation were done.

Developments B, C, and D are 27,500 feet, 30,500 feet, and 33,000 feet from the impact, respectively. For each of these developments, the marginal implicit prices for increments until the effect is negligible have been summed. For each development, the point at which increases in value at a given distance is negligible is between 44,000 feet and 46,500 feet.

Table 3 shows the estimation of aggregate benefits. The summation of MIP's represents the amount that the average house in the development would increase in annual rental equivalent if it were moved far enough from the impact so that the effects were

Table 3. Estimation of Aggregate Benefits

Development	**MIP's S**	**# of homes in development**	**Total increase in annual rent eq. $**
A	263.61	17	4481.37
B	25.13	29	728.77
C	23.12	13	300.56
D	14.87	23	342.01
			Total = 5852.71

negligible. This can also be interpreted as the amount that the average house in the development would increase in annual rental equivalent if mines were completely reclaimed. The product of this and the number of homes in the development is the total increase in annual rental equivalent.

The sum of the total increases in annual rental equivalent is $5852.71. To find the potential aggregate benefit, or increase in rental value to all houses from reclamation, one must convert from the rental equivalent form to the present value of the houses. The rental equivalent was found by multiplying the house value by 0.08:

rental equivalent = house value(0.08).

The increase in annual rental equivalent with reclamation was estimated to be $5852.71. Therefore the total aggregate increase in house value is ($5852.71)/(0.08) = $73,158.88.

In addition to this gain to property owners, local tax revenue will potentially increase due to reclamation. When the property values increase by a total of $73,158.88 and the average property tax rate is 6 percent, the increase in annual local tax revenue is calculated as follows:

$73,158.88 x 0.06 = $4389.53.

This means that with reclamation resulting in higher property values, local tax revenue will increase by an estimated $4389.53.

When the increase in local tax revenue is added to the total increase in house values, the total aggregate benefit equals $77,548.41. It should be noted that other authors (Driscoll, 1994 and Hite, 1995) have found that integrating under the Hedonic price function leads to an overstating of aggregate benefits. Therefore, this estimate should be regarded as an upper bound.

Travel Cost Method

In this section we apply the travel cost method to measure the adverse impacts of stripmining on lake recreation. The Travel Cost Method (TCM) is used to estimate the value of unpriced goods. Recreation is one such good that can be evaluated using this method. Note that demand for recreation has two dimensions; first, number of outings and second, hours of use per outing. With this in mind, the farther a person must travel to a recreation site the less they are expected to use (demand) the site's recreational services. Visitors who live closer to a recreation site are expected to demand more of the site services because the implicit price for recreation, as measured by travel cost, is lower than for more distant users. Based on a singe use, those more distant have higher WTP.

Hotelling (1948) first developed the Travel Cost Method (TCM) and Clawson (1959) applied it in 1959. TCM can be used to estimate demand and consumers' willingness-to-pay for a commodity, including environmental benefits. Clawson's (1959) first step to empirically estimate recreational benefits involved dividing the area around a recreation site into counties of visitor origin. Using data about visitor origins he calculated a visitation rate (visits per capita) from each county and this method became known as the zonal TCM.

In 1973 Brown et al., concluded that an econometrically more efficient method would use individually observed trips instead of zone aggregates. The individual observation method uses trips per year to the site by a household or individual as the dependent variable, while zonal TCM uses visits per capita from a zone of origin. A simple individual TCM model is:

(1) Trips = a + b price + c Income + e

where price is the sum of travel costs and entrance fees and e is the error term.

However, the individual observation method leads to a less elastic (steeper) demand curve and tends to overstate benefits depending on the type of recreation (Brown et al. 1983). This less elastic demand curve is a result of the fact that the individual behavior method omits the effect of higher travel costs to a site on lower probability of participation from more distant population zones. With activities for which recreators have acquired specialized equipment and skills, the probability of participation is less likely to be affected by travel costs. This study uses the individual behavior method and the activities in this study are likely to be affected by travel costs. Boaters and fishermen on Piedmont and Leesville Lakes must have smaller motors (10 hp) to be permitted on the lakes, but this does not prevent them from boating or fishing elsewhere. The only exception in this study would be the Muskellunge fishermen. Both lakes are stocked with Muskellunge and dominate the state in size and number of fish caught. Muskellunge fishermen must have specialized equipment, considerable skill and expend significant amounts of time to catch even one or two fish per season.

