LAND USE CHANGES AND RESERVOIR DEVELOPMENT: AN APPLICATION OF LAND USE INFORMATION SYSTEMS

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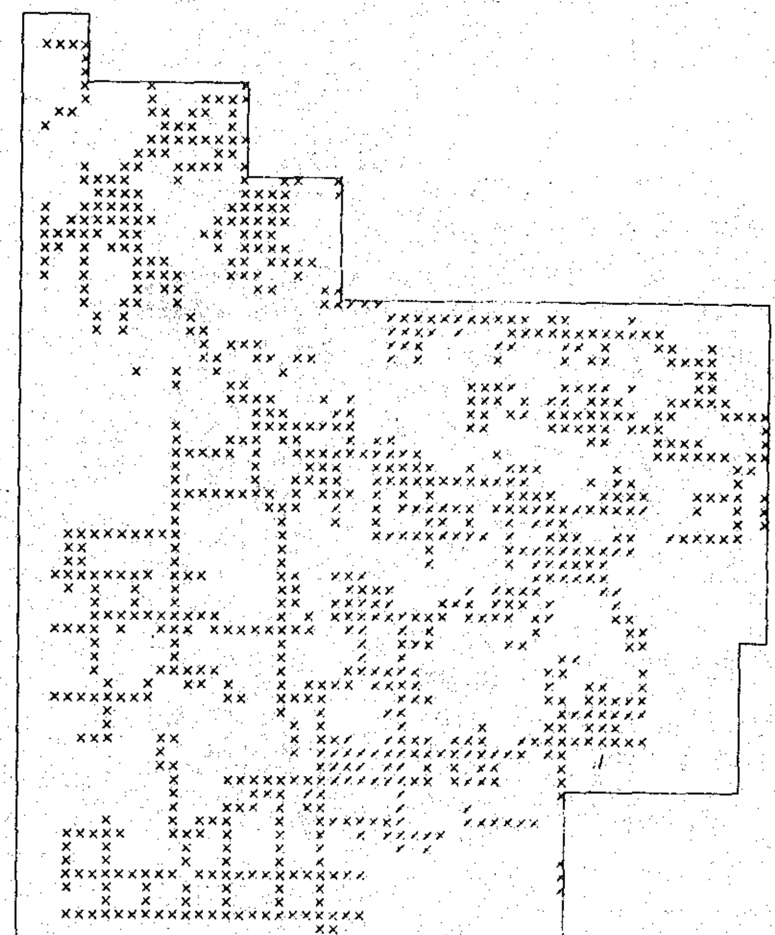

Submitted to
The Oklahoma Water Resources Research Institute
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PREFACE

This is the first of two reports which were supported by the Office of Water Resources and Technology, through matching grant B-Okla-33. This report explores the relationship between land use changes and the development of Keystone Reservoir (Oklahoma) from 1958 through 1970. It also provides an evaluation of a land-use information system (LUIS).

A supplemental volume, entitled "LAND USE CHANGE DETECTION CAPABILITIES OF LANDSAT-1 MULTISPECTRAL DATA UTILIZING LARSYS MACHINE PROCESSING TECHNIQUES: THE KEYSTONE OKLAHOMA CASE," evaluates the utility of machine-processed satellite imagery over a relatively short (1972-74) time period. In addition, it extends knowledge of the land use changes in several areas near the reservoir.

Special attention should be called to the working relationship between this project and the principle investigators of B-Okla-33, Dr. Evan Drummond and Dr. Dan Badger of the Oklahoma State University Department of Agricultural Economics. Considerable savings in data acquisition and processing were realized by this association.

Also the overall effort benefited from a cooperative arrangement between this project and the Laboratory for Remote Sensing at Indiana State University.

Not all of the individual contributions can be properly acknowledged here, but special attention should be directed towards the contributions of Keith D. Harries for his direction and wise counsel, Stephen W. Tweedie for his assistance in adapting MAPLOT for use in portraying land use changes, James E. Stine for his thoughtful suggestions, and Gayle Maxwell for her cartographic assistance. Graduate assistants Marcia Salkin, Vince Robinson, Tom Frank, Burrell Montz, Gary Lauver, and Cathy Cauldron made critical contributions. Chapter III was prepared by Vince Robinson. Burrell Montz assisted in the development of Appendix B.

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CHAPTER I

INTRODUCTION

There is increasing concern regarding the behaviors which affect the patterns of land use in this country. The "vanishing" wilderness, the strip-mining controversy urban sprawl, the conversion of premium agricultural lands, the insatiable demand for recreation resources..., these and many other current issues point up the interrelationships between policies and practices which jeopardize orderly, desirable, and efficient development of our land resources.

This report addresses the general issue of the relationship between water resources development and land use. While it is intuitively obvious that such relationships exist, nonetheless, a good deal of our nation's fiscal and natural resources have been invested in water resources development in the United States without much specific attention given to the area of anticipating the specific impacts of such projects on land uses in the immediate and surrounding areas. And even when land use changes have been anticipated, virtually nothing has been done to assess impact after the fact - to confirm or deny expectations with regard to these patterns.

It is believed that such impacts are important, that they are predictable, and that predicted changes can and should be used to assist in the evaluation of any water-resources project. It is believed that this study takes an important step in the direction of giving greater attention to such relationship in the planning process.

Another aspect of the research merits special attention. Given the requirements for use of Environmental Impact Statements (some of which include considerations of land use changes, plus the growing likelihood that Federal legislation will soon be passed which will require states to "design and implement" land use information systems) it seems likely that the development of semi-automated land use monitoring schemes will be necessary.

While some states (notably Illinois, New York, and Minnesota), certain planning as well as urban regions, have attempted to implement systems (of varying degrees of sophistication), most have not been used extensively in the planning process, or in research.

This lack of attention is partially due to the emphasis on system development and design, rather than on utilization. The research herein described is addressed, in part, to this deficiency. Water resources developments usually have considerable influence on subsequent land uses. It follows that change detection systems (land use information systems) need to be carefully studied in order to measure their utility in assisting in project evaluation.

The Evaluation of Secondary and Tertiary Impacts of Water Resources Projects

The direct benefits of water resources developments are usually anticipated, well-understood, and documented. For many years proposed projects have undergone sophisticated analysis of their flood control, navigation, irrigation, recreation, or other project purposes, especially with respect to the economic costs and benefits. While it has been long recognized that such projects also have important secondary and tertiary ramifications, the consideration of environmental, social, and other effects in the evaluation process have usually emerged as important only when measurement of direct impacts did not prove conclusive. This was due to the intangible and/or immeasurable characteristics of some of these possible project impacts.[1] But it seems likely that lack of recognition of the importance and extent of some impacts by policy-makers and resource managers may be more significant. It has also been suggested that this deficiency is related to the narrow and very specific mission-orientations of the principle public agencies responsible for water resources development.[2]

In any event the situation changed drastically with the National Environmental Policy Act of 1970 (EPA) and its requirement that environmental impact statements for most public works projects involving federal funds be developed. Subsequent judicial interpretations of the Act have substantially increased the significance and scope of the Environmental Impact Statements. And, as a result of the work of the Water Resources Council and the National Water Commission, even more effort has been given to incorporating other secondary and tertiary effects into the evaluation.

There is a growing body of research dealing with these effects, representative samples of which are summarized in Appendix A. In addition to research on the environmental impacts of water resources projects, there has been considerable work done on social effects, especially income redistribution, and impacts of social organizations, patterns of behavior change, and political impacts. Increasingly these effects are being incorporated into the Environmental Impact Statements required by the NEPA.

Evaluation of Water Resources Impacts on Land Uses

In the past the evaluation of water-resource development project has

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[1] Recreation benefits and reductions in loss of life are routinely incorporated and often heavily weighted.

[2] For a thorough discussion of the relationship of impacts from reservoir contruction to project planning see L. Douglas James, A Perspective on Economic Impact, Water Resources Institute, University of Kentucky, Report #37, 1972, 121 pages.

been carried on largely with the objective of ascertaining its economic efficiency. As a result when researchers and planners have attempted to incorporate secondary and tertiary benefits into the project evaluation, there has been a tendency to consider those effects which possess a clear economic dimension, or to express other effects largely in economic terms. Thus considerable attention has been given to the project impacts on local economies. Social change has been most often measured in terms of income redistribution, affects on fish and wildlife in terms of their ability to generate consumer surpluses for hunters or fishermen, and the effects on institutions have been measured in terms of their tax base and public expenditures.

In the case of impacts on land use a similar tendency can be observed. Much attention has been given the impact of project development on property values on the grounds that increases in property values are properly considered in cost-benefit analysis and that present procedures mistakenly confer public benefits upon a few private land holders. This research has used multiple linear regression techniques to assist in identifying the important factors associated with observed per acre or per parcel increases in sale prices for shoreline or other reservoir area property. These efforts have consistently identified proximity to reservoir and reservoir-access points, site qualities for construction and aesthetics, proximity to urban areas, and access to transportation and utilities as key variables.

Less attention has been given to impacts on land usage per se, in spite of the relatively greater availability of data and their more direct significance to environmental quality, in general, and to the planning process in particular.

Warner has discussed some theoretical relationships between land use and land values and their association to waterway development, but these relationships have not been tested.

Oyen and Barnard examine the effect of the construction of a flood control structure on downstream agricultural practices, though the predictability of conversion to cultivation using a multiple regression model is low ($R^2 = .32$). In an important early attempt Prebble examined land use changes around Lake Cumberland over a thirty year period. Attention was focused on conversion of land from agricultural to urban purposes for a set of arbitrarily defind quadrilateral cells on all peninsulas which extend into the lake. He determined that aggregate land use changes are significantly related to distance from water, ability to view the water, and type of road access, but that these have different effects at different times during the course of the reservoir's development. The author discourages reliance upon the regression equations on the grounds that they "exhibit excessive multicollinearity" and that many relationships are curvilinear.

There have been two important attempts to forecast changes in land use in the context of water resources development. Burby (1971, 1972) has undertaken research on existing residential (especially second home) land use patterns and their relationship to reservoirs and other variables.

While predictability from stepwise multiple regression equations is generally low (R^2 = .175), shoreline residential land use patterns are found to be significantly related to site characteristics, access to reservoirs, access to public roads, access to employment and urban centers, and availability of utilities. For recreation land use in non-shoreline situations predictability is somewhat higher (R^2 = .39) and significant explanatory variables emphasize site characteristics and utility availability and quality.

Burby, Donnally and Weiss present and test a residential land development model where residential location patterns are simulated through a procedure which takes into consideration availability of land, and its attractiveness. A number of variables were used to identify the attractiveness of vacant land near several large reservoirs, and the resultant simulations were tested and evaluated. The authors report a fairly close approximation of reality of the development patterns in the study areas.

A more general attempt at simulating land use changes has recently been completed by Steinitz Rogers Associates in conjunction with the U.S. Army Corps of Engineer District in Los Angeles (1975). It involves the development of a large data bank of site resources (43 variables) and land use elements (13 predominant land uses). An attractiveness model was used to generate attractive locations for future land uses, and a resource vulnerability model indicates the expected environmental impacts. Simulations were undertaken for the Santa Ana River Basin in California, but the model's accuracy has not been evaluated.

The Present Research

The general purpose of the present research is to extend knowledge regarding the impacts of investments in water resources projects. A secondary purpose is to evaluate the usefulness of land use information systems in extending this knowledge. More specifically, the study has the following objectives:

1. measurement of the types of changes in land use that are associated with the development of Keystone Reservoir;
2. identification of the extent of such changes;
3. identification of the variables which are relevant in stimulating land use changes;
4. development of and testing of a model which predicts such changes;
5. evaluation of the land use information system used in this research in order to ascertain its utility in assessing land use impacts from reservoir developments.

Our research differs from other efforts concerning the impact of reservoir

TABLE I

TYPES OF LAND USE CHANGES EXPECTED TO BE ASSOCIATED WITH RESERVOIR DEVELOPMENT

Changes Directly Related to Inundation or Land Development Associated with Project Needs

1. Elimination of Land Uses

   - especially cultivated, pasture, woodland, wildlife habitat, vacant, and waste land, extractive, structures

2. Relocation of Land Uses

   - especially highways, railroad, residences, businesses, utilities, structures, cemetaries, churches, etc.

3. Development of Land Uses

   - land devoted to servicing project purposes, offices, spillways, construction yards, recreation facilities, power station and lines, wildlife habitat

Changes Indirectly Associated with Project

1. Development of Land Uses Attracted by Reservoir

   - especially residential, including second home, commercial, irrigated land under cultivation.

2. Development of Land Uses Attracted in past by Reservoir

   - especially residential, commercial

3. Development of Land uses Relocated from the Reservoir Area

   - especially highways, railroads, residences, business, utilities, structures, cemetaries, churches, etc.

4. Decreases of Land Uses used for 1, 2, or 3

   - especially cultivated areas, vacant, woodland, pasture.

5. Development of land uses to service develops of type 1, 2, or 3

   - especially businesses, but also utilities, services, roads.

6. Decreases of land uses to service type 4

TABLE 2

FACTORS WHICH HAVE BEEN FOUND TO BE, OR ARE SUSPECTED TO BE, IMPORTANT IN INFLUENCING THE NATURE, THE EXTENT, AND THE LOCATION OF LAND USE CHANGE ASSOCIATED WITH RESERVOIR DEVELOPMENT

1. The Character of the Reservoir and Its Facilities

   - especially with respect to size, shape, water quality, scenery, recreation facilities

2. The Regional Context of the Reservoir

   - especially with respect to population settlement, access, climate number and location of other reservoirs

3. The Character of the Impoundment and Reservoir Development Areas

   - especially with respect to population, existing land use patterns

4. The Character of the Land Surrounding the Reservoir

   - especially with respect to existing land use, land value, and land ownership, but also slope, soil, elevation, drainage, and details of access to the impoundment

5. The Local Policy Environment

   - especially with respect to land use controls, availability of roads, and other utilities (water, electricity, sewage), availability of financing, and availability of services (fire, policy, health and education) development on land use in the following ways:

- emphasis is placed upon regional change, including areas at some distance from the reservoir as well as reservoir and shoreline zones;
- a broad range of land uses and land use change configurations are considered;
- analysis is undertaken in association with an evaluation of a comprehensive land use information system (LUIS);
- one high impact region is studied intensely in order to ascertain the influence of the "policy environment" on development related to reservoir development.

Some Perspectives on a Research Strategy

While it would be a considerable advantage to offer a predictive model capable of making non-probabilistic statements about what will happen to land uses if this or that proposed reservoir is built, this ideal is unattainable under present research capabilities. Some researchers prefer to make "predictions" couched in probabilistic terms, and in circumstances where assumptions limit transferability. Our research offers predictions only in the sense of conclusions, or surmises. Nevertheless this attempt involves measurements and "hard" data on land uses, and postulates a general model of land use change associated with reservoirs and tests this model in the case of Keystone reservoir. The report also describes and tests a model for predicting residential land use change within an area heavily influenced by the reservoir.

The Nature of Land Use Change Associated with Reservoir Development

Based upon previous research and experience with respect to land use dynamics, certain general observations can be made about the relationship between reservoir development and land use patterns. Certain land use changes can be expected as a direct result of the reservoir project. Land will be inundated. Land will be required for facilities, access roads, office buildings, spillways and other structures required for the construction and maintenance of the reservoir. These direct results include three types of impacts upon land uses, elimination of land uses, relocation of land uses, and development of new land uses (Table 1). In addition to these direct results of development, most reservoirs generate indirect effects upon land uses. These are likely to include increases in certain land uses, and decreases in others.

While it is clear that these or similar changes take place, the details with respect to the amount, the relative proportions and location, vary considerably with the specific project involved. Many of the factors which determine these details have been examined (Table 2).

TABLE 3: HYPOTHESIZED SPATIAL ORGANIZATION OF TYPES OF LAND USE IMPACTS, MAJOR FACTORS AND A TIME TABLE

	Anticipated Major Types of Land Use Change	Major Factors Responsible for Determining Extent, Mix, and locational details	Time Table
The Impoundment Zone	1. Elimination - especially cultivated, pasture woodland, wildlife habitat, vacant or waste land, extractive 2. Relocation - especially highways, railroads, residences, businesses, utilities, structures, cemeteries, churches, schools	Size, shape, purpose of reservoir; pre-project land use patterns; reservoir management practices may affect extent of elimination or relocation of certain uses (e.g. wildlife habitat, grazing activities, etc.)	Prior to or during construction
	3. Development - especially recreation, power, offices, access roads, maintenance facilities, wildlife habitat	project purpose and management practices	mostly prior to, but some after completion
The Shoreland Zone	4. Development of Land Uses Attracted by Reservoir - especially seasonal residential, and certain types of businesses	All of the factors suggested in Table 2 are relevant	Change begins during development, accelerates upon completion, and continues thereafter
	5. Development of Land Uses Attracted in part by Reservoir - especially permanent residences, businesses		
	6. Development of Land Uses relocated from reservoir - especially highways, railroads, residences businesses, utilities, etc.		
	7. Reduction in Land Use Associated with any of the above - especially cultivated, woodland, pasture		
	8. Diversion of rural land to less intensive or vacant for speculative purposes - especially cultivated or pasture to vacant or woodland		
	9. Development of land uses to service above developments - especially commercial but also some service and utilities		

The Shoreland Zone cont.	10. Reduction in land uses to services above - especially those to service land uses which have declined		
The Marginal Impact Zone	11. Development of land uses attracted in part by the reservoir - especially permanent residences, businesses	All of the factors suggested in Table 2 are relevant	Change tends to begin around completion, and grow steadily thereafter
	12. Development of land uses relocated from impoundment zone - especially highways, utilities, railroads, residences, businesses		
	13. Reduction in land use associated with any of the above - especially cultivated, woodland, pasture		
	14. Diversion of rural land to less intensive or vacant for speculative purposes - especially cultivated or pasture to vacant or woodland		
	15. Development of land uses to service types 11 and 12		
	16. Reduction in land uses to service type 14		
The Zone of No Impact	Land Use Changes not Related to Reservoir Development	Regional Land Use Trends and Other Local Factors - reservoir not a factor	Before, During, and After Reservoir development

A Hypothesized but General Model For Anticipating Land Use Changes

Table 3 presents a hypothetical model of anticipated relationships between reservoir development and land use change. It is believed that such a model can be useful in both conceptualizing and analyzing the effects of reservoir development on land use patterns.

Chapter 2 is devoted to an examination of land use changes near Keystone Reservoir in light of this model. Chapter 3 consists of a detailed examination of one type of factors thought to be significant to the high impact areas near the reservoir. Chapter 4 summarizes and indicates some implications of the research. As mentioned previously, Appendix A consists of an annotated bibliography of selected research on impacts from reservoir development, while Appendix B describes the characteristics of a Land Use Information System and evaluates the experience with the one developed in connection with this project. The remainder of this chapter is devoted to a general discussion of the Keystone study region.

The Keystone Study Area

The region used for this research is the area including and surrounding the Keystone Reservoir. Authorized by the 1950 Flood Control Act, the Keystone reservoir was created as part of the original Arkansas River Navigation Plan, a plan designed to serve navigation, flood control, hydroelectric power production, water supply, sediment control, recreation, and fish and wildlife propagation in the Arkansas River Basin. In January 1957, the U.S. Army Corps of Engineers initiated construction of an earth-fill dam near the confluence of the Arkansas and Cimarron Rivers. By 1964, the dam was in operation for flood control, and in 1968 began producing electrical energy (Table 4).

The surface area of Lake Keystone varies from approximately 26,000 (Conservation Pool) and 50,000 acres (maximum flood pool). With 26,000 surface acres the lake has approximately 300 miles of shoreline.

The lake is situated along the borders of a four-county area about fifteen miles west of Tulsa (Figure 1). The precipitation for the area is between 30 and 40 inches annually, and the land is covered alternately by scrub oak forests and grassland openings. The topography of the area consists of rolling sedimentary plains. Local slopes vary from relatively steep to very gentle.

Primary and secondary highways transect the area thoroughly with the exception of parts of Osage County. Highway 64, the Cimarron Turnpike, and Interstate 44 make the study area easily accessible to Tulsa by four-lane freeways. Four railroads also pass through the region, and also focus on Tulsa.

The economy of the area was once very rural in character. However, it has been experiencing a pronounced rural to urban shift, both in terms of population and economy. Moreover, the region is becoming increasingly associated with Tulsa. Thus agriculture and agricultural populations are mostly declining both in absolute terms and relative to other economic activities in the region (Table 5). The population of the region as a whole has increased and central places, particularly those near the reservoir have counted substantial increases (Table 6). The rural-non-farm population has grown rapidly, especially in those areas within commuting distance of Tulsa.

Indeed the commuting tie to the Tulsa area appears to be a most significant feature of the study area. In 1970, nearly 80 percent of the employed heads of households in the Southeast Osage Census County Division indicated that they commuted to Tulsa (Table 7). And for the five Census County Divisions which are included in the study area, nearly sixty percent of the employed heads of household find work in Tulsa County.

General Characteristics of Study Region

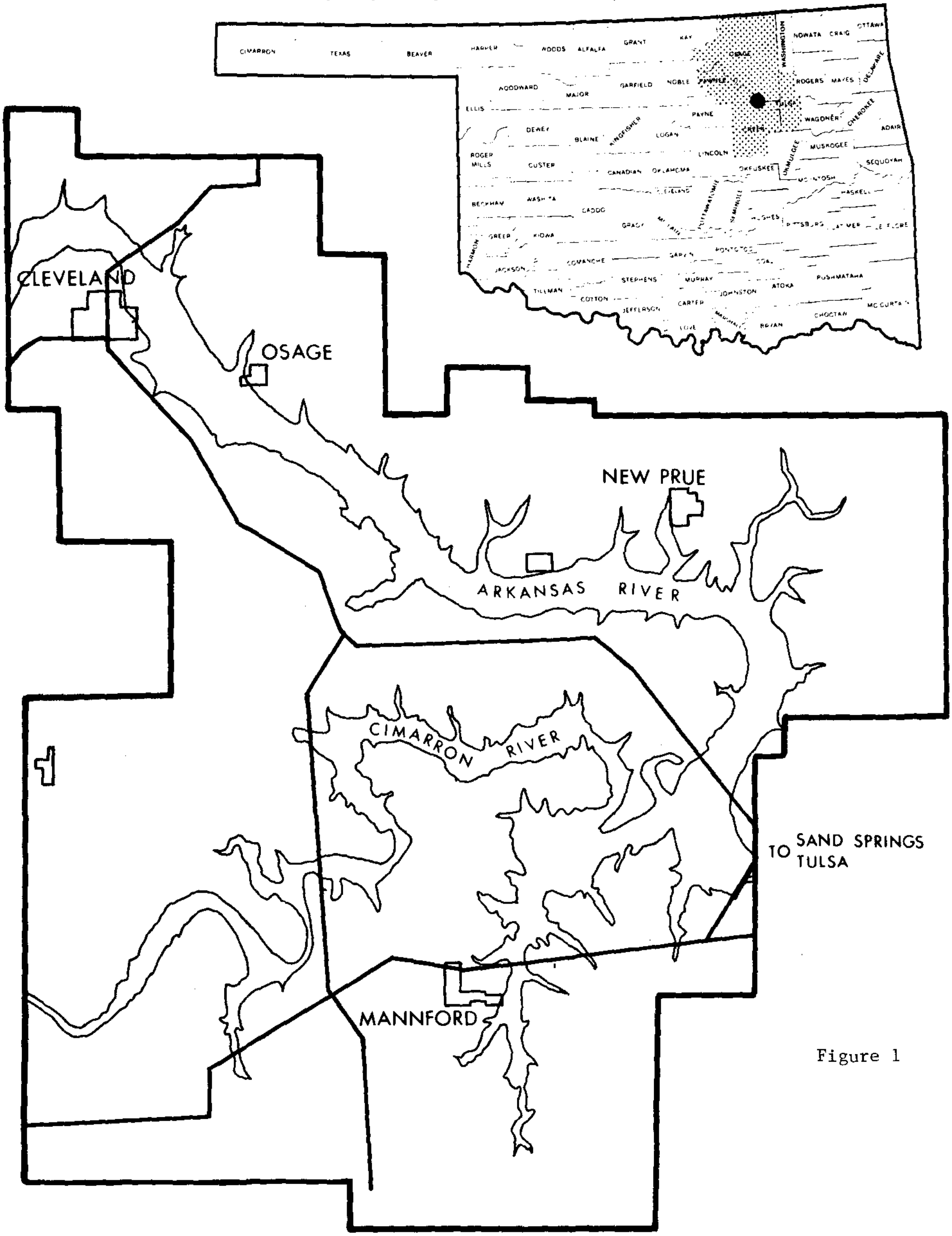

Figure 1

TABLE 4: A CHRONOLOGY OF THE KEYSTONE PROJECT: DATES OF SIGNIFICANCE TO LAND USE CHANGE

1946	Rivers and Harbors Act approved plan for Multi-purpose Project
1948-1950	Public hearings held; local residents and tradesmen protested relocation and disruption of existing trade patterns; Osage Indians concerned about loss of revenue from gas and oil production, railroad and utility officials concerned about relocation; public officials and downstream residents supported the project.
1950	Flood Control Act included project approval (see Senate Document 107, 81st Congress, 1st Session)
1957	Construction began
1962	28 percent of relocation of cemeteries, utilities, structures completed 66 percent of land purchased for rights of way and reservoir lands 62 percent of highway relocation accomplished 86 percent of railroad relocation accomplished
1964	diversion sluices closed, flood control begins
1965	99 percent of relocation work completed; Conservation pool filled (lake exceeds 26,300 acres)
1966	maximum pool elevation produced lake of approximately 30,000 acres
1967	maximum pool elevation produced lake of approximately 33,000 acres
1968	power generation begins
1970	maximum pool elevation produced lake of approximately 35,000 acres
1974	maximum pool elevation produced lake of approximately 55,000 acres

Source: Adapted from Department of Army, Corps of Engineers, Annual Reports of Chief of Engineers on Civil Works Activities, and U.S. Senate Document 107, 81st Congress, 1st Session.

TABLE 5: CHANGES IN AGRICULTURAL CHARACTERISTICS, THE KEYSTONE STUDY AREA, 1950 to 1969

	1950	1954	1959	1964	1969
Cropland Harvested (1000's of acres)					
Creek	64	44	24	28	22
Pawnee	83	70	54	50	46
Osage	107	94	78	75	75
Tulsa	84	72	58	36	41
Number of Farms					
Creek	2179	1559	1162	1375	1118
Pawnee	1426	1296	917	809	785
Osage	1917	1703	1318	1270	1184
Tulsa	2604	1807	1415	768	1010
Land in Farms (1000's of acres)					
Creek	460	386	368	434	379
Pawnee	334	339	328	326	332
Osage	1326	1223	1293	1282	1225
Tulsa	304	342	357	185	185

Source: U.S. Censuses of Agriculture, 1950, 1959, 1969

TABLE 6: POPULATION IN AND AROUND THE STUDY REGION, 1940 - 1970

	1940	1950	1960	1970
Creek County	55,503	43,143	40,495	45,532
Osage County	41,502	33,071	29,750	32,441
Tulsa County	193,363	251,686	346,038	401,663
Pawnee County	12,395	13,616	10,884	11,338
<u>4 County Total</u>				
Cleveland City	2,510	2,464	2,519	2,573
Mannford	1,390	881	352	892
Osage	828	423	220	170
Keystone Town	406	228	151	0
Keystone Lake	0	0	0	4,720
New Prue	0	0	0	202

Source: U.S. Censuses of Population, Number of Inhabitants, 1950, 1970.

TABLE 7: COMMUTING PATTERNS, CENSUS COUNTY DIVISIONS IN THE STUDY REGION

Percentage of Reporting Heads of Households*
by place of work, 1970

	Outside County of Residence	Inside County of Residence	Tulsa CBD	Other Tulsa City	Other Tulsa County
Keystone Lake CCD	52	48	5	25	17
Southwest Osage CCD	83	17	18	45	17
Fisher-Coyote Trail CCD (Tulsa County)	7	93	4	26	54
Cleveland CCD	52	48	31[1]	31[1]	7
Hominy CCD	19	81	4	9	1

* data based upon 15 percent sample of households

Source: U.S. Bureau of Census, 1970 Census of Population, Summary Tape, 4th Count, Table 35

1. combines CBD and other Tulsa City

Chapter 2

LAND USE AND LAND USE CHANGE PATTERNS AROUND KEYSTONE RESERVOIR

This chapter examines regional land use and land use change patterns with special reference to the development of Keystone Reservoir. The secondary influence of Tulsa is also described.

A Land Use Information System (LUIS) was developed in connection with these endeavors. It features a data set of 2341 one-half square kilometer cells (585 square kilometers or 95,000 acres) for three time periods. Data on the existence of the following land uses are included for 1958, 1964, and 1970: residential, commercial, manufacturing, institutional, pastureland woodland, cultivation, highway, railroad-utilities, and structures. The rationale specifications and evaluation of this system are discussed in detail in Appendix B. The data set is analyzed with the assistance of conventional descriptive statistics computer programs and a computer plotting routine.

