Investment Planning for Multiple Purpose Uses of Water Resource Projects in Oklahoma

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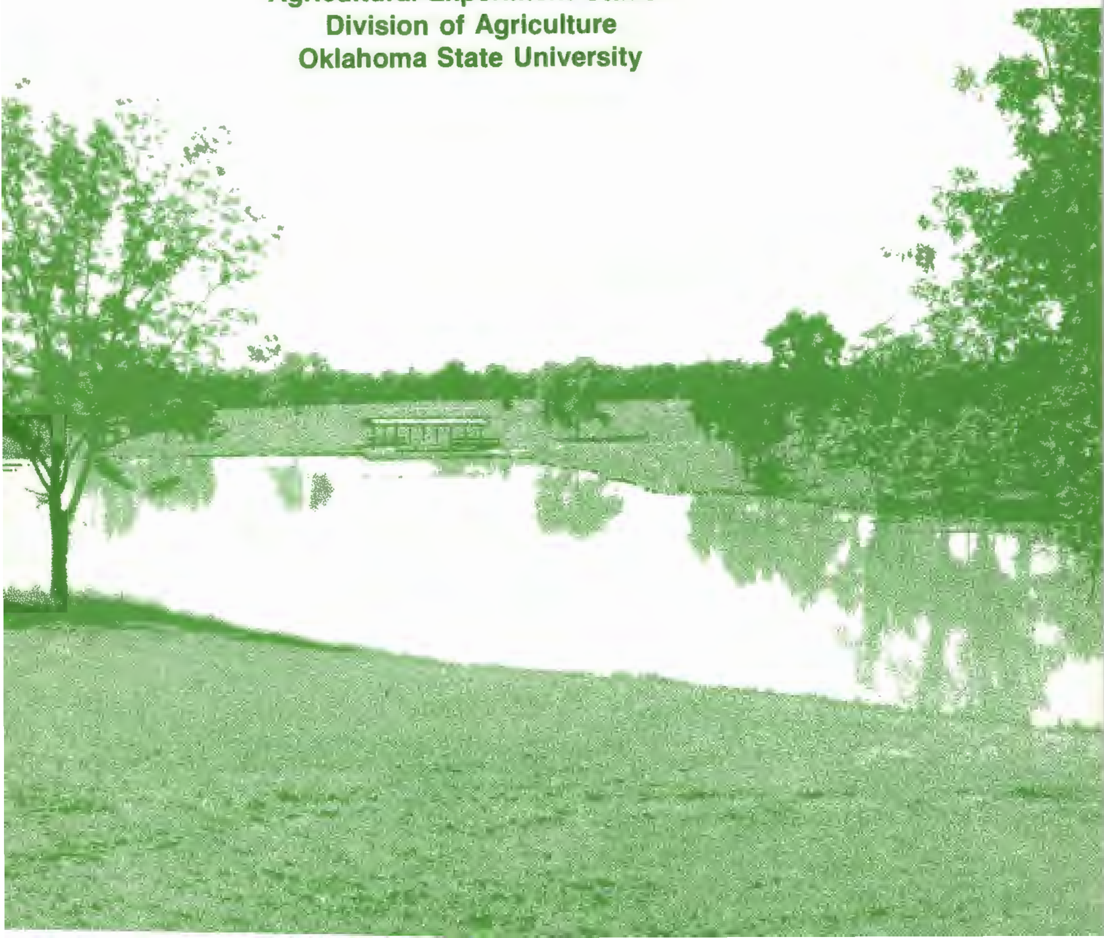

Abstract

This research bulletin develops and applies a methodology for planning optimum facility development in a multiple purpose water resource project. First, the economic criterion of efficient resource use for determining optimum investment by means of maximizing net social benefits is presented. The efficiency criterion is then relaxed for purposes of evaluating alternative policy options for assessing costs. Second, a mathematical programming model is presented for purposes of determining optimum facility development. And, third, application is made to recreation facility development at Lake Fort Gibson in Oklahoma. Results of the analysis are (1) information on the optimum timing and level of investment for recreation facility development; (2) information on total visitor days by time period, and total costs of supplying recreation services; and (3) information on the distribution of benefits and costs including private benefits, private costs, public costs, welfare loss, and net social benefits. This information should be useful to public decisionmakers in choosing among the various policy options.

Continued investment in recreation facility development at Lake Fort Gibson is in the best interests of society. If recreationists are charged all of the identified marginal costs of recreation facility development, the present value of marginal net benefits over the planning period 1975-2000 increase by about $49,500,000 in 1975 prices. Recreationists are price responsive to increases in charges for recreation services. If recreationists are charged less than their full marginal costs they will demand more recreation, investment costs will be greater, and society will suffer a welfare loss. The significant difference in results comes between charging recreationists no costs at the lake and charging at least the operation and maintanence costs of supplying recreation services. Assessing these charges reduces visitor days by 27 percent, reduces investment costs by 45 percent, increases present value of the marginal net social benefit by 7.4 percent, and increases the marginal benefit-cost ratio from 1.9 to 2.3.

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INVESTMENT PLANNING FOR MULTIPLE PURPOSE USES OF WATER RESOURCE PROJECTS IN OKLAHOMA

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INTRODUCTION

Background

Water and related land-based recreation is a major activity of the McClellan-Kerr Arkansas River Navigation System. Visitor day attendances increased from 240,000 in 1950 to a high of 39,198,000 in 1978 and a present visitor day attendance of about 32,000,000 (Table 1). The Navigation System in its present state includes 6 major lakes and 17 locks and dams in the Arkansas River Basin of the states of Oklahoma and Arkansas. The Navigation System is a multiple purpose system providing transportation, hydroelectric power, municipal and industrial water, soil and water conservation, flood control, scenic beauty, and recreation and wildlife benefits.

Badger, Schreiner and Presley (1977) analyzed expenditures for a sample of recreationists at the lakes and locks and dams in the summers of 1974 and 1975. Basis for the analysis was personal interviews with over 2,200 recreational groups. Results show that the estimated visitor day trip expenditures averaged $6.01 and the visitor day annual expenditures averaged $3.53.[2] Estimated aggregate recreation expenditures taking place over the entire navigation system equalled $224,000,000 for 1975. These expenditures were classified in the framework of input-output sectors for purposes of linking

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[2]Visitor day is defined as participation by an individual in any activity (fishing, boating, skiing, swimming, camping, or sight seeing) for any part of a day. The definition used here is consistent with methods developed by the U.S. Army Corps of Engineers in enumerating visitor days. Visitor day trip expenditures are based on total expenditures for the observed recreational group during this trip divided by the product of the number of individuals in the group times number of days in the trip. Visitor day annual expenditures are based on total annual expenditures by the observed recreational groups for water-based recreation activities (including equipment depreciation) divided by the product of the number of individuals in the group times number of days of water-based recreation per year (at all lakes).

Table 1. Recreation Attendance in Visitor Days by Lake and Area, McClellan-Kerr Arkansas River Navigation System, 1950-1984 (Figures in 1,000)

Year	Keystone	F. Gibson	Eufaula	Tenkiller	Oolagah	Oklahoma Main Channel	Arkansas Above Little Rock	Arkansas Below Little Rock	Total
1950	0	195	0	45	0	0	0	0	240
1951	0	489	0	93	0	0	0	0	582
1952	0	780	0	67	0	0	0	0	847
1953	0	1,287	0	552	0	0	0	0	1,839
1954	0	2,163	0	1,155	0	0	0	0	3,138
1955	0	2,746	0	1,413	0	0	0	0	4,159
1956	0	3,707	0	1,866	0	0	0	0	5,573
1957	0	3,988	0	2,130	0	0	0	0	6,128
1958	0	4,178	0	2,298	0	0	0	0	6,476
1959	0	4,213	0	2,398	0	0	0	0	6,611
1960	0	3,782	0	2,284	0	0	0	0	6,066
1961	0	3,512	0	1,627	0	0	0	0	5,139
1962	0	3,736	0	1,841	0	0	0	0	5,577
1963	0	2,479	0	1,663	324	0	0	0	4,466
1964	479	2,806	168	1,636	719	0	0	0	5,808
1965	1,582	2,466	2,305	1,782	1,148	0	1,589[a]	0	10,872
1966	2,001	2,427	2,158	1,842	937	0	1,318	0	10,683
1967	1,794	2,112	2,002	1,373	1,178	0	1,217	0	9,676
1968	1,833	2,406	2,313	1,466	1,093	0	1,034	0	10,145
1969	2,152	2,672	2,766	1,804	1,057	0	1,277	1,027	12,755
1970	2,440	2,937	3,215	2,311	966	0	1,559	1,266	14,694
1971	2,585	3,116	3,982	2,361	884	304[c]	2,693[b]	1,874	17,799
1972	2,893	4,419	4,602	3,096	1,103	1,093[d]	2,811	2,417	22,434
1973	3,138	4,008	4,522	4,055	1,326	1,172	3,413	2,462	24,096

Table 1. (Continued)

Year	Keystone	F. Gibson	Eufaula	Tenkiller	Oolagah	Oklahoma Main Channel	Arkansas Above Little Rock	Arkansas Below Little Rock	Total
1974	3,674	4,083	4,562	5,002	1,219	1,317	3,729	2,080	25,666
1975	3,022	4,110	4,695	5,226	1,421	2,128	4,330	2,348	27,280
1976	4,051	3,571	5,387	5,669	1,782	3,133	5,931	2,630	32,154
1977	4,236	6,790	6,550	6,575	1,842	3,774	6,592	2,696	39,055
1978	4,180	7,228	7,242	4,064	1,801	4,552	7,303	2,828	39,198
1979	4,156	4,451	6,455	4,595	2,145	3,717	7,552	2,537	35,608
1980	3,357	2,352	3,463	3,127	1,611	3,115	10,825	3,359	31,209
1981	4,602	4,404	4,115	3,493	3,630	3,651	8,191	2,410	34,496
1982	3,051	4,484	4,561	3,088	3,088	2,432	9,606	3,144	33,656
1983	3,105	3,544	4,059	2,134	2,524	2,688	9,150	3,290	30,494
1984	2,627	3,882	4,163	2,066	3,033	3,088	9,517	3,420	31,766

Source: The Tulsa and Little Rock Districts of the U.S. Army Corps of Engineers. See text for definition of visitor day.

[a]Beginning Lake Dardanelle

[b]Beginning of Ozark Lake, L&D #13, L&D #9, Toadsuck Ferry L&D, Murray L&D

[c]Beginning of Robert S. Kerr Lake and W. D. Mayo Lock and Dam

[d]Beginning of Webbers Falls Lake, Newt Graham L&D and Chouteau L&D

recreation activities to the total economic system both inside the Arkansas River Basin region and outside the region. Such a framework permits analysis of linkages of recreation expenditures to regional and interregional sector output, employment and income. Antle (1979) estimated that these recreation expenditures were associated directly and indirectly with an annual income of $390 million both within the region and outside the region.

The above analysis shows linkages of the Navigation System with the rest of the economy through recreation activities. However, the analysis does not show the benefits to society from the demand for recreation. The recommended procedure (U.S. Water Resources Council, 1979 and 1983) measures benefits in terms of willingness-to-pay for each increment of supply provided.

The primary objective of a second study by Schreiner, Willett, Badger and Antle (1985) was to estimate recreation benefits for the McClellan-Kerr Arkansas River Navigation System by the travel cost method using data from the 1974-75 survey. Weighted least squares regression was used to estimate recreation demand functions categorized by regional lakes and local lakes. Local lakes accounted for 80 percent or more of their visitor days coming from households located within a radius of 100 miles of the lake. Regional lakes had a radius in excess of 100 miles for 80 percent of their visitor days.

Price, income and population elasticities of demand were estimated individually for the regional and local lakes. Price elasticities varied from a low of -0.86 to a high of -1.12. Population elasticities, based on aggregate county data serving as observations for concentric zones around a lake, varied from a low of 0.31 to a high of 0.68. Income elasticities of demand, in general, lacked statistical significance. Estimated visitor day benefits ranged from $1.20 to $3.68. A conservative estimate of annual recreation benefits in 1975 dollars was estimated at $50,000,000 for the Navigation System as a whole.

Problem Statement

The above studies are an analysis of the current status of recreation development in Eastern Oklahoma. However, they do not tell the policy maker what should be the level of development of this major economic activity. The U.S. Army Corps of Engineers maintains a facilities and site development plan for each project or lake which is referred to as the Master Plan. The Master Plan provides information on the historical development of the project, the current status of the project, and what is proposed for long term development of the project.

Hence, the Master Plan is a document prepared and used by the U.S. Army Corps for purposes of long term development of a particular project (lake). This study provides elements of a planning methodology for purposes of developing a Master Plan. Application is made to Lake Fort Gibson as one project in the total McClellan-Kerr Oklahoma River Navigation System. A planning period of 25 years (1975 to 2000) is chosen to correspond with the base year of the early survey work and the end of the development period contained in the Lake Fort Gibson Master Plan (U.S. Army Corps of Engineers, Master Plan for Lake Fort Gibson, 1978).

Elements of a Proposed Planning Methodology

Three factors are important in planning recreation services: 1) demand for recreation including growth in demand, 2) cost of supplying recreation facilities and services, and 3) charges (prices) assessed for using recreation facilities and services.

Growth in population and real per capita income are major factors in projecting demand for water-based recreation. The Schreiner, Willett, Badger and Antle (1985) study provides an estimated recreation demand function for Fort Gibson which serves as a basis for projecting recreation demand to the year 2000.

Costs of supplying recreation services at the lake or project site include operation and maintenance (O&M) costs and capital costs of building new facilities and refurbishing existing facilities.

Operation and maintenance costs are a function of the total number of people visiting a project. Trash must be picked up and removed, bath houses and restrooms must be cleaned and serviced, and areas must be patrolled and safety regulations enforced.

Projects are designed and built to handle a certain capacity of recreationists. The number of recreationists visiting a project is not a smooth continuous flow each day of the year or recreation season. Rather, there are peak demand periods such a Memorial Day, Fourth of July and Labor Day weekends. Long-term development costs include maintaining existing capacity and increasing capacity to handle growth in demand during peak periods. Although O&M costs handle routine maintenance, project engineers plan to refurbish recreation facilities about every 15 years. These costs include such things as repairing or replacing picnic tables and camp site equipment, regrading and surfacing roads, and replacing other equipment and facilities that have deteriorated. Without periodic refurbishing of recreation facilities capacity of a project decreases.

Travel costs serve a dual role in the proposed planning methodology described here. Travel costs are a surrogate for price in estimating the demand for recreation. Results of the Schreiner, Willett, Badger and Antle study show that as travel costs increase due to increased distance to the lake and facilities, the quantity of recreation demanded decreased. Even though travel cost is the surrogate for price in estimating the demand for recreation and the willingness-to-pay for recreation, the assumption is that for any change in cost (price), such as a change in gasoline costs or a change in entrance fees, recreationists will respond the same as estimated using travel (distance) costs.

The second role served by travel costs is to show that, in the aggregate, the costs of serving more people from the fixed recreation site (lake) increases the further out those people are located from the site. The aggregate travel cost function increases as the quantity of visitor days increases. Therefore, the costs of supplying recreation to any individual include that individual's travel cost, marginal O&M costs, and marginal capital facilities cost.

The McClellan-Kerr Arkansas River Navigation System is a multi-purpose facility. The system, or some variant to the current system, probably would not have been built on the basis of recreation alone. Recreation, however, can be evaluated on the basis of separable costs and separable benefits. Development of recreation services found at the Navigation System requires additional costs over and above the costs in supplying the other system purposes. The question becomes one of who will pay for the separable costs of recreation and how will the assessment of these costs affect the quantity of recreation services demanded.

The substantial growth in recreation visitor days at the Navigation System (Table 1) has significantly increased the financial burden of maintaining the facilities and increasing the visitor days capacity of the projects. Until 1965 the costs of providing recreation services at the Navigation System by-in-large were the responsibility of the Federal government, specifically the U.S. Army Corps of Engineers. Beginning in 1971 charges or fees were assessed at some locations for overnight camping and use of certain facilities. Currently, gate attendants are hired and placed at specified locations for purposes of collecting entrance fees and assessing charges for using certain facilities.

