COMPARISONS OF THE E/T FACTOR WITH SELECTED CULTURAL FEATURES IN OKLAHOMA

By

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PREFACE

The writer, a native of Oklahoma, has been interested in the analysis of cultural features as related to climatological information concerning the state. Not being satisfied with the explanation of the distribution of cultural features upon the basis of ordinarily compiled data, the present Evaporation-Transpiration factor information obtained from public agency sources, invited close scrutiny to evaluate its worth in the explanation of such features.

The idea had been advanced that the Evaporation-Transpiration factor or E/T factor, might have value in showing the reason for cultural feature distribution. The purpose of this study is to evaluate the reliability of the Evaporation-Transpiration factor as a tool to measure the adaptability of cultural features in Oklahoma. From such an investigation its consideration for this and future application may be evaluated.

Statistical information, concerning the Evaporation-Transpiration factor, unfortunately, was rather limited, covering only a wetter five year cycle, ending September 30, 1943. Application in the interpretaion of the distribution of cultural phenomena during this period has been given.

Principal sources of the material of this thesis were meteorological and climatological data and primary calculations of the Water Resources Branch of the United States Geological Survey in Oklahoma. Considerable correspondence and library research were necessary to determine the amount of available material. Surprisingly, very little has been written concerning the E/T factor, probably because of its limited application to watershed and runoff problems.

Any geographic study of the state necessitates an inquiry into the origin and nature of the natural and cultural features; although here emphasis has been restricted to consideration of only those features that are related to climatic and runoff relationships.

The writer must remain indebted to Dr. David C. Winslow and Professor Robert C. Fite, under whose direction this study was made. The library staff of Oklahoma Agricultural and Mechanical College gave unstinted cooperation in procurement of information. Mrs. Joyce Wilson deserves thanks for typing the rough draft.

R.Z.M.

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CHAPTER I

INTRODUCTION

Some domestic crops and animals, along with some other cultural features, tend to form a pattern of wedge shapes extending toward the west in central Oklahoma. In contrast, ordinary climatic determinations, such as lines of average annual precipitation, tend to run north and south with only limited extension to the west in the southern portion of the state (See Maps 1 & 2). These minor westward extensions fail to coincide with those shown by the cultural features.

Explanation of this phenomenon of cultural feature distribution can possibly be approached, it appeared, by consideration of the Evaporation-Transpiration or E/T factor.[1] It showed some comparison with this pattern of distribution. Other explanations of such a distribution have appeared to be both unsatisfactory and inadequate. Although this investigation will not provide all of the answers to the pattern, it may be helpful in suggesting causes, trends, and relationships.

The purpose of this study is to evaluate the reliability of the E/T factor as a tool to measure the adaptability of cultural features in Oklahoma. Each of the features used in the comparisons are also compared with the more commonly used map of climatic adaptability, namely, the average annual precipitation map.

These time-consuming calculations, which were necessary to determine the E/T factor data, made by Government agencies, may be worthwhile for other purposes than those that were specifically in mind for their initial application.[2]

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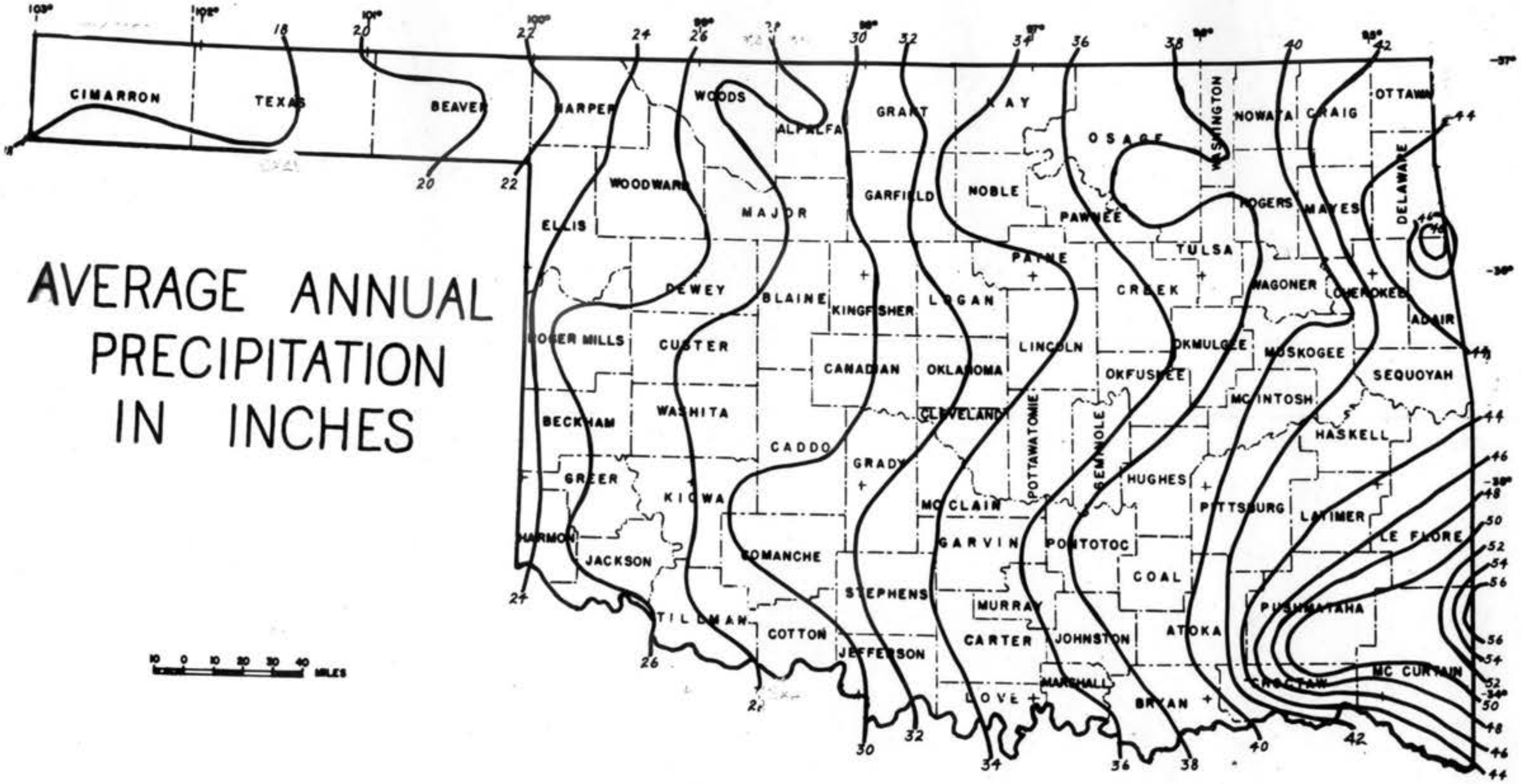
[1] Oklahoma Water. Quantity, Occurence, and Quality of Surface and Ground Water, prepared for Oklahoma Planning and Resources Board by United States Department of the Interior Geological Survey, Water Resources Branch, (March 1, 1945). p. 77.

[2] See page 4 for explanation of the E/T factor.

If such information proves of value, it should encourage further computation of such data. Unfortunately, the five-year period of 1938 to 1943 must be used because the calculated map is not available for 1943 to 1948. Previous determinations which must have consumed several work years have been made by the Water Resources Branch of the United States Geological Survey. Therefore, it is hoped that the utilization of the data in this thesis may be used to show an additional reason for further extensive calculation by periods of such information. The study may also suggest other possible applications of the prepared material.

Cultural features to be compared with the E/T factor in this study are average yield of corn for the period 1938-1943, average number of cattle per square mile for the period 1938-1943, average size of farms in 1940, and average wheat yield for the period 1938-1943. Comparison with the E/T factor map of these features on maps follow in later chapters with a discussion of each of them. The cultural features studied were chosen at random, but in such a manner as to show a variety of those features most common in Oklahoma.

AVERAGE ANNUAL PRECIPITATION IN INCHES



MAP 1

CHAPTER II

EVAPORATION-TRANSPIRATION FACTOR AND ITS SIGNIFICANCE

The Evaporation-Transpiration factor is expressed as the derived difference between effective precipitation and the total runoff. Henceforth, for convenience, the Evaporation-Transpiration factor shall be denoted as the E/T factor. It is calculated on a yearly basis. The E/T factor can be used to express geographically, on a map of Oklahoma, a pattern of distribution of evaporation and transpiration that is at variance with previously prepared representations based only upon measured climatic data such as precipitation.

To understand the technique of the E/T factor computations necessitates an understanding of the two terms, "effective precipitation" and "runoff," as defined for this particular purpose.

Effective precipitation as used herein is an analytical value derived from the weighted significance of various factors contributing to the quantity of moisture which is available for growing plants during any given season. Its average value over a long period is about proportional to the average observed precipitation.

In mathematical terms, effective precipitation is calculated by the equation: P_E equals $(1 - P_p)$ P_o plus C_pP_A or P_o plus $C_p(P_A - P_o)$ in which P_E is the annual effective precipitation in inches; P_o equals annual observed precipitation in inches for a given year; P_A equals annual observed precipitation in inches for the antecedent year; C_p equals a fraction representing the weight assigned to the antecedent year; $(1 - C_p)$ equals a fraction representing the weight assigned to a given year.[1]

Evaporation and transpiration, or total water loss from the plants and the soil, is the part of precipitation that is taken by nature, and over which man

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[1] Oklahoma Water. op. cit., p. 81.

has little control. Hence, it has been called "nature's take," by the Water Resources Branch of the U.S. Geological Survey.[2] However it appears more satisfactory to call this combined effect the Evaporation-Transpiration factor, or E/T factor, because it is a residual factor influenced by other elements. This derived factor is usually considered as based upon the rainfall minus runoff, but there are possible exceptional influences over short periods because of the difference of water stored in the ground or on the surface.

"Runoff" is determined as the surface and ground water loss that finds its way into streams where the water is measured as flow by gages. Inasmuch as this definition is somewhat at variance with the one usually used by geographers, it must be understood in order to compute the E/T factor.

With isohytel lines determined for a particular year, it is possible to ascertain the total amount of precipitation for each drainage area by means of a planimeter, an instrument used for measuring areas on maps or photographs. Then, by use of the arbitrary formula previously explained, it is possible to compute the effective precipitation for an individual watershed. Runoff records are used. Subtraction of the runoff from effective precipitation on a watershed yields the E/T factor for the year for that area. The final established E/T factor map of Oklahoma, which resulted from the calculation of the average for five years ending in 1943, was developed for use.

Public agency application of the E/T factor (nature's take) map has centered about problems concerning runoff. Differences in watersheds as to their evaporation and transpiration and runoff also are readily shown. This study, on the other hand, attempts to extend the use of the E/T factor by using it to interpret some cultural pattern distributions.

A pronounced westward protrusion or bending of the E/T factor lines is

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[2] Ibid., p. 77.

notable in Oklahoma. As these isopleths are a derived measurement of evaporation and transpiration, apparently both native vegetation growth and crop yields should follow their pattern since they are dependent upon soil moisture for growth. Other cultural features, such as cattle numbers and size of farms, are directly adjusted to this agricultural productivity of the land in forage and crops. Hence, it appears logical that there should be significance in these E/T factor lines if they are directly related in distribution to cultural features which man uses in his adjustment to the natural environment.

CHAPTER III

SOME GEOGRAPHIC ASPECTS OF OKLAHOMA INFLUENCING THE E/T FACTOR

In understanding the distribution of the E/T factor in Oklahoma and its peculiar applications here, it appears necessary to consider certain aspects of the geography of the state.

