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THE INFLUENCE OF HIGH VOLUMES OF TRAFFIC ON THE THRESHOLD POPULATIONS OF CENTRAL PLACE FUNCTIONS

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CHAPTER I

INTRODUCTION

One of the most significant pieces of theoretical geographic research appeared in 1933--Walter Christaller's Die Zentralen Orte in Süddeutschland.[1] This work stimulated a flurry of research activity, which continues today, among economic geographers concerned with what has come to be called Central Place Theory. One of the effects of this stimulus has been an increase in the number of geographers addressing themselves more to the search for general patterns rather than to the discovery and description of unique occurrences.[2] Their goal is to develop within geography a body of

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[1]Walter Christaller, Die Zentralen Orte in Süddeutschland (Jena: Gustav Fisher Verlag, 1933), translated by Carlisle W. Baskin, Central Places in Southern Germany (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1966).

[2]A short review of this thought is presented in Peter Haggett's Locational Analysis in Human Geography (New York: St. Martin's Press, 1966), pp. 2-4. See also William Bunge, Theoretical Geography, Lund Studies in Geography, Series C, General and Mathematical Geography, Number 1 (Lund, Sweden: C. W. K. Gleerup, 1962); Fred K. Schaefer, "Exceptionalism in Geography: A Methodological Examination," Annals of the Association of American Geographers, XLIII (1953), pp. 226-49.

theory concerned with explaining the location of phenomena traditionally studied by geographers.

Christaller viewed his work as a general deductive theory designed to explain the size, number and distribution of towns in the belief that some ordering principles govern their spatial distribution.[1] He felt that his theory should be called "the theory of location of the urban trades and institutions, to correspond with von Thünen's theory of location of agricultural production and Alfred Weber's theory of location of industries."[2]

In short, Central Place Theory outlines the manner in which economic functions are distributed in space. It postulates that a hierarchy of various order places will efficiently provide goods and services demanded by the surrounding population. A brief discussion of the basic terminology of Central Place Theory will provide an introduction for the ensuing discussion of the dissertation problem.[3]

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[1]Christaller, op. cit., pp. 1-4.

[2]Ibid., p. 7.

[3]A number of summary treatments of the theory have appeared, e.g., Brian J. L. Berry and Allen Pred, Central Place Studies: A Bibliography of Theory and Applications, Bibliography Series, Number One (Philadelphia: Regional Science Research Institute, 1965), pp. 1-18; Arthur Getis and Judith Getis, "Christaller's Central Place Theory," Journal of Geography, LXV (May, 1966), pp. 220-26; Brian J. L. Berry, Geography of Market Centers and Retail Distribution (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1967); Brian J. L. Berry, Theories of Urban Location, Commission on College Geography, Resource Paper Number 1 (Washington, D.C.: Association of American Geographers, 1968).

A settlement made up of a collection of homes and buildings which is located in the center of the region it serves is termed a central place. A central place then is a service center which serves a surrounding area with goods and services; this surrounding area is called the complementary region of that center.

Goods produced at a central place and the services offered there are called central goods and services. Many discussions dealing with the provision of central goods and services in central places often experience considerable semantic confusion over the meaning of important terms such as establishment, function and functional unit. Thomas has presented a clear-cut set of definitions and examples for these words:

> An establishment is essentially the physical manifestation of an activity and is generally the unit in which an activity is performed, e.g., the building in which the office for a filling station is located or the office of a physician are examples of establishments. In contrast, the term 'function' refers to activities which are performed in the establishments. According to these definitions, it is possible for more than one function to be associated with a particular establishment. Each occurrence of a function constitutes one functional unit. . . . Differences between these values may be illustrated as follows. Let us assume that there is a place with three establishments, A, B, C. Three functions are performed in establishment A; it is a gasoline filling station, bulk oil distribution station, and used-car lot. Two functions are associated with establishment B; it is a combination food store and filling station. Two functions are associated with establishment C; it is a combination food store and livestock feed store. There are, in this case, three establishments, five functions, and seven functional units.[1]

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[1]Edwin N. Thomas, "Some Comments on the Functional Bases for Small Iowa Towns," Iowa Business Digest, X (1960), p. 11.

Another concept fundamental to an understanding of Central Place Theory is the range of a good.[1] Christaller stated that every good has a range which:

> . . . is a ring around a central place. It has an outer (or upper) and an inner (or lower) limit. The upper limit of a particular good is determined by the farthest (economic) distance from which it can be obtained from this central place; and indeed, beyond this limit, it will either not be obtained, or it will be obtained from another central place. In the first case, the absolute limit (ideal range) is reached; and in the latter case the relative limit (real range) is reached. . . . The lower limit of the range of central goods is determined by the minimum amount of consumption of this central good needed to pay for the production or offering of the central good.[2]

Figure 1 represents a graphic illustration of the ideas mentioned above. This diagram presents a situation where central place B provides some good or service, e.g., a barber shop, for the population in the surrounding area. The circle labeled threshold level encompasses the minimum number of people required to support this function in place B; this is the lower limit of the range of a good or service. The upper limit of the range of a good or service is a relative distance defined as either the ideal range or the real range. Where there is no competing central place offering a similar function, the ideal range describes the farthest economic distance people are willing to travel in order to receive the good or service in question. The real range, which is always

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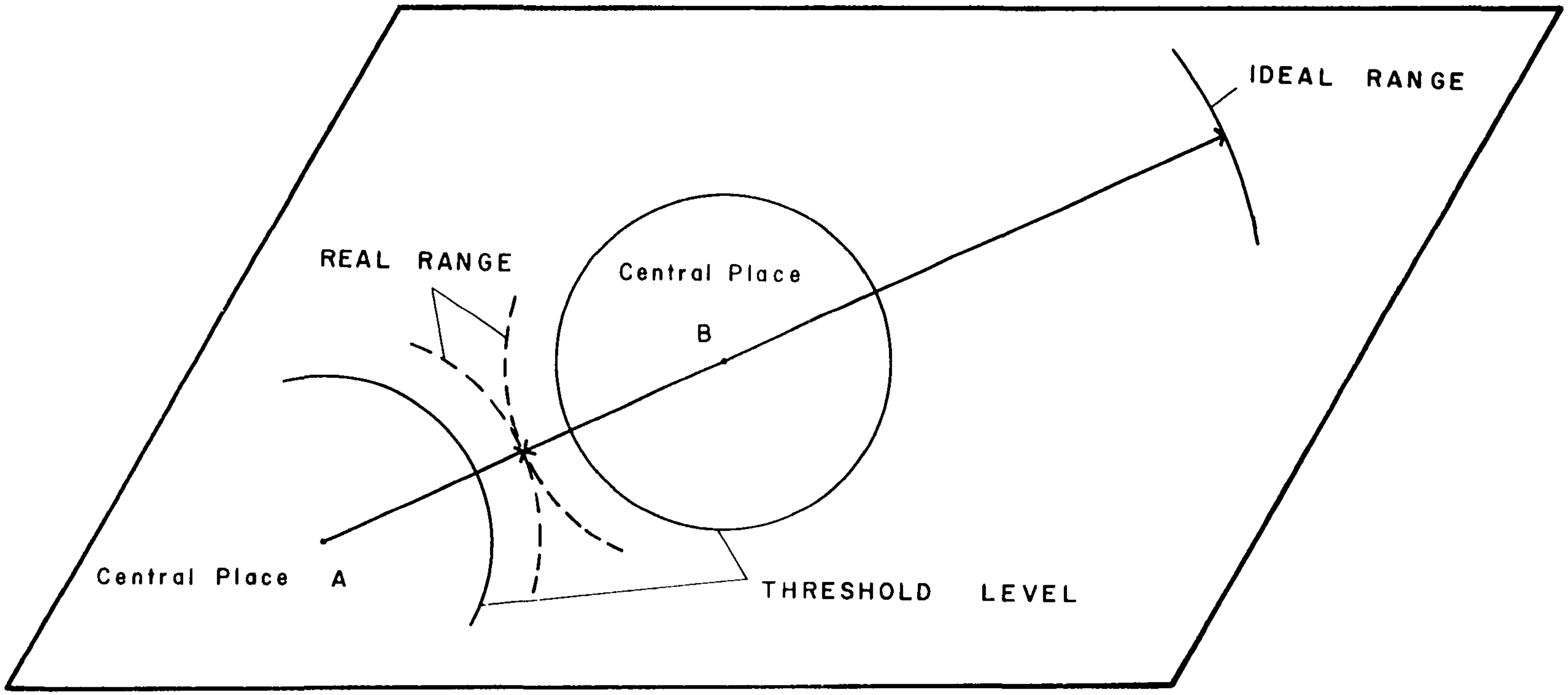
[1]Brian J. L. Berry and William L. Garrison, "A Note on Central Place Theory and The Range of A Good," Economic Geography, XXXIV (October, 1958), pp. 304-11.

[2]Walter Christaller, op. cit., p. 54.

FIG. 1

THE RANGE OF A GOOD



ADAPTED FROM A. GETIS & J. GETIS, JOURNAL OF GEOGRAPHY (MAY, 1966), P less than the ideal range, is achieved when there is a competing central place, such as place A in the diagram, offering a similar function.

The measurement of Christaller's lower limit is important to the particular focus of the present study. Berry and Garrison introduced the term "threshold population" to describe the minimum number of consumers necessary to provide a sales volume adequate for a particular good or service to be supplied profitably from a central place.[1] In other words, threshold population is defined as the minimum number of people required to support one establishment of a given functional type. The drug store, for example, illustrates the concept of this critical level of demand. If the threshold level for the drug store function is 425, then a drug store would not be found in a town of less than 425 people. A place with a population of less than 425 will not provide the necessary volume for a store of this kind to exist. However, another function such as a grocery store might be located in a town with a smaller population size if the threshold population for the grocery function were less than 425.

Each good or service has its own range due to the fact that the prices of various goods and services increase at different rates with increasing distance from the center, and to the fact that particular goods and services have

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[1]Berry and Garrison, _op. cit._; and Brian J. L. Berry and William L. Garrison, "The Functional Bases of the Central Place Hierarchy," _Economic Geography_, XXXIV (April, 1958), pp. 145-54.

different thresholds. Goods and services with lower thresholds are termed lower order goods; those with higher thresholds are called higher order goods. Hence, in theory, a low order central place offers only low order goods, while a higher order place provides both low order goods and some goods of a higher order.

A large body of literature dealing with various aspects of Central Place Theory has appeared;[1] however, only a few of the research efforts have been directed toward an empirical estimation of the ranges of specific goods. These latter studies have been concerned only with the determination of the lower limit (threshold population) of the range, and they have made no attempt to analyze the influence of particular variables on the threshold population value. It is in this respect that the present investigation contributes to the growing fund of information dealing with Central Place Theory. This study uses the threshold population value as a means to measure the influence of a high volume of traffic on various central place functions. A comparison of the threshold populations of the various functions of two distinct groups of places is the primary concern of the dissertation.

Threshold population, a term introduced as a descriptive synonym for Christaller's lower limit of the range of a good, was used by Berry and Garrison as a device for ranking central functions in their attempt to differentiate a number

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[1]Berry and Pred, op. cit.

of centers into a hierarchical arrangement of places.[1] They concluded that "the hierarchical system may be isolated and identified, and the exact identification of an hierarchical system has been completed for Snohomish County, Washington."[2]

A number of subsequent investigations have utilized the Berry-Garrison model to determine the threshold population of central place functions.[3] In the main, these studies can be classed as empirical tests of the model for different regional settings. Only the study by Brunn made any attempt to compare threshold populations between two diverse regions. It was discovered that the central places in an agriculturally prosperous section of Ohio required fewer people (a lower threshold population) to support most of the functions than

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[1]Berry and Garrison, "A Note on Central Place Theory and The Range of A Good," op. cit.; and Berry and Garrison, "The Functional Bases of the Central Place Hierarchy," op. cit.

[2]Berry and Garrison, "The Functional Bases of the Central Place Hierarchy," op. cit., p. 153.

[3]Leslie J. King, "The Functional Role of Small Towns in Canterbury," Proceedings of the Third New Zealand Geography Conference, New Zealand Geographical Society (Palmerston North, August, 1961), pp. 139-49; Donald A. Blome, "A More General Approach To The Concept of Threshold Population," Institute For Community Development, Michigan State University, December, 1966; Stanley D. Brunn, "Cross-Sectional Analysis of Two Central Place Systems in Ohio" (unpublished Ph.D. dissertation, The Ohio State University, 1966); James B. Kenyon, "On The Relationships Between Central Function and Size of Place," Annals of the Association of American Geographers, LVII (December, 1967), pp. 736-50; Maurice H. Yeates, "A Study of The Impact of the Area Development Agency Program on The Southern Georgian Bay Area, Ontario," a forthcoming research monograph of the Department of Geography, Queen's University, Kingston, Ontario.

did the central places in the relatively depressed area of southeast Ohio. Brunn also introduced a temporal variable by comparing the threshold populations of the functions in these two sections of Ohio in 1940 and 1964. He found both study areas had lower threshold population values for most functions in 1940 than in 1964. Brunn concluded that this reflected the greater number of rural residents and their closer ties to the agricultural trade centers in the early year.[1]

Blome's argument that the threshold value should be considered an interval based on confidence limits determined for a least squares estimate, rather than a single value is the only major addition to the model that has been advanced.[2] This addition has been incorporated into the present investigation.

The purpose of this investigation is not to apply an empirical test in a different regional setting; the basic intent is to measure the influence of a particular economic phenomenon (highway traffic) on the threshold population of central place functions. The choice of a high volume of traffic as the variable to be isolated was inspired by a criticism leveled at Berry and Garrison's threshold model by William Bunge. Bunge stated ". . . they ignore rural

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[1]Brunn, _op. cit._, p. 121.

[2]Blome, _op. cit._, p. 3.

and highway consumers which contribute to the geometric drop of the number of people per activity in small towns where the rural and highway users make up a large percentage of consumers."[1] His criticism has not been adequately answered. This dissertation should provide a means to evaluate the validity of such a criticism. In the process, the effect of high traffic volumes on the central place network of the study area can be assessed.

In addition, the methods used in solving the dissertation problem have an immediate practical purpose which can be employed in the planning and future development of small towns. The procedure for determining threshold populations provides a technique which makes it possible to evaluate the retail-service mix in the functions of a single town in relation to that of a number of other similar towns. For example, it may be discovered that a community with a population of 1,675 does not contain a jewelry store; assuming that the threshold population of a jewelry store has been determined as something less than 1,675, then it can reasonably be assumed that this town is able to provide the necessary support for such a function. The ramifications of this application are more fully discussed in a later chapter.

Following the introduction, the dissertation problem

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[1]Bunge, *op. cit.*, p. 146.

is identified and explained. At this point the specific hypotheses of the study are stated and clarified. A discussion of the methods of collecting and analyzing the data for the study precedes a description of the real world setting where the empirical test is applied. The most lengthy chapter presents and analyzes the results of the empirical test. In the concluding chapter, the major findings of the dissertation are reexamined in the light of their implications to the general body of Central Place Theory.

CHAPTER II

DETAILED STATEMENT OF THE PROBLEM

Most previous research dealing with the concept of threshold population has been concerned with simply determining threshold populations of various functions in a normal central place hierarchy. This study differs in that it adds an analysis of the influence of a particular phenomenon, a high volume traffic artery, on the threshold value. The focus of the investigation then, is not on threshold populations per se, but rather on a comparison of these values between two groups of places assumed to be similar in all respects except for the volume of traffic passing through them. The central question is: how does the occurrence of a major transportation artery carrying a high volume of vehicular traffic influence the threshold population of various central place functions?

A large body of literature has addressed itself to the question of the influence of traffic volume on business activity.[1] These studies tend to use a wide variety of

[1]Most state highway departments have conducted surveys on the economic impact of selected routes passing through their states; some representative examples include: Paul W. Zickerfoose, "Economic Survey of Tourist-Related

measures which are uniquely local in nature and thus are limited in their value for creating broader generalizations. The general concept of threshold population is an accepted measure which can be used to describe the relationship between a service center and its tributary area. Its theoretical logic is sound, and empirical tests seem to substantiate its validity in the real world. The value of using a more universal measure, one which can be compared on a one-to-one basis, should be apparent.

The use of a measure of this sort makes possible the evaluation of the adequacy of the functional offerings of a single town in terms of the composition of its retail

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Business Along Highway 66 (Interstate 40) in New Mexico, 1956-63," Bulletin Number 27, Engineering Experiment Station, New Mexico State University, November, 1963; Paul W. Zickerfoose, "Highway Economic Impact Studies in Urban Communities of New Mexico: Problems and Methods," Bulletin Number 16, Engineering Experiment Station, New Mexico State University, November, 1960; Paul W. Zickerfoose, "Economic Survey of Santa Rosa, New Mexico, 1950-58; The 'Before' Portion of A Highway Relocation Impact Study," Bulletin Number 10, Engineering Experiment Station, New Mexico State University, November, 1954; Jesse L. Buffington, An Economic Impact Study of Interstate Highway 35E on Waxahachie, Texas, Texas Transportation Institute, March, 1966; I. J. Sans, Economic Impact of Freeways Bypassing Small Communities, Oklahoma Department of Highways, Planning Division, May, 1963; A. H. Christensen, Economic Impact of Interstate and Defense Highway 35 on Perry, Oklahoma, Oklahoma Department of Highways, Research and Development Division, 1966. In addition, a large number of general studies are available, e.g., William L. Garrison and Marion E. Marts, Influence of Highway Improvements on Urban Land: A Graphic Summary, Highway Economic Studies, Department of Geography and Department of Civil Engineering, University of Washington, May, 1958; Phillip B. Herr, "The Regional Impact of Highways," Urban Land, XIX (February, 1960), pp. 3-8.

service mix. An alert business man could well put the results of such a study to immediate use. For example, it might be discovered that a particular town is overloaded in its offerings of automobile servicing establishments such as gas stations and garages, but that it is woefully lacking in the area of personal service facilities such as barber shops. This kind of evaluation is generally not made in the traditional highway impact studies.

Like most highway impact investigations, this inquiry will attempt to analyze the importance of transient traffic with regard to the economic support of a place. Quite obviously, providing goods and services for the highway traveler can be considered a basic industry.[1] One readily identifies the role a manufacturing plant plays in the economic support of a community. The employment opportunities afforded by such a plant, the local taxes paid, the financial support for local charities, and many other factors contribute to the general growth and well-being of the community. A fact often overlooked, especially in relatively small towns, is that non-manufacturing activities may provide a reasonable level of economic health. Great expenditures of effort and money are sometimes made to attract manufacturing establishments. If a similar effort were made

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[1]For a discussion of the basic-nonbasic concept of urban economic functions, see John W. Alexander, "The Basic-Nonbasic Concept of Urban Economic Functions," Economic Geography, XXX (July, 1954), pp. 246-61.

to attract highway oriented service activities, the realized return might be even greater. In addition, an organized approach of this sort, by giving thought to such questions as total community development and attractiveness, would undoubtedly provide an environment more pleasing to both the permanent resident and the transient than is illustrated in most highway towns today. Towns located along heavily traveled routes should attempt to exploit their comparative advantage more fully. This dissertation is devoted to identifying those functions which are most influenced by a high volume of traffic. Once identified, these activities can then be evaluated and analyzed in the light of existing local conditions.

The general research hypothesis is that a particular central function will have a significantly different threshold population if the place offering that function is located on a major transportation route. It is recognized that variables other than volume of traffic may influence the threshold size. Regional differences of variables such as income level, cultural values, or predominant economic activity might influence this minimum support measure. Topographic variations, or other differences in physical attributes of an area, may cause some fluctuation in the threshold value. Exhaustive studies to test the effects of these variables have not yet been conducted. However, the few investigations that have considered these variations have concluded that they are not very significant. King made a conscious attempt to duplicate the study design employed by Berry and Garrison[1] in their Snohomish County study in his investigation of the Canterbury Provincial District of New Zealand.[2] Of the twenty comparable functions, ten showed a discrepancy between the threshold populations of the two areas of over 200 persons (Table 1). King summarizes his comparison by stating:

> Functions such as 'Dentist,' 'Beauty Salon,' 'Florist,' and 'Motel,' which rank as highly specialized services (with higher threshold values) in Canterbury, are apparently more common among towns in Washington. . . . Several functions--most notably 'Motor Service Station,' 'Hardware,' 'Dry Cleaner,' 'Jewellery,' 'Funeral Director,' and 'Photographer'--have threshold populations which do not differ significantly from one region to another.[3]

A recent article, by Carter and others, although not specifically directed at the threshold population concept, noted the high degree of correlation between the population of a center and the number of functions offered there.[4] This article reported the following results from previous research: Stafford[5] in southern Illinois found a positive

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[1]Berry and Garrison, "The Functional Bases of The Central Place Hierarchy," op. cit.

[2]Leslie J. King, op. cit.

[3]Ibid., p. 148.

[4]H. Carter, H. A. Stafford, and M. M. Gilbert, "Functions of Welsh Towns: Implications For Central Place Notions," Economic Geography, XLVI (January, 1970), pp. 25-38.

[5]H. A. Stafford, "The Functional Bases of Small Towns," Economic Geography, XXXVIII (1963), pp. 165-75.

TABLE 1

COMPARISON OF THRESHOLD POPULATIONS FOR SELECTED SERVICES[a]

Services	Canterbury	Washington
Motor Service Station (Filling Station)[b]	261	196
Doctors (Physician)	491	380
Hairdresser (Barber Shop)	668	386
Insurance Agency	250	409
Dentist	1019	426
Hardware Store	414	431
Garage and Motor Engineer (Auto Repair)	293	435
Beauty Salon (Beautician)	1126	480
Barrister and Solicitor (Lawyer)	830	528
Draper and Mercer (Apparel Stores)	388	590
Bank	759	610
Agricultural Machinery (Farm Implement)	431	650
Florist	1280	729
Dry Cleaner	781	754
Jewellery Stores	926	827
Hotel	356	846
Motel	954	430
Sporting Goods	797	928
Funeral Director (Undertaker)	1137	1214
Photographer	1156	1243
Accountant (Public Accountant)	671	1300

[a]Adapted from L. J. King, "The Functional Role of Small Towns in Canterbury," Proceedings of the Third New Zealand Geography Conference, New Zealand Geographical Society (Palmerston North, August, 1961), p. 147.

[b]The names in parentheses are the terms used by Berry and Garrison; in each case the name listed first is the term used by King.

correlation of 0.93 between population and number of functions; King[1] reported 0.93 for the Canterbury Plain, New Zealand; and Berry and Garrison[2] 0.79 for Snohomish County, Washington. In a non-western area Gunawardena[3] returned a figure of 0.91 in southern Ceylon. Such high indications of relatedness led the authors to ponder the possibility ". . . that these high correlations may have been produced by the selection of study areas where the isotropic surface of theory is most nearly reproduced and also where there is a comparatively short history of settlement."[4] In order to test this hypothesis, the authors decided to conduct a similar study using the towns of Wales, an area that does not display those conditions of uniformity which are assumed by Central Place Theory. Their results showed that irregular terrain, a long history of urbanization, and marked regional contrasts in economic development do not significantly disrupt the population to number of functions relationship.

> In general this analysis has revealed basic similarities with other very different areas where similar studies have been made. The correspondence between

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[1]King, op. cit.

[2]Berry and Garrison, "The Functional Bases of The Central Place Hierarchy," op. cit.

[3]K. A. Gunawardena, "Service Centres in Southern Ceylon," (unpublished Ph.D. dissertation, University of Cambridge, 1964).

[4]Carter, Stafford, and Gilbert, op. cit., p. 26.

> Wales and areas outside in terms of the degree of relationships between population and functions and the types of functions performed is most striking.[1]

Additional work in this area is definitely needed to measure the impact of variables other than these on the threshold value. The present study is designed to contribute some understanding with respect to the influence of a high volume of traffic. The specific hypotheses to be tested are:

1. Certain central place functions will possess significantly lower threshold populations if the place offering that function is located along a route carrying a high volume of traffic.

2. Certain central place functions will possess significantly higher threshold populations if the place offering that function is located along a route carrying a high volume of traffic.

3. Certain central place functions will possess threshold populations that do not significantly differ regardless of location in relation to a major transport artery.

A few examples should help to illustrate these postulates. In reference to the first hypothesis, consider a function such as a motel which caters more to the traveler than to the local resident. One would expect to

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[1] *Ibid.*, p. 35.

find this function appearing in smaller towns located on a major highway. An off-highway town would require a much larger population to support such an establishment. Therefore, the threshold population for this function should be significantly lower among on-highway towns. On the other hand, there may be certain functions which have higher threshold values for on-highway places, due to the easy access to a higher order place provided by a high speed thoroughfare. An illustration of the second hypothesis is a furniture store offering goods in which the consumer finds certain advantages in comparative shopping on the basis of price and/or style. A furniture store may be able to survive in a smaller town with poorer transportation connections because the advantages of comparative shopping are outweighed by the increased expenditure of time and effort needed for travel to the larger center. Finally, as an example of the third hypothesis, a function such as a post office may not be influenced to any great degree by the location of the city in respect to heavily traveled arteries.

In addition to evaluating the three previously mentioned hypotheses, the determination of which specific functions fall into these three classes is also a primary purpose of this study. The techniques employed are such that it is possible not only to classify a variety of functions on the basis of traffic volume influence, but also to specifically identify the particular functions which are influenced the most or the least by this variable. That is, if one or more of the stated hypotheses are accepted, it will also be possible to identify the specific functions which illustrate that case.

CHAPTER III

METHODS OF COLLECTING AND ANALYZING DATA

Several methods have been utilized to determine threshold population. A number of these will be briefly reviewed, followed by a more complete explanation of the method employed in this study. Blome[1] identifies a paper by C. R. Hoffer as one of the earliest attempts to establish, at least implicitly, threshold population levels for selected economic activities in small communities.[2] Hoffer arbitrarily established ten population size groups of small urban centers and determined the percentage of the communities within each group that contained a specific economic function. Hoffer was not concerned primarily with calculations of the minimum number of people required to support various functions; however, he did state:

> . . . three types of specialty stores: drug stores, grocery stores and hardware stores are apt to exist in a town having a population of less than 500.

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[1]Blome, op. cit., p. 1.

[2]C. R. Hoffer, "The Study of Town-Country Relationships," Michigan Agricultural Experiment Station, Special Bulletin Number 181, East Lansing, 1928. The essence of this article can be found in C. R. Hoffer, Introduction to Rural Sociology (New York: Richard R. Smith, 1930), Chapter XVI, pp. 320-39.

> A town having a population of 1,000 is much more complete from the standpoint of a variety of services offered but some of the services which cannot exist in a town of that size have to locate in larger places.[1]

One of the simplest techniques for determining threshold population can be termed the absolute minimum method. For a given group of places the threshold value for a particular function would be the population of the smallest town where that function is observed. As an example, consider five towns, A, B, C, D, and E with populations of 200, 250, 275, 500, and 700, respectively. If both towns D and E possessed a barber shop, while A, B, and C did not, this method would identify the threshold population as 500 for the barber shop function. This approach has the obvious limitation of being greatly influenced by unusual or unique observations. Also it does not lend itself well to comparisons between separate groups at different points in time or different regional settings.

A single city approach might be devised in which an index or ratio of population to number of establishments of a particular function is calculated. A place of 2,000 population with five grocery stores would have a ratio of 400 people to each grocery store. This figure, however, is not really a threshold since it does not identify the minimum population at which the first grocery store appeared.

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[1] *Ibid.*, p. 19.

In addition, it fails to take into account certain economies of scale whereby a much larger population figure would be required for the support of second and later establishments than was required for the first business to appear. The reverse of the above situation may be true for other functions; i.e., a smaller population may be required for the support of second and later establishments.

Utilizing a technique developed by biologists,[1] Haggett and Gunawardena have suggested that the threshold of any function can be viewed as the middle point of its "entry zone."[2] Haggett summarized the method:

> . . . for a given function (F1), there is a lower population level at which no settlements of this size have F1; conversely there is an upper population level at which all settlements of that size have F1. By modifying a standard bioassay technique, the Reed-Muench method, the middle point of this entry zone can be measured to give the median population threshold.[3]

Gunawardena employed this technique for determining the thresholds for a number of settlement functions in the southern part of Ceylon.[4] Haggett notes the importance of

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[1] L. J. Reed and H. Muench, "A Simple Method of Estimating Fifty Per Cent Endpoints," The American Journal of Hygiene, XXXVII (May, 1938), pp. 493-97.

[2] P. Haggett and K. A. Gunawardena, "Determination of Population Thresholds For Settlement Functions By The Reed-Muench Method," The Professional Geographer, XVI (July, 1964), pp. 6-9.

[3] Peter Haggett, Locational Analysis In Human Geography (New York: St Martin's Press, 1966), p. 116.

[4] K. A. Gunawardena, "Service Centres in Southern Ceylon" (unpublished Ph.D. dissertation, University of Cambridge, 1964) as cited in Haggett, op. cit., p. 116.

Gunawardena's findings ". . . because they confirm for a non-Western area the type of threshold hierarchy which earlier work by Berry and Garrison[1] had established for the United States."[2]

In addition, the southern Ceylon study provided challenging evidence to one of the main criticisms of threshold determination, i.e., Bunge's remarks that Berry and Garrison's ". . . work is not actually concerned with thresholds for they do not deal with the total number of consumers necessary for the existence of an activity, but rather with the population of the center where these activities appear."[3] Haggett reports that ". . . Gunawardena was able to show that the population of the central settlement was significantly correlated with the total hinterland population for all the functions studied."[4] Moreover, Davies confirmed this relationship between population size of a center and the size of its hinterland when he asserted ". . . that population size is just as suitable a measure of the total business importance or centrality of the S.M.S.A.'s as any of the various selected business

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[1]Berry and Garrison, op. cit.

[2]Haggett, op. cit., p. 117.

[3]Bunge, op. cit., p. 146.

[4]Haggett, op. cit., p. 117.

indices are or the composite index utilized in this study."[1]

The Hattett and Gunawardena technique has not been put to widespread use in the geographic literature dealing with thresholds. The method employed in this study to determine threshold population was first developed by Berry and Garrison in 1958.[2] Since that time, this technique has become accepted for calculating threshold values.[3] In fact the technique is discussed and explained in a recently published college level introductory economic geography text and its companion supplement.[4] Berry and Garrison explained the derivation of the method in the following manner:

> Christaller suggested that through the working of the income mechanism the population of a center was a function of the number of types of central goods and services the central place provided. Hence it was specified that the population of a center is a function of the number of stores of each type. Fifty two scatter diagrams were prepared with population, P, and number of stores, N, as parameters to determine

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[1]Ross L. Davies, "A Note on Centrality and Population Size," _The Professional Geographer_, XXI (March, 1969), p. 111. See also Martin J. Beckman, "City Hierarchies and the Distribution of City Size," _Economic Development and Cultural Change_, VI (1958), pp. 243-48.

[2]Berry and Garrison, "The Functional Bases of the Central Place Hierarchy," _op. cit_.

[3]Brunn, _op. cit_.; Blome, _op. cit_.; King, _op. cit_.; Kenyon, _op. cit_.; Yeates, _op. cit_.

[4]Richard S. Thoman, Edgar C. Conkling and Maurice H. Yeates, _The Geography of Economic Activity_ (2nd ed., New York: McGraw-Hill, 1968), pp. 212-14; Maurice H. Yeates, _An Introduction to Quantitative Analysis In Economic Geography_ (New York: McGraw-Hill, 1968), pp. 16-18 and pp. 104-07.

