A SPATIAL ANALYSIS OF SHEEP-RAISING IN KANSAS

by

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THIS BOOK CONTAINS NUMEROUS PAGES WITH DIAGRAMS THAT ARE CROOKED COMPARED TO THE REST OF THE INFORMATION ON THE PAGE.

THIS IS AS RECEIVED FROM CUSTOMER.

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I also thank my friend Mr. John Johnson for supplying base maps. The help of my wife, Ying-Hwa, was invaluable in calculating and checking data as well as drawing graphs.

INTRODUCTION

This study is focused on two sets of geographic aspects of sheep-raising in Kansas--those of distribution in Part One and those of movement in Part Two. Strong emphasis is put on the spatial differentiation of these aspects.

In Part One a set of uniform regions is built on the basis of sheep density and flock size. Within this regional framework several interesting spatial contrasts pertinent to the distribution of sheep and lambs are discovered and analyzed.

In Part Two, through the testing of four hypotheses, a mathematical model is built to explain and predict the regional variation of the state's inshipments of stock sheep and lambs. As to the outward movement, the exportation of the state's fat sheep and lambs is contrasted against the general trend of livestock and meat movement in the United States. Finally, an effort is made to analyze the nodal relationships in marketing the sheep and lambs produced in Kansas.

It is fully realized that geography has been defined differently at various stages of its evolution, but no attempt will be made to fit this study into all the various definitions. It is simply assumed here that geography studies the spatial aspects of men and men's activities on the earth's surface, and that the most fundamental spatial aspects are those of distribution and movement. On this assumption alone it is hoped that this paper will be justified as an integral geographic study.

PART ONE

THE DISTRIBUTION OF SHEEP AND LAMBS IN KANSAS

> The most striking feature of the geographic distribution of livestock in Kansas is the much more nearly uniform distribution of cattle and calves than of the other livestock. The distribution of hogs is similar to that of corn production, being practically limited to the eastern third of the state and the northern tier of counties. . . . The distribution of sheep and lambs is irregular. There are a number of minor concentrations. The total number in most counties is not large and the presence of only three or four large lamb feeders in any one county is sufficient to show a concentration on the map.[1]

As suggested by the above quotation, the distribution pattern of sheep and lambs in Kansas is relatively irregular and unstable. The main challenge in this part of the study is to generalize this apparent irregularity into a more comprehensible and meaningful pattern by building a set of uniform regions. Furthermore, the instability through time is to be interpreted as a series of stages.

For more insight into the distribution problems, the change in sheep density is related to the changes in sheep farm density and in flock size. Finally, the relative competitiveness of sheep and lambs among all livestock is analyzed. Through this analysis the reason that some areas with ideal physical conditions for sheep-raising have consistently had very light sheep density becomes apparent.

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[1] L. M. Hoover, pp. 42-44.

CHAPTER ONE

REGIONALIZATION

This chapter will first consider the fundamental concepts of regionalization, and then generalize the distribution patterns of sheep and lambs in Kansas into six "sheep regions" and two sets of "non-sheep areas."

Section A

The Conceptual Basis of Regionalization

Any critically-defined region can be classified into either of two classes: (1) uniform region, or (2) nodal region. The latter covers all areal units which are connected to a focus (or foci) by a network of circulation; while the former contains all areal units which are uniform in terms of the criteria used in defining the region.[2] Those to be constructed here are a type of uniform region.

Two fundamental considerations in building uniform regions are: (1) the similarity, and (2) the contiguity of the areal units to be classified.[3] According to the first consideration, the regionalization is successful as long as all similar areal units are included in the

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[2]More detailed but not totally agreeable classification of regions was proposed by Whittlesey, in James and Jones, pp. 34-37.

[3]Peter Haggett, p. 254.

same region and different areal units are separated into different regions. As to the second consideration, the areal units belonging to the same region should be contiguous rather than scattered or fragmented. In other words, too many exclaves and enclaves are not advisable. However, in many cases similar areal units are not necessarily contiguous. In such contradictory cases, a minor sacrifice of either similarity or contiguity must be made. Otherwise, the criteria must be modified or changed. In this study some sacrifice on contiguity is made to preserve similarity, but the groups of non-contiguous similar areal units are to be called "areas," and the term "region" is reserved for the group of contiguous similar areal units.

The criteria chosen for regionalization must be the most pertinent aspects of the topic under study. It is obvious that there is some correlation between landform and natural vegetation on the one hand, and agricultural practices, on the other. For example, the Flint Hills area is associated with extensive livestock business; while the almost featureless western Kansas plains are dominated by commercial wheat farming. This study, however, does not attempt to use any aspect of physical environment as the basis for regionalization. Instead, the sheep density and flock size are the two criteria to be used. The sheep density tells the economic importance of sheep-raising in a given area, while the change in flock size of sheep and lambs, together with the change in number of sheep farms, determines the change in sheep density. (The term "sheep farm" used in this study refers to any farm which reported "sheep and lambs on the farm.")

The value of a regional pattern should be judged by its applicability through time. In other words, if a spatial feature is traced back for some period of time, the regional pattern based on this feature seems to be more persistent and meaningful. Therefore, this study extends far back to 1945, and the regional pattern established is expected to persist into the near future, perhaps with only a minor modification.

Section B

The Procedure of Regionalization

When more than one criterion is to be used, the procedure of regionalization can be either "sequential" or "parallel." The sequential procedure uses the most important criterion to set up the broadest regional frame. This frame is then divided into smaller ones by using the second criterion. If the regions then established are still too broad, a third criterion may be used to sub-divide them. This procedure goes on until the regions are in such size that they serve the research purpose best. Koppen's classification of the world climatic regions is essentially sequential.[4]

The parallel procedure uses all criteria at the same time. Weaver's crop-combination regions, which are based purely on an objective statistical method, are one example.[5] Hartshorne and Dicken's agri-

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[4]P. J. Tsiang, pp. 85-96.

[5]J. C. Weaver, pp. 175-200.

cultural regions of North America and Europe, which are classified with some subjective value judgement, are another example.[6]

As mentioned above, there are two criteria to be used in the regionalization of this study. The procedure to be used is sequential. The first step is to set up a large regional frame by using the first criterion, and the large frame is sub-divided with the assistance of a second criterion.

(a) The First Criterion--Sheep Density

The sheep density on the maps of Fig. I-1 and I-2 is computed from two sources: (1) publications of the Kansas State Board of Agriculture (January 1, 1947; January 1, 1959; January 1, 1962; and January 1, 1968); and (2) U. S. Census of Agriculture (January 1, 1945; April 1, 1950; November 7, 1954; and December 2, 1964).[7] This sheep density is derived from dividing the number of sheep and lambs on farms in each county by the county's areal extent.

These maps are the representatives selected from twelve distribution maps drawn for the period of 1945-1968. Different tones are used to indicate different density. The heavier the tone, the greater the density. The tones on all maps are comparable. The heavy solid lines on each map are the inter-sections between the datum plane of the state's average density and the actual density surface. From the areal extent

[6]R. Hartshorne and S. N. Dicken, pp. 99-120.

[7]The publications of the Kansas State Board of Agriculture used here are Biennial Report, No. 36 and Farm Facts (1959, 1962, 1968).

EXPLANATION OF FIGURE I-1

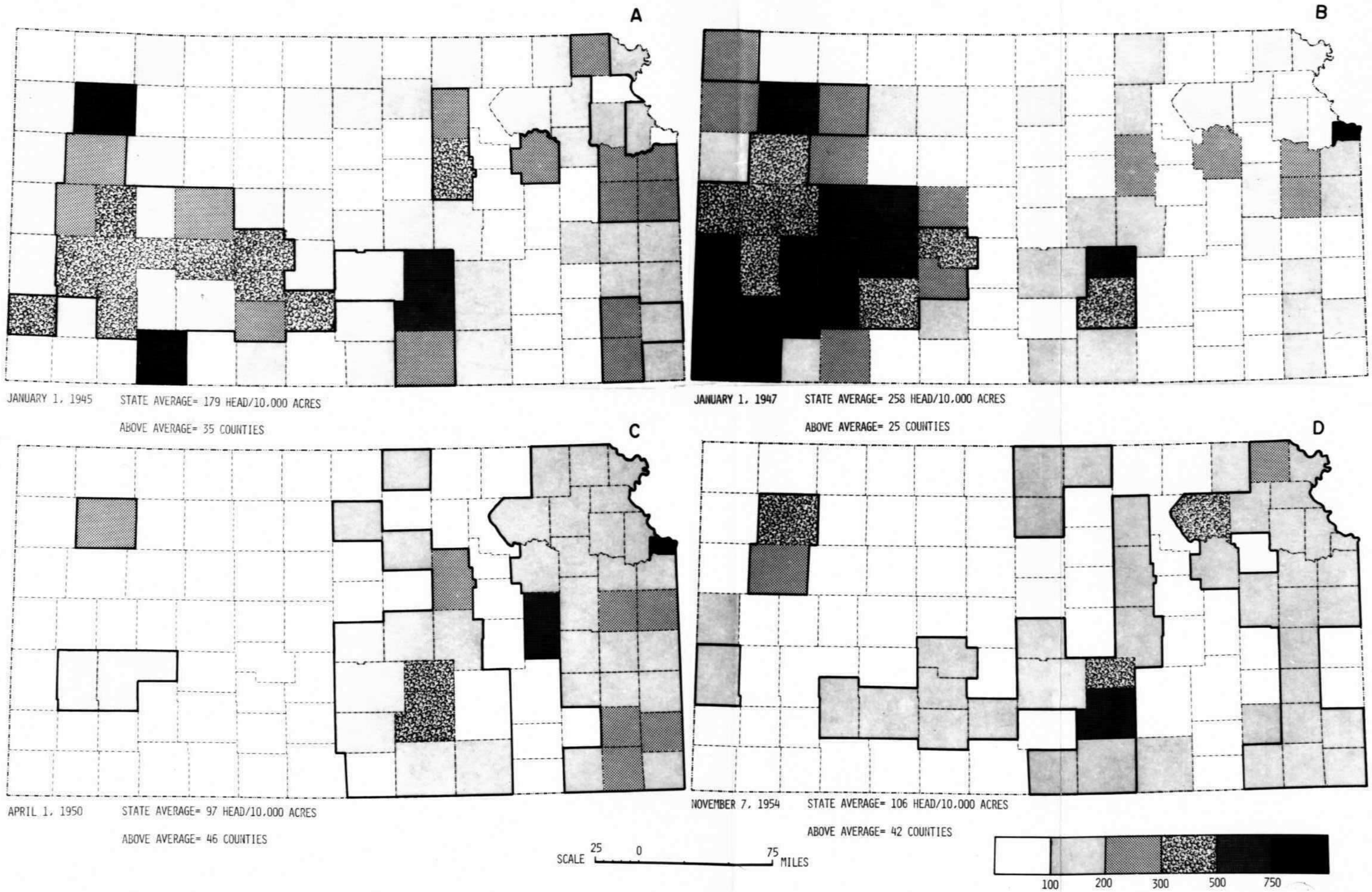
Sheep Density in Kansas (1945, 1947, 1950, 1954).

(Computed from (1) U. S. Bureau of Census, and

(2) Kansas State Board of Agriculture)

Note: In figures which follow, USBC and KSBA will be used as abbreviations for the two sources cited above.

FIGURE I-1

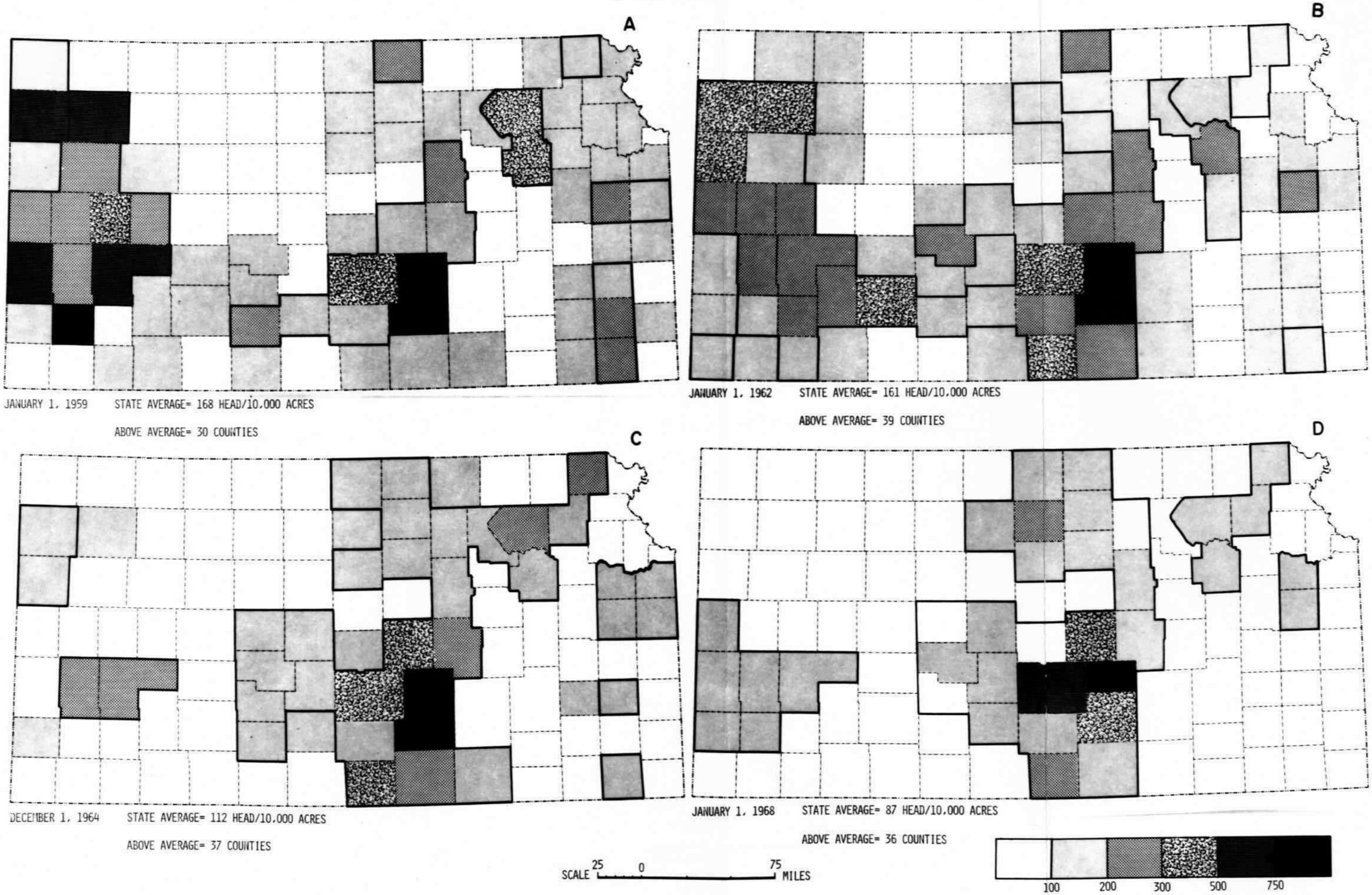

A
B
JANUARY 1, 1945 STATE AVERAGE= 179 HEAD/10,000 ACRES
ABOVE AVERAGE= 35 COUNTIES
JANUARY 1, 1947 STATE AVERAGE= 258 HEAD/10,000 ACRES
ABOVE AVERAGE= 25 COUNTIES
C
D
APRIL 1, 1950 STATE AVERAGE= 97 HEAD/10,000 ACRES
ABOVE AVERAGE= 46 COUNTIES
NOVEMBER 7, 1954 STATE AVERAGE= 106 HEAD/10,000 ACRES
ABOVE AVERAGE= 42 COUNTIES
SCALE 25 0 75 MILES
100 200 300 500 750

EXPLANATION OF FIGURE I-2

Sheep Density in Kansas (1959, 1962, 1964, and 1968).

(Computed from USBC and KSBA)

FIGURE I-2


A
JANUARY 1, 1959 STATE AVERAGE= 168 HEAD/10,000 ACRES
ABOVE AVERAGE= 30 COUNTIES
B
JANUARY 1, 1962 STATE AVERAGE= 161 HEAD/10,000 ACRES
ABOVE AVERAGE= 39 COUNTIES
C
DECEMBER 1, 1964 STATE AVERAGE= 112 HEAD/10,000 ACRES
ABOVE AVERAGE= 37 COUNTIES
D
JANUARY 1, 1968 STATE AVERAGE= 87 HEAD/10,000 ACRES
ABOVE AVERAGE= 36 COUNTIES
SCALE 25 0 75 MILES
100
200
300
500
750

enclosed by the solid lines, one can estimate the degree of concentration. The compactness or fragmentedness of the above-average areas is also apparent on the maps.

The maps of the mid-1940's show a strong concentration of sheep and lambs in western Kansas. For example, in 1945 (Fig. I-1-A), the fourteen contiguous above-average counties in the western third of the state, occupying 15 percent of the state's total land area, had 35 percent of the state's sheep and lambs. In 1947 (Fig. I-1-B), western Kansas had the record high density of sheep and lambs; only three out of the twenty-five above-average counties were in the eastern half of the state (two around Wichita and one near Kansas City).

In the decade following 1947 the sheep density in the state's western third appeared to be relatively light compared with the density of the mid-1940's. The maps of 1950 and 1954 (Fig. I-1-C & D) show the representative distribution patterns in the period of 1948-1957. Most of the above-average counties were in eastern and central Kansas. The eastward shift of the above-average areas was mainly due to the drastic decline of sheep-raising in western Kansas, because, as shown on the maps, the actual sheep density in central and eastern Kansas did not change much.

The maps of 1959 and 1962 (Fig. I-2-A & B) show the representative patterns in the period of 1958-1963 when the sheep density in the state's western extreme increased again. The maps of 1964 and 1968 (Fig. I-2-C & D) show the distribution patterns in recent years. This period is characterized by the relatively thin density in both the state's eastern and western extremes. Most of the above-average areas became concentrated in central Kansas.

All the maps in Fig. I-1 and I-2 show that while the areas of above-average density have shifted from place to place since 1945, there are some locations where sheep density has been persistently under average. In Fig. I-3 the heavy solid lines mark out these persistently under-average areas, designated as "non-sheep areas." Paradoxically, these non-sheep areas are located in relatively hilly and pastoral terrains; but not all hilly and pastoral terrains are non-sheep areas.