The Federal Water Project Recreation Act of 1965 (U.S. Statutes at Large, 1965) provides that federal agencies, such as the U.S. Army Corps of Engineers, should encourage non-federal agencies and private groups to operate, maintain and replace recreational facilities. The federal agency would provide one-half the cost of constructing and refurbishing the project, while the state and/or private recreationist would provide the other half, as well as all the costs of operation and maintenance.

Several consequences may result depending on the policy governing charges assessed the recreationist:

1. Recreationists will want to keep charges as low as possible because the less they pay for services the greater will be their derived benefits.

2. State and local governments will encourage as many visitor days as possible because of the perceived multiplier effects of recreation expenditures. If required to share in costs of constructing and maintaining additional facilities, state and local governments will weigh these costs against the perceived benefits of increased economic

activity. An alternative will be to pass on as much of the facility costs to the recreationists as is possible.

3. The federal government will try to reduce treasury costs as much as possible by a) charging the recreationist as much as possible, b) requiring state and local governments to cost share, or c) keeping the number of visitor days as low as possible and thus minimizing their costs.

4. Society as a whole will strive for efficiency in resource use by supplying the number of visitor days that equates the marginal social benefits derived from recreation with the marginal social costs of supplying recreation services.

There are various options that policy makers may use in charging for the use of recreation facilities. One option is to charge the full cost of supplying the recreation services and facilities. A second option is for recreationists to pay private (travel costs) plus O&M costs; the rest of the costs will be paid by the federal government. A third option is for recreationists to pay only private costs; all other costs are incurred by the government. A fourth option is based on the use of the policy guidelines in the Federal Water Project Recreation Act of 1965 where the recreationist may be asked to pay all but 50 percent of capital costs for facilities.

The need for a consistent planning methodology becomes apparent. The demand for recreation is changing over time and must be projected over the planning period. Costs of supplying recreation services must be estimated. The equilibrium between the demand for recreation and the supply of recreation services is dynamic and must be traced out over time. Furthermore, this equilibrium is dependent upon what the recreationist is charged for services. This study seeks to provide such an integrated planning methodology.

Results of the Planning Model

Before stating the specific objectives covered in this study it might be well to state the specific results that should come out of a planning methodology as discussed above:

1. The level of development of recreation services should be a primary output of the planning methodology. This is interpreted as the time path of visitor days over the planning period. It should state the needed capacity in recreation facilities to handle the projected visitor days. This in turn will determine the level and timing of investments to build the needed capacity.

2. Since the level of development is dependent upon economic criteria of resource use, these criteria should be specified in the planning methodology.

3. And since economic criteria of resource use in public projects such as recreation development are seldom specified without arbitration, policy options should be presented to decision makers with the attendant measurements of such variables as private benefits, private costs, public benefits and public costs including welfare loss.

Application to Lake Fort Gibson

The choice of a lake for application of the planning methodology was somewhat arbitrary but the following factors were considered:

1. Only lakes within the Arkansas Navigation System were considered since recent recreation demand functions were estimated for those lakes.

2. Fort Gibson was categorized as a local lake as defined by Schriener, Willett, Badger and Antle (1985) and thus represented a more limited market area and hence reduced data requirements in estimating recreation benefits.

3. Preliminary investigation indicated data were available from the Tulsa District Corps of Engineers on costs of supplying recreation services for the lake.

4. Lake Fort Gibson had a recent updated Master Plan which could be used for comparison with the results of this study.

5. Finally, the planning methodology developed and applied to Lake Fort Gibson is assumed applicable to any other recreation project.

Fort Gibson Dam is located on the Grand (Neosho) River in Wagoner and Cherokee counties, about 5 miles northeast of historic Fort Gibson, Oklahoma, from which it draws its name. The Fort Gibson project was authorized by the Flood Control Act of 1941 and was incorporated into the Arkansas River multiple-purpose plan by the River and Harbor Act of July, 1946. Designed and built by the Tulsa District Corps of Engineers, the project was started in 1942, suspended during World War II, and completed in September 1953, at a cost of $42,535,000.

The recreation plan was adopted in 1946 after a joint study by the National Parks Service and the U.S. Army Corps of Engineers. The federal government authorized the Corps to construct, maintain and operate public parks and recreation facilities in reservoir areas and to grant lease and license for lands, including facilities, preferable to federal, state or local government agencies (U.S. Army Corps of Engineers Master Plan for Lake Fort Gibson, 1978). The Master Plan for Lake Fort Gibson (1978) has set the development of the lake until the year 2000, which provides a comparative base for this study.

Objectives of the Study

The general objective of this study is to develop a planning methodology for determining optimal facility development for water-based recreation at Lake Fort Gibson. Specific objectives include:

1. To project the demand for water-based recreation at Lake Fort Gibson to the year 2000.

2. To estimate the unit costs of operating, maintaining and expanding water-based recreation facilities at Lake Fort Gibson.

3. To determine the optimal facility development for water-based recreation at Lake Fort Gibson to the year 2000 based on alternative policy options concerning assessment of costs to recreationists.

4. To evaluate alternative policy options and provide guidelines for water-based recreation management at Lake Fort Gibson.

METHODOLOGY FOR PLANNING OPTIMUM RECREATION FACILITY DEVELOPMENT

The purpose of this section is to develop a methodology for planning optimum recreation facility development. First, the economic efficiency criteria for determing optimum investment in recreation development by means of maximizing net social benefits is presented. This criteria is relaxed for purposes of evaluating different policy options for assessing the distribution of recreation benefits and costs. Second, a mathematical programming model is presented for purposes of determining optimum recreation facility development. And, last, a brief listing of the expected results of the analysis is offered.

Maximizing Net Social Benefit

The basic question to be answered is: How much investment should be made in recreation facility development? Water-based recreation projects are generally public projects and the question is then one of determining how much investment should be made in developing recreation facilities at a particular project.

Economic theory would state that recreation facility development should take place up to the point where the marginal social benefits derived from recreation are equal to the marginal social costs of supplying recreation (Herfindahl and Kneese, 1974, Chapters II and V in particular). If all of the social benefits and social costs of recreation at a particular project can be identified and quantified as depicted in Figure 1 then the optimum recreation facility development would be q_o visitor days. This is the point of maximum social benefits or the point where marginal social benefits is equal to marginal social costs. To supply fewer visitor days of recreation services would be giving up some net benefits society would like to have. To supply more visitor days of recreation services, the gain in benefits to society is less than the costs to society of supplying those additional visitor days. Clearly, then, net social benefits are a maximum when q_o visitor days are supplied.

The supply of recreation visitor days can be considered for a year or for a planning period. For short run (annual) analysis, facility development must be considered fixed. To extend the analysis to a planning period with possible additions to facilities requires maximizing present value of net social benefits where future benefits and costs are discounted at the social discount rate. Since the purpose of the present study is to assist project engineers in determining long term facility development for purposes of presenting a Master Plan, emphasis is placed on maximizing present value of net social benefits.

Seldom can all of the benefits and costs to society be identified for a particular project and frequently not all of the identified social benefits and costs can be quantified. This should not, however, prevent identifying and quantifying as many of the social benefits and costs of recreation services as possible and using this information in assisting project engineers in developing their Master Plan.

Policy Options for Assessing Costs of Recreation

Total benefits are equated with total wilingness-to-pay for recreation or the area under the demand curve for recreation. As a surrogate for marginal social benefits this study proposes to substitute benefits derived by people participating in recreation activities at Lake Fort Gibson or what might be called the private demand for recreation (Herfindahl and Kneese 1974, pp 189-191). In Figure 2, the demand for recreation is shown as D_a for zone A and D_b for zone B. The difference in demand between zone A and zone B is only the location of the curve; zone B has an apparent larger population and/or income base than zone A. The slope of the demand curves are equal.

Costs of supplying recreation services are broken down into several component parts. The first component is travel costs recreationists must pay to participate in recreation activities at the project. This cost is assumed equal to c_1 in Figure 2. The cost may be different by zone because zones may be at different distances from the lake. In Figure 2, zone B has a greater travel cost per visitor day because it is a greater distance from the lake. If recreationists paid only their travel costs they would demand q_4 visitor days at the lake.

A second component is the cost of operation and maintenance (O&M). This cost is incurred at the lake or project site and for a fixed number of total visitor days there is an average O&M cost per visitor day. Assume this cost is

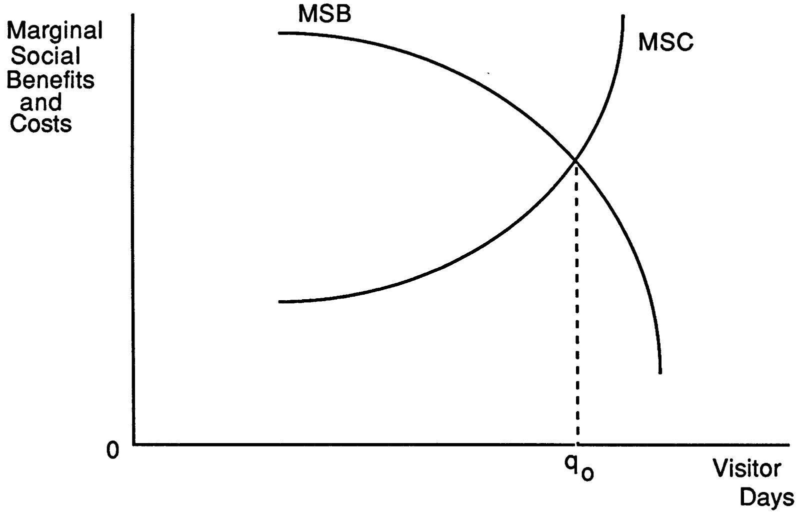

Figure 1. Marginal Social Benefit and Marginal Social Cost of Recreation Facility Development

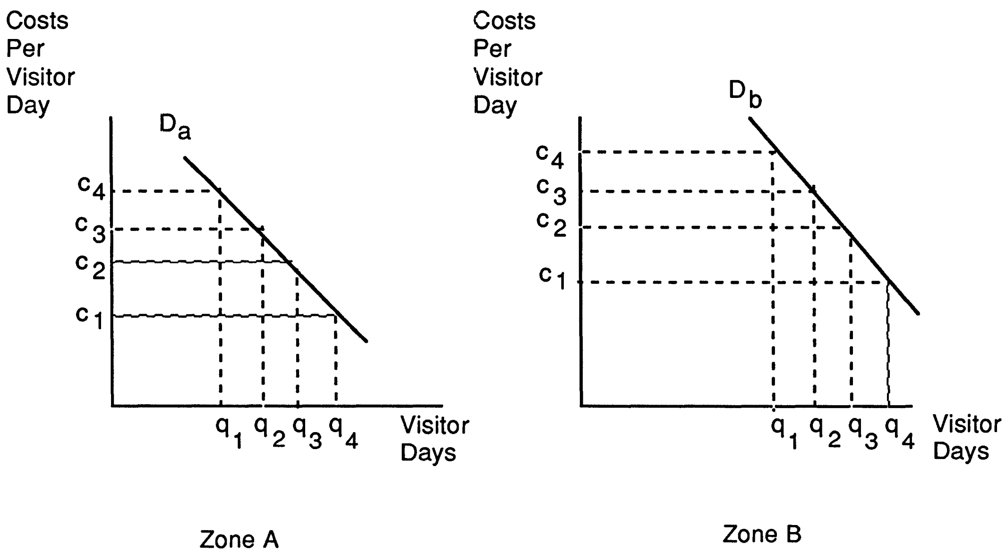

Figure 2. Demand for Recreation by Zone

equal to c_2 - c_1 in Figure 2. The O&M cost per visitor day is the same whether the visitor days come from zone A or zone B. In the aggregate, the average O&M cost may be decreasing, constant or increasing as the number of visitor days increases. This is an empirical question addressed in a later section. If recreationists paid their travel cost plus the average O&M cost they would demand q_3 visitor days at the lake.

Costs to maintain or increase capacity is another component of the total costs of supplying recreation services. These costs are further discussed and estimated in a later section. Here it is sufficient to indicate that to maintain the level of capacity that currently exists at the project or to increase capacity requires additional investment. Past investments prior to the beginning of the current planning period are fixed (sunk costs) and assumed not to effect current decisions on facility development. If a policy decision is to recoup part or all of past investments in recreation services, and these costs are passed on to recreationists in the form of entrance fees, then past investments can have an effect on current decisions to use recreation facilities. However, because no entrance fees were charged before 1971 it is assumed for this study that investments in recreation facilities prior to this date are not to be recovered.

For discussion purposes, assume a marginal investment cost to maintain and/or increase capacity to handle a specified quantity of visitor days. This is a marginal investment cost because it is additional investment to the sunk costs. Assuming an expected life of the investment and a discount rate, an annualized investment cost can be calculated. If the annualized investment cost is spread out evenly over all visitor days for the year it can be represented as the average annualized investment cost per visitor day and equal to c_4 - c_2 in Figure 2. Again, this cost is equal for both zones A and B. However, the annualized investment cost per visitor day may vary for two important reasons. First, depending upon how much additional capacity is put in place at one time, the unit cost per visitor day capacity may vary. Economies of scale in construction cost may decrease unit cost. However, as more and more of the lower cost sites at the lake are developed, the more hard to reach or more costly sites must be developed and the unit cost per visitor day capacity may increase. Second, as the number of annual visitor days varies from year to year (either through annual variations in environment and thus demand for recreation or through growth in demand for recreation), the annualized investment cost per visitor day will vary. However, once the marginal investments have been made, the annualized investment cost is fixed.

The purpose for dividing the annualized investment cost per visitor day into two equal parts (c_3 is half way between c_4 and c_2 in Figure 2) is in keeping with the guidelines of the Federal Water Project Recreation Act of 1965 that encourages state and local participation by a 50-50 cost sharing basis of new capital expenditures. If recreationists paid all of the former costs and only 50 percent of the annualized investment cost per visitor day they would demand q_2 visitor days. If, however, they paid all costs including 100 percent of the annualized investment cost they would demand q_1 visitor days.

The aggregate demand for recreation at Lake Fort Gibson is the summation of demands for all zones around the lake. This is identified as the marginal benefit (MB) curve or private demand curve for recreation in Figure 3. It is important to recognize that MB represents only those benefits attributed to recreationists utilizing facilities at the lake.[3]

The various cost curves in Figure 3 are an interpretation of the aggregation of costs given in Figure 2. MC_1 represents the travel costs of recreationists to arrive at the lake. The curve is represented as an increasing linear function from the origin. If a large number of zones are considered around the lake, this representation of MC_1 is logical. Presumably, those recreationists living next to the lake have zero travel costs but for zones further and further away from the lake the travel costs are higher and higher.[4] MC_1 is a perfectly discriminating marginal cost curve since each recreationist must pay his own travel cost and this is a function of distance from location of the zone to the lake. The marginal zone represents the intersection of the MB curve and MC_1 curve in Figure 3. If recreationists paid only their travel costs the aggregate number of visitor days demanded would be Q_4 which is the summation of q_4 visitor days for all zones (Figure 2).

MC_2 represents the additional O&M cost to the MC_1 travel cost. The assumption in Figure 3 is that unit O&M costs are constant and thus MC_2 is a fixed multiple of MC_1. If recreationists paid travel costs plus O&M costs they would demand Q_3 visitor days which equates their marginal benefits derived from recreation with their marginal costs of recreation. Q_3 of Figure 3 is the summation for all zones of the q_3 quantities of visitor days as shown in Figure 2.

MC_3 and MC_4 represent the additions of annualized investment costs to the travel and O&M costs. MC_3 assumes only 50 percent of the annualized investment costs are added whereas MC_4 assumes 100 percent of the annualized investment costs are added. It is also assumed that these costs are constant across all visitor days. If recreationists pay these costs in addition to travel and O&M costs they would demand Q_2 and Q_1 visitor days, respectively. The MC_4 curve in Figure 3 comes closest to representing the MSC curve in

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[3]There may be additional benefits enjoyed by society from these facilities but such benefits have not been identified or quantified for the study. Including those benefits would result in the MSB curve of Figure 1.

[4]In application, delineated travel zones would be represented by a step increase function.