Four regions are proposed to correspond with those hypothesized land use change zones described previously. These are defined as follows:

The Inundation Zone: The Conservation Pool Area

The Shoreland Zone: adjacent to the conservation pool, and including some flood pool; includes all cells touching either the flood pool or conservation pool;

The Intermediate Zone: Extending three kilometers from the shoreland zone

The Remote Zone: over three kilometers from the shoreland zone

The Pre-Project Characteristics of the Study Area

Prior to the Keystone project, the region appeared much like other parts of Oklahoma. For thirty years population had been steadily declining throughout Creek, Osage, and Pawnee counties, while population was increasing in Tulsa County. Moreover, the number of farms, the land in farms, and cropland harvested all had been decreasing for some years. In 1958, land usage for the study region as a whole was largely rural, with a large proportion of the region given to forest or pasture (Table 8). Indeed, 43 percent of all cells in the region were more than half forested, and only slightly more than one in three had any structures at all.

Over twenty-two percent of the cells had cultivated land.

Development in 1958 was not uniformly distributed throughout the region. Urban development tended to occur along major transportation arteries, and these, in turn, were associated with significant topographical features especially the Cimarron and the Arkansas Rivers (Figures 2 & 3). Agriculture was found in all sections of the region, but cultivated land tended to concentrate immediately adjacent to the rivers.

TABLE 8: LAND USES IN THE CENTRAL OKLAHOMA STUDY REGION, 1958

	Number of Cells with Land Use	Proportion of Cells with Land Use (N=2341)	Acreage *1 Acres	% of Total
Residential	366	15.6%	899	1.0
Commercial	33	1.4%	76	.1
Manufacturing	6	.3%	-	-
Institutional	36	1.5%	48	.1
Any Urban Use*	392	16.7%		
Highways/Parking	881	37.6%	1277	1.4
Railroads/Utilities	423	18.1%	495	.5
Extractive	346	14.8%	280	.3
Cultivated Land**	519	22.2%	6485	7.1
Pasture**	1606	68.6%	34404	37.5
Woodland*	1784	76.2%	47389	51.7
Structures	835	35.7%	-	-

Total Number of Structures = 4826
Density of Structures = 8.25 per square kilometer

* Includes cells having residential, commercial, manufacturing, or institutional land uses

** Includes cells have more than 10 percent of cell devoted to land use

1. Source: Evan Drummond, Department of Agricultural Economics, Oklahoma State University

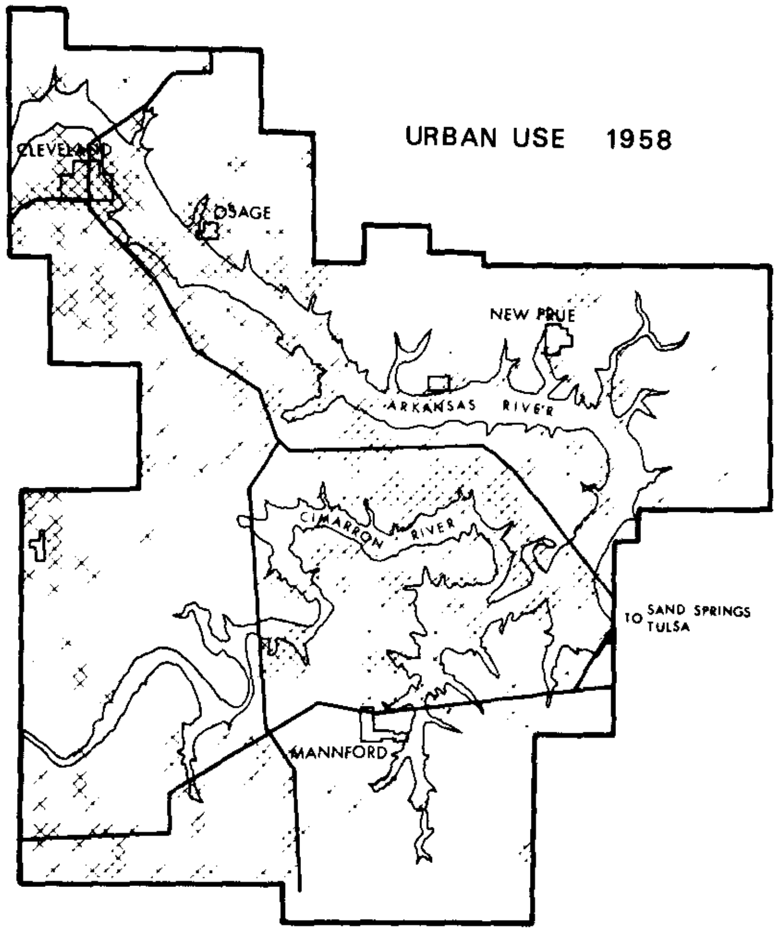

Figure 2 A

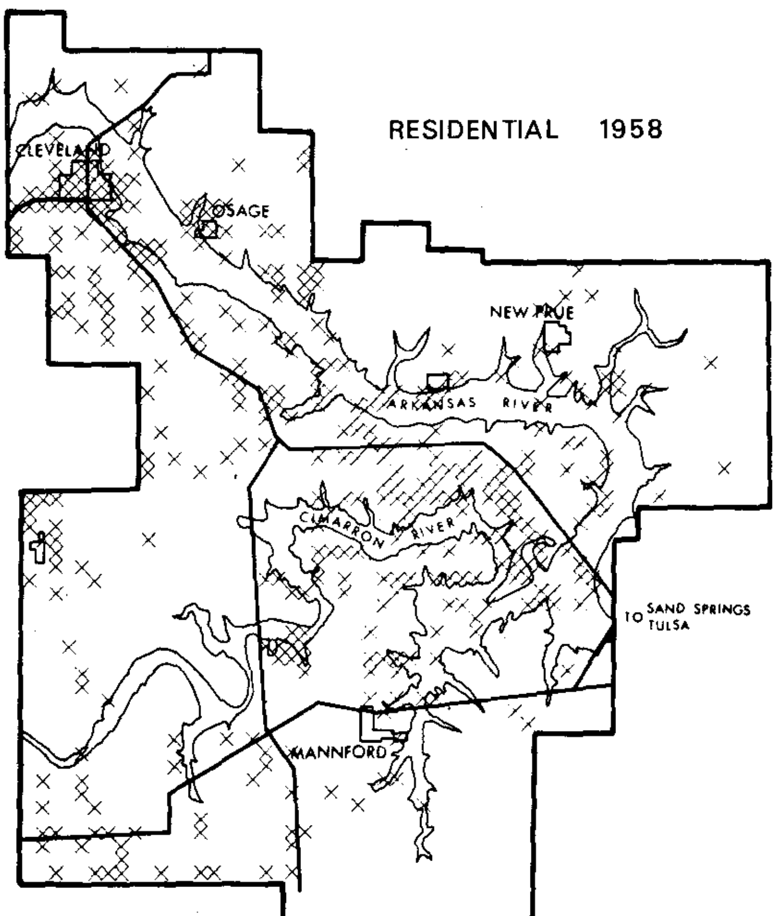

Figure 2 B

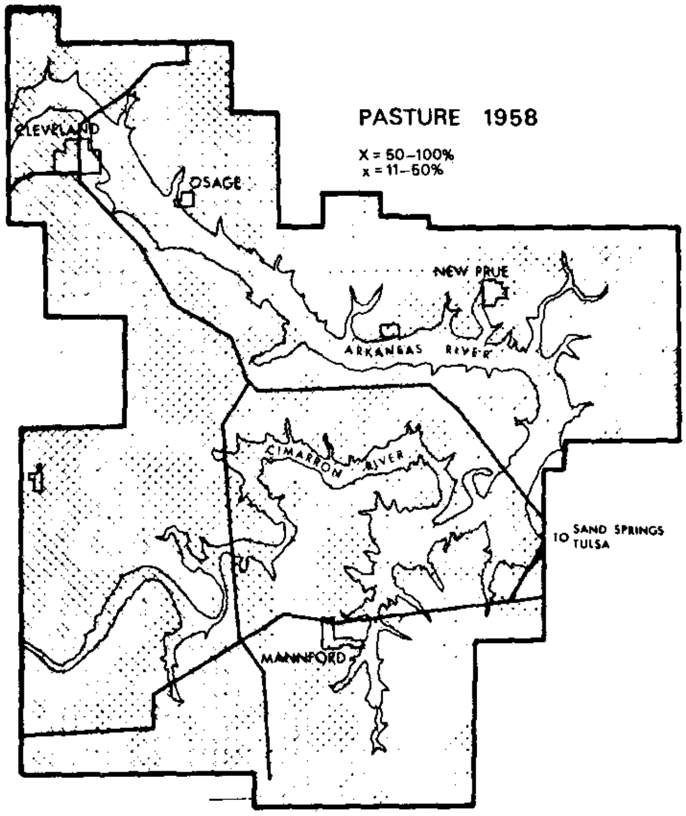

Figure 3 A

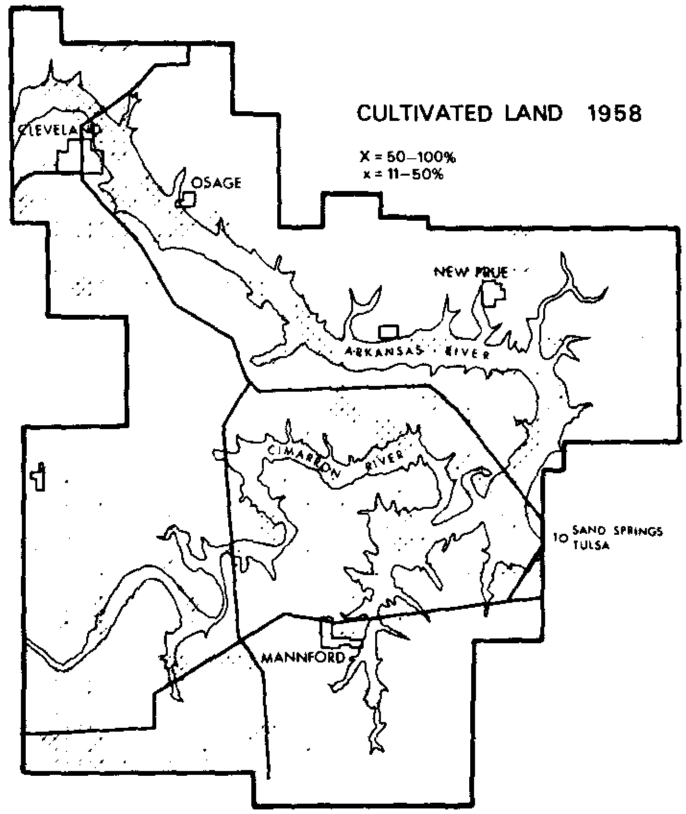

Figure 3 B

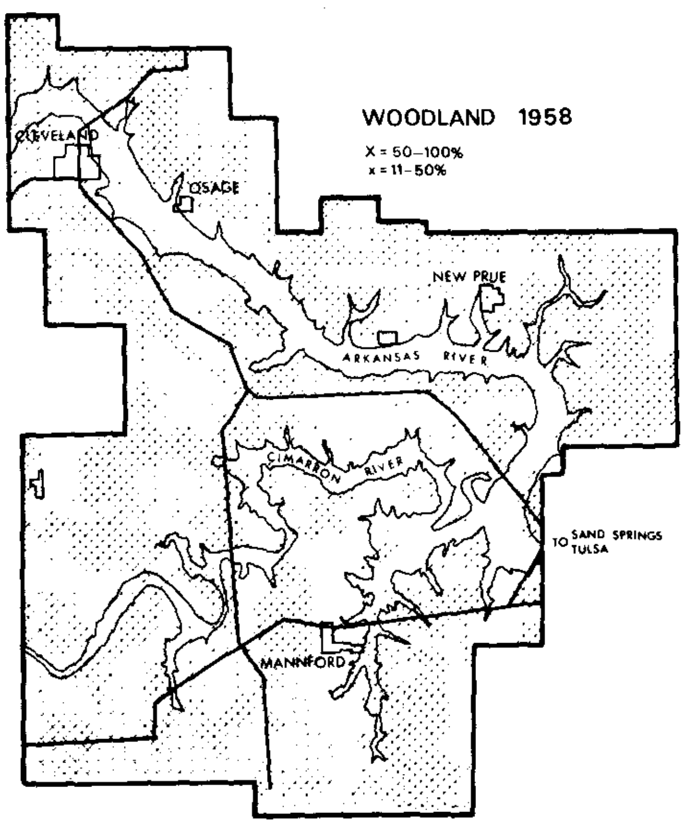

Figure 3 C

Pre-Project Land Use Characteristics by Zones

Table 9 summarizes pre-project land uses by zones. In general land use, intensity is measured by proportion of cells containing urban uses and structure density declines with distance from the reservoir until some point more than three kilometers beyond the reservoir. With increasing distance cropland falls off as does the proportion of cells devoted to railroads or utilities. Conversely, pastureland and woodland increase regularly with increases in distance.

TABLE 9: LAND USES BY ZONES, 1958

	Proportion of Cells in Zone with Land Use				
	Inundation Zone	Shoreland Zone	Intermediate Zone	Remote Zone	
Residential	18.1	16.1	13.9	15.1	
Commercial		1.6	1.4	1.0	
Manufacturing	.1	.3	.3	-	
Institutional	1.7	1.9	1.5	.3	
All Urban Uses*	18.6	18.1	14.7	16.4	
Highway/Parking	41.3	36.2	35.4	40.8	
Railway/Utility	20.2	18.0	18.0	15.1	
Extractive	10.9	12.4	16.5	12.5	
Cultivated Land**	31.4	26.1	16.5	14.1	
Pasture**	61.2	67.1	71.2	75.2	
Woodland**	68.3	76.1	79.6	80.1	
Structures	34.1	34.9	34.9	40.8	
N =	306	841	883	311	
Total Structures	620	1721	1814	650	4826
Density of Structures (per sq. kilometer)	8.18	8.24	8.21	8.36	8.24

* includes cells having residential, commercial, manufacturing, or institutional land uses

** includes cells having more than 10 percent denoted to the land use

The Construction Period, 1958-1974

Between 1958 and 1964 the Keystone Project was substantially completed. It was fully operational insofar as flood control was concerned, and its conservation pool was filled and being maintained. All land required for both the conservation and flood pools had been acquired. Nearly all resettlement of population and removal of structures in the affected areas took place during this period (Table 10).

The general land use picture in the study region changed substantially during this period (Table 11). There were notable increases in the number of cells containing urban uses in general and residential land uses in particular. On the other hand, the number of cells containing intensive agricultural uses declined substantially. There was a small loss in numbers of cells with structures and overall, nearly an 8 percent decline in numbers of structures. In absolute terms quite a number of land uses experienced little or no change.

Note that when an adjustment is made for the 306 cells which were inundated or part of the conservation pool and thereby flooded by the end of the period.[1] Those land uses which expand appear to have done even better in view of the declining area available to them. Similarly, land uses which were essentially stable in terms of the number of cells in which they were contained, actually appear to increase <u>in proportion to</u> the total available land. While those land uses which declined more nearly held their own, or even increased, if consideration is given to the reduced amount of available land.

There were both gainers and losers in all categories of land uses (Table 11). While there was a net gain of 91 cells with urban uses during the period, there were 281 cells which did not have any urban use in 1958 but did by 1964, and there were 190 cells which had urban uses but lost them during the same period. While nearly one in five cells lost their cultivated land during the period, over three percent of all cells gained some cultivated land. It is also of interest that while there was little <u>net</u> change in highway and related land uses or railroads/ utilities, in over one of four cells changes <u>did</u> occur with losers approximately equaling gainers.

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1. There were another 524 cells which were partially flooded, or flooded at certain times, but which contained other land uses.

TABLE 10: LAND USE AND LAND USE CHANGE PATTERNS, THE STUDY REGION, 1958-1964

	Proportion of Total Cells in the study area			Preparation of Cells in Study area excluding Inundation Zone	
	1958	1964	Net Change	1964	Net Change
Residential	15.6	19.2	+3.6	22.1	+6.5
Commercial	1.4	2.1	.7	2.4	+1.0
Manufacturing	.3	.7	.4	.8	.5
Institutional	1.5	1.3	-.2	1.5	+ .2
Any Urban Use *	16.7	20.6	+3.9	23.7	+7.0
Highway/ Parking	37.6	37.2	- .4	42.8	+5.2
Railroad/ Utility	18.1	18.8	+ .7	21.6	+3.5
Extractive	14.9	14.8	- .1	17.0	2.1
Cultivated**	22.2	6.2	-16.0	7.1	-15.1
Pasture**	68.6	58.1	-10.5	66.8	+ .2
Woodland**	76.2	73.7	- 2.5	84.8	8.6
Structures	35.7	34.4	- .7	39.7	4.0
N =	2341	2341		2035	
Total Structures	4826	4433	-393	4433	
Structure Density	8.25	7.57	- .68	8.71	+ .46

* consent of cells which contain residential, commercial, manufacturing or institutional land uses

** consents of cells in which more than 10% of area is devoted to land use

TABLE 11: SELECTED LAND USE CHANGE PATTERNS, THE STUDY REGION, 1958-1964

	Proportion of Cells N = 2341[a]			
	Net Change	Gainers	Losers	No Change
Residential	+3.6	11.4	7.9	80.7
All Urban Uses	+3.9	12.0	8.1	80.0
Highway/Parking	- .4	13.5	13.9	72.6
Cultivated	-16.0	3.1	18.9	78.1
Pasture	-10.5	10.6	21.1	68.3
Woodland	- 2.5	7.6	10.1	82.3
Structures	- .7	12.5	13.8	73.7

a -based on total cells including those which are flooded

The basic patterns of land uses in 1964 are similar to those which appeared in 1958 (Figure 4). However, close inspection reveals some important differences. A large part of the land use change appears to be closely related to the trauma of reservoir development during the period, as evidenced by the prevalence of change in those regions adjacent to the reservoir (Figures 5 & 6). It is important to note however, that many of the cells having no urban land use in either period, hence no change, were also located in the reservoir development area as well as in other parts of the study area (Figure 7a). Similarly, those cells which contained urban land in both periods are found generally, but not exclusively, adjacent to the reservoir (Figure 7b).

Land Use Changes by Zone during the Construction Period, 1958 - 1964

The most expected feature of the zonal land use picture by 1964 is the absence of land uses in the Inundation Zone (Table 12). Due to the relocation or elimination of pre-existing land uses (Table 13) and subsequent flooding. Instability was greatest throughout the shoreland zone and declined fairly consistently at greater distance from the reservoir (Tables 14 & 15). Net change in proportion of cells containing the various land uses was most pronounced in the Inundation Zone (Table 16). Beyond that the pattern is less regular. Urban uses experienced greater net gains in Intermediate and Remote zones than in

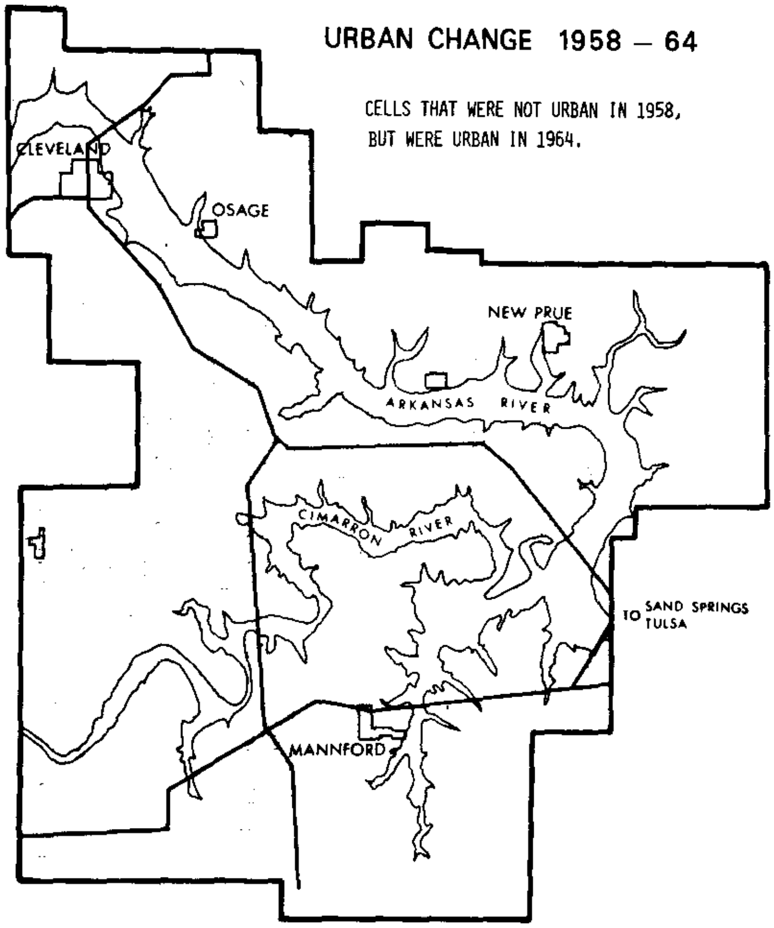


Figure 4 A

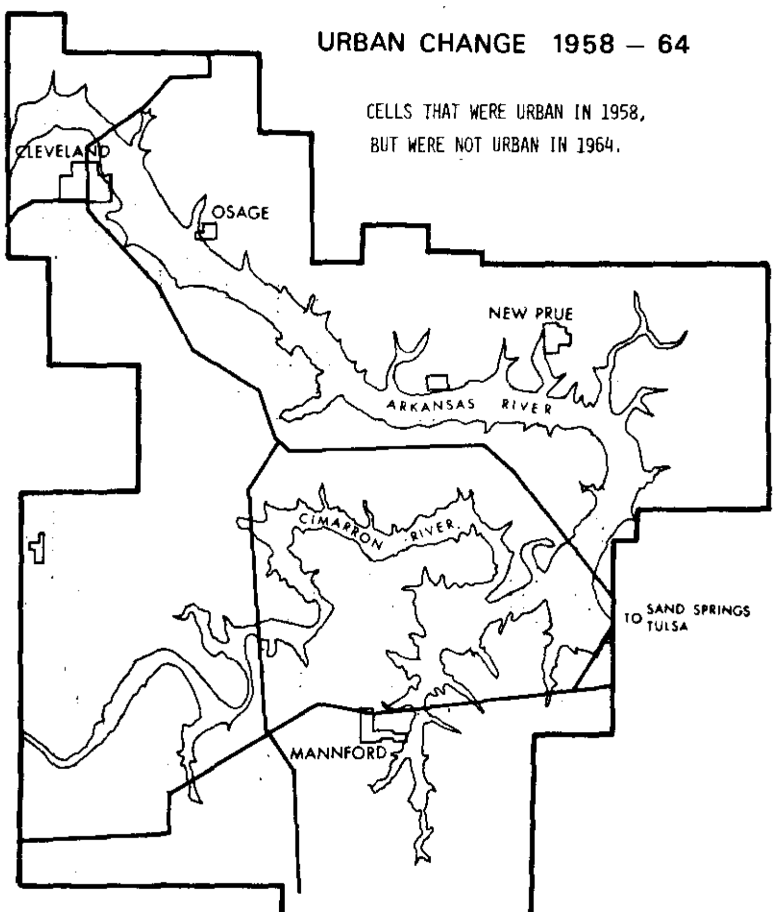
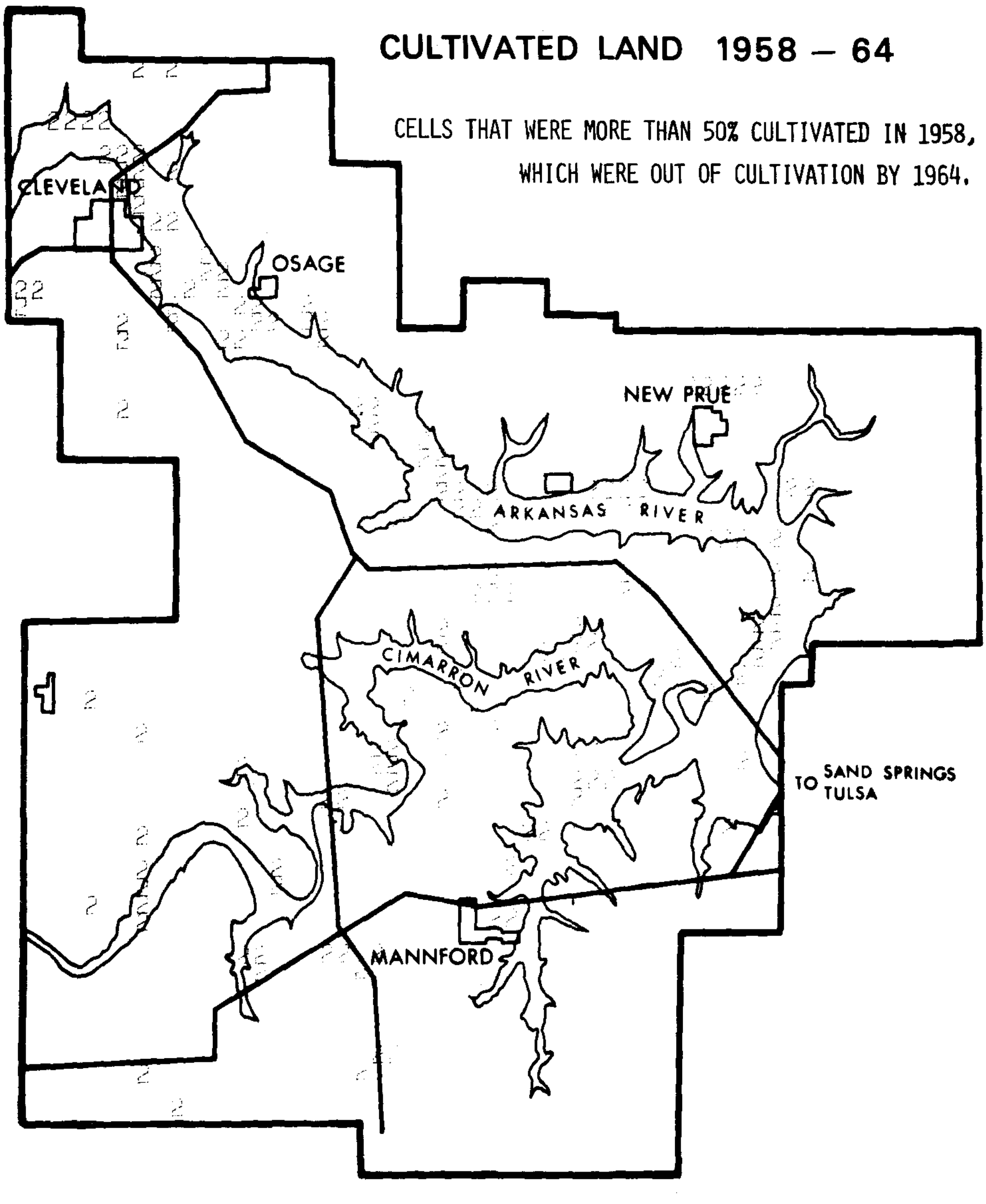


Figure 4 B

Figure 5


CULTIVATED LAND 1958 – 64
CELLS THAT WERE MORE THAN 50% CULTIVATED IN 1958, WHICH WERE OUT OF CULTIVATION BY 1964.
CLEVELAND
OSAGE
NEW PRUE
ARKANSAS RIVER
CIMARRON RIVER
TO SAND SPRINGS TULSA
MANNFORD