Oklahoma, in its attributes, is a transitional area because of location and size. It is neither in the northern, southern, eastern, or western portion of the United States. It is bounded by Texas on the south and west, Kansas on the north, and Arkansas on the east. Missouri, however, forms some forty miles of its eastern boundary, and a long strip extending from the northwestern corner of the state, called the Panhandle, adjoins on the states of New Mexico and Colorado. Oklahoma has an area of 70,057 square miles, which is somewhat more than that of all New England.[1] It is the seventeenth state of the Union in size and is larger than any state east of the Mississippi River. Its position and large area have caused it to have a transitional character. The state's position is such that some portions vary in their climatic conditions with a small change in the precipitation or evaporation. Therefore any condition that affects the available moisture, or other growth condition, may cause considerable variation in the productivity and use of the agriculture lands.

The southeasterly trend of the rivers and their drainage basins in Oklahoma is significant in that this pattern is related to the E/T factor figures which are calculated by watershed units. The main rivers flow in a southeasterly direction, the entire drainage being carried to the Mississippi by the Arkansas and Red Rivers. The Arkansas enters the state from Kansas about the

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[1] Angie Debo and J. M. Oskison, Editors, Oklahoma, A Guide to the Sooner State, Works Projects Administration in the State of Oklahoma, University of Oklahoma Press, Norman, Oklahoma, (1941), p. 7.

middle of the northern border; the Salt Fork, Cimarron, Grand, Verdigris, and Canadian Rivers all join with it inside the borders of Oklahoma. The North Canadian flows nearly across the state before entering its companion river, the Canadian. The Washita and a number of lesser streams in the western part of the state supply the Red River. The streams in the western and central parts usually do not carry a large volume of water. Most of them have wide and sandy beds. Nearly all of the water sinks beneath the surface sands during very dry periods. The streams are, however, subject to sudden rises in water level, occasionally amounting to ten feet or more in the course of a few hours. Fortunately such floods are usually of short duration.

Wide river valleys and higher elevations to the north and west in Oklahoma provide conditions more favorable to plant growth than one would be led to suspect upon the evidence of location alone. The highest point in the state, about 4,500 feet above sea level, is the Black Mesa, in the northwestern corner of Cimarron County. From there the altitude generally declines eastward and southward to a lowest elevation of somewhat less than 350 feet in the extreme southeastern corner of the state. The exceptions are elevated regions, ranging 200 to 1,200 feet higher than the surrounding plains. In the northeast, the Ozark Plateau extends into Oklahoma. It is a region of medium-sized hills with rather deep, narrow valleys and numerous clear streams. The base of this dissected plateau is a great limestone formation known as the Boone Chert.[2] The region is forested with oak, ash, hickory, elm, walnut, pecan, hard maple, and sycamore trees. Smaller elevated regions are comprised of the Wichita, Kiamichi, Ouachita, and Arbuckle Mountains. However, only the Ozark Region is of sufficient size to greatly influence climatic conditions.

South of the Ozark region, occupying most of the southeastern corner of

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[2] _Ibid._, p. 7.

the state, the Ouachita Mountain area, some of which is included in a national forest, consists of parallel ridges formed by the faulting of thick layers of sandstone. Many of the valleys are narrow, and each has its spring-fed stream, causing the runoff rate to remain unusually steady. This area contains pine forests as well as many hardwoods.

The northwestern counties of Oklahoma and the Panhandle are included in the High Plains region where there are level grasslands, treeless except for clumps of elms, cottonwoods, and willows largely restricted to stream valleys. The area is sparsely settled, and much of it is still in native pasture grasses. During World War I, heavy demands for wheat production induced the farmers to develop their lands. Huge-sized grain farms in the Panhandle became prominent features. As a consequence of this growth, Texas County was the banner wheat-producing county of the nation for several years. Sorghums also became more important for they could withstand the dry conditions there. Because of continued drought in the early 1930's, this section became part of the Dust Bowl area. Some of it is regarded as submarginal by experts and has been restored to grass under a conservation program. However, frequent rains and demands for grain crops and livestock recently have led to marked prosperity and breaking up of land, although the threat of dry period damage is ever present.

In the south central part of the state are the Arbuckle Mountains, comprising an area of 1,200 square miles. These old mountains, worn down to a height of about seven hundred feet above the surrounding plains, present a remarkable variety of geological formations--limestone, sandstone, shale, and granite rocks. The limestone formation is grass-covered, while most of the others are blanketed with timber. Many streams drain from this area. Although the section is upraised above the surrounding country the climate is little modified.

South of the Arbuckles and the Ouchitas to the Red River is a strip of sandy plain carved by water channels flowing to the Red River. This is classed as a part of the Gulf and Coastal Plains.

Northwest of the Arbuckle Uplift about seventy miles, the rough granite peaks of the Wichita Mountains rise abruptly from the surrounding plains and, with some outlying peaks, extend for sixty miles to the northwest. They are the tops of buried mountains, a part of a range which is known as the Amarillo Range. Erosive processes have left little except the bare granite out-croppings. There are a few scattered trees. Deterioration of range and water resources is receiving considerable attention here. High rates of runoff are common during heavy downpours.

Lands of eastern Oklahoma not included in the previously described Ozark, Ouachita, Arbuckle, and Red River areas are included within the sandstone hills region. The hills, of hard sandstones and limestones, are rather low and flat. The fertile valleys, derived from softer shale material, are broad, accounting for much of the state's best farm land. Oak and hickory trees have nearly disappeared before the ax. Only the nearly worthless blackjack oak remains on the sandy hills where severe erosion occurs and runoff is high.

A north- and south-trending strip of rough country known as the Cross Timbers, varies from five to thirty miles in width extending across the central part of the state. From the time of Washington Irving's "A Tour on the Prairies," this belt of matted, tangled undergrowth, stiff-branched black-jacks, shinnery, briars, and scions of fire-killed larger trees has made an unfavorable impression. It is usually a region of rocky, thin soil, gashed by ravines which prove difficult to cross. It makes a dividing line between the bluestem prairies of the eastern half and the buffalo grass of the western half of the state. Erosion and runoff are excessive.

To the west the sandstone hills region merges with the "red beds" region. The red beds extend all the way from the Kansas border to the Texas border, and from almost the center of the state to within forty miles of the western line. They are composed of shales and soft sandstones varying from twelve hundred to sixteen hundred feet in thickness. Their red color is derived from ferric (iron) oxide. Particularly fertile farm lands are extant within this gently rolling region.

In the western part of the red beds region there are several ledges of gypsum; and here the red and white combinations of rocks make striking scenery along the Cimarron River. The numerous gypsum strata differ in thickness and composition, some being nearly pure and hard, others softer and interbedded with shale. The hard layers topping the buttes of the Blaine Escarpment render these low mesas impressive, because of both their color and location upon otherwise flat plains. Selenite, is crystalline gypsum, breaking into pieces resembling fragments of glass or mica. The Glass, or Gloss Mountains, an outlier in the Blaine Escarpment, is so named because its sides are littered with flakes of selenite glistening in the sun. The "gyp hills" region forms a rough triangular section with its base describing a wide arc to the north of the Wichita Mountains and with its apex near the Kansas border. Cereal and livestock production are dominant agricultural activities.

The climate of Oklahoma is of a transitional nature. It is predominantly of a continental type, most of it lying within the plains region, however, much influence is exerted at times by warm, moist air originating from the Gulf of Mexico, particularly as it affects the lower and eastern portions of the state. The extreme western part including the Panhandle is within the middle latitude steppe climate.[3]

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[3] T. A. Blair, Climatology General and Regional, Prentice-Hall, Inc., New York, (1942), p. 149.

The southern part of the state lies in the area of humid subtropical climate, and the rest of the state in the humid continental climate.

Marked geographical range occurs in both temperature and precipitation influencing temperature, evaporation, and runoff conditions. Daily and seasonal temperature changes are pronounced over most of the area. Summers are long and occasionally hot. Winters are short and comparatively mild. Rainfall is usually of the plains type, characterized by marked concentration in the late spring and early summer, yet there is commonly great annual and seasonal variability. It is hard to generalize, considering such marked variations in the amount of precipitation received in the different parts of Oklahoma.

The mean annual temperature for the state as a whole is 60.5°F, which average is comparable to that for the month of March.[4] The area experiencing the highest mean annual temperature of 64°F, is found along the lower Red River Valley in the extreme southern portion of the state, while the lowest mean annual temperature of 54°F occurs over the more elevated portions of the Panhandle counties. The variation in temperature within this transitional state is remarkable.

The warmest years on record happened in 1933 and again in 1934 when average temperatures of 63.0°F occurred over the state. The coldest year was 1892 with an average temperature for the state of 58.2°F. July and January experienced the extreme annual temperatures of 81.8°F and 38.2°F, respectively.

Summer maximum temperatures in excess of 100°F have been recorded within the state as early as March and as late as October and may commonly occur during the summer months. The highest temperature on record is 120°F and was recorded during 1936 at Alva on July 18, at Altus on July 19 and August 12, at Poteau on August 19, and at Tishomingo on July 26, 1943. Clear skies, dry atmosphere

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[4] "Climate of Oklahoma," Oklahoma Planning and Resources Board, Oklahoma City, Okla. (1945), p. 4.

and moderate southerly winds are the usual accompaniment of the high summer temperature leading to rapid transpiration of plants and evaporation from water and land surfaces. Minimum subzero temperatures for the state occurred in 1897-98, 1920-21, and 1933-34. The lowest temperature on record is minus 27°F which was recorded at Vinita on February 13, 1905, and at Watts on January 18, 1930.

The average length of the growing or frost-free season is 213 days, ranging from 180 days in Cimarron County in the Panhandle to 240 days in southern McCurtain County in the extreme southeastern corner of the state. Along the northern tier of counties of Oklahoma the average date of the last killing frost varies from April 5th at the eastern corner to April 20th near the New Mexico state line. In the most southerly part of the state, in contrast, the average date of the last killing frost in spring varies from March 20th to March 30th. The average date of the first killing frost in the fall in the northern portion varies from October 20th to October 25th, while along the southern tier of counties from November 5th to November 10th is the average date. The later occurrence is in the more easterly section, being within the humid subtropical type of climate.[5] As the temperatures become more severe in the northwestern portion of the state, and the duration of cold condition is longer, it may depress yields of corn and wheat influencing the map patterns shown herein (see maps 3 and 9). Cold weather lowers evaporation.

Extreme frost penetration of the ground ranges from fifteen to twenty-five inches, within some of the colder and more elevated regions, or during the infrequent, sustained, sub-freezing spells; ground frost is of little significance with plowing and preparation of soils for planting possible in much of the state throughout the winter months. Frozen ground conditions, however,

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[5] Ibid. p. 5.

may lead to excessive runoff when there is precipitation during this period and upon its thawing there may be frost runoff.

Average annual precipitation for the state based on the records of fifty-two years is 32.66 inches. The wettest year for the state was in 1908 with an average total of 47.73 inches; the driest year was in 1910 with an average total of 18.92 inches. The greatest annual total precipitation at any official reporting station was 80.35 inches at Watts in 1927; the least annual total given was 8.62 inches at Boise City in 1934.

Rainfall sharply decreases from east to west with average annual amounts from 51 inches in the extreme southeast portion of the state to slightly less than 17 inches in the west end of the Panhandle. The mean annual precipitation over a fifty year period is as follows: 40.11 inches in the eastern portion of the state, 32.96 inches in the central portion, and 25.74 inches in the western portion. Maximum precipitation for the same period was 56.18, 52.49, and 36.87 inches for the three portions of the state, respectively. While minimum precipitation was 27.75, 22.77, and 18.66 inches respectively. It may be noted that there is the greatest range between the eastern portion and western portion in maximum precipitation, less in mean annual precipitation, and least in minimum precipitation. In fact, the five year period ending in September 30, 1943, showed the maximum precipitation in the eastern portion of Oklahoma to be 55.89 inches, while in the western portion it was 36.26 inches, a difference of 19.63 inches.[6] Thus, there is considerable variation in rainfall throughout Oklahoma.