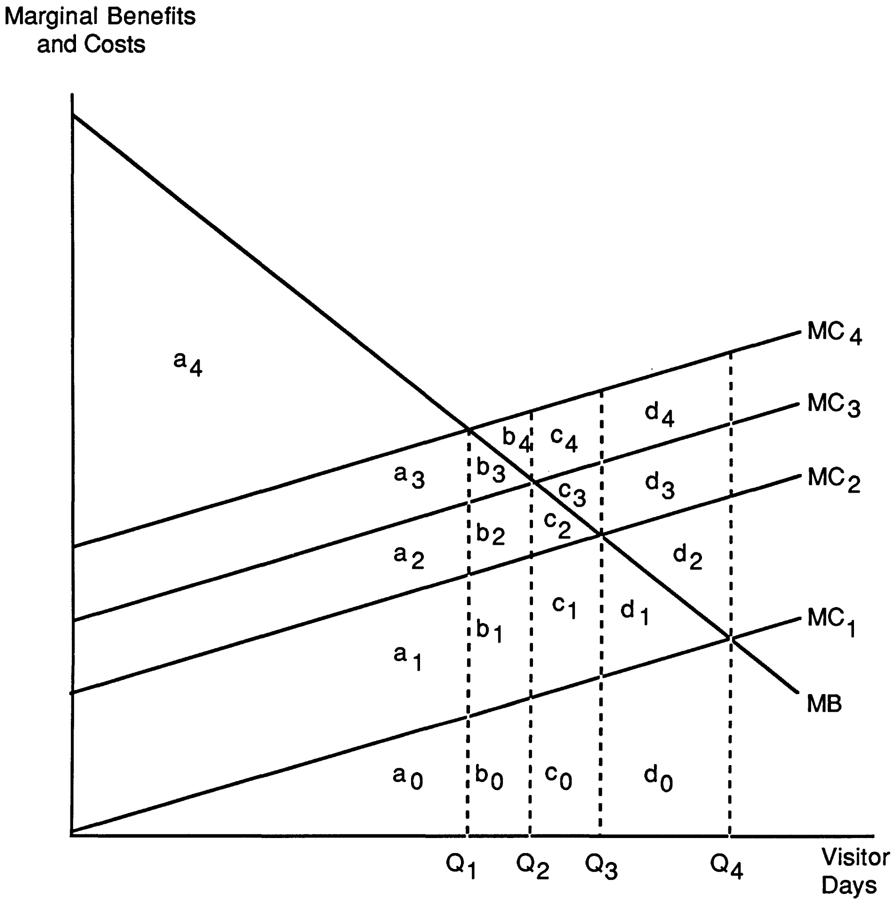

Figure 3. Identified Marginal Benefits and Marginal Costs of Recreation Facility Development

Figure 1. It identifies all of the known costs that appear in the private account of the recreationists and in the accounts of the project engineer.[5]

Assessing charges is sometimes a problem in recreation. Traditionally, water-based recreation was provided free to recreationists by the federal government on multiple purpose water projects. With a tightening of budgets, an increased perception of large untapped recreation benefits, and a changing attitude toward public goods by Congress, the Water Recreation Act of 1965 implies a more compensatory policy of charging local sectors that benefit from water-based recreation projects. However, because user charges are not yet standardized, there is ambiguity in public and private attitudes toward who should pay for water-based recreation projects.

To better understand the issue of assessing charges, four scenarios are introduced for analysis. Scenario 1 represents the full cost model, scenario 2 the Water Recreation Act of 1965 policy guideline pricing model, scenario 3 the O&M plus private cost model, and scenario 4 the private cost model. A discussion of the scenarios and consequences of assessing charges follows:

Scenario 1. The full cost model is the extreme case of assessing all identified costs of the recreation activity to the private recreationists. There are few projects in water-based recreation typified by the full cost model because the view of public policy is still not totally in this direction. In this scenario it is assumed the federal government paid all facility development costs up to the current planning period. But the recreationists will determine what facility development should occur over the future planning period by equating their marginal benefit with the total marginal cost of supplying recreation services. The amount of recreation services demanded is Q_1, in Figure 3.

Scenario 2. The policy guideline model (Water Recreation Act of 1965) is based on the federal government sharing in 50 percent of the new investment and refurbishing costs. The rest of the costs (i.e., the other 50 percent of new investment and refurbishing costs, O&M costs and private travel costs) are borne by the recreationists. The quantity of visitor days demanded will be greater for scenario 2 than for scenario 1 because the costs assessed recreationists will be lower. The amcunt of recreation services demanded is Q_2 in Figure 3.

Scenario 3. The O&M plus private cost model assumes recreationists are assessed O&M costs and they pay their own travel cost to and from the lake. The federal, state and local governments share in the costs of refurbishing and new investment. The quantity of visitor days demanded is Q_3.

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[5]As with social benefits, there may be some social costs not captured. One such cost may be the cost of increased traffic on local roads leading to the lake.

Scenario 4. This is the other extreme case of assessing no costs and the recreationists pay only travel cost. The costs of new investment, refurbishing, and O&M are borne by the federal and/or local and state governments. The private sector or recreationists pay only their travel costs to and from the lake. The lower costs increases the number of visitor days demanded to Q_4 in Figure 3.

Distribution of Recreation Benefits and Costs

The four scenarios discussed above are compared relative to the distribution of benefits and costs between the private recreationists and the public or society as a whole. The distribution of benefits and costs are summarized in Table 2 and are classified according to private benefits, private costs, net private benefit, public costs, welfare loss and net social benefit. For the moment, only consider the information presented in block form in Table 2. These blocks correspond to the policies discussed in the above scenarios. The information contained in the blocks represents areas presented in Figure 3. That is, for scenario 1, corresponding to recreationists paying full costs of recreation, private benefits is the area $a_0 + a_1 + a_2 + a_3 + a_4$ of Figure 3. The recreationists' private costs equal the area $a_0 + a_1 + a_2 + a_3$ and hence their net private benefit is equal to a_4. For this scenario there are no public costs, no welfare loss and the net social benefit is equal to a_4, the same as net private benefit.

For scenario 2, the recreationists are charged less, quantity of recreation demanded increases, net private benefit increases, public costs are equal to total costs minus private costs, welfare loss equals area b_4, and net social benefit is reduced from the level of scenario 1 by the amount of welfare loss.

The same trend holds for scenarios 3 and 4: net private benefit increases; public costs increase; welfare loss increases; and net social benefit decreases. Welfare loss represents the opportunity costs of too many resources allocated to recreation relative to the returns those resources would enjoy in production of goods and services elsewhere in the economy. That is, area b_4 represents the difference between the total cost and total benefit of expanding recreation from Q_1 to Q_2. Since this difference is negative there is a welfare loss from those resources allocated to recreation services instead of the production of alternative goods and services.

Six additional policy options are introduced in Table 2. These policy options arise out of scenarios 1, 2 and 3 and assume that the quantity of visitor days remains the same as in the original option but recreationists are assessed charges less than the amount equaling their marginal benefits. As an example, assume scenario 1 with Q_1 visitor days of recreation demanded. But instead of assessing recreationists costs equal to the area $a_0 + a_1 + a_2 + a_3$ they are assessed something less than full costs. In the above example, if the recreationists pay their individual travel costs (which discriminates among

Table 2. Distribution of Recreation Benefits and Costs Based on Policy Options of Assessing Recreation Costs

Distribution of Benefits and Costs	Charges Made to Recreationists: Travel Cost	Travel Cost Plus O&M Cost	Travel Cost Plus O&M Cost Plus 50% Invest.	Travel Cost Plus O&M Cost Plus 100% Invest.
	(1)	(2)	(3)	(4)
Scenario 1				
Private Benefits	$a_0+a_1+a_2+a_3+a_4$	$a_0+a_1+a_2+a_3+a_4$	$a_0+a_1+a_2+a_3+a_4$	$a_0+a_1+a_2+a_3+a_4$
Private Costs	a_0	a_0+a_1	$a_0+a_1+a_2$	$a_0+a_1+a_2+a_3$
Net Private Benefit	$a_1+a_2+a_3+a_4$	$a_2+a_3+a_4$	a_3+a_4	a_4
Public Costs	$a_1+a_2+a_3$	a_2+a_3	a_3	None
Welfare Loss	None	None	None	None
Net Social Benefit	a_4	a_4	a_4	a_4
Scenario 2				
Private Benefits	$a_0+a_1+a_2+a_3+a_4+b_0$ $+b_1+b_2+b_3$	$a_0+a_1+a_2+a_3+a_4+b_0$ $+b_1+b_2+b_3$	$a_0+a_1+a_2+a_3+a_4+b_0$ $+b_1+b_2+b_3$	
Private Costs	a_0+b_0	$a_0+a_1+b_0+b_1$	$a_0+a_1+a_2+b_0+b_1+b_2$	
Net Private Benefit	$a_1+a_2+a_3+a_4+b_1+b_2+b_3$	$a_1+a_2+a_3+b_1+b_2+b_3$	$a_3+a_4+b_3$	
Public Costs	$a_1+a_2+a_3+b_1+b_2+b_3+b_4$	$a_2+a_3+b_2+b_3+b_4$	$a_3+b_3+b_4$	
Welfare Loss	b_4	b_4	b_4	
Net Social Benefit	a_4-b_4	a_4-b_4	a_4-b_4	

Table 2. (Continued)

Distribution of Benefits and Costs	Charges Made to Recreationists: Travel Cost	Travel Cost Plus O&M Cost	Travel Cost Plus O&M Cost Plus 50% Invest.	Travel Cost Plus O&M Cost Plus 100% Invest.
	(1)	(2)	(3)	(4)
Scenario 3				
Private Benefits	$a_0+a_1+a_2+a_3+a_4+b_0$ $+b_1+b_2+b_3+c_1+c_2+c_3$	$a_0+a_1+a_2+a_3+a_4+b_0$ $+b_1+b_2+b_3+c_0+c_1+c_2$		
Private Costs	$a_0+b_0+c_0$	$a_0+a_1+b_0+b_1+c_0+c_1$		
Net Private Benefit	$a_1+a_2+a_3+a_4+b_1+b_2$ $+b_3+c_1+c_2$	$a_2+a_3+a_4+b_2+b_3+c_2$		
Public Costs	$a_1+a_2+a_3+b_1+b_2+b_3$ $+b_4+c_1+c_2+c_3+c_4$	$a_2+a_3+b_2+b_3+b_4+c_2$ $+c_3+c_4$		
Welfare Loss	$b_4+c_3+c_4$	$b_4+c_3+c_4$		
Net Social Benefit	$a_4-b_4-c_3-c_4$	$a_4-b_4-c_3-c_4$		
Scenario 4				
Private Benefits	$a_0+a_1+a_2+a_3+a_4$ $+b_0+b_1+b_2+b_3+c_0$ $+c_1+c_2+d_0+d_1$			
Private Costs	$a_0+b_0+c_0+d_0$			
Net Private Benefit	$a_1+a_2+a_3+a_4+b_1+b_2$ $+b_3+c_1+c_2+d_1$			

Table 2. (Continued)

Distribution of Benefits and Costs	Charges Made to Recreationists: Travel Cost	Travel Cost Plus O&M Cost	Travel Cost Plus O&M Cost Plus 50% Invest.	Travel Cost Plus O&M Cost Plus 100% Invest.
	(1)	(2)	(3)	(4)
Public Costs	$a_1+a_2+a_3+b_1+b_2+b_3+b_4+c_1+c_2+c_3+c_4+d_1+d_2+d_3+d_4$			
Welfare Loss	$b_4+c_3+c_4+d_2+d_3+d_4$			
Net Social Benefit	$a_4-b_4-c_3-c_4-d_2-d_3-d_4$			

recreationists) and the O&M costs, then they are assessed the areas $a_0 + a_1$ but the public picks up the costs corresponding to areas $a_2 + a_3$.

A practical problem arises, however, if the quantity of visitor days is fixed but the fee assessed recreationists is less than the amount equal to their marginal benefit. With the example above, if the recreationist is assessed only private travel cost plus O&M cost, the quantity of visitor days demanded is greater than Q_1. Clearly, if only Q_1 days are supplied, the project engineer must ration the visitor days.

The idea of rationing visitor days is not that strange to project engineers. During peak demand periods (i.e. Memorial Day, 4th of July and Labor Day) recreationists must arrive early to obtain the choice sites and some may decide not to stay if conditions are not suitable. It is logical to assume that the lower the charges the greater will be the quantity of visitor days demanded and, with a fixed supply of visitor days, the more rationing of sites will have to occur.

In Table 2 there are three pricing options for scenario 1 in addition to the full cost option. In each option the recreationist pays less than the full cost option and public costs increase by the amount of the reduced private costs. None of the additional options for scenario 1, however, induces a welfare loss or changes net social benefit. As the charges assessed recreationists are reduced the more rationing of visitor days must occur. If the recreationists pay only their own private travel costs and no entrance fees, the number of visitor days demanded that must be reduced through rationing is equal to $Q_4 - Q_1$.

Another way of analyzing the policy options is to look down a column in Table 2. Assume that the policy option is to assess no charges and the recreationists pay only their travel costs (column one in Table 2). As you move from scenario 1 to scenario 4, the following occurs: 1) more visitor days are demanded, 2) private net benefit increases, 3) public costs increase, 4) welfare loss increases, and 5) net social benefit decreases.

Mathematical Programming Model

Mathematical programming is used as the analytical tool for choosing that combination of recreation facility development which maximizes present value of net recreation benefit over a planning period. Even though some of the policy solutions could be obtained using classical optimization of continuous functions, mathematical programming is used because of the ease in handling multiple time periods and multiple travel zones. This section discusses the planning period, discount rate, decision time unit, model formulation and expected model results.

Planning Period

The 25-year planning period of 1975 to 2000 is assumed for application purposes. Several reasons are stated for this choice.

1. The year 1975 corresponds with the year surveys were taken at the navigation system and for which recreation demand functions were estimated.

2. The updated Master Plan for Lake Fort Gibson is to the year 2000. This document provides data for estimation of investment costs and provides a comparative base for results of this study.

3. Investments for creating new capacity are assumed to have a 25-year life. The life of such facilities can be extended if investments in refurbishing occur.

4. Assumptions on constant tastes and preferences, recreation technologies and relative prices seem more appropriate for a period of 25 years than for a longer period.

Discount Rate

A constant 5 percent discount rate is assumed for the planning period. This rate is less than the nominal 7.875 percent used by the U.S. Water Resources Council (1983) in evaluating government multiple purpose water projects but is slightly more than the real rate of return to investments in such sectors as manufacturing and agriculture.

Decision Time Unit

To reduce the size of the programming model and to approach more realistic decision time units for adding capacity or letting contracts for refurbishing existing capacity, 5 year decision units are assumed and the average annual result for data inputs for the 5 year decision units are entered in the program. This means that capacity can be added only once every 5 years either through refurbishing or new investment.

Model Formulation

A general description of the model is presented here with greater detail available in Chantaworn (1985). The benefit function for Lake Fort Gibson is derived from a set of nonlinear recreation demand functions representing the twelve counties within a 50-mile radius of Lake Fort Gibson. Exogenous factors of recreation demand are projected for each county and for each year in the planning period. The annual benefit functions are discounted and summed over the planning period and over all counties to obtain total present value of gross benefits. Because of the 5 year decision time unit only one out of 5 years is counted and this 1 year represents the average of the decision time unit. Separable programming, as illustrated by Duloy and Norton (1975), is used to approximate the nonlinear concave benefit functions and to render the optimization model compatible with generally available computer techniques.

The identified costs of recreation services presented in Figure 3 and discussed in a previous section enter the programming model as private travel costs, O&M costs, refurbishing costs and new investment costs. Travel costs per visitor day are constant for a county but vary between counties due to varying distances. Operation and maintenance costs are assumed to be a constant amount per visitor day. Recreation facilities need to be refurbished every 15 years on average. The assumption is made that new facilities will last 25 years before refurbishing is required. It is further assumed that capacity of existing facilities at Lake Fort Gibson in 1975 will decrease by one-fifth in each decision time unit unless those facilities are refurbished. The programming model can then either choose to refurbish existing facilities at the assumed rate of deterioration and maintain 1975 capacity or to let capacity decrease. Costs are assumed a constant amount per visitor day of capacity refurbished. These costs are annualized and then discounted to the present for the period from the time of refurbishing to the end of the planning period.

Capacity to handle more visitor days at the lake can increase with additional investment in recreation facilities. The expected life of new facilities is assumed to be 25 years at which time continued use is possible with refurbishing. Investment costs are annualized over the expected life of the facilities using the appropriate capital recovery factor and then discounted to the present for the period from the time of construction to the end of the planning period.

