

REGIONALIZATION FOR WATER PLANNING IN KANSAS

by

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B. A., Kansas State University, 1973

A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF ARTS

Department of Geography

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1977

Approved by:


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ACKNOWLEDGMENTS

I happily acknowledge my indebtedness to Dr. David E. Kromm, thesis director, upon whose kind advice and guidance I have relied throughout my graduate career. In addition, I offer humble appreciation to Dr. Sy Seyler, who led me into the field of geography, and Dr. Stephen E. White, who introduced me to quantitative techniques in geography, for their help with the statistical aspects of this study. Mr. Kris Arehart of the Kansas State University Computer Center deserves a hearty thanks for seeing me through the computer procedures involved. Mr. John C. Gottschamer, planner on the staff of the Kansas Water Resources Board, was instrumental in the series of events that led to this thesis, and I gratefully recognize his continuing support.

I am grateful to the Division of State Planning and Research, Kansas Department of Administration, Topeka for financial support for this project. I especially want to acknowledge Dr. Carl Heinze of that agency for the interest he has shown.

Ms. Linda Raborn, who designed and drafted all but one of the maps herein displayed, deserves immeasurable credit for her uplifting personal support. I also thank Mr. Huber Self of the geography faculty for use of the map in Figure 5-2. I extend a special thanks to Dr. T. M. Barkley of the Division of Biology, KSU, for his patient counsel and friendship, and I express sincere gratitude to all my friends who offered help, understanding, and laughter along the way.

Finally, I wish to extend warmest appreciation to my generous husband, Al Hanson, for putting up with me during the writing of this thesis.

TABLE OF CONTENTS

	Page
LIST OF TABLES	v
LIST OF FIGURES	vi
Chapter	
1. STRUCTURE OF THE THESIS	1
TRADITIONAL REGIONALIZATION FOR WATER PLANNING IN KANSAS	4
STATEMENT OF PROBLEM	9
JUSTIFICATION FOR STUDYING PROBLEM	11
PRESENTATION OF DATA AND ANALYSIS	14
2. REVIEW OF THE LITERATURE CONCERNING REGIONALIZATION AND WATER MANAGEMENT REGIONS	15
REGIONAL CLASSIFICATION	15
The Region	15
Regionalization	17
WATER MANAGEMENT	28
Importance of Water Planning	28
Current Thought on Water Planning Regions	32
Regional Alternatives	33
River basin regions	34
Economic unit regions	35
Field-level planning regions	38
Urban- or metropolitan-oriented regions	39
Summary	40

Chapter	Page
3. METHOD OF ANALYSIS	42
BERRY'S REGIONALIZATION PROCESS	43
Ordination	43
Similarity Scaling	47
Grouping Analysis	48
SELECTION OF VARIABLES	49
4. REGIONALIZATION FOR WATER PLANNING IN KANSAS	55
PRINCIPAL COMPONENTS ANALYSIS	55
Description of the Nine Components	56
Description of Unused Components	83
DISTANCE SCALING	85
GROUPING PROCEDURE	86
The Water Planning Regions	98
The Refinement Method	104
5. CONCLUSIONS AND IMPLICATIONS	115
COMPARISON WITH WATERSHEDS	115
IMPLICATIONS FOR PLANNING	119
METHOD USED	124
BIBLIOGRAPHY	128
APPENDICES	135
A. VARIABLES USED TO DERIVE WATER PLANNING REGIONS	136
B. RAW DATA	140

LIST OF TABLES

Table	Page
4-1. Rotated Variable Loadings for Nine Principal Components	57
4-2. Component Scores of Kansas Counties	60
4-3. Variable Loadings for Component One: Groundwater-dependent Irrigation and Aridity	66
4-4. Variable Loadings for Component Two: Urban Water Use	69
4-5. Variable Loadings for Component Four: Urban Water Demand Growth	72
4-6. Variable Loadings for Component Nine: Extensiveness of Irrigation Development	83
4-7. Variable Loadings for Five Unused Components	84
4-8. Steps in "Congroup" Procedure	87
4-9. Detail Lost in "Congroup" Steps	93

LIST OF FIGURES

Figure		Page
1-1.	Watersheds Used in Planning by the Kansas Water Resources Board	6
2-1.	Idealized Water Systems Planning Process	31
4-1.	Component One: Groundwater-Dependent Irrigation and Aridity	65
4-2.	Component Two: Urban Water Use	68
4-3.	Component Three: Irrigation Growth	71
4-4.	Component Four: Urban Water Demand Growth	73
4-5.	Component Five: Cattle Production	75
4-6.	Component Six: Increasing Cropland and High Water Cost	77
4-7.	Component Seven: Rangeland-Cropland Intensity	79
4-8.	Component Eight: Sprinkler Irrigation	81
4-9.	Component Nine: Extensiveness of Irrigation Development	82
4-10.	Kansas Counties in Alphabetical Order	91
4-11.	"Congroup" Regional Scheme After 84 Steps	96
4-12.	"Congroup" Regional Scheme After 75 Steps	97
4-13.	Final Regional Scheme for State Water Planning	99
4-14.	Major-Component-Scores Regions	106
4-15.	First Refinement	108
4-16.	Second Refinement	109
4-17.	Third Refinement	112
4-18.	Fourth Refinement	113
5-1.	Boundaries of the Ogallala Aquifer	117
5-2.	Groundwater Resources in Kansas	118

CHAPTER 1

STRUCTURE OF THE THESIS

This study defines a set of regions from which state water planning can be approached to provide the best combination of uses of water of sufficient quality and quantity to meet needs in the state of Kansas. The regions are devised by aggregating counties on the basis of similarities exhibited over a large number of water-related characteristics. The set of regions is designed as an alternative to the traditional watershed designation incorporated in current state-level water planning. At a minimum, the regions produced in this study can be used to assess on-going water planning activities.

The need for water management and planning¹ in Kansas is particularly acute, as irrigation serves to stabilize and increase the productivity of the agricultural pursuits on which the economy of the state is based. Irrigation increases crop yields significantly over non-irrigated practices, both in western Kansas, where precipitation is low and highly variable, and in eastern Kansas where supplemental irrigation provides protection against moisture deficits. In 1975,

¹ In a narrow sense, planning for water refers to assessing the current situation, projecting future needs, and recommending steps to meet those needs, whereas management implies a more encompassing process that aspires to "rational control of water" (M. B. McPherson, Prospects for Metropolitan Water Management, pp. 2-5). Management includes goal setting, information systems, research, planning, development, regulation, and financing (J. W. MacNeill, Environmental Management, p. 5), and is thus more comprehensive than water planning. In keeping with common practice, however, the terms planning and management are used interchangeably throughout this study.

approximately 14% of all acres planted to wheat, sorghum grain, and corn grain in the state were irrigated, accounting for about 23% of the total value of those crops.² The feedgrains produced through irrigation support a growing feedlot industry that generates increased revenue in some southwestern Kansas counties.

The variability of the Kansas climate greatly affects the amount and location of water available in the state. Ninety-nine percent of the surface water supply results from precipitation falling within state boundaries, but precipitation varies widely from year to year.³ Drought conditions alternate with floods, both of which incur great costs to Kansans, although these costs have not been measured in full and may not be measurable. Relatively heavy rainfall combined with non-porous rock result in the eastern one-third of Kansas being traversed by many moderate to large streams, yet underlain by very little groundwater. In the western two-thirds, surface flow is smaller because of lesser precipitation and greater evapotranspiration, but large underground aquifers have accumulated abundant groundwater reserves under selected areas. This groundwater provides for much of the state's irrigation activity, and it is being extracted more rapidly than it can be recharged naturally. This fact magnifies concern with water management and planning in the state. The water demands induced by agricultural and economic development in

²Calculated from figures derived from Kansas State Board of Agriculture, Kansas Agriculture, 58th Annual Report (Topeka: State Board of Agriculture, 1976) and DeLynn R. Hay, "1975 Kansas Irrigation Survey" (Manhattan, Kansas: Department of Agriculture Extension, Kansas State University, 1976). (Xeroxed copy.)

³Kansas Water Resources Board, Planning for Plenty (Topeka: Kansas Water Resources Board, 1966), p. 2.

Kansas must be met within these limits of surface and groundwater supply and distribution.

It has become apparent over the past half-century that the water resource in Kansas requires more effective attention. Recognition by the state government of an obligation to undertake water planning was first expressed in the Water Commission Act of 1917,⁴ but due to underfunding, activity was negligible until 1955 when the Kansas Water Resources Board was established as the state's water planning agency.⁵ Since its creation, the Board has prepared a state water plan and has sought policies and legislation to guide use, development, and control of water in the state. In addition to the Board, several state agencies maintain water planning functions and staff, such as the Division of Water Resources of the State Board of Agriculture, which is charged with administration of existing water laws, the Division of Environmental Health Services of the State Department of Health, the Kansas Geological Survey, the Kansas Parks and Resources Authority, the Kansas Forestry, Fish and Game Commission, the Kansas Corporation Commission, the State Department of Transportation, and the Soil Conservation Committee. Water planning efforts within the executive branch of state government currently are searching for a workable approach to the public management and planning of land and water resources.⁶ On a more local scale, many special districts involved with

⁴Kansas Water Resources Fact-Finding and Research Committee, Water in Kansas, 1955: A Report to the Kansas State Legislature (Lawrence: Fact-Finding Committee, 1955), p. 135.

⁵Statement by William E. Steps, deputy chief engineer of the Kansas Water Resources Board, personal interview, Topeka, Kansas, May 5, 1976.

⁶Statement by Dr. Carl Heinze, associate director of the Division of Planning and Research of the Kansas Department of Administration, personal interview, Sept. 29, 1976.

water have been organized since World War II, such as rural water, irrigation, levee, watershed, drainage, sewer, water supply, soil conservation, and groundwater management districts.⁷ At a larger scale, Kansas is divided by several major rivers, and some interstate water planning occurs within these large basins. Thus, water planning is being carried out on a continuum from the interstate to the local level, and in quasi-governmental organizations as well as governmental agencies. This study is concerned with comprehensive, state-level water planning.

Traditional Regionalization for Water Planning in Kansas

Throughout the United States, state planners traditionally have assumed a watershed approach in dealing with water resources, and this has been true in Kansas. The Kansas Water Commission Act of 1917 called for each watershed in the state to have a plan ". . .to secure the most advantageous adjustment of the interest involved in matters of floods, irrigation, water power and navigation."⁸ In 1927 the responsibilities of this act were passed on to the newly-formed Division of Water Resources of the State Board of Agriculture, but due to insufficient appropriated funds and involvement in World War II, the Division's efforts to analyze the state water situation or to produce any watershed plans were minimal.⁹ The Kansas Water Appropriation Act of 1945, prompted by the great

⁷See Kansas Water Resources Board, Special Water Districts in Kansas (Topeka: Kansas Water Resources Board, 1967).

⁸Kansas Water Resources Fact-Finding and Research Committee, p. 135.

⁹Steps' statement and Carl B. Shurtz, Kansas Water Law (Topeka: Kansas Water Resources Board, 1967), p. 49.

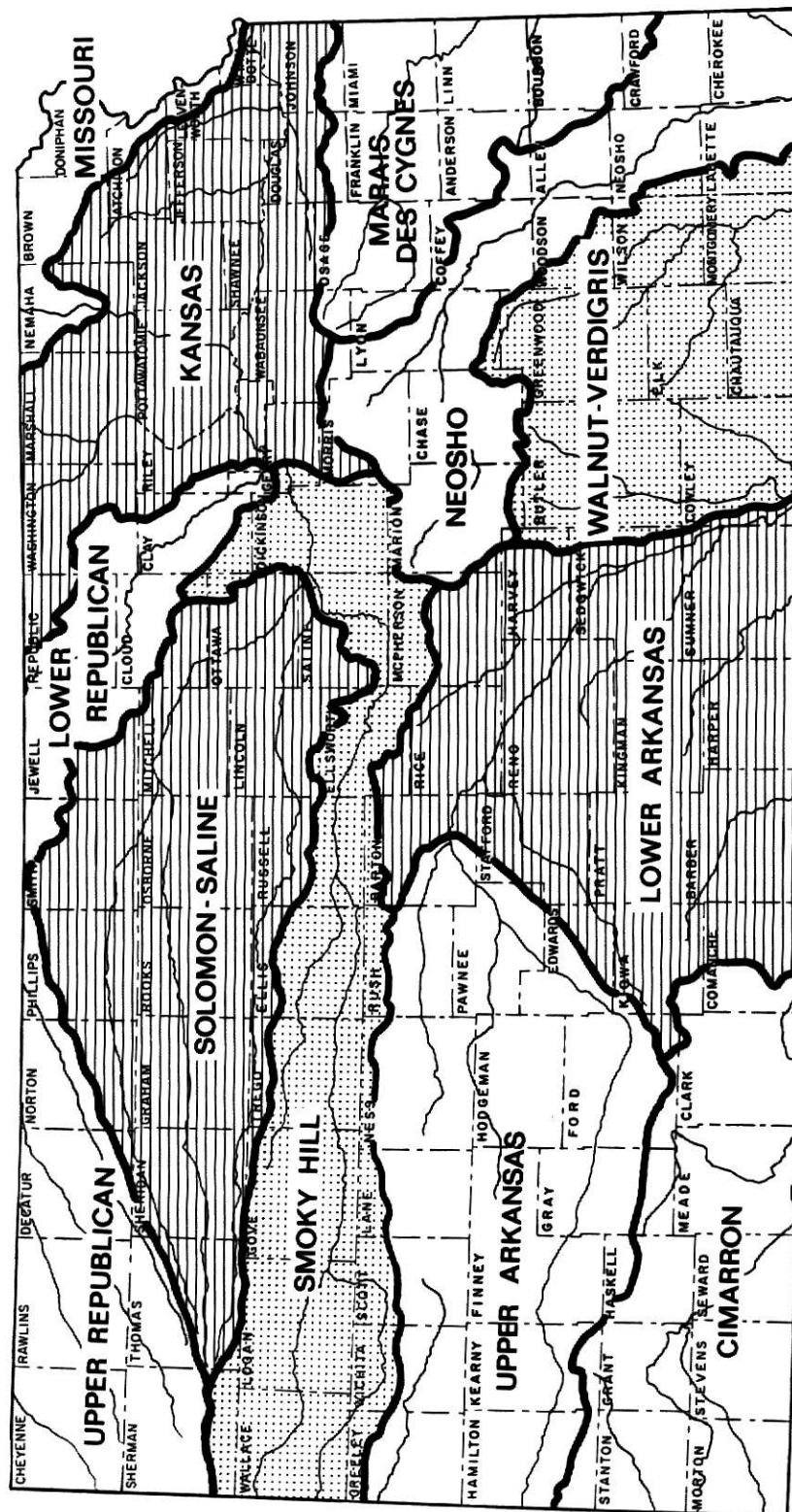
drought of the 1930's, dedicated Kansas waters to all the people of the state. This dedication was subject to the principle of beneficial use contained in the appropriation doctrine of water rights, which principle says water may be appropriated only in reasonable amounts and only for uses in the public interest. The flood of 1951 and subsequent years of drought again focused attention in the state legislature on the need for a state water management program. The result of that scrutiny was legislation creating the Kansas Water Resources Board in 1955. Among the duties specifically charged to the Board was the preparation of separate water plans for each of the twelve watersheds in the state.¹⁰

Figure 1-1 illustrates the twelve watersheds adopted by the Board for use in water resources planning. By 1961, the Board had prepared preliminary reports for each watershed. These reports merely appraised the available water supply, the nature of water uses and demands, the problems of water management, and estimates of future water requirements. In short, they were ". . .the background information necessary for the preparation of more detailed plans."¹¹ However, only one "more detailed plan" has been completed since 1961, that for a portion of the Lower Arkansas watershed, including parts of Rice, McPherson, Reno, Harvey, Marion and Sedgwick counties. Furthermore, the introduction to that publication called it an "investigation and report," not a plan, and stated, "The goal of this study was to provide the necessary information for the selection of management procedures and the implementation of

¹⁰Shurtz, pp. 50-51.

¹¹Kansas Water Resources Board, Section 5: Walnut-Verdigris Unit, State Water Plan Studies, Part A (Topeka: Kansas Water Resources Board, 1960), p. 8.

FIGURE 1-1



WATERSHEDS USED IN PLANNING
by the
KANSAS WATER RESOURCES BOARD

0 10 20 30 40 50

SOURCE: KANSAS WATER RESOURCES BOARD

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corrective or developmental measures. . . . It is hoped that the recommendations in the report will provide a starting point for conservation and management of the area's water resources by those who use them."¹² The Board currently is working on similar studies of two other areas--the Walnut River basin (part of the Walnut-Verdigris watershed) and all or parts of twelve counties in northwest Kansas. The Board has abandoned the twelve official watershed units in practice, and in northwest Kansas it has adopted a region based on county units.

The watershed may be defined as an area which is bounded by a water divide and which drains to a particular watercourse, and at first glance it may appear to be the most logical region for managing surface water, as the watershed occurs naturally, is easily recognized physically, and is self-contained. However, the approach presents several practical difficulties, the first of which lies in the varied meanings assigned the term "watershed." A watershed can range from a major river basin to the smallest drainage area discernible. One watershed may encompass other catchment areas, and thus the idea of a compact, observable, physiographic unit hinges upon selection of an appropriate level of division.

Acknowledging the difficulty of defining a watershed, the watershed focus consigns planners to a physical unit where patterns of use, supply, and management may be haphazard or illogical but which occur in the same catchment area. Humans alter the naturally occurring flow of water by creating reservoirs and by diverting water from one basin to use in another. In addition, human use may either improve or degrade the

¹²John J. Pinney, Jr., John A. Henderson, and Donald F. Kostecki, Little Arkansas Basin, State Water Plan Studies, Part C (Topeka: Kansas Water Resources Board, 1975), pp. 3-4.

quality of the water. Many factors affect the utility, supply, flow, and management of water that are not addressed in the traditional approach.

A major difficulty with the watershed approach is that it straddles political entities and fragments representative bodies, and there is no regional unit to implement or enforce the recommendations from the planning process. I feel that lack of an administrative structure in which planning may occur is partially responsible for the apparent inability to produce watershed plans in the state. Conflicts between political entities within watersheds can present obstacles first for creation and then for implementation of comprehensive plans and policies, as bickering and compromising may weaken the overall result. Thus, a watershed plan may or may not be implemented, regardless of its intrinsic worth. Data collection and recommendations within a watershed, without a mechanism for implementation and evaluation of plans, cannot aspire to the goals of water planning.

A further complication of the watershed approach is that watersheds do not adequately reflect the groundwater situation. Groundwater aquifers may correspond to surface water resources, but in most cases they do not. In Kansas, groundwater provides a major source of water, particularly for irrigation from the Ogallala aquifer in western counties, but also for municipal and industrial supplies throughout the state. The inherent logic of the watershed approach falters where groundwater is an important water source. The Kansas Water Resources Board has recognized this limitation in its abandonment of the surficially designated watersheds in northwest Kansas.

Water is unquestionably connected to many facets of the state's economy, including population distribution, the occupational spread of

the labor force, individual wealth, and governmental investment in public improvements projects. In fact, in our economic system, the value of water is generally measured in terms of indicators such as these rather than by any direct assessment of its intrinsic value. The many segments of the economy which are impacted by the availability and quality of water are in general unrelated to the physical watershed, and to attempt to observe them in that setting makes little sense. Measures of these segments usually are recorded within a governmental arrangement such as the county. Data for these important water-related items is not available on a watershed basis; thus, holding to a watershed approach to water planning complicates the planner's task notably. In light of the above considerations, the watershed approach to water planning in Kansas does not optimally represent political, physical, or socio-economic reality, and its utility for state-level water planning, either by functional agency or by the executive branch, should be reviewed.

Statement of Problem

Kansas could benefit by a water regionalization scheme that overcomes some of the difficulties of the watershed approach without imposing other, perhaps more severe, constraints. The purpose of this thesis is to create comprehensive, state water planning regions for Kansas based on pertinent variables reflecting the actual nature of the water situation in the state, as an alternative to the watershed planning tradition. This purpose requires examination of those variables that are significantly associated with the supply, use, and management of water to see where in the state those characteristics are similar. Areas with similar water-related traits would constitute regions in which water planning

might be addressed appropriately and effectively. The underlying hypothesis is that the water-related variables co-vary in a regional pattern. A further assumption is that the spatial pattern can be refined into a set of water planning regions that will promote efficacious state-wide water planning. As current and past attempts have achieved only marginal success, such a comprehensive regional approach may be a worthy contribution to productive water planning efforts and theory.

The preceding section illustrated that when considering the issue of regional water planning units, one needs to measure the efficacy of the approach from a political/implementation standpoint as well as its inherent physical cohesion. The spatial setting of an operation has a significant bearing on the attainment of that operation's objectives, and when political forces are called into play, as they would be in any attempt to manage publicly such an essential resource as water, the scale of performance becomes even more apparent and critical. For this reason, the seventy-one water-associated variables selected for this study are tabulated by county, as that unit provides a governmental framework in which decisions concerning water planning can be made and executed.

As far as this student could determine, this thesis is the first effort ever undertaken to construct politically-coherent, water planning regions analytically rather than by designation of the natural watershed unit for the purpose of state water planning. This is not an attempt to defy gravity, as I recognize that water flows downhill, but it is rather an attempt to insert water planning into existing political structures so that plans may be made, administered, financed, and enforced effectively.

To produce the new set of state water planning regions, a three-stage process of regionalization developed by the foremost geographer-

pioneer in the field of quantitative regionalization, Brian J. L. Berry, is employed. This process enables one to manipulate, compare, and interpret a large number of variables collected for an array of locations to obtain a regional scheme based on those variables.¹³ His procedure, or a modification thereof, has been used repeatedly for various types of regionalization and classification schemes, and will be presented in detail in Chapter 3. Following Berry's system facilitates the derivation of multi-factor water planning regions that exhibit attributes more similar within their boundaries than without. More importantly, the regionalization scheme will permit state water planners to make valid judgments concerning water management on the basis of differences or similarities of water characteristics between two or more regions. The scheme isolates areas between which basic assumptions must differ because of variations in water-related characteristics, a purpose designed to improve the water planning process.

Justification for Studying Problem

Geographers traditionally have considered regions and regionalization problems and procedures. A region is a subdivision of the earth's surface which meets certain criteria, whether the criteria are political or administrative, as in a priori regions such as states, or more specialized, as in natural resource homogeneity or a particular level of economic linkage. It is hardly surprising that regions captured

¹³Brian J. L. Berry, "Grouping and Regionalizing: An Approach to the Problem Using Multivariate Analysis," Quantitative Geography, Part I: Economic and Cultural Topics, Northwestern University, Studies in Geography, 13, ed. W. L. Garrison and D. F. Marble (Evanston, Ill.: Department of Geography, Northwestern University, 1967), pp. 219-251.

attention in the field, as geography "focuses on the similarities and differences among areas, on the interconnections and movements between areas, and on the order found in the space at or near the earth's surface."¹⁴ Organized regional study began in northwestern Europe after 1750, but did not stir interest in America until the next century.¹⁵ Compendious descriptions of the political divisions of the earth were produced. The focus remained regional variety within a country or continent rather than the systematic exploration of geographic topics until American geomorphologists and climatologists began topical studies in the 1920's, paralleling developments in Europe. Here is seen the contrast between two recognized approaches to regional study: the regional approach starts with an a priori region and examines its components, whereas the topical approach starts with a problem and seeks regional patterns related to it.¹⁶ This thesis assumes the topical approach in that it focuses on water and related characteristics and seeks regions to illustrate spatial patterns defined by these characteristics.

The general purpose of regional study, in the words of Preston James and Clarence Jones, is the "recognition, delimitation, and interpretation of segments of earth-space."¹⁷ Several, more specific purposes for which geographers study regions or apply the regional method to the study of particular problems have been listed by James and Jones. These

¹⁴Preston E. James and Clarence F. Jones, American Geography: Inventory and Prospect (Syracuse, N. Y.: Association of American Geographers, 1954), p. 23.

¹⁵*Ibid.*

¹⁶*Ibid.*, p. 32.

¹⁷*Ibid.*, p. 57

include satisfaction of curiosity about a region, differentiation of two or more regions, comparison of similar regions, clarification of the functional components of an area, exploration of cause and effect, distillation of a foundation for private or public policy, and establishment of operational administrative or military regions.¹⁸ The purpose of the regional study pursued in this thesis is contained in the last two, in that regions are sought in which plans and policies for water can be administered.

The delineation of planning regions is a continuation of a long-term trend toward applied geography. As D. Thomas has pointed out, ". . . the germ of the idea that geographical concepts, techniques, and methods should be applied to the study of the everyday problems of society lies deep in the history of modern geography."¹⁹ Herbertson argued for the application of geographical findings as long ago as the 1890's,²⁰ and more recently, four chapters in Trends in Geography: An Introductory Survey by Ronald U. Cooke and James H. Johnson²¹ were devoted to applied geography, reflecting its increased stature in the field today. Three of the four chapters concerned the interrelations between geography and planning. Geographers have contributed to the field of planning through concepts such as central place theory, techniques such as mapping and surveying methods, analytical studies of particular problems, input to

¹⁸Ibid., p. 55.

¹⁹D. Thomas, "Geography and Physical Planning," Trends in Geography: An Introductory Survey, ed. Ronald U. Cooke and James H. Johnson (London: Pergamon Press, 1969), p. 199.

²⁰Ibid.

²¹Ibid., pp. 199-243.

governmental operations, collection of pertinent data, and instruction to planning students.²² A logical extension to this list is regionalization techniques that might improve planning approaches. Although this student found no previous study attempting to define water planning regions, according to Johnston, ". . . geographers often study planning regions. . . . The selection of such formal or functional regions is often basically a political decision, but successful delimitation will indicate a successful test of the hypothesis that there exists some system of grouping of areal units in which all parts would derive utility from proposed planning activity."²³ The results of this thesis should confirm Johnston's observation.

Presentation of Data and Analysis

With the objectives of this study in mind, Chapter 2 presents a review of the literature, both within and outside the field of geography, concerning previous comparable regionalization attempts and current thought on proper water planning regions. In Chapter 3 the method followed in this study is detailed, along with comment on the variables selected. The major substance of the thesis is contained in Chapter 4, as it presents the results of the principal components analysis, distance scaling, and grouping analysis. It also includes the methods used to transform the analyses into a county-by-county regionalization and displays the final regional scheme produced. Chapter 5 discusses the validity of the statistically-derived regions, suggests implications of this study for the state water planning function in Kansas, and comments on the method employed.

²²Ibid., pp. 201-207.

²³R. J. Johnston, "Grouping and Regionalizing: Some Methodological and Technical Observations," Economic Geography, XLVI (1970), p. 294.

CHAPTER 2

REVIEW OF THE LITERATURE CONCERNING REGIONALIZATION AND WATER MANAGEMENT REGIONS

The subject matter of this thesis involves regional classification and regional management of water resources. This review is designed to familiarize the reader with the philosophy of regionalization in geography, to indicate the types of regionalizations that have been performed in the recent past with statistical techniques similar to those used in this study, and to review in more depth those regional schemes that are directly relevant to this research project. In addition, this chapter suggests current thought on regionalization for water planning and summarizes several articles which suggest particular regional approaches to water management.

Regional Classification

Before discussing regions and regionalization in terms of water planning, it is important to have a clear understanding of what these terms mean in the field of geography. The following notes on regionalization should help to clarify the purpose of, and procedures employed in, this thesis.

The Region

Despite universal use of the term "region," it is a concept that is difficult to define. Grigg said, "There is no agreed definition of the term 'region' when it is used unqualified by an adjective: but it seems

generally to be used to mean a part of the earth's surface which is distinguished in some defined way from surrounding areas."¹ (Emphases are mine.) Distinctive areal units are the aim and the result of the regionalization process.

Until recently, geographers generally recognized three types of regions: uniform or formal regions which are homogeneous regarding certain designated criteria; functional or nodal regions which illuminate relationships between phenomena and the space in which they occur, usually distinguished by linkages or flows between a central place or function and its hinterland; and administrative or institutional regions, usually arbitrarily defined by political boundaries, through which governmental decisions are made and which may be given legal recognition. A fourth type of region that has been acknowledged more recently is the perceptual or mental region, which may but vaguely resemble physical reality in illustrating thought or intuition about geographic areas, but which is important as it shapes individuals' ideas and decisions. In addition to these four types, regions also can be divided into two categories: generic and specific. Generic regions, alternately called regional types, are areas sharing certain characteristics throughout the world, and, thus, these regions are not unique. Coal regions serve as an example. On the other hand, specific regions are singular areas, distinguished by relative location as well as intrinsic attributes. The Manufacturing Belt in the United States is such a region.

¹David Grigg, "Region, Models, and Classes," Models in Geography, ed. Richard J. Chorley and Peter Haggett (London: Methuen, 1967), p. 464.

The question of whether the region exists in reality has been the subject of recurrent debate in this country in the past century. In 1954, Whittlesey wrote, "Acceptance of the region as objective reality is flatly rejected,"² but a 1967 study by Minshull concluded that substantial disagreement remained over the region as a conception of the geographer's mind versus physical reality.³ Despite this rekindling of the debate, American geographers today in general do not perceive regions, except a priori, political regions, as concrete reality, but rather see regionalization as an investigatory device for segregating areal features.⁴ Nevertheless, Soviet and Eastern European geographers to date largely regard the region as a real entity.⁵

Regionalization

The tradition of regionalization in geography is directly comparable to classification or taxonomy in other sciences.⁶ Given a set of objects (areal units), taxonomic procedures rearrange the set into a system of classes (regional types) based on some predetermined measurements chosen to reflect the item or items being examined. The criteria for

²Derwent Whittlesey, "The Regional Concept and the Regional Method," American Geography: Inventory and Prospect, ed. Preston James and Clarence Jones (Syracuse, N. Y.: Syracuse University Press, 1954), pp. 19-68.

³Roger Minshull, Regional Geography (Chicago: Aldine Publishing Co., 1967).

⁴Richard Hartshorne, Perspective on the Nature of Geography (Chicago: University of Chicago Press, 1959).

⁵Grigg, "Regions, Models, and Classes," pp. 472-3.

⁶For example, see Grigg, "The Logic of Regional Systems," Annals of the Association of American Geographers, LV (1965), pp. 465-491, and "Regions, Models, and Classes," p. 463; R. J. Johnston, "Grouping and Regionalizing: Some Methodological and Technical Observations," Economic Geography, XLVI (1970), pp. 293-305, and Classification in Geography, Concepts and Techniques in Modern Geography series, No. 6 (Norwich: Geo Abstracts Ltd., 1976).

regionalization must also reflect the type of region desired, i.e. uniform, nodal, etc., and logic must be employed in deciding which type is appropriate. If only contiguous areal units are entered into the same class during the classification procedure, a system of regions rather than regional types emerges. There is some controversy over the use of contiguity constraints in regionalization, because, as Johnston argued, they preclude testing of the assumption that contiguous homogeneous areas do exist.⁷ The use of the contiguity constraint, he asserted, changes the hypothesis from "Groups forming spatially compact units exist in the population" to "Contiguous areas exist which are to some extent alike." He further stated that "There is no basis in geographic theory, even that of functional regions, for the adjacency requirements."⁸ However, Spence and Taylor noted that contiguity, if necessary to the research purpose, is a legitimate requirement because regions are artificial by definition and a contiguity constraint cannot make them more so.⁹

It is imperative to note that there exists no "correct" classification or regionalization. The scheme produced depends on the criteria and characteristics considered in constructing the regions, which in turn depend on the specific purpose of the regionalization, i.e. to construct state water planning regions. One might select a single criterion to arrive at a single-feature region or several criteria resulting in a set

⁷ Johnston, "Grouping and Regionalizing," p. 295.

⁸ Ibid.

⁹ Nigel A. Spence and Peter J. Taylor, "Quantitative Methods in Regional Taxonomy," Progress in Geography, Vol. 2, ed. Christopher Board et al. (London: Edward Arnold Publishers, Ltd., 1970), pp. 49-50.

of multi-feature regions. A corollary of this idea is that a separate regionalization must be performed for each special topic being regionalized.

Regionalization in geography, as in other forms of classification, has three primary objectives, which are to give names to things, to transmit information, and to make inductive generalizations.¹⁰ The third reason is preeminent in most classification attempts, and both the transmittal of data and the construction of inductive generalizations are important in the regionalization that is the focus of this thesis. The production of a regional scheme should not be regarded as an end in itself, but as a facilitator for further research or decision-making. Two processes of regionalization are generally recognized: synthetic and analytic. In synthetic regionalization, also termed agglomerative or aggregative, base areal units are combined to form larger units, whereas a total population is subdivided into smaller regions in analytic or divisive regionalization. Agglomerative regionalizations are more common in geography,¹¹ and the process used to produce water planning regions in Kansas is an agglomerative technique combining counties on the basis of similarity among variables associated with water.

Historically, regionalizations were founded on general familiarity with an area, joined perhaps with some rudimentary mathematical observations. Quantitative techniques for regionalization were experimented with during the first half of the century, proof that the move to such methods antedated the "quantitative revolution" of the 1950's considerably. In

¹⁰ Grigg, "The Logic of Regions," p. 469.

¹¹ Spence and Taylor, p. 40.

1939, the British statistician M. G. Kendall published a study that divided the forty-eight English counties into regional types based on crop productivity.¹² Each county was ranked according to its yield for each of ten crops. Of importance to this thesis, Kendall constructed a productivity coefficient which referred to the result of a complex set of interrelated causes, i.e. fertility, management, moisture, etc., in much the same way that a principal component is composed of a set of interrelated variables. In the same vein, Margaret Jarmon Hagood, a statistician at the University of North Carolina, in 1943 regionalized the forty-eight coterminous states into six regions using principal components analysis.¹³ The regions were designed to be homogeneous regarding chosen agricultural, demographic, physiographic, economic, social, and cultural variables. Using a hierarchial series of principal components analyses, Ms. Hagood reduced tens of variables into one composite index for each of the six variable types in all forty-eight states, and then further reduced the six state indices into one representative state index for each state, which enabled Ms. Hagood to map a set of six regions. She imposed a simple contiguity constraint by requiring that each state be forced into a region not only of similar indices but of shared boundaries. These two studies by Kendall and Hagood opened the door to further exploration of quantitative regionalization approaches among geographers and others.

¹²M. G. Kendall, "The Geographical Distribution of Crop Productivity in England," Journal of the Royal Statistical Society, CII (1939), pp. 21-48.

¹³Margaret J. Hagood, "Statistical Methods for Delineating Regions Applied to Data on Agriculture and Population," Social Forces, XXX (1943), pp. 287-297.

