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AWRRC

Arkansas Water Resources Research Center

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NORTH LAKE CHICOT WATERSHED

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ABSTRACT

    Lake Chicot is divided by a levee into two basins, the high
quality northern basin and the extremely polluted southern basin.

    Water quality in the northern basin of Lake Chicot is dimin-
ishing due to soil erosion. Costs for alternative control programs
for the seventeen fare, 11,470 acre northern watershed were esti-
mated. Twenty-nine combinations of rotations and best management
practices were evaluated.

    Soil loss can be reduced almost 25 percent from 4.2 tons per
acre to 3.2 tons per acre, while increasing net returns to farmers
from $83.94 per acre to $107.28 per acre by altering present crop-
ping patterns. A prohibition on fall plowing would result in an
average net return of $106.28 per acre and reduce average soil loss
to 2.9 tons per acre. An average soil loss restriction would be
the most cost-effective policy, exclusive of administrative costs.

    Benefits of erosion control were estimated by the difference
between the value of recreational participation on the northern
basin and the value for the southern basin. Control programs
were highly cost-effective.

Descriptors: Arkansas/*Soil Erosion/Watershed Management/Farm
              Management/*Soil Conservation/*Lake Basins/Surface
              Water/*Economic Feasibility/*Cost-Benefit Analysis/
              *Recreation Demand

Authors: Robert N. Shulstad, C. Tim Osborn, Alan D. McQueen

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

The objectives of this study are threefold. First, to determine the costs that will be incurred by farmers of the North Lake Chicot Watershed to implement alternative Best Management Practices to decrease sediment runoff. These costs are measured as reductions in net income associated with a specific reduction in soil loss. Second, to determine the benefits, primarily recreational benefits, attributable to a soil erosion control program designed to protect the recreational viability of the northern basin of Lake Chicot. Third, to compare the present value of benefits to the present value of costs to determine if alternative erosion control programs can be established as an economically justifiable investment. These objectives were achieved in full.

Lake Chicot, a 5,025-acre oxbow lake created by the ancient meandering of the Mississippi River, is located near the town of Lake Village in Chicot County of southeastern Arkansas. Today the lake is separated into a northern basin of 1,154 acres and a southern basin of 3,871 acres by a levee maintained by the Arkansas Game and Fish Commission. The entire lake once offered excellent fishing and recreational benefits. But with channelization in the drainage basin and final closure of the Cypress Creek gap along the Mississippi River levee in 1920, drainage and flood waters from approximately 350 square miles of agricultural land were diverted into Connerly Bayou and thus, ultimately, into Lake Chicot.

1

Feeling that the entire lake would become too polluted to support recreation, the Arkansas Game and Fish Commission constructed the existing levee across the lake just above the point at which Connerly Bayou enters. This restricted the Bayou's silt-laden input to only a portion (the southern basin) of the overall lake. The resulting impact on the southern basin was to increase greatly its silt content, turbidity, and pesticide load, and drastically diminish the recreational benefits that this portion of the lake was capable of providing.

By contrast, the northern basin of Lake Chicot has remained, until most recently, quite clean, and free of significant amounts of pesticides. This part of the lake has long been thought of as a quality recreational resource boasting a fine sport fishery and a beautiful state park. During the past ten years, however, users have begun to notice increasing turbidity which has been attributed to the yearly input of an estimated 32,323 tons of sediment from the surrounding 11,470-acre watershed[1]. Ninety-seven percent of this sediment is produced by sheet and rill erosion from 10,190 acres of cropland within the watershed. It has been suggested that unless improved erosion control measures are implemented on the farmlands affecting the northern basin, the water quality of this portion of the lake will become like that of the southern basin with a corresponding loss in recreational benefits.

The Conservation District, in cooperation with U. S. Soil Conservation Service, is considering such an erosion control program. Their proposal, consisting of technical assistance and government subsidization, is directed toward encouraging farmers to adopt better soil conservation practices (6). Since the financing of this project would be accomplished with public monies, it is essential that the project be analyzed, at least in part, on the basis of whether or not the expected social benefits warrant the costs. If the benefit-cost ratio (b/c) is not greater than one, public investment in the project would be economically questionable. While this efficiency criterion is not the only basis upon which public projects should be judged, it nevertheless has to be of major concern to taxpayers and decision makers.

Research Procedures:

A linear programming model was used to address the first objective. A whole farm planning model was constructed to simulate conditions existing in the North Lake Chicot watershed. This included the specification of alternative crop rotations, tillage methods, and soil conservation practices. This required the estimation of erosion rates resulting from different management practices. An initial run depicting the current situation provided estimates of the current levels of net farm income and soil loss for the watershed. The model was then rerun to determine the

maximum net income available and its resulting soil loss. Soil loss restrictions were then imposed and the resulting loss in net farm income associated with each level of control was estimated. Both per acre soil loss and average watershed soil loss restrictions were examined. The resulting loss in net income can be used as a guide in establishing levels of subsidization required to implement the BMPs.

Objective (2), determining the increase in the value of North Lake Chicot resulting from decreases in sediment inflow, was accomplished through use of the indirect method of recreational demand estimation. This allowed the estimation of the demand for and value of recreation at Lake Chicot.

It had been predicted that without an erosion control program, the water quality of the northern basin of Lake Chicot would approach that of the southern basin. Correspondingly, if this were to happen, the value of recreational benefits which users extract from the northern basin would also decrease to the level of recreational benefits users derive from the southern basin. Since the purpose of an erosion control program would be to prevent this from occurring, the value of the benefits of such a program would approximate the present value of recreational benefits of the northern basin minus the present value of recreational benefits of the southern basin. The indirect method was employed to determine these values.

The indirect method determines an individual's valuation of a recreational resource or his willingness to pay indirectly by examining what he actually does pay to obtain the resource. These costs are composed of transportation costs, time costs during travel, variable onsite costs, etc. By knowing these costs, collectively known as transfer costs, coupled with the number of days an individual takes in recreation at a particular site, a demand curve can be derived. Estimates of the value of the recreation at the lake can then be made from this demand curve.

