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Analysis of Reservoir Recreation Benefits

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ANALYSIS OF RESERVOIR RECREATION BENEFITS

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INTRODUCTION

"The Analysis of Reservoir Recreation Benefits" is based on research performed as part of a project entitled "The Economic Impact of Flood Control Reservoirs" (OWRR Project No. A-006-KY) sponsored by the University of Kentucky Water Resources Institute and supported in part by funds provided by the United States Department of the Interior as authorized under the Water Resources Research Act of 1964, Public Law 88-379.

The project as a whole is examining the economic consequences which resulted from the construction of four existing reservoirs in the hope of being able to outline improved economic evaluation techniques. This report concentrates on recreation benefits realized from construction of two of the four reservoirs. As the research continues, subsequent reports on further findings will be issued.

Any comments the reader might have on the content of findings of this report are encouraged and should be directed to L. Douglas James, Project Director.

ABSTRACT

Recreation visitation to two Kentucky reservoirs (Rough River and Dewey) constructed by the U. S. Army Corps of Engineers was studied to develop mathematical expressions for estimating numbers of visitors and recreation benefits. Regression analysis was used to relate characteristics of 168 origin areas (120 Kentucky counties, the District of Columbia, and the remaining states excluding Hawaii and Alaska) to visitation from that area to Rough River Reservoir. The resulting equations were then applied to Dewey to test their generality. Good results were obtained when only air distance and population were used as the independent variables. Correlations including the age and income of the population, urbanization, highway quality, and competition from other reservoirs did not significantly improve the results for Rough River and resulted in a worse correlation when applied to Dewey.

Recreation benefits from the two reservoirs were estimated from a demand curve where the cost of effective travel distance was used to estimate price and the regression equation was used to estimate visitation. The effective or out-of-the-way distance (as contrasted with total distance) to the reservoir was estimated from collected data. The area under the demand curve equals the resulting benefits associated with the origin area and attributed to the reservoir.

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CHAPTER I

THE THEORY OF RECREATION BENEFIT ANALYSIS

Introduction

The purpose of this study is to use data collected at existing recreation reservoirs to determine which factors most influence the number of people living in a given origin area who visit a given reservoir, to develop an equation based on the statistically significant factors for predicting visitation to a recreation reservoir, and to apply the equation to estimate recreation benefits. The data used recorded the home county of 103,548 visitors to Dewey and Rough River Reservoirs in Kentucky. Hopefully, the results will serve to provide a more adequate basis for estimating the potential economic benefit from prospective recreation reservoirs.

Definition of the Recreation Experience

A recreation reservoir is a man-made body of water that provides facilities for water oriented activities and for leisure time rest and relaxation. Swimming, fishing, water skiing, and boating require direct use of the water while hiking, sightseeing, picnicking, golf, and camping comprise indirect activities. Water is actually required for the first type of activity; however, water only serves by its proximity to increase the enjoyment attained through the second type or to round out the recreation experience for those not wishing to spend all their time in the direct activities.

Each visitor to reservoir recreation facilities acquires a recreation experience consisting of five phases (1, p.75). The first phase is planning for the trip and provides enjoyment through anticipation. Equipment such as fishing tackle, boats and motors, and skis are purchased during this phase. The value of the equipment is some indication of the value the recreationist places on the experience; however, the full value is seldom properly ascribed to one particular reservoir.

The second phase consists of travel to the site and involves net expenditures amounting to cost of travel, cost of lodging in transit, and the increase in food cost over what is normally spent at home. Travel time also constitutes a real cost, and the quickest route frequently dictates the choice of a recreation site. The trip itself may provide substantial enjoyment depending on the route chosen and the number of stops at intermediate interest points.

The third phase consists of the experience at the recreation site. The expenditures involve money spent for recreation supplies, food and lodging, and entrance fees. The on-site activities furnish the bulk of the recreation experience for those visitors traveling short distances, but a smaller percentage for those traveling greater distances with many intermediate interest stops.

The fourth phase consists of traveling home, and expenditures are similar to those encountered in traveling to the site. The trip home often has less recreation value than the trip to the site because of weariness and eagerness to get home.

The final phase consists of recollection of the trip and usually involves expenditures for developing photographs. Reviewing souvenirs and photographs and possibly sun tans enhance the value of this phase and leads to anticipation for the next new experience.

The recreation reservoir provides the site for the third phase of the total recreation experience. The other four phases complement the experiences at the site in providing the total relaxation and enjoyment.

History of the Development of Outdoor Recreation Facilities

Lakes, rivers, and streams have always fascinated mankind; and from the earliest fishing stream or swimming hole, people have found relaxation and enjoyment in outdoor activities centered around water. However, the supply of water for recreation has been increasingly taxed by the expanding demand of an increasing urban population. Many streams are no longer abounding in fish, and pollution has all but destroyed many swimming holes (2, p. 20). Recreation reservoirs are so saturated with people on weekends that the expected open spaces viewed from one tent turns out to be the back of another tent. Every forecast indicates that the use of reservoirs for recreation will continue to expand much faster than the total population. From 1953 to 1963, attendance at Corps of Engineers Reservoirs increased an average of 13.6 percent per year (3, p. 1). During this period, the annual rate of population growth was 1.7 percent.

Several factors have combined in greatly increasing the use of outdoor recreation facilities. Increased incomes have allowed families and individuals to spend more on traveling and equipment related to outdoor enjoyment. Completed interstate highways have provided weekend access to places heretofore enjoyed only on a week's vacation. Decreased working hours coupled with longer vacations have provided more leisure time. However, leisure time distribution may well affect visitation more than total lesiure because of the particular appeal of reservoirs to overnight use. Increased population concentration in urban areas has motivated more people to seek outdoor recreation away from the urban environment. The United States is not alone with these problems as Canada also plans to more fully utilize its recreation potential (4, p. 957).

Reservoir recreation has become one of the most popular and easily accessable means of outdoor enjoyment. Like many American pastimes, this type of recreation was not planned in advance. Older reservoirs were not constructed with recreation as even a secondary purpose; however, the more alert planners soon recognized the potential and gradually received authority to plan facilities for recreation. Only minimum facilities were initially provided. Recreation was not allowed to interfere with the operations for which the reservoir was designed. Since recreation was not considered in project justification, recreation facilities were not planned in project installation. However, as recreation use increased, it was no longer possible to ignore it in reservoir planning and operation.

Shortly after completion of most major reservoirs and many smaller ones, private and local facilities for camping, boating, and fishing were established. As soon as they learned that a reservoir was being considered, land speculators and recreation enthusiasts began buying adjacent lands for resale or personal use. As more people benefitted from reservoir recreation facilities, pressures were first exerted to consider recreation in formulating operation policies for existing reservoirs, and then to consider recreation in the design of newly proposed reservoirs.

Legislation was passed to require consideration of recreation in project planning. As a result, recreation became a formal project purpose before adequate economic criteria for evaluating economic benefits were developed.

Although years have elapsed since the initial attempts to quantify the economic benefits derived from reservoir recreation, and many methods have been suggested and used, none have been entirely satisfactory. Procedures have been proposed and studied, but none have combined theoretical soundness with ease of practical application. Many theoretically conceived demand functions have not been based on sufficient data to insure their reliability. The various Federal, state, and local agencies have their own standards, and these standards may differ radically. However, one requirement which all Federal agencies must follow is found in the Federal Water Project Recreation Act of 1965 which stated:

> in investigating and planning any Federal ... water resource project, full consideration shall be given to the opportunities, if any, which the project affords for outdoor recreation and for fish and wildlife enhancement and ... it shall be constructed, operated, and maintained accordingly (5).

<u>Theoretical Analysis and Literature Review</u>

The accepted criteria for determining the relative merits of alternative water resources projects are based on welfare economics, using second order or economic efficiency (6, pp. 17-28). The goal is to maximize national welfare as expressed by total national income. The approach does not ignore such other goals as better income distribution or economic stabilization nor such extra market goals as preservation of sites of historical significance or scenic beauty. It rather separates evaluation of economic consequences from evaluation of extra market consequences and then combines both in the final decision making after they have been analyzed individually.

According to economic efficiency, the optimum degree of development for any project purpose may be determined by defining a demand curve which expresses the amount of goods or services demanded during a given time at a specific price and a supply curve which expresses the marginal cost of increasing the amount of goods or services available. A pair of such curves for reservoir recreation is illustrated by Figure 1. The optimum output is that for which the two curves cross. Demand curves for most goods slope downward and to the right indicating increasing quantities consumed at lower prices. The total area under the demand curve to the left of the quantity consumed equals the total benefits received (Area ABCDE for the optimum user capacity of Figure 1). Consumers surplus may be defined as benefits

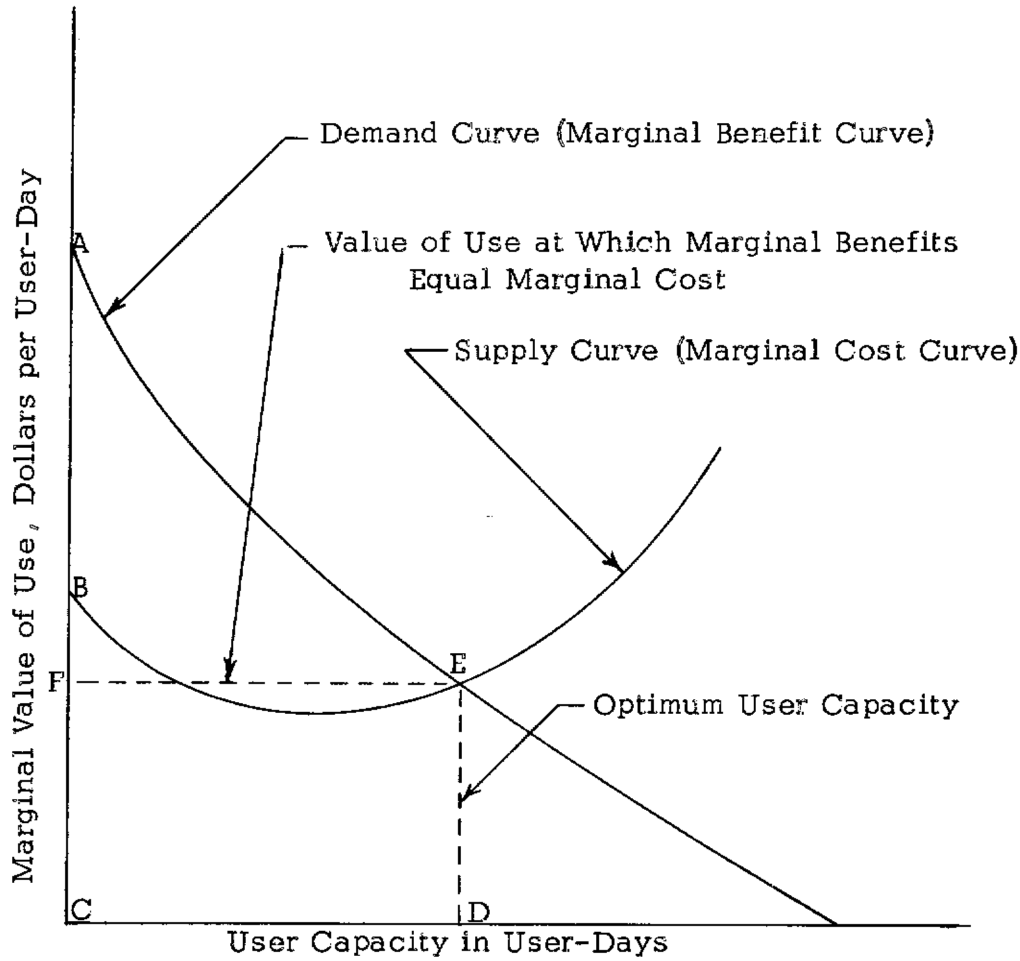


Fig. 1. -- Typical Marginal Supply and Demand Curves

received in excess of the amount paid. It would be represented by Area AFE on Figure 1 were Price CF charged for use of the facilities. Supply curves also slope downward and to the right because of economies of scale until they reach a minimum point where diseconomies of scale begin to cause a rise. For most water resources projects, the demand curve intersects the rising limb of the supply curve.

For a given project, total cost and total benefits may be determined for a range of probable reservoir sizes. The results when plotted provide total cost and total benefit curves. The supply curve is marginal cost or the slope of the total cost curve. The demand curve is marginal benefit or the slope of the total benefit curve. The intersection of the supply and demand curves indicates the economically efficient degree of development for the project under consideration (7).

Obviously the above approach depends on adequate measurement of benefits and costs. Evaluation of project cost is normally fairly straightforward. Benefit evaluation poses more problems. The greatest difficulty is that demand curves may only be directly determined for marketable goods or services. For example, the demand curve for apples would show the decrease in the number of apples which would be sold if the price of apples increased 10 cents a pound. The amount can be determined from analysis of the apple market. Here lies the crux of the problem of applying economic efficiency criteria to recreation project analysis. Recreation is not marketable, therefore the price quantity relationship cannot be directly defined by market analysis.

Indirect methods of deriving demand curves by use of pseudo prices based on economic values foregone to acquire goods and services have been developed and applied with reasonable accuracy to the analysis of water resources development. The application of this procedure in analyzing recreation has been accepted by the Federal Government. Senate Document 97 states:

> In the general absence of market prices, values for specific recreational activities may be derived or estimated on the basis of a simulated market giving weight to all pertinent considerations, including charges that recreationist should be willing to pay and to any actual charges being paid by users for comparable opportunities at other installations or on the basis of justifiable alternative cost. Benefits also include the intangible values of preserving areas of unique natural beauty and scenic, historical, and scientific interest (8, p. 10).

Senate Document 97 defines intangible benefits as:

> those benefits which, although recognized as having real values in satisfying human needs or desires, are not fully measurable in monetary terms, or are incapable of such expression in formal analysis (8, p. 8).

Although the satisfaction an individual receives from a recreation experience is intangible in that it cannot be assigned a monetary value, the cost the individual incurs in obtaining that experience is both tangible and easily evaluated. By using cost incurred to indicate value received, a market may be simulated. Simulations approximate tangible benefits which are defined as:

> those benefits that can be expressed in monetary terms based on or derived from actual or simulated market prices for the products or services, or, in the

> absence of such measures of benefits, the cost of the alternative means that would most likely be utilized to provide equivalent products or services (8, p. 8).

Therefore, recreation benefits may be derived by simulating markets which portray the willingness of the recreation user to pay for varying recreation experiences.

The simulated demand curve should display the following general characteristics:

1. The amount demanded should be based on a specified time duration, and the marginal value should be expressed in dollars;
2. The demand curve should indicate recreational enjoyment for which there is no direct expenditure by the recreationist and hence cannot be directly determined as a market demand;
3. The demand curve should be derived independently of the cost of providing the recreational facilities;
4. The demand curve should consist of a single curve which applies to recreationists as a group without regard to the form of recreation being enjoyed or to differences among individuals as to capacity to enjoy recreational benefits;

5. The demand curve should be recognized as specifically applying only to the particular area for which it was derived;

6. The demand curve should indicate values which are reasonable in the judgment of informed people (9, p. 201).

Several methods of estimating recreational benefits have been proposed and developed to varying degrees. Only five methods, however, appear to be practical, and only three of these have received Federal recognition. The oldest and most used method is to base recreation benefits on a selected average value of the experience to the user. The value is selected according to the quality of the experience available at the site and should according to Senate Document No. 97, Supplement No. 1 vary between $0.50 and $2.50 per user-day. Total recreation benefits would equal the product of the unit value and the number of visitors. The weakness of the method lies in the arbitrary nature and difficulty in selecting the unit value.

The second procedure involves estimating visitor expenditures for such goods and services related to the recreation experience as traveling cost, food cost above that normally spent at home, recreation equipment cost, and other similar expenses (9). Benefits attributable to the project are assumed by this method to equal the total number of visitors multiplied by the average expenditure. The method overestimates benefits by using the cost of all recreation related items to justify provision of one item, the body of water.

The third procedure involves asking the visitors, through questionnaires, what they would be willing to pay to use the facilities under study (10). The total project benefits would then equal the sum of the values that the visitors would be willing to sacrifice. The method is severely limited by the cost of questioning and difficulty in getting adequate replies.

The fourth procedure is an approved Federal practice and involves estimating the cost of alternative means of providing similar recreation facilities (8, p. 10). The estimated benefits attributable to the project analyzed equals the cost of the least costly alternative project that would provide the same visitor-day capacity with similar quality facilities. The Corps of Engineers applies this method by relating the cost of completed projects of various sizes to the cost of providing the project studies (11). The Bureau of Reclamation has also applied this method in estimating recreation benefits (9, p. 200). Alternate cost approaches only prove the project to be relatively better than another one without indicating any merit in an absolute sense.

The fifth procedure has been recognized as satisfactory by the Federal Government and has received the most favorable treatment in the literature. Many variations have been used, but all involve the derivation and utilization of a simulated price visitation demand curve based on travel distance and the cost of travel. Initially, visitation from a particular origin area is estimated by an equation having the form:

$$V = KP / d^n, \tag{1}$$

where V is the estimated annual number of visitor-days spent at the sight, P is the population of the origin area, d is the distance from the reservoir to the origin area, n is an exponent describing the relationship between distance and visitation, and K is a constant describing the propensity of the individuals in the origin area to visit the reservoir. A visitor-day is registered each time a visitor spends all or any part of a day at the site. K and n are evaluated by a regression analysis based on reservoir visitation data. Other equations relating V, P, and d are proposed in the literature (12, p. 1151); however, most may be converted to the form presented.

The following procedure may be used to develop a demand curve. The annual visitor-days expected at a given recreation site may be estimated by applying Equation 1 to each origin area and summing over the origin areas to get a grand total. The total estimated visitor-days may be plotted versus zero cost to get one point on the demand curve. Then for each origin area, an incremental distance is added to the actual distance to obtain a new visitor-day total estimate. If he would also have to travel this incremental distance, the visitor would incur an additional economic cost before he could use the reservoir. The difference between the first and the second number of visitors is the number of those visiting the reservoir who do not value the experience highly enough to make this sacrifice. The cost of travel equals the product of the incremental distance and the estimated traveling cost per unit of distance. This provides a second point on the demand curve. Repetition of the last cycle using a large range of incremental distances will provide all points necessary to complete the curve. The area under the demand curve represents the benefits attributable to the project. A more detailed theoretical discussion is available in Trice and Wood (9), Seckler (13), Clawson (14), Knetsch (12), or Merewitz (15).

The last method still fails to quantify the full value of reservoir recreation to an individual. No simulated market can ever duplicate the truly personal experience received through outdoor recreation. To pretend that it does would be to take an extremely materialistic interpretation of life. However, since some estimate of recreation benefit must be used for economic evaluation of alternative reservoirs and the fourth procedure conforms to Federal legislation and minimizes the major objections to the others, it was chosen for application in this study.

Two relationships must be established to apply this procedure. First, the visitation rate must be defined as a function of the various factors which influence the tendency of a given population to visit a given recreation reservoir. In other words, the K and n of Equation 1 must be determined. Secondly, the method of converting distance to price and thus benefits must be better defined by analyzing the incremental cost of travel.

Various approaches have been used for defining the population centers or origin areas for use in the analysis. Hotelling initially proposed that zones of equal population be defined around the reservoir at varying distances and assumed the propensity to visit (K) was constant for each zone (14). Clawson defined distance zones bounded by concentric circles and used each zone population and mean distance from the reservoir (14). Knetsch derived an equation relating visitation rates to population and distance from a least-squares correlation based on recreation visitation to Kerr Reservoir in North Carolina and Virginia. He obtained the expression:

$$\log_{10} (V + 0.80) = 3.82462 - 2.39287 \log_{10} C \quad (2)$$

which he found accounted for 97 percent of the variation in visitation rates (12). V is the annual visitation rate per thousand population in the zone of origin, and C is the dollar cost of travel. The constant 0.80 causes the demand curve to intercept the axes. The similarity between Equation 1 and Equation 2 may be seen from Equation 3 which is Equation 1 in logarithmic form.

$$\log_{10} V/P = \log_{10} K - n \log_{10} d \quad (3)$$

Although Knetsch's relationship provides a high degree of correlation between predicted and recorded visitation from a given population center to a given reservoir, the possibility of including other factors affecting visitation remains.

Statistical multiple correlation procedures provide techniques whereby additional variables may be incorporated, and logic supports the hypothesis that characteristics other than distance and population may affect visitation to a recreation reservoir. Population characteristics such as income and income distribution, age and age distribution, and degree of urbanization should affect visitation. The type of highway between the population centers and the reservoir and the competitive position of the reservoir with respect to alternative sites available to the population center should also have an affect. The type and quality of facilities available at the reservoir would also influence visitation rates.

An early application of multiple correlation techniques relating additional population characteristics with visitation by Boyet and Tolley (16, p. 987) produced the equation:

$$Y = 10^{\alpha} X_1^{\beta_1} X_2^{\beta_2} X_3^{\beta_3} X_4^{\beta_4} X_5^{\beta_5} X_6^{\beta_6} X_7^{\beta_7} e \qquad (4)$$

The total number of visitors Y from each state to several national parks was regressed with such factors as travel cost measured by distance X_1, population X_2, per capita income X_3, median age X_4, median education X_5, percent of population residing in census-defined urban areas X_6, percent of population that is white X_7, and a random variable e. α is a logrithmic product constant and the β's explain the elasticity with respect to the independent variables. Statistical analysis revealed extreme intercorrelation between X_4, X_5, X_6, and X_7, and they were excluded from the final equation. Thus their resulting equation related visitation to distance, population, and per capita income. As an alternative they tried another model that included a family income distribution variable in place of the per capita income, and a length of paid vacation distribution variable along with distance and population as independent variables. The model was

$$Z = \sum^{i} \sum^{j} \sum^{k} r_{ijk} P_{ijk} \qquad (5)$$

where

Z is the total number of visits,

r_{ijk} is the visitation rate from the ijkth population segment,

P_{ijk} is the population in the ijkth segment,

i is the distance class,

j is the income class, and

k is the paid vacation class.

However, instead of states as population centers they chose five counties in western North Carolina and attempted to establish relationships between characteristics of the individuals within the counties and their respective visitation rates. A chi-square test for goodness of fit rejected all attempts.

Merewitz (15) however, succeeded in fitting multiple correlation equations to predict the variation in visitation rates to the Lake of the Ozarks, Niangua Arm, Missouri. Forty-six different characteristics for 114 counties in Missouri were regressed with creel census visitation data indicating visitor-days of fishing, boating, surf-boarding, and water skiing. A list of the variables and the variable transformations attempted will not be reported here; however, the three equations he found to work best for estimating the relative number of visitors from the various origin areas were:

$$\log_e V_u = 2.4976 - 1.8945\, S_u + 0.0045/S_u^{\,3} + 0.0025\, P_u + 0.7978 \log_e PD_u \tag{6}$$

$$(V_u)^{\frac{1}{2}} = 0.9900 + 0.1024\, U_u + 0.8647\, S_u^{-2} + 0.4585\, P_u - 0.2261\, PD_u \tag{7}$$

$$V_u = 508 - 1.0354\, A_u + 7.4185\, S_u^{-3} + 48.2785\, P_u - 24.5457\, PD_u + 3.3723\, U_u \tag{8}$$

where V is the relative number of visitors from the origin area to the site as based on audited visits during 1950-1954 and 1956 censuses; S is air distance from the origin area to the Lake in hundreds of miles; P is the population of the origin area in thousands; PD is population density per square mile; U is the percent of population in political units of 2500 or greater; A is the area of the origin area in square miles; and the subscript u designates the origin area. The untransformed regression (Equation 8) had a high R^2 but also a high standard error of estimate. The two transformed regressions had low values of R^2 and low standard errors of estimate.

Subjects Requiring Further Study

From the above discussion, it can be seen that many procedures are available for analyzing recreation benefits. However, additional research is necessary to improve the empirical procedure and quantify some of the less studied relationships.

The available recreation activity composite stipulates the type of visitation data necessary for analysis. Creel census data obviously can be used in deriving visitation demand for fishing. However, they are undesirable for predicting demand for swimming. Therefore, the recreation activity analyzed must initially be defined. An example of fishing demand relationships may be found in Stevens (10). Merewitz (15) on the other hand employs creel census data indicating visitation relationships for fishing, boating, surf-boarding, and water skiing. Boyet and Tolley (16) used actual visitor surveys reflecting demand for composite facilities at national parks. Each analysis studied the demand for a particular facility, and each result cannot generally be applied to other facility types.

Distance from the site to the population center might be measured in air miles, measured road miles, or road miles estimated as a constant multiple of air miles. Determination of air miles is relatively straightforward; however, road miles depend on route selected which would in turn depend on the person selecting the route. The exponent (n) in Equation 1 depends both on the activities involved and the type of distance selected. Boyet and Tolley expressed the distance as travel cost and found the exponent to vary from 1.34 to 2.43 for national parks (16). Presumably, cost was estimated by figuring road miles as a multiple of measured air miles. Knetsch in Equation 2 used the same approach for a recreation reservoir and found the value to be 2.39. Logically, the larger and more popular a site becomes, the more visitors it attracts from greater distances thus decreasing the value of the exponent.

Another possible refinement is analysis of the varying propensity of people in various population zones to visit reservoirs for recreation. If visitation is to be correlated with population characteristics, the zones should be defined in a manner which permits use of published data to quantify the required socio-economic characteristics.

Refinements in the procedure of estimating benefits is also needed. Earlier studies by Clawson credited the full distance added in calculating travel cost for the demand curve (14). However, the full distance from the visitor's origin to the site cannot be attributed as travel cost expressly to visit a given reservoir because many visitors include the reservoir as but one point on an itinerary which includes visits to other sites, friends or relatives, athletic events, or other attractions. Only the out-of-the-way distance or the additional distance added to the trip to visit the site can be used to determine the travel cost for estimating willingness-to-pay. Trice and Wood (9, p. 204) proposed that the effective distance may be estimated by determining the percent of the total trip time spent at the reservoir studied. Although this estimate was better than nothing, better data are needed to establish out-of-the-way travel distance.

In summary, this project proposes several refinements in analysis techniques. First, more detailed and inclusive visitation data are needed to better portray the distribution of visitors from a large number of origin areas. Second, the visitation data should indicate demand for facilities normally provided at recreation reservoirs such as fishing, picnicking, boating, water skiing, camping, and sightseeing combined as opposed to creel census data that only reflects demand for fishing or related activities. Third, the propensity of a given population to visit a given reservoir should be correlated with travel route quality, recreation competition, income and age distribution, urbanization, and other variables influencing visitation rates from origin areas. Fourth, better data estimating effective out-of-the-way travel distance are needed for incorporation into the consumers' surplus procedure of predicting recreation benefits. Although all objections can never be eliminated, the procedures and techniques presented should improve the method used for analyzing recreation as a project purpose in water resources development.

Chapter II

DESCRIPTION OF RESERVOIRS STUDIED

Introduction

Four kinds of factors influence the propensity of a given population to visit a given reservoir for recreation:

1. The characteristics of the population,
2. The nature of the route between the population center and the reservoir,
3. The availability of other recreation reservoirs to the population,
4. The characteristic of the reservoir site.

In the subsequent analysis, multiple regression analysis will be used to evaluate the effects of the first three factors on visitation. Visitors from many population centers visit a single reservoir. Each population center has its own population characteristics, is associated with a particular route, and is specifically located with respect to other reservoirs. The effects of these variables can thus be correlated with the visitation per capita from the population center to one or two reservoirs.

The fourth factor also influences visitation, but the nature of the influence can only be studied by analyzing data from many reservoirs of varying characteristics. Such an analysis is not within the scope of this study. However, it is necessary at this point to describe the facilities at which data were collected to analyze the first three factors. The description serves the dual purpose of providing the reader a basis for evaluating the data used in the subsequent analysis and of indicating the characteristics of the site used so that the reader might have a starting point for adjusting the results for application at a sight of other characteristics. Reservoir characteristics describe the quality or quantity of the available facilities, the length of the recreation season, and prevailing weather conditions.

