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A Perspective on Economic Impact

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A PERSPECTIVE ON ECONOMIC IMPACT

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PREFACE

This research report serves as a technical completion report for a research project entitled "The Economic Impact of Flood Control Reservoirs" sponsored by the University of Kentucky Water Resources Institute and financially supported largely by funds provided by the United States Department of the Interior as authroized under the Water Resources Research Act of 1964, Public Law 88-379, as Office of Water Resources Research Project No. A-006-KY. Some financial help was also obtained from the Louisville and Huntington District Offices of the U. S. Army Corps of Engineers.

Eighteen people worked on the project in various capacities over a seven-year period. Each received a great deal of help and cooperation from the Corps of Engineers and a multitude of officials in state and local government. The staff of the University of Kentucky Computer Center helped in many ways to expedite the computational work. The total technical research results are presented in a series of thirteen reports, each by one of the graduate students listed on the title page and referenced in the List of References at the end of this report. Project findings and specific acknowledgments are contained in each report. This report summarizes the results and assesses the overall impact of the total study.

This report was written by the principal investigator at the conclusion of the total project. The interpretations it contains do not necessarily represent the unanimous agreement of all eighteen people working on the project nor of the various agencies that contributed information.

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ABSTRACT

The institutions responsible for water resources management in the United States have originated as political responses to major social issues. Each agency institutionalized a procedure for structuring and comparing alternatives in the formulation of its total program. Each agency originally sought to promote effective resolution of its social issue (flood control, development of arid lands, soil erosion, etc.), but more recent efforts have sought better coordination among agency practices through a common procedure largely derived from economic theory. Any procedure, however, varies in application with the interpretation and judgment of individual planners. Today, public pressures have brought political directives requiring consideration of the local and nationwide impacts of projects that occur through direct, indirect, and secondary means in the spheres of economic, social and environmental effects.

The body of the study reviews fourteen specific impact issues with the goals of providing planners a methodology for dealing with each one and of providing the theoretically inclined a basis for improving each methodology. The issues are reservoir effects on local property values, reservoir effects on the economy of the local county, changes in income and employment patterns around large reservoirs, patterns of land use change around reservoirs, reservoir effects on revenues and expenditures of local government, reservoir recreation benefits, application of marginal economic analysis to reservoir recreation planning, economic value of natural areas for recreational hunting, for stream fishing, the personal value of real property to its owner, reservoir project caused income redistribution, achievement of more flexible procedures for reservoir operation in order to match changes in demand for project output with time, estimation of flood damages by the time pattern in which they occur, and operation of reservoir systems for flood control. Each study is presented in detail in a referenced report, and this report discusses the significance of the findings of the studies, individually and as a group.

KEY WORDS: benefits, economic impact, economic justification, employment opportunities, estimated benefits, flood damage, government finance, hunting, institutional constraints, land use, political aspects, project planning, property values, recreation, reservoir operation, social adjustment, sport fishing.

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CHAPTER I

INSTITUTIONAL SETTING FOR RESOURCE MANAGEMENT

A PROBLEM ORIENTED HERITAGE

Each individual determines the use he wants to make of water and space in a given day; and individual wants, through interactive and then through cumulative processes, aggregate to fix the total usage of water and related land resources made by mankind at any point in time. Neither water nor land, however, are available for use in quantities exceeding a physically fixed upper limit. Furthermore, problems with quality or with distribution of availability by time or space impose increasingly severe constraints as total usage approaches this upper limit. Conflicts among users competing for the same resource become more severe, and opportunities for users to achieve complementary goals through cooperation become more evident. As an example, two growing towns may compete for the water in a single stream until they find that it can no longer meet their combined need and then combine forces to tap a more distant supply.

In many such situations, it becomes the role of government to act to promote the general welfare by regulating competing uses or by providing the institutional framework needed for individual interests to work together for mutual gain. Either kind of program begins with the assignment of specific duties and responsibilities to some governmental entity, which thereafter remains responsible for that aspect of resource management. The continued effectiveness of an authorized program requires regular allocation of sufficient funds to the designated agencies for them to develop and maintain the needed expertise and manpower to do the job.

The authorization of new agencies or the assignment of new duties to old ones essentially begins when the political leadership perceives a need. Leaders with foresight may perceive a need and then convince their constituency while more passive leadership may not recognize a coming issue until forced to do so by public pressure; but in either case it is a problem, present or anticipated, that provides the impetus for action.

The history of the water resources management activities of the United States government provides many examples. Out of an era when freer movement of commerce down rivers to the sea could make it possible for a nation of farmers to sell their produce and secure a cash income to support their families came the U. S. Army Corps of Engineers and a program to enhance navigation on inland waterways.. Out of the opportunity to prevent the westward movement of the frontier from becoming stalled where the rains gave out and to transform a barren wilderness into a garden of agricultural productivity, where those who knew only the grime of industrial centers or the poverty of subsistence agriculture could find a new and better life, came the Bureau of Reclamation and a program to irrigate the dessert. Out of the loss of topsoil by erosion until countless farms had to be abandoned and great billowing clouds of dust rolled across the plains came the Soil Conservation Service and a program to manage soil and water throughout rural America. Out of the opportunity to make it possible for one of the most poverty stricken sections of the nation to achieve a better life through wiser use of their natural resources came the Tennessee Valley Authority and a program to harness the rivers of an Appalachian valley. Today, out of a nationwide concern over destructive pollution and the gradual dissolution of many values from the natural environment is coming the Environmental Protection Agency and a closer review of the environmental impact of all human activity.

A PROBLEM ORIENTED MISSION

Each of these agencies was born as the nation perceived a problem and by political means achieved a consensus in establishing an action program to do something about it. Each agency was strongly committed to meet what it perceived as a major social need. Each agency once commissioned to attack a broad problem had to translate its mandate and commitment into specific actions to provide relief in specific problem situations. Each agency knew that its continued growth and even its existence depended on its ability to solve problems and develop a clientele of beneficiaries satisfied by its program. The authorization of new activities and, to a lesser extent, the continuation of old ones require that political decision makers continually perceive a broad base of support.

Agencies charged with water resources management responsibility are thoroughly ingrained with the need to listen to the problems that people bring to them and often conceive of program applications to help people in ways that they themselves do not perceive. A flood control reservoir, a power plant, or a navigable waterway does not spring up over-night. Each new project begins many years before its construction when some group of people perceive a community problem that can be remedied through a government project and express their concept through official channels (35, pp. 145-147). Such people seek to improve their well-being by working with designated agencies of government to prevent flood-caused devastation, to harness the energy of falling water, or to use rivers as pathways for commerce. The agencies use their expertise to develop appropriate technical designs through which their clients can realize their dreams.

A SITUATION ORIENTED ANALYSIS

The process has no better illustration than that found in the problems created by floods, the efforts by those who suffer flood damage to seek relief through institutionalized means, and the response of water management agencies to these requests. No consequence of flood waters rampaging through an inhabited area is more sure than a subsequent mobilization of people seeking to get something done.

When the agency responsible for dealing with flood hazards gets such a request, it must consider the situation in the light of a number of institutional factors. The inclination to help is constrained by a planning budget too small to study every request in detail, by a construction budget too small to build every project it deems worthy, and by the activities of those who stand to lose from the very measures which will profit those who request help. The planning entity needs to concentrate its energies on those requests most likely to be productive and thereby further its base of public support. The practical means for program formulation is a series of progressively finer screens for discarding from further consideration projects not found to meet established standards. The underlying concept is that only the more promising proposals warrant detailed study.

Each progressively finer screen requires a progressively more exacting design of an appropriate remedial action. Designs are refined by collecting additional data and completing a more comprehensive analysis in search of the most desirable way of doing the job. A host of subquestions are involved. What combination of measures (reservoirs, channels, flood proofing of structures in the flood plain, land use management, etc.) should be employed? What magnitude of flood should each measure be designed to handle? How should each individual measure be designed (exact location, materials, shape, etc.)? Through what operating procedure can a given design be most effectively employed?

The search for the best solution requires a thorough understanding of the way the problem affects people. The planner needs to go beyond the engineering expertise required to specify a physically functioning design. He must consider the problem as perceived by those who experience it, the way project supporters and opponents perceive the consequences of each alternative, and the long run effects proposed solutions will have on man and his environment. Furthermore, all such factors need to be analyzed in the context of <u>each flood situation</u> submitted for study. A project can only be well-planned as it is designed on the basis of the physical, economic, and social information portraying the situation at hand.

PLANNING PROCEDURES IN THEORY

Project design may be approached at several levels of sophistication. One may propose a levee that would contain a recent historical flood, but the next flood may rise higher. One may propose a levee to contain the largest possible flood, but the cost may be prohibitive. One may seek to compromise with a levee height that has the least total in a tradeoff between levee cost and flood damage, but the residual risk of drowning or the residual environmental disruption may be unacceptable. One may seek to further some broader definition of human welfare (one combining human lives saved and environmental preservation with economic factors) only to find himself confronted with so many emotionally charged, conflicting viewpoints and issues that the whole situation seemingly defies objective analysis. Ultimately, the design needs to reconcile what the prospective beneficiaries want from a flood control program with what would be in the overall public interest for their government to give them.

The Diversity of Flood Damage

People come away from flood experience with many kinds of memories. In a few special situations, certain subcultures may remember a social event held while the elements raged outside. Normally, however, people will recall the financial loss suffered through the destruction of their property, long hours of work spent in cleaning and repairing, and shock over the loss of items of particular personal or sentimental value. Those living in flooded areas may remember the physical discomfort caused by exposure to wet and often cold while fighting the flood or fleeing to higher ground. Severe events mean illness, injury, and even the loss of life. Those living on higher ground may feel an environmental loss as stately trees are uprooted. They will feel a different kind of loss if the uprooted trees batter and destroy a bridge and thereby disrupt travel to work, school, or medical facilities.

The Basis for Objective Comparison

The mentioned consequences of flood events are only suggestive of the diversity of the economic, social, and environmental disruption left in the wake of major floods. Flood control measures are justified by their success in reducing the severity and frequency of all types of damage. However, remedial measures produce their own set of consequences which may be just as diverse and are generally of the same overall magnitude, even if they are not as spectacular or as sudden, as the floods themselves. The planner must strive to balance the good against the bad in his search for what to do.

Objective analysis requires that all these diverse consequences be put on a common basis by measurement in the same units (18, p. 11). Economic or dollar units are the only reasonable ones for making differences in kind commensurable. Many items destroyed by or used in controlling floods are assigned dollar values through buying and selling in the marketplace. Because others are not, economist through theoretical constructs and empirical analyses are continually seeking better ways to impute the values people individually or collectively place on all manner of goods, services, and experiences. The imputed values can then be used to estimate the amount of harm caused by floods and the value of the opportunities for alternative investment sacrified to implement each proposed remedial measure.

To the degree that the techniques devised represent relative values in a socially meaningful way, the reduction of diverse effects into commensurable units provides a basis for comparing achievements and sacrifices. It opens the way to be objective in determining the design which maximizes the total well being of all those affected through the approximation of maximizing the net excess of values gained as floods are prevented over values sacrificed as resources and space are devoted to flood control measures rather than to other purposes. As summarized by Gaffney,

> One of the most important functions of economic analysis is to evaluate public policy. Economics, contrary to common usage, begins with the postulate that man is the measure of all things. Direct damage to human health and happiness is more directly 'economic,' therefore, than damage to property, which is simply an intermediate means to health and happiness. Neither do economists regard 'economic' as a synonym for 'pecuniary.' Rather, money is but one of the means to ends, as well as a useful measure of value. 'Economic damage' therefore includes damage to human function and pleasure. The economist tries to weigh these direct effects on people in the same balance with other costs and benefits . . . . One can decide which of many options is best, securing maximum net benefits over costs. And, having so decided, one can devise means to compensate the losers from the gains of the winners in the interest of distributive equity. (17)

The most ardent supporters of economic analysis have always recognized that such a procedure can never be entirely objective because of limitations in the ability to assign monetary value to many kinds of consequences. They recommend that a list be kept of factors that cannot be adequately reduced to monetary units and that this bundle of irreducible data be used together with the results of the economy study in the final decision making (18, pp. 17, 472-474). The difficulty is that the introduction of these "apples" to compare with the "oranges" transforms an objective to a subjective decision. The greater the relative importance of the irreducible data, the more subjective the process becomes. In essence, the main point made by the critics of "benefit-cost" analysis is that the values which cannot be expressed in monetary units are so great relative to those which can be so expressed that objectivity is impossible. The decision is inherently so subjective that a favorable benefit-cost ratio is no more than a legerdemain whereby those who know what they want convince an unsuspecting public that a project that helps them is in the best interest of all the people.

The point is best illustrated by the diametric shift that has recently occurred in the grounds most frequently used to criticize benefit-cost analysis.

Just a few years ago, the prevailing idea was that the strict requirements of the approach overlooked many legitimate benefits which, if only they could be included, would justify many more projects. Those with this viewpoint seemed to have the feeling that benefit-cost analysis was being used by special interest groups opposed to big government to restrict resource development that could greatly help the people of the country if only it were allowed. Now the prevailing idea seems to be that the government agencies are overlooking many legitimate costs which, if only they were recognized, would prove many projects to be unwise. Those with this viewpoint seem to feel that benefit-cost analysis is being used by government agencies to sell a program of exploiting the natural environment at the expense of the long run best interest of the country.

Those who would discard, on whatever grounds, attempts to be objective by reducing all consequences to commensurable (and thus for practical reasons economic) units before deciding among alternatives are forced to seek a way to overcome the practical difficulties in aggregating and defending decisions based on comparisons among diverse units. The recent trend has been toward defining progress toward multiple objectives and providing top level decision makers information on that progress (26). The concepts that earlier appeared in Marglin's general statement of the objectives of water resources development (40, pp. 17-87) have evolved into a recommendation to use an accounting system for simultaneously measuring projected consequences (both benefits and costs) in terms of the four objectives of national economic development, a high quality environment, improved social well-being, and regional development (57). The recommended approach to project formulation is for the plan making the maximum contribution to national economic development (having maximum benefit minus cost) to still be determined but for other designs which are significantly better in terms of one or more of the other objectives to also be defined. The full range of tradeoffs among significant conflicting objectives can thereby be examined by top level decision makers in plan selection (57, pp. 18-20). Many practical evaluation problems must be overcome if the method is to be made operational (8).

The Uncertainty of the Future

No flood control measure can restore one iota of the damages already suffered. Planning is for the future. The costs used as the price of implementing measures are forecast future costs. The benefits achieved through reduction in property damage as well as the environmental and social consequences of flood control programs occur over a period extending many years into the future.

Nothing about the future can be predicted with certainty. Forecasts and projections may be right, or they may be wrong. As it becomes possible to check forecasts against subsequent events, many differences are found. Some forecast events occur while others do not. Those that occur depart from predicted magnitudes by varying degrees. For example, some predicted changes in flood plain land use will not occur, and damages predicted for land uses that are found in the flood plain will miss by varying degrees.

Economic analyses or benefit-cost studies require a series of steps (35, pp. 15-17). In order, alternatives are defined, physical consequences are predicted, monetary values are placed on physical consequences, discounting is used to convert the predicted time stream of monetary values into a present worth (or equivalent uniform annual value), and the alternatives are examined to find the one with the largest net present worth. Like economic effects, the effects of an alternative on social well-being and on the environment will also occur in some time pattern over the life of the alternative. In a world of differential inflation, technological change, and fluctuating consumer preferences, forecasts of future economic values are prone to major error; but the problem is far more severe for future social and environmental accounts. One can easily appreciate the difficulty in assigning a value to the economic loss the owner of a building will suffer if it is inundated to a given depth 30 years hence; but he is more likely to be overwhelmed by the difficulty in forecasting how people at that time will view social welfare, regional development, or environmental quality. The error planners in 1941 would have made in forecasting the economic component of flood damages based on 1971 conditions is orders of magnitude less than that likely to have occurred in the predictions they would have made of the importance attached by society in 1971 to improving the lot of the urban poor, to the desirability of increasing concentrations of population and economic activity in major cities, or to protecting the ecologic value of swamps. Planners in 1971 are almost sure to experience just as much difficulty in forecasting for 2001. Without doubt, a requirement that a multiple objective approach be used greatly compounds the difficulty of forecasting for planning.

Multiple objective analysis also has major implications for discounting procedures. The fundamental reason for discounting is to achieve equivalence among units of value realized at different times. Monetary returns realized sooner are worth more because they are surer and can sooner be placed in alternative uses. Planners discount to bring out the advantage of projects producing benefits sooner. In considering future consequences to social well-being or to the environment, one still needs to recognize that environmental or social consequences occurring in one year are not equivalent to those occurring in another year. However, the discount rate for establishing time equivalence varies with the objective (41, p. 47ff). The discount rate used for economic effects is tied to the capital market and the expansion of capital goods for future production (35, pp. 119-131). Research is needed to establish appropriate discount rates with respect to other objectives.

Refinement of Approach

The key to good project planning is reliable procedures for forecasting project consequences. Reliability is tested by waiting for the time lapse to the forecast events to transpire and then checking the forecast with the experience. Each check can be used to refine the procedure. The better procedure can be used in the next forecast, and the process can be repeated in the feedback loop of an improving methodology directed toward an ideal end product.

The ideal planning procedure would correctly predict all future consequences for all reasonable alternatives, translate each consequence into an unambiguous numerical estimate of true social worth, and sort through all possible ways of combining elements from the alternatives in a way leading to selection of the composite approach best promoting human welfare. Each future effect would be correctly anticipated in character, magnitude, and timing. None could dispute the utility assigned each gain and each loss. All would agree that the planners had selected the design that would truly best serve the public interest.

PLANNING PROCEDURES IN PRACTICE

The Institutionalized System

In actual fact, water resources planners must work from limited and often partially incorrect information. Forecasts and projections are based on methods and assumptions that are open to serious question. Planners are known to consistently overlook major factors. The desirability of future consequences frequently becomes a matter of open debate. Controversy is likely to develop between those who are benefited and those who are harmed by a given proposal while others with a more altruistic viewpoint will debate the relative merits of alternative approaches to improving the general welfare.

Research within the planning agencies, related governmental entities, universities, and research foundations is continually striving to improve forecasts, to set more appropriate values on predicted effects, and establish decision making processes capable of more wisely assessing all the tradeoffs. New techniques are continuously being suggested, applied, and modified. Practicing planners decide among alternative problem solving approaches. In so doing, they must choose from among alternative analytic methods and be on the lookout for new theoretical developments, computational aids, and trends in public preference.

Practicing water resources planners are primarily employees of large Federal agencies (Corps of Engineers, Bureau of Reclamation, Soil Conservation Service, etc.) or of related state or local agencies or their consultants. In order to obtain the consistency in findings prerequisite to maintaining credibility as a body of experts, any large agency must institutionalize its planning approach. Each agency develops manuals to guide its professional employees by providing and often prescribing techniques for engineering, hydrologic, and economic analysis. In response to research, experience, personality changes, public pressures, and many other factors, planning manuals are continually being revised, hopefully in the direction of being more responsive to the evolving concept of social welfare.

Elaborate mechanisms have been established for administrative review to insure conformance to accepted procedure. The wording of planning documents and the questions asked and answered in the in-house review are largely set by standard policy. The phrasing used to justify key planning decisions is that learned by past experience to satisfy reviewers and not necessarily a clear statement of the reasoning used. Reviews concentrate on eliminating deviations from standard policy and often overlook the need to better document information critical to project justification from the theoretical viewpoint. A great deal of planning time and effort is spent on matters which could not conceivably alter the substance of the findings.

In summary, population and urban-industrial growth require fuller water resources development, and larger and more complex management systems are required to supply their wants. More complex system require bigger agencies, and agencies inherently become more inflexible as they grow because the mechanisms established to standardize procedures to insure an equal treatment for all clients grow geometrically with agency size. The resulting inertia runs counter to the need for greater flexibility as human wants approach the upper limits of resource availability. Neaa this limit, the waste associated with the following fixed rules rather than adjusting the roles to meet the most pressing needs becomes socially unacceptable. For example, fixed rules for allocating reservoir storage among uses become increasingly harder to justify as people suffer increasingly more in the dry season from want of water released downstream to provide more flood storage in the wet season.

The People in the System

No one appreciates the consequences of the inertia inherent in an institutionalized planning procedure more than do the planners themselves. When pressed for facts to substantiate a controversial recommendation, they invariably revert to a general philosophy of the worthwhileness of the mission of their agency or to a personal assessment of why they believe in a specific project in terms that cannot be expressed through the institutionalized system.

One outgrowth of this gulf between formal report requirements and planner feeling on feasibility is that many of the considerations which the planner thought about long and hard are not formally stated. They do not fit prescribed blanks in an institutional document. They will not survive institutionalized review. It is grossly unfair for anyone to say, for example, that planners failed to consider some specific environmental factor in project planning just because it does not show up in the report. More likely, many an in-house discussion looked at the situation, and the planners developed strong personal feelings on the matter. The final value judgment was made in the light of the planner's personal assessment of the importance of the project, but it was a considered judgment.