Demand equations were developed relating hours per visit to travel cost, onsite cost, income, investment in recreational equipment, number of visits per year, number in party, and age. These equations were developed for both basins of the lake using unaggregated data via multiple least squares regression. When best-fit equations were developed, the mean values of all independent variables except onsite cost were inserted into the equations and multiplied by their regression coefficients. Onsite cost served as the relevant price proxy since it is variable with respect to length of visit whereas travel cost is essentially fixed. By allowing onsite cost to vary, demand curves for the average recreational group in each basin were formed, enabling the estimation of the average consumer's surplus value for each group in each basin. These values were multiplied by the number of groups in each basin to develop basin consumer estimates. Finally, the

recreational value of the southern basin was subtracted from the recreational value of the northern basin to obtain the limiting case erosion control program benefit. The third objective, to determine the economic feasibility of alternative soil erosion control programs, was met through the use of benefit-cost analysis. A fifty percent reduction in sediment delivery was assumed to be necessary to maintain the water quality in the northern basin of Lake Chicot. The annual cost of each program to meet this criteria was estimated as the decrease in net revenue resulting from the implementation of the program. The present value of costs was determined assuming a project life of 50 years and a discount rate of 7 3/8 percent.

The present value of benefits were estimated assuming initial benefits would be zero and grow to equal the limiting case benefit over a period of 20 years. In the remaining years of the program the full limiting case benefit was used. The present value of benefits was determined using a project life of 50 years and a discount rate of 7 3/8 percent.

If the present value of benefits exceeded the present value of costs the program was considered economically feasible.

COST ESTIMATION

Erosion Rates Resulting from Different Management Alternatives:

Erosion in the north Lake Chicot watershed was determined through the use of the Universal Soil Loss Equation (USLE) (Wischmeir and Smith, 8). This equation uses six physical parameters to estimate the amount of gross soil loss. The equation appears as: $A = R \times K \times LS \times P \times C$

where

A = Computed soil loss in tons per acre per year (TAY)

R = rainfall/runoff factor

K = soil erodibility factor

LS = slope length/steepness factor

P = support practice factor

C = cover/management factor

The rainfall/runoff factor (R) quantifies the effect of raindrop impact and provides information on the relative amount and rate of runoff likely to be associated with the rain. The numerical value for this factor in the Lake Chicot area was determined to be 355 (8).

The soil erodibility factor (K) quantifies the natural susceptibility of different soil types to erode. Although the Soil Survey for the cropland of Chicot County indicates that nine soil types are present in the study area, with respect to the USLE they were grouped into three main categories: 1) clay soils with a K factor of 0.24 (5,184 acres); 2) loam soils having a K factor of 0.32 (1,137 acres); and 3) loam soils with a K factor of 0.37 (3,869 acres).

Topographic considerations affecting erosion rate, essentially steepness and length of slope, were combined into one factor (LS). Within the study area, topography is relatively uniform with an average slope of 0.25 and an average length of slope equaling 250 feet, yielding LS value of 0.09.

Support practices such as contouring, stripcropping, and terracing slow water runoff and reduce the amount of soil the water can carry. The support practice factor (P) is the ratio of the soil loss while employing a specific support practice and the soil loss resulting from up and down slope cultivation. Effectiveness of runoff retarding practices diminishes as land slope decreases. This was essentially the case for the lands in the study area, which yielded a P value of 1.0. Therefore, these practices were not considered further.

The factors of the USLE presented thus far have been largely outside the control of man in reducing erosion in the north Lake Chicot watershed. The cover and management factor (C), however, can be readily altered by adopting various crop rotations in combination with different management practices, and thus serves as a major concern for this phase of the study. Essentially this factor is the ratio of soil loss from cropland under specific conditions to the corresponding loss from clean tilled, continuous fallow. Actual soil loss from cropland depends on usage of cover crops, crop sequence (rotations), management practices (fall plow,

spring plow, no-till), as well as the particular stage of growth
and development of the vegetative cover at the time of rain.
C-values for all logical combinations of rotations and management
practices were calculated using the method described by Wischmeier
and Smith (8). These calculated C-values were substituted, along
with the other factor values discussed above, into the USLE to
estimate annual gross soil loss for all rotation-management prac-
tice combinations.

The predominant crops grown in the study area include cotton
and soybeans, with significant acreage devoted to rice and wheat[2].
In 1979, rice rotations existed for clay soils only because the
irrigation needed for rice production was available only to the
clay soils of the watershed. Soil loss and net return calculations
for the rotation-management combinations on clay soil are presented
in Table 1. Table 2 summarizes this information for the loam soil
of the watershed. The estimates presented in these tables repre-
sent the gross soil movement associated with various rotation-
management combinations. It should be emphasized that actual sed-
iment input to the northern basin is only some fraction of gross
soil loss, since a great deal of eroded sediment is deposited in
grassed and depressed areas and at the toe of the field. The
calculated sediment delivery ratio for the northern basin watershed
was estimated to be 0.22[3].

Linear Programming Analysis:

To determine least cost strategies leading to various levels of erosion reduction, an adaptation of a whole farm planning model was employed (2). As a linear programming technique, this model's objective is to maximize farm profit before taxes (net revenues), subject to constraints upon land, labor, time, machinery, and allowable erosion. This is accomplished through the mathematical selection of optimal and feasible rotation-management practice combinations.

Even though the watershed for the northern basin of Lake Chicot is composed of 18 farms, in part or in whole, for purposes of linear programming analysis the entire watershed (equipment complement, land, etc.) was considered as one farm. This is valid since the model does not adjust for the advantages that would be associated with economies of scale. Thus, total profit found in this manner is not significantly different from that found by evaluating each farm separately.

Because of the current lack of irrigation equipment in the watershed the model was constrained to a maximum of 160 acres of rice production each year. No-till soybeans were considered in the model only when following wheat. Weed problems in the study area associated with no-till production have severely limited its adoption.

Table 1. Net Returns and Soil Loss for Each Rotation on Clay Soils

(TAY - Tons/Acre/Year)

Rotation[1]	Soil Loss(K=.24)		Net Returns	
	TAY	Rank	$/Acre	Rank
Pasture	0.1	1	7.88	29
R,S,W/S; CC & N-T	1.2	2	75.62	14
R,S,W/S; N-T	1.4	3	79.13	11
S,W/S; CC & N-T	1.5	4	52.08	27
R,S,W/S; CC	1.5	4	95.14	4
W/S	1.5	4	113.55	1
C,S,W/S; CC & N-T	1.6	7	67.36	20
R,S,W/S; SP	1.7	8	101.81	3
R,S,S; CC	1.8	9	86.51	8
S,W/S; N-T	1.8	9	48.88	28
C,S,W/s; CC	2.0	11	78.82	12
C,C,C; CC	2.0	11	54.81	25
R,S,S; SP	2.1	13	89.44	6
R,S,W/S; FP	2.2	14	103.22	2
C,S,W/S; N-T	2.3	15	69.16	19
S,S,S; CC	2.3	15	54.76	26
C,S,; CC	2.4	17	72.67	17
C,S,S; CC	2.4	17	70.03	18
C,S,W/S; SP	2.7	19	86.23	9
C,C,C; SP	2.8	20	63.49	21
S,S,S; SP	2.8	20	57.78	23
R,S,S; FP	2.9	22	89.60	5
C,S,W/S; FP	3.3	23	87.55	7
C,S; SP	3.3	23	78.40	13
C,S,S; SP	3.3	23	75.01	15
S,S,S; FP	3.5	26	57.62	24
C,S,S; FP	3.8	27	74.75	16
C,C,C; FP	4.0	28	63.23	22
C,S; FP	4.0	28	79.36	10

[1]R, Rice: C, Cotton; S, Soybean; W/S, Wheat/Soybean Double crop, FP, Fall Plow; SP, Spring Plow; CC, Cover Crop, N-T, "No-Till."