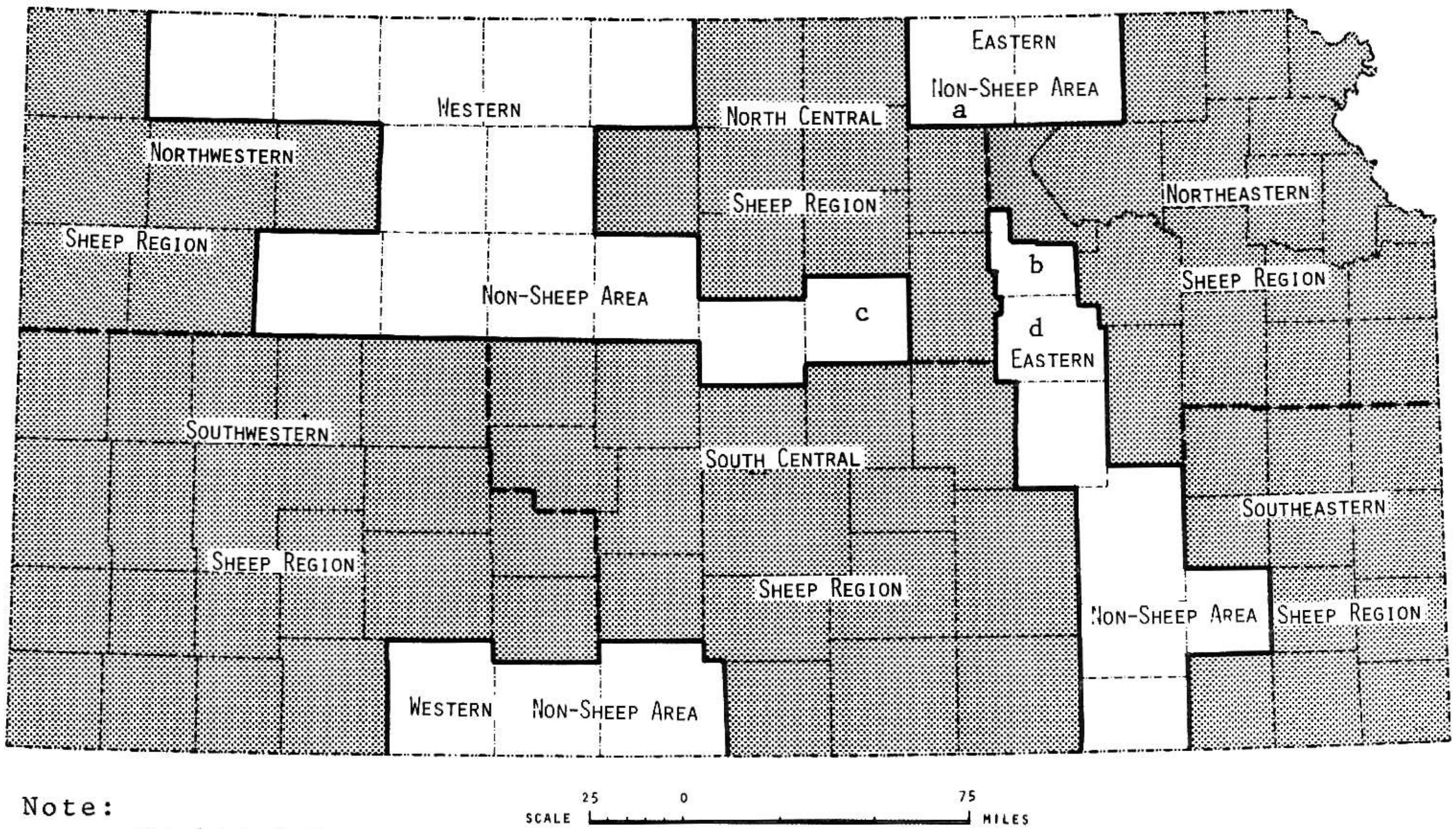
These heavy solid lines can be interpreted as the "outer limits" of the areas where sheep-raising has been relatively well-developed, and thus are used here as the basic regional framework. On the basis of the various distribution patterns since 1945, one may predict that in the near future sheep-raising will continue to be better developed within this framework.

Within this large framework six "sheep regions" are to be defined. Across the narrow necks between Washington and Geary counties (Fig. I-3-a & b), and between Saline and Morris counties (Fig. I-3-c & d), two lines are drawn to establish the North Central Sheep Region. With the help of the eight sheep density maps (Fig. I-1 and I-2) a boundary line is drawn through western Kansas where the areas of above-average density were discontinued when sheep-raising was relatively poorly developed in the state's western extreme. Thus, the Northwestern Sheep Region is established. The boundary line between Northeastern and Southeastern Sheep Regions is also drawn through the place of relatively low sheep

EXPLANATION OF FIGURE I-3

Sheep Regions and Non-sheep Areas in Kansas

FIGURE I-3



Note:
a. Washington
b. Geary c. Saline d. Morris

density. On the sheep density maps it is hard to decide where to draw a boundary line between Southwestern and South Central Sheep Regions. Therefore, an additional criterion is to be used.

(b) The Second Criterion--Flock Size

The criterion needed for separating Southwestern and South Central Sheep Regions must be one of the important properties of sheep-raising, which shows a strong spatial contrast in an east-west direction. Here the average flock size (or, in a more general term, the average operational scale) of sheep farms in each county is employed.

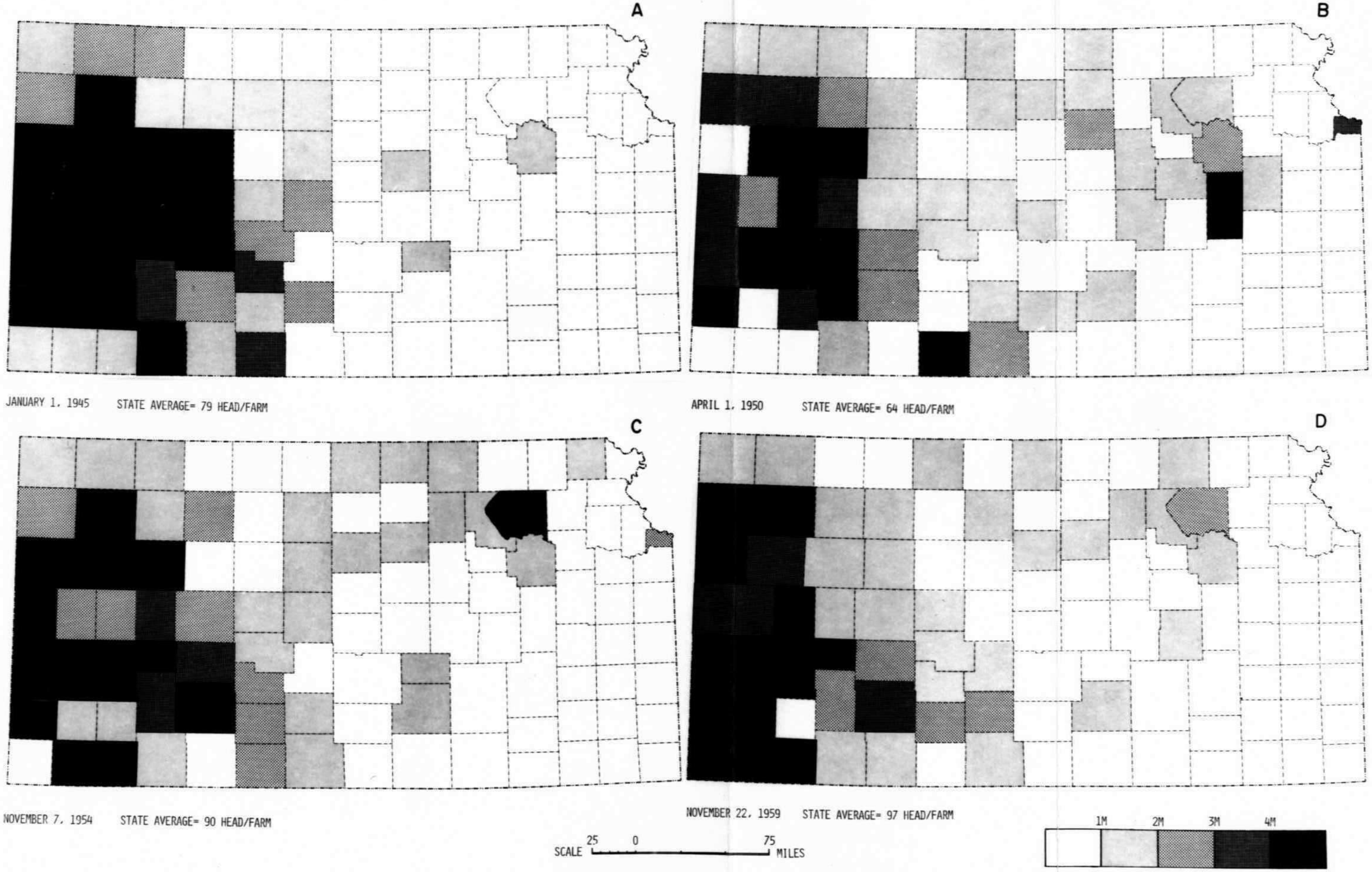
In Fig. I-4 and I-5, the average flock size of each county is "measured" by the state's average flock size. The tone between "1M" and "2M" represents the flock sizes, which are greater than or equal to the state's average flock size but smaller than twice the state's average. The other tones are defined in the same way.

All the maps of the five census years (Fig. I-4 and I-5) show the general decrease of flock size toward the east, except for some aberrations in the Northeastern Sheep Region. One of these was Wyandotte county near Kansas City, where large scale operation appeared in the early 1950's, probably due to the emergence of commercial feedlots. But the rapid urbanization of that county in the following years had practically driven out most of the sheep and lambs by the end of the 1950's. The other aberrations are in the northern middle stretch of the Flint Hills. This is the only part of the Flint Hills where sheep and lambs have survived relatively well. Sheep-raising here is dominated by feedlot operations. For example, in Riley and Wabaunsee

EXPLANATION OF FIGURE I-4

Average Flock Size on Sheep Farms
in Kansas (1945, 1950, 1954, and 1959).
(Computed from USBC)

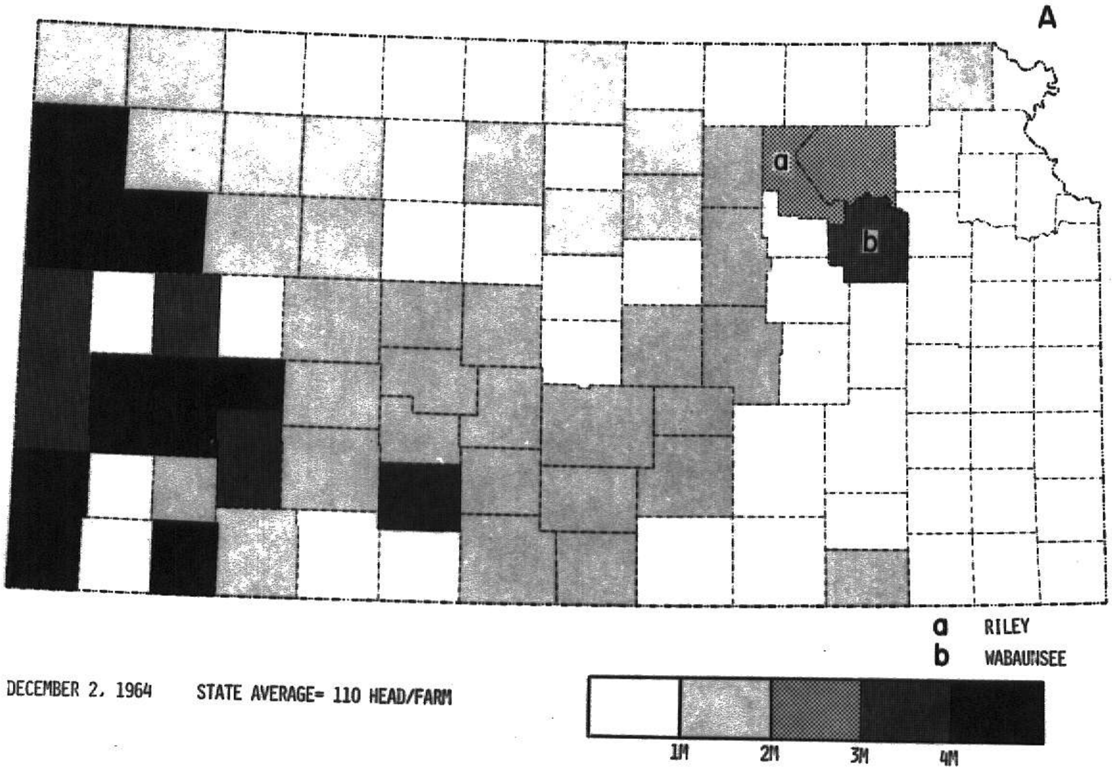
FIGURE I-4


A
B
JANUARY 1, 1945 STATE AVERAGE= 79 HEAD/FARM
APRIL 1, 1950 STATE AVERAGE= 64 HEAD/FARM
C
D
NOVEMBER 7, 1954 STATE AVERAGE= 90 HEAD/FARM
NOVEMBER 22, 1959 STATE AVERAGE= 97 HEAD/FARM
SCALE 25 0 75 MILES
1M 2M 3M 4M

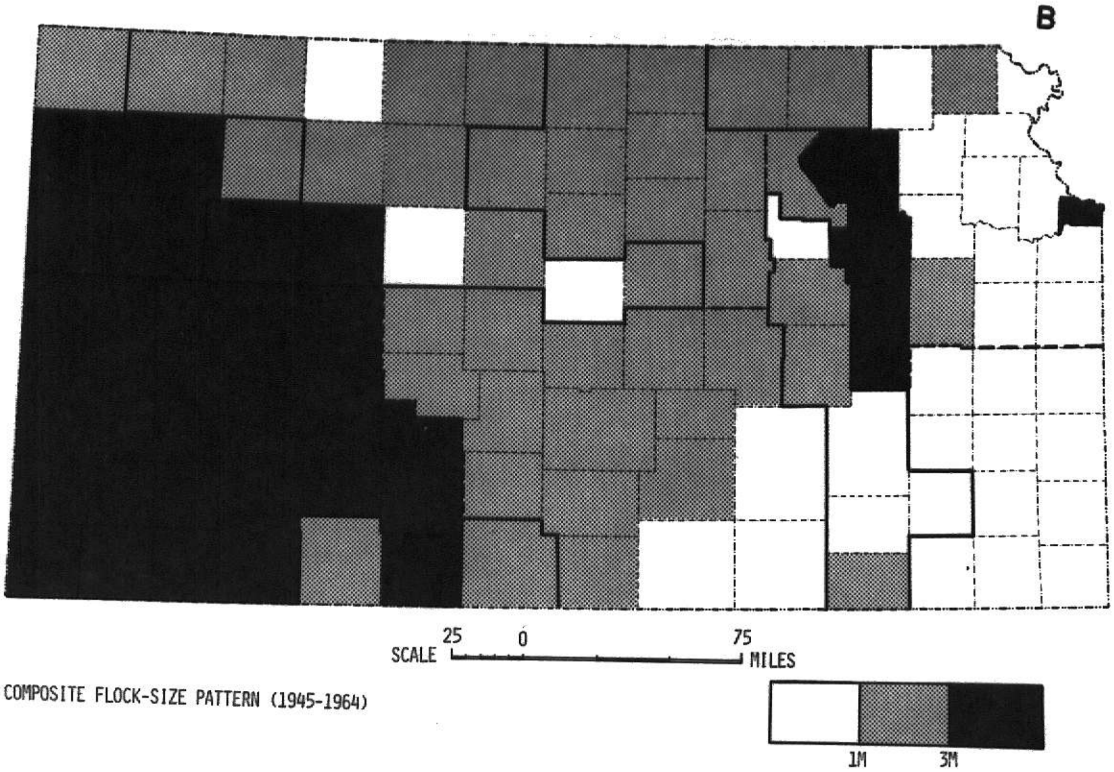
EXPLANATION OF FIGURE I-5

Average Flock Size on Sheep Farms
in Kansas (1964 (A), and Composite (B)).
(Computed from USBC)

FIGURE I-5



DECEMBER 2, 1964   STATE AVERAGE= 110 HEAD/FARM



COMPOSITE FLOCK-SIZE PATTERN (1945-1964) counties in March, 1969 (Fig. I-5-A-a & b), about 75 percent of sheep and lambs were in feedlots of the size of 3,000-5,000 head.[8]

By overlapping these five flock-size maps, a more regular pattern appears in Fig. I-5-B. On this map, the black areas include the counties which had large operational scale (i.e., with average flock sizes at least three times the state's average) for at least one census year. The stippled areas include the counties which had medium operational scale (i.e., less than three times the state's average but at least the same as the state's average) for at least one census year. The white areas include the counties which have persistently had small operational scale.

The eastern limit of the large operational scale is to be used as the boundary line between the Southwestern and South Central Sheep Regions. West of this line, most sheep and lambs have been raised on winter wheat pasture and in large feedlots. With large acreages of wheat pasture, most of the farmers in western Kansas usually make either of the two decisions: (1) to bring in a large flock of lambs to utilize their wheat pasture fully, or (2) not to bring in any lambs and, instead, to pasture cattle on the wheat. Very rarely have they bothered to raise sheep and lambs in small flocks. Therefore, large operational scale has been one of the persistent characteristics of the Western Sheep Regions.

East of this boundary line, in the South Central Sheep Region, the number of farms with small flocks of sheep and lambs increases. Although there have been quite a few large-sized lamb feedlots in this

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[8]Questionnaires, March, 1969.

region, the average flock size of each county there has never been very large due to the existence of many small flocks.

At this stage the process of regionalization is completed. With the original 105 areal units (counties) being reduced to six sheep regions and two sets of non-sheep areas, the distribution problems certainly become much easier to handle. The value of the regionalization, however, should be judged by whether it illuminates or obscures the spatial contrasts.

CHAPTER TWO

REGIONAL CONTRASTS

Using the regional framework built in the preceding chapter, this chapter will first study the temporal change in sheep density in each sheep region and non-sheep area. This change in sheep density will then be related to the changes in both sheep farm density and flock size. Finally, the regional contrast of the relative competitiveness of sheep and lambs among all livestock in Kansas will be analyzed.

Section A

Regional Contrast of Temporal Change in Sheep Density

The by-county data of the number of sheep and lambs on farms on January 1 of each year are available in publications of the Kansas State Board of Agriculture.[9] Here, only the data of every other year are used because it is believed that the main characteristics of the temporal changes in sheep density since 1945 can still be fairly well shown by eliminating the data of the remaining years.

According to the curves of the state's average sheep density in Fig. II-1, sheep-raising in Kansas since 1945 can be divided into four stages: (1) the first stage (1945-1947), when the state's sheep-raising was best developed, with density being about 250 head per 10,000 acres;

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[9] Kansas State Board of Agriculture, Biennial Report and Farm Facts.