Rough River Reservoir

Rough River Reservoir is located on Rough River, a tributary of Green River, in Breckinridge, Hardin, and Grayson Counties Kentucky. The geographical location within the United States and the air distance to states is presented in Figure 2. Figure 3 describes the location relative to Kentucky counties. The surrounding country is rolling hills, woods, and farmland. The dam is on the Breckinridge-Grayson County Line, 89.3 miles above the mouth of Rough River. It controls the run-off from a drainage area of 454 square miles. A minimum pool of 1,700 acres is maintained at elevation 465 feet above mean sea level

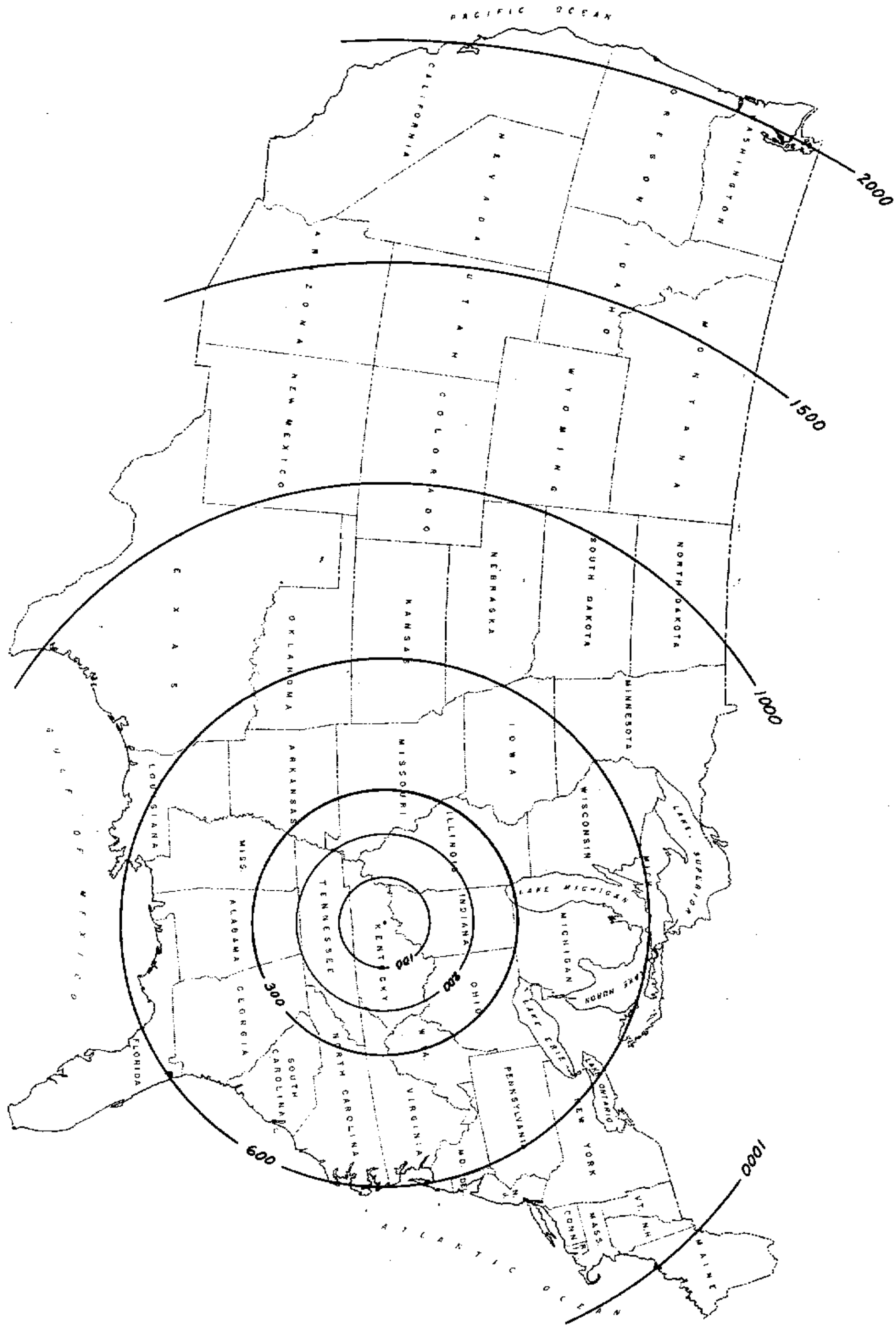


Fig. 2.-- Air Distance from States to Rough River Reservoir

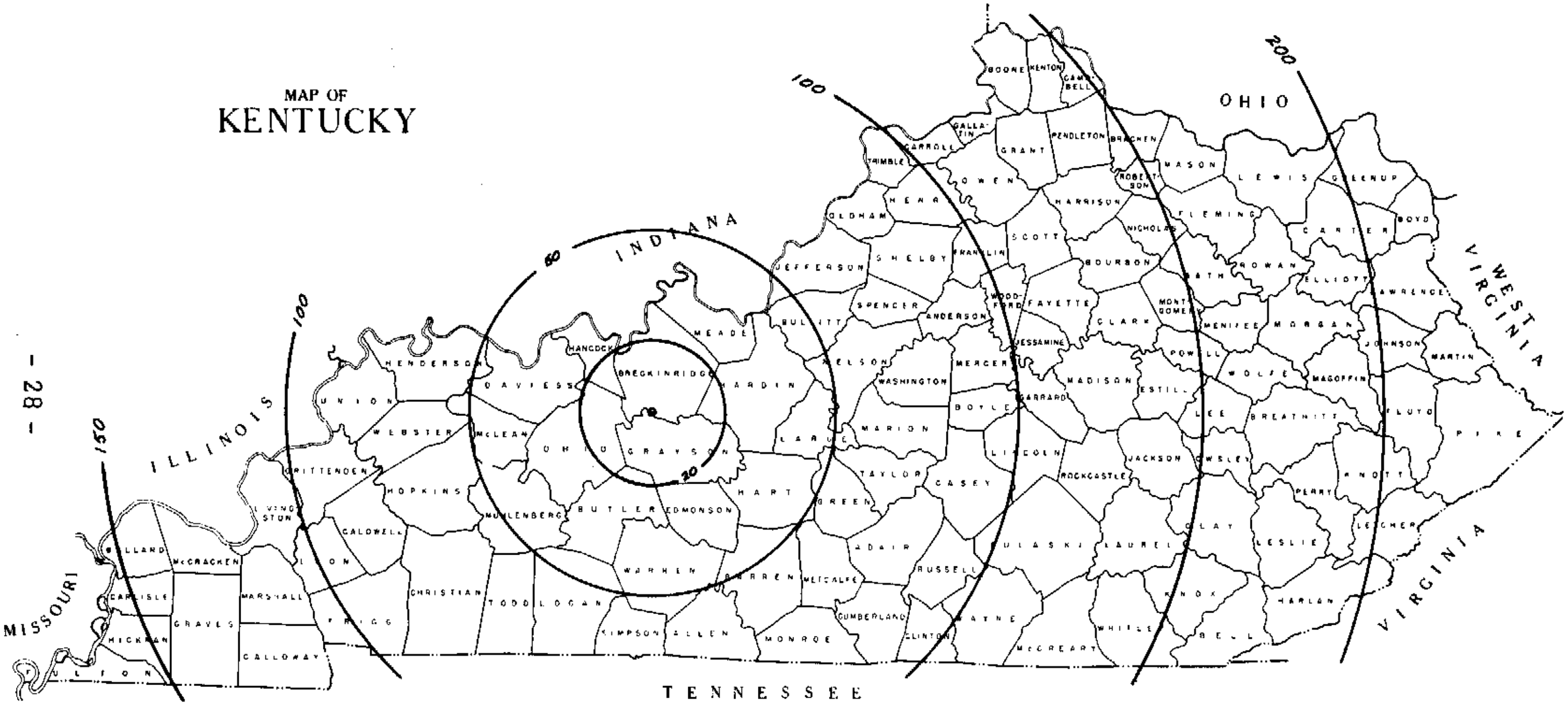


Fig. 3.-- Air Distance from Kentucky Counties to Rough River Reservoir

until about April 1 of each year. Thereafter, to provide for recreation and low flow regulation and because storage space is not needed for flood control during the summer months, the pool is raised as rapidly as practicable to elevation 495, at which level it covers 5,100 acres and contains 120,000 acre-feet of water creating 220 shoreline miles. Beginning in September the pool is lowered gradually to minimum pool level (17, p. 26).

The project was authorized for flood control in the Ohio River Basin by an Act of Congress approved 28 June 1938 (18). The U. S. Army Corps of Engineers began construction of the project in November, 1955; and the project was put into operation in December, 1960. Cost of the project through 30 June 1966 was about $9,780,000, all Federal funds. Through 1966, the flood control benefits attributed to the reservoir are about $5,300,000 (17, p. 26).

Before project construction, the Corps estimated the ratio of benefits to cost, adjusted to reflect the real worth of goods and services derived as a result of the project, compared with the goods and services needed for the project, would be 3.4 to 1 (19, p. 46). This figure included flood control benefits, land utilization benefits, navigation, and an average annual benefit of $53,000 for recreation.

An annual rainfall of 46.91 inches in Central Kentucky is generally well distributed throughout the year with a minimum average amount of about 2.47 inches during October and a maximum average amount of about 5.12 inches during January. The average annual temperature is approximately 57 degrees with July being the warmest month at 77 degrees. The average temperature and precipitation for each month of the year is shown on Table 1 (20).

TABLE 1

CENTRAL KENTUCKY DIVISION AVERAGE MONTHLY TEMPERATURE AND PRECIPITATION*

Month	Temp. °F	Prec. in..	Month	Temp. °F	Prec. in.
January	36.6	5.12	July	77.4	4.17
February	38.7	3.84	August	76.2	3.54
March	45.9	4.99	September	70.0	3.03
April	56.7	4.03	October	58.9	2.47
May	65.6	3.99	November	46.1	3.58
June	74.2	4.32	December	38.0	3.85

*Source (20)

Considerable precipitation, moderate cloudiness and wind movement, together with high humidity, are characteristics of the area (21, p. 2).

A population of slightly less than 60,000 lives within 25 miles of the reservoir and an additional 500,000 people live within 50 miles. The city of Louisville, Kentucky, with 770,000 people in its metropolitan area, lies just over 50 miles to the northeast. The Western Kentucky Turnpike comes within a few miles of the reservoir and provides excellent highway connections to the north and east. Connections to the south and west are much less satisfactory. No state parks are within 50 miles of the project; however, Mammouth Cave National Park is about 30 miles away. The nearest reservoir recreation facilities, reported in 1961, were at Herrington Lake about 95 miles due east and Lake Cumberland, about 110 miles southeast of the reservoir (21, p. 4). However, since 1961 another competing recreation reservoir (Nolin) has been constructed by the Corps of Engineers approximately 15 miles south of Rough River.

The Corps of Engineers considered recreation in planning Rough River Reservoir. To accommodate recreation visitors, eleven access points were planned for use by the public. Each site was to be provided with parking, boat-launching ramp, sanitation facilities, and picnic tables and outdoor grills (21, p. 8). Three of the sites (7, 9, and 10) have not yet been developed.

The Department of Parks, Commonwealth of Kentucky, leased in 1961 all lands and recreation facilities related to sites 1 and 8 with the exception of lands retained by the Corps for dam operation. All remaining sites are operated by the Corps of Engineers. The lease was granted for 50 years; and as a result, Rough River Reservoir became part of the Kentucky State Park system (21). Additional facilities have been provided at a cost to the state of approximately $1,465,000 through 1965, Table 2. The Corps through the same period has invested $816,200. Site locations with respect to highway access points are indicated in Figure 4

TABLE 2

ROUGH RIVER RESERVOIR SITE FACILITY INVENTORY*

	Recreation Sites	Parking Area	Boat Ramp	Water Supply	Rest Rooms	Shelter	Picnic Facilities	Camp Sites	Swimming Area	Lodging Facilities	Air Strip
1	Main Entrance	X	X	X	X	X	X		X	X	X
2	Laurel Branch	X	X	X	X		X	X			
3	Cave Creek	X	X	X	X		X				
4	Axtel	X	X		X	X	X	X			
5	North Fork	X	X		X		X	X			
6	Everleigh	X	X								
7	Calvert		Future Development								
8	Below Dam	X			X		X				
9	Panther Creek		Future Development								
10	Little Clifty		Future Development								
11	Peter Cave	X	X		X		X				

*Source (22)

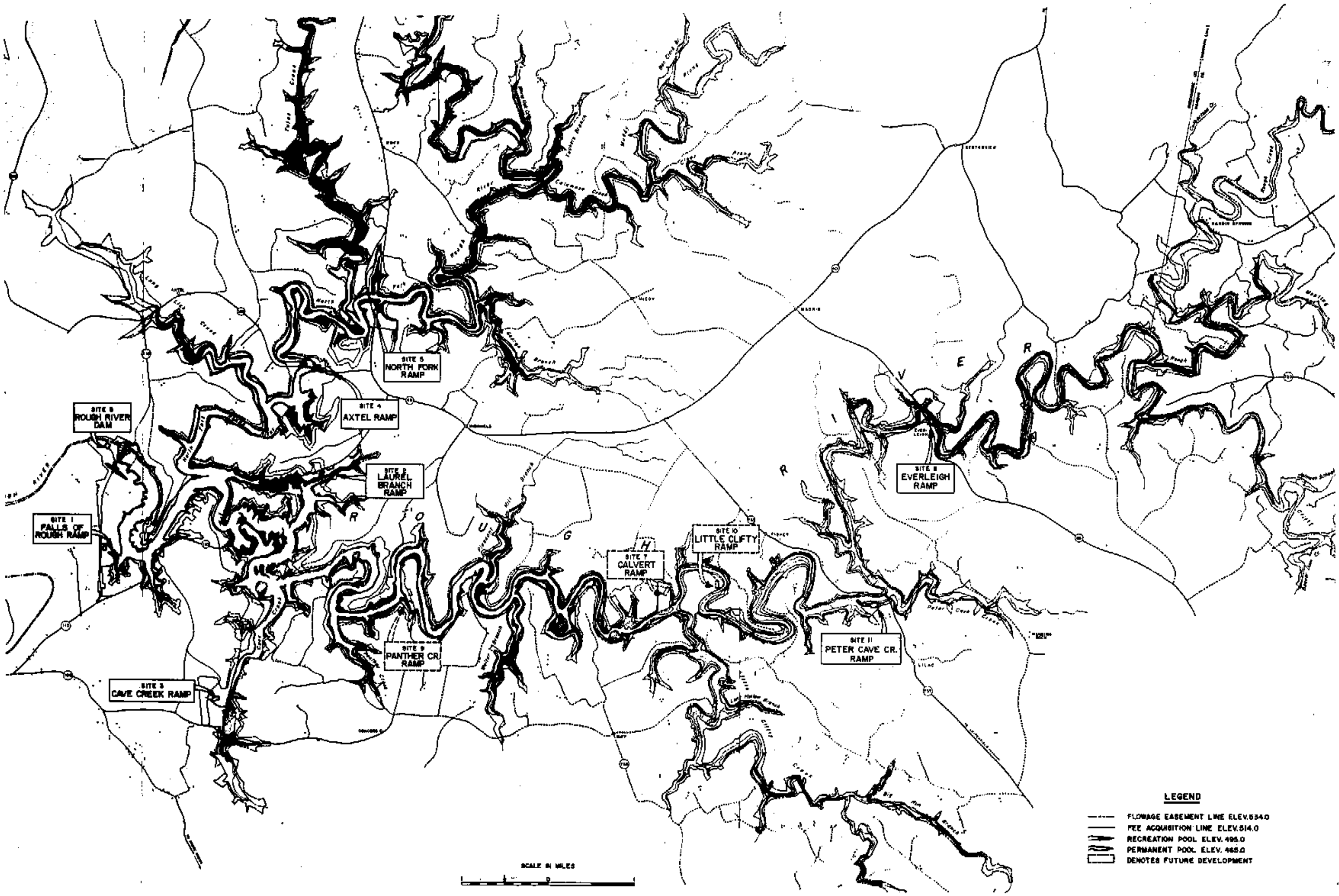


Fig. 4.-- Rough River Reservoir Plan Sheet

and photographs implying the quality of the park may be found in Figures 5 through 12. The Kentucky State Park system has an excellent reputation for providing high quality and well maintained facilities.

Annual attendance at the reservoir has steadily increased since completion, Table 3. The peak day attendance in 1965 was

TABLE 3

ROUGH RIVER RESERVOIR ANNUAL ATTENDANCE*

Year	Attendance	Year	Attendance
1959	8,870**	1963	554,318
1960	31,700	1964	695,300
1961	84,200	1965	777,500
1962	265,000	1966	824,200

*Source (23)

**Attendance for October, November, December only.

20,700 and the maximum monthly attendance was in August, but most years have a July peak. Monthly visitation in 1965 is shown on Table 4. The 1965 attendance distribution and area for each site is reported in Table 5.

Dewey Reservoir

Dewey Dam is located on Johns Creek, a tributary of the Levisa Fork of the Big Sandy River, in Floyd and Pike Counties, Kentucky. The topography is typical of Appalachia with narrow

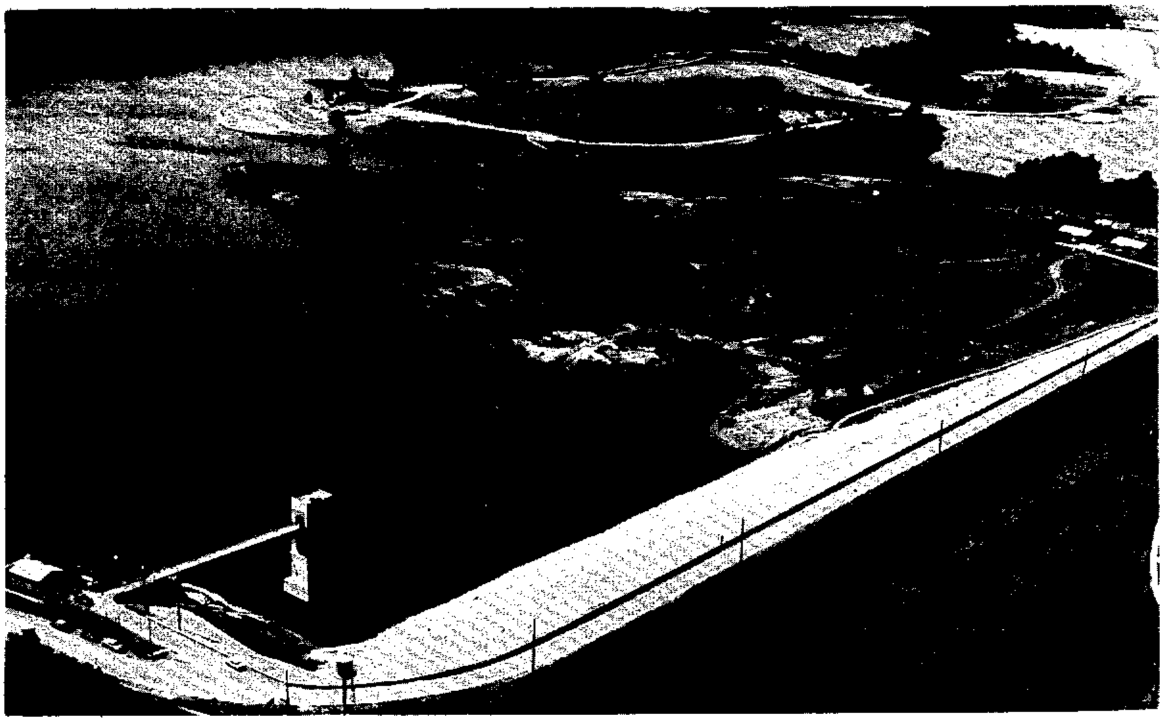


Fig. 5.-- Site 1,Rough River Dam and
State Park

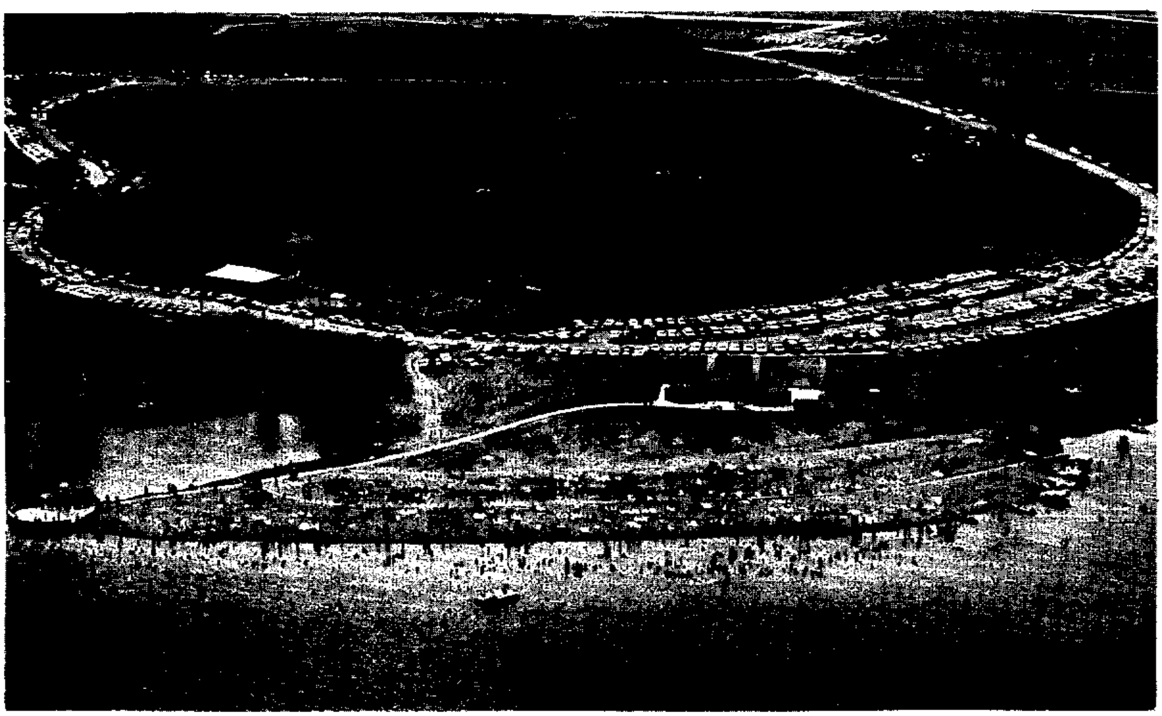


Fig. 6.-- Site 1, Swimming Beach and
State Park

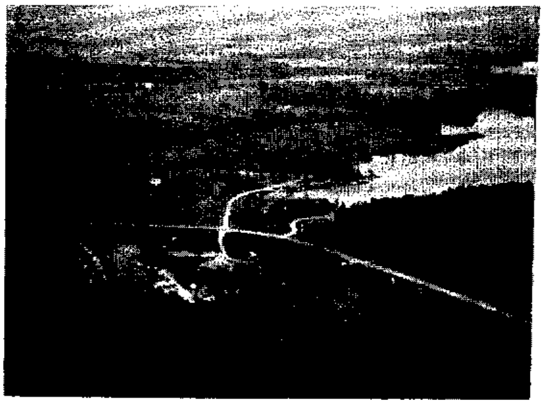


Fig. 7.--Site 4, Axtel

Fig. 8.--Private Residental Development

Fig. 9.--Site 1, State Park Beach,

Fig. 10.--Site 1,State Boat Dock

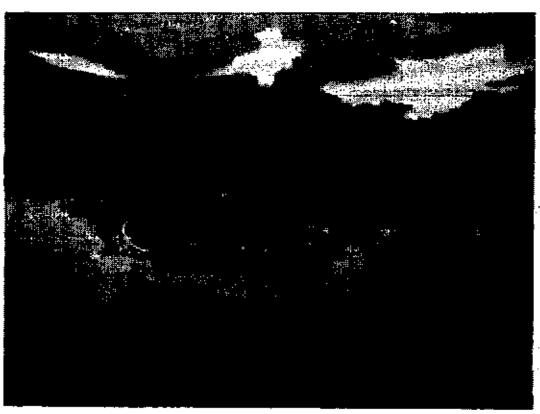


Fig. 11.--Site 2, Laurel Branch

Fig. 12.--Site 5, North Fork

TABLE 4

ROUGH RIVER RESERVOIR 1965 MONTHLY ATTENDANCE*

Month	Attendance	Month	Attendance
January	12,000	July	156,500
February	16,000	August	156,900
March	16,300	September	63,000
April	62,900	October	48,300
May	96,300	November	12,800
June	132,600	December	8,100
		Total	777,500

*Source (23)

TABLE 5

ROUGH RIVER RESERVOIR 1965 SITE
ATTENDANCE AND AREA*

Site	Attendance	Area Acres	Site	Attendance	Area Acres
Main Entrance	332,910	84	North Fork	108,710	26
Laurel Branch	58,101	22	Everleigh	29,998	31
Cave Creek	24,538	84	Below Dam	64,854	30
Axtel	128,056	46	Peter Cave	30,333	21
			Total	777,500	

*Source (24)

valleys between steep and wooded mountains. The geographical location within the United States and the air distance to states is presented in Figure 13. Figure 14 describes the location relative

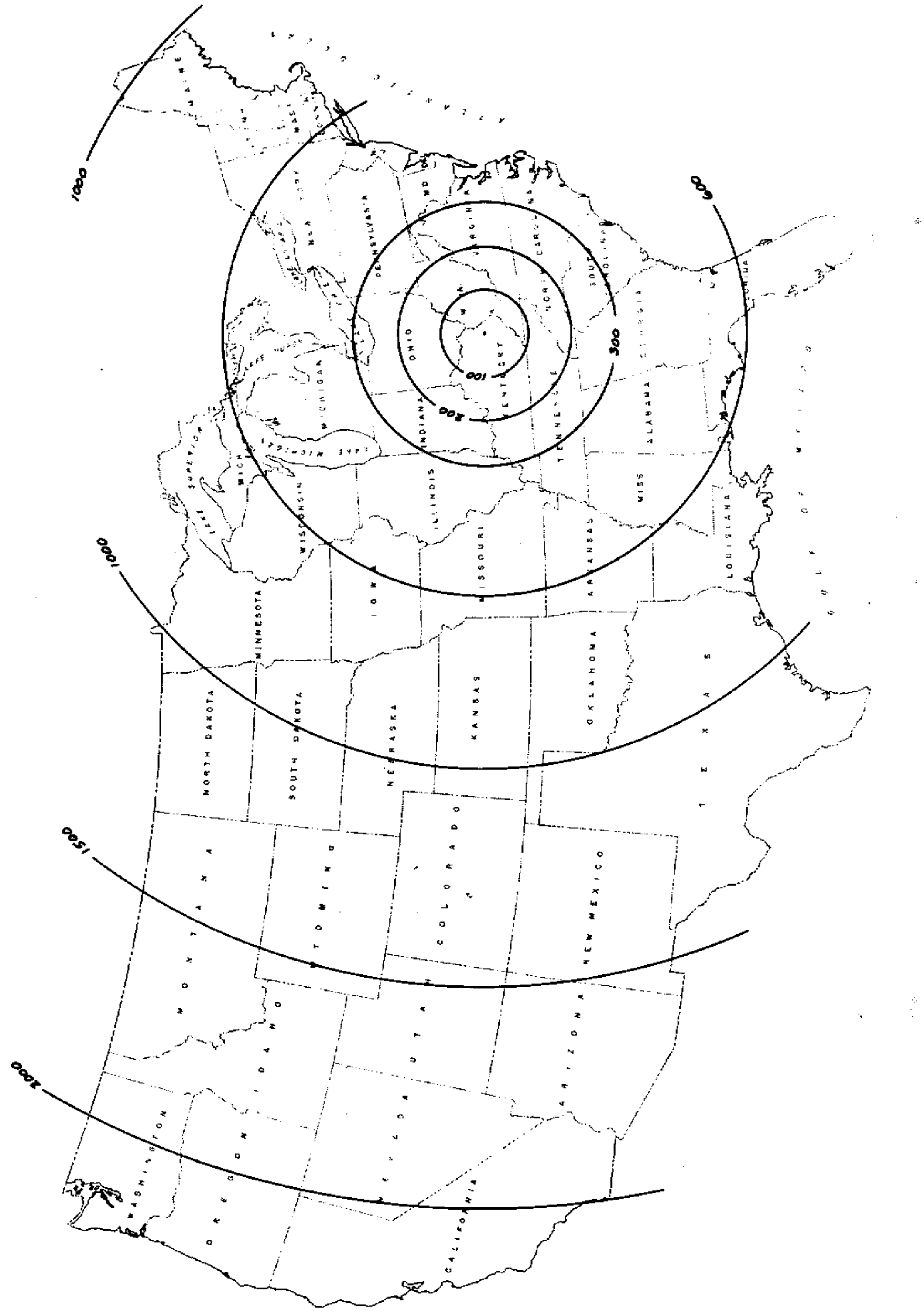


Fig. 13.-- Air Distance from States to Dewey Reservoir

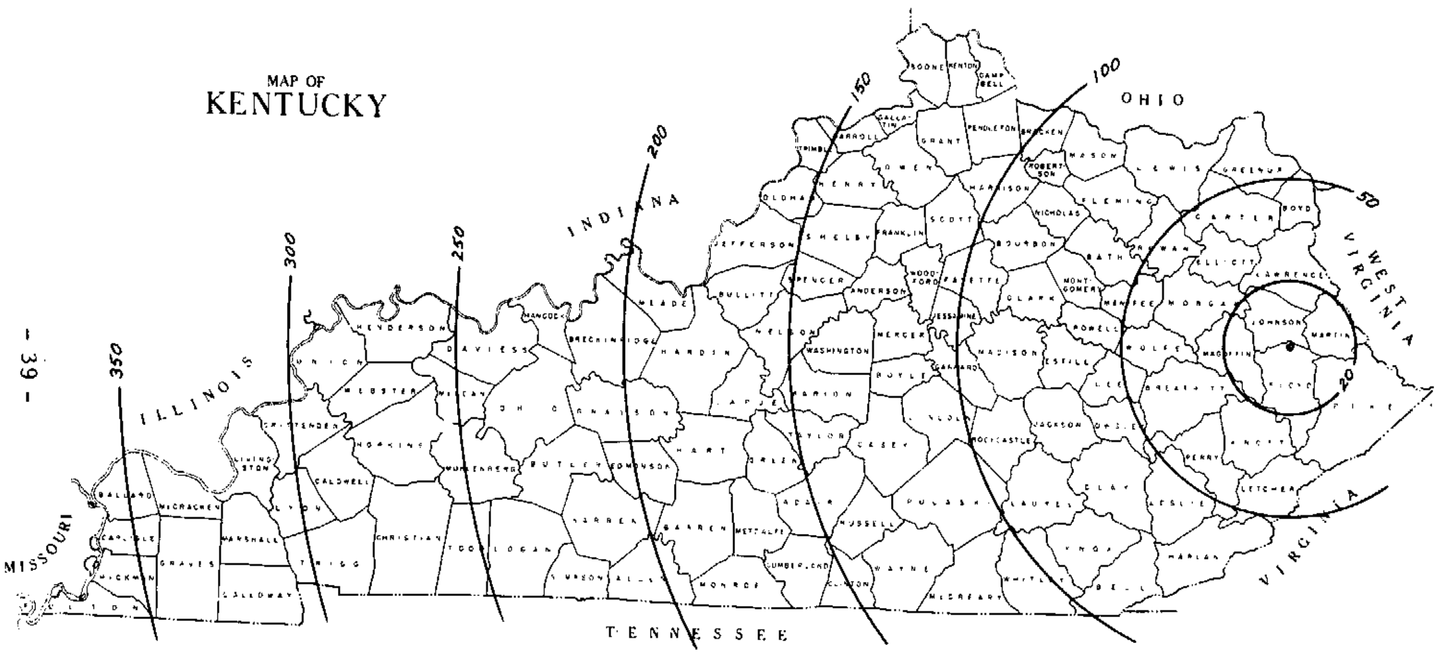


Fig. 14.-- Air Distance from Kentucky Counties to Dewey Reservoir

to Kentucky Counties. The dam is in Floyd County 5.4 miles above the mouth of Johns Creek. It controls the run-off from a drainage area of 207 square miles. A minimum pool of 880 acres is maintained at elevation 645 feet above mean sea level until about April 1 of each year. Thereafter, to provide for recreation and because storage space is not needed for flood control during the summer months, the pool is raised as rapidly as practicable to elevation 650, at which level it covers 1,100 acres and contains 17,200 acre-feet of water creating 52 shoreline miles. Beginning in November the pool is lowered gradually to minimum pool level (25). The lake and shoreline area is less than one fourth that of Rough River.

