

August 10, 1932

To the Committee on Graduate Study:

I submit herewith a thesis by Mr. Dewey LeRoy Outen, "An Inventory of the Climatic and Mineral Resources of Tennessee," and recommend that it be accepted for eighteen quarter hours credit in fulfillment of the requirements for the degree of Master of Science in Agriculture.

E. E. Allred

Major Professor

At the request of the
Committee on Graduate
Study, I have read
this thesis and recommend
its acceptance.

W. R. Woodruff

Accepted by the Committee

P. M. Hower

Chairman

AN INVENTORY OF
THE CLIMATIC AND MINERAL RESOURCES
OF TENNESSEE

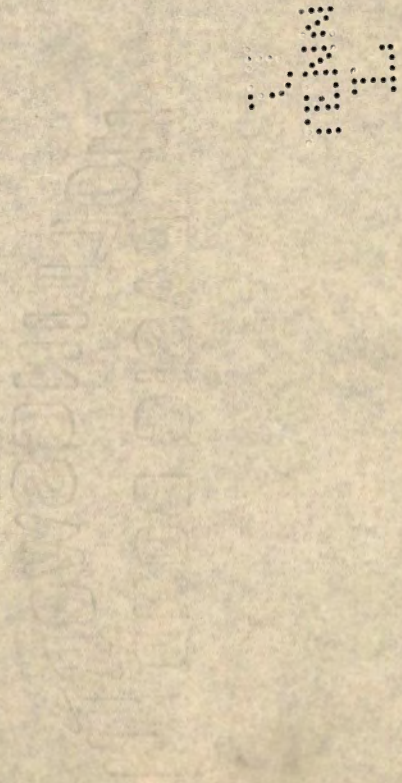
A THESIS

Submitted to the Graduate Committee
of
The University of Tennessee
in
Partial Fulfillment of the Requirements
for the Degree of
Master of Science in Agriculture

by

DEWEY LEROY OUTEN

August 1932



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PREFACE

Effective July 1, 1931, the Agricultural Experiment Station of the University of Tennessee joined with a number of neighboring state institutions and several Federal agencies in a cooperative study of the economic, social and civic problems of the Southern Appalachians. In this state the project was divided into four main divisions, and a graduate student put to work on each of them.

The Southern Appalachian area, as defined by Federal agencies, embraces the Great Smokies, the Cumberland Plateau, and all valleys among or lying between them. As thus defined the area includes the entire eastern end of the state as far west as the western border of the Plateau. This includes all or portions of 45 counties, or almost half the counties of the state.

In studying conditions in these counties it seemed desirable to have similar data for the other sections of the state, for comparative purposes, or to serve as measuring sticks for conditions in the mountain section; also, it does not require a great deal more time to compile the data for all the counties than to pick them out for half the counties. Hence it was decided, in assembling and analyzing the Southern Appalachian data for Tennessee, to include similar data for the other sections of the state.

The four principal divisions into which the project was divided, and the graduate student assigned to each, are as follows:

- A. A Physical and Biological Inventory - D. L. Outen.
- B. An Economic Inventory - A. S. Jenkins.
- C. A Sociological Inventory - Joe A. Elliott.
- D. A Civic or Governmental Inventory - G. D. Collins, Jr.

Each of these phases of the project is designed, when completed, to supplement the others. Theses by each of these men are being presented at this Commencement, August 1932.

Owing to the large amount of work involved it has not been possible to complete the entire study in one year, and the various cooperating states and Federal agencies are continuing the study during the fiscal year 1932-1933. Similarly, neither of the graduate students assigned to work on the project in this state during the first year was able to complete all phases of the division of the project which he was assigned. Each one has finished, however, several of the topics in his division, and these are being presented by him as his thesis. It is expected that other graduate students will be assigned to the various divisions of the study during the coming year, and that they will take up phases which were necessarily omitted last year.

C. E. ALLRED

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CHAPTER I.

CLIMATE

Introduction.

While Tennessee's climate is not ideal, it ranks favorably with most of the areas in the United States when all climatic factors are averaged up. It is characterized mainly by relatively long growing season, comparatively high percentage of sunshine, a mild temperature for the most part, with considerable range from the mountains of the East to the lowlands of the West, and on the average in abundant and well distributed rainfall. The state is infrequently visited by destructive snows and wind storms. However, it is in the second highest area of the most frequent wind storms.