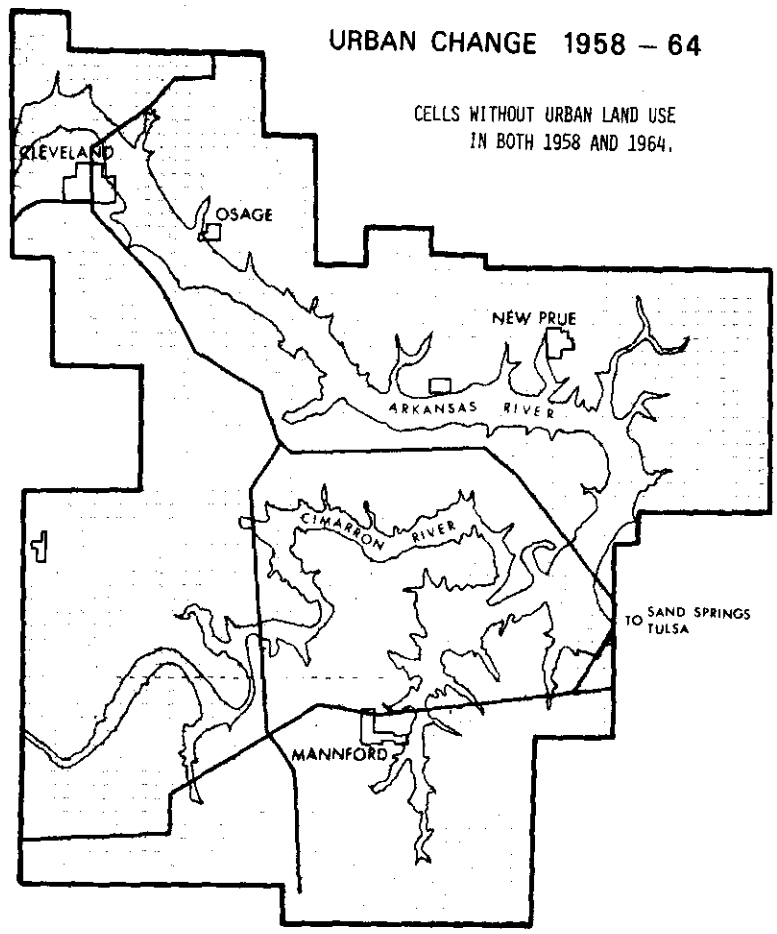


Figure 6 A

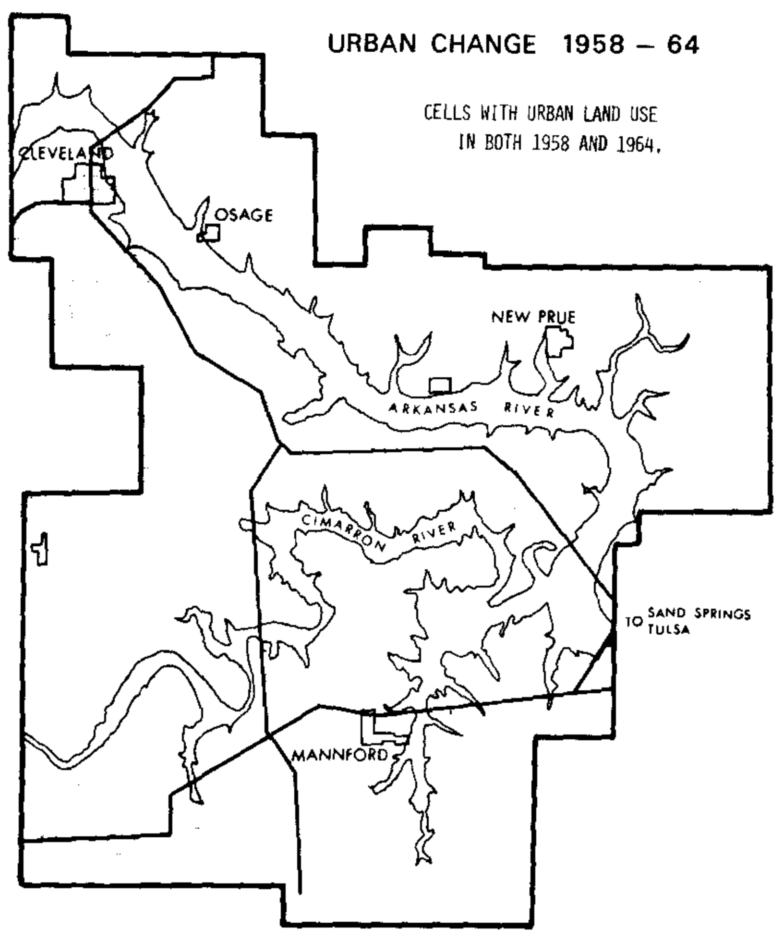


Figure 6 B

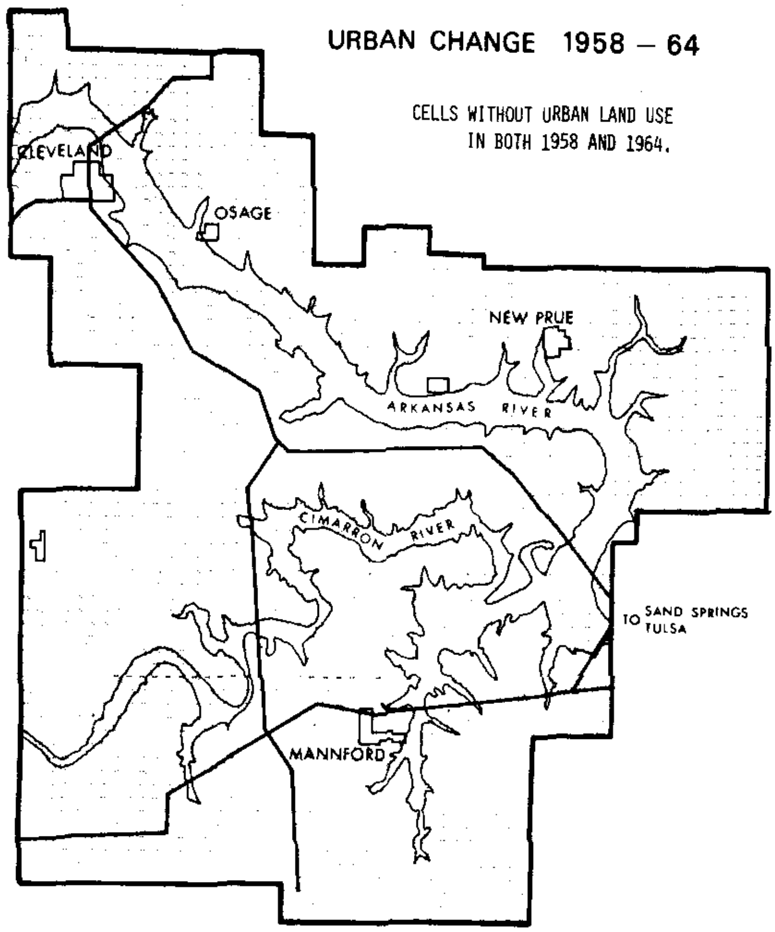


Figure 6 A

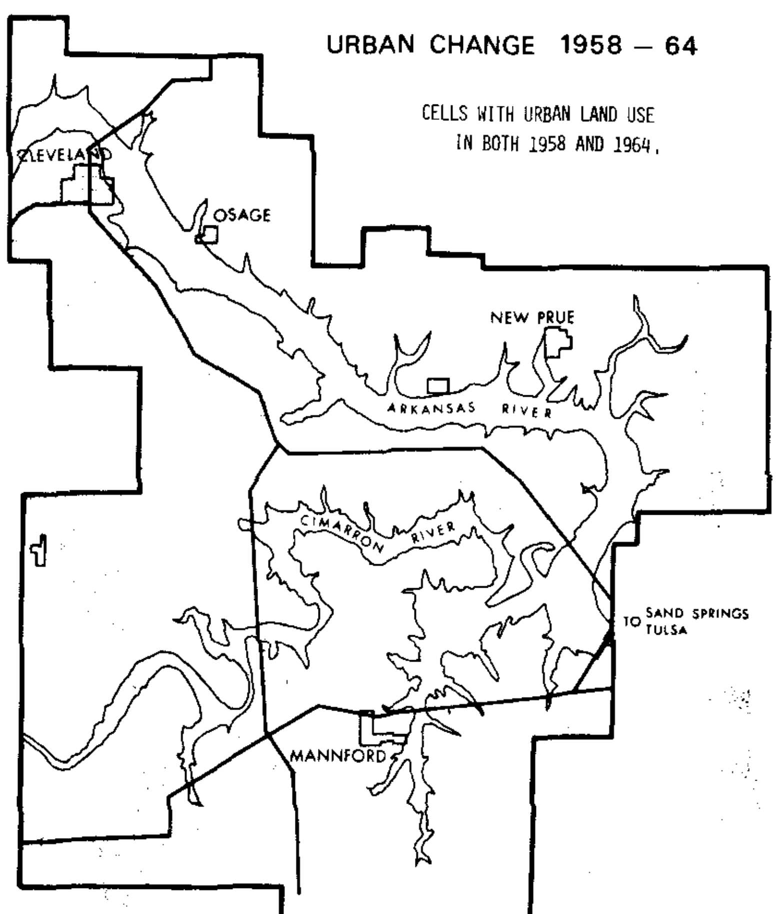


Figure 6 B

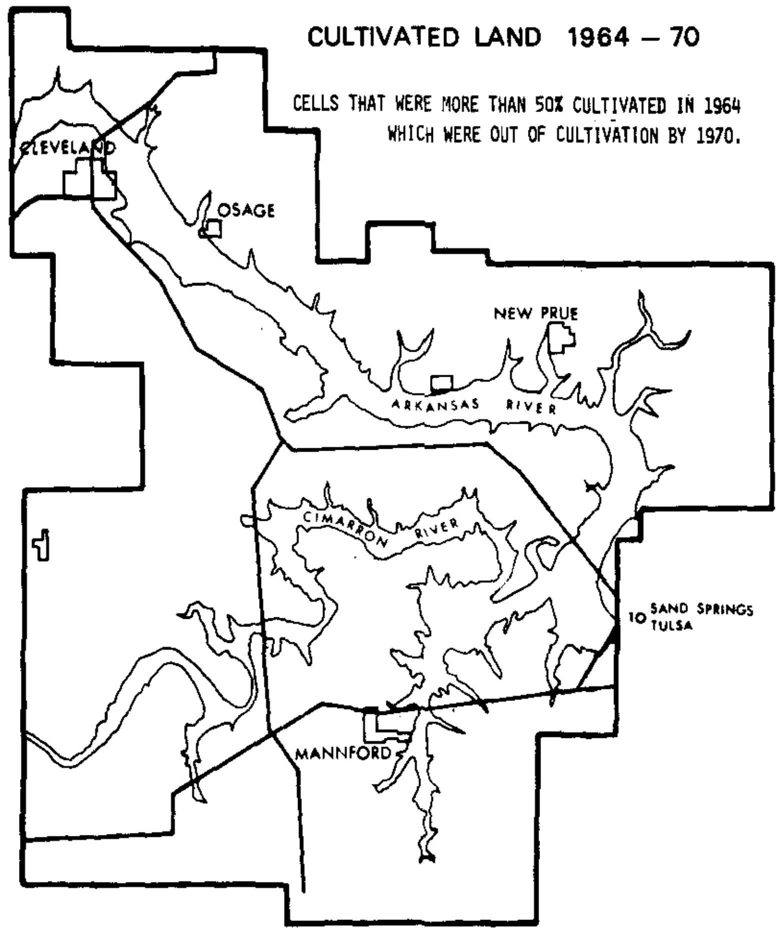


Figure 7 A

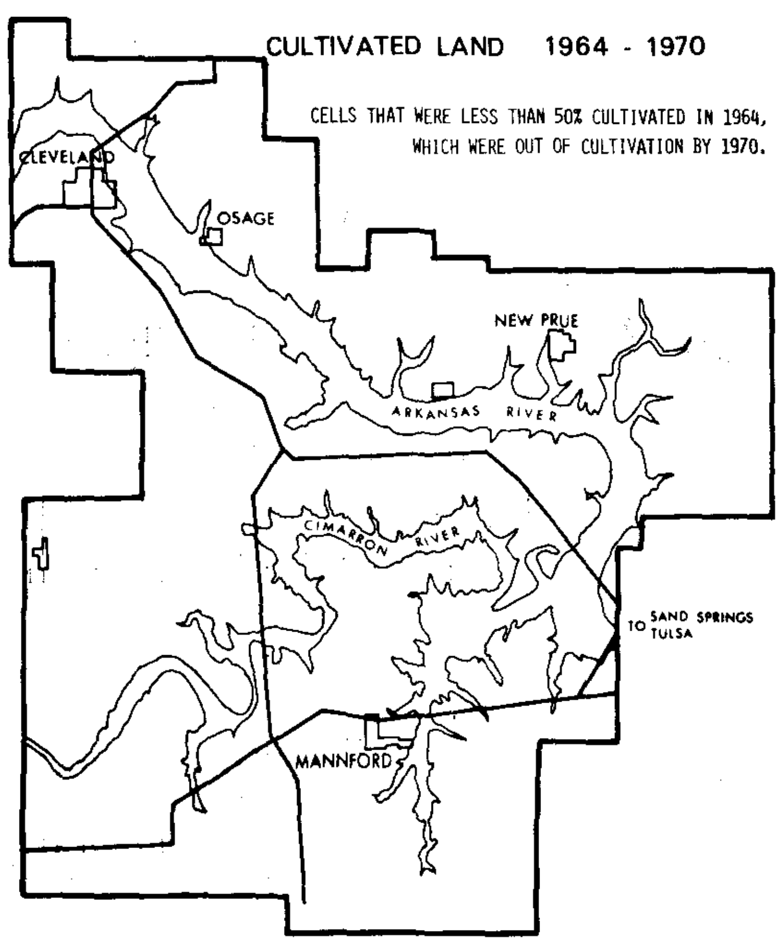


Figure 7 B

the Shoreland Zone. Instability with respect to transportation development decreased with increasing distance, and beyond the inundation zone net gains in these land uses were also smaller. Rural uses were generally more stable and registered smaller declines in the Intermediate and Remote Zones. Table 17 summarizes Land Use Changes by zone.

TABLE 12: LAND USES BY ZONES, 1964

	Percentage of Total Cells in Zone Having Land Use			
	Inundation Zones	Shoreland Zones	Intermediate Zones	Remote Zones
Residential	0	20.3	23.3	23.2
Commercial	0	1.6	3.1	2.9
Manufacturing	0	.3	1.4	.3
Institutional	0	1.5	1.8	.3
Urban Use	0	22.0	24.8	25.1
Highway/Parking	.9	46.8	40.9	41.1
Railroads/Utilities	0	17.6	24.6	23.8
Exactive	0	15.5	16.0	12.0
Cultivated Land	0	5.5	8.3	8.7
Pasture	0	64.8	67.5	69.8
Woodland	0	87.7	84.7	77.5
Structures	0	38.2	38.6	46.3
Total Structures	43.0	1355.0	2308.0	770.0
Structure Density per sq. km.	.56	6.44	10.46	9.9
N =	306.0	841.0	883.0	311.0

TABLE 13: U.S. ARMY CORPS OF ENGINEERS PRE-PROJECT ESTIMATES OF LAND USES AND RELOCATIONS

Land Uses to be Eliminated:	
Cultivated Area in Reservoir Area	20,000 acres
(average land value of cultivated acreage = $60 per acre)	
Oil wells	188
People and Facilities to be Relocated:*	
Farm Families in Reservoir Area	190
Population of Towns to be relocated:	
Keystone	406
Prue	110
Osage	628
Cleveland (part)	100
Other Relocation Required	
Graves - 150 -200	
miles of road 55	
miles of railroad 31	
miles of pipe lines and other utilities	169

* Note that because of the date they were made, it seems likely that figures for relocations were underestimates.

Source: U.S. Congress, 81st, 1st Session, Senate Document 107, Arkansas River and Tributaries, Washington, U.S. Government Printing Office, 1949.

TABLE 14: NUMBER OF CELLS WHICH WERE GAINERS VERSUS LOSERS BY LAND USE AND BY ZONE, 1958-1964

	Inundation Zone		Shoreland Zone		Intermediate Zone		Remote Zone	
	Gainers	Losers	Gainers	Losers	Gainers	Losers	Gainers	Losers
Residential		55	108	80	117	35	21	15
Any Urban Use		57	111	81	126	37	24	15
Highway/Parking		126	166	88	128	78	32	22
Cultivated land		96	28	211	28	101	15	35
Structures		104	136	108	118	85	37	21

TABLE 15: PROPORTION OF CELLS WHICH NEITHER GAINED NOR LOST KEY LAND USES, BY ZONES, 1958 to 1964

	Inundation Zone	Shoreland Zone	Intermediate Zone	Remote Zone
Residential	0	68.7	82.6	89.1
Any Urban Use	0	68.2	81.5	87.5
Highway/Parking	0	60.8	76.6	82.7
Cultivated Land	0	60.9	85.4	84.0
Structures	0	59.2	77.7	82.0
N =	306	841	883	311

TABLE 16: NET CHANGES IN PROPORTION OF CELLS WITH SELECTED LAND USES, BY ZONES, 1958 to 1964

	Inundation Zone	Shoreland Zone	Intermediate Zone	Remote Zone
Residential	-18.1	+3.2	+9.4	+8.1
Any Urban Use	-18.6	+3.6	+10.1	+8.7
Highway/Parking	-41.3	+8.4	+5.5	+ .3
Cultivated Land	-31.4	-22.9	-8.5	-8.7
Cells with Structures	-34.1	+5.8	+3.7	+5.5
N =	306	841	883	311
Structure Density (per square kilometer)	-8.18	-1.8	+2.25	+1.54

The Post-Construction Period, 1964 to 1970

During the period 1964 to 1970 the landscape of the study region continued to become more urbanized, and intensive agricultural land uses continued to decline (Table 18). Many shifts can be observed near the reservoir area during this period (Figures 8 and 9). However, with the exception of the occurence of residential, commercial, highway, extrative and structures, the net changes were less than a three-quarters of a percent.

In fact the period was one of considerably greater stability in gross land use patterns with a much smaller number of gainers and losers, with eight out of ten cells experiencing no changes in land uses (Table 19). On the other hand, it appears that land use intensity did increase substantially. Whereas in the earlier period there was a net decline of structures, in the 1964-70 period the total number of structures for the study region had grown by more than 1500 (a 34 percent increase over 1964 (Table 20). Moreover, almost forty percent of the cells counted some change in the number of structures and fifty cells had increases of ten or more structures, bringing the density to more than two and one-half structures per cell. Much of this intensification appears to be associated with the reservoir development (Figure 10).

These findings are consistent with other data available for the region. Thus there were net reductions in the harvested cropland for Pawnee and Creek counties, and net gains in Tulsa and Osage. The population of

Figure 8

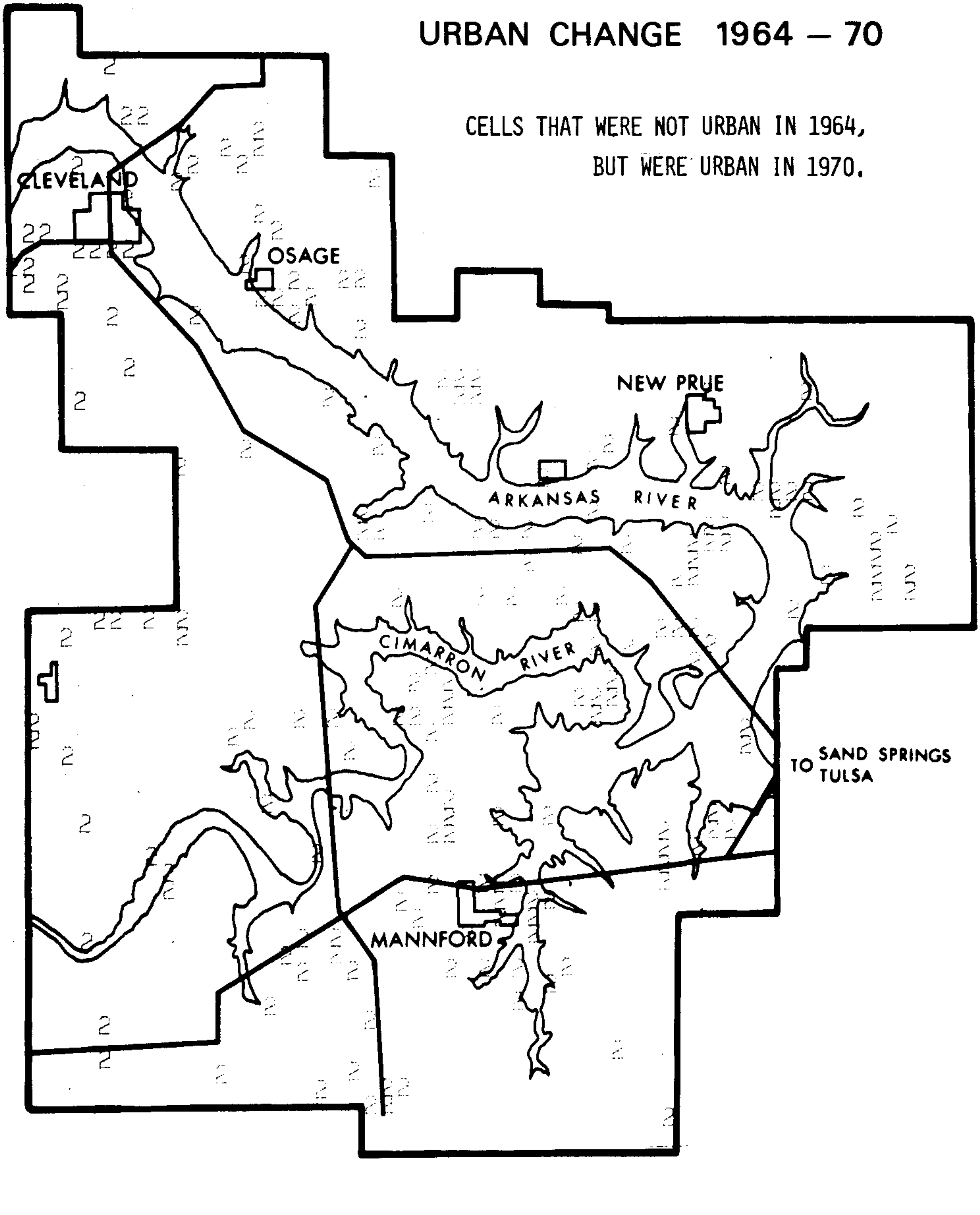

URBAN CHANGE 1964 – 70
CELLS THAT WERE NOT URBAN IN 1964, BUT WERE URBAN IN 1970.
CLEVELAND
OSAGE
NEW PRUE
ARKANSAS RIVER
CIMARRON RIVER
MANNFORD
TO SAND SPRINGS TULSA

Figure 9

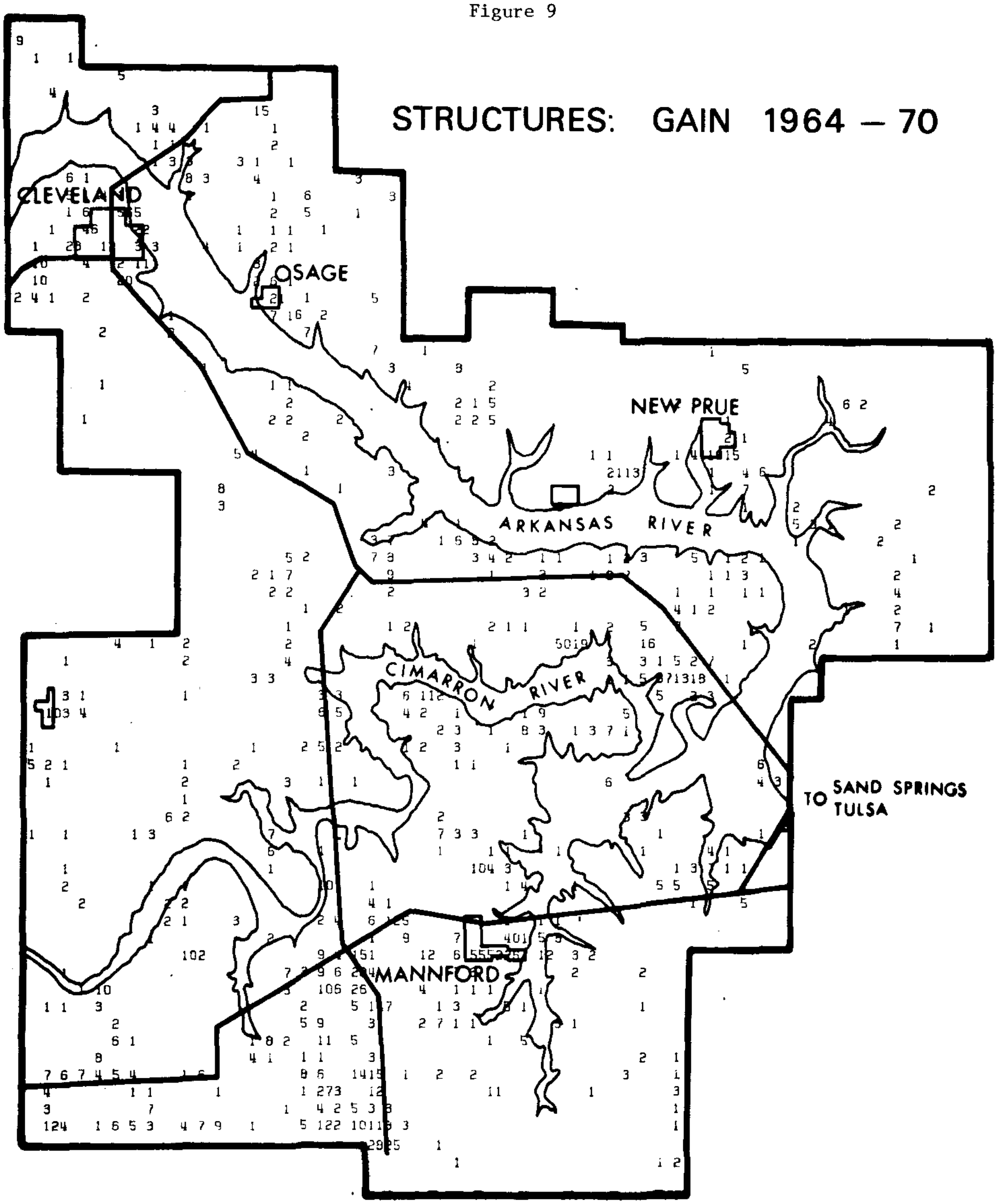

STRUCTURES: GAIN 1964 – 70
CLEVELAND
OSAGE
NEW PRUE
ARKANSAS RIVER
CIMARRON RIVER
TO SAND SPRINGS TULSA
MANNFORD

TABLE 17: SUMMARY OF LAND USE CHANGES NEAR KEYSTONE RESERVOIR, BY ZONES, 1958 to 1964

Inundation Zone

- All former existing land uses were eliminated or relocated to other regions
- Highways, railroads, most residences and other urban-type uses, as well as many structures were relocated to other zones
- No development took place in this zone

Shoreland Zone

- The area exhibited a high degree of instability with respect to all land uses
- Gainers outnumbered losers for residential land uses, but other urban uses were stable
- Cultivated land in particular, and other rural land uses to a smaller extent was lost
- A large proportion of cells exhibited changes in transportation and utilities, but gainers approximately equalled losers
- There was a gain of cells with structures, but there was a substantial loss of total number of structures

Intermediate Zone

- Greater stability was exhibited in land use structure (for most land uses three out of four cells showed no change), though there were losers and gainers in all land use categories
- There were large net gains in cells with residential land uses, and net gains in cells with other urban uses, including commercial, transportation and utilities
- There were net losses in cells with cultivation and pasture, but gains in woodland
- There was a large gain in total structures accompanied by a small gain in cells with structures

Remote Zone

- This zone showed a great deal of stability, with some land use changes affecting as few as 10 percent of cells
- Gainers and losers in all categories, but gainers outnumber in all urban land uses especially residential, transportation and utilities categories
- Rural land uses experienced declines
- Total structures increased by 18 percent and the number of cells with structures increased to a small extent

most communities in the region grew and the region became more established as a source of labor for the city of Tulsa.

TABLE 18: LAND USE AND LAND USE CHANGE PATTERNS, THE STUDY REGION, 1964 to 1970

	Proportion of Cells in the study area			Proportion of Cells in study area excluding inundation zone		
	1964	1970	Net Change	1964	1970	Net Change
Residential	19.2	22.5	+3.3	22.1	25.9	3.8
Commercial	2.1	3.2	+1.1	2.4	3.7	1.3
Manufacturing	.7	.5	- .2	.8	.6	- .2
Institutional	1.3	1.3	NC	1.5	1.5	NC
Any Urban Use	20.6	24.0	+3.4	23.7	27.6	3.9
Highway/Parking	37.2	38.2	+1.0	42.8	43.9	1.1
Railroad/Utility	18.8	18.9	+ .1	21.6	21.7	.1
Extractive	14.8	16.2	+1.4	17.0	18.6	1.6
Cultivated Land	6.2	5.9	- .3	7.1	6.8	- .3
Pasture	58.1	57.4	- .7	66.8	66.0	- .8
Woodland	73.7	73.5	- .2	84.8	84.5	- .3
Cells with Structures	34.4	35.7	+2.3	39.7	42.2	+2.5
N =	2341	2341	-	2035	2035	-
Total Structures	4433	5952	+1519	4433	5952	+1519
Structure Density per sq. kilometer	7.57	10.2	+2.7	8.7	11.7	+3.0

TABLE 19: SELECTED LAND USE CHANGE PATTERNS, THE STUDY REGION, 1964 to 1970

	Gainers	Losers	Percentage with no change
Residential	173	96	88.5
Any Urban Use	185	101	87.8
Highway/Parking	159	138	87.3
Cultivated	77	82	93.2

TABLE 20: STRUCTURAL CHANGE, THE STUDY REGION, 1964 to 1970

Net Change in Structures +1519

Percent Change 34.3%

Net Change in percentage of Cells with Structures 2.3

Percentage of Cells with change in total structures of ten or more 2.1%

percentage of Cells with no change in number of structures 62.1%

Land Use Changes by Zone in the Post Construction Period

By 1970 there are relatively fewer differences in the urban land use patterns in the three zones (Table 21), but there is a noticeably higher occurence of commercial use in the zones nearest the reservoir. Extractive and agricultural pursuits appear to intensify with increasing distance from the reservoir. The proportion of cells with structures grows as one moves from the reservoir, but intensity of development as measured by structure density is higher in the Intermediate zone.

These patterns result from substantial shifts since 1964. With respect to land use occurence, the zones nearer the reservoir are more volatile, especially in terms of growth. Conversely, there are fewer stable cells except in the case of cultivated land which showed decreases near the reservoir and increases in the outer zones (Table 22).