The project was authorized for flood control in the Ohio River Basin by an Act of Congress approved June 28, 1938 (18). The U. S. Army Corps of Engineers began construction of the project in March, 1946; and the project was put into operation in July, 1949. Cost of the project through June 30, 1964, was about $6,524,500, all Federal funds (25). Through 1966, the flood control benefits attributed to the reservoir were about $8,530,000 (17, p. 12).

During project planning (1938), the Corps estimated the ratio of benefits to cost would be approximately 2.0 to 1.

The benefits included an average annual value of $40,000 for recreation.

An average annual rainfall of 45.72 inches in Eastern Kentucky is well distributed through the year with a minimum monthly average of about 2.28 inches during October and a maximum monthly average of about 4.70 inches during July. The average annual temperature is approximately 57 degrees with July being the warmest month at 76 degrees. The average temperature and rainfall for each month of the year is shown on Table 6 (20). About

TABLE 6

EASTERN KENTUCKY DIVISION AVERAGE MONTHLY TEMPERATURE AND PRECIPITATION*

Month	Temp. °F	Prec. inches	Month	Temp. °F	Prec. inches
January	38.1	4.50	July	76.4	4.76
February	39.5	4.03	August	75.3	3.80
March	46.3	4.70	September	69.4	2.81
April	56.7	3.75	October	58.3	2.28
May	65.4	3.98	November	46.2	3.21
June	73.3	4.27	December	38.7	3.63

*Source (20)

75 percent of the lake waters are well sheltered from the prevailing westerly winds. However, the remainder of the lake is subjected to heavy cross winds, and may be hazardous to persons not experienced in boating (26, p. 8).

The Corps of Engineers considered recreation in planning Dewey Reservoir. They estimated, from the 1940 census, a population of approximately 800,000 within the range of 50 miles of the reservoir. According to the 1960 census about 573,000 people lived in this area with the largest concentration being 255,000 in the Huntington, West Virginia, Ashland, Kentucky metropolitan area. In 1949, access from all directions was by narrow mountain roads. The Mountain Parkway now provides excellent highway access to the west, but roads in the other directions remain tortuous with access from the southeast being particularly restricted. In 1949, there was no Federal or state park or recreational project within the 50-mile radius; however, a portion of the Cumberland National Forest intersects the western edge, and Breaks Interstate Park is located about 50 miles south. The nearest similar recreational facilities, reported in 1949, were at Norris Reservoir, Tennessee, about 250 miles south and at Herrington Lake, Kentucky, about 200 miles west (26, p. 4). However, since 1949 several closer recreation reservoirs have been constructed. Fishtrap Reservoir, the closest of these, is presently under construction, and lies approximately 30 miles southeast of Dewey. Basic facilities provided at Dewey consist of water and minimum sanitary facilities, parking areas, boat-launching ramps, picnic facilities, and highway access points.

The Department of Parks, Commonwealth of Kentucky leased in December, 1953, from the Corps of Engineers, 1,800 acres of land and the adjacent waters. The lease was granted for 50 years and as a result, Dewey Dam and Reservoir became a part of the growing Kentucky State Park System (Jenny Wiley State Park). The state of Kentucky has invested approximately $4,200,000 for capital improvements as of January, 1965 (27, 1964). The Corps, during this same period, has invested $78,400. However, the 1966 attendance of 960,300 people indicates increasing overuse of presently available facilities.

Present facilities are along the highway extending 5.0 miles upstream from the dam along the southwestern shore of the lake. Few other areas are available for extensive development due to the relatively steep sloping mountain ridges. The most developed site, located at Brandykeg access point 5.0 miles upstream from the dam, provides facilities for golfing, a boat dock for launching and mooring, an outdoor amphitheatre, and a rustic State Park lodge with cabins, Figure 15, A (28). Proceeding downstream, the swimming area and beach concessionaire along with a paved parking lot is located at mile 4.5 in the

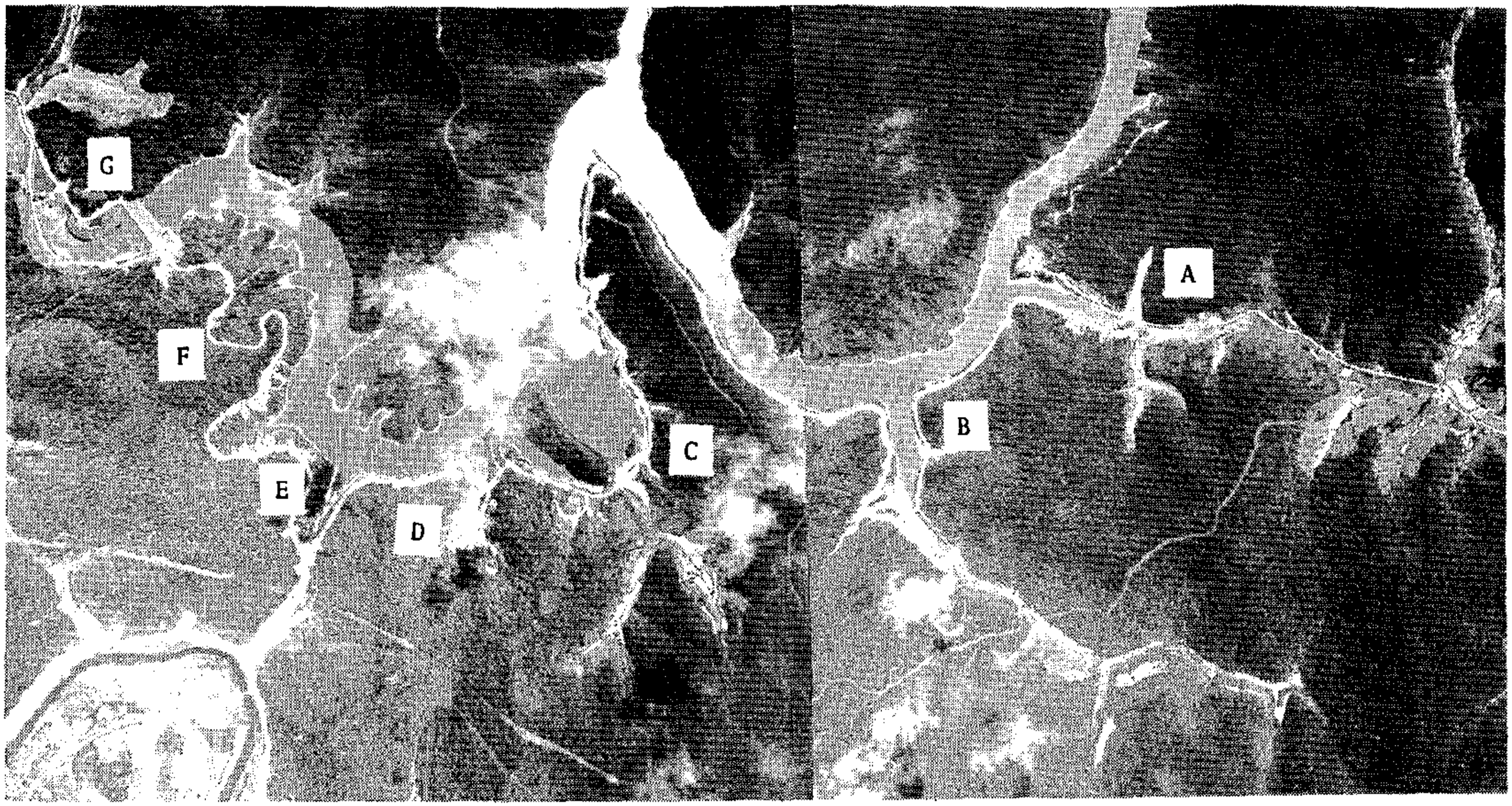


Fig. 15.-- Dewey Reservoir Plan Aerial Photograph

Stratton Branch cove, Figure 15, B. Picnicking and camping facilities are provided at Gobel Branch cove located at mile 2.0, Figure 15, C. A newly completed chair lift, under private contract, is available at mile 1.7, Figure 15, D. The second downstream access point, Hagers Gap, supports a privately leased boat dock at mile 1.4, Figure 15, E. Several scenic overlook parking areas are available from mile 1.4 to the dam, Figure 15, F. The third downstream access point crosses the dam where facilities are provided for sightseeing and fishing parking, Figure 15, G. Fishing development includes periodic restocking, seining to decrease population of less desirable fish, and sinking of junked automobile bodies to provide fish concentration areas, all activities supported and conducted through the Kentucky Fish and Wildlife Service. Additional recreational facilities are planned for the German site, approximately mile 13; however, development has progressed slowly due to poorer access and lower priority use. Photographs of available facilities at Brandykeg site are presented in Figures 16 and 18. A photograph of the swimming area taken in early spring is presented in Figure 17.

Annual attendance at the reservoir has fluctuated radically since completion; however, an all time high was recorded in 1966, Table 7. Low attendance periods have been attributed

Fig. 16.-- Brandykeg
Golf Course

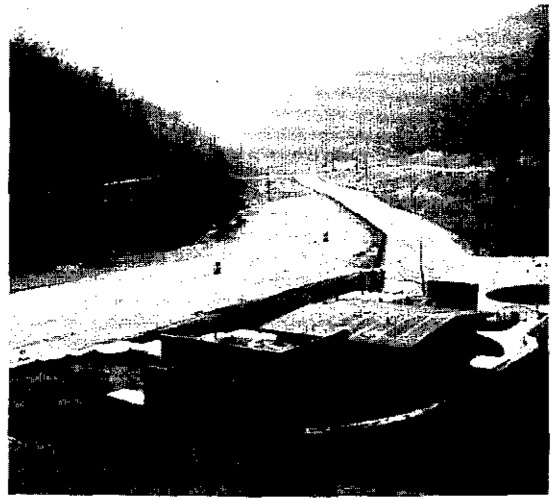


Fig. 17.-- Swimming Beach,
Bath-house

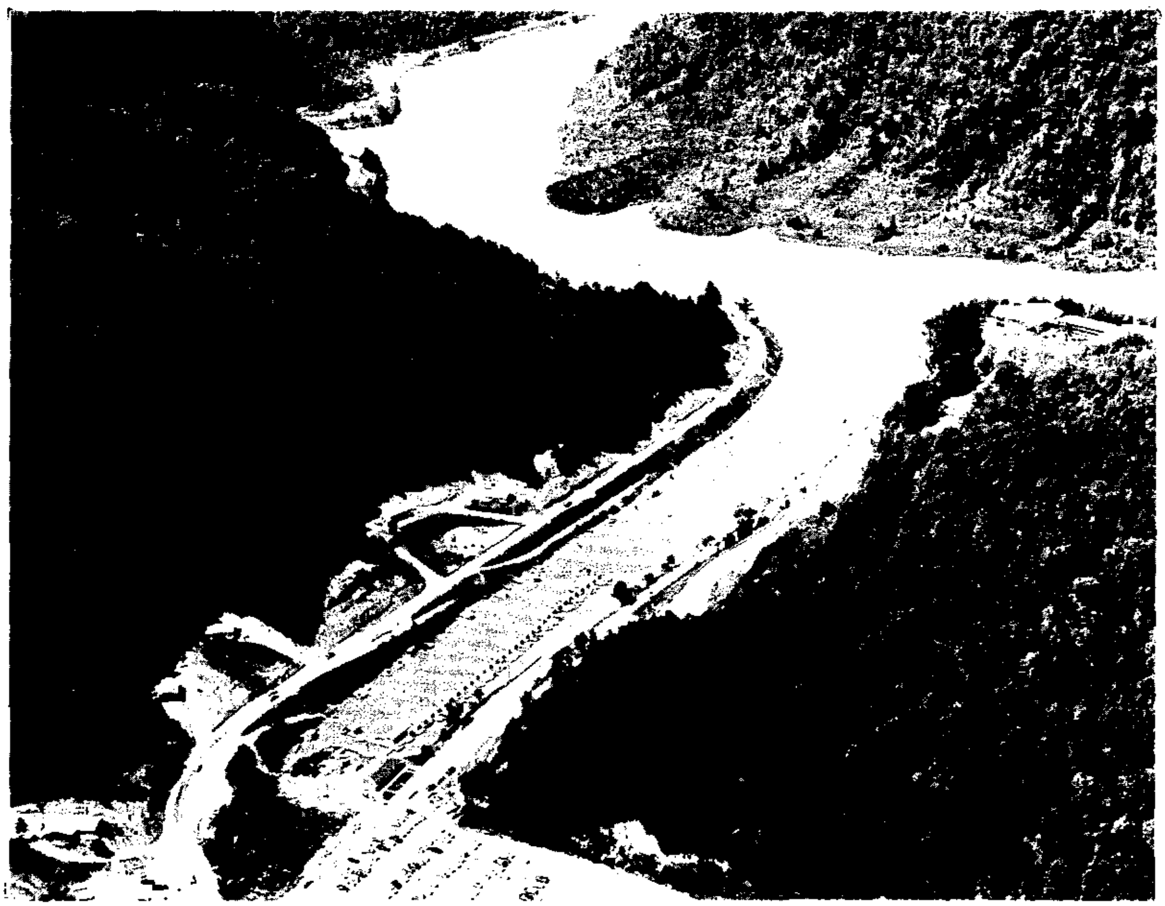


Fig. 18.-- Brandykeg Recreation Complex

TABLE 7

DEWEY RESERVOIR ANNUAL ATTENDANCE SINCE 1952*

Year	Attendance**	Year	Attendance**
1952	551,911	1960	369,600
1953	432,986	1961	365,300
1954	533,000	1962	425,300
1955	664,735	1963	764,700
1956	500,312	1964	592,900
1957	396,090	1965	779,100
1958	180,552	1966	960,300
1959	226,485		

*Source (27)

**Based on vehicle counts and an average of 3.2 persons per vehicle

to weather and fishing conditions, periods of general economic instability, and road damage caused by trucks hauling coal through the site as a short cut to their destination (27, 1964). The improvement of Jenny Wiley State Park has helped increase attendance since 1958. The peak day attendance in 1964 was 18,800 and the maximum monthly attendance was reported in June. Most years have a July peak. Monthly visitation is shown on Table 8.

TABLE 8

DEWEY RESERVOIR 1964 MONTHLY ATTENDANCE*

Month	Attendance	Month	Attendance
January	3,400	July	100,900
February	5,300	August	78,600
March	10,200	September	51,900
April	28,100	October	49,900
May	75,500	November	30,700
June	127,100	December	21,300
		Total	592,900

*Source (27)

Chapter III

DATA COMPILATION AND PRELIMINARY ANALYSIS

Introduction

The subsequent analysis has three basic goals: to evaluate average K and n in the basic equation for predicting reservoir visitation (Equation 1); to analyze the relationship between K and population characteristics, route characteristics, and competitive position; and to evaluate recreation benefits. Data were needed to accomplish each goal. For the analysis, 168 origin areas were defined: the 120 Kentucky counties, the 47 other states excluding Alaska and Hawaii, and the District of Columbia. Data were needed to define the characteristics of each origin area. Three kinds of data were needed for evaluating n and average K: the number of visitors from each origin area to each reservoir, the population of each origin area, and the mean distance from each origin area to the reservoir. Data for relating origin area K to population characteristics, route characteristics, and competitive position described each of these factors in a number of alternative manners in the hope that statistical analysis would reveal the most significant parameters. The only additional data collected for evaluating benefits were out-of-the-way or effective as contrasted with total travel distance. The methods used to collect the data and organize it into suitable form for the studies discussed in the next chapter are described below.

Visitation Data and Preliminary Analysis

To determine the number of visitors by origin area to both Dewey and Rough River Reservoirs, two different types of visitation data are utilized. The first type consists of data collected by the U. S. Army Corps of Engineers in visitor origin surveys. Rough River had been surveyed during selected dates in 1963, 1964, 1965, and 1966, Table 9. Dewey, however, had only been surveyed during 1964 and 1966, Table 10. Typically, Corps surveys are conducted over an eight hour period in which all vehicles entering the recreational area are stopped and the occupants are asked a number of questions including the name of their home county and the number of people in the vehicle. The numbers on Tables 9 and 10 represent the visitors or the total number of vehicle occupants during the indicated day at the indicated place. Weather data are shown to indicate conditions prevailing at the time of the survey as contrasted with average conditions because of the influence weather has on visitation. The visitation data were obtained for this study through the Ohio River Division Office of the Corps of Engineers.

TABLE 9

ROUGH RIVER RESERVOIR
U.S. ARMY CORPS OF ENGINEERS VISITATION SURVEYS

Date		NUMBER VISITORS SURVEYED										TEMPERATURE		
		Entrance		Laurel	Cave	Axtel	North	Ever-	Below	Peter	Prec	Max.	Min.	Monthly
		Park	Dock	Branch	Creek		Fork	leigh	Dam	Cave	in.	°F	°F	Average
1. 1963														
Thurs.	June 13	336*	*	227	35	-	-	-	86	-	-	86	58	73.1
Fri.	June 14	-	-	-	-	127	211	-	-	71	.02	91	61	73.1
Sat.	June 15	392*	*	493	83	-	-	-	276	-	-	90	58	73.1
Sun.	June 16	2535	435	-	-	444	879	-	-	166	.70	76	60	73.1
Thurs.	Oct. 31	62*	*	11	-	31	19	-	-	-	.35	65	32	61.6
Sun.	Nov. 3	229*	*	100	-	147	85	-	-	-	-	51	22	46.9
2. 1964														
Thurs.	June 18	351*	*	149	25	-	-	-	90	-	.30	83	69	75.5
Fri.	June 19	-	-	-	-	237	279	21	-	59	-	89	72	75.5
Sat.	June 20	1439*	*	498	178	-	-	-	206	-	-	93	73	75.5
Sun.	June 21	-	-	-	-	458	1117	47	-	324	-	95	70	75.5
Thurs.	Oct. 8	-	-	11	7	-	-	-	43	-	-	66	34	53.5
Fri.	Oct. 9	168	45	-	-	9	16	-	-	14	-	67	38	53.5
Sat.	Oct. 10	-	-	68	30	-	-	-	111	-	-	56	27	53.5
Sun.	Oct. 11	728	292	-	-	91	82	-	-	108	-	55	30	53.5

*Visitors from park entrance and dock entrance combined in a single total

TABLE 9 - Continued

Date		NUMBER VISITORS SURVEYED: Entrance Park	Entrance Dock	Laurel Branch	Cave Creek	Axtel	North Fork	Ever-leigh	Below Dam	Peter Cave	Prec. in.	TEMPERATURE: Max. °F	Min. °F	Monthly Average
3. 1965														
Mon.	Apr. 5	120	-	-	-	-	-	-	-	-	-	70	46	59.2
Fri.	Apr. 16	-	-	49	-	50	-	-	-	-	.26	68	45	59.2
Sat.	Apr. 17	-	-	83	-	-	-	-	-	-	-	60	36	59.2
Sun.	Apr. 18	-	-	-	-	218	-	-	-	-	-	77	52	59.2
Thurs.	Apr. 22	-	-	-	-	-	23	-	83	34	-	82	60	59.2
Sat.	Apr. 24	-	-	-	-	-	331	-	478	204	-	89	59	59.2
Sun.	Apr. 25	682	142	-	-	-	-	-	-	-	-	87	59	59.2
Tues.	May 4	-	60	-	-	-	-	-	-	-	-	82	53	70.5
Thurs.	June 17	369	178	126	44	-	-	-	-	-	-	80	56	73.6
Fri.	June 18	-	-	-	-	242	87	-	103	33	-	79	51	73.6
Sat.	June 19	-	-	596	239	-	-	-	357	182	-	80	49	73.6
Sun.	June 20	3000	1049	-	-	508	685	-	-	-	-	84	54	73.6
4. 1966														
Thurs.	May 19	288	148	143	49	-	-	-	-	-	.06	79	47	61.2
Fri.	May 20	-	-	-	-	170	92	-	106	87	-	77	43	61.2
Sat.	May 21	-	-	552	114	-	-	-	321	177	-	81	54	61.2
Sun.	May 22	2805	1059	-	-	624	884	-	-	-	.85	82	58	61.2
Thurs.	Aug. 11	885	517	509	231	-	-	-	-	-	.13	90	65	73.1
Fri.	Aug. 12	-	-	-	-	347	391	-	218	171	.42	76	64	73.1
Sat.	Aug. 13	-	-	638	274	-	-	-	397	177	-	82	63	73.1
Sun.	Aug. 14	2549	1119	-	-	561	549	-	-	-	.45	81	64	73.1

TABLE 10

DEWEY RESERVOIR
U. S. ARMY CORPS OF ENGINEERS VISITATION SURVEYS

Date	NUMBER VISITORS SURVEYED German	Hager Gap	Dam Site	Brandy-keg	Prec. in.	TEMPERATURE Max. °F	Min. °F	Monthly Average
1. 1964								
Wed. June 24	*	550	169	1451	0.50	94	68	71.4
Sat. June 27	*	**	298	2351	-	88	53	71.4
2. 1966								
Wed. May 18	61	239	**	286	-	86	57	61.8
Sat. May 21	309	949	**	1354	-	84	45	61.8
Wed. Aug. 3	39	768	**	1132	0.85	82	62	73.8
Sat. Aug. 6	165	1262	**	1934	-	86	65	73.8
Wed. Sept 14	16	122	**	333	1.51	67	60	65.3
Sat. Sept. 17	55	371	**	657	-	69	45	65.3

* Data were not tabulated in a usable form
** No survey

The number of visitors to each reservoir from each origin area were tabulated from the data. Initially, Corps data were tabulated separately according to weekend (Saturday or Sunday) or weekday (Monday through Friday), year in which the data were taken, time of the year in which the data were taken, and site at the reservoir where the survey was made. Since this project is interested in visitation attracted by the reservoir as a whole (composite facilities), the distinction by survey site was eliminated.

The second type of data consists of vehicle origin (drive-through) surveys made especially for this analysis. The number of vehicles (instead of visitors) was recorded for both reservoirs. Data were collected by driving a consistent route through the recreation area and recording the number of vehicles from each of the 168 origin areas by observing vehicle license plates. Kentucky license plates contain the county name.

The dates vehicle origin surveys were made are shown on Table 11 for Dewey Reservoir and on Table 12 for Rough River Reservoir. Early realization of a need for additional data at Dewey Reservoir prompted vehicle surveys beginning in October, 1965. Initially vehicle origin data for Dewey were to be collected for one full year; however, inability to get adequate help terminated data collection at Dewey in July, 1966. As a result, only nine months of data were collected. Rough River visitation data by the Corps of Engineers were more extensive; however, still additional data were collected, Table 12. Since vehicle origin data for Rough River were all collected during the same year and the same time of year, only the distinction between weekend surveys and weekday surveys was made in the tabulation. Dewey data, however, were collected over a longer period; and the tabulations of number of visitors from each origin area

TABLE 11

DEWEY RESERVOIR
KENTUCKY VEHICLE ORIGIN SURVEYS

Date		Survey Time Begin	End	No. Vehicles	Prec. in.	TEMPERATURE Max. °F	Min. °F	Monthly Average
Fri.	Oct. 22, 1965	14:50	15:30	55	1.35	66	57	53.9
Sun.	Oct. 24, 1965	14:30	15:15	88	-	59	40	53.9
Tues.	Nov. 2, 1965	10:15	11:05	51	-	62	26	46.2
Sun.	Nov. 7, 1965	13:15	14:15	162	-	75	41	46.2
Tues.	Nov. 16, 1965	10:30	11:10	38	-	65	30	46.2
Sun.	Nov. 21, 1965	14:45	15:30	38	-	54	21	46.2
Tues.	Nov. 30, 1965	9:45	10:30	53	-	39	25	46.2
Sun.	Dec. 5, 1965	13:00	13:45	40	-	46	20	37.4
Tues.	Dec. 14, 1965	10:30	11:15	55	-	54	44	37.4
Sun.	Dec. 19, 1965	15:15	16:00	43	-	43	24	37.4
Tues.	Dec. 28, 1965	11:20	12:00	27	-	49	13	37.4
Sun.	Jan. 2, 1966	13:45	14:30	27	.94	56	50	27.3
Tues.	Jan. 11, 1966	12:00	12:40	23	-	48	19	27.3
Sun.	Jan. 16, 1966	13:45	14:30	29	-	39	24	27.3
Tues.	Jan. 25, 1966	*	*	*	-	28	-1	27.3
Sun.	Jan. 30, 1966	13:30	14:15	34	.43	11	-4	27.3
Tues.	Feb. 8, 1966	14:05	14:40	31	.03	39	33	34.7
Sun.	Feb. 13, 1966	14:15	15:00	22	.95	50	45	34.7
Tues.	Feb. 22, 1966	14:00	14:40	32	-	33	8	34.7
Sun.	Feb. 27, 1966	14:15	15:00	49	-	45	21	34.7
Tues.	Mar. 8, 1966	13:10	13:50	33	-	31	16	45.2
Sun.	Mar. 13, 1966	12:30	13:45	103	-	75	37	45.2
Tues.	Mar. 22, 1966	14:15	15:00	51	-	77	33	45.2
Sun.	Mar. 27, 1966	13:45	14:30	109	-	59	19	45.2
Tues.	Apr. 5, 1966	13:45	14:30	35	-	43	28	52.8
Sun.	Apr. 10, 1966	12:30	14:00	137	-	46	27	52.8
Tues.	Apr. 19, 1966	14:00	14:50	48	-	84	40	52.8
Sun.	Apr. 24, 1966	13:30	14:50	236	-	82	54	52.8

*Survey not made because of inclement weather

TABLE 11 -- Continued

Date		Survey Time Begin	End	No. Vehicles	Prec. in.	TEMPERATURE Max. °F	Min. °F	Monthly Average
Tues.	May 3, 1966	14:30	15:30	56	-	64	37	61.8
Sun.	May 8, 1966	14:00	15:30	381	-	84	39	61.8
Tues.	May 17, 1966	12:00	15:00	266	-	79	48	61.8
Sun.	May 27, 1966	13:30	16:45	339	-	89	47	61.8
Tues.	May 31, 1966	14:30	16:30	155	-	73	37	61.8
Sun.	June 5, 1966	11:00	16:30	738	-	87	44	71.4
Tues.	June 14, 1966	12:30	16:30	210	.05	94	56	71.4
Sun.	June 19, 1966	11:00	17:15	853	-	85	55	71.4
Tues.	June 28, 1966	10:00	15:30	499	-	97	64	71.4
Sun.	July 3, 1966	9:30	18:00	1538	-	94	65	76.4
Tues.	July 12, 1966	10:00	16:00	856	-	89	63	76.4

TABLE 12
ROUGH RIVER RESERVOIR
KENTUCKY VEHICLE ORIGIN SURVEYS

Date		Survey Time Begin	End	No. Vehicles	Prec. in.	TEMPERATURE Max. °F	Min. °F	Monthly Average
Thurs.	May 26, 1966	13:20	16:43	124	-	78	50	61.2
Sat.	May 28, 1966	12:21	18:47	755	-	85	55	61.2
Thurs.	June 2, 1966	12:37	15:54	168	-	76	44	71.7
Sat.	June 4, 1966	9:37	14:41	547	-	81	60	71.7
Thurs.	June 9, 1966	13:00	16:52	282	.85	86	65	71.7
Sat.	June 11, 1966	8:30	13:41	201	-	70	47	71.7
Thurs.	June 16, 1966	13:19	17:31	187	-	85	64	71.7
Sat.	June 18, 1966	8:20	12:52	189	-	80	50	71.7
Thurs.	June 23, 1966	12:33	16:58	140	-	92	62	71.7
Sat.	June 25, 1966	8:31	13:47	257	-	92	59	71.7
Thurs.	June 30, 1966	13:07	17:11	241	-	89	69	71.7
Sat.	July 2, 1966	8:23	13:53	403	-	98	67	79.2
Thurs.	July 7, 1966	13:33	16:37	231	2.47	95	67	79.2
Sat.	July 9, 1966	8:46	13:04	338	-	90	68	79.2
Thurs.	July 14, 1966	12:41	17:13	214	-	102	74	79.2
Sat.	July 16, 1966	8:17	13:24	339	.05	85	65	79.2
Thurs.	July 21, 1966	12:30	15:42	220	-	83	53	79.2
Sat.	July 23, 1966	8:05	13:35	361	-	89	64	79.2
Thurs.	July 28, 1966	12:05	16:43	203	-	95	72	79.2
Sat.	July 30, 1966	8:27	13:31	340	.19	88	61	79.2
Thurs.	Aug. 4, 1966	12:47	16:30	244	-	83	51	73.1
Sat.	Aug. 6, 1966	8:36	13:50	381	-	86	55	73.1
Thurs.	Aug. 11, 1966	12:37	16:55	192	.13	90	65	73.1
Sat.	Aug. 13, 1966	8:07	13:38	128	-	82	63	73.1
Thurs.	Aug. 18, 1966	12:27	16:49	257	-	90	61	73.1
Sat.	Aug. 20, 1966	8:19	13:44	253	-	90	67	73.1
Thurs.	Aug. 25, 1966	12:45	16:35	258	-	74	50	73.1
Sat.	Aug. 27, 1966	8:43	13:55	339	-	84	53	73.1

distinguished both between weekend and weekday vehicles and the month surveyed.