Rainfall frequency, as determined from the average number of days with 0.01 inch or more, varies from ninety-five days a year in the extreme East to around forty-five days in some Panhandle and extreme western localities; this is a great variation for such a short distance.[7]

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6 Oklahoma Water, op. cit. p. 64.

7 "Climate of Oklahoma," op. cit. p. 6.

The average number of rainy days for the whole state is sixty-six days per year reaching a monthly maximum of eight days in May and a minimum of four days per month from November to February, inclusive. The greatest average annual frequency was a hundred and two days in 1941; the least was forty-seven days in 1910. If rainy days follow each other, the runoff is increased while transpiration and evaporation may be decreased. Torrential rainfall sometimes occurs. The greatest intensity of downpours is in the more humid portions. Seventy-five percent of the annual precipitation usually comes in the period extending from March to October. Heavy rains of short duration usually result in more runoff than the lighter rains of longer duration.

Excessive rainfall occurs at times. Amounts of ten inches or more within twenty-four consecutive hours have been recorded in several scattered localities. Greatest diurnal amount of rainfall officially recorded by the United States Weather Bureau reporting stations was 15.51 inches at Sapulpa on September 3-4, 1940. Unofficial measurements, however, for the same storm of the early morning of September 4th, between Maramac and Hallet in Southern Pawnee County, were investigated and verified by the Division of Water Resources of the Oklahoma Planning and Resources Board; these indicated a maximum fall of about twenty-four inches in a ten-hour period.

Heavy rains cause excessive runoff and severe soil erosion at times, particularly where unwise methods of cultivation have been followed. Prolonged and excessive rainfall in spring and early summer occasionally causes damaging floods along the state's rivers, principal among which are the Arkansas, Red, Cimarron, Washita, Canadian and North Canadian. Damaging floods seldom occur at other seasons.

Precipitation is usually adequate for successful production of many agricultural products which include cotton, broomcorn, corn, winter wheat, alfalfa, grain sorghums, and other crops. Spring and early summer rains are usually of more general and abundant character, while late summer and fall rainfall is more localized, less abundant, and of the shower and thunderstorm type. Autumn precipitation, except in some western districts where its occurrence at this season is uncertain, is usually adequate for giving fall-sown grains a good start and putting soils in good condition for working.

Snowfall for the state averages 7.8 inches annually, ranging from about two inches in the southeast, where snowstorms are rather infrequent, to approximately thirty inches in parts of the Panhandle. Heaviest average monthly snowfall of two and one-half inches occurs in February, although it is almost equally as heavy during January. Snow rarely remains on the ground more than a few days, seldom falling from April to September. Snow has fallen in the Panhandle, however, in every month except July and August. At times drifts grow large enough to be detrimental to highway traffic and to livestock. Melting snow may cause erosion and the water may run off quickly while on the other hand the moisture may be stored as snow.

Droughts develop in Oklahoma when intense heat is prolonged, rainfall is deficient and hot drying winds persist. Notable among the most severe drought periods were the years of 1930, 1934, and 1936 when the greater part of the entire United States was affected to an unprecedented extent. An attendant liability to drought periods is the prevalence of duststorms, particularly over the lighter rainfall areas of central and western Oklahoma where much of the natural vegetative cover has been destroyed. The greatest dust storm in Oklahoma, as well as the most dense ever known in the central and eastern portions, occurred on April 10-11, 1935. A recent trend to normally wetter years and practices of improved methods of tillage, have materially reduced the probability of a recurrence of these unfavorable conditions.

Evaporation is relatively high in the state of Oklahoma because of its high temperatures, strong and almost continuous winds and low relative humidity.

During the warm season, which extends from April to September inclusive, the amount of evaporation in different portions of Oklahoma varies. In the extreme southwestern part of the state, evaporation is usually in excess of sixty inches as measured by the open-pan method. Western Oklahoma, as a whole, generally has fifty to fifty-five inches of evaporation occuring from a freewater surface during the summer six months. Tanks similarly located as to longitude in Western Nebraska show an evaporation rate of only forty-one inches and in North Dakota only thirty-one inches, showing the influence in Oklahoma of higher temperatures and stronger winds. This large amount of evaporation in the state as compared with northern states causes twenty inches of rainfall in the Panhandle to be only as efficient as fifteen inches in North Dakota for crops. Since the area of Oklahoma is nearer the dry border of crop production, then, a slight deviation in available moisture makes considerable difference--more so than in the North.

Since winds affect the rate of transpiration and evaporation, they are important to an understanding of the E/T factor. Winds blow chiefly from the south, although there is a pronounced shift to the north which occurs about the beginning of winter, lasting through February. Records of wind velocity are meager and are available only for a few stations; these include Oklahoma City (1892-1950), Broken Arrow (1918-1930), and Tulsa (1942-1950). The velocity of wind is rather low in the southeast increasing in velocity toward the north and west. The average hourly velocity at Oklahoma City is recorded as 11.4 miles per hour, with the windiest period of the year extending from February through April and the least windy period being in July and August.[8] Monthly averages range from nine miles per hour in August to nearly fourteen miles per hour in March. Winds reach destructive force at times over very limited areas

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[8] Ibid., p. 8.

and except in the case of tornadoes are ordinary straight-line winds. The dessicating, or drying effect, of the winds is far more harmful to agriculture in Oklahoma than the violent storms, however, it appears.

Skies are generally clear, allowing for rapid ground and lower air heating leading to high rates of plant transpiration and surface evaporation. The annual average number of clear days is 195; partly cloudy, 90; and cloudy, 81. The maximum number of clear days recorded in the state was 233 in the year of 1898. The maximum number of clear days for any one month occurs in July when it is usually clear nineteen days of the thirty-one.

Sunshine, based on records compiled at Oklahoma City, shows an annual average of sixty-seven percent of the possible amount. Approximately eighty percent of the possible sunshine during July and August may be expected during July and August, but only a little less than sixty percent may generally be found during December and January. Sunlight is so closely related to temperature that it influences ground and soil temperature conditions.

Inasmuch as the natural vegetation is an important feature of the physical environment affecting both transpiration and evaporation, it deserves consideration. For example, areas under forest have a much more rapid loss of moisture than grass areas. Because much of it has been destroyed or substantially modified, usually it is much less important than formerly.

Native trees in Oklahoma comprise 133 varieties.[9] They include the shortleaf pine, oak, elm, ash, hickory, pecan, walnut, cottonwood, willow, magnolia and cypress. Throughout the state, and especially among the canyons of the Red Beds and Gypsum Hills regions, red cedar and juniper are abundant.

Prairie grasses provide excellent pasturage or support crops that make Oklahoma one of the leading cattle states of the Union. The livestock industry,

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[9] Angie Debo and J.M. Oskison, op. cit., p. 10.

based on grasslands, flourishes on the high plains of the West. The earlier Texas Longhorn cattle have finally disappeared, being replaced by Herefords and Shorthorns. Sheep raising has increased since 1935. Dairy animals, horses, mules, and poultry are also of considerable importance. About a million pigs are fattened for market each year. The heavy livestock pressure has led to vegetation and soil deterioration which has brought about conditions resulting in high rates of transpiration and excessive runoff.

Oklahoma usually ranks seventh among the crop-producing states. The vast, open ranges are limited in number, the former ranch land now being divided into neatly fenced farms. Cropping and land ownership practices, in some cases, cause conditions that result in excessive runoff and erosion.

Wheat fields of great dimensions are found in the north-central and western sections of the state. The rich valleys of the central and eastern sections support a corn economy. Oklahoma is one of the leading cotton-producing states. Of these crops, corn shows a marked comparison in distribution with the E/T factor. The growing season and other factors appear to restrict cotton production to certain areas and obscures the relationship, while wheat is influenced by even more numerous conditions.

In conclusion, geography of an area greatly influences available water supplies for plants. Other things being equal, the relative effects of geography and vegetation on the character of water supplies are generally as follows: an increase in depression storage causes a decrease in the ground water supply and loss due to evaporation-transpiration. An increase in length of overland flow causes a decrease in quantity and intensity of surface water runoff and an increase in the ground water supply and evaporation-transpiration loss. An increase in surface slope causes an increase in quantity and intensity of surface water runoff and a decrease in ground water and evaporation-transpiration loss. The shape of the watershed is of considerable importance as it affects total runoff. An increase in vegetal cover causes a decrease in quantity and intensity of surface water runoff and an increase in the loss due to evaporation-transpiration and causes the ground water supply to be variable. The evaporation-transpiration factor, the water evaporation from ground and water surfaces and transpired by vegetation, increases in amount in varying degrees with increases in temperature, wind movement, amount of sunshine, amount of precipitation within certain limits, and decreases with increases in relative humidity.[10]

