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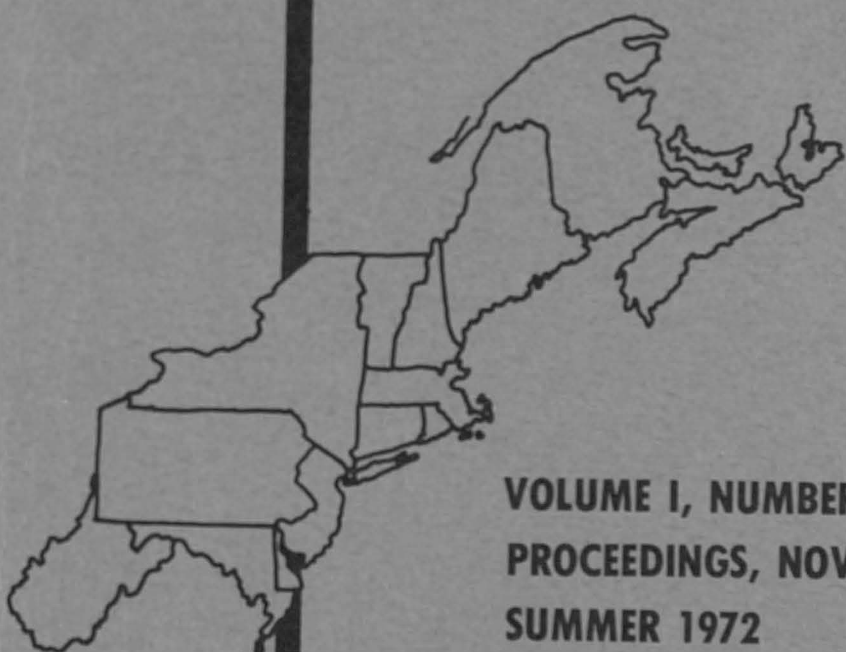

VOLUME I, NUMBER I
PROCEEDINGS, NOVA SCOTIA
SUMMER 1972

THE RELATIONSHIP BETWEEN STREAM WATER QUALITY AND REGIONAL INCOME GENERATED BY WATER-ORIENTED RECREATIONISTS.

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Introduction and Statement of the Problem.

Empirical estimates of some of the external diseconomies from polluting activities have posed difficult measurement problems for economists. Yet it is important to have some notion of the probable magnitude of the costs of pollution if society is to rationally and efficiently allocate resources to pollution abatement. Otherwise, one would not know whether too many or too few resources were being used for such purposes in terms of marginal optimality.

Streams and rivers have a number of uses including water for domestic and industrial purposes, transportation, irrigation, recreation, power generation, aesthetic appeal, and as a sewer (a medium in which to dispose of wastes). Some of these uses are compatible; others are not. When a stream or river is used as a sewer, other uses (such as recreation) may be curtailed or eliminated, or downstream water users may have to assume costs to return the water to a quality sufficient for their uses. There are, of course, costs other than these that are included in external diseconomies.

The main purpose of the study upon which this paper is based was to examine the relationship between the water quality of streams and the amount of water based recreational activity undertaken on these streams. The basic hypothesis was that a direct relationship exists between water quality and recreational use -- as water quality improves, the intensity of recreational use increases. Recreational use generally results in the expenditure of funds by recreationists. Some of these funds are expended in communities bordering streams, thus enhancing regional income. Therefore, a direct relationship would also exist between stream water quality and regional income. If one could estimate the reduction in regional income occasioned by a degradation of water quality, then one would have a measure of one of the external diseconomies from stream pollution.

A decrease in recreational expenditures caused by stream pollution does not automatically lead to a decrease in regional income, however. A substitution of expenditures for the same kind of recreation at another site in the area, for a different form of recreation within the area, or for other goods and services in the area may leave regional income unchanged (although the distribution of this income will probably be changed somewhat), or these sectoral substitutions could theoretically result in a higher level of regional income.

If the effect on national income of lower water quality in a given stream is considered, the possibility seems even greater that the level of national income will be unchanged or perhaps even move to a higher level after the adjustment induced by water quality degradation in that stream is completed. In addition to the possibilities mentioned above, when national income is being considered the alternative of substituting similar recreational activity (or of substituting different recreational experiences or other goods and services) in another region means that there may be a shift in income among regions with little or no effect on national income. The ambiguity in the direction (or amount) of change in regional income results, of course, from the concept of "opportunity cost" of water-based recreation on a given stream. There are second-best alternatives to which the expenditures which are no longer devoted to recreation on a now-polluted stream may be shifted, i.e. substitution of other recreational activities or of other goods and services may be made in this or another area.

Procedure

Seven and one-half minute quadrangles from the USGS maps of Pennsylvania were defined as the basic sampling blocks for streams and rivers in the state. There were 849 such quadrangles in the state. Quadrangles that contained a significant number of streams that were polluted with acid mine drainage and quadrangles that were within 25 miles of a SMSA (there are 12 SMSA's in Pennsylvania) were further identified to assure complete sampling. The two-way stratification resulted in four categories of quadrangles, and a proportionate random sample of quadrangles were then selected from each category. A total of 30 quadrangles were included in the study.