Insofar as structures are concerned, there was a consistent spread of development in the zones nearest the reservoir (Table 23). It is of special interest that the greatest changes in cell density occurred in the zones away from the reservoir, and it appears that growth in large concentrations of structures was particularly heavy in the zone which was farthest from the reservoir. Land use changes by zones are summarized in Table 24.

TABLE 21: LAND USE PATTERNS, BY ZONES, 1970

	Shoreland Zone	Intermediate Zone	Remote Zone
Residential	26.0	25.0	25.1
Commercial	3.8	4.5	1.0
Manufacturing	.4	.8	.3
Institutional	1.3	.1	.3
Urban Use*	27.6	27.2	26.6
Highway and Parking	45.5	42.9	40.1
Railroad and Utilities	17.0	24.5	24.9
Extractive	17.0	24.5	24.9
Cultivation**	3.7	8.5	10.6
Pasture**	59.0	68.7	70.7
Woodland**	81.0	85.1	80.4
Cells with Structures	40.3	41.6	46.2
N =	841	883	311
Total Structures	1818	3247	887
% of Cells with more than 10 Structures	5.0	8.7	10.6
Density of Structures (per sq. kilometer)	9.1	14.7	11.4

Urban Use - includes any cell with residential, commercial, manufacturing, or institutional land uses

** includes cells with more than ten percent of land in that use

TABLE 22: LAND USE CHANGE CHARACTERISTICS, SELECTED LAND USES BY ZONE, 1964 to 1970

	Net Change			Gainers			Losers			No Change		
	Shore-land	Interme-diate	Remote	Shore-land	Interme-diate	Remote	Shore-land	Interme-diate	Remote	Shore-land	Interme-diate	Remote
Urban Use	+6.5	+3.5	+1.1	11.1	7.0	7.7	4.6	4.8	6.8	84.3	88.0	82.2
Highway/Parking	+ .4	+1.9	+ .9	9.3	6.3	8.0	8.9	4.4	7.1	81.8	89.3	84.9
Cultivated Land	-1.6	+ .2	+1.9	2.2	4.1	7.4	3.8	3.9	5.5	94.0	92.0	87.1

TABLE 23: SELECTED CHARACTERISTICS OF CHANGE IN STRUCTURES BY ZONES, 1964 to 1970

	Shoreland Zone	Intermediate Zone	Remote Zone
Net Change in Proportion of Cells with Structures	+5.6	+2.9	-1.9
Net Change in Structures	+463	+939	+117
Proportion of Cells with considerable change (more than 10 structures)	1.8	2.2	4.2
Net Change in density of cells (per sq. km.)	+2.3	+3.8	1.5

TABLE 24: SUMMARY OF LAND USE CHANGES BY ZONE, POST-CONSTRUCTION PERIOD, 1964 to 1970

Inundation Zone

- No changes in this region

Shoreland Zone

- Stability in terms proportion of cells exhibiting changes is high relative to previous period, somewhat lower relative to other zones
- Gainers outnumber losers in terms of urban uses in general, and residential, commercial in particular
- Transportation land uses much more stable than others; once again gainers approximately equal losers
- Rural land uses decline, but by small amount
- A large increase in cells with structures relative to other zones; however the proportion of cells with large increases in structures is low; there is a 34 percent increase in total structures in this zone

Intermediate Zone

- Stability in gross land use patterns is higher relative to other time period
- Cells gaining residential and commercial uses outnumber those losing, but the proportion of cells involved is small relative to other zones
- Transportation shows small net gains
- There are small gains in all rural uses
- Gains in cells with structures are small, but there are large increases in total number of structures

Remote Zone

- Stability in gross land use patterns is high, but not as high as in the Intermediate zone
- There are small gains in residential land uses, and a very large jump in cells with extractive activities
- Rural land uses showed general increases
- There was little change in the number of cells with structures, and a small gain in structures and structure density relative to other zones; it appears that most of the increases in structures came in a relatively few cells

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The Tulsa Effect

As noted previously, during the period from 1958 to 1970, Tulsa experienced substantial population growth, and that by 1970 its commuting region had grown to include much of the study area. As a result of these changes, it is reasonable to suspect some relationship between Tulsa and the land use changes which took place around Keystone Reservoir.

There were important differences in pre-project land uses in different distance zones with respect to Tulsa (Table 25). However, the patterns are not easily explained in terms of distance from that city. With respect to urbanization, relatively less development occurs in the zone closest to Tulsa. Nor is there a consistent relationship between Tulsa and the other land uses or the measure of total structure or structure density. 1970 patterns show somewhat greater regularities (Table 26). Extractive, cultivated areas and pasture regularly decrease with increasing distance from the urban center, but the proportion of cells with urban uses remains highest in the zone between twenty-five and thirty kilometers from Tulsa. Furthermore, the intensity of development appears to be greatest in the zones farther away from Tulsa.

Gross stability patterns (the proportion of cells which did not acquire or lose a specific land use) are highly variable by distance zone but show few regularities that are understandable in terms of proximity to Tulsa (Table 27). Thus there appears to be a somewhat greater construction period stability with respect to urban uses in the zones. But in the post construction period there are no significant differences among the zones. In general, zone three appears to show somewhat less overall stability than other zones. Similar observations can be made with respect to net land use change (Table 28).

With respect to its significance in the various reservoir impact zones, distance from Tulsa does not appear to be a controlling factor. Indeed, the patterns described previously seem closely related to the proportion of each Tulsa proximity zone within the two most active zones relative to reservoir change, the Inundation Zone and the Shoreland Zone (Table 29). If land use changes are examined with respect to both proximity to Tulsa and the reservoir, some important conclusions can be drawn (Table 30). In the zones closer to Tulsa, urban and structure gains in the shoreland and intermediate zones are especially high. However in Remote zone there is considerably greater volatility in terms of structure change and urban development than in the zones farther from Tulsa. This suggests that while distance from the reservoir is more important to understanding land use change in the region, distance from Tulsa has some influence as well.

TABLE 25: DISTANCE FROM TULSA AND THE OCCURANCE OF LAND USES, 1958

	Proportion of Cells in Zone with Land Use				
	Less than 20 km	20-25 km	25.5 to 30 km	30.5 to 35 km	Over 35 km
Residential	11.5	16.4	15.5	11.4	21.9
Commercial	.9	1.0	1.1	.06	3.3
Manufacturing	.4	-	.5	-	.4
Institutional	1.7	1.4	1.6	1.3	1.8
Any Urban Use	12.4	17.6	16.6	12.7	22.8
Highway/Parking	32.9	33.6	35.8	37.8	46.7
Railroad/Utility	32.5	18.2	14.1	12.7	21.9
Extractive	6.9	11.5	14.5	16.8	19.9
Cultivated Land**	19.8	22.3	25.2	18.2	22.2
Pasture**	50.8	66.6	70.3	75.5	70.1
Woodland**	79.0	77.9	76.1	79.2	70.1
Structures	21.4	28.9	36.5	37.2	47.2
N =	238	494	548	543	508
Total Structures	282	616	1975	902	1951
Density of Structures (per sq. km.)	4.55	4.98	7.85	6.64	15.4

* includes cells with residential, commercial, manufacturing, or institutional

** includes cells having more than ten percent of the land use

TABLE 26: DISTANCE FROM TULSA AND THE OCCURANCE OF LAND USES, 1970

	Proportion of Land Use by Distance from Tulsa				
	Less than 20 km	20 to 25 km	25.5 to 30 km	30.5 to 35 km	Over 35 km
Residential	16.0	23.1	27.0	19.3	24.0
Commercial	1.3	4.7	5.1	.6	3.8
Manufacturing	-	.2	.5	.2	1.4
Institutional	.4	1.0	1.6	.4	2.8
Any Urban Use	16.0	25.1	29.9	19.5	25.8
Highway/Parking	40.1	34.4	42.0	36.6	39.4
Railroad/Utilities	21.1	12.6	11.9	20.3	30.7
Extractive	5.6	12.1	13.7	22.6	21.3
Cultivated Land**	-	2.8	5.5	7.9	10.4
Pasture**	12.9	49.4	61.5	66.6	72.4
Woodland	75.4	65.0	72.4	77.3	77.2
Structures with cells	22.9	32.8	38.1	39.6	42.3
Total Structures	182	455	1581	1076	2158
Density of Structures (per sq. km.)	2.94	3.68	11.54	7.93	16.99

* includes cells with residential, commercial, manufacturing, or institutional

** includes cells having more than ten percent of the land use

TABLE 27: THE TULSA EFFECT: GROSS STABILITY PATTERNS, SELECTED LAND USES BY PERIODS

Proportion of Cells in a Zone which did not Acquire or Lose a Specified Land Use

	Inundation Zone	Shoreland Zone	Intermediate Zone	Remote Zone	Total
Urban					
1958-64	82.1	82.4	73.2	78.3	83.5
1964-70	88.4	87.5	87.6	88.0	88.4
Highways					
1958-64	65.0	71.1	73.0	72.4	76.8
1964-70	84.5	82.6	92.4	88.8	88.0
Cultivation					
1958-64	68.3	72.8	65.9	76.8	69.4
1964-70	100.0	92.4	93.1	91.6	90.2
Structures					
1958-64	64.0	80.5	54.8	55.7	54.0
1964-70	79.0	64.6	59.5	60.2	56.9
N =	248	494	548	543	508

TABLE 28: THE TULSA EFFECT: NET CHANGE, SELECTED LAND USES BY PERIOD

Differences between dates in proporation to Cells with Land Uses

	Inundation Zone	Shoreland Zone	Intermediate Zone	Remote Zone	Total
Urban					
1958-64	-3.6	+ .2	+8.6	-8.8	NC
1964-70	+6.0	+7.3	+4.8	-2.0	+2.8
Highway					
1958-64	-6.5	+1.4	+6.0	-1.8	-4.8
1964-70	+14.1	- .8	-2.0	+ .8	-3.6
Cultivated					
1958-64	-19.8	-15.8	-19.3	-11.1	-15.8
1964-70	NC	- 5.6	- .3	- 1.4	+ .4
Cells with Structures					
1958-64	-2.6	- 1.6	+ .5	2.4	- 6.1
1964-70	5.2	+ 5.5	+ 1.1	NC	+ 1.2
N =	234	494	548	543	508

TABLE 29: PROPORTION OF TULSA PROXIMITY ZONES MADE UP OF INUNDATION AND SHORELAND ZONES

	< 20 km	20 to 25 km	25.5 to 30 km	30.5 to 35 km	Over 35 km
Tulsa Proximity					
Proportion of Zone in Inundation Zone	22	21	10	8	10
in Shoreland Zone	37	42	36	39	26
Total	59	53	46	47	36

TABLE 30: THE TULSA EFFECT AND DISTANCE FROM RESERVOIR: SELECTED MEASURES

Net change in proportion of cells having urban use

						Total
	8.8	12.5	2.9	2.3	9.1	+6.5
	8.3	5.1	3.2	.2	4.9	3.5
	4.9	8.3	11.6	-11.6	7.8	+ 1.1
N =						

Net change in proportion of cells having cultivated land

NC	-11.9	- .5	- .5	- .6	1.6
- .4	- 5.6	- .4	+1.9	+3.6	.2
+ .3	+ 8.3	+6.0	+6.5	-5.0	1.9

Net change in proportion of cells having structures

+8.6	5.7	- .5	-1.8	+6.8	5.6
10.0	+7.0	+1.3	-	2.7	2.9
-2.4	+16.6	+5.8	+5.1	-9.1	-1.9

Proportion of cells with no change in number of structures

	47.0	42.1	56.3	61.1	59.2	46.0
	75.0	67.1	54.6	55.6	55.3	58.6
	90.2	54.2	50.7	44.9	41.4	31.8
N =	193	389	495	502	496	

N is adjusted for loss of cells in Inundation zone

TABLE 31: THE SHORELAND ZONE: EXPECTED AND OBSERVED CHANGES

EXPECTED:

Development of land uses attracted by reservoir

Development of land uses attracted in part by reservoir

Development of land uses relocated from reservoir

Reduction in land use associated with any of above

Diversion of rural land to less intensive or vacant

Development of land uses to service new developments

Reduction of land uses to service land uses which are lost

OBSERVED:

- High degree of instability in both time period, but especially during the 1964 to 1970 period;
- Small increases in residential during 1958 to 1964; generally larger increases in urban uses, including residential and commercial during 1964 to 1970;
- Transportation land uses shifted from cell to cell throughout the period, but especially during 1958 to 1964;
- Rural land uses experienced large declines in 1958 to 1964, smaller ones, 1964 to 1970; a fairly large number of gainers, but not net gain in woodland and pasture categories;
- General increase in number of cells with structures in both periods; but large losses in total structures in 1958 to 1964 was followed by large gains in 1964 to 1970;
- General density of structure remained low throughout the period; expansion in structures was of low density type

TABLE 32: THE MARGINAL IMPACT ZONE AND THE INTERMEDIATE ZONE: EXPECTED AND OBSERVED CHANGES:

Changes Expected in the Zone of Marginal Impact

- development of land uses attracted in part by the reservoir
- development of land uses relocated from the impoundment zone
- reduction in land uses associated with development of those above
- diversion of rural land to less intensive or vacant land for speculative purposes
- development of land uses to service new developments

Changes Observed in the Intermediate Zone

- moderate stability in land use and structures in 1958 to 1964 and much greater stability in 1964 to 1970;
- in the first experienced gains in all types of urban uses; including residential, transportation, and utilities; in the second period gains were smaller;
- structural change exhibited a similar pattern; structures appear to become more heavily concentrated throughout the study period
- cultivated land decreased substantially in 1958 to 1964 but woodland had small net gains; in 1964 to 1970 all rural uses increased slightly

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TABLE 33: THE REMOTE ZONE AND THE ZONE OF NO IMPACT: EXPECTED AND OBSERVED CHANGES

Changes Expected in the Zone of No Impact

- land use changes not related to reservoir development

Changes Observed in the Remote Zone

- considerable stability experienced throughout the study period, but not as high as in Intermediate Zone in 1964 to 1970;
- urban uses gain by small amount in both periods
- extractive activities increase by a large amount in 1964 to 1970;
- relatively stable area with respect to structures; small increase in proportion of cells with structures but more increase in structures comes in a relatively few cells

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Comparison with Expected Changes

How well do the findings fit the land use changes hypothesized in Chapter 1? It seems sufficient to say that for the Inundation Zone, the expected changes were found. Because of the method used to operationally define the zone, no development took place. Reservoir oriented development such as parkland and facility construction was included in the Shoreland Zone. Other Land changes in the Shoreland Zone generally conformed with what had been anticipated. The Zone is characterized by net increases in residential development, but density remains low. There is considerable evidence of residential relocation with this region, a result of including some flood pool area. There is some diversion of rural land to less intensive uses, presumably for speculative purposes and overall rural land uses declines in the area. Development in this zone is greatest nearer to Tulsa, suggesting greater emphasis on permanant residential development within commuting range of the city.

The Intermediate Zone which corresponds generally to the Zone of Marginal Impact also recorded considerable growth, not only in residential uses, but in other urban uses as well. The large gains in urban and transportation during the construction period suggest that the zone was the recipient of much of the land uses which were relocated from the Inundation and Shoreland Zone. However, it seems likely that at least some of this urbanization is associated with residential movement into the area by Tulsa commuters accompanied by the services required for such development. Reduction in cropland is in part a result of conversion to urban uses or to speculative holdings, but there are likely persistent local and national trends at work here. The woodland increases are most probably the result of pasture land abandonment.

It is difficult to confirm that the hypothesized "Zone of No Impact" corresponds with the "Remote Zone" designated in this study. This zone exhibited relatively high stability throughout the study period. Urban change took place but changes were small. There were small increases in the proportion of cells with structures, but most increases in structure were concentrated in relatively few cells.

CHAPTER 3

LAND DEVELOPMENT IN A RESERVOIR AREA: THE POLICY ENVIRONMENT

While it is clear that reservoir development has had considerable impacts on general land use patterns, it is equally obvious that other factors are also involved in determining the specific arrangement of land uses in a given area.

In order to focus on some of these other factors it was determined to conduct a detailed review of the locational characteristics of residential development relative to selected variables effecting land use change. In particular, specific attention was given to those elements, which taken together, are referred to as the "policy environment". As mentioned previously, these include availability of vacant land, drinking water, utilities, financing, access, sewage disposal, fire, police and educational services and the existence of local subdivision regulations.

The focus on residential land uses is appropriate because residential change is one of the most important ingredients of land use change in connection with reservoir development.

METHODOLOGY

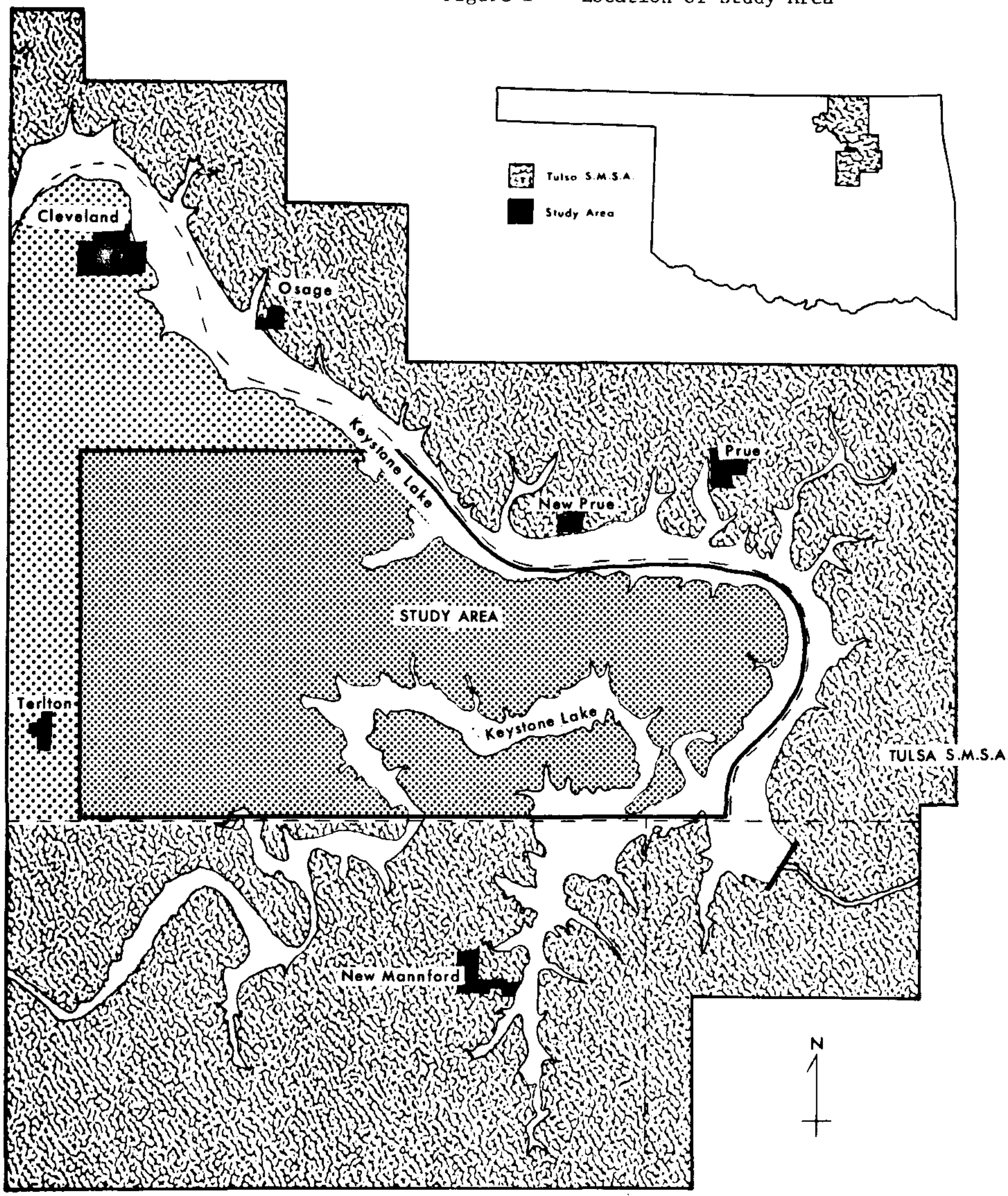
The Study Area

The study area is depicted in Figure 1. The area was chosen primarily for its shoreline wealth, lack of any urban centers, and its location entirely within one county. Data collection was facilitated by working within one county. The northern boundary was based on the northernmost extent of the Pawnee Rural Water District No. 1 (RWD#1). The western boundary was arbitrarily drawn in order to exclude the small town of Terlton from the study. The remaining boundaries are those of Pawnee County, Oklahoma. This study area is under the maximum influence of the reservoir, as indicated by shoreline, and contained only a small pre-reservoir population, thus providing a useful laboratory for examining the relationship between the policy environment, residential development, and reservoir development.

Data Collection

The location of residential developments was obtained by inspecting the records of the Pawnee County Clerk's office. Plats were the filing instrument examined for such information. Since plats are considered as indicating intent to develop. Platted developments were equated with being residential developments; legally, such is the case (Kratovil, 1968; Ring, *et. al.*, 1967)

Figure 1   Location of Study Area



Potential developments were sections which experienced a frequency of land turnover during the past year equalling or greater than one standard deviation from the mean frequency of land turnover within the study area from 1974-75, the past year. The use of this measure is based on two concepts. One is that property turnover is an indicator of interest (American Institute of Real Estate Appraisers, 1967). The other is that just prior to platting there is an intensification of selling and reselling in order to consolidate the land ownership (Wolfe, 1967). An example of what Wolfe (1967) described was observed to have occurred in the study area. In 1973, Northwest Properties was responsible for the acquisition of land which resulted in a frequency of land turnover, in that section, equalling eleven. That frequency of land turnover was 2 standard diviations (S.D.'s) from the mean (x). Subsequently, a plat of a subdivision, or development was filed in 1974 by Northwest Properties. However, commercial-manufacturing land speculation will dilute the effectiveness of this measure. Therefore, it should be kept in mind that it is used only as an indicator. Mineral exploration is not considered to have much influence on the measure since most mineral exploration in Oklahoma is carried out through gas and oil leases. Leases were <u>not</u> included in the construction of this measure.

The exurban policy environment consisted of policies of those organizations involved in providing on a local level the policies concerning utilities, services, or finances. Accessibility and amenities are included since these are important decision-making factors to developers (Kenney, 1972; Brandt, 1974; Kaiser, *et. al.*, 1968). In order to collect the information on the organization policies required to construct the policy environment, the representatives of the appropriate organizations were interviewed. The interviews were unsystematic in that certain information was requested, yet not in the same manner from each of the interviewees.

To analyze the relationship of the policy environment to the location of exurban developments, a measurement of overall policy environment which would serve as an indicator of the cummulative effect of the policies of the individual organizations as they relate to the establishment of exurban residential developments was needed. Therefore, a technique was devised which would produce such a measurement--Policy Environment a (PEI) index. The technique used to derive the PEI is a modification of the technique used by Robinson (1975a) to measure the exurban policy environment in the Stillwater, Oklahoma peripheral area. The results of the interviews were used as the main source of input for the weighting technique applied in this study. Each factor was assigned a weight which reflects the policy of the controlling organization as it relates to exurban developments (Table 34).

The equation used in this study for the calculation of the PEI is composed of two basic parts. One is made up of those factors essential for development to take place (EF). The other is composed of those factors which are not necessarily essential factors for development to occur (NEF), yet can either make an area more attractive or less attractive for development. Thus, the basic PEI equation is:

Table 34 The Weighting Criteria and Composition of the Policy Environment Index Factors

Factor	Weights	Weighting Criteria
L	0	Unavailable due to zoning or policy of controlling organization
	1	Available land
W	0	Unavailable due to the policies of the organization or the physical limitations of the system
	1	Available supply is severely restricted due to either policies or physical limitations
	2	Available, section is 2 miles or more from a main supply line
	5	Available, section is 1 mile from a main water supply line
	8*	Available, section is located in the same area as a major fresh-water aquifier, hence wells can be used with confidence
	10	Available, section contains or is adjacent to a main water supply line
U	0	Unavailable
	2.5	Available if developers pay for utility line installation and the section is not adjacent to an existing main line
	5	Available if developer pays for utility line installation and the section is adjacent to an existing main utility line
	10	Available with the utility company installing the lines with no charge to the developer
PM	0	Under 20% of potential home buyers cannot afford a conventional bank home loan
	1	Over 20% and under 50% of potential home buyers can afford a conventional bank home loan
	3	Over 50% of potential home buyers can afford a conventional bank home loan
S	0	Lagoon sewage disposal system is favored by regulating agency (50% or more developments are on a lagoon system)
	1	50% or more of the developments are on septic tanks
	2	Availablity of a rural or extended metropolitan sewer line is present
MR	0	Definitely regulation present
	1	Jurisdiction control is ambiguous
	2	No regulations present
CR	0	County subdivision regulations present
	1	Jurisdictional control is ambiguous
	2	County subdivision regulations absent

Factor	Weights	Weighting Criteria
FP	0	Fire protection is not available
	1	Fire protection is available
PP	0	Police patrolling is unavailable
	1	Police patrolling is available
E	0	Schooling is not available
	1	Schooling is available

$$PEI = (EF) \cdot (NEF)$$

PEI = Policy Environment Index
EF = Essential Factors
NEF = Non-Essential Factors

The factors which reoccur throughout the literature as weighing heavily on the developer's decision-making process were used as the factors which composed the (EF) package. These factors can be critical determinants of development. The factors were the availability of drinking water (W), utilities (U), land (L), financing (F), and access (Ac) (Brandt, 1974; Chapin, 1972; Kaiser, et. al., 1968; Kenney, 1972; Watcher, 1973). Although amenity (Am) was said to be an important part of the developer's decision-making process, it was not considered a critical factor. This is supported by Kaiser, et. al., (1968) and the discussed fact that there is an amenity value for exurbanites in just being out of the city (Hadden, et. al., 1973; Spectorsky, 1955; Zapata, 1974). Financing (F) was a sub-package consisting of factors of the availability of private financing (PM), government financing for individual home buyers or builders (GMH), and government financing for special districts such as rural water districts which can be conducive to the establishment of exurban developments (GMD).

The (EF) package is multiplicative due to the critical nature of the factors composing it. The availability of the factors would greatly enhance any additional attractive factors contained within the (NEF) package. Conversely, the non-availability of even one of the factors within the (EF) package would severely restrict development occurrence. Thus, the expanded equation is:

$$PEI = \left[L \cdot W \cdot U \cdot (PM + GMH + GMD) \cdot Ac\right] \cdot (NEF)$$

PEI = Policy Environment Index
NEF = Non-Essential Factors
L = Availability of Land
W = Availability of Water
U = Availability of Utilities

Financing Package:
PM = Availability of Private Financing
GMH = Availability of Government Financing for Home Buyers
GMD = Availability of Government Financing for Special Districts

Ac = Availability of Access

The Non-Essential Factors (NEF) package is composed of those factors which can add or detract from the desirability of an area for the location of a development. Generally, development can occur in the absence of any or all of the factors in the NEF package. The amenity (Am) factor weight is actually a control on the equation since there is no unavailability of amenity noted. The fact that the exurbanites are residing out of the city is an amenity in itself (Hadden, et. al., 1972; Zapata, 1974). This control prevents the NEF package from equaling zero, thus causing the PEI to equal 0. This would indicate a policy environment extremely unfavorable to developments when in fact it would not necessarily be.

The NEF package is composed of three sub-packages. First among the sub-packages is the amenity (Am) sub-package which consists of three factors. The control or "rural fantasy" factor which has a constant weight of 1, and the availability of a lake (Lk) are the factors which constitute the amenity (Am) package. The Subdivision Regulation (SR) package is composed of those agencies or organizations which exert regulatory power over the specification of the design, engineering, sewage disposal system, etc. in the building of a subdivision. Special service districts can have an attracting influence on individuals seeking exurban residences. Therefore, they have an attracting influence on developers since they need to make their developments as marketable as possible (Kaiser, et. al., 1968). Thus the third sub-package in the NEF package is a special service district (SSD) composed of the availability of fire protection (FP), police protection (PP), and education for the resident's children (E). The fully expanded equation is:

$$PEI = \left[L \cdot W \cdot U \cdot (PM + GMH + GMD) \cdot Ac \cdot (X + Wd + Lk) + (S + MR + C) + (FP + PP + E) \right] \div 100$$

PEI = Policy Environment Index

- (EF) Essential Factors
  - L = Availability of Land
  - W = Availability of Drinking Water
  - U = Availability of Utilities
  - (F) = Finance Package
    - PM = Availability of Private Financing
    - GMH = Availability of Government Financing for Home Buyers
    - GMD = Availability of Government Financing for Special Districts
  - Ac = Availability of Access
- (NEF) Non-Essential Factors
  - (Am) Amenity Package
    - X = Exurban Amenity Constant
    - Lk = Availability of Lake
  - (SR) Subdivision Regulation Package
    - S = Sewage Disposal Regulation
    - MR = Metropolitan Subdivision Regulation
    - CR = County Subdivision Regulation
  - (SSD) Special Service District Package
    - FP = Availability of Fire Protection
    - PP = Availability of Police Protection
    - E = Availability of Education for Children

For the majority of the factors the weighting criteria were expressed in terms of relative availability (Table 34, factors W, U, PM, GMH, GMD, Wd, Lk, S, MR, CR). This approach was chosen for those factors because not only does simple availability or non-availability of these factors play a role in the decision process, the relative cost or effect on development marketability has to be taken into consideration. For example, if a developer must invest in utility lines within his development and to the point of entry onto the main supply line, distance from such lines becomes related to cost. Therefore, if the developer is two miles from a main supply line his resulting costs will be at least twice as great as if he were one mile from the line. Considering the largely unsystematic, intuitive approach which characterizes the development industry (Kaiser, et. al., 1968), it seems reasonable to assume that land development evaluations are expressed in such relative terms.