In the field of geography, Brian J. L. Berry led the movement toward numerical taxonomy in the late 1950's and the 1960's. Since then, quantitative techniques have been incorporated nearly universally so that a regionalization can reflect many considerations simultaneously and so that relationships that might be indiscernible superficially might be detected. Several of Berry's papers developed his method,¹⁴ while others incorporated his techniques in the study of particular problems.¹⁵ Details concerning his specific method of approach are outlined in Chapter 3, but some of his studies will be summarized at this point in order to demonstrate his rationale and aims. As an example of his approach, in a 1961 article, Berry rank-ordered forty-three indices of level of economic development in ninety-five countries.¹⁶ Principal components analysis

¹⁴Brian J. L. Berry, "A Note Concerning Methods of Classification," Annals of the Association of American Geographers, XLVIII (1958), pp. 300-303; "An Inductive Approach to the Regionalization of Economic Development and Cultural Change," Essays on Geography and Economic Development, ed. Norton Ginsburg (Chicago: University of Chicago Research Paper #62, University of Chicago Press, 1960), pp. 78-107; "A Method for Deriving Multi-Factor Uniform Regions," Przegląd Geograficzny, XXXIII (1961), pp. 263-282; "Grouping and Regionalizing: An Approach to the Problem Using Multivariate Analysis," Quantitative Geography, Part I; Economic and Cultural Topics, Northwestern University Studies in Geography, #13, ed. W. L. Garrison and D. F. Marble (Evanston, Ill.: Northwestern University Department of Geography, 1967), pp. 219-251; "A Synthesis of Formal and Functional Regions Using a General Field Theory of Spatial Behavior," Spatial Analysis, ed. B. J. L. Berry and D. F. Marble (Englewood Cliffs, New Jersey: Prentice-Hall, 1968), pp. 419-28; "Numerical Regionalization of Political-Economic Space," Economic Regionalization and Numerical Methods, ed. B. J. L. Berry and Andrzej Wrobel, Geographia Polonica, XV (1968), pp. 27-35.

¹⁵Berry, "Identification of Declining Regions: An Empirical Study of the Dimensions of Rural Poverty." Areas of Economic Stress in Canada, ed. W. D. Wood and R. S. Thoman (Kingston, Canada: Industrial Relations Centre, Queen's University, 1965), pp. 22-70; "An Inductive Approach to the Regionalization of Economic Development and Cultural Change"; "Basic Patterns of Economic Development," Atlas of Economic Development, ed. Norton Ginsburg (Chicago: University of Chicago Department of Geography Research Paper #68, 1961), pp. 110-119.

¹⁶Berry, "An Inductive Approach to Regionalization."

revealed four distinct underlying dimensions which together summarized the information contained in the forty-three separate variables. Berry graphed the component scores for each country on each dimension in four-dimensional vector-space to demonstrate the degree of difference or similarity between the countries. From the graph, he constructed a linkage tree that successively grouped the most homogeneous pair of contiguous countries into larger sets of countries to maximize internal homogeneity. This piece of work is regarded as the beginning of modern, statistical regionalization attempts in geography.

Berry further developed his techniques in a 1965 study identifying and characterizing areas of rural poverty in Canada.¹⁷ Forty-seven variables were computed for each of 555 municipalities in Ontario and were then factor analyzed to reduce redundancies and distinguish relationships among them. Five separate factors were isolated. Maps prepared for some of the municipalities, based on factor scores, displayed a system of regional types rather than contiguous regions, as no contiguity constraint was applied. Analysis of factor loadings and scores, which show the contribution of each variable to the factor and the importance of each factor to the municipalities, respectively, enabled Berry to account for the differences between the regional types. In a later study, Berry again illustrated his factor analysis, distance scaling, and grouping analysis system by obtaining a regional scheme for a set of thirty-six business centers using thirty-four variables.¹⁸ As opposed to several of his other

¹⁷Berry, "Identification of Declining Regions."

¹⁸Berry, "Grouping and Regionalizing."

studies in which numeric values were attached to the variables used, this 1967 study employed nominal scaling, where a one or a zero indicated the applicability or inapplicability of each variable, demonstrating the use of his procedures in qualitative as well as purely quantitative studies.

Berry produced a further innovation in approach in 1966 when he tabulated sixty-three economic variables for thirty-six areas in India, where the variables were commodity flows rather than static numerical measurements.¹⁹ This greatly increased the complexity of analysis, as there were $36^2 - 36 = 1,260$ possible pairs of areas between which the commodities could flow.²⁰ In return, this procedure allowed Berry to obtain a functional rather than a homogeneous regional scheme. For economic analyses, functional regionalizations have obvious advantages over homogeneous regionalizations as the former are of more interpretative significance.

It is apparent throughout Berry's work that his concern with improving the process of regionalization is not with regionalization as an end product but with revealing patterns and interrelationships that illuminate dark areas in geographic research and promote better understanding and decision-making. Many subsequent regionalization attempts have followed Berry's leadership. It would serve no purpose to describe the many regionalizations here, but a few are cited to indicate the wide variety of subjects regionalized. Types of areas identified include

¹⁹Berry, Essays on Commodity Flows and Spatial Structure of the Indian Economy (Chicago: University of Chicago Department of Geography Research Paper #111, 1966).

²⁰Berry, "Numerical Regionalization of Political-Economic Space," p. 30.

agricultural regions,²¹ areas of similar levels of economic development,²² housing areas,²³ city classifications,²⁴ social areas,²⁵ and climatic regions.²⁶ These studies have demonstrated the value of regionalization and have verified Berry's approach. Despite the many regionalizations, only two studies were found whose explicit purposes were directly comparable to the attempt to delineate state water planning regions in this thesis.

James F. Bock in his 1973 Master's thesis at Kansas State University, entitled "The Regional Structure of the Kansas Economy," completed a principal components analysis, distance scaling, and grouping analysis for the 105 Kansas counties and thirty-six surrounding counties using sixty-two economic variables.²⁷ The stated purpose of Bock's work

²¹V. Zukovaskaja and L. Karpov, "Application of Multifactor Analysis in the Identification and Classification of Agricultural Regions," Papers of the Regional Science Association, XX (1967), pp. 55-62; P. M. Blaikie, "Spatial Organization of Agriculture in Some North Indian Villages, Part 1," Transactions of the Institute of British Geographers, LII (1971), pp. 1-40; R. J. C. Munton and J. M. Norris, "The Analysis of Farm Organization: An Approach to the Classification of Agricultural Land in Britain," Geografiska Annaler, LI-B (1969), pp. 95-103.

²²Mary Megee, "Economic Factors and Economic Regionalization in the United States," Geografiska Annaler, Series B. XLVII (1965), pp. 125-137; D. M. Smith, "Identifying the 'Grey Areas'-A Multivariate Approach," Regional Studies, II (1968), pp. 183-193; John H. Thompson et al., "Toward a Geography of Economic Health: The Case of New York State," Annals of the Association of American Geographers, LII (1962), pp. 1-20.

²³G. W. Carey, "The Regional Interpretation of Manhattan Population and Housing Patterns Through Factor Analysis," Geographical Review, LVI (1966), pp. 551-569.

²⁴K. J. Jones and W. C. Jones, "Toward a Typology of American Cities," Journal of Regional Sciences, X (1970), pp. 217-224.

²⁵J. B. Goddard, "Functional Regions Within the City Centre: A Study by Factor Analysis of Taxi Flows in Central London," Transactions of the Institute of British Geographers, XLIX (1970), pp. 161-182.

²⁶G. R. McBoyle, "Climatic Classification of Australia by Computer," Australian Geographical Studies, IX (1971), pp. 1-4.

²⁷James F. Bock, "The Regional Structure of the Kansas Economy," an unpublished M. A. thesis, Kansas State University, 1975.

was to determine the "true nature" of the Kansas economy and from that assessment to establish a relevant set of homogeneous economic regions. Bock believed that planning regions should reflect the actual character of the economic landscape and suggested that his regions could be adopted profitably as economic planning regions for Kansas.²⁸ Bock's study was modeled after Berry's ideas and rules for regionalization as discussed above. There are many similarities between Bock's study and this current effort.

Bock's analysis revealed ten underlying dimensions. After performing a distance scaling and centroid grouping of the ten components, he derived a system of thirteen regional types. Through a series of refinements, he forced the types into eleven contiguous regions, plus three metropolitan areas. The regions produced analytically bore little resemblance to the economic planning regions already adopted by the state.

In contrast to Bock, who searched for economic regions that might be used for planning, Benjamin H. Stevens and Carolyn A. Brackett in 1968 sought to delineate multi-county regions in Pennsylvania specifically for use in integrated development planning and programming.²⁹ The authors believed that multi-county regions were advantageous for planning purposes compared to single-county efforts, because as counties may have similar problems, economic efficiency is promoted if a single planning process is designed, administered, and financed for the group, and because competition among counties is avoided if cooperative planning efforts are

²⁸ Ibid., pp. 71-73.

²⁹ Benjamin H. Stevens and Carolyn A. Brackett, "Regionalization of Pennsylvania Counties for Development Planning," Economic Regionalization and Numerical Methods, pp. 153-187.

sought.³⁰ In seeking the optimal areal composition of development planning regions, Stevens and Brackett actually explored three types of multi-county regional schemes: homogeneous, nodal, and growth pole, which is a variation of the nodal type. To produce the homogeneous scheme, the two authors used Berry's technique of factor analysis, distance scaling, and grouping analysis with thirty-six social, economic, and political variables for the sixty-seven Pennsylvania counties. The results of that process were modified to construct a regionalization that "looked right," so that both single-county and overly large regions could be avoided.³¹ The nodal scheme followed the same basic routine except that, because only one variable was considered, the factor analysis step was not needed. The single variable was selected to represent functional linkages among the counties. The growth pole approach was based on the standard score³² of the population growth of each county, the assumption being that the higher the standard score, the more growth-inducing potential retained by the county. Counties with negative scores were attached to those with positive scores with the limitation that the summed scores remain positive. The authors developed a linear programming technique that linked sources of population growth in such a way as to maximize internal homogeneity in the growth pole regions.

Stevens and Brackett's three analytically-produced schemes varied considerably from one another. Operationally, the homogeneous regionalization

³⁰Ibid., pp. 153-154.

³¹Ibid., p. 177.

³²The standard score is mean minus the observed value, divided by the standard deviation, or in formula form, $\frac{\bar{x} - x}{s}$.

seemed the most straightforward and reliable, and the authors pointed out that the best criterion for defining homogeneity for planning purposes might be political, as such homogeneity would maximize the likelihood that plans would be implemented.³³ The reader will recall that this idea was stressed in Chapter 1 for water planning. Stevens and Brackett's nodal regionalization met the problem that counties may be too large to portray nodal linkages effectively, as one county might contain more than one node. Also, the authors' reliance on newspaper circulation by county as the sole measure of functional linkage illustrated the lack of linkage data available for this type of regional study. They experimented with a gravity formula to measure nodal linkages, but considered this approach to be highly unsatisfactory.³⁴ The third scheme, the growth pole regions, failed to recognize linkages between counties, the authors concluded.³⁵

The emphasis in the Stevens and Brackett article rested on theory and techniques for regionalization rather than on the resulting schemes. The authors ignored the implications of the regionalizations for development planning in Pennsylvania, and instead raised several questions concerning relative merits of different types of regionalization attempts, such as growth pole, nodal, and homogeneous; data problems; and criteria for establishing regions. They concluded that growth potential, homogeneity, and compactness are disparate criteria, and that therefore, by assigning weights to these criteria depending on the purpose to be furthered by

³³Stevens and Brackett, p. 157.

³⁴Ibid., p. 181.

³⁵Ibid., p. 184.

the scheme, one can achieve regionalization along a continuum of important variables.³⁶ This suggestion reinforces the notion that regions are devices for segregating areal features and do not exist in any "real" sense apart from the purpose for which they are defined.

Water Management

Importance of Water Planning

Management of water has been an on-going concern since the founding of this country, as evidenced by the commerce and property clauses of the Constitution, thousands of water disputes settled in court, operations of agencies such as the U. S. Army Corps of Engineers and the Bureau of Reclamation, and laws such as the Act of 1866 and the Rivers and Harbors Act of 1899. The National Water Commission, which was authorized in 1968, has stated national goals for water planning and development as follows:

1. to increase the efficiency of the national transportation system through water transport;
2. to develop the arid West;
3. to increase agricultural efficiency through irrigation and reclamation of wet lands;
4. to provide for flood protection;
5. to develop hydroelectric power;
6. to provide adequate water supplies for industry and municipal uses;
7. to increase recreational potential;
8. to preserve and enhance fish and wildlife;
9. to improve water quality;

³⁶ Ibid., p. 162.

10. to protect public health;
11. to promote aesthetic gains;
12. to induce economic development in low-income areas;
13. to provide for effective participation in water planning and development by states, lower levels of government, private enterprise, and the general public.³⁷

Thus, general water planning topics include flood control, water supply, recreation, irrigation, waste disposal, transportation, reclamation, power development, economic development, water quality enhancement, and fish and wildlife protection. However, many of these facets often have been ignored.

Until recently, water planning was synonymous with single-purpose, water resource development and displayed a strong economic and hydrologic-engineering orientation. Water was seen as a vehicle to enhance wealth, whether through irrigation, navigation and trade, industry, power installations, or tourism. Today the emphasis in water planning is shifting to water as a common-property resource which is recognized as the lifeblood on which our health, economic system, and technology thrive. As the wide-ranging importance of water to many facets of life is increasingly perceived, the approach to water planning is becoming less structural and more comprehensive. Also, more interests are becoming involved, as was pointed out in Chapter 1.

Although water planning occurs at the community, urban, metropolitan, regional, state, and national levels, this thesis primarily concerns state and substate-regional levels. State water resources planning today attempts to provide the best use or combination of uses of water and related

³⁷Charles F. Luce, "A Search for Goals in Water Resource Planning," Conflicts in Water Resources Planning, eds. Earnest F. Gloyna and William S. Butcher (Austin, Texas: Center for Research in Water Resources, 1972), pp. 9-10.

resources to meet foreseeable short- and long-term needs within the construct of state governmental priorities. Most of the goals set out by the National Water Commission apply as well to state water planning, although numbers one and two are more national in scope. In addition, it should be noted that state objectives, which are specific tasks designed to meet state goals, will vary from those employed at the federal, county, or private level. State water planning is characterized by a stress on regional integration, coordination of public and private water activities, multi-purpose and multi-means approaches, and research.³⁸ These items bind together the broad goals with the narrower objectives. It is the state water planner's task to recognize trade-offs and seek optimal resolution of conflicts over water use.

Water resources planning and management in an integrated framework is a recent evolutionary change, and the field is still developing. The abstractness of the systems approach to water planning modeled in Figure 2-1 reveals that the planning process is not well defined. As was pointed out in a recent book, Collective Decision-Making in Water Resource Planning, "All the elements, events, and activities we tend to include under the label 'water resource planning and decision-making' have not, as yet, been related to any basic, cohesive, and consistent theory. Water resource planning and decision-making do not have a set of overarching, guiding principles that can be called its own."³⁹ This

³⁸John R. Shaeffer et al., Metropolitan Water Resources Management as an Emerging Specialized Technical Area: A State-of-the-Art and Literature Review (Chicago: University of Chicago Center for Urban Studies, 1969).

³⁹Roy Burke III and James P. Heaney, Collective Decision-Making in Water Resource Planning (Lexington, Mass.: D. C. Heath & Co., 1975), p. xiii.

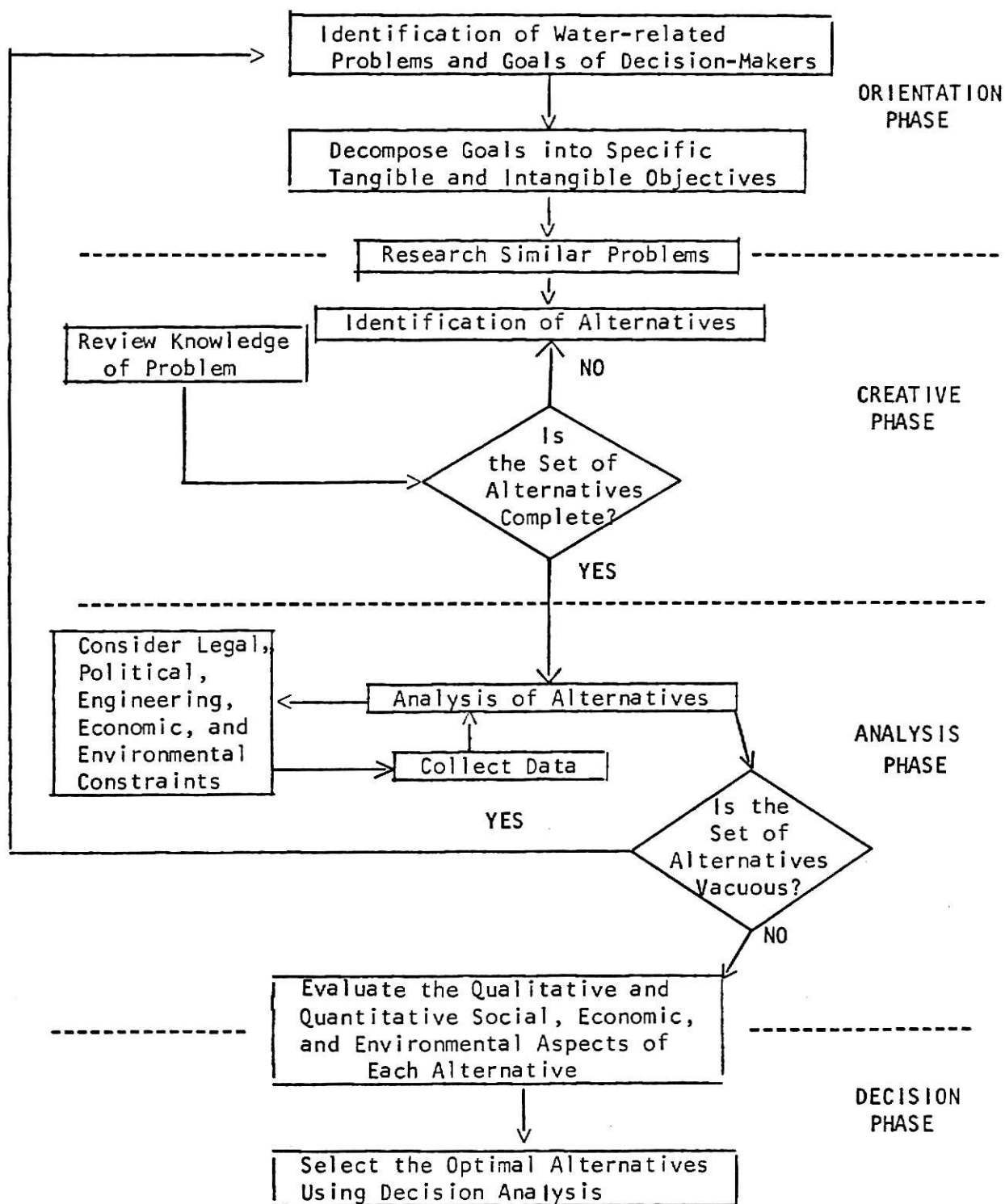


Figure 2-1. Idealized Water Systems Planning Process.
Adapted from Shih and Dean, 1973, pp. 36-37.

message stresses the importance of determining the appropriate or best spatial dimension in which water planning can be carried out. Any contributions to water resource planning theory are timely and desperately needed. It is hoped that this thesis might be such a contribution, as it suggests a method for determining the optimal spatial setting for state-level water planning.

Current Thought on Water Planning Regions

In all levels of water planning, the river basin has been used as the basic planning and development unit since the late nineteenth century. As political scientist Irving Fox pointed out in an article summarizing the development of water planning, "...The land and water resources of a river basin were seen as part of an enormous system that must be treated as a unit in planning and development programs."⁴⁰ Given this historical situation, despite the volume of material produced in the post-World War II period concerning management of natural resources and of water resources in particular, little attention has focused on the proper areal unit from which public and private management might most effectively be executed. This likely results from a general assumption that planning will be done on a watershed, usually a river basin, basis, due to that tradition. Though not usually explicitly stated, indications of this thought often are contained in the literature. A second feasible idea is that writers believe that their theory or approach to water planning could be applied to whatever areal scheme has been established in a given geographic

⁴⁰Irving K. Fox, "Review and Interpretation of Experiences in Water Resource Planning," Organization and Methodology for River Basin Planning, ed. C. E. Kindsvater (Atlanta: Georgia Institute of Technology Water Resources Center, 1964), p. 64.

context. An extension of this thought is that researchers may assume that the regional planning unit must be determined locally and that no universal statements can be made concerning propriety of various areal approaches. A less likely explanation for the lack of attention to water planning settings is that the attempt to define the proper spatial approach to water planning is not perceived as an important consideration.

The preceding paragraph is not intended to convey that regional settings for water planning have been totally ignored in the literature, for that would not be true. Rather it is meant to provide a mindset for the reader in which the relative sparcity of exploration into alternative water planning regions remains foremost. In the preceding section of this chapter, one saw that despite the many regionalization schemes produced, few had dealt with planning; now one sees the parallel case that despite the many writings about water planning, few have examined explicitly regional approaches to the subject. In short, regionalization for water planning has not been a subject of prolific debate.

Regional Alternatives

As the river basin has been the most widely accepted region, one important article serves to summarize thought concerning that unit. Other types of regions that have received attention include economic areas, field-level planning agencies, and urban- or metropolitan-oriented regions. This review is not exhaustive, but it touches upon the major types of water planning regions suggested. Because little has been written about the relatively new, comprehensive, state governmental water planning function, the literature reviewed herein may concern only specific aspects of water planning.

River basin regions. An important figure in United States water planning, Irving Fox, remarked that the establishment of the Tennessee Valley Authority had by the beginning of World War II marked the institutionalization of the river basin planning trend recorded during the previous seventy-five years.⁴¹ He said, "It was generally recognized that water resources planning should deal with the river basin as a unit."⁴² His article discussed alternative approaches to river basin planning since World War II and problems associated with those alternatives. Although his comments were directed toward large-scale river basin planning rather than toward state interests in water planning, several problems he identified are of interest here.

Fox questioned the lack of a "central authority to make a (planning) decision," believing that the voluntary nature of all agreements reached within the basin resulted in compromises which tended to weaken the effectiveness of the planning.⁴³ Another problem he cited was lack of continuity in planning, as basin planning commissions were established for a particular purpose, a plan was produced, and the commission was disbanded, leaving no one to follow through the implementation process. Implementation mechanisms were nonexistent or ineffective. A further difficulty lay in omission of an opportunity for total public scrutiny of the plans. Those special-interest groups and individuals who stood to gain by water development were well represented in the river basin planning and decision-making process, as they had financial incentive to be so, but

⁴¹ Ibid., p. 71.

⁴² Ibid.

⁴³ Ibid., p. 76.

Fox pleaded that those persons bearing much of the cost of such planning and development were not so well represented. It can be noted that the problems outlined by Fox are similar to those mentioned in Chapter I as reasons for shifting from watershed planning in Kansas to planning within groups of counties having similar water characteristics and also on-going, representative governmental structures for making decisions, implementing plans, and receiving public input.

In concluding his article, Fox opined that state water planning programs offer promise for more effective planning because "they (state programs) offer the possibility that. . . planning might become integrated with implementation and operation, that non-structural alternatives might be given greater consideration, and that water resources planning might be better related to other regional activities such as land use."⁴⁴ It would appear that Fox's view is being substantiated by the increased attention state governments currently are paying to water planning. This increasing attention also fuels the search for better water planning theory and practices, one aspect of which is sought in this thesis.

Economic unit regions.⁴⁵ In contrast to much of the literature that showed little or no direct concern with the areal setting for water planning, Lewis, Anderson, Fullerton, and Gardner very explicitly addressed regional delineation for water investment planning in 1973.⁴⁶ The purpose

⁴⁴Ibid., p. 85.

⁴⁵Economic unit regions are based on functional economic ties between areal units, usually counties or states, rather than on natural units or a priori political decisions.

⁴⁶W. Cris Lewis et al., Regional Growth and Water Resource Investment, (Lexington, Mass.: D. C. Heath & Co., 1973).

of their work was to evaluate the effectiveness of water resources investment as a means of achieving regional economic development,⁴⁷ and so their approach was not as comprehensive as that taken here concerning integrated planning for all aspects of water resources use and conservation. Instead, the authors' approach focused on the economic impacts of particular water investment projects, a facet which is only one of the goals of water planning set out by the National Water Commission (see above). In the authors' words, "Since the primary (economic) criterion for identifying a 'good' water investment is a benefit-cost test. . . , it seems appropriate that the basic spatial unit for analysis be defined primarily from an economic point of view."⁴⁸ To that end, the authors suggested the functional economic unit (FEA), which is a multi-county labor market defined by job-related commuting patterns around a metropolitan nodal city, as the best unit for the economic evaluation of water and other public projects.

In further discussing proper regions for water investment planning, Lewis et al. stated the desirability of constructing regions along county lines, because of the convenience of data collection and advantages of boundaries that coincide with recognized governmental units. Therefore they suggested that the FEA concept be modified to conform to county political jurisdictions. Lewis et al. viewed the river basin as sub-optimal, although they acknowledged that it was generally recognized as the appropriate unit for water resources study. They reasoned that despite the river

⁴⁷ Ibid., p. 3.

⁴⁸ Ibid., p. 9.

basin's homogeneity regarding some physical variables, other qualities such as economic and social parameters and functional linkages, which might be equally as important, might be ignored.

In a similar manner, Herbert W. Grubb argued that evaluation of alternative water investments should proceed on economic grounds, with regard to the total structure of the regional economy.⁴⁹ He described an input-output model procedure designed to analyze the interindustry structure of a regional economy to provide needed information to water planners and others. In general, input-output models state and relate the transactions of the individually identified sectors of the regional and statewide economies, representing trading of both input and final production, and Grubb explained that they could be used to express final demand for goods and services in terms of resource requirements such as acre-feet of water.⁵⁰

Grubb suggested his input-output model be applied to the nine, officially designated state economic regions. According to him, two criteria had been adhered to in delineating those regions: regional economic cohesion and homogeneity regarding natural resources, including water. Given that each established region was homogeneous concerning natural and economic variables, an input-output model could analyze and measure the "nature, extent, and economic implications of the underlying differences" among the regions.⁵¹ Grubb did not detail which variables were used to recognize economic cohesion or resource homogeneity, or what

⁴⁹ Herbert W. Grubb, "The Efficacy of a Coordinated Plan: The Texas Planning Model," Conflicts in Water Resources Planning, pp. 43-55.

⁵⁰ Ibid., p. 53.

⁵¹ Ibid., p. 49.

techniques were employed in defining regional boundaries for the nine economic regions, but he did indicate that the regions followed county lines. He made it clear that water investment planning should be done on the basis of these regions.

Field-level planning regions.⁵² Roy Burke and James P. Heaney in their 1975 book Collective Decision-Making in Water Resources Planning did not directly specify the areal configuration within which water planning might be carried out.⁵³ They did, however, develop the idea of "field-level water planning agencies" located conceptually between local interests and all extra-local concerns. This field-level agency was to serve as liaison and coordinator between local considerations and non-local interests, but no indication was given of what spatial area the agency was to represent nor of the governmental structure into which it was to fit.

Burke and Heaney argued that water planning must be related to the social system as well as to the physical and technical realms. They noted that, "This does not mean that water managers must be sociological theorists. Instead, it suggests that planning procedures should be adjusted until they 'become congruent with the conditions of the social environment' [quoting regional planner John Friedman]."⁵⁴ In this sense, the river basin

⁵²Field-level planning is carried out in non-specified areal settings intermediate between local and state or local and national levels, depending on the criteria employed to establish the agencies.

⁵³Burke and Heaney.

⁵⁴Ibid., p. 32.

approach to water planning ignores social and political aspects, whereas counties ignore the physical world. The regionalization attempted in this thesis utilizes both physical and socioeconomic data in an effort to integrate physical and social factors. Burke and Heaney also believe implementation of plans to be as important as their creation. The authors stated, "Plan formulation and program implementation must be considered together as interactive, integral components of the larger decision system."⁵⁵ This idea reinforces a similar one presented in Chapter 1 that data collection and plan formulation without implementation and evaluation are inadequate to the goals of water planning.

Urban- or metropolitan-oriented regions. Some of the writing on water resource planning and management centered on urban or metropolitan areas;⁵⁶ this urban-orientation for water planning often implies a regional approach based on the urban or metropolitan area. Shaeffer et al. indicated that the urban region might be nested within a larger water planning region, the river basin.⁵⁷ In the same book, a research need to develop workable methods to achieve regional integration for a range of management efforts concerning land and water resources was stated. The concept of "regional integration," however, remained vague.

⁵⁵ Ibid., p. 33.

⁵⁶ For example see Shaeffer et al., C. S. Shih and H. J. Dean, Decision Analysis on Water Resources Planning and Management for an Arid Metropolitan Center in West Texas (College Station, Texas: Texas A & M, University Water Resources Research Institute Technical Report #54, 1973); M. B. McPherson, Prospects for Metropolitan Water Management (New York: American Society of Civil Engineers, 1970).

⁵⁷ Shaeffer et al., p. 21.

Concerning metropolitan water planning, the rationale appears to be that metropolitan areas involve so many individual governmental units in such a compact area that some coordination of water planning functions is necessary from economic and practical standpoints. More than 68% of this country's population now resides in cities of 50,000 or more,⁵⁸ indicating that water planning for supply, use, and management in these metropolitan areas has an importance far out of proportion to the small land area they cover. There is usually a sharp division between state responsibilities for water management in rural and metropolitan areas, with the states assuming a hands-off approach in the latter other than for regulatory standards.

Summary

The reader should keep in mind that although some of the literature discussed in this section took exception in some manner to the river basin approach, that approach nevertheless remains the most widely accepted regional statement. However, the literature did indicate several problems with the river basin approach and suggested a need for research involving alternative approaches to water planning. I believe that a multi-county approach could overcome some of these inherent or operational difficulties with the river basin unit. I reject the economic unit approach to state water planning in Kansas, as data demonstrating functional linkages are quite difficult to select and obtain, and also because comprehensive water management involves facets other than water investments. Both authors recommending the economic unit approach addressed water investment

⁵⁸Calculated from United States Department of Commerce, Bureau of the Census, 1970 Census of Population and Housing, U. S. Summary, General Demographic Trends for Metropolitan Areas, 1960-1970 (Washington, D. C.: U. S. Government Printing Office, 1971).

planning. Economic variables are used in this study, as they are felt to be important to the homogeneous regionalization pursued. I also reject the urban or metropolitan-orientation for Kansas state water planning because of the rural nature of much of the state and because agriculture claims a much higher proportion of the water used in Kansas than do urban uses. It can be added that a system of multi-county regions such as sought in this study would seem to satisfy the requirements of the field-level planning agency suggested by Burke and Heaney. Also, this thesis employs a rationale similar to that apparent in the work of both Grubb and Lewis et al., i.e. water planning regions should reflect many variables related to the supply, use, and management of water, including socioeconomic elements.

CHAPTER 3

METHOD OF ANALYSIS

In recent decades geographers and others have attempted to define multi-factor regions involving a large number of variables. Procedures and techniques to handle many variables simultaneously, using advanced quantitative methods, have been developed, and these generally have replaced the variety of methods historically used to produce several types of regions. Single-feature regions, such as coal-producing, and regions based on natural features such as vegetation or climate, were easiest to derive, but attempts to regionalize based on several variables also were realized. Among the older, common methods was the simple map overlay using a small number of variables which generally were selected by intuition and were not often submitted to statistical tests to determine their validity. Areas in which characteristics showed similar patterns on the various maps were identified as cores of regions and areas between the cores were zones of transition in which boundaries were located. In other cases, the regionalizers considered themselves authoritative enough to draw regional boundaries based on their knowledge of an area. Many respectable studies resulted, despite the subjectivity of the methods employed. In modernizing their techniques, geographers have borrowed from taxonomic techniques introduced in other disciplines, including psychology, biology, statistics, and sociology. When, in the late 1950's, the biologists R. R. Sokal and P. H. A. Sneath introduced the school of numerical taxonomy, geographers began to apply quantitative

processes to regionalization problems on a large scale.¹ As numerical taxonomy refers to the numerical assessment of the similarity between taxonomic units and the classifying of the units according to their similarities, it parallels the application of quantitative techniques to regional problems.²

A leading contributor in the field of quantitative regionalization, Brian J. L. Berry refers to his work as "numerical taxonomy" as well. Berry has developed a three-stage process of regionalization: ordination, similarity scaling, and final grouping.³ As this study adheres to Berry's process, this is an appropriate point at which to present his regionalization system in some detail. Later in the chapter, the variables used in developing water planning regions are discussed.

Berry's Regionalization Process

Ordination

Ordination, the first stage in Berry's process, refers to attaching values to variables in an arrangement that facilitates comparison and understanding. The most widely used methods of ordination in regional taxonomy or classification have been principal components analysis and

¹Nigel A. Spence and Peter J. Taylor, "Quantitative Methods in Regional Taxonomy," Progress in Geography, Vol. 2, ed. Christopher Board et al. (London: Edward Arnold Publishers, Ltd., 1970), p. 5.

²*Ibid.*

³As presented in Brian J. L. Berry, "Grouping and Regionalizing: An Approach to the Problem Using Multivariate Analysis," Quantitative Geography, Part I: Economic and Cultural Topics, Northwestern University Studies in Geography, #13, ed. W. L. Garrison and D. F. Marble (Evanston, Ill.: Northwestern University Department of Geography, 1967, pp. 219-251, or "A Method for Deriving Multi-Factor Uniform Regions," Prezeglad Geograficzny, XXXIII (1961), pp. 263-279.

common factor analysis.⁴ Both techniques attempt to reduce a set of variables to a smaller set of underlying dimensions (patterns, stories, factors, components, etc.) without a great loss of explanatory power. In a list of variables, several items taken together may be highly correlated, yielding similar insights into the situation being studied. Principal components and common factor analyses seek those dimensions necessary to account for the interrelationships in the list, as identification of the underlying dimensions eliminates redundancies and condenses input to a more manageable level. Isolating the underlying components also illuminates relationships among the variables to aid in explaining observed reality. The major difference between principal components analysis and common factor analysis is that the former assumes that the variables selected explain all the variation in a given population (in this thesis, the water situation in the 105 Kansas counties), whereas the latter assumes that only a portion of the variation is explained by the variables. This study utilizes the principal components technique because it is operationally simpler and because a common factor analysis would offer no distinct advantages.

A sketch of the workings of principal components analysis demonstrates the procedure used to arrive at a set of water planning regions for Kansas. In the initial step, the variables are cast into an "n" by "m" data matrix ("n" locations, "m" variables per location). The data can be recast into a matrix of standard scores, each value being subtracted from the mean and divided by the standard deviation, so that diverse measures can be compared. For a regionalization problem, a

⁴Spence and Taylor, p. 9.

correlation coefficient matrix m by m is calculated from the matrix of standard scores. The correlation coefficient for each pair of variables represents the cosine of the angle between the two vectors representing the variables plotted in the standardized space for the locations (n -space). The correlation coefficient matrix thus eliminates the need to plot or visualize the plotting of points in more than three dimensions.

Principal components analysis draws out underlying dimensions in order of decreasing value in explaining the variation in the population at hand. Each dimension is a combination of variables that are highly correlated. The cluster is represented by a vector plotted in n -space so as to best describe all the variables in that cluster. The first such vector or component is analogous to the resolution vector in physics that represents or balances the weight and placement of all the variable point vectors. Once the first underlying dimension is found, the angle between it (the resolution vector) and each of the other plotted point vectors is measured. The cosine of each of the angles thus measured is the variable loading for each respective point and represents the contribution of the variable to the dimension. The higher the loading, the more important the variable in explaining or creating the dimension. Each variable loading, when squared, indicates the proportion of the variation in the variable that is associated with the variation in that component. Examination of variable loadings enables one to label the new dimension and interpret the component scores of each place for each new component. Component scores are calculated by multiplying the matrix of standard scores by the component loading matrix. This, in essence, multiplies each standard score by the strength with which it is associated with each dimension.