Agency planners are committed to the value of their program; however, they are required to perform many numerical exercises which to them seem superfluous, irrelevant, or even ridiculous. The wildest question asked in the institutional review has to be answered. The planning process is stopped until the most meticulous conformist in the series of required reviews is satisfied. The conscientious planner has little use for this type of busy work, for numerical exercises which quantify what cannot be quantified.

The planning formula which yields an answer that does not match the inner expectation of the planner as to what is really needed may cause him to decide, even at the price of extensive explanatory discussions, to do something else. The professional judgment that planners develop for assessing a situation, deciding upon the best approach to deal with it, and determining whether a project should be built is not an unmixed blessing in terms of promoting better planning. The same experience that is invaluable in reducing time spent in pursuing hopelessly inappropriate designs simultaneously works against many appropriate but unconventional ones. Seldom does the planner await the execution of the final step of his analysis to see whether a benefit-cost ratio will be 1.01 and 0.99 before making up his mind as to whether a given project is good or bad. Long before that point in time, his personal assessment begins to color his subsequent analysis.

Only recently has research begun to focus on the perceptual pattern planners acquire for assessing a situation and the logic they use in reaching a personal conclusion. Wilson found that agency planners tend to perceive nature to be valued as a servant to be harnessed to provide physical and economic needs rather to be valued for metaphysical or ecological reasons (62). He found most agency planners to picture themselves as technical consultants and to have an elitist outlook with minimal awareness of social impact. There can be no doubt that plans are altered in little ways to match values of planners that do not coincide with the values of those whom the plans serve.

Personal assessments collectively provide substantial institutional inertia against new techniques for analysis as well as unconventional designs. A planner who is used to a given analytic approach develops a feel for the results it will give and knows what inputs to change to produce results more in keeping with his judgment of what ought to be. He is at the same time distrustful of any new more sophisticated or computerized technique, even though it may give an answer much more quickly. He runs the risk that the answer may not be what he wants, and he will then have to revert to some qualitative argument to reject it. The old techniques do not impart this kind of pressure. Computerized procedures can greatly increase planning productivity, but they are consistently underused by planners who complain they are overworked. All of this is not to argue that professional planners should become nondiscriminating slaves of any canned approach. The need is rather for explicit recognition of the forces that create bias and work against needed flexibility.

LEVELS OF PLANNING

The point to remember is that planning takes place on three levels. First is the theoretical level of developing an intellectually satisfying conceptual method for searching among all possible combinations of physical measures and human adjustments to find the one combination best promoting true social welfare. Practically speaking, the search ends with a combination close enough to the optimum to be popularly accepted as satisfactory. Second is the institutionalized level of seeking the same objective within the framework of data availability and officially established guidelines standardized to promote consistency. Third is the personal level in which each planner seeks the best project design in light of his concept of the general good, constrained by institutionalized rules, but ultimately determined by forces governed by his conscience, his professionalism, and his commitment to his agency's mission. Factors on this third level often have an emotional appeal that can be very influential at all levels of decision making.

CHAPTER II

THE ROLE OF IMPACT ANALYSIS

DEFINITION OF IMPACT

Individuals regularly perceive ways to improve their lot by sacrificing fulfillment of immediate needs in order to channel their resources toward accumulating the wherewithal to enhance their long run welfare. Examples of capital accumulation range from the primitive hunter who misses a few meals while he makes a better spear to the modern corporation executive who reduces dividends to modernize his equipment. Each investment introduces a new spear, a new machine, a better trained individual, or some other entity. Some of these entities fail and others succeed from the viewpoint of those who sacrifice to produce them, but the effort made to create each one and the results of its subsequent use affect the user, his fellows, and his physical environment. Effects become causes that generate other effects. The total sequence of effects generated through such causal linkages, extending to times and places that are very difficult to anticipate, constitute the total <u>impact</u> of the original investment. The impacts of individual investment decisions are becoming stronger and more widely felt as technology makes possible larger and more sophisticated investments, increases interdependencies among economic sectors, and contributes to greater concentrations of population in limited areas.

CATEGORIZATION OF IMPACT

<u>Definition of Categories</u>

The total impact of such large investments as major flood control reservoirs has so many facets that informed project planning requires systematic classification for the orderly examination of total impact. The classification procedure specifies the kinds of distinctions that can be made among effects, defines some breakdown into groups by each kind of distinction, and recognizes effects that fall in each group as a category.

One kind of distinction is by the manner in which an effect is felt. Economic effects change income or the ability people have to satisfy their wants and thereby to improve their lot through buying and selling in the market place. Social effects change the way people live and the degree to which people are satisfied with their way of living through relationships with other people but in ways other than by changing their income. Environmental effects change flora, fauna, landscapes, or other properties of the physical world in which people live (36, 61).

A second kind of distinction is by the kind of linkage through which the effect is felt. Direct effects result from physical contact with the project itself or with the output the project is designed to produce. Indirect effects (technological external effects) result from physical changes caused by the project but not associated with direct encounters with the project as a physical entity nor with use of the output the project is designed to produce. Secondary effects (pecuniary external effects) result from economic signals transmitted from the project through buying and selling transactions helping or hurting others and causing them to act differently and thereby affecting still others (35, pp. 107-110).

A third kind of distinction is by location where the effect is felt. The system of regional accounting recommended for project analysis in the United States subdivides the country into 173 trade regions (57, p. VI-6). If one were to measure the effects felt in each region, he would note that some gains to one region would be offset by losses in another region. Other effects would be net gains from the national viewpoint. Local effects are transfers from other regions to the area near the project. National effects are net changes from the total national viewpoint.

A fourth kind of distinction is by the desirability of the effect. Beneficial effects are those that are desirable from the viewpoint of those affected. Adverse effects are those that are undesired.

A fifth kind of distinction is by the source of the effect (37). Implementation consequences are those that originate from the activities required to install the project or to operate it after installation or from the process the project uses to produce the desired output. Performance consequences are those that originate from the goods and services the installed project produces.

Examples by Category

Five kinds of distinctions among impact effects are specified in the preceding section. Subsequent definitions were used to subdivide two of these into three groups and the other three into two groups. The result is 72 (3 x 3 x 2 x 2 x 2) categories of impact, and each is illustrated by an example in Table 1. The examples, based on effects likely to be generated by a large flood control reservoir, are not meant to portray the full dimension of any project's impact. An exhaustive list would include many other items in each category. The purpose of Table 1 is to serve the twin functions of illustrating the diversity of project impact and of providing examples that can be used to reinforce points made later in the text.

IMPACT ANALYSIS FOR PROJECT PLANNING

Planning at the Theoretical Level

Planners have always been faced with the fact that as nice as it sounds to be comprehensive by rationally considering all factors in formulating the plan that will maximize the general welfare, practical realities necessitate a distinction between major effects and minor effects. With limited time and funds, the planner must judge some effects to be major and thereby deserving of analysis and other effects to be minor and not worth study. The effects in the gray area between major and minor deserves intermediate levels of attention.

TABLE 1

CLASSIFICATION OF IMPACTS

(Examples Based on Flood Control Reservoirs)

1. Beneficial Implementation Consequences

	Economic	Social	Environmental
Local (transfers)			
Direct	Increases in income to local workers and material suppliers.	Prestige gained by the community from being near a project.	Forced relocation of an unsightly sand and gravel operation to another location.
Indirect	Gains to businesses serving traffic diverted from roads through the reservoir site.	Educational value to children of the community from observing project construction.	Less noise and dust along roads leading to former gravel pits.
Secondary	Profit to local business made possible by construction worker spending.	Spirit of innovation that leads community to constructive change.	Spinoff benefits from creation of a greater environmental awareness.
National (net)			
Direct	Income from extra jobs during a recession period.	Opportunity for unemployed workers to learn construction skills.	Use of dredge tailings from previous mining for dam construction.
Indirect	Savings in travel cost to those using relocated roads.	Improved access to medical facilities for those living near relocated roads.	Upgraded conservation practices on lands acquired around reservoir.
Secondary	Increased income to those trading with newly employed workers.	Contagious optimism from seeing drop in unemployment.	Greater willingness of a growing economy to spend money for environmental improvement.

TABLE 1, (Continued)

2. Adverse Implementation Consequences

	Economic	Social	Environmental
Local (transfers)			
Direct	Local portion of construction cost.	Forced movement of local people from reservoir site.	Dust and noise around construction site.
Indirect	Cost of educating children of construction workers.	Friction between construction workers and local people.	Unsightliness of trailer park housing construction workers.
Secondary	Loss in local business from people forced to move out of reservoir site.	Opposition from those opposed to changing character of community economy.	Deterioration in appearance of buildings housing hurt businesses.
National (net)			
Direct	Total construction cost (money could be spent in other ways).	Ill-will created among those who believe funds would be better spent some other way.	Harm to fish from sediment washed from construction site.
Indirect	Increased travel cost of taking detours during construction.	Inconvenience from construction caused travel interruptions.	Environmental disturbance within borrow areas.
Secondary	Aggrevation of shortages of scarce materials used in project construction.	Trend toward more serious confrontations as conservationists react to change in the natural environment.	Greater environmental disturbance created by a growing economy.

TABLE 1, (Continued)

3. Beneficial Performance Consequences

	Economic	Social	Environmental
Local (transfers)			
Direct	Extra income to the community from industry relocated on flood plain sites.	Better job selection after new industry is relocated.	A stocked reservoir to enhance local fishing.
Indirect	Tourist expenditures attracted from other areas by recreation lake.	Intercultural exchange with recreation visitors attracted from elsewhere.	Facelifting efforts by community to attract recreation visitors.
Secondary	Expansion of local business supplying needs of growing tourist industry.	Cultural advantages of living in a more prosperous community.	New parks developed to serve a more affluent community.
National (net)			
Direct	Reduction in property losses during flood events.	Reduction in drownings during flood events.	Reduction in toppling of trees by flood waters.
Indirect	Reduction in cost spent in detouring around flooded areas.	Less frequent isolation (without medical care) by flood blocked roads.	Reduction in harm to wildlife because habitat trees toppled.
Secondary	Increased income from expansion of a chronically depressed economy.	Spirit of optimism resulting from seeing relief of depressed economy.	Greater effort spent for environmental enhancement as economy picks up.

TABLE 1, (Continued)

4. Adverse Performance Consequences

	Economic	Social	Environmental
Local (transfers)			
Direct	Cost of community services for industry relocated on flood plain.	Loss of farm income as flood plains develop for urban use.	Deterioration of water quality caused by industry relocating on flood plain.
Indirect	Loss to farmers when recreation visitors trample crops.	Ill-feeling from recreation visitors trespassing on private property.	Litter scattered over countryside by recreationists.
Secondary	Loss to local businesses as farm land is taken out of production.	Degeneration of communities who lose industry to project area.	Typical shoddy appearance of lake recreation oriented cabins.
National (net)			
Direct	Increased damages from rare floods caused by overdevelopment in partially protected flood plain.	Psychological shock as people realize they don't have complete protection.	Loss in fertility as sediments no longer deposit on flood plain.
Indirect	Increased cost of travel because more traffic on flood plain roads.	Social adjustment problems for those deprived of open space opportunity.	Environmental loss from induced flood plain urbanization.
Secondary	Price rises if critical farm commodity becomes in shorter supply.	Greater stress felt by people exposed to the bustle of economic growth.	Degradation brought on by wider acceptance of growth objective.

As political pressures force more comprehensive planning, planners are required to analyze effects previously delegated as minor. The first theoretical problem is to develop ways to measure these effects. Technology is asked to develop new and more sophisticated monitoring systems for observing effects as they occur and new and more sophisticated techniques for predicting future effects. The second theoretical problem is to express these effects in commensurable units to the maximum practical extent. The concept of capturing the full essence of project merit in a simple benefit-cost ratio may be naive, but the expression of project merit in a thousand pages of catalogued qualitative descriptions is ridiculous. Equivalence conversions are needed to express effects of different kinds and at different times in common units. The third theoretical problem is to develop wasy to increase the productivity of planners in measuring, predicting, and evaluating in an orderly procedure culminating in a well-formulated plan. As growing public pressure requires planners to be more thorough, they will become stalled in an impossible workload unless they are provided tools to do more work in less time.

Interactions with Agency Heritage

The diversity of effects noted on Table 1 and the impossibility of condensing the full import of every one of them into an unambiguous, universally accepted number has made it easier for special interest groups (project proponents and opponents alike) to select some aspect of the total impact as a basis for a crusade. For some crusaders, selected impacts have gained such status that their provision (or prevention) is not subject to compromise, and in many cases failure to compromise has resulted in over indulgence in single-purpose efforts to the long-run harm. During different periods in history, agencies have pushed crusades against the isolation of rural America, destructive floods, unproductive deserts, poverty, soil erosion, and pollution to the point of discarding or at least distorting rational tests for comparing benefits with costs, beneficial impacts with adverse impacts. As a consequence, each such crusade has built projects that now, from the perspective of hindsight, seem unwise. The role of objective comparison of alternatives in discarding crusade excesses is extremely important, and society will be the loser if the advocates of today's crusades are allowed to forget that theirs is not the only worthy cause.

The technique for planning based on four accounts has the advantage of explicit recognition of the diversity of human values and the disadvantage of a less well defined procedure for reconciling diverse values. The challenge to planners is to overcome the problems at the theoretical level in a way that will expedite better compromises among diverse viewpoints, and one of the most important compromises is that between our crusades and those of our children.

Interactions with Local Viewpoints

The excesses of nationwide crusades have been restricted by political limitations on how far national government can go in transferring benefits from one region to another. National government balances losers against gainers and balks against overindulging any one region or interest group. At the same time, those with a local viewpoint have often reacted strongly to refusal at the national level to invest in projects of major local benefit.

In fact, such local reactions have been a major force in pushing for studies on economic impact of the type undertaken in this research. Many thought that if only all the good things a water resources project does for a community could be documented through definitive research, the ammunition would convince the federal establishment to build many more projects. However, another force has gained a great deal of strength during the period this research has been in progress. It is pushing for research on environmental impact under the presupposition that if only all the bad things a water resources project does to its environment could be documented, the ammunition would stop new projects altogether. The true research need is to improve understanding of all aspects of impact in a way that will make it possible to formulate projects that will more effectively fulfill individual and community goals and simultaneously more effectively avoid undesirable effects from other viewpoints. What to build and what not to build is only a sub-issue under the heading of how to build better.

Planning at the Institutional Level

As new techniques for better planning are developed at the theoretical level, it is necessary to incorporate them into the institutionalized planning process. A number of specific problems are worth noting.

1. The introduction of more facets of impact into a major role in project formulation will require greater disciplinary diversity among agency employees and will over time gradually change agency character.

2. The introduction of new methods of analysis will make it increasingly difficult for agency people to preselect designs or approaches and then substantiate them afterwards with figures. This loss of control is likely to be a traumatic experience for many (e.g., the Bureau of Outdoor Recreation Planner who plugs information into a procedure only to be told that a reservoir should be built to inundate a pet park site or the Corps of Engineers Planner who learns that an inland waterway should be abandoned). Planners are going to be resorting to more sophisticated mechanisms, for proving what they want to be best, and strong interagency guidelines will be required to prevent abuses.

3. The training effort required to upgrade agency expertise and maintain it at a high level will reach major proportions. The resulting human capital should be considered as an investment essential to properly fulfilling the agency mission.

4. In the broadest context, planning is a trial and error process. Projects are planned, installed, and scrutinized in operation by the public. Feedback from the outcome changes the design of future projects. Ways are needed to make the feedback loop more efficient.

All four specific problems are part of the general problem of overcoming institutional inertia. A great many new procedures will have to be institutionalized. The problem of getting the job done as quickly and as expeditiously as possible is worthy of research on its own right.

Planning at the Personal Level

No matter how much care is taken to devise procedures to prevent plans from becoming biased by the personal viewpoints of the planners, people do the planning. Planners as people become committed to causes or develop beliefs that influence them to decide issues by categorizing situations to fit abstract principles even when their professional conscience tells them that they should be collecting and analyzing specific information. For example, one agency may have a bias toward viewing stream channelization as the means of making flood plain land more productive and hence better able to serve mankind. Another agency may have a bias toward preserving channels in their natural state to protect valuable ecological systems in the natural environment. A better method is needed for determining when channelization is in order and when it is not, and yet it is hard to believe that the most objective procedure would not be more likely to say to channelize when applied by a flood control agency than when applied by a fish and wildlife agency.

No matter how objectively a plan may be formulated, people are affected by the design. Affected people tend, instead of seeing the total project concept in perspective, to dwell on those aspects of project impact that affect them personally or affect causes to which they are committed. Selling a plan to the public requires an appreciation of the aspects of a plan that the individuals affected will watch most closely as well as overall objectively.

Institutional decision making is going to have to function in the context of decision making at the personal level by those both within and outside of the established agencies. Individuals are going to continue to turn one small aspect of total impact into causes, and mechanisms must be developed for channeling these causes toward better planning rather than allowing them to upset programs in the public interest.

IMPACT POST AUDIT

Original Concept of the Project

The original concept of the research is most succinctly contained in the proposal submitted to the Office of Water Resources Research in April, 1965, under the heading of "Significance of the Project." To quote:

> One of the greatest needs in planning national water-resources development is improved methods for economically evaluating potential alternatives. The methods which have developed have concentrated on predicting future consequences with altogether too little emphasis on a backwards look at past water-resource developments. This backward look is needed to improve economic evaluation techniques. It will increase the accuracy of predicting such items needed in economic evaluation as operation and maintenance costs, indirect and secondary benefits, the build-up period, and local economic impact.
>
> In relating the significance of the project to the economy of the state and region, one must remember that a large portion of Kentucky is in Appalachia and other areas suffering high unemployment. Part of the research involves determining the effect of reservoir construction on local employment, local economic activity, local economic structure, and the level of community services. Public works construction is the principal component of the federal program for aiding these areas; and if such construction is going to achieve the desired objective, the interactions between construction projects and the local economy must be more fully understood.

This basic concept was followed throughout the seven years (five years sponsored by OWRR) during which the research lasted even though, as one would expect, a number of the procedural details changed.

Revised Concept

The research approach contemplated at the time of the original proposal was to make post audits of the costs and benefits as well as various irreducible consequences of four existing reservoirs in or near Kentucky. A comparison of the effects that had resulted with the effects forecast during project planning would then be used as a basis for suggesting ways to modify planning techniques.

The primary change in strategy which evolved during the course of the research was dictated by the need to relate more realistically to the dynamics of planning methodology. Early findings showed that many project effects were radically different than those anticipated during project planning. Moreover, the institutionalized planning procedure contained feedback mechanisms that were already working to change planning methodology to the point that estimates made by currently used procedures would be much better. Rather than pursuing a study of the efficiency of these feedback mechanisms, the greater research need seemed to be to devise ways to bring neglected impacts into the analysis.

The new strategy was to review a group of projects selected for the case study to ascertain major economic and financial consequences of their construction that posed particular evaluation problems and to study these issues in depth. The case studies would not attempt the comprehensive review of the full range of project effects that is required to judge the overall merit of individual projects. Instead, the purpose would be to review situations in which projects were having economic impact of orders of magnitude to be a significant influence in project selection, design, or operation and in which planners were having difficulty in obtaining and structuring information for decision making. Once the kinds of impacts for further study had been selected, the issues relating to more satisfactory treatment of the impacts would be explored by devising a theoretically sound conceptual basis for approaching the problem and then using the existing reservoirs as sources of empirical data for use in the study.

ORGANIZATION OF THE RESEARCH

General Strategy

A large number of reservoirs have been constructed in a large variety of topographical and social settings in or near Kentucky. After reviewing the impacts generated by these reservoirs during their construction and subsequent performance, a series of specific topics for further study were selected on the basis of:

1. Importance of the issue to project planners from either the local or the national viewpoint. Importance was gaged in terms of interest expressed by employees of federal planning agencies, state agencies or local people affected by the project, or various special interest groups, particularly beneficiary groups and conservation groups.

2. Attractiveness of the issue in light of the research competence and interest of the members of the study team. The team expertise was in economics, water resources engineering, and statistics. An appropriate issue would be one toward which a graduate student working on a thesis topic could make a meaningful contribution. As such, it would have to relate to unresolved issues of theoretical interest and not require collection and analysis of more empirical data than would be practical under the constraints dictated by the total scope of the project. The study would have to be of general interest by amounting to more than deciding the best course of action in a specific situation.

3. Availability of suitable experience data. Because much time would be saved if the study could obtain data from the files of various governmental agencies and other researchers, the ready availability of relevant data was a strong plus factor. For this reason, the study began by making contacts with top level officials in the Corps of Engineers and the state government of Kentucky in order to secure their cooperation and become better informed as to the availability of various kinds of data.

Over the five-year project, topic selection became a feedback process. Initial studies were selected on the basis of the above criteria and conducted. The findings led to recommendations for pursuing new topics, and these were then attacked.