"The climate of a country is the result of all of its meteorological influences. It is modified by latitude, altitude, mountains and their direction, proximity of large surfaces of water, winds, and the nature of the soil. It acts an important part in agricultural development. If it is too hot, muscular energy is relaxed; if too cold, it is benumbed. If the climate is too moist and too hot, the exuberance of vegetation renders the labor of man insufficient to keep it in subjection, and the infection of malaria destroys the habit of systematic and hardy industry; if too dry, the vegetation withers and the labors of the husbandman are not rewarded by a bounteous yield of the fruits of the earth. If the growing season is short, the variety of crop is small; if continuous, the ameliorating effects of freezes are lost. The most happy combination of climate appears to be that in which the amount of humidity and sunshine is just sufficient to produce the highest degree in perfection and maturity in the crops, and when the degree of cold is just enough to invigorate the system; ameliorate the soil, and destroy the germs of disabling disease. Such a combination is to be met with in by far a larger portion of Tennessee - - - - - The days of sunshine and rain, of heat and cold, are beautifully ordered. Health is the rule, sickness the exception - -"(1)

(1) Killibrew, J. B., Introduction to the Resources of Tennessee, page 6 and 7.

Temperature.

A. Mean-Annual.

The average mean annual temperature from 1883 to 1931 for the state was 58.6 degrees. (Table 1). There are, however, considerable variations within the state, due largely to the differences in latitude and altitude and, to a lesser extent, to other factors. The range is from 52.4 degrees in the Northeast to 61.7 degrees in the Southwest.⁽¹⁾ Map 1 shows the mean annual temperature as recorded by fifty-three stations, by geographic groups.

The coldest areas in the state, as indicated by the mean annual temperature, are located in the central part of the Cumberland Plateau in Middle Tennessee, and in Johnson County in the Northeastern part of the state. (Map 1). The stations located here, and referred to hereafter as group I, have an annual mean temperature ranging from 52 degrees to 55 degrees, averaging 54.3 degrees.⁽²⁾ Their relatively low temperature is due largely to their location at an average elevation of 1,774 feet above sea level, which is considerably higher than any other group of stations in the state.⁽³⁾

The group II stations having a mean annual temperature of 55 degrees to 57 degrees, are located in the Northern part of East Tennessee, the Southern part of the Cumberland Plateau, and the Northeastern part of the Highland Rim. The mean annual temperature of this area is 56.8 degrees, which is 2.5 degrees warmer than the coldest sections. The elevations vary from 1,068 feet at Springdale, in Claiborne County, to 1,950 feet at

-
- (1) All temperature measurements in degrees fahrenheit.
 - (2) Group I has 4 stations with records averaging 23.5 years.
 - (3) Appendix Table 1 gives the county in which each station is located, the number of years covered by the record, elevation, monthly, seasonal and annual mean temperature for each of the fifty-three weather stations, and also the averages for the four groups and for the entire state.

Table 1.

Temperature by Years, 1883 to 1931.

(In degrees Farenheit)

Year	Mean Jan.	Mean July	Mean Annual	Mini- mum	Maxi- mum	Year	Mean Jan.	Mean July	Mean Annual	Mini- mum	Maxi- mum
Average			58.5	- 8	103						
1883	--	74.0	--	--	--	1907	48.2	79.2	59.0	- 8	103
1884	29.4	76.0	57.3	-16	99	1908	38.1	77.5	59.8	- 3	101
1885	33.6	77.2	58.0	- 5	102	1909	42.8	76.7	59.3	- 6	104
1886	30.5	75.4	55.9	-23	103	1910	38.4	77.0	57.8	-17	100
1887	37.2	78.8	58.8	- 2	103	1911	43.9	76.0	60.8	-17	107
1888	37.8	77.6	57.6	2	104	1912	33.0	77.4	57.3	-16	102
1889	40.3	76.8	58.4	5	97	1913	45.9	80.0	59.9	5	106
1890	50.0	78.2	60.2	10	102	1914	42.5	79.5	58.8	-18	110
1891	39.5	74.0	58.4	12	100	1915	37.2	77.0	58.6	3	105
1892	33.4	76.1	57.3	- 4	99	1916	45.1	77.9	58.6	-14	102
1893	31.1	79.0	57.6	-20	100	1917	42.0	78.4	56.3	-32	100
1894	42.5	75.4	58.5	-11	105	1918	26.5	74.7	59.0	-18	108
1895	34.9	75.9	56.8	-20	102	1919	39.3	79.2	59.8	- 8	104
1896	39.2	78.0	59.4	- 3	104	1920	38.9	76.6	58.0	- 6	98
1897	35.3	77.7	59.2	-17	105	1921	43.1	80.2	61.8	9	104
1898	43.8	77.8	58.9	-10	104	1922	38.9	77.4	60.4	- 3	104
1899	38.3	77.5	58.3	-30	105	1923	44.4	77.2	59.1	- 1	101
1900	39.3	78.2	59.3	-10	104	1924	34.2	75.7	57.2	-13	104
1901	40.1	81.1	57.0	-18	107	1925	40.1	79.1	60.4	- 5	112
1902	36.9	79.0	58.5	- 1	106	1926	38.4	77.9	58.5	- 4	107
1903	38.6	77.8	57.7	-11	102	1927	40.4	77.3	60.6	- 3	104
1904	36.1	75.4	57.6	2	101	1928	38.6	78.3	58.3	-10	101
1905	31.5	76.4	57.9	- 7	100	1929	39.9	78.0	58.7	- 5	102
1906	42.1	75.2	58.6	- 4	101	1930	38.1	81.7	59.5	-12	113
						1931	39.5	80.2	--	- 2	106
Period							38.7	77.4	58.6	- 8	103