> the relationships between P and N for each function. Each of the diagrams had 33 points, one for each of the 33 central places. Best fitting curves of the exponential growth series $P=A(B^N)$, where A and B are parameters to be estimated were fitted to each of the scatters using standard least squares techniques, after logarithmic conversion.
>
> Given these 52 best relationships it was then possible to rank the central functions on the basis of the threshold population of the center which was necessary for the first complete store to appear, that is, by the value of P where N=1.[1]

The above quotation points out that the relationship between population and number of establishments for a particular central place function is not linear (Fig. 2). Thus the choice of the exponential growth curve is logical since it illustrates a rather common phenomenon--that the increase at any moment is proportional to the size already attained, an example of which is the law of compound interest.[2] This curve appears linear on a semilogarithmic graph where the ordinate is expressed in common logarithms (Fig. 2).

When the dependent variable (population in this case) is logarithmically transformed, the resulting equation is referred to as a semilogarithmic linear trend model and is expressed in general form as:

$$\text{Log } P = \text{Log } A + N(\text{Log } B) \qquad (1)$$

where P is the population sizes of a set of central places and N is the number of establishments offering a particular central function within that set of central places. A and

---

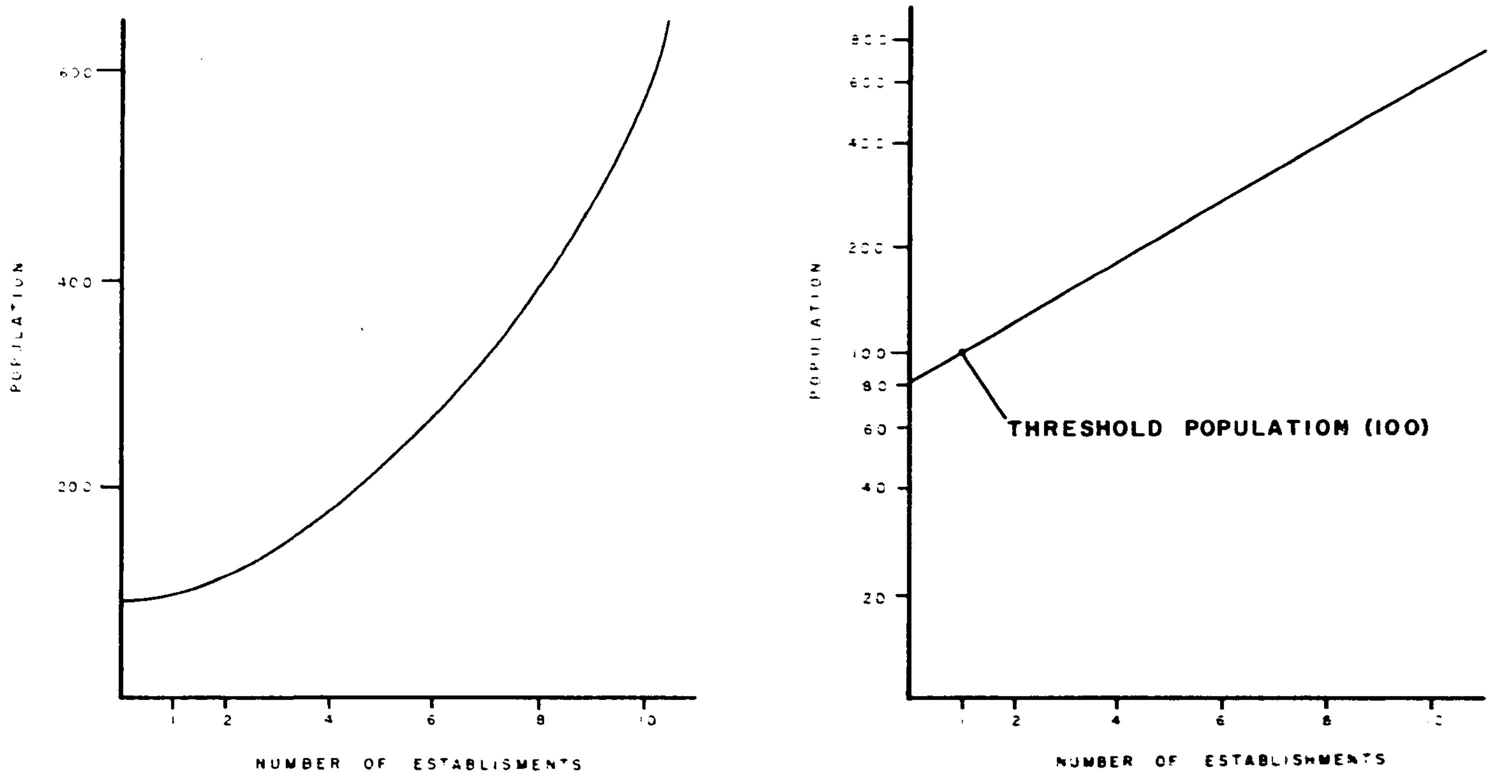
[1]Berry and Garrison, "The Functional Bases of the Central Place Hierarchy," op. cit., p. 149.

[2]Yeates, op. cit., p. 16.

FIG. 2

THE EXPONENTIAL GROWTH CURVE

ARITHMETIC CASE SEMILOGARITHMIC CASE



B are parameters determined by a least squares fit of Log P on N.

After A and B are determined, the threshold population is derived from equation (1) with N equal to one (Fig. 2). In other words, this operation determines the minimum number of people required to support a single specific central function.

This least squares estimate operation, i.e., determining the values of A and B, is repeated for each of the central functions considered in the study. Fifty-one different functions are treated, thus fifty-one separate equations were derived for each of the two groups of thirty on-highway towns and thirty off-highway towns. An IBM 360 Model 50 computer was utilized to perform these operations.[1]

In an evaluation of methods for determining threshold population, Yeates concludes that simple regression appears to be useful for at least two reasons. "In the first place, simple regression provides a method for estimating the 'average' or expected values for a set of data that are subject to error. Secondly, it provides a descriptive device that is useful for economic planning."[2] Blome maintains

> . . . as in almost any empirical research, the estimates which the model provides reflects the time period and regional setting where it is carried out.

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[1]The program for determining threshold populations is included in Appendix A.

[2]Yeates, op. cit., p. 104.

> Nevertheless, the close adherence of the model to the theoretical constraints and assumptions of central place theory attest to its conceptual validity.[1]

Berry and Garrison in a subsequent article are somewhat more restrained in their enthusiasm when they state ". . . the threshold measure thus provides only a crude approximation to the concept of inner range."[2] Since a better measure has still not been advanced, the decision was made to use the accepted Berry-Garrison technique for this study.

As with any least squares fit, the predicted threshold populations are subject to errors of estimate. That is, for a given level of probability, the "true" threshold population for each central function varies about the estimated value. In other words, at a significance level of .05, one would expect the true threshold population value to fall within the confidence limits 95 times out of 100. Thus, the threshold population should be considered an interval rather than a single value.[3] A 95 percent confidence interval was determined for each of the estimated threshold values using the following standard formulation:[4]

$$Y' + t_{\frac{\alpha}{2}}\, s \left[\frac{1}{N} + \frac{(1-\bar{x})^2}{\Sigma(x-\bar{x})^2}\right]^{\frac{1}{2}} < E(y/x=1) < Y' - t_{\frac{\alpha}{2}}\, s \left[\frac{1}{N} + \frac{(1-\bar{x})^2}{\Sigma(x-\bar{x})^2}\right]^{\frac{1}{2}} \quad (2)$$

---

[1]Blome, op. cit., p. 2.

[2]Berry and Garrison, "A Note on Central Place Theory and The Range of A Good," op. cit., p. 308.

[3]Blome, op. cit., p. 3.

[4]William Mendenhall, Introduction to Statistics (Belmont, California: Wadsworth Publishing Co., 1965), p. 227.

where E $(y/x=1)$ is read as the expected value of y given $x=1$, and it refers to the "true" threshold population for a specific central function; Y' is the estimated threshold population from equation (1) with N set equal to one; "t" is the sampling distribution with the confidence coefficient $\alpha=.05$; s is the standard error of estimate; N is the number of observations (towns); and $\bar{x}$ is the mean of the specific central function.[1]

Blome stresses, and it should be re-emphasized here, that the confidence interval presented above corresponds only with Christaller's lower limit of the range of a good and does not in any way allude to the theoretical upper limit or maximum range of a good.[2]

The heart of the dissertation problem is concerned with differences in threshold population between two groups of places, an on-highway group and an off-highway group. A difference between the means test between the means of the functions in the two groups is employed to identify any significant differences.[3] It is this comparison which sets this study off from the previous investigations concerned

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[1]It should be noted that Y' and s are used in their logarithmic form and the antilog of the upper and lower limits should not be taken until the final step in the operation.

[2]Blome, op. cit., p. 4.

[3]Both standard difference between the means tests, for non-paired variables and for paired variables, produced similar results.

with threshold populations of central place functions. This latter statistical test will be used as the basis to evaluate the hypotheses stated in Chapter II.

The nature of the dissertation problem made it necessary to be quite careful in the selection of places to be included in the study. The primary consideration was to attempt to isolate the influence of a high volume of traffic on the number and variety of functions offered in a central place. The difficulty of such a task becomes readily apparent when one considers the numerous socio-economic variables which, working in combination, provide an explanation of the number and variety of functions offered in a place. The relationship between the number and variety of functions offered in a town is conditioned by many factors; among the most important of such factors are population size of the community and its hinterland, cultural attitudes of the population, prosperity of the area and predominant economic activity throughout the region. Other than the population size factor, which is included in the determination of the threshold, the remaining variables mentioned are extremely difficult to identify and measure accurately. The assumption underlying the selection process was that at the present level of understanding, it was not possible to categorically state that the traffic volume factor had been precisely isolated; however, the selection technique was so designed that every effort was extended to approach the isolation of the influence of a high volume of traffic.

The overall design for selecting places to be included in the study involved choosing two groups of towns that were assumed similar in all respects except the average volume of traffic flowing through them daily. Since it was known that data would be collected by personal visit and observation, it was decided to place a limit of 3,500 population on the places to be included for study. Towns with populations exceeding 3,500 are extremely complex in their functional economic complexion, and would require an unavailable expenditure of time and effort for the collection of data.

A study area in western Oklahoma, the Panhandle of Texas and eastern New Mexico was delimited (Fig. 3), and thirty places located along the route of Interstate Highways 35 and 40 were selected (Fig. 4). Since the Interstate Highway System is not yet completed, the majority of these places have not yet been bypassed, and all traffic is directed through the centers of the towns. Thus, until the bypasses are complete there are few delimitation problems caused by concentrations of activity at significant interchanges. The thirty towns selected, all with relatively high average daily traffic volumes, much of which is long distance in nature, constitute the "on-highway" group (Table 2). The mean population for this group is about 710, with a range from 15 to 3,273 (Fig. 5). Average daily traffic volume for each of the towns is over 4,400[1] (Fig. 6); on many days and during

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[1]The traffic figures used in this study refer to official counts of the average number of vehicles on main

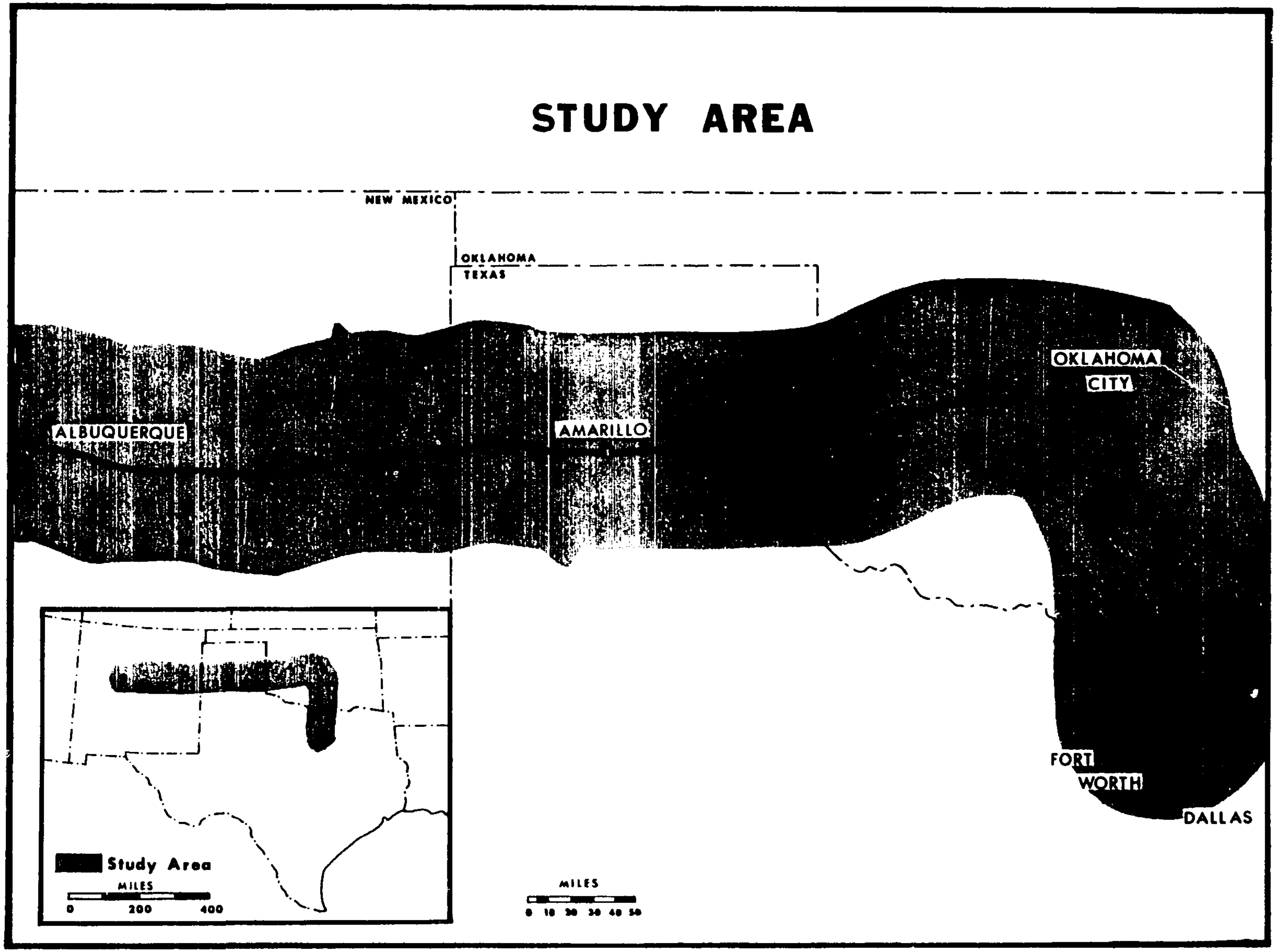
STUDY AREA
NEW MEXICO
OKLAHOMA
TEXAS
ALBUQUERQUE
AMARILLO
OKLAHOMA CITY
FORT WORTH
DALLAS
Study Area
MILES
0 200 400
MILES
0 10 20 30 40 50

FIG. 3

LOCATION OF STUD

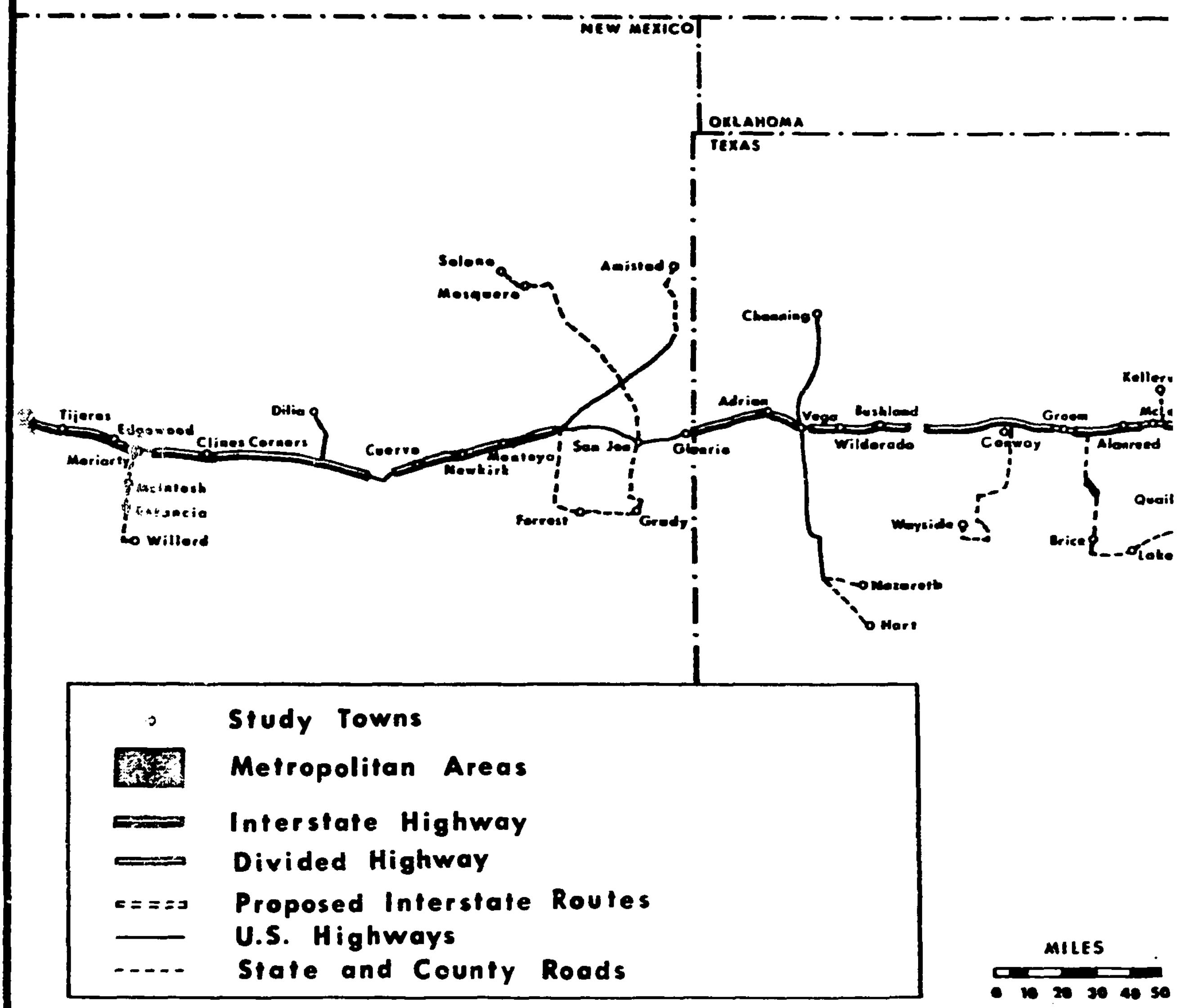

FIG. 4

OF STUDY TOWNS

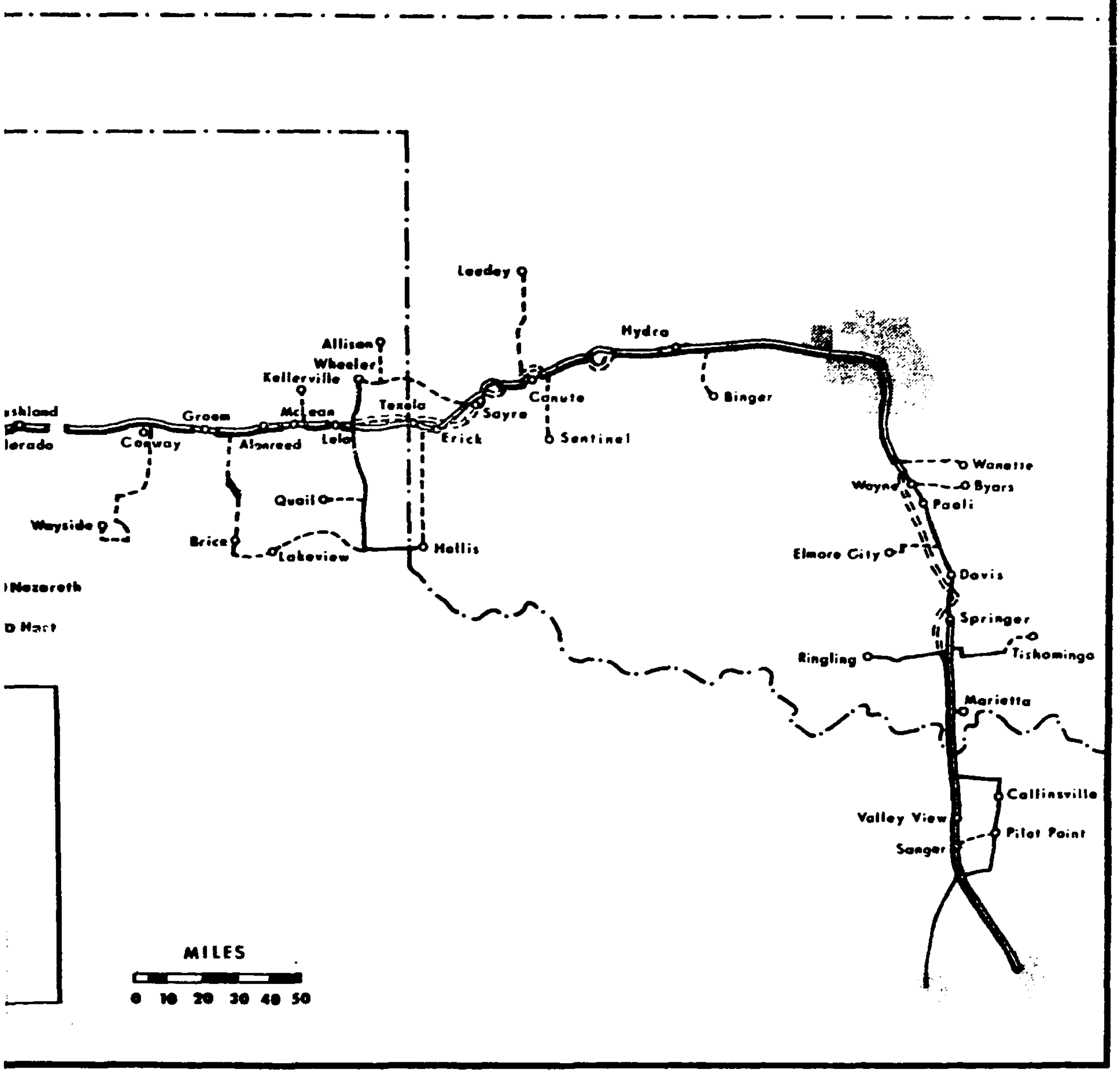

FIG. 4

TABLE 2

ON-HIGHWAY TOWNS

Place	Population (1969 estimate)[a]	Average Daily Traffic Volume (1968)[b]
Sanger	1575	7990
Valley View	790	7890
Marietta	2388	7400
Springer	212	8000
Davis	2645	9500
Paoli	479	7800
Wayne	655	8300
Hydro	850	7800
Canute	500	7600
Sayre	3273	7800
Erick	1525	5675
Texola	150	5050
Lela	110	5050
McLean	1500	5330
Alanreed	125	4800
Groom	850	5450
Conway	41	4890
Bushland	165	5910
Wildorado	200	5860
Vega	900	5690
Adrian	278	4680
Glenrio	60	4440
San Jon	350	4560
Montoya	25	5140
Newkirk	60	4750
Cuervo	51	4750
Clines Corners	15	5630
Moriarty	980	6370
Edgewood	150	7160
Tijeras	400	10580

[a]Estimate derived from: United States Census of Population: 1960; Oklahoma Data Book; Texas Almanac and State Industrial Guide; Commercial Atlas and Marketing Guide, 1969.

[b]Traffic Flow Map of New Mexico; Map of Oklahoma Average Daily Traffic Volumes For the State Highway System; State of Texas Traffic Map.

POPULATION SIZE OF

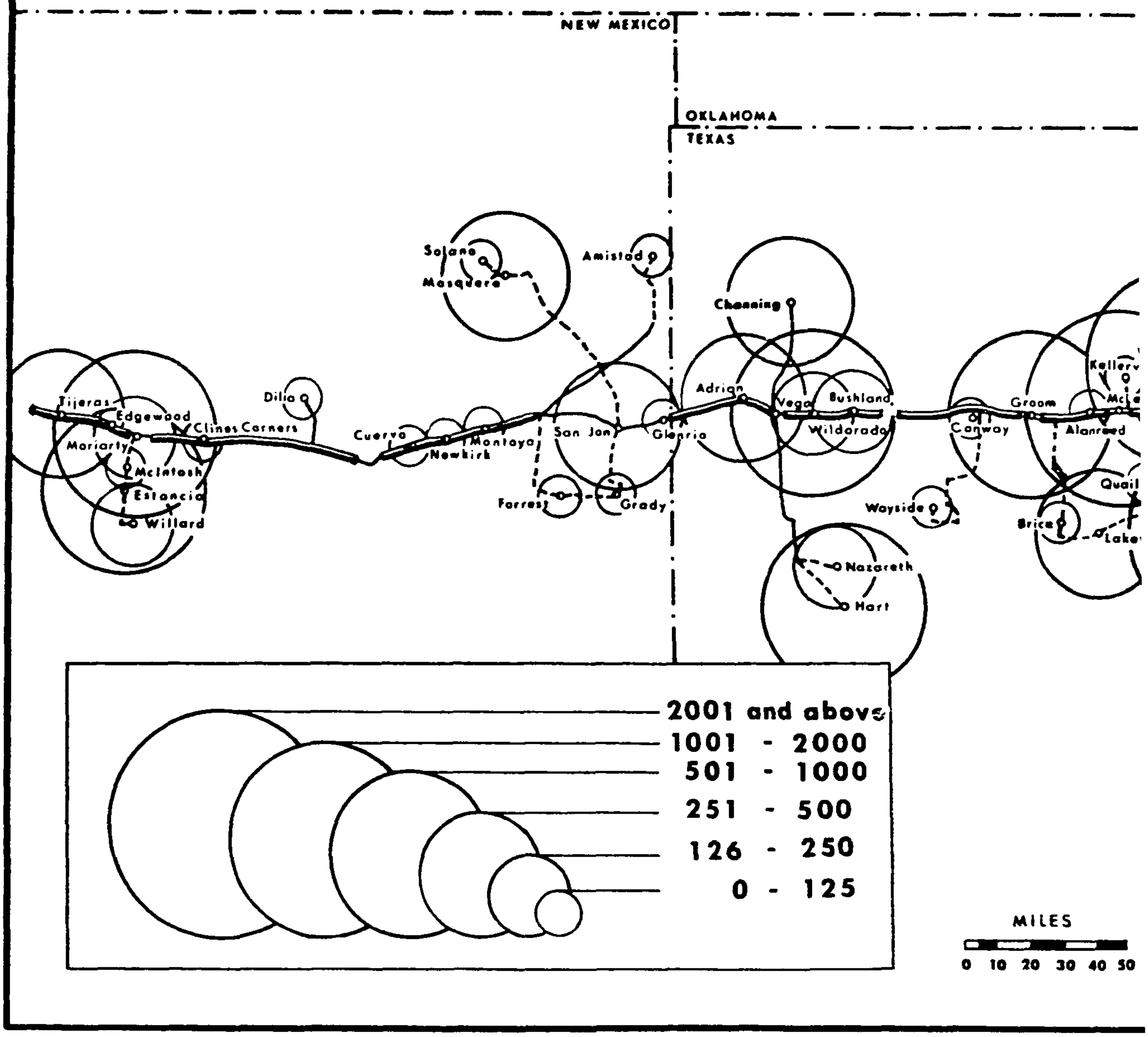

FIG. 5

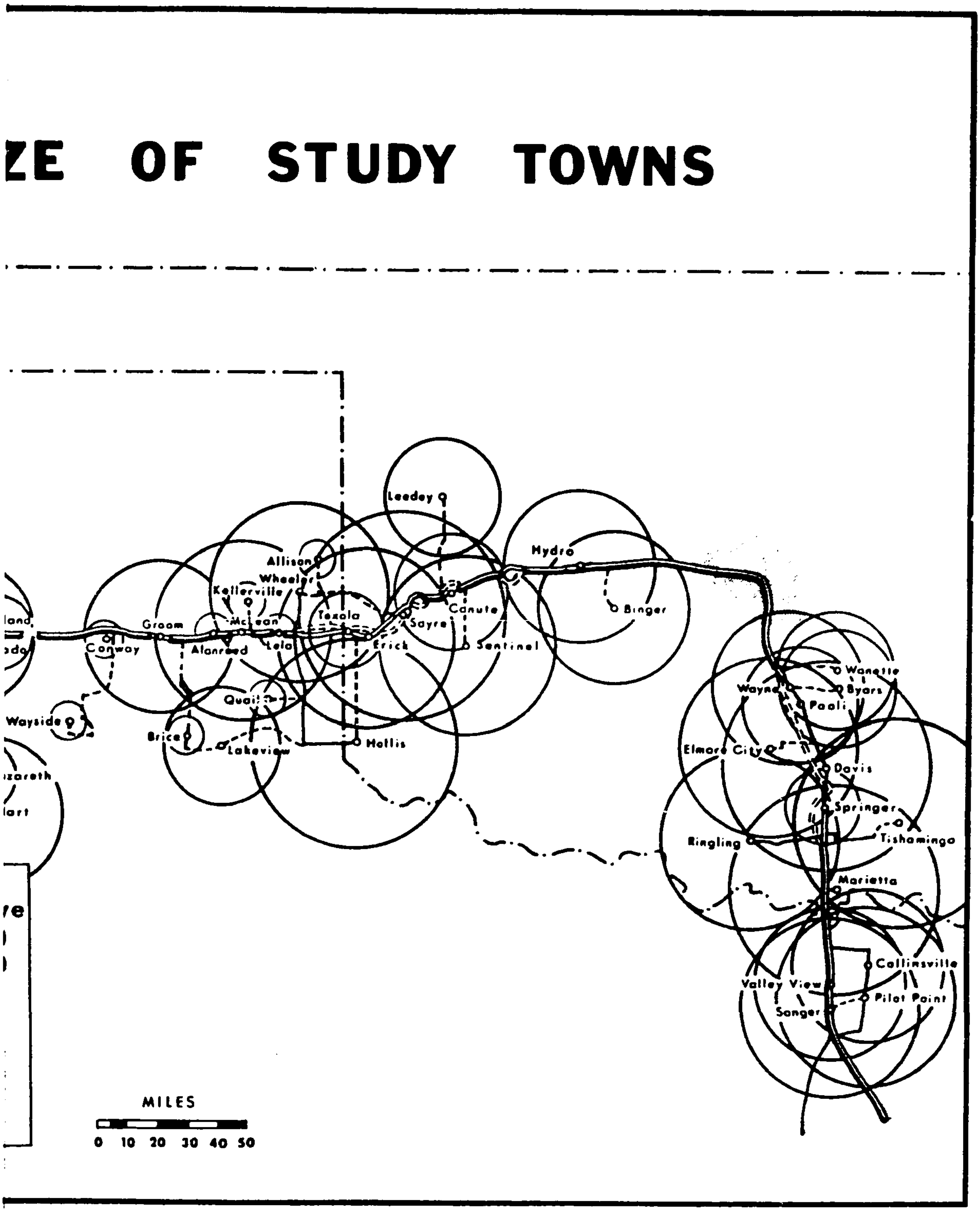
ZE OF STUDY TOWNS
Leedey
Allison
Wheeler
Kellerville
Hydro
Binger
Texola
Sayre
Canute
Sentinel
Groom
McLean
Lela
Erick
Conway
Alanreed
Quail
Wayside
Brice
Lakeview
Hollis
Wanette
Byars
Wayne
Paoli
Elmore City
Davis
Springer
Tishomingo
Ringling
Marietta
Collinsville
Valley View
Pilot Point
Sanger
MILES
0 10 20 30 40 50