The initial tabulation of visitor origin data thus distinguish weekend from weekday visitation, Corps data from drive-through data, data collected in one year from data collected in another year, and data collected at one time of year from data collected at another. Before combining the data of the various types, a statistical test was made to check whether or not the various types of data were drawn from the same population. For example, the test would show whether the origin area distribution determined by interview was compatible with the distribution determined by counting license plates. The statistical test used was the Fixed Effects Model: One Way Classification (29, p. 357). The required statistics were computed using the University of Kentucky Computing Center's IBM 7040 computer. Combining different kinds of data was considered valid if the level of significance exceeded 95 percent.

The sequence of testing Dewey visitation data, Table 13, began with comparing Corps weekend with Corps weekday visitors for each survey year and comparing total Corps visitors for one year with the total for the other year. After proving both combinations were valid, it was necessary to test whether converting

TABLE 13

DEWEY VISITATION DATA COMBINATION

Testing Combination of Data A with Data B A	B	F Values
1. 1964 Corps weekend visitors	1964 Corps weekday visitors	3.86
2. 1966 Corps weekend visitors	1966 Corps weekday visitors	6.95
3. 1964 Corps total visitors	1966 Corps total visitors	6.21
4. 1966 Corps weekend vehicles	1966 Corps weekend visitors	6.50
5. 1966 Corps weekday vehicles	1966 Corps weekday visitors	7.31
6. January drive-through weekend visitors	January drive-through weekday visitors	2.16*
7. February drive-through weekend visitors	February drive-through weekday visitors	1.93*
8. March drive-through weekend visitors	March drive-through weekday visitors	2.93*
9. April drive-through weekend visitors	April drive-through weekday visitors	3.18*
10. May drive-through weekend visitors	May drive-through weekday visitors	5.15
11. June drive-through weekend visitors	June drive-through weekday visitors	7.52

*Less than 95% level of significance
95% F = 2.66 99% F = 3.89

TABLE 13 -- Continued

Testing Combination of Data A with Data B A	 B	F Values
12. July drive-through weekend visitors	July drive-through weekday visitors	11.15
13. October drive-through weekend visitors	October drive-through weekday visitors	1.91*
14. November drive-through weekend visitors	November drive-through weekday visitors	3.82
15. December drive-through weekend visitors	December drive-through weekday visitors	2.16*
16. 1966 Corps total visitors	January total visitors	2.00*
	February total visitors	2.52*
	March total visitors	3.61
	April total visitors	4.20
	May total visitors	6.28
	June total visitors	9.26
	July total visitors	12.75
	October total visitors	4.36
	November total visitors	4.03
	December total visitors	2.96

*Less than 95% level of significance
95% F = 2.66 99% F = 3.89

vehicle counts to visitor counts by using an average number of visitors per vehicle affected the distribution.

This test was made by comparing the distribution of Corps visitors with the distribution of Corps vehicles on both weekend and weekday bases for 1966. As Table 13 (number 4 and 5) indicates, the distributions proved compatible; therefore, drive-through vehicles were converted to visitors by using the weekend average visitors per vehicle determined from the Corps data of 2.97 and the weekday value of 2.71. Visitors were estimated by multiplying these numbers by the number of vehicles, and rounding to the nearest lower integer. After conversion, the distribution of weekend visitors is compared with the distribution of weekday visitors for each month. Also, monthly distributions are compared with each other. The tests showed compatibility problems for January, February, October, November, and December, and the data for these months were eliminated from further analysis. Winter visitors are not attracted to the reservoir by the same activities as are summer visitors and seem to come in relatively greater numbers from closer areas. All other data proved compatible. That is, no significant differences were noted in the distribution of reservoir visitors by origin area between data taken in different years, data taken on weekends as contrasted with weekdays, and data taken by interviews as contrasted with license plate counts. The final Dewey visitor distribution by origin area was based on all Corps visitors plus estimated visitors from drive-through surveys for March, April, May, June, and July. The total number of visitors used was 32,572.

The Rough River tests, Table 14, involve a similar sequence of comparisons. As Table 14 indicates, all collected Rough River data are compatible to a 95 percent level of significance, and only two combinations are not compatible to 99 percent. Thus the final Rough River visitor distribution consists of all Corps data plus all drive-through estimated visitors. For Rough River, the weekend average visitors per vehicle was found to be 3.66 and the weekday average to be 3.69. The total number of surveyed visitors equals 70,976.

A review of Corps data for Rough River, Table 9, indicates several surveys within the months of October and November, months wherein visitation data were found to not be compatible with data for the rest of the year at Dewey. However, this data did prove compatible at Rough River, probably because Corps sampling excludes nonrecreational visitors.

Total Population Data

The total population of each origin area had to be established

TABLE 14

ROUGH RIVER VISITATION DATA COMBINATION

Testing Combination of Data A with Data B A	 B	F Values
1. 1963 Corps weekend visitors	1963 Corps weekday visitors	4.18
2. 1964 Corps weekend visitors	1964 Corps weekday visitors	2.84*
3. 1965 Corps weekend visitors	1965 Corps weekday visitors	5.55
4. 1966 Corps weekend visitors	1966 Corps weekday visitors	5.37
5. 1963 Corps total visitors	1964 Corps total visitors	3.29*
	1965 Corps total visitors	4.59
	1966 Corps total visitors	5.10
6. 1966 Corps weekend vehicles	1966 Corps weekend visitors	5.62
7. 1966 Corps weekday vehicles	1966 Corps weekday visitors	5.62
8. Drive-through weekend vehicles	Drive-through weekday vehicles	6.56

*Less than 99% level of significance
95% F = 2.66 99% F = 3.89

TABLE 14 -- Continued

Testing Combination of Data A with Data B A	 B	F Values
9. 1963 Corps visitors	Drive-through estimated visitors	4.99
10. Drive-through total vehicles	1963 Corps total vehicles	4.35
	1964 Corps total vehicles	3.89
	1965 Corps total vehicles	4.30
	1966 Corps total vehicles	5.03
	1963 + 1964 + 1965 + 1966 Corps total vehicles	4.41

for correlation with distance and visitation. The population used in each case was that reported in the 1960 census. Since the visitation data were collected in the years 1963 through 1966, origin area population in these later years might have been used; but population estimates between census years are less accurate and harder to obtain. Recreation planners would be more likely to use census data than other population estimates in their project analyses. Furthermore, the counties immediately surrounding both reservoirs account for the bulk of the visitors and for the most part have experienced little population change since 1960. Each population used is shown on Table 21.

Distance Data

The distance from each origin area to each reservoir was also needed for the statistical correlation required to evaluate K and n in Equation 1. Each distance was measured from a point within the origin area to the main entrance to the reservoir in question. For most counties, the county seat was taken as the point within the origin area. For a few of the closest counties, the center of population was figured more exactly. For most states, a larger city near the center of the state was used. For the closest states, a more detailed analysis of the population distribution within the state was made. The cities within each state which were finally selected are shown on Figure 19. The airline distance between each pair of points was measured by scaling from maps of Kentucky and the United States respectively. Each distance used is shown on Table 21.

Population Characteristics Data

One can conceive of a number of characteristics of a population which might influence the propensity of that population to visit a reservoir for recreation. Certainly income and age should have an effect. Those living in cities may come in different numbers than those living in the country. Other characteristics which might have an effect include race, sex, education, and length and distribution of working hours. The basic problems in correlating visitation propensity with population characteristics were determining which population characteristics should be used and which way the selected characteristics should be expressed. For example, income might be expressed as mean annual family income, fraction of families within a selected income range, or median per capita income. The selected expression might be mathematically transformed by taking the logarithm, the cube root, or raising to the 1.75 power.

Obviously, infinite combinations of population characteristics and transformations exist from which the best must be chosen.

The approach of this study was to take a fairly large number of the more promising characteristics and determine those having the greatest degree of statistical correlation with the visitation data. However, many population characteristics and transformations had to be eliminated to keep the correlation studies within reasonable bounds. The three population characteristics which seemed to be most promising were income, age, and urbanization. Data describing these characteristics for each origin area in various ways were collected for subsequent analysis. All collected data were based on the 1960 census.

Two approaches to urbanization were tried. One was the percent of the total area population living in communities of 2,500 people or more (30). The other was the percent of the total area population living in communities of 50,000 people or more (31). Both variables were initially recorded in terms of actual population and then by using 1960 census population data converted to percentage. A population over 2,500 is used by the U. S. Census Bureau to define an urban area (31).

Median family income and the percentage of the families in each of seven income ranges were tried as measures of income. Kentucky county median family income is available in census reports (32). Median family income for states is also available in census reports (31, p. 286). The seven income ranges included families making less than $3,000 annually, between $3,000 and $5,000, between $5,000 and $7,000, between $7,000 and $10,000, between $10,000 and $15,000, between $15,000 and $25,000, and greater than $25,000. Kentucky county data were converted from actual number of families to percentage distributions (32). However, state data were recorded in percentage and did not require conversion (31, p. 286). Median family income, percentage of families in each of the seven classifications, and percentage of families in a number of combinations of the seven classifications were tried.

Median individual age and the percentage of individuals in each of seven age ranges were also tried. Kentucky county median age and age distribution values are available in census reports (33, pp. 73-102). Median age and age distribution values for other states are also available in census reports (33, pp. 167-172). The seven age ranges were 9 years old or younger, from 10 to 19, from 20 to 29, from 30 to 39, from 40 to 49, from 50 to 64, and 65 years or older. Combinations of ranges were also tried. All age distribution data were converted from actual number of individuals within the range to percent of the total origin area population.

Route Characteristics Data

One would also expect the nature of the route between the population center and the reservoir to affect visitation. Virtually all visitors to the recreation reservoirs travel by highway so only highway routes were considered in the analysis. Four different classifications describing the influence were studied. The four variables considered were the ratio of the air distance to the road distance (a measure of the circuity of the route), the percentage of the road distance that is four or more lanes, the percentage of the road distance that is federal two lane, and the percentage of the road distance that is state two lane. All four factors depend on the highway route selected between the origin area and the reservoir.

All route factors for both reservoirs were based on highway routes to the reservoir from the point within the origin area used to measure air distance. Both population concentration and approximate geographical center were considered in defining the measurement points. More accurate analysis would involve subdividing origin areas into smaller units, but the additional work did not seem to be warranted. However, population concentration points and state size and position relative to Kentucky were considered in defining distance measurement points.

Obviously, the route factors between two points depend on the route selected. Measurement of the length of a selected route may be done directly from a road map. Highway routes from all Kentucky counties to both reservoirs were selected by the author. However, from origin areas outside Kentucky, American Automobile Association routes were incorporated as standards. The AAA office in the selected centrally located city of each state and the District of Columbia supplied suggested routes from that city to both Rough River and Dewey Reservoirs. Although 48 offices were contacted, only 27 replied. However, the 54 routes from 27 origin areas provided a sufficient aggregation of routes to permit relatively unbiased estimates of the remaining 42 routes. Figure 19 describes the selected routes and origin cities from which factors were obtained.

Competing Recreational Reservoir Data

Another factor considered in this study as having an influence on reservoir visitation is the capacity, quality, and nearness of available alternative reservoir recreation facilities. The capacity and quality factors were accounted for when selecting competing reservoirs. In other words, only reservoirs with similar quality and capacity were selected as competition for Dewey and Rough River. Nearness was estimated from the relative distance from the origin area to Dewey or Rough River as compared to the reservoir nearest that origin area.

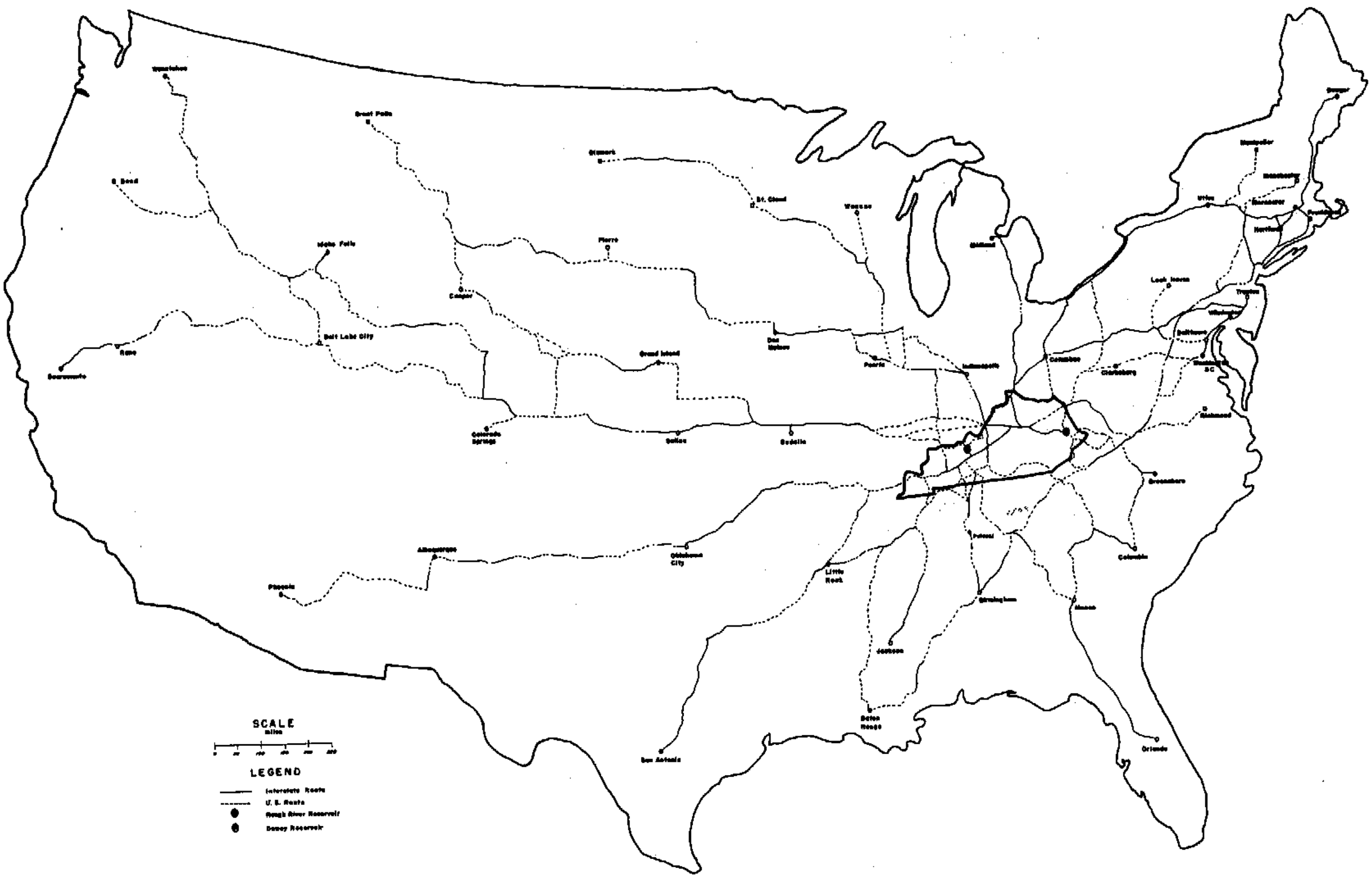


Fig. 19.-- U. S. Map of Highway Routes Used

The competition factor employed in this study is defined as the air distance from an origin area to the nearest selected competing reservoir divided by the air distance from the same origin area to the reservoir studied. A value of 1.0 signifies that the reservoir studied is nearer the origin area than any other reservoir. All states except West Virginia were assumed to have similar facilities much nearer the population than either Dewey or Rough River and were thus assigned factor values of zero. After reviewing the relative distances and available facilities for West Virginia, a competing reservoir was selected for that state. In addition 12 reservoirs located in Kentucky, Tennessee, and Ohio including both Rough River and Dewey since they compete with each other, were selected for analysis of Kentucky county factors, Table 15.

County competition factors for 120 Kentucky counties and West Virginia for Dewey and Rough River Reservoirs were determined by measuring the air distance from each origin area to the nearest competing reservoir. A sample calculation for Fayette County is presented in Figure 20.

Effective Distance Data and Preliminary Analysis

As previously mentioned in Chapter I, the procedure of calculating recreational benefits followed in this study involves using the cost of travel as a substitute for price in developing

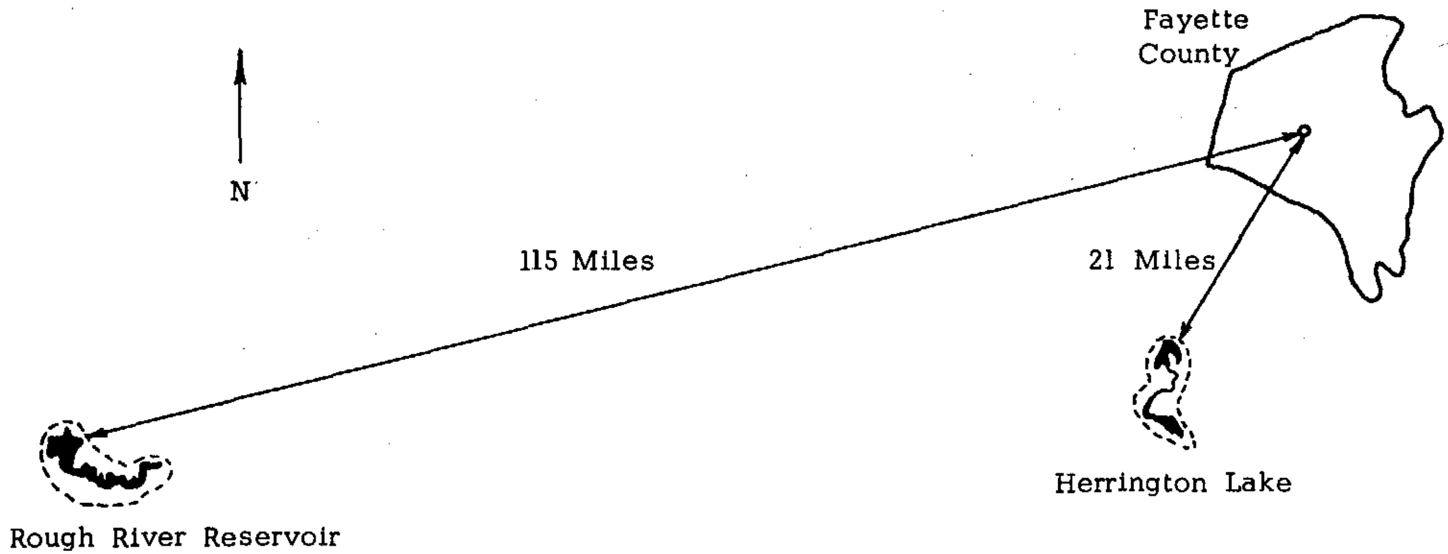
TABLE 15

COMPETING RECREATION RESERVOIRS

Reservoir	Location
1. Kentucky and Barkley	Southwestern Kentucky Northwestern Tennessee
2. Rough River	West Central Kentucky
3. Nolin	West Central Kentucky
4. Dale Hollow	South Central Kentucky North Central Tennessee
5. Cumberland	South Central Kentucky
6. Herrington	Central Kentucky
7. West Fork of Mill Creek	Southwestern Ohio
8. Fishtrap	Eastern Kentucky
9. Dewey	Eastern Kentucky
10. Norris	Northeastern Tennessee
11. Barren	Southwest Central Kentucky
12. Sutton	Central West Virginia
13. Reelfoot	Northwestern Tennessee

the demand relationships. The total travel distance from an origin area to a reservoir cannot be attributed to the reservoir studied. Only the out-of-the-way distance traveled to the site may be considered as determining the cost the visitor paid to reach the project. One might hypothesize that visitors traveling short distances to the reservoir have sole purpose of visiting the

Figure 20
Fayette County Competition Factor
Rough River Reservoir



Competition Factor = 21/115 = 0.18252

reservoir, and visitors traveling greater distances stop at intermediate interest points or to visit friends or relatives and thus their out-of-the-way travel distance to the reservoir would only be a portion of the distance from their home to the reservoir. Data were collected as part of this study to estimate out-of-the-way distance traveled by visitors attending both Dewey and Rough River Reservoirs as a function of total road travel distance.

Post card questionnaires accompanied by a letter explaining the purpose of this study and the best way to answer the questions were distributed at both reservoirs during the summer of 1966. A copy of both the letter and the post card is shown on Figure 21. Obviously, Dewey questionnaires involved altering question 1. Data obtained from the returned post cards provided visitor estimates of out-of-the-way travel distance.

Questionnaires at Dewey were distributed simultaneously with vehicle origin counts during April, May, June, and July, Table 16. One questionnaire was deposited under the driver side windshield wiper for every tenth vehicle encountered while surveying from Dewey Dam to Brandykeg Dike. If post cards remained after surveying all vehicles at sites on the drive-through route, on the return trip they were deposited on every fourth vehicle until all alloted for that day were distributed.

1. Does your trip away from home have any purpose other than to visit Rough River Reservoir?
   Yes ________ No ________

2. If your answer to Question 1 is yes, how far out of your way one way did you go to come here?
   ____________ Miles

3. In what city do you live? ____________________

Dear Recreation Visitor:

The construction of new reservoirs depends on the resulting benefits exceeding the cost. Part of the benefits from this reservoir accrue to you as a recreation visitor. The University of Kentucky Water Resources Institute is trying to develop a better method for evaluating recreation benefits and would greatly appreciate your help by answering the three questions on the attached post card and dropping it in the return mail.

The first question should be answered no if you left home with the sole purpose of your trip being to visit Rough River State Park. It should be answered yes if the trip also included visits to other parks or points of interest or with friends or relatives.

The second question should be answered only if your first answer is yes. The answer should be the one way distance from Rough River Reservoir to the nearest point on your route had you not come here.

Your cooperation is sincerely appreciated.

Fig. 21. -- Example Letter and Post Card Questionnaire

TABLE 16

DEWEY RESERVOIR EFFECTIVE DISTANCE
QUESTIONNAIRE SUMMARY

Survey Number	Date 1966	Number of Post Cards Distributed	Returned
1	April 5	14	2
2	April 10	14	2
3	April 19	14	2
4	April 24	14	0
5	May 3	25	2
6	May 8	25	9
7	May 17	25	4
8	May 22	25	0
9	May 31	25	7
10	June 5	44	1
11	June 14	44	0
12	June 19	45	4
13	June 28	45	0
14	July 3	50	1
15	July 12	48	0
	Total	457	34

The number distributed each day depended on the expected use for that day. More were distributed for July than April because July use exceeds April use. Of approximately 457 post cards distributed during 15 days, 34 were returned. Varying the survey day, quantity of cards distributed, and procedure of distribution provided an unbiased estimate of effective travel distance. However, because only 34 visitors replied out of 457 and many of these came from the local area, few data were available to determine out-of-the-way travel distance for visitors from greater distances. Therefore, to better define the relationship for the greater distances for which it is most significant in influencing benefits, procedures of distribution were altered at Rough River.

Questionnaires at Rough River were distributed primarily to visitors traveling greater distances. Two survey dates, September 5 (Labor Day) and August 12, 1966, were selected and approximately 200 questionnaires were distributed each day. About 75 percent of the post cards with letters were deposited on out-of-state vehicles. Fifty-five post cards were returned from the August survey and 48 were returned from the Labor Day survey. Data for both reservoirs were combined yielding a total of 137 replies. Elimination of illogical replies resulted in 132 satisfactory replies from which the effective distance curve was derived.