Using 1979 prices for all relevant inputs and products, plus current crop yield estimates for the different rotation-management practice combinations, 13 alternative erosion control plans were evaluated for net returns and erosion rates. Of these 13 plans, two were baseline situations; 1) the actual 1979 cropping pattern in the watershed, and 2) the cropping pattern resulting in maximum farm income. The remaining 11 alternative plans were viewed with regard to the second baseline situation.

Three of the plans considered the effectiveness of consistent cultivation practices by all watershed farmers. These included fall plow only, spring plow only, and cover crops. In the fall plow plan, the linear programming model maximized net return using only those rotations designated as "fall plow." The spring plow and cover crop plans were constrained similarly.

Three other plans assessed the impact of absolute annual soil loss restrictions on a per acre basis. Essentially, these plans simulated a direct regulation requiring farmers to reduce soil loss on each and every acre below the designated levels (5 tons per acre (TAY) limit, 4 TAY limit, and 3 TAY limit). Rotation-management practice combinations yielding a soil loss greater than the designated level were eliminated from consideration.

An alternative to the absolute soil loss restriction approach is an average soil loss restriction which could be enforced through a subsidy or taxing program. Here a total loss limit for the entire

-12-

Table 2. Net Returns and Soil Loss for Each Rotation on Loam Soils

(TAY - Tons/Acre/Year)

| Rotation[1] | Soil Loss | | | Net Returns | |
	TAY(K=.32)	TAY(K=.37)	Rank	$/Acre	Rank
Pasture	0.1	0.1	1	7.88	21
S,W/S; CC & N-T	2.0	2.2	2	66.58	20
W/S	2.0	2.2	2	142.02	4
C,S,W/S; CC & N-T	2.1	2.4	4	95.56	15
S,W/S; N-T	2.4	2.7	5	67.77	19
C,S,W/S; CC	2.7	3.1	6	133.66	8
C,C,C; CC	2.7	3.1	6	146.55	3
S,S,S; CC	3.1	3.6	8	68.23	18
C,S,W/S; N-T	3.1	3.6	8	110.87	13
C,S,S; CC	3.2	3.7	10	110.19	14
C,S,; CC	3.2	3.7	10	127.91	10
C,S,W/S; SP	3.6	4.1	12	135.25	6
C,C,C; SP	3.7	4.3	13	158.06	2
S,S,S; SP	3.7	4.3	13	71.12	17
C,S; SP	4.4	5.1	15	133.26	9
C,S,S; SP	4.4	5.1	15	115.42	12
C,S,W/S; FP	4.4	5.1	15	135.36	5
S,S,S; FP	4.6	5.3	18	71.60	16
C,S,S, FP	5.0	5.7	19	116.21	11
C,C,C; FP	5.0	5.8	20	158.12	1
C, S; FP	5.0	5.8	20	133.67	7

[1]R, Rice; C, Cotton; S, Soybean; W/S, Wheat/Soybean Double crop,
FP, Fall Plow; SP, Spring Plow; CC, Cover Crop; N-T, "No Till."

watershed is established by multiplying the desired average soil loss per acre by the number of acres of cropland in the watershed (2.5 TAY average, 2.0 TAY average, 1.5 TAY average, and 1.0 TAY average). Under the four plans representing this concept, no rotation-management practice combination was necessarily eliminated from consideration.

The final erosion control plan evaluated in the linear programming analysis was that proposed by the Soil Conservation Service. Briefly this plan calls for federal cost sharing of six best management practices (BMPs) at the levels indicated in Table 3. In addition the SCS plan encourages adoption of minimum tillage and conservation cropping systems. These practices, though, would not be eligible for federal cost sharing. However, they were considered for adoption in the model when evaluating the SCS plan.

Linear Programming Results:

The results of modeling the north Lake Chicot watershed are presented in Table 4. Column two shows the average maximum net return per acre for each plan, while column three indicates the accompanying soil loss in tons per acre per year. The fourth and fifth columns exhibit percent reductions in net returns and soil loss, respectively, when compared to maximum possible returns (situation one). Finally, column six indicates the estimated amount of sediment in tons per year entering the

Table 3. Soil Conservation Service "Best Management Practices"
and Costs

Best management practices	Unit	No. of units	Est. unit cost
Pipe drops	Number	145	$1,088
Drop inlets	Number	5	$12,000
Filter strips	Acres	100	$80
Sediment basins	Number	2	$20,000
Grass waterways	Acres	10	$500
Cover crops	Acres/year	10,000	$21.46 rice[1]
			$17.51 soybeans[1]

[1]Cover crop cost represents the additional cost incurred by the
farmer from cover crop use but does not include any indirect
benefits from improved soil fertility or humus content.

Table 4. Model Results

| Situation | Net Returns Per Acre | Average Soil Loss | % reduction of | | Estimated Sediment Entering Lake |
			Net Returns	Soil Loss	
	$/acre	TAY			Tons/year
1 Max returns	107.28	3.2			7646
2 Fall plow only	106.77	3.6	.5	-14	8543
3 Spring plow only	106.28	2.9	.9	9	6974
4 Cover crop only	103.57	2.3	3.5	28	5674
5 2.5 TAY average	106.56	2.5	.7	22	6077
6 2.0 TAY average	103.12	2.0	3.9	38	4956
7 1.5 TAY average	98.83	1.5	7.9	53	3835
8 1.0 TAY average	86.88	1.0	19.0	69	2714
9 5 T/A limit	106.68	2.9	.6	9	6974
10 4 T/A limit	105.22	2.5	1.9	22	6077
11 3 T/A limit	97.54	2.6	9.1	19	6145
12 1979 actual	83.94	4.2	21.8	-31	9898
13 SCS plan	99.99	2.3	6.8	28	5539

northern basin of Lake Chicot.[4] The Soil Conservation Service's
estimate for the amount of sediment entering the northern basin
in 1977 was 32,323 tons, while this study estimated that in 1979
only 9,898 tons of sediment entered the basin. Differences in
the factors used in the Universal Soil Loss equation explain
this large divergence. For example, the sediment delivery ratio
used in this study was calculated to be 0.22, whereas the SCS
developed a sediment delivery ratio of 0.42 for the entire Lake
Chicot watershed and then applied this to the watershed of the
northern basin. Differences in length of slope and percent slope
also contribute to the divergence. The Universal Soil Loss
equation factors used in this study were more specific to the
northern basin watershed than those used by the SCS.