The bias would be present in this this study, from using the individual observation method but here we use a different travel cost method than Brown (1983) uses to obtain consumer surplus estimates. Brown's method relies on individual observations to predict the participation rates of other recreators who traveled the same distance. This study method uses estimates of total visitation collected by the Army Corps of Engineers and does not rely on individual observations to predict participation; therefore, this bias does not apply to this study.

The TCM can be utilized to estimate recreation demand for the two lakes in this analysis in aggregate as well as any differences in recreation value due to increased stripmine reclamation. The TCM puts a value on unpriced goods by observing the expenditures consumers incur to consume the unpriced good, i.e., lake-based recreation. Those living closer to the good or recreation site (lake) are expected to demand more of it. Other factors like income and education may also increase demand for the good. A survey of users at the two sample lake sites was conducted to determine travel distance to the site, on-site costs, visitation rates, and several socioeconomic characteristics (See Appendix A).

TCM Analysis and Results

There are two major steps in the specification and estimation of the travel cost model in this analysis outlined below. First, the trip demand curve is estimated by a regression equation based on individual observations. Second, using coefficients found in the foregoing regressions, a representative household's demand curve and the consumer surplus (CS) for each individual is estimated.

First step: estimate the trip demand curve

(7) 1nN = F (TRC, Y, Season, Age, Camp, CFF, Air, Contaminants, House, Gender, School)

where

1nN = the natural log of the number of trips the visitor made to the lake in 1995 (questions 2).

TRC = the trip cost from the households residence to the lake and any on-site costs:

TRC = (2* dist * 0.27) + On-site trip costs + (Travtime * HI)

where

dist = the number of miles from the visitors home to the lake (question 3). This value is multiplied by 2 to account for a round-trip and then multiplied by $0.27, The American Automobile Association's estimated average cost per mile for travelers.

On-site trip costs = respondents reported costs per trip (question 6)

Travtime = (2 * dist)/50 the number of miles from the visitors home to the lake is again multiplied by two to account for a round trip and then divided by 50 (50 miles per hour) to produce an estimate of travel time to the site.

HI (Hourly Income) = HI_f + HI

where

HI_f = Income/2000 * EF and

HI_p = Income/1000 * EP in these equations

the visitor's reported income is divided by 2000 (an estimate of the number of hours a full-time worker might work in a year) if they indicated that they work full-time and divided by 1000 if they work part-time. This gives an estimate of hourly income for all respondents who work, but since some are retired or unemployed this value is multiplied by EF and EP. EF = dummy variable: 1 if employed full-time and 0 otherwise. EP = dummy variable: 1 if employed part-time and 0 otherwise (questions 8). If the individual is retired or unemployed, HI will be given a value of zero, and their opportunity cost of travel time will be zero.

Y = the midpoint of the income range reported (question 9).

Season = dummy variable: 1 if the individual has rented their camp site or marina boat slip for at least 30 days, 0 otherwise (question 2).

Age = the age of the respondent (question 10).

Camp = the respondent's importance rating (1-5) for the lake's campground facilities (question 4).

CEF = the respondent's importance rating for the category: Close to friends and/or family with respect to the lake's location (question 4).

Air = the respondent's importance rating for the environmental variable: air pollution (questions 4).

Contaminants = The respondent's importance rating for the water quality variable: hidden contaminants and pollution (question 4).

House = the number of people residing in the respondent's household, including themselves (question 14).

Gender = gender of the respondent; dummy variable: 1 if the individual is male, 0 otherwise (question 11).

School = the number of years of education completed by the respondent (question 12).

The expected and estimated coefficients for this foregoing variables are presented in

Second step: Derive the aggregate classic demand curve.

Initially the entry fee is assumed to be zero and each household is paying their implicit price, TRC. At this price each household or individual makes a predicted number of trips.