The data from the replies were developed into a curve relating road distance to out-of-the-way distance. By measuring the road distance from the reservoir attended to the origin as reported by question 3, Figure 21 above, and dividing this distance into the distance reported in question 2, a factor $\Delta D/D$ may be obtained. If the sole purpose of the trip was to visit the reservoir, the factor equals 1.0. The 132 points are plotted on Figure 22. A curve through the points was drawn by averaging $\Delta D/D$ values

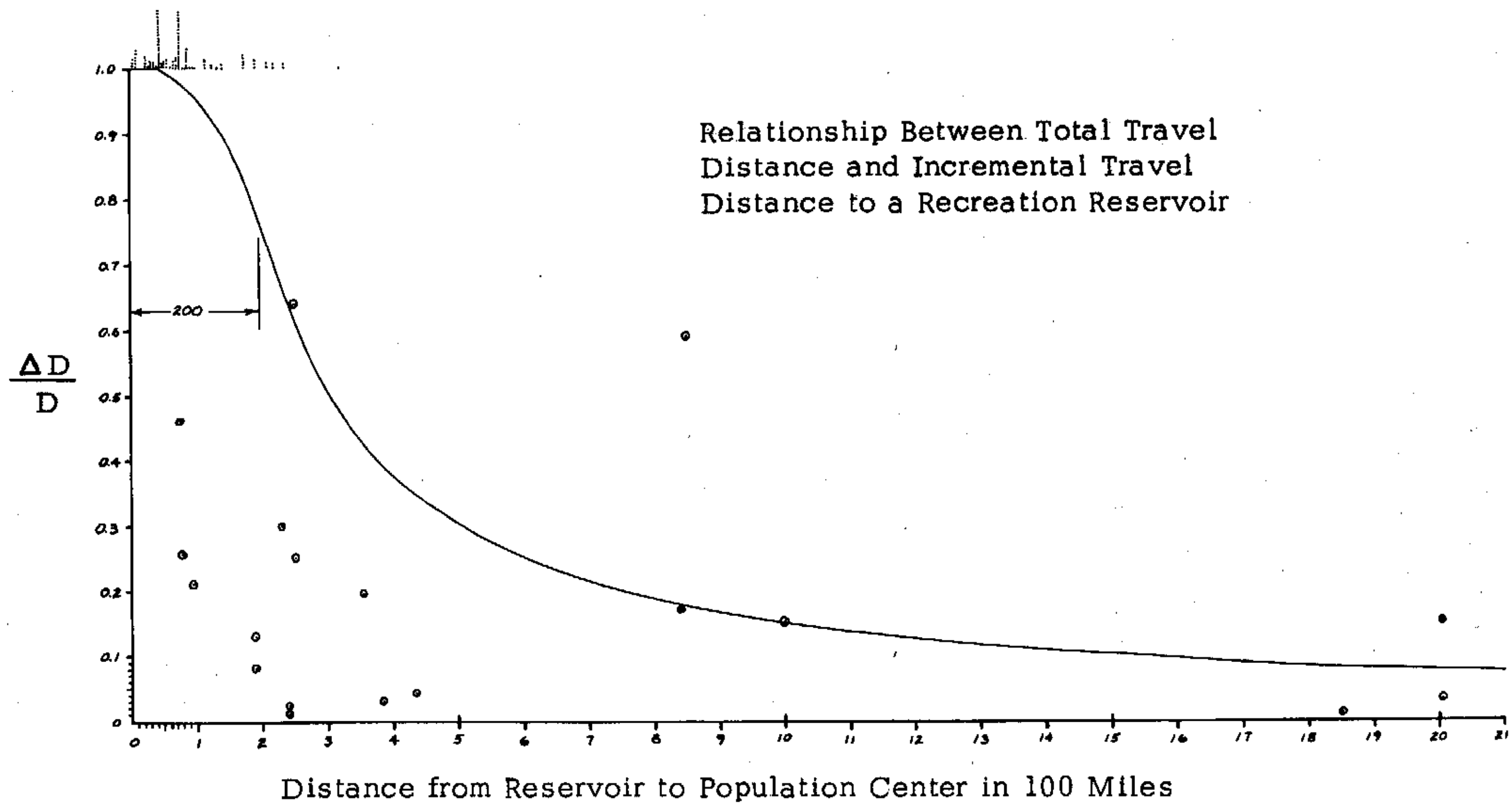


Fig. 22.-- Effective Distance Relationship

for distance ranges. The ranges used were from zero to 40 miles, from 40 to 100, from 100 to 200, from 200 to 300, from 300 to 400, and over 400. The curve on Figure 22 is plotted through these average points. The curve indicates a constant value of out-of-the-way distance of about 150 miles for visitors living more than 200 miles from the reservoir. In other words, the average visitor living more than 200 miles from the reservoir has only traveled 150 miles one way out of his way to get to Dewey or Rough River Reservoir. Although the data were limited, it is believed that Figure 22 reasonably approximates the true relationship between the variables.

Chapter IV

EQUATION DERIVATIONS AND APPLICATION

Introduction

The data described in Chapter III were used in a multiple linear regression analysis to estimate values for the coefficients n and K in Equation 1, and the results were used to estimate the number of visitors by origin area for both Rough River and Dewey Reservoirs. The initial regression was based on only population, visitation, and distance. Subsequent regressions tested inclusion of the other data. These data were correlated with the visitors by origin area for both reservoirs and either included or excluded from subsequent relationships depending on statistical F values (29). The selected relationships were tested for ability to describe variation in visitation rate by utilizing the coefficient of multiple determination.

The coefficients for the three selected regressions were based on Rough River data. The resulting equations were then applied to Dewey data and tested for degree of correlation. In addition, Equation 2 by Knetsch (12), and Equations 6, 7, and 8 by Merewitz (15) were applied to both Dewey and Rough

River data and the resulting visitation estimates statistically compared with results produced by this study.

Derivation of Equation Relating K, n, and d

Preliminary analysis of the visitation data as described in Chapter III produced a number of audited visits from each of the 168 origin areas to Rough River and Dewey Reservoirs. Total audited visitors were 70,976 to Rough River and 32,572 to Dewey. In order to develop a regression to predict total annual visitation by origin area, audited visitors were converted to annual visitors by assuming both types of visitors were distributed among the origin areas in the same manner. The 824,200 visitors to Rough River in 1966, Table 3, were proportioned to each origin area by:

$$V_i = V_a \times \frac{824,200}{70,976} \qquad (9)$$

where V_i is the estimated number of 1966 visitors, and V_a is the audited visitors. The sum of V_a for 168 origin areas equals 70,976, and the corresponding sum of V_i totals 824,200 visitors. Thus, the dependent variable V used in the subsequent analysis is 1966 visitation estimated in the above manner, hereinafter referred to as actual visitation. The same approach was used to estimate actual visitation to Dewey Reservoir based on 960,300 1966 visitors and 32,572 audited visitors. The relatively smaller sample size at Dewey indicates a relatively less reliable distribution of visitation by origin area. Audited and actual visits by origin area to both reservoirs are found on Table 24.

A University of Kentucky Computing Center Statistical Library Program entitled "Step-wise Multiple Linear Regression Analysis - MULTR" was employed in deriving all visitation estimate equations produced in this study (34, p. 59). The library program uses an F test to determine the most significant independent variable, establishes the correlation and regression coefficients for a correlation based on only that one independent variable, finds the second most significant variable, establishes the coefficients using a two independent variable correlation, and continues to add the remaining variables in order of decreasing significance in this manner until all have been included or a specified level of minimum acceptable significance has been reached.

Linear regression analysis to determine the values of K and n in Equation 1 required conversion to the form of Equation 3 to eliminate the exponent. The regression analysis was based on the actual visits on Table 24 and on the population and distance data on Table 21. Three distance variables were tested: air distance, road distance, and time of travel. Road distance, as previously described, was classified according to state two lane, Federal two lane, and Federal four lane. Time of travel in hours from each origin area was calculated using average velocities of 40 miles per hour for State two lane, 50 miles per hour for Federal two lane, and 60 miles per hour for Federal four lane. Table 17 indicates the correlation coefficients which resulted from each of the three ways of expressing distance. The correlation coefficients are based on an equation derived only from Rough River data but applied to both reservoirs. Air distance was selected as the most significant.

TABLE 17

CORRELATION COEFFICIENTS FOR TRAVEL STATEMENT

		Correlation Coefficients	
	Variable	Rough River	Dewey
1.	Air distance	.74	.96
2.	Road distance	.44	.95
3.	Time (hour)	.50	.93

The equation finally selected was thus based on air distance, 1960 census population and 1966 visitation and was derived using Rough River data. It was:

$$\text{Log}_{10} V/P = 3.411 - 2.445 \log_{10} d \qquad (10)$$

where V/P is the annual visitation per capita, the constant 3.411 is the antilogarithm of K to the base 10, and the constant 2.445 equals n. Equation 10 when converted to the form of Equation 1 is:

$$V = 2577\ P/d^{2.445} \qquad (11)$$

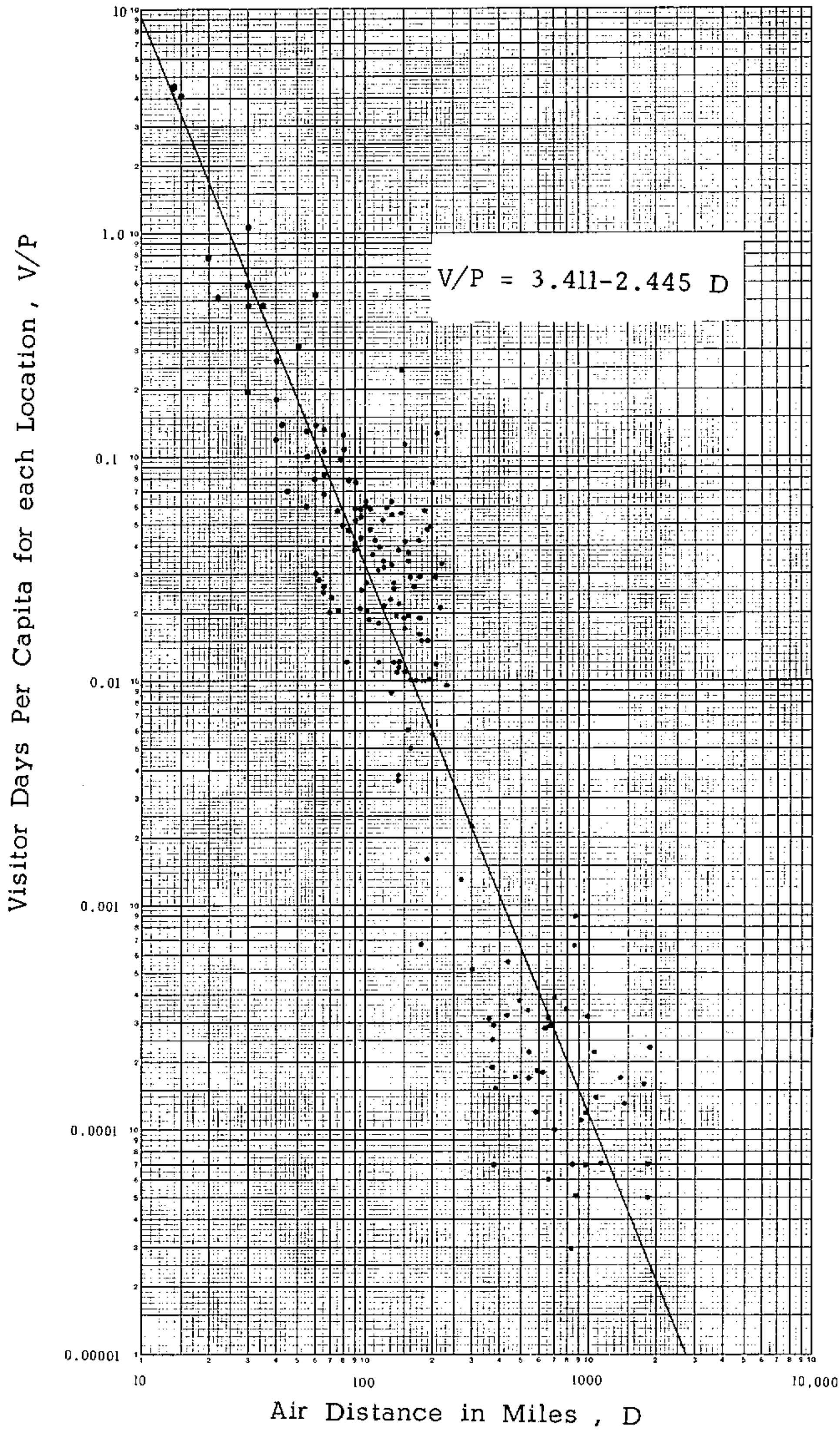
Equation 10 and the Rough River data are plotted on Figure 23. Equation 11 was used to estimate annual visitation from each origin area to each reservoir with the results on Table 24.

<u>Determination of Most Significant Population, Route, and Competition Characteristics</u>

The next step in the analysis was to try to improve the correlation of Equation 11 by bringing in additional variables; the population, route, and competition characteristics described in Chapter III. Many different variables had to be tested to find the ones having the most significant correlation with visitation. Data for both reservoirs were used in the significance testing. The testing was based on the hypothesis that the other variables accounted for at least part of the difference between visitation predicted by means of Equation 11 and actual visitation (Table 24). The test was to find the significance between the differences and the variable values.

Variable significance was tested using the Fixed Effects Model: One Way Classification (29). Population and air distance

Fig. 23.-- Rough River Visitation Per Capita Distribution, Eq. 19



were substituted in Equation 11 to estimate 1966 visitation to both reservoirs from each of the 168 origin areas. Actual visitors had previously been calculated from audited visitors by means of Equation 9. Significance testing required arranging the origin areas by ratios of estimated visitors to actual visitors in order from largest to smallest. Each variable to be tested was assigned the value appropriate for the origin area. The F test determines the correlation between the ordering and the variable value.

The process of arranging in order of the ratio of estimated to actual visitors had to be modified for origin areas from which no visitation had been recorded. These origin areas were arranged in order from the largest to smallest estimated visitation. The ratios for areas from which visits had been audited from the largest to smallest followed. The ratio values greater than 1.0 signify an overestimate of visitation. Values less than 1.0 signify underestimates when based on distance and population alone. Larger values of the suggested additional variables associated with overestimates and smaller values associated with underestimates suggest significant correlation. A significant reverse correlation would occur were small values associated with overestimates and large values with underestimates.. Statistical F values were calculated to measure the degree of correlation. F values greater than

2.66 indicate 95 percent and values greater than 3.90 indicate 99 percent correlation (29). This procedure is employed to provide preliminary estimates of distribution variable significance in order to eliminate the least significant variables from further analysis. Final significance of the selected variables is obtained when deriving the regression equations.

Seven classifications of income distribution were used. The seven were the percent of the families living in the origin area making less than $3,000 annually, between $3,000 and $5,000, between $5,000 and $7,000, between $7,000 and $10,000, between $10,000 and $15,000, between $15,000 and $25,000, and greater than or equal to $25,000. The results of testing the correlation of the seven classifications along with 24 selected combinations of the classifications with visitation ratios for both Dewey and Rough River are summarized on Table 18. The income distribution variable selected as the most significant was the percent of families making between $15,000 and $25,000 annually. The final F value in this test, however, failed to meet the 95 percent level of significance for either reservoir. However, later tests showed greater significance when K rather than the visitation ratio was used as the dependent variable.

Although the fraction of families within the $15,000 to $25,000

TABLE 18

INCOME DISTRIBUTION CORRELATION

Annual Family Income: < 3000	3000-5000	5000-7000	7000-10000	10000-15000	15000-25000	> 25000	"F" Values: Rough River	Dewey
■							2.07	1.18
	■						0.78	1.95
		■					1.54	0.43
			■				2.32	1.42
				■			2.15	1.68
					■		2.52 *	1.82
						■	1.06	1.60
■	■		■		■		1.81	0.94
■	■		■		■	■	1.84	0.91
■	■				■		2.02	1.13
■						■	2.08	1.16
■					■		1.99	1.13
	■					■	0.97	1.94
	■				■		1.21	1.95
	■		■			■	2.14	1.52
	■		■		■		2.32	1.56
■			■				1.81	1.06
■	■	■	■	■	■		0.31	2.25
	■	■					1.26	0.79
	■	■	■				1.90	0.94
	■	■	■	■			2.04	1.07
	■	■	■	■	■		2.12	1.12
		■	■	■			2.08	1.07
		■	■	■	■		2.15	1.13
				■	■		2.27	1.75
	■	■	■	■	■	■	2.10	1.14
		■	■	■	■	■	2.12	1.15
			■	■	■	■	2.29	1.59
	■				■	■	1.40	1.93
■	■	■	■	■		■	1.84	2.46
■	■	■	■			■	2.14	1.93

*Income distribution used in final correlation annual income range correlated better with the visitation ratio than the other fractions considered, this does not imply that families with incomes outside this range visit the reservoir less often than those with incomes in the range. It only means that the visitation ratio from an origin area having a large number of families within this income range tends to differ from the visitation ratio from an area having a smaller number of such families. The regression coefficient subsequently determined showed a positive correlation. This indicates that people living in an area having a larger number of people in this income range visit reservoirs more often than people living in other areas. It says nothing about the incomes of those actually visiting the reservoir.

Similar procedures were employed in selecting the most significant age distribution variable. Seven classifications of age distribution were tested. Tested were the percentage of individuals less than or equal to 9 years old, from 10 to 19, from 20 to 29, from 30 to 39, from 40 to 49, from 50 to 64, and 65 or older. The seven classifications along with 25 selected combinations of the classifications were tested using the procedure previously described. The results are summarized on Table 19. The most significant correlation, considering both reservoirs, was the percent of individuals with ages of 10 to 19 years old. This

TABLE 19

AGE DISTRIBUTION CORRELATION

Age ≤9	10-19	20-29	30-39	40-49	50-65	≥66	"F" Values Rough River	Dewey
■							1.29	4.57
	■						3.20 *	3.95
		■					0.71	1.02
			■				2.19	1.73
				■			0.96	3.76
					■		0.16	4.07
						■	0.86	5.21
			■	■			2.06	2.87
	■	■	■				0.05	2.82
■	■		■				1.23	5.56
■	■		■	■			1.03	4.51
■			■	■			1.59	1.28
■	■			■	■		2.35	3.00
■	■		■	■		■	1.53	3.34
■	■		■		■	■	1.65	2.10
	■		■				1.66	3.87
	■	■					0.72	3.08
			■	■	■		1.35	4.85
	■		■	■	■		0.32	1.27
	■			■	■		1.56	0.78
	■		■	■			0.81	1.68
	■			■			3.12	2.41
	■				■		2.76	1.00
■	■						1.95	6.04
				■	■	■	0.47	4.85
					■	■	0.43	4.50
■						■	0.39	4.02
■	■					■	2.68	4.94
■	■				■	■	2.23	2.41
■	■			■	■	■	1.56	1.55
■					■	■	0.04	2.58
■				■	■	■	0.05	2.82

*Age range used in final correlation

classification correlated with Rough River ratios at a significance level of over 95 percent and with Dewey ratios at a level of over 99 percent. For reasons discussed for income distribution, the age classification chosen does not necessarily indicate people in the selected age range are more likely to visit the reservoir than people of other ages. In reviewing the F values on Tables 18 and 19, it is apparent that age distributions correlated more closely with Dewey visitation and income distributions more closely with Rough River visitation.

The other variables tested were median family income, two classifications of urbanization, competition factor, median individual age, and four classifications describing highway routes. The F values are summarized on Table 20. Median family income did not significantly correlate with either reservoir visitation rate; however, later tests showed it to correlate with K more significantly. The percentage of people living in cities with over 50,000 people was selected over the fraction living in cities over 2,500 due to higher significance. The competition factor and the median individual age factor were tested but retained for further analysis. The percent of four-lane highway distance was selected as opposed to the air-road ratio, percent of state two lane, and percent of Federal two lane even though as shown on

TABLE 20

VISITATION CORRELATION WITH OTHER ORIGIN CHARACTERISTICS

Characteristic	F Values Rough River	Dewey
1. Median Family Income	2.03*	1.05*
2. Urbanization Population Percent in Communities over 2,500	4.52	2.10*
Population Percent in Communities over 50,000	5.68	3.45
3. Competition Factor	1.44*	8.19
4. Median Individual Age	1.79*	5.61
5. Route Air/Road Distance	1.33*	0.43*
Road Percent - State 2-Lane Highway	4.43	1.53*
Road Percent - Federal 4-Lane Highway	6.45	3.98
Road Percent - Federal 2-Lane Highway	6.92	4.25

*Less than 95 percent correlation

Table 20 the percent of Federal two lane was slightly more significant. The four-lane factor was selected because the data were believed to be more reliable and to permit analysis of the effect of construction of the interstate highway system on reservoir visitation. For practical purposes, Federal four-lane and interstate highway distance were found equivalent and used interchangeably in the following analysis.

In summary, the procedure described above was to select a representative age distribution, income distribution, urbanization, and route factor for use in subsequent correlation analyses. Whether or not the selected variables appeared in the final correlation depended on F values calculated in the regression analysis.

The seven variables describing each origin area carried into the subsequent correlation were:

1. Median family income,
2. Percentage of families making between $15,000 and $25,000 annually,
3. Percentage of people between the ages of 10 and 19,
4. Percentage of residents living in cities of over 50,000 population,
5. Median individual age,
6. A recreation competition factor as defined by Figure 20 and,
7. The percentage of the road distance from the reservoir to the origin area in four-lane highway.

Data describing the value of the seven variables are presented in Table 21. The competition factor, from Table 21 data, is the competition distance divided by Dewey or Rough River air distance. The route factor is the interstate distance divided by the road

TABLE 21

VISITATION CENTER DATA

		1960 Population	Urb. %	Inc. %	Age %	Med. Inc.	Comp. Dist.	Rough River-Distance Air	Rough River-Distance Road	Rough River-Distance Int.	Dewey Air	Dewey Road	Dewey Int.
1	Adair	14699	0.00	1.353	20.31	1939	15	75	104	0	150	173	0
2	Allen	12269	0.00	0.606	16.68	2205	10	65	72	0	200	240	0
3	Anderson	8618	0.00	0.553	17.37	3812	20	85	105	83	112	135	105
4	Ballard	8291	0.00	0.521	16.10	3036	42	145	158	87	356	392	318
5	Barren	28303	0.00	1.044	17.48	2738	25	55	69	0	182	211	0
6	Bath	9114	0.00	0.297	18.47	2326	58	155	176	150	64	104	50
7	Bell	35336	0.00	0.739	23.19	2443	10	165	218	197	88	121	0
8	Boone	21940	0.00	2.244	17.27	5794	17	135	206	182	144	190	160
9	Bourbon	18178	0.00	1.914	17.69	3801	39	130	146	112	90	112	72
10	Boyd	52163	0.00	1.899	18.41	5055	45	215	241	156	46	56	6
11	Boyle	21257	0.00	1.187	17.09	3838	5	90	119	58	119	164	85
12	Bracken	7422	0.00	0.550	16.34	3334	42	150	181	115	100	145	68
13	Breathitt	15490	0.00	0.984	24.48	1432	34	175	213	179	35	48	0
14	Breckenridge	14734	0.00	0.537	18.46	2637	14	14	14	0	203	247	202
15	Bullitt	15726	0.00	0.856	18.78	4640	47	50	74	59	164	204	181
16	Butler	9586	0.00	0.163	20.58	2059	23	30	34	0	224	263	223
17	Caldwell	13073	0.00	0.915	16.72	3202	10	85	112	96	288	327	306
18	Calloway	20972	0.00	0.824	18.69	3446	10	120	166	77	320	379	282
19	Campbell	86803	0.00	3.047	16.23	5932	15	150	203	153	126	192	136
20	Carlisle	5608	0.00	0.248	16.35	3137	30	150	170	96	354	394	314
21	Carroll	7978	0.00	1.400	17.82	3359	43	105	144	90	150	192	125
22	Carter	20817	0.00	0.569	22.21	2957	43	195	225	150	43	78	10

TABLE 21 -- Continued

		1960 Population	Urb. %	Inc. %	Age %	Med. Inc.	Comp. Dist.	Rough River-Distance-Dewey Air	Road	Int.	Air	Road	Int.
23	Casey	14327	0.00	0.000	22.73	1802	14	90	112	30	126	168	80
24	Christian	56904	0.00	1.330	17.43	3740	24	75	99	57	272	325	283
25	Clark	21075	0.00	2.252	17.83	4076	32	130	150	132	83	96	72
26	Clay	20748	0.00	0.463	24.04	1833	48	155	199	0	72	89	0
27	Clinton	8886	0.00	0.544	20.89	1714	8	95	117	0	151	186	9
28	Crittenden	8648	0.00	0.906	17.54	2747	18	90	121	78	298	345	303
29	Cumberland	7835	0.00	1.215	18.94	1898	10	80	99	0	160	192	9
30	Daviess	70588	0.00	2.109	18.10	4786	33	35	46	0	241	294	240
31	Edmonson	8085	0.00	0.589	22.49	2042	5	30	37	0	197	254	203
32	Elliott	6330	0.00	0.559	22.09	2054	33	190	216	156	34	60	0
33	Estill	12466	0.00	0.784	20.94	2489	40	140	188	157	66	85	45
34	Fayette	131906	47.62	2.916	15.82	5377	21	115	130	112	100	112	88
35	Fleming	10890	0.00	0.279	18.84	2640	68	160	191	127	72	112	54
36	Floyd	41642	0.00	0.872	24.49	2802	12	205	259	209	12	12	0
37	Franklin	29421	0.00	2.465	16.97	5424	31	95	138	120	122	142	118
38	Fulton	11256	0.00	1.180	17.48	3292	8	172	188	83	368	425	313
39	Gallatin	3867	0.00	1.064	19.16	3478	31	120	167	90	148	186	146
40	Garrard	9747	0.00	1.190	17.78	3088	8	105	125	57	104	144	80
41	Grant	9489	0.00	0.799	18.00	3727	36	125	173	155	125	160	136
42	Graves	30021	0.00	0.833	16.50	3549	25	138	166	105	336	380	309
43	Grayson	15834	0.00	1.202	20.08	2241	9	15	17	0	197	229	214
44	Green	11249	0.00	1.552	17.21	2842	30	55	69	0	160	208	101
45	Greenup	29238	0.00	1.427	19.79	4393	60	205	250	150	63	96	10
46	Hancock	5330	0.00	0.580	19.14	2952	22	22	32	0	224	259	175
47	Hardin	67789	0.00	1.258	22.14	3865	22	30	41	0	170	200	178

TABLE 21 -- Continued

		1960 Population	Urb. %	Inc. %	Age %	Med. Inc.	Comp. Dist.	Rough River-Distance-Dewey Air	Road	Int.	Air	Road	Int.
48	Harlan	51107	0.00	0.880	23.76	3076	35	190	240	0	72	86	0
49	Harrison	13704	0.00	1.738	16.42	3840	48	130	162	112	98	125	69
50	Hart	14119	0.00	0.401	18.78	2436	12	40	47	0	178	230	209
51	Henderson	33519	0.00	1.035	17.47	4095	60	62	71	0	269	319	240
52	Henry	10987	0.00	0.795	18.22	3282	52	95	126	90	135	160	116
53	Hickman	6747	0.00	1.133	17.39	2860	22	155	184	86	352	405	296
54	Hopkins	38458	0.00	1.372	17.66	4044	38	60	96	80	267	312	291
55	Jackson	10677	0.00	0.200	23.19	1651	41	135	169	62	71	94	0
56	Jefferson	610947	63.94	3.225	15.81	5796	48	60	90	74	170	192	169
57	Jessamine	13625	0.00	1.239	17.53	2630	12	105	136	106	103	128	94
58	Johnson	19748	0.00	0.335	21.89	2449	10	200	250	212	10	10	0
59	Kenton	120700	50.02	2.426	15.84	5810	17	140	193	168	130	178	148
60	Knott	17362	0.00	0.222	26.00	1876	27	195	245	179	30	34	0
61	Knox	25258	0.00	0.209	23.75	1722	29	150	205	0	89	115	0
62	Larue	10346	0.00	1.157	17.43	3134	20	40	48	0	166	200	161
63	Laurel	24901	0.00	0.777	22.25	2312	31	135	176	0	86	112	0
64	Lawrence	12134	0.00	1.042	21.38	2088	26	210	273	212	26	32	0
65	Lee	7420	0.00	0.680	22.18	1847	52	155	200	170	54	72	31
66	Leslie	10941	0.00	0.556	23.40	1838	52	175	240	0	54	69	0
67	Letcher	30102	0.00	0.564	24.42	2615	29	200	256	173	47	56	0
68	Lewis	13115	0.00	0.854	21.58	2826	68	185	208	118	72	105	6
69	Lincoln	16503	0.00	0.920	20.67	2498	12	100	125	83	107	150	88
70	Livingston	7029	0.00	0.616	17.73	2916	20	108	136	83	313	363	306
71	Logan	20896	0.00	1.697	17.58	2894	42	60	67	0	240	290	246
72	Lyon	5924	0.00	0.390	14.96	3232	2	100	112	87	300	336	304

TABLE 21 -- Continued

		1960 Population	Urb. %	Inc. %	Age %	Med. Inc.	Comp. Dist.	Rough River-Distance-Dewey Air	Road	Int.	Air	Road	Int.
73	McCracken	57306	0.00	2.006	16.59	4916	20	130	149	99	339	379	322
74	McCreary	12463	0.00	0.150	25.98	1835	22	130	176	6	119	147	0
75	McLean	9355	0.00	0.834	18.37	3200	42	42	52	0	249	304	256
76	Madison	33482	0.00	1.343	20.38	3381	20	120	155	134	86	119	81
77	Magoffin	11156	0.00	0.000	22.97	1504	19	185	230	212	19	24	0
78	Marion	16887	0.00	1.077	22.20	3250	29	65	82	0	138	185	138
79	Marshall	16736	0.00	0.514	16.87	4109	10	115	135	84	317	360	307
80	Martin	10201	0.00	0.340	24.73	2071	12	220	248	196	15	23	0
81	Mason	18454	0.00	1.039	16.99	3847	54	160	184	110	88	136	51
82	Meade	18938	0.00	0.611	16.84	4591	30	30	34	0	185	223	202
83	Menifee	4276	0.00	0.000	22.36	1733	50	160	190	156	51	62	0
84	Mercer	14596	0.00	1.385	16.80	3535	5	90	123	103	117	156	132
85	Metcalfe	8367	0.00	1.193	17.52	1922	25	65	80	0	168	191	0
86	Monroe	11799	0.00	0.957	19.71	1856	16	78	91	0	179	213	0
87	Montgomery	13461	0.00	0.700	19.03	3181	47	140	168	150	72	93	54
88	Morgan	11056	0.00	0.309	21.05	1976	30	180	225	188	31	42	0
89	Muhlenberg	27791	0.00	0.798	19.93	3355	45	45	51	32	245	279	258
90	Nelson	22168	0.00	1.101	20.45	4031	39	55	71	53	150	174	159
91	Nicholas	6677	0.00	1.134	16.67	2795	52	140	160	116	82	112	51
92	Ohio	17725	0.00	0.666	18.75	2508	20	20	33	0	232	269	238
93	Oldham	13388	0.00	1.862	17.01	4808	58	80	118	89	153	185	138
94	Owen	8237	0.00	1.869	17.23	3259	47	110	158	116	128	160	120
95	Owsley	5369	0.00	0.000	21.29	1324	53	155	213	174	57	72	0
96	Pendleton	9968	0.00	0.420	17.58	3757	34	140	189	155	112	176	136