Case Study Reservoirs

The determination of which reservoir or group of reservoirs to use as sources of empirical data for a particular study was largely determined by three criteria.

1. The reservoirs had to be of proper size and located in the proper setting for the study topic to be relevant and measurable through available data gathering capability. Because most impacts increase geometrically with reservoir size, this criterion strongly favored larger reservoirs.

2. The historical timing of the project had to be such that the needed data would be available. Studies dealing with construction impacts are more appropriately based on reservoirs completed recently enough to be fresh on the minds of federal planners and local officials. Studies dealing with performance impacts require a reservoir that has been operational long enough to have an established performance pattern. As an additional factor, many kinds of economic data that were not collected 20 or 30 years ago are now routinely compiled by various agencies.

3. A general study often requires observation of an impact in a variety of settings. Several reservoirs taken from as diverse as possible a group of representative settings were then selected.

Five reservoirs or reservoir complexes served as the principal sources of empirical data. They are:

1. West Fork of Mill Creek Reservoir in Hamilton County, Ohio. The reservoir was constructed about 1953 on the northern fringe of suburban Cincinnati and has since been largely surrounded by urban development. The lake has a water area of approximately 185 acres (seasonal pool acreages are given in each case) in the midst of a 2000-acre park operated by the Hamilton County Park District. The Corps of Engineers operates the facility for flood protection of a highly urbanized downstream area, and the County operates a day-use recreation facility that draws about 1,300,000 visitors annually.

2. Dewey Reservoir in Floyd County, Kentucky. The reservoir was constructed about 1949 in an isolated, narrow mountain valley near the West Virginia border. The mining-oriented local economy is characterized by low incomes, declining population, and settlement heavily concentrated in the flat flood plain areas by the ruggedness of the surrounding mountain terrain. The lake has a water area of approximately 880 acres, and an additional 13,000 acres of land (largely steep, forested mountain sides) from ridgetop to ridgetop were purchased at the time of reservoir construction. The Corps of Engineers operates the facility for flood protection of towns, primarily located in the valley immediately downstream, and the Kentucky Department of Parks provides a wide variety of recreation facilities at Jenny Wiely State Park that draw about 800,000 visitors annually.

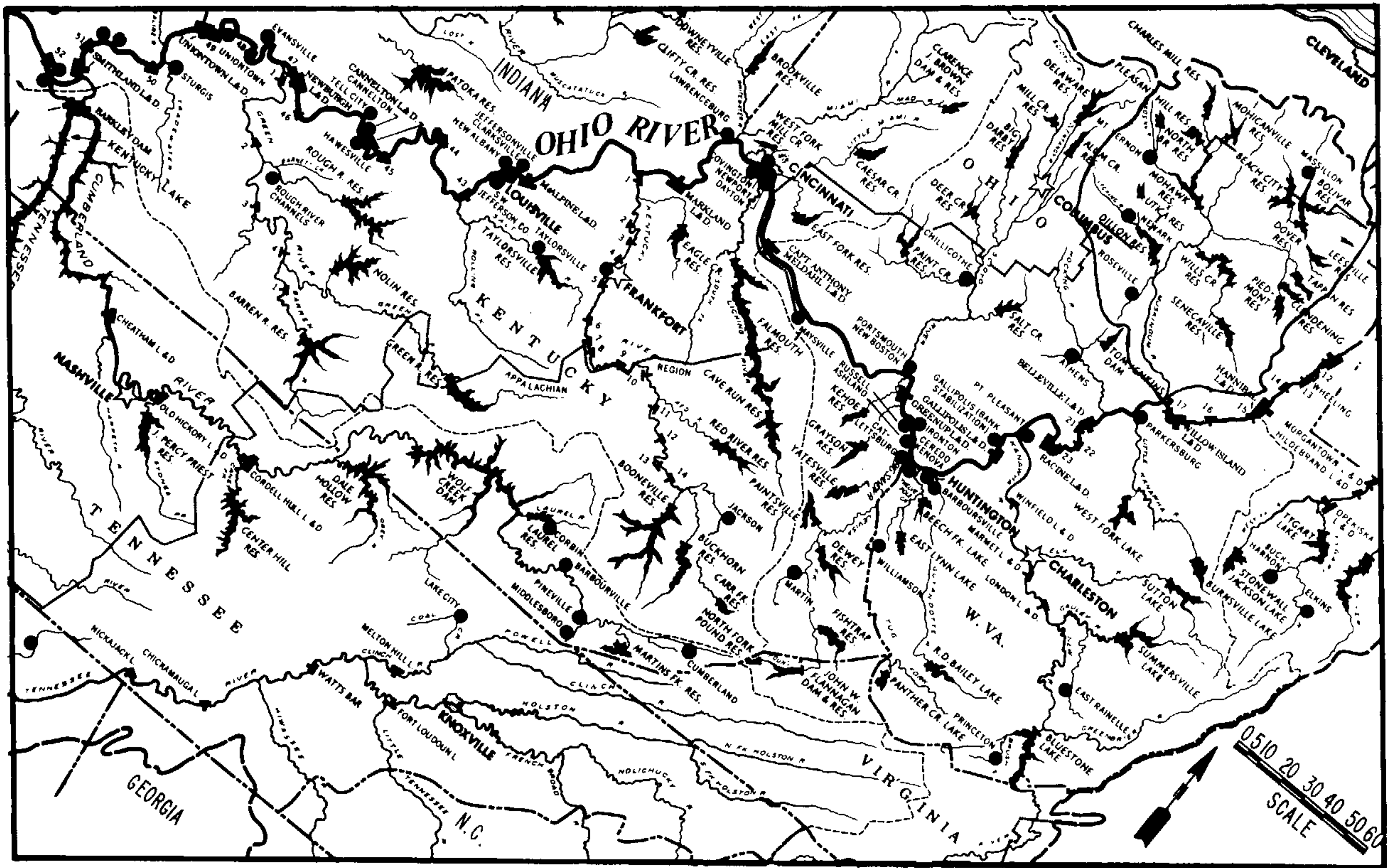
3. Rough River Reservoir in Grayson and Breckenridge Counties, Kentucky. The reservoir was constructed about 1960 in farm country about 60 miles from the metropolitan areas of Louisville, Kentucky, and Evansville, Indiana. Most farming is on the uplands, and relatively little farm income is generated from the narrow, wooded, incised valleys inundated by reservoir storage. The local economy is agriculturally oriented and characterized by relatively higher incomes than found in Appalachia, more stable population, and settlement primarily located on the uplands. The lake has a water area of approximately 5100 acres contained in many long narrow arms having a total shoreline length of over 200 miles, and about 5,000 acres of nearby land are dedicated to recreation. The Corps of Engineers operates the reservoir for flood control, primarily to protect urban areas located at some distance downstream, provides some low flow augmentation, and is directly involved in developing the recreation facilities. The Kentucky Department of Parks has established Rough River State Park near the dam and intensively developed the area. The recreation facilities draw about 800,000 visitors annually, over half from Louisville and Evansville.

4. Wolf Creek Dam backs up the waters of Lake Cumberland in Russell, Wayne, Clinton, and Pulaski Counties, Kentucky. The dam was

constructed about 1950 in a U-shaped canyon in south-central Kentucky. Bottomlands in the flood plain along the river are generally the most fertile areas for farming, but the uplands are also farmed in part even though much of the area is rolling and wooded. The local economy was agriculturally oriented at the time of project planning, but in recent years has shown a decided shift to small manufacturing, largely in the county seat towns. The lake has a water area of approximately 50,000 acres and attracts over 2,000,000 recreation visitors annually. The multiple purpose facility is operated primarily for flood control, with the largest concentration of benefits being in metropolitan Nashville, Tennessee, and hydroelectric power. Recreation development involves a number of facilities sponsored by federal and state as well as private funds.

5. Because the operation of a group of reservoirs must be coordinated to produce maximum net benefits, it was decided to select as a fifth primary source of empirical data a group of proximate reservoirs. Issues related to coordinated reservoir operation were studied on the basis of data for the fifteen reservoirs in the Muskingum River basin in South Central Ohio operated principally for flood control by the Huntington District, U. S. Army Corps of Engineers. Even though most of the reservoir are relatively small, a few are larger and contain some storage for other purposes.

In addition to these five principal sources of experience data, several other reservoirs were used in a more limited way to study aspects of impact for which relevant information from them was more readily available. The large Kentucky Lake Reservoir (approximately equal in size to Lake Cumberland), built just above the mouth of the Tennessee River in 1944 by the Tennessee Valley Authority, was used to study the effect a reservoir can have if it provides output critically needed for industrial expansion. Nearby Barkely Reservoir as well as the Barren River and Green River Reservoirs to the east were used to study the impact of reservoirs on the finances (both income and expenditure) of local government. All nine reservoirs used are



MAP FROM U.S. ARMY ENGINEER DIVISION, OHIO RIVER, CINCINNATI, OHIO, NOVEMBER 1968

FIGURE I RESEVOIR LOCATION MAP

located on Figure 1. In addition, many other data sources were used to obtain other specific information needed in the study. Whenever possible, suitable data collected previously by others was used in place of data collected directly for this project for economy reasons. More research progress could be made by purposely avoiding dogged pursuit of original data for the primary case study reservoirs when information obtained through others from different locations could be made to substitute.

Grouping of Study Topics

The impacts of the four multipurpose reservoirs selected to be the primary sources of empirical data at the start of the research were reviewed for major effects that are still not adequately handled in planning. The review revealed four major categories of topics that merited special attention. These were

1. The effects of projects on the local economy. The typical secondary effect of federally financed water resources development is to reduce economic growth by small amounts at a diversity of widely scattered locations and induce an approximately equivalent amount of growth in the area served. This areal concentration of secondary benefit encourages those with a local viewpoint to exert pressure on planning agencies to build projects, and the visability of both the effects and of the project supporters enhances the influence of secondary effects on planning decisions at the personal level. Consequently, this category was deemed particularly important. Specific topics pursued under this heading included the effect of the projects on nearby cities and towns in terms of their economic growth, the character of their economic base, land use, and the financial resources and demands for services faced by local government.

2. The relationship between projects and the demand people living in an industrialized and urbanized society have for leisure time activities. Most reservoirs provide a site for such activities as picnicking and swimming while simultaneously removing inundated areas as sites for hunting and stream

fishing. Topics under this heading include the estimation and economic evaluation of visitation to developed facilities, development of procedures for facility sizing or determining the optimum degree of recreation development, and the estimation and economic evaluation of the loss of use made of natural areas inundated by reservoirs.

3. The social impact of projects. Two from a large number of topics that might have been pursued under this heading were chosen. One was the way to incorporate information on the loss to people forced to sell their property or to move from their homes into the processes of comparing alternate designs or locations. The other was to study the effect projects have on income redistribution by taking money from taxpayers and paying it to suppliers of labor and material to benefit the recipients of project output.

4. The operation of completed projects. In the process of installing and operating a project, a number of conditions and situations are encountered that were not anticipated during planning. Needs for project output will change with time. Economic and impact analysis should not be forgotten with the final decision to build, but the operation of projects after they are built should be continually reviewed and modified as necessary to meet current needs. Topics under this heading include the reevaluation of tradeoffs among outputs in operating multipurpose reservoirs and reevaluation of tradeoffs among reservoirs in operating multireservoir systems.

The studies made under these four headings form the substance of the total research effort summarized in the four chapters to follow. The procedural details and more complete descriptions of the results are found in a series of thirteen research reports (2, 4, 5, 13, 20, 21, 23, 24, 46, 48, 51, 55, 58). The purpose of this report is not to repeat the details but rather to summarize the highlights and develop points based on the research as a whole rather than on any one study.

CHAPTER III

THE LOCAL ECONOMY

INTRODUCTION

The effects of large reservoirs on the local economy were explored in five of the fourteen studies included within the total project. The five study titles are

1. Covariance Analysis of Reservoir Development Effects on Property Tax Base.

2. Measurement of Economic Impact of a Large Water Resources Facility from County Economic Data.

3. Economic Development of Areas Contiguous to Multipurpose Reservoirs: The Kentucky-Tennessee Experience.

4. Patterns of Land Use Change Around a Large Reservoir.

5. The Effects of a Large Reservoir on Local Government Revenue and Expenditure.

The purpose of this chapter is to present the objective of each of the five studies, outline the research procedure, and state the nature and review the significance of the findings. Each study is presented in full in a referenced report, and those interested in more complete information on the procedures, the supporting statistics, or the reasoning used to establish the stated conclusions should refer to that report. The function of this report is to show how the studies as a group provide insights into economic impact that go beyond what any provides individually.

EFFECTS ON PROPERTY TAX BASE

Objective

The right-of-way required for reservoir construction is transferred from private to public ownership shortly before project construction. At this time, the property tax base available to local government drops by an amount equal to the value of the real property removed from the tax rolls. Small governmental units (cities, counties, and special districts) obtain much of their income from property taxes and suffer financial hardship in proportion to the fraction of their total tax base lost. However, in the long run, reservoirs may well attract peripheral land development that adds to property values and hence tax base. If such induced development continues, the tax base will eventually exceed the level it would have had without the project, and the long run gain will exceed the short run hardship. The goal of this study, undertaken by C. M. Vaughan, was to gather quantitative information on the short-run and long-run effects of reservoirs on the property tax base of the jurisdictions in which they are located (53, 58).

Procedure

The Wolf Creek Reservoir was used as the data base for this study because that reservoir was the only one of the four to remove a major portion of the assessed value of the property taxed by any governmental unit from the tax rolls. One county lost nineteen percent of its land area. Counties near the reservoir were divided into three groups: three counties losing land from their tax rolls, two counties containing substantial areas on the flood plain benefiting from the project, and three counties not directly affected by the project but starting from roughly the same economic base and serving as a control group (58, pp. 2-4).

Property values are continuously changing as time brings new improvements and subsequent depreciation and as market conditions and population pressures vary. Hard data for estimating total property value, however, is only available for the few scattered parcels that are sold in any given year. Many parcels in rural Kentucky pass from one generation to the next without a sale. Moreover, tax assessors have difficulty keeping up with all the improvements and changes in other factors affecting market value that occur and often face strong political pressures against major assessment changes. Consequently, total assessed value must be regarded as one possible index (as opposed to a precise measurement) of the total tax base available to local government. Other indices tried in this study were total market value, as estimated directly from records of sales, and total taxes collected. Data on each index for each county were collected for each of the 15 years from the date of project completion until the time of the study. Reliable data were unavailable for years before 1950.

Data for the incorporated towns and the rural areas of each county were tabulated separately and normalized to account for the differences in size of the jurisdictions involved. Each index of tax base as a dependent variable, was regressed against time as the independent variable. The analysis was based on a covariance model designed to determine whether the time rates of change in index value were significantly different among the three groups of counties (58, pp. 14-21).

Findings

1. Estimates of total tax base made directly from sale prices were found much more responsive to project effects than were either assessed value or collected taxes. The response of tax assessors to time changes in value was too sluggish to register an up-to-date effect of the reservoir on changes in property value.

2. Rural real property values in the counties in which the reservoir is located were found to be increasing with time since reservoir construction at a faster rate than corresponding values were in either the flood plain or the control counties. The rural areas adjacent to the lake in these counties were much larger than the areas in the flood plain in the two downstream counties. Moreover, by comparing the rates of increase of land values in the three counties containing the reservoir, the rate of increase was found to increase with the fraction of the county's area taken for project right-of-way. One would expect the value of land near the reservoir to be most affected, and the counties losing more land also contain more land near the reservoir.

3. The counties ranged from five to twelve years in the time it took them to pass the total market value they would have had if the reservoir had not been built and they had grown at the rate of the counties in the control group (58, p. 93).

4. Urban real property values were found to be increasing faster in the one town in the study area located in the flood plain than in any of the other towns, all of which were located at a distance from the reservoir and the river downstream. The data base did not provide a situation to study growth of a town located on the shore of the reservoir. Since the downstream town, of course, did not lose any area to reservoir right-of-way, the increased value was all net gain.

5. The sluggishness at which tax assessments adjust to changes in market value aggrevates the financial impact of a reservoir. Any delay in adjusting assessments to reflect gains in market value around the periphery extends the period during which tax revenues are less than what they would have been without the project.

Significance

At first glance, a finding that rural land values around the periphery of a newly completed reservoir increase more rapidly than the values of other land in the area and that property values in towns protected against further flooding increase more rapidly than values in other towns may seem trivial; but from the point of view of securing support for project construction from the people living in counties losing land from their tax rolls to project right-of-way, this is definitely not the case. These people are often considered (by both themselves and the planners) to be the losers from any construction project; however, in the case study of a reservoir involving a large permanent pool for recreation and dead storage for power, the hardest hit county was found to be experiencing a net gain in available tax base by twelve years after project completion. The ability of county government to obtain extra revenue from this gain in market value will depend on the success with which it can keep its tax rolls up-to-date. Furthermore, a program could be designed to encourage development and direct its character in accord with the desires of the community.

The gain in rural land values has implications for individual land holders as well as for the community at large. Individuals who lose some of their land to a reservoir project but have their remaining property along the shore of the resulting lake will realize a substantial gain in the market value of this shoreline land. This effect is definitely to be considered in establishing a fair land compensation policy. If the percentage of the parcel lost is not too great, the owner will realize a net gain in the value of his holdings and any compensation he receives will add further to that gain.

From another viewpoint, the compensation may be viewed as a source of income to help the owner through the period from when he loses part of his land until he can realize a gain from what is left. It is enhancing his rate of return on a risky investment. Similarly, the federal government has a program for subsidizing local government to soften the financial impact of projects that deplete the tax rolls. The findings of this research suggest that in the case of multipurpose reservoirs this subsidy be phased out over a ten-year period and possibly be coupled with payback provisions thereafter. Any other policy produces a direct tax transfer from the country as a whole to the impacted local governments when, as this study showed with other factors being equal, local governments near reservoirs are, even without these funds, in a stronger financial position than other local governments.

On the whole, this study showed the need for two subsequent lines of investigation, each purusing an understanding of the processes causing the noted trends. One is to explore the land use or value changes near a reservoir on a parcel, as opposed to a countywide, basis to determine the degree to which various properties at various locations are affected. The other is to explore the financial adjustments made by local governments that lose large amounts of land from their tax roles. The amount of undervalued property on the tax roles because of the time lag from market value change to assessment change and their ability to defer many capital expenditures gives local government a great deal of financial flexibility, and an empirical study is needed to determine how this flexibility is used.

ECONOMIC IMPACT FROM COUNTY DATA

Objective

Net economic impact occurs as the amount or form of capital accumulation is caused by a project to differ from what would have otherwise transpired. Some changes within an impact area would have occurred without the project; some can be directly attributed to the project; and some are jointly caused as the project interacts with other events. Input-Output models are the most powerful tool for estimating the economic change resulting from various combinations of factors (35, pp. 200-204); however, the time and expense required to collect the data appropriate for applying the method to a local area often make the procedure too costly for many planning studies. One possible short cut (for establishing rougher estimates for reconnaissance studies) is to develop an impact index and establish how that index varies among areas having varying degrees of contact with a reservoir. The most convenient index would be based on published data, and such data is not consistently available for units of area smaller than counties. The objective of this study was to investigate the feasibility of detecting degrees of economic impact from published county economic data (52).

Procedure

The approach was to review the literature on the methods that have been used to analyze economic impact and select the most promising approach for analyzing county economic data. Data on the estimated market value of assessed real property is published annually by the Kentucky Department of Revenue in conjunction with the program for making state aid available to local school districts. These estimates are made for every county after a less detailed study of current sale prices than that made by Vaughan (58).

Data were obtained for the counties containing Lake Cumberland as well as for other groups of counties randomly selected from those located at a distance from any reservoir, from a list of all counties arranged alphabetically, and from all counties arranged in order of per capita income. Variance and covariance analyses were applied to try to detect differences.

Findings

This study turned out to be the least conclusive in the total research project. The analyses did not detect any significant difference in time trends between countywide real property values in the 12 counties directly affected by Lake Cumberland and those in any of five different control groups of 12 counties each. The message was clearly that more concentrated analysis using original data is required to obtain definitive results, and the attempt to index impact from changes in countywide property value totals was abandoned in favor of the three approaches described later in this chapter.

Significance

Published economic data were found to be insufficient for estimating or even establishing the fact of positive economic impact from multipurpose reservoirs. Two factors are involved. Published statistics are on a countywide basis, and counties are often large enough for trends at more distant locations to mask the localized effect near a reservoir. Because the average size of Kentucky's 120 counties is one of the smallest in the nation, this problem would likely be more acute in other places. Secondly, published data are not collected with the viewpoint of measuring the kinds of effects important to impact analysis. For example, the needs of a program for achieving an equitable distribution of funds among school districts do not require the detail of information on changes in value with time that is needed for pinpointing economic impact. Observations of specific impact effects are needed.