The basic unit of observation in each quadrangle was a stream segment which is defined as the portion of a stream whose end-point consist of: a) the confluence of the stream with any other stream whether a tributary or recipient stream; b) the point of inflow or outflow from a lake, pond, or impoundment; c) the point of entry or exit of the stream on the topographic map; or d) any point on the stream where it appeared a priori that the instream water quality would be affected significantly by some facter in the stream or in its environment. All data relating to the physical or environmental characteristics of the stream and the expenditures and activities of recreationists were defined and collected on this basis. From these criteria, approximately 2500 stream segments were defined initially for inclusion in the study. This number was eventually reduced through elimination of stream segments because of intermittent stream flow and combination of other segments to a final set of 1581 observations.

Due to time and financial constraints, only those measures of water quality that could be readily measured were used. These measures included DO (dissolved oxygen), pH, and temperature. In addition, a number of environmental factors were included since these may be important determinants in explaining the degree to which a stream is used for recreation and must be accounted for. These environmental factors were divided into two groups: physical characteristics of the stream and its immediate environs and the cultural or man-made characteristics. The physical characteristics included a) visual attractiveness (presence or absence of trash, litter, yellowboy, aquatic growth, and miscellaneous pollutants); b) size of stream, (mean and minimum annual stream flow); c) nature of stream bottom (silt, sand, mud, rocks); and d) topography of surrounding area. The cultural characteristics included a) accessibility to nearby road; b) distance to nearest four-lane highway; c) land use adjacent to stream; d) total population and population density within specified zones of stream; and e) population by three income classes within 85 miles of the stream segment.

Two types of recreationists were recognized as being users of the stream - "cabin users" and "day users". Each recreationist within these two groups was also classified by the primary recreational activity undertaken during the visit (fishing, swimming, picnicking, etc.).

Data concerning the water quality variables and the environmental variables were collected through field surveys during the summer of 1968. These were supplemented by data from maps and secondary sources for some of the variables such as accessibility and population. Information about the water quality variables was collected through on-site inspection and sampling of the stream. Most segments were sampled at least once somewhere throughout their length, usually at the lower (downstream) end of the segment. If a segment was quite long or if it appeared that some condition was changing the values of the water quality indicators somewhere within the segment, additional samples were taken at appropriate places. Where the water quality had changed significantly, the original segment was divided into two segments. Where no significant changes were found in the water quality, mean values for the several water quality indicators were calculated and used for the original segment.

Data concerning the recreational activities and related expenditures of stream-oriented recreationists also were gathered during the summer of 1968 through a combination of direct interviews and questionnaires that were to be completed by the recreationists and returned by mail. The use of the mail-in questionnaire as a supplement to the direct, personal interview was dictated by the characteristics of the population which was being interviewed and the geographical dispersion of the study areas. Recreational activity is inherently difficult to observe and measure because of its temporal and spatial dimensions. Stream-oriented recreation is particularly difficult to measure in the absence of a large and intensive interviewing effort because of the short time duration (typically concentrated on weekends and holidays) during which the recreationist is available for interviewing and because this activity is geographically dispersed rather than concentrated at lakes or parks. These characteristics of stream-oriented recreators require one of two approaches to data collection: a large number of interviewers who are able to canvass many miles of streams and rivers at certain times; or a sampling technique whereby information obtained from a relatively small number of interviews can be expanded to estimates of the total for the population. The latter approach was used in this study.

Because it was considered infeasible to attempt to monitor all stream segments included in the study for each day throughout the summer (or year), a program of selective sampling and counts of recreationists was adopted. For cabin-users, this simply meant direct interviews of cabin occupants whenever possible and the distribution of mail-in questionnaires to all other cabins and trailers supplemented by a count of all cabins and trailers along each stream segment. The distribution of mail-in questionnaires was used also to obtain information about the expenditures and activities of day-users.

A total of 237 questionnaires was returned representing a response rate of about 23 percent. The data obtained from recreationists on the questionnaires pertained to their expenditures and activities undertaken on the stream segment. These expenditures were translated into estimates of the regional income generated before the relationship with in-stream water quality was determined. To facilitate the estimation of regional income, the expenditures were disaggregated by economic sector and location where the expenditure was made.

The conversion of expenditure data into estimates of regional income requires, of course, the multiplication of the expenditures made in each sector within the geographic area by the corresponding sectoral income multiplier. The source of the sectoral regional income multipliers used in this study was an interindustry analysis of Clinton County, Pennsylvania, by Hays Gamble and David Raphael.[1/]

The Clinton County study was selected because Clinton County was the most industrialized of the counties for which interindustry analyses were completed in Pennsylvania at the time of the study. Since several of the quadrangles are in or adjacent to counties in SMSA's, it appeared that the income multipliers from the Clinton County study would approach as nearly as possible a balance among the multiplier values for the various areas. The selection of sectors for the questionnaire and the calculation of regional income were determined by the kinds of expenditures hypothesized for various types of recreationists and by the economic sectors defined in the interindustry study used as the source of the sectoral regional income multipliers.