The second, third, and subsequent underlying dimensions are obtained following a modification of the original process. The number of components necessary to explain a satisfactory amount of the variation in the population depends on the strength of the dimensions, but in any case cannot exceed the number of variables. Since one of the aims of principal components analysis is data reduction, one hopes to keep the number of components low and the explained variance high. The sum of the squared variable loadings for each new dimension, called the eigenvalue, is used to derive the proportion of the total variation summarized by the underlying dimensions together. Familiarity with the problem at hand is helpful in deciding when enough components have been isolated, although several rules of thumb have been exposed. Kaiser suggests using only those dimensions whose eigenvalues exceed unity.⁵ Alternately, Morrison recommends that one should aim to explain some arbitrary proportion of the total variance, eighty-five to ninety percent, and should isolate as many dimensions as necessary to do so.⁶ King points out that any component contributing less than five percent to the overall explanation should be excluded because of random error variance.⁷ Once obtained, the components can be rotated on their axes in various ways to meet differing criteria. The usual criterion for rotation, as in this study, is simple structure, which insures that each variable loads highly on only one dimension and

⁵H. F. Kaiser, referred in D. C. D. Pocock and D. Wishart, "Methods of Deriving Multi-Factor Uniform Regions," Transactions of the Institute of British Geographers, XLVII (1969), p. 76.

⁶D. F. Morrison, referenced in Pocock and Wishart, p. 77.

⁷L. J. King, Statistical Analysis in Geography (Englewood Cliffs, N. J.: Prentice-Hall, 1969), p. 174.

that orthogonality (and therefore independence) is maintained, aiding in the labelling of the components. Once the rotated components have been interpreted and labelled and the component scores have been computed for each place of observation on each new component, the ordination stage is complete.

Similarity Scaling

Berry's second stage in regionalization measures similarity between the places of observation, in this study the 105 Kansas counties. Similarity is measured by distance between places plotted in r -space, where r equals the number of new underlying dimensions identified in the ordination stage. The closer two points lie in plotted space, the more similar they are. Distance between two plotted points "p" and "q" (each of which is a county) is equal to the square root of the sum of the squares of the differences of the component scores of the points on each of the components. In formula form:

$$D_{pq} = \sqrt{\sum_{i=1}^r (C_{ip} - C_{iq})^2}$$

where D_{pq} = distance from p to q

C_{ip} and C_{iq} = scores of p and q on component C

r = number of components C_i

$i = 1, 2, \dots, r$

$\sum$ = summation over all C's.

An "n" by "n" distance matrix is calculated giving the distance between each possible pair of places, where "n" is the number of locations. The distance matrix, showing the degree of similarity between the observations, is necessary in order to group places together logically and accurately.

Grouping Analysis

In a 1967 article entitled "Grouping and Regionalizing: An Approach to the Problem Using Multivariate Analysis," Berry outlined four categories of grouping-analysis methods: linkage analysis, cluster analysis, metric profiling, and bonded groups.⁸ However, in the same article, he described a type of cluster analysis called the centroid method as ". . . a more satisfactory method of grouping for maximum homogeneity" and as ". . . of value in determining whether 'natural' clusters of points are present."⁹ For this study, both these considerations are important, and therefore the centroid method is selected for use in grouping. This technique starts with the "n" observations in a distance matrix, links the closest pair, and calculates their centroid as well as the average intragroup distance. The centroid is figured by averaging the distances of the two points "p" and "q" from all other points (counties). The next step starts with n-1 points (treating the centroid as one point) and the procedure is repeated until a single centroid remains. When a centroid becomes linked, it is weighted by the number of original points represented within it. The procedure may be mapped in the form of a tree, with an accompanying profile of increments to average intragroup distance. Within groups of similar places, the incremental distance increases slowly but between groups jumps sharply, the steepness depending on the contrast exhibited by the locations. This centroid method yields a set of regional types, the members of which are not necessarily contiguous unless either a contiguity constraint is imposed or the counties form natural groups.

⁸Berry, "Grouping and Regionalizing," pp. 236-237.

⁹Ibid., p. 238.

In summary, Berry's system condenses a large, unmanageable set of data to a smaller but still meaningful and interpretable set of principal components that explain nearly as much variation between the counties as did the original set. The counties are then compared for similarities and differences regarding the underlying components, and are further divided into groups (regions) of similar counties based on that comparison. It is relatively simple then to review the analysis and tell exactly how two or more counties are alike, how they differ, and the magnitude of the relationships. This procedure is helpful when exploring an area about which little is known and to which, therefore, the relevance of selected variables is uncertain. This situation certainly holds when treating planning and management of the water resource. It is believed that incorporating Berry's three stages can produce the desired set of regions for water planning in Kansas based upon the seventy-one variables selected. It should be noted that Berry's system presupposes that the research project has been formulated, that a regionalization scheme is desired, and that the variables to that end have been selected, measured, and tabulated.¹⁰ Since selection of variables determines the form of the resulting regionalization scheme, it is important now to turn attention to the variables used in this study.

Selection of Variables

The seventy-one variables related to water, land use, and the socioeconomic situation in Kansas are selected according to the belief that they are associated with, relevant to, and will add insight into,

¹⁰ Ibid., p. 219.

the overall water picture of the state. Nearly 150 variables were considered at the onset of this study, but data limitations and condensation halved the final number. The idea is to examine information of diverse kinds and sources which might yield a better basis for water planning in Kansas. This approach overcomes the argument by Lewis et al., presented in Chapter 2, that the homogeneity criterion is sub-optimal as it ignores too many relevant factors. The variables chosen reflect past, present, and projected uses of water in the state. A list of the seventy-one variables is included as Appendix A. The list addresses several facets of the water resource and thus is divided into the five categories of physical data, land use, water supply, water use, and socioeconomic data. Much of the information for the variables is extracted or computed from published and unpublished Kansas Water Resources Board figures. Kansas Geological Survey, United States Geological Survey, and Bureau of Reclamation sources also are represented. Socioeconomic and farm data largely are taken from various Bureau of the Census publications. Sources of data for each variable are indicated in Appendix A. An attempt is made to utilize the most current data available, but the period represented by the recent variables is about ten years, from 1976 back to 1965. The author knows of no way to transform the data to approximate a single year. Appendix A indicates the year(s) in which data were originally generated.

The county is selected as the unit of observation because most data are available in this form and it is far less time-consuming to transform some non-county data into county figures than to overlay the state with a standardized grid and transform all variables to the

artificial standard unit. Secondly, the major alternative to the county or standardized unit is the watershed, which has all the difficulties described in the current state water planning system along with the drawback of data transformation, and it offers few advantages. Most importantly, because efficiency of governmental operation of planning regions is a large consideration in this study, the county unit should be employed, as it furnishes a ready governmental structure for administering, financing, and implementing water plans and policies. However, it is recognized that the grid system might yield a more "true" expression of reality as exhibited by the water variables and that the grid also would eliminate the necessity to weight by area, as all grids would be equal-area. Allowance is made for the size differentials among the counties by changing data to percentage, per capita, or per acre values where appropriate.

It may be observed that several variables are produced using a measure called differential shift. This measurement refers to changes in the percentage of the state total claimed by a county over a period of time. If county X accounted for five percent of irrigated acres in the state in 1954, for example, but only three percent in 1974, a differential shift of minus two percent occurred over the twenty-year period. This technique is superior to a percentage change within a county, as differential shift compares each county to the same external entity rather than to itself. If each county were to grow at the same rate as the state as a whole, no differential shift would be observed.

In any study dealing with water, data difficulties must be encountered because of the common-ownership nature of the resource and the relatively recent concern with its scarcity. Data difficulties remain in some of the variables tabulated for this study, a fact which should be

kept in mind. Much data one would seek intuitively concerning several facets of the water resource never have been collected. For example, it is desired to record average depth to the groundwater table and average change in groundwater level from 1950 (pre-irrigation) to 1975, but data are unavailable, and, at any rate, a county value would be misleading due to wide internal variation. In another case, indicators of land and water management are sought, including yearly investment in flood control, drainage, and water supply programs, but again the data are not available. In lieu of these figures, the number of special water districts operating in the county is substituted as an indicator of recognition of the desirability of managing the water resource.

A further difficulty with the data for this study is that for most water-related information, accuracy of the data cannot be determined. Water use figures and irrigation application rates are educated guesses, as no metering or taxing system is in operation to determine such quantities more precisely. Estimates of future water use are Kansas Water Resources Board guesses based on M. Jarvin Emerson's Interindustry Projections of the Kansas Economy,¹¹ and there is no way to test their accuracy or relative inaccuracy. It is unfortunate that actual water use figures are not available for a year since 1965, as more recent figures would establish a basis for assessing the reliability of the projected use values utilized in this study. Use figures are aggregated by county rather than per

¹¹ M. Jarvin Emerson, Interindustry Projections of the Kansas Economy (Topeka: Office of Economic Analysis and Kansas Department of Development Planning Division, 1969).

capita, as for planning purposes it is total demand that is important. Use of per capita figures would serve to obscure urban areas when in fact urban areas have important implications for planning and managing the water resource.

Many of the variables selected are subject to considerable yearly fluctuations. For several variables, such as total acres irrigated and percent of field crop production, data for several years are averaged to avoid unusual or unrepresentative figures caused by climatic irregularities. However, several other variables share the problem of data being available for only one year, and it is impossible to determine how representative these one-year values are. Also, to compensate for yearly variations, the water supply portion of the variables list notes indices of variability for streamflow and precipitation, as fluctuations of climatic influence are more extreme in western Kansas than in eastern Kansas.

The data search is shadowed somewhat by the county unit of measurement selected for this study. Several information points considered by the author, such as groundwater and surface water salinity, vary significantly within an area as large and physically varied as many Kansas counties, and oftentimes the variation is not well documented. In these instances, county averages are deemed unuseable for the purpose of classification. In other cases, where the variable is judged too important to be disregarded entirely, a county average is calculated despite its obvious limitations. Volume of groundwater available and several irrigation factors, which might be expected to vary widely throughout a county, are examples of this reasoning in practice. Where necessary, isopleth maps are drawn and figures for each county averaged from them. Despite the drawbacks, all variables are transformed to the county unit of observation.

I believe the accuracy sacrificed by this method does not affect the results of this study greatly. It is also fair to note that these types of measurement difficulties would pertain to whatever unit of observation chosen, whether county, watershed, census tract, or standardized grid.

The limitations noted notwithstanding, the author feels that the data represent the best obtainable in Kansas, short of laborious field collection and exhaustive searches of agency files. The variables list reflects reviews by several university and public agency personnel, and the author believes that the combined opinions have produced a comprehensive, meaningful list of variables logically related to water planning and management.

CHAPTER 4

REGIONALIZATION FOR WATER PLANNING IN KANSAS

In this chapter, the results of the principal components analysis, distance scaling, and grouping analysis described in Chapter 3 are presented, along with the final regionalization scheme. The raw data used in this study are available in Appendix B, making this work immediately reproduceable. Because this thesis treats a complex subject for which data are not often readily obtainable in county form, and because of the breadth of the water-related characteristics measured, the raw data become important. Decision-makers involved with water may find this information valuable regardless of further manipulation and interpretation.

Principal Components Analysis

It would be desirable for the major underlying dimensions isolated by the principal components analysis to be clearly defined, easily interpretable, few in number, mutually exclusive, and totally accountable for the variation in the seventy-one variables considered, but given the complex nature of the topic and the range of variables, fulfillment of this desire is beyond expectation. Actually, the analysis reflects the complexities of the water situation as well as data difficulties mentioned in Chapter 3, in that most of the components have relatively low eigenvalues,¹ which

¹An eigenvalue is the sum of the squared variable loadings for each underlying dimension and is used to calculate the proportion of the total variation summarized by the underlying components together.

means that many underlying dimensions are necessary to explain a large percentage of the total variation in the original variables. Nine interpretable components emerge from the principal components analysis which together account for 71.6% of the total variation in the variables measured.² Table 4-1 presents the rotated, orthogonal variable loadings for the nine components used. The eigenvalue of each component, the percentage of variation explained by each component individually, and the accumulated explained variation are noted at the bottom of the table. For example, Component Two has an eigenvalue of 9.985 and accounts for 14.1% of the total variation, and the accumulated explained variation of Components One and Two is 40.8%. Table 4-2 lists the component scores for each county, showing the degree to which each component is descriptive of each county, or conversely, the names of counties exhibiting certain combinations of characteristics.

Description of the Nine Components

The components depict three primary themes: irrigation, urbanization, and types of agriculture. The first and largest underlying dimension, which accounts for 26.7% of the total variation, is titled Groundwater-dependent Irrigation and Aridity. Significant variable loadings ($\geq .40$) are presented in Table 4-3. As can be seen, variables that indicate groundwater-dependent irrigation (variables 6, 39, 40, 45, 47, and 54) load positively, while those that indicate aridity (7, 12, 17, 18, 19, 41, and 48) load negatively. In summary, counties with high positive scores on

²The principal components routine used was a Biomedical program, BMD-03M, developed at the University of California at Los Angeles. It incorporated an orthogonal rotation of components. The IBM 370-158 computer at Kansas State University performed the routine.

TABLE 4-1
ROTATED VARIABLE LOADINGS FOR NINE PRINCIPAL COMPONENTS

Variable	Component								
	1	2	3	4	5	6	7	8	9
1	0.50319	-0.07932	-0.13904	0.03006	0.06668	-0.00608	0.07817	0.19161	0.66818
2	0.79853	-0.06825	0.02388	-0.01319	-0.06145	-0.02032	0.12356	0.16336	0.01779
3	-0.02406	0.08062	0.02302	0.08119	0.06423	0.10068	0.16598	0.04929	0.04566
4	0.32777	-0.03476	0.19313	0.03144	0.01455	-0.04572	0.09118	-0.072851	0.20077
5	-0.73296	0.06956	0.03620	-0.04707	-0.04794	-0.00127	-0.17079	0.00678	-0.54865
6	0.58273	-0.01149	0.07326	-0.05674	0.06861	0.05267	0.15929	-0.27187	0.55100
7	-0.57903	-0.00143	0.09740	0.06862	-0.11071	-0.13341	-0.46988	0.15972	0.01064
8	0.23332	-0.03828	-0.09848	0.09420	0.08031	0.10752	-0.47427	0.10059	0.03692
9	-0.27345	0.53086	0.01863	-0.72456	0.12466	-0.02796	0.04628	-0.00190	-0.04240
10	0.48899	-0.03227	-0.01865	0.12838	0.06990	0.04838	0.71174	-0.04619	0.34689
11	-0.14703	-0.16363	-0.01493	0.12089	-0.27959	0.00730	-0.76050	-0.00129	-0.32134
12	-0.73669	0.01150	0.04639	-0.11862	0.28651	-0.05560	0.05436	0.11687	-0.04537
13	0.67172	0.01454	0.03562	0.16889	-0.27782	0.12833	0.46094	0.02588	0.13543
14	0.84388	-0.18545	0.02011	0.02641	0.06825	0.05384	0.00113	0.08673	0.17717
15	0.08882	-0.13865	0.02613	-0.01936	0.07757	0.62921	0.23751	0.12996	0.11651
16	-0.65733	0.27524	0.06535	0.08815	0.03467	-0.04621	0.06367	0.18654	-0.09126
17	-0.87395	0.06509	0.01570	-0.11104	0.14630	-0.07918	-0.01046	-0.05557	-0.14238
18	-0.90060	0.11535	0.06127	-0.09230	0.02744	-0.11431	-0.06595	-0.05118	-0.24761
19	-0.54739	-0.02591	0.09499	0.02686	-0.03885	-0.18195	-0.39185	0.35328	0.00842
20	0.19344	-0.34407	-0.02753	0.03015	0.03383	-0.11396	-0.01209	0.17425	-0.34348
21	0.36363	-0.03226	0.09673	0.02045	-0.00273	0.42220	0.07016	-0.17733	0.72154
22	0.30256	-0.04829	0.07976	0.00668	0.07377	0.38978	0.09071	-0.17929	0.74393
23	-0.08785	-0.07438	0.02595	0.07739	0.07805	-0.08740	-0.07441	0.08836	-0.14768
24	-0.19319	-0.02213	0.04955	-0.00570	-0.27047	0.04602	-0.02821	0.03687	-0.02716
25	-0.08410	0.30204	-0.02457	0.02170	-0.06228	-0.00642	-0.14170	-0.06366	-0.10741

Variable	Component								
	1	2	3	4	5	6	7	8	9
26	0.08039	0.10353	0.10613	0.03807	0.18223	0.82593	-0.14004	-0.00402	0.08085
27	-0.05168	0.11965	-0.18014	0.09154	0.01250	0.74898	-0.04770	-0.03290	0.22962
28	0.12744	0.35292	0.25147	-0.10034	-0.08036	-0.21068	0.20462	-0.55332	-0.03778
29	0.19470	0.16220	-0.37741	-0.50448	-0.06730	0.00560	0.09685	0.07146	0.70120
30	-0.05666	0.90498	0.01741	-0.32743	0.00717	0.00984	0.02614	0.01362	-0.02276
31	-0.03962	0.49276	0.06088	-0.69584	0.00326	-0.00129	-0.02750	0.00352	0.06552
32	-0.13931	0.15685	-0.06626	-0.89215	0.04241	-0.01639	0.05121	0.01204	0.01630
33	-0.43056	0.07983	0.07106	0.22317	-0.54043	-0.05878	0.06834	0.02302	-0.39451
34	0.31482	-0.05978	-0.41540	0.02429	-0.10107	0.01431	0.08803	0.07729	0.81326
35	0.35345	-0.06005	-0.11323	0.02270	-0.05539	0.04478	0.06988	0.05163	0.88726
36	0.36956	-0.05830	-0.12113	0.02709	-0.12502	0.06110	0.09001	0.05360	0.86829
37	0.02516	-0.03413	0.79643	-0.02776	0.20418	-0.00147	0.05869	0.07359	0.06266
38	-0.08436	0.03742	0.87413	0.00371	-0.02097	-0.04656	0.02994	-0.05945	-0.12900
39	0.89923	-0.12369	-0.06309	0.09250	-0.01600	0.09945	0.04353	0.05237	0.25308
40	0.79925	0.12947	0.07725	-0.01391	0.15057	-0.05713	0.04289	-0.01581	0.32216
41	-0.79928	-0.12950	-0.07747	0.01382	-0.15053	0.05716	-0.04304	0.01569	-0.32202
42	-0.44714	-0.09015	0.02273	0.11127	0.02528	-0.03327	-0.08947	-0.64298	-0.16741
43	0.57555	0.08782	0.16102	0.08324	0.08151	-0.11131	-0.05093	0.52706	0.13223
44	-0.02414	-0.04678	-0.26301	0.06888	-0.11114	0.20930	0.27783	0.23184	0.11024
45	0.79694	-0.20851	0.00051	0.07448	0.00733	0.05102	0.10511	0.04934	0.31556
46	-0.07902	0.08808	0.02896	0.10694	-0.14482	-0.01642	-0.08685	-0.13408	-0.24492
47	0.79567	-0.04324	0.05707	0.18440	0.15048	-0.08796	-0.01292	-0.11396	0.27207
48	-0.79567	0.04324	-0.05706	-0.18440	-0.15048	0.08796	0.01292	0.11396	-0.27206
49	0.47920	0.16780	0.04279	-0.22018	-0.13824	0.08563	0.07697	-0.06064	0.71804
50	-0.03246	0.95760	0.01834	-0.08911	-0.00061	0.01028	0.05069	0.02086	-0.01465

Variable	Component								
	1	2	3	4	5	6	7	8	9
51	-0.11614	0.85636	0.01422	-0.41235	0.07445	0.00292	-0.02852	-0.02947	-0.01182
52	-0.02661	0.23801	0.02021	-0.88997	0.02345	-0.00921	-0.07837	-0.01717	-0.00643
53	-0.22993	-0.03318	-0.03259	0.10302	-0.90431	-0.09346	-0.01991	-0.00206	-0.11370
54	0.51154	-0.04548	0.03516	0.03131	-0.14865	0.08858	0.09824	-0.04794	0.74745
55	0.27813	-0.04749	0.63814	0.51535	-0.06291	0.09513	-0.05682	-0.18422	-0.21386
56	0.04505	0.63766	0.00371	0.55651	-0.01822	0.00753	0.09378	0.02496	0.00910
57	-0.10170	0.50140	-0.05787	0.38091	0.11497	0.00271	0.00325	-0.04034	-0.08415
58	-0.14048	0.09590	-0.01675	-0.88468	0.11688	-0.04216	0.05236	-0.01951	0.01670
59	0.13435	-0.13039	-0.12031	-0.09206	-0.68883	-0.06792	-0.10002	-0.02711	0.25805
60	0.08337	0.04561	0.74005	-0.00347	-0.00302	0.08043	-0.03431	-0.19534	-0.47193
61	-0.12954	0.95216	0.00911	-0.17149	0.04451	0.00322	0.02310	-0.00089	-0.03126
62	-0.11897	0.95159	0.00157	-0.14982	0.06135	0.00111	-0.00001	0.00447	-0.02174
63	0.32475	0.45256	-0.15477	0.00749	0.14017	0.16387	0.04686	-0.05761	0.30583
64	0.38292	0.36676	-0.18332	-0.02961	0.08498	-0.02124	-0.02943	0.21169	0.48223
65	-0.35174	0.23797	0.10402	0.09165	-0.02940	-0.11514	0.04616	0.11656	0.38005
66	-0.23259	0.39218	-0.13095	-0.11927	-0.06455	0.11471	0.14860	-0.05668	0.07269
67	0.22364	-0.39549	0.13224	0.11642	0.01907	-0.11000	-0.12922	0.05525	-0.08626
68	0.36182	-0.36322	0.03028	0.09332	-0.12622	-0.01752	-0.04434	0.10077	0.10011
69	-0.58493	0.26520	-0.00453	-0.16401	-0.02921	-0.12317	0.22719	-0.02653	-0.03884
70	0.31741	0.09912	0.02199	0.17393	-0.40052	0.07209	0.56697	0.01539	0.32197
71	0.08142	-0.08759	-0.03809	0.15553	-0.82764	-0.14592	-0.01599	-0.00428	0.23950
	18.991	9.995	5.394	4.413	3.358	3.120	2.152	1.800	1.627
	.267	.141	.076	.062	.048	.043	.030	.026	.023
	.267	.408	.484	.546	.594	.637	.667	.693	.716

TABLE 4-2

COMPONENT SCORES OF KANSAS COUNTIES

County	Component								
	1	2	3	4	5	6	7	8	9
1. Allen	-2.227	-0.392	0.533	0.508	0.961	0.294	1.930	1.672	0.155
2. Anderson	-1.520	-0.387	-0.102	0.242	0.284	-0.103	-0.287	-0.140	0.070
3. Atchison	-0.807	-0.378	0.049	-0.084	1.012	-0.801	1.322	0.172	-0.248
4. Barber	0.030	-0.101	-0.564	0.300	-0.015	-0.524	-0.734	-1.259	-0.640
5. Barton	0.933	0.289	0.278	-0.013	-1.381	-0.645	1.165	-0.409	-0.337
6. Bourbon	-1.461	-0.489	-0.161	0.114	0.592	0.365	-0.076	-0.703	-0.307
7. Brown	-0.671	-0.527	-0.387	0.010	-0.658	-0.166	1.374	-0.841	-0.669
8. Butler	-0.574	-0.21	0.290	-0.437	-4.037	0.364	-0.366	-0.388	-0.433
9. Chase	-0.748	-0.174	0.134	0.022	-2.176	-0.179	-2.398	-0.549	-0.061
10. Chautauqua	-1.512	-0.418	0.130	0.270	0.492	-0.167	-2.042	-0.450	0.073
11. Cherokee	-1.968	-0.838	-0.972	-3.634	0.973	-0.350	1.725	0.152	0.452
12. Cheyenne	1.217	-0.489	0.709	-0.205	0.096	1.671	-0.790	0.141	-0.117
13. Clark	1.098	0.225	-0.721	0.210	1.026	1.493	-3.591	-0.076	-0.670
14. Clay	0.032	-0.232	0.228	0.143	0.002	-0.495	0.467	0.304	-0.323
15. Cloud	0.328	-0.180	-0.664	0.241	0.845	-0.078	0.564	-0.095	-0.607
16. Coffey	-1.206	-0.468	0.486	-0.206	-0.390	-0.345	-0.816	0.322	-0.100
17. Comanche	0.262	-0.077	-0.429	0.283	0.461	-0.618	-1.115	-1.472	-0.570
18. Cowley	-0.630	0.272	-0.143	-0.151	-1.606	0.005	-0.430	1.183	-0.274
19. Crawford	-1.250	-0.195	-0.110	0.254	1.036	-0.081	0.255	-0.659	-0.070
20. Decatur	1.419	-0.290	0.186	-0.114	0.125	-0.391	-0.091	0.488	-0.746
21. Dickinson	-0.249	-0.039	-0.550	-0.183	-1.397	0.693	0.837	-0.303	-0.802
22. Doniphan	-0.903	-0.461	-0.091	0.223	1.339	-0.797	0.959	-0.590	-0.190
23. Douglas	-1.068	0.404	0.519	0.327	1.006	0.081	0.018	1.411	0.385
24. Edwards	0.988	-0.218	0.707	0.294	1.107	-1.111	-0.054	-3.350	0.338
25. Elk	-1.296	-0.367	0.021	0.125	0.017	-0.210	-1.923	0.604	-0.152

		Component								
		1	2	3	4	5	6	7	8	9
26.	Ellis	0.241	0.519	-0.425	0.545	-0.099	1.364	0.637	0.366	-0.697
27.	Ellsworth	0.243	-0.248	-0.360	0.002	0.352	0.244	-0.110	0.033	-1.065
28.	Finney	0.600	0.092	-4.741	0.181	-2.959	1.565	-0.782	-0.654	2.351
29.	Ford	1.480	0.034	0.760	0.128	-1.656	-0.179	0.539	-0.051	-0.062
30.	Franklin	-1.462	-0.420	-0.032	0.095	0.478	0.091	-0.209	0.655	0.069
31.	Geary	-0.180	0.123	0.152	0.615	0.907	-1.212	-2.223	0.832	0.192
32.	Gove	1.024	0.021	0.432	0.025	-1.372	-0.672	-0.290	1.137	-0.335
33.	Graham	1.155	-0.244	-0.197	-0.001	0.614	2.255	-1.119	0.070	-1.119
34.	Grant	0.239	-0.271	-3.807	0.129	1.202	-0.074	0.360	-0.524	3.216
35.	Gray	0.808	-0.323	3.159	-0.051	-0.585	-0.340	0.422	0.241	2.168
36.	Greeley	1.702	-0.318	-0.085	0.009	0.914	0.230	0.263	1.276	-0.221
37.	Greenwood	-0.955	-0.295	-0.184	0.204	-1.209	0.142	-2.223	-0.194	-0.326
38.	Hamilton	1.597	-0.115	-0.959	0.024	0.762	0.389	0.288	0.397	-0.935
39.	Harper	0.179	0.053	-0.463	0.405	0.253	0.104	0.036	-0.935	-0.538
40.	Harvey	-0.575	0.300	-0.096	0.133	0.587	-0.012	1.302	0.352	0.094
41.	Haskell	-0.643	0.187	1.949	-0.003	-0.425	-0.443	0.925	0.643	5.302
42.	Hodgeman	1.356	-0.231	-0.302	0.032	0.523	-0.540	-0.536	1.165	-0.613
43.	Jackson	-1.075	-0.214	-0.144	0.360	0.428	-0.798	0.122	-0.800	-0.085
44.	Jefferson	-0.812	-0.380	0.608	0.550	1.430	-1.058	0.342	1.238	0.120
45.	Jewell	-0.110	-0.175	-0.058	-0.133	-1.256	0.312	1.392	0.652	-0.866
46.	Johnson	-0.902	4.566	-0.374	1.283	1.280	0.289	-0.272	-1.660	-0.079
47.	Kearny	0.829	-0.407	0.205	-0.165	0.243	0.298	0.026	0.422	1.084
48.	Kingman	-0.034	0.019	-0.030	0.254	0.178	-0.585	0.435	-2.589	-0.222
49.	Kiowa	0.729	-0.065	0.472	0.226	1.132	-0.130	-0.797	-2.558	0.032
50.	Labette	-1.665	0.145	-0.010	0.435	-0.366	0.377	0.514	-0.437	-0.039

	Component								
	1	2	3	4	5	6	7	8	9
51. Lane	1.350	-0.281	0.374	0.111	0.606	-0.699	-0.126	1.450	-0.407
52. Leavenworth	-1.068	0.399	0.068	0.495	1.588	0.059	0.150	0.592	-0.132
53. Lincoln	0.335	-0.177	-0.220	0.006	0.491	0.023	-0.127	0.395	-0.866
54. Linn	-1.698	-0.547	0.002	0.317	0.620	0.192	-0.235	-0.211	0.076
55. Logan	1.258	-0.189	0.023	0.153	0.950	-0.462	-0.737	1.277	-0.557
56. Lyon	-1.175	0.224	0.452	0.315	-2.818	-0.101	-2.155	0.870	0.430
57. McPherson	-0.023	0.125	0.841	0.115	-0.529	0.421	1.195	0.519	-0.164
58. Marion	-0.347	-0.118	-0.015	0.364	-0.755	-0.502	0.653	0.737	-0.626
59. Marshall	-0.394	-0.401	-0.379	-0.255	-0.580	1.183	1.150	-0.016	-0.687
60. Meade	0.723	0.069	1.779	0.181	0.031	1.873	-1.199	0.176	1.345
61. Miami	-1.411	-0.759	-0.127	0.271	0.603	0.267	0.351	-0.013	-0.184
62. Mitchell	0.236	-0.197	-0.006	0.081	-0.000	0.241	0.740	0.668	-0.654
63. Montgomery	-1.727	0.068	0.115	0.035	0.450	0.311	-0.062	0.048	0.041
64. Morris	-0.770	-0.246	-0.117	0.239	-0.585	-0.156	-0.777	-0.231	-0.431
65. Morton	0.975	-0.127	0.410	0.245	1.656	-0.254	0.379	0.086	0.983
66. Nemaha	-0.704	-0.377	-0.160	0.162	-0.814	-0.036	0.965	-0.697	-0.538
67. Neosho	-1.816	-0.413	0.155	0.429	0.613	-0.015	0.304	0.382	0.040
68. Ness	1.263	-0.111	-0.477	0.125	0.263	0.247	0.488	1.193	-1.221
69. Norton	0.620	-0.182	-0.190	0.144	0.133	0.491	0.333	0.142	-0.713
70. Osage	-1.381	-0.606	0.177	0.341	0.199	-0.060	-0.944	0.201	0.200
71. Osborne	-0.014	-0.171	-0.369	-0.032	-0.417	1.028	0.873	0.574	-0.900
72. Ottawa	0.067	-0.457	-0.347	-0.052	0.491	-0.136	0.105	0.007	-0.690
73. Pawnee	1.299	-0.298	0.004	0.018	-0.106	-0.403	1.014	-0.932	-0.406
74. Phillips	0.117	-0.128	-0.285	0.120	-0.782	0.456	0.320	0.106	-0.802
75. Pottawatomie	-0.035	-0.201	0.257	0.047	-0.513	-1.222	-1.179	-0.204	-0.262

	Component								
	1	2	3	4	5	6	7	8	9
76. Pratt	0.867	-0.147	0.885	0.082	-0.788	-0.821	0.543	-3.961	0.329
77. Rawlins	1.510	-0.364	0.977	-0.097	-0.049	-0.946	-0.315	0.849	-0.589
78. Reno	0.499	1.056	0.968	0.050	-0.893	-0.751	0.918	-1.534	0.149
79. Republic	-0.204	-0.081	-0.329	-0.001	-1.008	-0.044	1.676	0.151	0.030
80. Rice	1.002	-0.501	0.134	-0.251	-0.015	-0.252	0.754	-0.743	-0.783
81. Riley	-0.339	0.524	0.069	0.604	0.810	-0.646	-0.807	0.512	0.091
82. Rooks	0.517	-0.376	-0.493	0.069	0.405	0.246	0.137	-0.758	-1.141
83. Rush	1.486	-0.480	-0.317	-0.101	0.850	-0.654	0.711	0.997	-1.349
84. Russell	0.213	-0.334	-0.444	0.052	0.463	0.801	-0.174	-0.054	-0.995
85. Saline	0.435	0.749	-0.885	0.434	0.542	0.091	0.099	0.139	-0.863
86. Scott	1.324	-0.534	-2.912	-0.170	-1.209	-1.565	0.264	0.758	1.137
87. Sedgwick	0.311	7.775	0.346	1.430	-0.470	0.019	0.871	0.633	-0.015
88. Seward	1.153	-0.608	0.289	-0.618	1.140	0.585	-0.907	-0.169	1.576
89. Shawnee	-0.069	2.911	-0.018	-0.347	0.883	-0.115	-1.096	0.985	-0.259
90. Sheridan	0.961	-0.156	2.783	-0.070	-0.987	-1.236	-0.096	0.534	0.830
91. Sherman	1.116	-0.553	1.427	-0.138	0.127	-0.783	-0.079	0.847	1.508
92. Smith	0.142	-0.041	-0.379	0.013	-1.407	0.760	1.214	0.620	-0.961
93. Stafford	0.897	-0.317	1.393	-0.071	0.178	-0.852	0.515	-3.575	0.270
94. Stanton	0.406	-0.038	-2.506	-0.018	0.797	-0.529	0.892	0.243	2.837
95. Stevens	0.426	-0.543	1.149	-0.098	0.719	7.292	0.457	-0.664	1.915

		Component								
		1	2	3	4	5	6	7	8	9
96.	Sumner	-0.195	0.319	0.025	0.359	-0.424	-0.068	1.705	1.125	-0.501
97.	Thomas	1.363	-0.393	2.525	0.084	0.051	0.360	0.467	0.530	0.628
98.	Trego	1.024	-0.379	-0.304	-0.102	0.472	-0.160	-0.354	-0.112	-1.171
99.	Wabaunsee	-0.434	-0.077	0.441	0.245	-0.085	-1.092	-2.527	0.749	0.200
100.	Wallace	1.051	-0.256	-0.164	-0.110	0.937	-0.250	-1.107	1.076	0.612
101.	Washington	-0.427	-0.102	-0.011	-0.121	-2.141	0.234	0.917	-0.072	-0.612
102.	Wichita	0.671	-0.250	-2.148	-0.166	-0.552	-2.067	0.088	0.993	2.521
103.	Wilson	-1.718	-0.425	0.112	0.215	0.404	0.105	-0.116		
104.	Woods	-1.385	-0.154	0.448	0.287	-1.004	0.125	-0.308	0.570	-0.017
105.	Wyandotte	-0.271	2.069	0.126	-9.241	0.389	-0.057	-0.764	-0.210	0.103