Solutions to the programming model vary depending on the scenario. Scenario 1 maximizes the present value of gross benefits minus travel, O&M and all investment costs. Scenario 2 maximizes the present value of gross benefits minus travel, O&M and 50 percent of investment costs. Scenario 3 eliminates all investment costs and scenario 4 eliminates all investment and O&M costs.

Expected Results

Results of the preceeding analysis should provide information useful to project engineers in preparing their Master Plan and in management decisions. The following are types of information made available:

1. Optimum level of facility development. The programming models provide information on the optimum timing and level of investment for refurbishing existing recreation facilities and for constructing new facilities.

2. Net benefit of recreation. Results of the analysis provide information on total visitor days by time period, costs of supplying total visitor days and net benefit of recreation.

3. Distribution of benefits and costs. Policy makers will have information on private benefits, private costs, public costs, welfare loss and net social benefit. This information should be helpful in choosing among the policy options as represented by the different scenarios.

DEMAND FOR WATER-BASED RECREATION AT LAKE FORT GIBSON

The framework for estimating water-based recreation demand at Lake Fort Gibson was formulated and applied in a previous study by Schreiner, Willet, Badger and Antle (1985). Results of that study are used to project demand to the year 2000.

Recreation Demand Based on Travel Cost Methodology

The travel cost method as developed by Hotelling (1949), Hotelling (1959), and Clawson and Knetsch (1966) is based on the premise that the use of recreation facilities will decrease as out-of-pocket outlay and travel cost increases. The method is valid under the assumption that travel and time costs are proxies for price in determining frequency of use. The method is not valid for users who base their decisions on other factors. Schreiner, Willett, Badger and Antle (1985) used the travel cost method to estimate demand for recreation at the various lakes and locks and dams on the McClellan-Kerr Arkansas River Navigation System. On the basis of these demand functions, benefits from recreation were estimated for the navigation system.

A survey of recreationists at Lake Fort Gibson during the period of May to August 1975 served as the basis of the demand study. A total of 146 recreation groups were interviewed at the lake. To determine the relationship between distance and frequency of use, the origin of all sample visitor days were plotted on a map. Approximately 86 percent of the recreationists came from within a 50-mile radius of the dam site. Twelve Oklahoma counties are included in the 50-mile radius: Adair, Cherokee, Creek, Haskell, McIntosh, Mayes, Muskogee, Okmulgee, Rogers, Sequoyah, Tulsa and Wagoner. The sample data were aggregated to the county unit and used to estimate the following demand equation:

$$\ln(VDAY_c) = -1.3 - 1.09 \ln(P_c) + 0.54 \ln(POP_c) + 1.56 \ln(Y_c) \quad (1)$$

where

$\ln(VDAY_c)$ = natural log of the 1975 sample of visitor days recorded at Lake Fort Gibson for county c,

$\ln(P_c)$ = natural log of the price of recreation (round trip travel cost per visitor day) from county c (1975 dollars),

$\ln(POP_c)$ = natural log of the 1975 population of county c (1,000), and

$ln(Y_c)$ = natural log of per capita income in 1975 for county c ($1,000).

These results indicate that for Lake Fort Gibson the price elasticity of demand is -1.09, the income elasticity of demand is 1.56, and the population elasticity of demand is 0.54.[6] The regression coefficients are statistically significant from zero at the 5 percent or better probability level. For further evaluations of the estimated demand function see Schreiner, Willet , Badger and Antle (1985).

Two results of the estimated demand function are important for the current analysis. First, equation (1) represents a series of demand functions for the lake: one for each of the 12 counties representing the market area for Lake Fort Gibson. As population, per capita income, and price of recreation (i.e., energy costs) change for a county, the demand for recreation at Lake Fort Gibson from that county will change.

Second, the demand function of (1) was estimated with sample data. These results must be adjusted to represent the total population of visitor days for Lake Fort Gibson. Sample and total population visitor days are presented in Table 3. The assumption is that the population of visitor days is distributed in proportion to the sample of visitor days, both for the recreation season of May through August and for the off-season of September through April. The population to sample ratio is 1,889 and thus the results obtained using the sample data are put on the population basis by multiplying by this factor.

Projection of Recreation Demand for Lake Fort Gibson

Projection Model

Growth in demand for recreation is influenced by three factors: growth in population, growth in income, and changes in price (cost). Consider the following model:

$$VDAY_t = VDAY_0 e^{vt} \quad (2)$$

where

$VDAY_t$ = visitor days at Lake Fort Gibson in time period t,

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[6] Interpretation of these elasticities is the following: (1) for a 1 percent increase in the round trip travel cost per visitor day (price) the number of county visitor days decreases by 1.09 percent, (2) for a 1 percent increase in per capita income the number of visitor days increases by 1.56 percent, and (3) for a 1 percent increase in county size population, the number of visitor days increases by .054 percent.

Table 3. Sample and Population Visitor Days at Lake Fort Gibson, 1975

County	Sample Visitor Days	Population of Visitor Days by Recreation Period[a] May-August	September-April	Total
1. Adair	10	11,565	6,739	18,304
2. Cherokee	221	263,945	153,805	417,750
3. Creek	104	124,548	72,576	197,124
4. Haskell	30	36,267	21,134	57,401
5. McIntosh	45	53,553	31,206	84,759
6. Mayes	25	30,059	17,516	47,575
7. Muskogee	403	481,689	280,689	762,378
8. Okmulgee	31	36,491	21,264	57,755
9. Rogers	8	104,984	61,177	166,161
10. Sequoyah	46	54,312	31,649	85,961
11. Tulsa	803	958,747	558,678	1,517,425
12. Wagoner	65	77,092	44,923	122,015
Total in Market Area	1,871	2,233,252	1,301,356	3,534,608
Outside Market Area	305	363,548	211,844	575,392
TOTAL	2,176	2,596,800	1,513,200	4,110,000

[a]Total visitor days for the recreation periods are from the Tulsa District of the U.S. Army Corps of Engineers.

$VDAY_0$ = visitor days for the base period 1975, and

e^{vt} = the exponential growth of visitor days where e is the base of the natural logarithm.

Therefore, the rate of growth of visitor days is equal to:

$$\frac{dVDAY}{dt}\frac{1}{VDAY} = VDAY_0\, e^{vt}\frac{v}{VDAY} = v \qquad (3)$$

hence

v = rate of growth of visitor days.

Using the result of equation (3) and the factors of recreation demand as expressed in equation (1), the rate of growth in recreation demand is the following:

$$\frac{dVDAY}{dt}\frac{1}{VDAY} = \left[\frac{\partial VDAY}{\partial P}\frac{dP}{dt} + \frac{\partial VDAY}{\partial POP}\cdot\frac{dPOP}{dt} + \frac{\partial VDAY}{\partial Y}\cdot\frac{dY}{dt}\right]\frac{1}{VDAY}$$

$$= \frac{\partial VDAY}{\partial P}\cdot\frac{P}{VDAY}\cdot\frac{dP}{dt}\cdot\frac{1}{P} + \frac{\partial VDAY}{\partial POP}\cdot\frac{POP}{VDAY}\cdot\frac{dPOP}{dt}\cdot\frac{1}{POP} + \frac{\partial VDAY}{\partial Y}\cdot\frac{Y}{VDAY}\cdot\frac{dY}{dt}\frac{1}{Y}. \qquad (4)$$

The following substitutions are made in equation (4):

$\frac{dVDAY}{dt}\frac{1}{VDAY}$ = v = rate of growth of recreation demand,

$\frac{\partial VDAY}{\partial P}\cdot\frac{P}{VDAY}$ = -1.09 = price elasticity of recreation demand,

$\frac{dP}{dt}\cdot\frac{1}{P} = p_r$ = rate of change (growth) in price of recreation,

$\frac{\partial VDAY}{\partial POP}\cdot\frac{POP}{VDAY}$ = 0.54 = population elasticity of recreation demand,

$$\frac{dPOP}{dt} \frac{1}{POP} = p_o = \text{rate of growth of population,}$$

$$\frac{\partial VDAY}{\partial Y} \cdot \frac{Y}{VDAY} = 1.56 = \text{income elasticity of recreation demand, and}$$

$$\frac{dY}{dt} \cdot \frac{1}{Y} = y = \text{rate of growth of per capita income.}$$

Thus, the following equation results:

$$v = -1.09\, p_r + 0.54\, p_o + 1.56\, y. \qquad (5)$$

Subsituting (5) into (2) gives the following:

$$VDAY_t = VDAY_o\, e^{(-1.09\, p_r + 0.54\, p_o + 1.56\, y)t}. \qquad (6)$$

Projection Results

Once the population and income growth rates are determined for each county in the market area for Lake Fort Gibson, the growth in recreation demand for that county can be determined assuming no change in price (cost).

Population projections by county are taken from the Oklahoma Employment Security Commission (1976). These data were smoothed into an annual growth rate from 1975 to 2000 and are presented in Table 4.

The per capita real income growth is computed for the state of Oklahoma and assumed for the Lake Fort Gibson market area. The growth function in exponential form is the following:

$$Y_t = e^{a_o}\, e^{yt} \qquad (7)$$

where Y_t is per capita real income and y is the rate of income growth. Taking the natural log of equation (7) results in the following equation which can be estimated using ordinary least squares:

$$\ln Y_t = a_o + yt\,. \qquad (8)$$

Time series data for per capita real income for the state of Oklahoma from 1969 to 1981 were used to estimate equation (8). The following result was obtained:

$$Y_t = e^{8.24}\, e^{1.91t}. \qquad (9)$$

Table 4. Projected Annual Population Growth Rate by County for Lake Fort Gibson Market Area, 1975-2000

County	Population Growth Rate (p_o) (Percent)
1. Adair	1.06
2. Cherokee	2.15
3. Creek	1.04
4. Haskell	0.86
5. McIntosh	0.93
6. Mayes	2.43
7. Muskogee	0.94
8. Okmulgee	0.84
9. Rogers	1.04
10. Sequoyah	1.10
11. Tulsa	0.98
12. Wagoner	2.03

Source: Computed from the Oklahoma Employment Security Commission (1976).

The per capita real income growth rate is 1.91 percent per annum and this rate is assumed for all counties in the market area.

Equation (6) is used to project the level of recreation demand by county and equation (5) is used to compute the rate of growth in recreation demand by county. The estimated rate of growth of recreation demand by county is given in Table 5 assuming no change in price (P_r = o).

Table 5. Annual Rate of Growth in Demand for Recreation by County for Lake Fort Gibson Market Area

County	Growth in Demand (v_c)[a/] (Percent)
1. Adair	3.55
2. Cherokee	4.14
3. Creek	3.54
4. Haskell	3.44
5. McIntosh	3.48
6. Mayes	4.29
7. Muskogee	3.49
8. Okmulgee	3.43
9. Rogers	3.54
10. Sequoyah	3.57
11. Tulsa	3.51
12. Wagoner	4.08

[a/]Computed from the following equation:

$$v_c = -1.09\ p_r + 0.54\ p_{oc} + 1.56\ y$$

where:

$p_r = 0$ = rate of change (growth) in price,

p_{oc} = rate of growth in population for county c (Table 4), and

$y = 1.91$ = rate of growth in per capita income.

ANALYSIS OF RECREATION COSTS AT LAKE FOR GIBSON

Costs of recreation consist of private travel costs, operation and maintenance costs (O&M), refurbishing costs, and new investment costs. Survey results for 1975 are the basis for estimating private travel costs. Annual O&M and refurbishing costs are taken from various reports of the U.S. Army Corps of Engineer's Office in Tulsa, Oklahoma. The investment cost data are taken from the Master Plan for Lake Fort Gibson (U.S. Army Corps of Engineers, 1978).

Private Travel Costs of Recreation

Travel cost was defined as a proxy for price in estimating the demand for recreation. It is also used as the private cost recreationists pay to arrive at the lake. Travel cost per visitor day is presented in Schreiner, Willett, Badger and Antle (1985) and is computed for Lake Fort Gibson from the following equations:

$$CVD_C = (CT_C)/AVD_C \qquad (10)$$

and

$$CT_C = (D_C\ 0.069) \cdot 2 \qquad (11)$$

where

CVD_C = travel cost per visitor day for the sample of recreationists interviewed at Lake Fort Gibson from county c,

CT_C = travel cost per trip for those recreating at Lake Fort Gibson from county c,

AVD_C = average number of visitor days per trip for the sample of recreationists interviewed at Lake Fort Gibson from county c, and

D_C = distance in miles from county c to the dam site at Lake Fort Gibson.

The variable D_C in equation (11) refers to the number of road miles from the county seat to the dam site at Lake Fort Gibson. The value 0.069 is the per mile cost of operating an automobile in 1975 as reported by the Department of Transportation for the following items: gas, oil, maintenance, accessories, parts, tires, and state and federal taxes. The unit mile cost is multiplied by two to obtain the round trip travel cost.

The estimated travel costs per visitor day are presented in Table 6. Travel costs are different for each county due to differences in distance to the lake as

Table 6. Private Travel Costs per Visitor Day for Sample of Recreationists at Lake Fort Gibson, 1975

County	Distance to Dam Site (miles)	Travel Cost Per Visitor Day ($)
1. Adair	46	1.59
2. Cherokee	13	0.13
3. Creek	56	0.59
4. Haskell	57	0.59
5. McIntosh	49	0.45
6. Mayes	42	1.45
7. Muskogee	13	0.22
8. Okmulgee	53	1.22
9. Rogers	54	0.57
10. Sequoyah	57	0.59
11. Tulsa	54	0.47
12. Wagoner	19	0.52

well as differences in average number of visitor days per trip for the sample of recreationists.

Operation and Maintenance (O&M) Costs

Operation and maintenance costs refer to all current year costs for direct labor, equipment, vehicles, supplies, utilities, fuel, administrative overhead, and other operating expenses needed to provide recreation services. The O&M cost is generally assumed to vary in a direct relationship to the number of visitor days. Four studies or sources of data are reviewed for estimates of O&M costs.

Reiling and Anderson (1983) estimated that O&M costs constituted about 72 percent of total costs of campground operations and 69 percent of total costs of day-use facilities. O&M costs averaged about $425 per campsite per year or $1.44 per visitor day.

A second study on water-based recreation facility costs is for the U.S. Army Corps of Engineers' lakes of Kaw and Keystone and estimated by Jordan, Badger and Schreiner (1976). O&M costs were estimated at $0.13 per visitor day.

A third source of data for annual O&M costs was provided by private communication with the Tulsa District of the U.S. Army Corps of Engineers for Lake Fort Gibson. The summary of O&M costs for the 1983 fiscal budget year is the following:

Categories	Cost
Labor, materials and supplies, vehicles, equipment, administrative costs	$498,500
Cleaning contract	55,000
Mowing contract	19,500
Gate attendant contracts	32,000
Total	$605,000

The average O&M cost for 1983 is computed at $0.14 per visitor day.

The fourth study reviewed for O&M costs was the Master Plan (U.S. Army Corps of Engineers, 1978) for Lake Fort Gibson. The annual operation and maintenance cost in 1978 prices was $580,000. An implicit price deflator was used to adjust O&M costs from the Master Plan back to the base period of 1975. The O&M cost in 1975 prices is about $0.12 per visitor day. It is this value that is taken as representative of O&M costs for Lake Fort Gibson per visitor day for 1975.

Refurbishing Cost

Recreation public use areas are refurbished periodically to repair damages, improve roads, replace worn equipment and upgrade facilities. Refurbishing costs are normal costs but do not appear in the annual operation and maintenance budget. To maintain facilities at the designed capacity, however, refurbishing must be done on a periodic basis.

The data for cost of refurbishing were not provided separately from investment costs in the Fort Gibson Master Plan. An estimate is made based on 1983 figures from the Corps of Engineers that show refurbishing is done every 15 years at a cost of about $1,000 per campsite. When deflated to 1975 prices, the result for refurbishing costs for Fort Gibson is $836.24 per campsite.

In 1975 there were 559 campsites operating at the lake. In the same year, total visitor days was 4,100,000. Therefore, an average number of visitor days per campsite is 7,335 even though not all visitors use the campsites. The costs of refurbishing per visitor day is estimated at about $0.11 in 1975 prices. Since the Corps of Engineers estimates that refurbishing lasts for an average of 15 years, the unamortized cost per year is about $0.0076 per visitor day. The amortized cost per visitor day at 5 percent discount rate is $0.010984 (the capital recovery factor used for 15 years at 5 percent is 0.096342).