ECONOMIC CHANGE IN CONTIGUOUS AREAS

Objective

Multipurpose reservoir projects distribute a variety of benefits over a wide area (e.g., to users of hydroelectric power or to people dwelling on flood plains many miles downstream); however, the effects of the projects on the economic growth and industrial development of the areas contiguous to project sites are of particular interest. First, the prospect of social disruption that local residents often associate with reservoir construction often makes them resist projects proposed to help people elsewhere. If local economic effects were understood in a way that would permit projects to be modified to further local objectives, such adjustments could well make people more willing than they are now to undergo financial disruption for the common good to provide flood protection and power to a distant city. Second, the expressed national objective of enhancing regional development (57) is best achieved by bringing the underutilized resources found in depressed sections of the country into fuller use. The role that multipurpose reservoirs can have in achieving this goal makes a better understanding of local economic effects imperative.

Local economic effects were for the purpose of this study defined as those transpiring in the geographical area immediately surrounding a reservoir. The economic ripples would be primarily generated by the physical effort required in project installation, the appeal of the constructed facility as an esthetic and recreational resource, and the use of water or power or protected flood plain land near the reservoir site. The goal of this study, undertaken by M. B. Hargrove, was to ascertain the economic effects occurring inside the counties in which reservoirs had been located so that planners could better direct these effects to further regional development (20).

Procedure

The study approached a better understanding of local economic effects in areas contiguous to reservoirs through trying to answer four questions.

1. Is there any theoretical basis for expecting multipurpose reservoirs to alter the course of economic development in contiguous areas? If so, what causative processes are causing the change? The question was attacked through a review of location theory for the factors that would logically effect site choices for various kinds of economic activity and an analysis of the ways in which a reservoir would change these factors.

2. Have the areas contiguous to existing multipurpose reservoir projects experienced a more rapid or different mix of economic development among industrial sectors than they would have had without the project? In order to consider a diversity of local situations, the twenty large reservoirs (over 65,000 AF) constructed by the Corps of Engineers, by the Tennessee Valley Authority, or by private power companies in Kentucky and Tennessee before 1955 were used as case studies (20, p. 43). The contiguous area for each reservoir was defined as the counties in which a major part of the lake is located. Sherr's "Index of Regional Homogeneity" (50) was used to select the ten from the 215 counties in Kentucky and Tennessee having in 1940 the distribution of employment among eight economic sectors (agriculture, mining, construction, manufacturing, transportation and utilities, wholesale and retail trade, finance, and services) most like that in the counties in the contiguous area taken as a whole. Thus a ten-county control area was established for each contiguous area. Data were obtained for each county in each contiguous or control area for each census (1940, 1950, and 1960) on population, income, and employment by economic sector. Time changes in employment distribution for each county were expressed by Amemiya's "Index of Economic Differentiation" (1) in numbers that range downward from one to zero with the degree of change over the ten-year period. The differences between contiguous and control areas were expressed in a linear model expressing a measure of economic development (population, per capita income, or employment distribution) in a county as a sum of an overall mean, a treatment effect differentiating control from contiguous counties, a time-period effect, an effect of the interaction between treatment and time period, an effect peculiar to a given

reservoir, and a random error term for that county (20, pp. 58-59). F ratios were used to test the significances of differences in treatment and time-treatment interaction effects between pairs of contiguous and control counties.

3. One would logically expect some reservoir projects to have a statistically significant effect on contiguous counties while others do not. With the reservoirs that have had a significant effect known, can the reasons for that effect be isolated? The changes that had occurred in the area contiguous to each reservoir were reviewed, and more detailed case studies were undertaken of one reservoir that had had a significant effect on contiguous counties and one that had not. The idea was to review differences in terms of the factors noted in the initial review of location theory.

4. How can multiple purpose reservoir projects be designed and operated to enhance the beneficial and minimize the adverse effects on the contiguous economy? Some answers to this question were deduced from the empirical evidence gathered in answering the first three.

Findings

1. Reservoirs were found to relate in a number of ways to factors logically affecting industrial location decision. They stabilize downstream flows to provide flood control, water supply, and low flow augmentation for water quality control that benefit the contiguous area immediately downstream from the dam. Less expensive electric power and ready access to a navigable waterway may also be important. However, all these effects are well known and are not of primary concern for the counties contiguous to a reservoir. Recreation users come to the contiguous area, generate a demand for certain goods and services, and induce facilities to the area that also serve business entertaining requirements. The esthetic and recreation potential (60) of the lake serves as a "fringe benefit" to workers living in the area and to people looking for a retirement location. However, the most revealing linkage, as found by talking to those promoting economic development

in Kentucky, was that the process of adjusting to changes brought by the presence of and by people attracted to a reservoir seems to increase the desire of the people of the community to promote economic development and other social change. Large projects seem to weaken forces favoring preservation of the status quo and encourage a reevaluation of community goals. Much more research is needed in this area.

2. Because the statistical model could not be directly applied to reservoirs in only one county, the 20 reservoirs were grouped in 13 blocks. The analysis of the county data for differences between contiguous and control counties as a whole showed that over the 20 years from 1940 to 1960 the contiguous counties had experienced a greater diversification of employment (generally a greater shift from dependence on agriculture and mining to other kinds of employment) but a decline in per capita income relative to the control counties. No significant difference was found for population change. Block by block comparisons showed that in five blocks the employment base in the contiguous counties was becoming significantly more diverse while in one block it was becoming less so. The other seven blocks showed no significant trend either way. For per capita income, four blocks showed a relative decrease in the contiguous area and one showed a relative increase. For population, contiguous counties showed a relative increase in two and a relative decrease in two cases.

3. The overall findings were that the reservoirs had on the whole produced a more diversified employment pattern but that the shift had generally not been to higher paying employment categories (for example, recreation oriented employment does not command high wages). Since populations were not differing significantly, more workers were changing from agricultural jobs in the contiguous counties but a given change was bringing a smaller increase in income than it was in the control counties.

4. The review of the individual experiences of the contiguous county groups showed that counties around projects isolated from population

centers, with poor land transportation systems, or in terrain unsuited for industrial development were not developing as fast as their control counties; that industrial development making direct use of project provided output was occurring around several reservoirs; and that every contiguous area that has experienced significantly more rapid economic growth than its control area has had its principal manufacturing growth in the chemical industry.

5. The more detailed case studies clearly demonstrated that the role a water resources project has in regional economic development depends on the factors restricting local economic growth. Projects become a key element in growth when they provide factors whose lack has previously restricted economic growth but have only minimal effect when they do not.

Significance

While the increase in the value of real property around the periphery of large reservoirs was found to add to the financial resources available to local government and while the reservoirs were found to be changing employment patterns in the contiguous area, the projects were on the whole actually found to have an adverse effect on the total income of the people living in contiguous counties (see also 11). The reservoirs were working to change the wealth of a county from being based on the value of the output from its farms and factories to being based on the capitalization in land values of access to esthetic views and recreational opportunities. For the Lake Cumberland area where Vaughan found a significant increase in property values, Hargrove found an increase in per capita income significantly smaller than that experienced in the control counties. This change is of great importance in determining the character of a community and should be considered in the light of community goals.

The Lake Cumberland situation was one where the lake could do little to enhance contiguous development other than that oriented to recreation and esthetics because of its remote location and unsatisfactory transportation connections. Even Kentucky Lake which showed the greatest change in the character of its economic base as it changed from an agricultural to a recreational and chemical industry orientation did not experience a relative increase in local per capita income. The reservoirs brought profound change, but the change was not one that brought direct economic dividends.

For a humid region, water resources development was not found to be an effective way to enhance the economic development of areas upstream from and contiguous to projects. It was able to enhance the economic development of downstream contiguous areas only if these areas already possessed all the other factors prerequisite to economic growth. For economic development to occur in many of these downstream areas, a multi-program approach to development planning is needed to coordinate the spending of public money to provide the needed infrastructure and to attract the needed private capital. Such a procedure could be linked to an effort to encourage dispersion of economic development throughout the country and thereby reduce the rate of increasing congestion in metropolitan areas.

LAND USE CHANGE IN CONTIGUOUS AREAS

Objective

Land development is associated with both an increase in property values and a change in employment opportunities. Furthermore, changes in land use with time and by location are relatively easier to measure. Both logical expectation and casual observation indicate reservoir induced changes in land use to occur most frequently at locations having good views and ready access to the lake and to occur at a rate that diminishes with distance. More careful observation, however, shows some spots are developed soon after project completion while other parcels, in what would seem to be good locations, remain undeveloped many years after the lake is filled.

The findings of the previous studies based on countywide statistics were clearly not telling the full story of how reservoirs change the local economy; however, a deeper probe would require an examination of the change at a much smaller scale level. The goal of this study, undertaken by B. R. Prebble, was to examine in detail the patterns of land use change that occur around a large reservoir (43, 44, 45, 46) and thereby to build a better understanding for project planning of the kinds of changes to expect.

Information on the site characteristics that favor development provides probability estimates that are needed to develop the capability to stimulate changes in the use of surrounding lands subsequent to construction of a proposed reservoir (6, 54). Simulated changes in land use can be translated to increases in the value of land and improvements by geographical units all the way down to individual parcels in size. They can also be translated to environmental changes. Such forecasts can be used to guide land use planning, to forecast pressures on local government to provide various kinds of services, and to establish control and incentive mechanisms able to maintain a higher quality environment.

Procedure

Lake Cumberland was chosen as the locale to examine through the collection of empirical data. The choice makes it easier to build on the background already developed by Vaughan and Hargrove. More important, the lake is so isolated that only minimal land development would have occurred without the project. An assumption that all changes to a higher order of development were caused by the lake obviated any need to distinguish changes from other causes.

Aerial photographs covering the entire land area in the vicinity of the lake were obtained for 1938, 1951 (the approximate time of project completion), 1960, and 1967. Nearly the entire area was in farms and forests in 1938. The land areas developed by 1967 were found to be largely within an area inscribed by a ring of straight lines connecting the points where backwater from the lake extends the greatest distance up adjacent tributary streams. The arms of the lake divide the total area into nineteen peninsulas.

The probability of a given site being developed logically relates to four factors. These are the characteristics of the peninsula as a whole on which it is located, the position of the site on that peninsula, the physical characteristics of the site, and the type of access available. Peninsulas were distinguished by whether they were on the side of the lake oriented toward major population centers, whether they were close to through highways, and then simply by number. A grid system was developed for comparing development as a function of relative position on a peninsula. Each peninsula was divided into 100 quadralaterals numbered so that the quadralateral of a given number fell at the same relative location on each peninsula. For example, quadralateral 45 was in each case bounded on one side by the ridge line between five and six tenths of the distance from the point of the peninsula to the base line connecting the upper end of the arms of the lake on either side and extended therefrom one fifth the distance to the water on the right side (46, p. 31). Site characteristics tested were slope, water frontage, and view of the lake. Access was classified by road type from dead end to through highways.

Four land uses were defined: agricultural, residential, commercial, and public. Land use was measured for each quadralateral at each of the four dates (1938, 1951, 1960, and 1967) from the aerial photographs as supplemented by inquiries of local people and field inspection. Land use changes during each of the three periods between the four dates were then calculated for each quadralateral. A linear regression model was set up to predict the probability of land use change, estimated as the percentage of the acreage changed from one land use to another during a period, from the measured characteristics of the peninsula and the site. Multicollinearity was reduced by eliminating variables associated with diagonal elements in the inverse correlation matrix having values near 1.0 before the "t" test was used to test the significance of the remaining variables. Analysis of variance was used to test the significance of the more highly intercorrelated variables. The goal was to pinpoint significant factors by time period and assemble data on the probability of land use change for various combinations of values for the significant factors.

Findings

As of 1938, only 0.34% of the land area was not in farms or forests. By the end of the period of planning and construction in 1951, 0.95% was in other uses. By 1960 1.33% and by 1967 6.73% was devoted to other uses. Over 95% of the development was for residential use. Evidence from one project could not be used to determine whether the recent acceleration in lake oriented development relates to project or to calendar time. Probably, the time lapse since project completion is not as important as the nationwide trend toward greater interest in leisure time facilities.

Tests of the significance of the associations between period changes in land use and the various dependent variables revealed a definite pattern in the significance of the several independent variables with time. During the period when the project was still under construction, access was the pervading factor. Development started on the northside of the reservoir, because that side is closer to population centers, and along roads. After the lake filled, spots close to the shoreline had an added attraction but many still had poor road access. Development was relatively evenly divided between areas toward the interior of the peninsulas where road access was better and areas along the edges where water access was better. More recently, better road access has been provided near the shoreline, and new development has concentrated closer to the lake.

The typical peninsula at Lake Cumberland has a flat top and bluffs descending toward the shore. The earliest development was along roads on the top. After the lake filled, development at first concentrated on the bluffs having good views of the lake. When roads were built down the bluff and closer to the shoreline, development moved closer to the shoreline. Very steep slopes ($>$ 29% grade) were consistently avoided because of more expensive construction.

The significance of road access as a factor influencing the location of development has changed from being the dominate to becoming a negative factor. Individual buildings were constructed along roads in the earlier periods, but now developers want larger tracts of undeveloped land. This usually means locations too remote from roads for scattered development to have already transpired. The peninsulas where scattered development began before 1951 are still being developed in small units, but peninsulas that went to 1960 with little development are now being developed in large tracts unless they contain large acreages in very steep bluffs.

The observed probabilities of development under various combinations of conditions are tabulated by Prebble (46, pp. 79-103). This form is the most useful for providing input to land use change simulation models (54).

Significance

The acreage around Lake Cumberland that changed from farm or forest use to reservoir oriented and often seasonal residences relates closely to previous findings of increasing land values with little change in population or income. Individuals who develop seasonal homes are still counted in the population and income data at the location of their permanent residence. Seasonal homes bid up local land prices but bring few high paying jobs into an area.

While the specific results may to a large degree be unique to the situation at Lake Cumberland (See 39 for a study in a metropolitan setting), the study provided much important insight into issues that need to be resolved in order to relate reservoirs to local economic impact. Hargrove showed that reservoirs, except in limited cases where they provide some output that industry needs and has difficulty finding, can not be expected to do much to attract industry. However, they do attract developers desiring to exploit their esthetic and recreational attractiveness. The degree of impact on the local economy is going to depend on the extent of this exploitation and this in turn depends on how the land areas around a reservoir rate with respect to the site qualities that attract such development. This study made an important contribution to understanding the development patterns one might expect.

Furthermore, the local governments need not remain passive observers of land use changes around reservoirs. They can employ such indirect influences as limiting or enhancing access or direct tactics such as land use controls. Their decision as to what to do should be based on criteria relating to the type of community they want, and their success at achieving their objectives depends on their ability to forecast the consequences of alternative policies. Simulation is the most powerful tool for making such forecasts, and simulation requires a great deal of data on the probabilities of various potential responses to various combinations of circumstances. This study contributed to a better understanding of what combinations of circumstances are relevant and some data on probabilities for a particular setting. Followup studies are needed to establish more generalized probabilities and to convert probabilities to models for simulating land use change (6, 9).

EFFECTS ON LOCAL GOVERNMENT FINANCE

Objective

When officials in local government face the prospect of a large reservoir being built within their jurisdiction, they often express concern over the effect the project will have on the ability of the jurisdiction to finance needed governmental services. They commonly expect a loss in revenue proportional to the value of the real property to be removed from the tax rolls to provide project right-of-way. They may as well expect the problem to be accentuated by increases in demand for services stemming from the needs of the construction forces. Even if they expect long-run increases in property values as economic activity is attracted by the project, they must still pay current bills.

The financial position of local government is determined in part by an ability to collect property taxes that are based on value assessments that can never exactly match true property value. It is also determined by the politically expressed wants of the people in the context of professional standards or state controls. Both assessments and wants are subject to change with time. Changes often come in quantum jumps rather than small increments, and a cultural shock within a community is often the impetus required for a review of the recorded assessed values or an extension of provided services. The forced migration of people from right-of-way areas (7) and the influx of construction workers may be such a shock.

The goal of this study, undertaken by C. T. Bates, was to investigate the time patterns and magnitudes of the changes in revenue and expenditures experienced by local governments during and immediately following a period of reservoir construction (2, 3). Relevant questions were how did local government adjust to revenue losses, what changes in expenditure did the local officials associate with the project, and how did the overall financial position of the government change with project time.

Procedure

Experience data from the four reservoirs primarily used in the other studies were not available in a form suitable for this study. The projects either removed too small a portion of the county tax base from the tax rolls or were constructed too long ago for either adequate records to still be available or for those records that were available to be meaningful in the context of today's expectations of service from local government. As a result, the three largest reservoirs constructed in Kentucky between 1957 and 1968 were substituted. Since reservoirs are usually and were in this case built in rural areas, no municipal governments were involved; however, each reservoir affected two county governments and two county schools systems. Data were collected from the Kentucky Departments of Education and Revenue and from direct contacts with local government officials. Information was collected for each year on property tax income, full-market value of the tax base (according to the estimating procedure employed by the Department of Revenue), and total personal income within each jurisdiction. Information was also collected on perceived project related expenditures.

Tax severity was defined as the property tax assessment divided by the ability of the taxpayers to pay. Two methods of estimating tax severity were tried. One indexed ability to pay taxes by the value of the property in the county while the other indexed it by the income of county residents. Tax severity was computed for each year over the period of project construction for each affected county government and each affected county school district. It was also computed for each year as a statewide average for county governments and for school districts as a whole. For each government, it was noted whether the tax severity was becoming greater or less over the period of construction than it was for like governments throughout Kentucky.

Findings

1. For all six affected county governments, tax severity as measured by property values became relatively less severe over a period spanning project construction when compared with Kentucky counties as a whole. The least difference was noted in the counties losing the least land. This reinforces Vaughan's finding of the fastest growth in property values in the counties losing the most land and relates to Prebble's finding of concentration of property value increases near the shoreline. Counties that lost the most land generally have the longest shoreline. For five of the six affected county school districts, tax severity as measured by property values was becoming relatively less severe. The only expectation was in one of the two counties losing the least land. The evidence is thus quite strong that these governments are not hurting (3, p. 117).

2. For five of the six affected county governments, tax severity as measured by income of county residents was becoming relatively less severe compared with Kentucky counties as a whole. The only exception was in the county losing the least land. For only two of the six affected county school districts, tax severity as measured by income was becoming relatively less severe in the impacted counties.

3. School districts were more likely to be placed under financial strain than were county governments. County government in rural areas seems to be generally operating with sufficient excess capacity to adjust to increased demands for service without requiring increased funds. School districts are operating with close to maximum student-teacher ratios and under greater pressure to upgrade facilities and increase salaries and thus seek new tax revenues. Two districts were receiving federal assistance granted to districts losing more than ten percent of their tax base to federal projects.

4. Both levels of government were worse off financially when tax severity was measured by income of county residents than when it was measured by property values. Hargrove found incomes in counties containing reservoirs to be relatively decreasing while Vaughan found property values to be relatively increasing and Prebble found major reservoir induced land use change and property value enhancement. Property values are increased by the demand of people living outside the area for seasonal residential sites and by improvements they make to the property they acquire. Property values are also increased as local people use some of the money they receive from selling land to the project to upgrade their remaining holdings. Neither kind of investment contributes much to total county income. Since local government primarily relies on property tax revenues, it is helped financially by the change even in cases where the overall economy of the area it serves is hurt according to most other indices.

5. The land required for right-of-way was removed from the tax rolls on a piecemeal basis over periods of from three to six years. This period was long enough to give the local governments ample time to make the necessary financial adjustments. The removal of property from the tax rolls was found to be encouraging careful reassessment of the value of the remaining property and adjustments to pick up some of the slack. This attitude was also making assessments respond quicker to land use changes near the lake.

6. Construction workers were generally found to prefer living in a larger town 30 to 50 miles from the project site to living in the closer but smaller towns in the counties containing the project. Thus, in a state with small counties, the local governments required to provide services to construction workers were not the same as those losing tax base.

7. In the county displaying the most rapid rise in per capita income over the construction period, the primary factor turned out to be that the people displaced by the project were largely from the lower income agricultural sector while the economy of the county seat town remained in tact. Most of the displaced people left the county, and the higher income people remained.

Significance

While there would logically be an upper limit to the rate at which the loss of real property could be absorbed by a local government without increasing tax severity, the governments studied lost up to twenty percent of their total assessed value and ended financially stronger than they began. This finding of itself should be of great help in alleviating the fears of local officials; however, the fact that these officials were worried over what would happen when construction began may be the very reason why they came through so well. They were worried enough to review carefully previous assessments to make sure no properties were valued too low and to watch more carefully for new improvements as they came along. The increase in property values was sufficient to meet the need, and the assessments were responsive enough to capture this increase.

The results, however, suggested three situations in which the financial effect could be severe. The greatest increase in land values is that concentrated near the lake and associated with the land use changes studied by Prebble. Any reservoir that because of poor access or climatic or topographic factors did not generate this kind of change would impart a more severe financial effect on local government. Second, a situation in which local people sell all their land and leave the community (public purchase of all areas near the lake for recreational use) would work greater hardship than one in which they sell part of their land and reinvest the proceeds in upgrading the remainder. Third, situations moving substantial numbers of construction workers into a small rural jurisdiction is likely to exceed the slack capacity of county government and particularly more likely to exceed the slack capacity of county schools. The need for substantial extra expenditures would be more likely to create financial hardship.