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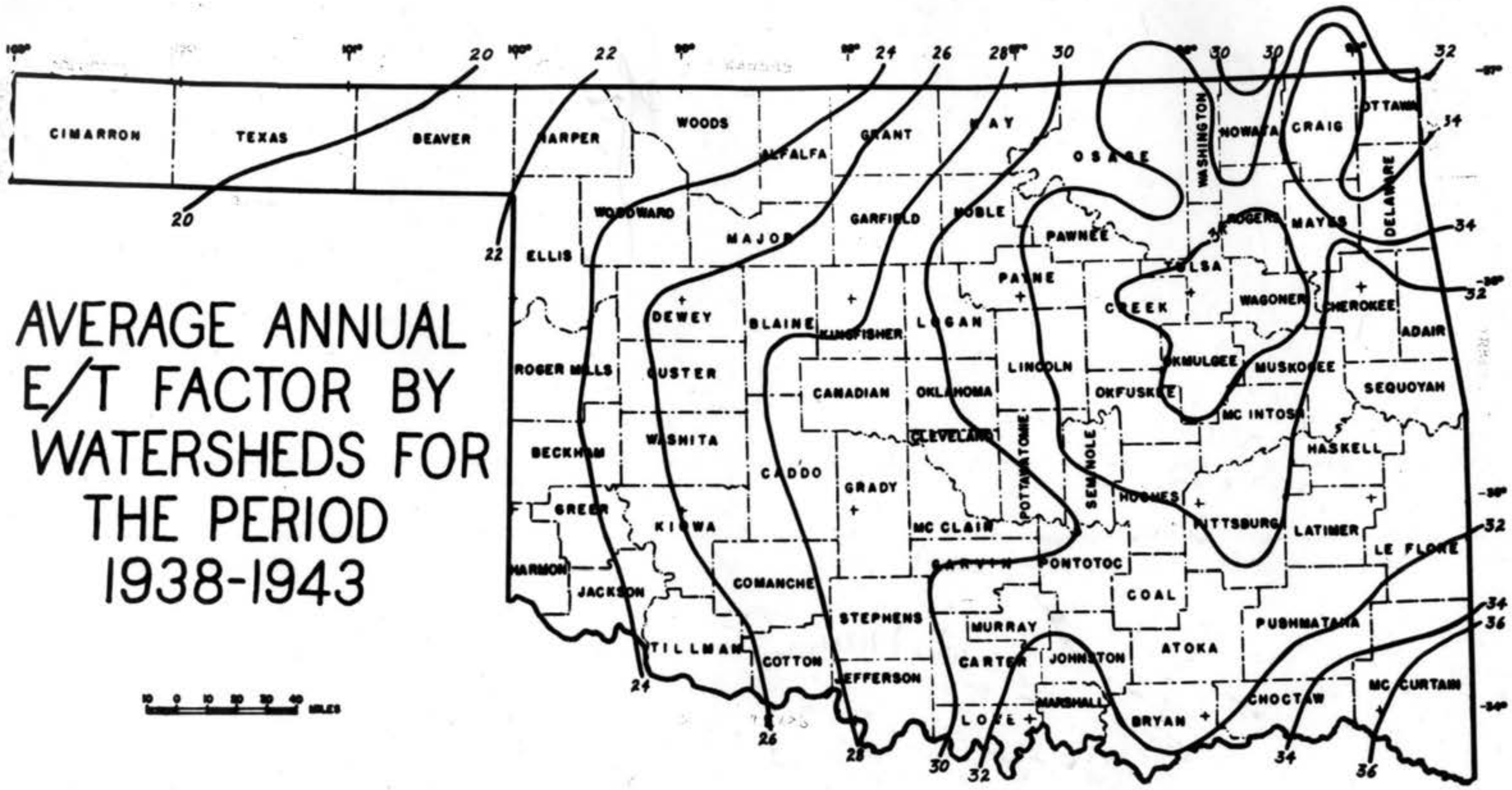
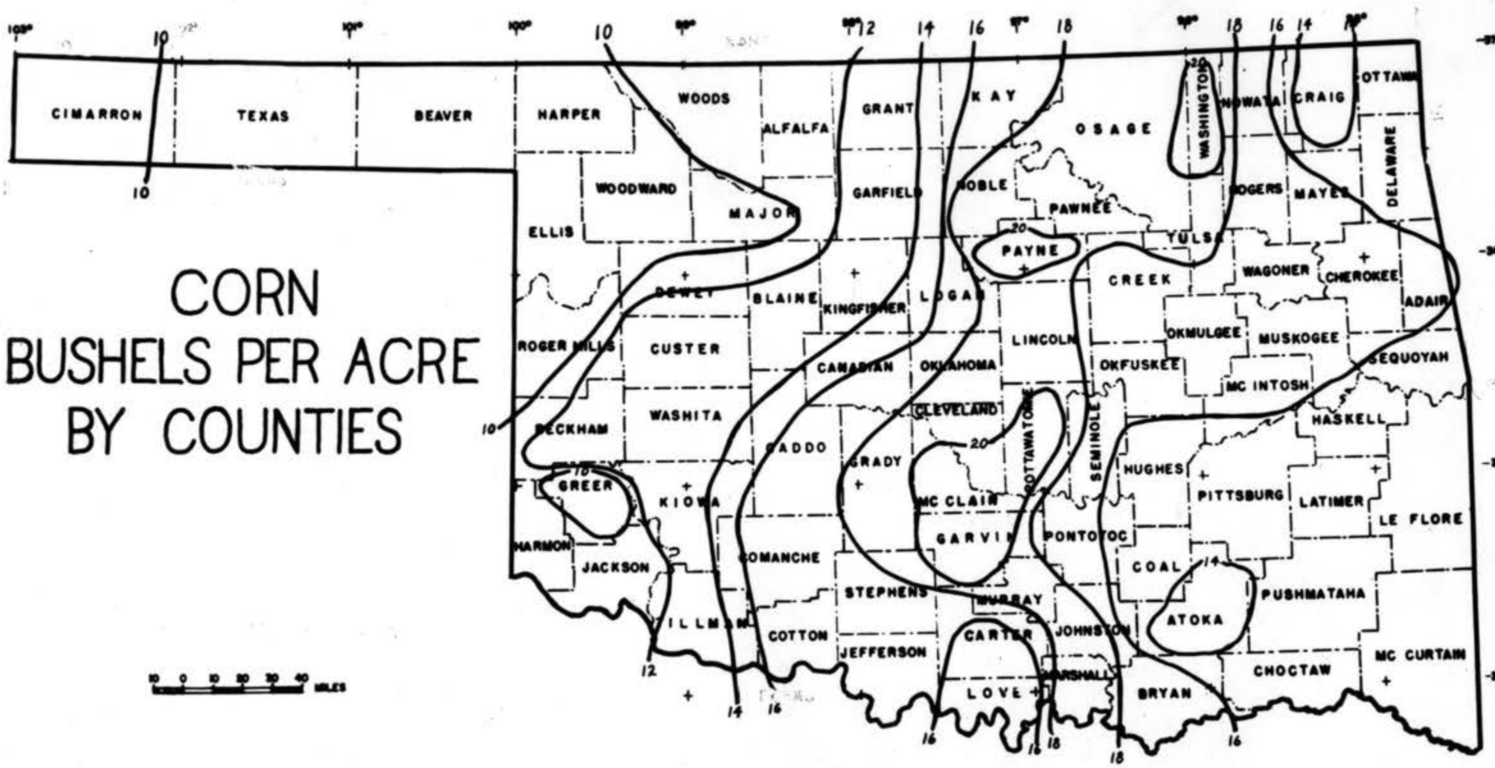
[10] Oklahoma Water. op. cit., p. 6.



AVERAGE ANNUAL E/T FACTOR BY WATERSHEDS FOR THE PERIOD 1938-1943

MAP 2



CORN
BUSHELS PER ACRE
BY COUNTIES

MAP 3

CHAPTER IV

CORN YIELD AS RELATED TO THE E/T FACTOR

From east to west across Kay and Grant counties, in northern Oklahoma, the yield of corn and the E/T factor decrease almost at an equal rate (6 units in approximately 70 miles). (See Maps 3 and 4.) However, in the next tier of counties to the south, i.e., Noble, Garfield, Major and Woodward, the E/T factor decreases 6 units in about 110 miles, while the yield of corn decreases 6 units in approximately 40 miles. Further south, in the tier of counties comprised of Oklahoma, Canadian, Blaine, Custer, and Roger Mills counties, the rate of decrease is again the same at the outward extremities (6 units in 165 miles). At the southern border of the state, along the Red River, the decrease of 6 units spreads over a space of nearly 180 miles for corn and over approximately 110 miles for the E/T factor. This gives about a 74 percent favorable comparison for corn yield and the E/T factor in the western protion of the state.

The lines connecting areas of equal average yield of corn and the lines connecting equal E/T factors both tend to present a wedge-shaped pattern to the west. The wedge formed by corn yield, on the one hand, extends across McClain, Grady, Caddo, Kiowa, Washita, and Backham counties while the wedge formed by the E/T factor, on the other hand, is across Blaine, Dewey, and Woodward counties, some 100 to 200 miles to the north. This is just south of an area where corn yields tend to decline.

In the area where the lines of equal yield extend eastward, which is in reality a trough, the 10 bushel per acre line extends into the area where the

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[1] Map 3 was taken from Oklahoma Water, op. cit., p. 80., and map 4 was prepared from data obtained from Oklahoma Agricultural Statistics, A Statistical Handbook of Oklahoma Agriculture. Experiment Station Miscellaneous Publication MP-14, Oklahoma Agricultural Experiment Station, Stillwater, Okla., (January, 1949), p. 73-78.

E/T factor is as much as 26. It is quite possible that this could be due to the lack of fertility in the soil since the area where the lines form a wedge-shaped pattern toward the west actually lie along the fertile valley of the Washita River. This would make it seem that here the fertility of the soil had more to do with production of corn than does the E/T factor. Throughout the area along the Washita River the E/T factor lines actually continue in a nearly straight line.

The Panhandle, being such a narrow strip of small area, does not present enough data for comparison purposes.

Throughout the eastern half of Oklahoma, the E/T factor presents such an erratic pattern that it would be hard to compare anything with it. In an over-all pattern, nonetheless, the corn yield declines nearly four units, from 18 to slightly more than 14 bushels per acre while the E/T factor increases four units, from 32 to 36. This appears to show that when the E/T factor exceeds 30 it goes beyond the optimum conditions for corn growth. Therefore, as the factor grows larger, production decreases, more or less, proportionately. This comparison appears to show a relationship of some significance.

Average annual precipitation, like the E/T factor, decreases 6 units (36 to 30 inches) in the northern tier of counties, including Kay and Grant counties, over a distance of approximately 70 miles as compared to 6 units drop for corn yield over the same distance. In the next tier of counties to the south, which includes Pawnee, Noble, and Garfield, the rate of decline is 6 units in approximately 40 miles. In central Oklahoma, comprised of a tier of counties including Okfuskee, Lincoln, Oklahoma, and Canadian counties, the precipitation drops 6 units in 100 miles as compared to 6 units in 165 miles for corn yield. At this point the 36 inch rainfall line and the 18 bushel per line—the west 18 bushel per acre line which was used in the first comparison—is some 70 miles apart, the rainfall line being the farthest east. Along the Red River the distance and area between the two sets of lines nearly coincide again with both showing a decrease of 6 units in approximately 80 miles. This gives average annual precipitation a 78 percent favorable comparison in the western part of the state, or a comparison relationship just four percent above that of the E/T factor.

In the eastern portion of the state the average annual precipitation lines tend to form a regular pattern, showing considerable Gulf influence in the southeast corner of the state. The 16 bushel per acre line of eastern Oklahoma shows strong tendencies to follow the 42 inch precipitation line. The comparison of the average annual precipitation with corn otherwise appears difficult, since corn yields tend to level off at a little above 14 bushels per acre.

The tendency appears to be that the corn yield is greatest just a little above the 30 E/T isopleth in the northern part of the state and slightly below the same value in the southern portion, following a wedge-shaped pattern of westward penetration into Caddo County. The 16, 14, and 12 bushels per acre lines follow wedge-shaped patterns into Washita and Backham counties. In areas where the evaporation-transpiration factor is 30, the average yield of corn is from 18 to 20 bushels per acre. McClain County, with an average of 22.7 bushels per acre, has the highest yield. Production drops off as the distance increases either to the east or to the west from this zone of highest yield. In western Oklahoma, where the E/T factor ranges from 21 to 24, the drier conditions cause the average yield to drop to 10 and 12 bushels an acre. In the eastern part of the state, where the E/T factor is from 32 to 36, the average yield ranges downward to a low of 14 bushels per acre in isolated areas as in Atoka and Craig counties.

The zone of highest corn yield, where the yield is 18 or more bushels per acre, almost coincides with the zone formed between the 28 and the 31 E/T factor lines. Westward, yields in bushels of corn per acre and the E/T factor decrease at approximately the same rates. The westward extending wedge-shaped pattern of corn production, as shown previously, is somewhat to the south of the westward extension of the E/T factor wedge. This may indicate that other factors, as well, are influential.

At one time, corn was the leading crop in Oklahoma. In 1909 it occupied over five million acres, a greater acreage than that of wheat and cotton added together.[2] The importance of corn in the early days was due largely to the fact that most of the settlers came from the eastern states and were accustomed to raising corn. By 1928 there was a two-fifths decrease. Only about three million acres were planted, or less than one-third of the total acreage under wheat and cotton. This decline in corn production, it appears, was due to the fact that corn is a water-loving plant being more easily damaged by dry spells and periods of drought than cotton, wheat, and grain sorghum. Soil depletion and erosion also may have played a part.

Corn is grown in every county in the state of Oklahoma, although its average yield per acre is somewhat varied from county to county. Production tends to drop off in both the southeast and the northwest section of the state. It is highly probable that the eastward extension of the lines of equal production along the Cimarron River may be due to the inability of the drier sandy soil to produce satisfactory yields. This indicates that the crop does not produce well where there is an excess of moisture or where there is a deficiency.