TABLE 4-3

VARIABLE LOADINGS FOR COMPONENT ONE: GROUNDWATER-DEPENDENT IRRIGATION AND ARIDITY

Variable	Loading	Variable Name
18	-.901	Average annual precipitation, inches
39	.899	Irrigation water applied per irrigated acre, av.
17	-.874	Average annual streamflow, cfs/sq. mile
14	.844	Percent of cropland acres lying fallow
40	.799	Percent of irrigation from groundwater
2	.799	Irrigable acres - class two (%)
41	-.799	Percent of irrigation from surface water
45	.797	Irrigation as percent of water demand, 1965
47	.796	Percent of water demand met by groundwater, 1965
48	-.796	Percent of water demand met by surface water, 1965
12	-.737	Percent of county land in forests
5	-.733	Non-arable acres (%)
13	.672	Total cropland acres
16	-.657	Number of special water districts currently operating
69	-.585	Percent of labor force in manufacturing
6	.583	Percent of land underlain by groundwater ≥ 100 gpm
7	-.579	Flood payments per acre
43	.576	Method of irrigation-gated pipe
19	-.547	Variability for streamflow
54	.512	2000 irrigation water demand
1	.503	Acres suitable for irrigation--class 1 (%)
10	.489	Percent of county that is cropland
49	.479	2000 total water demand
42	-.447	Method of irrigation--sprinkler
33	-.431	1965 livestock water demand

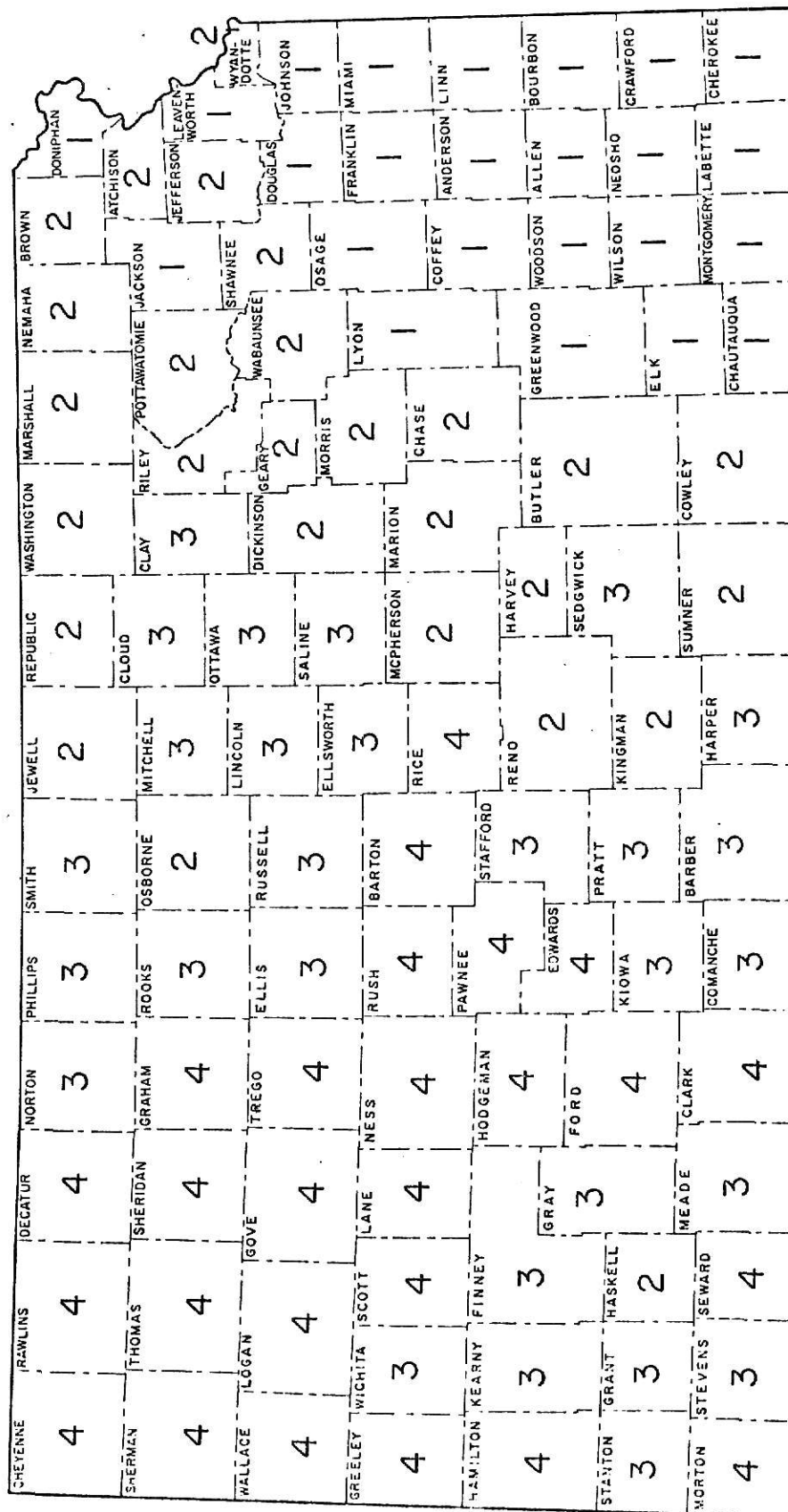
Groundwater-dependent Irrigation and Aridity have great water demands, use a large proportion of their water for irrigation, meet most of their water demand from groundwater, and have little surface water because of light precipitation. Component One divides the state into halves along a generalized line running from the eastern border of Jewell County south

to the eastern boundary of Harper County (Figure 4-1). Those counties in the western section score positively, while those in the eastern half register negative scores. A continuum from arid west to humid east is discernible. Haskell County inexplicably stands out as an exception, although the raw data indicate that it should score highly positive, its data being similar to Logan and Kearny counties'.

The second component, contributing 14.1% of the explained variation in the population, is termed Urban Water Use. Significant variable loadings tabulated in Table 4-4 involve voluminous current and future water demand for industrial and domestic uses and urban characteristics such as large population, large percentage of county devoted to urban activities, high percent of population that is urban, and substantial household incomes. A strong positive score on this component implies a large population with substantial water demands that are expected to climb still higher in comparison to other counties by the year 2000. Conversely, a negative score indicates a rural county that has low water demands for industry or domestic uses, and earns lower per family incomes. As could be expected, the major urban areas of the state, particularly the Kansas City-Topeka corridor and the Wichita-Hutchinson area, have high positive scores on this component, as shown on Figure 4-2. The Manhattan-Ft. Riley and Salina-McPherson counties score moderately high, whereas several southern counties have low positive scores. The majority of counties in the state load negatively, demonstrating the predominantly rural character of the state.

Component Three is labelled Irrigation Growth, as it corresponds to change in irrigation from 1954-55 to 1973-74 and expected continued growth.

FIGURE 4-1



$<-.91$ = 1
 $-.90$ to 0 = 2
 0 to $.90$ = 3
 $>.91$ = 4

COMPONENT ONE: GROUNDWATER-DEPENDENT IRRIGATION & ARIDITY

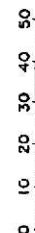


FIGURE 4-2

CHEYENNE	2	RAWLINS	2	DECATUR	2	NORTON	2	PHILLIPS	2	SMITH	2	JEWELL	2	REPUBLIC	2	WASHINGTON	2	MARSHALL	2	NEMAH	2	BROWN	1	DONIPHAN	2	ATCHISON	2	JEFFERSON	2	LEAVENWORTH	3	WYATT	4	JOHNSON	4	DOUGLAS	3	FRANKLIN	1	MIAMI	1	ANDERSON	2	LINN	1	BOURBON	2	CRAWFORD	2	CHEROKEE	1		
SHERMAN	1	THOMAS	2	SHERIDAN	2	GRAHAM	2	ROOKS	2	OSBORNE	2	MITCHELL	2	CLOUD	2	CLAY	2	RILEY	4	POTTAWATOMIE	2	JACKSON	2	SHAWNEE	4	WABAUSSIE	2	OSAGE	4	DICKINSON	2	GEARY	3	MORRIS	2	LYON	3	COFFEY	2	WOODSON	2	ALLEN	2	NEOSHO	2	WILSON	2	MONTGOMERY	3	LABETTE	3	CHAUTAUQUA	2
WALLACE	2	LOGAN	2	GOVE	3	TREGO	2	ELLIS	4	RUSSELL	2	LINCOLN	2	OTTAWA	2	SALINE	4	DICKINSON	2	MORRIS	2	CHASE	2	MCPHERSON	3	RICE	1	HARVEY	3	SEDOGWICK	4	BUTLER	2	GREENWOOD	2	WILSON	2	NEOSHO	2	WILSON	2	MONTGOMERY	3	LABETTE	3	CHAUTAUQUA	2						
GREELEY	2	WICHITA	2	LANE	2	NESS	2	RUSH	2	BARTON	3	ELLSWORTH	2	MCPHERSON	3	RICE	1	HARVEY	3	SEDOGWICK	4	BUTLER	2	GREENWOOD	2	WILSON	2	NEOSHO	2	WILSON	2	MONTGOMERY	3	LABETTE	3	CHAUTAUQUA	2																
HAMILTON	2	KEARNY	2	FINNEY	3	HODGEMAN	2	PAWNEE	2	STAFFORD	2	RENO	4	HARVEY	3	SEDOGWICK	4	BUTLER	2	GREENWOOD	2	WILSON	2	NEOSHO	2	WILSON	2	MONTGOMERY	3	LABETTE	3	CHAUTAUQUA	2																				
STANTON	2	GRANT	2	HASKELL	3	MEADE	3	CLARK	3	BARBER	2	KINGMAN	3	SUMNER	3	COWLEY	3	CHAUTAUQUA	2																																		
MORTON	2	STEVENS	1	SEWARD	1	MEADE	3	CLARK	3	BARBER	2	KINGMAN	3	SUMNER	3	COWLEY	3	CHAUTAUQUA	2																																		

COMPONENT TWO: URBAN WATER USE

$<-.51$ = 1
 $-.50$ to 0 = 2
 0 to $.50$ = 3
 $>.51$ = 4

0 10 20 30 40 50

TABLE 4-4
VARIABLE LOADINGS FOR COMPONENT TWO:
URBAN WATER USE

Variable	Loading	Variable Name
50	.958	2000 domestic water demand
61	.952	1975 population
62	.952	2000 projected population
30	.905	1965 domestic water demand
51	.856	2000 industrial water demand
56	.638	Differential shift in domestic water demand, 1965-2000
9	.531	Percent of county land that is urban
57	.501	Differential shift in industrial water demand, 1965-2000
31	.493	1965 industrial water demand
63	.453	Net effective buying income per family
67	-.395	Percent of population that is rural
66	.392	Percent of population that is urban

This component, which accounts for 7.6% of the populational variation, is dynamic in that it measures both past and future changes. Differential shifts³ in irrigated acres from 1969-74 and from 1954-74 (variables 37 and 38) place highly positive loadings on this component at .873 and .796 respectively. Expected differential shifts in irrigation and total water demands from 1965 to 2000 (variables 60 and 55) also load significantly positive at .740 and .638. Irrigation water and total water demand in 1965 (variables 34 and 29) load lightly negative at -.415 and -.377, magnifying the expected growth and differential shifts by the year 2000, and indicating relatively low present (1965) demand.

³Differential shift refers to change in the percentage of the state total accounted for by a county over a period of time. See discussion in Chapter 3.

Counties exhibiting high positive scores on Component Three have experienced great increases in irrigated acreage since the major surge toward groundwater irrigation in the early 1950's, and are anticipated to increase this shift to irrigated agriculture. Negatively scoring counties either had substantial irrigation development prior to 1954, have not developed irrigation so dramatically, or are expected to decline in water demand for irrigation because of decreasing water supply. Three groups of irrigation growth counties stand out in Figure 4-3. The first is comprised of counties in southwestern Kansas--Gray, Haskell, Meade, Stevens, and Ford. Another group is Sheridan, Thomas, Sherman, Rawlins, and Cheyenne counties in the northwest corner. Four south-central counties--Stafford, Reno, Edwards, and Pratt--in the Arkansas River valley, score less strongly. One major group of southwestern counties registers large negative scores on this component, however. Although irrigation has been extensive in Finney, Grant, Scott, Stanton, and Wichita counties, they score negatively on Irrigation Growth, but several explanations for this are possible. First, these counties, especially Scott and Wichita, had substantial pre-1954 irrigation, so the increase since that date appears less marked than in other counties. Also, since irrigation water demand in 1965 loads negatively on this component, the quite large irrigation demands polled by these counties tend to force their component scores to the negative side. Finally, present conditions suggest that groundwater depletion will preclude great expansion of existing irrigation in these counties as reflected in negative differential shifts in irrigation and total water demand from 1965-2000. The magnitudes of the component scores in these five counties directly parallel the

FIGURE 4-3

CHEYENNE	RAWLINS	DECATUR	NORTON	PHILLIPS	SMITH	JEWELL	REPUBLIC	WASHINGTON	MARSHALL	NEMAH	BROWN
4	4	3	2	2	2	2	2	2	2	2	2
SHERMAN	THOMAS	SHERIDAN	GRAHAM	ROOKS	OSBORNE	MITCHELL	CLOUD	CLAY	POTAWATOMIE	JACKSON	ATCHISON
4	4	4	2	2	2	2	2	3	3	2	3
WALLACE	LOGAN	GOVE	TREGO	ELLIS	RUSSELL	LINCOLN	OTTAWA	DICKINSON	GEARY	SHAWNEE	JEFFERSON
2	3	3	2	2	2	2	2	3	3	2	3
GREELEY	WICHITA	LANE	NESS	RUSH	BARTON	ELLSWORTH	SALINE	MORRIS	OSAGE	FRANKLIN	MIAMI
2	1	3	2	2	3	2	1	2	3	2	2
HAMILTON	KEARNY	FINNEY	HODGEMAN	PAWNEE	STAFFORD	RICE	MCPHERSON	MARION	CHASE	COFFEY	ANDERSON
1	3	1	2	3	3	3	4	2	3	3	3
STANTON	GRANT	HASKELL	GRAY	EDWARDS	PRATT	KINGMAN	SEDGWICK	BUTLER	GREENWOOD	WOODSON	ALLEN
1	1	4	4	3	4	2	4	3	2	3	3
MORTON	STEVENS	SEWARD	MEADE	COMANCHE	BARBER	HARPER	SUMNER	COWLEY	ELK	WILSON	NEOSHO
3	4	3	4	2	2	2	3	2	3	3	2
									CHAUTAUQUA	MONTGOMERY	LALETTE
									3	3	2
											CHEROKEE
											1

COMPONENT THREE: IRRIGATION GROWTH

$< .71 = 1$
 $-.70 \text{ TO } 0 = 2$
 $0 \text{ TO } .70 = 3$
 $> .71 = 4$

0 10 20 30 40 50

severity of groundwater depletion and inversely correspond to past irrigation growth. It is interesting to note that few counties have strong negative scores on this component, confirming the increasing importance of and reliance on irrigation throughout the state.

Variable loadings (Table 4-5) on the fourth component, Urban Water Demand Growth, which accounts for 6.2% of the variation, lead to the observation that water demand for utilities will account for an increased proportion of total water demand, that domestic demand will increase, and that industrial demand will grow, but at a slower rate, in the next twenty-five years. Growth is anticipated in counties scoring positively on this component (Figure 4-4), as reflected in increased utilities, industrial, and domestic demands over time, whereas decline is expected in negatively scoring counties. Few counties stand out with high scores on either the

TABLE 4-5
VARIABLE LOADINGS FOR COMPONENT FOUR:
URBAN WATER DEMAND GROWTH

Variable	Loading	Variable Name
32	-.892	1965 utilities water demand
52	.890	2000 utilities water demand
58	.885	Differential shift in utilities water demand, 1965-2000
9	-.725	Percent of county land that is urban
31	-.696	1965 industrial water demand
56	.557	Differential shift in domestic water, 1965-2000
55	.515	Differential shift in total water demand, 1965-2000
29	-.504	1965 total water demand
51	-.412	2000 industrial water demand
57	.381	Differential shift in industrial water demand, 1965-2000

positive or negative end of the urban growth continuum. Johnson and Sedgwick counties register the highest scores (≥ 1.0), with Riley-Geary, Jefferson-Leavenworth, Ellis, and Allen scoring moderately high values (.495 to .615). Wyandotte and Cherokee have component scores of -9.249 and -3.634 respectively, indicating lessened urban demands, and by extension, loss of population and industry. These two counties currently have enormous water demand for utilities, a demand that is expected to decline, accounting in large part for the counties' scores. The Urban Water Demand Growth component may be problematic because it is highly defined by utility water demand, and the location of future utilities growth is difficult to predict thirty-five years in advance. Therefore, this component is viewed somewhat carefully throughout the remainder of the regionalization.

Component Five concerns livestock and is consequently labelled Cattle Production. Significant variable loadings for this component are all negative, composed of livestock water demand in 2000 (variable 53, loading -.904), percent of state cattle production by value (variable 71, loading -.828), differential shift in livestock water demand (variable 53, loading -.540), and percent of state field crop production (variable 70, loading -.401). This dimension contributes 4.8% of the total populational variation. Figure 4-5 distinguishes clusters of counties that raise large numbers of cattle from those that do not, but it does not separate feedlot from rangeland and pasture production. The northeast corner of the state is not an important cattle producing area, and the same observation applies to Cherokee and Crawford counties in southeast Kansas. Several western counties score highly positive on this component, specifically Wallace,

Logan, Greeley, Grant, Morton, Seward, Clark, Kiowa, Edwards, Stevens, Stanton, Hamilton, and Rush. The pattern of negative scores, outlining important cattle producing areas, clearly defines the southern Flint Hills region and the north central area. In addition, several western counties appear with substantial cattle production, the northern ones from grazing and the southern ones from feedlots.

Component Six is called Increasing Cropland and High Water Costs, and explains 4.3% of the total variation in the state water situation. Water supply revenues and expenditures (variables 26 and 27) load highly at .826 and .749 respectively. Differential shift in cropland acres between 1949 and 1974 (variable 15) also loads strongly at .629, and total volume of groundwater available (variable 21) appears lightly at .422. A high positive score on Component Six therefore indicates costly water investment correlated with growth in cropland. Negative scores isolate counties with low water investments and decreasing acres in cropland. Three exceptions must be noted on Figure 4-6, however. Wichita, Scott, and Rawlins counties emerge with strong negative scores, but these are misleading, as data for water supply revenues and expenditures were unavailable and therefore recorded as zeros, resulting in negative component scores for these counties. With valid information, these counties probably would have scores similar to Finney and Cheyenne, based on similarity of raw data.

Component Seven is clearly a measure of dependence on cropland versus rangeland, and is labelled Rangeland-Cropland Intensity, contributing three percent of the explained variation in the original seventy-one variables. Two variables, percent of county land in cropland (variable 10)

and percent of state field crop production (variable 70) load positively on this dimension at .712 and .567 respectively. Percent of county land in pasture and rangeland (variable 11) shows a negative loading of .761, while total cropland acres (variable 13) registers lightly positive at .461. Based on these four variables, a county with a strongly positive score is primarily a crop agriculture county, and is apt to be relatively productive as well. However, a positive score does not preclude cattle production but indicates that crop production is considerably more important. Negatively scoring counties have relatively large shares of land in pasture and rangeland and account for only a small percentage of state field crop production.

The map of the Rangeland-Cropland Intensity Component, Figure 4-7, demonstrates that this component highlights extremes of cattle or crop production rather than substantially equal cattle-cropland mixes. Thus, the primarily cropland area near the eastern Kansas-Nebraska border appears prominently, as do some south-central counties. Conversely, the southern Flint Hills are easily seen as predominantly cattle counties, as are a few, sporadically-located western counties. This overlaps the pattern displayed in Figure 4-5 depicting the Cattle Production component. However, many western counties which register strongly negative or positive on Figure 4-5 are much more modest in their scores on Component Seven, reflecting the fact that many counties have symbiotic feed-grain-feedlot or cropland-pasture combinations and therefore are more balanced in the production of crops versus cattle.

Non-suitability for sprinkler irrigation is the main theme of the eighth component, which is labelled Sprinkler Irrigation. Two and six-tenths percent of the total variation is explained by this dimension.

Strong loadings are tallied by acres suitable for sprinkler irrigation (variable 4, loading $-.729$), method of irrigation--sprinkler (variable 42, loading $-.643$), volume of groundwater recharge per acre (variable 28, loading $-.553$), and method of irrigation-gated pipe (variable 43, loading $.527$). A positive score thus shows non-sprinkler suitability and activity, whereas a negative score illustrates suitability for and actual irrigation from sprinkler systems. The map of this component, Figure 4-8, clearly identifies the sandy south-central, Great Bend prairie and Red Hills areas as the state's sprinkler irrigation suitability region. Areas of west-central Kansas score particularly strongly, indicating non-suitability for sprinkler systems, as do some of the urban eastern counties. This is a component on which rapid change can be anticipated as sprinkler systems become more widespread and less expensive.

The final interpretable component reflects another aspect of irrigation and is called the Extensiveness of Irrigation Development component. Table 4-6 lists variables that contribute to this dimension. Despite the large number of significant variables, component nine accounts for only 2.3% of the total variation. All significant variables load positively and concern irrigated acreage, irrigation water and total water demand, and availability of groundwater. Thus, high positive scores reveal counties with large absolute numbers of irrigated acres, correspondingly large proportions of cropland irrigated, high demand for irrigation water and parallel total water demand, and extensive groundwater reserves. Much of western Kansas, particularly the southwest, falls in this category, as is apparent from Figure 4-9. Many north-central counties score highly negative on this component, indicating lack of groundwater, little irrigation, and small irrigation water demand.

TABLE 4-6

VARIABLE LOADINGS FOR COMPONENT NINE:
EXTENSIVENESS OF IRRIGATION DEVELOPMENT

Variable	Loading	Variable Name
35	.887	Percent of cropland acres irrigated, 1973-74
36	.868	Total number of acres irrigated, 1973-74
34	.813	1965 demand for irrigation
54	.747	2000 demand for irrigation
22	.744	Volume of groundwater available per acre
21	.722	Total volume of groundwater available for pumping
49	.718	2000 total water demand
29	.701	1965 total water demand
1	.668	Acres suitable for irrigation--class 1 (%)
6	.551	Percent of land underlain by groundwater ≥100 gpm
5	.545	Acres that are non-arable (%)
64	.482	Natural growth rate
60	-.472	Differential shift in irrigation demand, 1965-2000

Description of Unused Components

In addition to the nine interpretable components, the principal components analysis produced five non-useable components with eigenvalues of greater than one, the cut-off point for rotating components suggested by Kaiser⁴ and used in this study. These five dimensions together contribute 11.2% of the variation in the original variables. Table 4-7 lists significant variable loadings and eigenvalues for the five unused components. It is obvious from the table that few variables load on

⁴H. F. Kaiser, referred in D. C. D. Pocock and D. Wishart, "Methods of Driving Multi-Factor Uniform Regions," Transactions of the Institute of British Geographers, XLVII (1969), p. 76.

TABLE 4-7
VARIABLE LOADINGS FOR FIVE UNUSABLE COMPONENTS

	Variable Loading	Variable Name
<u>Component A:</u>		
Variable 46	-.665	Change in irrigation as percent of total water demand, 1965-2000
Variable 57	.572	Differential shift in industrial water demand, 1965-2000
Eigenvalue: 2.318		
Explained variation: 3.3%		
<u>Component B:</u>		
Variable 23	-.654	Storage in existing reservoirs
Eigenvalue: 1.987		
Explained variation: 2.8%		
<u>Component C:</u>		
Variable 3	.743	Acres suitable for irrigation--class 3
Variable 44	-.527	Method of irrigation--open ditch
Eigenvalue: 1.304		
Explained variation: 1.8%		
<u>Component D:</u>		
Variable 24	.765	Storage in reservoirs under construction
Variable 25	-.621	Storage in proposed reservoirs
Eigenvalue: 1.267		
Explained variation: 1.8%		
<u>Component E:</u>		
Variable 67	-.745	Percent of population that is rural
Variable 66	.715	Percent of population that is urban
Variable 68	-.705	Percent of labor force in agriculture
Eigenvalue: 1.100		
Explained variation: 1.5%		

these dimensions, a fact which by itself makes reliable interpretation and labelling hazardous. Components A and C are rejected because the component loadings do not "tell a story" that can be understood, even when the component scores are mapped. Both variables loading on Component A are future estimates, and because of uncertainty involved in predicting future use, interpretation of a component defined only by such estimates would be subject to error of unknowable proportions. In addition, the two-member clusters contained in Components A and C do not by themselves contribute significant insights into the water planning situation. Components B and D have high loadings only on reservoir data. The few Kansas counties that have or will have reservoirs register five- and six-digit numbers for acre-feet of storage. This contrasts to zeros for counties without reservoirs. Because the data are extremely skewed, it is felt that the component may exaggerate the importance of reservoir storage. Component E appears to be an urban population dimension, but mapping of the component scores does not support this conclusion. Several highly urban counties, such as Sedgwick and Johnson, score negatively, while some rural counties, such as Miami, score positively. The component is deleted because the reason for this discrepancy cannot be determined. These five unusable components are omitted throughout the remainder of this study.

Distance Scaling

At this point, each county has a component score on each of the nine principal components, but a means is needed to summarize the status of each county regarding the components and to indicate how similar or different the various counties are among themselves. For example, how

does a county with high positive scores on Components One, Three, and Nine, indifferent scores on Components Two and Eight, and strongly negative scores on Components Five, Six, and Seven compare to a county with corresponding scores on One, Five, and Seven; Two, Four, and Six; and Three, Eight, and Nine? Distance scaling, as described previously in Chapter 3, is employed to make such comparisons. Briefly, each county is plotted in nine-dimensional vector space corresponding to the nine principal components, and the plotted distance is measured between each pair of counties. Similarity, a direct function of distance as plotted in vector space, is a squared Euclidean distance involving sums of squares of differences between component scores. The resulting 105 by 105 distance matrix is used in the next step of the analysis, the grouping procedure, which scans the matrix to find and combine those counties that are most similar.

Grouping Procedure

Using the distance matrix as input, a computer program titled "Congroup"⁵ performs a hierarchical 104-step process to transform the 105 one-county regions into one 105-county region by combining similar counties. The step-by-step grouping, which follows the centroid method explained in Chapter 3, is shown in Table 4-8. Numbers combined refer to the Kansas counties arranged in alphabetical sequence, as illustrated in Figure 4-10. For planning purposes, both one-county and 105-county regions are of negligible utility, so an intermediate step, less detailed than the 105 counties individually but less general than one state-wide region, must be selected that best represents the actual water regionalization in the state. It

⁵CNGRP Program written by Neely and Mazukelli at the University of Chicago and modified by Dierk Rhynsbarger at the University of Michigan.

TABLE 4-8: STEPS IN "CONGROUP" PROCEDURE

STEP 1	SUM =	0.156370E 00	MIN DIST =	0.156370E 00	FOR ITEMS	54	AND	103	WITH	1	1	MEMBERS
STEP 2	SUM =	0.401282E 00	MIN DIST =	0.204912E 00	FOR ITEMS	2	AND	54	WITH	1	2	MEMBERS
STEP 3	SUM =	0.673495E 00	MIN DIST =	0.272217E 00	FOR ITEMS	27	AND	53	WITH	1	1	MEMBERS
STEP 4	SUM =	0.101013E 01	MIN DIST =	0.344635E 00	FOR ITEMS	7	AND	66	WITH	1	1	MEMBERS
STEP 5	SUM =	0.137974E 01	MIN DIST =	0.361611E 00	FOR ITEMS	27	AND	72	WITH	2	1	MEMBERS
STEP 6	SUM =	0.175587E 01	MIN DIST =	0.376129E 00	FOR ITEMS	42	AND	55	WITH	1	1	MEMBERS
STEP 7	SUM =	0.215401E 01	MIN DIST =	0.398139E 00	FOR ITEMS	10	AND	25	WITH	1	1	MEMBERS
STEP 8	SUM =	0.259686E 01	MIN DIST =	0.442854E 00	FOR ITEMS	2	AND	63	WITH	3	1	MEMBERS
STEP 9	SUM =	0.306792E 01	MIN DIST =	0.471054E 00	FOR ITEMS	45	AND	92	WITH	1	1	MEMBERS
STEP 10	SUM =	0.356313E 01	MIN DIST =	0.495211E 00	FOR ITEMS	73	AND	80	WITH	1	1	MEMBERS
STEP 11	SUM =	0.406688E 01	MIN DIST =	0.503755E 00	FOR ITEMS	4	AND	17	WITH	1	1	MEMBERS
STEP 12	SUM =	0.463386E 01	MIN DIST =	0.566575E 00	FOR ITEMS	2	AND	67	WITH	4	1	MEMBERS
STEP 13	SUM =	0.512907E 01	MIN DIST =	0.495210E 00	FOR ITEMS	2	AND	30	WITH	5	1	MEMBERS
STEP 14	SUM =	0.571582E 01	MIN DIST =	0.586751E 00	FOR ITEMS	2	AND	61	WITH	6	1	MEMBERS
STEP 15	SUM =	0.638520E 01	MIN DIST =	0.669385E 00	FOR ITEMS	27	AND	84	WITH	3	1	MEMBERS
STEP 16	SUM =	0.658054E 01	MIN DIST =	0.595745E 00	FOR ITEMS	27	AND	69	WITH	4	1	MEMBERS
STEP 17	SUM =	0.765283E 01	MIN DIST =	0.671883E 00	FOR ITEMS	42	AND	51	WITH	2	1	MEMBERS
STEP 18	SUM =	0.836970E 01	MIN DIST =	0.716875E 00	FOR ITEMS	6	AND	19	WITH	1	1	MEMBERS
STEP 19	SUM =	0.913762E 01	MIN DIST =	0.767920E 00	FOR ITEMS	59	AND	71	WITH	1	1	MEMBERS
STEP 20	SUM =	0.959811E 01	MIN DIST =	0.860487E 00	FOR ITEMS	39	AND	82	WITH	1	1	MEMBERS
STEP 21	SUM =	0.108988E 02	MIN DIST =	0.500696E 00	FOR ITEMS	2	AND	6	WITH	7	2	MEMBERS
STEP 22	SUM =	0.118389E 02	MIN DIST =	0.940095E 00	FOR ITEMS	15	AND	27	WITH	1	5	MEMBERS
STEP 23	SUM =	0.127554E 02	MIN DIST =	0.516490E 00	FOR ITEMS	15	AND	39	WITH	6	2	MEMBERS
STEP 24	SUM =	0.137081E 02	MIN DIST =	0.552676E 00	FOR ITEMS	3	AND	22	WITH	1	1	MEMBERS
STEP 25	SUM =	0.146678E 02	MIN DIST =	0.959727E 00	FOR ITEMS	14	AND	62	WITH	1	1	MEMBERS
STEP 26	SUM =	0.156613E 02	MIN DIST =	0.553530E 00	FOR ITEMS	16	AND	70	WITH	1	1	MEMBERS

STEP 27	SUM =	0.167029E 02	MIN DIST =	0.104161E 01	FCR ITEMS	15	AND	98	WITH	9	1	MEMBERS
STEP 28	SUM =	0.178195E 02	MIN DIST =	0.111657E 01	FOR ITEMS	14	AND	58	WITH	2	1	MEMBERS
STEP 29	SUM =	0.189924E 02	MIN DIST =	0.117287E 01	FOR ITEMS	21	AND	74	WITH	1	1	MEMBERS
STEP 30	SUM =	0.200281E 02	MIN DIST =	0.103579E 01	FCR ITEMS	21	AND	59	WITH	2	2	MEMBERS
STEP 31	SUM =	0.210396E 02	MIN DIST =	0.101149E 01	FOR ITEMS	21	AND	45	WITH	4	2	MEMBERS
STEP 32	SUM =	0.222228E 02	MIN DIST =	0.118317E 01	FOR ITEMS	20	AND	77	WITH	1	1	MEMBERS
STEP 33	SUM =	0.235202E 02	MIN DIST =	0.129742E 01	FCR ITEMS	20	AND	42	WITH	2	3	MEMBERS
STEP 34	SUM =	0.248358E 02	MIN DIST =	0.131559E 01	FCR ITEMS	16	AND	64	WITH	2	1	MEMBERS
STEP 35	SUM =	0.262144E 02	MIN DIST =	0.137867E 01	FOR ITEMS	38	AND	68	WITH	1	1	MEMBERS
STEP 36	SUM =	0.276146E 02	MIN DIST =	0.140020E 01	FOR ITEMS	76	AND	93	WITH	1	1	MEMBERS
STEP 37	SUM =	0.290374E 02	MIN DIST =	0.142277E 01	FOR ITEMS	31	AND	99	WITH	1	1	MEMBERS
STEP 38	SUM =	0.304611E 02	MIN DIST =	0.142373E 01	FOR ITEMS	16	AND	104	WITH	3	1	MEMBERS
STEP 39	SUM =	0.319178E 02	MIN DIST =	0.145674E 01	FCR ITEMS	9	AND	37	WITH	1	1	MEMBERS
STEP 40	SUM =	0.334001E 02	MIN DIST =	0.148226E 01	FOR ITEMS	15	AND	85	WITH	9	1	MEMBERS
STEP 41	SUM =	0.349050E 02	MIN DIST =	0.150488E 01	FOR ITEMS	5	AND	29	WITH	1	1	MEMBERS
STEP 42	SUM =	0.364313E 02	MIN DIST =	0.152633E 01	FOR ITEMS	23	AND	52	WITH	1	1	MEMBERS
STEP 43	SUM =	0.380380E 02	MIN DIST =	0.160669E 01	FOR ITEMS	38	AND	83	WITH	2	1	MEMBERS
STEP 44	SUM =	0.396203E 02	MIN DIST =	0.158230E 01	FCR ITEMS	36	AND	38	WITH	1	3	MEMBERS
STEP 45	SUM =	0.413135E 02	MIN DIST =	0.169325E 01	FOR ITEMS	2	AND	50	WITH	9	1	MEMBERS
STEP 46	SUM =	0.430111E 02	MIN DIST =	0.169756E 01	FCR ITEMS	14	AND	57	WITH	3	1	MEMBERS
STEP 47	SUM =	0.445328E 02	MIN DIST =	0.152172E 01	FOR ITEMS	14	AND	96	WITH	4	1	MEMBERS
STEP 48	SUM =	0.462313E 02	MIN DIST =	0.169853E 01	FOR ITEMS	2	AND	43	WITH	10	1	MEMBERS
STEP 49	SUM =	0.479472E 02	MIN DIST =	0.171593E 01	FOR ITEMS	3	AND	40	WITH	2	1	MEMBERS
STEP 50	SUM =	0.497314E 02	MIN DIST =	0.178422E 01	FOR ITEMS	14	AND	21	WITH	5	6	MEMBERS
STEP 51	SUM =	0.511681E 02	MIN DIST =	0.143663E 01	FCR ITEMS	14	AND	79	WITH	11	1	MEMBERS
STEP 52	SUM =	0.529601E 02	MIN DIST =	0.179203E 01	FOR ITEMS	2	AND	16	WITH	11	4	MEMBERS
STEP 53	SUM =	0.547569E 02	MIN DIST =	0.179685E 01	FOR ITEMS	20	AND	36	WITH	5	4	MEMBERS