SUMMARY

A series of five studies on the effects of large multipurpose reservoirs in Kentucky on the local economy showed the property values to be increasing relatively faster with time in the impacted than in other counties. The counties are experiencing a more rapid change in employment patterns than are other counties; however, the change is not resulting in higher incomes and is largely associated with esthetically and recreationally oriented development on lands with easy access to the lake. The trend toward this type of development is accelerating and moving toward larger development units. Local governments are successful in generating sufficient tax revenue from taxing this development so as not to suffer financial hardship, as compared to other counties in the state, from tax base lost to the project. All these general trends will vary in detail from site to site. Differences among sites and ways to adjust a plan for a given site to better meet the needs of the local people should be carefully considered in project planning. The principal objective of this series of studies was to enhance the understanding needed to do this.

CHAPTER IV

THE UTILIZATION OF LEISURE

INTRODUCTION

A large reservoir provides a location where many people have the opportunity to enjoy a variety of outdoor leisure time activities. Simultaneously, it inundates areas that could otherwise provide other types of activities. Four of the fourteen studies included within the total project related to evaluating these effects. The titles are

1. Analysis of Reservoir Recreation Benefits;

2. Application of Marginal Economic Analysis to Reservoir Recreation Planning;

3. The Economic Value of Natural Areas for Recreational Hunting;

4. The Economic Value of Streams for Fishing.

This chapter describes each of the studies and evaluates the significance of the findings.

RESERVOIR RECREATION BENEFITS

Objective

All of the four reservoirs originally chosen for intensive study are annually visited by at least 500,000 people pursuing water oriented outdoor recreation. At the time this study began (1965), the gravity model was beginning to be used to estimate reservoir visitation and the Hotelling-Clawson application of the model to impute a willingness-to-pay to travel was just emerging from among several possible approaches for estimating benefit. The objective of this study by R. C. Tussey (29, 32, 55) was to use the large amounts of data collected by the Corps of Engineers at these reservoirs, as supplemented by data collected through the project, in order to clarify points needed to develop a better method for predicting recreation visitation to proposed reservoirs and estimating the associated direct recreation benefits.

Procedure

The approach began by hypothesizing four kinds of factors as influencing the propensity of members of a given population to visit a given reservoir. These are the characteristics of the population, of the travel route to the reservoir, of the reservoir and its recreation facilities, and of alternative recreation sites. The similarity of the four sites did not permit analysis of reservoir characteristics, but the other three factors were studied. The methodology was to define specific variables that one might reasonably use to measure each factor, collect data on each defined variable for both Dewey and Rough River Reservoirs, use a multiple regression model on the Rough River data to test the significance of each variable in explaining observed visitation, develop a visitation prediction model based on the significant variables and the Rough River data, and test the model by its ability to predict observed visitation to Dewey.

Data were collected on population characteristics by dividing the United States into 168 population centers consisting of the 120 Kentucky counties, the 47 other contiguous states, and the District of Columbia. Data recording the home population center of 103,500 visitors to Dewey and Rough River Reservoirs were used to estimate the average annual visitation from each population center to each of the two reservoirs. The population characteristics of each center were measured by data collected on population, income distribution, age distribution, and the rural-urban distribution. The characteristics of the travel route from each population center to each reservoir were measured by distance and by how that distance was divided among roads of varying quality. The availability of alternative recreation sites to each center was measured as the distance from each population center to the closest recreation reservoir other than the one being studied. Multiple regression analysis was used to determine which variables were significant in explaining visitation and to develop a visitation prediction model.

The visitation prediction model was used to estimate direct recreation benefits by a modified Hotelling-Clawson approach. One major modification was the distinction between total travel distance from home to reservoir and the incremental or out-of-the-way distance actually added to multipurpose trips to reach the reservoir. Visitors to the reservoirs were interviewed to collect data to estimate average incremental as a fraction of total travel distance. The second major modification was the derivation of a formula and the estimation of values for its parameters to translate distances into dollars.

Findings

1. The two variables of primary importance in explaining observed visitation from a population center to a reservoir are the population of the center and its distance to the reservoir. The relative importance of all other variables is several orders of magnitude smaller. The derived prediction equation (applicable to reservoirs of the general size and in the climatic and geographical setting studied) for estimating visitation from a population center having P people to a reservoir d air miles away was

$$V = 2577\ P/d^{2.445} \qquad (1)$$

The equation is used to estimate total visitation to a reservoir by dividing the surrounding area into population centers, applying the equation to each center, and summing the individual visitation totals.

2. Use of airline distance consistently worked better than road distance or travel time in explaining observed visitation. For Rough River, correlation coefficients were 0.74 with air distance, 0.44 with road distance, and 0.50 with travel time (55, p. 84). Furthermore, air distance is much

more quickly measured and can be estimated with greater precision because the time and subjectivity required to estimate travel routes and velocities are avoided.

3. The correlation coefficient between estimated and observed visitation based on Rough River data was improved by adding the independent variables: median family income, fraction of families with annual incomes between $15,000 and $20,000, fraction of residents living in cities over 50,000, fraction of residents of ages 10 through 19, the ratio of distance to nearest other reservoir to distance to reservoir of interest, and the fraction of road distance to the reservoir being interstate highway (55, p. 106). Only the association with median family income was negative. Equation 1 explained 74 percent of the variation in the Rough River data, and adding the other six independent variables explained 61 percent of the remaining variation. However, a different set of secondary independent variables proved to be significant with the Dewey data; and replacing equation 1 with an equation containing variables other than population and distance based on data from one reservoir actually made estimates worse with respect to the other reservoir. The available data simply did not justify introducing more variables than shown in equation 1 for general use in predicting visitation to sites for planning.

4. The recommendation for use of equation 1 to estimate visitation to a proposed reservoir site should not be taken to mean that the other independent variables have no effect. For example, the study did not prove that construction of a new interstate freeway would not increase visitation by making travel easier. Tussey developed an equation (55, p. 106, eq. 21) that can be used to estimate effects on visitation of new freeways or of new competing reservoirs. Further research is particularly needed to improve this procedure, but use of Tussey's equation is certainly better than assuming no effect.

5. Visitors living within 50 miles of the reservoir were consistently found to have reservoir recreation as the soil purpose of their trip while

those living over 200 miles away were found to travel an average of 150 miles out of their way to get to the reservoir no matter how much further away they lived. A curve for estimating incremental from total travel distance was derived (35, p. 412).

6. An equation was developed for estimating the cost of travel per mile of airline distance, and the literature was surveyed to list typical values for the various parameters it contains (35, pp. 411-412).

7. Direct recreation benefits per visitor-day were found to average $1.27 at Rough River Reservoir and $1.47 at Dewey Reservoir (See 35, pp. 413-416 for computational procedure).

Significance

Equation 1 is believed to give reasonably valid results for estimating reservoir recreation visitation in Eastern United States at the latitude of Kentucky. Values will probably be higher to the south and lower to the north because of differences in the length of the recreation season. Visitation will also definitely be reduced if a reservoir and the nearby land area is not open to any of the standard activities of boating, swimming, fishing, picnicking, or camping. It will also be reduced if the facility is too small to accommodate the estimated number of visitors. Special care needs to be used in applying equation 1 to estimate visitation to reservoirs very close to major population centers. At least census tract and probably block data should be used, and travel time may be a more appropriate measure of distance.

The research definitely did not justify the common practice of defining a recreation impact area and basing visitation and benefit estimates entirely on the people who live within it. Visitors to two Kentucky reservoirs were encountered from every county in the state and from every state of the union except Montana and Utah. Failure to allow for these visitors would result in a significant underestimate of the size of the needed facilities, and furthermore, the availability of computers and the ease of estimating distances to states makes it almost as easy to include as to omit them. No foreign visitors, however, were encountered in the data. As for benefits, the study found that a maximum incremental travel distance of 150 miles should be translated into dollars, but travel distances for single-purpose reservoir recreation trips may be longer in the less densely populated sections of the country.

The procedure used to estimate recreation benefits should not be applied without recognizing the philosophical problems in imputing benefits from expressed willingness to travel and then using the resulting figures in project planning in the same way that estimates of the sale price of hydroelectric power or of flood damages prevented are used (47). None should pretend that true equivalence can be achieved in situations in which different monetary values are associated with different sets of irreducibles. The spiritual renewal achieved by floating across a lake is different than the extra sense of security brought by knowing one's house is less likely to be washed away. The argument for imputing recreation benefits is that providing decision makers estimates of benefits that can be reduced and supplementing that information with statements describing the irreducible consequences leads to better decisions than would occur were monetary benefits not estimated at all.

The sacrifice required to obtain a good or service is measured by the cost incurred to procure it. For most market goods, the cost to procure essentially amounts to the price paid because the incremental travel cost to obtain the item is relatively small. Shopping is done relatively close to one's home, and many items are purchased in a single shopping trip. Reservoir recreation opportunities are more often further away, are less often realized in a general shopping trip, and typically involve nominal, if any, charges for entry after getting to the site. The cost to procure recreation is largely travel rather than purchase cost.

Furthermore, the cost of travel includes the value of time spent as a significant component. This fact probably relates to the negative correlation found between income and reservoir visitation because the poor have as much time as the rich. Findings of positive correlation between income and recreation visitation have been reported by others, but other studies have emphasized the urban rather than the rural poor. The data for Dewey Reservoir clearly showed extensive use of the facility by people living in rural poverty conditions.

MARGINAL ANALYSIS APPLIED TO RECREATION PLANNING

Objective

Procedures such as those applied by Tussey to estimate visitation to a reservoir for recreation and the resulting benefits are characteristically applied to a fixed design. Sufficient recreation facilities (beach areas, camp ground, boat ramps, etc.) can then be provided to accommodate the visitation, and the benefits can be used to demonstrate economic justification of the total project (56). Little attention has been given to the problems inherent in incorporating the analysis of recreation benefits into sizing the facility to provide the optimum degree of development (35, pp. 188-189). Such optimization requires a procedure to estimate the effect of the size of the reservoir and the facilities provided on visitation and benefits so that the marginal benefit associated with a larger facility can be estimated. It also requires better information on the marginal cost of accommodating visitation. An important element in comparing marginal benefits with costs is information on how to place costs for providing (if not keeping open) a facility all year long on a common basis with benefits that depend on visitation and hence vary with season, day of the week, and time of the year as well as weather. The objective of this study by J. E. Sirles (31, 51) was to develop a procedure for comparing the benefits and costs of facilities of different sizes and to collect empirical information at the study reservoirs so that it could be applied. As much as possible, his objective was to present the information in a generalized form so that it can also be applied to other reservoirs.

Procedure

Visitation to a reservoir for recreation can logically be expected to increase with the size of the facility. The logical pattern is for the marginal increase in visitation from further enlargement to decrease and eventually to approach zero for a reservoir so large that the visitation would remain constant even if the size were larger. This maximum annual visitation is defined as the potential visitation and is a property of a location under consideration because at some locations, it is possible to attract more visitors to a recreation facility than it is at others. In light of the variables in equation 1, potential visitation is a function of the spatial distribution of the population with respect to the site. The gravity model of equation 1 can, with the proper numerical coefficient and exponent, be applied as a potential model (42). Empirical analysis is required to determine whether Rough River reservoir is able to accommodate potential visitation and thus whether equation 1 has the numerical values of a potential model.

Capacity coefficients had to be estimated in order to determine the number of visitors a facility of given description can accommodate. During peak use periods, the number of visitors per acre in the activity areas that appeared to be being used to capacity were estimated. Observed numbers of visitors in a given area for a given activity were found to be bounded by an upper limit, and the numerical value of this upper limit was taken as the capacity coefficient for that activity.

The two recreation facilities studied in detail were those at West Fork of Mill Creek (Winton Woods Park) and Rough River Reservoirs. The total capacity of each facility was estimated by applying the capacity coefficients to the designated activity areas at each site. In order to relate total annual visitation to capacity, additional empirical data were gathered on the distribution of visitation by hour of the day, day of the week, and month of the year based on Rough River and checked against available data for other large reservoirs in the area. The resulting distribution factors were used to estimate peak hourly from annual visitation, and the result was a figure substantially smaller than the estimated capacity. This comparison was taken as evidence that Rough River Reservoir is attracting its full recreation potential.

The distribution factors for Winton Woods when applied to the annual visitation to that park gave estimates of peak hourly visitation approximately equal to the capacity estimate. This was taken to mean that the facility was not realizing its potential visitation because of crowding associated with too small a capacity. The amount by which visitation was reduced by crowding at various times of the year was estimated, and the distribution factors for the two reservoirs were used to establish a relationship between capacity provided as a fraction of peak potential hourly visitation and annual visitors accommodated as a fraction of potential annual visitation.

Cost records were obtained from the agencies operating the recreation facilities at Dewey and Rough River Reservoirs and Winton Woods Park. The costs were corrected for inflation, and capital costs were placed on an average annual basis. Visitation data were also collected. The data were used to develop three curves relating the marginal cost of recreation facilities (as opposed to changes to the reservoir) that will add to the visitation versus the visitation realized. All three curves were found to have the same general shape, and reasons for this shape were summarized. Finally marginal costs were compared with marginal benefits for the three reservoirs to determine how close each recreation development was to optimum.

Findings

1. Activity capacity coefficients for estimating peak use were found to be 600 swimmers per acre of beach, 2.5 boaters per acre of water surface, and 20 campers and 50 picnickers per acres designated for use in the respective activities. Sightseers were found to comprise half of the users during peak periods. Total capacity was thus found to be best estimated by doubling the sum of the products of acreages and coefficients. Fishing use was not a significant factor during peak periods.

2. A great deal of valuable data on the distribution of recreation visitation over the day, week, and year were collected and tabulated in a form that permits estimation of expected visitation at a reservoir during any hour of the year (35, pp. 402-404).

3. The fact that a reservoir does not have sufficient capacity to accommodate all the visitors that want to go there during peak periods of use was found to reduce total annual visitation much more than can be accounted for by the unaccommodated visitors during these times (31, pp. 21-23). Such reservoirs seem to be made relatively unattractive by their reputation for being crowded and possibly by a lower quality maintenance.

4. A curve was developed for estimating the fraction of the potential visitors which can be accommodated from the fraction of the potential peak hourly visitation represented by the reservoir capacity to accommodate recreation users (35, p. 406). Potential peak hourly visitation is defined as the number of potential visitors during the peak hour of the year. It was found to equal about 0.73 percent of the potential annual visitors. The fraction read from the curve can be multiplied by potential annual visitors or potential annual benefits to estimate the respective quantities for reservoirs too small to accommodate the potential visitation. The method is not reliable for reservoirs having capacity less than 10% of the potential peak hourly visitors, and further research is needed in order to estimate visitation and benefits for these very small facilities.

5. The total cost of the recreation facility is of two sorts. The first is the cost of the dam and reservoir. The second is the cost of providing and maintaining the facilities provided to serve the recreation visitor. The marginal cost of constructing a larger size dam and reservoir must be estimated from topographic, hydrologic, and unit cost information for a given site. The specific recreation facilities are much less variable from site to site and the marginal cost curves derived for them have more general interest. The total cost curves follow a stair-step shape. Visitation with absolutely no

expenditure for provision or maintenance of recreation facilities will be minimal because the site will deteriorate until it becomes repulsive, but a substantial number of visitors can be attracted at a low marginal cost spent in maintaining an attractive natural area. However, there is an upper limit to the number of visitors that can be attracted without some capital intensive features such as picnic tables, supervised campgrounds, and boat ramps supplemented by the maintenance features they require. The point on the marginal cost-visitation curve at which these facilities are provided is associated with a sharp increase in cost for the marginal visitor. Once the facilities are provided, visitation can again be sharply increased by better maintenance at a low marginal cost per additional visitor attracted. This level of development is the one available at the three reservoirs studied, and the potential visitation and benefit estimates made in this research really all implicitly assume this level of development. Higher levels of development involving golf courses, night life attractions, etc. would show another quantum jump cycle, but the association of such features with the reservoir is more tenuous. The data showed the development at Rough River and Dewey Reservoirs to be starting into this second quantum jump, but Winton Woods is not.

6. At 1961 price levels, average capital costs per visitor-day are about 23 cents at the two Kentucky reservoirs and about 5 cents at Winton Woods. Average operation and maintenance costs is 7 cents at Winton Woods, 9 cents at Dewey and 13 cents at Rough River. Marginal cost per visitor-day including both capital and maintenance expenditures are about 5 cents per visitor-day for all four reservoirs.

7. In all three cases, the size of the reservoir is essentially fixed by requirements for flood control rather than by recreation. The benefit per marginal visitor attracted of about $1.40 is far more than the marginal cost of about $0.05 of attracting him. Because the marginal cost of providing and keeping recreation facilities is so low until it rises steeply to attract the last few potential visitors (to the standard mix of facilities), the economic optimum

provision of facilities is to provide for the potential peak hour visitor unless the size of the reservoir is too small to do so. This is the way Rough River is being operated (as a whole but not necessarily with respect to every activity). Dewey is not realizing its potential visitation because of too few facilities, and additional ones could profitably be added. Winton Woods already has about the maximum possible level of facilities for the size of the lake. It is likely that this hindsight information would show that a larger lake could have been justified on recreation grounds at the time of project planning, but right-of-way costs would make the expense of enlargement at the present time prohibitive.

8. A computational procedure for estimating the optimum lake size for use in planning was outlined (35, p. 417).

Significance

The basic accomplishment of this study was the derivation of a method by which the optimum extent of facilities for reservoir recreation can be determined through marginal economic analysis. As this decision has heretofore been made for each reservoir site essentially without any quantitative analysis; the technique, if applied, can make a significant contribution to obtaining more value per dollar spent on water-oriented recreation facilities. For example, for two of the reservoirs studied, more overall recreational value would have been obtained if some of the money spent for facilities at Rough River had instead been spent at Dewey.

In its headlong rush to produce a working method, the study had to sidestep many theoretical and empirical issues. A great deal more work is needed to resolve many of these. One important aspect is the need for data to more firmly establish the relationships found for the Ohio River Valley and to extend them to other locations. An example of the need for more data is in the use of just one reservoir serving its full potential visitation together with one too small to do so to establish a curve for estimating the relationship between facility size and visitation. Use of more reservoirs of both types would give better estimates.

NATURAL AREAS FOR RECREATIONAL HUNTING

Objective

The benefits from a new reservoir that accrue to those who use it for such recreation experiences as camping, picnicking, and fishing is not all net gain. Whatever value the land inundated by the reservoir or otherwise developed as part of the project would have had as an esthetic recreational resource without the project is lost. The questions of esthetic and environmental differences between conditions with versus without a project are worthy of study in their own right, but study is also needed on the economic value of the recreation experiences that will never materialize because a dam is built. This economic value should be deducted from reservoir recreation benefits to estimate net benefits for project planning. A natural area attracts a variety of hikers and sightseers who are seeking to enjoy various aspects of nature, to exercise their bodies, or to escape from their routine existence; but the greatest observed use of such areas has been for sport hunting and sport fishing. Furthermore, data regularly collected by fish and game people for better planning of their own programs provide, for evaluating these two uses, a ready source of information that is not available for other kinds of recreational hiking.

The objective of this study by K. G. Holbrook (24) was to obtain the data collected from hunting license owners in Kentucky through surveys conducted by the Kentucky Department of Fish and Wildlife and adapt the procedure used by Tussey to estimate the economic value of recreational hunting. The desired output was a procedure that could be followed to estimate an economic value of recreational hunting for any area in Kentucky for use in water resources planning and other decision making with respect to land development or land use control policy.

Procedure

The gravity model was adopted as the approach for estimating the annual number of hunters in a given area. The general equation is:

$$H_{IJ} = P_I A_J K_{IJ} D_{IJ}^{-N_{IJ}} \qquad (2)$$

where H_{IJ} is the average annual number of hunter-days spent by people hunting in area J and living in population center I, P_I is the total number of people living in population center I, A_J is the area in square miles of hunting area J, and D_{IJ} is the average airline distance in miles between the homes of hunters living in area I and the place they hunt in area J. K_{IJ} is the propensity to hunt, and N_{IJ} is the gravity model exponent that indexes the rate at which inclination to hunt decreases with distance. The general equation denotes the possibility of different values of K and N between every pair of home and hunting areas, but this degree of flexibility must be reduced to keep the model from being overdetermined and to make estimation of values for K and N possible.

Before proceeding to estimate these parameters, it was necessary to review the data available from the Kentucky Department of Fish and Wildlife. The data came from a survey of 2,215 of 225,059 licensed hunters in Kentucky in 1963. Each person (whose home county was known) was asked for the species he hunted, the counties he hunted in, and the number of hunting trips he made during the year. The results were expanded by the ratio of licensed hunters to interviewed hunters by home county to establish information to fill a set of seven matrices, one per species groups, in which each element contained the estimated number of hunting trips from a home to a hunting county. The seven groups of species are squirrel, rabbit, bobwhite, farm menace (groundhog, crow, racoon, and fox), sectional winged (dove, grouse, woodcock), deer, and waterfowl.