It can be seen that the 1979 actual situation has a higher
soil loss and a lower net return than the maximum return situation.
Thus it would be possible not only to reduce soil loss but also
to increase farm income by changing from current production
practices. An intensive educational program that informs farmers
about the income advantages of alternative crop rotations could
achieve this end. The solution for maximum returns shows the
land use in the watershed to be as follows;

1619 acres-continuous cotton; fall plow; loam soils

846 acres-cotton, soybeans; fall plow; loam soils

2122 acres-cotton, soybeans, wheat/soybeans; spring
plow; loam soils

4645 acres-wheat/soybeans; clay soils

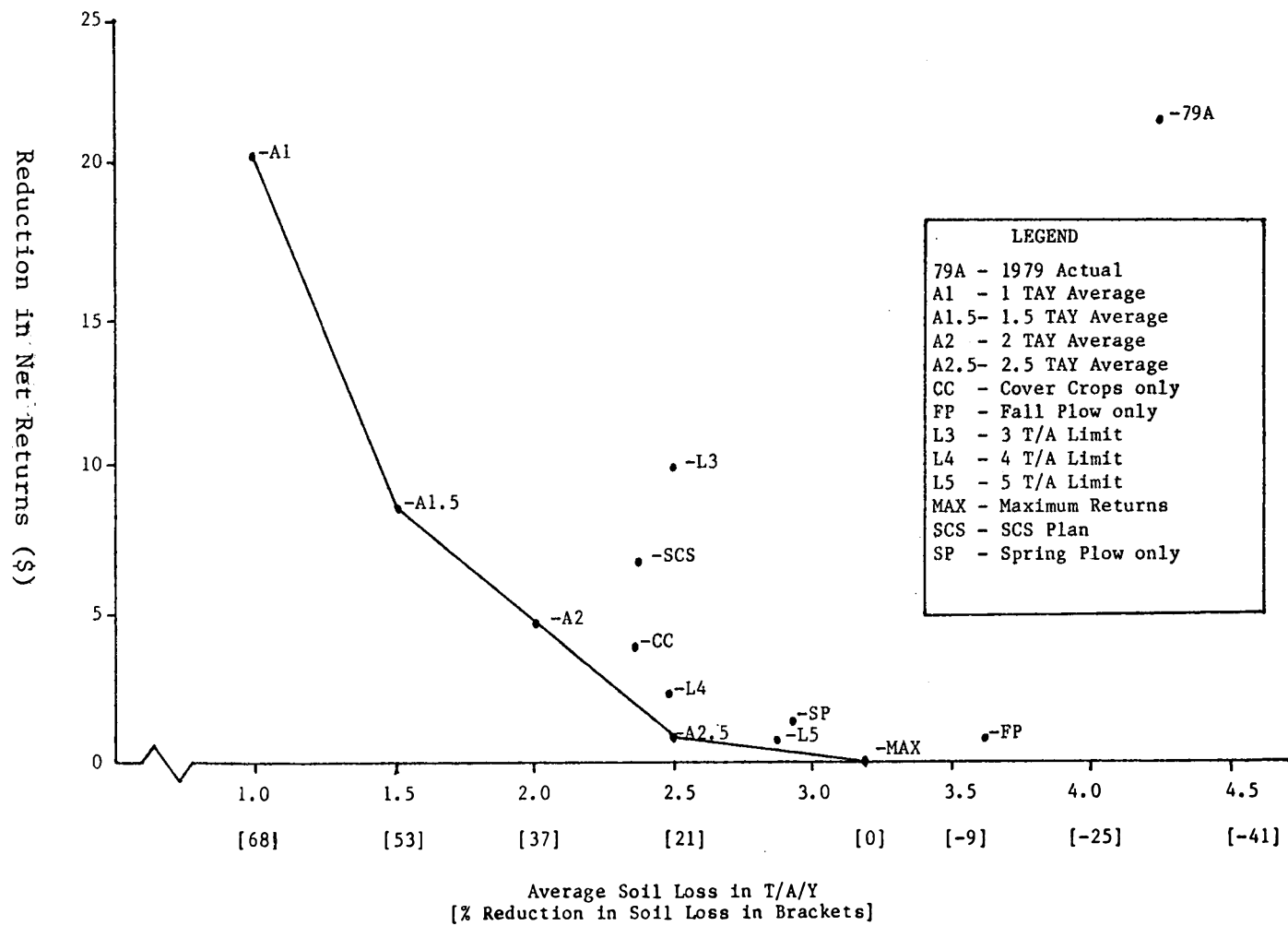217 acres-cotton, soybeans, wheat/soybeans; fall plow; clay soils

480 acres-rice, soybeans, wheat/soybeans; fall plow; clay soils

261 acres-continuous soybeans; spring plow; clay soils

Fall plow rotations enter the maximum net returns solutions because of a limitation on the machinery complement of the study area. This limitation results in a shortage of hours available in the spring for tilling and planting, forcing the model to select some rotations that begin land preparation in the fall. Unfortunately, fall plowing leaves the land bare during the entire winter, resulting in a greater amount of erosion than does spring plowing. The machinery complement limitation is an important factor when considering the average soil loss restriction.

The information of Table 4 is graphically displayed in Figure 1 where changes in soil loss are expressed both as tons per acre year and percent reduction from the soil loss associated with maximum returns.