FIG. 5

AVERAGE DAILY TRAFFIC

STUDY TOWN

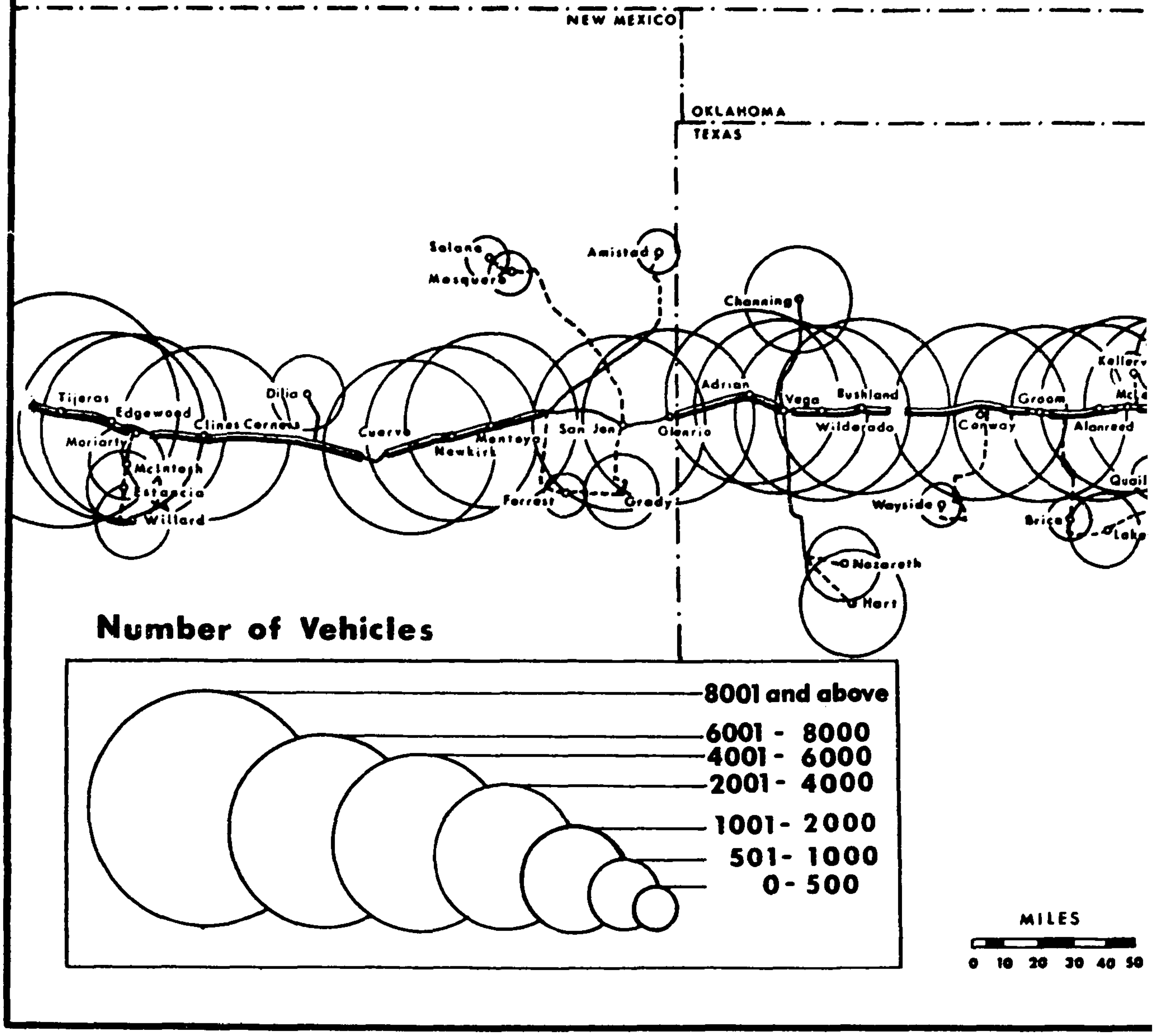

FIG. 6

RAFFIC VOLUME IN

Y TOWNS

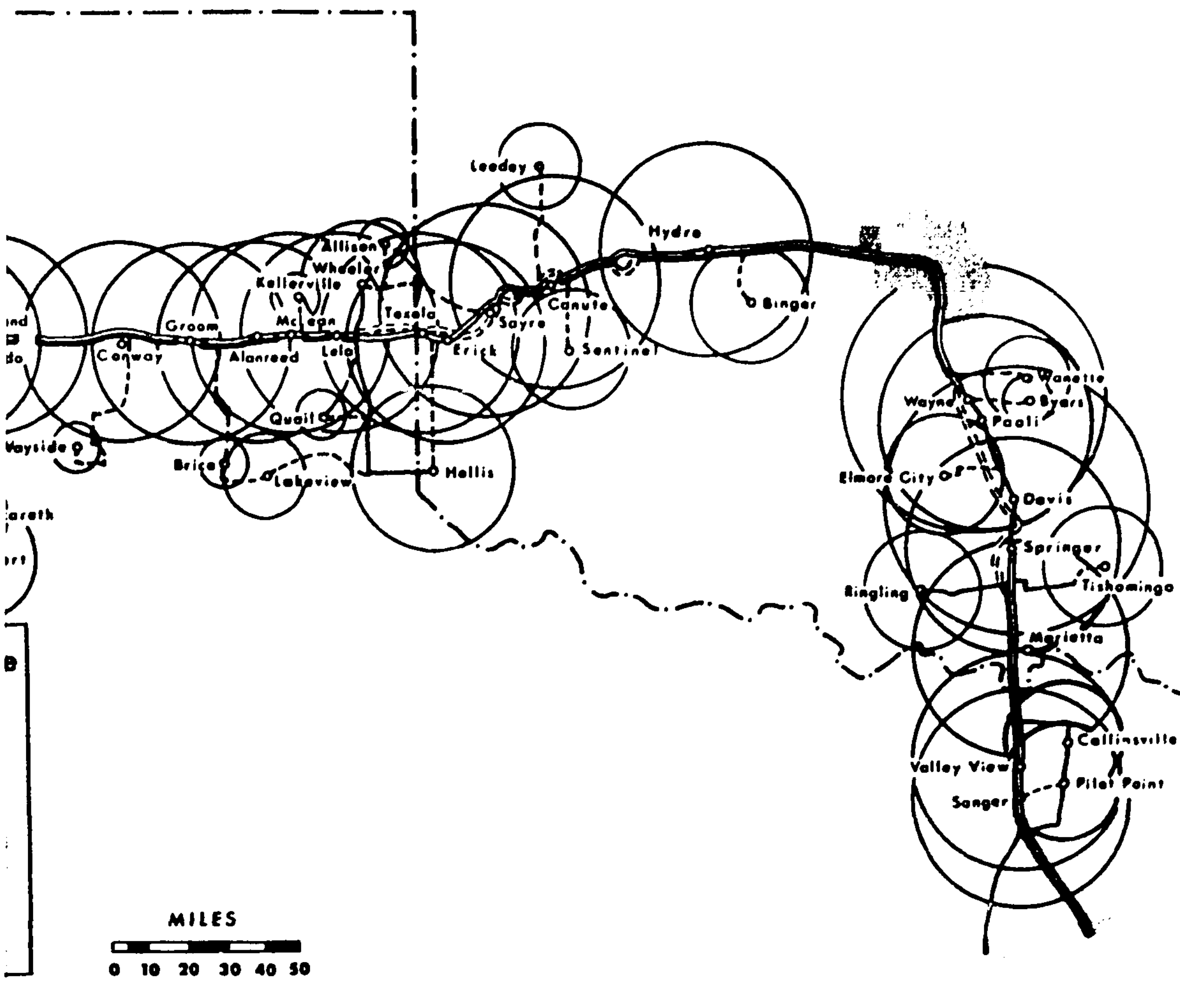

FIG. 6

certain times of the year, close to 20,000 vehicles pass through several of the towns in this group. Although data are not complete for all of the places in this group, selected samples show that a large percentage of the movement along this route can be classified as "through traffic."[1] Detailed origin and destination surveys prepared for Elk City and Clinton, Oklahoma, two larger towns excluded from the study, show 79.09 percent and 85.16 percent respectively of the total volume of traffic along Interstate Highway 40 as through traffic,[2] much of which is transcontinental traffic originating in or destined for southern California.

Thirty towns constituting the "off-highway" group were selected in a more systematic manner (Fig. 3). In order to attempt to isolate the influence of traffic volume, each off-highway selection was matched with an on-highway

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arteries leading into the town; these counts are usually taken at the edge of town. The sources of data are: New Mexico State Highway Department, Planning and Programming Division, Traffic Flow Map of New Mexico (Santa Fe, January, 1968); Oklahoma State Highway Department, Planning Division, Oklahoma Average Daily Traffic Volumes For The State Highway System (Oklahoma City, 1968); Texas State Highway Department, Planning Survey Division, State of Texas Traffic Map (Austin, March, 1969).

[1]Through traffic is generally defined as vehicular trips originating and terminating outside of the place of study.

[2]Oklahoma Department of Highways, Planning Division, Origin and Destination Survey: Elk City (Oklahoma City, 1966), p. 6; Oklahoma Department of Highways, Planning Division, Origin and Destination Survey: Clinton (Oklahoma City, 1967), p. 6.

town. The process of matching was guided by three prime criteria: (1) the straight line distance between the two places should be less than fifty miles; (2) the average daily traffic volume of the off-highway town should be less than 25 percent of the average daily traffic volume of the on-highway place; and (3) the population size of the towns should be similar.

A distinct effort was made to pair towns from the same general economic region and to eliminate any highly specialized single-function towns, such as college towns, resort spots or manufacturing centers. The distance and size factors were introduced in an attempt to come up with pairs of similar sized places in close proximity. Similarity of these two elements alone of course, will not insure that the towns chosen are similar in all respects; however, this method does help to reduce gross differences between the matched pair of towns. It can be assumed that the influence of any unidentified variable would have a similar effect on both the on-highway and off-highway places; thus, the influence of such a variable would be neutralized for the purposes of this study. The traffic volume factor, on the other hand, was introduced in a distinct attempt to have one variable which differentiated the pair of towns.

A systematic method was employed to satisfy these criteria before random sampling was done. This involved the use of a circle with a radius of fifty miles. With the circle centered on the on-highway place, a list of all places which satisfied the remaining two standards was compiled. The off-highway place was chosen randomly from the towns on the list. This process was repeated thirty times until the total off-highway group was selected and matched (Table 3). The off-highway group, therefore, can be considered a systematic random sample.

The populations of the off-highway group range from 14 to 3,500, with a mean of about 630 (Fig. 5). In addition to the traffic volume of this group being low in relation to the on-highway set (Fig. 6), the nature of this traffic is predominantly local rather than inter-regional. This volume is composed mainly of short trips originating or destined within a few miles of the service center.

In a number of cases it was not possible to satisfy all of the stated criteria (Table 4). Three towns selected in the off-highway group (Hollis, Sentinel, and Wheeler) had slightly more than one-fourth the average daily traffic volume of the on-highway match. Six other selected places (Hart, Nazareth, Mosquero, Solano, Grady, and Forrest) are located more than fifty miles from their highway pair. These six cases are all located in the western part of the study area where settlements are more widely dispersed than the eastern section of the delimited region. In all nine of these cases, there was not one town which met the stated criteria; therefore, the criteria were extended in these situations to

TABLE 3

OFF-HIGHWAY TOWNS

Place	Population (1969 estimate)[a]	Average Daily Traffic Volume (1968)[b]
Pilot Point	1600	1710
Collinsville	540	1670
Ringling	1350	1775
Byars	256	500
Tishomingo	2735	1700
Wanette	381	650
Elmore City	1108	1575
Binger	603	1900
Leedey	475	850
Hollis	3500	2400
Sentinel	1211	1550
Kellerville	100	300
Quail	75	450
Wheeler	1150	1780
Allison	125	300
Lakeview	350	990
Brice	39	460
Wayside	75	120
Channing	351	1200
Hart	850	1290
Nazareth	200	960
Amistad	25	130
Mosquero	310	350
Solano	39	350
Grady	110	640
Forrest	30	150
Dilia	60	530
Estancia	950	940
McIntosh	14	700
Willard	250	830

[a]Estimate derived from: United States Census of Population: 1960; Oklahoma Data Book; Texas Almanac and State Industrial Guide; Commercial Atlas and Marketing Guide, 1969.

[b]Traffic Flow Map of New Mexico; Map of Oklahoma Average Daily Traffic Volumes For the State Highway System; State of Texas Traffic Map.

TABLE 4

TOWN PAIRS COMPARED

Town Pairs	Distance Between Pairs (Miles)	Off-Highway ADT as % of On-Highway ADT
Sanger - Pilot Point	14	21.4
Valley View - Collinsville	18	21.2
Marietta - Ringling	31	23.9
Springer - Byars	38	6.3
Davis - Tishomingo	31	17.9
Paoli - Wanette	15	8.3
Wayne - Elmore City	20	18.9
Hydro - Binger	20	24.4
Canute - Leedey	30	11.2
Sayre - Hollis	36	30.8
Erick - Sentinel	39	27.3
Texola - Kellerville	32	5.9
Lela - Quail	24	8.9
McLean - Wheeler	27	33.4
Alanreed - Allison	47	6.3
Groom - Lakeview	45	18.2
Conway - Brice	46	9.4
Bushland - Wayside	42	2.0
Wildorado - Channing	37	20.5
Vega - Hart	65	22.7
Adrian - Nazareth	61	20.5
Glenrio - Amistad	50	2.9
San Jon - Mosquero	58	7.7
Montoya - Solano	52	6.8
Newkirk - Grady	55	13.5
Cuervo - Forrest	54	3.2
Clines Corners - Dilia	37	9.4
Moriarty - Estancia	17	14.8
Edgewood - McIntosh	16	9.8
Tijeras - Willard	39	7.8

choose the next best match. Nevertheless, these few cases should not significantly bias the total sample. Statistical tests show that the populations of the two groups of towns are not significantly different, whereas a clear cut difference can be shown between the average daily traffic volumes of the two groups of places.[1] The mean distance between the town pairs is 36.5 miles, which is well within the limits of the distance criterion.

The data collected for each of the selected places included a 1969 population estimate of the place and a catalogue of the number and type of commercial and service establishments located in the place. The population estimate was derived from a consultation with the Postmaster in each town. The figure provided by this individual was then evaluated with respect to available published estimates;[2] the accepted estimates were made on the basis of this evaluation.

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[1]The standard difference between the means test was applied to this data with the following results:

critical t .05(58) = 2.00

computed t = .3789 for difference between the population sizes of two groups signifies no statistical difference between these two samples.

computed t = 17.0611 for difference between the average daily traffic volumes of the two groups signifies a large statistical difference between these two samples.

[2]Bureau of Business Research, Oklahoma Data Book (Norman, Oklahoma, 1968), pp. 8-13; Dallas Morning News, Texas Almanac and State Industrial Guide (Dallas: A. H. Belo Corp., 1965), pp. 141-154; Rand McNally, Commercial Atlas and Marketing Guide, 1969, (Chicago: Rank McNally, 1969).

Acquiring a catalogue of the number and type of establishments posed a far more difficult problem. A number of published sources were investigated, but each of these were found to have limited value due to incomplete coverage or lack of sufficiently refined classification schemes.[1] Therefore, it was necessary to make a personal visit to each of the sixty selected towns and record the necessary data by personal observation.[2] The visits proved beneficial not only for collecting specific data, but they also provided an opportunity to observe the study towns in a more general way--comparing the similarities and differences in tertiary economic activity by direct sensory observation.

Several problems were encountered in the collection and classification of data. Towns of the size included in this study characteristically possess single establishments which perform multiple functions. A common example of this is the combination of the gas station, grocery store and post office functions in one establishment. These combinations occur because there is not sufficient demand to support separate establishments, yet there is enough demand to require the offering of the separate functions. The

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[1]The sources investigated and spot checked included the _Census of Business, 1963_, Dun and Bradstreet's _Reference Book, 1969_, and the Classified Section of the _Telephone Directory_.

[2]A copy of the form used to record this information is included in Appendix B.

multiple function establishment satisfies this conflict by realizing certain economies of consolidation such as labor, physical structure and maintenance costs. In such cases it was decided to record fractional value; i.e., in the above example a value of one-third was given to each of the functions. An alternative solution would be to identify and record a value of one for each of the functions; however, it seems this method would tend to unfairly overemphasize multiple function establishments. Another possible solution would be to classify a multiple function establishment in a separate category; it was felt that this technique would not provide an accurate picture of the true situation since there are innumerable types of combinations possible. The fractional method, although not perfect, appears to be a good compromise since it takes into account the existence of a particular function, and it also takes cognizance of the fact that there is not sufficient supporting population to warrant separate single-function establishments.

This fractional technique was also employed in cases where the good or service was not offered on a regular day-to-day basis. That is, several situations were discovered where a doctor or a barber would be available in a town only certain days of the week. Usually this individual maintains his principal practice in a higher order place, and he spends his "days off" in the smaller city. The barber normally follows this arrangement to enhance his income, whereas the doctor views this as more of an obligation. Whatever the reasons, if a service was found to be regularly provided two days a week, it was recorded with a value of two-sixths or two-fifths, depending on the length of the normal work week for that activity.

Various establishments are multifunctional by their very nature, but they are commonly recognized as single function businesses. For example, hardware stores, supermarkets, and dry goods stores, all of which sell diverse lines of merchandise and services, can be identified as a single function and the multiple function offerings within them were not counted. This principle is basic to most classification systems attempting to group similar economic establishments; an attempt was made to conform to the classification employed by the Standard Industrial Classification system.[1] The remaining functions were recorded on the basis of the primary activity carried on in an individual building. A complete list of the number and type of functions found in the study towns is presented in Chapter V (see Tables 7 and 8, pages 65 and 66).

The above discussion of the mechanical aspects of collecting and analyzing data logically leads into a discussion of the real world setting of this study. Though

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[1]U.S., Bureau of the Budget, Technical Committee on Industrial Classification, Office of Statistical Standards, Standard Industrial Classification Manual (Washington: Government Printing Office, 1957).

the dissertation is based to some degree on theoretical grounds, the basic hypotheses of the investigation are concerned with empirical results from a selected area of the earth's surface.

CHAPTER IV

THE TEST AREA

The nature of the hypotheses previously set forth are such that they should be valid with regard to any specific area or region; hence, any area possessing within its bounds both a sufficient number of towns located on a high volume, inter-regional traffic artery, and a group of towns situated along less traveled routes could be utilized. For reasons of convenience and familiarity, a test area in western Oklahoma, the Panhandle of Texas and eastern New Mexico was delimited for the present study (Fig. 3, page 34). The general economic and physical character of this area approaches the isotropic conditions assumed in classical Central Place Theory. In addition, two segments of major inter-regional highways (Interstate Highways[1] 35 and 40) cross the area; the high volumes of traffic flowing on these routes are quite important for this study.

Since the total geographical character of the study area is not at all the prime focus of this investigation, only broad generalizations will be set forth to describe

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[1]Henceforth, the abbreviation I.H. will be utilized for Interstate Highway.

the complexion of the region. The area can be considered as largely within the American Southwest, a realm of relatively dry climatic conditions and diverse topography. Morris has noted:

> . . . the outstanding and unifying characteristics of the Southwest are aridity and distance. So dominant is the force of aridity in the life of the area that it greatly influences the other natural factors--vegetation, land forms, water resources, wildlife--as well as the activities of mankind. . . . Small towns are far apart and most cities are well over a hundred miles from their largest neighbor.[1]

Except for wide sandy river valleys, there are few topographic constraints to overland travel in the study area; thus highway construction costs are relatively low. The Arbuckle Mountain area of south-central Oklahoma has hindered the completion of a major segment of I.H. 35, but construction of the new route is well underway and it should be open to traffic in the near future. The route of I.H. 40 gently rises westward until it passes over the high rolling topography of the southern extension of the Sangre de Cristo range in central New Mexico.

Because of the occasional winter snow or ice storms in the area, these higher elevations in central New Mexico cause the greatest climatic inconveniences to the traveler. Although the routes passing through the area tend to be preferred by winter time travelers over routes farther north,

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[1]John W. Morris, The Southwestern United States (New York: Van Nostrand Reinhold Co., 1970), p. 2.

the major roads in the area are occasionally closed because of hazardous driving conditions. High temperatures in the summer generally add to the discomfort of long drives, but with the growing popularity of air conditioners in automobiles this discomfort has been greatly reduced. In general, rainfall decreases from east to west across the study area. Average annual amounts of precipitation range from around 35 inches in the east to approximately 10 inches in the western sections of the area.[1] Isolated summer thunderstorms can bring irritation and delays to automobile travelers, but usually the effects of these storms pass before major problems occur. All in all, the elements of the physical environment may be characterized as more conducive than restrictive with regard to highway travel in the study area.

The physical character of the area is an important influence on the economic activity of the region. This part of the United States is noted more for primary economic activity than for secondary or tertiary pursuits. Ranching and farming are widespread throughout, with selected spots focusing on the extraction of various minerals. The agricultural activity becomes more extensive as one moves westward, i.e., the tendency is toward smaller farms in the east and large ranches farther to the west. Crops also show an east

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[1]U.S., Department of Agriculture, Yearbook of Agriculture, 1941 (Washington, D.C.: Government Printing Office, 1941), pp. 1011 and 1067.

to west transition, with cotton in the east giving way to wheat and finally open natural range country in the west.

The High Plains area of the Texas Panhandle is noteworthy because of its prosperous agricultural base. Irrigation agriculture and the growing of dry land grain sorghum have been increasing in recent years due to the rapid development of the cattle feeding industry. Large feed lots are quite noticeable by both sight and smell in the area. The decentralization of the meat packing industry into the Great Plains and away from the Midwest has played an important role in the economy of the study region. A large portion of western Oklahoma and the Texas Panhandle are included as a southern extension of the national bread basket.

> This area along with western Kansas is the heart of the American Winter Wheat Belt. Here mile after mile of gently sloping and almost level land is planted in wheat. Forty years ago the area was more densely populated for most farms ranged in size from 160 to 320 acres, or one-fourth to one-half square miles in area. Today many wheat farms have more than 1,000 acres and farms of 3,000 acres or larger are fairly common. Very few wheat farms are irrigated; thus, all types of moisture and soil conservation are practiced.[1]

The small off-highway towns selected for study are primarily agricultural service centers providing goods and services for their surrounding prosperous agricultural hinterland. The economic support of these communities follows closely the tenets set down in Central Place Theory.

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[1]Morris, op. cit., p. 73.

Quite different from towns of a similar size in other parts of the country, many of these places appear economically and socially vibrant. These are not merely "Saturday towns"--there is activity throughout the week. The vibrancy of these towns is an interesting phenomenon worthy of further investigation.

The study area is served by a relatively dense network of primary and secondary roads (Fig. 7). The greatest volumes of traffic are carried on the routes comprising the National System of Interstate and Defense Highways (Fig. 8). Garrison has succinctly characterized this network:

> The Interstate System comprises 41,000 miles of high-speed, low transportation cost, limited-access facilities linking many of the major cities of the nation. The concept of the Interstate System dates back a number of years prior to implementation in 1956. Previous federal highway policy has resulted in the federal aid primary system of about a quarter of a million miles, the federal aid secondary system (the farm-to-market system), and certain national parks and forest roads. The result of this previous policy is a relatively fine-scale network linking urban centers of all classes with each other, and linking urban centers with their tributary areas. The Interstate System is more gross in scale--in a sense it lies on top of previous highway systems, and it emphasizes linkages within and between major cities.
>
> Perhaps two things may be gleaned from this brief statement. First, the Interstate System may be thought of as a large-city or metropolitan system of highways, since it provides links between (and within) metropolitan areas. This represents a marked shift in federal policy, because previous highway policy might be characterized as catering to rural areas and small urban centers. Another notion is that the Interstate System may be thought of as a new highway network. In many ways it is more

ROAD NETWORK IN S

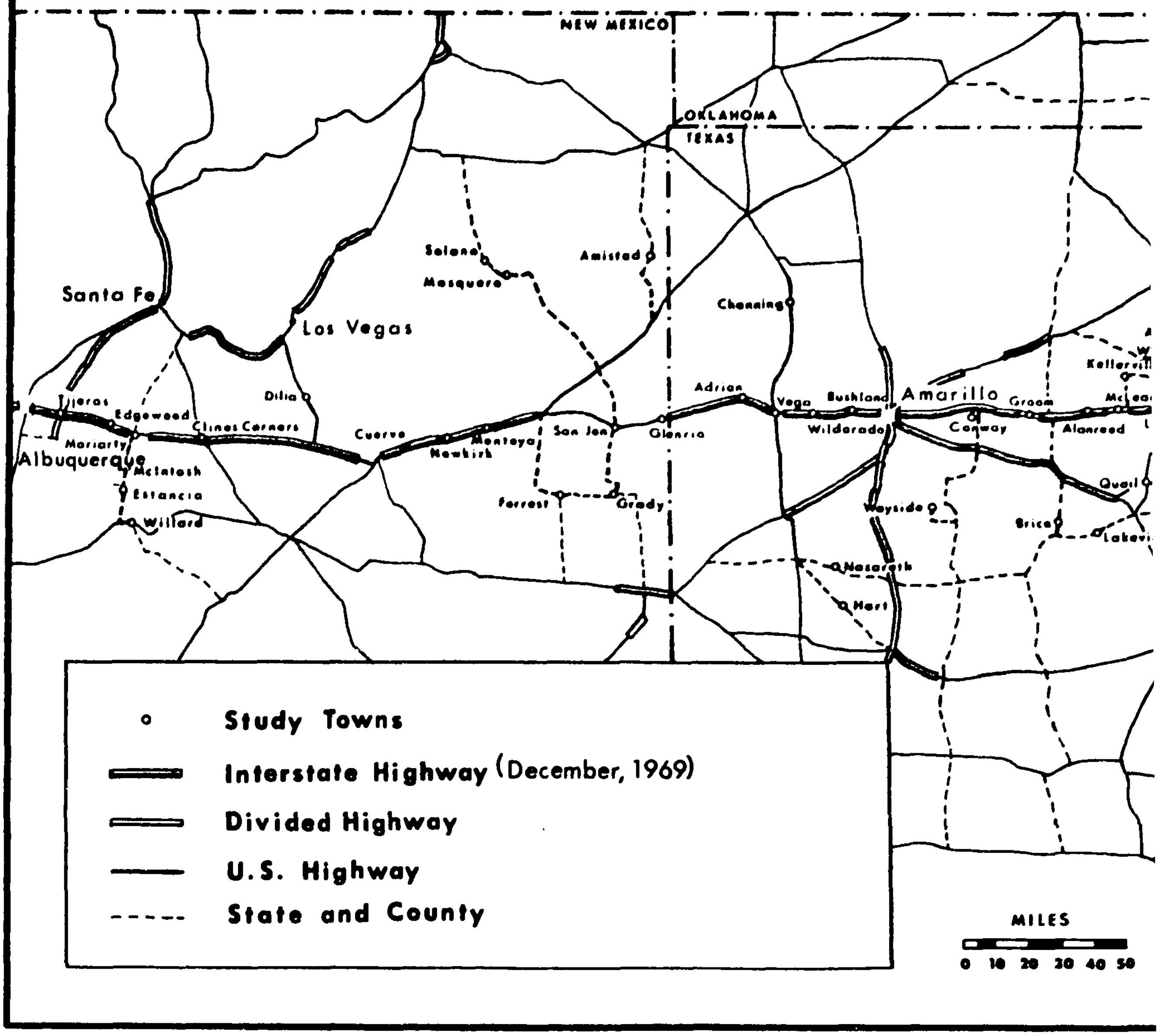

FIG. 7

RK IN STUDY AREA

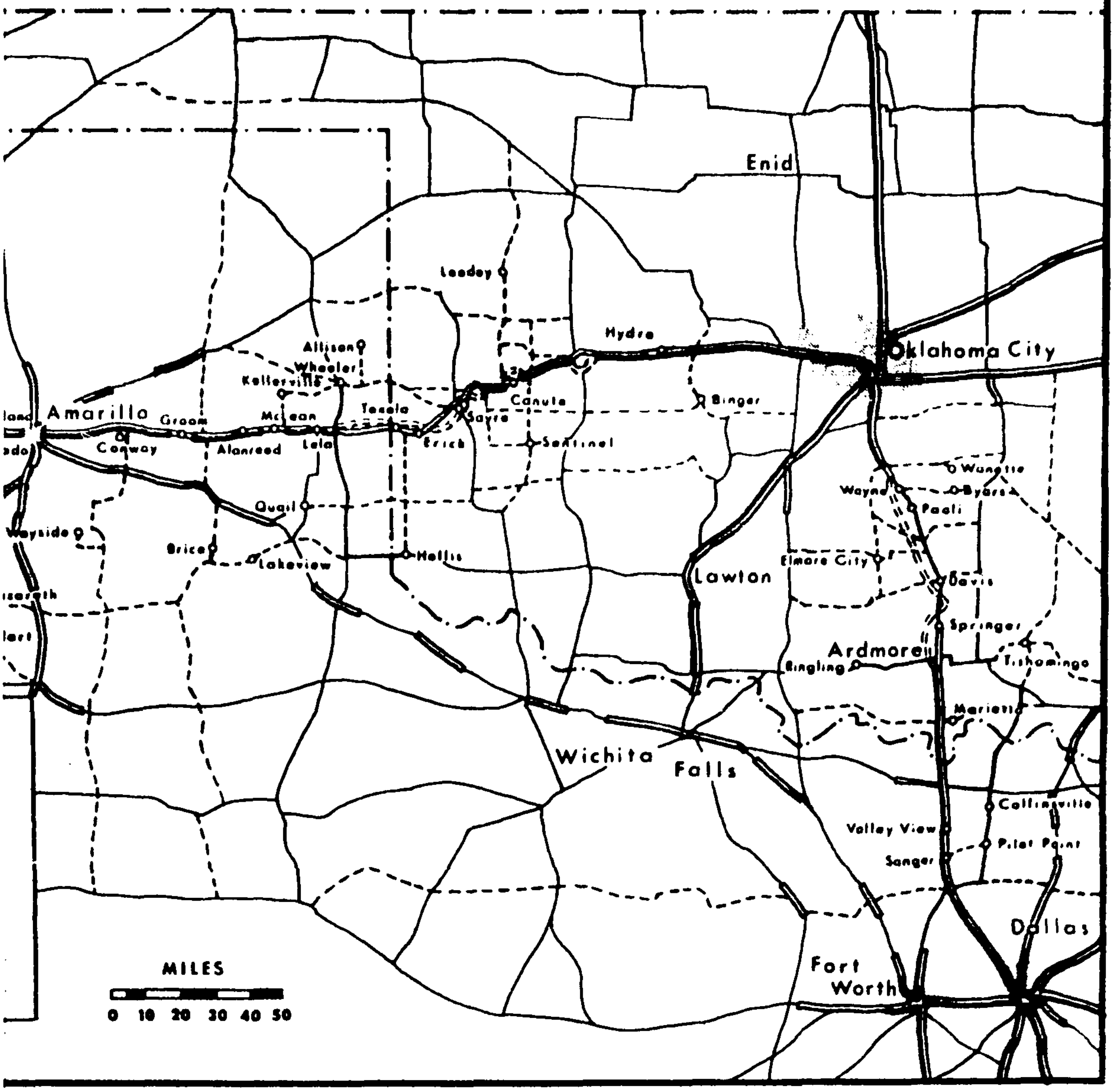

FIG. 7

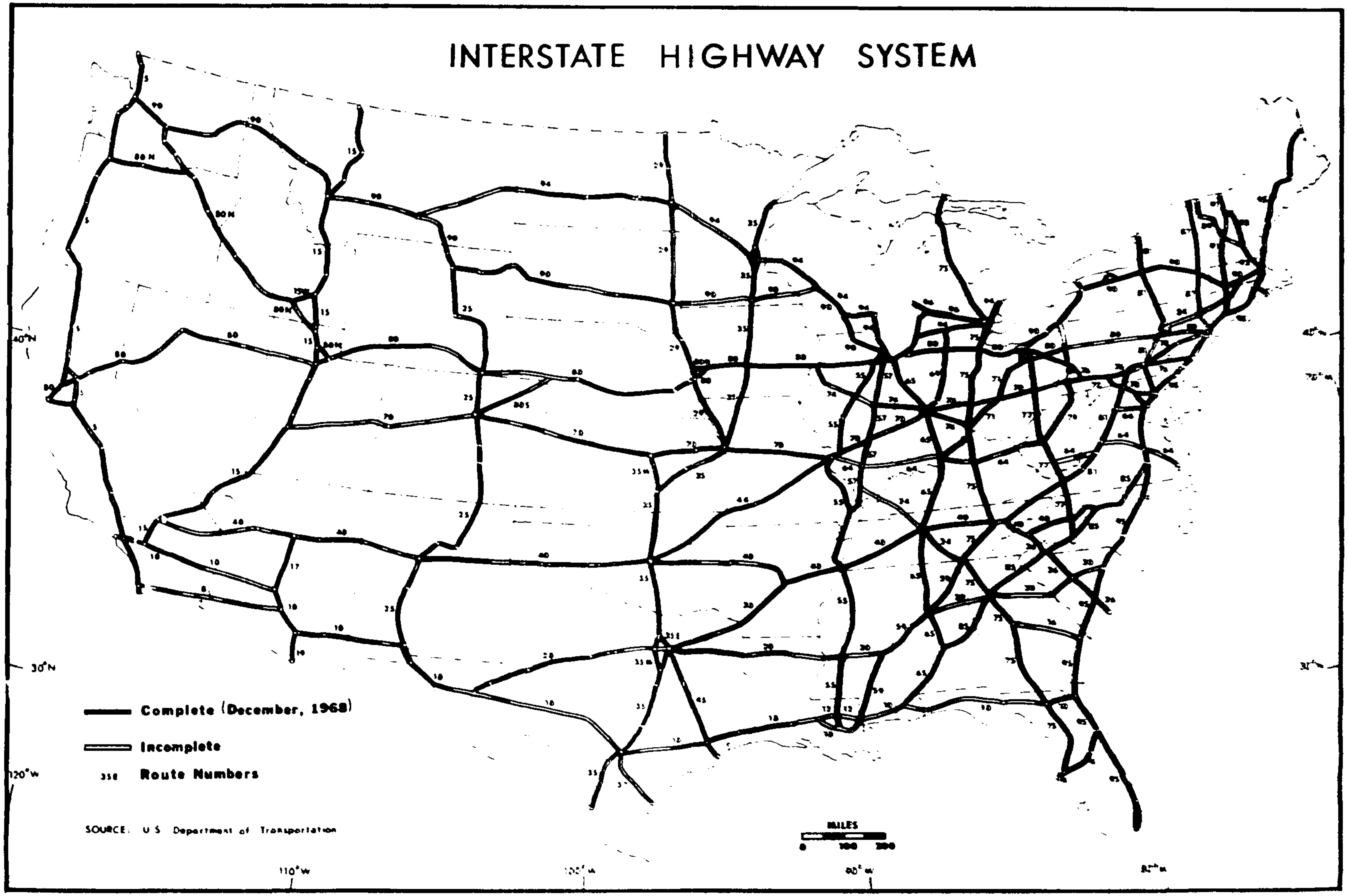
INTERSTATE HIGHWAY SYSTEM
Complete (December, 1968)
Incomplete
Route Numbers
SOURCE: U.S. Department of Transportation
MILES
0
100
200

FIG. 8

comparable to networks of airline and railroad routes than present highway networks.[1]

The location of two segments of the National System of Interstate and Defense Highways is very important for this study. Interstate Highway 35, extending north-south through the center of the nation, runs from Laredo, Texas to Duluth, Minnesota. The portion of this route lying within the study area is the approximately 215 mile leg connecting the metropolitan areas of Dallas-Fort Worth with Oklahoma City. Interstate Highway 40, the primary east-west route in the southern section of the United States, is nearly transcontinental in length; it extends from Barstow, California to Durham, North Carolina. Some 550 miles of this road are included in the study area, from Oklahoma City through Amarillo, Texas to Albuquerque, New Mexico.