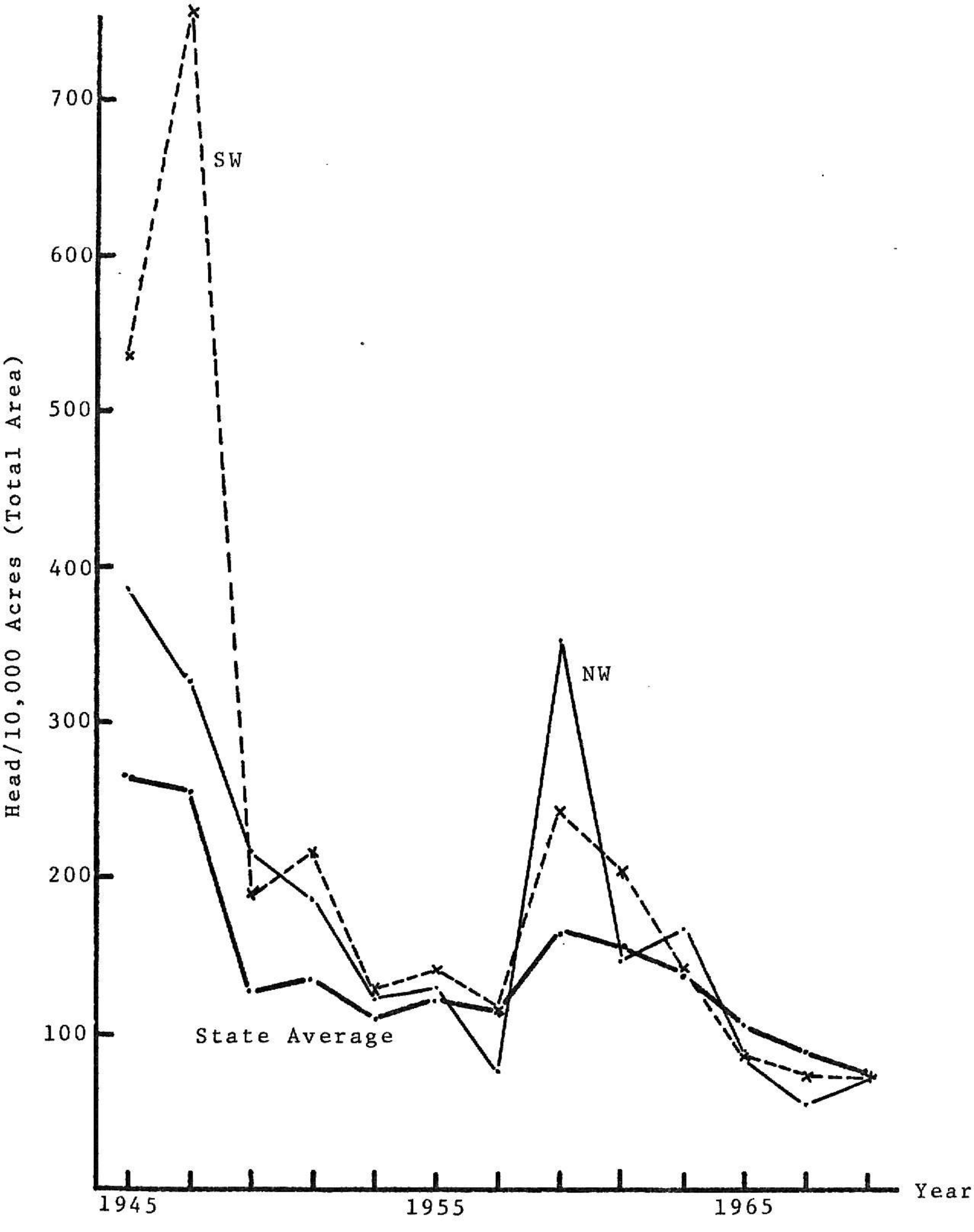

Fig. II-1. Change in Sheep Density in Western Sheep Regions. (Computed from KSBA)

(2) the second stage (1948-1957), when sheep-raising was affected primarily by prolonged drought (to be explained later), with density being between 100 and 150 head per 10,000 acres; (3) the third stage (1958-1963), when wet and mild weather conditions permitted good growth of pasture and feed crops, which, in turn, permitted an increase in the number of sheep and lambs, with density being between 150 and 200 head per 10,000 acres; and (4) the fourth stage (1964-1969), when the average sheep density, following the nation's declining trend, decreased to about 100 head or less per 10,000 acres.

Because the state's long-run decline since the 1940's has generally followed that of the country as a whole, sheep-raising in Kansas seems to have been rather strongly controlled by nationwide unfavorable factors. According to M. E. Ensminger, these nationwide unfavorable factors since the 1940's are:

> (1) lower returns and higher risks from sheep than from cattle and some crops in many areas; (2) scarcity and high wages of competent sheep herders; (3) uncertainties in tariff levels and imports, wool incentive payments, and grazing allotments on public domain; and (4) application of more science and technology in competing meat and fiber industries.[10]

As to the state's short-run fluctuations, the local weather conditions appear to be one of the most important factors. Table II-1 lists the annual total precipitation since 1945 for the representative station in each sheep region. Because dryness should be defined in terms of precipitation and temperature, this table tells only part of the story. Furthermore, in a subhumid state like Kansas, precipitation

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[10] M. E. Ensminger, pp. 17, 18.

Table II-1

Annual Precipitation in Kansas, 1945-1968 (Unit in Inches)

Sheep Region: Station:	NE Topeka	SE Iola	NC Concordia	SC Wichita	NW Goodland	SW Dodge City
1945	38.35	42.66	28.68	36.71	*14.38 (1.24;0.18)	21.93 (2.58;1.17)
1946	*32.18	*29.60	32.67	*23.67	18.91 (0.66;1.67)	*19.04 (2.16;4.56)
1947	37.53	40.31	*23.88	*25.93	*14.97 (0.17;0.51)	20.34 (0.01;0.56)
1948	*30.51	42.08	26.19	31.33	16.71 (0.34;0.03)	23.67 (0.62;0.32)
1949	43.27	43.27	26.66	38.17	21.54 (0.47;0.94)	25.44 (0.55;4.48)
1950	38.31	*32.34	36.65	30.87	*12.58 (0.79;0.23)	*14.55 (0.49;0.66)
1951	50.84	57.84	40.74	50.48	20.96 (1.47;0.58)	32.76 (0.05;0.06)
1952	*21.33	*23.20	*17.83	*20.03	*12.37 (0.31;0.05)	*14.20 (0.18;0.00)
1953	*22.28	*27.33	*20.44	*19.11	17.37 (0.03;0.30)	*11.46 (0.65;0.89)
1954	*28.21	*27.04	*22.39	*14.53	*11.12 (0.79;1.39)	*12.01 (1.37;1.51)
1955	*28.87	*20.04	*16.19	*23.77	*10.81 (1.69;0.10)	*17.42 (2.47;0.07)
1956	*25.35	*26.80	*12.83	*12.73	* 9.19 (0.05;0.56)	25.86 (0.02;1.73)
1957	38.99	38.99	*25.33	37.15	18.69 (0.31;0.83)	25.46 (3.76;0.71)
1958	38.73	39.68	31.73	31.66	*15.99 (4.97;0.65)	22.23 (1.17;0.06)
1959	42.60	-	26.12	33.58	*15.06 (2.97;1.83)	20.09 (3.86;3.30)
1960	*25.64	*33.42	28.74	36.79	19.92 (0.65;2.05)	20.14 (2.91;2.04)
1961	41.66	-	35.12	39.27	18.73 (1.64;0.36)	21.34 (0.43;1.78)
1962	*32.26	*33.49	27.32	32.55	19.53 (0.79;0.67)	27.97 (4.24;0.41)
1963	*19.07	*15.74	*23.25	*28.10	*16.24 (4.84;0.03)	*12.97 (1.86;0.65)
1964	35.98	*33.28	28.61	34.21	*10.81 (1.56;0.02)	21.25 (1.75;0.83)
1965	37.97	*32.40	33.24	38.97	20.87 (4.31;3.06)	24.95 (2.63;3.04)
1966	*19.30	*26.10	*15.16	*12.15	*11.40 (1.00;1.23)	*14.14 (1.89;0.32)
1967	50.64	-	38.24	*23.44	*15.72 (4.13;0.52)	21.30 (2.38;0.31)
1968	40.58	37.53	30.01	33.42	*13.70	*11.98
Normals	32.36	36.93	25.39	28.41	16.50	19.25

Table II-1 (continued)

Note: Normal precipitation is the average in the period of 1931-1960.

Figures indicating less than the normal precipitation are preceded by asterisks.

September and October data are in parentheses, and, if less than one inch, are underlined.

Source: Weather Bureau, U. S. Department of Commerce.

is very unevenly distributed during the year, and, consequently, the distribution of precipitation is as important as the total amount. To remedy the drawback of lacking distribution information, Table II-1 gives precipitation data of September and October for the stations in the western sheep regions, where the autumn precipitation is of critical importance to winter wheat pasture.

In this chapter the change in sheep density between regions will be contrasted, and the short-run fluctuations of this change will be qualitatively related to the dryness or wetness of weather conditions. Before relating them, one should clarify the notion of "drought." To range economists drought is defined as "a period of time in which net returns are reduced because of a deficiency of soil moisture."[11] Usually, there are several months of time lag between the end of the last ample rainfall and the time when a deficiency of soil moisture becomes apparent. Therefore, the lack of precipitation in the second half of a year usually affects the sheep density of the following year.

Since the regional contrast of the change in sheep density is mainly in an east-west direction, Fig. II-1, II-2, and II-3 are drawn for the western, central, and eastern sheep regions, respectively, with the state's average density serving as a reference line.

In Fig. II-1, the curves of southwestern and northwestern sheep regions show the greatest magnitude of short-run fluctuation and the sharpest long-run decline among all regions. The greatest drop of sheep

[11] J. R. Gray, p. 401.

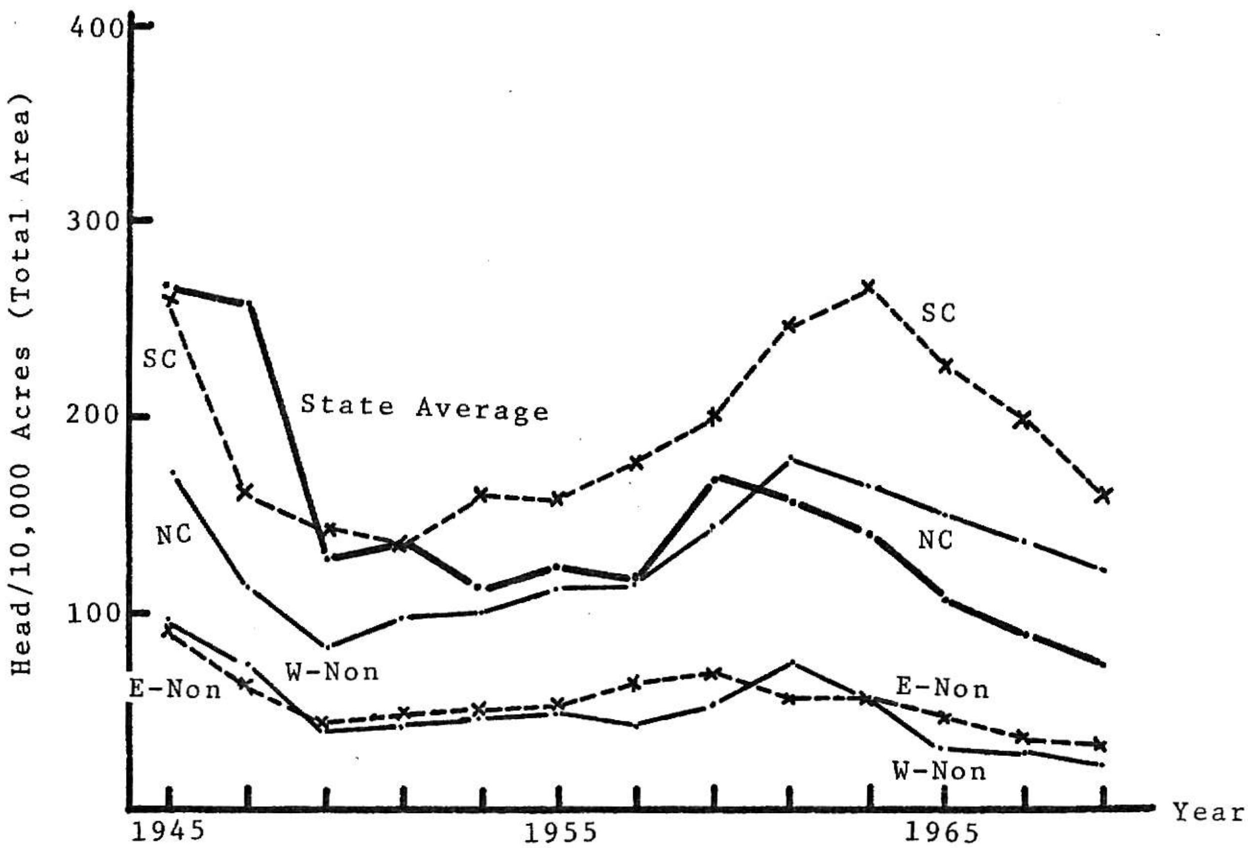

Fig. II-2. Change in Sheep Density in Central Sheep Regions and Non-sheep Areas. (Computed from KSBA)

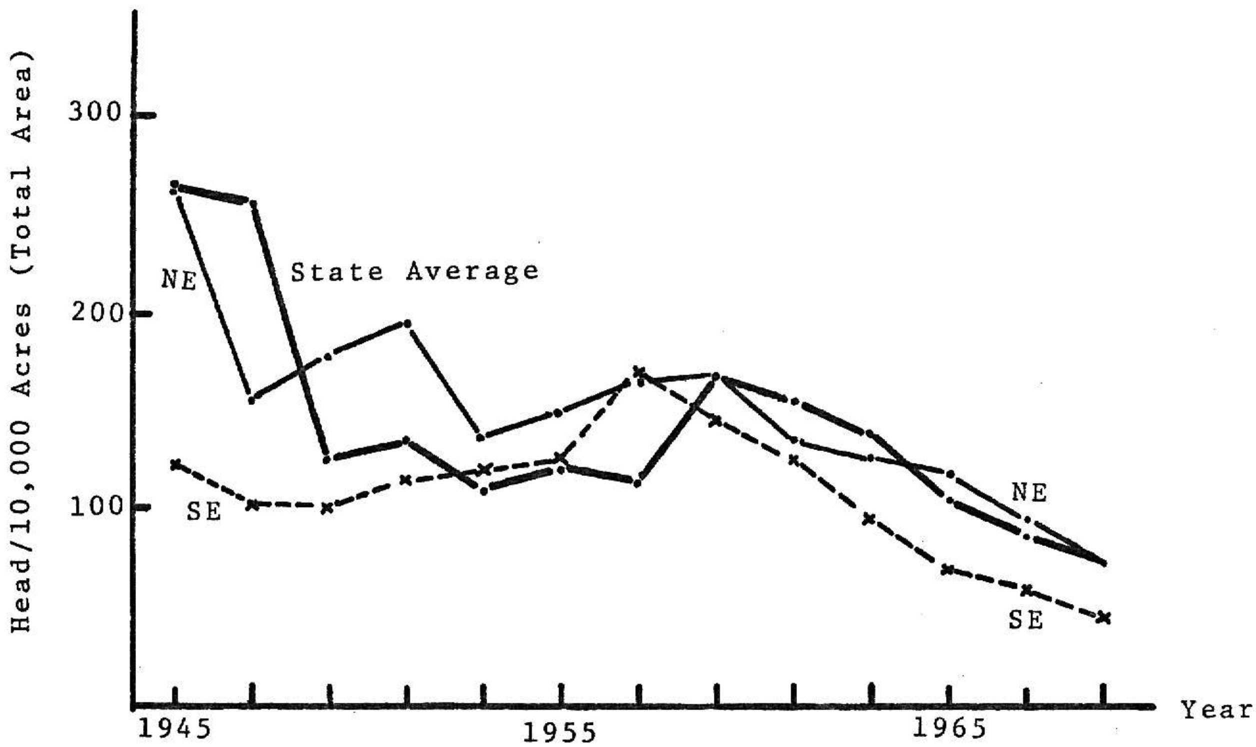

Fig. II-3. Change in Sheep Density in Eastern Sheep Regions. (Computed from KSBA) density in the southwestern sheep region occurred in the interval between 1947 and 1949. In that region within this time interval, the annual total precipitation was above normal, but the unfavorable distribution of precipitation greatly affected sheep-raising. This drastic change was explained by Biennial Report, No. 36, Kansas State Board of Agriculture:

> January 1, 1947, found a record number (900,000) of sheep and lambs on wheat fields and in feedlots in the state--the result of heavy inshipment in the fall of 1946 for feeding on the excellent fall growth of wheat in western Kansas. These animals made excellent gains with marketing off of wheat fields in volume from January until April. In the fall of 1947, retarded wheat development did not permit heavy inshipments, and on January 1, 1948, the number of sheep and lambs feeding on wheat fields and in feedlots was placed at only 382,000 head, with the exception of 1944 the smallest number since 1940.[12]

As shown in Fig. I-1, most sheep and lambs of 1947 were concentrated in the southwestern sheep region where the fall precipitation of the preceding year was exceptionally high, as shown in Table II-1. The dry autumns of 1948 and 1949 initiated a prolonged dry period through most of the 1950's. The decline of sheep-raising in these western sheep regions continued until the late 1950's when relatively wet years (or autumns) permitted the recovery of soil moisture and, consequently, of wheat pasture and, consequently, of sheep-raising. Even though the increased sheep density in this relatively wet period was not so high as that of the mid-1940's, the drastic rise from the low level of the mid-1950's and the equally drastic drop towards the late 1960's typified the density change of the western sheep regions.

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[12]Kansas State Board of Agriculture, Biennial Report, No. 36, p. 448.

Compared with the western sheep regions, the north and south central sheep regions (Fig. II-2) show less short-run fluctuation and only very slight long-run decline (if it is indeed declining; maybe some economists would rather describe the changes as "livestock cycles"). Both curves of these central sheep regions are essentially parallel to each other, with low density in the droughts of the 1950's and again in recent years. Since both curves have not quite followed the downward trend of the state's average density, they have changed gradually from below average in the 1940's to far above average in the 1960's. In fact, the central sheep regions are the only two regions with density substantially higher than the state's average in the late 1960's. The overwhelming importance of the south central sheep region is clearly shown by the wide margin (about 100%) above the state's average density.

Compared with the western and central sheep regions, the curves of the eastern sheep regions (Fig. II-3) do not form a wide and deep hollow in the 1950's. These two regions are located in the wettest part of Kansas, and the climatic factor appears to be less important. The long-run decline is apparent in these eastern regions, but not as strong as in the western regions.

In Fig. II-2 the density curves of the eastern and western non-sheep areas have crept far below the state's average density curve through the last two decades, with little short-run fluctuation and not much long-run decline. Paradoxically, the curve of the western non-sheep areas, where climate is relatively unstable, appears to be as stable as that of the eastern non-sheep areas.

For further understanding, one may ask whether the change in the number of sheep and lambs in each region is mainly due to the change in the number of sheep farms or due to the change in flock size. In answering this question, another interesting regional contrast is discovered.

Section B

Regional Contrast of Relationships Between Change in Number of Sheep and Lambs and Changes in Number of Sheep Farms and in Flock Size

Publications of the U. S. Census of Agriculture are the only sources where the number of farms reporting sheep and lambs on farms is available. Therefore, this analysis will be based on the five census years since 1945. Unfortunately, only one census year (1945) used January 1 as the reporting date, and the others used April 1 (1950), November 7 (1954), November 22 (1959), and December 2 (1964), respectively. Since these data are not strictly comparable through time, the curves drawn from these data may not be totally the same as those drawn in the preceding section. For example, the enumerations taken before and after lambing season of a year would possibly be quite different.