TABLE 21 -- Continued

		1960 Population	Urb. %	Inc. %	Age %	Med. Inc.	Comp. Dist.	Rough River-Distance-Dewey Air	Road	Int.	Air	Road	Int.
97	Perry	34961	0.00	1.061	23.49	2689	38	185	240	180	41	52	0
98	Pike	68264	0.00	0.997	23.87	2803	5	230	262	206	23	25	0
99	Powell	6674	0.00	0.522	21.26	2597	48	150	174	156	68	72	48
100	Pulaski	34403	0.00	0.733	19.89	2376	3	115	155	0	112	144	0
101	Robertson	2443	0.00	0.000	18.09	1930	52	145	202	126	98	153	79
102	Rockcastle	12334	0.00	0.297	21.77	1898	24	120	136	60	87	135	75
103	Rowan	12808	0.00	0.870	23.95	2913	38	175	192	150	38	85	0
104	Russell	11076	0.00	0.835	20.71	1704	3	90	112	0	138	180	0
105	Scott	15376	0.00	2.036	18.33	3901	36	115	144	126	104	122	98
106	Shelby	18493	0.00	2.042	17.96	3963	40	80	119	101	143	166	143
107	Simpson	11548	0.00	1.048	17.04	2834	28	60	83	32	224	290	229
108	Spencer	5680	0.00	0.402	19.16	3234	38	70	92	64	135	171	137
109	Taylor	16285	0.00	1.601	19.20	3706	33	65	87	0	146	201	104
110	Todd	11364	0.00	0.851	18.59	2595	42	65	83	0	254	316	214
111	Trigg	8870	0.00	0.522	18.50	2306	5	95	120	57	292	347	283
112	Trimble	5102	0.00	1.645	18.84	3554	58	95	120	81	147	177	117
113	Union	14537	0.00	1.379	18.44	3698	43	83	96	0	288	342	240
114	Warren	45491	0.00	1.462	18.52	3572	19	40	59	9	213	267	206
115	Washington	11168	0.00	0.916	20.45	3029	24	70	88	49	136	176	139
116	Wayne	14700	0.00	1.160	21.37	1729	7	101	110	0	134	170	9
117	Webster	14244	0.00	1.342	15.57	3259	38	65	83	0	272	336	288
118	Whitley	25815	0.00	0.763	22.31	2272	28	140	181	5	107	136	0
119	Wolfe	6534	0.00	0.000	23.06	1455	40	165	206	188	40	50	26
120	Woodford	11913	0.00	1.885	17.90	4509	18	100	118	100	112	134	110

TABLE 21 -- Continued

	1960 Population	Urb. %	Inc. %	Age %	Med. Inc.	Comp. Dist.	Rough River-Distance-Dewey Air	Road	Int.	Air	Road	Int.
121 Alabama	3266740	26.69	1.600	19.28	3937	0	300	348	156	385	442	127
122 Arizona	1302161	50.08	3.100	17.99	5568	0	1435	1620	695	1630	1828	903
123 Arkansas	1786222	12.25	1.200	18.94	3184	0	370	424	110	555	630	316
124 California	15717204	49.16	4.700	15.99	6726	0	1860	2170	1245	2050	2400	1475
125 Colorado	1753947	37.36	3.000	16.96	5780	0	980	1035	600	1185	1230	800
126 Connecticut	2535354	39.00	5.100	15.45	6887	0	792	966	925	612	757	516
127 Delaware	446292	21.47	4.900	15.79	6197	0	610	685	280	415	500	146
128 District of Columbia	763956	100.00	5.700	13.30	5993	0	515	570	165	315	385	80
129 Florida	4951560	27.54	2.600	15.60	4722	0	700	777	563	650	806	456
130 Georgia	3943116	24.08	2.000	18.85	4208	0	365	430	170	335	410	90
131 Idaho	667191	0.00	2.100	18.86	5259	0	1390	1620	920	1540	1850	1160
132 Illinois	10081158	45.48	4.600	15.42	6566	0	270	372	82	462	500	438
133 Indiana	4662498	30.04	2.800	16.83	5798	0	141	188	148	219	270	253
134 Iowa	2757537	24.05	2.300	16.75	5069	0	475	666	532	642	750	627
135 Kansas	2178611	22.77	2.600	16.31	5295	0	598	630	400	800	830	610
136 Louisiana	3257022	32.54	2.100	18.40	4272	0	580	692	115	692	848	268
137 Maine	969265	7.49	1.500	17.38	4873	0	1040	1260	1130	885	1040	765
138 Maryland	3100689	38.67	4.400	16.78	6309	0	532	646	504	340	425	183
139 Massachusetts	5148578	46.19	3.800	15.66	6272	0	840	990	870	655	770	580
140 Michigan	7823194	39.85	3.500	16.72	6252	0	432	556	520	420	530	500
141 Minnesota	2413864	39.51	2.800	16.87	5573	0	660	850	300	800	975	645
142 Mississippi	2178141	6.63	1.200	20.13	2884	0	424	515	185	570	712	400
143 Missouri	4319813	35.09	2.600	15.91	5127	0	377	424	160	570	625	400
144 Montana	674767	16.04	2.400	17.46	5403	0	1450	1705	638	1610	1897	991

TABLE 21 -- Continued

		1960 Population	Urb. %	Inc. %	Age %	Med. Inc.	Comp. Dist.	Rough River-Distance-Dewey					
								Air	Road	Int.	Air	Road	Int.
145	Nebraska	1411330	30.48	2.300	16.19	4862	0	660	800	336	845	973	461
146	Nevada	285278	40.62	4.700	15.64	6736	0	1750	2000	1120	1955	2120	1325
147	New Hampshire	921606	9.58	2.300	16.61	5636	0	870	1084	959	700	939	769
148	New Jersey	6066782	30.82	5.200	15.18	6786	0	652	770	590	465	610	345
149	New Mexico	951023	21.16	2.900	18.83	5371	0	1120	1225	640	1320	1430	845
150	New York	16782304	60.22	4.800	14.89	6371	0	700	800	700	548	655	305
151	North Carolina	4556155	15.95	1.500	19.64	3956	0	382	478	148	200	222	79
152	North Dakota	632446	0.00	2.000	18.42	4530	0	960	1220	415	1100	1410	800
153	Ohio	9706397	37.74	3.300	16.29	6171	0	250	320	290	160	175	90
154	Oklahoma	2328284	27.82	2.200	17.37	4620	0	635	675	375	835	870	567
155	Oregon	1768687	23.95	2.800	17.06	5892	0	1820	2065	1020	2010	2295	1260
156	Pennsylvania	11319366	34.96	3.000	15.95	5719	0	540	632	400	370	455	115
157	Rhode Island	859488	49.31	2.500	15.94	5589	0	856	1053	938	672	808	576
158	South Carolina	2382594	9.63	1.400	20.89	3821	0	378	510	163	270	375	105
159	South Dakota	680514	9.62	1.700	17.56	4251	0	845	1100	540	1000	1360	840
160	Tennessee	3567089	25.52	1.600	18.38	3949	0	177	230	77	300	410	40
161	Texas	9579677	45.68	2.600	17.56	4884	0	920	1041	667	1090	1225	831
162	Utah	890627	29.15	2.600	19.20	5899	0	1350	1555	967	1540	1785	1197
163	Vermont	389881	0.00	1.900	17.88	4890	0	865	1040	960	700	855	530
164	Virginia	3966949	31.51	2.800	17.95	4964	0	495	630	429	295	386	144
165	Washington	2853214	31.08	3.300	16.97	6225	0	1830	2200	950	2000	2430	1095
166	West Virginia	1860421	11.98	1.700	19.28	4572	48	360	406	182	180	238	31
167	Wisconsin	3951777	30.70	3.000	16.58	5926	0	540	695	200	620	810	510
168	Wyoming	330066	0.00	3.100	17.40	5877	0	1095	1300	540	1270	1470	720

distance. Median individual age is excluded from Table 21 because it did not appear in the final correlation.

Derivation of Equation Including Population, Route, and Competitive Characteristics

In the idealistic sense, the best empirical equation for relating a dependent variable to various independent variables can only be found by comparing all possible variable combinations including transformed combinations. The best equation would be the one minimizing the sum of the squares of the departures of predicted from actual values of the visitation. Obviously, it is not practical to compare all possible combinations, and the correlation approaches must be selected according to the nature of the probable cause and effect relationship among the variables and the experience gained through previous attempts.

Three basic types of regression equations were tried. In the first type, visitors was used as the dependent variable and the independent variables were KPd^{-n} and the seven variables selected in the previous section. The result was an equation of the form:

$$V = a + bKPd^{-n} + cX_1 + dX_2 + eX_3 + fX_4 + gX_5 + hX_6 + iX_7 \qquad (12)$$

where V is the annual visitation from the origin area to the reservoir, K is the propensity of the population of the origin area to visit the reservoir as defined by Equation 1 and evaluated in

Equation 11 to be 2577, P is the number of people living in the origin area according to the 1960 census, n is the exponent defined by Equation 1 and evaluated as 2.445 in Equation 11, X_1 through X_7 are the seven independent variables in the order they are tabulated on p. 94, and the lower case letters are the coefficients to be determined by the regression analysis.

The regression, when based on Rough River data produced the equation:

$$V = -1410 + 0.755\ KPd^{-n} + 253X_4 \quad (13)$$

Almost all the deviation in the dependent variable was explained by the first independent variable, and the only other independent variable to come in at the 95 percent significance level was the percentage of the population living in cities over 50,000. The coefficient of multiple determination was 0.311.

In the second type of regression, visitors per capita was used as the dependent variable. The independent variables were Kd^{-n} and the same seven X variables. The equation had the form:

$$V/P = a + bKd^{-n} + cX_1 + dX_2 + eX_3 + fX_4 + gX_5 + hX_6 + iX_7 \quad (14)$$

The regression based on Rough River data produced:

$$V/P = 0.320 + 0.555Kd^{-n} \quad (15)$$

None of the seven values of X were found to be significant.

The coefficient of multiple determination was 0.970. This type of regression thus proved much more successful in predicting visitation than the type of Equation 12, but it was no help in studying the X variables. A logarithm transformation was then tried of the form:

$$\begin{aligned} \operatorname{Log}_{10} V/P = a + b \log_{10} Kd^{-n} + c \log_{10} X_1 + d \log_{10} X_2 \\ + e \log_{10} X_3 + f \log_{10} X_4 + g \log_{10} X_5 \\ + h \log_{10} X_6 + i \log_{10} X_7 \end{aligned} \tag{16}$$

Regression with Rough River produced:

$$\begin{aligned} \operatorname{Log}_{10} V/P = -2.55 + 0.901 \log_{10} Kd^{-n} - 0.141 \log_{10} X_4 \\ + 0.971 \log_{10} X_1 \end{aligned} \tag{17}$$

Urban population percentage and median income were the two additional significant variables. The coefficient of multiple determination was 0.893.

For the third type of regression, an imputed K for each origin area was calculated from Rough River data based on known values of V, P, and d in Equation 11. The 168 imputed values of K are shown on Table 22. The regression equation was of the form:

$$K = a + bX_1 + cX_2 + dX_3 + eX_4 + fX_5 + gX_6 + hX_7 \tag{18}$$

In attempting a regression of this form, one is confronted with the fact that the imputed values of K are much more reliable for origin areas having a large number of audited visitors than for origin areas having a smaller number. Random data bias is reduced by increasing the sample size. Weighting the regression may provide more accurate results. The values of K together with the associated values of the independent variables were weighted by inclusion in the regression analysis a number of times proportional to the number of audited visits. For comparison purposes, a correlation of the type of Equation 18 was tried both with and without weighting.

One other variation of Equation 18 was tried. In Equation 18, K is correlated with population, route, and competition characteristics. If only population characteristics are included, the correlation takes the form:

$$K = a + bX_1 + cX_2 + dX_3 + eX_4 + fX_5 \qquad (19)$$

because X_6 is the competition factor and X_7 is the route factor. The advantage of an equation of the form of Equation 19 is that the remaining data are much easier to collect; and if there is no significant loss in accuracy, the simpler equation would be preferred. Both forms were to be tested and compared.

The nonweighted equations, however, failed to provide meaningful results. The coefficient of multiple determination (R^2) for both trials was less than 10 percent. Only one variable, median family income, entered Equation 19, and only two, median family income and percent four lane, entered Equation 18 at the 95 percent significance level. Weighting was tried next.

The number of times the data for a given origin area were included in the weighted correlation was proportional to visitation from the origin area. The percent of audited visitors from each area was multiplied by 10.0 to determine the number of times to include the data. Due to rounding, 1034 sets of origin area data were produced. MULTR was again employed in calculating regressions based on Equations 18 and 19 from Rough River visitation data. This time met with reasonable success, and the following two equations were obtained:

$$\underset{3490}{K} = -1116.81744 + \underset{8.222}{221.33237\,X_4} - \underset{0.208}{0.40325\,X_1} - \underset{300.336}{1684.04123\,X_2} + \underset{80.055}{382.38046\,X_3} \tag{20}$$

$R^2 = 55.51\%$ Total F = 320.96

$$\underset{3253}{K} = -8046.34509 + \underset{12.047}{104.70310\,X_4} - \underset{0.209}{1.26378\,X_1} + \underset{342.512}{767.71530\,X_2} + \underset{75.548}{522.28737\,X_3} + \underset{452.065}{5292.15125\,X_6} + \underset{5.951}{64.79635\,X_7} \tag{21}$$

$R^2 = 61.43\%$ Total F = 272.59

The standard error with respect to each variable is indicated below the variable. The resulting total F indicates far over 99 percent probability of a relationship between predicted and actual values of K. The R^2 values were greatly improved over the nonweighted derivation, but still small due to exclusion of distance and population as independent variables. The actual values of K along with estimates using Equations 11, 20, and 21 for both reservoirs are presented in Table 22. K estimates by Equation 20 are equal for both reservoirs since only population characteristics were considered. However, differences in route and competition factors from one origin area to the two reservoirs cause estimates by Equation 21 to vary.

Equation 1 was employed in converting estimates of K by both equations to estimates of annual visitation. Air distance, population, and the value of n found in Equation 11 along with values of K provided visitation estimates. However, extreme overestimates of visitation to Dewey reservoir from nearby Kentucky Counties suggested the need for further modification.

By reviewing the portion of the total visitation prediction caused by each of the independent variables, it was learned that the age distribution variable, X_3, was the one causing the overestimate. The mountain counties of Eastern Kentucky have much

TABLE 22

VISITATION PROPENSITY BY LOCATION

		ROUGH RIVER K[1]			DEWEY K[1]		
		Actual	Eq. 20	Eq. 21	Actual	Eq.20	Eq. 21
1	Adair	2187	3470	2046	0	3470	1517
2	Allen	2257	3403	0	15254	3403	0
3	Anderson	4152	3057	3001	701	3057	2618
4	Ballard	10800	2939	2027	0	2939	2808
5	Barren	1885	2706	831	4901	2706	0
6	Bath	4337	4502	6384	2701	4502	6792
7	Bell	2694	4301	6056	2466	4301	481
8	Boone	4455	0	1763	3056	0	1453
9	Bourbon	9334	892	4418	5747	892	4319
10	Boyd	10569	686	1939	4676	686	2509
11	Boyle	4626	1870	391	660	1870	519
12	Bracken	8520	2862	2297	7100	2862	1960
13	Breathitt	5035	4296	7819	1714	4296	6486
14	Breckenridge	2802	3975	3967	1756	3975	4339
15	Bullitt	4499	2753	6698	9279	2753	3823
16	Butler	1918	5426	3980	13738	5426	5960
17	Caldwell	2459	2445	3519	0	2445	3590
18	Calloway	2755	3294	1567	0	3294	3107
19	Campbell	2297	0	687	3715	0	494
20	Carlisle	23852	3453	1438	0	3453	2333
21	Carroll	5098	1987	4310	0	1987	3828
22	Carter	18640	4380	4586	1006	4380	5222
23	Casey	2337	5804	2681	0	5804	3796
24	Christian	824	1801	2776	5581	1801	3461
25	Clark	3334	264	4847	15233	264	4742
26	Clay	1397	5012	2077	2275	5012	3966
27	Clinton	2956	4924	1097	0	4924	1245
28	Crittenden	3145	2957	3575	7651	2957	4350
29	Cumberland	2202	3314	1042	4614	3314	1015
30	Daviess	2882	323	1968	5020	323	2992
31	Edmonson	805	4716	1153	0	4716	5584
32	Elliott	17806	4761	5832	3830	4761	5369

[1] The value of K for Equation 11 is 2577 for all locations.

TABLE 22 -- Continued

		ROUGH RIVER K[1]			DEWEY K[1]		
		Actual	Eq. 20	Eq. 21	Actual	Eq. 20	Eq. 21
33	Estill	659	4207	6779	599	4207	6494
34	Fayette	4342	8394	7196	11342	8394	6849
35	Fleming	2615	4554	5231	4805	4554	6795
36	Floyd	5265	3932	5066	3048	3932	4820
37	Franklin	3680	0	3218	21654	0	2586
38	Fulton	12380	2254	938	152626	2254	2718
39	Gallatin	4009	3016	3242	0	3016	4578
40	Garrard	4172	2433	1609	0	2433	2258
41	Grant	7877	2918	4588	5416	2918	4290
42	Graves	3370	2358	1782	0	2358	2387
43	Grayson	3082	3603	3665	22782	3603	6787
44	Green	1209	1704	1429	643	1704	2681
45	Greenup	13034	2274	3268	3747	2274	3547
46	Hancock	990	4034	3955	0	4034	3561
47	Hardin	4348	2854	2362	3587	2854	4932
48	Harlan	594	3808	163	281	3808	1760
49	Harrison	4878	686	3444	955	686	3179
50	Hart	1510	4405	577	8640	4405	5234
51	Henderson	694	2167	1816	9989	2167	2750
52	Henry	3985	3189	5459	1737	3189	4670
53	Hickman	8592	2470	2069	0	2470	3356
54	Hopkins	733	1694	5870	11179	1694	3916
55	Jackson	1937	5528	4451	8915	5528	3523
56	Jefferson	11943	11330	11643	7672	11330	9279
57	Jessamine	1642	2438	4390	1085	2438	4110
58	Johnson	31605	4979	5321	1718	4979	4854
59	Kenton	2026	9585	6269	3930	9585	6066
60	Knott	3991	5400	5666	3648	5400	4962
61	Knox	3659	5484	1407	1774	5484	2108
62	Larue	2199	2335	629	3059	2335	3837
63	Laurel	4454	4290	1289	127	4290	1982
64	Lawrence	60692	3934	6248	4358	3934	5853
65	Lee	7813	4641	7870	2806	4641	8473
66	Leslie	5833	4853	2076	93	4853	5600

[1] The value of K for Equation 11 is 2577 for all locations.

TABLE 22 -- Continued

		ROUGH RIVER K[1]			DEWEY K[1]		
		Actual	Eq. 20	Eq. 21	Actual	Eq.20	Eq. 21
67	Letcher	2449	4527	4674	3159	4527	2793
68	Lewis	3406	3953	5105	1330	3953	4852
69	Lincoln	4757	3974	4886	3276	3974	4344
70	Livingston	3409	3448	2935	0	3448	3800
71	Logan	1820	1580	2484	27043	1580	5203
72	Lyon	2133	2642	1119	0	2642	1878
73	McCracken	1316	0	1065	6330	0	1763
74	McCreary	8114	5538	1312	0	5538	1174
75	McLean	1318	3211	3434	0	3211	4491
76	Madison	1599	2906	5641	5347	2906	4799
77	Magoffin	20023	5924	7015	1986	5924	5791
78	Marion	727	3407	1480	895	3407	5065
79	Marshall	3339	2813	460	4598	2813	1661
80	Martin	17638	5123	5453	1440	5123	4277
81	Mason	1235	2078	2422	3724	2078	2440
82	Meade	2414	2444	710	5989	2444	2146
83	Menifee	7326	5832	7183	5163	5832	5398
84	Mercer	2437	1549	3043	461	1549	3032
85	Metcalfe	3611	2799	1627	0	2799	379
86	Monroe	4207	4061	1725	5644	4061	1112
87	Montgomery	4273	3696	5970	3811	3696	5625
88	Morgan	5153	5214	6436	2554	5214	5261
89	Muhlenberg	797	3806	8092	5899	3806	5698
90	Nelson	2378	3051	6740	8913	3051	5447
91	Nicholas	2154	2220	4661	15840	2220	4305
92	Ohio	1176	3921	4382	3036	3921	5279
93	Oldham	5585	312	4914	968	312	3030
94	Owen	4011	1009	5286	4578	1009	5070
95	Owsley	0	5997	7829	0	5997	5647
96	Pendleton	6802	3382	3307	303	3382	3321
97	Perry	5344	3660	5762	1422	3660	4721
98	Pike	5573	3722	4970	3512	3722	2154
99	Powell	4008	4605	7021	8556	4605	7574
100	Pulaski	1329	4294	37	176	4294	41

[1] The value of K for Equation 11 is 2577 for all locations.

TABLE 22 -- Continued

		ROUGH RIVER K[1]			DEWEY K[1]		
		Actual	Eq. 20	Eq. 21	Actual	Eq. 20	Eq. 21
101	Robertson	46732	5023	4904	0	5023	5118
102	Rockcastle	6284	5265	4146	0	5265	5289
103	Rowan	8858	3891	5597	1790	3891	4678
104	Russell	3463	4438	1063	909	4438	1002
105	Scott	1982	894	5492	2460	894	5202
106	Shelby	4863	715	6041	9209	715	4958
107	Simpson	3070	2492	3045	18531	2492	3856
108	Spencer	863	4227	5560	0	4227	4861
109	Taylor	2880	2054	1241	0	2054	3103
110	Todd	720	3510	2454	0	3510	4297
111	Trigg	1436	4149	2459	0	4149	4478
112	Trimble	1716	1882	6168	0	1882	4934
113	Union	590	2119	710	0	2119	3305
114	Warren	1028	2062	1737	0	2062	3706
115	Washington	676	3767	4697	0	3767	5326
116	Wayne	1635	3880	1472	0	3880	1724
117	Webster	1878	1263	92	0	1263	3291
118	Whitley	637	4330	1351	733	4330	1499
119	Wolfe	7048	5944	7757	4066	5944	9222
120	Woodford	4696	734	3493	0	734	3219
121	Alabama	588	7880	3974	758	7880	2932
122	Arizona	7008	9379	4715	0	9379	5136
123	Arkansas	359	5531	1705	170	5531	3274
124	California	22992	5252	4280	4466	5252	4545
125	Colorado	6689	6254	3478	1103	6254	3936
126	Connecticut	4207	2056	5521	1895	2056	3733
127	Delaware	1178	0	1029	1499	0	272
128	District of Columbia	0	14086	8048	794	14086	7519
129	Florida	3568	4664	3711	3824	4664	2682
130	Georgia	461	6356	3098	335	6356	1959
131	Idaho	8435	437	448	0	437	831
132	Illinois	1177	4452	1433	1745	4452	5681
133	Indiana	2129	4914	3812	1914	4914	4782
134	Iowa	591	4692	3753	314	4692	3994

[1]The value of K for Equation 11 is 2577 for all locations.

TABLE 22 -- Continued

		ROUGH RIVER K[1]			DEWEY K[1]		
		Actual	Eq. 20	Eq. 21	Actual	Eq. 20	Eq. 21
135	Kansas	1117	3647	2276	849	3647	2924
136	Louisiana	714	7861	2259	1275	7861	3230
137	Maine	5142	2694	2618	1955	2694	1573
138	Maryland	1560	3904	5226	972	3904	2961
139	Massachusetts	925	6167	5656	397	6167	4842
140	Michigan	1544	5678	5702	7585	5678	5754
141	Minnesota	453	7116	2295	920	7116	4294
142	Mississippi	822	4815	2698	297	4815	4010
143	Missouri	574	6271	1877	2618	6271	3579
144	Montana	0	2888	190	0	2888	1151
145	Nebraska	2258	5985	1943	0	5985	2292
146	Nevada	13858	3221	3097	0	3221	3609
147	New Hampshire	10097	1209	2007	579	1209	1581
148	New Jersey	2331	15	3489	550	15	2188
149	New Mexico	2094	3716	2827	0	3716	3271
150	New York	927	7252	7338	402	7252	4685
151	North Carolina	304	5802	2039	49	5802	2338
152	North Dakota	1440	732	0	0	732	1062
153	Ohio	2560	5419	5019	2018	5419	2479
154	Oklahoma	2029	6115	3390	1059	6115	4014
155	Oregon	4920	3617	1276	0	3617	1633
156	Pennsylvania	808	5361	3119	719	5361	656
157	Rhode Island	800	9429	6071	0	9429	4919
158	South Carolina	147	4765	1725	98	4765	1468
159	South Dakota	490	3151	1247	0	3151	2068
160	Tennessee	209	7274	2634	358	7274	1097
161	Texas	1906	9359	5883	3128	9359	6126
162	Utah	0	5912	3593	0	5912	3909
163	Vermont	13124	549	2553	0	549	588
164	Virginia	1454	6005	4918	3930	6005	2923
165	Washington	6569	4181	1533	0	4181	1655
166	West Virginia	556	4201	2417	8350	4201	1062
167	Wisconsin	1044	4575	506	2059	4575	2721
168	Wyoming	3806	0	0	6942	0	0

[1]The value of K for Equation 11 is 2577 for all locations.

higher values for this variable than do any of the other origin areas. It was thus hypothesized that extrapolation of the linear relationship developed between K and X_3 from Rough River data where the major origin areas had low values of X_3 to Dewey Reservoir was causing the problem. In other words, the relationship between K and X_3 became curvelinear for higher values of X_3. In order to approximate this curvelinear relationship with two line segments, various ceiling values to X_3 were tried. For origin areas having a value of X_3 greater than the ceiling value, the ceiling value was used in Equations 20 and 21.

The ceiling value was selected by starting at a ceiling value just above the highest value of X_3 for any origin area and reducing it one percentage point at a time until R^2 was no longer increased. The ceiling value selected was 20 percent. It changed visitation estimates for 45 counties and 2 states. At Rough River using Equation 20, 29 location estimates changed for the better and the remainder got worse. Using Equation 21, 31 increased in accuracy; and 16 decreased. Likewise, at Dewey for Equation 20, 40 estimates increased, and 7 decreased in accuracy; and using Equation 21, 39 increased, and 8 decreased.

Comparison of Equations Derived in This Study

The relative success of the various correlations attempted is summarized on Table 23. The sum of the squares of the derivations of estimated values from actual values using Equations 11, 20, and 21 respectively to estimate visitation, along with R^2 values indicate the degree of accuracy attained. The sum of the squared derivations for Equations 20 and 21 denotes a slight decrease in accuracy for Rough River estimates with the age ceiling limit. However, Dewey estimates were significantly improved.

Incorporating population, route, and competition factor variables, Equations 20 and 21, was found to increase accuracy for Rough River

TABLE 23

ACCURACY OF VISITATION ESTIMATE

	Without Age Ceiling*	With Age Ceiling*		
	$\frac{\Sigma(V_a - V_e)^2}{10^{10}}$	R^2 Percent	Mean $(V_a - V_e)$	$\frac{\Sigma(V_a - V_e)^2}{10^{10}}$
1. Rough River				
Eq. 11		44.12	+1024	6.869
Eq. 20	1.965	83.67	-2438	2.007
Eq. 21	0.7659	93.10	-1450	0.849
2. Dewey				
Eq. 11		91.22	-62	1.047
Eq. 20	17.91	23.81	-4731	9.087
Eq. 21	25.36	26.97	-3292	8.710

*V_a = Actual Visitation

V_e = Visitation as estimated from indicated equation

Reservoir. Table 23 indicates the increasing success of using Equation 21 over using Equation 20 and of Equation 20 over Equation 11. Equation 11, however, produces the highest correlation for Dewey Reservoir. The low regression coefficients and high sum of the departures squared for Dewey is caused primarily by overestimating visitation from adjacent mountain counties. The better results for Rough River Reservoir stem from a rather close estimate of visitation from Jefferson County, the origin area from which the most visitors come. Both statistics are largely dependent on how closely visitation from the major origin areas is estimated. On the whole, the equations derived from Rough River data were reasonably successful in estimating Dewey visitation, but correlating K with origin area characteristics did not effect a significant improvement.