Of the nearly 800 miles of the Interstate System included in the study area, a large percentage of the route was complete and open to traffic by late 1969. Since 1956, when the Federal Aid Highway Act calling for about 41,000 miles of new interstate highways was passed, the development of the system has followed a patchwork pattern. That is, the routes have been constructed in short segments rather than long uninterrupted links. Due to local political pressures, the urban bypasses are the last segments to be completed.

[1]William L. Garrison, "Connectivity of the Interstate Highway System," Papers and Proceedings of the Regional Science Association, VI (1960), p. 123.

This is strikingly illustrated in the study area, where most of both Interstate routes are completed except for the urban bypasses, where in most cases all traffic exits from the high speed facility and follows downtown streets through each of the non-bypassed towns. Only ten of the thirty on-highway towns considered in this investigation have been bypassed; most of these are very small places in the western section of the area. Of the seven towns located on I.H. 35, three have been bypassed. Sixteen of the twenty-three I.H. 40 towns have not yet been bypassed. It is interesting to note that the largest of the study towns to be bypassed is in Oklahoma (Marietta), whereas that state in relation to Texas and New Mexico, has the poorest record of completed urban bypasses.

The two segments of I.H. 35 and I.H. 40 included in the study area carry high volumes of traffic. The average daily traffic volume ranges from 4,270 vehicles between Glenrio and San Jon, New Mexico to over 10,000 in the environs of the four major metropolitan areas. Outside of the major urban concentrations, the greatest percentage of this volume is non-local or through traffic. Two available examples clearly illustrate this point. Well over 80 percent of the traffic on I.H. 40 through Clinton, Oklahoma has an origin or destination outside of the city (Table 5).

A traffic survey conducted by the New Mexico State Highway Department in 1968 reported that only 10.1 percent

TABLE 5

NATURE OF TRAFFIC ON INTERSTATE 40
THROUGH CLINTON, OKLAHOMA

Station Location	Total 24 Hour Traffic	Local Traffic		Through Traffic	
		Volume	Percentage	Volume	Percentage
I-40 East	9,156	1,478	16.14	7,678	83.86
I-40 West	8,580	1,273	14.84	7,307	85.16

Source: Oklahoma Department of Highways, Planning Division, Origin and Destination Survey: Clinton (Oklahoma City, 1967), p. 6.

of the total traffic on I.H. 40 east of Clines Corners, New Mexico consisted of New Mexico passenger cars.[1]

The economic impact of this through traffic is crucial to this study. A high volume of traffic regardless of origin is important, but more important here is the inter-regional character of the traffic. Cross country travelers are quite dependent individuals; they have desires and needs very different from local drivers. Thus, the establishments providing goods and services for transients draw their support from a much larger service area. In other

[1]New Mexico State Highway Department, Planning and Programming Division, New Mexico Traffic Survey; 1968 (Santa Fe, 1968), p. 36. New Mexico passenger cars are defined as all passenger cars bearing New Mexico license plates or U.S. Government plates.

words, an explanation for the existence of a number of on-highway establishments can be attributed to the demand created by the travelers passing through these towns. The highway, then, can be viewed as a basic industry to the economies of the on-highway group, since money is brought into the town from outside the area. This fact is often overlooked by local community supporters who concentrate all of their efforts on attracting manufacturing establishments in an attempt to generate economic growth. Possibly a greater return could be realized if more attention were given to highway oriented business and service activities. The following chapter will focus on an analysis of those activities most influenced by highway traffic.

There are marked monthly and daily variations in the traffic flow along the Interstate Highways. However, the daily variation is not nearly as pronounced as the month to month differences. There is a gradual increase of average daily traffic from a low on Monday (4,500) to a peak on the weekend, Saturday (5,283) and Sunday (5,297) (Table 6). These data are fairly representative of the situation found along other portions of the highway. More trips tend to be taken on a weekend, since most people have these days free from their work. Yet, the relatively high counts recorded for the week days illustrate that the interstate routes are very important for long trips as well as for shorter weekend outings. In fact, routes carrying a higher proportion of

TABLE 6

AVERAGE DAILY TRAFFIC VOLUMES, 1968
BY MONTH AND DAY OF WEEK

Location: I.H. 40, West -- Tucumcari, New Mexico

Month	Day of Week							Average Day
	Mon.	Tue.	Wed.	Thur.	Fri.	Sat.	Sun.	
Jan.	2857	3009	3218	3416	3468	3247	3032	3178
Feb.	2933	3082	3375	3361	3443	3513	3503	3316
March	3048	3464	3547	3754	3798	3916	3616	3592
April	3697	3834	4151	4117	4333	4311	4187	4090
May	3923	4076	4295	4545	4593	4653	4715	4400
June	6946	6843	7049	6890	7229	8312	8598	7410
July	7145	7164	7189	7353	7252	8014	7801	7417
Aug.	7199	7267	7438	7429	7632	8433	8379	7682
Sept.	4879	4785	5252	5311	5166	5321	5646	5194
Oct.	4016	4297	4757	4667	4766	4711	4772	4571
Nov.	3528	3536	4075	3802	3845	4118	4118	3869
Dec.	3813	3391	3282	3776	4377	4844	5193	4097
Daily Mean	4500	4562	4802	4868	4992	5283	5297	4901

Source: New Mexico State Highway Department, Planning and Programming Division, New Mexico Traffic Survey, 1968 (Santa Fe, 1968), p. 44.

local traffic show a much greater concentration of use on the weekends.[1]

The monthly variation of traffic flow on I.H. 40 has a pronounced seasonal trend (Table 6). Three of the summer months (June, July, and August), with an average of more than 7,000 vehicles on a typical day, record more than twice as many vehicles as the low month of January. The summer months are traditionally used by American families for extended pleasure trips, since school children are free at that time. However, even the winter months show an average of over 3,000 vehicles per day. This points out the importance of the route during the cold time of the year when northern transcontinental roadways suffer from treacherous driving conditions. It is not unusual for a midwestern or eastern based traveler to drive several hundred miles out of his way to avoid slow and hazardous conditions on the northern routes in favor of the less precarious southern route, I.H. 40. The break in the general trend of traffic flow posted in December can most likely be accounted for by travelers enroute to the homes of friends or relatives in order to spend the holiday season.

A comparison of the seasonal traffic variation graphs for a route dominated by local traffic and one primarily used by through traffic emphasizes the point of the prounounced

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[1]New Mexico State Highway Department, Planning and Programming Division, op. cit., p. 60.

summer peak on I.H. 40 (Fig. 9). Over 92 percent of the movement on this portion of Oklahoma State Highway 73 originates in or is destined for Clinton, whereas approximately 85 percent of the Interstate traffic west of Clinton is designated as through traffic.[1] Local routes maintain a more even distribution over the year than do inter-regional roads.

It is not the purpose of this dissertation to analyze the effect of this seasonal variation on the economic activity of towns along the highway, yet this appears to be a ripe field for some future study. An analysis of the impact of a high volume of traffic on the threshold population of central place functions is the subject of the following chapter.

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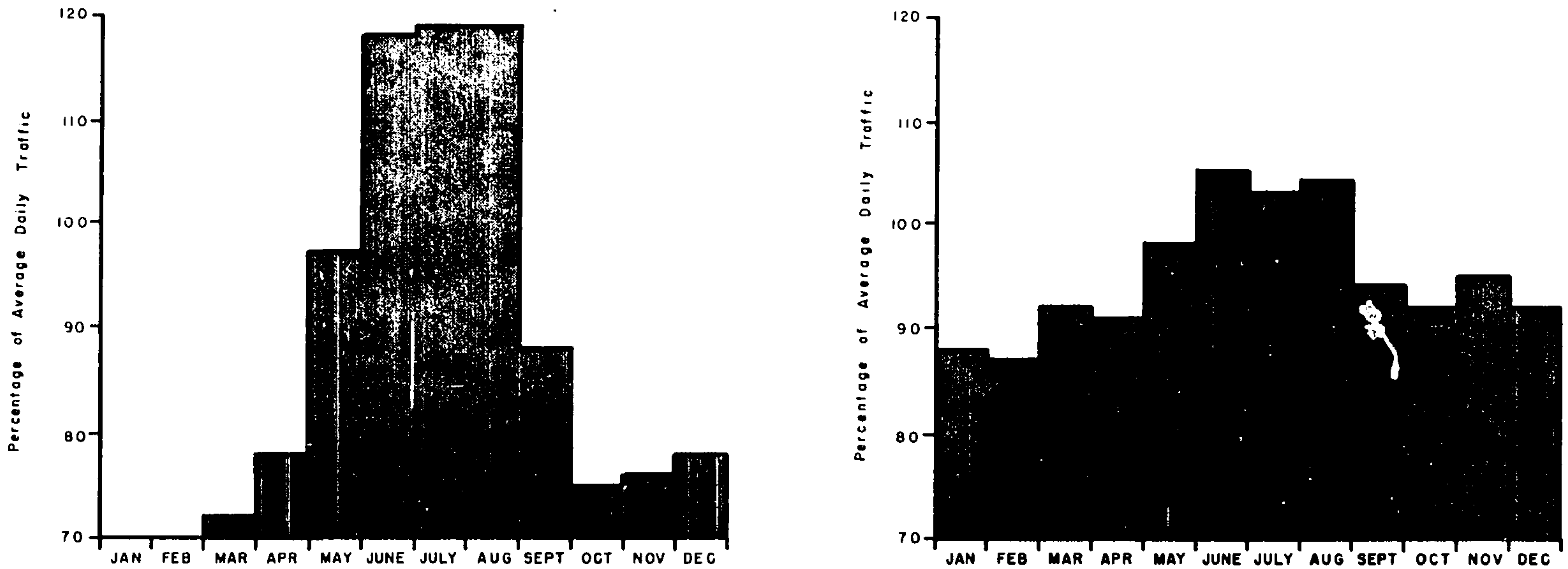
[1]Oklahoma Department of Highways, Planning Division, op. cit., p. 6.

FIG. 9

COMPARISON OF SEASONAL TRAFFIC VARIATION BY MONTH AS A PERCENTAGE OF AVERAGE DAILY TRAFFIC

Interregional Route - I. H. 40
Western Edge of Clinton, Oklahoma

Local Route - S. H. 73
Western Edge of Clinton, Oklahoma



SOURCE OKLAHOMA DEPARTMENT OF HIGHWAYS, ORIGIN AND DESTINATION SURVEY, CLINTON (OKLAHOMA CITY, 1967), PP 28 & 33

CHAPTER V

COMPARISON OF THE FUNCTIONAL COMPOSITION OF ON- AND OFF-HIGHWAY TOWNS

Fifty-nine separate functions have been identified in the study towns. Of this number, fifty-one are variable functions, i.e., functions which are offered by more than one establishment in at least one of the study places; the remaining eight are non-variable functions. The non-variable functions portray a presence or absence situation, that is, a town either possesses an establishment performing this function or it does not. Unless otherwise noted, the following discussion deals only with the variable functions since the model used to determine threshold populations requires variation among the functions.

Relationship Between Population and Number of Establishments

One of the basic principles of Central Place Theory is that functional complexity increases with an increase in city size (Tables 7 and 8). In other words, a large place offers a greater variety of goods and services than does a smaller place. This principle is well illustrated by the towns included in the present study. A high positive

	VARIABLE ACTIVITIES	POPULATION	GAS STATION	CHURCH	REST. CAFE	AUTO REPAIR	BEAUTY SHOP	MOTEL	GROCERY	INS. RL. EST.	TAVERN	BARBER SHOP	FEED AND SEED	GIFT STORE	LAUNDROMAT	GENERAL STORE	FRAT. ORG.	POST OFFICE	OSTEO. CHIRO.	LAWYER	DRY GOODS	DRUG STORE	GEN. WELDING	BOTTLED GAS	DOCTOR	SECOND HAND	FAMILY CLOTH.	DRY CL.(DEP.)	FARM IMPLMT.
Lower Threshold			[illegible]	[illegible]	[illegible]	111	[illegible]	134	156	[illegible]	152	247	227	175	253	113	290	[illegible]	[illegible]	267	313	313	303	314	300	279	337	165	307
THRESHOLD POPULATION			[illegible]	[illegible]	[illegible]	[illegible]	210	[illegible]	[illegible]	273	[illegible]	327	335	340	355	384	404	423	[illegible]	[illegible]	[illegible]	[illegible]	492	[illegible]	[illegible]	[illegible]	563	[illegible]	[illegible]
Upper Threshold			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	496	725	[illegible]	1207	[illegible]	701	[illegible]	[illegible]	[illegible]	[illegible]	767	745	780	[illegible]	[illegible]	1735	1381
[illegible]AYNE	172.5	[illegible]	15.0	14.0	10.0	8.0	10.0	6.0	7.0	8.0	3.0	4.0	3.0	--	3.0	1.0	3.0	1.0	2.0	4.0	3.0	3.0	4.0	2.0	5.0	3.0	2.0	--	--
MARIETTA	140.0	[illegible]	14.0	12.5	11.0	6.0	5.0	3.0	8.0	8.0	2.0	3.0	3.0	1.0	4.0	--	2.0	1.0	4.0	5.0	2.0	3.0	2.0	2.0	1.0	2.0	2.0	--	--
[illegible]	110.0	[illegible]	13.0	12.0	5.0	4.0	[illegible]	4.0	7.0	3.0	2.0	3.0	1.0	--	2.0	--	3.0	1.0	--	--	3.0	2.0	2.0	[illegible]	2.0	1.0	3.0	1.0	2.0
BRICK	87.0	[illegible]	15.0	7.0	7.0	[illegible]	5.0	7.0	3.0	2.0	2.0	3.0	2.0	--	2.0	--	2.0	1.0	--	1.0	2.0	2.0	1.0	1.0	2.0	--	--	--	2.0
MCLEAN	[illegible]	1599	[illegible]	7.0	[illegible]	3.0	[illegible]	[illegible]	4.0	3.0	--	1.0	1.0	[illegible]	[illegible]	--	[illegible]	1.0	--	1.0	2.0	[illegible]	2.0	1.0	2.0	--	3.0	--	--
[illegible]	73.0	[illegible]	[illegible]	13.0	[illegible]	2.0	[illegible]	1.0	4.0	3.0	--	2.0	2.0	--	1.0	--	1.0	1.0	--	--	2.0	2.0	2.0	2.0	1.0	1.0	1.0	--	1.0
MORIARTY	71.0	[illegible]	14.0	[illegible]	[illegible]	[illegible]	[illegible]	11.0	1.0	3.0	[illegible]	2.0	--	[illegible]	1.0	1.0	1.0	1.0	--	--	--	--	1.0	1.0	--	--	--	1.0	1.0
VEGA	[illegible]	[illegible]	11.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3.0	2.0	--	1.0	2.0	--	[illegible]	--	[illegible]	1.0	--	1.0	1.0	1.0	--	[illegible]	1.0	--	1.0	--	2.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.0	--	--	1.0	2.0	--	[illegible]	--	[illegible]	1.0	[illegible]	--	[illegible]	[illegible]	--	1.0	--	--	1.0	--	1.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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VALLEY VIEW	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	--	[illegible]	[illegible]	[illegible]	--	--	[illegible]	[illegible]	[illegible]	[illegible]	--	[illegible]	[illegible]	--	--	--	--	[illegible]	--	--	--	--	--	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	--	--	--	[illegible]	[illegible]	--	--	[illegible]	[illegible]	[illegible]	--	--	--	--	--	[illegible]	--	--	--	--	--
[illegible]	[illegible]	[illegible]	3.0	[illegible]	[illegible]	--	[illegible]	--	[illegible]	[illegible]	--	[illegible]	[illegible]	--	[illegible]	[illegible]	--	[illegible]	--	--	--	--	--	--	[illegible]	--	--	--	--
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.0	2.0	--	[illegible]	[illegible]	[illegible]	--	[illegible]	[illegible]	[illegible]	--	--	--	[illegible]	--	--	--	--	--	[illegible]	--	--	--	--	1.0
[illegible]	[illegible]	111	[illegible]	4.0	1.0	2.0	1.0	1.0	[illegible]	--	--	--	--	--	--	1.0	--	[illegible]	--	--	--	--	--	--	--	[illegible]	--	--	--
[illegible]	15.0	[illegible]	4.0	[illegible]	--	--	--	[illegible]	--	--	[illegible]	--	--	[illegible]	--	--	--	1.0	--	--	--	--	--	--	--	--	--	--	--
[illegible]	10.0	[illegible]	[illegible]	2.0	--	1.0	[illegible]	--	[illegible]	--	[illegible]	--	--	1.0	--	--	--	[illegible]	--	--	--	--	--	--	--	--	--	--	--
[illegible]WOOD	11.0	[illegible]	4.0	1.0	[illegible]	--	--	[illegible]	--	--	--	--	--	1.0	1.0	--	--	1.0	--	--	--	--	--	--	--	--	--	--	--
[illegible]	11.0	[illegible]	3.0	2.0	--	[illegible]	--	--	[illegible]	--	1.0	--	--	--	--	0.5	--	[illegible]	--	--	--	--	--	--	--	[illegible]	--	--	--
[illegible]	[illegible]	[illegible]	2.0	1.0	1.0	1.0	--	--	1.0	--	--	--	--	--	--	--	--	[illegible]	--	--	--	--	1.0	1.0	--	--	--	--	--
[illegible]	[illegible]	124	2.0	1.0	2.0	1.0	--	1.0	--	--	--	--	--	--	--	--	--	[illegible]	--	--	--	--	1.0	--	--	--	--	--	--
CONWAY	[illegible]	41	3.3	--	2.0	--	--	1.0	0.3	--	--	--	--	--	--	--	--	0.3	--	--	--	--	--	--	--	--	--	--	--
CUERVO	[illegible]	1	2.0	2.0	--	--	--	--	--	--	1.0	--	--	--	--	[illegible]	--	[illegible]	--	--	--	--	--	--	--	--	--	--	--
[illegible]	[illegible]	110	1.5	1.0	--	--	--	--	0.5	--	--	--	--	--	1.0	--	--	1.0	--	--	--	--	--	--	--	--	--	--	--
CLINES CORNERS	4.0	15	1.0	--	1.0	--	--	1.0	--	--	--	--	--	--	--	--	--	1.0	--	--	--	--	--	--	--	--	--	--	--
MONTOYA	1.5	24	0.3	1.0	--	--	--	--	--	--	--	--	--	--	--	0.3	--	0.3	--	--	--	--	--	--	--	--	--	--	--

TABLE 7.--FUNCTIONAL COMPOSITION OF C

[illegible]	DRUG STORE	GEN. WELDING	BOTTLED GAS	DOCTOR	SECOND HAND	FAMILY CLOTH.	DRY CL. (DEP.)	FARM IMPLMT.	T.V. REPAIR	NEW CAR DLR.	DOMINO/POOL	LIQUOR STORE	AUTO PARTS	ELEC., GAS CO.	[illegible]	[illegible]	[illegible]	[illegible]	HARDWARE	[illegible]	VARIETY STORE	BANK	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	CAR WASH	FUNERAL HOME	[illegible]	[illegible]
[illegible]	313	303	314	330	279	337	166	327	341	373	[illegible]	337	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	514	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	750	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	3.0	4.0	2.0	5.0	3.0	2.0	--	--	[illegible]	[illegible]	2.0	3.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	3.0	2.0	2.0	1.0	2.0	2.0	--	--	3.0	2.0	1.0	2.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	--	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	2.0	2.0	2.0	2.0	1.0	3.0	1.0	2.0	--	[illegible]	1.0	2.5	[illegible]	--	[illegible]	[illegible]	[illegible]	--	[illegible]	[illegible]	--	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	--	--	[illegible]	[illegible]	[illegible]
[illegible]	2.0	1.0	1.0	2.0	--	--	--	2.0	2.0	2.0	2.0	1.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	--	--	[illegible]	--
[illegible]	2.0	2.0	1.0	2.0	--	3.0	--	--	1.0	1.0	1.0	--	[illegible]	[illegible]	[illegible]	[illegible]	--	--	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	--	--	--	[illegible]	--	[illegible]	--	[illegible]
[illegible]	2.0	2.0	2.0	1.0	1.0	1.0	--	1.0	--	2.0	1.0	--	--	--	[illegible]	[illegible]	[illegible]	--	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	--	--	--	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	--	1.0	1.0	--	--	--	1.0	1.0	2.0	--	--	--	[illegible]	--	[illegible]	--	--	[illegible]	--	--	--	[illegible]	--	--	--	--	--	--	--	--	--	--
[illegible]	1.0	--	2.0	1.0	--	1.0	--	2.0	1.0	--	1.0	--	[illegible]	[illegible]	--	[illegible]	[illegible]	[illegible]	--	[illegible]	--	[illegible]	--	--	[illegible]	--	--	[illegible]	--	--	[illegible]	--
[illegible]	1.0	--	1.0	--	--	1.0	--	1.0	1.0	--	2.0	1.0	[illegible]	[illegible]	[illegible]	[illegible]	--	--	[illegible]	1.	--	[illegible]	--	[illegible]	--	--	--	[illegible]	--	--	1.	[illegible]
[illegible]	1.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	--	1.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	--	[illegible]	--	[illegible]	--	[illegible]	[illegible]	--	--	[illegible]	--	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	--	[illegible]	--	--	--	[illegible]	--	--	--	--	1.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	--	--	--	--	[illegible]	--	--	--	[illegible]	[illegible]	--	--	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	--	--	--	--	--	--	--	--	--	--	--	--	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	--	1.	--	--	--	--	--	1.	[illegible]	[illegible]	[illegible]	--	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	--	[illegible]	[illegible]	[illegible]	[illegible]	--	[illegible]	--	[illegible]	--	--	[illegible]	[illegible]	--
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[illegible]	--	--	--	--	1.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
[illegible]	--	1.0	1.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
[illegible]	--	1.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
[illegible]	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1.	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
[illegible]	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
[illegible]	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
[illegible]	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
[illegible]	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

COMPOSITION OF ON-HIGHWAY TOWNS

	VARIABLE ACTIVITIES	POPULATION	CHURCH	GENERAL STORE	GAS STATION	BEAUTY SHOP	GROCERY	INS., RL. EST.	REST., CAFE	FEED AND SEED	AUTO REPAIR	BARBER SHOP	[illegible]
Lower Threshold			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
THRESHOLD POPULATION			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Upper Threshold			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
HOLLIS	[illegible]	[illegible]	[illegible]	--	12.5	8.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TISHOMINGO	[illegible]	[illegible]	[illegible]	--	10.5	[illegible]	[illegible]	7.0	10.6	[illegible]	[illegible]	4.0	[illegible]
RINGLING	81.0	[illegible]	[illegible]	--	7.0	5.0	5.0	[illegible]	5.0	1.0	[illegible]	[illegible]	[illegible]
WHEELER	81.0	[illegible]	[illegible]	--	7.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
PILOT POINT	72.0	[illegible]	[illegible]	--	7.5	5.0	[illegible]	[illegible]	[illegible]	[illegible]	--	[illegible]	[illegible]
SENTINEL	62.0	[illegible]	[illegible]	--	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
BINGER	[illegible]	[illegible]	[illegible]	--	[illegible]	[illegible]	1.5	1.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
HAIGT	[illegible]	[illegible]	[illegible]	--	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.0	[illegible]
ELMORE CITY	[illegible]	[illegible]	[illegible]	--	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
CHANNING	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

TABLE 8.--FUNCTIONAL COMPOSITION OF

COMPOSITION OF OFF-HIGHWAY TOWNS

correlation was identified between the total number of establishments and the population sizes of the two groups of towns selected for study (Fig. 10). The correlation coefficient (r) for this relationship is .967 for the thirty on-highway places and .968 for the thirty places in the off-highway group.

The wide variations in population size are matched by a wide range of establishments per town. The on-highway group ranged from 1.9 establishments in Montoya, New Mexico (population 24) to 180.5 establishments in Sayre, Oklahoma (population 3,273). The range in the off-highway towns is from 1.0 establishment in Brice, Texas (population 39) to 173.4 establishments in Hollis, Oklahoma (population 3,500). The similarity of the "r" values for both the on- and off-highway groups indicates that this basic relationship between total establishments and total population is not influenced to any large degree by a high volume of traffic. However, the number and types of establishments may differ between the two groups. For example, the on-highway town of Moriarty, New Mexico (population 979) has 71.0 total establishments, while the off-highway town of Estancia, New Mexico (population 949) has only 37.2 total establishments (Table 9). The relatively large difference in total number of establishments (33.8) is accounted for by the excess of businesses in Moriarty providing goods and services to highway travelers. There are 12 more gas stations, 11 more motels, 7 more restaurants and cafes,

FIG. 10

RELATIONSHIP BETWEEN POPULATION AND NUMBER OF ESTABLISHMENTS

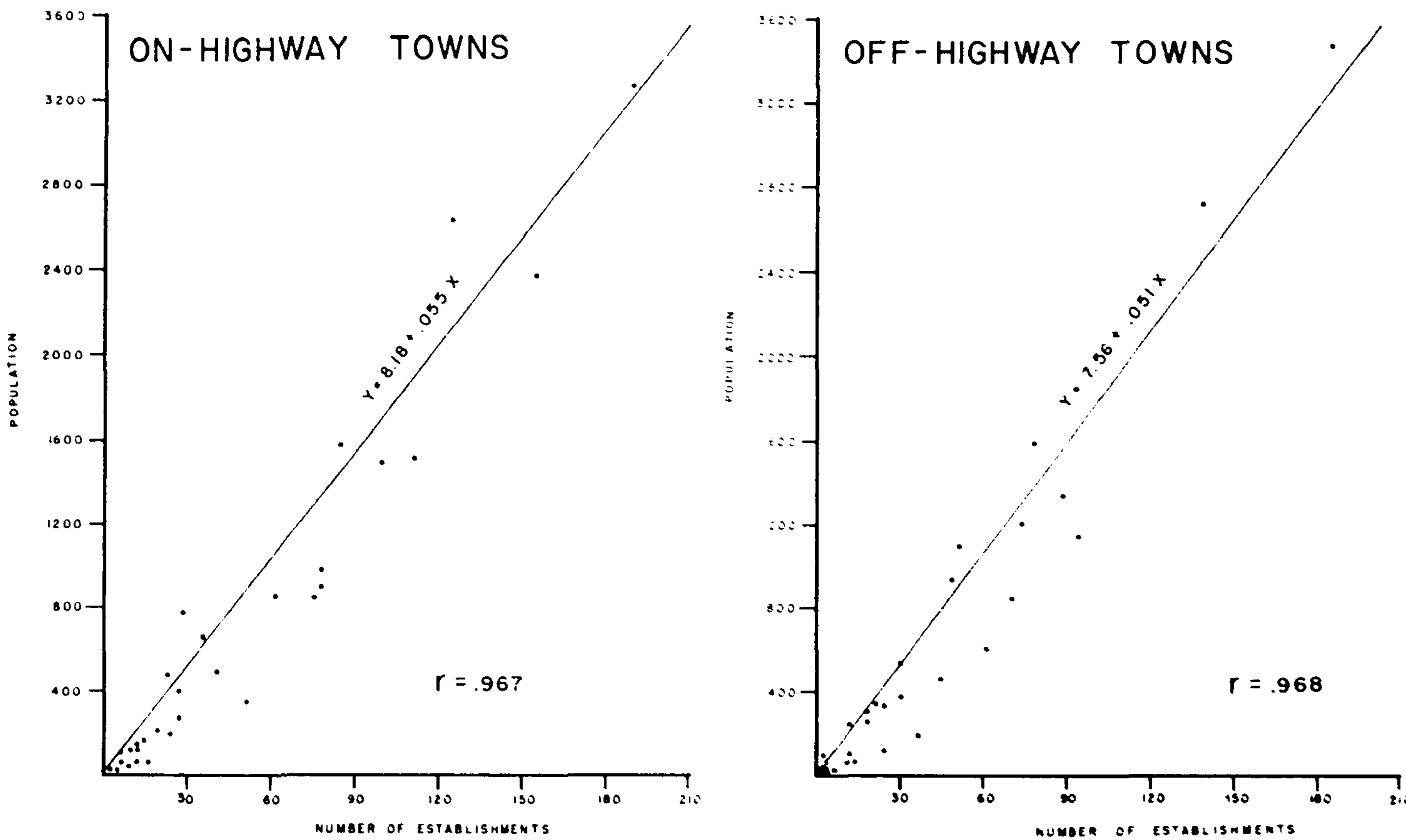


TABLE 9

COMPARISON OF THE FUNCTIONAL COMPOSITION OF AN ON-HIGHWAY TOWN (MORIARTY, NEW MEXICO) WITH AN OFF-HIGHWAY TOWN (ESTANCIA, NEW MEXICO)

Function	Number of Establishments	
	Moriarty	Estancia
Gas Station	14.0	2.0
Motel	11.0	0.0
Restaurant/Cafe	9.0	2.0
Auto Repair	5.0	1.0
Church	5.0	5.0
Gift Store	3.0	0.0
Tavern	3.0	2.0
Insurance/Real Estate	3.0	2.0
Barber Shop	2.0	1.0
Beauty Shop	2.0	2.0
T.V. Repair	2.0	2.0
Auto Parts	1.0	0.0
Farm Implement Dealer	1.0	0.0
General Welding	1.0	0.0
Junkyard	1.0	0.0
General Store	1.0	0.0
Post Office	1.0	1.0
Fraternal Organization	1.0	2.0
Bank	1.0	1.0
Laundromat	1.0	1.0
Bottled Gas Dealer	1.0	2.5
Grocery	1.0	1.0
Dry Cleaner (Depot)	1.0	0.0
Dry Cleaner (Establishment)	0.0	1.0
Hardware	0.0	1.0
Household Appliance	0.0	0.5
Feed and Seed	0.0	4.0
Medical Doctor	0.0	0.6
Dentist	0.0	0.6
Electric/Gas Co. Office	0.0	1.0
Clinic	0.0	1.0

and 4 more auto repair shops in Moriarty than in Estancia. Clearly, the additional establishments offering these four functions in Moriarty are supported, to a large degree, by the relatively high volumes of transient traffic passing through. Serving the passing traffic is a basic industry in Moriarty and other highway oriented towns.