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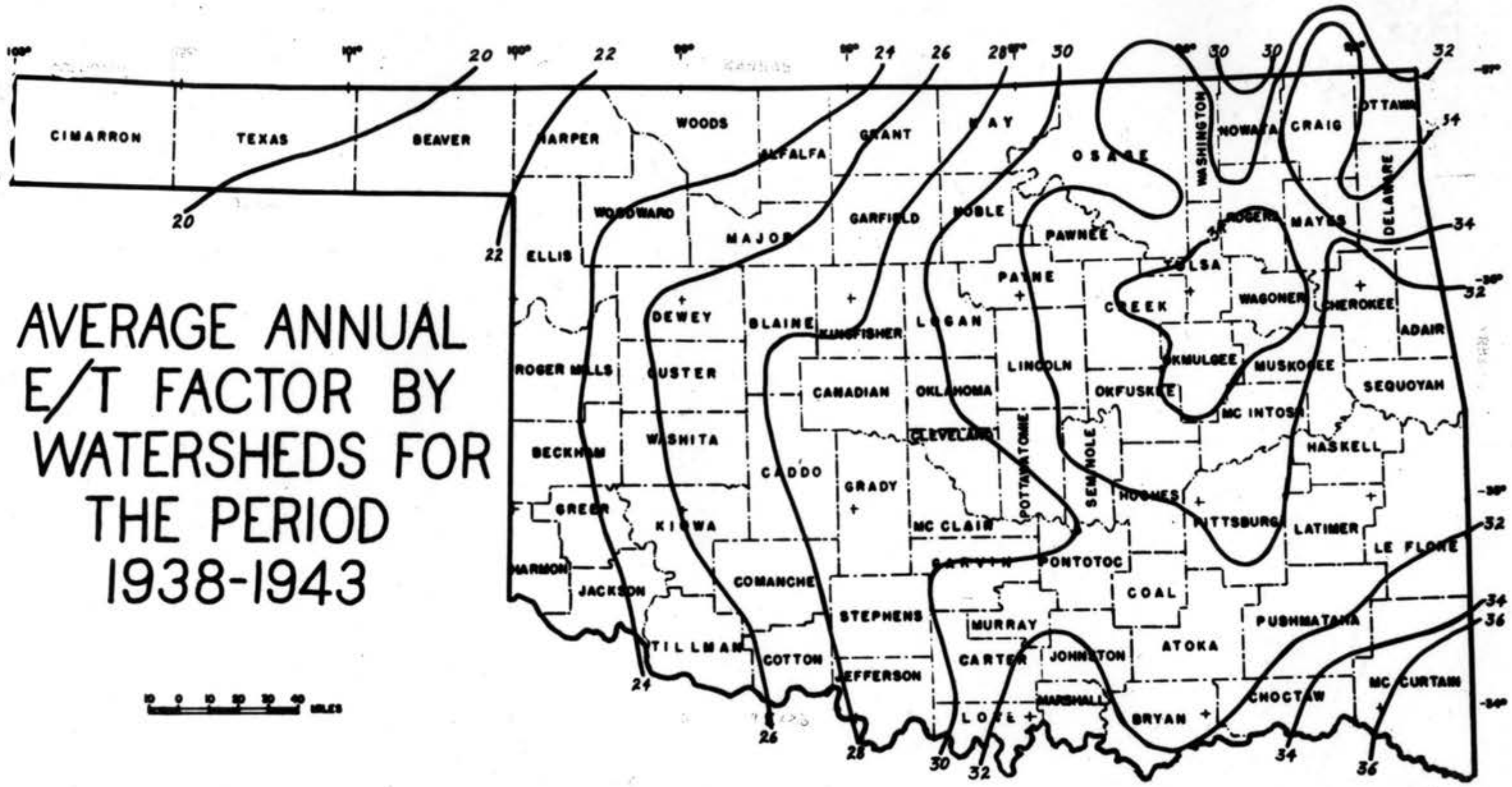
[2] R. E. Dodge and E. E. Lackey, Advanced Geography, Geography of Oklahoma Section, by C. J. Bollinger, (1930), p. 34.

Corn remains an important crop in the eastern part of the state, giving way to wheat in the northwestern portion and to cotton in the southern part. Over the years, evidence shows, a better adaptation to natural conditions has brought about a limitation of its area of distribution to those places which are most suitable for its growth, i.e., where there are proper water, evaporation, and transpiration relationships. Hence, the reaction of corn production to the greater available moisture in the areas of higher E/T index, indicated by the westward extension of the E/T factor isopleths, is particularly significant.

The E/T factor and average annual precipitation in western Oklahoma showed comparisons with corn yields of 74 and 78 percent, respectively. In the eastern part of Oklahoma the E/T factor showed an inverse relationship while average annual precipitation displayed little discernable relationship. It appears, then, that the E/T factor does help to show the overall pattern of distribution. The lack of high relationships between production figures and each of the climatic criteria in many instances, particularly in the eastern section, leads to the conclusion that other factors such as soil types, slope and fertility are significant controlling factors.


AVERAGE ANNUAL
E/T FACTOR BY
WATERSHEDS FOR
THE PERIOD
1938-1943
CIMARRON
TEXAS
BEAVER
HARPER
WOODS
ALFALFA
GRANT
KAY
OSAGE
WASHINGTON
NOWATA
CRAIG
OTTAWA
DELAWARE
WOODWARD
ELLIS
MAJOR
GARFIELD
NOBLE
PAWNEE
ROGERS
MAYES
TULSA
PAYNE
DEWEY
BLAINE
KINGFISHER
LOGAN
CREEK
WAGONER
CHEROKEE
ADAIR
ROGER MILLS
CUSTER
CANADIAN
OKLAHOMA
LINCOLN
OKMULGEE
MUSKOGEE
SEQUOYAH
OKFUSKEE
MC INTOSH
BECKHAM
WASHITA
CADDO
GRADY
CLEVELAND
POTTAWATOMIE
SEMINOLE
HASKELL
HUGHES
PITTSBURG
LATIMER
LE FLORE
GREER
KIOWA
MC CLAIN
GARVIN
PONTOTOC
HARMON
JACKSON
COMANCHE
STEPHENS
COAL
MURRAY
PUSHMATAHA
TILLMAN
COTTON
JEFFERSON
CARTER
JOHNSTON
ATOKA
MC CURTAIN
MARSHALL
CHOCTAW
LOVE
BRYAN
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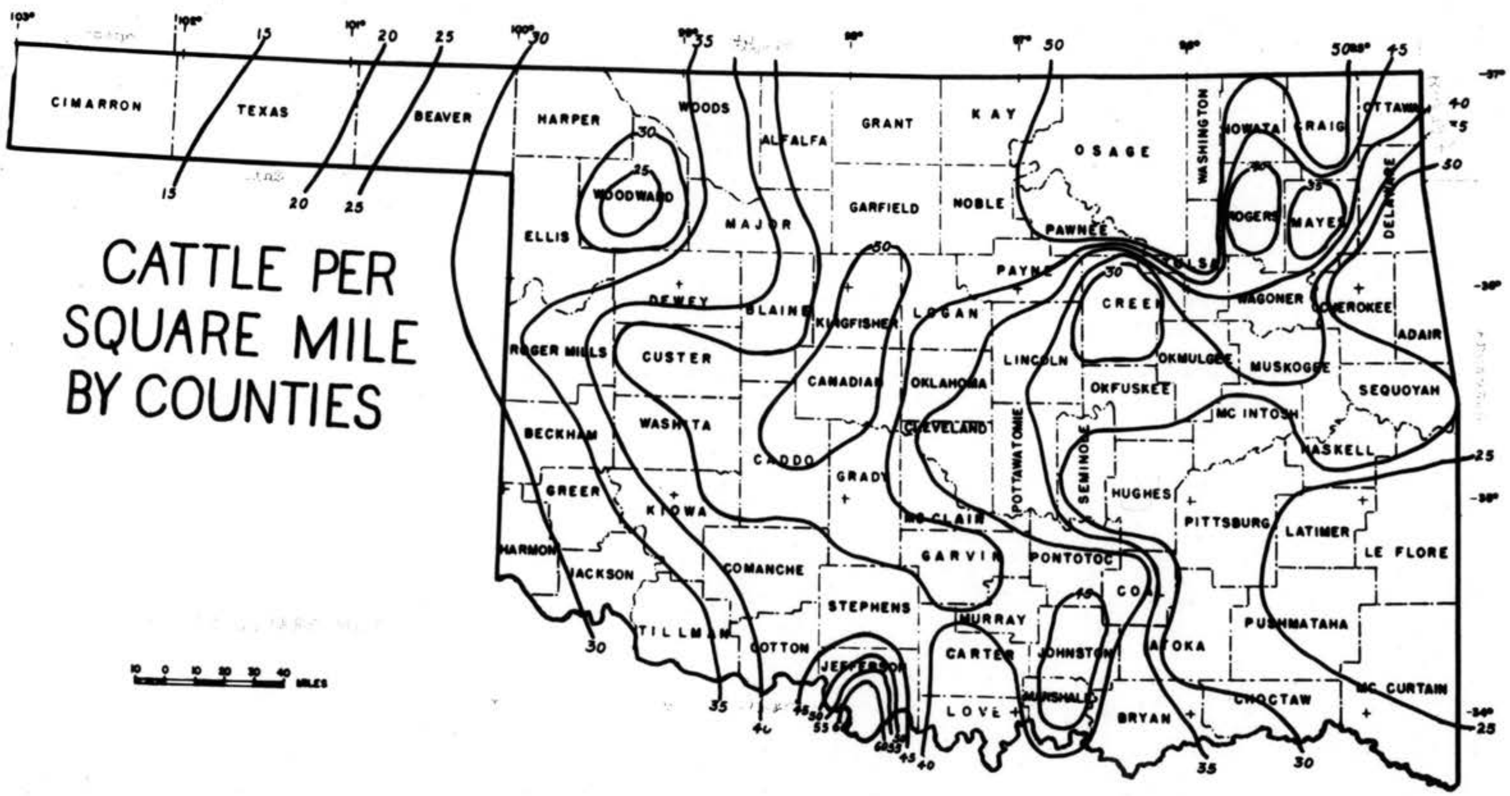
36
MILES

MAP 4


CATTLE PER SQUARE MILE BY COUNTIES
CIMARRON
TEXAS
BEAVER
HARPER
WOODS
ALFALFA
GRANT
KAY
OSAGE
WASHINGTON
NOWATA
CRAIG
OTTAWA
WOODWARD
MAJOR
GARFIELD
NOBLE
PAWNEE
ROGERS
MAYES
DELAWARE
ELLIS
DEWEY
BLAINE
KINGFISHER
LOGAN
PAYNE
CREEK
TULSA
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CHEROKEE
ADAIR
ROGER MILLS
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MUSKOGEE
SEQUOYAH
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MC INTOSH
BECKHAM
WASHITA
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GRADY
CLEVELAND
POTTAWATOMIE
SEMINOLE
HASKELL
GREER
KIOWA
MC CLAIN
HUGHES
PITTSBURG
LATIMER
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HARMON
JACKSON
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GARVIN
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COAL
STEPHENS
MURRAY
PUSHMATAHA
TILLMAN
COTTON
JEFFERSON
CARTER
JOHNSTON
ATOKA
MC CURTAIN
LOVE
MARSHALL
BRYAN
CHOCTAW
MILES

MAP 5

CHAPTER V

CATTLE PER SQUARE MILE AS RELATED TO THE E/T FACTOR

A notable similarity of the two sets of lines of the E/T factors and average number of cattle per square mile is shown by the wedge-shaped pattern in the western part of the state (Maps 5 and 6).[1] The lines denoting number of cattle per square mile form a wedge-shaped pattern through Caddo, Custer, and Roger Mills counties while the lines of equal E/T factors form a wedge-shaped pattern through Blaine, Dewey and Woodward counties ranging from 50 to 100 miles to the north of the wedge in the number of cattle per square mile. There is, however, a decrease in the number of cattle where the wedge in the E/T factor extends through Blaine County.