Calculation of visitors per capita based on estimates of visitation using Equations 11, 20, and 21 revealed varying R^2 values for the same visitation estimate. For example, the R^2 value for applying Equation 11 to Rough River data equalled 44.12 percent. With the same visitation stated in terms of visitors per capita, the value of R^2 equalled 92.15 percent. The moral is the expression of the same regression equation in different terms can greatly improve the regression coefficient even though the results remain identical. A higher value of R^2 does not automatically mean a better correlation if the improved R^2 is obtained by shifting the form of the equation.

The audited visitors, annual visitors estimated from actual visitors, and annual visitors estimated from Equations 11, 20, and 21 to both Rough River and Dewey Reservoirs are presented on Table 24.

Comparison with Equations Derived in Other Studies

For comparison purposes, Merewitz's Equations 6, 7, and 8 were applied to data for the 120 Kentucky Counties to estimate relative visitation from each county to each reservoir. Merewitz's Equations do not lend themselves to applications to areas as large as states. Equations 11, 20, and 21 were also applied to the 120 counties for comparisons. The resulting estimates were normalized so total estimated visitors equalled total actual visitors for both Rough River and Dewey Reservoirs. In other words, the number of visitors estimated by the equation from each origin area was multiplied by the proper constant to make total estimated visitors equal the actual recorded total. This was necessary to get all equations in terms of total annual visitors before comparing them. Table 25 indicates the relative success attained by each equation, stated in terms of deviation squarred and coefficient of multiple determination (R^2).

TABLE 24

VISITATION AT ROUGH RIVER AND DEWEY RESERVOIRS

	ROUGH RIVER RESERVOIR					DEWEY RESERVOIR				
	Aud. Visits	Actual Visits	Eq. 11 Est.	Eq. 20 Est.	Eq. 21 Est.	Aud. Visits	Actual Visits	Eq. 11 Est.	Eq. 20 Est.	Eq. 21 Est.
1 Adair	72	836	985	1327	782	0	0	181	244	106
2 Allen	88	1022	1167	1541	0	15	442	75	99	0
3 Anderson	59	685	425	504	495	2	59	217	257	220
4 Ballard	40	465	111	126	87	0	0	12	14	13
5 Barren	255	2961	4049	4251	1306	14	413	217	228	0
6 Bath	15	174	103	181	256	32	943	900	1572	2372
7 Bell	31	360	344	575	809	52	1533	1602	2674	299
8 Boone	52	604	349	0	239	12	354	298	0	168
9 Bourbon	99	1150	317	110	544	59	1739	780	270	1307
10 Boyd	94	1092	266	71	200	711	20962	11551	3073	11246
11 Boyle	141	1637	912	662	138	4	118	461	334	93
12 Bracken	26	302	91	101	81	23	678	246	273	187
13 Breathitt	22	255	131	218	397	151	4452	6691	11157	16843
14 Breckenridge	5601	65041	59820	92272	92105	2	59	87	133	146
15 Bullitt	427	4958	2840	3034	7383	19	560	156	166	231
16 Butler	387	4494	6037	12712	9324	8	236	44	93	102
17 Caldwell	53	615	645	612	881	0	0	33	31	45
18 Calloway	41	476	445	569	271	0	0	40	52	49
19 Campbell	82	952	1068	0	285	80	2359	1636	0	314
20 Carlisle	55	639	69	92	38	0	0	8	11	8
21 Carroll	40	465	235	181	393	0	0	98	76	146
22 Carter	84	975	135	229	240	72	2123	5436	9241	11017

TABLE 24 -- Continued

	ROUGH RIVER RESERVOIR					DEWEY RESERVOIR				
	Aud. Visits	Actual Visits	Eq. 11 Est.	Eq. 20 Est.	Eq. 21 Est.	Aud. Visits	Actual Visits	Eq. 11 Est.	Eq. 20 Est.	Eq. 21 Est.
23 Casey	48	557	615	1385	640	0	0	270	608	398
24 Christian	105	1219	3813	2664	4108	12	354	163	114	219
25 Clark	41	476	368	38	692	221	6516	1102	113	2028
26 Clay	11	128	236	458	190	46	1356	1536	2988	2365
27 Clinton	33	383	334	638	142	0	0	108	206	52
28 Crittenden	39	453	371	426	515	2	59	20	23	34
29 Cumberland	33	383	448	577	181	5	147	82	106	32
30 Daviess	2937	34106	30493	3823	23289	18	531	272	34	316
31 Edmonson	137	1591	5092	9318	2278	0	0	51	93	111
32 Elliott	26	302	44	81	99	148	4363	2935	5424	6116
33 Estill	4	46	182	296	478	9	265	1142	1864	2877
34 Fayette	451	5237	3108	10124	8679	653	19252	4374	14248	11626
35 Fleming	10	116	114	202	232	51	1504	806	1425	2126
36 Floyd	42	488	239	364	469	9888	291522	246465	376134	461023
37 Franklin	136	1579	1106	0	1381	171	5041	600	0	602
38 Fulton	41	476	99	87	36	31	914	15	14	16
39 Gallatin	11	128	82	96	103	0	0	49	58	87
40 Garrard	40	465	287	271	179	0	0	294	277	257
41 Grant	48	557	182	206	325	13	383	182	206	304
42 Graves	51	592	453	414	313	0	0	51	47	48
43 Grayson	5594	64960	54306	75933	77249	30	884	100	140	264
44 Green	65	755	1609	1064	892	1	29	118	78	123
45 Greenup	73	848	168	148	213	148	4363	3001	2649	4130
46 Hancock	237	2752	7166	11217	11000	0	0	25	39	34
47 Hardin	6203	72032	42690	47279	39126	29	855	614	680	1176

TABLE 24 -- Continued

		ROUGH RIVER RESERVOIR					DEWEY RESERVOIR				
		Aud. Visits	Actual Visits	Eq. 11 Est.	Eq. 20 Est.	Eq. 21 Est.	Aud. Visits	Actual Visits	Eq. 11 Est.	Eq. 20 Est.	Eq. 21 Est.
48	Harlan	7	81	353	521	22	14	413	3784	5593	2585
49	Harrison	39	453	239	64	320	6	177	477	127	589
50	Hart	222	2578	4400	7522	985	13	383	114	195	232
51	Henderson	83	964	3577	3009	2521	13	383	99	83	106
52	Henry	55	639	413	511	875	4	118	175	216	317
53	Hickman	22	255	77	73	62	0	0	10	10	13
54	Hopkins	109	1266	4447	2924	10131	17	501	116	76	176
55	Jackson	11	128	170	365	294	96	2830	818	1755	1118
56	Jefferson	28198	327446	70646	310639	319204	559	16481	5535	24338	19932
57	Jessamine	22	255	401	379	683	6	177	420	398	670
58	Johnson	127	1475	120	232	248	4127	121674	182542	352730	343851
59	Kenton	119	1382	1758	6539	4277	109	3214	2107	7838	4960
60	Knott	15	174	112	236	247	525	15478	10934	22915	21055
61	Knox	38	441	311	661	170	26	767	1114	2370	911
62	Larue	237	2752	3224	2921	787	4	118	99	90	148
63	Laurel	59	685	396	660	198	2	59	1194	1988	918
64	Lawrence	133	1544	66	100	159	622	18338	10843	16554	24628
65	Lee	22	255	84	152	257	41	1209	1110	1999	3651
66	Leslie	18	209	92	174	74	2	59	1637	3083	3557
67	Letcher	15	174	183	322	332	263	7754	6324	11109	6855
68	Lewis	11	128	97	148	191	17	501	971	1490	1828
69	Lincoln	87	1010	547	844	1038	20	590	464	715	782
70	Livingston	22	255	193	258	220	0	0	14	19	21
71	Logan	147	1707	2416	1481	2330	29	855	81	50	164
72	Lyon	14	163	196	201	85	0	0	13	14	10

TABLE 24 -- Continued

	ROUGH RIVER RESERVOIR					DEWEY RESERVOIR				
	Aud. Visits	Actual Visits	Eq. 11 Est.	Eq. 20 Est.	Eq. 21 Est.	Aud. Visits	Actual Visits	Eq. 11 Est.	Eq. 20 Est.	Eq. 21 Est.
73 McCracken	44	511	1000	0	414	8	236	96	0	66
74 McCreary	59	685	218	468	111	0	0	270	581	123
75 McLean	114	1324	2588	3224	3448	0	0	33	42	58
76 Madison	38	441	711	802	1556	113	3332	1605	1810	2990
77 Magoffin	55	639	82	189	224	561	16540	21465	49351	48239
78 Marion	39	453	1606	2123	922	3	88	255	337	501
79 Marshall	44	511	394	430	70	2	59	33	36	21
80 Martin	29	337	49	98	104	663	19547	34986	69560	58070
81 Mason	8	93	194	156	182	41	1209	836	675	792
82 Meade	962	11171	11926	11311	3287	11	324	140	132	116
83 Menifee	11	128	45	102	125	50	1474	736	1665	1541
84 Mercer	51	592	626	376	740	2	59	330	198	388
85 Metcalfe	96	1115	796	864	502	0	0	78	85	11
86 Monroe	101	1173	718	1132	481	7	206	94	149	41
87 Montgomery	28	325	196	281	454	50	1474	997	1430	2175
88 Morgan	15	174	87	176	218	216	6368	6426	13002	13120
89 Muhlenberg	173	2009	6494	9592	20392	8	236	103	152	228
90 Nelson	252	2926	3171	3755	8295	32	943	273	323	577
91 Nicholas	7	81	97	84	176	75	2211	360	310	601
92 Ohio	1182	13726	30084	45779	51161	3	88	75	114	154
93 Oldham	143	1661	766	93	1461	2	59	157	19	185
94 Owen	29	337	216	85	444	9	265	149	58	294
95 Owsley	0	0	61	142	185	0	0	704	1638	1542
96 Pendleton	33	383	145	191	186	1	29	251	329	323

TABLE 24 -- Continued

	ROUGH RIVER RESERVOIR Aud. Visits	Actual Visits	Eq. 11 Est.	Eq. 20 Est.	Eq. 21 Est.	DEWEY RESERVOIR Aud. Visits	Actual Visits	Eq. 11 Est.	Eq. 20 Est.	Eq. 21 Est.
97 Perry	46	534	258	366	576	192	5661	10257	14568	18791
98 Pike	55	639	295	427	570	3806	112210	82324	118897	68801
99 Powell	11	128	82	147	224	64	1887	568	1015	1670
100 Pulaski	36	418	811	1351	12	2	59	865	1441	14
101 Robertson	51	592	33	64	62	0	0	85	166	169
102 Rockcastle	55	639	262	535	421	0	0	575	1175	1180
103 Rowan	32	372	108	163	235	106	3125	4525	6833	8215
104 Russell	55	639	475	818	196	2	59	167	288	65
105 Scott	24	279	362	126	772	15	442	463	161	935
106 Shelby	172	1997	1058	294	2481	31	914	256	71	492
107 Simpson	137	1591	1335	1291	1578	13	383	53	52	80
108 Spencer	13	151	451	739	972	0	0	90	148	171
109 Taylor	149	1730	1548	1234	745	0	0	214	171	258
110 Todd	26	302	1080	1472	1029	0	0	39	53	64
111 Trigg	16	186	333	537	318	0	0	21	34	37
112 Trimble	11	128	192	140	459	0	0	66	48	126
113 Union	15	174	760	625	209	0	0	36	30	47
114 Warren	487	5655	14177	11347	9556	0	0	237	190	342
115 Washington	20	232	886	1295	1615	0	0	175	255	361
116 Wayne	26	302	476	716	272	0	0	238	359	159
117 Webster	85	987	1354	664	48	0	0	41	20	52
118 Whitley	8	93	376	632	197	7	206	725	1219	422
119 Wolfe	15	174	64	147	192	109	3214	2036	4697	7288
120 Woodford	62	720	395	112	536	0	0	299	85	374

TABLE 24 -- Continued

	ROUGH RIVER RESERVOIR					DEWEY RESERVOIR				
	Aud. Visits	Actual Visits	Eq. 11 Est.	Eq. 20 Est.	Eq. 21 Est.	Aud. Visits	Actual Visits	Eq. 11 Est.	Eq. 20 Est.	Eq. 21 Est.
121 Alabama	145	1684	7380	22569	11383	40	1179	4010	12263	4562
122 Arizona	15	174	64	233	117	0	0	47	171	93
123 Arkansas	29	337	2416	5187	1599	2	59	897	1924	1139
124 California	315	3658	410	836	681	19	560	323	659	570
125 Colorado	49	569	219	532	296	2	59	138	334	210
126 Connecticut	75	871	533	426	1143	25	737	1002	799	1452
127 Delaware	7	81	178	0	71	9	265	456	0	48
128 District of Columbia	0	0	460	2517	1438	16	472	1532	8374	4470
129 Florida	168	1951	1409	2550	2029	85	2506	1689	3057	1758
130 Georgia	85	987	5515	13602	6631	30	884	6801	16775	5171
131 Idaho	10	116	35	6	6	0	0	28	5	9
132 Illinois	1159	13459	29467	50910	16383	182	5366	7924	13689	17468
133 Indiana	4748	55136	66735	127274	98716	573	16893	22739	43366	42202
134 Iowa	40	465	2025	3687	2950	4	118	969	1765	1503
135 Kansas	34	395	911	1290	805	5	147	447	633	508
136 Louisiana	35	406	1468	4478	1287	16	472	953	2908	1195
137 Maine	18	209	105	110	106	4	118	155	163	95
138 Maryland	90	1045	1726	2615	3501	66	1946	5158	7814	5926
139 Massachusetts	29	337	938	2245	2059	9	265	1723	4125	3239
140 Michigan	374	4343	7246	15968	16033	775	22849	7763	17107	17335
141 Minnesota	12	139	793	2190	706	6	177	496	1368	826
142 Mississippi	58	674	2112	3946	2211	4	118	1024	1914	1594
143 Missouri	107	1243	5582	13585	4067	70	2064	2031	4944	2822
144 Montana	0	0	32	36	2	0	0	25	28	11

TABLE 24 -- Continued

		ROUGH RIVER RESERVOIR					DEWEY RESERVOIR				
		Aud. Visits	Actual Visits	Eq. 11 Est.	Eq. 20 Est.	Eq. 21 Est.	Aud. Visits	Actual Visits	Eq. 11 Est.	Eq. 20 Est.	Eq. 21 Est.
145	Nebraska	35	406	464	1077	350	0	0	253	589	225
146	Nevada	4	46	9	11	10	0	0	7	8	9
147	New Hampshire	52	604	154	72	120	2	59	262	123	161
148	New Jersey	160	1858	2054	12	2781	34	1002	4693	27	3986
149	New Mexico	6	70	86	124	94	0	0	57	83	73
150	New York	148	1719	4775	13439	13598	46	1356	8689	24453	15799
151	North Carolina	58	674	5701	12835	4510	18	531	27741	62459	25174
152	North Dakota	4	46	83	24	0	0	0	60	17	25
153	Ohio	2930	34024	34246	72024	66704	2709	79868	101988	214493	98124
154	Oklahoma	57	662	841	1995	1106	6	177	430	1022	670
155	Oregon	8	93	49	68	24	0	0	38	54	24
156	Pennsylvania	164	1904	6075	12639	7354	145	4275	15313	31856	3896
157	Rhode Island	4	46	150	547	352	0	0	270	989	516
158	South Carolina	15	174	3059	5656	2048	9	265	6964	12878	3968
159	South Dakota	2	23	122	149	59	0	0	81	99	65
160	Tennessee	204	2369	29280	82651	29926	38	1120	8058	22747	3429
161	Texas	89	1034	1397	5075	3190	38	1120	923	3353	2195
162	Utah	0	0	51	117	71	0	0	37	85	56
163	Vermont	29	337	66	14	66	0	0	111	24	25
164	Virginia	128	1486	2634	6138	5027	483	14240	9338	21761	10593
165	Washington	17	197	77	126	46	0	0	62	101	40
166	West Virginia	50	581	2691	4388	2524	1611	47496	14656	23897	6039
167	Wisconsin	74	859	2121	3766	416	41	1209	1513	2686	1598
168	Wyoming	4	46	31	0	0	2	59	22	0	0

TABLE 25

VISITATION ACCURACY COMPARED WITH OTHER STUDIES

Expression	Rough River*		Dewey*	
	R^2 Percent	$\frac{\Sigma(V_a - V_e)^2}{10^{10}}$	R^2 Percent	$\frac{\Sigma(V_a - V_e)^2}{10^{10}}$
1. 120 Origin Areas				
A. Merewitz				
Eq. 6	94.55	0.6459	-80.26	19.89
Eq. 7	5.06	11.26	- 9.20	12.05
Eq. 8	-13.15	13.42	52.97	5.19
B. This Study				
Eq. 11	58.93	4.87	92.98	0.7748
Eq. 20	95.99	0.4745	85.47	1.60
Eq. 21	95.91	0.4852	87.34	1.40
2. 168 Origin Areas				
A. Knetsch				
Eq. 2	33.09	9.21	90.70	1.28
B. This Study				
Eq. 11	44.12	6.87	91.22	1.05
Eq. 20	83.67	2.01	23.81	9.09
Eq. 21	93.10	0.8488	26.97	8.71

*V_a = Actual Visitation

V_e = Visitation as estimated from indicated equation

The coefficient of multiple determination (R^2) was found to not always be very helpful in defining how well estimated values agree with actual values. As defined:

$$R^2 = 1.0 - \frac{\Sigma(V_{actual} - V_{estimate})^2}{\Sigma(V_{actual} - \overline{V}_{actual})^2} \quad (22)$$

where $\overline{V}_{actual}$ is the mean value of actual annual visitation as found by Equation 9 (29). Negative values of R^2, Table 25, are obtained when the numerator is greater than the denominator. Corrections for degrees of freedom were neglected because of a large sample size. This study used both R^2 and the numerator of Equation 22 in describing accuracy of resulting expressions. As indicated on Table 25, by both R^2 and squared deviations Merewitz's estimates were generally less accurate than results from this study for both Dewey and Rough River Reservoirs.

Knetsch's Equation 2 was also applied to Dewey and Rough River data for comparison, Table 25. Estimates, however, were not normalized for the 168 origin areas. The values of R^2 and sum of squared deviations can only be compared, in all fairness, to Equation 11, because neither Equation 2 nor Equation 11 include origin area descriptive variables other than distance, population, and a constant K. Table 25 indicates that Equation 11 from this study, however, proved more accurate in estimating visitation.

To the author's knowledge, Equation 2 by Knetsch and Equations 6, 7, and 8 by Merewitz represent the latest and most accurate methods of estimating reservoir visitation. Table 25 indicates the equations proposed by this study more accurately estimate visitation to the two Kentucky Reservoirs than equations by either Knetsch or Merewitz.

Chapter V

BENEFIT ESTIMATES

Introduction

A modified Hotelling-Clawson procedure of estimating reservoir recreation benefits was used in this study (14). The method consisted of adding incremental travel distances to the air distance from each origin area to the reservoir and relating the resulting reduced visitation to the cost of traveling the portion of the incremental distance the visitor is estimated to have travelled out of his way to reach the reservoir. The full incremental distance is used to estimate visitation to count visitors who come within the vicinity of the reservoir for other reasons and then go on to visit the reservoir. However, only the out-of-the-way (effective) distance can be associated with the cost spent to enjoy the experience.

The incremental added distance was converted to effective distance, Figure 22, and cost of traveling the increment was calculated as the product of effective distance and a unit cost per mile. Added distance had added cost and reduced visitation. The demand curve expressed visitation as a function of incremental travel cost. The area under the demand curve equals recreation benefits attributable to the reservoir. Four demand curves were determined for each reservoir. The first was derived using the actual annual visitation estimated for the origin area from the visitor surveys as the initial visitation and the remaining three used respectfully Equations 11, 20, and 21 in defining initial conditions. The three values based on the three equations were then compared with the benefit estimated from visitor survey counts for each reservoir.

Procedure

Equations 11, 20, and 21 provide estimates of visitation corresponding to the combination of distance, population, route, and competition characteristics applying to a particular origin area. If all other characteristics are held constant and distance is increased by increments, estimated visitation decreases. The cost of traveling the incremental distance was calculated as the product of the incremental distance, the fraction of the total distance being out-of-the-way distance as read from Figure 22, and a unit cost per mile. Plotting visitation for each increment as a function of cost for that increment produced the demand curve. The area under the curve was calculated and equalled recreation benefits.

All values and equations, except one, necessary in calculating benefits have been previously presented. The one remaining value needed is an average cost per mile of travel required on the part of a visitor to spend a day at the site. The cost was calculated using:

$$C = 2.42 \left[(1 + a)\, m + \frac{t}{v} \right] / bp \tag{23}$$

where C is the cost per mile in dollars per visitor-day spent at the site, 2.42 is the product of 2.0 which accounts for round trips and 1.21 an average value of road distance divided by air distance, b is the average number of days a visitor remains at the site, p is the average number of visitors per vehicle, m is the variable vehicle operating cost in dollars per mile, t is the value of a vehicle-hour of traveling time in dollars, v is the mean travel velocity in miles per hour, and a is the expense incurred for food and lodging above that spent at home expressed as a fraction of vehicle operating cost. The equation determines the extra expense the visitor would incur to visit the site if he lived one mile further away.

A wealth of data has been collected by highway planners for use in evaluating the terms of Equation 23 (35). Ullman determined the values of 2.0 for b and 3.5 for p from data collected at Meramac State Park, Missouri (36). The University of Kentucky Bureau of Business Research found average values of 2.27 for b and 2.55 for p for Kentucky State parks (37). Wilbur Smith and Associates have estimated the national average of the marginal travel cost as 0.053 dollars per mile (38). Knetsch quotes a value of 0.0516 (39). Merewitz also quotes a value of 0.0516 (15). The importance of including travel time in the analysis is pointed out by the fact that time required for the trip rather than vehicle operating cost is often the primary factor deciding whether a family will drive to the lake. Most highway planning studies currently use a value of $1.55 based on 1.8 persons per vehicle, however, this value was rounded to $1.50 for this study (35). The value of a varies from zero for those living close to the site to over 1.0 for those coming long distances. If reliable information were available for relating the value of the variables in Equation 23 to travel distance, C could be expressed as a function of distance and the results incorporated into the solution. However, this was not attempted in this study. The only variable evaluated from data collected as part of this study was the average number of visitors per vehicle, all other variables were evaluated from other studies.

The computational procedure used to estimate recreation benefit to a selected origin area is illustrated in Example 1. The benefits were, however, actually calculated by programming the illustrated procedure for the IBM 7040 computer.

Cost associated with each increment indicated on Table 26 is

EXAMPLE 1: SAMPLE CALCULATION OF RECREATION BENEFIT

The following example estimates annual benefit accruing to Jefferson County, Kentucky, as a result of the construction of Rough River Reservoir. Jefferson County contains the city of Louisville and accounts for nearly 40 percent of the total visitation to Rough River. Both actual benefits (benefits based on visitors actually counted) and Equation 21 benefits are calculated.

1. The population of Jefferson County is 610,947 and the air distance to Rough River is 60 miles, Table 21. Actual visitation to the reservoir for 1966 was 327,445, and Equation 21 estimated visitation is 319,204, Table 24.

2. A value for C, the cost per additional mile per visitor-day was estimated from Equation 23 using $\bar{b}$ = 2.27 days, p = 3.67 visitors per vehicle, m = 0.053 dollars per mile, t = 1.50 dollars per hour, v = 40 miles per hour, a = 0.50. The result is:

$$C = 2.42 \left[1.50\ (0.053) + 1.50/40\right] / (2.27)(3.67) = \$0.034$$

C was evaluated in the same manner for calculating benefits from Dewey Reservoir except that Dewey visitor counts indicated only 2.65 persons per vehicle.

EXAMPLE 1 (Continued)

3. The incremental distances added to the 60 miles to Jefferson County are tabulated in the first column on Table 26. Effective distance corresponding to each incremental distance added was determined from Figure 22 and also indicated in Table 26. Costs were calculated as the product of C and ΔD.

4. KP was calculated for visitors actually counted by solving Equation 1 to get Vd^n where n was taken as 2.445 from the correlation of Equation 11. KP would also equal the product of actual K from Table 22 and P. For Jefferson County,

$$KP = Vd^n = 327,445 \times 60^{2.445} = 7,297,000,000$$

The reduction in visitation which would take place were Jefferson County further from Rough River was estimated from the product of KP and $d^{-2.445}$ for each incremental distance.

5. KP based on Equation 21 was calculated as:

$$KP = 11,643 \times 610,947 = 7,113,000,000$$

The value of K found by substituting the population, route, and competition characteristics of Jefferson County with respect to Rough River Reservoir is shown on Table 22 to be 11,643. Reduced visitation for incremental distance increases was calculated by multiplying this second KP by $d^{-2.445}$.

6. Table 26 lists the calculated points on the demand curve. Columns 3 and 5 are plotted as the demand curve based on actual visitation in Figure 24. The area under the curve indicates an annual benefit of $381,537 to Jefferson County visitors. The demand curve based on visitation predicted by Equation 21 is not plotted since it agrees well with the curve shown. Estimated benefits or the area under the unplotted curve totalled $371,934. Both benefit estimates indicate a benefit per visitor-day for Jefferson County visitors to Rough River Reservoir of about $1.16.

TABLE 26

COMPUTATIONS FOR DERIVING MARGINAL BENEFIT CURVE
JEFFERSON COUNTY TO ROUGH RIVER RESERVOIR

Added Distance D (1)	Cost Distance ΔD (2)	Cost C_d (3)	Visitation Distance d (4)	Actual KP=7,297,000,000 $V=KPd^{-2.445}$ (5)	Estimate Eq. 21 KP=7,113,000,000 $V=KPd^{-2.445}$ (6)
0	0		60	327,445	319,204
10	10	0.340	70	224,615	218,962
20	20	0.680	80	162,045	157,966
30	30	1.020	90	121,494	118,436
40	40	1.360	100	93,900	91,537
50	49	1.683	110	74,379	72,507
60	59	2.007	120	60,124	58,611
70	68	2.316	130	49,437	48,192
80	77	2.633	140	41,243	40,205
90	86	2.937	150	34,840	33,963
100	95	3.233	160	29,754	29,005
120	112	3.803	180	22,308	21,746
140	127	4.332	200	17,242	16,808
160	139	4.733	220	13,657	13,313
180	146	4.975	240	11,040	10,762
200	150	5.100	260	9,077	8,849
300	150	5.100	360	4,096	3,993
600	150	5.100	660	930	907
1200	150	5.100	1260	191	187
2400	150	5.100	2460	37	36

calculated as the product of column 2 and a constant. Column 2 is thus the effective distance of column 1. Some might wonder why the demand curve does not plot column 5 against cost from column 4 distance instead of column 2 distance. However, the total area under the curve would then equal travel cost plus consumers surplus. The travel cost is actual distance traveled times cost per mile. The fallacy of including both is indicated by considering those people living close to the reservoir. The average cost of getting to the reservoir is not the value of the recreation experience to these people, because many of them would still pay to visit even if the distance were much further or if a user charge were initiated. The purpose of Equation 11 is to estimate the number of people who would still visit at various cost levels.

Application

The procedure illustrated by Example 1 was applied to calculate benefits from Rough River Reservoir to all 168 origin areas. Except for the modification to C caused by a difference in the average number of visitors per vehicle as mentioned in Example 1, the identical process was repeated at Dewey. Benefits based on actual visitation and visitation predicted by Equations 11, 20, and 21 were calculated for each reservoir. Summing the visitation from all the origin areas for a given distance increment gives one point on the total demand curve. Repeating for each incremental distance yielded the total reservoir demand curve expressing visitation as a function of cost. A tabulation of origin area benefits by each method for both reservoirs is presented on Table 27. By dividing representative benefits on Table 27 by representative visitation from Table 24, one can see how the average actual benefit per visitor-day increases from about $0.36 for the closest origin areas to about $4.61 for the furthest origin areas. The values are for the most part within the range of from $0.50 to $2.50 per visitor-day as recommended by Senate Document 97.

Two of the resulting demand curves for Rough River (actual and Equation 21 visitation) are presented on Figure 25. Likewise, the same two curves are presented for Dewey on Figure 26. Total actual and estimated visitation, benefits, and per capita benefits for each of the three equations and each reservoir are presented on Table 28.