(8) $1nN_i = a_o + a_1\ (TRC_i) + a_2\ (Y_i) + a_3\ (Season_i) + a_4\ (Age_5) + a\ (Camp_i) + a_6\ (CFF_i) + a_7\ (Air_i) + a_8\ (Contaminants_i) + a_9\ (House_i) + A_{10}\ (Gender_i) + a_{11}\ (School_i)$

where

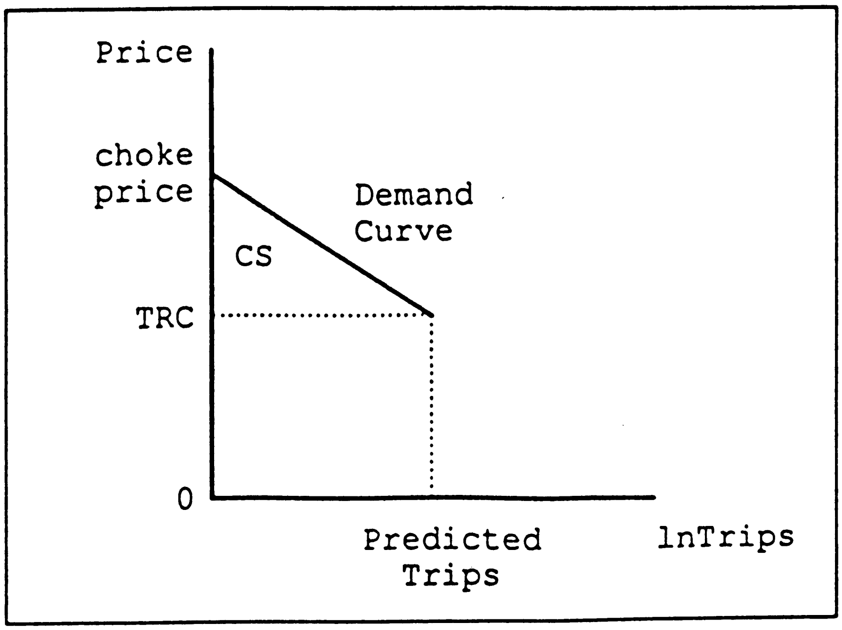
$1nN_i$ = household or individual i's predicted number of trips

$a_o, \ldots a_{11}$ = the intercept term (a_o) and the parameter estimates for each variable

$TRC_i, \ldots, School_i$ = the variables' observed value for the ith household or individual

After solving for $1nN_i$ we can plot one point on an individual's demand curve for lake recreation ($1nN_i$, TRC_i). Then we must solve to find the individual's choke price (P_{ci}) or the price at which they will make no trips to the lake (see figure 3). The line between these two points ($1nN_i$, TRC_i) and (O,P_c) is the individual's demand curve, and the area under this line is their CS. See Tables 5 and 6 for results on household and aggregate consumer surplus.

Figure 3: Individual Demand Curve and Consumer Surplus



The adjusted R^2 for the regressions is around .40 meaning 40 percent of the variation in the dependent variable is explained by the independent variables in the regression. For Leesville Lake, the annual consumer surplus for recreation is $6,178,503 and for Piedmont Lake the annual consumer surplus is $5,928,011. The difference between these two estimates of $250,492 can be viewed as an upper bound estimate of the potential annual benefit of stripmine reclamation to recreators at Piedmont Lake.

Variables	Expected Signs	Estimated Signs
TRC (Trip Cost)	-	-*
Y (Income)	+	+
Seasonal Rental	+	+*
Camp Area Rating	+	-*
Close to Friends and/or Family Rating	+	-
Hidden Contaminants and Pollution Rating	+	+*
Number in Household	-	+*
Gender (Male vs. Female)	+	+
Educational Level	+	-*

* indicates significant variables (0.20 level)

Table 4: Coefficients Expected and Estimated Signs

	Leesville	Piedmont
Mean Number of Trips (lnN)	1.657	1.412
Mean Predicted Number of Trips ($\ln\hat{N}$)	1.639	1.433
Mean Choke Price (P_c)	$1209.13	$1122.02
Mean per Household CS	$1145.44	$895.47
Mean Trip Cost (TRC)	$170.64	$214.41

Table 5: Household Consumer Surplus

	Total Visitors	Aggregate Consumer Surplus
Leesville	5,394	$6,178,503
Piedmont	6,620	$5,928,011
Difference: Estimated Annual Benefits of strip-mine reclamation		$250,492

Table 6: Aggregate Consumer Surplus

Value of FGD By-Product

According to U.S. Geological Survey topographical maps, one-third of the drainage basin that contains Piedmont Lake has been stripmined. One-third of this area is yet unreclaimed. The drainage basin is 116,480 acres in total area. Therefore, there are 12,942 acres of unreclaimed stripmines. Some improperly reclaimed areas may also be contributing to downstream water pollution, but will not be included in the following analysis.

Initial studies estimate that from 20 to 200 tons of wet FGD can be used per acre in the reclamation of stripmines (Ohio State University, Departments of Agronomy and Civil Engineering). The low estimate represents FGD as a substitute for topsoil while the high estimate maximizes FGD use rather than minimizing it as a means for disposing of the by-product.