From Fig. II-4 to II-8, 1945 is used as an index year. The data of the remaining census years are converted into the percentages of the data of the index year and plotted on the graphs. Smooth curves are drawn through the five census years to show the general trends of changes in number of sheep and lambs on farms, number of sheep farms, and flock sizes. The curves of "number of sheep and lambs" in these graphs fit

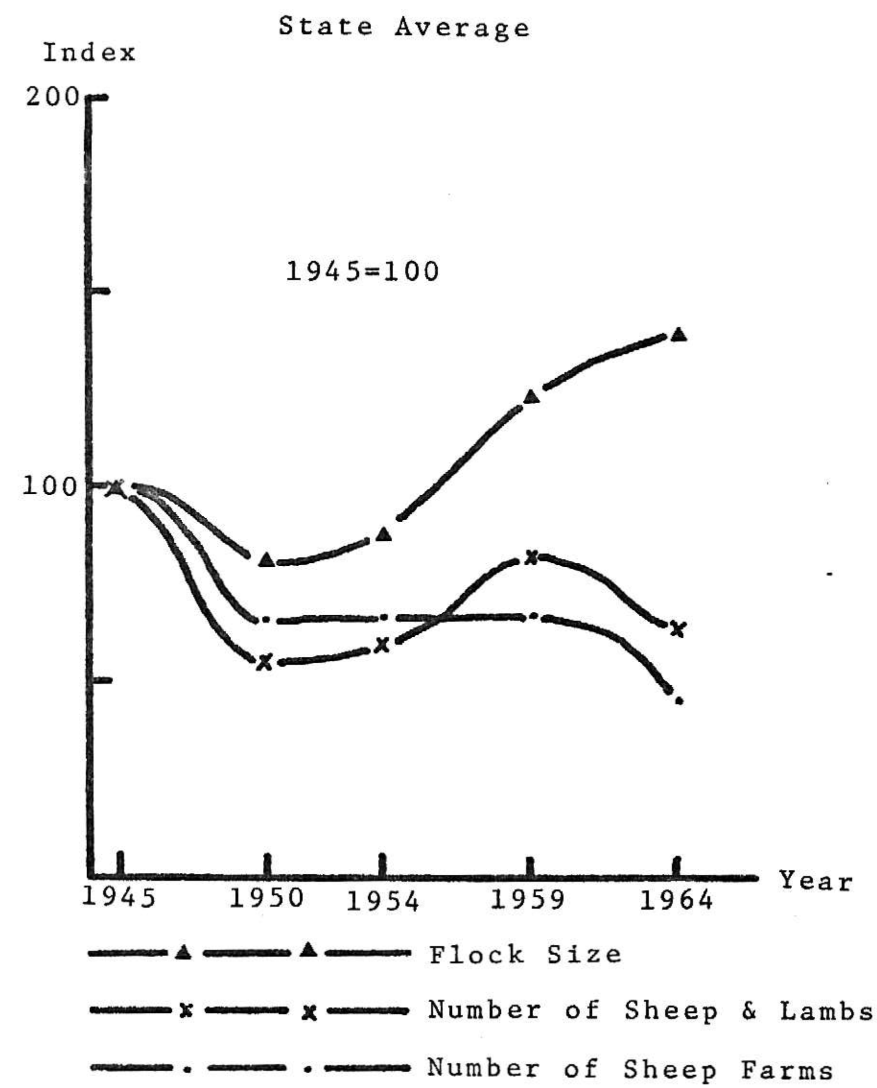

Fig. II-4. Changes in Number of Sheep and Lambs, Number of Sheep Farms, and Flock Size in Kansas. (Computed from USBC) fairly well into the curves of sheep density in Section A (above) for the state and all the sheep regions, except for the eastern ones. Even for these two regions, the discrepancy only appears in the short-run fluctuation.

In Fig. II-4 the curves show that the decrease in the number of sheep and lambs in Kansas from 1945 to the early 1950's was due to the relatively sharp decrease in the number of sheep farms and the relatively moderate decrease in flock size. The increase in the number of sheep and lambs in the late 1950's was mainly due to the increase in flock size, because the number of sheep farms remained almost the same. In the 1960's the positive effect of the increase in flock size was not great enough to balance the negative effect of the decrease in number of sheep farms, and, thus, the number of sheep and lambs showed a downward trend. In general, taking the state as a whole, the flock size has been expanding while the numbers of both sheep farms and sheep and lambs have been decreasing. Within the state there is a strong regional contrast in these changes.

In Fig. II-5 the curves of the western sheep regions suggest the strong climatic control on not only the change in number of sheep farms but also the change in flock size. The curves of both flock size and the number of sheep farms have fluctuated in the same direction through time. Therefore, the number of sheep and lambs in these western sheep regions has shown the greatest magnitude of fluctuation. All three curves show the long-run downward trend.

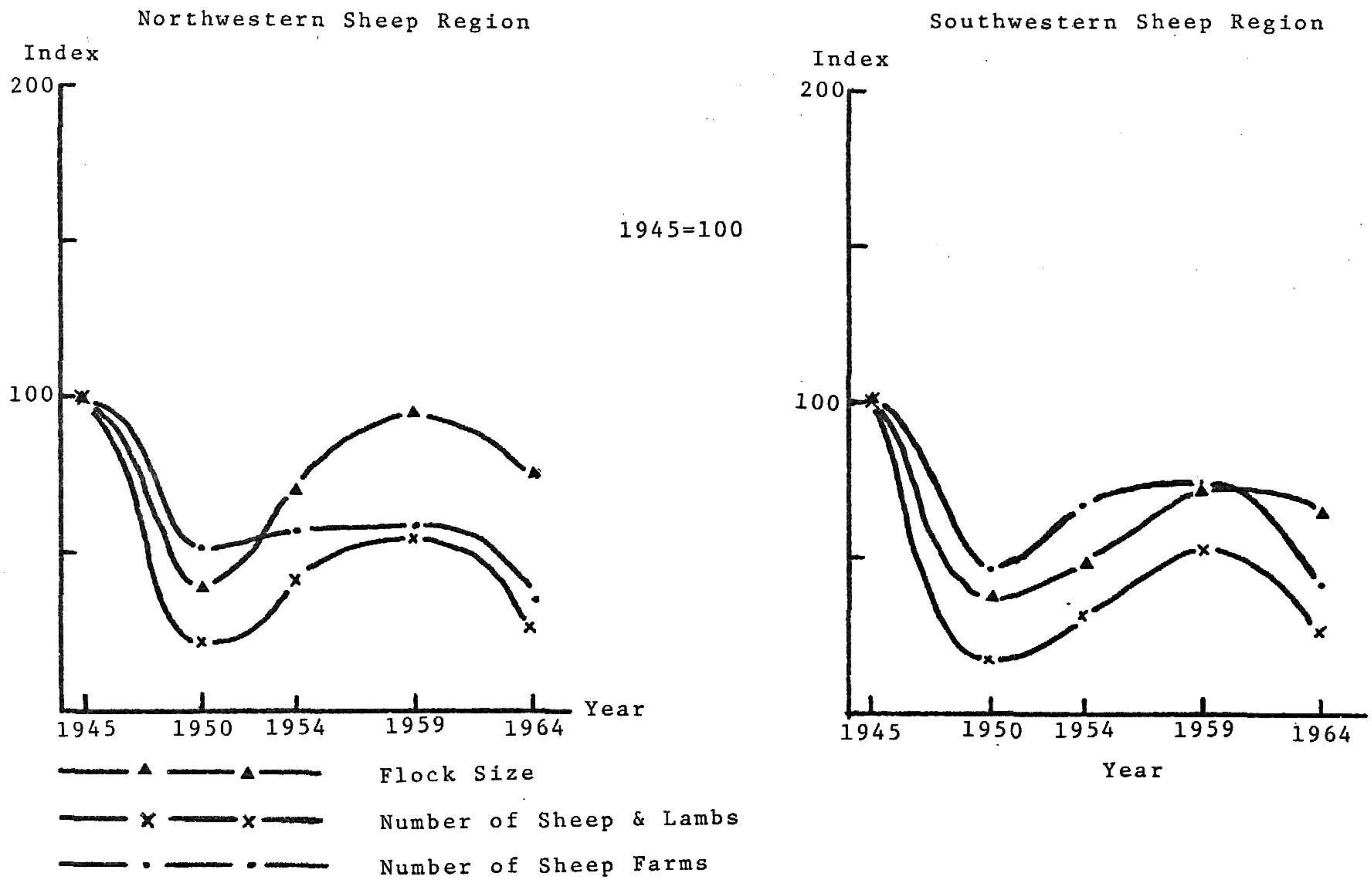

Fig. II-5. Changes in Number of Sheep and Lambs, Number of Sheep Farms, and Flock Size in Western Sheep Regions. (Computed from USBC)

In Fig. II-6 the most striking feature is the sharp upward trend of the curves of flock size in the central sheep regions. Here the drought of the 1950's showed little or no negative effect on flock size. Therefore, the decrease in the number of sheep and lambs from the mid-1940's to the early 1950's was mainly due to the decrease in the number of sheep farms. However, the sharp increase in the number of sheep and lambs towards the end of the 1950's was mainly due to the sharp increase in flock size. Towards the mid-1960's the positive effect of the increasing flock size appeared to have difficulty balancing the negative effect of the declining number of sheep farms. However, these central sheep regions are the only two regions where the number of sheep and lambs remained at the high level of the mid-1940's when sheep-raising in Kansas was in its golden period.

As mentioned in Section A, the drought of the 1950's appeared to have had the least effect on the number of sheep and lambs in the eastern sheep regions. Fig. II-7 reveals that the number of sheep farms was sharply reduced in that dry period, but its effect was nullified by the equally sharp increase in flock size. In general, the eastern sheep regions are characterized by the steady decrease in the number of sheep farms and by the sharp expansion of flock size (but not so sharp as that of the central sheep regions). Their number of sheep and lambs has been declining, especially in the southeastern sheep region (but the decline is not so great as in the western sheep regions).

Fig. II-8 discloses the strong contrast between the eastern and western non-sheep areas. In Fig. II-2, the curves of sheep density of

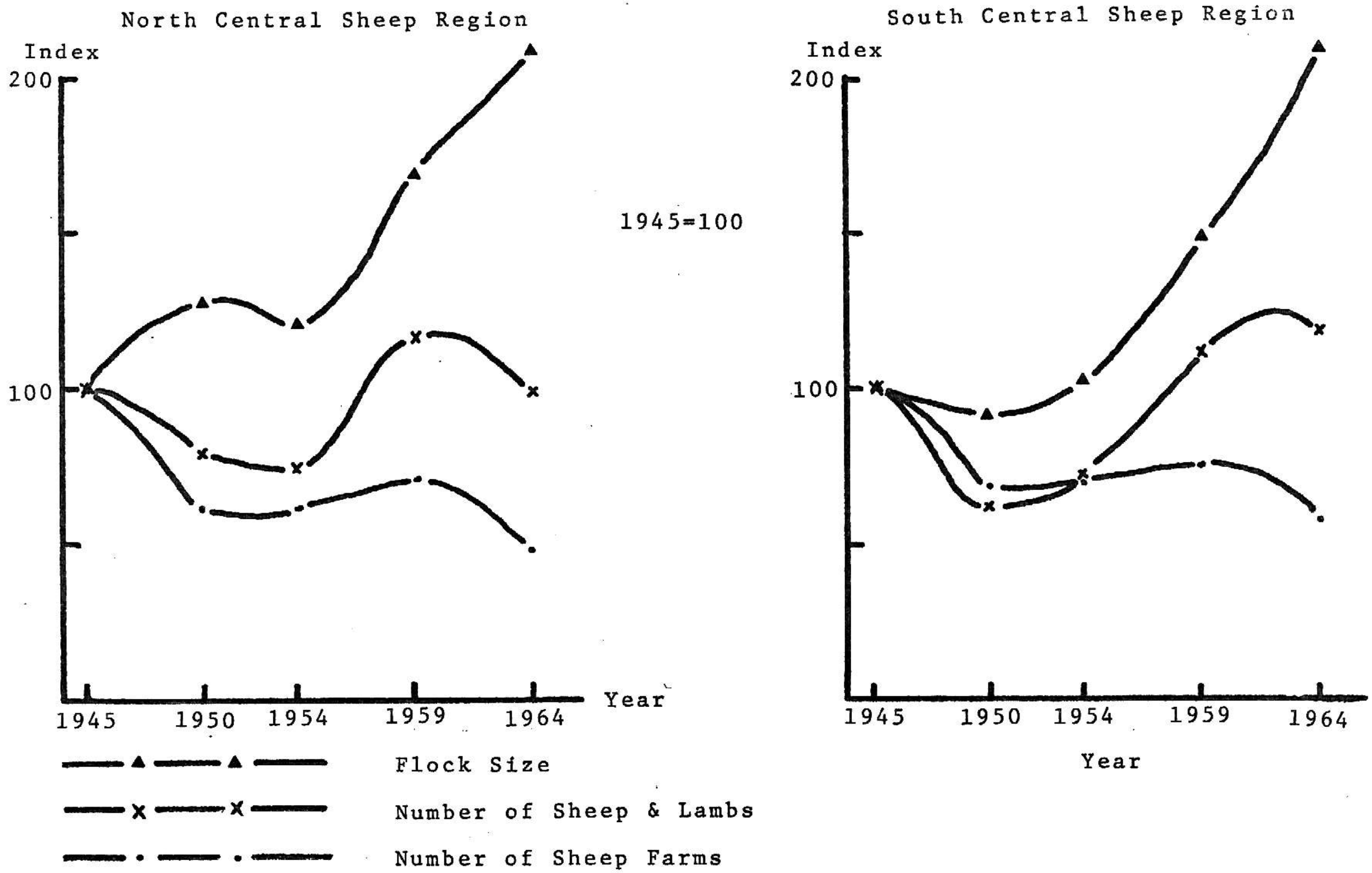

Fig. II-6. Changes in Number of Sheep and Lambs, Number of Sheep Farms, and Flock Size in Central Sheep Regions. (Computed from USBC)

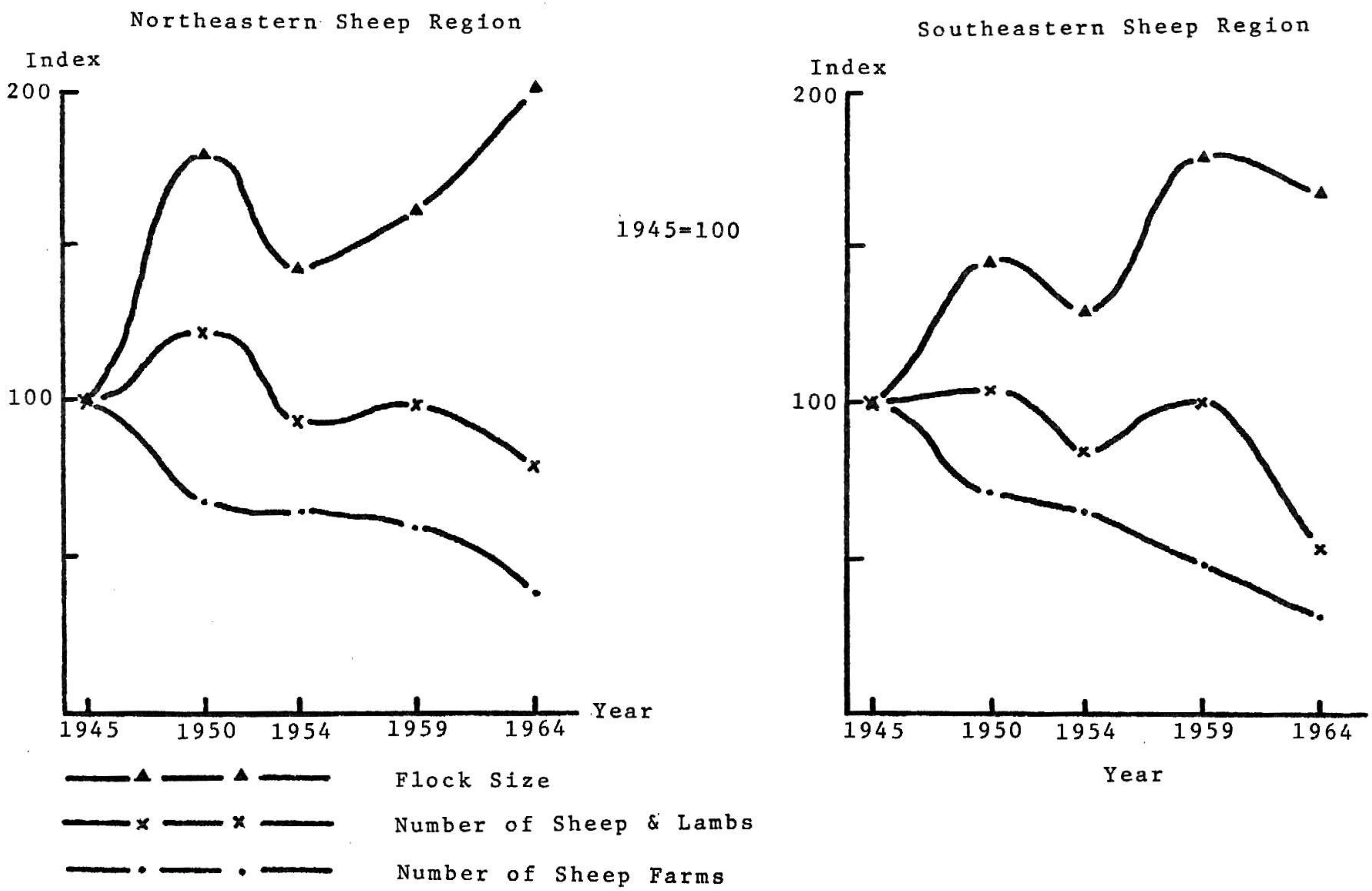

Fig. II-7. Changes in Number of Sheep and Lambs, Number of Sheep Farms, and Flock Size in Eastern Sheep Regions. (Computed from USBC)

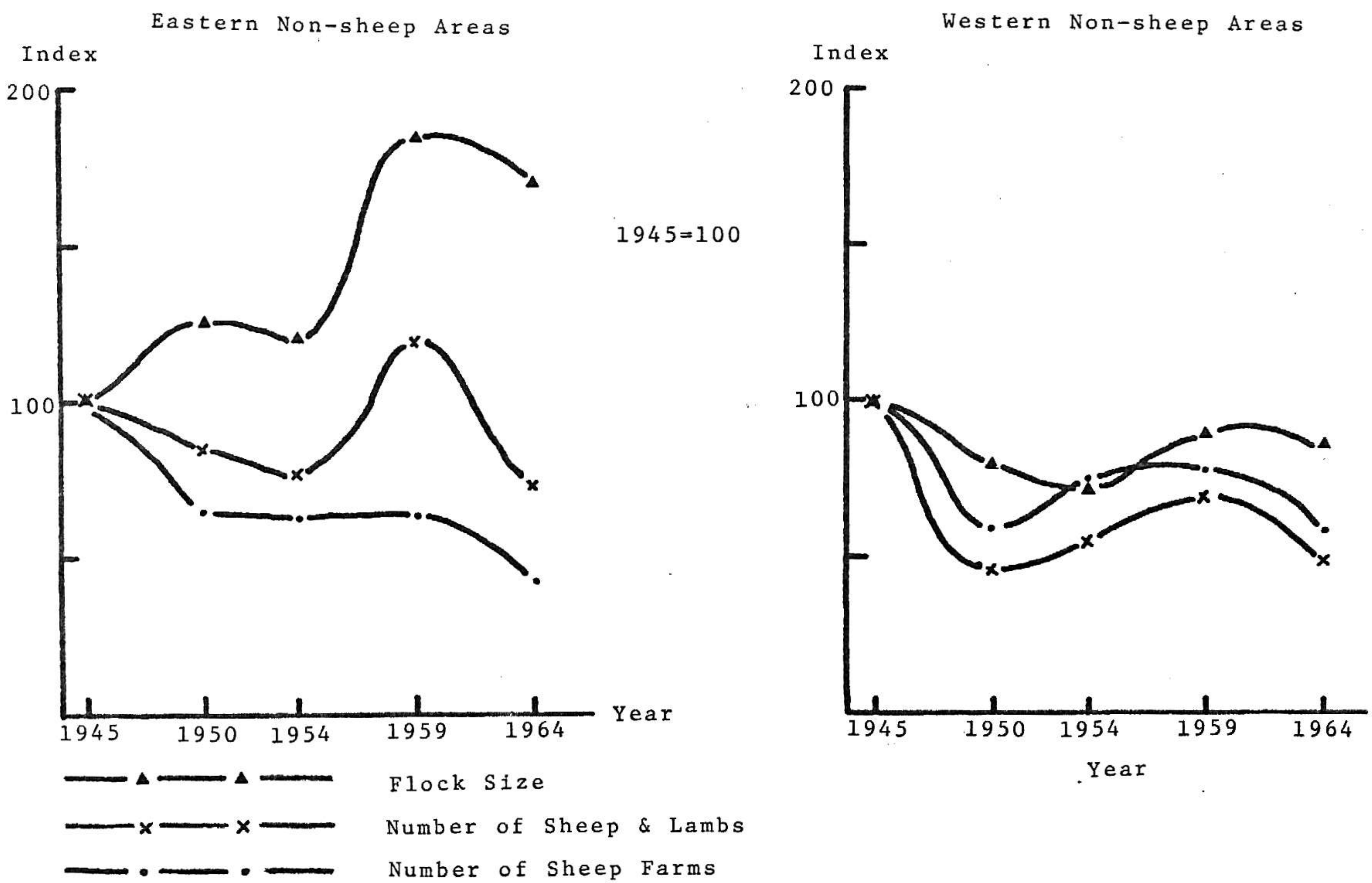

Fig. II-8. Changes in Number of Sheep and Lambs, Number of Sheep Farms, and Flock Size in Non-sheep Areas. (Computed from USBC) these two sets of non-sheep areas were very close together through time. However, when the change in the number of sheep and lambs is related to the changes in the number of sheep farms and in flock size, the western non-sheep areas appear similar to the western sheep regions while the eastern non-sheep areas are similar to the eastern sheep regions.