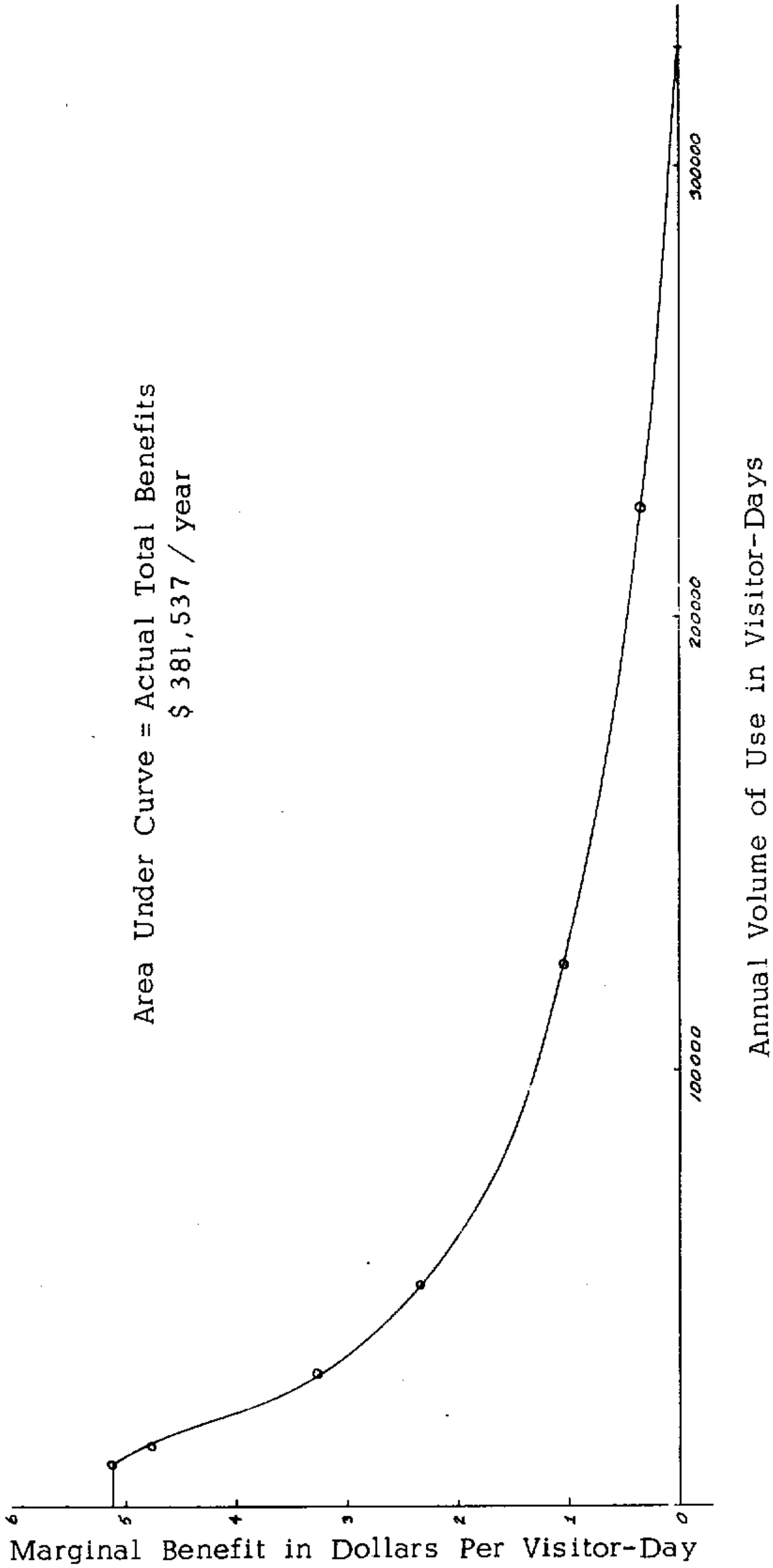


Fig. 24.-- Rough River Reservoir, Jefferson County Demand Curve

TABLE 27

BENEFITS BY LOCATION

		ROUGH RIVER BENEFITS				DEWEY BENEFITS			
		Actual	Eq. 11	Eq. 20	Eq. 21	Actual	Eq. 11	Eq. 20	Eq. 21
1	Adair	1152	1357	1828	1078	0	545	735	321
2	Allen	1266	1445	1908	0	1559	263	348	0
3	Anderson	1033	641	761	747	149	546	648	555
4	Ballard	991	237	270	186	0	56	64	61
5	Barren	3225	4409	4630	1422	1386	729	765	0
6	Bath	386	230	401	569	1600	1526	2667	4023
7	Bell	827	791	1321	1860	3283	3430	5725	640
8	Boone	1235	714	0	489	1042	878	0	495
9	Bourbon	2298	634	220	1088	3784	1697	587	2843
10	Boyd	2879	702	187	528	27437	15119	4023	14720
11	Boyle	2571	1432	1039	217	309	1207	876	243
12	Bracken	657	199	221	177	1586	575	639	438
13	Breathitt	606	310	517	941	4662	7007	11683	17638
14	Breckenridge	23560	21668	33424	33363	209	307	474	517
15	Bullitt	5008	2869	3065	7457	1777	493	527	732
16	Butler	2990	4017	8459	6204	879	165	347	381
17	Caldwell	928	973	923	1329	0	136	129	189
18	Calloway	905	847	1082	515	0	176	225	212
19	Campbell	2073	2325	0	620	6406	4443	0	852
20	Carlisle	1390	150	201	84	0	38	51	35
21	Carroll	810	409	316	685	0	296	228	440

TABLE 27 -- Continued

		ROUGH RIVER BENEFITS				DEWEY BENEFITS			
		Actual	Eq. 11	Eq. 20	Eq. 21	Actual	Eq. 11	Eq. 20	Eq. 21
22	Carter	2450	339	576	603	2631	6738	11453	13655
23	Casey	875	965	2174	1004	0	733	1652	1080
24	Christian	1680	5255	3672	5662	1439	665	464	893
25	Clark	952	735	75	1383	13386	2264	232	4167
26	Clay	283	523	1017	421	2513	2846	5536	4381
27	Clinton	625	544	1040	232	0	326	622	157
28	Crittenden	711	583	669	808	249	84	96	142
29	Cumberland	554	648	833	262	461	258	331	101
30	Daviess	25781	23050	2890	17604	2046	1050	132	1220
31	Edmonson	1059	3388	6200	1516	0	179	327	387
32	Elliott	748	108	200	245	4461	3001	5545	6253
33	Estill	97	380	620	999	461	1982	3236	4995
34	Fayette	9693	5752	18736	16062	45016	10227	33316	27186
35	Fleming	262	258	457	525	2786	1494	2640	3939
36	Floyd	1256	615	938	1209	131112	110848	169167	207346
37	Franklin	2574	1803	0	2251	13420	1597	0	1603
38	Fulton	1119	233	204	85	4184	71	62	75
39	Gallatin	243	156	183	196	0	147	172	261
40	Garrard	810	500	472	312	0	705	666	618
41	Grant	1087	356	403	633	1036	493	558	820
42	Graves	1227	939	859	649	0	228	208	211

TABLE 27 -- Continued

		ROUGH RIVER BENEFITS				DEWEY BENEFITS			
		Actual	Eq. 11	Eq. 20	Eq. 21	Actual	Eq. 11	Eq. 20	Eq. 21
43	Grayson	24765	20704	28949	29451	3094	350	489	922
44	Green	822	1752	1159	972	92	370	245	385
45	Greenup	2184	432	381	548	7312	5028	4438	6920
46	Hancock	1418	3693	5781	5669	0	92	144	127
47	Hardin	47930	28406	31460	26035	2767	1987	2201	3804
48	Harlan	201	874	1292	55	765	7010	10362	4789
49	Harrison	905	478	127	639	408	1101	293	1359
50	Hart	2175	3712	6346	831	1271	379	648	770
51	Henderson	1152	4275	3595	3013	1552	400	337	427
52	Henry	1041	673	833	1426	334	496	613	898
53	Hickman	567	170	163	136	0	46	45	61
54	Hopkins	1475	5182	3407	11804	2023	466	307	709
55	Jackson	261	348	746	601	5190	1500	3218	2050
56	Jefferson	381537	82315	361954	371934	53329	17910	78754	64496
57	Jessamine	446	699	662	1192	422	1002	949	1599
58	Johnson	3753	306	591	632	48565	72860	140789	137245
59	Kenton	2889	3675	13670	8941	8899	5835	21705	13736
60	Knott	438	283	592	621	14268	10079	21123	19408
61	Knox	961	677	1440	369	1654	2404	5116	1967
62	Larue	2322	2720	2464	664	377	317	288	472
63	Laurel	1401	811	1350	406	124	2516	4188	1935

TABLE 27 -- Continued

		ROUGH RIVER BENEFITS				DEWEY BENEFITS			
		Actual	Eq. 11	Eq. 20	Eq. 21	Actual	Eq. 11	Eq. 20	Eq. 21
64	Lawrence	4027	171	261	415	15016	8878	13555	20166
65	Lee	567	187	337	571	1797	1651	2973	5428
66	Leslie	496	219	413	177	88	2434	4585	5290
67	Letcher	443	466	819	846	10326	8422	14795	9129
68	Lewis	312	236	362	468	929	1799	2760	3388
69	Lincoln	1705	924	1425	1752	1442	1135	1750	1913
70	Livingston	454	343	459	391	0	62	83	91
71	Logan	1989	2815	1726	2714	3291	314	192	633
72	Lyon	274	332	340	144	0	57	58	41
73	McCracken	1021	2000	0	827	1048	427	0	292
74	McCreary	1370	435	935	221	0	708	1521	322
75	McLean	1162	2271	2830	3027	0	130	163	227
76	Madison	839	1352	1524	2960	7019	3383	3814	6300
77	Magoffin	1561	201	462	547	10492	13616	31306	30600
78	Marion	561	1989	2629	1142	254	731	967	1438
79	Marshall	946	730	797	130	255	143	156	92
80	Martin	898	131	261	278	10323	18478	36737	30669
81	Mason	210	438	353	412	2588	1791	1445	1696
82	Meade	7433	7936	7526	2188	1098	472	448	393
83	Menifee	289	101	230	283	2095	1046	2367	2191
84	Mercer	930	983	591	1161	153	855	514	1006

TABLE 27 -- Continued

		ROUGH RIVER BENEFITS				DEWEY BENEFITS			
		Actual	Eq. 11	Eq. 20	Eq. 21	Actual	Eq. 11	Eq. 20	Eq. 21
85	Metcalfe	1381	985	1070	622	0	251	272	37
86	Monroe	1663	1019	1606	682	687	314	494	135
87	Montgomery	680	410	588	950	2731	1846	2649	4030
88	Morgan	420	210	425	524	6032	6087	12315	12427
89	Muhlenberg	1865	6028	8904	18929	916	400	591	885
90	Nelson	3187	3453	4089	9033	2845	823	974	1739
91	Nicholas	170	203	175	368	4504	733	631	1224
92	Ohio	6549	14353	21841	24409	335	284	433	583
93	Oldham	2399	1107	134	2110	180	479	58	563
94	Owen	606	389	152	798	728	410	160	806
95	Owsley	0	135	315	411	0	1092	2541	2393
96	Pendleton	801	304	398	390	74	631	829	814
97	Perry	1306	630	894	1408	6750	12230	17370	22406
98	Pike	1740	804	1162	1552	83069	60944	88019	50933
99	Powell	278	179	319	487	3350	1009	1803	2965
100	Pulaski	774	1500	2500	22	149	2179	3632	35
101	Robertson	1264	70	136	133	0	196	383	390
102	Rockcastle	1215	498	1018	801	0	1221	2495	2506
103	Rowan	882	257	387	557	3502	5070	7656	9205
104	Russell	1003	746	1285	308	169	480	826	187
105	Scott	516	670	233	1429	1062	1112	386	2245

TABLE 27 -- Continued

		ROUGH RIVER BENEFITS				DEWEY BENEFITS			
		Actual	Eq. 11	Eq. 20	Eq. 21	Actual	Eq. 11	Eq. 20	Eq. 21
106	Shelby	2885	1529	424	3584	2680	750	208	1443
107	Simpson	1854	1556	1505	1839	1428	199	192	297
108	Spencer	198	590	968	1273	0	256	420	483
109	Taylor	2143	1918	1529	923	0	635	506	765
110	Todd	374	1338	1823	1275	0	152	207	254
111	Trigg	303	544	875	519	0	90	144	156
112	Trimble	208	313	228	748	0	197	144	376
113	Union	258	1128	927	310	0	151	124	194
114	Warren	4771	11959	9572	8061	0	864	691	1242
115	Washington	304	1160	1696	2115	0	497	726	1027
116	Wayne	513	808	1217	462	0	672	1012	450
117	Webster	1223	1678	822	60	0	166	82	212
118	Whitley	194	786	1321	412	505	1775	2982	1032
119	Wolfe	400	146	338	440	3755	2380	5489	8517
120	Woodford	1215	667	190	904	0	755	215	943
121	Alabama	5150	22573	69033	34817	5485	18649	57031	21216
122	Arizona	780	287	1044	525	0	295	1075	589
123	Arkansas	1115	8001	17174	5295	306	4660	10002	5921
124	California	16854	1889	3850	3137	3608	2081	4243	3671
125	Colorado	2412	929	2255	1254	357	833	2023	1273
126	Connecticut	3549	2174	1734	4657	3928	5340	4260	7735

TABLE 27 -- Continued

		ROUGH RIVER BENEFITS				DEWEY BENEFITS			
		Actual	Eq. 11	Eq. 20	Eq. 21	Actual	Eq. 11	Eq. 20	Eq. 21
127	Delaware	312	683	0	273	1265	2175	0	230
128	District of Columbia	0	1692	9252	5286	2038	6618	36176	19310
129	Florida	7745	5593	10124	8056	13550	9132	16528	9506
130	Georgia	3252	18171	44818	21849	3912	30086	74205	22873
131	Idaho	518	158	27	28	0	173	29	56
132	Illinois	39401	86265	149039	47962	26470	39088	67531	86170
133	Indiana	115753	140105	267202	207247	62277	83825	159866	155574
134	Iowa	1668	7272	13241	10592	636	5226	9516	8101
135	Kansas	1510	3485	4932	3078	834	2530	3581	2871
136	Louisiana	1542	5571	16994	4883	2588	5229	15951	6553
137	Maine	895	448	469	456	680	896	937	547
138	Maryland	3876	6402	9699	12984	8655	22943	34759	26361
139	Massachusetts	1388	3867	9256	8488	1437	9335	22344	17543
140	Michigan	15147	25271	55689	55916	109396	37166	81903	82998
141	Minnesota	546	3107	8579	2767	1001	2803	7741	4671
142	Mississippi	2335	7321	13679	7665	617	5361	10016	8343
143	Missouri	4141	18604	45275	13554	10801	10632	25874	14767
144	Montana	0	145	163	11	0	158	177	70
145	Nebraska	1592	1816	4219	1370	0	1449	3366	1289
146	Nevada	213	40	49	48	0	42	53	59
147	New Hampshire	2506	640	300	498	324	1442	676	885

TABLE 27 -- Continued

		ROUGH RIVER BENEFITS				DEWEY BENEFITS			
		Actual	Eq. 11	Eq. 20	Eq. 21	Actual	Eq. 11	Eq. 20	Eq. 21
148	New Jersey	7257	8022	47	10860	4955	23199	135	19703
149	New Mexico	302	371	536	407	0	352	508	447
150	New York	6823	18958	53351	53984	7024	45006	126656	81831
151	North Carolina	2255	19087	42974	15102	1871	97782	220157	88735
152	North Dakota	196	351	100	0	0	357	101	147
153	Ohio	96298	96926	203847	188790	249895	319105	671116	307016
154	Oklahoma	2569	3263	7745	4294	1009	2455	5827	3825
155	Oregon	427	224	314	111	0	245	344	155
156	Pennsylvania	7092	22625	47069	27386	19608	70235	146115	17872
157	Rhode Island	192	619	2264	1458	0	1473	5388	2811
158	South Carolina	581	10204	18868	6831	1076	28243	52225	16094
159	South Dakota	96	504	617	244	0	477	583	383
160	Tennessee	5656	69906	197330	71449	4747	34146	96386	14531
161	Texas	4333	5858	21279	13374	6693	5515	20030	13111
162	Utah	0	226	519	315	0	231	529	350
163	Vermont	1396	274	58	272	0	610	130	139
164	Virginia	5402	9573	22309	18272	59929	39298	91582	44581
165	Washington	908	356	578	212	0	400	650	257
166	West Virginia	1904	8824	14387	8276	158507	48911	79750	20155
167	Wisconsin	3200	7899	14025	1550	6462	8088	14361	8541
168	Wyoming	200	136	0	0	360	134	0	0

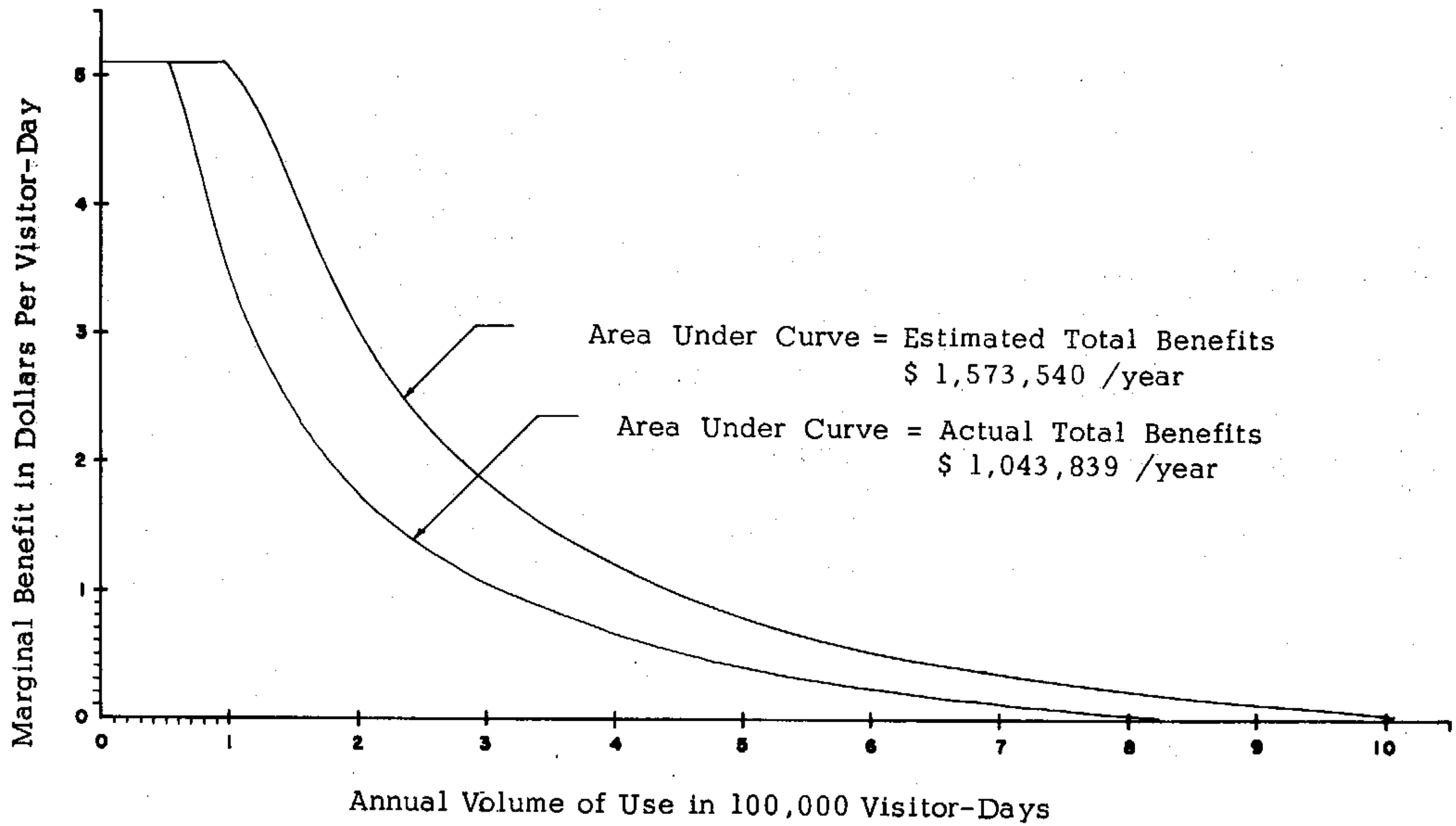


Fig. 25.-- Rough River Reservoir Recreation Demand Curve

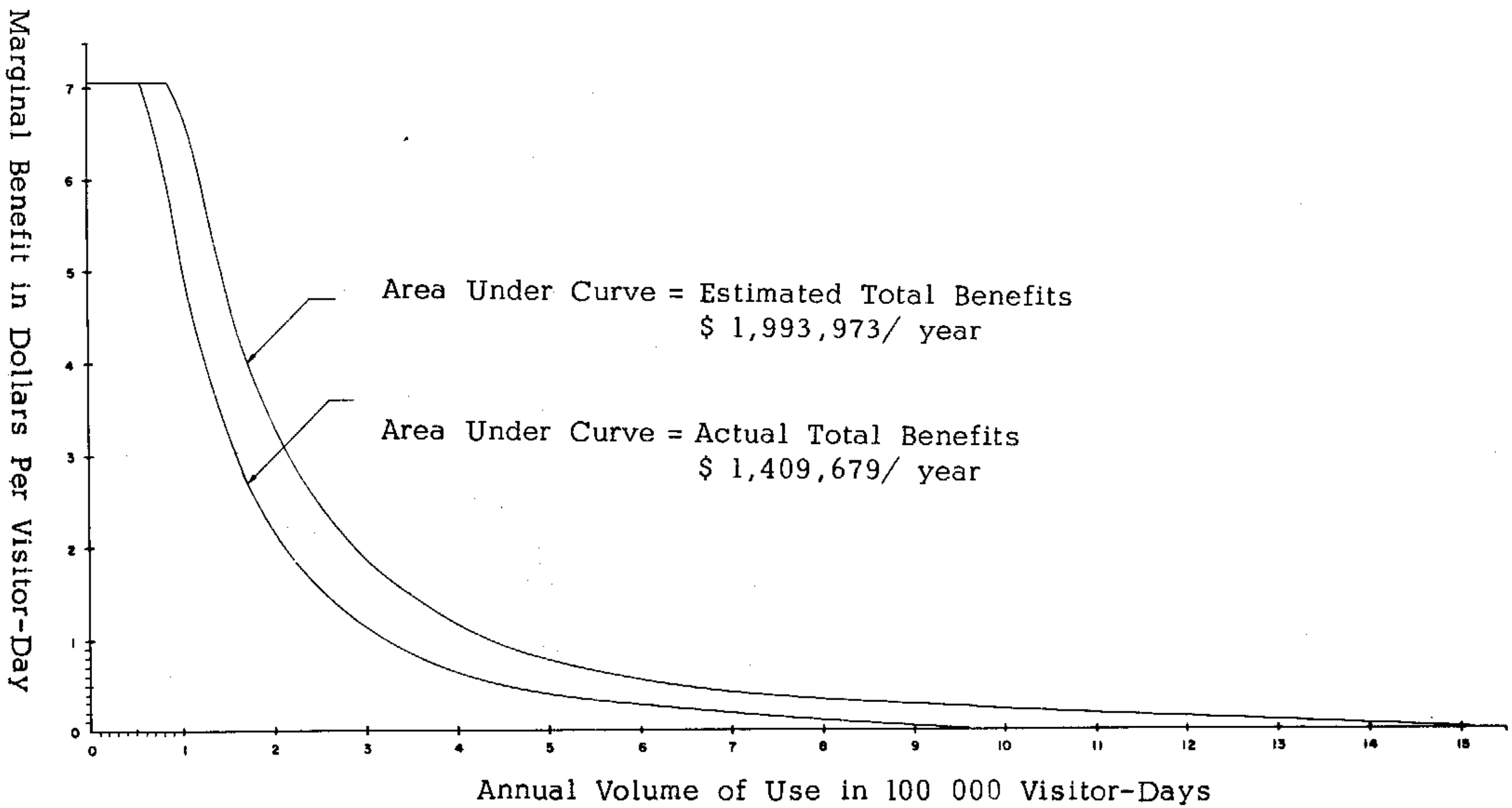


Fig. 26.-- Dewey Reservoir Recreation Demand Curve

TABLE 28

VISITATION AND BENEFIT SUMMARY

	Visitation Visitor-Days	Benefit Dollars	Dollar Benefit per Visitor-Day
1. Rough River			
Actual	824,200	1,043,838	1.266
Estimated			
Eq. 11	652,085	996,718	1.528
Eq. 19	1,233,877	2,071,612	1.679
Eq. 20	1,067,785	1,573,539	1.474
2. Dewey			
Actual	960,300	1,409,678	1.468
Estimated			
Eq. 11	970,846	1,526,002	1.572
Eq. 19	1,755,279	3,023,694	1.723
Eq. 20	1,513,517	1,993,972	1.317

Chapter VI

SUMMARY AND CONCLUSIONS

Evaluation of Results

Results obtained through this study may be classified into three categories. An equation was developed for estimating visitation to a recreation reservoir by dividing the surrounding area into origin areas, applying the equation to the population of the origin area and the air distance from the origin area to the reservoir, and summing the origin area visitations. The equation was refined by incorporating population, route, and competition characteristics. The visitation equations were applied to the analysis of recreation benefits for use in project economic analysis.

Visitation estimated from distance and population alone explained most of the variation in visitation among origin areas for Rough River Reservoir for which the constants in the basic relationship were developed. The method proved just as accurate when the Rough River constants were applied to Dewey Reservoir. While the constants should not be applied without empirical verification to reservoirs significantly different in character or setting than Rough River, good results should be achieved in predicting visitation to similar reservoirs.

Incorporation of population, route, and competition characteristics improved visitation estimates for Rough River Reservoir as Rough River data were used to establish the regression coefficients, but the refined equation gave worse results than the equation of the first type when applied to Dewey Reservoir. Possible reasons for this lack of generality in the Rough River regression include nonlinear relationship between visitation rates and the characteristics considered, the great diversity between the characteristics of Jefferson County, the major origin area for Rough River Reservoir, and the mountain counties contributing the bulk of the visitors to Dewey, and characteristics overlooked in the analysis. Some deviation in estimating Dewey visitation from equations derived from Rough River may be attributed to the geographical setting in which the facilities are located and differences in quantity and quality of facilities available.

The method of benefit analysis applied in this study makes the reliability of estimated benefits depend directly on the reliability of the distribution of total visitors among origin areas. The benefit estimates labelled actual are actual only in the sense they are based on the actual distribution of visitors among origin areas and not in the sense of being a universally uncontroversial value. Benefits evaluated from the actual visitation distribution are the best estimates this study could produce of the annual economic benefit resulting from recreation at the two reservoirs and agreed well with estimates based on Equation 11 for both reservoirs. They differed from estimates based on Equations 20 and 21 because these equations did not do as well as Equation 11 in distributing total visitation among the origin areas. Even for Rough River Reservoir where the correlation including population, route, and competition characteristics improved the regression coefficient based on K as the dependent variable, it gave a less reliable benefit estimate. This is because of the higher unit benefit per user-day with increased distance from the origin area to the reservoir (divide benefits on Table 26 by visitation on Table 24). This study provides little encouragement for the use of factors other than population and distance in a visitation prediction equation used for benefit evaluation.

The method of benefit evaluation used is an improvement over the previously used procedures due primarily to substitution of effective for total travel distance. The modification worked well and should be incorporated into future analytic procedures. However, data defining the effective distance curve were limited, and additional data might vary its plotted position.

Application of Results

The method proposed for evaluating reservoir recreation benefits may be applied in analyzing both existing reservoirs and proposed reservoirs. Logically, benefit estimates for existing reservoirs should be based on actual counts of visitors by origin area as presented in this study. Where only total visitation and not visitation by origin area is known, total visitors may be distributed among origin areas by normalizing on the basis of Equation 11.

Visitation and benefit estimates for a proposed reservoir with a climate and size similar to Rough River and Dewey Reservoirs would be best determined using Equation 11. The inclusion of other characteristics is more work and failed to increase accuracy for either reservoir. As an alternative, Equations 20 and 21 estimates of visitation and benefits might be improved by the collection and analysis of additional data.

One specific application of interest for which Equation 21 can be used is to estimate visitation changes caused by construction of new four-lane highways or new recreation reservoirs. Once route and competition factors have been developed for a given reservoir, factors revised by construction of either a highway or a reservoir may be substituted in Equation 21 to produce new visitation estimates. The effect of the changed visitation on benefit can be determined by repeating the benefit analysis with and without the change. Equation 20 or 21 might also be used to estimate changes in visitation or benefit caused by time changes in population characteristics.

Suggested Additional Research

In reviewing literature presented in Chapter I, it is readily apparent that limits are unbounded as far as needed, if not necessary, additional research in the field of recreational analysis. One obvious topic requiring further study is the variation of visitation rates as a function of quantity and quality of the available facilities. This information is required to develop a marginal benefit curve. Likewise, the effect of climate or geographical setting on visitation should be researched. Both expansions would involve detailed analysis of many reservoirs of varying size and in varying geographical and climatological settings.

In addition, data should be collected describing variations in the unit cost of distance travelled as a function of the distance. Although not specifically used in this analysis, visitors per vehicle were found to vary with distance from the reservoir. Many other variables described in Example 1 would logically vary with distance.

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