The third major input to the procedure was an expression derived by integrating the area under the consumers' surplus curve (24, pp. 47-51) to obtain:

$$U_{IJ} = \frac{1}{N_{IJ} - 1} \; C \, D_{IJ} \qquad (3)$$

where U_{IJ} is the mean economic benefit per hunter-day hunters from population I receive from hunting area J, and C is the cost attached to overcoming a mile of airline distance. An alternate expression may be substituted by only integrating to an upper limit L defined as the maximum distance from home that a significant number of hunters will travel to hunt.

The procedure followed was to use the available data to estimate K and N. The two-step process was first to determine with which of home county, hunt county, and species the parameter vaired and second to estimate values of each parameter by each appropriate subscript. The results could be applied through equation 2 to estimate the number of hunters and then through equation 3 to estimate benefits. The details were illustrated by application to the lands taken by Rough River Reservoir.

Findings

1. The cost attached to traveling a mile of airline distance for hunting was found to average 16.1 cents as compared to the 3.4 cents found by Tussey for reservoir recreation. The difference relates to the fact that fewer vehicle-miles of travel are required per visitor-day spent in recreation since people travel in larger groups and remain at recreation sites for longer periods. The typical hunting party was two men traveling together for a one-day hunt while the typical group going to a reservoir was a family interested in several days of recreation.

2. This difference in the makeup of typical parties was also found to be an important factor relating to the distance the two types of parties are willing to travel for a recreation experience. Families were found visiting lakes located hundreds of miles from their homes as part of a general vacation that also involved a number of other recreation experiences. For these groups, equation 2 was found to be appropriate for estimating visitation, but an out-of-the-way rather than the total distance was found appropriate for use in equation 3 to estimate benefits. Hunters were very seldom found to travel beyond some maximum distance or to hunt one area as part of a trip having a number of other

purposes as well. For reservoir recreation, an average out-of-the-way distance of 150 miles was found to apply to all trips over 200 miles. For average Kentucky hunting, a cutoff distance of 160 miles was found to apply; i.e., estimation of both visitation and benefits are appropriately based on the assumption that no one travels more than 160 miles to hunt. Further research is needed to be able to approach unusual areas that attract hunters from great distances; however, strong extra economic arguments exist for not inundating most such areas.

3. Better quality hunting areas draw a larger share of their hunters from greater distances and were consequently found to have lower values of N. Hunting in a given geographical area was found to have values of N varying by species because a very good area for hunting one species is often mediocre for hunting another. Holbrook tabulates values of N by species and by county hunted (24, pp. 91-105). The home county of the hunter did not turn out to be a significant factor in estimating N as the data did not show much difference among the inclinations of the populations of various counties as a whole to go hunting.

4. Values of K were found to vary only with species, and values by species are tabulated by Holbrook (24, p. 113). The implication of K but not N varying with hunting area quality is that good areas attract many more hunters from a distance but relatively not so many more from nearby.

5. The tables of values of K and N established from the Kentucky data were employed to estimate the economic value of the hunting-days lost because of construction of Rough River Reservoir. The tables can be used to make similar estimates for any other area in Kentucky.

6. Values found per hunter-day (1968 price levels) varied greatly over the state by species and by county hunted (24, pp. 91-105). Values for squirrels ranged from $0.32 to $2.88; for bobwhite, from $0.23 to $2.97; for farm menace species, from $0.23 to $2.03; for the sectional winged species, from $0.23 to $1.72; for deer, from $0.23 to $7.45; and for waterfowl, from

$0.17 to $2.80. In a number of counties, none of those surveyed hunted the last three species groups. The low values for each species were in counties where a few local people would hunt near their homes but no one would come from a distance.

7. The annual value of the land for hunting at the Rough River site was estimated at about $300.00 per square mile annually. For the total inundated area the hunting value was $2,440 annually as compared with $10,410 annually for fishing. These figures compare with about $1,000,000 annually in reservoir recreation benefits.

Significance

This study used hunter willingness-to-pay as evidenced from data on hunter willingness to travel as an information base for estimating the economic value of recreational hunting in any defined geographical area. Specifically, Kentucky hunter data were used to evaluate parameters in the gravity model for estimating the economic value of any hunting area in Kentucky. More generally, data for other regions can be used to establish appropriate parameter values so that the same method can be used elsewhere.

The objective of the study is to establish a tool that can be used by planners in advising public officials on decisions that directly or indirectly affect land use. The application presented is for water resources development, but examples from transportation or land planning and zoning policy could just as well have been used. The economic value is, of course, but one of a series of pieces of information that must be integrated into such decisions, and this study makes no attempt to identify nor to evaluate esthetic or ecologic values for such areas. The limitations of the available data and the approximations used to estimate parameter values also suggest that better estimates could be established with further data collection and analysis, but the estimates provided by this study seem to be of a reasonable order of magnitude and to have greater estimating precision than do estimates of many other relevant effects.

STREAMS FOR FISHING

Objective

The second principal recreational use of natural areas is for sport fishing. The objective of this study by D. H. Bianchi (4) was to obtain data on where people live with respect to where they fish and to use the information to establish a procedure comparable to those already described for reservoir recreation and hunting to estimate the economic value of stream fishing. A procedure was sought that could be followed to estimate an economic value for fishing in any stream in Kentucky.

Procedure

This research also began with the basic gravity model of equation 2 except that A_J was redefined as the length of the stream in miles. The search for data for use in the study did not uncover suitable information already collected by others as occurred in the case of hunting, and an interviewing procedure had to be established specifically for this study. With the help of the county conservation officers employed by the Kentucky Department of Fish and Wildlife in 25 Kentucky counties, 3,321 fishermen were interviewed as they were encountered fishing streams in all parts of the state. The interviewer simply noted where the fisherman was fishing and asked him where he lived. Distances between the two points were measured from maps as the information was received.

The data were obtained to estimate values for the parameters K and N in the gravity model (equation 2) and in the expression for estimating the economic value of a fisherman-day (equation 3). Insufficient information was available to differentiate parameter values by species of fish; and, in accord with the findings of the hunting study, no attempt was made to differentiate parameter values by home county of the fisherman. However, it was necessary to differentiate by size of stream. As suggested by research in zoology showing a definite correlation between the species found in a stream (38) and the order of the stream (25), stream order was used to index size. Following Horton's definition of order, each headwater stream (detectable on a topographical map of scale one inch represents 2000 feet) is defined as first order. A second order stream begins where two first order streams join; a third order stream begins at the junction of two second order streams, etc. A stream does not change order when joined by a lower order stream. Topographic maps were used to determine the order of each stream where a fisherman was interviewed.

Whereas the sampling process used in the hunting study provided a means to extrapolate from interviews of a known fraction of licensed hunters to an estimate of the total number of hunter-days in a given area, information from chance encounters with fishermen did not provide a basis for estimating the total annual number of fisherman-days. Supplemental information on the total annual number of fisherman-days expected on four Kentucky streams previously made by the U. S. Department of Fish and Wildlife and from studies by the Outdoor Recreation Research Review Commission were obtained and used to estimate K.

The procedure followed was thus to use the interview information collected through the help of the Kentucky Department of Fish and Wildlife plus supplemental interviews made directly by Bianchi and the data on total annual number of fisherman days to estimate appropriate values for K and N, differentiated by stream order and location of the stream within the state. The results would then be worked into a procedure for estimating annual numbers of fisherman-days and associated economic values for any stream in Kentucky. The details were illustrated by application to the streams submerged by construction of Rough River Reservoir and the numerical estimates were compared with those for hunting.

Findings

1. The cost attached to traveling a mile of airline distance for fishing was found to average the same 16.1 cents as it did for hunting. Fishing

groups have very similar characteristics to hunting groups.

2. Of the fishermen interviewed, 79.4% were fishing within 25 miles of their home, 15.3% were fishing between 25 and 50 miles from their home, while 5.3% were over 50 miles from their home. This contrasts sharply with the reservoir recreation data where 32 to 65% of the visitors were over 50 miles from home. While the same cutoff distance of 160 miles as used for hunting was also adopted for fishing (data were too sparse for an independent estimate), the short distances from where so many fishermen lived to their fishing spot necessitated use of a different procedure for estimating numbers of fishermen. For hunting, equation 2 was applied to all county units within 160 miles of the site and the results summed. For fishing, it became necessary to determine the location of the fishing spot relative to where people live in the county. Thus the smallest possible census units were used. Visitation from all of these within 30 miles of the site are summed using equation 2, and the total is increased by a fixed percentage to include fisherman coming from distances between 30 and 160 miles.

3. The data did not demonstrate any significant variation in the estimate of N by quality of fishing site. The best overall estimate was found by nonlinear regression to be 1.75.

4. The best overall estimate of K was found to be 0.054, but the survey data showed the value to vary by stream order. Fishing was found to be negligible in first and second order streams (38). The overall average value of K should be multiplied by 0.36 for estimating fishing in third order streams, 1.27 for fourth order streams, and 2.91 for fifth or higher order streams.

5. The economic value of a fisherman-day was found to vary geographically over the state as well as by stream order. Average values for streams of all orders vary from $1 in the eastern and western coal field areas to $2 in the central part of the state and are plotted by Bianchi on a map of the state (4, p. 101). Factors for multiplying by the average value to estimate value by order are 1.05 for third and fourth order streams, 1.02 for fifth order,

0.95 for sixth order, and about 0.7 for seventh or larger order. Values per fisherman day were thus found to vary between $0.70 and $2.10.

6. The average value of N and the value of K adjusted for stream order can be applied through equation 2 to estimate the annual number of fishermen-days per mile of stream by summing the individual estimates for all census units within 30 miles of the site. This number of fishermen-days can then be multiplied by a unit economic value per fisherman-day read from a map of the state and adjusted by a stream-order factor to estimate the economic value of the fishing.

7. Rough River Reservoir submerged 75.6 miles of stream of orders two through five with 48.9 miles being of fourth order. The land area involved was about 8 square miles. Under these conditions as this where the annual number of stream fishermen turned out to be about 5700 or roughly four times the number of hunters. Annual fisherman-days per mile were 27 for third order streams, 97 for fourth order, and 221 for fifth order.

Significance

The tool established for estimating numbers of stream fishermen and the economic value of their fishing was comparable to that also established for reservoir recreation and for hunting. All give estimates having a precision at least comparable to other figures used in planning, but none should be taken as the last word. Additional Kentucky data could be used to refine the estimates of the parameters used in the model. Data for other areas could be used to extend the procedure to areas outside Kentucky or to particularly high quality fishing streams.

The methods for both hunting and fishing are based on areal averages. The hunting estimates are based on areas of average hunting quality for a species within a county. The fishing estimates are based on streams of average fishing quality for a given order. Further study is needed to differentiate values by particular fields or stream sections. The differentiation will need to be based on species' habitat requirements as compared to local habitat conditions as well as on observations of what hunters and fishermen do because people will go where they can find game.

It is particularly important to stress that these last two studies are attempting to estimate the amount of activity and the willingness of the people taking part in the activity to pay for their experience. Any value people who do not fish place on keeping theoptionof being able to go fishing is excluded. So is any value the fish have through their position in the natural environment in food chains or other types ecological linkages. So is any contribution the species or their habitat make to esthetics. In short, fish and animals have many values outside those achieved through the recreation people enjoy in fishing or hunting them; and the estimation of all such was outside the scope of this research.

SUMMARY

A series of four studies into the recreational use made of large reservoirs and into the recreational experiences lost as lands and streams are submerged by stored water provided a methodology for estimating the magnitudes and economic values of both types of effects and for combining marginal benefits and costs in economic analysis. More extensive data needs to be gathered and analyzed to refine the approach and add precision to the estimates, but an important first step has been made in understanding the relative quantities involved and in determining the issues that must be explored to understand them better.

CHAPTER V

SOCIAL WELL-BEING

INTRODUCTION

The recently recommended "Procedures for Evaluation of Water and Related Land Resource Projects" (57) require explicit analysis of how such projects may affect the social well being of people. Two of the fourteen studies included within this research project examined specific ways that projects affect people but which are not customarily incorporated into benefit-cost analysis. Both studies began by selecting a specific effect projects have on social well being, continued by gathering detailed data on that effect for the cast study projects, and concluded by evaluating that effect in terms of information on how the individuals themselves or society in general felt about the effects. One objective, in each case, was to form some idea on appropriate weighting factors (35, pp. 95-118) for comparing social welfare effects with economic benefits and costs. The two studies are:

1. The Effect of Landowner Attitude on the Financial and Economic Costs of Acquiring Land for a Large Public Works Project.

2. Review of Economic Benefits and Costs Resulting from Dewey Reservoir.

The second study is described under the heading of Social Well Being because its primary emphasis is on the income redistribution effects of a reservoir in one of the poorer areas of Appalachia.

The role of this chapter is to review these studies and discuss the significance of their findings. The supporting details are contained in the referenced reports.

RIGHT-OF-WAY COST IMPLICATIONS OF LAND OWNER ATTITUDE

Objective

Attitude is defined as an individual's feelings toward and beliefs about some object or topic and is measured by observing various types of self expression including spontaneous behavior and responses to prodding or questioning (49). Attitude includes both a directional (good or bad feeling) and an intensity (strength of feeling) component (49, p. 15). Landowners faced with the prospect of losing their property to right-of-way for a proposed project display varying attitudes. Some feel good about being able to sell their property for a cash value, but most feel bad about being forced to sell (16). Individuals in both groups vary greatly in their intensity of feeling. The aggregate feeling of a group of affected landowners is in part a summation of individual feelings but is also reinforced or damped by socialization processes among members of the group and between the group as a whole and outside interests.

Even though landowners threatened with the loss of their property are usually found in the forefront of the opposition to any project, the intensity of feelings is well known to vary greatly among individuals. Attitude depends on the perception of the individual as to the nature of his physical and social surroundings without the project and as to how these will be changed by the project. The perception and evaluation of the desirability of the perceived change depend on various characteristics of the individual, the property, and the neighborhood. The first goal of this study was to isolate those factors that are most significant in determining the attitude of a large group of owners as a whole toward the loss of their property to construction of a proposed reservoir. The objective of this study by J. M. Higgins (23, 33) was to develop factors that could be used to predict the overall attitude of those affected by a proposed project and the effect this attitude has on the economic and financial costs of project construction. The concept was to develop a planning tool for use in project evaluation rather than an instrument appropriate for adjusting prices to be paid for any particular parcel.

Financial cost is defined as the expenditure of funds required to obtain the needed right-of-way. Attitude affects this cost because a hostile landowner increases the administrative cost of right-of-way purchase by protracting negociations and taking sales to court. He may also increase the sale price if the purchasing agency raises its offer to achieve a settlement or if the court awards a higher amount.

Economic cost is defined as the value assigned an item in a planning study for the purpose of establishing commensurable units for comparing gains and losses as a step in reaching a decision on what to do. Economic cost is assigned for the purpose of making decisions furthering objectives seen as important from the viewpoint of the decision maker while financial cost is assigned for the purpose of estimating how much money will be required to pay the bills.

The theory behind right-of-way reimbursement is to compensate for a property on the basis of a price that would be reached by mutual agreement between a willing buyer and a willing seller. The power of condemnation enables a public agency seeking right-of-way for a public works project to force purchase from an unwilling seller. This very unwillingness implies that the owner attaches a greater value to the property than others are willing to pay in a market exchange. The property has a market value but it also has an additional personal value to the owner. The standard procedures used to evaluate real property seek to establish market value. Personal value may be defined as the amount of money above the fair market value that it would take to induce an unwilling (at the market price) seller to sell.

Because the proper viewpoint for public works project planning is the general welfare of society as a whole, the viewpoint of each individual needs to be considered. In what has become a basic criterion of welfate economics Kaldor states (35, pp. 102-103)

> A change is an improvement if those who gain evaluate their gains at a higher figure than the value which the losers set upon their losses.

Therefore, personal value as well as market value is a relevant consideration in assessing the merit of a proposed project, and it needs to be explicitly considered in comparing design alternatives. For example, if two alternatives are more or less equivalent except in that the first involves the loss of much more personal value on the part of those who lose their land than does the second, the second should be favored. For it to be, a way to estimate personal value is needed. In the terminology of this study, personal value is considered part of economic cost; and the research goal is to seek ways to estimate the personal value of the right-of-way required for any proposed project from information about the property and the people who live on it.

Procedure

The concept behind the procedure is that various characteristics of a property, of the individual, and of the local social structure work to shape a person's attitude toward his real property and that this attitude determines personal value. Data were collected on characteristics, attitudes, and personal values. The sampled population was the 872 landowners who sold property to provide right-of-way for Rough River, Dewey, and West Fork Reservoirs. The fact that the sales of these properties were transacted from 7 to 18 years before the study was thought to contribute to a more detached and less emotional response, but it did make it more difficult to find the individuals involved. Of the total, 317 were located and sent mail questionnaires and 95 of these responded (23, p. 31).

The questionnaire was used to obtain information on the personal characteristics of the individual, to scale his attitude towards the project and the sale, and to obtain a direct estimate of personal value (the extra amount the seller felt that he should have gotten). Information on the prices and physical characteristics of properties was obtained from the files of the Corps of Engineers and supplemented from records available within the county. Short questionnaires were also sent to people living in protected flood plain areas and in other parts of the local community in order to get a reading on the relative attitudes of the various groups.

The collected information provided for each of the 93 former property owners who returned usable responses an estimate of personal value, a scaled attitude on the project, information on the circumstances of the sale, and a set of data on the characteristics:

1. The length of time the property had been in the family,
2. Whether or not a family cemetery was relocated,
3. Whether or not the owner's home was involved,
4. The market value of the home sold,
5. The resulting change in landowner income,
6. The local availability of equivalent property for purchase,
7. The value of the property sold,
8. The portion of his total real property the owner sold,
9. The degree to which owner use of property sold for easement would be restricted,
10. The portion of his income producing property the owner sold,
11. The age of the owner,
12. The regularity with which the owner voted in local elections,
13. The way the owner felt he was treated during the sale transactions,
14. The knowledge the owner had of the project.

Also developed were scaled attitudes toward the project for 28 flood plain residents and 82 local citizens in general.

Based on this information, multiple regression techniques were used to study the relationship between the 14 listed characteristics and attitude and between attitude and personal value. A large number of variable transformations and groupings were used to find the best combination for estimating the personal value a property has to an unwilling seller, and a procedure for making this estimate was established (33, p. 370). Attitude was also correlated with the probability of the owner taking the sale to court and with the extra amount he was awarded by the court. Attitudes were also compared among landowner, beneficiary, and community groups.

Findings

1. Information on the set of 14 characteristics was found to explain 90% of the variation in attitude; however, for planning purposes, information on perceived treatment during the transaction and knowledge of the project would not be readily available. If these two items are omitted, a correlation that explained 73% of the variation in attitude results.

2. Knowledge of the project turned out to be the single most important factor in determining attitude. Knowledge was scaled from questions on first impression of the proposed project, opinion on whether the lake would benefit the community, and whether the individual felt properly informed of what was going on. This finding clearly shows the importance of benefits visable to the local public to acceptance of a reservoir by a local community and the savings in financial cost, not to mention economic cost, that can result from extra effort to keep the local people feeling that they are well informed.

3. The second most important variable in explaining attitude was whether or not the owner's home was involved. Other factors in order of decreasing importance were the effect of the sale on personal income, a factor relating to personal loss (years the property belonged to the family, presence of a family cemetery, etc.), and the ability of the owner to find substitute property to replace lost income.

4. Personal values ranged from very small amounts for individuals happy with the project (in some cases negative values occur because people support a project strongly enough to be willing to donate property) to about half of market value for those with a neutral attitude to over twice market value for those scaling as extremely unhappy. For the individual projects, personal value as a fraction of market value ranged from 0.86 at Dewey where most owners lost their homes when nearly all the property was taken in a mountain valley, to 0.66 at Rough River where farmland but few homes were affected, to 0.39 at West Fork where much of the area was investment property on the urban fringe.

5. Probabilities of taking the sale to court increased from about 0.08 for those with a neutral attitude to about 0.45 for the most antagonistic. The effect of the sale on the owner's income and the market value of the property were the two most significant variables determining the extra award a property owner could get by going to court. Accounting records did not provide data on the extra administrative cost involved in handling the purchase of property from uncooperative sellers, but qualitative information suggested that substantial amounts were involved.

6. The responses of the landowners to the questionnaire showed a sharp contrast in attitude between those at Dewey and those at Rough River Reservoir. Those at Rough River favored the project by over two to one while those at Dewey opposed in by better than three to one. The majority at Rough River, but only twenty percent at Dewey, felt that the value of their remaining property would be increased by the lake. Those at Rough River were evenly divided on feelings as to whether their compensation had been adequate while those at Dewey were unanimous in believing that it had not. A substantial number at Rough River believed that the project had increased their income, but those at Dewey perceived only losses in income.