Most Frequently Occurring Functions

The most frequently occurring functions in the two groups of towns are similar; however, the on-highway group shows a definite bias towards automobile travelers (Table 10). Of the five functions most commonly occurring in towns along a major highway, four are definitely concerned with catering to the needs of the traveler (gas station, restaurant/cafe, auto repair garage, and motel). Only the gas station and restaurant/cafe functions appear in the top five of the most frequently occurring functions on the off-highway list (Table 11). Gas stations occur most frequently among the on-highway towns, with churches being the second most common establishment. The reverse of this ranking appears on the off-highway list. With the exception of the top five ranked functions, the two lists are markedly similar. This fact implies that with only a few anomalies, small towns in the study area perform similar functions for their tributary area regardless of the location of these towns in relation to high volume of traffic arteries.

TABLE 10

RANK ORDER OF MOST FREQUENTLY
OCCURRING FUNCTIONS
(ON-HIGHWAY TOWNS)

Rank	Function	Frequency (Number of Establishments)
1.	Gas Station	171.6
2.	Church	127.0
3.	Restaurant/Cafe	102.5
4.	Auto Repair	67.5
5.	Motel	66.0
6.	Beauty Shop	61.0
7.	Grocery	51.3
8.	Insurance/Real Estate	40.0
9.	Tavern	33.0
10.	Barber Shop	29.4
11.	Feed and Seed	28.5
12.	Post Office	27.6
13.	Laundromat	27.0
14.	Fraternal Organization	24.0
15.	Drug Store	20.0
16.	Bottled Gas Dealer	20.0
17.	Dry Goods	19.5
18.	General Welding	17.0
19.	Medical Doctor	1[illegible].0
20.	New Car Dealer	14.0
21.	Domino/Pool Hall	14.0
22.	Bank	14.0
23.	Auto Parts	[illegible]
24.	Lumber Yard	13.5
25.	Family Clothing	13.0
26.	Second Hand Store	13.0
27.	Dry Cleaner (Establishment)	13.0
28.	T.V. Repair	13.0
29.	Farm Implement Dealer	12.5
30.	Gift Store	12.0
31.	Lawyer	12.0
32.	Liquor Store	11.0
33.	Junkyard	11.0
34.	Household Appliances	10.0
35.	Florist	10.0
36.	Osteopath/Chiropractor	10.0
37.	Electric/Gas Co. Office	10.0
38.	Hardware	9.5
39.	Rest Home	9.5
40.	Heating and Plumbing	8.0
41.	General Store	7.3
42.	Variety Store	7.0
43.	Furniture	7.0
44.	Funeral Home	7.0
45.	Frozen Food Locker	6.[illegible]
46.	Western Auto Type	6.0
47.	Hotel	6.0
48.	Clinic	5.5
49.	Dentist	5.0
50.	Dry Cleaner (Depot)	5.0
51.	Car Wash	4.0

TABLE 11

RANK ORDER OF MOST FREQUENTLY
OCCURRING FUNCTIONS
(OFF-HIGHWAY TOWNS)

Rank	Function	Frequency (Number of Establishments)
1.	Church	117.0
2.	Gas Station	85.3
3.	Beauty Shop	65.0
4.	Grocery	55.0
5.	Restaurant/Cafe	51.0
6.	Insurance/Real Estate	48.2
7.	Feed and Seed	42.0
8.	Auto Repair	32.5
9.	Barber Shop	30.2
10.	Fraternal Organization	27.0
11.	Post Office	25.8
12.	Bottled Gas Dealer	21.0
13.	Laundromat	21.0
14.	Dry Goods	19.0
15.	Tavern	19.0
16.	General Welding	17.5
17.	Domino/Pool Hall	17.0
18.	Second Hand Store	16.5
19.	Lumber Yard	15.0
20.	T.V. Repair	15.0
21.	Medical Doctor	14.0
22.	Drug Store	14.0
23.	Auto Parts	13.5
24.	Family Clothing	13.0
25.	Dry Cleaner (Establishment)	13.0
26.	Funeral Home	13.0
27.	Hardware	12.5
28.	Variety	12.0
29.	Household Appliances	12.0
30.	Liquor Store	12.0
31.	Bank	12.0
32.	New Car Dealer	12.0
33.	Motel	12.0
34.	Rest Home	11.0
35.	Electric/Gas Co. Office	10.0
36.	Lawyer	9.0
37.	Dry Cleaner (Depot)	9.0
38.	Clinic	9.0
39.	Heating and Plumbing	8.0
40.	Junkyard	8.0
41.	General Store	7.8
42.	Furniture	7.0
43.	Farm Implement	7.0
44.	Car Wash	7.0
45.	Frozen Food Locker	6.5
46.	Florist	6.0
47.	Western Auto Type	6.0
48.	Hotel	6.0
49.	Dentist	3.6
50.	Osteopath/Chiropractor	3.0
51.	Gift Store	2.0

The anomalies, however, become quite significant when the absolute number or frequency of establishments for each function is compared (Tables 10 and 11). There are more than twice as many gas stations, eating establishments, automobile repair shops, and motels in the on-highway group as are recorded for the communities composing the off-highway set. This points out a very interesting phenomenon. The total of all establishments in the on-highway group is 1,260.7, while the total number of establishments in the off-highway group is 1,030.9. The difference between these two figures, 229.8 is almost completely accounted for by the additional 226.5 automobile oriented establishments found along the highway. In other words, only four specific functions (gas stations, 86.3; eating places, 51.2; motels, 54.0; and auto repair garages, 35.0) account for the relatively large difference in total establishments between the two groups of places. The implication is that towns located along a heavily traveled artery have a greater number of establishments, but not necessarily a greater variety of functions than towns located away from a major road.

Comparison of Threshold Populations

The threshold population value provides a more refined measure for comparison of the two groups of places because it takes into account not only the gross number of establishments of various functional types, but it also relates this total number to the population size of each community. The list of functions ranked according to threshold populations is similar to the list based on total establishments alone (Table 12). This association reaffirms the high correlation reported previously between population size and number of establishments.

The lowest order functions, i.e., those with low threshold populations, are in most cases activities serving the automobile and the traveler. The function having the lowest threshold population and no apparent direct relationship to automobile travel is the church. At least one church is recorded for all but three of the sixty study towns. An interesting cultural trend can be identified with regard to this function. The nature of the predominant religion of a town is an important variable with respect to the number of places of worship in the town. In the western portion of the study area Catholicism is more prevalent, and under the parish system of spatial organization the number of individual churches is less than in the eastern part of the study area where smaller Protestant congregations are generally the rule (Fig. 11).

Sixteen functions have lower threshold populations for the on-highway group of places (Table 13). According to the present data, these sixteen functions require less local support among towns in the on-highway group; i.e., these functions will appear in smaller sized communities along a

TABLE 12

COMPARISON OF THRESHOLD POPULATIONS

Function	Threshold Population		
	On-Highway Towns	Off-Highway Towns	Difference
Gas Station	104	134	30*
Church	113	81	32
Restaurant/Cafe	140	200	60*
Auto Repair	164	253	89*
Beauty Shop	210	140	70
Motel	222	465	243*
Grocery	225	178	47
Insurance/Real Estate	273	190	83
Tavern	315	341	26*
Barber Shop	327	265	62
Feed and Seed	335	210	125
Gift Store	356	2007	1651*
Laundromat	358	385	27*
General Store	394	95	299
Fraternal Organization	404	302	102
Post Office	423	417	6
Osteopath/Chiropractor	449	1174	725*
Lawyer	459	562	103*
Dry Goods	459	367	92
Drug Store	460	522	62*
General Welding	482	361	121
Bottled Gas Dealer	483	377	106
Physician	484	470	14
Second Hand Store	515	350	165
Family Clothing	563	481	82
Dry Cleaner (Depot)	566	338	228
Farm Implement Dealer	576	492	84
T.V. Repair	583	486	97
New Car Dealer	595	528	67
Domino/Pool Hall	609	507	102
Liquor Store	614	374	240
Auto Parts	658	617	41
Electric/Gas Co. Office	696	488	208
Junkyard	729	881	152*
Dry Cleaner (Estab.)	744	613	131
Rest Home	752	508	244
Dentist	760	886	126*
Hardware	777	666	111
Lumber Yard	784	550	234
Variety Store	806	567	239
Bank	830	1123	293*
Household Appliances	832	693	139
Florist	907	1036	129*
Heating and Plumbing	981	715	266
Western Auto Type	983	643	340
Furniture Store	1017	744	273
Hotel	1065	1156	91*
Car Wash	1184	1473	289*
Funeral Home	1301	649	652
Clinic	1902	505	1397
Frozen Food Locker	1913	1737	176

*On-highway threshold population is lower.

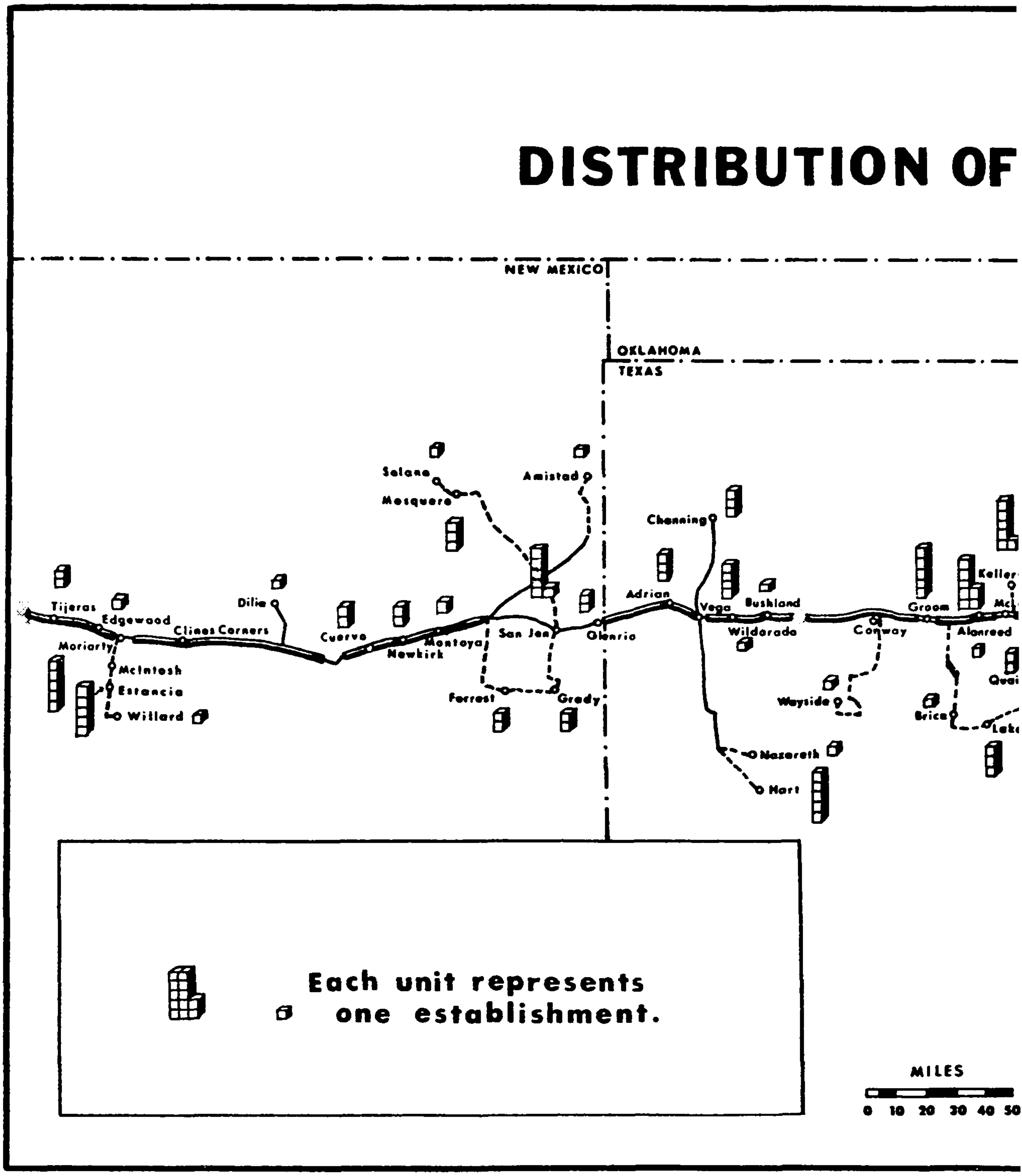
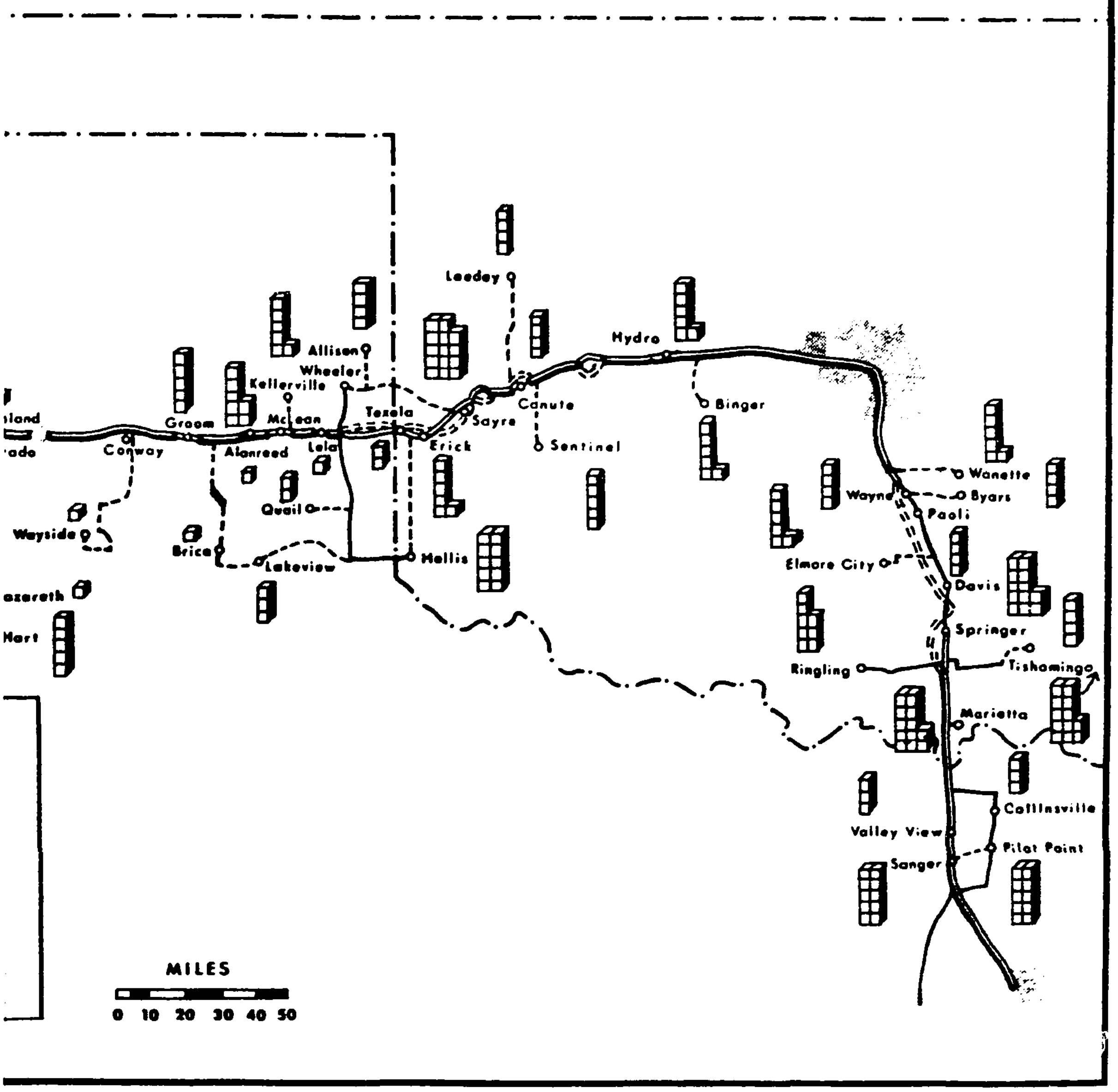

DISTRIBUTION OF
NEW MEXICO
OKLAHOMA
TEXAS
Solano
Mosquero
Amistad
Channing
Tijeras
Edgewood
Moriarty
Clines Corners
Dilia
Cuervo
Montoya
Newkirk
San Jon
Glenrio
Adrian
Vega
Bushland
Wildorado
Conway
Groom
Alanreed
McIntosh
Estancia
Willard
Forrest
Grady
Wayside
Brice
Nazareth
Hart
Each unit represents
one establishment.
MILES
0 10 20 30 40 50

FIG. 11

JTION OF CHURCHES



IG. 11

TABLE 13

FUNCTIONS WITH LOWER THRESHOLD POPULATIONS
AMONG ON-HIGHWAY TOWNS

Function	Threshold Population		
	On-Highway Towns	Off-Highway Towns	Difference
Gift Store	356	2007	1651
Osteopath/Chiropractor	449	1174	725
Bank	830	1123	293
Car Wash	1184	1473	289
Motel	222	465	243
Junkyard	729	881	152
Florist	907	1036	129
Dentist	760	886	126
Lawyer	459	562	103
Hotel	1065	1156	91
Auto Repair	164	253	89
Drug Store	460	522	62
Restaurant/Cafe	140	200	60
Gas Station	104	134	30
Laundromat	358	385	27
Tavern	315	341	26

heavily traveled traffic artery. To illustrate this point, a population of 465 is necessary before a motel will occur in a town located away from a major highway, while a motel will appear in an on-highway town when the population reaches 222.

Based upon gross differences between the threshold populations of the two groups of study places, the gift store function shows the greatest contrast. This variation can easily be explained by the large number of souvenir stands occurring along major tourist highways (Fig. 12). The ever present souvenir and curio shop along the highway seems to be a response to the almost insatiable demand of many American tourists for assorted plates, spoons, ash trays, and other "trinkets" which can be displayed on the mantle back home in testimony of last summer's journey.

A very noticeable trend illustrated in the list of functions with lower threshold populations among the on-highway group is the strong association with activities concerned with maintaining the operation and/or appearance of the automobile. Every community in the on-highway group of study towns possesses an establishment offering gasoline (Fig. 13). Most of the major national oil companies and many local or regional brands are represented along the highway. In addition to the minor repair facilities offered at most modern service stations, a wide variety of specialty auto repair shops are more prevalent among major highway towns (Fig. 14). The automatic or "do it yourself" car wash is a