New Investment for Increasing Capacity

The 1978 Master Plan for Lake Fort Gibson indicates that an investment cost of $4,751,000 is necessary to support the increase from 4.1 million visitor days in 1975 to 6.5 million in 2000. In 1975 prices, this is equal to $3,972,967.

If it is assumed that the cost per year per visitor day to keep the 4.1 million capacity refurbished is $0.0076 (see previous section) then the total refurbishing costs are 4.1 million x $0.0076 x 25 years = $779,000. The amount remaining is assumed available for new facilities:

Master Plan Investment	$3,972,967
Minus estimated refurbishing cost	779,000
Investment for new facilities	$3,193,967

Since the projected increased capacity is 2.4 million visitor days, the investment cost per visitor day capacity is $1.33 ($3,193,967 ÷ 2,400,000 = $1.33). Assuming a 25 year life for investment in new facilities, amortized cost at 5 percent discount rate is $0.094366 per visitor day.

Investment costs for increasing capacity as derived from the 1978 Master Plan for Fort Gibson is compared to recent investments in public use areas for Big Hill Lake at Big Hill Creek, Kansas (U.S. Army Corps of Engineers, 1980). The project in 1980 called for facilities that included 147 picnic units or campsites. The government cost estimate was $3,420,761 or an average of

$23,270 per site. The lowest price contract bid was $2,987,720 or an average of $20,325 per site. If we assume the average number of visitor days per site as existed at Fort Gibson for 1975 (7,335) this would equal an investment cost of $3.17 per visitor day for the government bid and $2.77 per visitor day for the lowest bid price. This equals $2.26 and $1.97, respectively, as the investment cost per site in 1975 prices.

The visitor day investment cost of $1.33 as derived from the 1978 Master Plan is used in further development of this study.

INVESTMENT MODEL FORMULATION

Model Components and Data

The Benefit Functions

The benefits associated with a given consumption of recreation are measured by the consumers' willingness-to-pay or the area under the demand curve for recreation. The demand for recreation from county c at Lake Fort Gibson is the folowing:

$$VDAY_c = 2.491\ e^{-1.30}\ P_c^{-1.09}\ Y_c^{1.56}\ POP_c^{0.54} \qquad (12)$$

where

$VDAY_c$ = sample visitor days demanded at Lake Fort Gibson for county c,

e = natural logarithm,

P_c = price of recreation as round trip travel cost per visitor day from county c (1975 dollars),

Y_c = per capita income in 1975 for county c ($1,000),

POP_c = population of county c in 1975 (1,000),

2.491 = a correction factor used in the prediction model to assure that the sum of the predicted sample observations equals the sum of the actual observations (See Schreiner, Willett, Badger and Antle, 1985 page 56). For further discussion concerning the prediction bias with logarithmic dependent variable, see Kennedy, 1983,

-1.30 = intercept value,

-1.09 = price elasticity of recreation demand,

1.56 = income elasticity of recreation demand, and

0.54 = population elasticity of recreation demand.

Two factors are noted for the recreation demand function given in equation (12). First, this function is representative of the sample of visitor days. It must be multiplied by 1,889 to represent the population of visitor days (Table 3). Second, this function is representative of each of the twelve counties making up the market area for Lake Fort Gibson and for any particular time period.

Using the information from Table 5, the growth in recreation demand for any particular county can be represented as in Figure 4. $VDAY_{c0}$ represents the demand function for the base period (1975) and growth shifts the function to the right for each additional decision time unit until $VDAY_{c5}$ which represents average annual demand for the period 1995-2000.

The benefit function can be expressed in present value as the following:

$$f_{c\tau}\ (VDAY_{c\tau}) = \bar{\alpha}_{\tau} \int_{0}^{VDAY_{c\tau}} P_c\ (VDAY_{c\tau})\ d\ VDAY_{c\tau} \qquad (13)$$

where

$f_{c\tau}(VDAY_{c\tau})$ = present value of recreation benefits for county c in decision time unit τ,

$\bar{\alpha}_{\tau}$ = average annual discount factor for decision time unit τ, and

$P_c(VDAY_{c\tau})$ = inverse recreation demand function for county c in decision time unit τ.

Two factors are noted for the benefit function (13): 1) the exponential function of equation (12) is undefined at $VDAY_{c\tau} = 0$ and hence equation (13) is not differentiable, and 2) the solution of equation (13) is dependent upon the level of visitor days ($VDAY_c$) and hence becomes a nonlinear element in the objective function of the linear programming model.

First, consider the undefined nature of equation (13) for $VDAY_{c\tau} = 0$. An arbitrary decision rule is proposed to solve the integral of equation (13). The observed prices (P_c) for the twelve counties are given in Table 6. The range is from $0.13 for Cherokee county to $1.59 for Adair county. This might be interpreted as the relevant range of the demand function. If at the price of $1.59 the slope of the demand function is determined and then the intercept of this slope solved on the P_c axis, a two stage integration process can be used to determine the area under the demand curve. This procedure has been

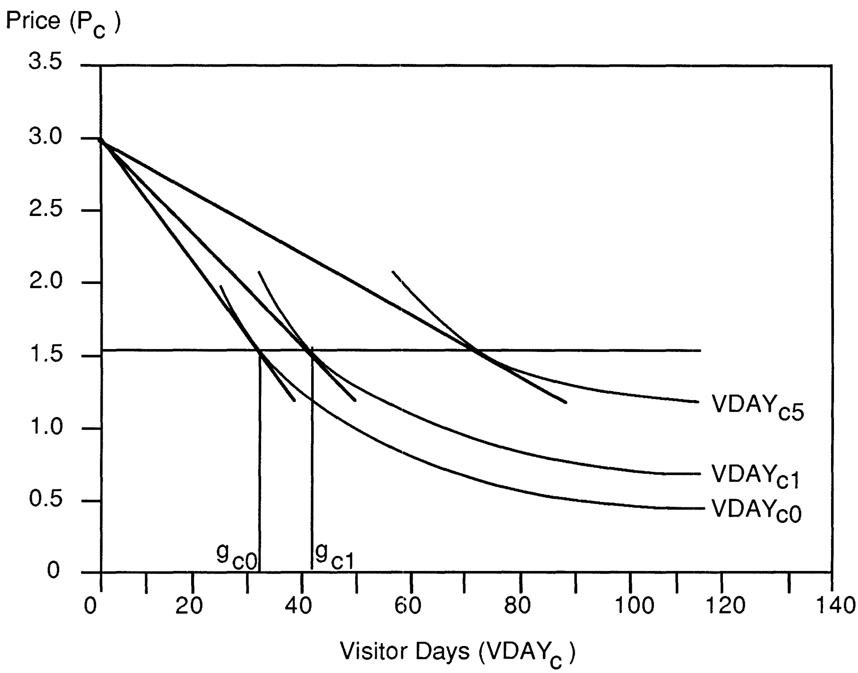

Figure 4. Recreation Demand for County c at Lake Fort Gibson

completed in Figure 4 and the intercept price computed at $3.04. Equation (13) can be replaced with the following equation:

$$f'_{c\tau}\,(VDAY_{c\tau}) = \overline{\alpha}_{\tau}\{[1.59\,q_{c\tau} + 0.5\,(3.04 - 1.59)\,q_{c\tau}] + \int_{q_{c\tau}}^{VDAY_{c\tau}} P_c\,(VDAY_{c\tau})\,d\,VDAY_{c\tau}\} \qquad (14)$$

Consider the sample demand function for Cherokee county in the base period 1975:

$$VDAY_o = 2.491\,e^{-1.30}\,P_o^{-1.09}\,Y_o^{1.56}\,POP_o^{0.54} \qquad (15)$$

and since $Y_o = 3.267$ and $POP_o = 25.41$ in 1975, equation (15) becomes:

$$VDAY_o = 24.689\,P_o^{-1.09}\,. \qquad (16)$$

When $P_o = 1.59$ as proposed above, $VDAY_o = 14.923$ which is the same as q_{co} in Figure 4. The inverse demand function from equation (16) is equal to:

$$P_o = 18.946\,VDAY_o^{\,-0.917}. \qquad (17)$$

The solution to the benefit function of equation (14) for the base year for Cherokee county is equal to:

$$f'_o\,(VDAY_o) = [1.59\,(14.923) + 0.5\,(3.04 - 1.59)\,(14.923)] + \int_{14.923}^{VDAY_o} 18.946\;VDAY_o^{-0.917}\;d\;VDAY_o \qquad (18)$$

The benefit function of equation (18) is nonlinear and increases at a decreasing rate.

The second consideration is how to formulate the benefit function to render the optimization model compatible with currently available computer techniques. Piecewise or grid linearization is proposed following Duloy and Norton (1975). Grid linearization requires prior specification of a relevant range of values of the demand curve and the use of variable interpolation weights on the grid point. The interpolation weights become variables in the model and their values are jointly constrained by a set of convex combination constraints.

The procedure is applied to Cherokee county for purposes of exposition. The relevant range of the demand curve for Cherokee county in the base year is shown in Figure 5 and is from a price of $1.59 per visitor day down to $0.13 which is the travel cost for Cherokee county (Table 5). The corresponding sample visitor days are 14.92 and 221.01, respectively.

The relevant range of the demand curve is partitioned into 11 segments by evenly dividing the difference between the quantity of visitor days at a price of $0.13 and the quantity at a price of $1.59 into 10 parts. The quantity of visitor days (Q) for each segment in the base period is given in Column (1) of Table 7. For each segment end point the cumulative area under the demand curve (B) is computed and recorded in Column (1) of Table 7. Hence, for segment 1, the quantity of sample visitor days is 14.92 and the benefit is 34.55 whereas for segment 11, the quantity of sample visitor days is 221.01 and the benefit is 116.17.

The quantity of visitor days and the total area under the demand curve can be expressed as a weighted combination of the segments:

$$Q = \sum_{s=1}^{11} Q_s W_s$$

and

$$B = \sum_{s=1}^{11} B_s W_s$$

where W_s is a weight variable such that

$$\sum_{s=1}^{11} W_s \leq 1.$$

Duloy and Norton show that no more than 2 consecutive points on the quantity (VDAY) axis will enter the optimal basis.

A similar set of segments are computed for the projected demands in each of the decision time units. These segments in terms of quantity of visitor days and discounted benefits are presented for Cherokee county in Table 7. The benefits are presented in present value by applying the appropriate discount factor for each decision time unit.

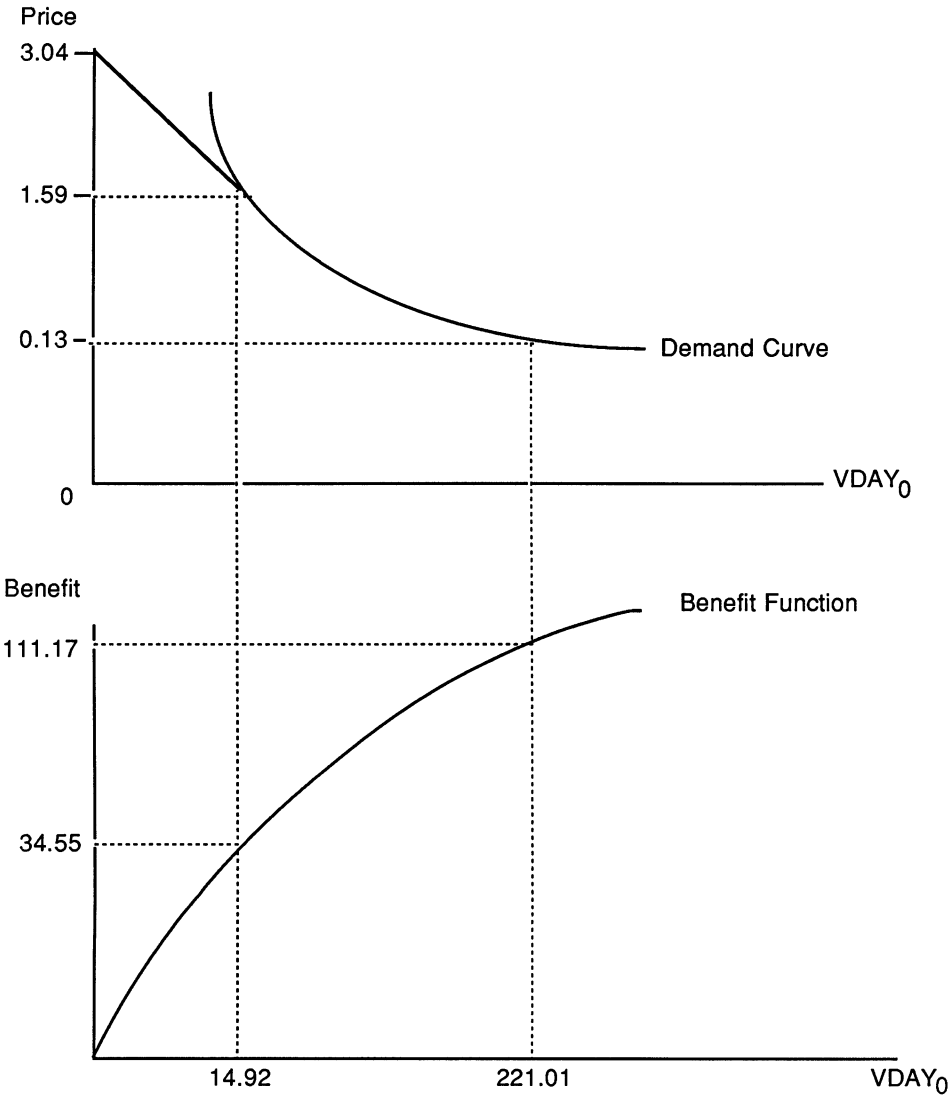

Figure 5. Recreation Demand and Benefit Functions for Cherokee County in Base Year

Table 7. Quantity and Discounted Benefit of Segmented Demand for Cherokee County by Decision Time Unit

Segment	Quantity (Q) Benefit (B)	Decision Time Units 1975	1975-1980	1980-1985	1985-1990	1990-1995	1995-2000
		(1)	(2)	(3)	(4)	(5)	(6)
1	Q (VDAY)	14.92	16.88	20.75	25.46	31.28	38.43
	B ($)	34.55	33.84	35.58	31.33	30.16	29.04
2	Q	35.53	40.20	49.40	60.62	74.47	91.51
	B	55.85	54.71	52.67	50.65	48.75	46.94
3	Q	56.14	63.52	78.05	95.78	117.66	144.58
	B	67.71	66.33	63.86	61.60	59.10	56.91
4	Q	76.75	86.83	106.70	130.94	160.85	197.65
	B	76.08	74.55	71.75	68.99	66.41	63.94
5	Q	97.36	110.15	135.35	166.10	204.04	250.73
	B	82.59	80.93	77.90	74.90	72.09	69.42
6	Q	117.97	133.46	164.00	201.25	247.23	303.80
	B	87.94	86.17	82.94	79.75	76.76	73.92
7	Q	138.97	156.78	192.25	236.41	290.42	356.88
	B	92.49	90.64	87.24	87.88	80.74	77.74
8	Q	159.18	180.10	221.30	271.57	333.62	409.95
	B	96.46	94.52	90.98	87.48	84.20	81.80
9	Q	179.79	203.41	249.95	306.73	376.81	463.02
	B	99.99	97.48	94.31	90.68	87.28	84.04
10	Q	200.40	226.73	278.60	341.89	463.19	516.10
	B	108.28	101.08	97.29	93.55	90.05	86.70
11	Q	221.01	250.04	307.25	377.05	463.19	569.17
	B	116.17	103.91	100.02	96.17	92.56	89.13

The Cost Functions

Cost of recreation services have been identified to include: 1) private travel costs, 2) O&M costs, 3) refurbishing costs, and 4) new investment costs. In addition, fixed costs of past recreation development must be considered in the context of constraints to current capacity.

Fixed Costs. Two assumptions are made relative to recreation development that occured prior to 1975. First, it is assumed that the recreation facilities existing in 1975 were used at capacity. This would mean that recreation capacity for Lake Fort Gibson at the beginning of the planning period was 4,100,000 visitor days. Supporting evidence of this assumption is the fact that the Master Plan of 1978 recommended additional investments in recreation facility development. As explained earlier, more visitor days can always be handled in nonpeak demand periods but during peak periods most lakes in Eastern Oklahoma are crowded.