7. No significant trend could be detected in attitude toward the project between those living in the flood plain immediately downstream from the reservoir and those living elsewhere in the local community. Flood plain residents were more in favor of the project at Rough River but less in favor at Dewey and West Fork. The downstream farmers at Dewey would apparently rather have suffered continued flooding than see their upstream neighbors move away.

8. The community as a whole was more strongly for the project at Dewey (towns people) than it was at the other two sites. This produced much greater attitude polarization between beneficiaries and losers than was found at the other locations. Many more people living near Dewey felt that they had personally benefited from the project.

Significance

A procedure for estimating the personal value of real property has been published (33, p. 370) and provides a reasonable estimate for project planning purposes. The collection of more extensive data and a more exhaustive analysis of the relationship among the variables could be used to refine the estimates, but use of the method as given would certainly lead to much better planning decisions than can be made without this information.

When a project takes a person's property, that person is directly affected at the personal level. His personal contacts influence other decisions at the personal level by other members of the community as well as by those having professional and political responsibility for the project. The extent of these personal contacts and a number of other social effects of a project relate to the attitude of landowners as the driving force motivating them to various kinds of action. Project planners certainly recognize the role feelings in a local community can have in determining the political feasibility of a project, but the effort made to explicitly pick alternatives or mold the design of chosen alternatives to minimize generation of adverse attitudes has been much less extensive. The contribution of this study is certainly not its reiteration of the well known fact that landowners do not like having their property condemned. The contribution is a tool for use in designing to minimize adverse impacts.

Because of data collection difficulties, the study was less successful in estimating the financial impact of adverse attitudes. Under present right-of-way reimbursement policy, the biggest financial impact relates to extra administrative cost in dealing with landowners holding adverse attitudes.

The major question of equity that this research did not explicitly address was whether it is right for landowners to only be compensated for market value. Should some people by an unfortunate accident of residential location be forced to sacrifice major personal values, ones for which they show a willingness to pay, for the public good? On the other hand, if they were to be compensated all or in part, one person would receive a greater price than another for an identical property just because he happened to like it better. The second person could then say he liked his equally well, and it would be very difficult to prove him wrong. This research is not intended to provide more than a planning tool and is entirely inadequate for estimating personal value by individual parcels. Furthermore, it is doubtful whether personal value should be a basis for compensation even if it could be estimated.

The findings of this study relate closely to those described in the earlier studies on the effects of reservoirs on land use around their peripheries. Landowners who perceive a way to use residual property to increase their income after selling part of their holdings to the project have a much better attitude about the situation than do those who don't. Some would advocate buying considerable shoreline land for development and possible subsequent resale in order to avoid unjust enrichment of individuals from public funds. This research suggests that allowing owners to retain partial parcels along the shoreline of a reservoir may in fact be an appropriate way of compensating for personal value losses. Certainly, it is now more acceptable, socially and institutionally, than direct compensation. This research showed a much less favorable attitude toward the project by landowners in the case of Dewey Reservoir where whole parcels were purchased. Another factor is the degree to which retention of partial parcels mitigates the financial effect on local government.

INCOME REDISTRIBUTION FROM DEWEY RESERVOIR

Objective

Economic analysis is designed to determine whether a project makes a net contribution to national income whereas the determination of a project's contribution to social well being requires specific information on who will reap the benefits and who will pay the costs. While it is generally known that projects tend to concentrate their benefits on users of project output and rely on funds collected nationwide, only a few studies have attempted explicit determination of gainers and losers in this income redistribution (15, 22, 59).

This study by D. H. Rosenbaum (27, 34, 48) sought to estimate, from the advantage of hindsight, the costs incurred and the benefits resulting from construction of Dewey Reservoir. The next step was to determine the income distribution of those receiving the direct benefits and of those paying the costs. This two step procedure provided the information necessary to accomplish the underlying research objective of assessing the effectiveness and desirability of reservoir projects as income redistribution endeavors. The location of Dewey Reservoir as a primarily Federally financed facility in a low income area in the heart of Appalachia made it a location where income redistribution effects would likely be near maximum.

Procedure

Data on costs were obtained from all agencies and groups involved in providing or maintaining facilities at Dewey Reservoir. Project effected stage reductions to floods that have occurred since project completion and stage damage curves by river reach were obtained from the records of the Corps of Engineers to estimate direct flood control benefits. Recreation benefits were estimated from the previously described study by Tussey (55). Other direct benefits were much smaller and were estimated through contacts with the beneficiary groups. The Thomas uncertainty fund (35, pp. 184-185 and 254-256) was used as a basis for estimating the flood control benefit resulting from the decreased probability of catastrophic flooding (for an alternate approach, see 59). Higgin's method was used to estimate the personal value landowners attached to the lands they lost for right-of-way (33).

The direct flood control benefits were estimated by the counties in which damages were reduced from the benefits by all river reaches on a line from the Reservoir downstream to the mouth of the Ohio River at Cairo, Illinois. Data were collected as part of this project to determine how the mean value and distribution of incomes of people living on flood plains compared with mean values and distributions of incomes of people in a county as a whole. Published census data are available on income distribution by county. Each countywide income distribution was converted to an income distribution for flood plain dwellers in that county and this distribution was then used to estimate the distribution of flood control benefits realized in the county by income category. The aggregate estimates were summed from county totals.

Direct recreation benefits were also estimated by county. Based on Tussey's inability to show any consistent pattern by which people of different income levels vary in their propensity to engage in recreation at Dewey Reservoir, the distribution of incomes of reservoir recreation beneficiaries living in the county was assumed to follow the same distribution as the incomes of all people living in the county.

Each category of project expenditure was estimated and allocated among appropriate groups by using available records and interviews with the people involved. The income distribution of the people in each such group (local labor, local landowners, imported construction workers, etc.) was approximated from published income statistics; and these distribution were used to distribute payment recipients by income category.

Dewey Reservoir was primarily financed by federal funds, but state funds were used to finance recreation facilities and access roads. Published statistics on federal income tax incidence by income category were used to distribute federal funds used to finance the project by income category. State funds to finance the project were distributed by state income tax incidence. Data on changes of tax incidence with time were used to correct for the fact that taxes are collected to pay for a project a number of years before benefits are realized, and hence time changes in income tend to cause projects to distribute income from relatively poorer people in the present to wealthier people in the future.

Projects redistribute income by taking money through taxes from one group of people and using it to pay for goods and services obtained from a second group in order to produce output benefiting a third group (35, pp. 174-177). The above information provided estimates of cash flows by income category for all three groups.

The relative importance of the income redistribution effect in comparison with the promotion of national income effect of the project was assessed by use of weighting factors calculated from marginal income tax rates following a method outlined by Haveman (22, pp. 132-139). The final product was an estimate of the overall relative importance of the income redistribution achieved in the case study situation.

Findings

1. Total annual costs of the Dewey Reservoir project in 1961 dollars were estimated to be $1,067,000. Category values were $248,000 for the dam and appurtances, $44,000 for reservoir operation and maintenance, $123,000 for the market value of land and relocations, $92,000 additional in present worth of lost future income from the right-of-way (35, p. 179), $64,000 for the personal value of right-of-way, $281,000 for highway construction, $23,000 for highway maintenance, $125,000 for construction of recreation facilities, and $67,000 for maintenance of recreation facilities net of operating revenues. The economic value of lost hunting and fishing areas is not included above but amounts to about $8,000 annually.

2. Total annual efficiency benefits from the project in 1961 dollars were estimated to be $1,538,000. These were divided between $815,000 for recreation and $723,000 for flood control. The overall ex post facto benefit-cost ratio of 1.44 indicates that the project has been a good investment from the point of view of economic efficiency.

3. The most striking difference between the project as originally planned and the project as it exists is the greatly expanded cost for access and recreation facilities and the fact that the majority of the benefits are from recreation. The fact that the division of the total annual cost into three broad categories gives 27% for the dam and reservoir, 26% for land, and 47% for access and recreation facilities demonstrates that recreation has definitely not been an inexpensive sidelight. The fact is emphasized more strongly by Sirles' finding that, even with this expenditure, the recreation

facilities are not developed to an economically optimum extent. Federal water planners have not generally appreciated the magnitude of the nonfederal cost involved in recreation development and the small fraction dam construction cost is of the total cost of a multiple purpose facility.

4. When benefits and costs were distributed to incident income ranges, the benefit-cost ratio by range were as shown in Table 2. Flood control provides the greatest gain to middle income people who own enough property to suffer significant damage but are not wealthy enough to be in the highest tax brackets. Recreation facilities provide a valuable opportunity to low income groups living nearby. The income redistribution to them does not come through a cash income but rather through an enhancement of the way they spend their time.

5. In most areas, residential property values on the flood plain were found to be less than those on higher ground. For example in Louisville, Kentucky, median assessments were $10,400 on the flood plain and $17,400 off the flood plain (48, p. 69). In contrast in Appalachia, the higher ground is too steep for convenient building, and the pressure to build on flatter ground causes the distribution of property values on the flood plain to be essentially the same as that for the county as a whole.

6. Income redistribution benefits based on the assumption that marginal federal income taxes collected represent group consensus on equi-marginal sacrifice amount to 18.2 percent of the efficiency benefits. The total amount of $281,000 comes from $224,000 from the difference in income between the taxpayers and the recipients of project expenditures, $134,000 from recreation, and -$77,000 from flood control. One would have to conclude from these figures that reservoirs are not very effective as income redistribution measures. They are particularly not effective at increasing the monetary incomes of the people living nearby. The Dewey Reservoir setting in an area where incomes are very low with respect to the national average is one of the most favorable possible; smaller distribution effects could be

TABLE 2

INCOME REDISTRIBUTION EFFECTS OF DEWEY RESERVOIR

Item	Annual Income Range: 0 to 3000	3000 to 5000	5000 to 7000	7000 to 10,000	Over 10,000	Total
Costs - United States						
Dam Construction (1950)	40,630	78,350	33,290	40,660	148,170	341,100
Operation and Maintenance (1960)	1,750	5,120	7,710	9,420	19,800	43,800
Access Highways (1960)	5,620	16,450	24,750	30,230	63,550	140,600
Costs - Kentucky						
Park and Access Highways (1960)	7,260	34,730	55,470	65,320	96,420	259,200
Operation and Maintenance (1960)	2,530	12,090	19,300	22,730	33,550	90,200
Total Costs	57,790	146,740	140,520	168,360	361,490	874,900
Flood Control						
Costs	42,380	83,470	41,000	50,080	167,970	384,900
Benefits	58,320	203,720	193,330	131,700	138,580	725,650
Benefit-Cost Ratio	1.38	2.44	4.72	2.63	0.83	1.89
Recreation						
Costs	15,410	63,270	99,520	118,280	193,520	490,000
Benefits	259,460	170,230	167,120	129,670	88,240	814,720
Benefit-Cost Ratio	16.84	2.69	1.68	1.10	0.46	1.66
Over-all						
Costs	57,790	146,740	140,520	168,260	361,490	874,900
Benefits	317,780	373,950	360,450	261,370	226,820	1,540,370
Benefit-Cost Ratio	5.50	2.55	2.56	1.55	0.63	1.76

All values are in 1961 dollars. Costs not paid by the taxpayers are not included.

expected at most other sites; and negative values are likely in locations where incomes are above the national average. The reservoir was more effective in providing a water-oriented recreation opportunity to people who would not otherwise have one and thereby in increasing their income in a nonmonetary way. This contribution of the reservoir to the esthetic and recreational value of an area, without increasing the monetary income of its inhabitants, collaborates the findings of the studies on the local economy.

7. The estimated income stabilization benefits achieved because the project provides the inhabitants of downstream flood plains a more regular annual income, by suppressing irregular and often financially catastrophic flood losses, amounted to $338,000 annually at the 0.5% catastrophy level (35, p. 185). The majority of these benefits accrue in the town of Paintsville, Kentucky, immediately downstream from the reservoir.

8. From the economic efficiency viewpoint project annual benefits were $1,538,000, annual costs were $1,067,000, and the benefit-cost ratio was 1.44. With the weighting factors used for this study, multiple objective benefits were $1,933,000 annually, costs were $853,000, and the benefit-cost ratio was 2.27. Secondary and environmental effects are omitted from these computations.

Significance

This ex post facto review of the benefits and costs associated with a completed reservoir project showed the project to have made a net contribution to the national economy. The distribution of benefits by purpose was radically different but the total was somewhat larger than that estimated during project planning. During planning, the costs were underestimated, the most severe underestimation of recognized costs was for right-of-way, and the cost of developing the resource for recreation was just not fully considered. All these discrepancies would be greatly reduced if Dewey Reservoir had been planned on the basis of currently used procedures.

The central issue at hand is the uncertainty associated with estimating future social needs. Reservoir recreation was not popular when Dewey was planned in the 1930's, and no one could anticipate how important it would become in the 1960's. Today we know the wants of our times, but it is much less sure that in a day of accelerating change in life styles we can do much better in anticipating the needs of the 1990's. In the case of Dewey Reservoir, the project made a net contribution to providing unanticipated needs. Thirty years from now, we may find today's projects detracting from the satisfaction of the needs we do not now anticipate. The role of social and environmental impact studies should be to reduce the probability of this happening.

One can indulge in lengthy arguments over whether the weighting factors used in this study for placing income redistribution and income stabilization effects on an equivalent basis with economic efficiency effects were appropriate. One can even wonder whether attempting to put measures of progress toward such diverse social goals in commensurable units is appropriate. Certainly, this study shows the futility of working for precise estimates of events in the distant future. The more logical approaches to improved planning would be through better ways to meet immediate social needs and better ways to work to avoid long run environmental deterioration.

SUMMARY

A study of the value people of various characteristics put on their real property was used to develop a procedure for estimation of the personal value of property from readily available information about the people and their property. A study of the incidence of benefits and costs from a completed reservoir project was used to analyze the effectiveness of such projects as instruments for income redistribution. The project was not found effective in redistributing cash income, but it was worthwhile from an economic viewpoint.

CHAPTER VI

DYNAMIC OPERATION

INTRODUCTION

The prevailing concept of water resources planning has been to satisfy human needs for water supply, recreation, flood control, and other project outputs by constructing new facilities. Once a facility becomes operational, the possibilities of adjusting its use to meet a composite of needs different than those expected during planning are seldom fully considered. Efforts are made to use better hydrologic information and analysis techniques to increase the water supplied by a given reservoir, but reallocation of reservoir storage among project purposes is often blocked by financial commitments and legal or political constraints established at the time of project construction. As a consequence, a city may be forced to pay $2,000,000 for a new reservoir when it could get the same amount of water from an existing reservoir at a sacrifice of flood control benefits having a present worth of $500,000. As new reservoir sites become more scarce and concern over the ecological effects of developing new lakes becomes more intense, planners are going to have to shift their emphasis from searching for new development sites to searching for ways to use existing developments more efficiently. It will be necessary to seek ways to make project operation dynamically responsive to changing economic and social needs.

The major problems that need to be overcome are legal and institutional in character; however, many technical problems exist as well. The problems studied in this chapter relate to finding what kinds of modifications in operating policy would maximize economic welfare. The three titles are:

1. Derivation of Reservoir Operating Rules by Economic Analysis,
2. The Generation of Flood Damage Time Sequences,
3. The Operation of Flood Control Reservoir Systems.

The pages of this chapter review these studies and discuss the significance of their contribution to making operating policy sensitive to time changes in economic need. The supporting details are found in the referenced reports.

ECONOMIC ANALYSIS OF RESERVOIR OPERATION

Objective

Capital investment decisions are based on economic tradeoffs. In the case of reservoir design, it is necessary to decide whether society is better off spending money to construct a new facility or using that money instead for some other purpose. At a different level, the planner must decide whether a given reservoir should be designed to utilize the entire storage capacity of a site for water supply or to reserve a portion for flood control. This study by C. O. Dowell (13, 30) sought to examine the economic tradeoffs involved in optimizing the operating policy of an existing reservoir where Rough River Reservoir was taken on a cast study basis.

One of the more important operating decisions is the target amount of water best kept in the reservoir by time of year. The concept is to store additional water flowing into the reservoir when storage is below the target level and to release water when storage exceeds the target quantity. Reservoir capacity provides storage for flood control, yield for a variety of beneficial uses, and a place for recreation. Flood control benefits increase as the quantity of water kept in the reservoir for long periods is reduced. Recreation benefits increase as long-term storage is increased and kept at more constant levels. Water supply benefits decrease if the water level is reduced to provide more flood control space when the water is not needed for beneficial use or if the reservoir is not allowed to fill during high runoff periods.

The objective of this study was to develop a procedure for using marginal economic analysis to select the optimum target storage range by month of the year. In order to do this, it was necessary to express both the benefits to be gained by storing additional water in the reservoir during that month and the benefits to be gained by keeping storage space empty on marginal bases with respect to storage. The optimum point could then be found as the point where the marginal benefit gained by storing additional water equalled the marginal benefit lost by holding additional storage space in reserve for future floods. Analyses for each month of the year would be used to develop the annual pattern in optimum operating policy.

Procedure

The case study used for this analysis was Rough River Reservoir operated for flood control, water supply, and recreation. Water supply is actually a minor purpose at the reservoir under current conditions, but it was included in the study for the purpose of analyzing the economic tradeoffs it involves. The overall strategy was to determine the benefits the reservoir could produce if it were operated solely for each of these purposes taken individually, to distribute these benefits by month of the year, to note months when operation for one purpose conflicted with operation for one or more of the others, and to estimate how much the benefits achieved for a given purpose in a given month drop as a function of the degree to which storage for that purpose is reduced during the month.

Total annual recreation benefits were taken from Tussey's previous work (55) and allocated by month of the year proportionally to historical visitation patterns by assuming equal unit value per visitor-day during each month. The methodology used to estimate the storage required during the month to realize this monthly recreation benefit and the amount by which the benefit declines if storage drops below that level was based on the concepts expounded by Sirles (51). However, this study did not have benefit of his finding that capacity limitations reduce visitation by much more than can be accounted for by visitors who cannot be physically accommodated during periods of peak use (31, pp. 21-23). Consequently, only the physical limitation was considered, and the marginal reduction in recreation benefit with decreased storage was understated. This difference effects the optimum storages tabulated by Dowell (13, pp. 110-113), but not the principles stated in describing his findings below.

Flood frequency relationships were derived for each month of the year. The reservoir is large enough to more than contain the 200-year flood. It was assumed that virtually the full flood control benefit would be realized if the flood control storage in every month equalled the volume of the flood having a 0.5 percent change of occurring during that month. Marginal reductions in flood control benefit, if less storage were assigned to flood control during a month, were estimated by routing floods of various frequencies for that month through the reservoir and using stage-discharge and stage-damage curves to estimate marginal increases in flood damage. A relationship between the fraction of the drainage area controlled and flood peak reduction was derived to extend the estimates of marginal reduction in flood control benefit to downstream reaches.

The yield the reservoir could provide for water supply was estimated by using the 26 years of available historical record to generate a 500-year trace of synthetic monthly flows (14). Standard reservoir operation techniques were then used to use this trace to estimate firm yield (35, pp. 287-291). Maximum firm yield from a given reservoir requires complete freedom to store water during high flow periods and to use it during low flow periods. Firm yields is reduced by any restriction on maximum drawdown or maximum storage levels. A series of maximum drawdowns were specified for each month, and a corresponding estimate of firm yield was made. The same procedure was followed with a series of maximum storage levels. Two marginal curves resulted for each month with respect to water supply. One indicated the marginal decrease in yield with lower maximum storage levels, and the second indicated the marginal decrease in yield with higher minimum storage levels.

The final step was to combine these marginal values to determine the optimum target storage for each month of the year. Because Rough River reservoir is not required to develop a large water supply and water supply benefits are difficult to estimate even when the water is needed, each target storage was estimated as a function of the marginal value of water. With a marginal value of water known (say from sale prices in the service area) or assumed, one can read a target storage from the curve.

Findings

1. The procedure of determining the conflicting storage requirements of competing reservoir uses and estimating the marginal loss in benefit with respect to one purpose when another purpose infringes on its requirements proved to be a workable method for defining an economically optimum operating policy. The method may be applied directly as was done in the case study to a single existing reservoir or adapted for application to a group of reservoirs in a coordinated system.

2. Monthly flood control benefits were largest in late winter and early spring when flood danger is most severe and drop to minimal values in early fall. Furthermore, when an infringement on flood control storage is expressed as a fraction of the volume of the 200-year flood for that month, marginal losses from storage reductions are also most severe during the same late winter and early spring months.

3. As one would also expect, recreation benefits and marginal benefit losses from storage reductions are maximum in midsummer, July and August.

4. The firm yield was estimated to be about 80% of the storage capacity. The greatest storage requirement for maximum yield and the greatest sensitivity of yield to infringement on maximum storage requirement was found to be in March. March (or more generally the last month in the spring when normal rainfall exceeds normal evaporation) thus becomes the critical conflict month between flood control and water supply requirements.