Along the northern border of Oklahoma, the decrease is 4 units for cattle and the same for the E/T factor in 175 miles. In central Oklahoma, through Canadian, Blaine, Custer, and Roger Mills counties, the change is 4 units for cattle and 3 units for the E/T factor in 110 miles. In the southern part of the state, which includes Garvin, Grady, Comanche, Kiowa, Greer and Harmon counties, the decrease is 4 units for cattle and 5 units for the E/T factor in 140 miles. This shows an 88 percent comparison for number of cattle per square mile and the E/T factor.

Following the same comparisons for average annual precipitation the decline was 4 units of cattle to 7 units for precipitation, 4 units for cattle as compared with 3 units for precipitation, and 4 units for cattle as compared with

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[1] Map 5. Oklahoma Water, op. cit., p. 80.
Map 6 was prepared from data obtained from C. E. Batschelet, Areas of the United States 1940, Sixteenth Census of the United States, United States Government Printing Office, Washington, D.C., (1940).

five units for precipitation. This gives a 67 percent comparison for average annual precipitation or 21 percent less than the E/T factor.

As one proceeds westward out of the wooded country, both grass and cattle tend to increase until the short grass country is reached where the grazing resource becomes limited. Where the short grass country begins, the number of cattle per square mile seems to decrease. The western boundary of the wooded country follows, to a great extent, the 30 E/T isopleth. The eastern boundary of the short grass country is approximately the 24 E/T isopleth. It is between these two boundaries on the west and the east that the greater number of cattle per square mile is found. Throughout the zone that lies between the 30 and the 24 E/T factor lines, forty or more cattle are found per square mile. Penetration westward of an E/T factor ridge in Woodward County is not followed by similar cattle distribution, possibly because of the dominance of grain farming.

Throughout the western portion of Oklahoma the lines of equal number of cattle per square mile and those that denote average annual precipitation tend to follow the same overall pattern. The wedge-shaped pattern presented by each is nearly coincident in Custer and Roger Mills counties. The E/T factor shows a better relationship in the regular sweep of its lines that are less irregular than the rainfall lines.

In the eastern part of the state comparisons of cattle and average annual precipitation are difficult to point out. There is, however, a tendency for the number of cattle to decrease as the E/T factor exceeds 31 in the southeastern portion of the state. In the northeastern part of Oklahoma these values appear to be unrelated. There is a general decrease in the number of cattle as the average annual precipitation decreases, an exception being Craig County.

In the southeastern part of the state, where farms are quite small, on the average the number of cattle per square mile decreases to as little as 20. This seems to show that where the farmer is devoting most of his land to rowcrop farming he has little space for cattle other than those which he keeps for milking purposes.

The exceptionally large numbers of cattle per square mile found in Jefferson County on the south and in Osage County on the north are the result of influences entirely unrelated to moisture availability. The native grasslands have been preserved because they were granted to Indians by the Government with stipulations in the deeds which prevent sale of the properties. In many cases the Indian owners have withdrawn to city life and have leased their land to cattlemen. Large ranches were thus formed and have been able to withstand the normal pressure for crop land utilization.

The eastward extension of a zone with 30 to 40 cattle per square mile along the Arkansas River near Tulsa and Muskogee is probably due to the large dairy herds that supply the cities of the area. Since the farms of the eastern and southeastern part of the state are small and much more numerous than those of the western portion, it would seem that a large percentage of the cattle of that area are small herds of dairy cows used to supply family needs. This would be true, particularly, in the extreme southeast corner of the state.

In the early days there were at least four large areas that were unoccupied by Indians where the cattle industry arose in Oklahoma. The largest of these areas was that part of the Cherokee Outlet that had not been ceded to the tribes under the Osage and Ponca agencies. West of this strip lay "No Man's Land," which was later to become the Panhandle of Oklahoma. This strip of high, level prairie was about 170 miles long and over 34 miles wide. In the extreme southwestern part of the state, between the two branches of the Red River, is the third region which is some 70 by 90 miles in size. The fourth region, known as the Unassigned lands or Old Oklahoma, lay in the center of the state. The latter region comprised nearly 2,000,000 acres of well-watered, fertile plainland.[2]

Oklahoma is well adapted for the livestock industry. The mild winters minimize the need for shelters for the stock and the abundance of feed assures them a year round diet. Before the coming of white man to what is now the state of Oklahoma vast herds of buffalo grazed the plains. The buffalo gave way to the Texas longhorn which in turn gave way to the high-grade cattle or to cultivated crops which may be used as feed. The introduction of the barbed-wire fence and of the homesteaders into Oklahoma marked the decline in the early cattle industry. At present ranching is carried on only where the land is not suitable for farming or where stock raising became so deeply rooted that other types of agriculture could not displace it. A good example of ranching country that remains is Osage County.

In conclusion, it appears that the E/T factor shows a closer comparison than average annual rainfall with cattle distribution per square mile in central and western Oklahoma. In the eastern portion of the state there is little apparent relationship of the E/T factor and the cattle lines. Some exceptions to the distribution pattern are probably due to social, political and economic conditions.

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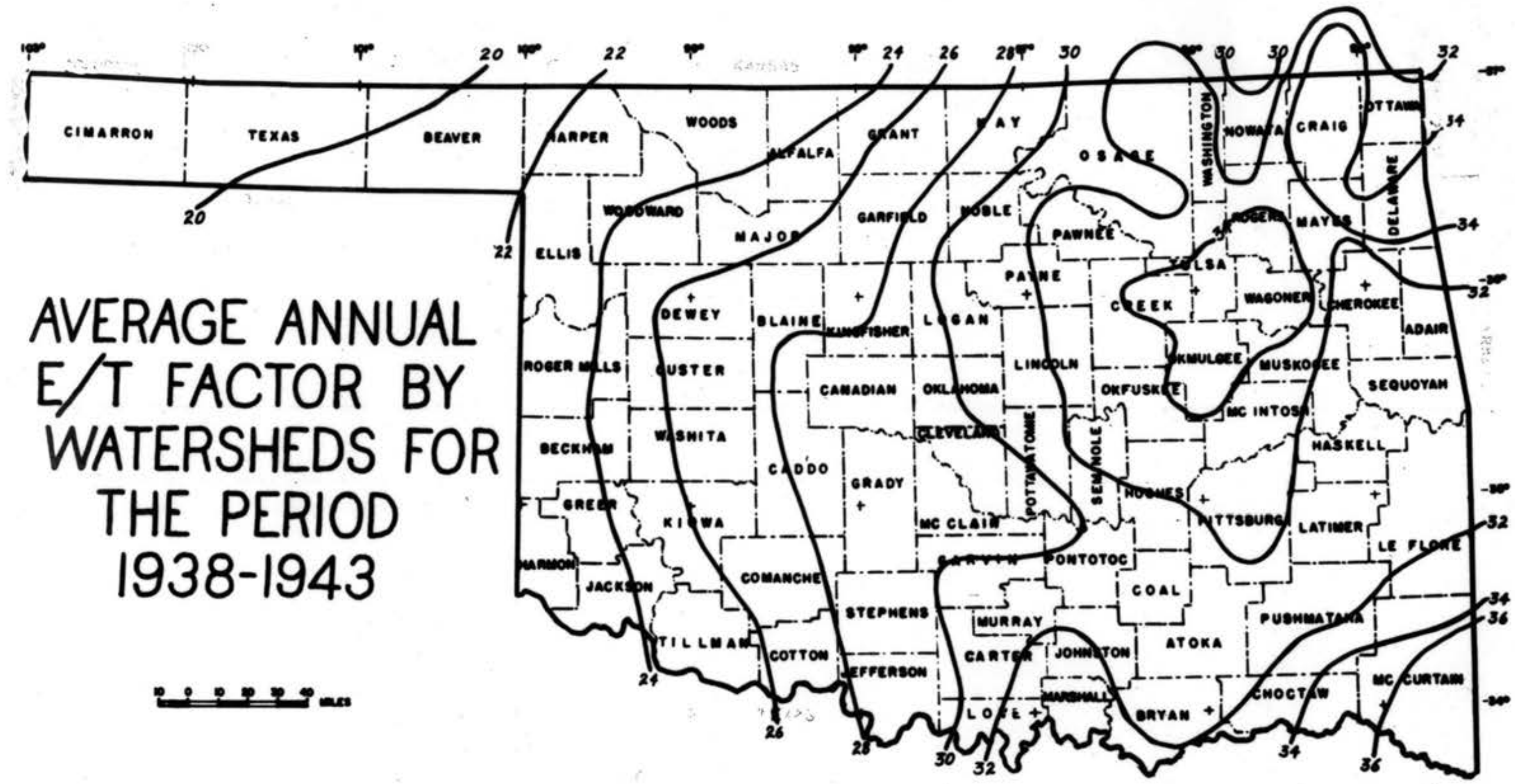
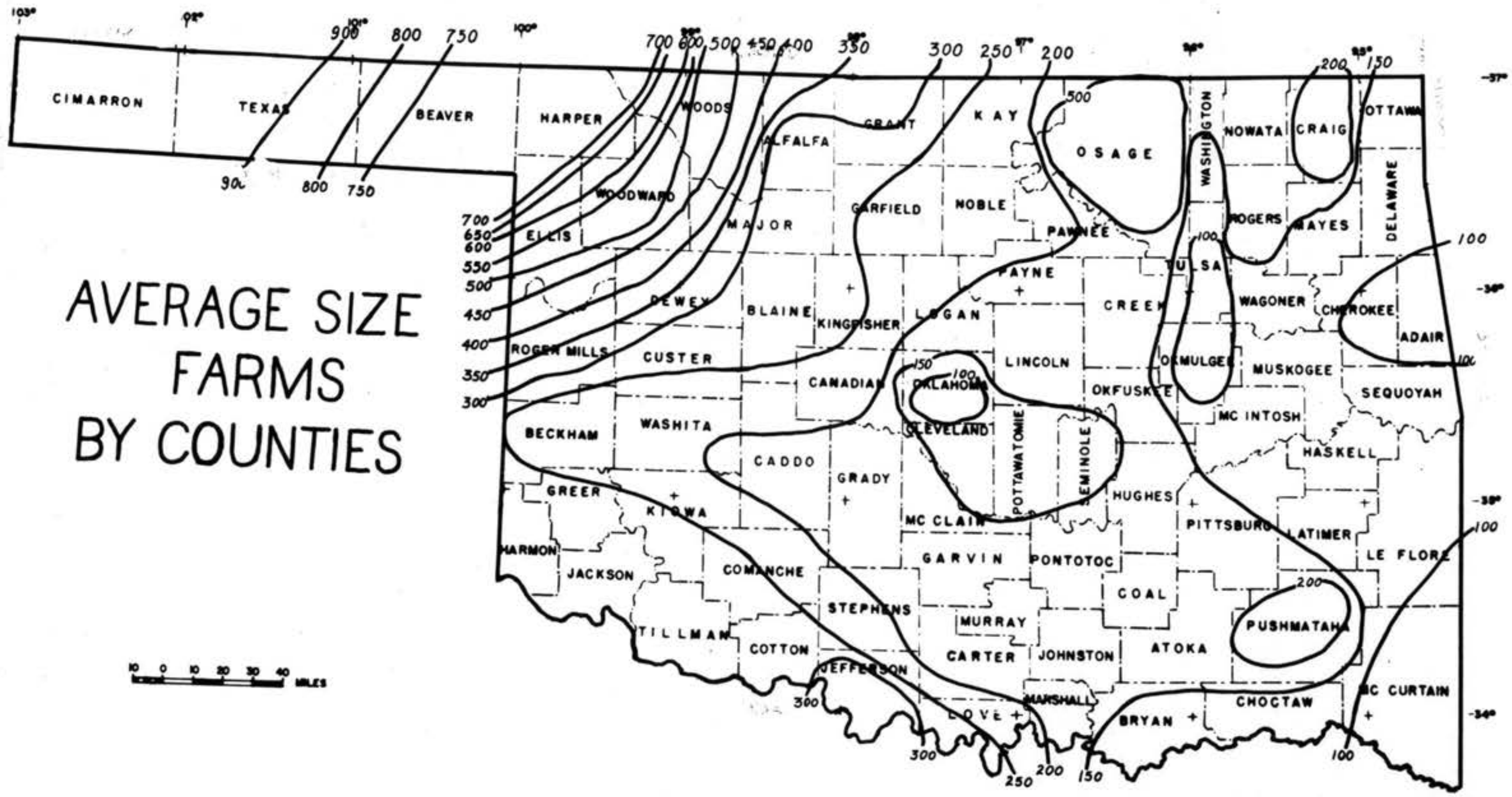
[2] E.E. Dale & M. L. Wardell, History of Oklahoma, Prentice-Hall Inc., New York (1948).