DISTRIBUTION OF GIFT

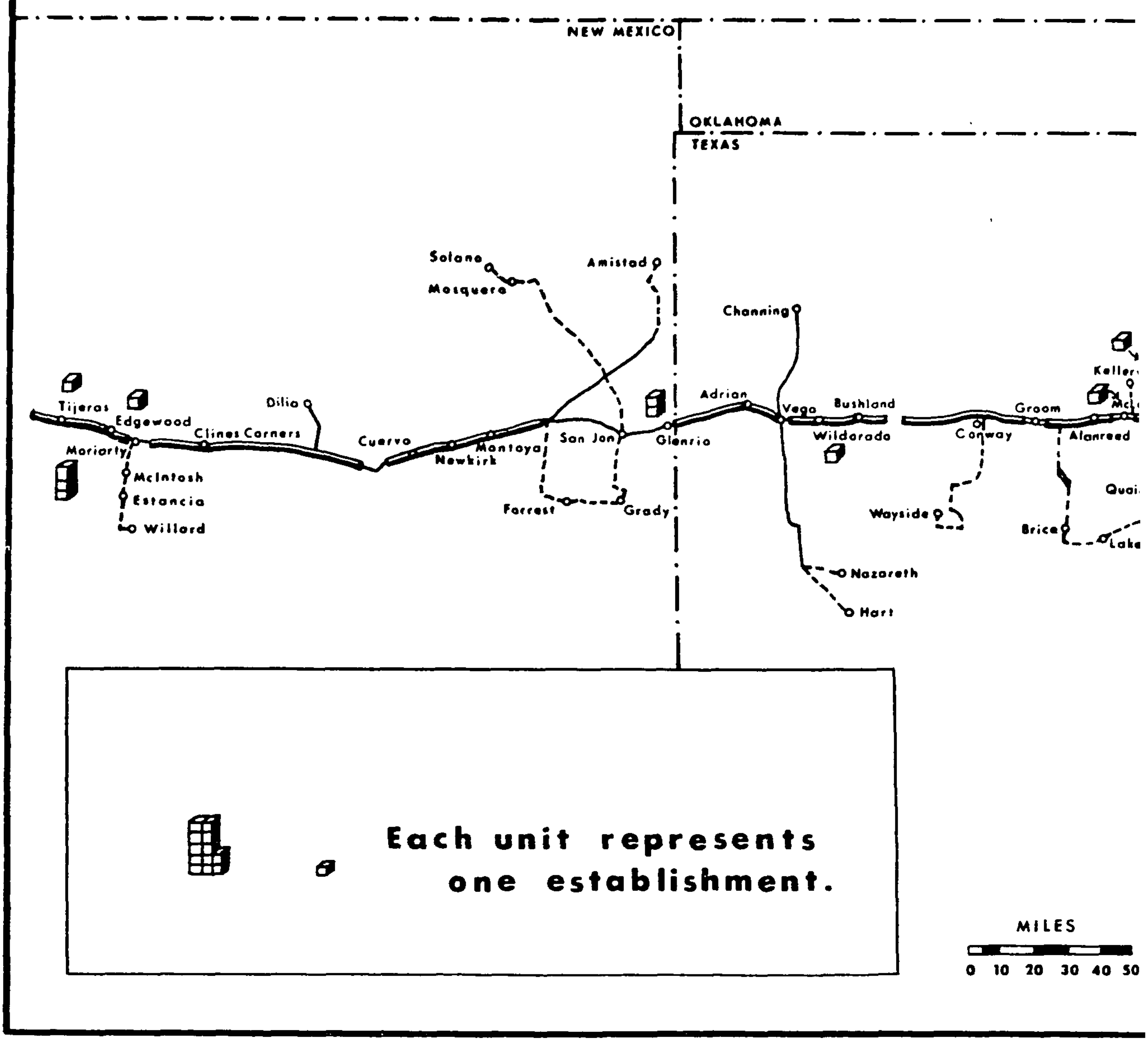


FIG. 12

)F GIFT STORES

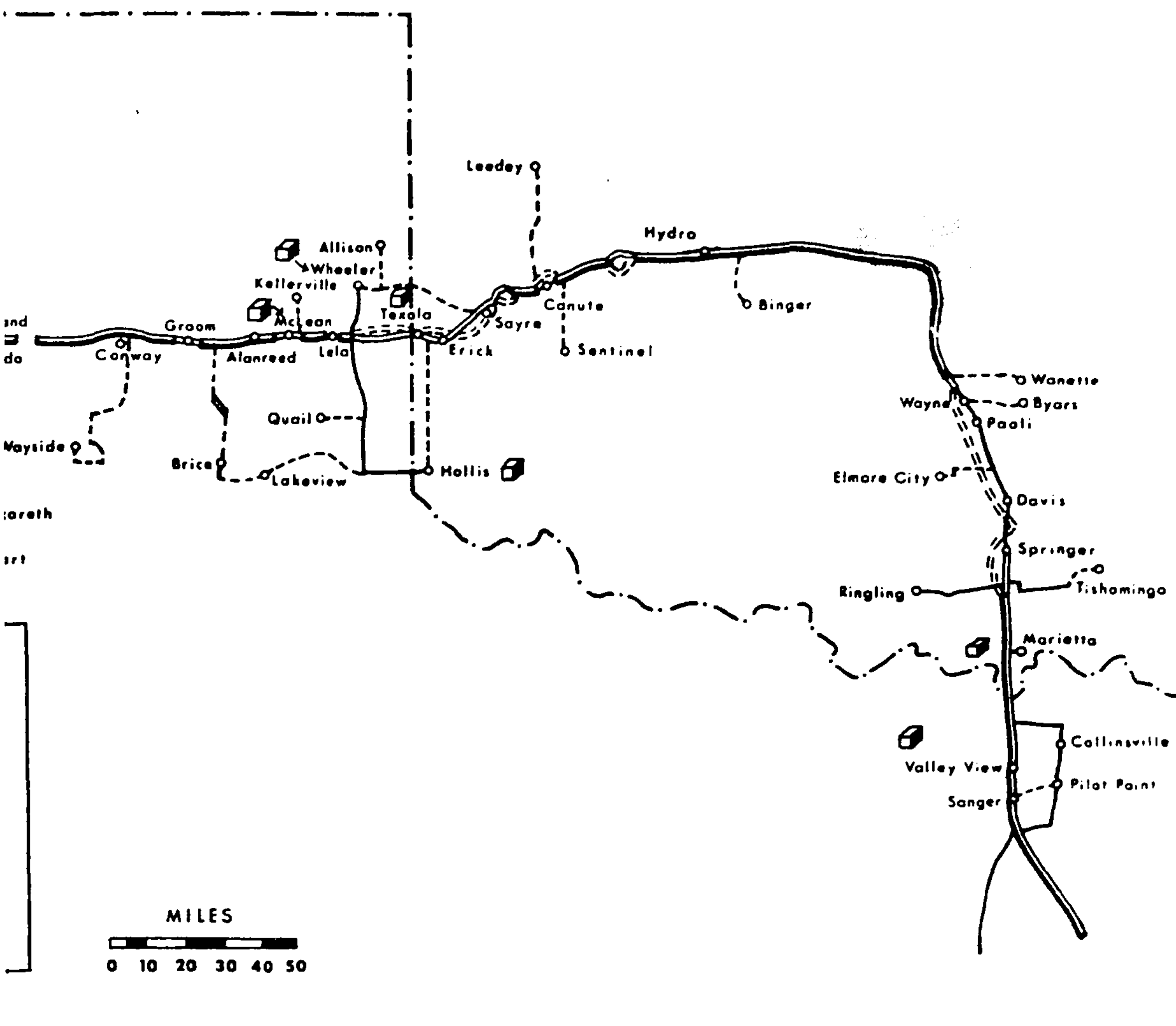


FIG. 12

DISTRIBUTION OF GAS

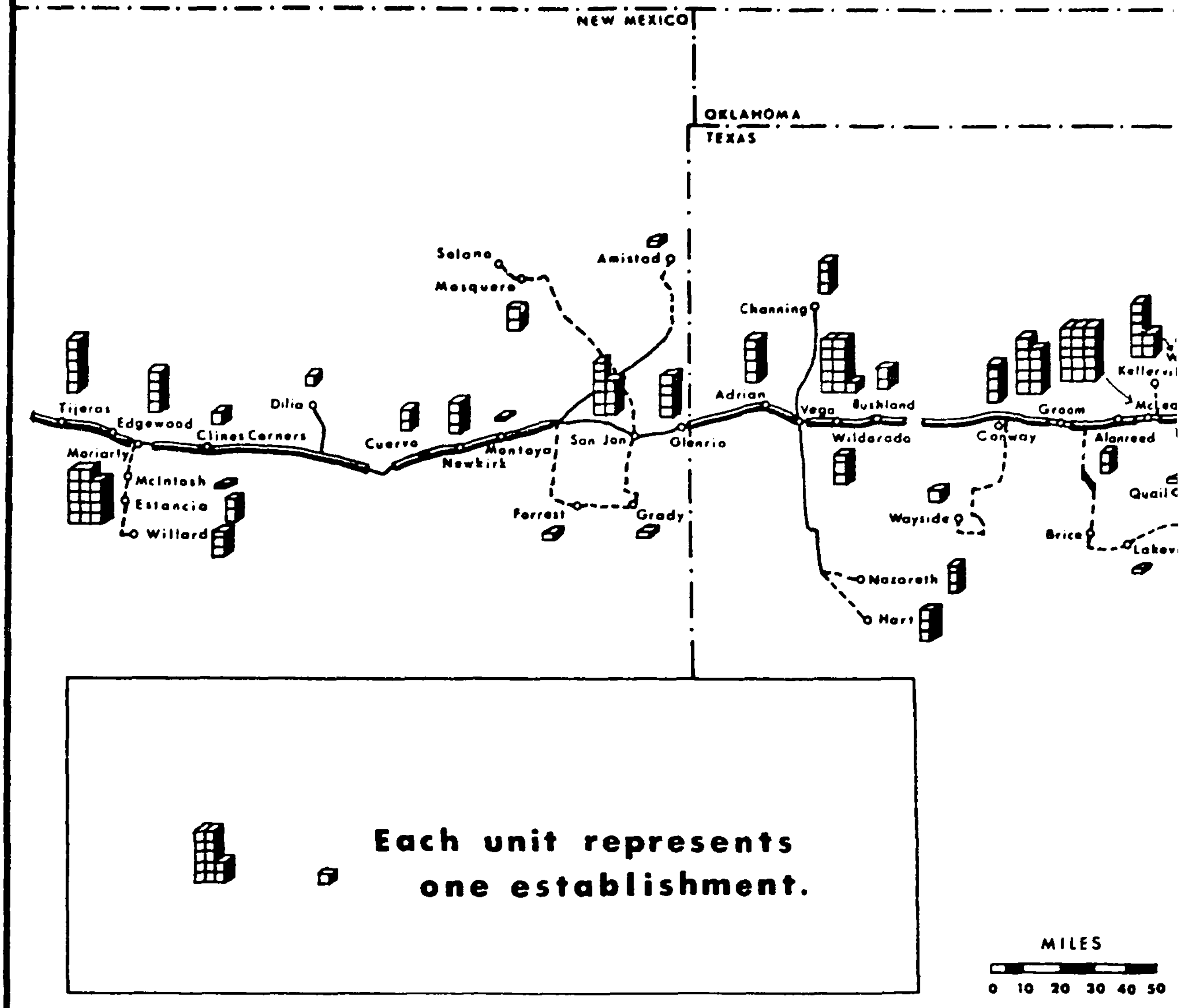


FIG. 13

N OF GAS STATIONS

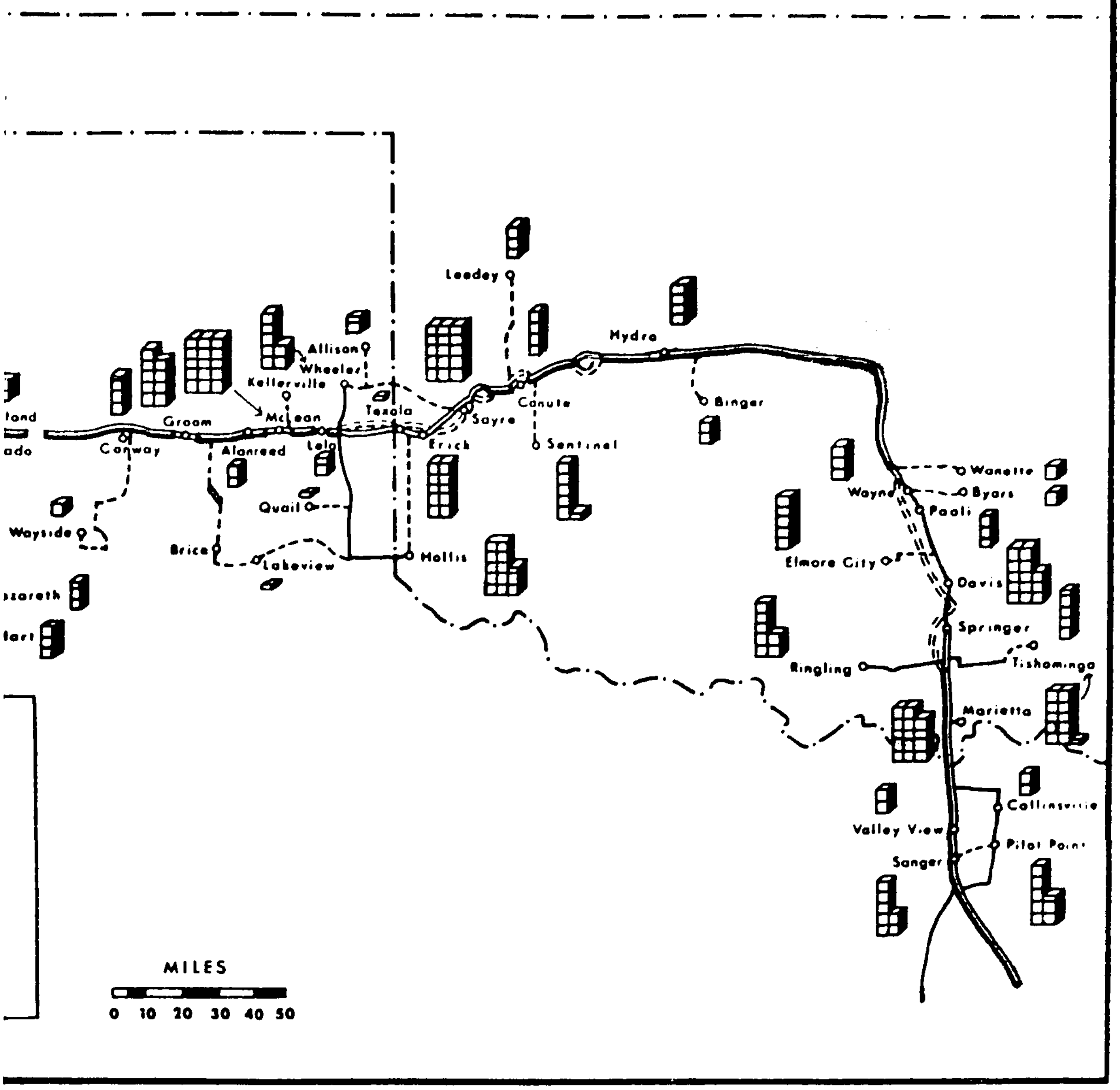


FIG. 13

DISTRIBUTION OF AUTO

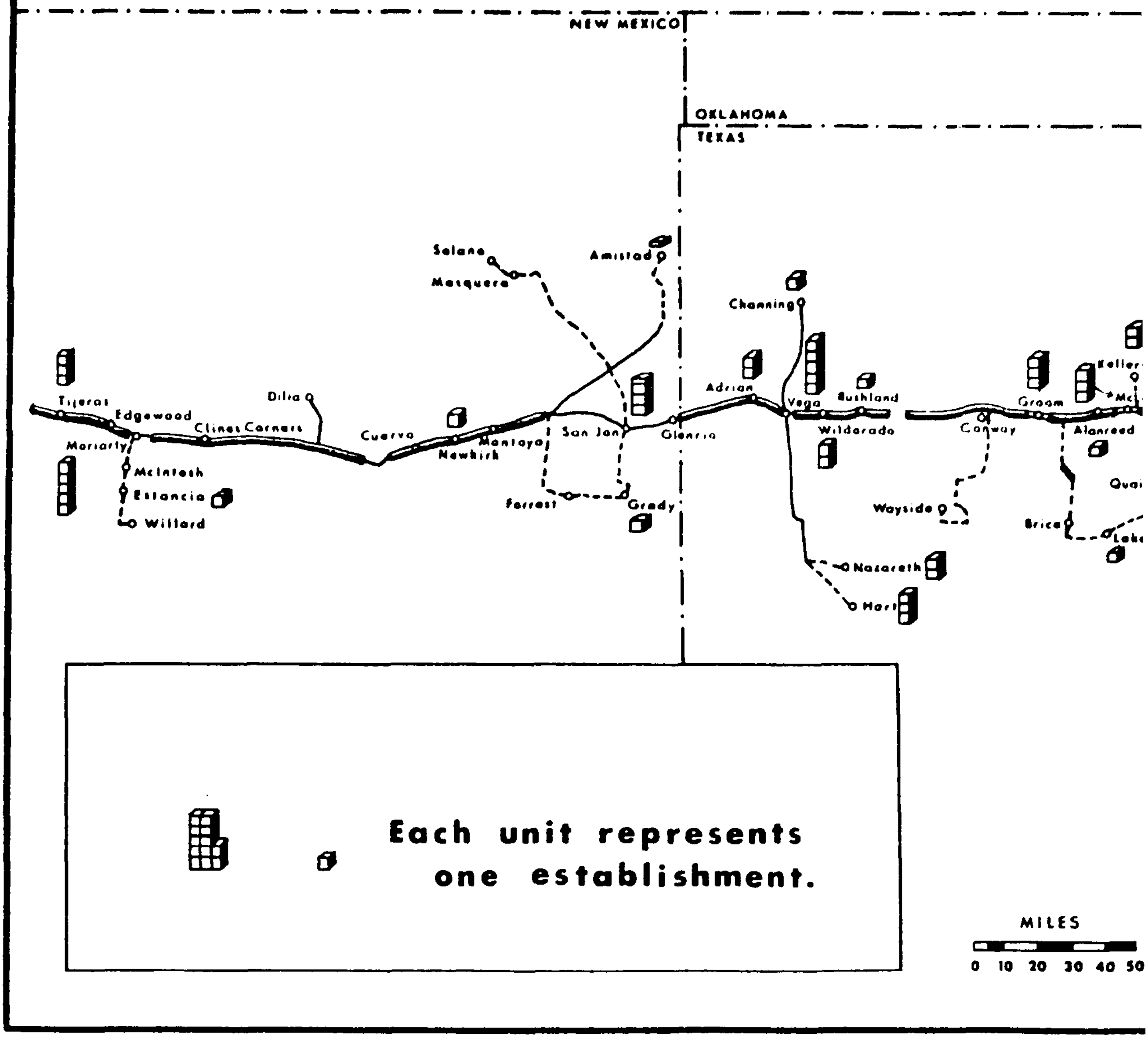


FIG. 14

AUTO REPAIR GARAGES

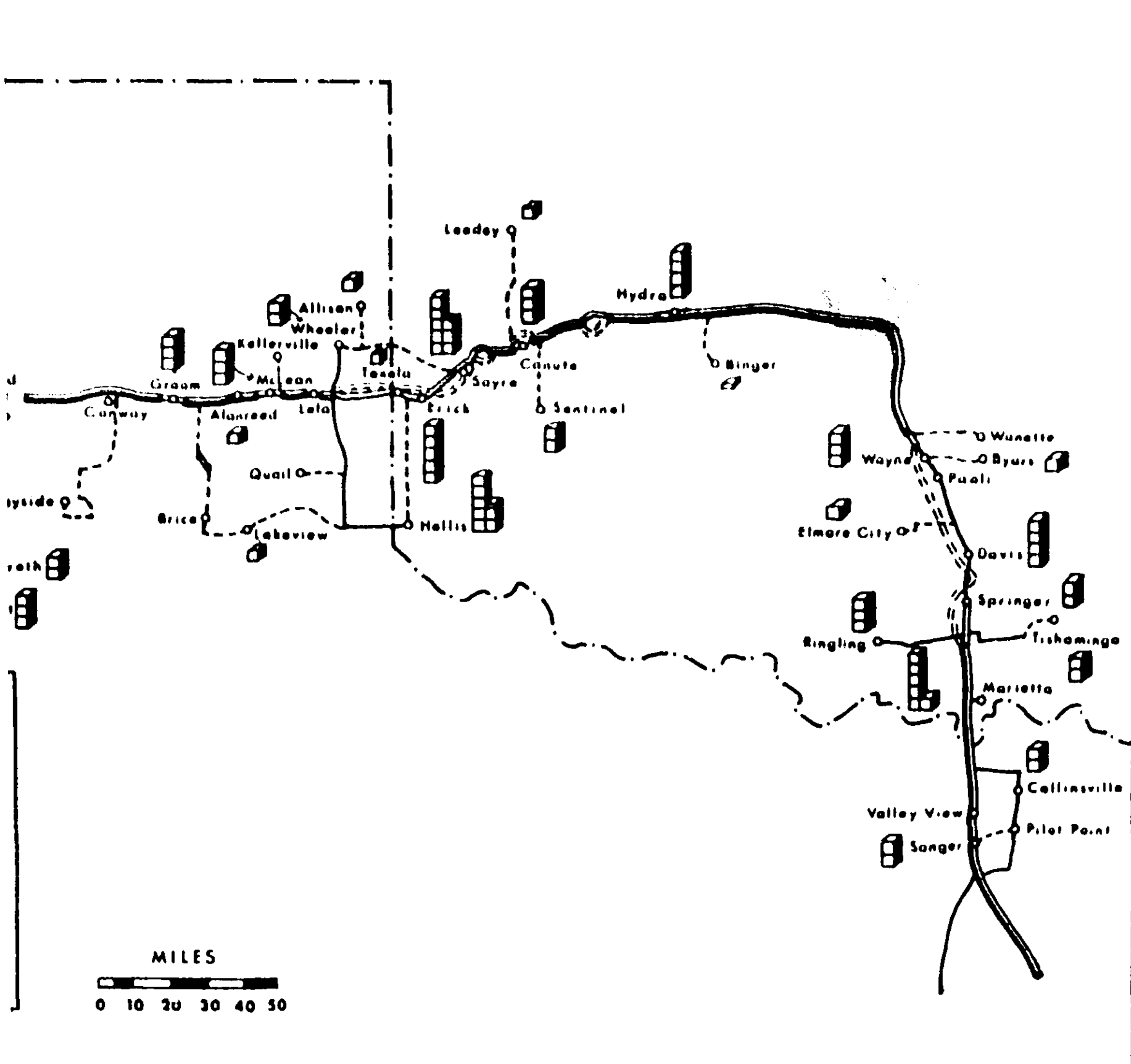


FIG. 14

relatively recent phenomenon on the landscape. The difference of 289 units in the threshold population of this function between the two groups of places indicates that it is influenced by a high volume of traffic.

No specific data were collected to identify the proportion of the business of these automobile service functions accounted for by non-local traffic; however, the spatial orientation to the major thoroughfare of the establishments offering this type of service indicates a strong reliance upon transient trade. As the traveler enters a typical on-highway town he is bombarded by a myriad of signs and advertisements attempting tc attract his attention and business (Fig. 15). The importance of transient traffic to the support of many service stations is illustrated clearly in towns where the Interstate Highway has been completed and the urban bypass channels traffic away from the main street of the town. Numerous gas stations along the old route are abandoned (Fig. 16), and in many cases new and modern stations are opened at an interchange on the Interstate Highway. Usually these moves do not involve changes in management or ownership; the move is simply a reaction to the rerouting of through traffic. Therefore, in addition to the evidence supplied by lower threshold populations for these functions among major highway towns, the location of automobile service establishments within the town indicates that these functions derive an important proportion of

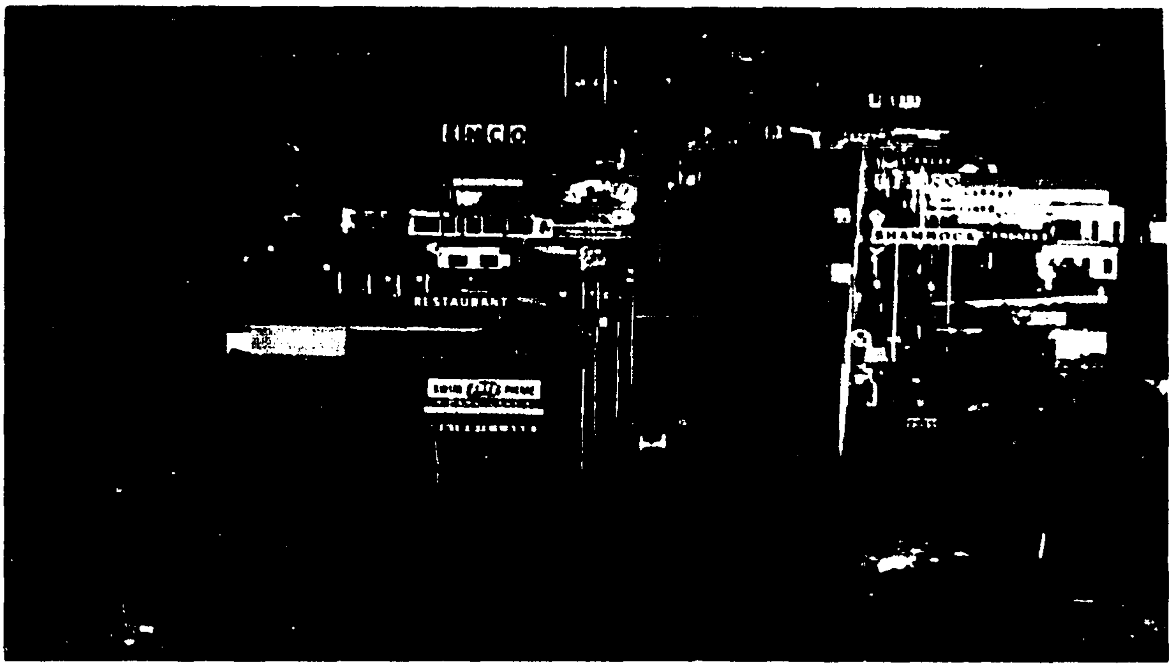


Fig. 15. --U. S. 66 entering Santa Rosa, New Mexico

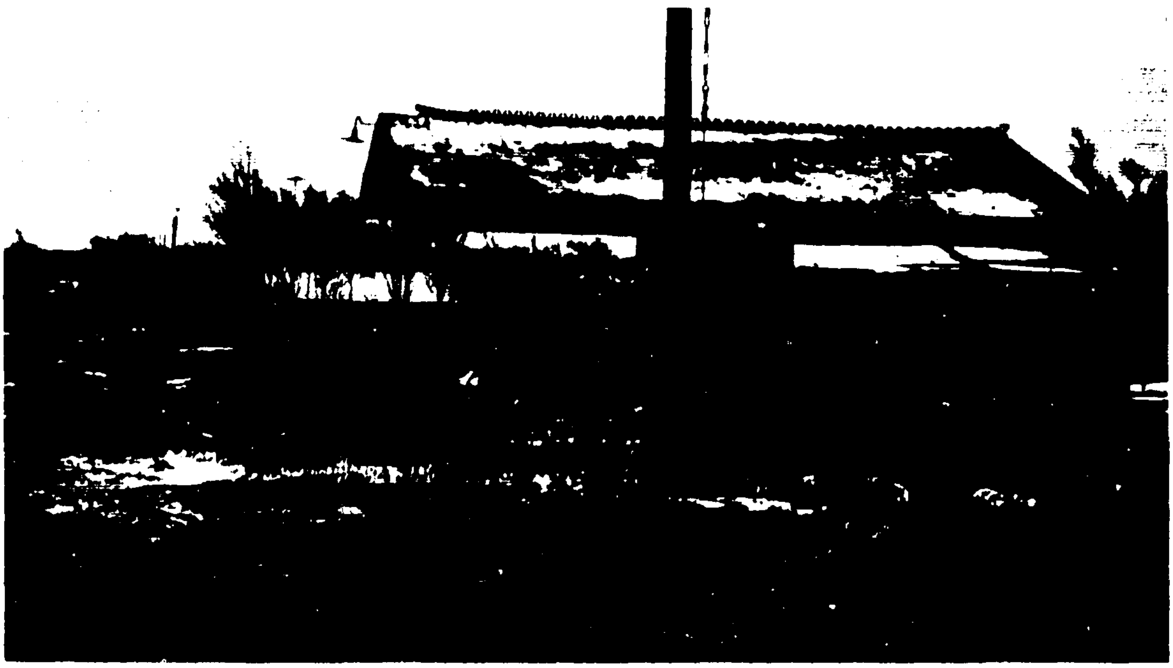


Fig. 16. --Abandoned gas station in Alanreed, Texas

their support from non-local sources, i.e., through traffic.

Another group of functions with lower threshold populations for towns located along an artery carrying relatively high volumes of traffic are those which cater to the basic needs of travelers. As might be expected, eating places such as restaurants and cafes, and drinking places such as taverns, can survive in smaller places along a major highway because much of the support of these establishments is provided by travelers desiring food and drink during their journey. This group of establishments shows the same type of locational orientation as was noted previously for gas stations, auto repair shops and car washes. Drive-in restaurants and other assorted franchised food outlets are common occurrences in towns on main inter-regional routes (Fig. 17). The numerous drive-in eating places which offer curb service are attractive to the traveler who desires quick satisfaction of his food needs. Certainly, many local residents patronize these eating establishments, but the proliferation of them in highway towns attests to the support provided by hungry travelers.

Establishments such as motels and hotels, which offer a place for rest and relaxation, are clearly oriented to high volumes of inter-regional traffic (Fig. 18). There is a much greater difference in threshold populations for motels than hotels between the two groups of study places, although each of these functions has a lower threshold population in

DISTRIBUTION OF RESTA

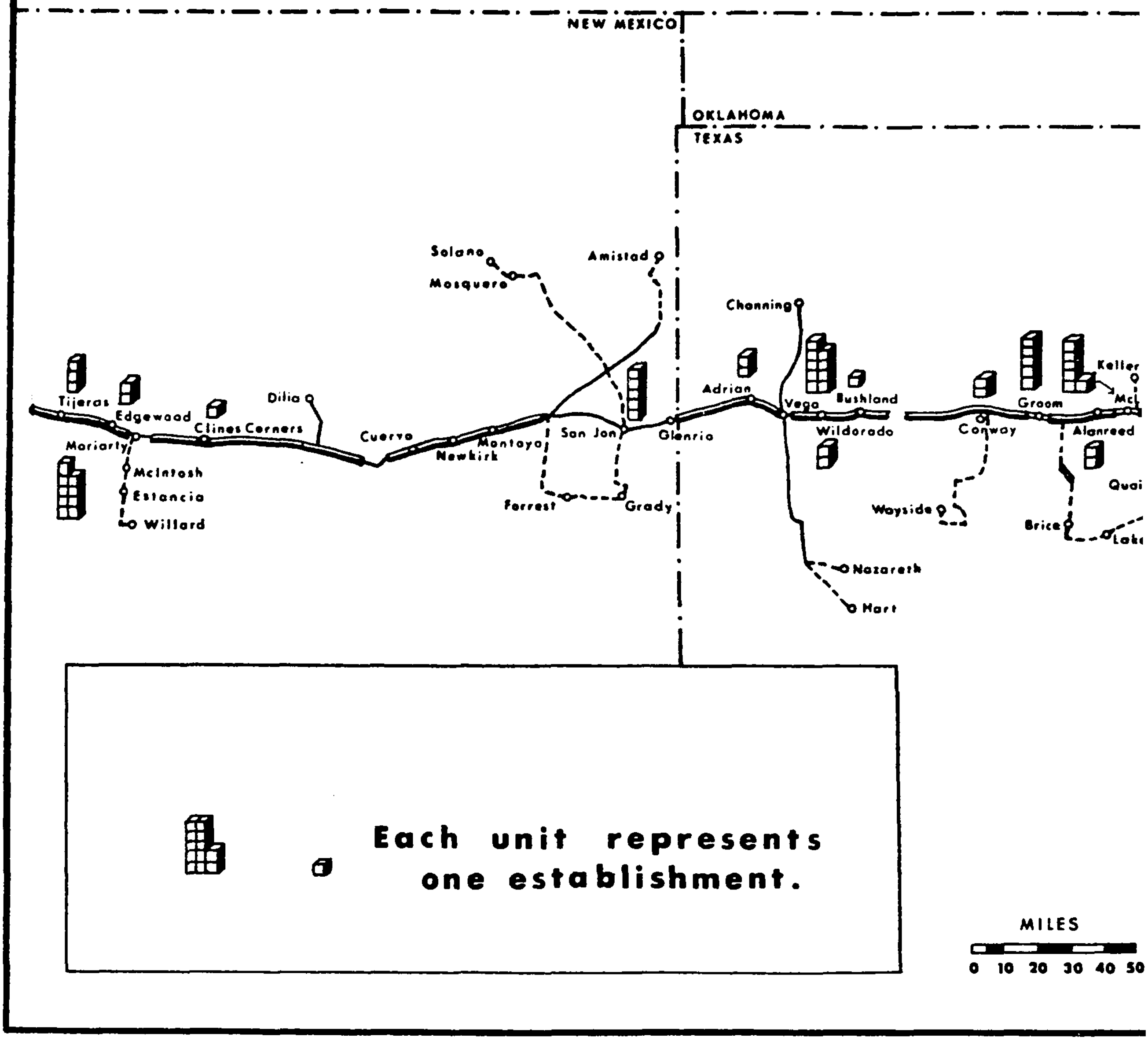


FIG. 17

F RESTAURANTS/CAFES

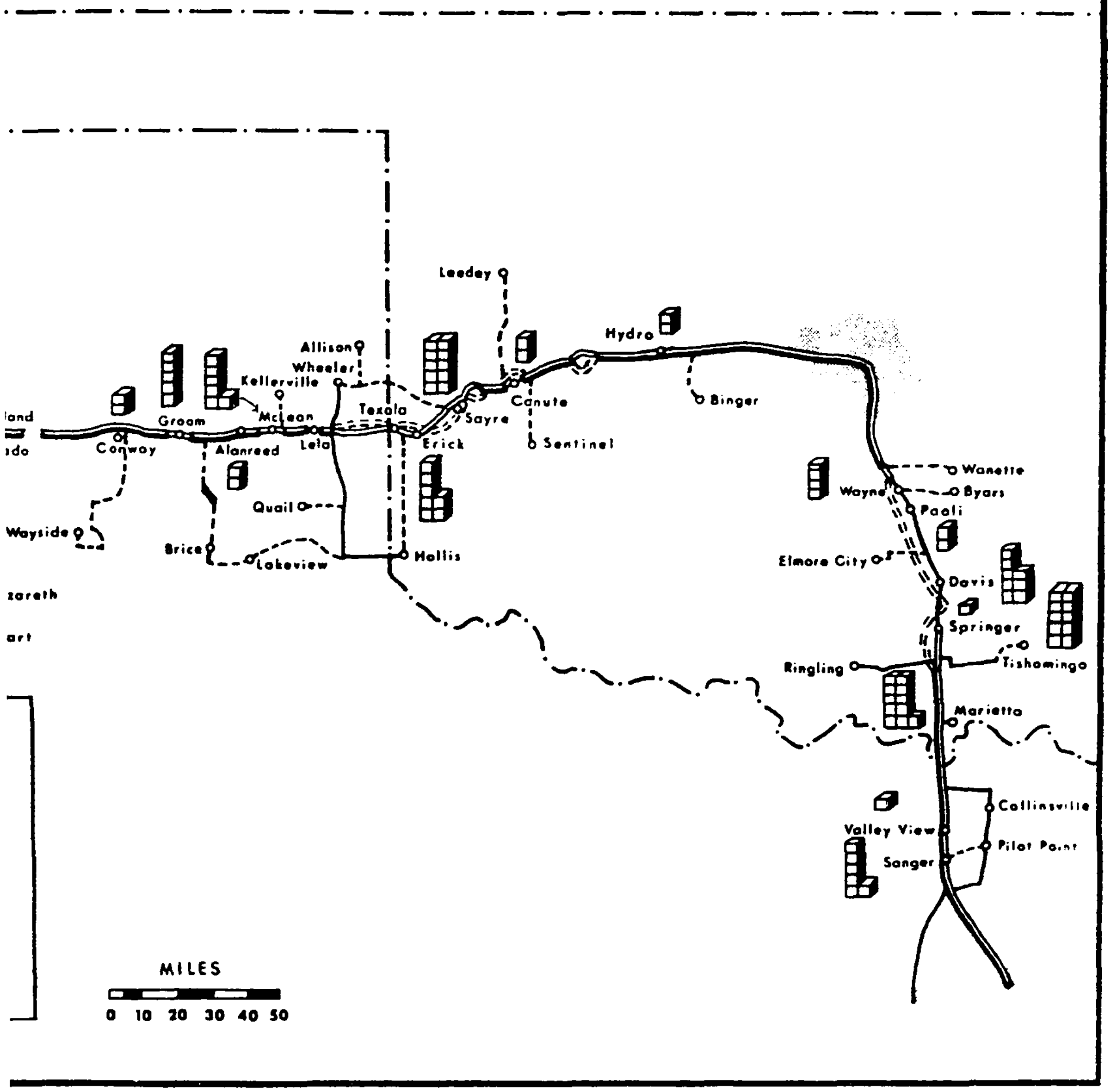


FIG. 17

DISTRIBUTION OF

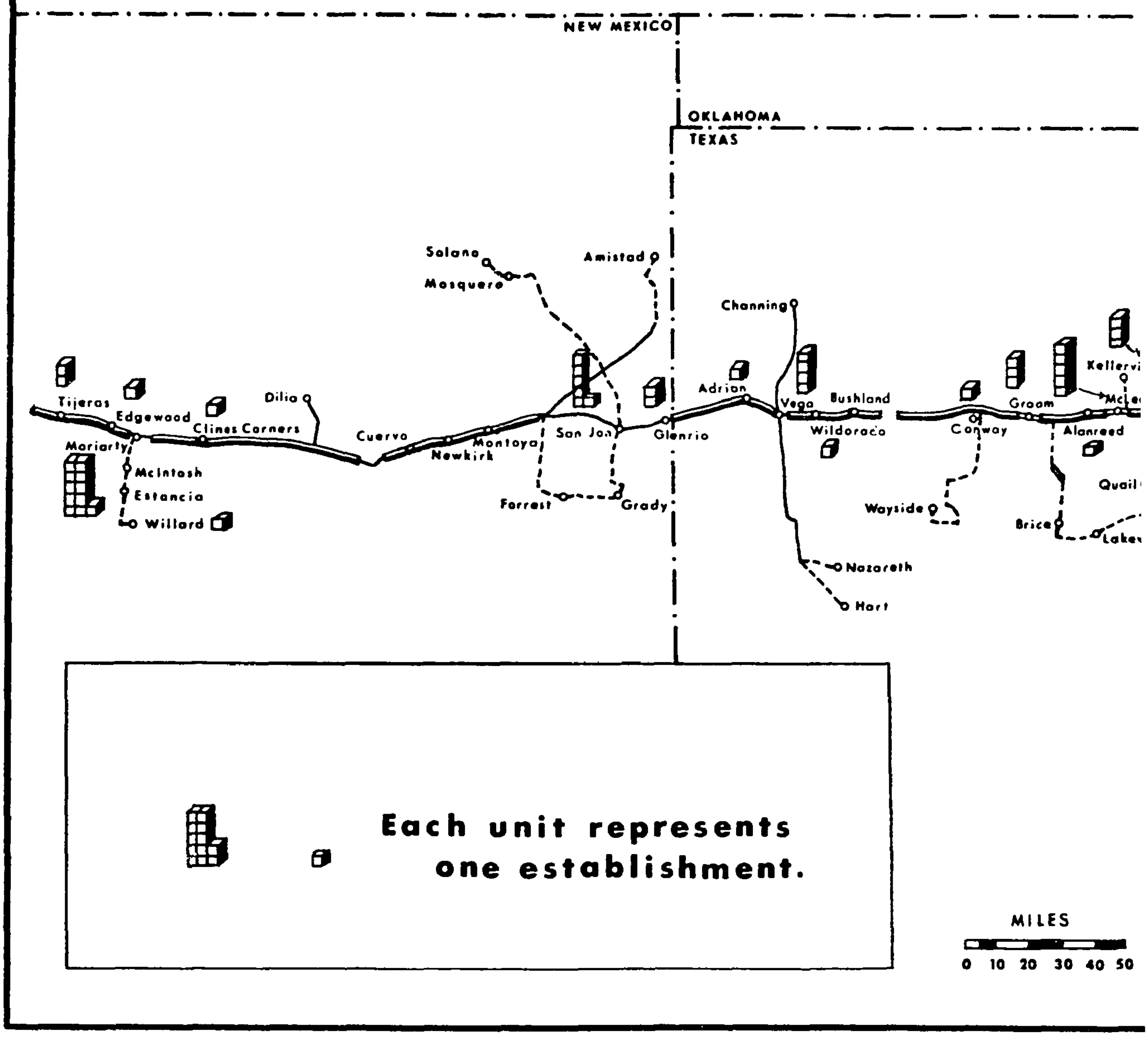


FIG. 18

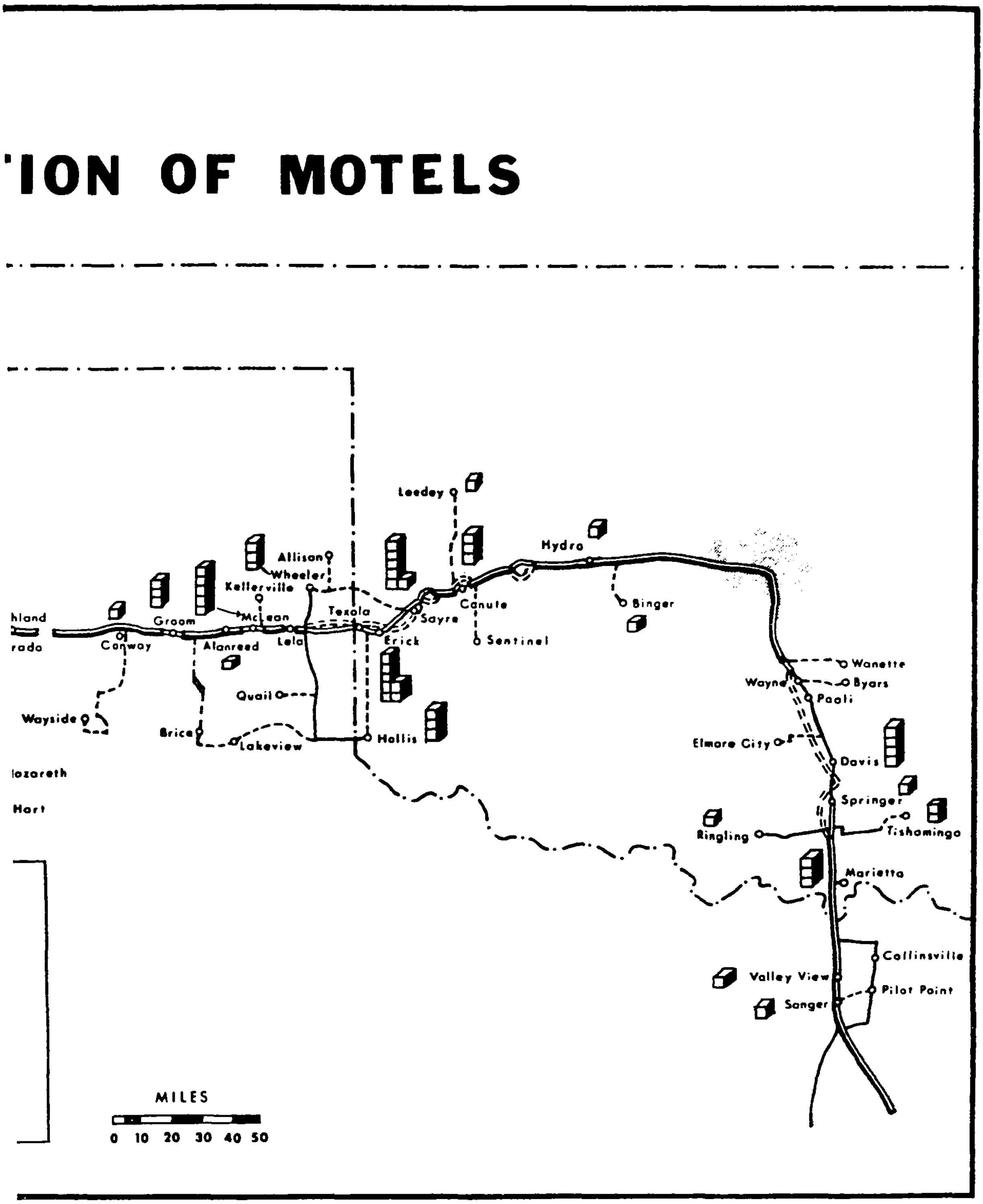

'ION OF MOTELS
Leedey
Hydro
Allison
Wheeler
Kellerville
Texola
Sayre
Canute
Binger
Sentinel
hland
Groom
McLean
rado
Conway
Alanreed
Lela
Erick
Quail
Wayside
Brice
Lakeview
Hollis
lazareth
Hart
Wanette
Wayne
Byars
Paoli
Elmore City
Davis
Springer
Ringling
Tishomingo
Marietta
Collinsville
Valley View
Pilot Point
Sanger
MILES
0 10 20 30 40 50

FIG. 18

on-highway towns. Hotels in the study area tend to be considerably older in age than motels. The hotels are generally located in close proximity to an existing or former railroad route. Thus, although these establishments, motels and hotels, seem to offer similar services, the clientele of each is quite distinct. In fact, many hotels in the study area derive an important proportion of their support from permanent tenants, who have apartments in them.