5. The greatest drawdown requirement for maximum yield was found to be in November (or more generally the last month in the fall when normal evaporation exceeds normal rainfall). However, recreation use is at low levels at this time of year and hence there is little conflict. The greater conflict is in late summer as drawdown requirements for water supply began to increase toward their fall maximum but recreation use is still at high levels.

6. A series of twelve monthly operating rules were derived (13, pp. 110-113). Each one said to keep at least X acre-feet of water in the reservoir and to hold the maximum conservation storage at or below Y acre-feet. X is determined by the marginal values for that month of storage for recreation versus drawdown for water supply. X is a function of the annual visitation and the marginal value of water. Y is determined by the marginal values for that month of storage space for flood control versus water stored for water supply. Y is a function of the magnitude of downstream flood damages and the marginal value of water. Optimum reservoir operation in a month is to allow the water level to fluctuate freely in response to immediate needs for water supply between storages X and Y. The operating policy would not allow storage to drop below the X level nor exceed the Y level except on a temporary basis during flood periods. The quantity of water to be supplied should be reduced at times when storage is approaching either limit.

7. The implementation of these operating rules is limited by the availability of sufficient inflows to raise storage to the minimum requirement in foing from one month to the next (30, pp. 1228-1229). The principal problem comes with the additional water required to accommodate increasing recreation attendance in the spring. The filling should allow enough lead time for the required levels to be reached and this takes a long time if inflows are low. In some cases, a marginal tradeoff between flood control or water supply drawdown in one month and recreation requirements in a subsequent month must be considered.

8. The precise levels of X and Y change with time because of changes in downstream flood plain development, changes in recreation visitation, and changes in the demand for water. If the target range is stated as a function of these variables, optimum operating policy can be easily reviewed from year to year and adjusted to match current needs.

9. The zone of conflict was small in the case of Rough River reservoir because sufficient storage was available to prevent direct conflicts between flood

control and recreation. A smaller reservoir exhibits greater conflicts among competing purposes.

Significance

The general trend of the above findings are not surprising and pretty much follow contentional practice (30, p. 1219). The significance of this study lies not in the pattern over the year of the derived operating policy but rather lies in two other aspects. First, it employs marginal economic tradeoffs to make each decision. Whenever an operating question arises, it looks at the advantages of going one way versus the advantages of going the other and selects the best compromise. Second, it states the optimum operating policy as a function of the demands for the various project outputs. Thus, operating policy need not be set at fixed levels for many years but can rather be adjusted to meet the needs of the year at hand. Furthermore, the curves developed by the method provide a ready means for estimating losses from severe flow sequences exceeding the reservoir design level. This kind of flexibility will make it much easier to supply future water needs from existing reservoirs without having to resort to new construction.

In order to expedite the type of reservoir operation policy advocated, various legal problems must be overcome. Parties supplied by water from the reservoir may have a legal right to the water, and any transfer of rights (e.g., to increase recreation or flood control benefits) may be prohibited. Even if it is not legally prohibited, the water supply beneficiaries may have paid for the reservoir; and some equitable system of compensation must be established for any of their water to be taken away. Another kind of legal liability arises when a shift of operation harms such parties as downstream people who find their flood damages increasing in order that other beneficiaries may enjoy more water for municipal use or recreation. Specific arrangements for financial reimbursement must be developed.

FLOOD DAMAGE TIME SEQUENCES

Objective

The standard procedure for estimating average annual flood damage begins with a frequency analysis of recorded (or, if necessary, simulated) annual flood peaks. Then, flood peaks of selected frequencies are converted to damages, and damages are plotted against frequency. The area under the curve provides an estimate of the expected average annual damage (35, pp. 183-184). The average annual benefits provided by a flood control measure are then estimated by repeating the process for conditions expected with the measure and deducting the resulting estimate of residual damages from the original total.

Hydrologists have long recognized that the frequency of given streamflow cannot be equated to the frequency of the rainfall producing it, primarily because of time variations in basin antecedent moisture. The estimation of flood damages, however, frequently does not take into account the fact that the frequency of the annual flood peak may not be the same as the frequency of the annual total flood damage (28, pp. 1-7). Several small storms during a year may do more damage than a single larger storm. Furthermore, flood damage depends on factors other than flood peak. Summer storms cause more agricultural damages than do winter storms. Floods that inundate property for long periods of time do more damage than do those of short duration.

The relative importance of damages not caused by annual flood peaks increases with the degree to which flows in the watershed are controlled. Flood control storage can retain enough water to reduce greatly the damage from major flood events. However, the stored water must later be released. Often channels must flow near bankful capacity for long periods while the reservoirs empty. The protection provided by the flood control reservoirs encourages more intensive use of flood plain lands, and some low lying lands may be damaged (e.g., by being too wet for farming) by a wetness conditions maintained longer into the spring. In addition, any small storm that develops over the uncontrolled portion of the watershed will cause damage as the channels no longer have reserve capacity. One way to reduce both types of damage during a long draw-down period would be to increase releases, to empty the reservoirs quicker, but this would cause flows to remain at flood stages for longer periods of time during major floods. Another way would be to decrease releases, so that the channels would not run so full, but this would increase the chances of uncontrolled flooding were another major storm to occur because the reservoirs would be fuller. According to the principles developed in the last section, these questions should be answered by examining the marginal trade-offs, but the standard procedure for estimating damages is inadequate for this purpose. The flood damage for the year is determined by the peak, and the procedure does not vary damages with flows during hydrograph recession.

In a situation where a large quantity of flood storage works to reduce major flooding but also works to increase the chances of minor flooding, a more careful analysis of the pattern of flood damages is needed in order to establish an optimum operating policy. The concept of this study by J. P. Breaden (5) was to develop a procedure for estimating flood damages hour by hour directly from storm hydrographs. The estimating procedure is designed to estimate the damage that occurs in a given hour as a function of the variables that control the amount of that damage. The procedure is written as a sub-routine that can be attached to a computer program for routing or simulating flows in a channel system and will estimate the damages added each hour any flooding continues and sum the results to obtain an annual total. The process can be repeated for the years with damaging floods (often just a few of the total years of record). Expected average annual damages can then be estimated from a plot based on a frequency analysis of the damage totals for the individual years.

Procedure

The estimation of flood damages as they occur during a flood is based on a careful classification of damages by type and by location and by keeping track of recent flood history at each location. The basic damage estimator assumes flood damage during any hour to be a function of depths, duration, time of the year, and state of repair at the beginning of the flooding. Agricultural damages are summed from crop damages, field damages (including fences, erosion, debris cleanup, etc.), and damages to crops stored in the fields. Urban damages are summed from damages to buildings, damages to public facilities, and losses associated with not being able to use buildings and public facilities while they are under water.

Crop damages depend on the crop, the time of the year as it affects the conditions of the crop in the field and the opportunity to replant after flooding subsides. If the same crop is inundated more than once during the growing season, the damages added the second time are adjusted downward according to the harm caused the first time. Provision is made for seasonal growth changes in each crop. Field damages depend on depth and duration. Additional flooding increases duration until the water subsides sufficiently for the farmer to go to work to restore his field and causes a lesser damage if it resumes before he has had time for complete restoration. The location accounting provides for farmers being able to get back into higher fields sooner than the lower ones. Stored crops are kept in the field to feed livestock from harvest time to the subsequent spring. Once they are destroyed, no further losses can occur until the next harvest.

Building damage is estimated from depth and duration of continuous flooding. Once the flooding recedes, restoration of the building is assumed to begin. If flooding occurs again before full repair is effected, damages are reduced proportional to the state of repair. The same principle is used for estimating damages to public facilities except that faster restoration rates are used.

The subroutine is provided information on the depth and area of inundation for several flood peaks and contains formulas for interpolating to estimate these values for any other flood peak. Cropping patterns, building values, and potential damage to public facilities are provided by zones designated by elevation above flood stage and by river reach. Such data are normally collected in flood plain studies. From these data, the program estimates damages independently by zone. Zone totals are summed for reach totals, and reach totals are summed for grand totals.

The basic information for estimating crop damage was obtained from the Soil Conservation Service. The urban damage totals and the flood plain information were based on data obtained from the Corps of Engineers for the Muskingum River Basin.

The data required by the subroutine is essentially the same as that customarily used to estimate flood damage. For each crop, data is required on damage by depth, duration, and month of the year (the numbers were developed directly from SCS data), on crop unit price, on yield and plantings by soil type, and on the last day in the spring for planting by crop. For each reach, data is required on fraction of the land farmed, channel capacity, flows and flooded area by flood stage, soil type, value of stored crops, market value of buildings and contents, and damageable value of public facilities.

Findings

The estimating procedure was developed, debugged, and adjusted until it worked satisfactorily in optimizing operation of the Muskingum River Basin reservoir group. Damage patterns with time depend on the data supplied the subroutine and hence on conditions in a particular flood plain. In the case study, a significant part of the damage total was resulting from periods outside the duration of the major flood hydrograph. Damages occur most rapidly during the time of most rapid rise on the leading edge of the flood hydrographs but continue at low levels as long as fields and buildings remain inundated. If flooding is severe enough to cause a complete loss of crops in the field, crop damages from a reduction in yield because of later replanting continue until flooding continues past the last possible planting date for the crop that can be planted latest in the spring. Building and public facility damages occur as temporary homes and alternate transportation routes are required.

Significance

The primary significance of this study was in its success at developing a procedure for estimating flood damages from generalized information on the susceptability of different kinds of property to flood damage, specific information on conditions in the flood plain under study, and a sequence of flood flows. The procedure provided the estimates needed to optimize reservoir operation for the Muskingum system under conditions where standard estimating procedures could not be used. Standard procedures provide reasonable results in cases where nearly all the flood damage is caused by one standard-shaped flood hydrograph. A procedure of the type developed provides a better estimate in situations where flood damage occurs several times a year. It is essential for reliable estimates where available flood detention storage is very large compared with downstream channel capacity and estimates of flood damage are needed to optimize release policy.

OPERATION OF FLOOD CONTROL RESERVOIR SYSTEMS

Objective

The subroutine developed for estimating flood damages for the last study was used to examine the tradeoffs inherent in operating a system of reservoirs to minimize downstream flood damage. One issue is whether flows entering storage after the outflow hudrograph has crested should be retained in order to shorten the duration of downstream flooding as much as possible or be released more rapidly to minimize damages from storms that might occur before drawdown is completed. A second issue is how to allocate total releases determined by channel capacity at a critical point along the stream among the upstream reservoirs. A third issue is what drawdown policy will minimize flood damage from runoff from uncontrolled areas caused by storms that occur while channel capacity is largely being used for drawdown. The purpose of this study by K. R. Harman (21) was to resolve these issues in a case study of the 15 flood control reservoirs in the Muskingum River Basin in South Central Ohio.

In order to concentrate on the central issues, the scope of the study was defined to prevent the analysis from becoming sidetracked on peripheral concerns. The existing system was taken as given both as to physical characteristics of the reservoirs and channels and as to land use and stage damage functions. The analysis was based on single purpose operation of the system for flood control, excluded effects on the Ohio River downstream from the mouth of the Muskingum, and considered only economic effects of the damage (excluded environmental quality and social well-being effects). The technique developed by Dowell of examining conflicts among uses for storage space could be applied to consider a reallocation of storage space among uses. Effects on Ohio River flooding could be added as constraints to operation.

Procedure

Some of the reservoirs in the Muskingum River basin are in series while others are in parallel. The bulk of the damages occur along the main stem of the Muskingum River between Dover Reservoir and the mouth of the river at Marietta 173 miles downstream. The primary damage points are in the towns of Coshocton, Zanesville, and McConnelsville but a total of 13 damage reaches were used. Eight reservoirs, including Dover, operate in parallel on tributaries entering the main stem and regulate runoff from 5015 of the 8051 total square miles in the watershed. Total storage amounts to 1,590,000 acre-feet or 5.95 inches for the controlled area. Based on the 24,000 cfs channel capacity (a higher value can be used in the winter when crop damage is not a factor), approximately 50 days would be required to empty all the stored flood water were all the storage reserved for flood control filled during a major storm. The problems and protests by farmers created by this long drawdown period were a primary factor inspiring this study.

The other seven reservoirs are upstream from the eight parallel reservoirs and contribute to reducing flood damages in the (intermediate) reaches between the two as well as on the main stem as described above. Since the primary problem was operation to minimize main stem damages, all the storage in each series reservoir was assumed to be in the downstream parallel reservoir for the initial operation optimization. Once proper operation of the parallel system to minimize mainstem damages had been determined, each series system could then be analyzed to see if it could be operated without causing damage under the constraint of the optimization for the main stem. If it could, rules for doing so were prescribed. If it could not, the tradeoff between intermediate reach damage and main stem damage was analyzed to determine the minimum total damage compromise.

The analysis of operation of the parallel reservoirs to minimize damages on the main stem was based on the recorded floods for six historical years 1913, 1935, 1937, 1959, 1964, and 1969. The March, 1913, flood was the flood of record on the main stem and at four of the parallel reservoirs. The January, 1937, flood produced record volumes at the other four. All six floods produced runoff volumes exceeding storage capacity for at least one of the reservoirs. The August, 1935, and July, 1969, floods occurred in the summer while the other four were winter floods.

A computer model was established for routing flood hydrographs through the reservoir and channel system. Inflow hydrographs for each of the parallel reservoirs for each of the six historical years and for the thirteen uncontrolled local inflow points were established. These flows were routed through the channel system and processed by the damage subroutine to estimate damage totals if no reservoir storage were available. They were routed through the system as currently operated to see if the model was reproducing historical hydrographs and damages. The flood plain as a whole is one where development is changing relatively slowly with time. Local or uncontrolled inflows alone were routed to determine the damages that would occur if the reservoirs could completely contain upstream flows. This amount represents the minimum possible value to which flood damages could be reduced.

Thirteen control points exist in the main stem area. Target flows were established for each one. At any given time, some of the target total is taken by local inflows. The balance is used in the model to allocate among upstream reservoirs by a formula based on the volume of empty flood control storage they currently contain in terms of inches over the drainage area. Each reservoir will have an allocated release based on the control points downstream from it, and the minimum of these values will control.

The optimization procedure was a trial-and-error application of the program designed to route flows based on reservoir operation to achieve specified target releases and estimate consequent flood damages. After a given trial, the times and circumstances producing damages exceeding the minimum achievable values (caused by runoff from the uncontrolled watershed) were reviewed, and modifications were made to the control point target values (seasonally adjusted) and to the formula allocating the total among upstream reservoirs. The adjustment continued until no further damage reduction could be achieved.

In more conventional terminology, the optimization process utilized a simulation model able to reproduce flow hydrographs and consequent flood damages at thirteen points in the system (35, pp. 463-466). The flows and damages were inspected, and the system was adjusted to reduce those flows (by time and control point) causing the damage. Each adjustment was made with a watchful eye on increasing other flows and hence other damages. The procedure was nearly able to reduce damages to minimum possible values through a knowledge of how the system functions instead of more formal search procedures which assume a much lower level of information about the response surface.

Findings

The procedure succeeded in reducing flood damages caused by four of the six storms to quite near the values caused by runoff from the uncontrolled watershed. This was not possible for the two largest floods where tributary runoff volumes exceeded the storage capacity of nearly every reservoir.

In all cases, the damages were significantly less than those associated with current operating procedure; and this reduction was achieved by extending, by reducing releases during, drawdown periods. The argument against this policy stems from the chance that a large flood will occur while the reservoirs are still part full and cause a great deal of damage because insufficient storage space will be available to contain them. When storms are evaluated by frequency of annual flood peaks, the analysis of this situation requires a study of the probability of back-to-back events. However, this study was based on all flows (including a number of back-to-back floods) that occurred from the time all the reservoirs first began to fill until they were all empty again. The flood damage totals covered this entire period of time and thus had the historical back-to-back event damages summed.

Significance

Computer simulation of flow and damage sequences can be used to test alternative operating policies for a group of flood control reservoirs that must respond to floods that vary by primary source area and time patterns from flood to flood. Once the simulation model is established, simulated damage patterns can be inspected, and the target releases causing the damages can be adjusted in a process that was found to converge to the optimum (or least-damage) operating policy rather quickly.

The least-damage operating policy for one flood may not necessarily be the least-damage operating policy for another flood. For example, a slow release to reduce damage during a single-peaked flood followed by a long dry spell may increase damages during a sequence of large flood peaks separated by a few weeks. As the sequence is a rarer event, in terms of damage than the magnitude of the highest peak would indicate by hydrologic analysis, one can expect a tradeoff between reducing damages during more frequent events at the expense of increasing damages during rare events. The procedure as applied provides damage information for examination of this tradeoff.

Therefore, in addition to providing a tool for resolving the operating issues outlined in the statement of research objectives introducing this study, the approach also provides a handle on the issue involving joint probabilities of flood events of various magnitudes within varying periods of time. Existing operating practice is overrun with arbitrary rules of thumb, mostly very conservative, for dealing with this issue. The damage subroutine for summing annual damage totals for each decision alternative and then using a frequency analysis of the annual damage totals to compare the alternatives provides a means for explicit analysis of the situation.

SUMMARY

The conflicts by month of the year among demands for storage space in a large reservoir by flood control, water supply, and recreation were examined for the purpose of deriving an optimum reservoir operating policy. Each tradeoff was expressed as a function of demand level for project output so that operating policy could be adjusted as demands change with time. A simulation model was developed for estimating the effect of various manipulations of hydrograph shape on flood damage and used to converge on an optimum operating policy for flood control for the fifteen reservoirs in the Muskingum Basin.

CHAPTER VII

PROJECTS AND PEOPLE

The first chapter of this report developed the concept that even though theoretically correct procedures for comparing alternatives may be adopted for planning they are almost of necessity implemented through formal and rather rigidly institutionalized procedures. Meanwhile, many of the most critical planning decisions are based on "gut-level" reactions. Such reactions introduce the bias of the planners and provide the spirit behind organized pressure efforts on the part of laymen. The second chapter categorized the various types of effects coming within the scope of project impact and discussed how many individual facets of the total impact can be used to build an emotionally appealing argument either for or against any given project.

At any point in time, the science of decision economics (35, p. 1) has progressed to the point where it can satisfactorily capture the essence of certain classifications of impact in commensurable units for use in decision making. Other aspects of impact have not yet been analyzed in sufficient detail for this to be done. While the academically inclined pursue research efforts to clarify the issues which must be objectively resolved to analyze impacts that are poorly understood, those with strong feelings on the impacts use them to build support or opposition for particular projects or entire resource development programs. Whereas the institutionalized planning procedures are too formalized to respond rapidly to changes in academic or popular thought on the advantages and disadvantages of various kinds of impact, planning on the personal level swings with the thinking of the multitude though not necessarily in conformance with majority opinion.

The objective of this research was to reach out from those aspects of impact that are currently handled in a theoretically satisfactory way to some of those aspects that are not so handled and are being used as the "gut issues" by those with particular axes to grind. Planners need tools for dealing with these issues objectively.

With this vision, eighteen people at the University of Kentucky investigated the issues involved in the ways multipurpose reservoir projects affect local government, provide economic opportunities for people living in contiguous areas, change the character of land use around their shores, attract recreation visitors, stop hunting and stream fishing in inundated areas, take homes and lands from private ownership, provide benefits and require tax collections from people in various income groups, require changes in operation policy to match changing needs, and must be integrated with other reservoirs in operation to advance the public welfare. They analyzed the impacts a group of Kentucky and Ohio projects have had and devised methods for estimating and evaluating the impacts future projects will have for use in project planning. They have tried to expand capability for planning on the theoretical level.

The project has also been active in working to change institutionalized planning procedures. Several hundred project produced reports have been sent to key officials in the agencies charged with water resources planning and management. Many additional copies have been requested and furnished others in these agencies. Key findings have been incorporated into the technical literature and into textbooks. Material developed through project research is being taught in courses in water resources planning and economics all over the country. While institutional procedures change too slowly for any research project to point to the specific differences it has caused in officially sanctioned procedures (if not in approaches to specific case studies) by the time its completion report is due, there can be no doubt that this study is having an impact on the technology of comparing alternative water resources management schemes.

The question of impact in light of the broader issues involved in deciding whether the research is contributing to the formulation of projects that better serve the people is much more nebulous. If planning decisions were all made on the theoretical level, a better theory would produce better results. However, many decisions are made on the personal level. It is informative to note the historical trend. When an issue first arises it usually leads to heated discussions, largely conducted on the personal level. Later theory is expanded to deal with the issue in a way that generally comes to be accepted as reasonable, and the die-hard proponents and opponents of particular projects move on to new issues to support their viewpoints. The evolution of procedures for evaluating reservoir recreation benefits are a case in point.

A better planning theory can help people make better decisions. Given advances will be introduced into institutionally recognized procedures. Eventually, they may become ingrained in the popular viewpoint. Each individual determines the use he wants to make of water and related land resources in a given day. Hopefully, this research will help people, individually and collectively, to make better decisions.

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