AVERAGE ANNUAL
E/T FACTOR BY
WATERSHEDS FOR
THE PERIOD
1938-1943

MAP 6


AVERAGE SIZE
FARMS
BY COUNTIES
CIMARRON
BEAVER
HARPER
WOODS
ALFALFA
GRANT
KAY
OSAGE
WASHINGTON
NOWATA
CRAIG
OTTAWA
DELAWARE
WOODWARD
ELLIS
MAJOR
GARFIELD
NOBLE
PAWNEE
ROGERS
MAYES
TULSA
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WAGONER
CHEROKEE
ADAIR
DEWEY
BLAINE
KINGFISHER
LOGAN
CREEK
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MURRAY
PUSHMATAHA
TILLMAN
COTTON
CARTER
JOHNSTON
ATOKA
JEFFERSON
MARSHALL
CHOCTAW
MC CURTAIN
BRYAN
900
800
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700
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450
400
350
300
250
200
150
100
MILES

MAP 7

CHAPTER VI

AVERAGE SIZE OF FARMS AS RELATED TO THE E/T FACTOR

Average size of farms, calculated by counties, shows an inverse relationship to the lines of the E/T factor (Maps 6 and 7).[1] That is, the smaller the farm area the greater the E/T factor, and the larger the farm size the samller the E/T factor. Farms in the state of Oklahoma vary in size from an average of eighty-six acres in the southeast corner to an average of eighteen hundred acres in the western end of the Panhandle. Area of farms is determined to a great extent by climate, with topography, type of soil, character of people, and marketing features as limiting factors.

Since care of rowcrops requires much more work than husbandry of cereal crops, farms in the areas of corn and cotton are smaller of necessity than in small grain sections. They tend to be diminutive, in fact, when compared with those of the western part of the state where machinery permits extensive farming. In rowcrop farming the operator will not cover as much ground in one day, thus limiting his need for land.

On the other hand, operators using large, modern tractors can plow much more area per day. The writer, for example, has plowed ninety-four acres in six days with a tractor and a plow. In another instance he plowed eighty-five acres in sixty-four hours of actual plowing time in a large flat field.

As numbers indicated the average E/T factor decrease, the average size of farms increase, particularly in the western part of the state. This appears to indicate that when the E/T factor declines in amount there is a decrease in the overall ability of the lands of western Oklahoma to produce. Such a

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[1] Map 6, Oklahoma Water, op. cit., p. 80.
Map 7 was prepared from data obtained from C. E. Batschelet, Areas of the United States 1940, Sixteenth Census of the United States, United States Government Printing Office, Washington, D.C., (1940)

condition makes it necessary for a farmer to utilize more land in order to maintain the same standard of living as on a smaller area where production is intense. However, this does not imply that the standard of living in the eastern section of the state on small farms is as high as on the larger farms of the west.

Insufficient figures for the Panhandle lead to a distorted picture of that area. One point is not enough to determine a line;for this reason most of the isopleths in the Panhandle were ommitted. The area of individual farms averages around 1,800 acres per individual farm in the extreme western county of the state.

Osage County presents a striking deviation on the map. Indian land status makes it possible for ranchers to lease large quantities of land in single blocks thus accounting for the huge farms of that area as compared with the farms of the surrounding counties.

By far the larger portion of the state of Oklahoma is divided into farms whose average size ranges from one hundred and fifty to three hundred acres per farm. This region is generally bounded by the 22 and 32 E/T isopleths. Only the southwestern corner of the state is an important exception to this rule.

Intensive land use, common in the vicinity of urban districts, has resulted in small farms surrounding Oklahoma City and Tulsa. High land values and part time availability for agricultural exploitation in these two areas determine farm size. Possible future use of the land also entered the picture, i.e., town sites, and special or general farming.

Many of the exceptions to the above comparisons regarding farm size can be attributed to the arbitrarily laying out of the Indian allotments and determining the size of homesteads by Governmental decree. At that time, lawmakers and other Government officials had no conception of the true productive capacity of the land and, consequently, the proper size of individual farms to be established.

In most cases the true worth of agricultural land has been determined by its production. Exceptions appeared where oil or other minerals entered the picture. In some cases original farms were grouped into much larger units as in northwestern Oklahoma. Other circumstances caused the land to be divided into smaller units as in the vicinities of Oklahoma City or Tulsa.

The average size of farms increases almost continuously from the southeastern corner of Oklahoma to the northwestern corner. This increase becomes very rapid and pronounced to the northwest of Roger Mills, Dewey, Major, and Grant counties.

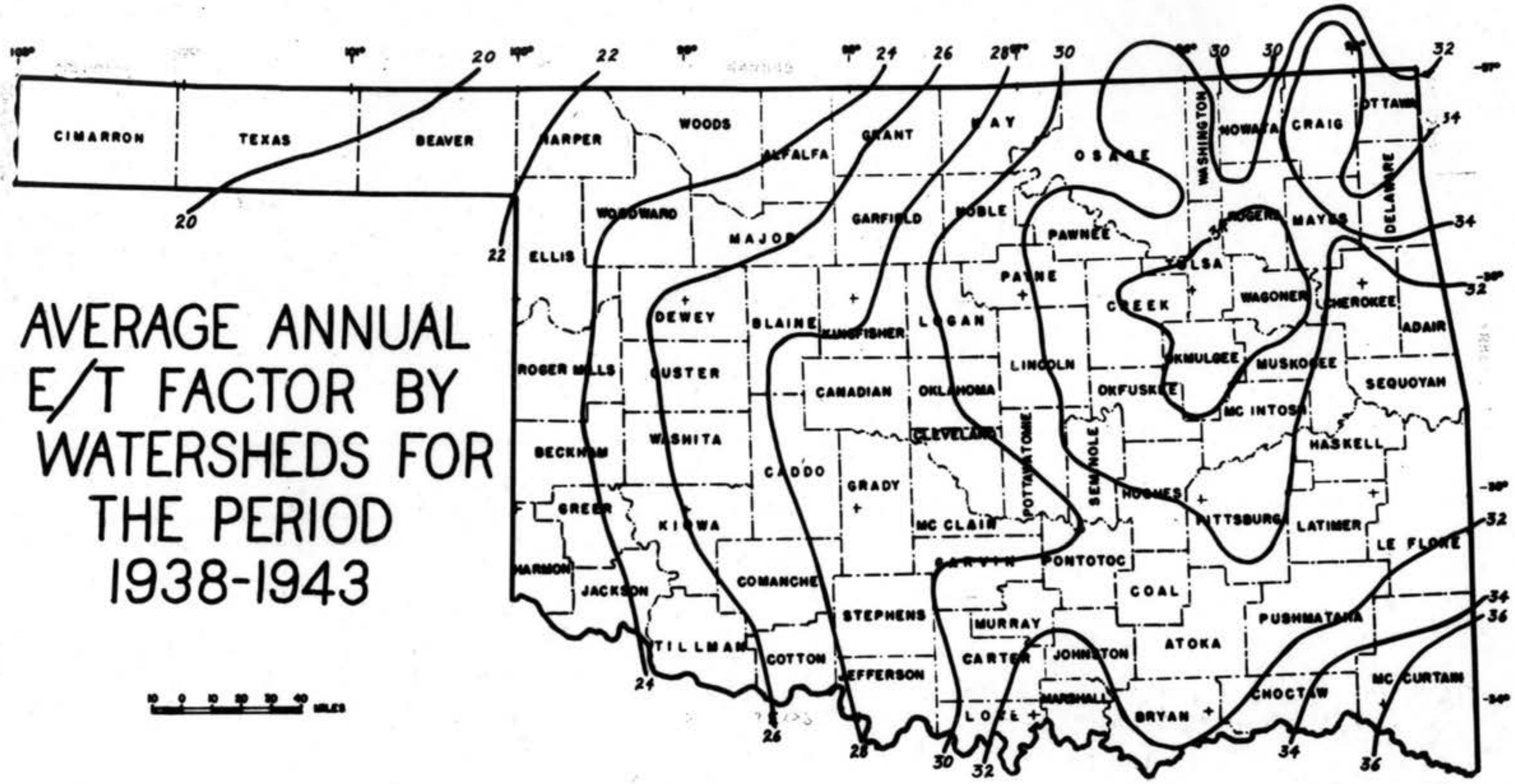
The lines of equal average size of farms also tend to form a wedge-shaped extension, in this case a trough, throughout Caddo, Washita, and Backham counties, which is in harmony with the general inverse relationship to the E/T factor. This area of smaller farms extending into the west lies in the valley of the Washita River and may be accounted for by the fertile soils there. This trough is from 50 to 75 miles south of the E/T factor wedge.

Along the north border of Oklahoma there is a variation of $10\frac{1}{2}$ units (50 acres equals 1 unit) in 175 miles in the average size of farms as compared to $4\frac{1}{2}$ units for the E/T factor. In central Oklahoma, Oklahoma, Canadian, Caddo, Custer, and Roger Mills counties, the ratio is 5 units to 150 miles for the average size of farms as compared to 4 units for the E/T factor. In the southern part of the state, Murray, Carter, Stephens, Comanche, Tillman, and Harmon counties there is a ratio of 2 units to 165 miles as compared to 5 units for the E/T factor. This shows a 54 percent comparison.

Average size of farms and average annual precipitation show no coincident patterns in any part of the state. However, using the same east-west lines across the state that were used for E/T factor the ratio for precipitation is 7 units to 175 miles for average annual precipitation and $10\frac{1}{2}$ units for average size of farms. In central Oklahoma the ratio is 4 units to 150 miles for average annual precipitation and 5 units for the average size farms. In southern Oklahoma the ratio is 2 units to 165 miles for average annual precipitation and 2 for the average size of farms. In other words, this shows an 82 percent comparison.

The irregular patterns presented by both sets of lines in the eastern portion of the state show little comparison except that the E/T factor increases from 30 to 36 and the average annual precipitation increases from 34 inches to 56 inches over the area where the average size of farms decrease from 200 acres to about 85 acres. Here the precipitation pattern more closely compares with the size of farms than does the E/T factor.

In conclusion, the E/T factor shows a 54 percent comparison in western Oklahoma, while the average annual precipitation shows 82 percent comparison. In eastern Oklahoma the comparisons are difficult to show and inconclusive.