Curve A in Figure 1 represents the minimum cost at which a reduction in soil loss can be achieved. This curve, composed of the average soil loss restriction plans, should be used in estimating the relevant social costs for a given level of soil loss reduction. Points representing the various absolute soil

Figure 1

Relationship between Reduction in Net Returns
and Soil Loss

Reduction in Net Returns ($)

25

20 ●-A1

●-79A

LEGEND

79A - 1979 Actual
A1 - 1 TAY Average
A1.5- 1.5 TAY Average
A2 - 2 TAY Average
A2.5- 2.5 TAY Average
CC - Cover Crops only
FP - Fall Plow only
L3 - 3 T/A Limit
L4 - 4 T/A Limit
L5 - 5 T/A Limit
MAX - Maximum Returns
SCS - SCS Plan
SP - Spring Plow only

15

●-A1.5

10 ●-L3

●-SCS

5 ●-A2

●-CC

●-L4

●-SP
●-L5   ●-FP

0 ●-A2.5 -MAX

1.0   1.5   2.0   2.5   3.0   3.5   4.0   4.5

[68]   [53]   [37]   [21]   [0]   [-9]   [-25] [-41]

Average Soil Loss in T/A/Y
[% Reduction in Soil Loss in Brackets]

loss restrictions also are indicated. Note that the cost of
the 3-ton per acre per year limit is greater than of the 4-ton
per acre per year limit with no significant decrease in soil loss.

The point representing the Soil Conservation Service pro-
posed plan (SCS) indicates that the same amount of soil loss
reduction (29%) could be accomplished at a lesser cost by ini-
tiating an average soil loss restriction.[5] The cost for the SCS
plan is estimated to be approximately $356,400 over a five-year
period, not including administrative costs. However, only 36
percent of this expenditure is scheduled for management prac-
tices designed to control sheet and rill erosion, although sheet
and rill erosion from cropland are estimated to contribute 99
percent of the sediment entering the northern basin of Lake
Chicot. Field evaluation will be required to determine if fed-
eral monies used for such a plan would be cost effective.

Model results show that farmers in the study area are far
from maximizing returns. Table 4 indicates that net returns
could be increased by 28 percent, from $83.94/acre to $107.28/acre,
by changing cropping practices. This would also result in a de-
crease in soil loss. Even the most restrictive situation con-
sidered, 1.0 TAY average, has a greater net return than the
1979 actual situation and results in a soil loss reduction of
76 percent.

The reason farmers in the north Lake Chicot watershed are
not maximizing return may be due to: a) a lack of information
or, b) objectives other than profit maximization. Such alter-
native management objectives may include maximizing leisure or
minimizing risk. In the wheat-soybean double crop rotation,
for example, net returns are high and soil loss is low; un-
fortunately, this rotation has a higher probability of crop
failure and greater management requirements than does single
cropping.

Once the maximum net returns situation has been reached,
the most cost effective program for reducing soil loss would be
an average soil loss restriction. This could be implemented
through a per unit charge or a subsidy. A 1.5 TAY average soil
loss restriction, for example, results in a 53 percent reduction
in soil loss with only a 7.9 percent reduction in net returns,
compared to the maximum returns situation. A 3 T/A limit, on
the other hand, results in only a 21 percent reduction in soil
loss with a 9.1 percent reduction in net returns.

Thus reduction in soil erosion and sediment delivery to
Lake Chicot from the north Lake Chicot watershed is feasible at
relatively low cost depending on the regulatory technique used
to implement the program. The value of benefits to be derived
from erosion control will now be examined.

BENEFIT ESTIMATION

The objective of the benefit estimation phase was to approximate the recreational benefits resulting from an erosion control program designed to at least maintain the present water quality and recreational viability of the northern basin.

It was assumed that in the absence of an erosion control program the water quality of the northern basin would, over time, degrade to that of the southern basin and the northern basin recreational benefits also would diminish to the value of the recreational benefits derived from the southern basin. Since the main purpose of an erosion control program would be to prevent this from occurring by at least maintaining the present water quality level, the value of the benefits for the program in any particular year would be the difference between the recreational value of the northern basin in that year and the lesser value that would have occurred had the program not been undertaken. A limiting case benefit would occur at the point when the northern basin recreational value would have fallen to just equal the current recreational value of the southern basin. The magnitude of the benefit in that year would simply be the difference between the current value of the northern basin and the current value of the southern basin.

This limiting case benefit was of prime importance since, once it was derived, any reasonable scenario concerning the rate at which the water quality of the northern basin would deteriorate may be used to model the flow of benefits through time as a result of program adoption. Benefits to landowners adjacent to the lake and to other potential users also may result from an erosion control program, but estimating these secondary benefits was beyond the scope of this study.

To arrive at the limiting case benefit it was necessary first to estimate the current recreational values of both basins. This was not a simple task, since outdoor public recreation has no well defined market price. One simply cannot purchase five units of camping from the corner store as he would a multitude of other goods and services. Therefore, over the years a number of techniques have been used to deal with this nonpecuniary complication.[6] The outgrowth of these techniques, the indirect method, is presently the accepted method for estimating recreational value.

Even though outdoor public recreation has no well defined market price, it nevertheless is not a costless pursuit. Recreationists do have to pay a "price" in the form of travel expenses, onsite variable expenses, token entrance fees, foregone wages, etc. The indirect approach uses these actual expenses borne by the recreationist as an indication of his willingness

to pay. By observing the "price" and length of stay for a large number of recreating groups it is possible to derive an average party's demand curve for the recreational site. As the price of recreation increases we note that the quantity demand declines. From this curve it is possible to establish measures of recreational value.

The indirect method avoids many of the biases encountered in other value estimation techniques and is therefore the most reliable method of recreational value estimation currently available. The indirect approach, as modified by Gibbs (3) in his Klamath Lake study, was chosen for this analysis.

The measure of recreational value selected for this study is known as the consumer's surplus. The basic argument behind the consumer's surplus is that every consumer has a price that he would be willing to pay to avoid having to do without a certain commodity. Often the price he actually has to pay is less than the price he would have been willing to pay. The difference between these two prices is in a real sense a net benefit to that consumer. If his net benefit were added to the net benefits gained by all other consumers of the commodity, a measure of the commodity's value could be established. Since the demand curve, by definition, indicates what individuals would be willing to pay, consumer's surplus in geometric terms is merely the area above

the price actually paid and below the demand curve.[7] Given this, the recreational value of each basin of Lake Chicot was found by multiplying the consumer's surplus of the average party for a visit to each basin by the respective number of basin visits per year.

Sampling Design:

Since detailed data on recreationist expense and usage were nonexistent, it was necessary to survey the Lake Chicot user population. During the summer of 1980, via random onsite personal interviews, 96 groups were questioned. From this presample it was determined statistically that a total sample size of 385 parties would be required. To obtain the remaining 289, a mail survey of users was undertaken. Names of recreationists who had visited the lake from October 1979, to September, 1980, were chosen randomly from State Park records. Of the 470 questionnaires mailed, 283, or 60.2 percent, were eventually returned in usable form.[8]

To investigate the possibility that nonresponse bias affected the integrity of the sample, a random 10 percent of the nonresponding portion of the mail survey group was questioned by phone. It was determined statistically that the responses given by those not responding originally were not significantly different from those given by parties responding to the questionnaire.