Motels are not only more recent in construction than hotels, but also they are strongly oriented to highway traffic. The nature of the services provided by a motel is such that only a small proportion of its support is provided by local customers. Overwhelmingly, it is the long distance traveler who supports the establishments along "motel row."

The appearance of the tavern as a highway oriented establishment raises some interesting points. First of all, it should be pointed out that the liquor laws vary throughout the study area. In Oklahoma only beer is sold in public taverns, whereas in New Mexico taverns may serve mixed drinks in addition to beer. A more complex situation is found in Texas where each county has an option concerning the sale of alcoholic beverages. Even in the "wet" counties in Texas, only beer can be sold in public taverns. The variability of liquor laws is quite important in explaining the difference in threshold populations for taverns between the two groups of study places. Unusual concentrations of such establishments are noted wherever a "wet" jurisdiction is adjacent to a "dry" area. This point is clearly illustrated along the route of I.H. 40 through the Texas Panhandle (Fig. 19) The gateway counties, Wheeler on the east and Oldham on the west, are both completely "dry." Adjacent to each of these Texas counties are the border towns of Texola, Oklahoma and Glenrio, New Mexico. The economies of these two towns are influenced markedly by the fact that they can legally provide alcoholic beverages to their neighbors living under a different political jurisdiction. Texola, with 12 total establishments, has 4 taverns and 1 package liquor store. Of the 16 establishments in Glenrio, 5 are taverns. Hence political geographic patterns can also influence the threshold population value.

It might be argued that the support of these border towns is dependent more upon their function as a "wet" oasis in an alcoholic desert than upon their function as a highway oriented service center. However, the easy access provided by a high speed thoroughfare is an important factor in the development of these places as suppliers of alcoholic beverages.

The variability of liquor laws is manifested somewhat differently among the off-highway group of towns. The liquor store is much more common in this group of places (Fig. 20), whereas the tavern is more prevalent along heavily used highways. For example, Nazareth, Texas is a "wet spot" surrounded by "dry" territory; there are 4 liquor stores and 1.5 taverns in this off-highway town. The implication of this

DISTRIBUTION OF TA

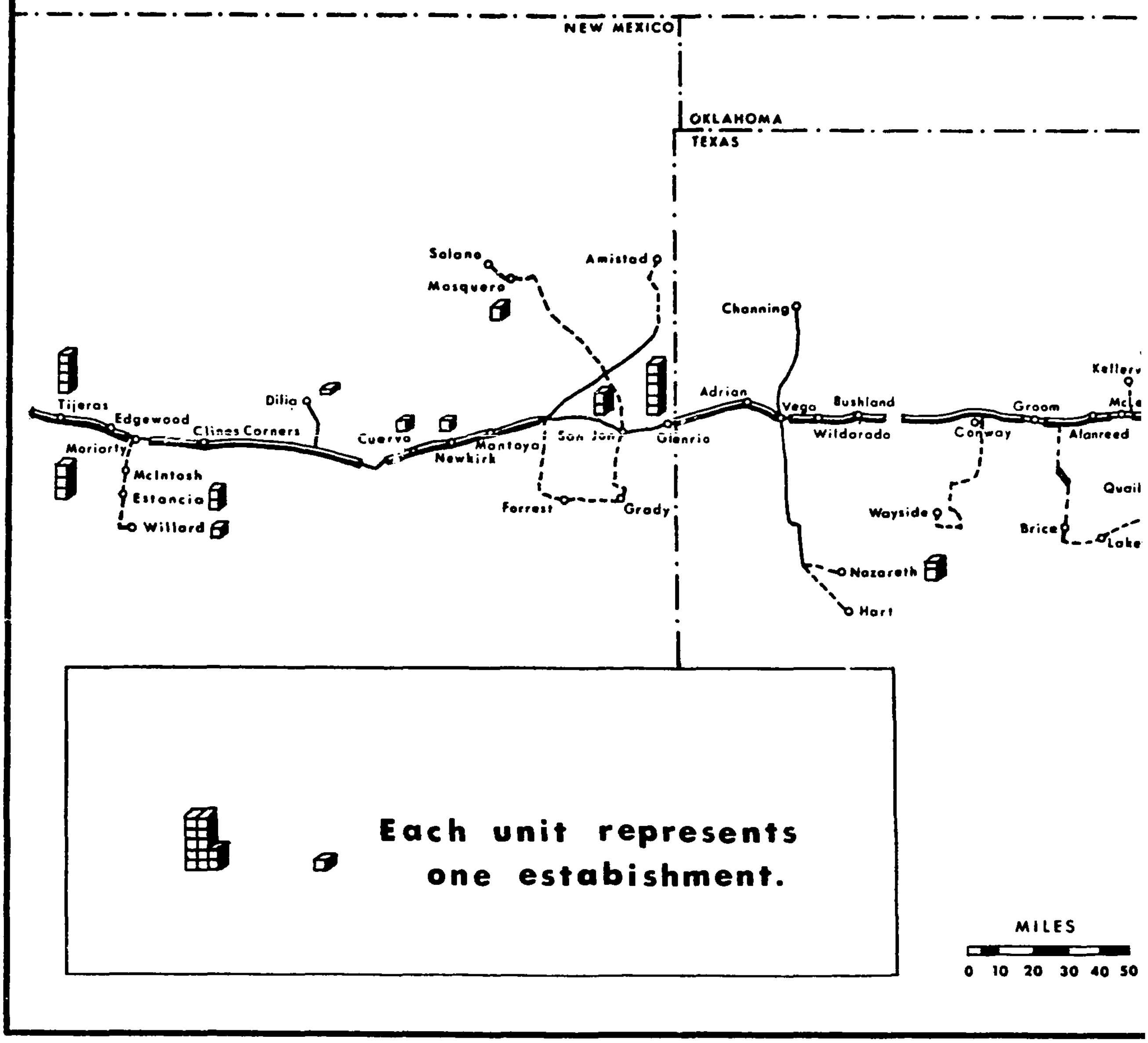


FIG. 19

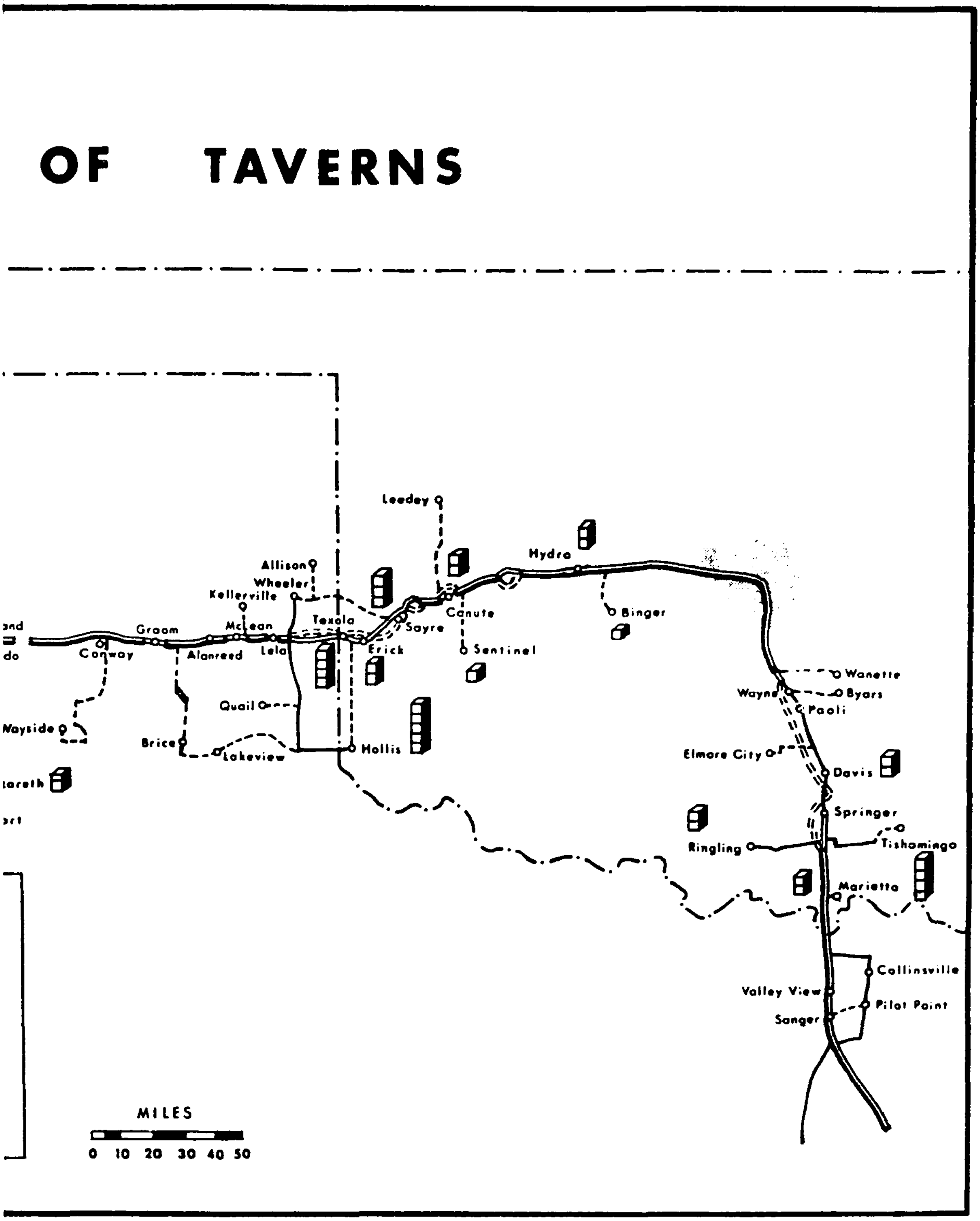

OF TAVERNS
Leedey
Hydra
Allison
Wheeler
Kellerville
Groom
McLean
Texola
Sayre
Canute
Binger
Conway
Alanreed
Lela
Erick
Sentinel
Quail
Wayside
Brice
Lakeview
Hollis
Wanette
Wayne
Byars
Paoli
Elmore City
Davis
Springer
Ringling
Tishomingo
Marietta
Collinsville
Valley View
Pilot Point
Sanger
MILES
0 10 20 30 40 50

FIG. 19

DISTRIBUTION OF LIQU

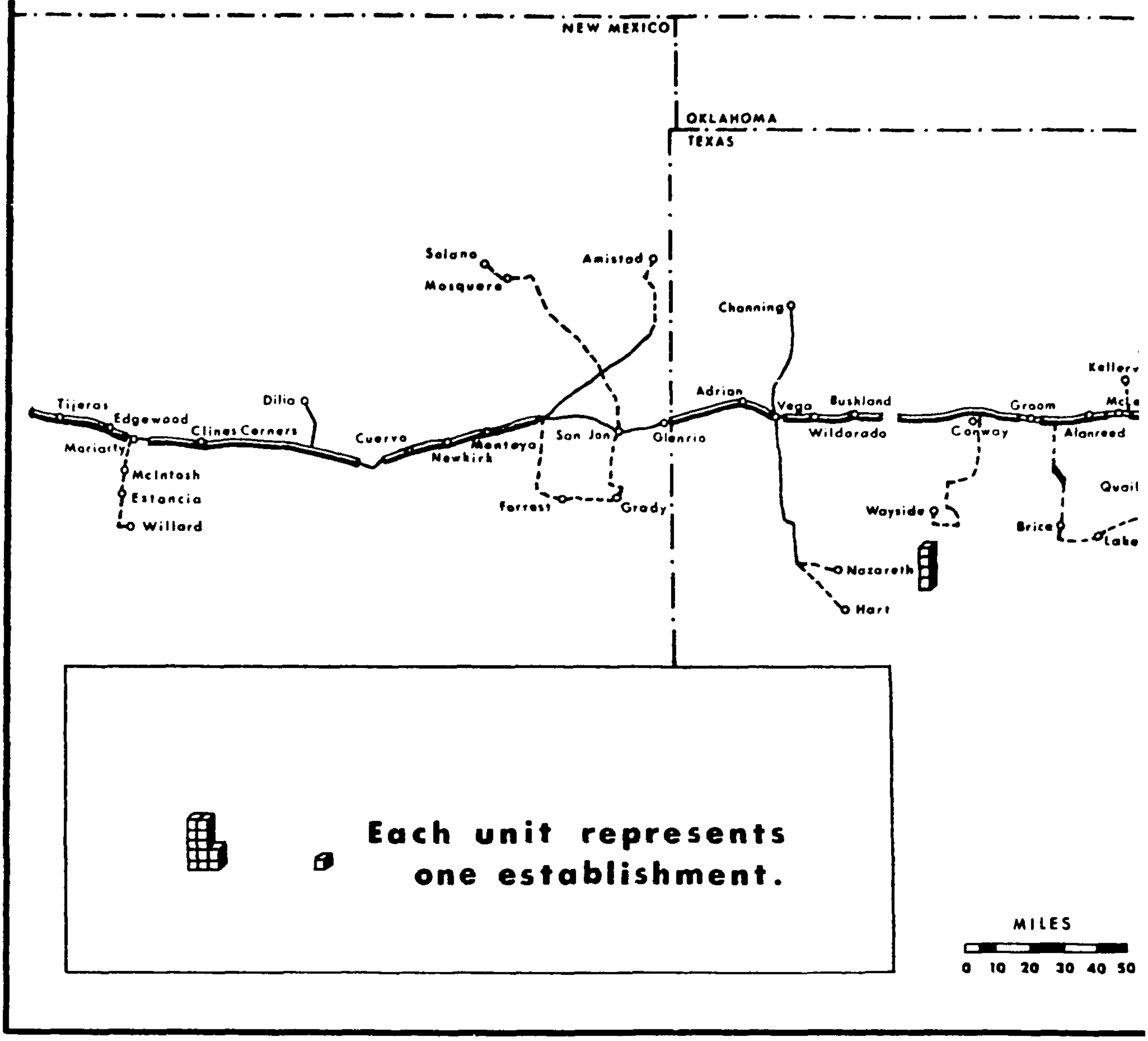


FIG. 20

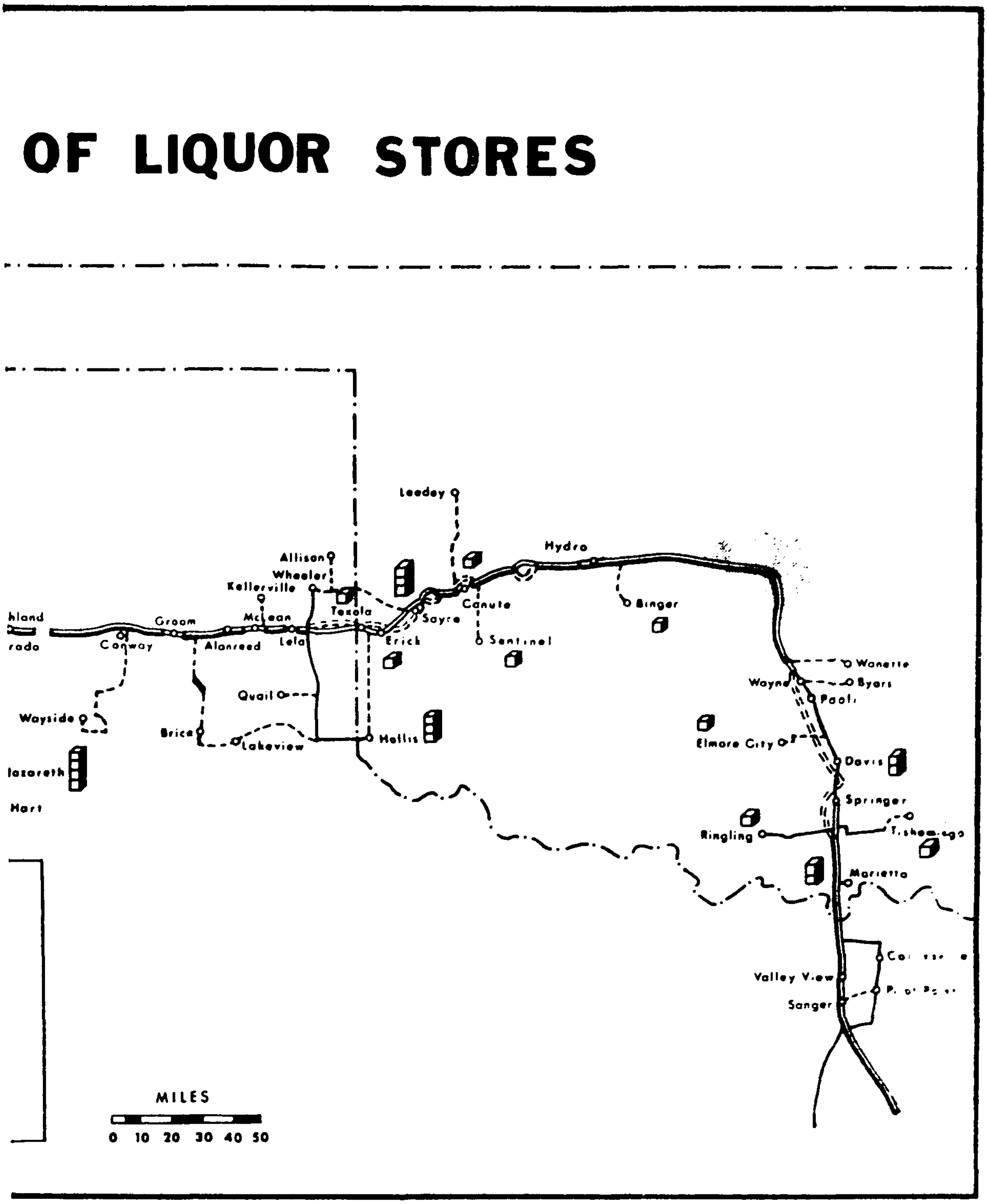

OF LIQUOR STORES
Leedey
Allison
Wheeler
Kellerville
Hydro
Texola
Canute
Binger
Sayre
Groom
McLean
Erick
Sentinel
Conway
Alanreed
Lela
Wonette
Wayne
Byars
Paoli
Quail
Wayside
Brice
Lakeview
Hollis
Elmore City
Davis
Springer
Ringling
Marietta
Valley View
Sanger
Hart
MILES
0 10 20 30 40 50

FIG. 20

is that off-highway towns serve the liquor needs of the immediate hinterland, whereas on-highway towns such as Texola or Glenrio serve not only the local area but also the traveler passing by. The nature of the two functions is such that travelers are more likely to make a short refreshment stop at a tavern than at a liquor store.

Significant Differences Between Threshold Populations

Lower threshold among on-highway towns

Of the previously discussed functions which have lower threshold populations for the on-highway group, only five show a statistically significant difference between the two groups of study places (Table 14). These five functions are: gas station, auto repair, restaurant/cafe, gift store, and motel. Two separate standard statistical difference tests were applied to the data. Both of these tests, the difference between the means test for non-paired variables and the difference between the means test for paired variables, resulted in similar conclusions. At the .05 significance level, the most common level used in social science research,[1] these five functions are significantly different between the two groups of places. This finding permits the rejection of the null hypothesis that there is no significant

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[1]Hubert M. Blalock, Jr., Social Statistics (New York: McGraw-Hill Book Co., 1960), p. 161.

TABLE 14

COMPUTED "t" STATISTICS FOR FUNCTIONS WITH LOWER THRESHOLD POPULATIONS AMONG ON-HIGHWAY TOWNS

Function	Paired Variable Test "t" Statistic	Non-Paired Variable Test "t" Statistic
Gas Station	4.932[a]	2.782[b]
Auto Repair	4.436[a]	2.434[b]
Restaurant/Cafe	4.297[a]	2.197[b]
Motel	4.039[a]	3.579[b]
Gift Store	2.408[a]	2.380[b]
Tavern	1.721[c]	1.323
Florist	1.682	.941
Drug Store	1.579	.869
Laundromat	1.549	.795
Car Wash	1.361	.896
Junkyard	1.000	.766
Bank	1.000	.455
Dentist	.664	.354
Lawyer	.516	.396
Hotel	0.0	0.0

[a]Significant at .05 significance level (critical t at .05 level with 29 degrees of freedom = 2.048).

[b]Significant at .05 significance level (critical t at .05 level with 58 degrees of freedom = 2.000).

[c]Significant at .10 significance level (critical t at .10 level with 29 degrees of freedom = 1.700).

difference between the threshold populations of functions offered in on- and off-highway towns. Therefore, the first specific hypothesis of this study, which stated that certain central place functions will possess significantly lower threshold populations if the place offering that function is located along a route carrying a high volume of traffic, is accepted.

The remaining eleven functions with lower threshold populations for the on-highway group do not show a significant difference at the .05 significance level. It can be concluded that these functions are not influenced as greatly by a high volume of traffic as the aforementioned five which showed a strong statistically valid difference. The appearance of this latter group of eleven functions on the list of functions with lower threshold populations may be due to random sampling error; however, the chances are high that they are also related to the traffic flow. The data illustrate that these functions are influenced to some degree by high volumes of traffic, but the influence is not strong enough to cause a significant difference between the threshold populations of the two sets of study towns. However, it should be pointed out that the tavern function, although not significantly different according to the "t" test employed at the stated significance level, shows a "t" statistic that is significant at the .10 acceptance level.

Seven functions have lower threshold populations for the on-highway group of towns, but they do not illustrate the strong nearly absolute locational orientation to the major inter-regional highways as observed in the functions discussed previously. That is, it is common to find the establishments offering one of these seven functions located some distance away from the major highway running through town. The seven functions can be grouped as professional services (lawyer, dentist, osteopath/chiropractor, and bank) and personal services (laundromat, drug store, and florist). The fact that these functions have lower threshold populations for towns along a primary highway cannot be readily explained. The most probable cause is random sampling error for this particular case study; thus, it cannot be assumed that these seven functions will have lower threshold populations among on-highway towns in any future similar investigation. None of these seven functions show a significant statistical difference between the threshold populations of the two groups of places at either the .05 or .10 significance levels (Table 14).

Lower threshold among off-highway towns

Thirty-five functions have a lower threshold population among off-highway towns. That is, nearly 70 percent (68.6) of the variable functions considered in this investigation require a lower population size for off-highway towns than for places located along a route with relatively high average daily traffic volumes. However, only one of these functions, the funeral home, shows a statistically significant difference between threshold populations for the two study groups at the .05 significance level (Table 15). In fact, no other function listed in Table 15 is significant, even at the .10 significance level.

This situation contrasts sharply with that discussed previously concerning functions influenced by a high volume of traffic. Of the 15 functions with lower threshold populations among the on-highway set of places, one-third (5) are significantly different at the .05 level of significance, and one other function showed a significant difference at the .10 significance level. Viewed in another perspective, only a few of the functions offered by small towns are significantly influenced by a high volume of traffic passing through the community. The presence of a high traffic volume influences the threshold population of more functions than does the absence of such traffic.

A significantly lower threshold population for the funeral home among the off-highway group of places was not anticipated and cannot be readily explained. It was expected that functions such as feed and seed stores and farm implement dealers, which are directly related to serving an agriculturally based trade area, would have lower threshold populations in towns located away from a major highway. The implication of this finding is that small central places in

TABLE 15

COMPUTED "t" STATISTICS FOR FUNCTIONS WITH LOWER THRESHOLD POPULATIONS AMONG OFF-HIGHWAY TOWNS

Function	Paired Variable Test "t" Statistic	Non-Paired Variable Test "t" Statistic
Funeral Home	2.693[a]	1.296
Feed and Seed	1.663	1.392
Variety Store	1.581	.912
Dry Cleaner (Depot)	1.161	1.034
Church	1.095	.378
Farm Implement Dealer	.938	1.033
Insurance/Real Estate	.843	.499
Clinic	.815	.725
Second Hand Store	.754	.435
Hardware	.733	.672
Fraternal Organization	.722	.403
Domino/Pool Hall	.682	.515
Household Appliances	.680	.416
Grocery	.632	.206
Post Office	.597	.298
Lumber Yard	.551	.280
New Car Dealer	.528	.316
Beauty Shop	.472	.203
T.V. Repair	.441	.308
Rest Home	.441	.249
Doctor	.298	.130
Barber Shop	.297	.085
Bottled Gas Dealer	.250	.167
Liquor Store	.205	.151
General Store	.155	.154
Dry Goods	.120	.060
General Welding	.093	.065
Heating and Plumbing	0.0	0.0
Family Clothing	0.0	0.0
Furniture	0.0	0.0
Western Auto Type	0.0	0.0
Dry Cleaner (Estab.)	0.0	0.0
Auto Parts	0.0	0.0
Electric/Gas Co. Office	0.0	0.0
Frozen Food Locker	0.0	0.0

[a]Significant at the .05 significance level (critical "t" at .05 significance level with 29 degrees of freedom = 2.048).

the study area provide goods and services for agricultural activities regardless of the location of the place in relation to an inter-regional traffic artery. Thus, towns along a heavily used route receive economic support from highway travelers as well as from residents of the local trade area. Actually only five automobile oriented functions appear to derive an important portion of their support from the transients passing through the on-highway places.

The data collected for this study show that a town located along a high volume traffic artery requires at least a population of 1,301 before a funeral home will establish there. On the other hand, an off-highway community can support this function with a population of 649. All towns in the on-highway group with populations of 1,301 or more have at least one funeral home. There are no funeral homes located in major highway towns having populations smaller than 1,301. Even more significant is the fact that the six on-highway towns with populations between 649 and 1,301 do not have any funeral homes.

This situation implies that residents of towns along a main highway with a population of less than 1,301 are willing to travel to a larger, higher order place when they need the services provided by a funeral home. The relative ease of traveling on a high speed road offers the residents of on-highway towns an alternative shopping place, a larger more diversified center. This possibility, then, pirates some of the support away from the local community so that it cannot offer a service such as a funeral home. The off-highway towns, due to poorer transportation links, do not have such a ready alternative. Since it is not as easy, in terms of either time or effort, to travel to a larger center, the residents of communities located away from a major highway do not partition their support for functions such as a funeral home among higher order places. The result is that a funeral home can be supported in a smaller town if there is no easily accessible alternative.

In addition, there may be several non-economic factors which help to explain the lower threshold population of funeral homes among off-highway places. In small towns there tends to be a strong personal relationship developed between the undertaker and the residents of the service area. Most of the funeral homes in the study area have been in business for a long time, and they are well established in the community. This enterprise may be an illustration of a function that is one of the last to be affected in a town or region experiencing population decline. This function, due to tradition or some other cause, may be able to survive once it is established long after its initial support level has withered away.

Nevertheless, due to the fact that funeral homes show a significantly higher threshold population among towns in the on-highway group, the second specific hypothesis of this study is accepted. This hypothesis, which stated that certain central place functions will possess significantly higher threshold populations if the place offering that function is located along a route carrying a high volume of traffic, can be accepted only with regard to one function, the funeral home. The remaining 34 functions with higher threshold populations among on-highway towns do not show enough difference between the two groups of places to be statistically significant. According to the present data, the slight differences noted for these 34 functions can be attributed to random sampling error.

Six separate functions, which show a significant difference at the .05 level of significance between the two groups of study places, have been identified. Motels, gas stations, auto repair shops, restaurants/cafes, and gift stores have significantly lower threshold populations for towns along a major highway, whereas funeral homes have a significantly higher threshold population among the towns in this group. In addition, the tavern function shows a significant difference of threshold population between on- and off-highway places at the .10 significance level. Therefore, with respect to the present data, seven functions are influenced by high average daily traffic volumes along major highways. The remaining 44 variable functions considered in this investigation show no significant difference of threshold population between the two sets of study places. These results support the acceptance of the third study hypothesis which stated that certain central place functions possess threshold populations that do not significantly differ regardless of location in relation to a major transport artery.