1/ Hays B. Gamble and David L. Raphael, A Microregional Analysis of Clinton County, Pennsylvania (University Park, Pa.: The Pennsylvania Regional Analysis Group, The Pennsylvania State University, 1966) 2 volumes, pp. 59-74.

Analysis and Results

The initial analysis of the data was directed toward a sorting of the variables to determine which ones appeared to be of explanatory value in a classical linear regression model. Additional objectives at this stage were to test alternative formulations of several variables and to discover and if possible eliminate collinearity between variables. The results of the initial analysis were tested again in a limited variable dependent (LIMDEP) model to obtain the final estimates of the parameters in the relationship.

From the results of the LIMDEP estimation, it appears that the basic hypothesis concerning the effect of changing water quality on regional income generated by recreationist expenditures is supported. Dissolved oxygen is the only water quality measure that is statistically significant at the 0.05 level. Each of the other measures of water quality--pH, temperature, aquatic growth, and miscellaneous pollutants, although not significant at a level that would warrant their retention in the regression equation, indicated by their algebraic sign that lower quality as measured by each indicator resulted in lower regional income from recreation-related expenditures. Table 1 presents in summary fashion the indicators of water quality with their coefficients, t-values, and significance levels. Each coefficient indicates the change in regional income generated by recreation-related expenditures for each 100 yards of stream segment length during the year. The positive coefficients of DO and pH indicate that an additional amount of regional income of \$125.04 and \$194.91 respectively would be generated annually for each 100 yards of stream length for an increase of one mg/l for DO or an increase of one unit in the pH value (indicating less acidity in the stream). The rest of the measures have negative signs for the coefficients with temperature and aquatic growth being continuous variables and trash and miscellaneous represented by dummy variables. The equation as measured by the chi-square statistic ($-2 \ln\lambda$) is significant well past the 0.0005 level with 15 degrees of freedom.

Table 1.
Summary Table for the Relationship of Water Quality Variables to Regional Income Generated by Recreationist Expenditures

Variable	Coefficient	t-value	Significance level
Do	125.04	3.74	0.001
pH	194.91	0.87	--
Temp[a/]	-32.64	0.95	--
Trash	-201.14	1.04	0.30
Aquatic	-3.35	1.87	0.10
Misc	-231.65	0.02	--

a/ The magnitude of the coefficient for Temp is not comparable with the others because it was not taken from the same equation as the others.

The other variables in the equation or that were tested and rejected were included to remove the effect of variation in the environmental characteristics that also influence recreational activity on streams. The benefit from including these variables, apart from standardizing between segments, is the additional information that was obtained about the relationship between several of the physical and environmental characteristics of streams and recreational use of these streams. Among the variables describing the physical attributes of the stream only mean stream flow was of significance in explaining recreational use.

None of the results is surprising, nor do they rebut hypothesized relationships formulated earlier. Streams that are easily accessible tend to have more use than those which are not; streams in areas of greater topographic variability seem to have greater recreational potential than those in areas of more uniform topography. If Access is interpreted as an indicator of quadrangle location within the state rather than a simple measure of ease of access by four-lane highway, the coefficient of this variable indicates that streams in more remote areas have greater appeal for water-based recreationists than those closer to or within the more heavily populated areas of the state. An exception to the statement just above, this tends to disprove one of the initial hypotheses used in selecting the stream sample--that demand for recreational resources is greater in areas of greater population concentration, and enough greater that recreationists will possibly accept a penalty in terms of water quality or less attractive physical and environmental characteristics in return for the proximity of recreation sites.

Because of the rather restricted basis on which they were calculated, the results of the analysis stated in the terms of 100 yards of stream segment do not convey effectively the meaning for streams with lower water quality within an area in terms of their impact on regional income. The effect of these results in terms of differing levels of regional income associated with differing levels of water quality may perhaps be better illustrated by comparing the predicted and actual recreation-derived regional income for longer sections of streams exhibiting a range of water quality.

Four streams were selected in such a way that their characteristics other than water quality as measured by DO were quite similar, and the dissolved oxygen levels of these streams represented a range of values between 5.4 mg/l and 10.3 mg/l. Multiplying the expected value and the observed value of the dependent variable by the length of each segment in units of 100 yards and aggregating over the number of segments in each stream yielded predicted value and the observed value of regional income generated annually for the entire stream section.

The results of this excercise are given in Table 2.

A comparison of the predicted values of the dependent variable, regional income generated by recreationist expenditures, and the observed values for these streams indicates in a general way the effect of varying levels of water quality on the amount of regional income generated by

Table 2.
Predicted and Observed Values of Regional Income on Four Streams.

Stream	Length (yards)	DO	Predicted Value of Dependent Variable	Observed Value of Dependent Values
Quittapahilla Creek	4828	5.39	$151.	0
Ridley Creek	5410	7.24	118.	0
Lower Little Swatara Creek	5327	8.42	443.	0
Fishing Creek	5236	10.33	4017.	6905.

water-based recreationist expenditures. The first three streams in the illustration differ primarily in the level of DO in the water. An examination of DO values for these segments and the corresponding predicted values of the dependent variable constitutes a concrete expression of the water quality-recreational use relationship.