Although these figures (Fig. II-4 to II-8) show that the flock size has increased about 100 percent in the central and eastern sheep regions and decreased about 25 percent in the western sheep regions since 1945, the east-west contrast in flock size has remained practically intact. This persistent contrast can be seen both in Fig. I-3 and I-4 (at county level) and in Table II-2 (at regional level).

Table II-2

Regional Contrast of Sheep Flock Size in Kansas

Sheep Regions:	NW	NC	NE	SW	SC	SE	State
Year		Unit: Head of Sheep and Lambs					Sheep Farm
1945	432	61	39	508	63	24	79
1950	177	78	70	187	58	35	64
1954	309	74	56	242	65	31	70
1959	413	102	63	366	93	42	97
1964	326	127	78	331	129	40	110

Source: Computed from U. S. Bureau of Census.

The east-west contrast in the number of sheep farms also has essentially remained intact, even though the rate of decrease varied from region to region. To demonstrate this persistent contrast at county level, two sets of profiles cutting through the southern and northern sheep regions are shown in Fig. II-9. The width of each column is proportional to the width of each county along the profiles, and the height of each column represents the county's density of sheep farms. The horizontal dashed lines show the state's average density; while the vertical dashed lines at the bottom are the regional boundaries.

The southern profiles show the strong concentration of sheep farms in the southeastern sheep region and the core area of the south central sheep region. The sheep farm density in the eastern non-sheep areas has been relatively low, compared with the neighboring sheep regions. The southwestern sheep region has been characterized by the extremely light density of sheep farms, even in the mid-1940's when sheep and lambs were mostly concentrated in that region.

The northern profiles show the three-stepped development: high in the northeastern sheep region; about the state's average in the north central sheep region; and low in the northwestern sheep region. The western non-sheep areas between the northwestern and north central sheep regions have had very light sheep farm density through time.

To conclude this section: (1) the regional contrast of the relationships between the change in the number of sheep and lambs and the changes in the number of sheep farms and in flock size is mainly in the east-west direction; and (2) the spatial contrasts of sheep farm density and of flock size are more profound and persistent than the spatial contrast of sheep density.

FIGURE II-9

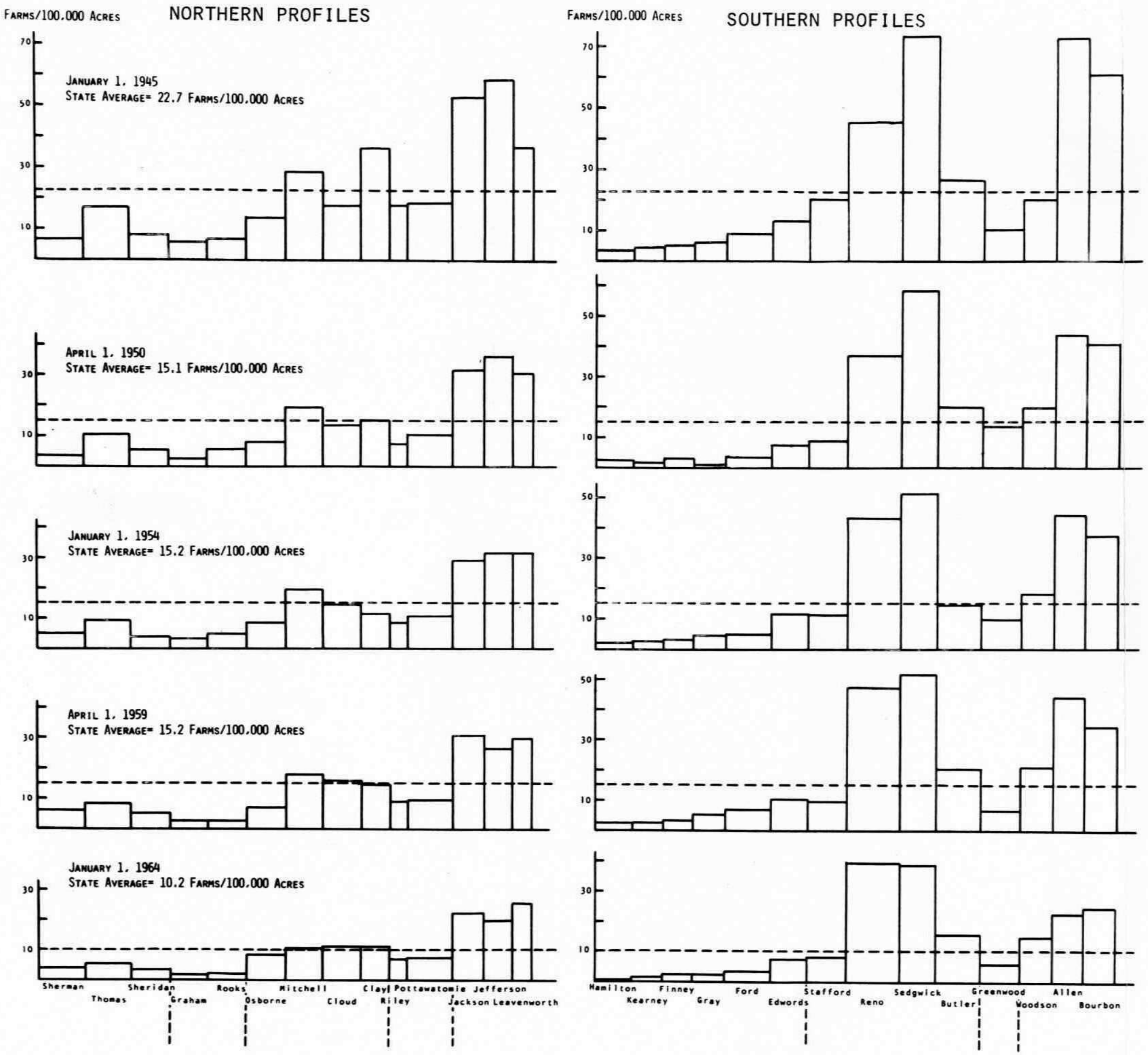

Fig. II-9. Profiles of Sheep Farm Density in Kansas. (Computed from USBC)

Section C

Regional Contrast of Relative Competitiveness of Sheep and Lambs Among All Livestock

In Chapter One it was found that most non-sheep areas in Kansas are located in the relatively hilly and pastoral terrains. As attempts were made to explain this paradoxical finding, another regional contrast was discovered and will be presented in this section.

The relative competitiveness of sheep and lambs among all livestock can be indicated by the ratio of the animal units of sheep and lambs to the animal units of all livestock. But, for the reason to be explained later, this study uses the ratio of animal head, rather than of animal units, to indicate the relative competitiveness of sheep and lambs.

The data of the number of livestock on farms on January 1 of 1947, 1953, 1959, and 1965 are sampled from publications of the Kansas State Board of Agriculture.[13] The numbers of sheep, hogs, and cattle in each year are summed up and changed into percentages for all areal units (i.e. the state as a whole, the sheep regions, and the non-sheep areas). Then, according to their percentages of sheep, hogs, and cattle, all areal units are plotted in the "ternary" diagrams. The resulting patterns are shown in Fig. II-10, II-11, and II-12. The diagrams in Fig. II-11 and II-12 are the right-hand corners of their respective

[13] Kansas State Board of Agriculture, <u>Biennial Report</u>, No. 36, and <u>Farm Facts</u> (1953, 1959, 1965).

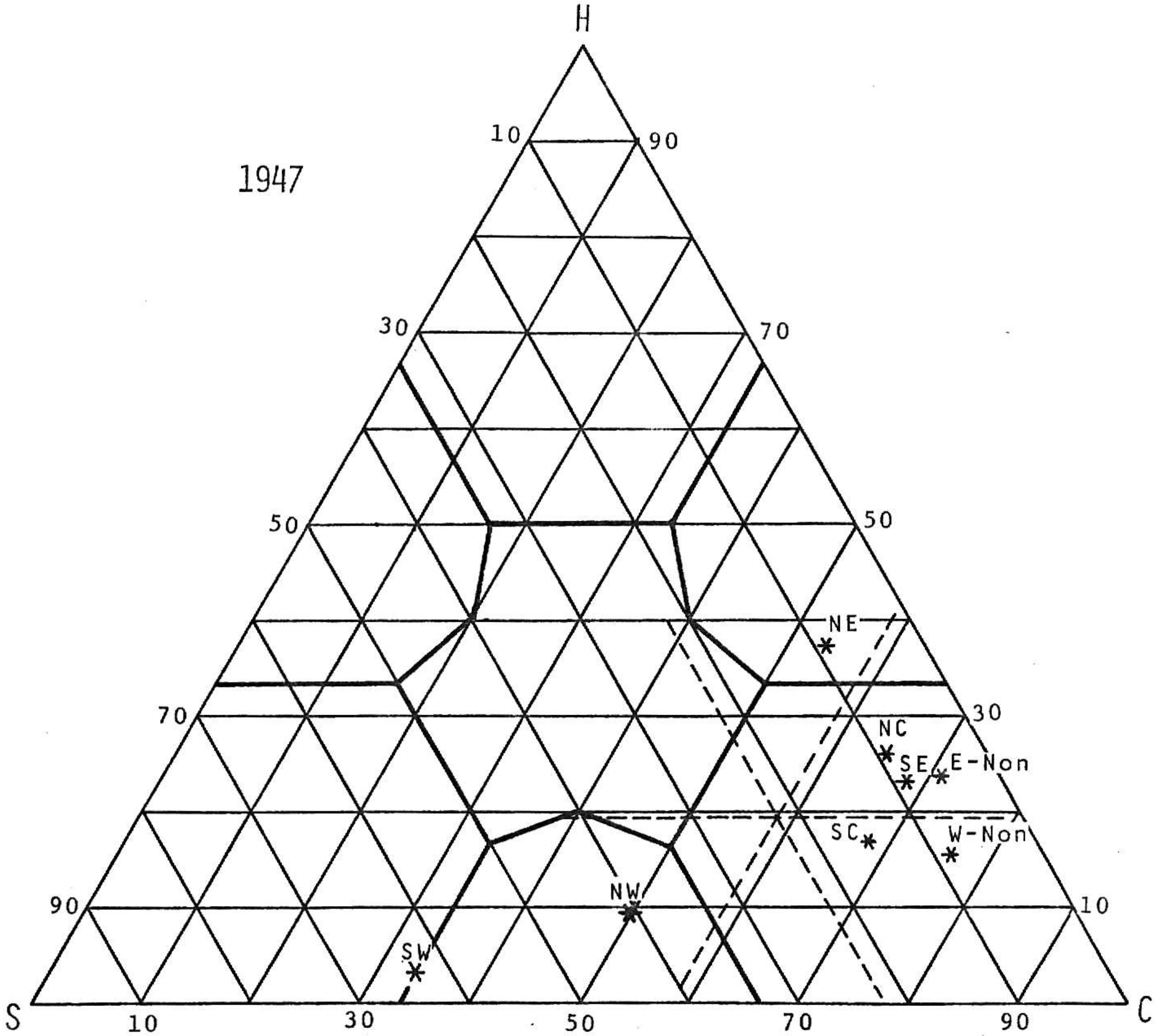

Fig. II-10. Relative Competitiveness of Sheep, Cattle, and Hogs in Kansas, 1947. (Computed from KSBA) complete ternary diagrams. In Fig. II-10 and II-11 the state average is located by the intersection of three dashed lines while all other areal units are shown by asterisks.

The heavy solid lines in each diagram are the boundaries of "single-component," "two-component," and "three-component" sectors.[14] Obviously, Kansas has been a single-component cattle state, because the location of the state average in each diagram is in the single-component sector near the cattle apex. If animal unit is used as the criterion, the state average point will be pulled even closer to the cattle apex, and all other points will get closer, too. However, the interest of this study is to illustrate spatial contrast of sheep's competitiveness within the state, which is better illuminated by using animal head as the criterion. Of course, if Kansas were not overwhelmingly dominated by cattle, animal unit would be the better criterion to use.

Since this study is concerned with the spatial contrast within the state, one should pay attention to the relative location of each areal unit within the six sectors constructed by the three dashed lines from the point of the state average in Fig. II-10 and II-11.

Through the last two decades the eastern sheep regions have been located in the sectors where the relative competitiveness of sheep is below the state's average; while the western sheep regions, on the contrary, have been located in the sectors where the relative competitiveness of sheep is above the state's average. Sheep-raising in the eastern (especially, northeastern) sheep regions has experienced

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[14] Peter Haggett, p. 218.

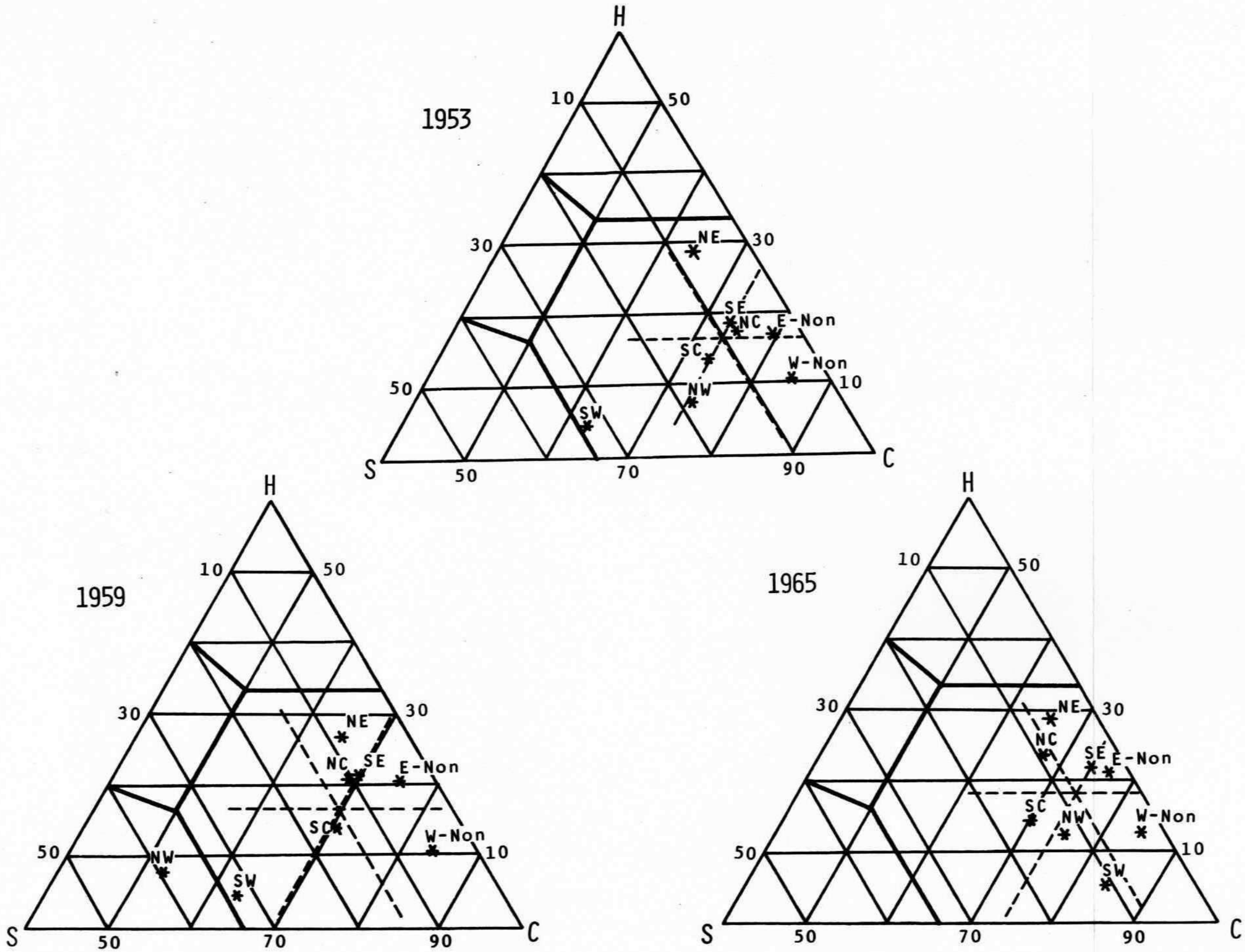

Fig. II-11. Relative Competitiveness of Sheep, Cattle, and Hogs in Kansas, 1953, 1959, and 1965. (Computed from KSBA) strong competition not only from cattle but from hogs also. The relative competitiveness of sheep in the central sheep regions has changed from below to above the state average. This change coincides with the increasing concentration of sheep and lambs in these two regions.

The most interesting finding in Fig. II-10 and II-11 is that sheep-raising in the eastern and western non-sheep areas has encountered the strongest competition from other livestock, mainly cattle. Without exception these two non-sheep areas are lowest on the "sheep scale" in all diagrams.[15] On the basis of these diagrams, one can probably say that, even though the non-sheep areas are mostly hilly and pastoral, sheep-raising there has not been and will not be well-developed because of the strong competition from other livestock.