The second assumption pertains to the need for refurbishing of existing facilities and the reduction in capacity if such refurbishing does not take place. No information is available on the need for refurbishing at Lake Fort Gibson other than the indirect knowledge that facilities should be refurbished on the average of every fifteen years. The assumption is that the capacity of 4,100,000 visitor days will show a straight line decay function from the beginning of the planning period to the end of the planning period. Hence, if no refurbishing takes place during the planning period, by the year 2000, capacity at Lake Fort Gibson will be zero visitor days.

Capacity constraints by decision time unit are presented in Table 8. A straight line decay function is presented in Column 2 of Table 8. Column (3) shows the amount of capacity used by the market area and is equal to 86 percent of column (2). Column (4) is the maximum refurbishing needed to reestablish capacity for the market area.

Private Travel Costs. Travel costs by county and by decision time unit are presented in Table 9. The base period travel costs are from Table 6. These costs are discounted to present value for each of the decision time units.

O&M Costs. O&M costs are defined for the lake and apply to all visitor days. The present value of O&M costs are given in column (2) of Table 10.

Refurbishing Costs. Refurbishing costs by decision time unit are presented in column (3) of Table 10. The refurbishing cost of $0.03 for the decision time unit 1975-1980 is interpreted as the present value of the annualized cost for refurbishing one visitor day during this time unit and that this visitor day capacity is retained for the rest of the planning period. This value, however, represents only one-fifth of the cost for the planning period since only 1 out of 5 years is counted.

Table 8. Capacity Constraints by Decision Time Unit for Lake Fort Gibson (Visitor Days)

Decision Time Unit	Capacity	Utilized by Market Area (V_τ)	Maximum Refurbishing Market Area ($V-V_\tau$)
(1)	(2)	(3)	(4)
1975 (Base)	4,100,100	3,526,000	--
1975-1980	3,690,000	3,173,400	352,600
1980-1985	2,870,000	2,468,000	705,200
1985-1990	2,050,000	1,763,000	705,200
1990-1995	1,230,000	1,057,800	705,200
1995-2000	410,000	352,600	705,200

Table 9. Present Value of Travel Costs per Visitor Day by Decision Time Unit and by County (Dollars)

County	Decision Time Units					
	1975	1975-1980	1980-1985	1985-1990	1990-1995	1995-2000
1. Adair	1.59	1.38	1.18	0.85	0.66	0.52
2. Cherokee	0.13	0.11	0.09	0.07	0.05	0.04
3. Creek	0.59	0.51	0.40	0.31	0.25	0.19
4. Huskell	0.59	0.51	0.40	0.31	0.25	0.19
5. McIntosh	0.45	0.39	0.31	0.24	0.19	0.15
6. Mayes	1.45	1.26	0.98	0.77	0.60	0.47
7. Muskogee	0.22	0.19	0.15	0.12	0.09	0.07
8. Okmulgee	1.22	1.06	0.83	0.65	0.51	0.40
9. Rogers	0.57	0.49	0.39	0.30	0.24	0.19
10. Sequoyah	0.59	0.51	0.40	0.31	0.25	0.19
11. Tulsa	0.47	0.41	0.32	0.25	0.20	0.15
12. Wagoner	0.52	0.45	0.35	0.28	0.22	0.17

Table 10. Present Value of O&M, Refurbishing and New Investment Costs per Visitor Day and by Decision Time Unit (Dollars)

Decision Time Unit τ	O&M Cost $\alpha_\tau b$	Refurbishing Cost $\beta d \sum_{\tau=j}^{5} \alpha_\tau$	New Investment $\beta e \sum_{\tau=j}^{5} \alpha_\tau$
(1)	(2)	(3)	(4)
1975 (Base)	0.12	0.00	0.00
1975-1980	0.10	0.03	0.27
1980-1985	0.08	0.02	0.18
1980-1990	0.06	0.01	0.12
1990-1995	0.05	0.008	0.07
1995-2000	0.04	0.004	0.03

New Investment Costs. Capacity beyond the 4,100,000 visitor days is added through new investment in recreation facilities. The present value of annualized cost of new investment during any decision time unit is given in column (4) of Table 10.

Model Formulation

The linear programming model is summarized in this section. The assumptions of the model are first stated and then the equational form of the model is presented.

Assumptions

1. Recreation demand in year t is a function of price in that year and no other period.
2. The price elasticity of demand is assumed constant throughout the relevant range of the demand function.
3. Demand segments enter as linear approximations and are expanded by a sample-to-population factor of 1889.
4. Five year decision time units are assumed and model results are representative of the mid-year of the decision time unit.
5. All costs and benefits are assumed to occur as a lump sum for the representative mid-year of the decision time unit.
6. There are no economies of scale in O&M, refurbishing and investment costs. Travel costs are constant per visitor day within a county but vary between counties.
7. An annual discount rate of five percent is used and is assumed constant over the planning period.
8. Inflation effects on benefits and costs are not considered. All values are expressed in present value of 1975 dollars.
9. The planning period is chosen as 25 years and is assumed to be the life of new investments before refurbishing needs to take place.
10. No substitutes are considered currently or over the planning period for recreation at Fort Gibson.

The Model Equations

A solution to the model is derived for each scenario as discussed earlier. The scenarios vary only by differences in the cost components of the objective function. The most general objective function is the following:

$$\text{Max PVNB} = 5 \left\{ \left[\underbrace{\sum_{\tau=1}^{5} \sum_{c=1}^{12} \sum_{s=1}^{11} \bar{\alpha}_\tau B_{sc\tau} X_{sc\tau}}_{\text{Gross Benefit}} \right. \right.$$

$$\left. - \underbrace{\sum_{\tau=1}^{5} \sum_{c=1}^{12} \bar{\alpha}_\tau a_c Q_{c\tau}}_{\text{Travel Cost}} - \underbrace{\sum_{\tau=1}^{5} \sum_{c=1}^{12} \bar{\alpha}_\tau b Q_{c\tau}}_{\text{O\&M Cost}} \right] \tag{19}$$

$$\left. - \left[\underbrace{\sum_{j=1}^{5} \beta_r d R_j \sum_{\tau=1}^{5} \bar{\alpha}_\tau}_{\text{Refurbishing Cost}} + \underbrace{\sum_{j=1}^{5} \beta_s e S_j \sum_{\tau=1}^{5} \bar{\alpha}_\tau}_{\text{New Investment Cost}} \right] \right\}$$

subject to

1. Recreation demand and supply equilibrium

$$-\sum_{c=1}^{12} Q_{c\tau} + \sum_{c=1}^{12} \sum_{s=1}^{11} X_{sc\tau} \leq 0 \tag{20}$$

2. Recreation capacity

$$\sum_{c=1}^{12} Q_{c\tau} - \sum_{j=1}^{\tau} R_j - \sum_{j=1}^{\tau} S_j \leq V_\tau \tag{21}$$

3. Maximum refurbishing

$$\sum_{j=1}^{\tau} R_j < V - V_\tau \tag{22}$$

4. Convex combination constraint

$$\sum_{s=1}^{11} X_{sc\tau} \leq H \qquad (23)$$

Definition of Variables

$X_{sc\tau}$ = demand segment s for county c and decision time unit τ

$Q_{c\tau}$ = quantity of recreation visitor days for county c and decision time unit τ

R_j = refurbishing activity in visitor day capacity in decision time unit one and through the planning period ($j = \tau = 1, 2, 3, 4, 5$)

S_j = new investment activity in visitor day capacity in decision time unit one and through the planning period ($j = \tau = 1, 2, 3, 4, 5$)

Definition of Parameters

α_τ = average annual discount factor at 5 percent for decision time unit τ

β_r = capital recovery factor for 15 years at 5 percent discount rate

β_s = capital recovery factor for 25 years at 5 percent discount rate

$B_{sc\tau}$ = benefit for demand segment s for county c in decision time unit τ (1975 dollars)

a_c = travel cost per visitor day for county c (1975 dollars)

b = O&M cost per visitor day (1975 dollars)

d = cost of refurbishing per visitor day capacity (1975 dollars)

e = investment cost per visitor day of new capacity (1975 dollars)

V_τ = visitor day capacity in time period τ assuming no refurbishing of the 1975 capacity for market area

V = visitor day capacity in 1975 for market area

H = population-to-sample ratio and is equal to 1889

τ = decision time unit and equals 1, 2, 3, 4, 5

c = county and equals 1, 2, . . ., 12

s = demand and benefit segment and equals 1, 2, . . .,11

j = activity index and equals 1, 2, 3, 4, 5

OPTIMUM RECREATION FACILITY DEVELOPMENT

Results and analysis of the recreation investment programming models are presented for each of the 4 scenarios in terms of total visitor days, additions to capacity, total gross benefits, total private costs, total public costs, net private and social benefits, and net benefits per visitor day. The investment budget and timing of the facility development are shown by decision time unit. A comparative analysis of policy options based on alternative recreation charges or fees is presented for the 25-year planning period.

Results of the Investment Programming Models

Results are presented for the market area. An expansion to total visitor days could be done on the assumption that gross benefit per visitor day for those coming from outside the market area is equal to the average gross benefit of those in the market area. The data on benefits and costs are presented in undiscounted form for ease in making comparative analysis between decision time units and between scenarios. All data are presented as annual averages for the decision time unit except capacity which is in terms of the additions put into place during a time unit.

Scenario 1 - Full Cost Model

Scenario 1 is the extreme case where all identified marginal costs are paid in full by private recreationists. Results are summarized in Table 11.

The obvious result is a reduction in visitor days from what existed in the base year of 1975. Visitor days decreased from 3,526,000 in the market area in 1975 to 2,861,255 in the period 1975-1980. It is not until the fourth decision time unit (1990-1995) that visitor days increase beyond the 1975 level. In the fourth time unit capacity was increased by 390,223 visitor days to serve the increased demand. In the fifth time unit capacity was increased by 801,346 visitor days for a total planning period increase of 1,191,569 visitor days.

Refurbishing of the maximum capacity of 352,600 visitor days occurred in decision time unit one even though the capacity was not needed until time unit two. It was preferable to maintain capacity through refurbishing than to let facilities deteriorate and rebuild in later periods. In all of the model results for all scenarios it was preferable, less costly, to maintain facilities for future growth in demand than to let facilities deteriorate.

Gross benefits increase from $4,326,960 in time unit one to $7,153,650 in the last time unit. This is a 63 percent increase in gross benefits even though recreationists are paying their full marginal costs. Total costs to the recreationists increased by 80 percent during the same period although 76 percent of these costs in the last decision time unit are private travel costs.

Table 11. Results of the Recreation Investment Programming Model for the Market Area by Decision Time Unit, Scenario 1

	Unit	1975-1980	1980-1985	1985-1990	1990-1995	1995-2000
Visitor Days (annual)	VDAY	2,861,255	3,419,438	3,526,000	3,916,223	4,717,569
Additions to Capacity	VDAY					
Refurbishing		352,600	705,200	705,200	705,200	705,200
New Capacity		0	0	0	390,223	801,346
TOTAL		352,600	705,200	705,200	1,095,423	1,506,546
Gross Benefits (annual)	$1,000	4,326.96	4,514.21	5,111.79	5,889.84	7,153.65
Private Costs (annual)	$1,000					
Travel Costs		1,286.71	1,536.23	1,649.11	1,847.68	2,223.37
O&M Costs		337.05	403.21	417.88	460.73	563.79
Refurbishing		3.87	11.72	19.36	27.11	34.86
New Investment		0.00	0.00	0.00	36.82	112.44
TOTAL		1,627.64	1,951.17	2,086.35	72.35	934.45
Public Costs (annual)	$1,000					
O&M Costs		0.00	0.00	0.00	0.00	0.00
Refurbishing		0.00	0.00	0.00	0.00	0.00
New Investment		0.00	0.00	0.00	0.00	0.00
TOTAL		0.00	0.00	0.00	0.00	0.00

Table 11. (Continued)

	Unit	1975-1980	1980-1985	1985-1990	1990-1995	1995-2000
Net Benefits (annual)	$1,000					
Private		2,699.32	2,563.04	3,025.04	3,517.49	4,219.20
Social		2,699.32	2,563.04	3,025.04	3,517.49	4,219.20
Net Benefits Per Visitor Day	$					
Private		0.943	0.750	0.858	0.898	0.894
Social		0.943	0.750	0.858	0.898	0.894

Net private benefits are equal to net social benefits in this scenario since recreationists are paying all marginal costs. Net benefits for those recreationists within the market area increased from $2,699,320 in time unit one to $4,219,200 in the last time unit for a 56 percent increase. Clearly, on the basis of the benefit and cost components contained in this analysis it is privately and socially beneficial to increase recreation activities at Lake Fort Gibson.

Net benefits per visitor day are highest in the first time unit for this scenario and for all other scenarios. This is consistent with the fact that recreationists early in the planning period are living on past investments. In particular, this scenario has little investment costs to recoup in the first time unit -- most costs are associated only with travel and O&M.

Scenario 2 - Policy Guidelines Model

This scenario is based on the federal government sharing in 50 percent of the additional investments for facility development. It is assumed that the recreationists pay the other 50 percent of additional investments plus all O&M and private travel costs. The results of the model for the market area are presented in Table 12.

Visitor days for this scenario are the same as scenario 1 for the first two time units. Beginning in time unit three visitor days increase for scenario 2 relative to scenario 1 since recreationists are only charged half of new capacity investment costs. By the last decision time unit visitor days for scenario 2 equal 5,263,189 versus 4,717,569 for scenario 1. This is about a 12 percent increase in scenario 2 over scenario 1.

As in scenario 1, scenario 2 refurbishing brings capacity back up to the original level in all decision time units. New capacity increases for scenario 2 over scenario 1 by 165,690 visitor days in time unit three, by 317,891 visitor days in time unit four, and by 62,039 visitor days in time unit five. This is a total increase in visitor day capacity for scenario 2 of 1,737,189 or 545,620 more than in scenario 1. This is about a 46 percent increase in capacity for scenario 2 over scenario 1. It also represents a 49 percent increase in capacity for scenario 2 by the end of the planning period over what existed in the base period of 1975.

Gross benefits increase only marginally for scenario 2 over scenario 1. In the last decision time unit, annual gross benefits are only about 4 percent more for scenario 2 than for scenario 1. Total private costs are marginally less for scenario 2 over scenario 1 for the first two time units and then increase, primarily because of more visitor days for scenario 2 in later time units. Net private benefits are marginally greater for scenario 2 than for scenario 1 because recreationists are paying marginally less and because visitor days increase toward the end of the planning period. Social net benefits are marginally less for scenario 2 than for scenario 1 because of the increase in

Table 12. Results of the Recreation Investment Programming Model for the Market Area by Decision Time Unit, Scenario 2

	Unit	1975-1980	1980-1985	1985-1990	1990-1995	1995-2000
Visitor Days (annual)	VDAY	2,861,255	3,419,438	3,691,690	4,399,804	5,263,189
Additions to Capacity	VDAY					
Refurbishing		352,600	705,200	705,200	705,200	705,200
New Capacity		0	0	165,690	708,114	863,385
TOTAL		352,600	705,200	870,890	1,413,314	1,568,585
Gross Benefits (annual)	$1,000	4,326.96	4,514.21	5,186.72	6,160.83	7,452.01
Private Costs (annual)	$1,000					
Travel Costs		1,286.71	1,536.23	1,649.35	2,024.27	2,415.53
O&M Costs		337.05	403.21	437.52	517.61	628.96
Refurbishing		1.94	5.86	9.68	13.56	17.43
New Investment		0.00	0.00	7.82	41.23	81.97
TOTAL		1,625.70	1,945.29	2,149.37	2,596.64	3,143.89
Public Costs (annual)	$1,000					
O&M Costs		0.00	0.00	0.00	0.00	0.00
Refurbishing		1.94	5.86	9.68	13.56	17.43
New Investment		0.00	0.00	7.82	41.23	81.97
TOTAL		1.94	5.86	17.50	54.79	99.40

Table 12. (Continued)

	Unit	1975-1980	1980-1985	1985-1990	1990-1995	1995-2000
Net Benefits (annual)	$1,000					
Private		2,701.26	2,568.92	3,037.35	3,564.19	4,308.12
Social		2,699.32	2,563.06	3,019.85	3,509.40	4,208.72
Net Benefits Per Visitor Day	$					
Private		0.944	0.751	0.823	0.810	0.819
Social		0.943	0.750	0.818	0.798	0.800

public costs. Public costs for scenario 2 are rather minimal during the early part of the planning period and increase to an annual amortized cost of $99,400 during the final time unit.