The weighting system for the SR package, particularly that concerning the presence of metropolitan and county subdivision regulations, reflects the undesirability of location in areas of definite subdivision control (Robinson, 1975). However, in areas where the basis for control is ambiguous there is some confusion as to what and how to regulate. Therefore, developers may develop and not conform to regulations by taking advantage of the ambiguous situation (based on comments found in Robinson, 1975a). The weighting criteria are arbitrarily constructed so as to reflect this gradation in desirability of locating in areas where regulatory powers are present.

Although the PEI is basically a measure of relative attractiveness of the policy environment for development, it has been systematically approached and structured (Figure 2). The inputs are not intuitive since the information has been obtained through interviews. The interviews provided the input for the subjective translation of the policies into the assigned weights (Table 34). The weights were then assigned areally.

The areal unit used in this analysis was the square mile section based on the United States Land Survey System (Meurer Abstract and Title, 1974). The following factors prompted the use of the section as the areal development units; 1) the transportation network generally follows section line boundaries (Figure 3), 2) utility lines follows roads, hence, section lines (Indian Rural Electric Co-operative, 1974), and 3) many of the special districts service area boundaries were based on section lines (most notable were the water districts). Each section was evaluated on the basis of the weighting criteria (Table 35). Then the Policy Environment Index (PEI) was calculated for each section.

The PEI values were then categorized. Natural breaks in the distribution of the spatially varying factor weights were utilized in setting the category limits. Four Policy Environment (PEI) categories were constructed. The characteristics of each category were discussed to insure each category was assigned an identifying label describing its major identifying characteristics.

The tendency of developments to locate in a certain policy environment was measured by the density (number of developments per number areal units) of developments within a PEI category. Thus, a comparison of the density of developments within each category was utilized as the measure indicating which policy environment tends to attract the greatest density of developments. Since the characteristics of each policy environment type (PEI

Table 35 Summary of the Relationship of the Interview Response Results and Assigned Weights

Factor	Weight	Weighting Criteria	Summary of Response Results	Description of Controlling Organization or Affected Area
L (availability of land)	0	Unavailable due to zoning of policy of controlling organization.	The Corps of Engineers is the major controlling organization, preventing developments within their jurisdiction. NO developments can be established on Corps of Engineers' land or other public use parks.	Corps of Engineers' land (i.e., flowage easements & public use parks.
	1	Land is available for developments.	(Assumption: remaining land is available)	Total Study area
W (availability of water)	0	Unavailable due to policy or physical limitations.	None	N/A
	1	Availabile supply is severely restricted due to policy or physical limitations	None	N/A
	2	Available, section is 2 miles or more from a main water supply line	There were sections in these categories. However, they also fit the criterion of weight 8. Therefore, they were assigned that weight.	
	5	Available, section is 1 mile from a main water supply line.		Total Study Area
	8	Available due to the existence of a major freshwater bearing aquifer reachable by wells.	All sections not in special water districts and many within such districts.	Area underlain by the Vamoosa Formation
	10	Available, section is adjacent to or contains a main water supply line.	1) Developers must invest in connecting an intra-development water lines. 2) Additional development can be accomodated, so water is available	Pawnee Co. RWD#1 RWD#2 RWD#2, Inc.

U	0	Unavailable	None	N/A
(availability of utilities)	1	Available if developers pay for utility line installation & the section is <u>not</u> adjacent to an existing utility line.	1) No piped gas is available 2) Bottled gas is available throughout the study area 3) Electricity is available for those developers willing to invest in the line installation	City of Mannford (serves RWD#2, Inc.); Indian Electric Co-Operative, Inc.; Ark Valley Gas; Shell Gas; Arkla Gas; DX Sun Gas
	5	Available if developers pay for utility line installation and the section <u>is</u> adjacent to or contains an existing line.		
	10	Available, the utility company installs the lines with no charge to the developer.	None	N/A
PM	0	Under 20% of potential home-buyers can afford a conventional bank loan	None	N/A
(availability of Private Financing)	1	Over 20% and under 50% of the potential home buyers cannot afford a conventional bank loan.	1) Based upon the statement of the Okla. Home Builders Assoc. Pres. & the acknowledged "tightness" of loan monies within the study area. 2) Interest rates ran 10-11%.	Total Study Area
	3	Over 50% of the potential home buyers can afford a conventional bank home loan	Again based upon the statement of the O.B.A. and the general agreement of the local financial institutions, such was the case when interest rates were in the area of 7 3/4% and less.	
GMH	0	Unavailable	None	N/A
(availability of government sponsored home financing)	1	Availability restricted by income group.	1) The government agency operating with a major policy of attracting urban people to rural areas is the Farmer's Home Administration	Total Study Area

			2) Farmer's Home Administration home loans are restricted to those who have an adjusted yearly income of $10,300 or below. 3) Interest rates are adjustable to 1% depending upon the percent of monthly income the payments will equal (the % is not to exceed 20%)	
	3	Availability not restricted by income group.	None	N/A
Lk	1	Amenity constant	This is the amenity constant described as the amenity of being in 'exurbia'	Total Study Area
(availability of a lake)	0	Section which is not lake-containing or contiguous to a section which is lake-containing	(Criteria is self-explanatory)[1]	Total Study Area
	1	Section is contiguous to a section which contains a lake.		
	2	Section contains a lake		
S (sewage disposal regulation)	0	Lagoon sewage disposal systems are favored (50% of the developments are on lagoon systems)	None	N/A
	1	50%+ of the developments are on septic tank systems.	1) There is no Pawnee County Health Dept. 2) Only <u>one</u> certified sanitarian resides in Pawnee County 3) Response indicated that septic tanks are the rule 4) Only <u>one</u> development plat mentioned need for algoon system.	
	2	Availability of a rural or extended metropolitan sewer line is present	None	N/A

GMD	0	Unavailable	None	N/A
(availability of gov't financing	1	Availability has been reduced due to the attitude or policy of the agency or local agent	This is evidenced by several situations. 1) RWD#1 was refused an initiating loan, they were deemed "too non-rural" by the local FmHA ofc. in Pawnee, Okla. 2) RWD#2 has had chronic difficulty in receiving loans within a reasonable length of time. 3) A development Co. which RWD#2 was anticipating as an addition to their distribution system, pulled out when the FmHA ofc. insisted that the developers invest in a booster pump station in lieu of the use of FmHA funds. The development Co. considered the cost of the booster station <u>and</u> lines as prohibitive--approximately $20,000. Also, the RWD#2 officials sided with the development company.	Total Study Area
	3	Availability is not being reduced by the attitudes or policies of the agency or local agent.	(see above; GMD wt. = 1)	N/A
Ac (availability of access)	0	No access roads contained or contiguous to the section	(criterion is self-explanatory)[1]	Total Study Area
	5	All access roads contained or contiguous to the section are <u>unpaved</u>.	Tulsa Okla. was considered the "parent city" U.S. Highway 64 was considered the paved, direct access route.	
	8	At least one <u>paved</u> road, not a direct access route to the "parent" city, is contained or contiguous to the section.	If a section did not contain an access point on the Cimarron Turnpike, the turnpike's presence was ignored in the assigning of Ac weights.	

	10	At least one <u>paved</u>, <u>direct</u> access road is contained or contiguous to the section		
MR (metropolitan Subdivision Regulation)	0	Definitely regulation present*		N/A
	1	Jurisdiction control is ambiguous	(see appendix B)	
	2	No regulation present		
CR (county subdivision regulation)	0	Regulation present		
	1	Jurisdiction control	None	N/A
	2	Regulation absent	No regulation of subdivisions	Total Study Area
FP (fire protection availability)	0	Fire protection is unavailable	(see below; FP wt. = 1)	Areas not in RWD#2, Inc.
	1	Fire protection is available	1) RWD#1 has a fire truck & is renting a building on state land for $1.00/yr. It is a volunteer fire protection organization. 2) The cluster of developments known as Westport also has a volunteer fire dept. 3) RWD#2 Inc. received fire protection from the City of Mannford.	RWD#1 RWD#2, Inc. Westport
PP (police protection)	0	Police patrolling is unavailable	The Pawnee Co. Sheriff's department does not patrol	Total Study Area, except Westport
	1	Police patrolling is available	1) Oklahoma Highway Patrol does patrol. However, this agency's primary purpose is traffic, not crime prevention. It was not considered as a source of police patrolling. 2) The cluster of developments known as Westport has a part-time, one man police force which occasionally does patrol	The Westport cluster of developments.

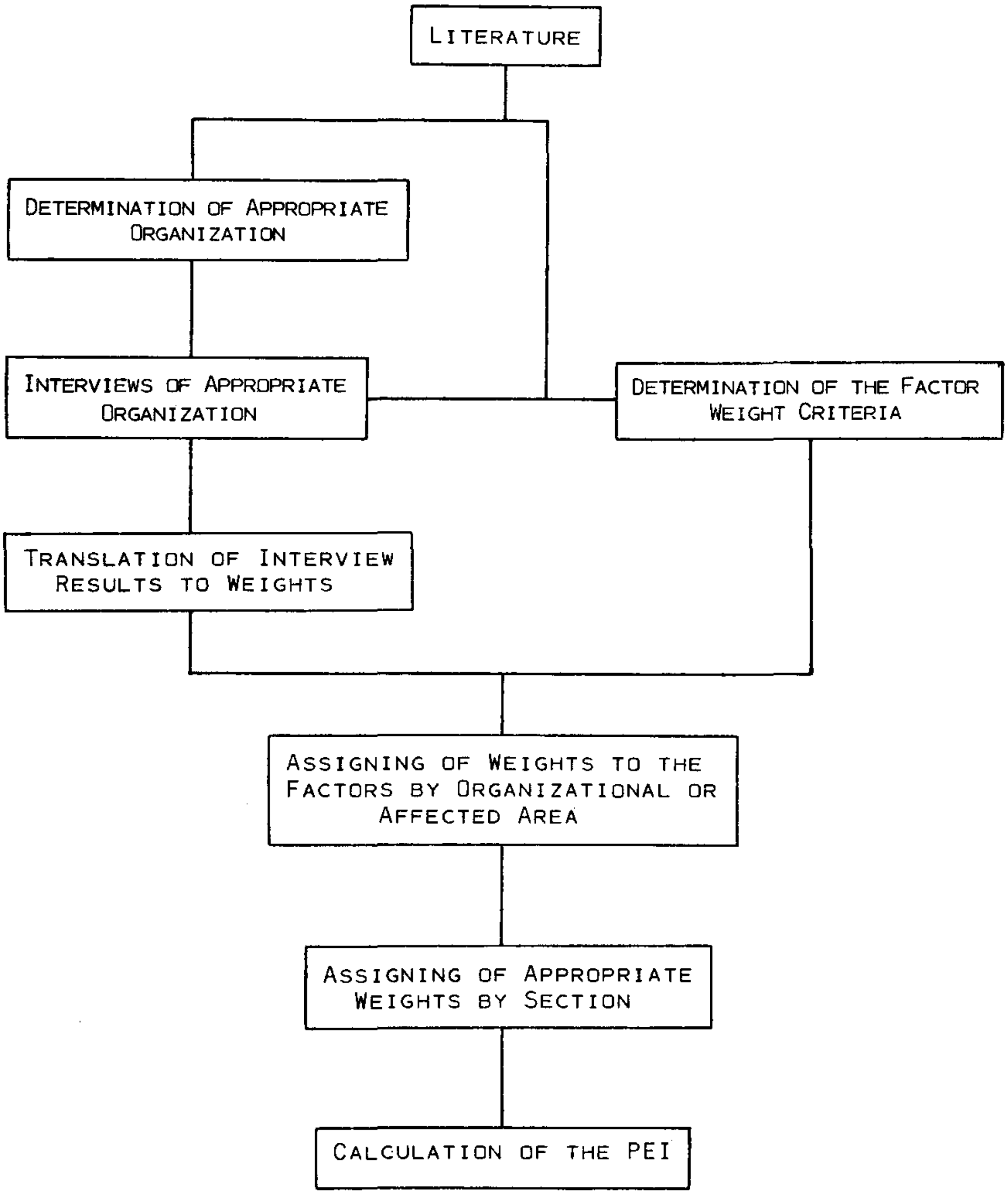
E (education)	0	Schooling is not available	No relevant responses
	1	Schooling is available	The entire study area is serviced by three school districts.

Sources: The list of sources can be found in Appendix A

[1] Oklahoma Department of Highways. General Highway Map of Pawnee County, Oklahoma, 1973 (all data except culture).

*See Appendix B for detailed explanation.

Figure 2 Conceptualization of the System for Determination of the Policy Environment Index (PEI)



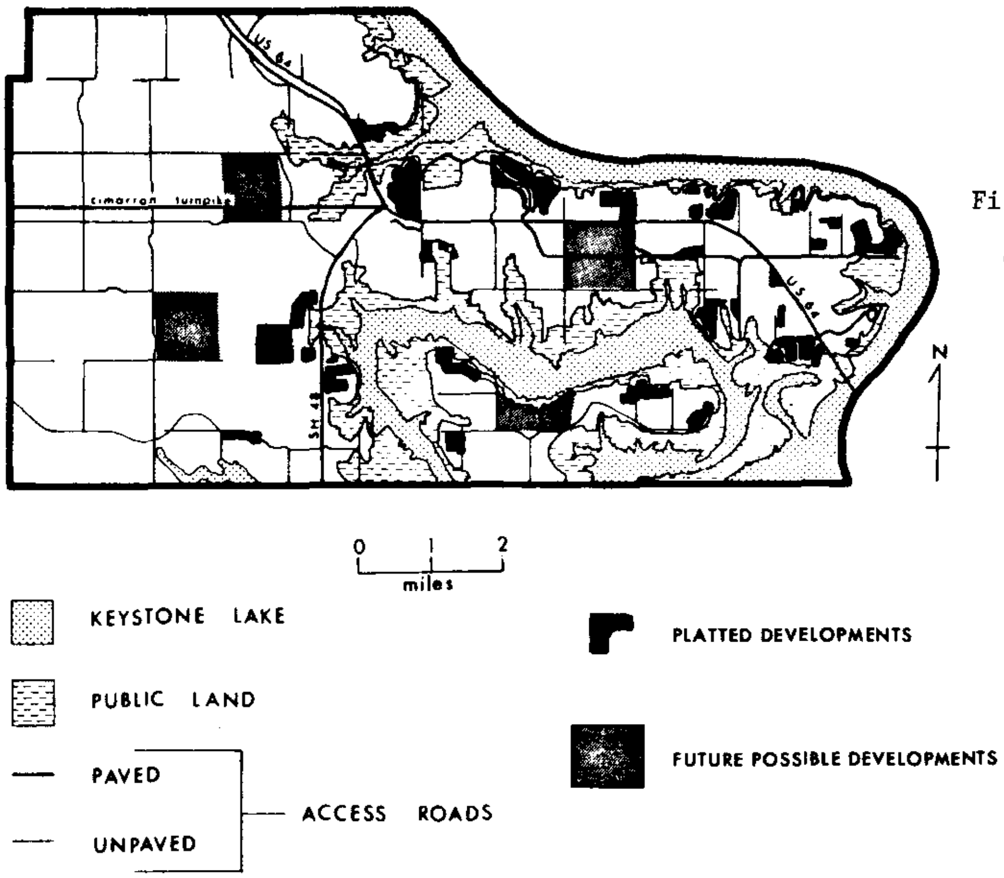


Figure 3

The Study Area

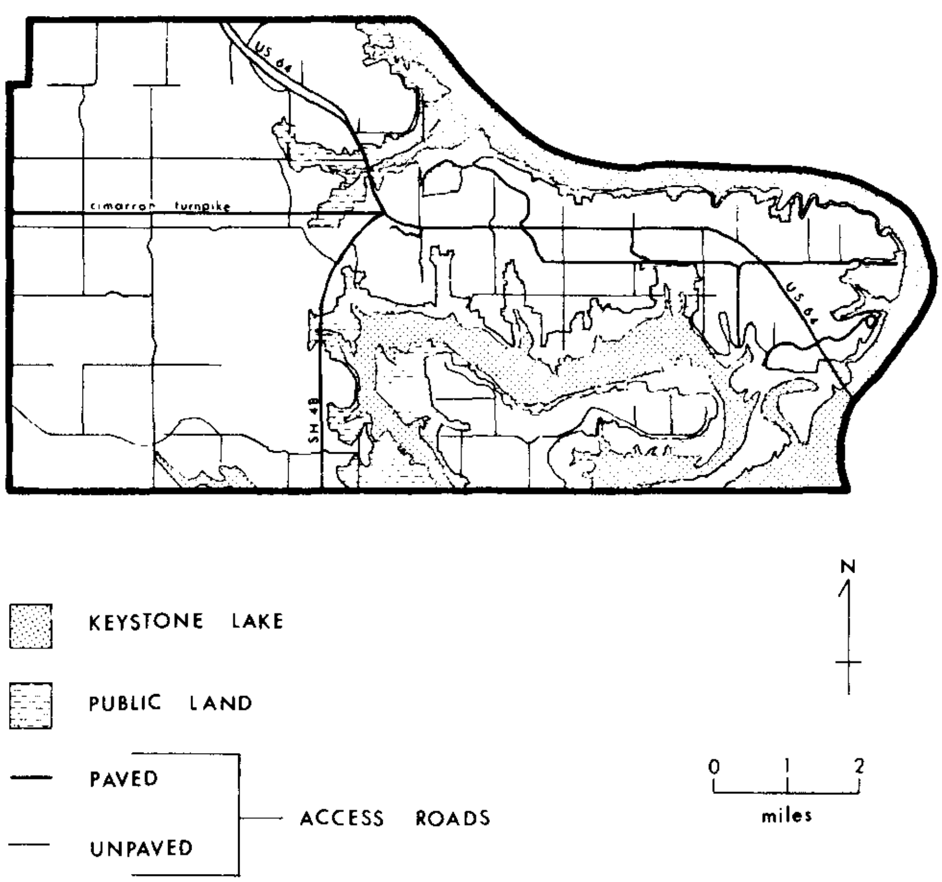


Figure 4

Distribution of Development Types

category) are known, a statement can be made concerning those factors which appear to be the major determinants of development location with respect to policy.

RESULTS AND DISCUSSION

Status of Exurban Developments

Platted Developments

Within the 75 areal units contained in the study area there were 52 platted developments. Thus, the density of developments within the total study area was .69 developments per areal unit. However, a glance at Figure 4 reveals that developments are not distributed uniformly over the study area. The greatest densities are located in close proximity to Keystone Lake (Figure 5).

The plats of the 52 developments in the study area contain information (i.e., lot layouts) the sum of which, indicates that there are over 2700 lots within the platted developments. Interestingly, 2330 of the lots were contained on the plats of 39 developments which were platted prior to 1966 and after 1960. Over half the housing lots and developments were platted 10 years (approximately) ago. It has been estimated by the staff of the Central Oklahoma Economic Development District (COEDD) that the presently platted developments can absorb over 60% of the projected population increase of approxminately 7,000 by the year 2000 on the Keystone Peninsula (Figure 6; COEDD, 1975). This indicates that there are quite a few developments either empty or containing very few constructed units. The amount of still available living space within the developments indicates that developers may have been over-optimistic about demand and/or desired to obtain the land before any competitors did. Apparently, it is not unusual to see large percentages of development lots remaining undeveloped. The same phenomenon was observed by Robinson (1975a) in the peripheral area of Stillwater, Oklahoma.

In summary, the density of developments is concentrated in those areas of close proximity to the shoreline of Keystone Lake: even after nearly a decade, most developments still maintain considerable potential for absorbing additional housing pressure.

Location of Future Possible Developments (FPD)

Even though present platted developments can absorb an appreciable amount of additional housing pressure, speculators and developers are not prevented from continuing their land acquisition activity for future development sites. It should be kept in mind that those locations designated as future possible developments (FPD) may reflect commercial-manufacturing land speculation.

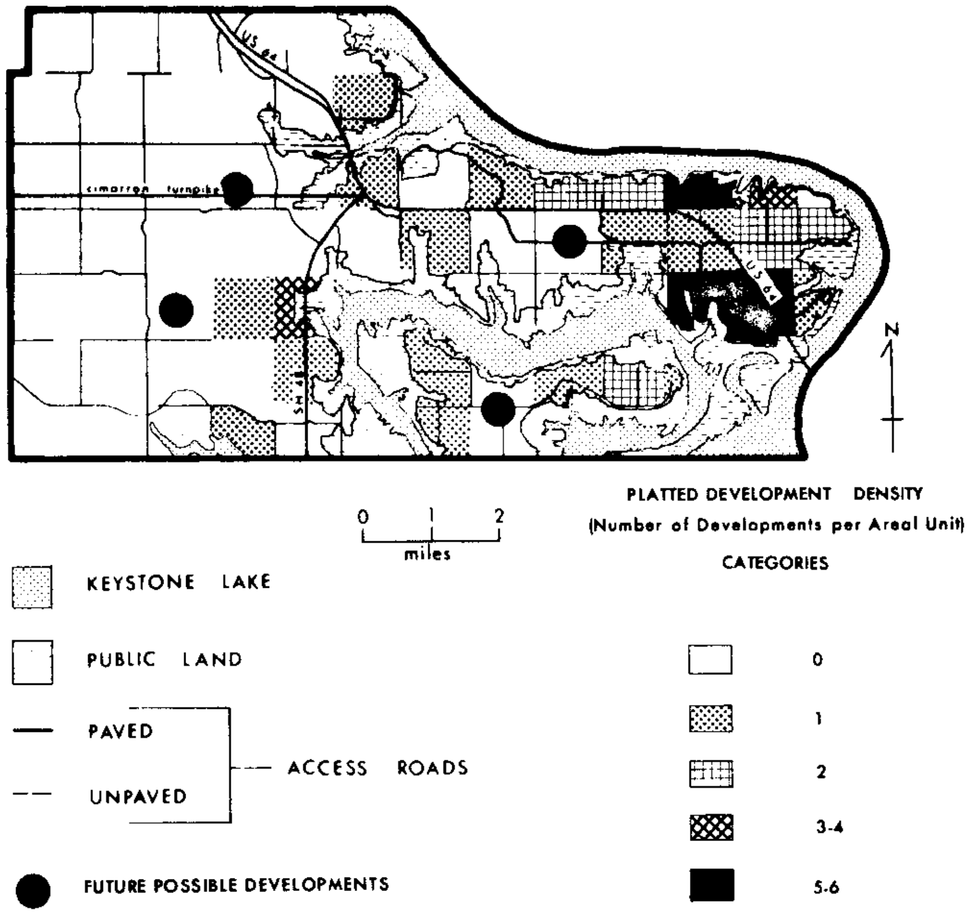


Figure 5

Distribution of Development - Type Density

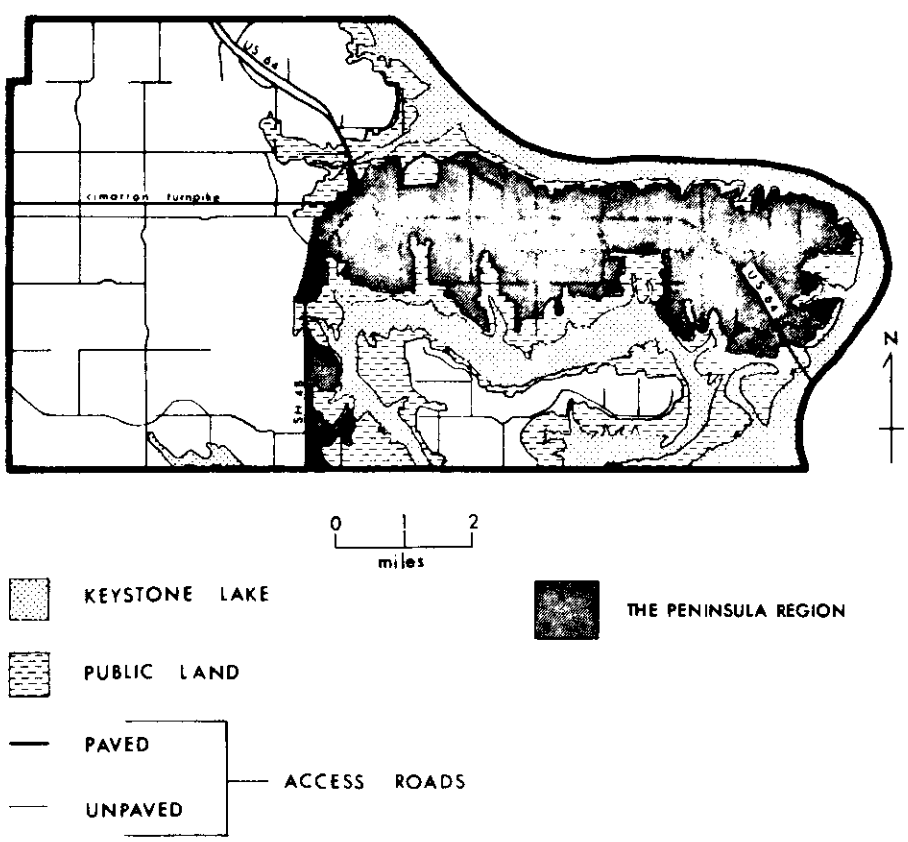


Figure 6

Location of the Keystone Peninsula Region Within the Study Region

Four FPD locations were determined to exist in the study area (Figure 4). Two were located in the central area of the study focus and two were located on the periphery of the major developed areas. Of the four FPD's only one was considered as a possible indicator of commercial land speculation. Its location relative to the transportation arteries and development densities suggest such a possibility.

The others are seen as most probably locations of future residential developments. Three of the four FPD's were in areal units contiguous to units which contained developments. This supports the observations of Brandt (1974) and Robinson (1975a) that previous development tends to attract future developments.

In general, the location of FPD's illustrates two processes in action. One is the "filling-in" of available developable space. The other is the further extension and diffusion of developments, in the study area, to the west of Keystone Lake

THE POLICY ENVIRONMENT

To facilitate the comparative measuring of the overall policy environment, the interview results were utilized in assigning the appropriate weights in the PEI model (Table 35).

In assessing the overall policy environment as measured by the PEI, there were two primary areas of consideration: (1) the types of PEI categories and (2) the distribution of the PEI categories.

Types of Policy Environment

The categorization of the PEI values was based on the scrutinization of the distribution of the spatially varying factor-weights. Category limits were based on what appeared as general changes in the occurrence of said factor-weights. The result of this categorization procedure were PEI categories which can be identified by the frequency of occurrence of the various spatially varying factor-weights (Tables IV, V).

PEI Category I -- Harsh

This category is attributed to be a "harsh" policy environment. The title is deserved. Amenity (Am) package weights are generally low (60% are less than or equal to 2). Utility availability is distant at best. There are no paved roads and practically no fire protection available within this category (Table IV). Water availability is evenly balanced between the occurrence of areal units close to water district supply lines and those in which wells could be drilled. However, it should be noted very few areal units within the study area are not within the area designated as underlain by the Vamoosa Formation, a major freshwater bearing aquifer. Thus, the only major shift in water availability can be toward proximity to water district supply lines as is the case in PEI Category IV (Table IV).

TABLE 36

Distribution of the Spatially Varying Factor Weights Within the PEI Categories: Percent of the Total Number of Areal Units Within Each PEI Category by Factor Weight

PEI	Amenity Package Weights				Water Availability Weights			Utility Availability Weights			Access Availability Weights					Fire Protection Availability Weights		
	1	2	3	total%	8	10	total%	2.5	5	total%	0	5	8	10	total%	0	1	total%
I	12	48	40	100	48	52	100	100	00	100	10	90	00	00	100	84	16	100
II	30	40	30	100	49	51	100	10	90	100	00	90	00	10	100	40	60	100
III	11	11	78	100	55	45	100	00	100	100	00	00	88	12	100	22	78	100
IV	00	66	34	100	00	100	100	00	100	100	00	00	00	100	100	00	100	100

Source: Author's calculations

PEI Category II --- Marginal

This policy environment category is improved, somewhat, over the previous policy environment. PEI Category II resembles PEI (Category I in the distribution of water availability. However, it (Category II) has less amenity orientation, slightly better access, and better distribution of fire protection (60% of FP wt.'s equal 1). The most dramatic change in characteristics was in the utility availability factor. Ninety percent of the areal units in PEI Category II were at least adjacent to a main utility line (Table 3).

The policy environment characterized by PEI Category II is an improvement over PEI Category I. However, it is marginal since it still lacks the total attractiveness as would be indicated by the prevalent occurrence of higher factor weights in amenities, water availability, access, fire protection, and even utility availabilty.