STEP 54	SUM =	0.569218E 02	MIN DIST =	0.216482E 01	FOR ITEMS	7	AND	14	WITH	2	12	MEMBERS
STEP 55	SUM =	0.591289E 02	MIN DIST =	0.220712E 01	FOR ITEMS	23	AND	44	WITH	2	1	MEMBERS
STEP 56	SUM =	0.613969E 02	MIN DIST =	0.226805E 01	FOR ITEMS	7	AND	101	WITH	14	1	MEMBERS
STEP 57	SUM =	0.637644E 02	MIN DIST =	0.236752E 01	FOR ITEMS	23	AND	81	WITH	3	1	MEMBERS
STEP 58	SUM =	0.661507E 02	MIN DIST =	0.238627E 01	FOR ITEMS	24	AND	49	WITH	1	1	MEMBERS
STEP 59	SUM =	0.688036E 02	MIN DIST =	0.265298E 01	FOR ITEMS	12	AND	33	WITH	1	1	MEMBERS
STEP 60	SUM =	0.715101E 02	MIN DIST =	0.270645E 01	FOR ITEMS	47	AND	88	WITH	1	1	MEMBERS
STEP 61	SUM =	0.742238E 02	MIN DIST =	0.271370E 01	FOR ITEMS	15	AND	73	WITH	10	2	MEMBERS
STEP 62	SUM =	0.769385E 02	MIN DIST =	0.271475E 01	FOR ITEMS	47	AND	100	WITH	2	1	MEMBERS
STEP 63	SUM =	0.796317E 02	MIN DIST =	0.269322E 01	FOR ITEMS	47	AND	65	WITH	3	1	MEMBERS
STEP 64	SUM =	0.823697E 02	MIN DIST =	0.273800E 01	FOR ITEMS	15	AND	20	WITH	12	9	MEMBERS
STEP 65	SUM =	0.852255E 02	MIN DIST =	0.285581E 01	FOR ITEMS	7	AND	26	WITH	15	1	MEMBERS
STEP 66	SUM =	0.882486E 02	MIN DIST =	0.302304E 01	FOR ITEMS	2	AND	23	WITH	15	4	MEMBERS
STEP 67	SUM =	0.910716E 02	MIN DIST =	0.282310E 01	FOR ITEMS	2	AND	3	WITH	19	3	MEMBERS
STEP 68	SUM =	0.942048E 02	MIN DIST =	0.313314E 01	FOR ITEMS	24	AND	48	WITH	2	1	MEMBERS
STEP 69	SUM =	0.973746E 02	MIN DIST =	0.316584E 01	FOR ITEMS	4	AND	75	WITH	2	1	MEMBERS
STEP 70	SUM =	0.100557E 03	MIN DIST =	0.318239E 01	FOR ITEMS	34	AND	94	WITH	1	1	MEMBERS
STEP 71	SUM =	0.103859E 03	MIN DIST =	0.320186E 01	FOR ITEMS	35	AND	90	WITH	1	1	MEMBERS
STEP 72	SUM =	0.107201E 03	MIN DIST =	0.334194E 01	FOR ITEMS	5	AND	32	WITH	2	1	MEMBERS
STEP 73	SUM =	0.110563E 03	MIN DIST =	0.336184E 01	FOR ITEMS	35	AND	97	WITH	2	1	MEMBERS
STEP 74	SUM =	0.113521E 03	MIN DIST =	0.255873E 01	FOR ITEMS	35	AND	91	WITH	3	1	MEMBERS
STEP 75	SUM =	0.116948E 03	MIN DIST =	0.342651E 01	FOR ITEMS	24	AND	76	WITH	3	2	MEMBERS
STEP 76	SUM =	0.120612E 03	MIN DIST =	0.366380E 01	FOR ITEMS	7	AND	15	WITH	16	21	MEMBERS
STEP 77	SUM =	0.124142E 03	MIN DIST =	0.353052E 01	FOR ITEMS	5	AND	7	WITH	3	37	MEMBERS
STEP 78	SUM =	0.127918E 03	MIN DIST =	0.377608E 01	FOR ITEMS	86	AND	102	WITH	1	1	MEMBERS
STEP 79	SUM =	0.131729E 03	MIN DIST =	0.381101E 01	FOR ITEMS	9	AND	56	WITH	2	1	MEMBERS
STEP 80	SUM =	0.135913E 03	MIN DIST =	0.418337E 01	FOR ITEMS	4	AND	10	WITH	3	2	MEMBERS

STEP 81	SUM =	0.139786E 03	MIN DIST =	0.387383E 01	FOR ITEMS	2 AND	4 WITH	22	5 MEMBERS
STEP 82	SUM =	0.143850E 03	MIN DIST =	0.406397E 01	FOR ITEMS	2 AND	5 WITH	27	40 MEMBERS
STEP 83	SUM =	0.148699E 03	MIN DIST =	0.484852E 01	FOR ITEMS	2 AND	18 WITH	67	1 MEMBERS
STEP 84	SUM =	0.153782E 03	MIN DIST =	0.508338E 01	FOR ITEMS	2 AND	47 WITH	68	4 MEMBERS
STEP 85	SUM =	0.160350E 03	MIN DIST =	0.656725E 01	FOR ITEMS	24 AND	78 WITH	5	1 MEMBERS
STEP 86	SUM =	0.167185E 03	MIN DIST =	0.683540E 01	FOR ITEMS	12 AND	60 WITH	2	1 MEMBERS
STEP 87	SUM =	0.174640E 03	MIN DIST =	0.745531E 01	FOR ITEMS	2 AND	12 WITH	72	3 MEMBERS
STEP 88	SUM =	0.183139E 03	MIN DIST =	0.849852E 01	FOR ITEMS	9 AND	31 WITH	3	2 MEMBERS
STEP 89	SUM =	0.191384E 03	MIN DIST =	0.824502E 01	FOR ITEMS	2 AND	9 WITH	75	5 MEMBERS
STEP 90	SUM =	0.200835E 03	MIN DIST =	0.945134E 01	FOR ITEMS	34 AND	86 WITH	2	2 MEMBERS
STEP 91	SUM =	0.211457E 03	MIN DIST =	0.106215E 02	FOR ITEMS	2 AND	35 WITH	80	4 MEMBERS
STEP 92	SUM =	0.222784E 03	MIN DIST =	0.113274E 02	FOR ITEMS	2 AND	24 WITH	84	6 MEMBERS
STEP 93	SUM =	0.235457E 03	MIN DIST =	0.126736E 02	FOR ITEMS	2 AND	89 WITH	50	1 MEMBERS
STEP 94	SUM =	0.248628E 03	MIN DIST =	0.131707E 02	FOR ITEMS	1 AND	2 WITH	1	91 MEMBERS
STEP 95	SUM =	0.266311E 03	MIN DIST =	0.176831E 02	FOR ITEMS	1 AND	34 WITH	92	4 MEMBERS
STEP 96	SUM =	0.284288E 03	MIN DIST =	0.179775E 02	FOR ITEMS	1 AND	8 WITH	56	1 MEMBERS
STEP 97	SUM =	0.303122E 03	MIN DIST =	0.188335E 02	FOR ITEMS	1 AND	13 WITH	97	1 MEMBERS
STEP 98	SUM =	0.325135E 03	MIN DIST =	0.220123E 02	FOR ITEMS	46 AND	87 WITH	1	1 MEMBERS
STEP 99	SUM =	0.348943E 03	MIN DIST =	0.238088E 02	FOR ITEMS	1 AND	11 WITH	98	1 MEMBERS
STEP 100	SUM =	0.383933E 03	MIN DIST =	0.349893E 02	FOR ITEMS	1 AND	41 WITH	99	1 MEMBERS
STEP 101	SUM =	0.425542E 03	MIN DIST =	0.416093E 02	FOR ITEMS	1 AND	28 WITH	100	1 MEMBERS
STEP 102	SUM =	0.467694E 03	MIN DIST =	0.421517E 02	FOR ITEMS	1 AND	46 WITH	101	2 MEMBERS
STEP 103	SUM =	0.528675E 03	MIN DIST =	0.609812E 02	FOR ITEMS	1 AND	95 WITH	103	1 MEMBERS
STEP 104	SUM =	0.620982E 03	MIN DIST =	0.923076E 02	FOR ITEMS	1 AND	105 WITH	104	1 MEMBERS

FIGURE 4-10

CHEYENNE	RAWLINS	DECATUR	NORTON	PHILLIPS	SMITH	JEWELL	REPUBLIC	WASHINGTON	MARSHALL	NEMAH	BROWN	
12	77	20	69	74	92	45	79	101	59	66	7	DONIPHAN
SHERMAN	THOMAS	SHERIDAN	GRAHAM	ROOKS	OSBORNE	MITCHELL	CLOUD	CLAY	RILEY	POTTAWATOMIE	JACKSON	LATCHISON
91	97	90	33	82	71	62	15	14	81	75	43	3
WALLACE	LOGAN	GOVE	TREGO	ELLIS	RUSSELL	LINCOLN	OTTAWA	DICKINSON	GEARY	SHAWNEE	WABAUENSEE	JEFFERSON
100	55	32	98	26	84	53	72	21	31	89	23	44
GREELEY	WICHITA	LANE	NESS	RUSH	BARTON	ELLSWORTH	SALINE	MCPHERSON	MORRIS	OSAGE	DOUGLAS	JOHNSON
36	102	51	68	83	5	27	85	57	64	70	30	46
HAMILTON	KEARNY	FINNEY	HODGEMAN	PAWNEE	STAFFORD	RICE	MC	CHASE	COFFEY	ANDERSON	LYON	FRANKLIN
38	47	28	42	73	93	80	58	9	16	2	54	MIAMI
STANTON	GRANT	HASKELL	FORD	EDWARDS	PRATT	RENO	HARVEY	BUTLER	GREENWOOD	WOODSON	ALLEN	BOURBON
94	34	41	29	24	76	78	40	8	37	104	1	6
MORTON	STEVENS	SEWARD	CLARK	KIOWA	BARBER	KINGMAN	SUMNER	COWLEY	ELK	WILSON	NEOSHO	CRAWFORD
65	95	88	13	49	4	48	96	18	25	103	67	19
			MEADE	COMANCHE		HARPER			CHAUTAUQUA	MONTGOMERY	LABETTE	CHEROKEE
			60	17		39			10	63	50	11

KANSAS COUNTIES in ALPHABETICAL ORDER



should be remembered that no one step of the 104-step process isolates the "correct" regionalization scheme for water planning. Each step merely shows the degree of similarity between the counties regarding the original seventy-one water-related variables with a given percent of detail lost and a certain ratio of within group to between group distances (see Tables 4-8 and 4-9). For water planning regions, one needs a spatial display that links similar counties into a set of regions that can be refined to obtain a final reasonable number and configuration of regions representing differing water conditions. The grouping procedure shown in Table 4-8 must be halted at a point that facilitates this purpose.

Table 4-9, showing percent of detail lost and distances squared within and between groups, is helpful but insufficient for the task of selecting the most convenient end point of the computer grouping procedure. Percent of detail lost is calculated by dividing the within group distance squared at a given step by the total within group distance squared at step 104 (620.98 in this case), or conversely by dividing the between group distance squared at the step by the total between group distance squared at step one (also 620.98) and subtracting the quotient from 100. The percent of detail lost increases slowly at first and does not begin a more rapid growth until the last one-third of the process. For example, it takes fifteen steps before one percent of the detail is lost, eight more steps before an additional one percent is lost, and six steps again to reach a three percent loss. After step eighty-four, more than one percent is lost in one step. Also at that point, the differences between consecutive steps in the "sum = XXX" column in Table 4-8 begin to increase much more rapidly, indicating that this is an appropriate point at which

TABLE 4-9
DETAIL LOST IN "CONGROUP" STEPS

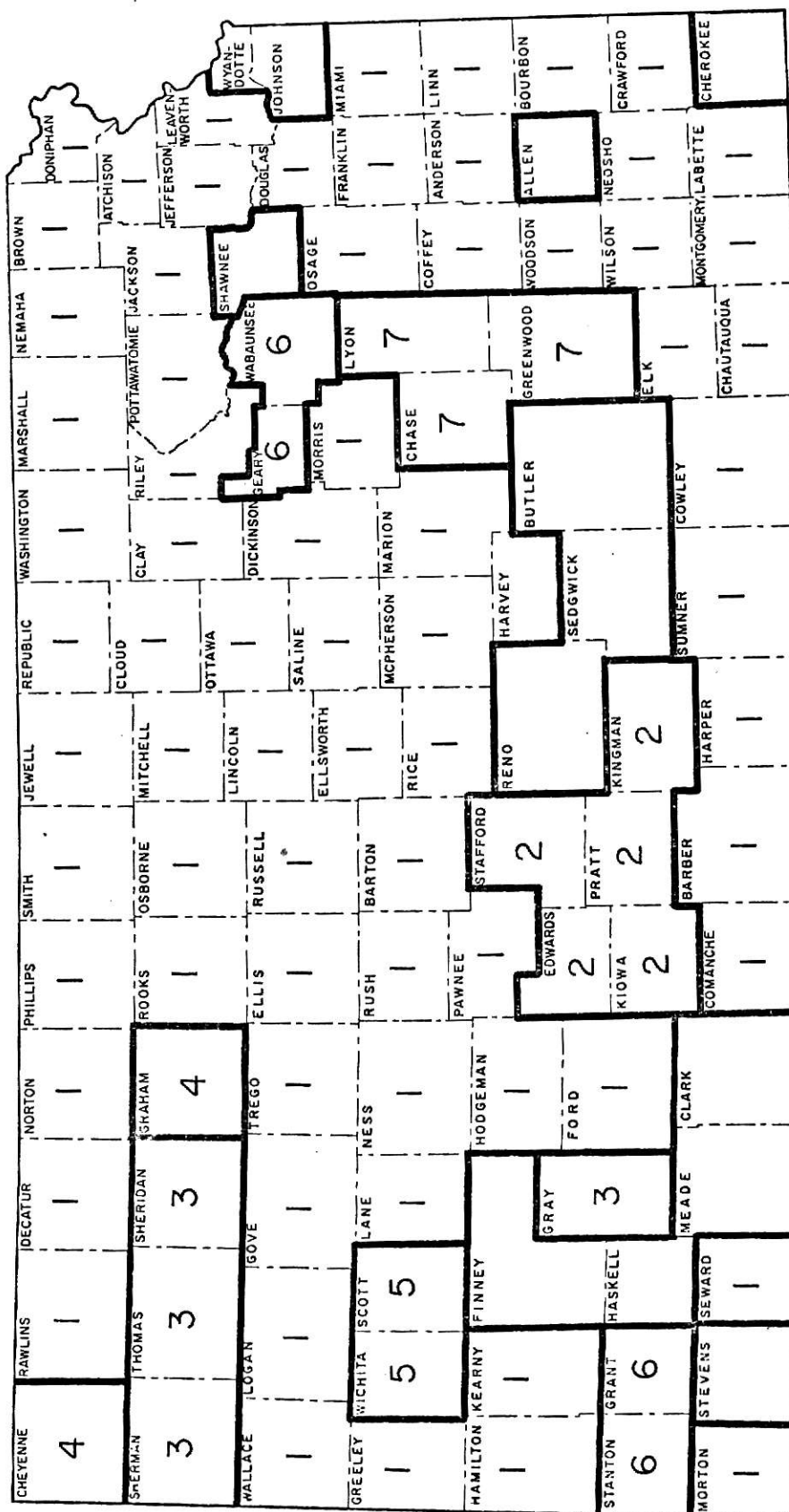
STEP	I	J	% LOSS	WITHIN DSQ	BETW DSQ
0			0.00	0.00000E 00	0.62098E 03
1	54	103	0.03	0.19637E 00	0.62079E 03
2	2	54	0.06	0.40128E 00	0.62058E 03
3	27	53	0.11	0.67250E 00	0.62031E 03
4	7	66	0.16	0.10181E 01	0.61996E 03
5	27	72	0.22	0.13797E 01	0.61960E 03
6	42	55	0.28	0.17559E 01	0.61923E 03
7	10	25	0.35	0.21540E 01	0.61883E 03
8	2	63	0.42	0.25969E 01	0.61839E 03
9	45	92	0.49	0.30679E 01	0.61791E 03
10	73	80	0.57	0.35631E 01	0.61742E 03
11	4	17	0.65	0.40669E 01	0.61692E 03
12	2	67	0.75	0.46339E 01	0.61635E 03
13	2	30	0.83	0.51291E 01	0.61585E 03
14	2	61	0.92	0.57158E 01	0.61527E 03
15	27	84	1.03	0.63852E 01	0.61460E 03
16	27	69	1.12	0.69809E 01	0.61400E 03
17	42	51	1.23	0.76528E 01	0.61333E 03
18	6	19	1.35	0.83697E 01	0.61261E 03
19	59	71	1.47	0.91276E 01	0.61184E 03
20	39	82	1.61	0.99981E 01	0.61098E 03
21	2	6	1.76	0.10899E 02	0.61008E 03
22	15	27	1.91	0.11839E 02	0.60914E 03
23	15	39	2.05	0.12755E 02	0.60823E 03
24	3	22	2.21	0.13708E 02	0.60727E 03
25	14	62	2.36	0.14668E 02	0.60631E 03
26	16	70	2.52	0.15661E 02	0.60532E 03
27	15	98	2.69	0.16703E 02	0.60428E 03
28	14	58	2.87	0.17819E 02	0.60316E 03
29	21	74	3.06	0.18992E 02	0.60199E 03
30	21	59	3.23	0.20028E 02	0.60095E 03
31	21	45	3.39	0.21040E 02	0.59994E 03
32	20	77	3.58	0.22223E 02	0.59876E 03
33	20	42	3.79	0.23520E 02	0.59746E 03
34	16	64	4.00	0.24836E 02	0.59615E 03
35	38	68	4.22	0.26214E 02	0.59477E 03
36	76	93	4.45	0.27615E 02	0.59337E 03
37	31	99	4.68	0.29037E 02	0.59194E 03
38	16	104	4.91	0.30461E 02	0.59052E 03
39	9	37	5.14	0.31918E 02	0.58906E 03
40	15	85	5.38	0.33400E 02	0.58758E 03
41	5	29	5.62	0.34905E 02	0.58608E 03
42	23	52	5.87	0.36431E 02	0.58455E 03
43	38	83	6.13	0.38038E 02	0.58294E 03
44	36	38	6.38	0.39620E 02	0.58136E 03
45	2	50	6.65	0.41314E 02	0.57967E 03
46	14	57	6.93	0.43011E 02	0.57797E 03
47	14	96	7.17	0.44533E 02	0.57645E 03
48	2	43	7.44	0.46231E 02	0.57475E 03

49	3	40	7.72	0.47547E 02	0.57304E 03
50	14	21	8.01	0.49731E 02	0.57125E 03
51	14	79	8.24	0.51168E 02	0.56981E 03
52	2	16	8.53	0.52960E 02	0.56802E 03
53	20	36	8.82	0.54757E 02	0.56623E 03
54	7	14	9.17	0.56922E 02	0.56406E 03
55	23	44	9.52	0.59129E 02	0.56185E 03
56	7	101	9.89	0.61397E 02	0.55959E 03
57	23	81	10.27	0.63764E 02	0.55722E 03
58	24	49	10.65	0.66151E 02	0.55483E 03
59	12	33	11.08	0.68804E 02	0.55218E 03
60	47	88	11.52	0.71510E 02	0.54947E 03
61	15	73	11.95	0.74224E 02	0.54676E 03
62	47	100	12.39	0.76939E 02	0.54404E 03
63	47	65	12.82	0.79632E 02	0.54135E 03
64	15	20	13.26	0.82370E 02	0.53861E 03
65	7	26	13.72	0.85226E 02	0.53576E 03
66	2	23	14.21	0.88249E 02	0.53273E 03
67	2	3	14.67	0.91072E 02	0.52991E 03
68	24	48	15.17	0.94205E 02	0.52678E 03
69	4	75	15.68	0.97375E 02	0.52361E 03
70	34	94	16.19	0.10056E 03	0.52043E 03
71	35	90	16.72	0.10386E 03	0.51712E 03
72	5	32	17.26	0.10720E 03	0.51378E 03
73	35	97	17.80	0.11056E 03	0.51042E 03
74	35	91	18.28	0.11352E 03	0.50746E 03
75	24	76	18.83	0.11695E 03	0.50403E 03
76	7	15	19.42	0.12061E 03	0.50037E 03
77	5	7	19.99	0.12414E 03	0.49684E 03
78	86	102	20.60	0.12792E 03	0.49306E 03
79	9	56	21.21	0.13173E 03	0.48925E 03
80	4	10	21.89	0.13591E 03	0.48507E 03
81	2	4	22.51	0.13979E 03	0.48120E 03
82	2	5	23.16	0.14385E 03	0.47713E 03
83	2	13	23.95	0.14870E 03	0.47228E 03
84	2	47	24.76	0.15378E 03	0.46720E 03
85	24	78	25.82	0.16035E 03	0.46063E 03
86	12	60	26.92	0.16718E 03	0.45380E 03
87	2	12	28.12	0.17464E 03	0.44634E 03
88	9	31	29.49	0.18314E 03	0.43784E 03
89	2	9	30.82	0.19138E 03	0.42960E 03
90	34	86	32.34	0.20084E 03	0.42015E 03
91	2	35	34.05	0.21146E 03	0.40953E 03
92	2	24	35.88	0.22278E 03	0.39820E 03
93	2	89	37.92	0.23546E 03	0.38552E 03
94	1	2	40.04	0.24863E 03	0.37235E 03
95	1	34	42.89	0.26631E 03	0.35467E 03
96	1	8	45.78	0.28429E 03	0.33669E 03
97	1	13	48.91	0.30312E 03	0.31786E 03
98	46	87	52.36	0.32513E 03	0.29585E 03
99	1	11	56.19	0.34894E 03	0.27204E 03
100	1	41	61.83	0.38393E 03	0.23705E 03
101	1	28	68.53	0.42554E 03	0.19544E 03
102	1	46	75.32	0.46769E 03	0.15329E 03
103	1	95	85.14	0.52867E 03	0.92308E 02
104	1	105	100.00	0.62058E 03	0.0

to halt the grouping process. At this step, approximately one-quarter of the detail is lost and eighty percent of the joining is complete. However, mapping the joins up through step eighty-four (Figure 4-11) shows that a large number of the counties have coalesced into one broad region while many of the remaining counties have not entered the analysis. Scanning back through Table 4-8, it is seen that major joins occur at steps eighty-four, eighty-three, eighty-two, eighty-one, seventy-seven, and seventy-six, contributing to the one, very large group apparent in Figure 4-11. Mapping of the analysis through step seventy-five shows a much more detailed and meaningful pattern (Figure 4-12), and is selected as the starting point for the final regionalization. At this step, seventy-one percent of the grouping is complete, and eighty-one percent of the detail is retained.

A few words should be directed to the map of the first eighty-four steps. It illustrates very clearly the distinctiveness of the western third of the state as well as the major urban areas, as compared to most of the eastern two-thirds. Despite the obvious differences between many of the counties included in the huge Region One in Figure 4-11 (for instance, contrast Greeley with Douglas or Gove with Doniphan), those counties are nevertheless more similar to one another than are many of the southwestern or primarily urban counties to each other. Thus, Finney and Haskell counties, although neighbors, are less alike with respect to the variables measured than are Rawlins and Labette, for example, and the same observation holds for Sedgwick and Johnson, which, though they are both highly urban, do not join until step ninety-eight. This situation indicates that water planning for the western, especially the southwestern,

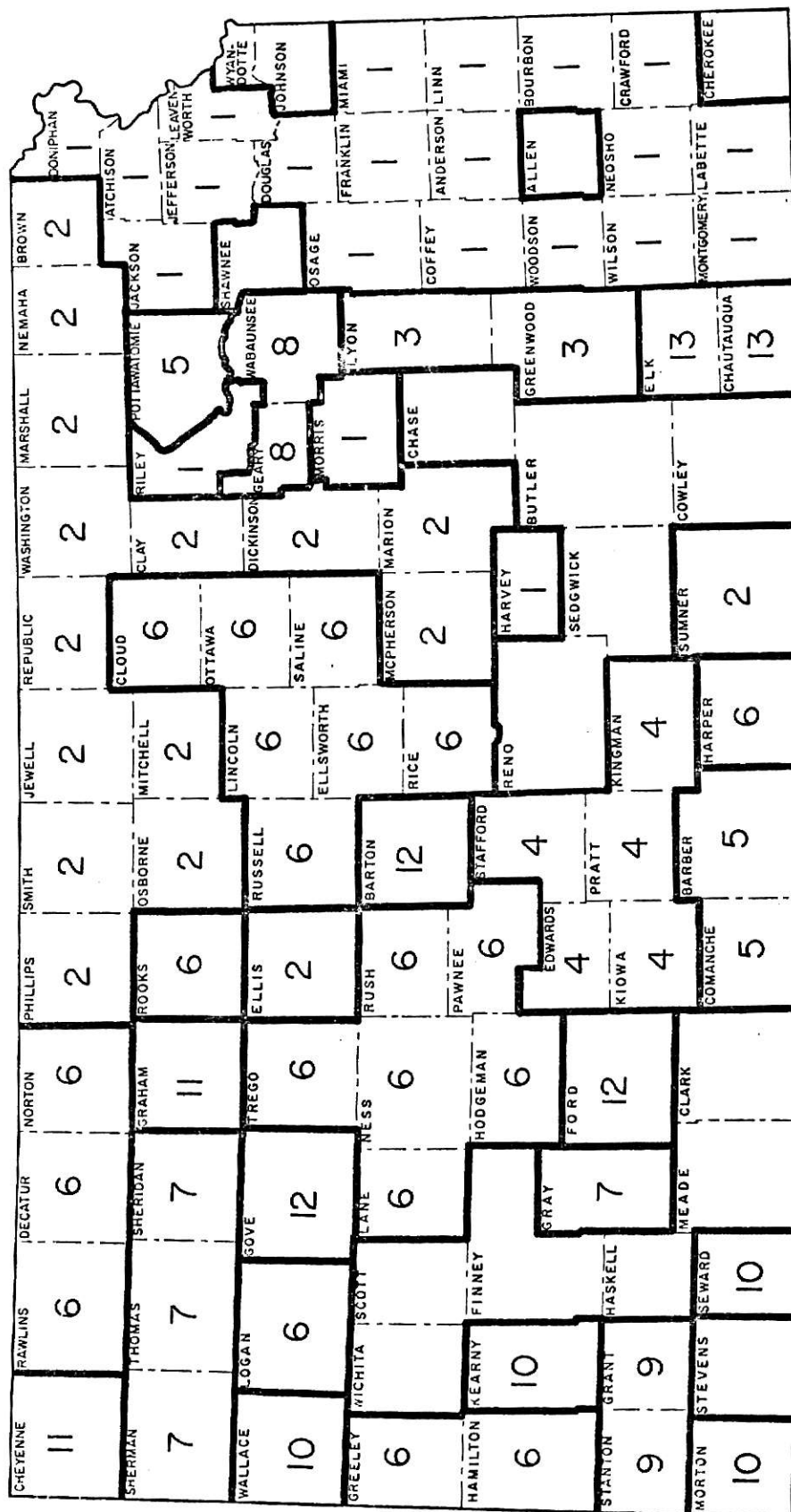
FIGURE 4-11



"CONGROUP" REGIONAL SCHEME AFTER 84 STEPS

0 10 20 30 40 50

FIGURE 4-12



"CONGROUP" REGIONAL SCHEME AFTER 75 STEPS

0 10 20 30 40 50

counties and the urban counties must deal with situations that differ considerably from the majority of the counties of the state as well as from each other.

Figure 4-12 demonstrates the spatial ordering of the water situation in Kansas within the limitations imposed by the variables selected, the data available, and the step selected as the final step in the computerized grouping program. It is immediately apparent that non-contiguous regional types have been isolated rather than contiguous, compact regions, but cores of areas are discernible. This set of regional types in their present form is not usable for state water planning, and a series of refinements are necessary to reach the objective of this study, namely to devise a set of water planning regions based on the realities of the supply, use, and management of water in the state.

The Water Planning Regions

Figure 4-13 presents the final, refined regionalization scheme for water planning in Kansas. Before retracing the guiding principles and procedures involved in the refinement from Figure 4-12 to Figure 4-13, it is important to describe the final regions. It should be kept in mind that the descriptive comments apply to each region in general and not necessarily to specific counties or sub-county areas. Comments are restricted to those relevant to water management and planning. The descriptions are based on county scores for each of the nine components, and fifteen individual variables having particular import for water planning, such as total volume of groundwater available and total water demand (variables 21 and 29).

Region One, the eastern one-fifth of the state, is a non-arid section with little irrigation development, whose declining population is largely rural. In this area, called the Humid, Non-Irrigated Region, crop production tends to be more significant than cattle production, but cattle are raised in large numbers in some counties, especially in the central part of the region. Per capita water supply costs are relatively low, and existing irrigation relies principally on surface supplies. For planning purposes, the region is subdivided into two sub-sections, "a" and "b." The division between Douglas and Franklin counties is based on the Congroup step-wise procedure and also on component scores. Counties in subregion 1-b rely more on groundwater supplies, are more urban, are losing population less rapidly, and emphasize crops over cattle. The southern subregion, 1-a, is more rural, relies more on surface water, and produces cattle in significant numbers. Regarding broad water characteristics, the two subregions are substantially similar and are grouped together in the Congroup routine; therefore they remain as one region here. However, the division described in Figure 4-13 constitutes a logical re-definition to achieve smaller yet coherent water planning regions.

The agriculture of Region Two, titled Crops with Cattle Region, is mixed cropland and cattle production, but the former is more intense, as shown by significant negative scores on the Cattle Production component but positive scores on the Rangeland-Cropland Intensity component. Scores on Components Three and Nine show little irrigation development, with only minor growth. Cropland acreage has increased since 1949 according to positive scores on the Cropland and High Water Cost component. Total water demand is low and is largely met with surface water. Like Region

One, the Crops with Cattle Region is composed of two subareas, though in this instance the areas are non-contiguous. Despite the separation, the water pictures involved are similar, implying common planning needs, problems, and approaches. The population of Region Two is largely rural, although the southern subarea is more urban than the northern extension.

Region Three roughly corresponds to the Flint Hills and is labelled Productive Cattle-Raising Region. Cattle grazing is the predominant agricultural activity, as shown by strong negative scores on both Components Five and Seven, Cattle Production and Rangeland-Cropland Intensity. Scores on Components Two and Four show that urban water demands are slight and will grow only slightly, as the counties are mainly rural except for Riley, Geary, and Lyon counties. There is some irrigation development and slight increases are anticipated in future irrigation. In the southern one-half of this region, total water demand is met largely with surface water, whereas the opposite is true in the northern counties. Again, total water demand is relatively low.

In Region Four, groundwater reserves are plentiful and the soil is suitable for sprinkler irrigation, hence, its title, Groundwater and Sprinkler Irrigation Region. Irrigation as of 1973-74 was only lightly developed, but most irrigation was by sprinkler. The most meaningful distinction for this region is its great potential for growth in irrigation. Groundwater recharge in this area is relatively high, as the groundwater drawn upon is essentially underflow from the Arkansas River rather than historically accumulated reserves. Agriculture in the area focuses on crop production.

Region Five, though suitable for sprinkler irrigation as shown by negative scores on Component Eight, lacks substantial groundwater, and

irrigation is therefore both undeveloped and undevelopable as given by negative scores on Components Nine and Three. Agriculture is cattle-rangeland oriented, but cattle production is less than in eastern areas such as the Flint Hills, leading to the label Semi-Arid, Cattle-Producing Region. Total water demand and urban population are low, and cropland decreased slightly from 1949 to 1974.

Region Six, termed the Semi-Arid, Non-Irrigated Region, is the most difficult to describe, as it loads strongly on only one component, Extensiveness of Irrigation, showing very little actual irrigation. The area is at least moderately arid, but it lacks groundwater reserves on which to base irrigation. The region is largely rural and is losing population through outmigration. Crops are more important than cattle production, probably because the area has lost its comparative advantage in cattle grazing to parts of southwestern Kansas where irrigated feed-grains have promoted the expansion of cattle feedlots.⁶

The overriding characteristic of Region Seven is highly positive scores on Groundwater-dependent Irrigation and Aridity, and Irrigation Growth, and therefore it is called the Major Irrigation Growth Region. The counties involved also register moderately high positive scores on the Extensiveness of Irrigation Development component. Region Seven, like Regions One and Two, has two extensions, one in the northwest corner, the other in the southwest. These two sub-areas are regions of anticipated growth in irrigation development and water demand. Most of the agricultural land in the counties is largely unsuited to sprinkler

⁶Based on research conducted by the author for a paper titled "The Role of Water in Regional Economic Development: The Case of Western Kansas," (unpublished) Fall, 1976.

irrigation, although there has been considerable sprinkler irrigation development compared to other areas. There is little uniformity of scores among these counties on the Cattle Production or Rangeland-Cropland Intensity components because of the complexities of feedlot development in the southwest versus rangeland in the northwest. Unlike many of the other regions described thus far, population is growing and total water demand is large in both Regions 7a and 7b.

Region Eight, Slight Irrigation Potential Region, shares many characteristics in common with the Semi-Arid, Non-Irrigated Region, the main difference being that Region Eight does have enough groundwater to support a limited amount of irrigation. Compared to Region Seven, especially subregion "b," Region Eight's groundwater reserves are small, but they nevertheless distinguish these six counties from those to the east. To date, however, irrigation has been quite modest. The area is rural and declining in population, and total water demand remains fairly low.

Region Nine is typically recognized as the irrigated crops and feedlot area in southwest Kansas, and is labelled Slowing Irrigation Growth Region. This area was the first part of the state to begin irrigation from groundwater on a large scale in the late 1940's and early 1950's, and development has mushroomed since then, as indicated by high positive scores on the Extensiveness of Irrigation Development component. Growth in irrigation, however, is expected to be relatively slight, as shown by high negative scores on Component Three. This prediction reflects declining water demand for irrigation from 1965 to 2000, a measurement based on declining groundwater reserves. Total water demand is high.

The Refinement Method

The prior description of the final regions facilitates understanding of the steps involved in refining the regions given in Figure 4-12. Three major criteria or guiding principles were employed in the intermediate stages between the seventy-fifth step of the Congroup regional scheme and the final regionalization. The first principle involved size and shape. Productive planning requires good communication among officials and representatives from different counties. Planning is apt to be more effective if each region is small enough that the member counties feel themselves related enough to participate fully. On the other hand, regions should be large enough to support an effective planning operation and to include relevant planning variables. Certainly, Berry argued, the regionalization should result in "...units that are larger than the socio-economic entities that are to be affected,"⁷ so single-county regions should be avoided if possible. Additionally, counties within a region should be contiguous to at least one other member and preferably to the center of the region. This observation implies a compact shape approaching circular, which cannot be realized given the generally polygonal dimensions of the Kansas counties.