Summary

All three of the specific study hypotheses are accepted. It has been shown that high average daily traffic volumes do, indeed, influence the functional offerings of small central places in the study area. However, this influence is restricted to only a relatively small number of functions; the great majority of functions (86.3 percent) are not significantly influenced by high average daily traffic volumes. Transient trade provides a significant proportion of the economic support for a small number of automobile oriented functions offered in towns along a major highway. On the other hand, a high speed route provides residents of these towns ready access to an alternative shopping place; the effect of this is that some of the support for certain functions is funneled away from the local community. In the main, however, most functions offered in small towns are not significantly influenced by the traffic volume variable.

CHAPTER VI

CONCLUSIONS

The facts presented in the preceding chapters have demonstrated that relatively high average daily traffic volumes do influence the functional offerings of small towns in the study area. Five functions, represented by gas stations, motels, auto repair shops, restaurants/cafes, and gift stores, can survive and prosper in significantly smaller communities located along the route of a major inter-regional highway. These functions are definitely oriented to transient motorists, who provide an important share of the economic support of the establishments offering these services. These travelers are also helping to maintain the existence of a number of small places whose economies are based, to a large degree, on non-local trade. This latter point has often been overlooked in discussions dealing with the decline of small service centers in the United States. Thomas, in his investigation of small Iowa towns, recognized this dichotomous situation when he stated, "while the combination of the automobile and all-weather roads has led to the economic decline of the small town, at the same time that combination now provides the basis of its existence."[1]

The implications of this to the general body of Central Place Theory are noteworthy. The support for selected functions in towns located along major highway routes is derived from a combination of both local and non-local sources. The numerous travelers passing through these towns provide support for a large number of establishments catering predominantly to the needs of these transients. These automobile oriented functions can be considered as a basic industry of the highway town since money is being brought into the trade area from outside the immediately surrounding complementary region. The development of basic industries is an important contributor to the economic growth of a place. A basic industry does not necessarily have to be in the class of manufacturing enterprises. Thus, service establishments in many small towns, although classed as tertiary industries, may contribute significantly to local economies. This fact should be given more serious consideration by community leaders in towns which possess a comparative advantage with regard to their location along roads carrying relatively high average daily traffic volumes. The benefits for towns of this nature of a coordinated development plan with emphasis on activities serving motorists may

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[1]Thomas, <u>op. cit</u>., p. 10.

well be greater than those that would accrue from frustrating attempts to attract manufacturing plants.

Whatever the practical utilization of the results of the present investigation, a primary point to be emphasized is that this study has identified a number of functions which are influenced by high traffic volumes. These findings should be recognized and incorporated into future research projects concerned with the economic complexion of central places. Research designs employing central place notions such as threshold population should be particularly aware of the effect of the average daily traffic volume variable. Most likely, there are other significant variables influencing the threshold population value. These variables need to be specifically identified and measured. With this information it will then be possible to extend certain aspects of central place inquiry. For example, a fertile field for investigation would be the measurement of similarities and differences between threshold populations for various different regional settings. Is there regional variation in this value? If so, what are the possible explanations for such variations?

Several points need to be considered with regard to a critical evaluation of the techniques and methods employed in this study. First, the term threshold should be questioned. The term implies a growing economy where new functions are being added to the system. This is not always the case in studies dealing with small towns where decline is sometimes more characteristic than growth. Brunn has suggested the term "dropout population" as a more descriptive term for declining functions which have not yet disappeared completely and are still counted in the functional composition of the small central place.[1] The point is well taken and it may be that the funeral home function previously discussed is an illustration of this point. Certain functions may be able to withstand a short lag period between the decline of their economic support and their actual removal from the system.

The towns in the present study area show no universal trend in this respect. That is, a number of the study places are experiencing considerable growth, others are on the decline, and still others are relatively stable in population. Thus, this point may not be of importance in this specific study area. However, in areas experiencing rapid change, cognizance should be given to Brunn's suggestion.

The model for determining threshold population needs to be re-examined and possibly modified. In certain relatively unique cases where a particular function is manifested by an unusual concentration of establishments, the Berry-Garrison exponential growth model is not able to efficiently portray the actual situation. In these cases establishments are actually added much more rapidly than is predicted by

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[1] Brunn, op. cit., p. 53.

the model; thus, a large standard error of the estimate is introduced and the applicability of the original model is questionable. Some relationship other than the exponential curve would be more suitable in such instances. The Berry-Garrison technique is based on simple regression, a method of calculating a "best fitting" equation for the relationship between two sets of observed data. Extreme observations greatly increase the amount of error in the "best fitting" equation; thus, this is not a desirable technique in situations where the data have large extremes.

This very problem was encountered when it was decided to examine the behavior of the model by inserting two towns each with an extremely large number of gas stations. It was expected that the threshold value for gas stations would be lowered considerably. However, this was not the result; the threshold population for gas stations, in fact, increased rather than decreased. The addition of these two extreme observations also increased the standard error of the estimate of the regression equation. This indicates that when extreme observations are included in the data, the exponential growth model is not the most efficient explanatory tool, and thus, it should be modified or replaced by some better model. Although this check on the model did not influence the analysis previously discussed, because these two special case towns were not included in the study group, it did point out that the model needs modification in cases where extreme observations are included in the data.

The statistical tests employed to determine significant differences between the threshold populations of the two groups of study places are not entirely satisfactory. The technique of simple regression can be viewed, in a general sense, as an averaging method; therefore, the use of difference between the means statistical tests to determine differences between two sets of samples appears to be consistent. However, it is possible, and the circumstance was encountered on several occasions, that the mean number of establishments for a particular function might be the same for both the on- and off-highway group of towns, whereas the threshold populations for this function were different between the two groups. In such cases, the calculated "t" statistic is determined as 0.0 indicating no difference between the two groups for that particular function, when in fact there may very well be a slight difference. This is a relatively rare occurrence, and even when it does take place the actual difference is so slight that it would not be significant. Nevertheless, future comparative studies should be aware of this situation and attempt to introduce a remedy. One possible solution would be to handle the evaluation of differences in a purely descriptive manner rather than attempting to access differences in the light of statistical inference.

A final point that needs to be criticized involves the determination of confidence limits on the estimated threshold value. Actually this is more of a mechanical problem than a methodological one. Blome's logic is sound when he argues that since the predicted threshold populations are subject to errors of estimate, it is more realistic to consider threshold population as an interval rather than a single value.[1] However, due to the fact that one of the variables (population) is logarithmically transformed at the outset, the calculation of standard confidence limits for least squares estimates is adversely affected by the population variable in logarithmic form. A great deal of error is introduced by using one variable in logarithmic form and then transforming the confidence limits into actual numbers. The use of confidence limits, although imprecise in this case, does have value, since it identifies large errors of estimate in the original regression equation.

This study has made a contribution to the general body of Central Place Theory by identifying the influence of a particular variable, average daily traffic volume, on the functional composition of small towns. In addition, the techniques employed and the methodology followed have a very distinct practical application in the area of community development and planning. The model used to calculate threshold population not only determines the minimum support for

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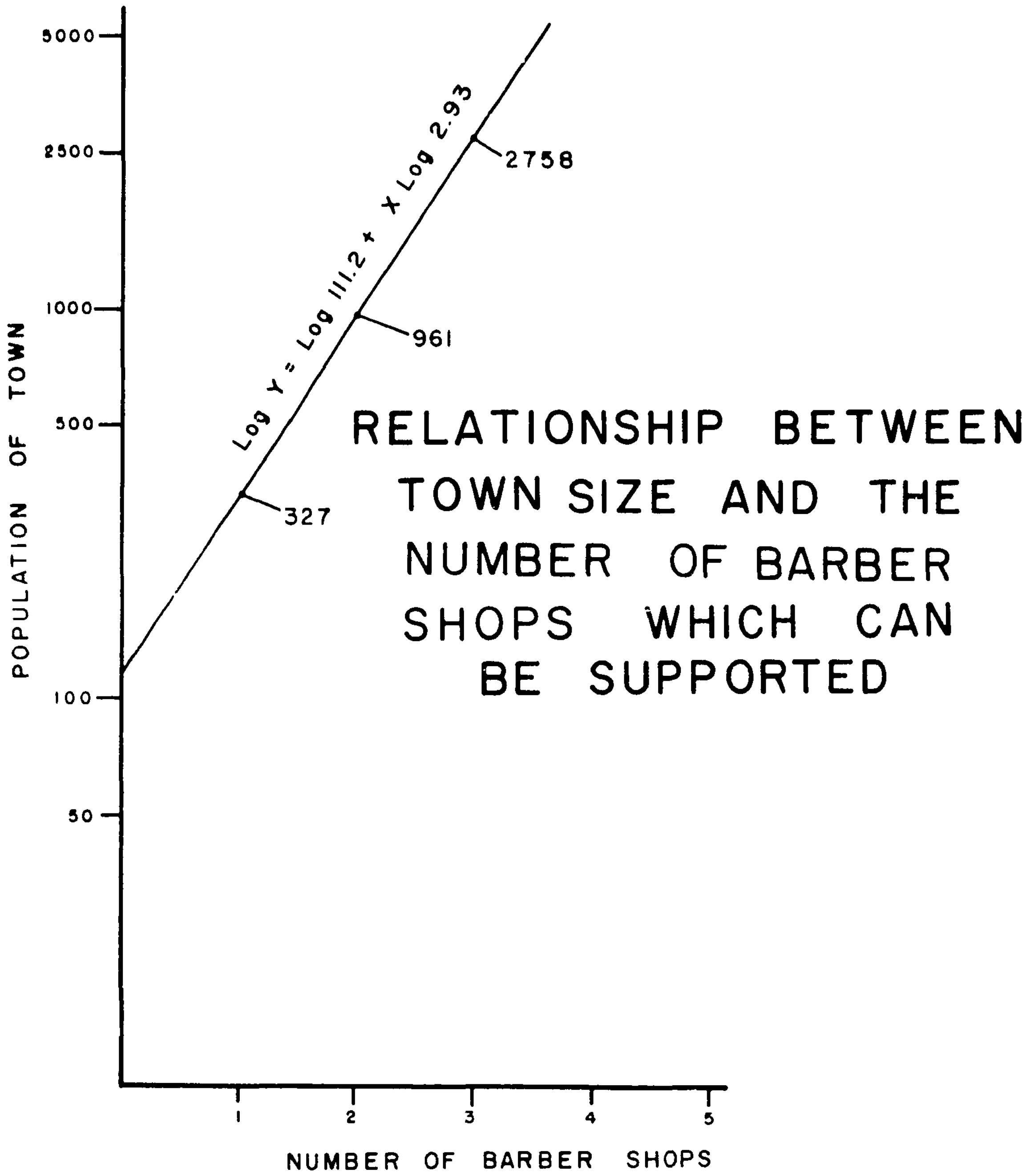
[1]Blome, op. cit., p. 3.

the first establishment of a functional type, but it also can be used to show the amount of support necessary for additional establishments of that same functional type. For example, the threshold population for the first barber shop in an on-highway town is 327. By plotting the regression line calculated for this function on a graph, it is possible to identify the minimum amount of support necessary for two, three, or more barber shops in towns of this group (Fig. 21). Figure 21 illustrates that a town population of 961 is necessary to support two barber shops, and three barber shops can survive in a town when the population reaches 2,758. Vega, Texas provides an illustration of a town which is on the verge of being able to support an additional barber shop. At the present time, Vega has one barber shop serving a city population of 899. According to Figure 21, an increase in population of only 62 persons would provide the necessary support for a second barber shop in this Texas town.

Information of this sort is valuable to several individuals or groups. A local barber who considers expanding his business by opening a second shop wants to know if there is enough support for two barber shops. A new barber in town could be encouraged to establish another competitive barber shop if it could be shown that the necessary support existed for an additional barber shop. The banker or other financier would be more willing to lend money to an aspiring businessman if he felt the chances for survival and success

FIG. 21


5000
2500
1000
500
100
50
POPULATION OF TOWN
Log Y = Log 111.2 + X Log 2.93
2758
961
327
1
2
3
4
5
NUMBER OF BARBER SHOPS
RELATIONSHIP BETWEEN TOWN SIZE AND THE NUMBER OF BARBER SHOPS WHICH CAN BE SUPPORTED

were present. Chambers of Commerce, planning agencies, and other similar groups could use this information to counsel and direct the development of the town. Thus, this type of information can be used in a positive way for the betterment of the entire community. The information could also be utilized to discourage would-be businessmen in situations where the necessary economic support is non-existent.

In a broader sense, individual towns could use the techniques developed in this dissertation to evaluate the functional offerings of their particular community. That is, in comparison with places of a similar nature, a town can appraise the number and variety of goods and services it provides for its supporting population. Possibly the necessary support is available for a number of functions that are not now being offered. If this is the case, several new businesses may be encouraged to establish there and thus provide the citizenry a wider range of goods and services. There is a possibility that significant growth might occur if this information is put to proper use.

Whatever the use or the effects of the techniques presented on the economies of small towns, the point to be emphasized is that these methods have real world applications that can be valuable. The theoretical implications of the influence of routes carrying relatively high average daily traffic volumes on threshold populations are significant as are the tools employed. This study has direct value for evaluating the functional complexion and economic structure of small urban places.

APPENDIX A

COMPUTER PROGRAM FOR DETERMINING

THRESHOLD POPULATIONS

```
      DIMENSION XBAR(40),STD(40),D(40),RY(40),ISAVE(40),B(40),
     1          SB(40),T(40),W(40)
      DIMENSION RX(1600)
      DIMENSION R(820)
      DIMENSION ANS(10)
      DIMENSION DP(60,3)
      DIMENSION SCAV(40)
      COMMON SCAV
      DATA DELM/'STOP'/
    1 FORMAT(A4,A2,I5,2I2)
    2 FORMAT(25H1MULTIPLE REGRESSION.....A4,A2//6X,14HSELECTION.....I2//
     1)
    3 FORMAT(9H0VARIABLE,5X,4HMEAN,6X,8HSTANDARD,6X,11HCORRELATION,4X,
     110HREGRESSION,4X,10HSTD. ERROR,5X,8HCOMPUTED/6H   NO..18X,9HDEVIAT
     2ION,7X,6HX VS Y,7X,11HCOEFFICIENT,3X,12HOF REG.COEF.,3X,7HT VALUE)
    4 FORMAT(1H ,I4,6F14.5)
    5 FORMAT(10H DEPENDENT)
    6 FORMAT(1H0/10H INTERCEPT,10X,F16.5//23H MULTIPLE CORRELATION  ,F13
     1.5//23H STD. ERROR OF ESTIMATE,F13.5//)
    7 FORMAT(1H0,21X,39HANALYSIS OF VARIANCE FOR THE REGRESSION//5X,19HS
     1OURCE OF VARIATION,7X,7HDEGREES,7X,6HSUM OF,10X,4HMEAN,12X,7HF VAL
     2UE/30X,10HOF FREEDOM,4X,&HSQUARES,9X,&HSQUARES)
    8 FORMAT(30H ATTRIBUTABLE TO REGRESSION  ,I6,3F16.5/30H DEVIATION F
     1ROM REGRESSION     ,I6,2F16.5)
    9 FORMAT(1H ,5X,5HTOTAL,19X,I6,F16.5)
   10 FORMAT(36I2)
   11 FORMAT(1H ,15X,18HTABLE OF RESIDUALS//9H CASE NO.,5X,7HY VALUE,5X,
     110HY ESTIMATE,6X,*HRESIDUAL)
   12 FORMAT(1H,I6,F15.5,2F14.5)
   13 FORMAT(53H1NUMBER OF SELECTIONS NOT SPECIFIED.  JOB TERMINATED.)
   14 FORMAT(52H0THE MATRIX IS SINGULAR.  THIS SELECTION IS SKIPPED.)
  100 READ (5,1) PR,PR1,N,M,NS
      IF(PR.EQ.DELM)GO TO 300
      REWIND 13
      IO=0
      X=0.0
      CALL CORRE (N,M,IO,X,XBAR,STD,RX,R,D,B,T)
      REWIND 13
      IF(NS) 108, 108, 109
  108 WRITE (6,13)
      GO TO300
```

```
109 DO 200 I=1,NS
    WRITE (6,2) PR,PR1,I
    READ (5,10) NRESI,NDEP,K,(ISAVE(J),J=1,K)
    CALL ORDER (M,R,NDEP,K,ISAVE,RX,RY)
    CALL MINV (RX,K,DET,B,T)
    IF(DET) 112, 110, 112
110 WRITE (6,140
    GO TO 200
112 CALL MULTR (N,K,XBAR,STD,D,RX,RY,ISAVE,B,SB,T,ANS)
    MM=K+1
    WRITE (6,3)
    DO 115 J=1,K
    L=ISAVE(J)
115 WRITE (6,4) L,XBAR(L),STD(L),RY(J),B(J),SB(J),T(J)
    WRITE (6,5)
    L=ISAVE(MM)
    WRITE (6,4) L,XBAR(L),STD(L)
    WRITE (6,6) ANS(1),ANS(2),ANS(3)
    TP=10.0**(ANS(1)+B(1))
    WRITE(6,301)TP
301 FORMAT(1HO,'THRESHOLD POPULATION',F16.5//)
    T=CTR=2.002
    IF(N.EQ.30)TFCTR=2.048
    LSAVE=ISAVE(1)
    CONFU=10**(ANS(1)+B(1)+TFCTR*ANS(3)*SCAV(LSAVE))
    CONFL=10**(ANS(1)+B(1)-TFCTR*ANS(3)*SCAV(LSAVE))
    WRITE(6,305)CONFU,CONFL
305 FORMAT('095% CONFIDENCE INTERVAL'/'    UPPER LIMIT ',F20.5,
   2   /'     LOWER LIMIT ',F20.5///)
    WRITE (6,7)
    L=ANS(8)
    WRITE (6,8) K,ANS(4),ANS(6),ANS(10),L,ANS(7),ANS(9)
    L=N-1
    SUM=ANS(4)+ANS(7)
    WRITE (6,9) L,SUM
    IF(NRESI) 200,200, 120
120 WRITE (6,2) PR,PR1,I
    WRITE (6,11)
    MM=ISAVE(K+1)
    DO 140 II=1,N
    READ (13) (W(J),J=1,M)
    SUM=ANS(1)
    DO 130 J=1,K
    L=ISAVE(J)
    DP(II,1)=W(L)
130 SUM=SUM+W(L)*B(J)
    RESI=W(MM)-SUM
    DP(II,2)=W(MM)
    DP(II,3)=SUM
140 WRITE (6,12) II,W(MM),SUM,RESI
    REWIND13
    GO TO 100
300 CONTINUE
    STOP
    END
```

```
      SUBROUTINE CORRE (N,M,IO,K,XBAR,STD,RX,R,B,D,T)
      DIMENSION X(1),XBAR(1),STD(1),RX(1),R(1),B(1),D(1),T(1)
      DIMENSION FORMT(18)
      DIMENSION SCAX(40),SCAXX(40),SCAV(40)
      COMMON SCAV
      DO 100 J=1,M
      B(J)=0.0
  100 T(J)=0.0
      K=(M*M+M)/2
      DO 102 I=1,K
  102 R(I)=0.0
      FN=N
      L=0
      IF(IO) 105, 127, 105
  105 DO 108 J=1,M
      DO 107 I=1,N
      L=L+1
  107 T(J)=T(J)+X(L)
      XBAR(J)=T(J)
  108 T(J)=T(J)/FN
      DO 115 I=1,N
      JK=0
      L=I-N
      DO 110 J=1,M
      L=L+N
      D(J)=X(L)-T(J)
  110 B(J)=B(J)+D(J)
      DO 115 J=1,M
      DO 115 K=1,J
      JK=JK+1
  115 R(JK)=R(JK)+D(J)*D(K)
      GO TO 205
  127 IF(N-M) 130, 130, 135
  130 KK=N
      GO TO 137
  135 KK=M
  137 CONTINUE
      READ(5,999)FORMT
  999 FORMAT(18A4)
      WRITE(6,998)FORMT
  998 FORMAT(///' THE VARIABLE FORMAT IS . . .',18A4///)
      DO 3001 ISCA=1,M
      SCAX(ISCA)=0.
      SCAXX(ISCA)=0.
 3001 CONTINUE
      DO 140 I=1,KK
      READ(5,FORMT)(D(III),III=1,M)
      WRITE (13) (D(III),III=1,M)
      DO 140 J=1,M
      T(J)=T(J)+D(J)
      L=L+1
      SCAX(J)=SCAX(J)+D(J)
      SCAXX(J)=SCAXX(J)+D(J)*D(J)
```

```
 140 RX(L)=D(J)
     FKK=KK
     DO 150 J=1,M
     XBAR(J)=T(J)
 150 T(J)=T(J)/FKK
     L=0
     DO 180 I=1,KK
     JK=0
     DO 170 J=1,M
     L=L+1
 170 D(J)=RX(L)-T(J)
     DO 180 J=1,M
     B(J)=B(J)+D(J)
     DO 180 K=1,J
     JK=JK+1
 180 R(JK)=R(JK)+D(J)*D(K)
     IF(N-KK) 205, 205, 185
 185 KK=N-KK
     DO 200 I=1,KK
     JK=0
     READ(5,FORMT)(D(III),III=1,M)
     WRITE (13) (D(III),III=1,M)
     DO 190 J=1,M
     SCAX(J)=SCAX(J)+D(J)
     SCAXX(J)=SCAXX(J)+D(J)*D(J)
     XBAR(J)=XBAR(J)+D(J)
     D(J)=D(J)-T(J)
 190 B(J)=B(J)+D(J)
     DO 200 J=1,M
     DO 200 K=1,J
     JK=JK+1
 200 R(JK)=R(JK)+D(J)*D(K)
 205 JK=0
     DO 3002 ISCA=1,M
     SCAV1=(1.-SCAX(ISCA/FN)**2
     SCAV2=SCAXX(ISCA)-SCAX(ISCA)*SCAX(ISCA/FN
     SCAV(ISCA)=SQRT(1./FN+SCAV1/SCAV20
3002 CONTINUE
     DO 210 J=1,M
     XBAR(J)=XBAR(J)/FN
     DO 210 K=1,J
     JK=JK+1
 210 R(JK)=R(JK)-B(J)*B(K)/FN
     JK=0
     DO 220 J=1,M
     JK=JK+1
 220 STD(J)= SQRT( ABS(R(JK)))
     DO 230 J=1, M
     DO 230 K=J,M
     JK=J+(K*K-K)/2
     L=M*(J-1)+K
     RX(L)=R(JK)
     L=M*(K-1)+J
```

```
      RX(L)=R(JK)
      IF(STD(J)*STD(K)) 225,222, 225
  222 R(JK)=0.0
      GO TO 230
  225 R(JK)=R(JK)/(STD(J)*STD(K))
  230 CONTINUE
      FN=SQRT(FN-1.0)
      DO 240 J=1,M
  240 STD(J)=STD(J)/FN
      L=-M
      DO 250 I=1,M
      L=L+M+1
  250 B(I)=RX(L)
      RETURN
      END
      SUBROUTINE ORDER (M,R,NDEP,K,ISAVE,RX,RY)
      DIMENSION R(1).ISAVE(1),RX(1),RY(1)
      MM=0
      DO 130 J=1,K
      L2=ISAVE(J)
      IF(NDEP-L2) 122, 123, 123
  122 L=NDEP+(L2*L2-L2)/2
      GO TO 125
  123 L=L2+(NDEP*NDEP-NDEP)/2
  125 RY(J)=R(L)
      DO 130 I=1,K
      L1=ISAVE(I)
      IF(L1-L2) 127, 128, 128
  127 L=L1+(L2*L2-L2)/2
      GO TO 129
  128 L=L2+(L1*L1-L1)/2
  129 MM=MM+1
  130 RX(MM)=R(L)
      ISAVE(K+1)=NDEP
      RETURN
      END
      SUBROUTINE MINV(A,N,D,L,M)
      DIMENSION A(1),L(1),M(1)
      D=1.0
      NK=-N
      DO 80 K=1,N
      NK=NK+N
      L(K)=K
      M(K)=K
      KK=NK+K
      BIGA=A(KK)
      DO 20 J=K,N
      IX=N*(J-1)
      DO 20 I=K,N
      IJ=IZ+I
   10 IF( ABS(BIGA)- ABS(A(IJ))) 15, 20, 20
   15 BIGA=A(IJ)
```

```
      L(K)=I
      M(K)=J
   20 CONTINUE
      J=L(K)
      IF(J-K) 35,35,25
   25 KI=K-N
      DO 30 I=1,N
      KI=KI+N
      HOLD=-A(KI)
      JI=KI-K+J
      A(KI)=A(JI)
   30 A(JI)=HOLD
   35 I=M(K)
      IF(I-K) 45,45,38
   38 JP=N*(I-1)
      DO 40 J=1,N
      JK=NK+J
      JI=JP+J
      HOLD=-A(JK)
      A(JK)=A(JI)
   40 A(JI)=HOLD
   45 IF(BIGA) 48,46,48
   46 D=0.0
      RETURN
   48 DO 55 I=1,N
      IF(I-K_ 50,55,50
   50 IK=NK+I
      A(IK)=A(IK)/(-BIGA)
   55 CONTINUE
      DO 65 I=1,N
      IK=NK+I
      HOLD=A(IK)
      IJ=I-N
      DO 65 J=1,N
      IJ=IJ+N
      IF(I-K) 60,65,60
   60 IF(J-K) 62,65,62
   62 KJ=IJ-I+K
      A(IJ=HOLD*A(KJ)+A(IJ)
   65 CONTINUE
      KJ=K-N
      DO 75 J=1,N
      KJ=KJ+N
      IF(J-K) 70,75,70
   70 A(KJ)=A(KJ)/BIGA
   75 CONTINUE
      D=D*BIGA
      A(KK)=1.0/BIGA
   80 CONTINUE
      K=N
  100 K=(K-1)
      IF(K) 150,150,105
  105 I=L(K)
      IF(I-K) 120,120,108
  108 JQ=N*(K-1)
```

```
      JR=N*(I-1)
      DO 110 J=1,N
      JK=JQ+J
      HOLD=A(JK)
      JI=JR+J
      A(JK)=-A(JI)
  110 A(JI)=HOLD
  120 J=M(K)
      IF(J-K) 100,100,125
  125 KI=K-N
      DO 130 I=1,N
      KI=KI+N
      HOLD=A(KI)
      JI=KI-K+J
      A(KI)=-A(JI)
  130 A(JI)=HOLD
      GO TO 100
  150 RETURN
      END
      SUBROUTINE MULTR (N,K,XBAR.STD,D,RX,RY,ISAVE,B,SB,T,ANS)
      DIMENSION XBAR(1),STD(1),D(1),RX(1),RY(1),ISAVE(1),B(1),SB(1),
     1          T(1),ANS(1)
      MM=K+1
      DO 100 J=1,K
  100 B(J)=0.0
      DO 110 J=1,K
      L1=K*(J-1)
      DO 110 I=1,K
      L=L1+I
  110 B(J)=B(J)+RY(I)*RX(L)
      RM=0.0
      BO=0.0
      L1=ISAVE(MM)
      DO 120 I=1,K
      RM=RM+B(I)*RY(I)
      L=ISAVE(I)
      B(I)=B(I)*STD(L1)/STD(L))
  120 BO=BO+B(I)*XBAR(L)
      BO=XBAR(L1)-BO
      SSAR=RM*D(L1)
  122 RM= SQRT( ABS(RM))
      SSDR=D(L1)-SSAR
      FN=N-K-1
      SY=SSDR/FN
      DO 130 J=1,K
      L1=K*(J-1)+J
      L=ISAVE(J)
  125 SB(J)= SQRT( ABS((RX(L1)/D(L))*SY))
  130 T(J)=B(J)/SB(J)
  135 SY= SQRT( ABS(SY))
      FK=K
      SSARM=SSAR/FK
      SSDRM=SSDR/FN
```

```
F=SSARM/SSDRM
ANS(1)=BO
ANS(2)=RM
ANS(3)=SY
ANS(4)=SSAR
ANS(5)=FK
ANS(6)=SSARM
ANS(7)=SSDR
ANS(8)=FN
ANS(9)=SSDRM
ANS(10)=F
RETURN
END
```

APPENDIX B

FORM USED TO CATALOGUE NUMBER AND TYPE OF ESTABLISHMENTS

TOWN ____________________ 1960 POP.__________ 1969 POP.(est.)__________

COMMERCIAL

RETAIL BUSINESS

- ___ Lumber Yard & Bldg. Supply
- ___ Heating & Plumbing
- ___ Hardware
- ___ Department Store (over 25 emp)
- ___ 5 & 10 Variety Stores
- ___ Dry Goods & Gen'l Mdse.(less 25 emp)
- ___ Gen'l Store (food primary sales)
- ___ Grocery Stores
- ___ Retail Bakery
- ___ Misc. Food Store ______________
- ___ Family Clothing
- ___ Shoe Store
- ___ Tailor & Art Needlework
- ___ Furniture Store
- ___ Household Appliances; Radio & TV
- ___ Restaurants & Cafe
- ___ Tavern
- ___ Drug Store
- ___ Liquor Store
- ___ Antique & Second Hand Store
- ___ Sporting Goods
- ___ Animal Feed & Seed
- ___ Jewelry
- ___ Florist
- ___ Bait
- ___ Gift & Souvenir
- ___ Bottled Gas Dealer
- ___ Western Auto Type

PROFESSIONAL OFFICES

- ___ Physician
- ___ Dentist
- ___ Osteopath
- ___ Chiropractor
- ___ Lawyer

BUSINESS OFFICES

- ___ Savings & Loan
- ___ Insurance Agent
- ___ Real Estate Agent
- ___ Bank
- ___ Newspaper & Printing

PERSONAL OR BUSINESS SERVICE

- ___ Laundromat
- ___ Dry Cleaners (establishment)
- ___ Dry Cleaners (depot)
- ___ Photographer
- ___ Beauty Shop
- ___ Barber Shop
- ___ Funeral Home
- ___ TV Repair Shop
- ___ Shoe & Leather Goods Repair

MOTOR VEHICLE SALES OR SERVICE

- ___ New & Used Car Dealer
- ___ Auto Parts Store
- ___ Gasoline Service Station
- ___ Farm Implement Dealer
- ___ Auto Repair Shop
- ___ Car Wash

COMMERCIAL RECREATION

- ___ Dance Hall
- ___ Bowling Alley
- ___ Movie Theater
- ___ Domino/Pool Hall

COMMERCIAL RESIDENTIAL

- ___ Hotel
- ___ Motel

INDUSTRIAL

NON-MANUFACTURING

___ Junk Yard
___ Grain Elevator & Storage
___ Frozen Food Locker
___ Feed Mill
___ Veterinarians
___ General Welding

NON-DURABLE MANUFACTURING

___ Food & Kindred Products
___ Textile Mill Products
___ Paper & Allied Products

DURABLE MANUFACTURING

___ Lumber, Furniture, & Wood Prod.
___ Stone, Glass, Clay Products
___ Fabricated Metals
___ Misc. Manufacturing

INSTITUTIONAL

PUBLIC ADMINISTRATION

___ U.S. Post Office
___ State Highway Maint. Facilities
___ County Highway Maint. Facilities
___ City Hall

EDUCATIONAL

___ Elementary School
___ High School

CULTURAL

___ Library

RELIGIOUS

___ Churches

HEALTH & WELFARE

___ Hospital
___ Clinic
___ Rest Home
___ Fraternal Organizations
___ Law Enforcement
___ Fire Protection

TRANSPORTATION

___ Bus Depot (intercity)
___ Taxi
___ Truckers, Local & Long Distance

UTILITIES & COMMUNICATIONS

___ Electric Substations
___ Telephone/Telegraph Office
___ Electric/ Gas Office

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