PEI Category III --- Indirect Access - Amenity

As in the study of the Stillwater area (Robinson, 1975a), PEI Category III is the category most heavily endowed with high amenity weights (Table IV). In addition to the amenities, high utility availability, indirect paved access roads, and fire protection availability characterize the PEI Category. The policy environment indicated by the category is favorable and its dominant characteristics are indirect paved access to the "parent" city and amenities (Table 36).

PEI Category IV --- Direct Access

Although this category does not lack amenities, its high factor weights are not concentrated in the amenities as Category III's are (Table IV). All areal units in this category are adjacent to or contain a direct paved access road to the "parent" city--Tulsa, Oklahoma. This is the single most distinguishing characteristic of this category. In addition to its direct access orientation, utilities, special district water, and fire protection are highly available (Table 36). In summary, this category depicts the areas with the "best of everything", with the possible exception of amenities.

Distribution of the Policy Environment

As a result of the PEI determination system (Figure 2, Table 35), the variation of the PEI categories over space could be displayed and analyzed (Figure 7).

PEI Category I --- Harsh

This policy environment type is concentrated to the west of the lake. Reasons for this are quite apparent. Paved access roads, utilities, and amenities (espec. lake-related) are not highly available west of U.S. 64 and S.H. 48 in the study area.

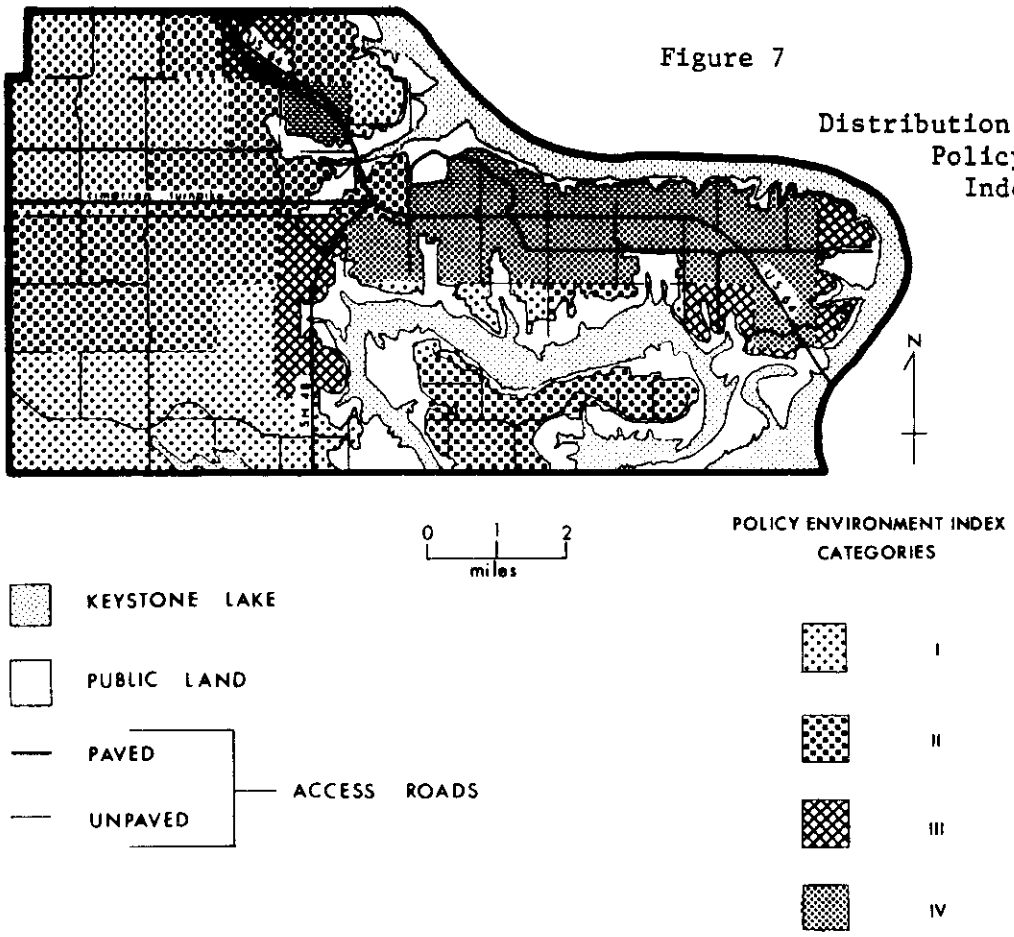
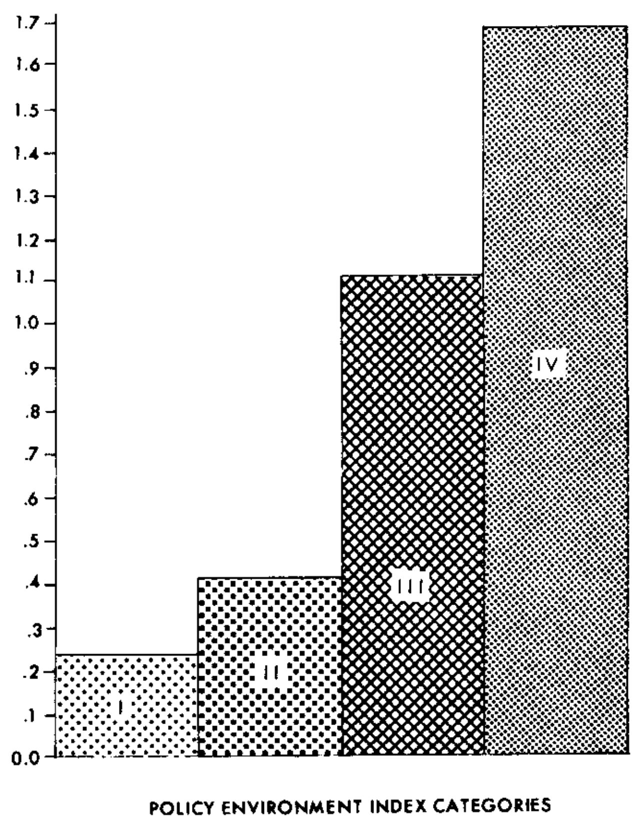


Figure 7

Distribution of the Policy Environment Index (PEI)

Figure 8

The Relationship of Platted Development Density to the PEI Catagories



The areas containing institutional land, lacking access, and utility availability, yet located on the shore of the lake also experience this type of policy environment. It should be noted that not all units on the lakeshore are of this policy environment type.

PEI Category II --- Marginal

As can be expected, this category is found primarily on the periphery of PEI Categories III and/or IV. Also indicated, are areas which without high availability of primarily utilities could very likely be classified as PEI Category I.

PEI Category III --- Indirect Access - Amenity

In a study taking place on a lake, it can only be expected that the amenity oriented policy environment be located primarily on the lakeshore. Only one areal unit does not follow that pattern (Figure 7). The reason is that it is also the only areal unit in PEI Category III that is located on a direct paved access route. Thus, it is deficient in some factor weight which prevents it from becoming a PEI Category IV policy environment--- a Lake Availability (Lk) factor weight of at least 1. It is a very favorable policy environment located too far from the lake.

PEI Category IV ---Direct Access

This category's distribution is limited to approximately the location of U.S. Highway 64--the direct access route to Tulsa. The frequency of this category is not as restricted as PEI Category III (Table 36), yet Category IV is apparently just as favorable a policy environment which with the added attractiveness of a direct paved access route to the "parent" city has become the best policy environment available in the study area at this time.

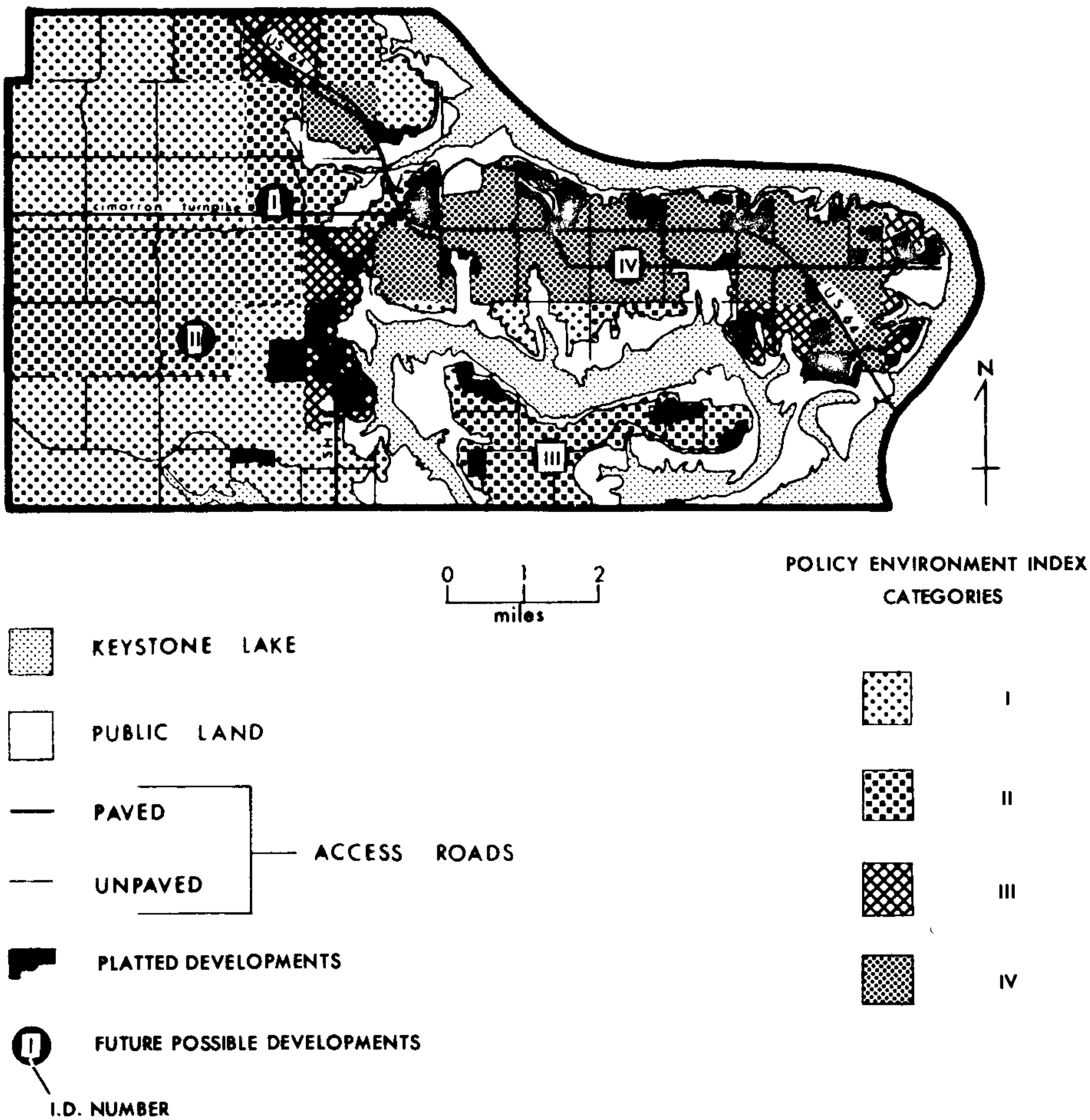
The Policy Environment and Developments

Platted Developments and Policy Environment

Since the PEI was devised to indicate the relative attractiveness of differing policy environment types with respect to developers, it is logical to expect the most favorable policy environments to contain the greatest densities of developments. This, in fact, is just what is observable in the study area (Figure 8). As the favorableness of the policy environment declines (note: PEI Category I is least favorable and PEI Category IV is most favorable) the density of developments also declines.

Even though the concentration of PEI Category I is to the west and generally removed from the lake, the developments to be found in this category are located in units which contain lake shoreline (Figure 9). There is one exception, it is approximately ½ mile west of S.H. 48 and the plat on the development has been "vacated". The developer apparently realized his mistake since vacating is analagous to nullifying the intent

Figure 9 Distribution of Development - Types and PEI Catagories



to develop which the plat symbolized (interpreted from: Kratovil, 1967; Ring et. al., 1967).

Nearly all of the developments in PEI Category II are concentrated on the portion of Pawnee County isolated by the lake from the remainder of the county. In addition, 5 of the 8 developments found in PEI Category II are in units containing shoreline.

Thus, the lake can be seen as an attractor of development in spite of deficient or marginal policy environments.

Understandably the next two PEI Categories, III and IV, contain the majority of development (69%) while occupying only 32% of the areal units in the study area. Even though the units designated as PEI Category III are few and contain a substantial amount of public undevelopable land (Figure 9), the category possesses a high density of developments (Figure 8). In contrast to PEI Category III, PEI Category IV has a wider distribution (Table 37). However, the density of developments is also higher in PEI Category IV than in any other category. This is logical since the policy environment characterized by PEI Category IV is theoretically the "best" in the study area.

Note should be made concerning the fact that although densities in some PEI categories are relatively high, they are fewer than two developments per unit. A glance at Figure 9 reveals that there is still developable land in PEI Categories III and IV. However, little of it could be classed as shoreline. Thus it appears as though developers believe that their customers would rather pay for living in less favorable policy environments if they, the consumer, can live very close to the lake. This is the major trade-off situation observable in the study area.

Future Possible Developments (FPD) and Policy Environment

Each of the areal units classified as a future possible development location appeared to be expressions of decisions based on varying reasons. Even so, FPD IV is the only one not located in a marginal policy environment (Figure 9). This prediction of FPD's for the marginal policy environment follows the same observations made by Robinson (1975a) in the Stillwater, Oklahoma peripheral area.

FPD I's location is obviously based on its proximity to access to the Cimarron Turnpike. The developer of FPD I may be anticipating, perhaps rightly so, that the policy environment will improve or that consumers will shoulder the higher costs and inconveniences of living in such a development in order to have convenient direct paved access to Tulsa and be less than 3 miles from Keystone Lake.

The hypothetical developer of FPD II may be using the same general intuitive reasoning since FPD II is close to S.H. 48 and it is endowed with proximity to main utility supply lines. Also, FPD II appears to have been attracted by a previous development located in a harsher policy environment (Figure 9).

TABLE 37

Distribution of PEI Values and Categories

Policy Environment Index Categories	PEI Values	Frequency of Occurrence (Number of Areal Units)	Approximate percen of total number of Areal Units Within the Study Area
Category I	0	5	7
(PEI 38.5)	24	5	7
	26.25	2	3
	27	4	5.3
	30	7	9.3
	33.75	1	1.3
	37.5	4	5.3
	38.4	1	1.5
	Sub-total =	29	39
Category II	42	2	3
(38.5 PEI 85)	48	4	5.3
	52.5	4	5.3
	54	1	1.3
	60	4	5.3
	67.5	3	4
	75	4	5.3
	Sub-total =	22	29
Category III	86.4	3	4
(85 PEI 130)	96.0	2	3
	120	4	5.3
	Sub-total =	9	12
Category IV	135	10	13.3
(PEI 130)	150	5	7
	Sub-total =	15	20
	(N) Total =	75	100

Source: Author's Calculations

FPD III is apparently trading location in a marginal policy environment for location on or very near the shoreline. Therefore, this is an indication that the trend of development location in PEI Category II as previously discussed is continuing.

FPD IV can be attributed to be a result of either residential or commercial land speculation. Both can be the cause. The commercial location would be in close proximity to the most densely developed region of the study area (Figure 5) and accessible to not only the resident population but also to transients using U.S. Highway 64. A residential development would be near the lake, in a highly favorable policy environment, and have direct paved access to the "parent" city--Tulsa (Figure 9).

As speculated in Robinson (1975a) the FPD's appear to be best explained by the intuitive, unsystematic, and sometimes highly individualized decision-making process of developers (Kaiser et. al., 1968). Why should there be any incentive for future development if in the Peninsula Region alone the presently platted developments can absorb another 6-7000 person increase in the population (COEDD, 1975)? That is a question this study cannot answer.

Still, the pattern of Future Possible Developments suggests the operation of various ongoing processes: 1) the "filling-in" of the highly favorable policy environment areas with either residential or commercial development, 2) the continued attraction value of "lakeside living", 3) the diffusion of development outward from the lake-oriented development core area (i.e. the Peninsula Region.).

Conclusions

The attractiveness of the lakeshore location is such that in marginal policy environments the attractiveness of the lakeshore location outweighs the burden of developing in a marginal policy environment. The combination of both a favorable policy environment and relative proximity to the lake has attracted the majority of developments. This situation has resulted in the high density of developments to be found in either PEI Category III or IV (Figure 8).

Therefore, even though the lake itself attracts developments to shoreline locations, developments were concentrated within those policy environments favorable to their existence.

Location of Future Possible Developments in relation to the policy environment types indicated that; 1) the PEI Category IV areas are still experiencing development even though such areas are the most heavily developed at present, 2) in marginal policy environments the attractiveness of "lakeside living" is such that development is continuing, and 3) the marginal policy environments on the periphery of the more favorable policy environments are attracting the developments which seem to be diffusing outward from the high development density areas.

The Rise and Fall of the Keystone Lake Area Planning Commission (KLAPC): an addendum*

The most generally applicable part of the model is its basic structure (see Robinson, 1975a:21). In other words, the factors and their relationship within the model are the most generally applicable features of the model. This model's structure and resulting use illustrate the potential, for planners in particular, that additive and/or multiplicative models have in the construction of special indices. The basic structure of the model needs no improving modification. Modification of the model should be done within the framework of factors, weights, and weighting criteria.

A note of caution, this model was developed to produce a general relativistic measurement of the overall policy environment. Thus, the more detailed and complex the weighting scheme and accompanying criteria become, the greater the likelihood that the model will become unmanageable and awkward. More importantly, it will then tend to be used for a purpose it was not intended--the calculation of an absolute value.

In the Fall of 1974 a group of people residing in the Peninsula Region (Figure 7), the most densely developed part of the study area (Figure 6), formed the Keystone Lake Area Planning Commission (KLAPC). It was formed following the proper legal procedure as outlined by Oklahoma law.

Technically, major portions of Tulsa's subdivision regulations were used in lieu of any written expressly for the KLAPC. In reality, the regulations were functionally non-existent.

The office of the Central Oklahoma Economic Development District (COEDD) in Shawnee, Oklahoma was approached to write a grant proposal for funding of the formulation of an initial plan for the peninsula area by the KLAPC and COEDD. The project was funded and an initial plan was presented at a public hearing in Westport, Oklahoma in February, 1975.

Apparently, many of the residents had not been aware of the existence of the KLAPC prior to the public hearing. Therefore, a great deal of

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* This discussion is based on interviews with Robert Echols (COEDD) and Bill Harrington of the Keystone Lake Area Planning Commission as well as an article in the Tulsa World by Larry Clark entitled "Plan Nixed, Lake Panel to Dissolve" on May 7, 1975.

resistence was directed towards the KLAPC primarily and the initial plan secondarily.

However, probably the most outstanding reason behind the opposing of the KLAPC and the Plan was the mistrust the pre-reservoir residents voiced in reference to the 'outsiders', or post-reservoir development dwellers. The membership of the KLAPC was largely composed of such 'outsiders'.

This reaction to 'outsiders' is not unusual since it has previously been described by Folse (1961). Therefore, the involvement of such people in the KLAPC served to intensify the pre-reservoir residents' mistrust for the initial plan, planning, and KLAPC in particular. The initial plan was not in print at the time of this public hearing. Approximately a month (2 wk. - 1 mo.) later, copies of the "Initial Plan for the Keystone Peninsula Area" were distributed to any interested parties.

In May, 1975, another public hearing on the "Initial Plan for the Keystone Peninsula Area" was held at the Pawnee County Fairgrounds. Approximately three hundred people attended the hearing.

The prime objective of the KLAPC was to formulate a plan for the orderly growth of the peninsula area. The plan itself was to "establish rules insuring good quality construction of lake area subdivisions". On the other hand, the opposition saw it, the plan and the KLAPC, as the putting of "control of their land into the hands of 'outsiders'".

Therefore, at the public hearing held at the Pawnee County Fairgrounds, the property owners present voted 212 to 77 to disregard the plan. On Friday, May 9, 1975, the Pawnee County Commission passed two resolutions. One rejected the "Initial Plan for the Keystone Peninsula Area". The other resolution dissolved the KLAPC.

The dissolving of the KLAPC removed any hope of obtaining any orderly growth in the near future. Therefore, the policy environment as described in this study will determine to a large extent the future pattern of land-use in the study area.

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Chapter 4

Summary and Implications of Findings

The following are the major findings of this research:

1. That a land use information system provides a useful means with which to evaluate regional land use changes or a specific planning or research problem;

2. That there are differences in reservoir related land use changes between the construction and the post-construction period;

   - In terms of general patterns of land use, changes were greatest in the construction period; a corollary is that during this period, large increases in some land uses were matched or exceeded by large decreases; also during the construction period there was a general tendency towards dispersion of intensive uses;

   - The post-construction period was one of general increases in urban development but also greater stability; conversion of land from rural uses decreased, and the period is marked by substantial increases in the intensity of urban land uses;

3. That there are four major zones with respect to the effect of reservoir development on land use - the zone of Inundation, the Shoreland, the zone of Marginal Impact, and the zone of No Impact; there are differences in land use changes among the different zones:

   - The inundation zone loses all of its former land uses during the Construction period;

   - The Shoreland zone shows moderate instability decreasing with time; increases involved spread of urban uses, especially residential land uses, and declines in rural uses; transportation land uses are very volatile throughout but not much net change; early declines in structures erased by subsequent gains, but structure density remains low; some evidence of reduction in intensive rural uses due to speculation;

   - The zone of Marginal Change (Intermediate Zone) shows only moderate stability initially, but becomes quite stable in the post-construction period; initial large land use increases are recorded in residential and other types of urban land uses; in the post-construction phase urbanization continues, but at a low rate; intensification of land use continues throughout;

   - The zone of No Impact (the Remote Zone) exhibits considerable stability throughout the study period; non-reservoir related changes observed; stable area with respect to total structures; small increase in proportion of cells with structures, but most increases in structures come in a relatively few cells.

4. Within a small region close to the reservoir, nearly all residential development has taken place in areas very close to the shoreline;
5. Those areas with shoreline plus superior policy environments, exhibit the highest residential development density;
6. The reservoir can be seen as an attractor of residential development in spite of deficient or marginal policy environments;
7. Future residential expansion is likely to continue near the lake, because of the distribution of available land within existing platted developments plus the demonstrated tendency of people to seek residential sites adjacent to the reservoir.

Significance of the Findings

Reservoir developments have profound influences upon land use patterns. Reservoir-associated changes in land uses are exhibited most frequently in the impoundment area and the so-called shoreland areas - those lands immediately adjacent to the reservoir. However, changes in land use patterns in turn have important subsequent effects on environment, governance, economic, and social conditions in a much wider area. These effects can be (after James, 1972) adverse or beneficial, local or national. Some of the specific effects are summarized in tables 1 and 2 .

Among reservoir planners and developers these side or subsequent effects are generally recognized but not generally accounted for in the process of evaluating proposed projects. It seem desirable that consideration should be given to likely land use changes, not only in the impoundment zone, but also in the highly impacted shoreland area and even to the lesser impacted zones away from the reservoir. Perhaps more importantly, the side-effects need to be a part of the evaluation processes. The removal of land from cultivation has important long-range national significance and the attraction of both seasonal residents into rural communities, and environments has important regional implications, as does the migration of reservoir residents out of their former communities and neighborhoods.

Table 1 Some Examples of Likely Local and Regional Effects of Land Use Changes Associated with Reservoir Development

General Class of Effect	Effects Generally Regarded as Adverse	Effects Generally Regarded as Beneficial
Economic	Decrease in property tax revenues as a result of replacement of taxed land uses with non-taxed land uses; loss of agricultural land may have repercussions among local businesses; local	Increase in property tax revenues as a result of residential/commercial development; expansion in certain sectors of local economy especially service and construction businesses and developers;

	living costs may increase due to speculation in land and housing	improvement of rural incomes as a result of increase in amount or intensity of cultivated land in region; increases in property values of land owners.
Social	Reduction in community cohesiveness & traditional values by disruptions caused by adding new residents who have substantial differences in goals, interests, opinions, and needs from the old residents; conflicts between permanent and seasonal residents, old and new residents, residents and property owners, especially speculators	Reduction in unemployemnt and improvement of labor force skill; improvement of housing among relocated residents; improvement in prestige of communities as a result of growth in population and higher quality housing
Governmental	Increased pressure on and resultant reduction in quality of existing services, schools; new problems (crime, pollution/zoning) may require expansion of governmental activities.	Expansion and improvement of services as a result of pressure from new residents and new tax base
Environmental	Reduction in wildlife habitat possible increase in population especially in dispersed type of residential development; possible changes in environment due to increasing cultivated acreage, irrigation area, etc.	

Table 2 Some Examples of Likely Regional or National Effects of Land Use Changes Associated with Reservoir Development*

General Class of Effect	Effects Generally Regarded as Adverse	Effects Generally Regarded as Beneficial
Economic	Removal of land from agricultural use in general, and cultivation in particular means losses to GNP	Development of land for power and flood control structures and impoundments will mean increments to GNP Construction in general, and 2nd home development especially makes a net contribution to GNP
Social	Residential migration into area may result in disruption and deterioration of neighborhood elsewhere	Construction associated with land development may mean reduction in unemployment, development/improvement of skills
Government	Income tax revenue decreases as income are diminished or lost because conversion of land to non-productive uses	Income tax base increases as income and employment increases as a result of jobs associated with residential and commercial development
Environmental	Larger proportion of country influenced by urban area; reduction in wildlife habitat and possible elimination of certain species results in ecological adjustments	Spreads population more evenly through landscape, enhancing recuperative capabilities of environment from urban impacts

* Assumes reservoir would not be developed elsewhere

Local officials should look forward to important and often unanticipated changes in their communities as a result of reservoir development. They too need to recognize that land use changes will be most pronounced in impoundment and shoreland areas, but at the same time they should anticipate that the side-effects of such development can be important and widespread. At the outset community leaders and planners need to make explicit the type of communities they want and develop policies and programs to achieve their ideals. They should actively participate in deliberations concerning reservoir size and shape, management policies, relocation plans, and the location and design of auxiliary developments such as recreation facilities, power generating and distribution equipment.

Perhaps a reasonable charge against the project would be provision for regional planning assistance to all communities likely to be faced with impacts from major land use changes. In any event these officials should institute carefully developed plans which are sufficiently flexible as to be capable of responding to changing trends and events which may have a bearing on subsequent development. Plans should be specific regarding the services and the general policy environment which guides development in acceptable directions. Yet planners and policy-makers should realize that while they can control and shape development to a large degree by changing the policy environment, they cannot fail to ignore the overwhelming attractiveness of reservoir locations. Given a chance, such land will likely experience residential and other land-use developments.

For their part, individuals in the region near the reservoir should realize that land use changes will affect them. Only a very few will get rich. Many more will suffer either the end of the place oriented way of life to which they are accustomed, as their land is taken from them or through the relocation of their residences or businesses. All will feel the significance of land use changes through changes in property taxes, traditional community structure, and local and regional economies. Because of this individuals must make themselves heard, for they have a considerable and often unanticipated stake in reservoir development projects.

Appendix A

Secondary and Tertiary Impacts of Water Resources Development Projects:

Abstracts of Representative Studies

This bibliography attempts to provide the reader with a summary of existing knowledge of the relatively recent literature on secondary and tertiary impacts resulting from water resources development projects. In order to fairly represent the research, published abstracts provided by the authors themselves are used wherever possible. No attempt is made to indicate all research efforts on a given topic, but rather to portray the range of research endeavors and findings. Several references to environmental impact statements and to environmental impact statement methodology are also included.

Sources of abstracts are indicated at the end of each entry as follows:

WRA - Water Resources Abstracts

WRRC - Water Resources Research Catalog

JA - Abstract by journal in which article appeared

AA - Abstract by author

AI - Abstract by Principle Investigator of this research

APPENDIX A

Environmental Impacts

R. E. Carlson, Environmental Effects of Recreational Uses of Monroe Reservoir Water Resources Research Center, Bloomington, Indiana 47401, Indiana University.

"A study of problems resulting from the recreational use of Monroe Reservoir in southern Indiana will attempt to determine how recreational activities affect the quality of water and land immediately surrounding the reservoir and to discover a means of developing greater public concern for the care and wise use of the environment."

C. M. Cowan, (1972) "Ecological Impact of Surface Water Impoundments in the Great Plains Area," Nebraska University, 46p.

"The proposed location of the Corps of Engineers Platte River Dam was analyzed from the standpoint of its environmental impact. A technique was developed which offers an objective approach to environmental analysis and an alternative to the more subjective cost-benefit ratio. The philosophies behind the method is founded in statements of relative truth while the actual technique is based on the probabilities of occurrence of resources and the desires or demands for the resource. The applications of the method to the Platte Dam using the categories of agriculture, recreation, bird habitat, mammal habitat and fish habitat indicated that, from the standpoint of the aforementioned categories, the Platte Dam would have been feasiable assuming optimum water levels were maintained. The agriculture and mammal habitat categories scored in favor of the present river system, while the other three categories favored the proposed lake.