The change of the relative competitiveness of sheep in each areal unit through time is shown in Fig. II-12. The years of 1947, 1953, 1959, and 1965 are represented by 1, 2, 3, and 4, respectively. From 1947 to 1953 all points moved down the sheep scale, especially the points of the western sheep regions. This was mainly due to the sharp decrease of sheep and the steady increase of cattle during the dry years of the early 1950's.

From the dry 1953 to the wet 1959, all points moved up the sheep scale, except that of the southwestern sheep region where the increase of cattle surpassed the increase of sheep and lambs. In this period the relative competitiveness of sheep in the northwestern sheep region showed

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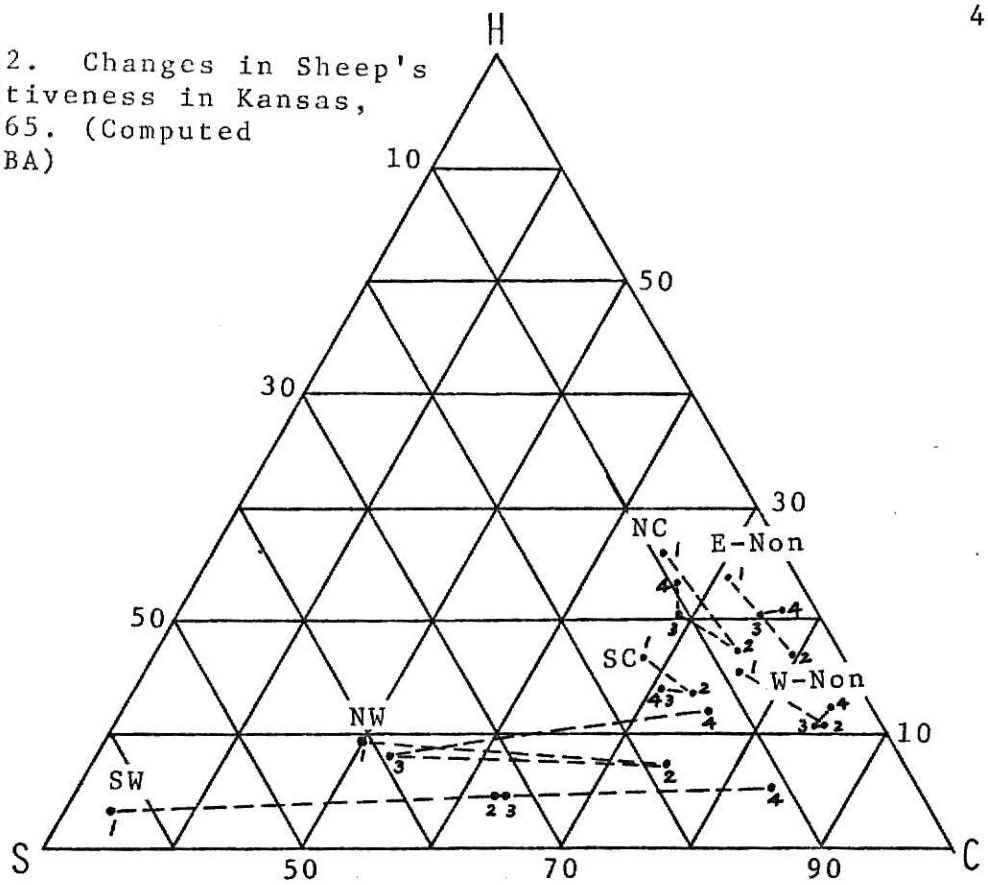
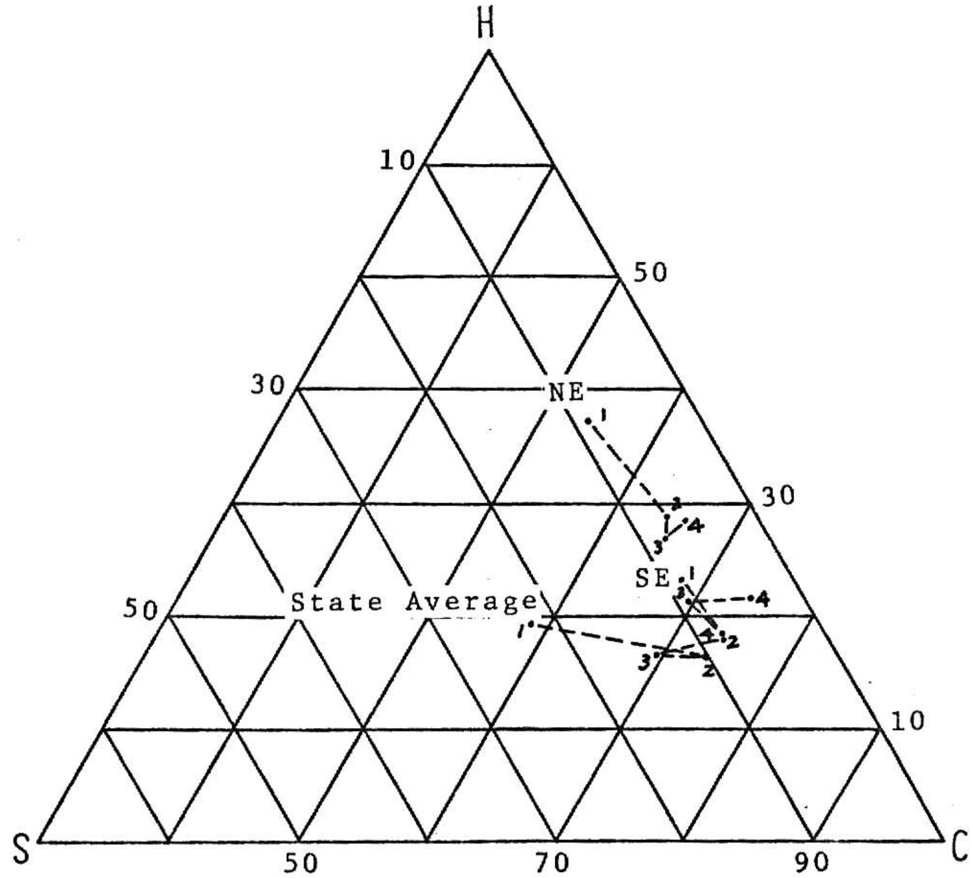
[15]The sheep scale is shown on the H-S edge of each diagram.

Fig. II-12. Changes in Sheep's Competitiveness in Kansas, 1947-1965. (Computed from KSBA)





the greatest increase. From 1959 to 1965 all points moved down the sheep scale again, except that of the south central sheep region which remained at the same location. The greatest decline of sheep's competitiveness in this period was in the two western sheep regions. From these points' similar upward and downward movement on the sheep scale, one may say that sheep-raising in most parts of Kansas is more affected by the climatic factor than is cattle-raising.

In the long-run sheep have lost their competitiveness in all areal units to varying degrees except in the two central sheep regions where sheep-raising is now best developed (compared with the other regions). The most dramatic loss of sheep is in the southwestern sheep region where the percentage of sheep and lambs among all livestock dropped from 63.4 percent in 1947 to 10.8 percent in 1965.

By comparing Fig. II-10 and II-11, one can also see that the regional variation of sheep's competitiveness (suggested by the disperseness of the points in each diagram) has decreased with the decrease of sheep's competitiveness. The state's average percentage of sheep among all livestock dropped from 22.1 percent in 1947 to 7.9 percent in 1965, and the regional variation of sheep's competitiveness declined from 58.1 percent to 12.7 percent in the same period.

PART TWO

THE MOVEMENT OF SHEEP AND LAMBS IN KANSAS

A corollary to the advancement of a country's economy is the increasing diversification and regional specialization of production. The stronger the regional specialization, the greater the need for moving goods from place to place. In a highly developed country like the United States, it is not difficult to find a production unit acquiring its raw materials from a place hundreds of miles away and selling its products across the distance of more than a thousand miles to its final market. The sheep farms in Kansas are a good example. As will be shown later, a large proportion of the state's sheep replacements are imported from the western range states, and the majority of the state's fat lambs are sold to other states, mainly to those on the east coast. Conservatively estimated, the average lamb raised in Kansas travels, either live or after being dressed, more than a thousand miles before being put into pots and pans.

Aware of the great amount and length of movement involved, one can not help being curious about the movement aspects of the sheep and lambs in Kansas. Chapter Three will study the inward movement, with special attention being paid to the allocation of the inshipped stock sheep and lambs to different parts of the state. Chapter Four will investigate the outward movement, with special attention being paid (1) to the relative importance of live animal transportation and meat transportation, and (2) to the relationships between the focal points and their spheres of influence.

CHAPTER THREE

INWARD MOVEMENT

The lambs dropped in Kansas have not been numerous enough to provide all the replacements needed by the state's sheep industry. Therefore, a large number of sheep and lambs must be shipped in from other states. In the period of 1945-1950 the state's average number of lambs saved per year was 321,300 head; while the average yearly number of inshipped sheep and lambs was 868,100 head.[1] The corresponding figures were 382,000 and 382,000 (i.e. both were the same) in the period of 1955-1960; and 381,000 and 370,000 in the period of 1961-1966.[2] These figures suggest that, although the number of lambs saved has held steady and the number of inshipped sheep and lambs has been declining, a large proportion of the state's sheep replacements are still coming from other states.

As shown in Table III-1, most of the state's inshipments are from the western range states, with Texas, the leading sheep producing state of the United States, supplying 50 percent and Colorado supplying 15 percent. The heavy dependence on Texas is not only because there are more feeder lambs available there, but, perhaps, because they are available at relatively low prices. In 1967 the average prices of feeder lambs (spring, choice grade) were $23.26 per 100 pounds at Denver, Colorado;

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[1]Kansas State Board of Agriculture, <u>Biennial Report</u>, No. 38, p. 87.

[2]Statistical Reporting Service, U. S. Dept. of Agriculture, <u>Meat Animals</u>, 1955-1966.

$21.32 per 100 pounds at South St. Paul, Minnesota; and $19.39 per 100 pounds at Fort Worth, Texas.[3] It seems that the apparent price difference between Fort Worth and Denver is more than enough to compensate for the locational disadvantage (if there is any!) of Texas.

Table III-1

Stock Sheep and Lambs Shipped into Kansas
by State of Origin, 1964-1967

State of Origin	1964 No. of Head	1967 No. of Head	1964-1967 Average No. of Head	(%)
Texas	171,549	84,579	98,861	50.9
Colorado	38,324	20,603	28,756	14.8
New Mexico	36,122	9,886	17,575	9.1
Missouri	13,597	11,860	9,199	4.7
Oklahoma	14,266	2,861	7,311	3.8
Arizona	-	4,315	2,337	1.2
Wyoming	9,604	5,659	4,885	2.5
Nebraska	1,321	786	1,402	0.7
Other States	16,235	29,451	23,874	12.3
Total	301,000	170,000	242,750	100.0

Source: Kansas State Board of Agriculture.

One interesting aspect of the state's inward movement of sheep and lambs is that the imported stock sheep and lambs (including those destined to farms and feedlots) are extremely unevenly allocated within the state. Through the testing of four hypotheses, this chapter will be able to create a mathematical model which successfully explains this uneven allocation.

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[3] Ibid., Livestock and Meat Statistics, 1968, p. 126.

The areal units to be used in this analysis are the nine almost-equal-sized "crop reporting districts" (namely northwest, west central, southwest, north central, central, south central, northeast, east central, and southeast), simply because these are the smallest units used in reporting the data of sheep and lamb inshipments by the Kansas State Board of Agriculture.

The method of testing the four hypotheses is simple regression analysis. Although it is realized that simple regression analysis is to be used when one tries to explain a dependent variable by an independent variable, this paper will use this analysis even in the cases when a dependent variable is to be explained by <u>two</u> independent variables. It is hoped that this chapter will be able to demonstrate that, when more than one independent variable is of concern, multiple regression analysis, which seems to be too advanced for many geography students, is not absolutely necessary. A little thought may make a relatively simple method applicable to a relatively complex problem.

Hypothesis I. <u>The number of stock sheep and lambs imported into a district from other states in a year is positively correlated to the number of sheep and lambs on farms in that district at the beginning of that year</u>.

The logic of this hypothesis is (1) that the number of sheep and lambs on farms at the beginning of a year indicates very well the degree of development of sheep-raising, and (2) that the demand for lamb replacements is greater in an area where sheep-raising is better developed. Since the lambs dropped in Kansas can only provide about 65 percent of the replacements needed by the state's sheep industry, and all districts in the state import more or less sheep and lambs from other states, it may be assumed that the movement of stock sheep and lambs in Kansas is mainly inter-state instead of intra-state.[4] In other words, the demand for lamb replacements of a district is mainly supplied by other states rather than by the other districts of the same state.

The numbers of sheep and lambs inshipped and on farms in 1967 (Table III-2) are plotted in a scatter diagram for the state's nine districts (Fig. III-1). Through simple correlation analysis, the correlation formula and correlation coefficient (r-value) in Fig. III-1 are found. The moderately high r-value of 0.80 suggests that the

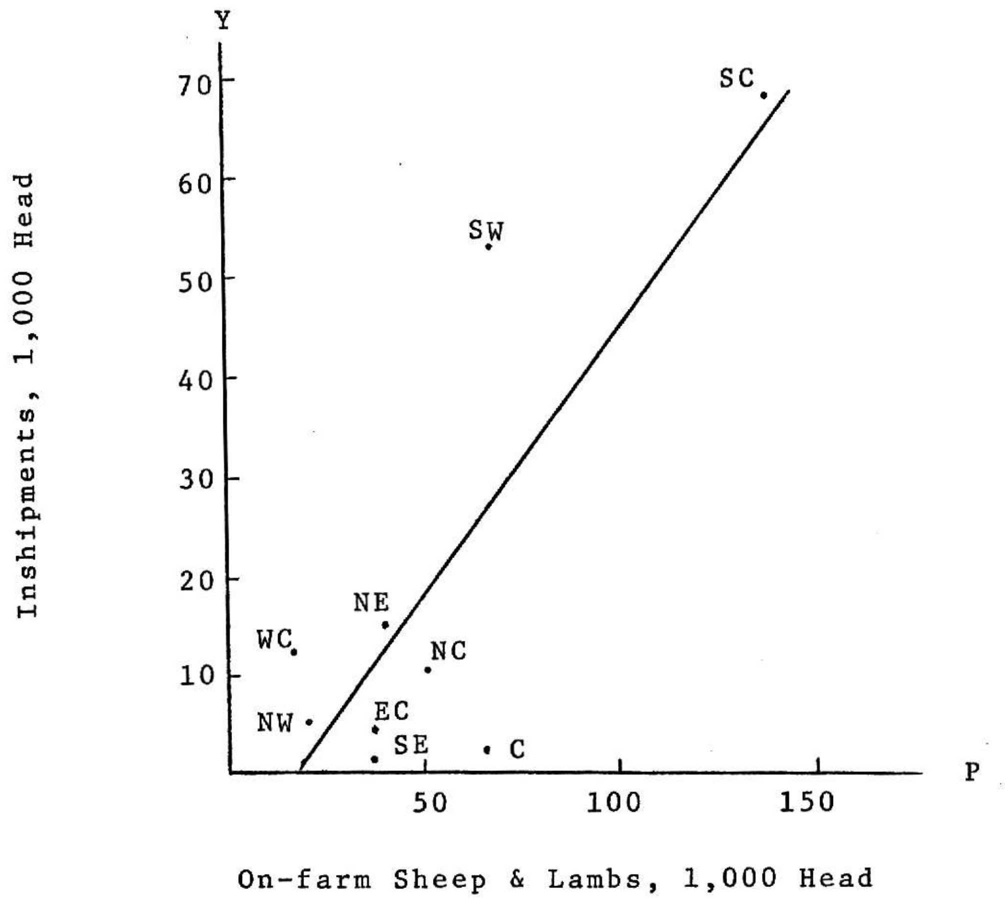
Table III-2

Number of Inshipped and On-farm Sheep and Lambs, and Breeding Indices in Kansas, by Districts

District	Inshipments 1967 1,000 head	Number on Farms 1967 1,000 head	Breeding Index Census Average %
Northwest	5	20.5	44.30
West Central	12	16.0	39.73
Southwest	53	66.5	32.08
North Central	10	49.6	61.66
Central	2	66.0	59.83
South Central	68	135.9	49.56
Northeast	15	39.7	47.93
East Central	4	36.5	60.78
Southeast	1	37.3	65.97

Data: (1) Kansas State Board of Agriculture, and computed from (2) U. S. Bureau of Census.

[4] Ibid., p. 36.



$Y=0.5438P-9.390$

$r=0.8037$

$r^2=64.6\%$

Fig. III-1. Correlation of Hypothesis I. (Data from Table III-2) correlation is rather strong and is positive as expected. Looking at the arrangement of the points in the lower left-hand corner of the diagram, one would, however, hesitate to give hearty support to this hypothesis.

Hypothesis II. The number of stock sheep and lambs brought into a district from other states is negatively correlated to the "breeding index" of that district.

The breeding index of the ith district (Ii) is defined as Ii = Ei/Ti, where Ei is the number of ewes and Ti is the total number of sheep and lambs on farms in the ith district.

This hypothesis is based on the assumption that the lower the breeding index (i.e. the proportion of ewes among the total sheep and lambs), the fewer the lambs dropped locally, and, thus, the higher the demand for imports. For example, the area with a breeding index of zero (i.e. no ewes at all) must, of course, import all the replacements; while, at the other extreme, the area with a breeding index of one (i.e. totally ewes) does not need any importation (except a few yearling ewes and rams to replace the old ones) and will be able to export young lambs, instead, unless the sheep-raisers there decide to expand their flocks drastically. Among the state's nine districts, there are no such extreme cases, but, in general, one may assume that the demand for importation decreases with the increase of breeding index.

Unfortunately, the data concerning the number of ewes on farms are only available for the agricultural census years (1945, 1950, 1954, 1959, and 1964), and the only data of inshipments by crop reporting districts available for this analysis are those of 1967, a non-census year. But, since the spatial variation of the breeding index had been very similar through the five census years since 1945 even at the county level, the average breeding index of these five census years is to be used as the surrogate for the breeding index of 1967 (Table III-2).

In Fig. III-2 inshipment is plotted against breeding index. If the nine districts are separated into three groups--eastern, central, and western, the first and the third groups support this hypothesis separately. But, the overall arrangement of points in this diagram is apparently poorer than in the previous one. The simple correlation analysis of this hypothesis only yields an r-value of -0.53, but the negative sign of the r-value clearly suggests that the importation of stock sheep and lambs increases with the decrease of the breeding index, if they are really correlated.

If one read Table III-2 carefully and realized that the number of sheep and lambs on farms varies greatly among the nine districts, he might predict that the r-value of the second hypothesis should not be too high. This hypothesis would be more promising, if the spatial variation of the number of sheep and lambs on farms were not so great.