In addition to information about recreationist expenses and usage, information was collected concerning other economically important factors that could affect the demand for recreation.

Analysis of Empirical Models:

Computer analysis of models by multiple least squares regression was accomplished through the use of the General Linear Models procedure of the Statistical Analysis System at the University of Arkansas. Models using both the linear and the curvilinear form of the dependent variable Y were tested.[9] The curvilinear form produced the best predictive results, only those models using the curvilinear form of the dependent variable are presented here. The general theoretical model can thus be written:

$$Z = f(X1, X2, X3, X4, X5, X6, X7)$$

Where: Z = natural log of length of stay

$X1$ = travel cost; $X2$ = onsite cost

$X3$ = income; $X4$ = investment

$X5$ = visits per year; $X6$ = number in party

$X7$ = age

The determination of travel cost (X1) was limited to those expenses actually incurred by a party on their way to and from the lake. In the majority of cases the party's trip was to re-

create at Lake Chicot specifically. For some parties, however,
the visit was merely a side stopoff on a much longer journey.
In such situations, travel cost was calculated as only the ex-
penses the party incurred to go out of their way to visit the
lake. Obviously a major component of travel cost was gasoline
expense. In addition, however, expenses included food and bev-
erages, lodging, souvenirs, and entertainment. Food and beverage
expenses were those above and beyond what the party would have
consumed over the same time period had they elected to stay at
home (6). Total travel cost was found by summing the above ex-
penses. Economic theory would indicate that travel cost should
affect length of visit in a positive manner.

Onsite cost (X2) was limited to those expenses groups in-
curred while actually recreating at the lake. This included such
items as food and beverage, camping fees, boat rental, boat operation,
bait, camping equipment rental, camera supplies, minor equipment re-
pair, onsite auto milage, souvenirs, entertainment, etc. In addition
this study included in onsite cost any wages or income foregone by
members of the recreating group (if a group was on a paid vacation
their opportunity cost was simply zero). As before, food and beverage
expenses were those above and beyond what the party would have incur-
red had they elected to remain at home (6). After summing all these
expenses, the resulting total variable cost was divided by the length
of visit to yield onsite cost per hour. This variable was used

as the proxy for price in regard to number of hours per visit. It was expected that a negative effect would be shown.

Income (X3) was obtained through a question requesting that the respondent indicate to which of a number of income categories his family belonged. The 16 categories ranged from $0 to $43,000 and above. This approach was adopted in the hope of minimizing non-response. For analysis, the midpoint of the chosen range was taken as the approximate family income. It was expected that income would have a positive effect on length of visit, or that the higher the income, the greater the amount of recreation demanded.

Current value of investment in recreation equipment (X4) was obtained by presenting each respondent with a comprehensive list of various equipment items. If the family did own one, they were asked to supply the year of purchase, the original purchase price, and their appraisal of its current value. In addition they were asked to indicate the percentage of the item's total use time devoted to Lake Chicot. Purchase year and purchase price were used only to check the reasonability of the individual's appraisal of current value. When at all possible, the respondent's current value estimate was used. For each item of equipment, the current value was multiplied by its percentage of total use time at Lake Chicot to determine the actual investment in that item toward Lake Chicot recreation.

Total investment expenditure toward Lake Chicot was obtained by summing all items owned by the family. Investment in recreation equipment can generally be considered as an indication of strong preferences for recreational activities and may, in many cases, substitute for onsite expenditures. Thus, amount of investment expenditure was hypothesized to have a positive effect on length of visit.

Number of visits per year ($X5$) was obtained by asking interviewed groups how many times in the previous 12 months they had visited the lake. As an independent variable, number of visits per year was hypothesized to have a negative effect on length of visit. One would expect that as more visits are taken, the duration of each particular visit would become shorter.

Number in party ($X6$) was acquired through the use of a direct question. In most cases the party was composed of a single family unit. It was hypothesized that the number in the party would be positive in its effect on length of visit.

The determination of age ($X7$) was also accomplished through a direction question. Age in this study represented that of the individual being interviewed. In most cases this was the male head of household, the so-called leader of the group. The effect of age on length of visit and number of visits per year depends primarily on the age structure of the market population.

Populations composed of large percentages of the middle-aged tend to exert a negative effect on recreation while those composed of large percentages of younger or older individuals tend to have a positive effect on quantity of recreation demanded.

Cross correlation coefficients for all independent variables were calculated and analyzed for possible problems such as multicolinearity. It was determined that no such problem existed.

Subjecting the data collected for both basins of Lake Chicot to multiple least squares regression using the general theoretical model, the following empirical models were obtained:

Northern Basin
(1)
$Z = 3.34023844 + .01992230\ X1 - .18000183\ X2 - .00000146\ X3$
$+ .0000884\ X4 + .01108047\ X5 + .03047755\ X6 + .00273282\ X7$
R-SQUARE = .386668   ADJUSTED R-SQUARE = .373775
F-VALUE = 29.99   X1, X2, & X4 significant at 10%

Southern Basin
(2)
$Z = .84735896 + .39097763\ X1 - .00684022\ X2 + .00000778\ X3$
$+ .00046729\ X4 - .10522047\ X5 + .08261355\ X6 - .01630419\ X7$
R-SQUARE = .493128   ADJUSTED R-SQUARE = .423557
F-VALUE = 7.09   X1 and X4 significant at 10%

Where:
Z = natural log of length of stay

$X1$ = travel cost; $X2$ = onsite cost

$X3$ = income; $X4$ = investment

$X5$ = visits per year; $X6$ = number in party

$X7$ = age

T-tests indicated that in the model for the northern basin, income, visits per year, number in party, and age were not significant predictor variables for length of visit. To refine the model, differing combinations of these non-significant variables were dropped from the model. Special attention was given to the movement of the adjusted r-square. This statistic should be used in addition to the regular r-square since it tends to compensate for the loss of predictor variables. An increase in the adjusted r-square signals a model with superior explanatory power with fewer independent variables. The resultant model was one in which income, visits per year, number in party, and age were dropped causing the adjusted r-square to improve. This model appears as:

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Northern Basin
(3)
Z = 3.57406434 + .01943378 X1 - .18256554 X2 + .0000972 X4
R-SQUARE = .386112          ADJUSTED R-SQUARE = .381025
F-VALUE = 75.89             X1, X2, & X4 significant at 10%
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For the southern basin, t-tests indicated that onsite costs, income, visits per year, number in party, and age were not significant predictors of length of visit in the regression analysis.