AVERAGE ANNUAL E/T FACTOR BY WATERSHEDS FOR THE PERIOD 1938-1943
CIMARRON
TEXAS
BEAVER
HARPER
WOODS
ALFALFA
GRANT
KAY
OSAGE
WASHINGTON
NOWATA
CRAIG
OTTAWA
DELAWARE
MAYES
ROGERS
WOODWARD
MAJOR
GARFIELD
NOBLE
PAWNEE
ELLIS
TULSA
PAYNE
CREEK
WAGONER
CHEROKEE
ADAIR
DEWEY
BLAINE
KINGFISHER
LOGAN
LINCOLN
OKMULGEE
MUSKOGEE
SEQUOYAH
ROGER MILLS
CUSTER
CANADIAN
OKLAHOMA
OKFUSKEE
MC INTOSH
BECKHAM
WASHITA
CLEVELAND
POTTAWATOMIE
SEMINOLE
HASKELL
CADDO
GRADY
HUGHES
PITTSBURG
LATIMER
LE FLORE
GREER
KIOWA
MC CLAIN
HARMON
JACKSON
COMANCHE
GARVIN
PONTOTOC
COAL
STEPHENS
MURRAY
TILLMAN
COTTON
CARTER
JOHNSTON
ATOKA
PUSHMATAHA
JEFFERSON
MARSHALL
LOVE
BRYAN
CHOCTAW
MC CURTAIN
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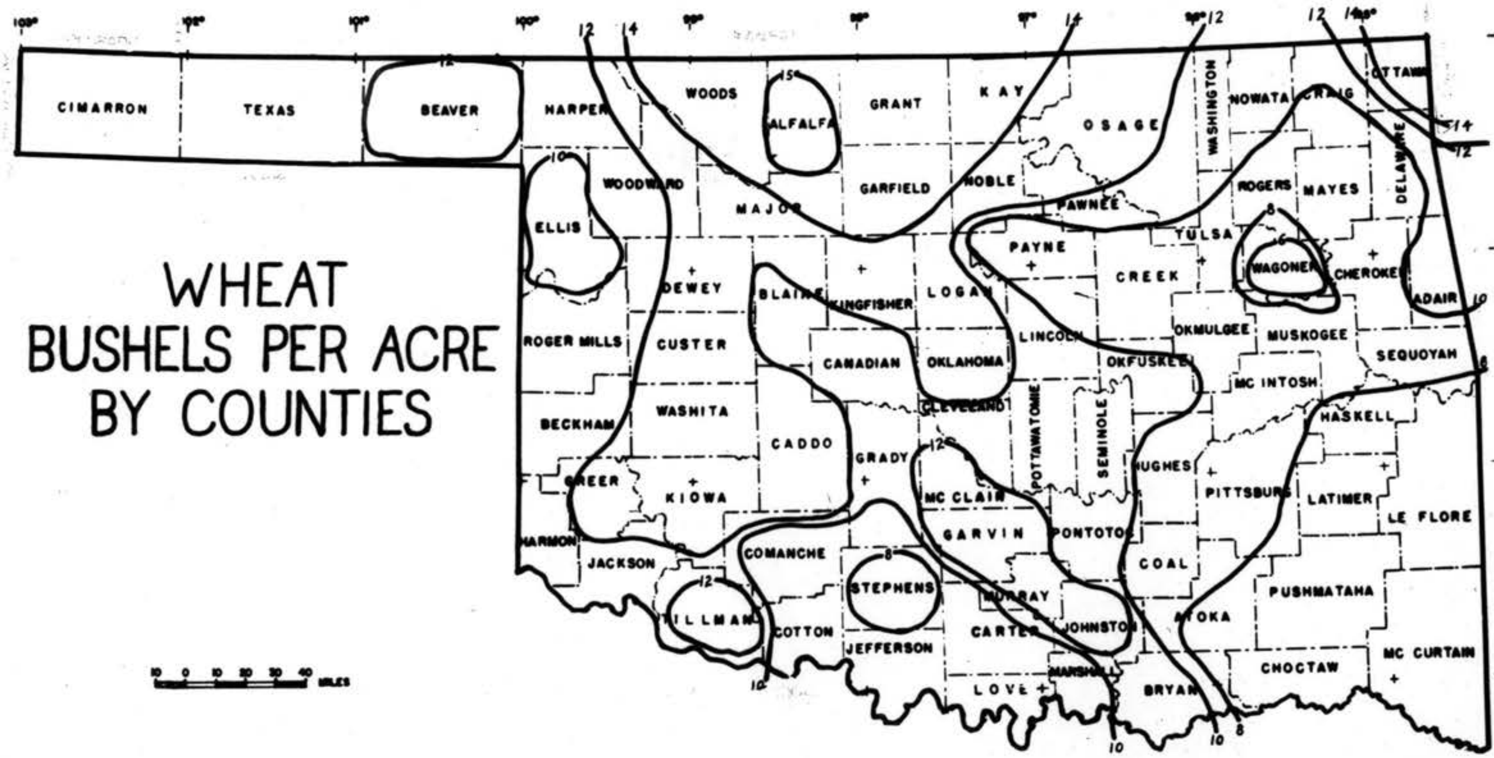
36
MILES

MAP 8


WHEAT
BUSHELS PER ACRE
BY COUNTIES
CIMARRON
TEXAS
BEAVER
HARPER
WOODS
ALFALFA
GRANT
KAY
OSAGE
WASHINGTON
NOWATA
CRAIG
OTTAWA
WOODWARD
MAJOR
GARFIELD
NOBLE
PAWNEE
ROGERS
MAYES
DELAWARE
ELLIS
DEWEY
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TULSA
WAGONER
CHEROKEE
ADAIR
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COAL
TILLMAN
STEPHENS
MURRAY
PUSHMATAHA
COTTON
CARTER
JOHNSTON
ATOKA
JEFFERSON
LOVE
MARSHALL
BRYAN
CHOCTAW
MC CURTAIN
MILES

MAP 9

CHAPTER VII

WHEAT YIELDS AS RELATED TO THE E/T FACTOR

Despite the fact that the cultural features previously discussed show moderately favorable comparisons with the E/T factor and average annual precipitation maps, wheat shows very little (Maps 8 and 9).[1] The average yield of wheat in bushels per acre as calculated by counties presents an erratic pattern when represented by isopleths on a map of Oklahoma.

In general, wheat seems to be affected more by topography, types of soil, and rainfall at certain times during its growing season rather than the total amount. Then too, cultural factors such as the practice of fallowing and land utilization following a farmer's preferences are important.

Wheat is of a different nature from corn, being similar in its physiognomy to the native wheat grass. Under present competitive conditions, it requires much larger tractors and equipment to raise and to harvest crops, therefore production is usually not important over rough terrain or in small field units. Raising of wheat, then, is restricted to those sections where the land is characterized by smooth topography and by fields of reasonable size.

Yields are lower in the southeastern corner of Oklahoma comprising McCurtain, Choctaw, LeFlore, Latimer, and Pushmataha counties.

Another reason for decreased yields in the Southeast is lack of particular minerals required for optimum yields. The soils have been leached of their soluble minerals by excessive rainfall. The moist climate favors pests, rusts and other plant diseases. Heavy rainfall during late spring lowers the quality of the wheat and often interferes with the harvest.

The areas of the wheat belt with the highest yield per acre occur in the

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[1] Map 8, Oklahoma Water, op. cit., p. 80.
Map 9, Oklahoma Agricultural Statistics, op. cit., p. 58-63

zone between the shortgrass country and the galeria forest valleys in the northern part of the state and a little west of the center.

The fact that wheat production does not compare as favorably with the E/T factor as does other cultural features does not necessarily mean that it is not affected by this factor. Oklahoma is near the southern limit of extensive wheat production and the southern part, lying as it does in an area where the rainfall is affected by the Gulf air stream, has its annual rainfall distribution altered somewhat from the continental type rainfall of the major portion of the wheat belt. Rainfall continuing too late in the spring can lower the yield considerably by blighting the kernels or causing the wheat stalks to fall before harvest. Another physical condition that enters the picture is the difference in types of soil. Receiving more rainfall than the northwestern portion, the soils of the southeastern part of the state would naturally be more leached.

Lines on the map showing an equal production of wheat as compared with the lines on the E/T factor and average annual precipitation maps present such an irregular pattern throughout the state that it is impossible to show any significant comparisons anywhere in the state.

Oklahoma became a major wheat producing state in about 1914. Production for that year was approximately 27,000,000 bushels; however, this figure rose until in 1931 the production stood at a peak of nearly 80,000,000 bushels. The acreage rose from 2,701,000 to 4,960,000 acres between 1914 and 1936, and in 1938 six million acres were planted. The harvested acreage varied greatly from year to year, depending on the area abandoned each year for not being worth harvesting. The lowest average yield for the state was 8.0 bushels per acre in 1936 and the highest was 17.5 bushels per acre in 1914. In 1944 Oklahoma ranked third among the producers of wheat being exceeded only by North Dakota and Kansas.

Since 1894, the acreage of wheat in Oklahoma has been characterized by four separate periods of growth. The first, from 1894 to 1910, was a gradually upward trend. From that date until the World War I peak in 1919, acreage planted increased sharply and steadily. After the war, planted acreage leveled off at 4 to 5 million acres, with the most deviation occuring apparently in response to favorable prices in the middle 1920's. The fourth change is the spectacular increase beginning in 1934 and continuing into 1938 when the Agricultural Adjustment Administration placed restrictions and allotments on the growing of wheat.[2]

No discernible relationship between wheat production and the E/T factor or average annual precipitation could be found; other factors are more important, it appears.

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[2] K. D. Blood and Marjorie Lee Hill, "Wheat Production in Oklahoma, 1894-1938", Agricultural Marketing Service, United States Department of Agriculture, Okla. A. & M. College Agri. Exp. Sta., Stillwater, Okla., Exp. Sta. Cir. No. 92., (April, 1944), p. 5.

CHAPTER VIII

CONCLUSION

In the western portion of the state the E/T factor and the cultural features--corn, cattle, and average size of farms--show an average comparison of 74, 88 and 54 percent, respectively. Average annual precipitation comparisons of the same cultural features show 78, 67, and 82 percent respectively. In these three comparisons in western Oklahoma, then, it appears that in two out of three cases the average annual precipitation showed a closer relationship, showing 72 percent for the E/T factor and 76 percent for the average annual precipitation. However, the best comparison found, of 88 percent, was in the case of cattle per square mile and the E/T factor.

The isopleths on the maps presented more or less irregular patterns throughout the eastern portion of the state making comparison difficult in all cases concerned. It was practically impossible to figure percentages for this area. Only an estimate could be made and it gives an almost equal comparison for the E/T factor and the average annual precipitation maps.

No discernible relationship between wheat production and the E/T factor or average annual precipitation could be found. It appears that other factors play a more important roll in determining the yield of wheat.

There appears to be about the same comparative value between the E/T factor and the average annual precipitation and the cultural features. There were five closer comparisons over the entire state in each case of an equal number.

It appears that the E/T factor shows trends in some cases. In other instances it helps to explain causes and relationships that average annual precipitation does not show. In fact, the two appeared to supplement each other. However, its value alone for comparison is about comparable to that of the average annual precipitation. The E/T factor proved disappointing in not displaying more comparisons than were found.

There were some cases where the E/T factor lines coincided with those of cultural features. It appears that if such calculations by the Government are worthwhile, they would not be justified for cultural feature studies alone because average annual precipitation and other destributions show somewhat similar comparative relationships.

Future investigation of the E/T factor and cultural or natural features might be carried on in a dry cycle period. Also, other natural and cultural features might be compared to ascertain if there be any significant relationships. Statistical methods might be further utilized. Smaller units of distribution might show better comparisons.

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