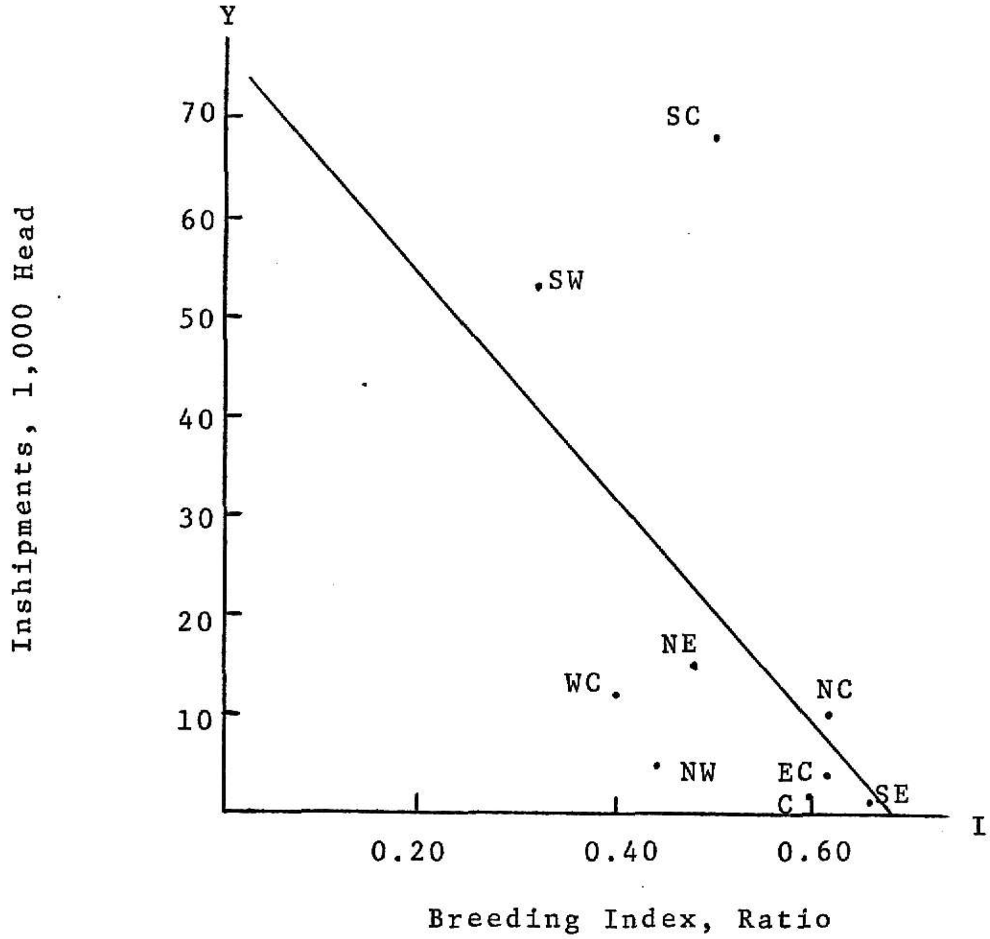
Hypothesis III. <u>The number of stock sheep and lambs imported into a district from other states is positively correlated both to the number of sheep and lambs on farms and to the complement of the breeding index of that district.</u>

Stated mathematically: $Yi = BXi + A$,

$$Xi = Ti(1 - Ii),$$

where Ti = total number of sheep and lambs on farms in the i<u>th</u> district on January 1,

Ii = breeding index of the i<u>th</u> district,



Y=-113.2I+76.981

r=-0.5335

r^2=28.5%

Fig. III-2. Correlation of Hypothesis II. (Data from Table III-2)

Yi = annual total number of stock sheep and lambs imported from other states into the ith district,

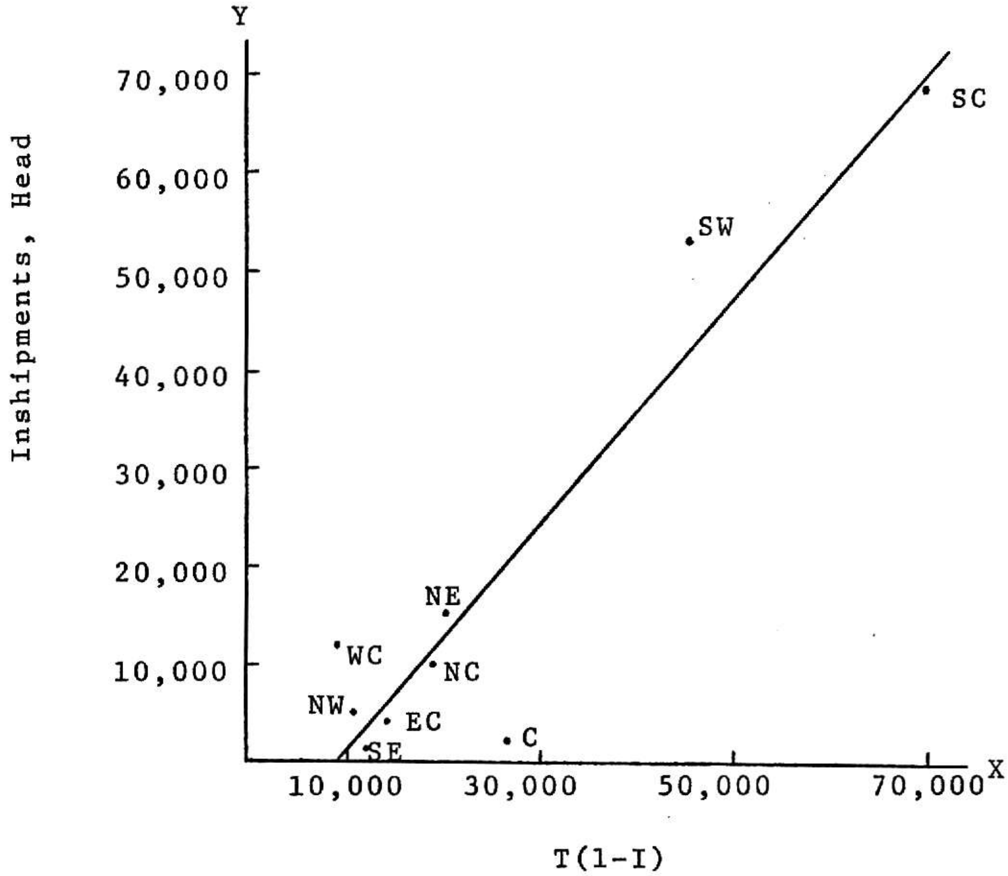
A = "y-intercept", a constant,

and B = regression coefficient, a constant.

It is believed that the drawback of hypotheses I and II is their over-simplicity. Instead of rejecting them hastily or accepting them reluctantly, we synthesize them into the third hypothesis. This hypothesis is, of course, based on the assumption that the number of sheep and lambs on farms and the breeding index are the two most important factors determining the number of inshipped sheep and lambs.

In Fig. III-3, Yi is plotted against Xi for the state's nine districts in the scatter diagram. The arrangement of the points in this diagram shows a great improvement from the previous ones. The correlation coefficient is raised to 0.93. Obviously, by increasing the complexity of the functional relationship, this hypothesis gets stronger support from the actual data. The number of sheep and lambs on farms and the breeding index combinedly "explain" 87 percent (i.e. the r^2-value) of the spatial variation of the sheep and lambs inshipment.

Of special interest is that in Fig. III-3 all districts on the positive side of the regression line are those with relatively low breeding index (see Table III-2); while the districts with relatively high breeding index all fall on the negative side of the regression line. This contrasting arrangement suggests that the complement of the breeding index is not given enough weight in the hypothesis.



$Y=1.164X-10.602$

$r=0.9334$

$r^2=87.1\%$

Fig. III-3. Correlation of Hypothesis III. (Data from Table III-2)

Hypothesis IV (The Model). <u>The number of stock sheep and lambs shipped into a district from other states is positively correlated both to the number of sheep and lambs on farms and to the square of the complement of the breeding index of that district.</u>

Stated mathematically: $Yi = BXi + A,$

$$Xi = Ti(1 - Ii)^2,$$

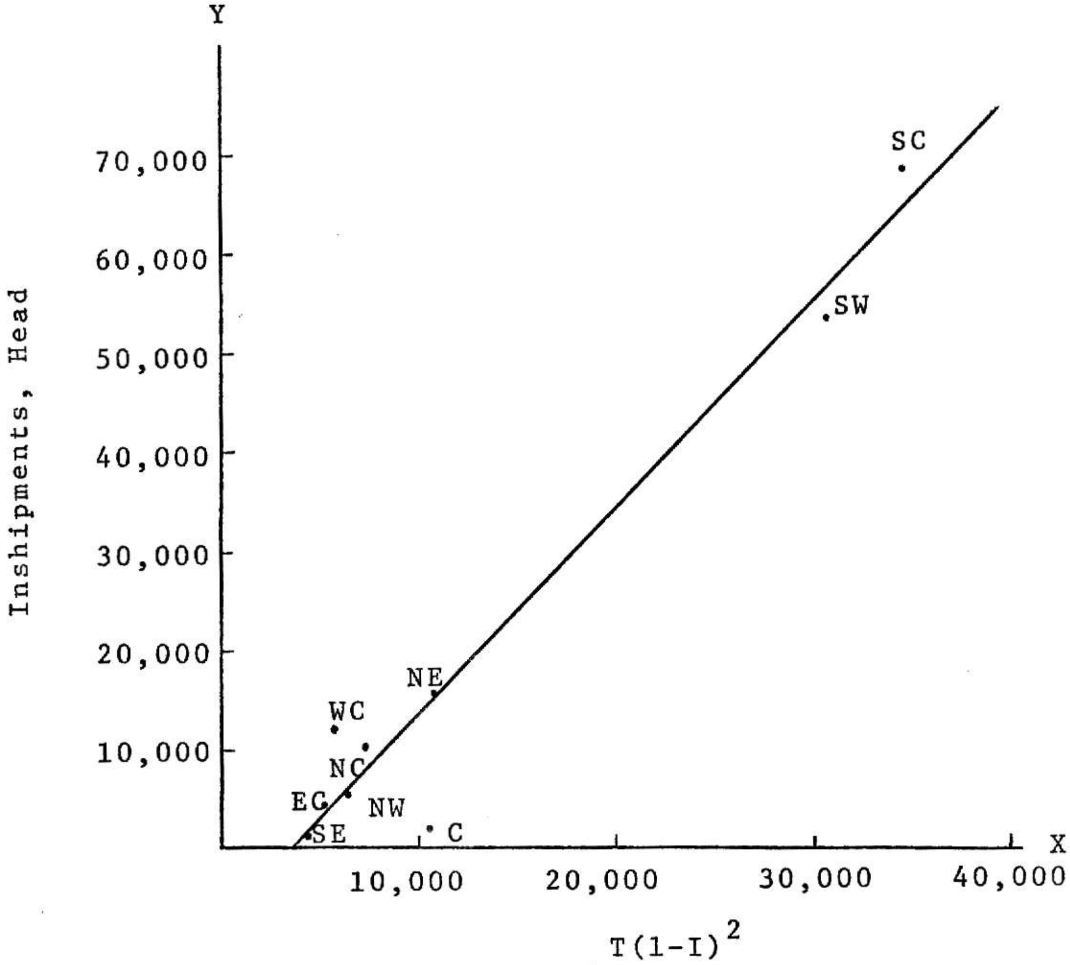
where Ti, Ii, Yi, A, and B were defined in hypothesis III.

This hypothesis is based on the awareness that, in Fig. III-3, by increasing the weight of the complement of the breeding index, one will be able to push the points with positive residuals to the right and the points with negative residuals to the left, and, consequently, all points will be aligned closer to a straight line. Therefore, the complement of the breeding index is raised to the power of two.

Fig. III-4 shows the expected result. The arrangement of points becomes more linear, with r-value of 0.97. The level of explanation is increased from 87 percent in the third hypothesis to 96 percent now.

There is no need to say that the fourth hypothesis is much better than the previous ones. But one may suspect that by raising the complement of the breeding index to the power of two, too much or not enough weight might have been given to it. As a matter of fact, the reason for raising to the power of two was only because it is relatively easy to calculate.

In order to find out the optimal weighting and see how the correlation coefficient changes with the change in the exponent of



Y=2.072X-7.832

r=0.9740

r^2=95.9%

Fig. III-4. Correlation of Hypothesis IV. (Data from Table III-2) the complement of breeding index, a computer program is written, which lets the exponent change from 1.0 to 3.0 with the increment of 0.1 and prints out the correlation coefficient for each exponent used. The output of this program is plotted in Fig. III-5, with the ordinate representing the correlation coefficient and the abscissa representing the exponent of the complement of breeding index.

The best-fit exponent is 2.1, which yields an r-value of 0.97399; while the exponent of 2.0 yields an r-value of 0.97398. The difference is only 0.00001, which does not make any sense as far as the precision of the data to be correlated is concerned. Therefore, the fourth hypothesis is the one with optimal weighting and can be termed as "the model."

As shown in Fig. III-4, the only two significant aberrations in the model are central and west-central districts. The central district has less importation from other states than the model expects, perhaps because it lies right in the middle of Kansas and has the best access to the lambs dropped in all parts of the state, and, consequently, its demand for importation from other states is reduced. For unknown reasons the west-central district, on the contrary, imports more than the model expects.

With a high r-value of 0.97, the model may well be used to predict the inshipments of stock sheep and lambs into the nine districts of Kansas in the near future. One should, however, realize that this model is based on the inshipment data of a single year (1967), and that the breeding index used in the model is a surrogate derived from the

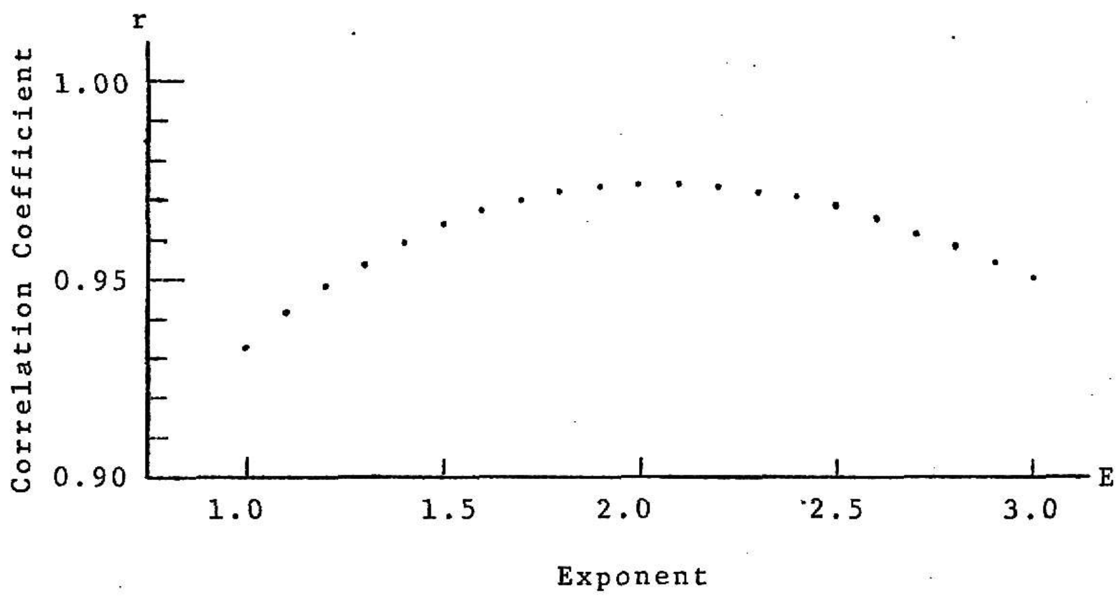


Fig. III-5. Testing of the Optimal Weighting.

last five census years. But, when more data become available, by following the same line of thought (if not using the same formula), one may very possibly make a good prediction on the annual inshipments of stock sheep and lambs at the beginning of a year, given that the data of the numbers of sheep and lambs and ewes on farms on January 1 of that year are available.

CHAPTER FOUR

OUTWARD MOVEMENT

As mentioned in Chapter Three, Kansas has been a deficient state in terms of stock sheep and lamb replacements. Therefore, Chapter Four will only be concerned with the outward movement of fat sheep and lambs. To be more specific, this chapter will try (1) to divide the outward movement into two stages and evaluate, against the United States as a whole, the relative importance of these two stages of movement in Kansas, and (2) to find out the main focal points of the outward movement and analyze the relationships between these focal points and their tributary areas.

Section A

The Two Stages of Movement

Fattened meat animals pass through two stages of movement: first, from farms or feedlots to slaughterhouses when the animals travel live; and secondly, from slaughterhouses to retail stores when only the better parts of the animal bodies are transported. Any one who is familiar with the history of the livestock industry in the United States knows that the relative importance of these two stages of movement changed greatly in the past, mainly due to the development of refrigerator cars, and, later, the improvement of highway systems.

The perishability and the high "weight-loss ratio" of livestock products are two of the most important considerations in livestock and meat transportation. In the pre-refrigerator car period, perishability outweighed all other considerations, and many animals, with about 50 percent waste materials in their bodies, had to be moved live across long distances by train (or on foot in much earlier days) to be slaughtered in the consuming areas. In 1851 the first refrigerator railroad car appeared, and the transport of highly perishable livestock products became technically and economically feasible.[5] In 1871, meat packers began shipping "western-dressed beef" to the markets on the east coast.[6]

Until the 1910's the shift from live animal to meat transportation, however, had been hindered by the hostile attitude of railroad companies, because it was less profitable for them to carry meat than to carry live animals. Freight rates on meat were deliberately set to be much higher than the actual cost of shipping, and numerous rate cases were brought before the ICC.[7] The appearance of refrigerator trucks and the improved highway systems, however, undermined the railroad companies' monopolistic position. As highway transportation developed rapidly after about 1920, the livestock slaughtering and meat packing industry

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[5]J. R. Ives, p. 76. The first livestock product shipped by refrigerator railroad cars was butter from Ogdensburg, New York, to Boston in 1851.

[6]W. F. Williams and T. T. Stout, p. 21.

[7]J. R. Ives, p. 83.

shifted toward livestock producing areas, and meat transportation became more important.[8]

Two studies, which provide the data for comparing the relative importance of slaughter livestock movement and meat movement in the United States in 1955 and 1960, are Spatial Structure of the Livestock Economy, No. I and No. II, the North Central Regional NCM-25 Project Committee. In these two studies, the United States is divided into twenty-six regions, which are individual states or combinations of several states. From the proportions of slaughter livestock and meat brought across the boundaries of these regions, the relative importance of slaughter livestock movement and meat movement can be estimated.

As shown in Tables IV-1 and IV-2, the proportion of meat moved across regional boundaries (i.e. consumed extra-regionally) was greater than the proportion of slaughter livestock moved across regional boundaries (i.e. slaughtered extra-regionally) in both 1955 and 1960. Comparing the figures of these two years, one can see the trend towards more meat movement and less slaughter livestock movement. Incidentally, the proportions of both slaughter sheep and lambs and mutton and lamb moved across the regional boundaries were greater than those of the other slaughter animals and meat. This reflects the fact that, among all kinds of livestock, the distribution of sheep and lambs has been most different from the distribution of population.

Also from the data supplied by the two studies cited in Tables IV-1 and IV-2, two flow charts of the disposition of sheep and lambs fattened in Kansas in 1955 and 1960 are drawn in Fig. IV-1. As one

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[8]W. F. Williams and T. T. Stout, pp. 76-85.