Net benefits per visitor day are marginally lower for scenario 2 compared to scenario 1. This result is consistent throughout the analysis -- as visitor days increase, marginal benefits decrease, marginal costs increase and net benefits per visitor day decrease.

<u>Scenario 3 - O&M Plus Travel Cost Model</u>

Recreationists pay none of the marginal investment costs under scenario 3 but pay all O&M plus travel costs. Results of this model would be consistent with the Policy Guidelines Model if state and/or local government paid 50 percent of additional facility development costs and the federal government paid 50 percent as in scenario 2. Results of the model are presented in Table 13.

Visitor days again do not change from scenarios 1 and 2 for the first two time units. In time unit three scenario 3 has 390,873 more visitor days than scenario 2; 486,508 more visitor days in time unit four; and 581,158 more visitor days in time unit five. This means that more capacity must be added under scenario 3 than under scenario 2. This increase in capacity for the planning period is 581,158 visitor days more than for scenario 2 and 1,126,778 more visitor days than for scenario 1. The total increase in capacity for scenario 3 over what existed in base period 1975 is 2,318,347 visitor days or a 66 percent increase.

Gross benefits increase by about 3.9 percent in the last decision time unit over scenario 2 and by 8.2 percent over scenario 1. This corresponds to an 11.0 percent increase in visitor days over scenario 2 and a 23.9 percent increase over scenario 1. Total private costs decrease for scenario 3 over scenarios 1 and 2 for the first two time units because visitor days remain the same and recreationists are not charged the marginal investment costs. However, private costs increase in time unit three because of increased visitor days and by the last time unit total private costs are 5.7 percent more than scenario 2 and 13.2 percent more than scenario 1. Even at that, the percentage increase in visitor days is significantly more than the percentage increase in private costs.

Public costs in the form of annualized investment costs go from zero in time unit one for scenario 1, to $1,940 for scenario 2, and to $3,870 for scenario 3. For the last time unit, public costs are zero for scenario 1, $9,400 for scenario 2, and $253,630 for scenario 3. The next section discusses the investment budget for each scenario whereas the investment costs presented in the tables here only pertain to the annualized investment costs for refurbishing and new capacity.

Table 13. Results of the Recreation Investment Programming Model for the Market Area by Decision Time Unit, Scenario 3

	Unit	1975-1980	1980-1985	1985-1990	1990-1995	1995-2000
Visitor Days (annual)	VDAY	2,861,255	3,419,438	4,082,563	4,886,312	5,844,347
Additions to Capacity	VDAY					
Refurbishing		352,600	705,200	705,200	705,200	705,200
New Capacity		0	0	556,563	803,749	958,035
TOTAL		352,600	705,200	1,261,763	1,508,949	1,663,235
Gross Benefits (annual)	$1,000	4,326.96	4,514.21	5,381.46	6,405.07	7,742.56
Private Costs (annual)	$1,000					
Travel Costs		1,286.71	1,536.23	1,834.67	2,201.29	2,624.72
O&M Costs		337.05	403.21	483.84	574.85	698.43
Refurbishing		0.00	0.00	0.00	0.00	0.00
New Investment		0.00	0.00	0.00	0.00	0.00
TOTAL		1,623.76	1,939.45	2,318.50	2,776.14	3,323.15
Public Costs (annual)	$1,000					
O&M Costs		0.00	0.00	0.00	0.00	0.00
Refurbishing		3.87	11.72	19.36	27.11	34.86
New Investment		0.00	0.00	52.52	128.37	218.77
TOTAL		3.87	11.72	71.88	155.48	253.63

Table 13. (Continued)

	Unit	1975-1980	1980-1985	1985-1990	1990-1995	1995-2000
Net Benefits (annual)	$1,000					
Private		2,703.19	2,574.76	3,062.96	3,628.94	4,419.41
Social		2,699.33	2,563.04	2,991.08	3,473.45	4,165.78
Net Benefits Per Visitor Day	$					
Private		0.945	0.753	0.750	0.743	0.756
Social		0.943	0.750	0.733	0.711	0.713

Net private benefits increase marginally for scenario 3 over scenario 2 and scenario 1. Private benefits are 6.1 percent greater than social benefits during the last decision time unit for scenario 3. This compares to a 2.4 percent difference for scenario 2 and, of course, no difference for scenario 1. Divergence between private net benefits per visitor day and social net benefits per visitor day increases from scenario 2 to scenario 3 and from the beginning of the planning period to the end of the planning period. This is because of increased public costs for maintaining facilities and adding new capacity.

Scenario 4 - Travel Cost Model

This is the other extreme case where recreationists pay none of the marginal investment and O&M costs. Their only cost is to travel to the lake and back again to their residence. Although recreationists may seek this pricing scenario, Lake Fort Gibson and other lakes in Eastern Oklahoma do not typify this scenario. Results of the model are presented in Table 14.

Visitor days increased in the first decision time unit by 387,597 over the base period of 1975. This is the only scenario that shows an increase in visitor days for the first time unit. The reason, of course, is the reduced cost (price) of recreation and an increase in the quantity of visitor days demanded. Visitor days increase significantly for each time unit with annual visitor days equalling 8,029,824 for the last time unit. This is a 128 percent increase over the base period of 1975. This compares to a 65.8 percent increase for scenario 3, a 61.6 percent increase for scenario 2, and a 33.8 percent increase for scenario 1.

Both private costs and public costs increase for scenario 4 over scenario 3. Private costs increase because of the significant increase in visitor days and the associated travel costs. Public costs increase because more of the costs are borne by the public sector and there are more visitor days. For the last decision time unit, the public sector pays 29.6 percent of total costs for scenario 4 compared to 7.1 percent for scenario 3, 3.1 percent for scenario 2, and zero percent for scenario 1.

Total public costs under scenario 4 equal $1,419,460 during the last time unit versus $253,630 for scenario 3 and $99,400 for scenario 2. Clearly, private recreationists are the gainers under scenario 4 compared to all other scenarios. To reiterate, as the number of visitor days expands beyond the quantity in scenario 1, the marginal benefit per visitor day decreases and the marginal cost increases. As costs are shifted from the private recreationists to the public sector, net private benefit per visitor day increases and net social benefit decreases.

Investment Budget for Facility Development

The investment budget for each scenario is presented in Table 15. The results are presented by time unit and in undiscounted 1975 dollars.

Table 14. Results of the Recreation Investment Programming Model for the Market Area by Decision Time Unit, Scenario 4

	Unit	1975-1980	1980-1985	1985-1990	1990-1995	1995-2000
Visitor Days (annual)	VDAY	3,913,597	4,689,092	5,598,667	6,343,200	8,029,824
Additions to Capacity	VDAY					
Refurbishing		352,600	705,200	705,200	705,200	705,200
New Capacity		387,597	775,495	909,575	744,533	1,686,624
TOTAL		740,197	1,480,695	1,614,775	1,449,733	2,391,824
Gross Benefits (annual)	$1,000	4,747.17	5,017.12	5,975.89	6,979.68	8,553.60
Private Costs (annual)	$1,000					
Travel Costs		1,652.73	1,974.50	2,359.70	2,690.71	3,380.67
O&M Costs		0.00	0.00	0.00	0.00	0.00
Refurbishing		0.00	0.00	0.00	0.00	0.00
New Investment		0.00	0.00	0.00	0.00	0.00
TOTAL		1,652.73	1,974.50	2,359.70	2,690.71	3,380.67
Public Costs (annual)	$1,000					
O&M		461.01	552.92	663.53	746.25	959.59
Refurbishing		3.87	11.72	19.36	27.11	34.86
New Investment		36.58	109.76	195.59	265.85	425.01
TOTAL		501.46	674.40	878.48	1,039.21	1,419.46

Table 14. (Continued)

	Unit	1975-1980	1980-1985	1985-1990	1990-1995	1995-2000
Net Benefits (annual)	$1,000					
Private		3,094.44	3,042.62	3,616.19	4,288.97	5,172.93
Social		2,592.98	2,368.22	2,737.71	3,249.76	3,753,47
Net Benefits Per Visitor Day	$					
Private		0.791	0.649	0.646	0.676	0.644
Social		0.663	0.505	0.489	0.512	0.467

Table 15. Investment Budget for Water-Based Recreation Facility Development at Lake Fort Gibson by Scenario and Decision Time Unit (1975 Dollars)

Investment Category	1975-1980	1980-1985	1985-1990	1990-1995	1995-2000	Total
			Scenario I			
Refurbishing	38,786	77,572	77,572	116,358	155,144	465,432
New Capacity	--	--	--	518,997	1,065,790	1,584,787
TOTAL	38,786	77,572	77,572	635,355	1,220,934	2,050,219
			Scenario 2			
Refurbishing	38,786	77,572	77,572	116,358	155,144	465,432
New Capacity	--	--	220,368	941,792	1,148,302	2,310,462
TOTAL	38,786	77,572	297,940	1,058,150	1,303,446	2,775,894
			Scenario 3			
Refurbishing	38,786	77,572	77,572	116,358	155,144	465,432
New Capacity	--	--	740,229	1,068,986	1,274,187	3,083,402
TOTAL	38,786	77,572	817,801	1,185,344	1,429,331	3,548,834
			Scenario 4			
Refurbishing	38,786	77,572	77,572	116,358	155,144	465,432
New Capacity	515,504	1,031,408	1,209,735	990,229	2,243,210	5,990,086
TOTAL	554,290	1,108,980	1,287,307	1,106,587	2,398,354	6,455,518

Refurbishing costs equal $0.11 per visitor day. The number of visitor days refurbished appears in Tables 11 through 14. The only modification is that those visitor days refurbished in the 1975-1980 time unit must be refurbished again in the 1990-1995 period and hence the investment cost is repeated again for that period. The same is true for the time unit 1980-1985 which must be repeated again in 1995-2000.

New capacity costs $1.33 per visitor day and the number of visitor days comes from Tables 11 through 14. No economies of scale were permitted in the programming model which may be somewhat unrealistic when viewing the investment amounts in Table 15. That is, the contract price for refurbishing 352,600 visitor days or about 48 campsites is $38,786 for the first decision time unit. When this is doubled to 705,200 visitor days or about 96 campsites the cost is also doubled to $77,572 for time units two and three. For time units four and five this is again increased by 50 percent to 144 campsites and a contract price of $116,358. This assumption needs to be verified or changed.

The total investment budget for the market area by scenario for the 25-year planning period is given in the last column of Table 15. Since the market area accounts for only 86 percent of total visitor days there would need to be an upward adjustment in the investment budgets. The adjustment would be less than proportional since scenarios 1, 2, and 3 have excess capacity in one or more of the time units. For scenario 4 the investment in new capacity would need to be increased by a factor of 1.163 to account for visitor day capacity needed for those outside the market area.

The investment budget for scenario 1 is about $2,050,219. Compared to scenario 1, scenario 2 would require about a 35 percent increase in the investment budget; scenario 3 a 73 percent increase; and scenario 4 a 215 percent increase. Scenario 4 requires a 132 percent increase in the investment budget over the Policy Guidelines scenario (scenario 2) and an 82 percent increase over scenario 3 which could assume state and/or local governments cost sharing with the federal government.

If the federal and state and/or local governments shared investment costs of scenario 3, the federal government share would be $1,774,417 and the state and/or local governments share would also be $1,774,417. This public cost would have to be weighed against expected public or social benefits derived from increased recreational activity in the region.

Under scenario 1 the assumption is that recreationists will pay the investment costs as well as O&M and travel costs. Therefore, entrance fees or user charges must be established not only for O&M costs but also for facility development. To be equitable among recreationists, variable fees would need to be established according to usage of facilities such as campsites, electrical hook-ups, dump stations, boat ramps, etc.

Comparative Analysis of Policy Options

In Figure 3 and Table 2, a set of policy options were proposed and discussed for the four different scenarios. The scenarios are based on the economic rationale that recreationists equate their marginal benefit with their marginal cost. Differences exist among the four scenarios because recreationists are presumed to be assessed different proportions of the total marginal costs. Additional policy options arise if after the quantity of visitor days is fixed, based upon the different scenarios, recreationists are not charged the presumed marginal cost but some lesser amount. These options require a certain amount of rationing of visitor days, either directly by limiting the number of user permits or indirectly by discouraging recreationists through crowding on weekends and special holidays.

The various policy options are summarized in Table 16 with respect to the following variables: gross benefit, private cost, net private benefit, public cost, welfare loss and net social benefit. Results are in present value (1975 dollars) for the entire planning period (1975-2000) and include visitor days in the market area plus outside the market area. A simple proportional expansion of the programming model results was made to include the visitor days accounted for outside the market area. This basically assumes that visitor days outside the market area have a gross benefit equal to the average for visitor days within the market area. Similarly, costs are assumed to be the same for visitor days outside the market area as for visitor days inside the market area. These assumptions tend to underestimate costs but may also tend to underestimate gross benefits. Table 16 represents the empirical counterpart to Table 2.

Scenario 1 is the most socially efficient of the four scenarios. It has the highest net social benefit and no welfare loss. If recreational facility development took place at Lake Fort Gibson that was consistent with scenario 1, the expected present value of net social benefits would be $49,568,972 or close to 50 million dollars. At this level of facility development there are four policy options available:

Option (4) - Recreationists pay full cost and public costs are zero. Under this option net social benefits are equal to net private benefits.

Option (3) - Recreationists pay all but 50 percent of the investment costs. The present value of public costs are equal to $281,808.

Option (2) - Recreationists pay none of the marginal investment costs but all of the travel and O&M costs. Public costs increase to a present value of $563,605.

Option (1) - Recreationists pay no costs at the lake and only their private travel costs. Public costs increase significantly due to shifting of O&M costs from the recreationists to the public. The public costs equal a present value of $7,327,680. Under this policy

Table 16. Level and Distribution of Recreation Benefits and Costs Under Alternative Policy Options for Development of Recreation Facilities at Lake Fort Gibson, Planning Period 1975-2000 (Present Value in 1975 Dollars)

Variable	Policy Option: Recreationists Pay			
	Travel Cost (1)	Travel Plus O&M Cost (2)	Travel Plus O&M Plus 50% Investment Cost (3)	Travel Plus O&M Plus 100% Investment Cost (4)
Scenario 1 - Full-Cost Model				
Gross Benefit	83,223,591	83,223,591	83,223,591	83,223,591
Private Cost	26,326,945	33,091,020	33,372,816	33,654,619
Net Private Benefit	56,896,646	50,132,571	49,850,775	49,568,972
Public Cost	7,327,680	563,605	281,808	0
Welfare Loss	0	0	0	0
Net Social Benefit	49,568,972	49,568,972	49,568,972	49,568,972
Scenario 2 - Policy Guidelines Model				
Gross Benefit	84,677,527	84,677,527	84,677,527	
Private Cost	27,258,974	34,345,212	34,753,450	
Net Private Benefit	57,418,553	50,332,315	49,924,077	
Public Cost	7,902,715	816,477	408,238	
Welfare Loss	53,134	53,134	53,134	
Net Social Benefit	49,515,838	49,515,838	49,515,838	

Table 16. (Continued)

Variable	Policy Option: Recreationists Pay			
	Travel Cost (1)	Travel Plus O&M Cost (2)	Travel Plus O&M Plus 50% Investment Cost (3)	Travel Plus O&M Plus 100% Investment Cost (4)
	Scenario 3 - O&M Plus Travel Cost Model			
Gross Benefit	86,422,120	86,422,120		
Private Cost	28,518,125	36,017,909		
Net Private Benefit	57,903,995	50,404,211		
Public Cost	8,648,214	1,148,430		
Welfare Loss	313,192	313,192		
Net Social Benefit	49,255,780	49,255,780		
	Scenario 4 - Travel Cost Model			
Gross Benefit	95,288,747			
Private Cost	36,331,659			
Net Private Benefit	58,957,088			
Public Cost	13,111,242			
Welfare Loss	3,723,128			
Net Social Benefit	45,845,844			

option, a considerable rationing of visitor days would have to occur.