The second guiding principle was the assumption that earlier aggregations listed in Table 4-8 were more significant than later ones, and that therefore, if a group appearing in Figure 4-12 were to be subdivided, the redelineation should break later rather than earlier joins. The final criterion pertained to assigning or reassigning individual counties or two-county regions to larger groups. A workable method of making such assignments is by comparison to a map of all 105 counties

⁷Brian J. L. Berry, "Numerical Regionalization of Political-Economic Space," Economic Regionalization and Numerical Methods, ed. B. J. L. Berry and A. Wrobel, Geographic Polonica, XV (1968), p. 34.

based on the largest component score or scores of each. In illustration, all counties whose largest component score appears on a particular "component X" would constitute one region or regional type. This method actually has been used to regionalize areal units incorporating a factorial analysis approach without the distance scaling and grouping procedure developed by Berry.⁸ Mapping component scores in this way provides a regionalization based on the most important or most descriptive component or two for each county, and thus only part of the available data is utilized. Figure 4-14 shows a series of regions based on combinations of eight of the nine components. In some cases, counties scored similar high scores on two components and this is reflected in the regions. This figure is a slightly refined version of the original mapping, but no major modification has occurred. It seemed logical that by comparison to these major-component-scores regions, independent counties in Figure 4-12 could be assigned to the most appropriate regions.

With these considerations in mind, the initial refinement commenced. The groupings at the seventy-fifth step, as shown in Figure 4-12, displayed four major difficulties. First, several dispersed counties, shown as independent counties on the map, had not yet been assigned to regions. Second, several members of regions were not contiguous with other regional members. Third, several two-county regions remained, and fourth, several of the regions were too large to be effective planning regions. The first logical step in refining the regional set was to assign

⁸ As in David E. Kromm, "Measuring Regional Variation in Slovenian Tourism" (presented at the 23rd International Geographical Congress of the International Geographical Union, Moscow, U.S.S.R., November, 1975).

the independent counties to regions based on statistical similarities. This was accomplished by comparing Figures 4-12 and 4-14. Figure 4-15 shows the first refinement. For example, Reno County was grouped with Region Four, Allen with Region One, etc. This procedure worked well for every situation except Cherokee County, which appeared in Figure 4-14 as an isolated, declining urban water demand region because of high current utility water use that is expected to decrease dramatically by 2000. Cherokee was grouped with Region One, however, as its second highest component score (see Table 4-1) was highly negative on Component One. At this step, Shawnee and Sedgwick counties were left as independent urban counties because their water situations differed radically from their surrounding areas. However, Johnson and Wyandotte were combined to form a new region because of their known economic interrelations in the Kansas City area.

The second refinement combined isolated regional members with the surrounding regions, unless a strong case existed for having single-county regions, as in the urban counties noted above. Again, isolated counties were reassigned by comparison to Figure 4-14, and the regrouping is shown in Figure 4-16. Thus, Cheyenne, Graham, Gove, Wallace, and Ellis counties were reassigned to Region Six, Gray to Region Ten, Kearny to Region Nine, and Morris, Riley, and Pottawatomie to Region Three. This routine was deviated from in the cases of Barton and Harper counties. Figure 4-14 called for Barton County to be part of Region Two, but that change would have left the problem unresolved, as the county would still have been non-contiguous with the rest of its region. Instead, Barton was added to Region Six to blend in with its neighboring counties, even though its component scores indicate it differs from Region Six counties in having

some groundwater. The choice of combining Barton with Region Four was rejected in spite of the availability of groundwater because irrigation in Barton County is relatively undeveloped and potential for irrigation growth is more in line with opportunities in Region Six. Figure 4-14 showed Harper County in a large region combining Comanche, Barber, and Harper with the rest of Region Four. At this second refinement, it was decided to group Harper with Comanche and Barber as part of Region Five rather than Four, because Harper, like Comanche and Barber, is distinct from Kingman, Pratt, et al., in that it has little or no groundwater to support irrigation. Thus, despite highly negative scores on the Sprinkler Irrigation Component, Comanche, Barber, and Harper differ legitimately from the rest of Region Four for water planning purposes, as they have little potential growth in irrigation.

At this point, no unattached counties remained, except Shawnee and Sedgwick, but there were several two-county regions. For planning, two-county regions generally are to be avoided as too small in area unless the region is a particularly significant one. In my opinion, there was reason to retain the Johnson-Wyandotte merger because of the complexities of planning for water in densely urban areas such as Kansas City. Despite the fact that Wyandotte County is losing population through outmigration, it will remain an important consumer of water for urban uses, especially for utilities. Also, Johnson and Wyandotte are closely integrated economically and operationally, being part of the Kansas City Standard Metropolitan Statistical Area.⁹ For these reasons, they were left as a separate

⁹A Standard Metropolitan Statistical Area is a county or group of counties containing at least one city of 50,000 persons. The counties in a SMSA are metropolitan in character and must be economically and socially integrated with the county of the central city.

region. However, in the pairs of Elk-Chautauqua, Geary-Wabaunsee, and Ford-Clark, there was no advantage to keeping two-county water planning regions, and those counties were regrouped with neighboring regions as indicated in Figure 4-17, the third step in the refinement process. Elk-Chautauqua and Geary-Wabaunsee were reassigned as guided by Figure 4-14, but that technique was not helpful in reassigning Ford-Clark, as those two counties appeared as a two-county region on that map. Examination of all component scores and raw data led to the determination that Ford is more similar to Region Ten and Clark to Region Five, as Ford has groundwater and mixed agriculture but Clark lacks groundwater and relies more on cattle production.

One other consideration is reflected in Figure 4-17. Region Two had a south-reaching extension through Clay, Dickinson, Marion, McPherson, Harvey, and Sumner counties. For planning, such a configuration is awkward, and a choice was demanded between dividing Region Two into two parts separating Clay and Washington counties, or reassigning some of the counties to other regions. Figure 4-14 showed Dickinson and Marion counties belonging in Region Three because of high negative scores on the Cattle Production and Rangeland-Cropland Intensity components. Consequent reassignment left a north-south parcel of Region Two from McPherson to Sumner counties, as shown in the final regionalization pattern in Figures 4-18 and 4-13.

One final difficulty remained with the third refinement, that being the large size of Regions One and Six. In seeking to subdivide these two areas into smaller, more manageable but still coherent planning regions, all component scores and some individual raw data values were re-examined. It was found that Cheyenne, Rawlins, and Decatur counties shared two important characteristics with Region Seven, in that they have

substantial groundwater reserves and significant expectations for growth in irrigation. For this reason, the three counties were reassigned to Region Seven, as Region Six depicts counties with little irrigation and little opportunity for expansion. Close comparison of Regions Seven and Ten revealed them to have quite similar implications for water planning and management, and therefore they were reclassified and relabelled 7-a and 7-b on Figures 4-13 and 4-18. In another refinement of Region Six, the r-shaped region of Lane, Gove, Logan, Wallace, Greeley, and Hamilton counties was separated from the rest of Region Six and renamed Region Eight because they have some possibility for irrigation growth, as indicated by slightly positive scores on the Irrigation Growth component and raw values on variable 21, total volume of groundwater available.

To complete the regionalization, Region One was subdivided into 1-a and 1-b between Douglas and Franklin counties based on breaks in the Congroup procedure and also on component scores. The differences between the "a" and "b" segments were discussed earlier in this chapter. Except for labelling differences, Figures 4-18 and 4-13 are identical, showing regions within which water-related characteristics are similar, thereby constituting logical water planning regions for Kansas.

CHAPTER 5

CONCLUSIONS AND IMPLICATIONS

Conclusions are offered concerning the set of state-level water planning regions derived in this study and the method employed in the derivation. This chapter demonstrates the contributions of this thesis to state water planning in Kansas and comments on the effectiveness of Berry's three-stage process of regionalization for this type of regional study.

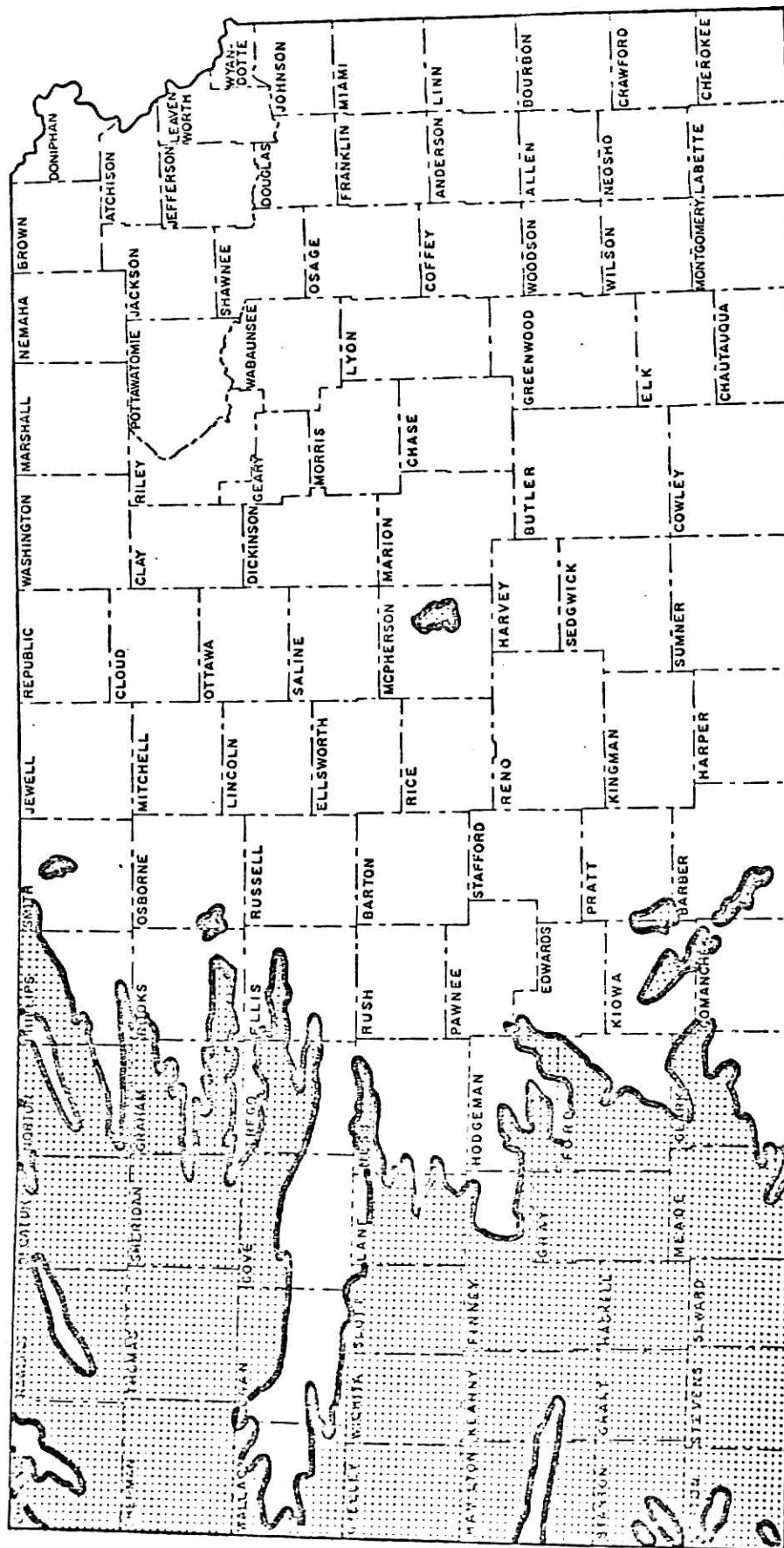
Comparison With Watersheds

A comparison between Figures 1-1 and 4-13 shows a wide disparity between the statistically-derived regions and the natural watershed units used by the Kansas Water Resources Board. The watersheds cut across as many as six alternative regions each, indicating that the counties in the watersheds exhibit major differences among themselves regarding the seventy-one variables measured in this study. The Solomon-Saline unit, for example, contains counties that have substantial groundwater reserves and irrigation but also counties where grazing is more important than cropping and where there is no groundwater. If the variables used in this thesis are important to water planning, then significant considerations are ignored in the watershed approach. The question becomes whether the watershed offsets these deficiencies by accounting for other significant factors that are not treated in the regionalizing process used in this study. I believe that, given the great reliance on groundwater throughout much of the state

and the number of variables related to water supply contained in the analysis, the watershed approach does not offer any focus that is neglected in the statistically-produced regional scheme. I would not offer the revised alternative regionalization as necessarily the optimal set of state water planning regions because of data difficulties, but I feel that the new regions are more logical and operational for water planning than are the watersheds, because the statistically-derived regions are areas of similar water characteristics and because they have a representative governmental framework that is lacking in the watershed.

Groundwater distribution in Kansas serves to illustrate well the advantages of the analytically-defined regions over the watershed. In western Kansas, the watershed units in no way bound the Ogallala aquifer, Figure 5-1, but that formation is of singular importance to the area. Going further, the watershed configurations bear little relation to groundwater availability throughout the state, as shown in Figure 5-2. Given the importance of groundwater and the imminence of managing the resource, it is clearly desirable for planning regions to reflect groundwater availability in this state. A comparison of the regionalization scheme produced in this study, Figure 4-13, with Figures 5-1 and 5-2, reveals much closer relationships than do the last two figures with Figure 1-1, the watershed units utilized by the state's water planning agency. Within groundwater-dependent western and south-central Kansas, the analytical procedure further has identified areas with significant planning implications. Region Seven is a growth area, whereas Region Nine needs immediate action because of rapidly declining groundwater yields. Due to the relatively high groundwater recharge rate in south-central

FIGURE 5-1



BOUNDARIES of the OGALLALA AQUIFER

SOURCE: STATE GEOLOGICAL SURVEY OF KANSAS

LR

Kansas, depletion there is not such a pressing concern. In the eastern half of the state, the principal components analysis, distance scaling, and grouping analysis have indicated a breakdown into several regions that share a common reliance on surface water but which still have differing water uses and needs, and which entail differing implications for water planning. Thus, the regionalization scheme reflects the physical presence of groundwater and surface water, but is not determined solely by the presence of one or the other. As the new regions represent more comprehensive considerations, they constitute an improvement over the watershed units for efficacious, state water planning.

Implications for Planning

The analysis in this thesis demonstrates that water-related characteristics in Kansas do covary in broad patterns, but that uniform, compact planning regions of the type used in most forms of state-wide planning do not appear clearly nor instantaneously. From a traditional planning standpoint, the three-stage procedure ideally would have revealed a set of twelve to fifteen uniformly-shaped, compact divisions. In the initial section of the grouping procedure, no contiguity constraint was imposed, as suggested by Johnston,¹ resulting in several large, contiguous regions and several more, smaller regions, with a few outlying members in each category, as depicted in Figure 4-12. In refining Figure 4-12, contiguity became an important consideration in order to make the regions operational for governmental planning purposes. It is fair to note that

¹R. J. Johnston, "Grouping and Regionalizing: Some Methodological and Technical Observations," Economic Geography, XLVI (1970), p. 295.

all refinements were made only after the computerized, statistical grouping procedure had indicated objectively the actual nature of the water situation in Kansas, and that each step in the modification was taken with the reader's full knowledge.

Although the statistically-derived regions show counties that have similar water-related characteristics, it is up to the state water planner to assess needs, conflicts, and potentials within them. To this end, the raw data, the principal components and county component scores, and the grouping procedure in this study should facilitate the state planner's task. The labelling and discussion of the regions in Chapter 4 suggested specific planning implications, and these need not be repeated. However, a few general observations can be added, even though this study made no attempt to define particular water planning problems and needs throughout the state. The heterogeneity of the counties in the western half of the state as compared to the eastern half is readily apparent and the distinctions between the regions defined in the west are more clear and possibly more meaningful for water planning than those in the eastern divisions. The east as a whole is humid, or at least non-arid, has relatively low total water demand, relies mainly on surface water although some areas do pump substantial proportions of their supply from groundwater, and is non-irrigated. Most of the state's urban dwellers reside in the eastern counties, which means that water planning must directly address needs and problems associated with urban supply, use, and disposal, flood control, and future growth strategies. A final major point distinguishing the eastern half of the state is that planning there, especially in the southeast quadrant, will of necessity concern quality as

much as quantity of the water supply. Because of data difficulties, water quality indices were not included in this study, so the regional planning breakdown does not reflect quality considerations. Quality is a component of the water planning scene that is relatively local in nature and must be considered in all planning that deals with water. Discussion with geologists in the U. S. Geological Survey confirmed this assessment.²

In the western part of the state, there is more variation in the county water situations, as illustrated by the county component scores, the various steps of the grouping procedure, and the larger number of final regions outlined there as compared to the three larger regions in the east. Those counties in the state that would without study be surmised to present the biggest water planning difficulties and the greatest need for comprehensive water planning are among the last to enter the grouping analysis, indicating their relative individuality. In summary, the importance of the water planning regions endorsed in this study is enhanced in the western half of the state.

Looking more closely at the alternative regionalization for water planning, the Groundwater and Sprinkler Irrigation, Major Irrigation Growth, Slight Irrigation Potential, and Slowing Irrigation Growth regions share a common concern with groundwater reserves. The last three rely upon the Ogallala aquifer, whereas the Groundwater and Sprinkler Irrigation region draws upon river underflow and alluvial deposits. Water demand in Regions Four, Seven and Nine will be quite large in the future, and meeting it will require continual mining of a finite groundwater reserve. The

²Statements by Art Diaz and Melvin Thompson, staff members of the United States Geological Survey, personal interviews, Lawrence, Kansas, January 21, 1977.

economies of these areas are firmly tied to the depletion of this resource, and certain areas in western Kansas are already experiencing the effects of lessening supply and increasing costs. Planning efforts in these regions must address, at the very least, the questions of over how long a period of time the utilization of the remaining groundwater reserves should be spread, how groundwater use should be controlled, how consequences of declining reserves should be minimized, and similar questions. These questions are especially meaningful in areas of expected irrigation growth, such as Regions Seven and Four, although activities in Region Nine, the Slowing Irrigation Growth region, may set the precedent for state action in water planning. State water planners may take a constructive, leading role in stabilizing the economies of counties with increasing dependence on a diminishing resource and thus in preserving the economic identity of Kansas as a whole.

The eastern regions, the Humid, Non-Irrigated, Crops with Cattle, Productive Cattle-Raising, and Semi-Arid, Non-Irrigated regions, are distinguished by differing agricultural practices and reliance on surface water. In one manner, the economies of these regions are not as prone to change as those in the west, as dependence on a declining water supply is not so prevalent. This situation combined with lower water demands means that planning needs throughout the east are not as crucial or timely as they are in western counties. The state water planner's role in eastern Kansas is less riddled with legal and temporal pressures.

Planning for water in the three urban areas of the state, Topeka, Kansas City, and Wichita, involves a different set of needs and approaches. These cities have planning concerns, such as recycling industrial waters

or providing storm sewers, that might be inapplicable to some more rural, non-industrialized counties. Urban counties often obtain their water supply from reservoirs in neighboring counties, and conflicts over priorities and schedules for use require that the urban county interact with all surrounding areas. It is my suggestion that the four urban counties take a cooperative role with near-by regions so that the impacts of urban water demands, uses, and supply can be assessed properly and completely by all affected counties.

In summary, the regionalization for water planning created in this thesis represents actual water-related characteristics in the state and therefore constitutes logical areal settings within which state planning for the supply, use, and management of water can be attempted efficaciously. As planning for water undoubtedly will become increasingly important, water planners need to know the basic differences in the water situation throughout the state, and this thesis provides such information. This study can serve as a criterion by which to assess current water planning activities being carried out by state agencies and special districts described in Chapter 1. Although the impacts of water supply, use, and management situations are most immediately felt at the local level, the resource and the economies it supports are vital to all people in the state. State government therefore provides the proper forum for making decisions concerning water use and conservation. In addition, one advantage of state-level planning is that state efforts can transcend county lines, demand intercounty cooperation, and monitor regional activities while measuring them against statewide considerations and goals. The county unit used as the building block of the statistically-derived

regions provides a framework for receiving citizen input, financing plans and planning recommendations, and implementing plans. The traditional watershed approach offers no distinct advantages for planning purposes and suffers from several deficiencies compared to the statistically-derived regions. It is pertinent to note, however, that the spatial ordering of the Kansas counties presented in this study is accurate for only a brief period of time, as changes recorded by the counties on some or all of the variables might change the scheme a few years hence.

Although the watershed unit has the aspect of stability, it is impossible to know whether and to what extent the seventy-one water-related characteristics might change. The dynamics of the water situation would have to be taken into account under any spatial arrangement for management, including the watershed.

Method Used

The method used in this study resulted in the definition of logical water planning regions in Kansas. The principal components analysis enabled the consideration of a large number of variables. Without a form of factorial analysis, comparison of seventy-one characteristics would have been confusing at best, and without a computer the calculations would have been extremely time-consuming and probably impossible. Assuming that the interpretation and labelling of the principal components were reasonably accurate, the task of comparison was greatly facilitated through use of this statistical method. The results were rewarding, as the nine components found accounted for nearly 72% of the total variation in the original seventy-one variables. The distance scaling and grouping analysis took

the results of the principal components analysis and statistically arrayed the 105 counties according to their similarity. Without these additional mathematical operations, comparison of the counties would have been much more arbitrary and prone to error imposed by the researcher's preconceptions. In summary, incorporation of Berry's three-stage regionalization process enabled the definition of an alternative set of state water planning regions for Kansas and demonstrated that it is possible to establish rational, defensible regions based on considerations other than the natural watershed.

It might be argued that map overlays of the principal components would have produced a comparable set of regions. Additionally, the case could be made that mapping of just a few pertinent variables would have presented much the same picture as the elaborate statistical procedure. However, Berry's process gives quantitative results, i.e. numbers, that cannot be questioned and that can be reproduced easily given the original variables and the selected cut-off point for rotating components. There is great value in having hard, verifiable, repeatable evidence to support research and conclusions and to replace intuition. The computer gives actual correlation coefficients, rotated variable loadings, and component scores; the 105 by 105 Euclidean distance matrix has no biases; and the Congroup aggregations coldly show which counties or groups of counties are most similar regarding the variables measured. Whether hunches are confirmed or denied, the cold, hard data show the actual relationships involved and add confidence to the resulting regional scheme.

A further note is in order regarding simpler methods of regionalization. It is true that the final set of state water planning regions shown in Figure 4-13 resembles the map of major component scores, Figure 4-14,

and, as mentioned before, studies have used major component scores to regionalize. However, as the distance scaling and grouping analysis are not nearly so time consuming as the principal components analysis and they require only about half as much computer time, one may as well acquire the additional computer analyses, even if only for comparison to simpler methods.

Despite the impersonality of the computerized procedures used in this study, it is readily admitted that they were not as completely objective as it might appear. Subjectivity entered the analysis in the selection of variables, although a number of university and agency personnel were consulted for input to the list in an effort to insure selection of sensible and relevant variables. A lesser degree of subjectivity was involved in interpreting the components, as some information known by the author beyond that contained in the variables and analysis influenced the interpretation. This latter observation is particularly true of the refinement process, but such subjectivity is not necessarily a negative force, as all information known to the analyst can legitimately and should enter the study as long as it does so in a recognized and manifest manner. The comparison of Figure 4-12, the map of the regional grouping through the seventy-fifth step of the Congroup procedure, with Figure 4-14, the major-component-scores map, promoted objectivity in the refinement.

The regionalization undertaken in this thesis successfully produced a set of nine regions and three urban areas that could be adopted beneficially as official state water planning regions in Kansas. This study supports Johnston's contention that delimitation of planning regions is

"...a successful test of the hypothesis that there exists some system of grouping of areal units in which all parts would derive utility from proposed planning activity."³ The new regional set produced has advantages over the traditional watershed approach used in the state. The data incorporated in the study represent the best available and comprehensively cover the water situation except for strictly local considerations. The procedure used to derive the new regions is well known in geography and regional studies, and its use for establishing water planning regions is now demonstrated.

³Johnston, "Grouping and Regionalizing," p. 294. See Chapter 2 of this thesis.

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APPENDICES

APPENDIX A

VARIABLES USED TO DERIVE WATER PLANNING REGIONS

Numbers in parentheses refer to sources at end of list.

Physical Data

1. Acres suitable for irrigation--class 1 (% of total) (1)
2. " " " " class 2 " " " (1)
3. " " " " class 3 " " " (1)
4. " " " " sprinkler " " " (1)
5. Acres that are non-arable (% of total) (1)
6. Percent of land underlain by groundwater $\geq$ 100 gpm (2)
7. Insurance payments for excessive moisture and flood loss to wheat crop per insured acre, 1947-75 (3)
8. Insurance payments for drought loss per insured acre, 1947-74 (3)

Land Use

9. Percent of county land that is urban (4)
10. " " " " " " cropland (1)
11. " " " " " " pasture and rangeland (4)
12. " " " " " " forests (4)
13. Total cropland acres (4)
14. Percent of cropland acres lying fallow (4)
15. Differential shift in cropland acreage from 1949-74 (5)
16. Number of special water districts currently operating (6)

Water Supply

17. Average annual streamflow, cfs/sq. mile (7)
18. Average annual precipitation, inches (8)
19. Variability for streamflow (7)
20. Variability for precipitation (skewness of logs) (8)
21. Total volume of groundwater available for pumping, 1967 (9)
22. Volume of groundwater available per acre, 1967 (9)
23. Acre-feet of storage in existing reservoirs as of 1976 (10)
24. " " " " " " reservoirs under construction in 1976 (10)
25. " " " " " " proposed reservoirs as of 1976 (10)
26. Water supply revenue per capita per year (11)
27. Water supply expenditure per capita per year (11)
28. Volume of natural recharge to groundwater per acre (9)

Water Use

29. Total water demand--1965 (12)
30. 1965 water demand--domestic (12)

31. 1965 water demand--industrial (12)
32. " " " utilities (12)
33. " " " livestock (12)
34. " " " irrigation (12)
35. Percent of cropland irrigated, 1973-74 (13)
36. Total number of acres irrigated, 1973-74 (13a)
37. Differential shift in irrigated acres, 1954-55 to 1973-74 (13a)
38. Recent differential shift in irrigated acres, 1969-70 to 1973-74 (13a)
39. Irrigation water applied per irrigated acre, average (9)
40. Percent of irrigation that is from groundwater, 1972 (14)
41. " " " " " " surface water, 1972 (14)
42. Method of irrigation--sprinkler, 1975 (% of total) (15)
43. " " " gated pipe " " " " (15)
44. " " " open ditch " " " " (15)
45. Irrigation as percent of water demand, 1965 (17)
46. Change in irrigation as percent of water demand, 1965-2000 (17)
47. Percent of total water demand met by groundwater, 1965 (16)
48. Percent of total water demand met by surface water, 1965 (16)
49. Estimated future (2000) water demand--total (12)
50. Estimated future (2000) water demand--domestic (12)
51. " " " " " industrial (12)
52. " " " " " utilities (12)
53. " " " " " livestock (12)
54. " " " " " irrigation (12)
55. Differential shift in water demand (1965-2000)--total (17)
56. " " " " " " domestic (17)
57. " " " " " industrial (17)
58. " " " " " utilities (17)
59. " " " " " livestock (17)
60. " " " " " irrigation (17)

Socioeconomic Data

61. 1975 population (18)
62. 2000 projected population (19)
63. Net effective buying income per household (18)
64. Natural growth rate, 1960-70 (18)
65. Net migration rate, 1960-70 (18)
66. Percent of population that is urban (20)
67. " " " " rural (20)
68. Percent of labor force in agriculture (20)
69. " " " " manufacturing (20)
70. Percent of state field crop production by value, 1971-73 (21)
71. " " " cattle production by value, 1971-73 (21)

SOURCES

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APPENDIX B

RAW DATA *

County	Variable							
	1	2	3	4	5	6	7	8
Allen	0	0	.66	0	99.33	0	.90	.30
Anderson	0	0	20.48	0	79.52	0	1.45	.67
Atchison	0	1.50	6.33	0	92.16	6	.44	.14
Barber	0.33	3.60	.13	1.22	94.72	23	.01	.36
Barton	10.76	19.83	13.90	8.05	47.46	39	.04	.33
Bourbon	0	0	3.20	0	96.80	23	.52	.58
Brown	0	0.23	10.58	0	89.19	9	.09	.49
Butler	0	0	.66	0	99.34	6	.76	.78
Chase	0	0	2.36	0	97.64	0	2.30	.56
Chautauqua	0	0	0	0	100.00	0	1.98	.48
Cherokee	0	0	.09	0	99.91	72	.75	.07
Cheyenne	15.60	12.42	8.73	5.68	57.56	85	0	.37
Clark	9.37	3.46	3.46	2.31	81.39	12	.03	5.37
Clay	1.10	4.62	5.20	0	89.08	15	.15	.18
Cloud	6.99	7.06	6.46	0	79.48	18	.02	.43
Coffey	0	0	.60	0	99.40	0	3.21	.64
Comanche	1.29	3.77	1.70	8.70	84.54	9	0	.33
Cowley	.28	.51	4.10	.08	95.03	10	.34	.18
Crawford	0	0	0	0	100.0	50	.39	.48
Decatur	8.84	37.28	.78	0	53.10	95	.01	.72
Dickinson	1.73	6.70	4.97	.47	86.14	18	.41	.30
Doniphan	1.62	5.77	2.38	0	90.24	10	.98	.82
Douglas	0	2.69	12.80	0	84.50	7	1.97	.12
Edwards	7.92	13.83	.56	44.28	33.41	100	.01	.60
Elk	0	0	.49	0	99.51	0	1.34	.36
Ellis	7.35	15.59	.27	0	76.78	8	.01	.65
Ellsworth	1.57	11.56	4.44	0	82.43	7	.01	.56
Finney	32.21	24.22	6.42	6.37	30.78	78	.01	.64
Ford	17.02	35.88	6.34	10.84	29.92	97	0	.63
Franklin	0	.81	23.85	0	75.34	0	2.30	1.09
Geary	3.22	2.09	1.27	0	93.42	22	3.65	.44
Gove	21.59	23.93	3.91	0	50.57	32	.01	.97
Graham	4.12	20.22	2.77	0	72.89	62	0	.23
Grant	55.50	10.21	10.00	5.40	10.69	100	.01	.94
Gray	34.94	27.07	1.72	13.31	22.96	97	0	.97
Greeley	82.44	10.31	0	0	7.25	38	0	1.51
Greenwood	0	0	.17	0	99.83	0	1.36	.99
Hamilton	41.20	28.23	.69	.53	29.34	12	0	1.54
Harper	4.12	1.11	.02	.47	94.28	29	.05	.61
Harvey	.24	0	34.88	0	64.88	47	.49	.35
Haskell	85.67	2.11	.39	1.55	10.28	100	0	.57
Hodgeman	16.86	30.05	9.61	0	43.48	72	0	1.33
Jackson	0	0	5.66	0	94.34	0	.37	.80
Jefferson	0	2.57	5.69	0	91.74	0	1.13	.22

County	Variable							
	1	2	3	4	5	6	7	8
Jewell	3.33	10.06	2.20	0	84.40	6	.01	.49
Johnson	0	.31	6.71	0	92.98	8	.44	.12
Kearny	35.41	24.03	4.97	.67	34.92	78	0	1.11
Kingman	3.10	5.40	1.50	15.14	74.86	81	.11	.52
Kiowa	13.83	1.87	3.24	17.49	63.57	57	.05	.95
Labette	0	0	.52	0	99.48	0	.48	.26
Lane	49.23	18.96	1.37	.21	30.23	27	0	.81
Leavenworth	0	3.19	4.02	0	92.79	1	.91	.50
Lincoln	.48	3.18	11.46	0	84.88	11	.02	.84
Linn	0	0	7.10	0	92.90	0	1.88	.77
Logan	33.11	20.14	.75	0	46.00	21	0	.68
Lyon	0	0	1.32	0	98.68	0	6.32	1.27
McPherson	0	.05	2.88	0	97.07	44	.24	.19
Marion	0	.80	4.46	0	94.74	10	.57	.21
Marshall	.67	.87	42.60	0	55.86	1	.26	.30
Meade	38.49	2.14	1.29	3.53	54.55	59	0	1.26
Miami	0	0	10.61	0	89.39	0	1.88	.45
Mitchell	5.20	9.57	4.96	0	80.27	18	.01	.55
Montgomery	0	0	2.20	0	97.80	0	1.28	.29
Morris	0	0	.42	0	99.58	9	1.04	.45
Morton	52.36	8.16	1.26	6.33	31.89	100	0	.01
Nemaha	0	0	4.16	0	95.84	10	.32	.25
Neosho	0	0	1.35	0	98.65	0	1.31	.33
Ness	15.06	29.26	.28	0	55.40	13	.01	1.00
Norton	2.80	13.43	7.38	0	76.39	79	.01	.52
Osage	0	0	13.13	0	86.87	0	2.62	1.44
Osborne	4.53	4.44	.77	0	90.26	4	.01	.76
Ottawa	3.19	3.26	15.08	0	78.48	20	.08	.17
Pawnee	8.20	32.99	.39	21.52	36.90	69	.01	.70
Phillips	4.82	8.62	.99	0	85.57	12	.00	.77
Pottawatomie	2.48	4.14	2.59	0	90.79	9	1.69	.59
Pratt	12.36	9.59	2.31	39.63	36.12	100	.02	.30
Rawlins	21.43	26.57	.85	0	51.15	74	.00	.50
Reno	4.34	8.07	11.47	17.95	58.18	78	.24	.54
Republic	12.33	12.43	.75	0	74.49	24	.01	.49
Rice	11.60	21.95	4.34	7.54	54.58	38	.08	.14
Riley	1.71	2.19	.95	0	95.16	7	.99	.54
Rooks	3.23	12.53	0	0	84.24	4	.01	.24
Rush	7.15	29.56	0	0	63.29	10	.01	.53
Russell	5.56	6.36	2.40	0	85.69	5	.10	1.06
Saline	2.37	6.17	13.18	0	78.28	24	.24	.32
Scott	50.17	26.92	2.73	6.70	13.48	70	.00	.53
Sedgwick	4.51	9.85	13.39	2.49	69.76	55	.52	.59
Seward	31.42	13.21	1.54	13.49	40.35	100	.01	.71
Shawnee	1.14	7.31	8.11	0	83.44	12	1.28	.64
Sheridan	19.57	26.14	3.88	0	50.41	11	.01	.16
Sherman	16.52	23.23	21.56	2.60	36.09	95	.00	.79
Smith	5.12	9.41	1.99	0	83.48	4	.01	.41

County	Variable							
	1	2	3	4	5	6	7	8
Stafford	2.65	7.53	9.84	39.34	40.64	99	.01	.51
Stanton	75.56	7.24	6.15	2.95	8.11	99	0	1.13
Stevens	33.40	15.64	9.64	14.75	26.57	100	0	.54
Sumner	2.10	5.64	10.87	1.22	80.17	12	.11	.50
Thomas	26.07	27.04	20.17	4.34	22.39	96	0	.40
Trego	8.13	21.07	5.11	0	65.68	48	.02	.81
Wabaunsee	1.84	1.97	6.45	0	89.74	4	3.17	2.03
Wallace	12.20	16.71	23.14	.59	47.35	42	0	1.33
Washington	0	.78	6.03	0	93.20	1	.08	.31
Wichita	72.62	11.64	0	0	15.74	72	0	.64
Wilson	0	0	3.12	0	96.88	0	1.44	.16
Woodson	0	0	.52	0	99.48	0	1.38	.23
Wyandotte	0	5.53	.12	0	94.35	22	.35	.16