Clark, W. J., (1971) The Impact of Water Development on the Ecology of River Systems, in: Water for Texas; Proceedings of the 15th Annual Conference on Water for Texas, Nov. 23-24, 1970, Texas A & M University College Station, pg. 49-54.

"Ecological implications of modifying the natural course event in one part of the hydrological cycle, the river system, are discussed. The way man uses the land can modify the course of precipitation after impact . . . Urbanization and land use practices can cause ecological differences between permanent and intermittent streams . . . Water development projects will have widespread ecological effects. The nature of these effects must be known if intelligent overall planning is to be done. Proper design, location and operation of dams and other structures may permit water supply goals to be obtained without serious ecological effects.

K. L. Dickson & J. Cairns, Jr., "Ecological Data for Water Resource Management," (1972), Virginia Polytechnic Inst. and State University. Ecological Impact of Water Resource Development -- A technical Session of the Symposium, Water, Man and Nature. p. 1-6.

"Present advances in biological monitoring combined with physical and chemical monitoring capabilities indicate that in the near future we can develop and operate a river basin with varied water resource uses to maximize beneficial use without ecological damage. A river basin management system which inclues reservoirs, agriculture uses, industries and towns, is illustrated. Conceptually utilizing a central control center are rapid physical, chemical, and biological monitoring systems, ecological damage could be prevented through the operation of the system as a whole rather than each water resource user being concerned only with his own desired discharge. If an industry in the system had a spill of toxic material which was rapidly detected through the continious monitoring systems, the following activities might be coordinated by the control center: (1) upstream reservoirs could increase discharges for dilution of toxicants, (2) municipal water use could curtail use of water and depend on reservoir until toxicity was dissipated; and (3) downstream industries could shunt to holding ponds to prevent synergistic interactions. The water resource management scheme depends on the cooperation activities of State and Federal government as well as private users of water resources."

R.D. Estes (1971) "Ecological Impact of Fluctuating Water Levels in Reservoirs," in Ecological Impact of Water Resource Development--A Technical Session of the Symposium 'Water, Man, and Nature: Bureau of Reclamation Report REC-ERC-72-17. p. 7-9.

"The littoral zone is the most important area of a reservoir from the standpoint of fishes and other higher animals and plants. Reservoirs usually require the use or eventual release of water for hydroelectric power production, for domestic and industrial water supply, for irrigation, or flood control. Seldom does the demand for the water coincide with the supply; therefore, changes in volume of water occur. Even reservoirs designed for nonconsumptive usage of water, such as navigation or recreation, usually undergo some fluctuation of water levels. The greatest concern to fishery biologists regarding fluctuation has been the effects on the reproduction of fishes. Results from numerous studies on reservoir fishery management indicate that the general consensus is the water-level fluctuation may cause loss of Centrachidae eggs but usually not a complete failure of a year-class.

C. R. Goldman, (1972) "Environmental Impact and Water Development", Journal of the American Water Works Association, Vol. 64, No. 9, p. 545-549.

"The environmental movement and how environmental interest might be incorporated to achieve a better balance between water development and environmental quality are discussed. There was a time when 'face-changing' a region was an acceptable adjunct to resource improvement, however changes in public attitudes and values have discouraged this acceptance. These attitudes and values are conditioned by man's response to his environment, and the situation is complicated by the fact that individuals respond to the same stimulus in different ways. In order to meet the challenge of incorporating contemporary attitudes toward environmental as well as developmental interests into all aspects of water development, particularly the planning. The planning of water projects should be separated from the construction and regulatory agencies, and physical, biological and social scientists should be part of the planning team, together with the traditional engineering and economic talent. It would seem appropriate that this planning agency be established at the Federal level because of the size and scale of most water projects. New methodologies exist and are being created for planning water-quality environments, what remains to be accomplished is effective procedures for incorporating environmental quality into benefit-cost analysis.

U.S. Government Printing Office, (1971) Water, Man, and Nature: A Symposium Concerning the Ecological Impact of Water Resource Development. 27 p.

"Proceedings of a symposium on the ecological impact of water resource development are summarized. Eight basic topics were discussed: what ecological information if necessary and how it can be used in water resources planning; ecological impact of recreation at reservoirs; effect of water resource operations upon the environment; ecological impact of atmospheric water resource development; ecology of reservoir effect of water resource development on wildlife and waterfowl habitats; ecological and environmental impacts during construction operations; and ecological effect of coal-fired power plants. Several general conculsions were made. There is a need for expanded research and data collection: water resource development planning at the very beginning; long term ecological research will be necessary; conclusions and data collected from one ecosystem area may not be easily applied to another ecosystem; engineers need a wider range of environmental recommendations from ecologists; research is needed for developing models of complex ecosystems; research on basic reservoir ecology is needed to classify reservoirs on the basis of biomes; effects of hydroelectric power generation on downstream biota and habitat need to be examined; long term studies to determine changes in biota up and downstream from reservoirs after impoundments are needed research to determine the effect of fluctuating water levels on the littoral zone; it is necessary to develop a better informed public; water resource managers should develop a conservation ethnic and outlook toward resource development.

T. L. Wirth, Manipulation of Reservoir Water for Impact on Quality and Fish Population Response, State Department of Natural Resources, Madison, Wisconsin 53701.

"Within Wisconsin it has been found that dam building alters downstream channels. The fertility of the streams is such that reservoirs quickly become eutrophic with limited aesthetic value due to aquatic nuisances. Recreational angling has decreased due to intense algae growth and adverse environments which limit fish production to steep-sided basins.

This study attempts to better conditions through the regulation of outflow from two dams on the same river; the downstream impoundment to release hypolimnion water and the upstream dam to relaese epilimnion water. The effect on manipulation of these flows on water temperature, PH, transparency, nutrients, etc. and fish production, growth, age, catch, and vegetation will be monitored.

Environmental Impact Statements

N. Dee, J. Baker, N. Drobny, K. Duke and L. Whitman (1973) "An Environmental Evaluation System for Water Resource Planning", Water Resources Research, 9, 3. 523-535.

"The Environmental Evaluation System (EES) is a methodology for conducting environmental impact analysis. Developed by an interdisciplinary research team, it is based on a hierarchical arrangement of environmental quality indicators that classifies the major areas of environmental concern into major categories, components, and ultimately into parameters and measurements of environmental quality. The EES provides for environmental impact evaluation in four major categories: Ecology, environmental pollution, esthetics, and human interests. These four categories are further broken down into 18 components and finally into 78 parameters. The method provides a means for measuring or estimating selected environmental impacts of large-scale water resource development projects in commensurate units termed 'environmental impact units' (EIU). Results of using EES include a total score in EIU with and without the proposed project; the difference between the two scores developed in the EES are based on the magnitude of specific environmental impacts and their relative importance. Another major output from EES is an indication of major adverse impacts called 'red flags', which are concern of and by themselves. These flags indicate fragile elements of the environment, which must be studied in detail."

Environmental Impact Center, Inc. (1973), A Methodology for Assessing Environmental Impact of Water Resources Development, National Technical Information Service, Final Report, 148 p.

"Environmental impacts of water resource projects are assesses using a dynamic simulation model. The model consists of modular sectors that forecast regional population and industry, intra-regional land use patterns and recreational activities. These are linked to water quality in terms of dissolved oxygen and carbonaceous and nitrogenous oxygen demand. Evaluation of water quality includes effects of point sources, domestic or industrial, and dispersed source wastes from urban runoff. Biological activities, including algae concentrations and fish populations, are modeled separately . . . The model can be used to test alternative plans and policies for water resource projects and to identify both indirect environmental impacts.

U. S. Army Corps of Engineers (1972) Hipes Lake Project, Craig Creek, Virginia (Draft Environmental Impact Statement). Norfolk, Virginia: Army Engineer District.

"Proposed action calls for the construction of a 172 foot high earth and rockfill dam for a multipurpose reservoir on Craig Creek, about 15 miles above its confluence with the James River in Bototourt and Craig counties, Virginia. The project will also consist of a trout rearing station and muti-level outlet storage release to establish a cold water fishery habitat in the stream below the dam. The project would provide flood control, water quality control, recreation, fish and wildlife conservation and economic development. The project will establish 23 miles of warm water stream fishing habitat. About 5,000 acres of forest wildlife habitat, 150 homesteads and numerous summer cabins will be destroyed. The small town of Oriskany with 25 homes will be dislocated, and a free flowing stream scenic area would be replaced with a body of water in an essentially lakeless region."

U. S. Army Corps of Engineers, (1972) Canyon Lakes Project, Texas (Final Environmental Impact Statment). Available from the National Technical Information Service, 55pg.

"This project involves the acquistion and development of lands within Lubbock, Texas, for public outdoor recreation purposes. Facilities include: 6 lakes totaling 175 acres, picnic shelters, a recreation pavilion, a fishing dock, a water collection system, an irrigation system and many other park related facilities. The project will provide recreation opportunities for local residents and enhance the overall environment of the community. The water in the park will be recycled and used for irrigation purposes and maintenance of proper lake water levels. The project is also expected to stop a trend in the surrounding neighborhood from residential to a mixture of wrecking yards, asphalt plants, and scrap metal businesses. Principal adverse effects will occur with the relocation of people and businesses to new locations. Alternatives considered include noproject, line-of-sight acquisition for additional development, enlargement of the project to eight lakes and acquisition of the same lands with minimal recreation development. Comments from interested agencies are included."

United States Department of Agriculture. (1971) Council Bluff Reservoir Potosi Ranger District, Clark National Forest, Iron County, Missouri (Final Environmental Impact Statment). Milwaukee: Forest Service, Eastern Region. 20 p.

"The project area will occupy 14 square miles of Ozark highland terrain in the Clark N. F. The reservoir will be created by the construction of a dam on Big River in Iron County, Missouri. The project will change a free flowing stream to a reservoir . . . The stream's ecosystem will be replaced by a lake ecosystem, and upland game animal habitat will be lost through inundation. A major effect of the project will be changed from one oriented toward limited agriculture to one oriented to recreation . . ."

Social Problems

W.H. Andrews, G.E. Madsen, G.J. Legaz, "Social Impacts of Water Resource Developments and Their Implication for Urban and Rural Development: A Post-Audit Analysis of the Weber B Basin Project in Utah," Institute for Social Science Research on Natural Resources, Logan, Utah, December, 1974.

"This reports the results of a post-audit on the impacts on water supply, irrigation, recreation, power and flood control components. Estimates of perceived impacts on security, quality of life, leisure time utilization, administrative problems, and other so-called social aspects. The conclusion deals with the significance of these results in the context of the original project goals as well as the work recently done by the National Water Resources Council and the Western States Technical Committee (Strawman)."

Raymond J. Burby III and Shirley F. Weiss, "Community Problems in Reservoir Recreation Areas," Research Previews 18 (April, 1971) pg. 1-13.

"Study of community problems based on survey of vacation home households with property adjacent to Lake Norman, North Carolina and Lake Sidney Lanier, Georgia.

R. J. Burdge and K. S. Johnson (1973),"Social Costs and Benefits of Water Resource Construction," Kentucky Water Resources Institute, Research Report, no. 64, Lexington, pg. 36.

"The process of relocating individuals and families who must move due to reservoir construction in Kentucky is analyzed and described utilizing data collected in previous research . . . Psychological, social, economic, and material costs and benefits associated with forced relocation are presented, and the role of the relocation agency (The Army Corps of Engineers) in the process is described. Generally, the younger, more affluent and educated migrants fare better . . . then the older, poorer and less educated migrants. Particular attention is paid to those people who found relocation psychologically costly because these are unanticipated and usually unrecorded real costs reservoir construction. Suggestions are given for easing the burden of relocation among those affected. The framework for this project is longitudinal describing the relocation process from pre-migration to post-relocation."

P. Drucker and C. R. Smith and A. C. Turner, (1972), "Impact of a Proposed Reservoir on Local Land Values, Anthropological Analysis of Social and Cultural Benefits and Costs From Stream Control Measures - Phase 3," Kentucky Water Resources Institute, Research Paper no. 51, 101 pg.

"This project was designed to study the social impact and economic impact of private pre-constuction acquisition of real priority in a Central Kentucky Rural area in which a multi-purpose dam is planned. The research design was built around use of anthropological concepts and research techniques. By these means it was possible to analyze attitudes toward, and social values of land to traditionalist residents, among which social and economic security concepts are paramount. Recent land purchases locally believed to have been made for purposes by outsiders at prices out of line in terms of local agricultural worth, have been extremely unsettling, contributing to the anxiety patterns typical of persons facing forced relocation by sale or condemnation. A newly developing pattern of land purchase, with values related to residential convenience and access to the urban center, rather than to go agricultural criteria is identified through regression analysis. Social change manifested in a partial urbanization is evident among a segment of the local population who try to take advantage of urban economic opportunities while participating in rural society and activities."

Hultquist, J. F. (1973) People and the Reservoir, Iowa University, Iowa City. Institute of Urban and Regional Research.

"The many aspects arising from the planning, development, construction, and operation of a reservoir often present serious disruptions in the lives of the region's residents. Potential disruption impacts are accentuated when the rate of change in the region is accelerated. While the Relocation Assistance Act of 1970 recognized the pecuniary impacts caused by federal projects that displaced residents, non-pecuniary impacts on residents' lives, which often cannot be ameliorated, have been disregarded. Pecuniary and non-pecuniary costs of disruption come in many forms. They result partially from uncertainty as to the ultimate impact of the project. The disruptive impact of Iowa's proposed Ames Reservoir is discussed."

Leadley, S. M. (1973) Sociological Impact of a Flood-Control Reservoir. Institute for Research on Land & Water, Pennsylvania State University, University Park, Pennsylvania.

"The social organization of a community adjacent to a newly constructed flood-control reservoir and four reservoir-based recreation areas is under pressure to change. This research has collected and analyzed data from 89 community leaders and their organizations, both public and private. This analysis attempts to relate ecological change in occupational and recreational opportunities, identify the potential roles of community to its new environment and assess the feasibility adaptive organizational programs based on membership resources. Survey data from a 1970 household enumeration will be supplemented by data from studies completed in this community in 1937, 1949, and 1960. Time-series analysis of modes of household and organizational adjustment to environmental change is planned."

D. E. Mann, (1972) "Social Objectives of Water Resources Development in the United States" Water Resources Bulletin., Vol. 8, No. 3, p. 553-560.

"Social well-being depends primarily on equity, or how society apportions benefits and costs among its citizens. Equitable income distribution usually refers to distribution in favor of the disadvantaged. Consequently, the concern for social well-being must involve more than helping regions where unemployment is high and the poor are numerous. Water resources development projects, for instance, may help poor areas but may be of little or no benefit to the poor and the unemployed. The problem, of course, is to identify the groups and individuals who get the benefit and find whether the poor get more benefits than they pay in taxes and charges. Several studies have attempted to identify which groups benefit from water resources development projects. However, these studies depend on crucial assumptions which must be replaced with actual information if these analyses are to be recognized as valid and reliable. Other social well-being benefits, which the Task Force of the Water Resources Council has identified as major elements of the social well-being account, are a stable economy assurance of steady flow of goods and services, and improvement of the social infrastructure."

R. N. Singh and K. P. Wilkinson (1974) "On The Measurement Of Environmental Impacts Of Public Projects From A Sociological Perspective" Water Resources Bulletin

"The major objectives are (1) to identify the problems involved in measuring the environmental impacts of public projects from selected perspectives, and (2) to elaborate a sociological approach used in an empirical investigation in that respect. The construct of environmental impact of a planned action is generally operationalized from different perspectives and with different methodological emphases in the various disciplines. Even the same environment does not elicit agreement among users as to its exact meaning. Although there has been a steady increase in the number of studies from a sociological perspective concerns environmental problems, there is lack of sociological counsel in writing environmental impact statements. Overall, we lack sociological methodology and operational procedures for that purpose. In an attempt to bring some empirical focus to this field attitudinal measures employed to discover how residents of a river basin perceived negative and positive environmental impacts of a proposed watershed development project are reviewed. These come from a study of creation of the Cooper Reservoir and Dam in Texas. Data on 343 heads of households in the selected areas were collected through structured questionnaires with items on personal information, a vested interest scale, a knowledge of the project scale, and an environmental impact scale. Data show that perception of impacts by residents is influenced significantly by degree of their vested interests involved. Variables for inclusion in a sociological model of environmental impact are suggested."

C. R. Smith & P. Drucker, (1973), Social and Cultural Impact of a Proposed Reservoir On A Rural Kentucky School District, Kentucky Water Resources Institute, Research Report, no. 60, p. 180.

"This study uses anthropological concepts and research methods to study attitudes toward education and the educational system of a central Kentucky school district with the goal of predicting the impact on it of a proposed multipurpose reservoir and of proposed options for stalling dysfunctional social aspects of that impact. The social impact will result from the fact that although the county is now rurally oriented, the proposed reservoir will attract (has already begun to attract) urbanite residents from Louisville, ...who can be expected to bring urban values concerning education, as well as other social values. Massive social change and cultural change can be anticipated. To assess probably directions of change in education, a school in an upper middle class suburban Louisville the sort of millieu from which most of the urban intrusion will come, was also studied. . . . "

Income Redistribution

J. F. Donnermeyer, P. F. Korsching, and R. J. Burdge, (1974) An Interpretative Analysis Of Family And Individual Economic Costs Due To Water Resource Development. Water Resources Bulletin.

"This article reports information on the economic costs not covered by resettlement procedures to force migrants from a flood-control reservoir. Data come from a sample of 200 families relocated due to construction of the Carr Fork Reservoir in the Coal Region of Eastern Kentucky (Knott County). Responses indicated that economic costs were higher than the monetary settlement provided by the Corps of Engineers and that economic costs are not randomly distributed among the relocated persons. Analysis showed that persons who were more likely to be victims of greater economic costs due to relocation were pensioners, older families with one or two members, persons with lower incomes and persons who were long time residents of the area. It is suggested that change agencies not only include property purchased by necessity in the cost-benefit ratio, but also other costs that have a direct bearing on the welfare of the target population. In addition, it is suggested that case workers visit individuals during and after the relocation process to assist in solving various adjustment problems."

L. D. James, ( ) "A Case Study of Income Redistribution from Reservoir Construction,"Water Resources Research, Vol. 4, p. 499-506.

"Because water resources investment has been evaluated from the economic efficiency objective, benefit and cost analysis has been critized as ignoring other goals. Benefit and cost data were used to determine the incidence of benefits and cost among income intervals. Recreation as a project purpose proved more effective in redistributing income than flood control. Weighing the income maximization and income retribution objectives according to the value that income taxes collected represent equimarginal sacrifice showed income distribution benefits to equal 18.2 percent of efficiency benefits. The percentage would be lower in higher income areas."

L. A. Shabman & R. J. K lter, (1969) "The Effects of Public Programs for Outdoor Recreation on Personal Income Distribution," American Journal of Agricultural Economics, Vol. 51, p. 1516-1519.

"A flow of funds analysis revealed that the New York State outdoor recreational program does have an annual redistribution effect. The upper income groups realized negative net transfer impacts, while lower income groups obtained positive net transfer."

Recreation Behavior

R. D. Hecock & J. F. Rooney, Jr., (1972) The Impact of a New Major Reservoir Upon Recreation Behavior. Stillwater: Oklahoma Water Resources Research

"Identifies nature and extent of recreational behavior changes resulting from development of Lake Keystone. Results based on household samples of residents within 90 miles of reservoir. Greatest effects are on residents within 10 miles. Beyond 50 miles fewer than 9% indicate changes in behavior attributable to new reservoirs."

J. L. Lindsay, "Socio-Environmental Relationship Between Pineview Reservoir, Cache National Forest and the Residents of Metropolitan Weber Co., Utah" Utah State University, School of Agricultural, Logan, Utah 84321

"This study explores the "socio-environmental" relationship between Pineview Reservoir and urban residents. Survey research techniques are used to obtain data on urban residents' socio-economic characteristics, outdoor recreational use characteristics and their needs regarding this particular resource. Recommendations were made and an "interestingly different relationship" between socio-economic characteristics and outdoor recreation use was found."

J. S. Matthias (1973) "Recreational Impacts of Federal Multi-Purpose Reservoirs," Purdue University Joint Highway Research Project, Lafayette, Indiana 47907

"This study is concerned with the development of a model capable of predicting recreational trips to new reservoirs. It will make use of road distance, courtly population and the influence of similar facilities as the only variables. The technique used is non-linear simultaneous equation regression analysis."

Local Governments

C. T. Bates & D. M. Soule (1971), "Reservoirs and Local Government Finance", Growth and Change, Vol. 2 , No. 3 , p. 47-51.

"Not all economic changes related to development of multi-purpose reservoirs are desirable. A commonly held belief to be tested is that reservoir development causes local taxes to become more severe, because demands for government services increase relative to the local area's ability to pay. A severity index equal to the percentage increase in local tax revenue divided by the percentage increase in local taxpaying ability (full value of taxable property and personal income) is introduced. Three reservoirs in Kentucky are studied over a period from one year prior to initial land acquisition to 1 year following construction of the dam. Percentage changes are shown for property tax revenue, full value of taxable property and personal income for the county and school government. The computation of the tax severity index showed generally low values for the ratios in two of the three project areas. Four factors explain this phenomenon: 1) increasing property values; 2) less than anticipated increases in demands for government services and the existence of some unused capacity in government facilities; 3) development of new revenue sources, including changes in state aid-to-education funds; and 4) the extended period in which the development took place."

D. J. Epp, (1971) "The Effect of Public Land Acquisition for Outdoor Recreation on the Real Estate Tax Base" Journal of Leisure Research, p. 17-27.

"Fifteen public land acquisitions for water-oriented outdoor recreation in Pennsylvania were examined to determine the effects on the property tax base... Analysis of the annual rate of increase in land values suggested the following hypothesis: At the time of public acquisition, or very shortly thereafter, the value of the land near the recreation site increases rapidly, followed by a period where values again increase at about the rate to be expected without recreational development."

A. Ersoz & B. R. Miller (1972) Aggregate Returns From Water Resource Development in Georgia, 1946-1965. Athens: Georgia University: Dept. of Agricultural Economics. Research Report No. 133, July 32 p., 7 tab, 51 ref.

"Between 1946 and 1965, over $414 million was spent by the federal government on the development of Georgia's water resources. The impact of these investment expenditures on Georgia's income is estimated as the difference between gross benefits from the investments and the charges levied upon the residents as a result of the investments. The gross benefits of a particular program to a region are assumed to depend on both the number and cost of the projects constructed in the region and the returns per unit of costs in these projects. The charges or costs levied on the residents of a region to secure the benefits of the program consist of (1) the initial construction costs borne by the region, (2) the present value of future operation, maintenance, and repair costs borne by the region, (3) the region's share of federal taxes used to support the Corps of Engineers national construction program, and (4) the region's share of federal taxes used to finance operation, maintenance, and repair costs of all the Corps' projects. Georgia's per capita income increased by slightly more than $100 for the entire period as a result of the Corps' program."

J. H. Wicks & A. H. Taylor, (1972) "Formulation of Techniques to Predict the Impact of Major Water Resource Construction Projects on Local Government Finances," Office of Water Resources Research, University of Montana, p. 20.

"The study attempts to estimate predictors of the impact of major water resource projects on expenditures and tax bases of local governments."

S. M. Wymann, (1973) The Political and Administrative Problems of Insuring Appropriate Residential Services in the Perry and Clinton Reservoir Areas. Lawrence, Kansas Graduate School, University of Kansas.

"This study is focused on political and administrative problems facing governments responsible for controlling the impact of residential development on water quality in the Perry and Clinton Reservoir areas in Kansas. Descriptions will be based on attitude surveys of developers, small parcel owners, and state and local government officials regarding improvement costs, tax burdens, and changes in governmental policies, structures and powers.

Local Economies

E. Attanasi, (1975) Regional Impact of Water Resource Investments in a Developing Area. Water Resources Bulletin, pp. 69-79.

"Regional development and industrialization patterns are investigated and related to regression analysis to water resource investments for the island of Puerto Rico. Although results of this study indicate such investments have little immediate or short-term impact, significant relationships and variations in regional responses appear over longer time periods. This is shown by applying a variation of Zellner's method of performing seemingly unrelated regressions jointly. By this method, subsets of parameter coefficients of specific economic variables were restricted across regional equations while unrestricted coefficients were interpreted as explaining systematic regional variations in response to public investment. Regional differences, obtained by using this method, are frequently neglected when simply examining the overall development process. Among the more interesting results in terms of policy implications is the apparent significant relationship, over the period considered, between changes in the distribution of income and the pattern of water resource development."

C. J. Cicchetti, V. K. Smith, & J. Carson, (1975) Water Resource Projects and Regional Economic Growth, Water Resources Research, pp. 1 - 12.

"The purpose of this paper is to analyze the effects of the Bureau of Reclamation's water resource projects over the period 1930-1970 on regional economic growth in the Southwest. The empirical results indicate that these investments have had an impact on regional economic growth and that the extent of the effect depends on the nature of the water investment, the state of the regional economy, and the amount and nature of other investments in the region."

J. S. Drake (1973) Indirect Economic Effects, Iowa University, Iowa City, Institute of Urban and Regional Research.

"A gross method to estimate secondary 'stemming from' and 'induced by' economic benefits is illustrated for a number of flood protection alternatives in Iowa's Skunk River Basin. The methodology was limited to the tracing of the immediate linkages between the agricultural sector, the farm machinery, and the food and kindred products sectors. ... Application of the model is illustrated using 1966 secondary data for the Skunk River Basin. The proposed methodology indicated that potential 'induced by' secondary benefits were almost zero for all alternatives. 'Stemming from' benefits caused by increases in output for the food and kindred products sector under strict assumptions were estimated at approximately $80,000 a year. The degree of variation in the secondary benefits between the flood control alternatives was too slight to allow their ranking."

C. Garbacz (1971) "The Ozarks: Recreation and Economic Development", Land Economics, 41, 418-421.

"This article explores the economic impact of the Greens Ferry Reservoir, a water-based recreation complex, on the development of the surrounding area (Cleburne and Van Buren counties in Arkansas). Official agency estimates of the benefit (nearly $3 million in 1970) uncharacteristically underestimated the real effect. The real impact is presented as follows:

increase in recreation-based employment of 1140 persons, an increase of several hundred mobile and non-residential homes (stimulating construction industry), employment on maintaining the dam (41 persons), personal spending by the visitor ($1.25 per head; 2½ million visitors in 1970). The two counties have not prospered equally, about 75% of the benefits accruing to Cleburne."

C. B. Garrison (1974) "Case Study of Local Economic Impacts of Reservoir Recreation", Journal of Leisure Research, Vol. 6, pp. 7-19.

"Reservoir recreation affects the economy of the local area in which the reservoir is located. Expenditures by recreation visitors represent exports of goods and services by the public and private enterprises catering to their demands. Availability of a comprehensive survey of expenditures made by visitors to Norris Lake made it possible to estimate the impact on both personal income and employment in the three-county area in which the bulk of Norris shoreline is located. Economic base theory is used to estimate the secondary economic impact of recreation expenditures. Although Norris is one of the most popular TVA reservoirs, it was found that recreation's contribution to the local economy had been negligible, especially when compared to either the positive effect of manufacturing or the negative effect of the agricultural decline."

R. C. Hinnan (1969) The Impact of Reservoir Recreation on the Whitney Point Microregion of New York State. Ithaca: Cornell University. Water Resources and Marine Sciences Center, p. 73.

"The setting, background, and development of the Whitney Point Reservoir Recreation Area are discussed. The study estimates the economic impact of the investment in developing the area, as well as the impact of the outside users who come to sail, swim, camp, fish, relax, and sun. Two methods of analysis and measurement were utilized: (1) a reservoir user survey, and (2) an input-output model in intersection transaction analysis. The user survey method gave an estimate of the gross expenditures by reservoir users. The input-output model showed the underlying structure and interdependencies of the microregional economy. One conclusion of the study is that the introduction of reservoir recreation at Whitney Point has caused a spectacular economic growth in the microregion."

L. D. James, (1972) "A Perspective on Economic Impact", Water Resources Institute, Lexington, Kentucky.

"In order to provide water resource managers with a useful planning methodology, the economic impact of five reservoir complexes is studied. . . Analysis of the impact of these reservoirs proceeds by analyzing fourteen specific impact issues. These issues are reservoir effects on the economy of the local county, changes in income and employment patterns around large reservoirs, patterns of land use change around reservoirs, reservoir effects on revenues and expenditures of local governments, recreation benefits, application of marginal economic analysis to reservoir recreation planning, economic value of natural areas for

recreational hunting and for stream fishing, the personal value of real property to its owner, reservoirs associated income redistribution, demand-oriented reservoir operations, estimation of flood damages, and operation of reservoir systems for flood control."

R. C. Kite & W. D. Schutz, (1967) Economic Impact on Southwestern Wyoming of Recreationists Visiting Flaming Gorge Reservoir. Laramie, Wyoming Agricultural Experimental Station Res. Journal, 11, University of Wyoming.