All possible combinations of the above variables were dropped from the model, but in no instance did the price proxy, onsite costs, show even the slightest significance. The resultant best model was one in which X2, X3, X5, and X6 were dropped yielding;

-31-

Southern Basin
(4)
Z = 1.19307737 + .39428329 X1 + .00047120 X4 − .01546546 X7
R-SQUARE = .462516   ADJUSTED R-SQUARE = .435624
F-VALUE = 17.21   X1, X4, and X7 significant at 10%

Since X2, onsite costs, was shown to be highly insignificant, price must have had little effect on the quantity of recreation demanded on the southern basin at moderate price levels. Travel costs, investment expenditures, and age were better predictors in regard to length of stay on this basin.

To establish the northern basin demand equation for the average party, the mean values of X1 (travel cost) and X4 (investment expenditure) were inserted into equation (3) for the northern basin. By converting the curvilinear form of the dependent variable back to the linear form, the price quantity relationship became:

Northern Basin Demand Equation
(5)

$$Y = e**(4.0810548 \text{ x } .18256554 \text{ X2})$$
where ** indicates exponentiation

By allowing X2, onsite costs, to vary from the minimum northern basin onsite cost of $0.09/hour to the maximum northern basin onsite cost of $13.04/hour, the average party demand equation for the northern basin was established.

The demand equation for the southern basin was obtained by substituting its mean values for X1, X4, and X7 into equation 4. The resulting equation after converting Z to Y became:

Southern Basin Demand Equation
(6)

$$Y = 3.5939458$$

This equation results in a perfectly inelastic demand curve for the average southern basin party, from the minimum southern basin onsite cost of $0.33/hour to the maximum southern basin onsite cost of $11.01/hour.

Consumer's Surplus and Limiting Case Benefit:

To determine the consumer's surplus value for the northern basin, equation 5 was integrated from the average northern basin price of $1.48/hour to the maximum northern basin price of $13.04/hour. The result of this integration indicated that the consumer's surplus for an average party visit to the northern basin was $217.53. In other words, the average party receives $217.53 worth of benefit above and beyond their expenses for a visit to the northern basin. To obtain the total consumer's surplus value for the northern basin, the number of visits per year to this basin was multiplied by $217.53. According to information obtained from the Arkansas Department of Parks and Tourism, approximately 45,100 visits were made to the northern basin from October, 1979, to September, 1980. Thus the consumer's surplus value for the northern basin for these 12 months was $9,810,603.00.

Consumer's surplus value for the southern basin was found
by taking the integral of equation 6 from the average onsite
cost for this basin of $2.27/hour to the maximum basin onsite
cost of $11.01/hour. The outcome of this integration indicated
that the average party's consumer's surplus per visit equaled
$31.38. To approximate the total yearly consumer's surplus value
for the southern basin, the number of visits to this basin during
the period was multiplied by $31.38. From the sample taken in
this study it was determined that 17 percent of the groups vis-
ing the northern basin also visited the southern basin on a par-
ticular visit. Additionally, for all practical purposes, no
one travels to the lake with the purpose of recreating solely
on the southern basin. Therefore, the number of visits to the
southern basin for the period of October, 1979, to September,
1980, was approximated as 17 percent of the number of visits
to the northern basin over the same period, or 7,834 visits.
Thus, the resulting yearly total consumer's surplus value for
the southern basin was $245,826.84. From this information it
was possible to estimate the limiting case benefit of the pro-
posed soil erosion control program simply as the difference be-
tween the northern basin recreational value and the southern
basin recreational value. The consumer's surplus limiting case
benefit was equal to $9,564,776.16.

SUMMARY ANALYSIS

Using the information developed in the preceding sections,
it was possible to calculate a benefit-cost ratio (b/c) for the
soil erosion control program that would at least maintain the
present water quality of the northern basin of Lake Chicot. If
the resulting b/c ratio, found by dividing the present value of
benefits by the present value of costs, was greater than one,
the program was desirable from an economic viewpoint since it
adds more to society's well-being than it takes away.
Alternatively, if the b/c ratio was less than one, implementa-
tion of the program would be questionable since costs would be
greater than benefits.

Present Value of Costs:

In the cost estimation phase of this study it was shown
that the least cost method to effect any reduction in soil ero-
sion was through an average soil loss restriction. In the ab-
sence of expert consensus or actual physical investigation, it
was assumed that soil loss from the surrounding watershed would
have to be decreased by approximately 50 percent to maintain
the present water quality of the northern basin of Lake Chicot.
Thus, soil loss would have to be reduced from the 1979 actual
loss of 4.2 TAY to approximately 2.0 TAY. As shown in Table 4
the 2.0 TAY average restriction would accomplish this in a least

cost manner. In comparison to maximum returns, a restriction of this level would cost (in terms of subsidies or taxes) $4.16 per acre each year. Multiplying this by the number of acres of cropland in the watershed yielded a total yearly program cost of $42,390.00 not including administrative costs. Assuming a project life of 50 years and a discount rate of 7 3/8 percent, the present value of costs for such a program would equal $599,583.00.[10]

Present Value of Benefits:

It is to be expected that, in the absence of a soil erosion control program, the recreational value of the northern basin would decline little in the very near future. Thus, for the first few years of any erosion control program, benefits would be small. As time passed, however, we would expect that program benefits would increase until they reached an upper bound equaling the limiting case benefit. From that point on, for the life of the program, each year's benefit would be equal to the limiting case benefit. It has been assumed that given present erosion rates in the absence of a soil erosion control program, it would take approximately 20 years for the water of the northern basin to become like that of the southern basin in terms of recreational usage. It was additionally assumed that during this period the decline would proceed at a constant rate. Therefore, starting with an initial year benefit of zero and using the

consumer's surplus limiting case benefit derived earlier, it is clear that benefits in years 1 through 20 would increase yearly by $478,238.81. In year 20 and for the remaining years of the program, the full limiting case value of $9,564,776.20 would be realized.

Again assuming a discount rate of 7-3/8 percent and employing the consumer's surplus limiting case benefit, the present value of benefits for the program would be $67,694,000.00

Project Feasibility:

Dividing the present value of benefits found using the consumer's surplus limiting case benefit by the present value of costs yields a b/c ratio for the 50-year project of 112. If one were to employ a 20-year planning horizon while retaining all other assumptions, the resulting b/c ratio would equal 81. The magnitude of these ratios clearly implies that initiation of such a program would be highly desirable from society's standpoint.