County	Variable							
	9	10	11	12	13	14	15	16
Allen	5.25	53.33	33.92	4.70	172,372	0.0	.076	18
Anderson	4.81	46.12	41.03	6.23	170,308	0.0	.040	11
Atchison	6.55	66.27	12.74	10.04	182,792	0.0	.049	10
Barber	1.57	34.80	60.74	.79	255,203	0.7	-.013	2
Barton	4.71	71.73	17.76	.34	412,712	20.5	.050	2
Bourbon	4.81	42.27	37.47	13.03	172,868	0.2	.023	3
Brown	3.12	70.07	20.84	3.68	259,191	0.0	.038	6
Butler	4.87	30.18	61.18	2.00	279,124	0.0	-.124	21
Chase	1.94	15.54	79.04	2.14	76,989	0.0	.007	9
Chautauqua	2.70	11.88	66.44	16.67	49,188	0.0	-.068	8
Cherokee	12.90	57.07	16.78	9.74	214,400	0.0	.021	11
Cheyenne	3.13	61.61	33.63	.38	404,932	40.1	-.102	1
Clark	1.76	33.63	63.06	.33	211,774	28.4	-.100	1
Clay	3.31	59.45	29.35	2.00	250,729	0.0	-.021	4
Cloud	4.64	63.06	28.28	1.80	286,967	9.0	.050	10
Coffey	10.31	42.87	34.62	3.53	179,990	0.9	.019	10
Comanche	1.28	39.56	58.16	.43	202,534	12.4	-.126	2
Cowley	4.72	33.70	56.16	2.86	245,671	0.0	-.053	14
Crawford	8.32	54.35	26.12	8.73	208,000	0.0	.020	10
Decatur	3.28	58.31	36.60	.68	335,479	41.2	.054	1
Dickinson	5.61	64.20	27.11	1.01	351,326	0.9	.092	3
Doniphan	6.70	60.38	9.68	14.31	153,790	0.0	.015	10
Douglas	7.41	53.73	23.72	11.37	163,010	0.0	-.032	22
Edwards	2.95	69.35	24.95	.33	274,751	35.9	-.168	1
Elk	3.39	19.32	69.22	6.52	80,000	0.0	-.081	6
Ellis	3.48	53.02	41.41	.07	305,416	17.2	-.024	6
Ellsworth	3.06	48.89	43.67	.72	226,234	28.9	.026	0

County	Variable							
	9	10	11	12	13	14	15	16
Finney	2.16	64.2	32.58	.13	535,062	31.3	-.170	3
Ford	3.87	75.26	19.11	.17	525,479	35.2	.047	4
Franklin	8.53	48.74	30.12	9.40	179,974	0.0	.019	12
Geary	3.50	27.24	46.22	4.11	69,906	0.0	-.108	5
Gove	2.16	52.03	44.81	.01	356,272	36.2	.082	1
Graham	2.68	48.18	39.14	.26	319,280	43.8	-.035	1
Grant	2.87	83.44	12.29	.06	304,919	23.9	-.016	1
Gray	3.02	76.41	19.03	.22	426,918	31.0	.123	2
Greeley	2.96	84.14	12.52	.00	421,646	46.0	.163	1
Greenwood	1.98	15.20	75.68	3.63	111,868	0.0	-.083	9
Hamilton	1.66	67.46	29.50	.49	428,316	44.4	.117	1
Harper	2.46	64.76	30.81	.70	331,989	11.4	.035	3
Harvey	3.99	74.55	18.52	.93	257,657	4.2	-.013	6
Haskell	3.74	87.02	8.14	.00	323,034	33.8	.095	1
Hodgeman	2.12	60.02	36.69	.07	330,331	35.8	.018	1
Jackson	3.81	50.89	35.91	5.98	213,655	0.0	-.135	10
Jefferson	4.05	47.90	22.63	12.03	169,223	0.0	-.052	28
Jewell	5.43	60.41	29.29	2.33	353,771	19.6	-.071	4
Johnson	17.23	47.40	19.24	8.76	145,000	0.0	-.104	14
Kearny	1.47	62.19	34.67	.33	342,709	39.1	.177	2
Kingman	2.93	58.81	35.20	.85	325,545	10.4	.008	1
Kiowa	2.55	54.99	41.54	.09	253,391	30.3	-.029	1
Labette	4.08	52.45	31.60	7.10	219,522	0.0	-.018	13
Lane	1.90	67.22	29.95	.04	309,744	35.6	.129	3
Leavenworth	8.34	49.82	18.90	14.90	150,509	0.0	-.033	15
Lincoln	3.57	52.65	40.93	.65	244,643	17.4	.107	6
Linn	3.78	48.73	30.38	14.67	189,635	0.0	-.008	8
Logan	1.86	54.14	43.33	.03	371,757	36.9	.043	1
Lyon	4.05	38.53	51.79	2.64	210,071	0.0	-.063	9
McPherson	3.64	70.45	23.10	.96	403,979	4.9	.055	12
Marion	2.65	57.81	31.82	3.68	354,786	0.0	-.022	10
Marshall	3.28	60.68	28.92	3.91	353,802	0.0	.100	9
Meade	1.74	54.98	42.19	.06	344,485	33.2	-.033	2
Miami	3.22	54.67	27.14	11.46	207,133	0.5	-.024	9
Mitchell	2.43	64.55	25.44	.89	295,776	27.3	.009	6
Montgomery	10.40	40.16	34.48	10.26	166,796	0.0	-.044	25
Morris	2.33	37.57	54.57	1.93	170,009	0.0	-.014	2
Morton	2.00	68.11	4.66	.39	317,341	28.4	-.123	1
Nemaha	2.89	67.62	21.52	3.81	306,847	0.0	.045	7
Neosho	4.32	51.34	34.45	6.97	192,880	0.0	.038	35
Ness	2.65	61.16	34.93	.06	423,154	40.9	.226	1
Norton	3.01	56.88	36.16	.96	320,367	33.0	.066	2
Osage	3.23	45.54	40.67	5.75	210,158	0.0	-.041	13
Osborne	3.99	53.61	39.25	.94	308,098	18.8	.152	5
Ottawa	2.45	52.23	41.23	1.64	241,658	0.0	-.014	4

County	Variable							
	9	10	11	12	13	14	15	16
Pawnee	3.51	.79.48	14.75	.42	384,067	23.0	.063	2
Phillips	2.73	53.96	39.48	1.18	312,897	10.3	.033	2
Pottawatomie	2.04	32.64	56.16	4.80	178,376	0.0	-.049	8
Pratt	2.24	76.74	19.02	.24	358,105	26.8	-.065	1
Rawlins	2.84	55.92	39.90	.29	385,783	41.4	-.054	1
Reno	4.63	69.76	20.92	.86	563,455	0.9	-.235	14
Republic	3.49	69.05	21.76	3.04	317,736	5.6	.052	7
Rice	4.37	71.50	20.34	1.17	331,758	15.4	.038	2
Riley	4.46	28.25	32.48	7.75	113,185	0.0	-.045	4
Rooks	3.18	55.08	38.29	.23	314,804	34.9	.020	3
Rush	3.85	73.02	21.54	.09	338,351	35.1	.029	2
Russell	3.39	47.81	43.58	.25	274,483	24.0	.051	6
Saline	5.18	55.18	27.79	1.11	254,260	7.1	-.055	6
Scott	2.08	77.69	19.36	0.0	360,000	39.9	.155	2
Sedgwick	14.02	68.68	11.94	1.05	443,060	0.0	-.036	18
Seward	3.42	63.05	30.33	.44	260,665	31.0	-.037	1
Shawnee	12.53	43.87	33.18	6.07	155,000	0.4	-.076	26
Sheridan	2.22	61.49	35.02	.16	351,454	43.7	-.119	1
Sherman	2.42	71.83	25.03	.00	485,000	36.1	-.284	1
Smith	2.41	59.00	36.84	.51	337,188	28.2	.013	2
Stafford	4.13	70.29	18.92	.55	357,617	25.2	-.081	1
Stanton	1.58	87.66	10.17	.00	379,256	29.1	.110	1
Stevens	1.93	81.11	15.70	.13	379,446	18.4	1.302	1
Sumner	4.87	72.17	19.56	1.47	548,225	0.0	.095	9
Thomas	1.90	82.62	14.99	.00	565,770	41.7	.005	1
Trego	1.84	53.25	40.98	.00	307,059	39.2	-.063	1
Wabaunsee	3.12	25.51	65.30	3.93	129,786	0.0	-.032	5
Wallace	1.60	50.50	46.97	.03	294,414	37.4	.113	2
Washington	4.06	55.95	33.45	3.67	319,025	0.1	.063	4
Wichita	2.96	76.24	20.17	.00	353,272	35.3	.024	1
Wilson	3.91	44.61	40.03	9.53	163,872	0.0	.059	17
Woodson	3.74	36.11	48.40	6.32	116,469	0.0	.010	8
Wyandotte	40.56	24.76	13.07	12.73	25,200	0.0	-.031	4

County	Variable							
	17	18	19	20	21	22	23	24
Allen	.675	37.4	1.15	-.427	0.0	0.0	0	0
Anderson	.617	39.4	1.15	-.526	0.0	0.0	0	0
Atchison	.450	35.2	.78	-.265	1.40	5.08	0	0
Barber	.664	25.2	.75	-.428	.71	.97	0	0
Barton	.075	25.1	.55	-.264	4.74	8.24	0	0
Bourbon	.788	39.9	.96	-.251	0	0.0	0	0
Brown	.450	33.9	.66	.241	.57	1.54	0	0

County	Variable							
	17	18	19	20	21	22	23	24
Butler	.343	33.1	.82	-.477	.02	0.0	0	145,887
Chase	.345	32.0	.86	-.323	0	0.0	0	0
Chautauqua	.463	37.8	1.08	-.495	0	0.0	9,970	0
Cherokee	.783	40.8	.86	-.606	.04	0.0	0	0
Cheyenne	.020	19.2	.88	.055	7.54	11.47	0	0
Clark	.068	22.8	.64	-.420	1.16	1.84	0	0
Clay	.206	29.4	.69	-.261	.34	.81	207,676	0
Cloud	.163	26.1	.65	-.245	.63	1.38	0	0
Coffey	.525	37.4	1.17	-.057	0	0.0	46,875	0
Comanche	.102	23.2	.73	-.675	.70	1.37	0	0
Cowley	.341	32.9	.95	-.359	.28	.38	0	18,075
Crawford	.750	40.3	.96	-.242	0	0.0	0	0
Decatur	.041	20.0	.71	-.246	5.67	9.85	0	0
Dickinson	.206	27.8	.71	-.023	.17	3.10	0	0
Doniphan	.450	34.4	.65	-.067	.49	1.92	0	0
Douglas	.483	36.3	1.08	-.445	.25	.82	0	75,300
Edwards	.057	22.0	.63	-.589	8.27	20.88	0	0
Elk	.470	36.2	1.12	-.459	0	0.0	0	0
Ellis	.086	22.9	.58	-.394	.10	.17	0	0
Ellsworth	.108	26.7	.58	-.087	.32	.69	61,382	0
Finney	.016	18.9	.89	-.655	26.13	31.30	0	0
Ford	.043	19.9	.78	-.209	8.87	12.70	0	0
Franklin	.550	37.2	1.17	-.159	0	0.0	0	0
Geary	.250	33.4	.93	-.202	.17	.66	207,676	0
Gove	.032	19.5	.94	-.516	1.32	1.93	0	0
Graham	.050	21.6	.78	-.093	3.42	6.00	0	0
Grant	.012	17.1	.58	-.452	25.12	68.74	0	0
Gray	.020	21.0	.78	-.262	15.08	27.00	0	0
Greeley	.006	16.6	.71	.042	2.76	5.51	0	0
Greenwood	.438	34.6	1.07	-.196	0	0.0	21,400	0
Hamilton	.008	16.9	.58	-.321	2.14	3.37	0	0
Harper	.158	27.6	.82	-.646	.85	1.66	0	0
Harvey	.244	31.4	.63	-.534	5.55	16.00	0	0
Haskell	.015	18.6	.60	-1.119	25.69	69.21	0	0
Hodgeman	.043	20.4	.91	-.447	.94	1.71	0	0
Jackson	.375	34.4	.90	-.407	1.00	2.38	0	0
Jefferson	.450	34.1	.93	-.001	.32	.91	243,220	0
Jewell	.125	25.7	.71	-.187	.60	1.02	24,930	0
Johnson	.575	36.6	.96	-.346	.04	0	0	0
Kearny	.088	16.1	.65	.012	13.57	24.63	0	0
Kingman	.241	29.0	.65	-.624	3.10	5.60	37,945	0
Kiowa	.084	22.3	.60	-.604	6.19	13.43	0	0
Labette	.750	40.4	.93	-.742	0	0	0	20,560
Lane	.020	19.1	.95	-.140	1.49	3.23	0	0
Leavenworth	.470	35.8	.96	-.175	.06	0	0	0
Lincoln	.111	24.7	.59	-.159	.14	.30	0	0
Linn	.785	39.1	1.00	-.282	0.0	0	0	0
Logan	.015	19.9	1.09	-.350	1.28	1.86	0	0

County	Variable							
	17	18	19	20	21	22	23	24
Lyon	.040	34.7	1.15	-.166	0	0	15,625	0
McPherson	.266	31.2	.68	-.310	4.03	7.03	0	0
Marion	.303	29.1	.91	.070	0	0	82,900	0
Marshall	.159	28.6	.57	-.118	1.76	3.02	64,100	0
Meade	.040	19.5	.60	-.654	20.37	32.51	0	0
Miami	.688	37.9	1.00	-.067	0	0	0	68,000
Mitchell	.118	24.8	.65	-.481	.04	0	119,863	0
Montgomery	.670	36.9	1.04	-.635	0	0	33,500	5,140
Morris	.308	32.6	1.00	-.140	0	0	41,900	0
Morton	.010	16.4	.55	-.424	9.79	21.01	0	0
Nemaha	.388	32.6	.82	.070	3.50	7.71	0	0
Neosho	.738	39.0	1.11	-.242	0	0	0	0
Ness	.051	20.8	.81	-.376	.64	.93	0	0
Norton	.050	21.4	.70	-.313	5.02	8.91	30,651	0
Osage	.450	35.9	1.22	-.154	0	0	207,603	25,100
Osborne	.083	23.1	.70	-.128	.06	0	59,037	0
Ottawa	.140	27.0	.64	.170	.39	.84	0	0
Pawnee	.052	23.3	.59	-.137	4.57	9.46	0	0
Phillips	.068	23.3	.70	-.198	.35	.60	69,800	0
Pottawatomie	.300	32.2	.95	-.020	.28	.51	64,100	0
Pratt	.155	24.2	.57	-.531	10.68	22.89	0	0
Rawlins	.018	19.3	.84	.040	6.77	9.81	0	0
Reno	.155	28.7	.58	-.259	13.27	16.43	113,835	0
Republic	.176	27.6	.64	-.416	.56	1.22	0	0
Rice	.091	25.0	.57	.300	4.14	8.92	0	0
Riley	.269	32.6	.96	-.159	.19	.47	64,100	0
Rooks	.060	23.5	.71	-.226	.17	.30	47,400	0
Rush	.067	22.3	.58	.322	.22	.47	0	0
Russell	.104	25.5	.58	-.054	.15	.26	248,835	0
Saline	.131	27.2	.58	-.021	.75	1.63	0	0
Scott	.014	19.7	.95	.182	3.44	7.42	0	0
Sedgwick	.279	30.1	.69	-.989	5.90	9.15	0	0
Seward	.020	19.2	.57	.021	30.78	74.46	0	0
Shawnee	.383	33.2	1.07	-.293	.18	.51	0	0
Sheridan	.045	20.1	.88	-.188	8.87	15.52	0	0
Sherman	.009	17.3	1.03	.141	16.93	25.07	0	0
Smith	.086	22.1	.72	-.291	.08	0	0	0
Stafford	.080	24.3	.57	-.162	11.90	23.39	0	0
Stanton	.009	15.6	.56	-.667	12.56	29.03	0	0
Stevens	.015	18.5	.56	-.435	44.57	95.27	0	0
Sumner	.250	33.1	.86	-.629	.96	1.26	0	0
Thomas	.020	18.5	1.05	-.523	14.20	20.74	0	0
Trego	.063	22.2	.66	-.014	.76	1.32	130,100	0
Wabaunsee	.349	35.0	1.11	-.156	.14	.28	0	0
Wallace	.008	17.1	.94	-.305	3.37	5.78	0	0
Washington	.242	28.5	.69	-.441	.04	0	0	0

County	Variable							
	17	18	19	20	21	22	23	24
Wichita	.009	17.6	.88	-.166	5.04	10.88	0	0
Wilson	.630	35.8	1.20	-.541	0	0	0	0
Woodson	.575	36.7	1.15	-.391	0	0	5,000	0
Wyandotte	.550	37.3	.86	-.543	.14	1.38	0	0

County	Variable							
	25	26	27	28	29	30	31	32
Allen	0	16.24	13.74	0	4,791	1,483	1,851	5
Anderson	28,000	6.75	6.60	0	1,941	623	23	0
Atchison	0	.83	3.05	.08	5,719	2,571	2,343	0
Barber	0	5.07	3.66	.08	3,995	1,326	4	0
Barton	0	4.20	3.12	.14	19,269	4,440	959	1,350
Bourbon	74,000	16.27	13.03	0	3,281	1,811	97	0
Brown	0	6.31	6.25	.09	2,946	1,254	138	2
Butler	123,800	15.83	11.64	.10	15,348	4,226	7,912	17
Chase	0	5.95	6.05	0	1,616	352	64	0
Chautauqua	0	12.72	9.21	0	1,895	555	0	1
Cherokee	0	10.36	9.59	0	174,414	2,232	5,724	165,707
Cheyenne	0	46.84	35.78	.02	38,325	1,146	0	2
Clark	0	47.03	9.94	.02	3,665	750	0	2
Clay	0	10.50	11.02	.06	7,883	1,029	99	215
Cloud	0	12.38	12.63	.05	13,906	1,639	86	265
Coffey	35,110	7.04	6.99	0	2,040	645	0	1
Comanche	0	5.57	5.14	.03	3,454	534	9	1
Cowley	0	14.59	9.43	.11	51,088	4,757	3,390	37,921
Crawford	0	14.12	19.80	0	5,643	4,309	241	3
Decatur	0	5.29	5.92	.03	21,771	971	9	0
Dickinson	0	19.91	14.46	.14	24,649	2,622	711	17,601
Doniphan	0	6.02	5.75	.08	1,611	701	0	0
Douglas	0	18.70	32.09	.08	17,152	4,160	6,210	2,604
Edwards	0	8.85	9.72	.21	16,865	912	27	0
Elk	0	8.61	5.80	0	1,984	426	430	0
Ellis	0	20.28	33.13	.03	15,875	3,138	43	205
Ellsworth	0	12.12	7.30	.04	4,105	879	1	4
Finney	0	13.13	79.55	.02	227,933	3,549	287	10,852
Ford	0	11.98	8.03	.05	43,898	4,364	410	6,755
Franklin	0	10.96	14.56	0	4,294	2,060	278	10
Geary	0	8.64	7.34	.11	3,777	2,175	452	0
Gove	0	9.38	4.69	.02	9,486	736	0	0
Graham	0	54.39	41.08	0	3,997	940	10	528
Grant	0	14.22	14.07	0	205,866	1,157	806	107
Gray	0	9.20	8.51	.03	77,435	835	2	0

County	Variable							
	25	26	27	28	29	30	31	32
Greeley	0	18.77	14.28	0	26,834	488	0	0
Greenwood	0	11.88	12.31	0	3,176	972	1	0
Hamilton	68,000	12.83	6.42	0	32,331	761	0	1
Harper	0	12.73	16.38	.12	3,456	1,316	12	113
Harvey	0	11.75	8.45	.26	8,922	3,592	273	0
Haskell	0	14.72	11.14	.03	181,466	838	1,107	0
Hodgeman	0	6.98	6.85	0	19,770	587	0	1
Jackson	0	6.59	3.30	.11	1,948	872	4	1
Jefferson	0	16.30	8.65	.08	3,002	891	77	0
Jewell	0	6.93	4.89	.02	11,399	658	5	0
Johnson	117,700	22.91	25.08	.11	17,884	15,060	982	0
Kearny	0	8.74	10.06	.02	86,508	682	6	0
Kingman	0	7.97	5.74	.36	4,015	1,252	30	4
Kiowa	0	13.35	10.93	.22	11,203	910	2	11
Labette	0	17.35	18.45	0	6,372	2,701	577	1,850
Lane	0	6.26	3.13	0	13,467	610	2	0
Leavenworth	0	19.71	19.30	.08	5,971	4,624	217	0
Lincoln	0	8.09	4.04	.05	2,339	739	27	0
Linn	0	7.50	28.58	0	1,764	574	1	0
Logan	0	10.43	8.97	0	13,001	1,168	1	0
Lyon	0	12.10	12.05	0	6,180	3,097	993	0
McPherson	0	25.00	14.97	.24	16,446	4,131	1,927	220
Marion	0	6.31	7.26	.08	3,700	1,476	201	4
Marshall	0	20.42	18.02	.17	5,111	1,566	90	0
Meade	0	35.78	38.33	.03	43,313	1,159	17	1
Miami	0	6.98	28.61	0	3,185	1,899	41	0
Mitchell	0	11.99	12.98	.05	8,203	1,037	17	4
Montgomery	0	17.23	21.68	0	10,749	4,372	4,928	307
Morris	0	6.84	3.42	0	2,136	589	152	0
Morton	0	22.52	17.63	.03	50,822	435	0	0
Nemaha	0	11.48	5.90	.10	3,089	1,052	81	28
Neosho	0	13.96	14.18	0	5,106	2,435	1,163	170
Ness	0	8.91	6.95	.01	11,546	1,021	0	0
Norton	0	9.86	11.55	.03	7,948	1,443	15	0
Osage	0	13.19	13.11	0	2,440	1,144	5	8
Osborne	0	12.39	10.29	.02	15,285	971	27	0
Ottawa	0	11.94	7.64	.05	4,087	1,044	165	1
Pawnee	0	8.90	9.31	.11	34,532	1,536	12	84
Phillips	0	10.37	11.06	.03	8,600	1,209	937	1
Pottawatomie	90,000	1.52	1.42	.11	7,095	1,206	37	2
Pratt	0	7.97	7.39	.36	16,133	2,395	25	37
Rawlins	0	0	0	.02	10,718	960	1	0
Reno	0	13.04	5.65	.34	31,853	7,115	13,831	2,724
Republic	0	6.99	5.45	.04	47,817	1,151	22	6
Rice	0	12.95	11.77	.16	18,537	2,209	1,960	5

County	Variable							
	25	26	27	28	29	30	31	32
Riley	0	11.26	11.02	.08	11,229	5,472	136	0
Rooks	0	13.87	11.02	.03	5,866	1,324	0	11
Rush	0	7.58	7.60	.03	13,904	725	87	2
Russell	0	15.37	14.86	.02	5,015	1,447	2	27
Saline	0	14.63	14.53	.05	20,084	6,000	333	0
Scott	0	0	0	0	167,617	1,342	404	188
Sedgwick	0	16.22	20.22	.30	74,053	35,594	17,637	9,924
Seward	0	17.16	15.34	.02	75,826	3,095	19,627	989
Shawnee	124,200	19.19	14.97	.07	51,388	19,846	10,219	13,110
Sheridan	0	6.33	2.44	.25	29,094	890	0	0
Sherman	0	10.03	5.01	.02	86,317	1,719	8	11
Smith	0	10.19	10.29	0	14,963	952	1	0
Stafford	0	7.68	3.75	.37	15,778	1,253	1	4
Stanton	0	10.45	11.12	.03	197,992	668	0	1
Stevens	0	69.91	67.02	.03	81,463	1,201	1	1
Sumner	0	9.89	10.64	.10	6,193	3,545	45	117
Thomas	0	13.57	13.03	.03	33,377	1,718	8	205
Trego	58,000	8.28	7.02	.02	4,470	883	0	0
Wabaunsee	0	2.60	3.72	.17	3,440	549	0	0
Wallace	0	11.25	5.62	0	65,607	511	0	55
Washington	0	8.72	4.78	.06	7,256	1,238	136	1
Wichita	0	0	0	.02	184,257	745	3	0
Wilson	0	13.55	12.97	0	5,409	1,554	2,480	4
Woodson	0	9.05	9.68	0	1,297	376	1	0
Wyandotte	0	10.57	8.09	.23	270,369	26,753	37,822	187,270

County	Variable							
	33	34	35	36	37	38	39	40
Allen	942	400	.17	335.5	.001	.016	.9	0
Anderson	1,078	150	.08	175	.009	.009	.9	0
Atchison	761	44	.04	62	-.007	.003	1.1	61.8
Barber	1,175	1,150	.29	709	-.276	-.018	1.6	83.4
Barton	896	10,900	4.59	21,520.5	.131	.239	1.6	92.8
Bourbon	1,257	110	.16	287.5	-.021	.011	.8	0
Brown	1,244	290	.05	126	-.002	.001	1.2	0
Butler	1,883	500	.07	197	-.044	-.019	1.2	10.5
Chase	811	300	.09	78.5	-.132	-.014	1.2	1.0
Chautauqua	815	500	.00	0	-.054	-.056	1.0	0
Cherokee	603	50	.05	105	-.009	-.018	.8	0
Cheyenne	698	36,200	8.56	31,971.5	1.050	-.072	1.9	98.9
Clark	859	1,980	1.29	2,469	.093	-.071	1.8	100.0

County	Variable							
	33	34	35	36	37	38	39	40
Clay	992	5,300	3.34	8,740	.243	.068	1.4	82.7
Cloud	716	11,200	2.07	6,237	.074	-.330	1.5	86.4
Coffey	1,118	230	.10	201.5	-.035	-.001	1.0	0
Comanche	843	2,000	1.02	1,879.5	-.218	-.031	1.7	74.8
Cowley	1,512	2,400	.13	329.5	-.114	-.031	1.2	26.1
Crawford	867	30	.06	116.5	-.006	-.004	.8	0
Decatur	831	19,800	2.71	9,162.5	.199	-.033	1.8	89.9
Dickinson	1,376	2,100	.45	1,778	-.216	-.060	1.3	51.2
Doniphan	686	200	.08	139	-.017	-.005	1.1	24.3
Douglas	1,060	920	.07	104.5	-.088	.001	1.1	69.0
Edwards	479	15,300	7.80	21,699	-.237	.104	1.7	100.0
Elk	873	200	.07	59	-.015	-.007	1.1	0
Ellis	875	11,200	2.48	7,612.5	.287	.014	1.7	33.5
Ellsworth	765	670	.17	413	-.095	-.009	1.5	2.9
Finney	892	212,000	34.10	155,979	-11.072	-1.042	1.8	86.7
Ford	1,269	30,600	7.63	39,116.5	-.172	-.099	1.8	93.4
Franklin	1,289	620	.31	596	-.026	.014	1.0	0
Geary	530	620	.52	368	-.123	-.014	1.3	23.3
Gove	946	7,700	5.11	17,659	.609	.189	1.8	96.5
Graham	598	1,700	1.77	5,172.5	.100	.084	1.7	89.7
Grant	223	200,000	42.95	116,847	-3.953	-1.074	2.0	97.6
Gray	595	76,000	29.66	127,032	4.008	.838	1.9	97.9
Greeley	322	26,000	7.53	24,852	.839	-.266	2.0	100.0
Greenwood	1,358	360	.15	211	-.071	-.019	1.1	0
Hamilton	320	31,200	4.68	17,803	-1.524	-.149	2.0	81.1
Harper	865	730	.19	681	-.030	-.037	1.4	90.3
Harvey	1,006	3,600	1.81	4,748	-.280	.029	1.3	77.6
Haskell	401	179,000	57.45	178,647	4.218	.813	1.9	99.5
Hodgeman	912	18,000	6.24	17,521	-.630	-.150	1.8	96.4
Jackson	1,031	40	.02	46.5	-.027	.002	1.2	0
Jefferson	1,074	960	.25	454	-.026	-.007	1.1	93.0
Jewell	1,105	9,600	2.39	8,009	.163	-.059	1.6	2.7
Johnson	765	230	.09	115	-.052	-.017	1.0	22.0
Kearny	350	85,000	20.50	64,686	3.295	-.207	1.9	77.9
Kingman	1,088	1,540	1.65	5,459	.147	.064	1.4	54.6
Kiowa	516	9,500	6.45	16,790.5	.576	.024	1.7	94.8
Labette	1,165	70	.17	378.5	.004	.016	.8	0
Lane	643	12,200	4.68	15,270	.389	.007	1.8	94.1
Leavenworth	912	120	0	7	-.023	-.007	1.1	28.4
Lincoln	903	670	.35	984.5	.017	.011	1.6	42.5
Linn	975	150	.05	83	-.042	.001	.9	0
Logan	465	11,300	3.44	11,839	.255	-.014	1.8	94.9
Lyon	1,390	200	.16	335	-.048	-.003	1.1	0
McPherson	1,511	8,400	3.36	14,365	.320	.149	1.4	67.7
Marion	1,607	360	.14	539.5	-.108	-.001	1.3	21.4
Marshall	1,375	2,080	.28	1,065.5	-.134	-.001	1.3	20.3
Meade	750	41,300	22.16	72,198	2.053	.490	1.8	98.7

County	Variable							
	33	34	35	36	37	38	39	40
Miami	1,158	50	.01	22.5	-.025	-.007	.9	0
Mitchell	662	6,400	1.39	4,661.5	-.024	.004	1.6	28.3
Montgomery	944	180	.49	891.5	-.028	.011	.9	8.5
Morris	1,135	180	.03	57.5	-.030	-.010	1.2	0
Morton	215	50,000	15.44	44,341.5	1.449	-.061	2.0	100.0
Nemaha	1,684	140	.02	46.5	-.049	.001	1.2	0
Neosho	898	320	.11	228	-.027	-.005	.9	0
Ness	938	9,400	1.00	4,652	-.509	-.210	1.8	90.6
Norton	835	5,600	2.34	6,920	-.302	.027	1.7	39.1
Osage	1,103	180	.10	210	-.010	.005	1.1	0
Osborne	983	13,200	2.85	9,822	.100	-.150	1.7	20.2
Ottawa	726	1,900	1.32	3,214	-.020	-.082	1.5	53.8
Pawnee	621	32,000	8.82	35,503	-.170	-.009	1.7	93.6
Phillips	1,010	2,700	1.90	5,983.5	-.177	.025	1.7	11.4
Pottawatomie	1,312	4,400	2.41	4,860.5	-.209	.017	1.3	82.4
Pratt	556	12,000	5.72	19,240.5	.562	.189	1.6	98.3
Rawlins	723	9,000	4.61	17,973	.542	.234	1.8	91.0
Reno	1,545	4,600	1.48	8,059	-.355	.105	1.4	94.4
Republic	963	45,000	11.60	37,417.5	1.293	-.191	1.5	77.4
Rice	763	11,700	1.75	5,987.5	.207	-.079	1.5	96.5
Riley	921	4,700	.97	1,305	-.221	-.022	1.3	86.2
Rooks	747	3,600	.88	2,814	-.001	.033	1.7	21.8
Rush	583	12,400	3.29	11,258.5	-.756	.021	1.7	94.8
Russell	721	1,900	.30	900.5	-.015	.007	1.6	11.4
Saline	796	6,600	.93	2,339.5	-.364	-.073	1.4	44.6
Scott	680	165,000	23.19	88,007	-6.039	-.670	1.9	99.6
Sedgwick	1,295	4,000	1.98	8,874.5	.100	.045	1.3	92.9
Seward	348	45,600	23.09	52,806.5	1.000	-.531	1.9	99.9
Shawnee	733	6,200	3.41	5,440	-.206	-.051	1.1	98.0
Sheridan	851	27,000	16.58	49,711.5	2.267	.624	1.8	96.8
Sherman	501	83,600	19.01	85,051.5	3.588	.092	1.9	99.2
Smith	1,110	12,900	2.30	8,025	-.015	-.169	1.7	40.2
Stafford	681	13,600	6.46	23,164	.800	.223	1.6	98.2
Stanton	311	197,000	27.48	113,072	.062	-.685	2.1	99.3
Stevens	220	80,000	20.65	74,849.5	1.302	-.132	1.9	99.6
Sumner	1,136	800	.19	1,072	-.142	.030	1.3	57.5
Thomas	588	30,600	8.57	46,593.5	1.999	.468	1.8	99.6
Trego	715	2,700	1.14	3,343	.129	.020	1.8	44.8
Wabaunsee	1,130	1,700	1.68	2,497	-.027	.056	1.2	47.7
Wallace	413	64,600	17.64	49,235	1.549	-.144	1.9	98.8
Washington	1,581	4,300	1.05	3,760.5	-.093	.018	1.4	16.0
Wichita	368	183,000	32.68	110,638	-.085	-.932	1.9	99.5
Wilson	749	450	.43	781.5	.003	.015	1.0	0
Woodson	625	200	.08	96.5	-.011	-.006	1.0	0
Wyandotte	181	230	.05	9	-.018	-.008	1.0	65.4

County	Variable							
	41	42	43	44	45	46	47	48
Allen	100.0	0	0	100.0	8.35	18.72	8	92
Anderson	100.0	100.0	0	0	7.72	19.10	21	79
Atchison	38.2	0	0	0	.77	5.72	46	54
Barber	16.6	100.0	0	0	28.79	25.89	75	25
Barton	7.2	43.3	50.0	6.7	56.57	22.09	89	11
Bourbon	100.0	100.0	0	0	3.35	11.98	15	85
Brown	100.0	100.0	0	0	9.84	12.68	66	34
Butler	89.5	100.0	0	0	3.26	18.32	18	82
Chase	99.0	73.3	20.0	6.7	18.56	11.78	50	50
Chautauqua	100.0	100.0	0	0	26.39	21.33	21	79
Cherokee	100.0	80.0	10.0	10.0	.03	6.11	2	98
Cheyenne	1.1	36.7	63.3	0	94.46	4.59	95	5
Clark	0	51.0	49.0	0	54.02	38.86	92	8
Clay	17.3	25.4	74.6	0	67.23	3.95	73	27
Cloud	13.6	60.0	40.0	0	80.54	8.77	86	14
Coffey	100.0	66.7	33.3	0	11.27	.98	20	80
Comanche	25.2	100.0	0	0	57.90	30.37	74	26
Cowley	73.9	0.0	95.0	5.0	4.70	67.10	19	81
Crawford	100.0	100.0	0	0	.53	1.72	87	13
Decatur	10.1	26.6	71.9	1.5	90.95	5.67	86	14
Dickinson	48.8	72.3	27.7	0	8.52	54.26	21	79
Doniphan	75.7	100.0	0	0	12.41	1.67	69	31
Douglas	31.0	37.5	62.5	0	5.36	20.34	43	57
Edwards	0.0	80.0	20.0	0	90.72	8.12	99	1
Elk	100.0	100.0	0	0	10.08	39.05	15	85
Ellis	66.5	9.3	3.5	87.2	70.55	-15.99	43	57
Ellsworth	97.1	30.0	50.0	20.0	16.32	36.01	68	32
Finney	13.3	36.2	25.5	38.3	93.01	4.92	77	23
Ford	6.6	50.0	49.4	0.6	69.71	26.64	96	4
Franklin	100.0	73.9	26.1	0	14.44	3.00	21	79
Geary	76.7	0	100.0	0	16.42	24.85	79	21
Gove	3.5	30.2	69.8	0	81.17	-1.12	85	15
Graham	10.3	56.6	42.7	0.6	42.53	30.63	87	13
Grant	2.4	12.6	30.6	56.8	97.15	1.52	100	0
Gray	2.1	36.8	62.5	0.7	98.15	1.34	95	5
Greeley	0	2.3	87.9	9.8	96.89	1.73	100	0
Greenwood	100.0	80.0	20.0	0	11.34	26.55	25	75
Hamilton	18.9	17.3	33.3	49.3	96.50	2.16	73	27
Harper	9.7	86.7	13.3	0	21.12	67.29	86	14
Harvey	22.4	43.7	56.3	0	40.35	33.08	10	90
Haskell	0.5	7.6	70.7	21.7	98.64	.40	100	0
Hodgeman	3.6	11.1	85.4	3.5	91.05	6.50	95	5
Jackson	100.0	100.0	0	0	2.05	4.39	55	45
Jefferson	7.0	16.7	62.5	20.8	31.98	4.80	67	33
Jewell	97.3	4.7	28.6	66.7	84.22	1.29	13	87
Johnson	78.0	100.0	0	0	1.29	.18	42	58
Kearny	22.1	28.8	42.7	28.5	98.26	.88	57	43
Kingman	45.4	99.3	0	0.7	38.36	48.78	67	33