Table IV-1

Intra-regional and Extra-regional Slaughter of Meat Animals in the U.S., 1955 and 1960*

Type of Slaughter	Year	Sheep and Lambs	Cattle	Hogs
		%	%	%
Intra-regional	1955	70.1	81.3	80.6
	1960	71.5	82.0	81.4
Extra-regional	1955	29.9	18.7	19.4
	1960	28.5	18.0	18.6
Total	1955	100.0	100.0	100.0
	1960	100.0	100.0	100.0

Table IV-2

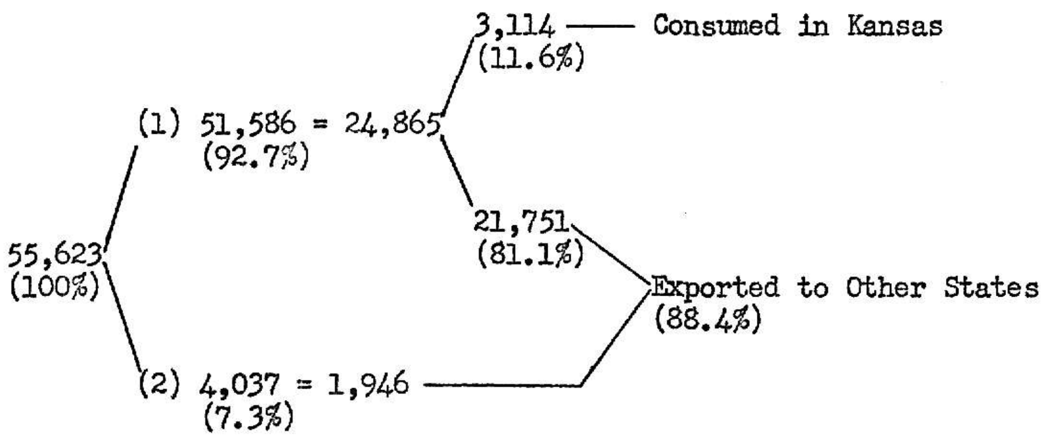
Intra-regional and Extra-regional Consumption of Meat in the U.S., 1955 and 1960*

Type of Consumption	Year	Sheep and Lambs	Cattle	Hogs
		%	%	%
Intra-regional	1955	56.1	71.2	61.8
	1960	52.0	68.1	60.0
Extra-regional	1955	43.9	28.8	38.2
	1960	48.0	31.9	40.0
Total	1955	100.0	100.0	100.0
	1960	100.0	100.0	100.0

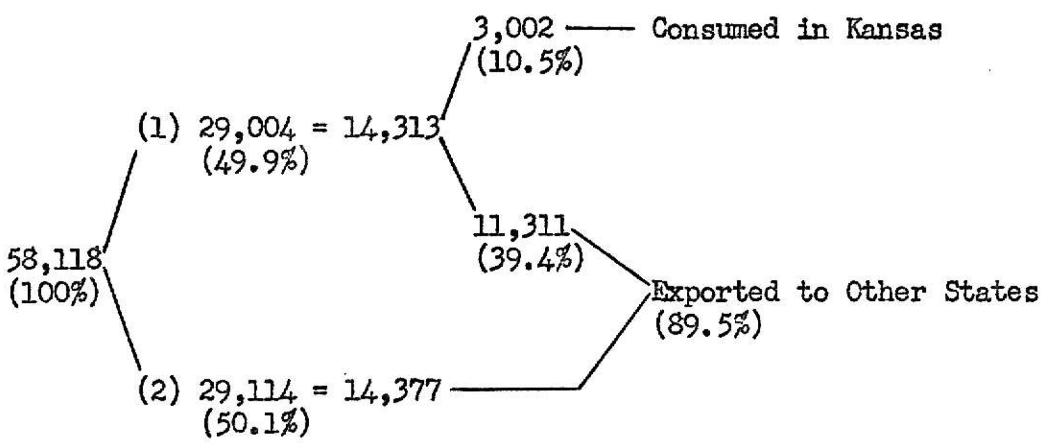
*Data: Computed from North Central Regional NCM-25 Project Committee.

would expect, these charts suggest that only about 10 percent of the state's fat sheep and lambs have been consumed within the state. Similar to the general way of livestock movement in the United States,

(a) 1955



(b) 1960



Note: Branch (1) -- Slaughtered Within Kansas.
Branch (2) -- Slaughtered in Other States.
Live Weight in 1,000 lbs -- before "=".
Dressed Weight in 1,000 lbs -- behind "=".

Fig. IV-1. Flow Charts of the Disposition of Sheep and Lambs Produced in Kansas, 1955 and 1960.

(Computed from North Central Regional NCM-25 Project Committee) the 1955 flow chart (Fig. IV-1-a) shows that most sheep and lambs produced in Kansas were slaughtered in the state and then exported as mutton and lamb to other states. The 1960 flow chart (Fig. IV-1-b), however, shows that the outward movement of sheep and lambs (50.1%) became more important than the outward movement of mutton and lamb (39.4%). This is against the general trend of the shift from slaughter livestock movement to meat movement.

There are good reasons to believe that this deviation from the general trend has continued until the present. A letter of April 8, 1969,from Mr. G. W. Shepherd, extension agricultural agent of Sedgwick county (where the Wichita livestock market is located), said that most of the fat lambs sold to Wichita are shipped live to "the New Jersey, New York, and Boston area" and slaughtered there. Furthermore, Professor R. F. Cox, a sheep specialist at Kansas State University said in a personal interview in March, 1969, that there are no more lamb slaughterhouses in Kansas City, Wichita, and St. Joseph, Missouri. The extension agricultural agents of Sedgwick and Leavenworth counties stated in questionnaires that the lamb slaughterhouses in these cities were closed in the 1960's.

The shipping of sheep and lambs, instead of mutton and lamb, across long distances from Kansas to the east coast is not only uneconomic but also troublesome; but economic considerations, though very important, sometimes are outweighed by other factors. For example, the kosher custom practiced by many Jews in the metropolitan areas of the east coast (the principal market of Kansas fat lambs) may be the main reason for the continuation of this heavy movement of live sheep and lambs, because "livestock for Kosher trade is generally slaughtered near the consumer."[9] Therefore, how long this deviation from the general trend of the shift from livestock movement to meat movement will last depends mainly on how firmly the final consumers on the east coast will preserve their old custom.

Section B

The Focal Points of Outward Movement and Their Tributary Areas

The findings of this section are based on questionnaires, because no statistical data are available. A questionnaire was sent to each extension agricultural agent of the 105 counties in Kansas. In it, the question, "To which markets are most of the fat lambs in your county sold?" was asked. The answers are plotted on the map, Fig. IV-2. Although 24 percent of the agents did not answer this question, an interesting pattern emerges out of this map.

Except in the western fourth of the state, where the main markets are in Colorado, most counties in Kansas sell fat lambs to Wichita, Kansas City, and St. Joseph, Mo. Because, as mentioned in Section A, there are no more lamb slaughterhouses in these three cities, most fat lambs sold to these cities are shipped to the eastern market areas.

Since the general movement is towards the north-east, one may assume that it is not economical for the counties in the state's

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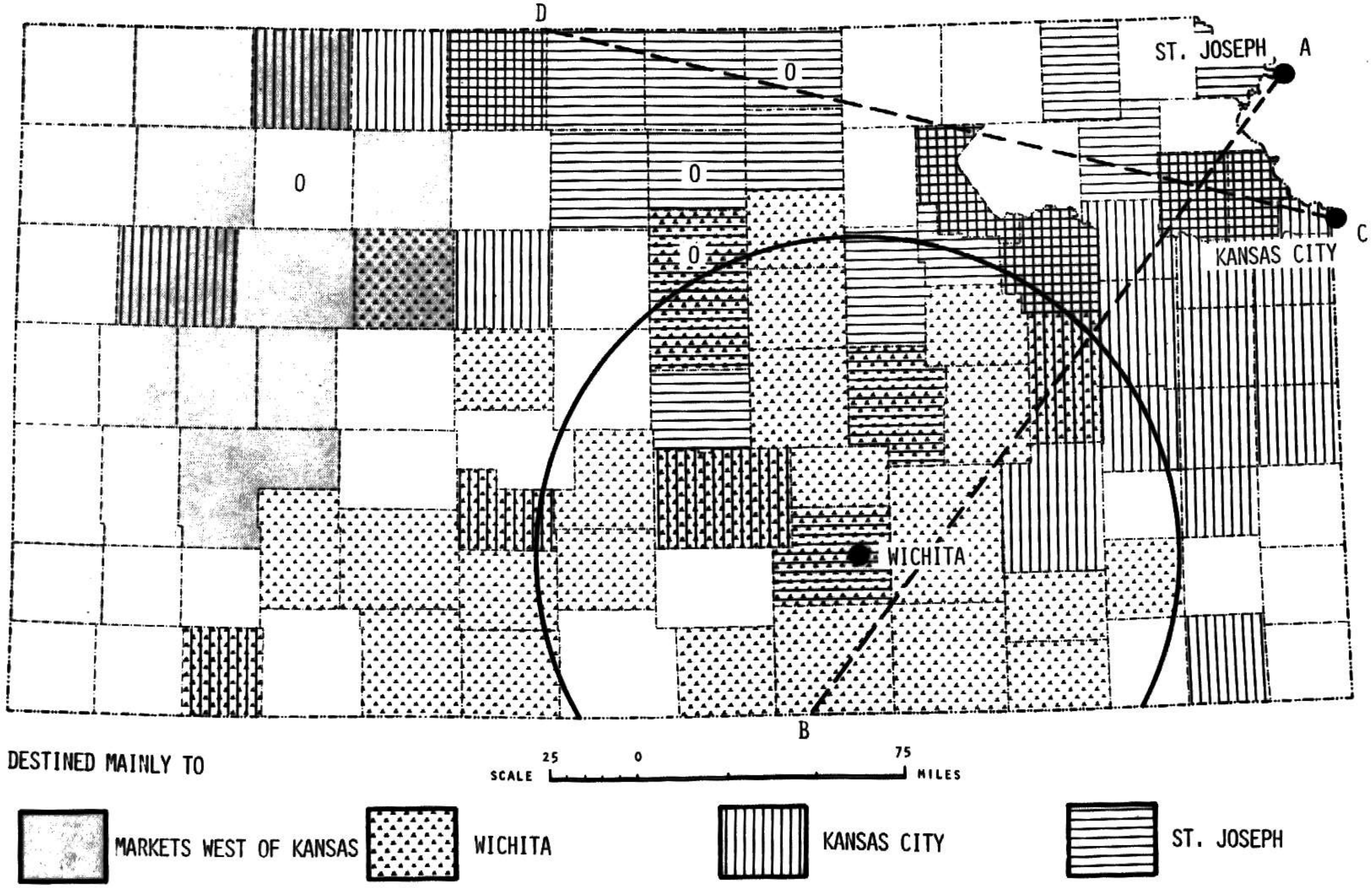
[9] Swift and Company, p. 4.

EXPLANATION OF FIGURE IV-2

Pattern of the Nodal Relationships in Terms of Marketing Fat Lambs Produced in Kansas, 1969.

(From Questionnaires, March, 1969)

FIGURE IV-2



NOTE: 0: DESTINED MAINLY TO OMAHA
BLANK: UNKNOWN DESTINATIONS

eastern extreme to sell fat lambs to Wichita instead of the other two cities; and that it is economical for all counties in the state's eastern three-fourths to sell fat lambs to either St. Joseph or Kansas City because the freight rates on fat lambs at Wichita, merely due to its greater distance from the final markets, tend to be higher than the freight rates on fat lambs at St. Joseph and Kansas City.[10] To test whether there is some validity in this assumption, a circle is drawn around Wichita with half the distance between Wichita and St. Joseph as radius (Fig. IV-2). Quite interestingly, no county east of this big circle claims Wichita as its main fat lamb market; while within, and west of the big circle, a number of counties claim St. Joseph or Kansas City as one of their main markets. Furthermore, the tributary area of Wichita is elongated away from the strong competing centers to the east. This elongated tributary area is one of the "distorted fields," classified by Peter Haggett.[11]

Also of interest is the relationship between the tributary areas of St. Joseph and Kansas City, both of which are equi-distant from the final markets on the east coast. Both cities share a large sector of tributary area in Kansas between the two dashed lines AB and CD in Fig. IV-2. But the importance of St. Joseph fails to reach eastern

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[10]No data of the freight rates for shipping fat lambs from Wichita, St. Joseph or Kansas City to the east coast are available. P. L. Kelley's study threw some light on the freight rate differences between these shipping points. According to his study, the freight rates in December, 1958, for shipping live hogs on double-deck railroad cars to Trenton, N. J., were $2.08/100 lbs from Wichita, and $1.88/100 lbs from Kansas City.

[11]Peter Haggett, pp. 33-37.

Kansas south of Kansas City; while Kansas City is unable to show its importance above the CD line. Being too close together, both centers lose a large sector of tributary area to each other. Omaha, Nebraska, another large fat lamb market, also plays a role in northern Kansas, but it is located too far north to be important in the state.

In reading Fig. IV-2, one should realize that the focal point which has more extensive tributary area does not necessarily handle more fat lambs produced in Kansas, because not all counties produce the same number of fat lambs. Therefore, in order to evaluate the relative importance of the three focal points, one should relate Fig. IV-2 to Fig. I-2-D, the representative distribution pattern of sheep and lambs of recent years. Wichita seems to have handled most fat lambs produced in Kansas because it is located in the south central sheep region where sheep density has been about 100 percent above the state's average density in recent years.[12]

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[12]According to Livestock and Meat Statistics, the total salable receipts of sheep and lambs at public stockyards in 1967 were 1,165 at Kansas City, Mo.; 147,547 at St. Joseph, Mo.; and 180,091 at Wichita, Kansas.

SUMMARY AND CONCLUSION

The apparently irregular distribution patterns of sheep and lambs in Kansas since 1945 can be generalized into six "sheep regions," where sheep-raising has been relatively well-developed, and two sets of "non-sheep areas," where sheep-raising has been poorly developed. Even though the non-sheep areas are mostly hilly and pastoral, sheep density there has been and will be very light, because of the strong competition from cattle. Among the six sheep regions sheep and lambs in the near future will be mostly concentrated in the south central and north central ones. There is some chance that sheep density in the two western sheep regions may sharply increase again, if the weather once more becomes extremely favorable. But the increased density will not be as high as that of the mid-1940's, because the relative competitiveness of sheep there has been drastically reduced by the steady westward spread of cattle. Sheep density will be thinner in the eastern sheep regions than in the central ones, because sheep-raising in the former regions has been and will be mostly a side line business (as suggested by the extremely small average flock size).

The spatial contrast of the change in sheep density through time has been in an east-west direction. The change in sheep density in the western sheep regions is characterized by the sharp long-run decline and drastic short-run fluctuation. Sheep density in the central sheep regions has less short-run fluctuation and no long-run decline. The prolonged drought of the 1950's, which strongly affected sheep density in the western and central sheep regions, appears to have been non-effective on sheep density in the eastern sheep regions.

When the change in number of sheep and lambs is related to the changes in number of sheep farms and in flock size, the spatial contrast is also in an east-west direction. In the western sheep regions, both the number of sheep farms and flock size have declined, and, consequently, the number of sheep and lambs has declined most sharply. In the central sheep regions, the expansion of flock size has been so great that the decrease in number of sheep farms has been unable to pull down the long-run trend of the number of sheep and lambs. In the eastern sheep regions the decrease in number of sheep farms has affected the long-run decline in number of sheep and lambs, even though the flock size has been expanding. Compared with the spatial variation of sheep density, the spatial variations of both sheep farm density and flock size have been much more persistent in Kansas since 1945.

In terms of lamb replacements Kansas is a deficient state. Most of the state's lamb inshipments are coming from the western range states, especially from Texas and Colorado. The imported sheep and lambs are extremely unevenly allocated within the state. This uneven allocation is mainly determined by two factors--the number of sheep and lambs on farms and the "breeding index."

Most of the fat lambs produced in Kansas are shipped live to the east coast and slaughtered there. The main reason for shipping live sheep and lambs, instead of mutton and lamb, across long distances is that the final consumers strongly prefer newly dressed meat to frozen meat. This deviates from the national movement trend--towards more meat movement and less live animal movement. How long this deviation will last depends mainly on the firmness of the final consumers' religious belief, which overweighs economic considerations.

The majority of the state's fat lambs to be shipped to the east coast are sold to three large livestock markets--Wichita, Kansas City, and St. Joseph. Since the general movement of these lambs is toward the north-east, Kansas City and St. Joseph, being closer to the final consuming areas, are <u>spatially</u> more competitive than Wichita. Being too close together, Kansas City and St. Joseph lose a large sector of tributary area to each other.

With the above findings summarized, it seems proper to conclude this paper by evaluating two of the most important methods used--regionalization and regression analysis. The former is a useful method to generalize the apparently irregular and unstable distribution patterns into a comprehensible and meaningful regional pattern, which illustrates strong spatial contrasts. The latter enables this paper to find out the complex relationship among three different spatial phenomena--a relationship that can not be discovered by map comparison alone.

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A SPATIAL ANALYSIS OF SHEEP-RAISING IN KANSAS

by

KAO-LEE LIAW

B. S., National Taiwan University, 1965

AN ABSTRACT OF A MASTER'S THESIS

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MASTER OF ARTS

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KANSAS STATE UNIVERSITY

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1970

This study is focused on the distribution and movement aspects of sheep-raising in Kansas. Strong emphasis is put on the spatial differentiation of these aspects.

The apparently irregular and unstable distribution patterns of sheep and lambs in Kansas since 1945 are generalized into six "sheep regions," where sheep-raising has been relatively well-developed, and two sets of "non-sheep areas," where sheep-raising has been poorly developed. Even though the non-sheep areas are mostly hilly and pastoral, sheep density there has been and will be very light, because of the strong competition from cattle. Among the six sheep regions sheep and lambs in the near future will be mostly concentrated in the south central and north central ones. In the eastern sheep regions sheep-raising has been and will be mostly a sideline business, while the relative competitiveness of sheep in the western sheep regions has been drastically reduced by the steady westward spread of cattle.

The spatial contrast of the change in sheep density through time has been in an east-west direction. When the change in number of sheep and lambs is related to the changes in number of sheep farms and in flock size, the spatial contrast is also in an east-west direction. Compared with the spatial variation of sheep density, the spatial variations of both sheep farm density and flock size have been more persistent since 1945.

In terms of lamb replacements Kansas is a deficient state. Most of the state's lamb inshipments are coming from the western range states, especially from Texas and Colorado. The imported sheep and lambs are extremely unevenly allocated within the state. This uneven allocation is mainly determined by two factors--the number of sheep and lambs on farms and the "breeding index."

Most of the fat lambs produced in Kansas are shipped live to the east coast and slaughtered there. The main reason for shipping them on hoof across long distances is that the final consumers strongly prefer newly dressed meat to frozen meat.

The majority of the state's fat lambs to be shipped to the east coast are sold to three large livestock markets--Wichita, Kansas City, and St. Joseph, Mo. Since the general movement of these lambs is toward the north-east, Kansas City and St. Joseph, being closer to the final consuming areas, are spatially more competitive than Wichita. However, being so close together, Kansas City and St. Joseph lose a large sector of tributary area to each other.

Two of the most important methods used in this paper are regionalization and regression analysis. The former is useful in generalizing the apparently irregular and unstable distribution patterns into a comprehensible and meaningful pattern which illustrates strong spatial contrasts. The latter is powerful in analyzing complex relationships which can not be discovered by map comparison alone.