"The purpose of this study was to analyze the economic impact of expenditures by recreationalists visiting Flaming Gorge Reservoir in Southwest Wyoming in 1965. Through the use of personal interview, the average expenditure for 173 parties was determined . . . The Leontief static, open input-output model was used in analyzing economic impact. An overall multiplier of 2.067 was found. This expanded direct benefits from $529,728 to a total benefit of $1,094,798. Sectors receiving the greatest total benefit were, in order of importance: (1) gasoline service stations, (2) other retail, (3) general wholesale, (4) households, and (5) food and beverage establishments. This study is important in showing impact of recreational spending . . ."

Land Values

J. R. Conner, K. C. Gibbs, J. E. Reynolds, (1974), "The Effect of Water Frontage on Recreational Property Values," Journal of Leisure Research 5, 2:26-38.

"Two methods of estimating the value of the presence of water frontage to a typical residential property are presented. The first method uses multiple regression to analyze the effect of several independent variables, including lake frontage on vacant residential lot sales. The second attempts to estimate the value attributed to the presence of water frontage from owners' estimates of the value of their property with and without water frontage. The primary purpose for presenting both methods is to obtain estimates of the value of water frontage to vacant residential lots and lots with structures. Lake front and non-lake front vacant residential lot sale prices were estimated as a function of the year of the sale, the size of the lot to the nearest paved road, the number of utilities available in the subdivision, and the percent of wood homes in the subdivision. From the lot sales analysis, it was estimated that the presence of lake frontage would contribute about 65 percent to the total value of a typical vacant residential lot. In a survey of lakefront residents of the area, the respondents indicated that the presence of lake frontage contributed about 48 percent to the total value of the property."

J. C. Day & J. R. Gilpin, (1974) The Impact of Man-Made Lakes on Residential Property Values: A Case Study and Methodological Exploration Water Resources Research.

"Dams and reservoirs are often partially justified on the basis of an intangible benefit related to the property value changes that they allegedly induce. This assumption is tested by using the G. Ross Lord Dam and parkland on the west Don River in Toronto. The project had virtually no impact on residential property values in the summer of 1972 while the dam was under construction. The magnitude of the social benefit related to the residential land value changes induced by such a project is considered."

J. L. Knetsch, (1964) "The Influence of Reservoir Projects on Land Values," Journal of Farm Economics 46:231-243.

"The economic effects of water resource development projects may be more fully appraised by taking account of land value changes. An estimate is made of the anticipated land increment of a planned project, based on an analysis of value changes near existing TVA reservoirs. The estimated values of the land effected are found to vary, depending on site and locational characteristics. The value increases, in the case examined, are substantial, and are due mainly to the value of the project as a recreational and amenity resource, although not all of the recreational benefits are thereby calculated."

W. M. Mann, & J. K. Mann, (1968) "Analysis of the Influence of the Pearl River Reservoir on Land Prices in the Area," Appraisal Journal, 38, 43-52.

"A statistical analysis of sales records in the Pearl River Reservoir area in Mississippi shows that a sharp increase in market sales price occurred after the official announcement was made of the location and boundaries of the proposed reservoir site. To conduct the research necessary to appraise the effect of the reservoir on surrounding land prices, recorded sales data of land surrounding the reservoir and a control area similar except for the reservoir, were analyzed. The period from 1950 to 1959, when the official announcement was made was selected to establish a normal trend of sale price per acre was established from 1950 to 1963. Magnitude of the speculative influence of the reservoir is shown by comparison of actual sale prices of the same parcel of land from 1954 to 1963. The median price trend and resulting differences or percentage of price per acre increase before and after 1959 are charted to show the speculative influence resulting from the reservoir construction."

W. A. Schutjer, & M. C. Hallberg (1968), "The Impact of Water Recreational Development on Rural Property Values," American Journal of Agricultural Economics 50, 3:572-583.

"Public investment in water-based recreation facilities is made to increase the recreation potential of an area and to improve the economic resource base of the area. Estimates of the impact of one such investment on the structure of the land market and on property values were made for a rural area in Pennsylvania. The findings of the study support the general hypothesis that investment in water-based recreation facilties does significantly influence the value of rural property and the structure of the rural land market. Property characteristics and subdivision activity on surrounding proportion had to be considered in addition to distance from the recreational development to measure the impact of this public investment."

L. Warner, D. D. Badger, G. M. Lage (1973) The Economic Impact of Tenkiller Ferry Lake, Research Foundation, Oklahoma State University.

"This project examined a large number of economic indicators for the counties which are adjacent to this lake. Input-output analysis was employed to determine various effects of Tenkillers Ferry Lake."

V. Whetzel, (1973) Reservoir Impacts on Land Use and Values in Appalachia. Morgantown, W. Va. U.S.D.A. Nat. Resource Ec. Division, West Virginia University.

"Determine effects of the Sutton Reservoir in the Braxton County, Va. area by testing the hypotheses that it has: caused shifts and intensification in the use of land; increased land values and caused changes in the tax base; and these changes reflect certain related changes in economic activity."

Land Use

L. Warner, (1972) Land Tenure and Value Responds to Waterway Improvement: Theory and Preliminary Research Design, Water Resources Research Institute, Oklahoma State University, Stillwater, Oklahoma, pp. 22.

"Describes some theoretical considerations of the impacts on land values and their relationship to land uses."

R. J. Burby III, (1969) The Role of Reservoir Owner Policies in Guiding Reservoir Land Development. Raleigh: North Carolina Water Resources Research Institute.

"Land adjoining reservoirs with recreation potential has been developed at an increasing pace since 1960. A survey of 105 large multipurpose reservoirs in the Southeast indicated that these reservoirs have attracted over 60,000 homes and summer cottages... under 10% of the reservoirs surveyed have land use plans, zoning, or subdivision regulations to guide the development of adjacent non-public land. In the absence of local government initiative reservoir owners may have a key role in maintaining the quality and public usefulness of reservoir shorelines. This report investigates reservoir owner policies which may be used to influence the location and character of shoreline development. Policies considered include land acquisition, residential, commercial, industrial, recreation, and forest land utilization, land management, and inter-agency cooperation."

D. B. Oyen & J. R. Barnard, (1974), "Land Use Change Connected with a Small Flood Control Project" Working Paper Series No. 74-14. College of Business Administration, the University of Iowa, pp. 19.

"This study examines agricultural land use change in the flood plain of the Iowa River as a result of building the Coralville Dam. Estimates of land use change and the benefits realized from the project are compared to the original project study benefits estimated by the Corps of Engineers.

Actual realized benefits exceed Corps of Engineers estimates of historical price and cost data are used to value benefits. An analysis of the factors affecting land use change is carried out through regression model to determine those variables that explained observed land use change. The regression results indicate that the probability of land use change increases with increases in the numbers of acres available for conversion, the age of the landowners, and the years of education of the landowners. As distance from the dam increases, and the number of acres of existing crop land increase, the probability of land use change decreases."

B. R. Prebble, (1969) Patterns of Land Use Change Around a Large Reservoir Lexington: Kentucky Water Resources Institute.

"By examining the spatial patterns of land use changes around a reservoir planners may anticipate wind fall profits to landowners, improve environmental quality control, guide the land use planning of surrounding communities, and project future demands for increased services placed on local governments. Several hypotheses concerning the effects of relative location around the reservoir, the effects of relative location, the effects of the characteristics of an individual site, and the effects of road access are tested using analysis of variance and multiple regression. The data used for the analysis is based on Lake Cumberland, a reservoir in Southern Kentucky."

Steinitz Rogers Associates, Inc. and U.S. Army Engineer District, Los Angeles, THE SANTA ANA RIVER BASIN, AN EXAMPLE OF THE USE OF COMPUTER GRAPHICS IN REGIONAL PLAN EVALUATION, U.S. Engineer Institute for Water Resources, Fort Belvoir, Va., 1975, pp. 290.

"This report explores the possibilities of computer graphics as a tool in the process of watershed planning. The research project involved a study of the Upper Santa Ana River basin in California and addressed techniques for predicting future land use patterns, analyzing the effects of future land use on resources, the identification of desirable alternative plans for resource development, and the application of these methods toward the generation of environmental impact studies, particularly for regional-scale development decisions. The project consisted of the creation of a computerized data bank of site resources and land use elements, the development of locational attractiveness models defined by major activities or land use decision, the analysis of the vulnerability of various natural systems to impacts caused by future land use change, and the analysis of the attractiveness models and the impact models by evaluating two locally specified land use plans."

S. F. Weiss, R. J. Burby, and T.G. Donnelly, (1972) "The Effects of Authorization For Water Impoundments on Shoreland Transition," National Technical Information Service, North Carolina University, Chapel Hill. Center for Regional Studies.

"Private capture of social benefits created by reservoir construction threatens ability of public agencies to efficiently provide land and facilities to meet projected demands for water-oriented recreation. Objectives of this research are: (1) identify and evaluate factors which explain the location of land transactions, changes in land prices or value, and changes in land use patterns which occur after the authorization of water impoundments; (2) develop and test a model to predict short-term changes in land ownership land value, and land utilization; (3) develop a system for monitoring changes in land values, land use, and predictive factors utilizied in the transition model as they occur in reservoir areas; and (4) prepare policy guides to enable the Corps of Engineers and state and local governmental agencies to prevent the exploitation of land in authorized reservoir areas and to facilitate desirable development to meet public land use objectives. Major accomplishments during FY 1972 were: (1) completion of interviews with random sample of landowners who purchased property in the reservoir study areas after authorization by Congress; (2) formulation and tests of computer program for isolating key factors associated with landowners decisions to hold or sell property after authorization and factors associated with variations in sales prices; and (3) calculation and coding of property characteristics associated with complete inventory of the transactional history of 6,545 parcels in the reservoirs study areas."

Appendix B

A Land Use Information System: The Keystone Experience

A land use information system provides for the identification and encoding of land uses in a manner that allows for the rapid and convenient aggregation, manipulation, and retrieval of the data. This information (land use) is determined through the use of aerial photographs and/or field observation. Once classified and coded, the data are stored in a computer and are readily available for a potential user.

The steps involved in developing and employing a land use information system include:

1. Classification
2. Encoding
3. Geocoding
4. Data Evaluation
5. Storage
6. Retrieval
7. Analysis

Each step will be discussed in the following.

Classification

This step is, perhaps, the most important since a number of decisions must be made which affect the entire study and can determine its usefulness (or worthlessness). In choosing a classification system, or in devising a new one, certain considerations must be included if the system is to be complete. These considerations are, however, totally dependent upon the purpose of the study and the user's needs. Including all of them in one system would bring about a complexity with which the lay user would be unable to cope. It must be remembered that major concepts of the land must be included, but the extent to which this is done depends upon the uses to which the system will be put. It would be ludicrous to expect a potential user to undertake an exhaustive study of the data to determine how much (or how little) is of value to him. The important considerations may include:

1) Location - The data must be capable of being associated with a specific location. Whereas location in unchangeable, its relation to other tracts of land is not.

2) Activity on the land - What is it being used for?

3) Natural qualities of the land - These include the surface and subsurface characteristics and the vegetative cover.

4) Improvements to or on the land - This accounts for the relationships between improvements and activity.

5) Intensity of land use - This takes into consideration the amount of activity per unit of area.

6) Land tenure - Who owns it? Who uses it? Is there any relationship between the two?

7) Land prices, land market activity - What does it sell for? How much credit is based upon the land?

8) Interrelations in use between different tracts of land - The externalities of a piece of land affect activity on it more than the internalities.

9) Interrelations between the activities on the land and other economic and social activities.

(Clawson and Stewart, 1965, pp. 2-4)

However, for most uses, a classification system including only information on location and activity on the land is quite sufficient.

Clawson and Stewart outlined several requirements needed to develop an ideal classification system. They are:

1) It must be built upon logical concepts.

2) All data about the land should relate to a specific, exactly defined area.

3) In the basic enumeration stage, it should be concerned with securing maximum detail. Groupings and summaries should be included at a later stage.

4) It must be flexible.

5) It must provide the data readily to any user.

6) It should be efficient.

(Clawson and Stewart, 1965, pp. 161-64)

Several classification systems have been devised by various agencies, and the emphasis of each of these systems reflects the needs of the particular agency (Table 1). For instance, the Standard Industrial Classification of the Bureau of the Budget is concerned primarily with urban areas. While it does, in fact, provide classifications of non-urban land, it is sketchy and cannot adequately serve the needs of states with a great deal of rural land; nor does it concern itself sufficiently with land use -- it deals more efficiently with economic activity. However, it is a flexible system in that it allows for as much detail as the user deems necessary. (Clawson and Stewart, 1965).

The USGS system of land use classification is an attempt at a standard system for the United States. This system is excellent in that it shows

Table 1 Pros and Cons of Two Commonly Used Land Use Classification Systems

Classification System	Pros	Cons
USGS System	Shows activity	Doesn't show who owns land
	Shows natural qualities	Doesn't show improvements made (unless compared to old land use map, if available
	Shows interrelations in use between different tracts of land	Doesn't show land prices, credit, etc.
	Possibility of becoming standard system	Question as to whether it shows interrelations between activities on the land and other social and economic activities
	Detail can vary according to needs of users	
Standard Land Use Coding Manual (Urban Renewal Admin. & Bureau of Public Roads)	Shows activity	Doesn't show who owns land but has appendix which puts all private ownership in 1 category. Includes "public" under "services"
	Shows natural qualities	Doesn't show improvements
	Shows interrelations in use	Doesn't show land prices
	Detail can vary according to needs of users	Very sketchy for rural uses until you get to 4 digit levels
	Very detailed for urban uses	Can become much too detailed
	Can use auxiliary codes - for activities separated from but linked to other activities (dept. warehouse)	Concerned more with economic activity than with use
		Doesn't fit all recreational uses
		Needs modification to deal with multiple uses

the activity(s) on the land, its natural qualities, and the interrelations in use between different tracts of land. It accounts for both rural and urban land and it shows different levels of use. These levels are dependent upon the imagery used and the amount of detail required. Several states have set up their own classification systems using a modification of this one -- thus indicating its compatibility. (Anderson, Hardy, and Roach, 1972, p. 2-4)

Encoding

Once a classification system is chosen, it is necessary to determine a location identifier to be used in the process of coding. Tomlinson discussed four categories for locational identifiers which are:

1) External index - This identifies the data belonging to a particular geographic area or location and must be used with a map. Examples of an external index include street addresses, census tracts, and traffic zones. Unfortunately, this category does not allow for easy data manipulation.

2) Coordinate reference - This system uses the central point of an area to describe the parcel. Its main weakness lies in the fact that the coordinate reference contains little information regarding the boundaries of the parcels.

3) Arbitrary grid - This includes boundaries and coordinates that are a function of the size and location of the grid cell. While it is difficult to match grid cells to real areas, the arbitrary grid is used most frequently because it is easily implemented and manipulated and lends itself to computer cartographic techniques.

4) Explicit boundary - In this system, lines are described by widely spaced nodal points. The explicit boundary provides information about relative location, and it has extensive manipulation capabilities. However, it requires an extensive subsystem which adds to its complexity. (Tomlinson, 1970)

Table 2 summarizes the advantages and disadvantages of encoding systems which are currently in common use.

Geocoding

This step involves the spatial coding of geographical data and is a result of the first two steps. The geographical data involved in geocoding are obtained by measuring "...certain aspects of the land, the environment, the resources, the population, etc." (Tomlinson, 1970, p. 36) There are three dimensions the data may take. They are:

1) Thematical - What is being measured;
2) Spatial - A single data element refers to a certain location on the earth's surface and data sets are collected within a certain study area;
3) Temporal - The data is valid for a certain point in, or period of, time.

(Tomlinson, 1970, p. 36)

The data may also be measured in several ways, including:

1) Nominal - data of the presence/absence kind;
2) Ordinal - larger than or better than, such as soil capability ratings;
3) Continuous - can be measured on a continuous scale to any degree of required accuracy. An interval scale has an arbitrary 0 so ratios have a meaning. (Tomlinson, 1970, pp. 38-39)

Whatever form the process of geocoding takes is dependent upon the manner in which the data is gathered.

Gathering data

For most purposes remotely-sensed data provide an efficient means of determining land use for an area. The selections of level of detail is governed by the purpose of the inventory as well as its types and scales of imagery utilized. Using the USGS system, the first level contains the least amount of detail. Given the present state of the art, the information for Level I can be obtained from satellite imagery with little supplementary information. Level II is a bit more detailed but it can be obtained only if supplemented by topographic and/or high altitude photographs. Level III requires data from medium-altitude remote sensing (1:20,000) combined with detailed topographic maps and other supplemental information. Level IV, the most detailed, uses low-altitude imagery, but often the imagery must be supplemented with field observations or other independent services.

Data Evaluation

Once the data are encoded, the resulting information can be evaluated. Patterns of specific land uses may become apparent and areas of changing land uses (over time) can be determined. The data evaluation is a flexible step in that it is entirely dependent upon the user's needs. Once all of the land uses are coded, evaluation of the data is a simple process since, many times, it merely involves aggregating like codes.

Storage, Retrieval, and Analysis

These three steps, while important, are secondary to the others. Geocoding of land uses makes the storage and retrieval of the data a relatively simple process with a computer. The retrieval may be in the form of computer-generated maps or graphics or of land uses by location -- whatever the user desires. The analytical methodology to be employed will have some bearing on the type of output specified.

Methodology for the Keystone Land Use Change Study

In order to achieve a major objective of this research a Land Use Information System was developed for the study area which included the reservoir. It was decided to encode land uses using a modification of the United States Geological Survey Land Use Classification System, and an uniform grid system which consists of cells one-half kilometer on a side

Table 2 Advantages & Disadvantages of Several Encoding Systems

ENCODING SYSTEM	ADVANTAGES	DISADVANTAGES	AGENCIES & PRINCIPLE USERS
Point	1. Easy 2. Inexpensive 3. Can use any geographic referencing scheme for describing data	1. No areal extent 2. Graphic output - limited to dot maps 3. Requires digitization of parcel centroids or actual point location	For environmental plans - locations of wells, sources of air & H_2O pollution emission BATSC - "Bay Area Transportation System"
Uniform Grid	1. Easy to design & implement 2. Capable of overlaying attributes of cells & presenting results in mapped form 3. Can use weighting function 4. Storage, retrieval, data overlay, graphics straightforward 5. Can sum attributes of all cells 6. Flexible - can use complete sequential or compact encoding	1. Little data based on uniform grid systems available - so must obtain new data 2. Grid lines don't conform to natural or political boundaries	LUNR - NY State land use & Natural Resources Inventory GRIDS - Dept. of Natural Resources CMS - Composite Mapping System (Dpt. of Commerce-Eco. Dev. Admin) ORRMIS - Oak Ridge Regional Modeling Info System (Oak Ridge National Laboratory)
Non-Uniform Grid	1. Similar to uniform grid but uses rectangular public land survey 2. Can aggregate data 3. Can produce tabular summaries 4. Uses weighting function 5. Mapped output 6. Can collect data when naturally or politically defined cells	1. Have to obtain new data if finer resolution wanted	NARIS - Natural Resource Info Systems MLIS - Minnesota Land Info System

General Parcel	1. Accept any system of polygons which cover the study area 2. Can collect data when naturally or politically defined cells 3. Aimed at retrieval, aggregation, tabulation rather than weighing and mapping 4. Conforms to natural or political boundaries 5. Don't have to digitize data	1. More difficult to build than uniform grid - more expensive to design & develop 2. Need new data collection for finer resolution	GRDSR - "Geographically Referenced Data Storage & Retrieval System" (Dominion Bur. of Statistics, Can.)"
Area Boundary	1. Most general 2. Potentially most accurate 3. Can use any geographic referencing scheme 4. Virtually all existing data can be processed 5. Can reference data initially at finest resolution possible - avoids future data collection efforts	1. Difficult & expensive to develop 2. Have to digitize area boundaries before data can be input in the data base 3. Have to digitize or prepare on scanners maps of the data 4. Organize data too finely-shows specifics, not trends	CGIS -"Canadian Geographic Information System" (Canadian Dept. of Regional Eco. Expansion) IIPS - "Inter-Institutional Policy Simulation" (Univ. of British Columbia) Also uses generalized parcel
Network	1. Cost of development & operaation similar to parcel 2. Capable of manipulating network data & preparing tabular summaries of data with digitizer input 3. Can use any geographic referencing scheme 4. Problem of geographic referencing reduced to problem of point referencing	1. Requires digitizers or scanners to prepare mapped output	"Waterways System" - U.S. Army Corps of Engineers STORET - "Water Quality Data Storage & Retrieval System" EPA

(approximately forty acres). Aerial photography at the scale of 1:20,000 was utilized to encode land uses for each of three years, 1958, 1964, and 1970.

The grid employed is the Universal Transverse Mercator (UTM) Grid which is available on U.S. Geological Survey quadrangles at a 1:24,000 scale. Cells were thereby identified and geocoded using a seven-digit number with four designating north-south location and three designating east-west location of each cell. (Note: Actually the seven-digit number describes the southwest corner of each ½ km X ½ km cells). Land use and other relevant information from the aerial photographs was transferred to printed coding sheets (Figure 2) with the assistance of transparent grid overlays which correspond to the aerial photographic scale and which assisted in accurately locating the cells relative to the UTM grid.

Student assistants undertook the interpretation and geocoding of land uses, one year at a time. Quality control was maintained by utilizing teams of two interpreters who were instructed to obtain consensus, both in terms of the correct location of the cell's boundaries on the aerial photograph, and its land use characteristics.

Land use information was transferred from coding sheets to computer cards which were verified and subsequently transfered to magnetic tape. In all, approximately 9000 data observations were obtained, approximately 300 for each time period. In order to facilitate subsequent retrieval and analysis, data were "merged" in such a way as to produce a single card for each cell containing land use information for each of the three periods. Because of the variable coverage patterns of the aerial photography for the three time periods, a data set of 2341 cells, each containing land use information for all three time periods was obtained and utilized for most subsequent purposes. This data set was stored on disc, tape and cards.

Land use data were subsequently retrieved and summarized utilizing several standard statistical processing packages, and displayed in map form with the assistance of MAPLOT, a computer mapping program (Figure 1).

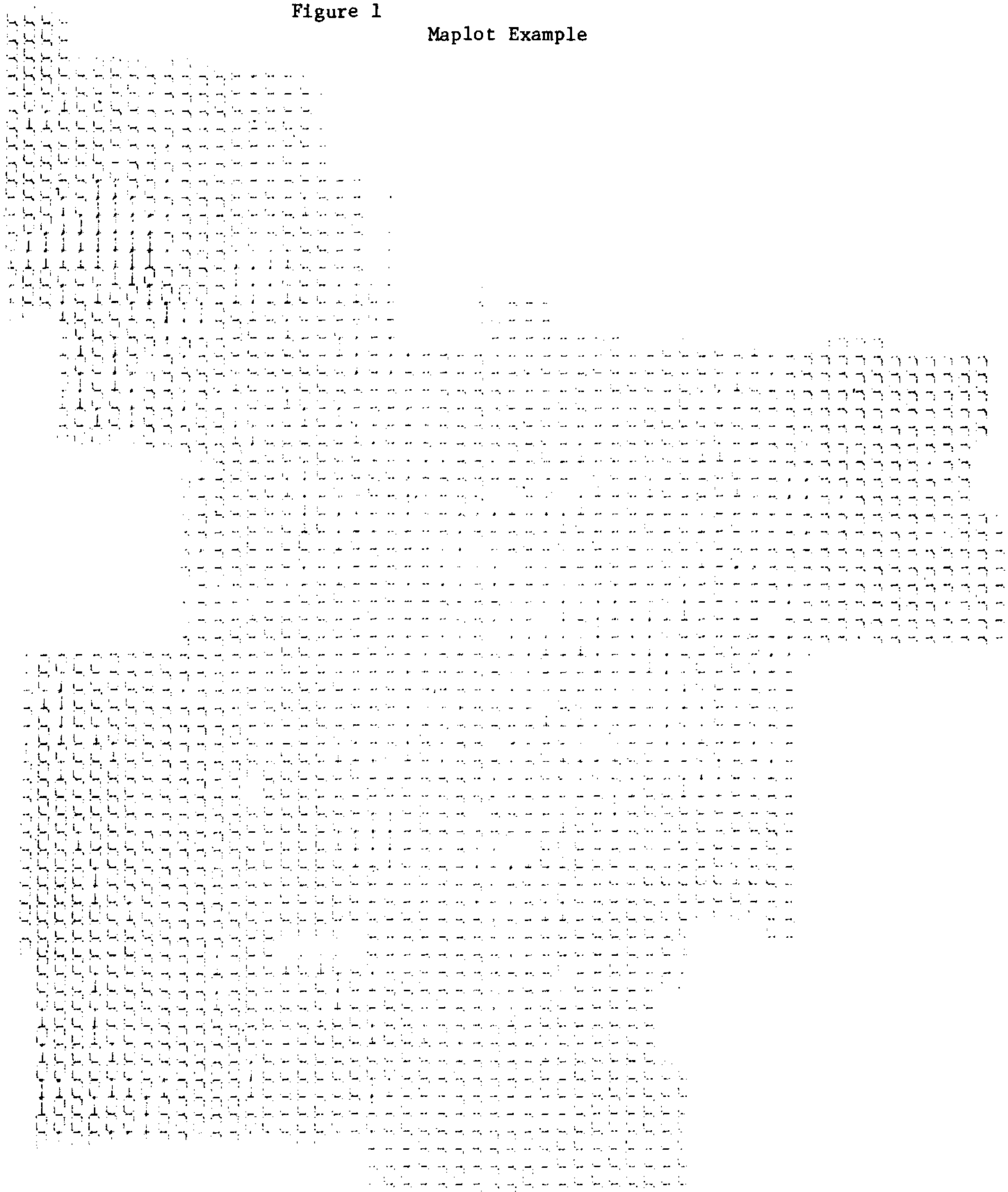
An Evaluation

Evaluation of the Land Use Information System employed in this study was deemed an important project objective. To a large extent, this evaluation can be undertaken by the reader himself by careful assessment of Chapter 2 of this report. Nevertheless, it may be useful to know the reactions of the principle investigators with respect to both the virtues and the shortcomings of the system. In addition an attempt is made to provide cost estimates for the development and utilization of the system.

The system seemed to work satisfactorily for the purposes for which it was designed. In particular, the cell size was consistent with the level of generalization desired. The binary coding procedure (presence or absence of a series of land uses) used for most land use variables could be done

Figure 1

Maplot Example



rapidly and with relatively few interpretative problems. The encodement of interval data on structures seemed useful and was subsequently used as an index of development intensity. No particular difficulties were experienced with the classification of land uses, either in interpretation, encoding data, or analyzing or understanding the results. While no sophisticated analysis of encoding errors was undertaken, subsequent experience with the data set indicated that it was relatively reliable. Estimated costs are presented in Table 4.

The encoding format and the data storage format allowed access and analysis which were consistent with the principle investigator's aims and resources. The use of MAPLOT in connection with the data set allowed land uses and land use change configurations to be displayed in useful form.

There were some shortcomings. Perhaps the most important one was the failure to efficiently designate cells that were completely flooded from those which were sometimes or partially flooded. This was largely an interpretative problem that could have been corrected had it been noticed soon enough. The decision to classify all structures together was probably ill-advised, for the structure count included oil wells and storage tanks, storage sheds, with residential and commercial structures.

Classification and geocoding accuracy could have been improved (at greater cost) by having interpreters check land uses in a given cell for all time periods simultaneously instead of checking all cells at one time period then proceeding to the next time period.

Table 3 Land Use Coding Sheet

(1-3)	______	X coordinates (East-West)	of SW corner
(4-7)	______	Y coordinates (North-South)	
(8)	______	Residential (1 if present)	
(9)	______	Commercial (1 if present)	
(10)	______	Manufacturing (1 if present)	
(11)	______	Extractive (1 if present)	
(12)	______	Highway Transportation or Parking (1 if present)	
(13)	______	Railroads or Other Utilities (1 if present)	
(14)	______	Institutional (1 if present)	
(15)	______	Cultivated Land, Orchards, Horticulture, Feedlots	0 = 0 - 10% 1 = 11 - 50% 2 = 50 - 100%
(16)	______	Pasture, Rangeland, Grassland	
(17)	______	Woodland	
(18)	______	Lake Water 0 = None 1 = Conservation 2 = Flood (854') 3 = Both	
(19)	______	Other Impoundments, Ponds (1 if present)	
(20-1)	______	Count of Structures present. All man-made structures.	
(22)	______	Study Region 1 = Keystone 2 = Pine Creek	
(23-4)	______	Year (last two digits)	
(25-6)	______	Coder Initials	
(27)	______	Proximity to Lake	
(28)	______	Proximity to Tulsa	

Table 4 Estimates of Costs Associated with the Keystone Land Use Information System

	Hours of Labor	Non-Labor Dollars Expended
Organization and start-up; obtaining airphotos	80 hrs.	$750.00
Classification and Encoding Land Use Data for Approximately 10,000 Observations	600 hrs.	$250.00
Punching, Verifying, Storing Data	200 hrs.	-
Programing for Merge, Cross-Tabulation, and Plotting Procedures	100 hrs.	-
Computer Changes for Land Use Cross-Tabulation for One Time Period*		$ 1.00
Land Use Change Tabulation for One Land Use by Region		$ 3.00
Maplot for One Land Use or One Land Use Change Pattern		$ 10.00

* Computer charges are for an IBM 360-65 System

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