County	Variable							
	41	42	43	44	45	46	47	48
Kiowa	5.2	94.8	5.2	0	84.80	13.64	91	9
Labette	100.0	100.0	0	0	1.10	4.70	11	89
Lane	5.9	8.3	89.0	2.7	90.59	7.26	98	2
Leavenworth	71.6	50.0	50.0	0	2.01	3.57	27	73
Lincoln	57.5	21.1	78.9	0	28.64	44.14	78	22
Linn	100.0	100.0	0	0	8.50	22.25	22	78
Logan	5.1	15.8	84.2	0	86.92	6.93	85	15
Lyon	100.0	0	0	0	3.24	34.19	15	85
McPherson	32.3	8.6	90.8	.6	51.08	43.60	69	31
Marion	77.6	20.0	60.0	20.0	9.73	55.56	76	24
Marshall	79.7	48.6	51.4	0	40.70	24.37	45	55
Meade	1.3	13.5	85.4	1.1	95.35	3.03	96	4
Miami	100.0	100.0	0	0	1.57	1.83	25	75
Mitchell	71.7	14.0	86.0	0	78.02	10.33	33	67
Montgomery	91.5	100.0	0	0	1.67	5.82	8	92
Morris	100.0	60.0	0	40.0	8.43	33.11	48	52
Morton	0	7.0	83.8	9.3	98.38	-.06	100	0
Nemaha	100.0	100.0	0	0	4.53	13.70	68	32
Neosho	100.0	100.0	0	0	6.27	13.93	8	92
Ness	9.4	2.9	50.5	46.6	81.41	4.32	87	13
Norton	60.9	14.4	42.8	42.8	70.46	16.40	82	18
Osage	100.0	100.0	0	0	7.38	2.13	25	75
Osborne	79.8	7.0	18.8	74.3	86.36	2.18	16	84
Ottawa	46.2	47.3	52.8	0	46.49	40.03	56	44
Pawnee	6.4	38.2	54.6	7.2	92.67	4.06	86	14
Phillips	88.6	28.9	21.3	49.8	23.81	19.95	65	35
Pottawatomie	17.6	50.0	50.0	0	62.02	-11.23	70	30
Pratt	1.7	94.2	5.8	0	74.38	21.55	95	5
Rawlins	9.0	18.0	82.0	0	83.97	14.06	96	4
Reno	5.6	78.2	21.8	0	14.44	72.13	95	5
Republic	22.6	35.2	5.3	59.4	94.11	.50	33	67
Rice	3.5	61.2	38.8	0	63.12	32.48	92	8
Riley	13.8	13.3	33.3	53.3	41.86	19.69	75	25
Rooks	78.2	100.0	0	0	61.37	-6.00	81	19
Rush	5.2	4.7	93.3	2.0	89.18	.26	94	6
Russell	88.6	0	0	0	37.89	17.20	46	54
Saline	55.4	38.5	61.5	0	32.86	36.47	79	21
Scott	0.7	2.4	76.7	20.9	98.44	.30	100	0
Sedgwick	7.1	25.9	72.7	1.4	5.40	27.84	73	27
Seward	0.1	25.0	75.0	0	60.14	32.52	100	0
Shawnee	2.0	9.3	90.7	0	12.07	12.52	27	73
Sheridan	3.2	20.2	78.2	1.6	92.80	6.24	95	5
Sherman	0.8	19.2	80.8	0	96.85	2.19	100	0
Smith	59.8	0.4	8.7	90.9	86.21	-1.80	14	86
Stafford	1.8	80.0	20.0	0	86.20	12.28	94	6
Stanton	0.7	9.0	35.4	55.6	99.50	-.02	100	0
Stevens	0.4	23.1	38.5	38.5	98.20	1.21	100	0
Sumner	42.5	15.3	84.7	0	12.92	61.53	68	32

County	Variable							
	41	42	43	44	45	46	47	48
Thomas	.4	38.0	62.0	0	91.68	7.54	100	0
Trego	55.2	51.4	48.6	0	60.40	22.26	56	44
Wabaunsee	52.3	12.2	87.8	0	49.42	21.01	65	35
Wallace	1.2	14.3	78.8	6.9	98.47	.80	100	0
Washington	84.0	57.7	38.5	3.8	59.26	-3.00	40	60
Wichita	0.5	1.6	68.4	29.9	99.32	-.14	100	0
Wilson	100.0	100.0	0	0	8.32	24.08	7	93
Woodson	100.0	0	0	100.0	15.42	10.65	31	69
Wyandotte	34.6	0	0	0	.09	.11	11	89

County	Variable							
	49	50	51	52	53	54	55	56
Allen	10,342	1,857	899	516	1,743	2,800	-.062	-.118
Anderson	5,592	1,005	616	64	2,124	1,500	-.014	.003
Atchison	7,710	1,882	3,242	0	1,676	500	-.111	-.514
Barber	17,556	1,407	491	0	2,256	9,600	.020	-.164
Barton	113,021	7,355	2,870	2,910	3,290	88,900	.325	.063
Bourbon	5,870	1,499	1,432	0	1,817	900	-.052	-.322
Brown	7,550	1,343	1,100	39	3,368	1,700	-.028	-.026
Butler	49,109	7,397	4,397	10,542	6,818	10,600	-.069	.155
Chase	8,241	450	66	0	5,180	2,500	.017	-.026
Chautauqua	7,125	533	52	19	1,754	3,400	.000	-.082
Cherokee	13,039	2,692	5,030	2,005	1,480	800	-5.170	-.202
Cheyenne	296,008	956	73	12	1,767	293,200	1.220	-.202
Clark	37,039	1,076	6	14	1,452	34,400	.187	-.028
Clay	18,966	1,974	405	442	2,504	13,500	-.086	.077
Cloud	40,419	1,834	664	476	1,345	36,100	-.096	.181
Coffey	17,495	718	139	12,045	2,624	1,800	.079	-.072
Comanche	18,127	528	12	7	1,560	16,000	.042	-.075
Cowley	71,867	6,027	5,444	736	3,712	51,600	-.967	-.362
Crawford	13,324	4,844	5,320	44	1,649	300	-.064	-.470
Decatur	118,189	1,302	118	30	1,970	114,200	.292	-.058
Dickinson	26,441	3,966	629	196	3,775	16,600	-.532	-.051
Doniphan	3,551	1,285	30	0	1,417	500	-.020	.039
Douglas	49,803	9,495	13,977	11,996	1,444	12,800	-.119	.662
Edwards	197,988	1,172	297	1	690	195,700	1.081	-.066
Elk	4,681	371	10	0	1,980	2,300	-.022	-.071
Ellis	45,824	6,898	2,534	569	1,376	25,000	-.112	.438
Ellsworth	8,599	1,464	336	28	1,388	4,500	-.055	.014
Finney	670,914	5,756	1,767	1,024	4,032	657,000	-1.502	.022
Ford	407,665	7,118	2,335	1,617	3,395	392,800	1.949	.036
Franklin	10,322	2,339	3,118	695	2,188	1,800	-.047	-.219

County	Variable							
	49	50	51	52	53	54	55	56
Geary	11,146	5,048	663	0	835	4,600	-.024	.365
Gove	28,359	1,279	11	0	4,247	22,700	-.059	.024
Graham	22,964	1,388	88	1,016	1,509	16,800	.064	-.026
Grant	394,734	1,745	631	366	785	389,500	-3.053	.023
Gray	530,583	1,253	37	0	1,370	527,900	1.923	-.019
Greeley	157,985	554	0	0	1,631	155,800	.458	-.052
Greenwood	10,030	973	503	0	3,661	3,800	-.015	-.134
Hamilton	106,119	623	0	90	638	104,700	-.125	-.137
Harper	43,208	1,623	97	180	1,742	38,200	.242	-.110
Harvey	49,029	6,622	4,448	0	1,696	36,000	.124	.206
Haskell	491,494	1,114	1,383	0	1,684	486,800	-1.538	-.052
Hodgeman	83,038	489	0	0	1,393	81,000	.069	-.103
Jackson	4,655	1,511	636	74	2,121	300	-.022	.028
Jefferson	6,525	1,572	291	0	1,671	2,400	-.039	-.035
Jewell	26,431	871	28	0	2,932	22,600	-.133	-.041
Johnson	108,325	31,651	72,119	0	987	1,200	.330	1.765
Kearny	294,631	806	45	0	965	292,100	-.248	-.065
Kingman	43,032	1,356	183	50	1,712	37,500	.225	-.149
Kiowa	180,728	1,155	28	26	822	117,900	1.114	-.069
Labette	22,402	4,051	13,644	340	3,067	1,300	-.013	-.060
Lane	101,995	702	45	0	1,441	99,800	.413	-.062
Leavenworth	14,332	9,115	3,436	0	934	800	-.066	.403
Lincoln	10,168	898	303	32	1,535	7,400	.011	-.065
Linn	4,553	799	378	0	1,935	1,400	-.016	-.027
Logan	39,000	1,287	16	27	1,070	36,600	-.080	-.134
Lyon	28,323	4,639	6,931	0	5,470	10,600	.041	-.070
McPherson	165,193	4,739	412	812	2,682	156,400	.831	-.429
Marion	32,165	1,986	3,813	68	3,154	21,000	.147	-.085
Marshall	15,984	1,474	208	0	2,946	10,400	-.027	-.238
Meade	319,470	1,713	83	24	1,939	314,300	1.258	-.031
Miami	8,812	2,393	1,519	2,623	1,748	300	-.025	-.185
Mitchell	33,165	1,823	125	70	1,847	29,300	.019	.039
Montgomery	26,713	5,432	12,351	1,035	2,252	2,000	-.110	-.357
Morris	6,740	892	421	0	2,614	2,800	-.011	-.011
Morton	200,567	1,277	660	0	681	197,200	.075	.135
Nemaha	7,130	1,482	524	45	3,779	1,300	-.036	-.046
Neosho	12,378	2,847	2,212	887	1,928	2,500	.055	-.241
Ness	25,778	1,192	5	2	1,409	22,100	-.142	-.101
Norton	31,890	2,099	38	57	1,677	27,700	.016	-.047
Osage	5,260	1,911	550	81	2,184	500	-.032	.020
Osborne	28,236	1,035	177	17	1,798	25,000	-.235	-.119
Ottawa	23,463	1,312	314	42	1,495	20,300	-.065	-.082
Pawnee	183,911	2,671	63	350	1,925	177,900	.434	.050
Phillips	49,362	1,928	702	2	2,709	21,600	.054	-.001
Pottawatomie	34,262	1,684	118	11,811	3,120	17,400	.060	-.056
Pratt	204,005	2,517	232	344	3,208	195,700	1.152	-.302
Rawlins	167,094	1,207	13	3	1,935	163,800	1.019	-.076
Reno	325,187	15,321	18,932	5,706	2,999	281,500	1.651	.919

County	Variable							
	49	50	51	52	53	54	55	56
Republic	107,393	1,743	270	60	3,288	101,600	-.583	-.021
Rice	170,083	2,285	936	24	2,093	162,600	.806	-.287
Riley	31,357	9,466	704	0	1,591	19,300	-.088	.170
Rooks	15,533	1,655	119	21	1,526	8,600	-.052	-.106
Rush	37,792	1,378	178	24	1,200	33,800	-.117	.051
Russell	16,519	2,224	487	72	1,175	9,100	-.019	-.020
Saline	65,054	13,610	4,506	0	1,627	45,100	-.084	.934
Scott	468,404	1,772	894	111	3,107	462,500	-1.305	-.086
Sedgwick	329,422	81,439	72,190	12,018	2,438	109,500	.408	5.707
Seward	315,248	7,014	961	945	410	292,100	.241	.480
Shawnee	116,292	27,920	52,218	6,283	1,136	28,600	-.619	-.868
Sheridan	348,257	894	1	1	2,434	344,900	1.919	-.122
Sherman	489,707	2,463	498	55	1,281	485,000	1.325	-.139
Smith	29,617	1,387	121	0	3,109	25,000	-.215	-.031
Stafford	270,914	1,519	118	42	1,649	266,800	1.700	-.111
Stanton	391,535	736	0	7	1,285	389,500	-2.841	-.077
Stevens	435,866	1,558	5	36	603	433,300	1.039	-.083
Sumner	44,055	5,668	1,495	730	2,278	32,800	.167	.002
Thomas	521,447	2,263	121	382	1,258	517,400	3.182	-.111
Trego	16,452	943	41	1	1,161	13,600	-.003	-.108
Wabaunsee	12,353	968	192	0	2,466	8,700	-.005	.021
Wallace	212,754	467	4	5	1,078	211,200	-.274	-.081
Washington	15,465	1,675	8	54	4,832	8,700	-.095	-.069
Wichita	429,529	763	2	0	2,764	426,000	-2.121	-.098
Wilson	12,037	1,448	4,392	101	2,014	3,900	-.067	-.239
Woodson	5,753	782	270	0	3,093	1,500	.007	.042
Wyandotte	509,964	29,216	86,409	391,621	526	1,000	-4.078	-3.118

County	Variable							
	57	58	59	60	61	62	63	64
Allen	-1.014	.105	-.237	.008	15,455	15,665	8,046	.49
Anderson	.127	.013	-.212	.007	8,539	8,479	8,401	2.71
Atchison	-.799	.000	-.070	.003	21,288	18,657	9,536	4.72
Barber	.110	.000	-.258	.039	6,880	5,767	10,401	3.01
Barton	.028	.308	.513	.348	36,102	32,023	11,686	10.64
Bourbon	.266	.000	-.545	.003	15,740	15,750	7,848	-.62
Brown	-.027	.008	.170	.003	13,061	10,398	8,103	-.70
Butler	-5.396	2.170	1.036	.077	39,522	46,824	11,042	7.32
Chase	-.027	.000	1.461	.010	3,554	3,142	8,211	.18
Chautauqua	.012	.004	-.094	.010	5,051	3,906	6,750	-4.45
Cherokee	-2.618	35.480	.013	.005	22,532	22,059	7,945	1.76
Ch�yenne	.017	.002	.040	1.139	4,005	2,896	8,912	1.76
Clark	.001	.003	-.277	.234	2,833	3,570	9,025	1.24
Clay	.028	.044	.054	-.108	10,139	11,460	9,102	.66
Cloud	.096	.038	-.171	-.158	14,072	12,596	9,110	1.10

County	Variable							
	57	58	59	60	61	62	63	64
Coffey	.032	2.484	-.029	.007	8,282	8,500	8,048	-2.55
Comanche	-.003	.001	-.211	.061	2,839	2,356	7,674	2.42
Cowley	-.983	-8.062	.034	.376	34,800	38,155	10,863	2.78
Crawford	1.067	.008	-.197	.002	38,127	39,690	8,519	.12
Decatur	.021	.006	-.013	.192	5,036	5,042	9,447	2.41
Dickinson	-.324	-3.773	.211	.062	21,927	29,511	9,282	2.69
Doniphan	.007	.000	-.105	-.004	10,094	9,937	8,739	5.11
Douglas	-.877	1.910	-.500	.079	63,833	73,475	11,714	12.01
Edwards	.050	.000	-.209	1.152	4,507	4,538	10,860	1.99
Elk	-.282	.000	-.054	.012	4,042	3,481	6,217	-6.87
Ellis	.556	.073	-.330	-.262	24,293	28,273	13,070	15.92
Ellsworth	.076	.005	-.204	.012	7,232	7,284	8,440	-.56
Finney	.218	-2.140	.854	-3.232	23,323	36,000	12,644	17.50
Ford	.267	-1.129	.156	2.316	24,495	31,791	11,421	11.32
Franklin	.535	.141	-.412	-.010	20,591	23,201	10,339	3.37
Geary	-.145	.000	-.199	.016	24,474	40,973	9,183	27.23
Gove	.003	.000	.892	-.128	4,000	4,457	9,787	12.98
Graham	.013	.096	.032	.082	4,630	5,374	10,609	8.27
Grant	-.387	.052	.112	-5.200	7,055	10,500	13,429	19.66
Gray	.008	.000	-.027	1.572	4,943	5,088	10,222	8.61
Greeley	.000	.000	.388	.306	2,210	2,062	12,214	9.30
Greenwood	.115	.000	.179	.019	9,154	9,143	7,645	-.45
Hamilton	.000	.019	-.059	-.401	3,076	2,317	11,536	8.78
Harper	.014	.013	-.153	.003	8,140	7,544	10,658	-.47
Harvey	.845	.000	-.327	.177	28,934	45,482	9,823	7.23
Haskell	.412	.000	.326	-3.364	4,096	4,525	9,086	13.75
Hodgeman	.000	.002	-.362	-.039	2,744	2,185	7,615	5.84
Jackson	.144	.015	-.163	.001	11,288	13,490	9,385	.79
Jefferson	.016	.000	-.412	-.020	12,816	15,597	10,766	4.23
Jewell	.003	.000	.124	-.213	6,006	4,340	8,351	-1.84
Johnson	15.971	.000	-.386	.001	241,781	332,462	19,598	16.64
Kearny	.006	.000	.055	-1.028	3,307	3,132	13,127	10.14
Kingman	.022	.009	-.410	.282	10,043	10,000	9,398	3.53
Kiowa	.005	.003	-.189	1.241	4,030	4,237	11,378	1.04
Labette	2.763	-.331	.120	.009	25,274	31,344	10,206	1.34
Lane	.009	.000	-.047	.393	2,842	2,985	9,385	10.03
Leavenworth	.649	.000	-.570	.002	50,702	95,754	11,557	7.88
Lincoln	.052	.007	-.288	.039	4,793	4,471	8,945	-1.64
Linn	.086	.000	-.186	.006	8,364	8,395	8,795	-4.06
Logan	.003	.006	-.022	-.157	3,806	4,077	10,959	10.16
Lyon	.942	.000	.962	.090	31,133	43,606	10,828	7.86
McPherson	-1.177	.119	-.431	1.090	25,167	32,566	11,255	4.39
Marion	.746	.013	-.321	.180	16,209	14,783	9,303	2.15
Marshall	-.009	.000	.163	.005	13,919	10,267	8,361	-.67
Meade	.008	.005	.061	1.110	5,058	5,425	11,140	5.99
Miami	.323	.541	-.469	.001	20,906	25,133	11,621	3.00
Mitchell	.018	.013	.115	-.009	8,115	9,074	9,518	2.93

County	Variable							
	57	58	59	60	61	62	63	64
Montgomery	-.406	.147	-.008	.011	42,741	42,033	9,102	1.04
Morris	-.003	.000	-.053	.018	6,895	7,240	8,206	.55
Morton	.152	.000	.074	-.367	3,495	3,707	11,929	12.79
Nemaha	.068	.003	-.123	.006	12,104	10,863	8,458	4.67
Neosho	-.257	.146	-.105	.009	17,782	22,030	8,743	2.55
Ness	.001	.000	-.383	-.209	4,653	4,368	9,104	4.55
Norton	-.001	.012	-.149	.012	7,213	8,603	10,015	3.02
Osage	-.124	.015	-.212	-.003	13,368	14,788	9,547	1.93
Osborne	.023	.004	-.256	-.350	6,371	4,804	9,738	1.15
Ottawa	-.037	.009	-.114	.106	6,419	7,032	8,506	-1.05
Pawnee	.007	.054	.195	.247	8,068	10,947	11,645	3.47
Phillips	-.456	.000	.126	.083	8,287	8,394	9,053	3.28
Pottawatomie	.003	2.436	-.016	-.032	13,035	15,031	9,388	2.97
Pratt	.037	.063	.846	1.298	9,148	10,317	10,910	3.57
Rawlins	.002	.001	.088	1.132	4,301	4,204	7,760	6.00
Reno	-4.764	.587	-.324	2.426	64,900	91,253	10,662	8.61
Republic	.047	.011	.439	-1.040	8,272	9,336	8,964	-1.71
Rice	-1.077	.004	.117	1.002	11,681	10,620	9,687	2.91
Riley	.072	.000	-.282	-.028	41,029	76,829	10,786	15.31
Rooks	.027	.002	-.123	-.079	7,313	6,788	9,336	6.12
Rush	-.016	.005	-.091	-.232	5,299	5,649	9,505	2.06
Russell	.111	.009	-.253	.001	9,707	10,331	10,607	4.54
Saline	.818	.000	-.130	.129	47,596	72,911	11,182	15.28
Scott	-.061	-.018	.665	-2.972	6,453	7,197	13,320	12.97
Sedgwick	4.996	.329	-.306	.846	339,223	436,285	12,634	15.01
Seward	-12.731	-.019	-.194	.713	16,644	21,247	14,202	15.95
Shawnee	5.289	-1.544	-.283	-.007	173,418	262,406	12,680	14.65
Sheridan	.000	.000	.175	2.028	3,856	3,279	8,356	8.98
Sherman	.110	.009	.034	.835	8,424	9,167	12,200	9.91
Smith	.027	.000	.198	-.337	6,588	6,444	9,375	-.28
Stafford	.026	.008	.005	1.891	6,207	6,226	9,511	-1.45
Stanton	.000	.001	.243	-5.067	2,523	2,741	11,278	20.21
Stevens	.000	.007	.034	.512	4,865	5,800	12,820	11.07
Sumner	.314	.126	-.206	.271	24,166	30,366	8,733	3.33
Thomas	.023	.035	-.071	3.480	7,826	9,627	11,385	10.18
Trego	.009	.000	-.253	.008	4,564	3,651	9,368	5.77
Wabaunsee	.044	.000	-.114	.006	6,746	8,639	9,074	.45
Wallace	.001	-.011	.039	-.883	2,228	2,100	12,082	12.66
Washington	-.088	.011	.466	-.109	9,319	9,724	7,082	.55
Wichita	-.002	.000	.850	-4.109	3,697	5,200	10,914	17.29
Wilson	-.625	.020	.096	.016	14,217	13,615	8,455	-1.13
Woodson	.061	.000	.719	.005	4,796	6,052	6,672	-3.36
Wyandotte	-5.047	40.215	.041	-.001	187,833	239,373	12,107	12.83

County	Variable						
	65	66	67	68	69	70	71
Allen	-8.60	43.2	56.8	12.6	21.7	.807	.636
Anderson	-8.62	37.3	62.7	21.8	13.5	.861	.750
Atchison	-13.01	65.6	34.4	9.5	20.3	.756	.494
Barber	-22.48	36.3	63.7	20.9	11.1	.725	1.339
Barton	-15.90	64.7	35.3	8.9	9.4	1.430	2.193
Bourbon	-4.82	58.9	41.1	12.5	12.4	.600	.786
Brown	-10.98	28.8	71.2	24.3	10.3	1.508	1.009
Butler	-6.64	47.3	52.7	6.9	24.8	1.160	2.698
Chase	-13.26	0.0	100.0	35.5	4.5	.299	1.369
Chautauqua	-17.61	0.0	100.0	28.8	8.3	.172	.805
Cherokee	-5.03	53.6	46.4	7.2	30.3	.776	.444
Cheyenne	-11.36	0	100.0	34.8	1.4	1.066	.673
Clark	-15.96	0	100.0	26.1	2.0	.451	.962
Clay	-6.70	50.2	49.8	23.2	8.6	.986	.920
Cloud	-7.64	53.6	46.4	16.4	5.9	1.137	.645
Coffey	-9.43	0	100.0	26.9	5.3	.738	.932
Comanche	-19.81	0	100.0	32.9	5.9	.412	.884
Cowley	-10.31	70.3	29.7	7.2	20.1	1.001	1.825
Crawford	2.09	60.1	39.9	6.8	15.9	.794	.567
Decatur	-16.08	0	100.0	31.4	4.4	.857	.817
Dickinson	-10.01	49.1	50.9	15.6	10.9	1.330	1.347
Doniphan	-9.99	14.1	85.9	20.6	17.3	1.080	.452
Douglas	20.49	83.2	16.8	3.9	16.3	.744	.628
Edwards	-12.49	0	100.0	25.2	12.7	.845	.767
Elk	-16.70	0	100.0	30.6	5.3	.227	.838
Ellis	.34	62.3	37.7	8.3	7.3	.736	1.125
Ellsworth	-19.38	0	100.0	26.6	7.8	.682	.687
Finney	.74	77.6	22.4	12.5	9.0	2.255	2.108
Ford	-3.45	62.5	37.5	10.6	10.8	1.449	2.032
Franklin	-1.02	55.2	44.8	11.0	19.2	.799	.721
Geary	29.55	83.7	16.3	1.7	2.4	.335	1.079
Gove	-17.04	0	100.0	35.9	28.2	.965	1.701
Graham	-23.22	0	100.0	24.3	2.5	.761	.648
Grant	-6.53	63.4	36.6	19.5	10.7	1.133	.825
Gray	-5.50	0	100.0	31.3	5.1	1.708	1.717
Greeley	-22.14	0	100.0	37.6	1.3	.826	.536
Greenwood	-18.32	39.1	60.9	18.2	8.1	.373	1.475
Hamilton	-21.41	0	100.0	34.3	0.8	.826	.579
Harper	-17.03	33.7	66.3	20.5	6.7	1.250	1.101
Harvey	-1.93	56.7	43.3	6.4	22.8	1.058	.704
Haskell	9.06	0	100.0	40.2	5.5	1.816	2.191
Hodgeman	-20.39	0	100.0	45.6	1.8	.831	.958
Jackson	-.47	29.6	70.4	21.6	21.9	.669	.815
Jefferson	1.93	0	100.0	13.1	19.1	.664	.625
Jewell	-13.65	0	100.0	40.6	2.4	1.175	1.078
Johnson	36.41	91.8	8.2	1.1	18.6	.544	.297

County	Variable						
	65	66	67	68	69	70	71
Kearny	-12.10	0	100.00	28.9	1.9	.918	1.384
Kingman	-14.30	40.8	59.2	24.0	11.1	1.078	.988
Kiowa	-12.67	0	100.00	18.5	2.4	.608	.515
Labette	-5.18	50.5	49.5	7.4	25.0	.711	1.281
Lane	-21.57	0	100.00	38.9	1.5	.897	.894
Leavenworth	2.05	69.4	30.6	4.5	10.6	.521	.400
Lincoln	-15.89	0	100.0	33.5	5.3	.820	.745
Linn	-2.03	0	100.0	24.9	12.1	.693	.694
Logan	-15.66	0	100.0	17.7	1.5	.785	.509
Lyon	11.24	72.7	27.3	7.2	14.0	.860	1.672
McPherson	-2.36	54.9	45.1	11.7	20.1	1.639	1.154
Marion	-10.13	19.6	80.4	23.2	13.0	1.305	1.244
Marshall	-15.09	27.3	72.7	25.2	4.8	1.378	.956
Meade	-16.77	0	100.0	23.7	3.7	1.107	.929
Miami	-6.17	46.3	53.7	11.3	18.9	.679	.810
Mitchell	-12.59	51.4	48.6	20.0	5.4	1.145	.781
Montgomery	-12.28	70.3	29.7	4.7	25.7	.557	.671
Morris	-13.54	0	100.0	28.7	6.3	.628	1.067
Morton	-6.17	0	100.0	21.8	3.3	.779	.284
Nemaha	-12.98	0	100.0	28.9	7.9	1.084	1.218
Neosho	-5.86	55.0	45.0	8.9	22.2	.717	.684
Ness	-16.97	0	100.0	33.2	1.9	1.002	.877
Norton	-12.43	49.8	50.2	22.2	2.9	.786	.763
Osage	1.68	19.5	80.5	14.3	11.4	.837	.757
Osborne	-15.67	0	100.0	31.5	4.0	.905	.936
Ottawa	-7.74	0	100.0	20.0	11.8	.875	.689
Pawnee	-20.73	53.8	46.2	16.9	5.8	1.308	1.087
Phillips	-12.71	41.1	58.9	24.6	7.3	.802	1.057
Pottawatomie	-4.66	27.1	72.9	18.4	7.9	.695	1.200
Pratt	-20.63	67.0	33.0	13.5	6.5	1.001	1.307
Rawlins	-22.79	0	100.0	36.4	1.9	1.009	.717
Reno	-5.72	60.7	39.3	6.7	20.1	2.007	1.063
Republic	-11.29	36.0	64.0	30.0	4.6	1.399	1.037
Rice	-14.34	35.3	64.7	15.3	10.3	1.176	.915
Riley	20.17	74.5	25.5	4.2	2.5	.480	.568
Rooks	-27.76	34.4	65.6	17.3	8.7	.720	.725
Rush	-18.99	0	100.0	8.3	5.5	.913	.630
Russell	-21.46	57.0	43.0	12.0	4.1	.774	.565
Saline	-30.13	80.9	19.1	4.5	11.6	.848	.830
Scott	-5.74	71.4	28.6	26.5	7.8	1.294	1.792
Sedgwick	-12.84	90.5	9.5	1.3	24.3	1.766	.806
Seward	-17.12	85.6	14.4	5.9	11.7	.930	1.067
Shawnee	-4.71	85.1	14.9	1.3	12.9	.690	.427
Sheridan	18.54	0	100.0	40.0	1.6	1.199	1.262
Sherman	6.70	70.7	29.3	22.0	4.3	1.595	.669

County	Variable						
	65	66	67	68	69	70	71
Smith	-12.82	0	100.0	34.0	4.6	1.061	1.226
Stafford	-18.79	0	100.0	23.1	4.8	1.157	.859
Stanton	-11.71	0	100.0	42.0	1.1	1.349	.875
Stevens	-15.66	65.2	34.8	27.6	1.0	1.254	.348
Sumner	-10.30	39.0	61.0	11.7	21.7	2.266	1.103
Thomas	-8.24	62.1	37.9	19.9	3.6	1.445	.560
Trego	-24.71	0	100.0	34.0	1.8	.738	.748
Wabaunsee	-4.23	0	100.0	25.6	9.2	.491	1.045
Wallace	-5.61	0	100.0	37.3	2.2	.836	.475
Washington	-14.42	0	100.0	43.3	3.3	1.298	1.542
Wichita	1.12	0	100.0	37.4	2.9	1.051	1.708
Wilson	-12.33	56.3	43.7	13.4	27.2	.676	.633
Woodson	-8.33	0	100.0	22.5	6.0	.465	1.118
Wyandotte	-12.10	92.0	8.0	0.8	22.3	.092	.075

* Measurement units used in Appendix B.

Measurement	Variable(s)
Percent	1, 2, 3, 4, 5, 6, 9, 10, 11, 12, 14, 35, 40, 41, 42, 43, 44, 45, 46, 47, 48, 64, 65, 66, 67, 68, 69, 70, 71
Dollars	7, 8, 26, 27, 63
Acres	13, 36
Differential Shift	15, 37, 38, 46, 55, 56, 57, 58, 59, 60
Number of Special Districts	16
Cubic Feet/Second/Sq. Mile	17
Inches	18
Skewness of Logarithms**	19, 20
Acre-feet	21, 22, 23, 24, 25, 28, 29, 30, 31, 32, 33, 34, 39, 49, 50, 51, 52, 53, 54
Persons	61, 62

** $g = \frac{N(x-M)^3}{(N-1)(N-2)s^3}$ where

g = skewness of logs
M = mean of logs
x = logarithms of the observations
N = number of observations
s = standard deviation of logs

REGIONALIZATION FOR WATER PLANNING IN KANSAS

by

JOANN LUEHRING

B. A., Kansas State University, 1973

AN ABSTRACT OF A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF ARTS

Department of Geography

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1977

This thesis defines a set of nine water planning regions for Kansas based on county units that may be used at the state governmental level. An alternative regionalization is needed because of problems inherent in the currently employed watershed approach, as the watersheds straddle political entities and lack a representative administrative structure for implementing plans. Also, the surficially-designated watersheds bear no relation to the groundwater which is extremely important to the state's agricultural economy. Finally, few data are available by watershed, complicating integration of state water planning with other types of planning. The fact that no comprehensive plans have been completed for any of the twelve watersheds used by the Kansas Water Resources Board further supports the need for this study.

The water regionalization scheme is devised through tabulation by county of seventy-one variables associated with the supply, use, and management of water resource. Variables selected fall into the categories of physical base, land use, water supply, water use, and socioeconomic data. (All raw data are included.) It is assumed that areas sharing common water-related traits constitute efficacious water planning regions.

To determine areas of similarity, a three-stage process is employed, consisting of principal components analysis, distance or similarity scaling, and a centroid grouping analysis. The principal components analysis reveals nine underlying dimensions in the data set which account for nearly 72% of the variation in the original variables. The similarity scaling plots the component scores of each of the 105 counties on each of the nine components in nine-dimensional vector space. Similarity, a function of distance as plotted in vector space, is a squared Euclidean distance involving sums of squares of differences between component scores. The result of this scaling is a 105 by 105 distance matrix showing the degree of similarity among the counties and is used as input into the grouping analysis.

The grouping step is a hierarchical 104-step process transforming the 105 one-county regions into one 105-county region by scanning the distance matrix and combining similar counties. Distances are recomputed between each of the steps. For the purpose of defining water planning regions, it is necessary to halt the grouping procedure somewhere between the first and 104th steps. By examining the detail lost at each step and the change in ratio of within group to between group distances, and also by mapping various steps, a step is selected that represents a reasonable number and configuration of regions illustrating differing water conditions and planning needs.

This set of regions is refined such that one-county regions are avoided and later aggregations in the grouping procedure are dissolved before earlier ones. In addition, refinement is guided by a map of the largest one or two component scores for each county. These procedures result in a set of nine water planning regions plus three independent urban areas. Reflecting past, present and expected conditions, the nine regions are Major Irrigation Growth; Slight Irrigation Potential; Slowing Irrigation Growth; Arid, Non-Irrigated; Arid, Cattle Producing; Groundwater and Sprinkler Irrigation; Productive Cattle Raising; Crops With Cattle; and Humid, Non-Irrigated.

A wide disparity exists between the watershed units and the analytically-defined regions, indicating that the counties in the watersheds exhibit major differences among themselves regarding the seventy-one variables. Thus, if the variables are important to water planning, significant considerations are ignored in the watershed approach. The alternative regions are more logical and more operational for water planning than are the watersheds, given the great reliance on groundwater throughout much of the state, the number of supply-related variables used in the analysis, and the representative governmental framework provided by the county units. Therefore, the new regions have substantial implications for state water planning in Kansas and deserve further study.