In addition to the recreational benefits resulting from the erosion control program, other benefits may result. First, individuals owning homes near the lake would probably enjoy higher property values associated with living next to a clean versus silty body of water. Second, some individuals who never use the lake for recreation may nevertheless derive utility from the mere fact that the lake is being kept clean. For some

at least, their option to use the lake at a future date is thus preserved. Lastly, other benefits that may result include maintaining the productive capacity of the soil over a longer period of time, reduced maintenance cost for drainage ditches, and multiplier effects to the local economy from increased farm incomes. While these are real benefits that could be credited to such a program, for the purposes of this study only recreational benefits were counted. Due to the nature of the lake, recreational benefits are by far the most significant, and their preservation is the primary goal of the proposed program.

Recommendations:

The purpose of this study was to determine the most cost effective soil erosion control program to maintain the current recreational viability of the northern basin of Lake Chicot and, given this, through benefit-cost analysis to establish whether or not such a program could be economically justified. Studies of this type are essential if scarce public monies are to be used in an efficient manner. Results indicate conclusively that a project of this sort should be undertaken.

Initially top priority should be given to an intensive educational program designed to inform farmers that alternative production practices could not only reduce soil loss but also increase their net returns. Currently farmers in the north Lake Chicot watershed are neither maximizing net returns nor

minimizing soil loss. It is assumed that the benefits of an educational program (up to $23/acre) would greatly exceed the costs incurred to administer such a program.

The single most important factor affecting soil loss, and net returns to the farmer, is wheat production. When wheat is grown as a double crop with soybeans, soil loss is reduced by 57 percent and net returns are increased by 97 percent. Converting all the continous soybean production in the 1979 actual situation to wheat-soybean double cropping could account for most of the increase in returns and reduction in soil loss of the maximum returns situation compared to the actual 1979 situation.

The decrease in soil loss above that associated with maximum net returns could be accomplished most economically through an average soil loss restriction. A 2.0-ton per acre per year average, 1.2-ton per acre per year less than the maximum returns situation, would result in a 50 percent decrease in soil loss compared to 1979. Operationally this restriction could take form as an erosion reduction subsidy, by paying farmers $3.47 for each ton of soil loss reduced from the loss associated with maximum returns ($4.16 decrease in net returns divided by a 1.2-ton per acre per year reduction in soil loss). Alternatively, implementation of this restriction could be accomplished through a soil loss tax whereby farmers would be charged $3.47 for each ton lost per year.

An average soil loss restriction would give the farmer
flexibility in deciding for himself how best to decrease his
soil loss. The average soil loss restriction theoretically
achieves a given total soil loss reduction at the least cost.
However, this is true only if administrative costs, which were
not estimated in this study, are ignored. Unfortunately, these
costs may be prohibitive, given the nature of the problem. Other
programs such as the cover crop only alternative may be more
easily administered, resulting in significant reductions in
soil loss (2.32 TAY average) and having little impact on farm
income.

The Soil Conservation Service, through the Conservation
District, can provide the expertise needed to develop individual
control plans and to determine the farmer's soil loss before
and after initiation of controls. Each farmer should be en-
couraged to contact the Soil Conservation Service and his/her
county Extension agent to develop effective crop rotations and
soil conservation plans.

[1]Soil Conservation Service estimate for 1977.

[2]Wheat is grown only as a double crop following soybeans. 1978 acreages were: soybeans, 8430 acres (82.7% of watershed cropland); cotton, 1600 acres (15.7%); rice, 160 acres (1.6%); wheat double crop, 1200 acres.

[3]Calculated from information given in the Soil Conservation National Engineering Handbook.

[4]This takes into consideration gross erosion from other sources in the watershed (2148 tons per year) and a sediment delivery ratio of 0.22.

[5]The contribution of sediment basins in the SCS plan has never been determined. Therefore, for purposes of this study their effect was assumed to be insignificant.

[6]The interested reader is directed to Barkley (1) for a review of the history of these techniques.

[7]The price actually paid is the mean onsite cost for all groups visiting the site.

[8]A copy of the questionnaire/interview form can be found in Osborn (5) or obtained from the Department of Agricultural Economics and Rural Sociology, Room 222 Agriculture Building, University of Arkansas, Fayetteville 72701.

If the completed questionnaire was not returned within four weeks of the original mailing, a follow-up postcard was sent. If after another four weeks no response was forthcoming a third and final correspondence containing a second questionnaire was sent.

[9]The curvilinear form of the dependent variable Y (length of visit) is the natural logarithm of Y which shall be indicated as Z.

[10]A discount rate of 7 3/8 percent is consistent with rates presently being used in other federal programs.

LIST OF PUBLICATIONS FROM PROJECT

"A Benefit Cost Analysis of a Soil Erosion Control Program for the Northern Watershed of Lake Chicot, Arkansas." C. Tim Osborn, Alan D. McQueen, and Robert N. Shulstad, Arkansas Agricultural Experiment Station Bulletin 856 and Arkansas Water Resources Research Center Bulletin 79, University of Arkansas, Fayetteville, November 1981, 23p.

"Economic Analysis of Controlling Erosion in the North Lake Chicot Watershed." Alan D. McQueen, University of Arkansas, Department of Agricultural Economics and Rural Sociology, Master's thesis, 1981. 125p.

"The Value of Recreational Benefits Due to Controlling Erosion in the North Lake Chicot Watershed." C. Tim Osborn, University of Arkansas, Department of Agricultural Economics and Rural Sociology, Master's thesis, 1981. 84p.

"Economic Feasibility of Controlling Soil Erosion in Lake Chicot's Northern Watershed." C. Tim Osborn, Alan D. McQueen, and Robert N. Shulstad, in Arkansas Farm Research, Arkansas Agricultural Experiment Station, March-April, 1982, p. 11.

"Controlling Agricultural Soil Loss in Arkansas' North Lake Chicot Watershed: A Cost Analysis." Alan D. McQueen, Robert N. Shulstad, and C. Tim Osborn, in Journal of Soil and Water Conservation. Vol. 37, Number 3, May-June 1982, p. 182.

"Controlling Agricultural Soil Loss in Arkansas' North Lake Chicot Watershed: An Analysis of Benefits." C. Tim Osborn and Robert N. Shulstad. Forthcoming in Journal of Soil and Water Conservation.

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