Assuming 20 tons per acre are used to reclaim all 12,942 acres, this totals 258,840 tons of FGD. To estimate lakeside property value benefit per ton of FGD, the aggregate benefit estimates are divided by total tons.

($47,304.53)/258,840 tons = 0.18

($67,699.76)/258,840 tons = 0.26

Therefore, the total benefit per ton of FGD is between $0.18 and $0.26 assuming the 20 ton rate and $.018 to $.026 at the 200 ton rate. It should be noted that these estimates only include the benefits to property owners and not other lake users or property owners near landfills who avoid property value loss due to less landfilling of FGD. As stated earlier, these estimates do not include use of FGD by-product to correct reclamation failures that may be contributing to the problems at Piedmont lake. A substantial amount of FGD could be used to fix these past reclamations, but data are not available.

Summary and Conclusions

This research was conducted in response to an increased need to find beneficial uses for the by-products of FGD technology. This technology will likely be used increasingly resulting in increased output of by-products. This research focused on the use of FGD in stripmine reclamation. Specifically, the goal was to determine if stripmine impacts resulted in lower property and recreation values. Consequently, if property and recreation values are significantly lower, reclamation would positively affect values. There may be additional or improvements in reclamation activity as a result of the availability of FGD by-product. Assuming that the reclamation performed to reverse the impact on Piedmont Lake would use FGD by-product, the resulting increase in recreation and property values would be a tangible benefit of the by-product.

The hedonic regression equation explained 44 percent of the variation in house price and most of the signs were consistent. For a study such as this one, using secondary data, 44 percent is a reasonable amount of explained variation. The unexplained variation is most likely comprised of differences in quality of the lots and views. Also, there may have been differences in architectural features that were omitted.

The most interesting finding was that as distance to the impact increases, annual rental equivalent or property value increases. The variable for distance to the impact was significant at a 0.046 level. This is interpreted as a 4.6 percent chance of making a Type I error or a 4.6 percent chance of saying the coefficient is significant when it is not. Therefore it may be stated with confidence that the coefficient is significantly different from zero.

The coefficient was then used to determine marginal implicit prices for distance to the impact. The marginal implicit prices vary according to where the cottage is located with respect to the impact. For cottages very close to the impact, a one unit increase in distance is worth more than for a cottage that is already a significant distance away. It was determined that for observations that are 5,000 feet away, a 1,000 foot increase in distance increases the yearly rental equivalent by $49.71. As the homes were located further from the impact, the change in value was less pronounced. For example, when the distance from the impact is 30,000 feet, the increase in annual rental equivalent for a one thousand foot increase in distance is only $1.86.

The estimate of total benefits of reclamation using the marginal implicit prices, was based on three assumptions. The first is that reclamation leads to 100 percent clean-up of the lake. The second is that the disamenity changes are marginal. The third is that when the cottage is far enough from the impact that a one-unit increase in distance results in an increase in rental equivalent less than $1.00, this is equivalent to the value of a cottage when the impact does not exist.

The total aggregate benefit was estimated by summing the MIPs of incremental increases in distance until the increases had a negligible effect on house value. This was done for each of the developments and multiplied by the number of homes in each development. When converted from total increase in annual rental equivalent to total increase in house value, the total aggregate benefit to property owners was $73,158,88. Again, it should be noted that this is only an estimate of the aggregate benefit and should be regarded as an upper bound estimate.

Using the results from the regression TCM equation, recreational demand for 1995 was estimated for each lake. Recreational demand at Leesville was $6,178,503 and for Piedmont $5,928,011. These figures reveal that lake-based recreation is economically important and the local economies are likely to receive many of the benefits.

To estimate the benefits of reclamation to lake-based recreators two assumptions were made. The first assumption is that reclamation of the mines above Piedmont will result in 100 percent clean-up of the lake as before. The second is that the difference between the demand for Leesville and Piedmont Lakes is the estimated value of water quality problems at Piedmont Lake.

The total aggregate benefit estimate for 1995 was found by taking the difference between the demand estimates for Leesville and Piedmont Lakes and adding the value found in Friedman's study. The total aggregate benefit of stripmine reclamation to Piedmont Lake's recreators in 1995 was $256,344.71. It should be noted that this is an upper bound estimate of aggregate use-related benefits.

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