Scenario 2 is consistent with the currently proposed level of facility development where the federal government pays half of the marginal investment costs. The quantity of visitor days under this scenario is consistent with the recreationists being charged the other half of the marginal investment cost. Two additional policy options are available, however, in charging the recreationists. Net social benefits are only marginally lower for scenario 2 compared to scenario 1. Welfare loss is minimal at a present value of only $53,134. This compares to a difference in net private benefits between the two scenarios ranging from $73,302 for policy option (3) to $521,907 for policy option (1).

Scenario 3 is the level of facility development consistent with the recreationists paying travel plus O&M costs. This scenario would also be consistent with the Federal Policy Guidelines if the state and/or local governments picked up the 50 percent share of marginal investment costs instead of the recreationists. This arrangement would be consistent with policy option (2) under scenario 3. Welfare loss increases under scenario 3 to $313,192. Public costs increase to $1,148,430 for policy option (2) which would be $574,215 as the federal share and an equal amount for state and/or local governments. Public costs under policy option (1) increases significantly to a present value of $8,648,214.

Scenario 4 has the lowest net social benefit, highest welfare loss, highest public cost and highest net private benefit. However, it pays to compare this policy option, as the only policy option for scenario 4, with the similar policy option for the other three scenarios. Welfare loss equals a present value of $3,723,128 for scenario 4 compared to $313,192 for scenario 3, $53,134 for scenario 2, and zero welfare loss for scenario 1. In comparing policy option (1) of scenario 4 with scenario 1, net social benefits decreased by 7.5 percent and net private benefits increased by only 3.6 percent. Public cost for scenario 4 increased by 51.6 percent over scenario 3 and by 78.9 percent over scenario 1. In contrast, net private benefit for scenario 4 increased by only 1.8 percent over scenario 3 and by 3.6 percent over scenario 1. Clearly, one would have to ask whether the marginally small increases in net private benefits are worth the sizeable increases in public costs.

Comparison of Programming Results With Master Plan

The overall objective of this study was to develop and apply a planning methodology to assist project engineers in completing a Master Plan for facility development. In this section the results of the study are compared to the existing Master Plan for recreation facility development at Lake Fort Gibson. Comparisons of the various scenarios with the Master Plan are presented in Table 17. Data are not available in the Master Plan to compare all variables but

Table 17. Comparison of Recreation Facility Development Results by Scenario with Master Plan for Lake Fort Gibson, Market Area Plus Outside Market Area

Variable	Unit	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Master Plan
Visitor Days	(Annual)					
1975 Base		4,100,000	4,100,000	4,100,000	4,100,000	4,100,000
1975-1980		3,327,041	3,327,041	3,327,041	4,550,694	5,230,000
1980-1985		3,976,091	3,976,091	3,976,091	5,452,433	3,733,200
1985-1990		4,100,000	4,292,663	4,747,166	6,510,078	N/A[a]
1990-1995		4,553,748	5,116,051	5,681,758	7,375,814	N/A
1995-2000		5,485,545	6,119,987	6,795,752	9,337,005	6,500,000[b]
Investment Costs	($1975)	2,383,976	3,277,784	4,126,551	7,506,416	3,972,967
Average Visitor Day Net Benefit	($)					
Private		0.869	0.824	0.777	0.672	N/A
Social		0.869	0.815	0.753	0.515	N/A
Present Value of Marginal Gross Benefits	($1975)	83,223,591	84,677,527	86,422,120	95,288,747	N/A
Present Value of Marginal Total Costs	($1975)	33,654,619	35,161,688	37,166,339	49,442,901	N/A

Table 17. (Continued)

Variable	Unit	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Master Plan
Present Value of Marginal Net Social Benefits	($1975)	49,503,972	49,515,839	49,255,781	45,845,846	N/A
Marginal Social B/C		2.47	2.41	2.33	1.93	N/A

[a]N/A - Not Available

[b]For year 2000

the important variables of projected visitor days and investment budget are available.

Results of the programming models were expanded to include visitor days outside the market area. Investment costs were increased proportionally to the increase in visitor days outside the market area. For some scenarios this would be a slight overestimation of investment costs in the first decision time unit because of the higher weighting needed for new capacity relative to refurbishing existing capacity. The effects of this assumption would modestly overestimate investment costs of scenarios 1, 2, and 3 and underestimate costs of scenario 4. This proportionality assumption would also modestly effect costs and net benefits in a similar manner. Benefits, however, may be undervalued for visitor days outside the market area. The problem stems from not having a demand function, and subsequently a benefit function, for those visitor days outside the market area.

The column for Master Plan in Table 17 shows the number of visitor days in the base period and the average annual visitor days for the 1975-1979 period and the 1980-1984 period using the data from Table 1. Reported visitor days increases from 4,100,000 to 5,230,000 in the 1975-1979 period and decreases to 3,733,200 in the 1980-1984 period. One must be a little skeptical about the accuracy of visitor day counts when viewing some of the reported data. However, the overall trend for Eastern Oklahoma was a buildup of visitor days during the early to later part of the 1970s, a change in trend during the latter years of the 1970s and early 1980s, and then an increasing trend again in the more current years.

The direction of these trends is consistent with the changes in energy costs and the changes in policies for user charges and entrance fees. Although energy costs are assumed constant at the 1975 level, scenarios 1, 2, and 3 would be a reflection of changes in policies on user fees. Scenario 4 would reflect a continuation of early policies of no charges for facility use.

Projection of visitor days in the Master Plan of 6.5 million for the year 2000 would put the result somewhere between scenario 2 and scenario 3 of the programming results. This is encouraging in terms of validation of the planning methodology and data used for the programming models. The policies assumed for the Master Plan in terms of charges made to recreationists would be somewhere around scenarios 2 and 3. Recreationists are expected to pay more than only their travel costs as in scenario 4 and less than full cost as in scenario 1. In fact, the 6.5 million visitor days of the Master Plan is very close to the Policy Guidelines Model of scenario 2 when the results of the latter are for the year 2000 instead of the midpoint of the decision time unit of 1995-2000.

Investment costs given in the Master Plan again compare very favorably with scenarios 2 and 3 of the programming results. Since investment costs on a per visitor day basis were estimated from the Master Plan and then used as data in the programming models, one would expect that if visitor day results are close to one scenario then the investment costs would also be close to that scenario.

The Master Plan does not have information on recreation benefits so the data on average visitor day net benefit, present value of marginal gross benefits, present value of marginal total costs, present value of marginal net social benefits and marginal social benefit-cost ratios are not available for comparative purposes. However, since there is close agreement between the Master Plan and scenarios 2 and 3 on visitor days and investment costs, one can infer results of these other variables as likely results of policy choices by decision makers on recreation facility development for Lake Fort Gibson.

The direction of the Master Plan implies an average visitor day net benefit between $0.75 and $0.82. The present value of marginal gross benefits at a 5 percent discount rate for the entire planning period is around $85,000,000, the present value of marginal total costs is about $36,000,000, and the present value of net social benefits is about $49,000,000. The marginal social benefit-cost ratio is estimated to be between 2.3 and 2.4. Clearly, the direction of recreation facility development proposed in the Master Plan for Lake Fort Gibson is one of providing what society desires and is close to the level of optimum resource use.

CONCLUSIONS, POLICY GUIDELINES AND STUDY LIMITATIONS

Conclusions

1. Continued investment in recreation facility development at Lake Fort Gibson is in the best interests of society. If recreationists are charged all of the identified marginal costs of recreation facility development, the present value of marginal net benefits over the planning period 1975-2000 increase by about $49,500,000 in 1975 prices.

2. Recreationists are price responsive to increases in charges for recreation services. If recreationists are charged less than their full marginal costs they will demand more recreation, investment costs will be greater and society will suffer a welfare loss. In comparing results of the scenario where recreationists pay full costs to the scenario where recreationists pay only their own travel costs, recreation demand increases from 5,485,545 visitor days to 9,337,005 visitor days by the year 2000; investment costs increase from $2,383,976 to $7,506,416; present value of net private benefits increase from $49,568,972 to $58,957,088; present value of public costs increase from zero to $13,111,242; and present value of welfare loss increases from zero to $3,723,128.

3. Use of an investment programming model similar to the one presented here is practical and feasible in developing a Master Plan for a project. The major data components needed include demand or benefit functions for recreation, estimates of costs of supplying recreation services, and proposed charges for recreation. The results are in terms of projected visitor days, an investment budget, distribution of benefits and costs between the private and public sectors, level of present value of marginal net benefits, and an estimate of the marginal social benefit-cost ratio.

Policy Guidelines

1. The most efficient use of resources for society as a whole comes about when recreationists are charged their full marginal costs and, in turn, recreationists are able to equate their marginal costs with the marginal benefits they derive from the recreation services. The planning methodology used in this study shows how such results can be approximated.

2. The significant difference in results comes between charging recreationists no costs at the lake and charging at least the O&M costs of supplying recreation services. Charging recreationists their O&M costs reduces visitor days by 27 percent, reduces investment costs by 45 percent, increases present value of the marginal net social benefit by 7.4 percent and increases the marginal social benefit-cost ratio from 1.9 to 2.3. Charging recreationists their marginal investment costs in addition to their O&M costs reduces visitor

days by only 19.3 percent, reduces investment costs by 42 percent, increases present value of the marginal net social benefit by 0.6 percent and increases the marginal social benefit-cost ratio from 2.33 to 2.47.

3. The difference between the results for the most efficient use of resources and what is proposed as Policy Guidelines for recreation projects is minimal for Lake Fort Gibson. Annual visitor days for the period 1995-2000 changes by only 634,442; investment costs increase by only $843,808; and the marginal social benefit-cost ratio changes minimally from 2.47 to 2.41. It doesn't cost the federal government much in the way of investment costs for society to gain close to $84,000,000 gross benefits over the planning period.

4. State and/or local governments may choose to pay 50 percent of marginal investment costs and shift 50 percent on to the federal government. For about $870,000 in investment costs to state and/or local governments, visitor days increase by about 1.3 million annually and present value of marginal gross benefits increase $3,200,000.

Limitations

The results, conclusions and policy guidelines of this study are limited by the accuracy of the data and assumptions used. Projections of demand for recreation are based on assumptions of constant 1975 travel costs and constant tastes and preferences. Competition from other lakes in Eastern Oklahoma on the demand for recreation at Lake Fort Gibson was not considered.

Estimates of costs of supplying recreation services at Fort Gibson used in this study should be considered as first approximations. More definitive research should be done on estimating O&M costs, refurbishing costs and additional capacity costs. Economies and diseconomies of scale in supplying recreation services should be tested. Effects of crowding at the lake on costs of services should be considered.

Methodology on how to include visitor days outside the market area in the analysis should be improved. Specifically, a benefit function for those visitor days should be more fully developed.

First consideration to further research is improvement on the limitations expressed above. Estimates of costs of supplying recreation services could be improved by further interaction with project engineers and using cross section data from several different projects or lakes. Seasonality factors and peak demand period problems should be addressed in any further work on methodologies for estimating demand, estimating cost and investment planning.

Realistic methods for assessing charges and costs of collecting fees should be investigated and integrated in the analyses on effects of policy options. This would include analysis of assessing specific charges for use of specific services.

Competition between a local lake and a regional lake could be studied for use of limited investment resources or limited budgets for supplying recreation services. Cross price effects on competing demands for recreation at a local lake and a regional lake could be built into an improved investment programming model.

REFERENCES

Antle, G., 1979. "Recreation at the McClellan-Kerr Arkansas River Navigation System," Water Resources Bulletin, 15: 1408-1417.

Badger, D.D., D. F. Schreiner, and R.W. Presley, 1977. Analysis of Expenditures for Outdoor Recreation at the McClellan-Kerr Arkansas River Navigation System, U.S. Army Corps of Engineer Contract Report 77-4.

Chantaworn, P., 1985. "Planning Optimum Investment in Water-Based Recreation Through Year 2000 for Lake Fort Gibson," Unpublished Ph.D. dissertation, Oklahoma State University, Stillwater.

Clawson, M. Methods of Measuring the Demand for and Value of Outdoor Recreation, Resources for the Future, Washington, 1959.

Clawson, M. and Knetsch, J., 1966. Economics of Outdoor Recreation, John Hopkins Press, Baltimore.

Duloy, J.H., and R.D. Norton, 1975. "Prices and Incomes in Linear Programming Models," American Journal of Agricultural Economics, 57: 591-600.

Herfindahl, O.C. and A.V. Kneese, 1974. Economic Theory of Natural Resources, Charles E. Merill Publishing Company, Ohio.

Hotelling, H.A., 1949. Letter quoted by Roy E. Prewitt in An Economic Study of the Monetary Evaluation of Recreation in the National Parks, U.S. Department of Interior, National Park Service, Washington, D.C.

Jordan, E., D. D. Badger and D. F. Schreiner, 1976. "Recreational Facility Costs at Corps of Engineer Lakes." Department of Agricultural Economics, Oklahoma State University, Stillwater, Oklahoma, December.

Kennedy, P., 1983. "Logarithmic Dependent Variables and Prediction Bias," Oxford Bulletin of Economics and Statistics, Vol. 45, No. 4, November, 389-392.

Oklahoma Employment Security Commission and Oklahoma State Employment Service, 1976. Research and Planning Division, County Employment and Wage Data, Oklahoma 1975. Oklahoma City, November.

Reiling, S. D. and M. W. Anderson, 1983. Estimation of the Cost of Providing Publicly Supported Outdoor Recreational Facilities in Maine, Maine Agricultural Experiment Station, University of Maine at Orono, Bulletin 793, July.

Schreiner, D. F., D. A. Willett, D. D. Badger and L. G. Antle, 1985. Recreation Benefits Measured by Travel Cost Method for McClellan-Kerr Arkansas River Navigation System and Application to Other Selected Corps Lakes, U.S. Army Corps of Engineers Contract Report 85-C-1.

U.S. Army Corps of Engineers, Oklahoma, 1978. Lake Fort Gibson, Grand (Neosho) River, Okla. DM No. 1c. Master Plan (updated), Tulsa District.

U.S. Army Corps of Engineers, Oklahoma, 1984. Lake Fort Gibson FY 1983 Budget.

U.S. Army Corps of Engineers, Oklahoma, 1980. Big Hill Project, Contract Document provided by Corps of Engineers in Tulsa, Oklahoma.

U.S. Statutes at Large, 1966. Public Law 89-72, Vol. 79, "Federal Water Project Recreation Act," Washington D.C., U.S. Government Printing Office, pp. 213-218.

U.S. Statutes at Large, 1965. Public Law 89-80, "Water Resources Planning Act," Washington D.C.: U.S. Government Printing Office, pp. 224-254.

U.S. Water Resources Council, 1979. "Part IX: Procedures for Evaluation of National Economic Development (NED) Benefits and Costs in Water Resources Planning (Level C), Final Rule," Federal Register, December 14.

U.S. Water Resources Council, 1983. Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies, Washington, D.C.

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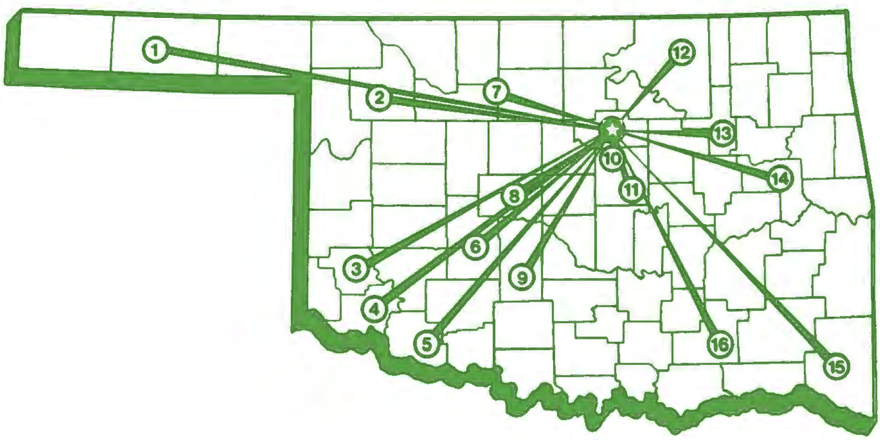

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