Source: United States Weather Bureau, Climatological Data.
Vol. 34, 35 and 36.

Map 1.
MEAN ANNUAL TEMPERATURE, BY GEOGRAPHIC AREAS IN TENNESSEE, THROUGH 1931

(Degrees Fahrenheit)



Source: Data from U. S. D. A. Weather Bureau,
Climatological Data, Tennessee Section.

Sewanee in Franklin County, and average 1,403.7 feet.

The largest portion of Tennessee is in group III, which includes stations having a mean annual temperature of 58 degrees and 59 degrees. The average mean annual temperature of this area is 58.9 degrees. This area includes the Central Basin, part of the Highland Rim, Northwest Tennessee and the South and South central part of East Tennessee. This area, as can be seen from Map 1, extends, but not continuously, almost the entire length of the state from East to West. It touches both the Northern and Southern boundaries of the state in Middle Tennessee, giving a range in latitude of approximately 1.7 degree. There is also considerable variation in the altitude of this area, but the average is 765.6 feet. There are twenty-nine weather stations in this group, with an average of 27.7 years record.

Most of West Tennessee, and the extreme South central part of Middle and East Tennessee, are the hottest parts of the state, having a mean average of 60.4 degrees. This area constitutes the fourth area in Map 1. It has an average elevation of only 433 feet, which largely accounts for its relatively high temperature.

In general the mean annual temperature decreases considerably as one proceeds from the Northeastern part of the state to the Southwest. Differences in elevation account for the more striking exceptions, notably in the Cumberland Plateau. Along a line running through the center of the state, the temperature for East Tennessee is about 58 degrees, for Middle Tennessee about 59 degrees, and for West Tennessee about 60 degrees. When allowance is made for the difference in elevations it will be found that the temperature increases from East to West. (1)

(1) This was noted by J. B. Killibrew in Resources of Tennessee, p. 7 (1874). He estimated the temperature of each area 1 degree less than the above.

The mean of Tennessee is about the same as that of Southern Europe. "Its isothermals pass through Northern Spain, touches Southern France, traverses the vine-clad hills of Italy and the classic lands of Greece, through fig-growing Smyrna, crossing the Caspian Sea near its Southern extremity, through the tea growing districts of China, and through the spicy fields of the Japan Island, reentering the United States at San Francisco - - -" But, "the range in temperature is not so great in the European states mentioned as in Tennessee. Our summers are hotter but not so long, and our winters are colder." (1)

Huntington and Cushing have the following to say on the effect of altitude on temperature:

"Temperature decreases with altitude. In the free air the fall is about 1 degree Fahrenheit for 330 feet of altitude in summer and for 400 feet in winter.

"The fall is more marked where mountains rise steeply above a lowland, as in the Alps, than in a region like the Great Plains where one can rise from sea level to Denver almost without noticing any grade. Nevertheless, the average yearly temperature at Denver is about 3 degrees lower than at Indianapolis, which lies in the same latitude but 4,500 feet lower." (2)

Differences in latitude affect the temperature in this state only slightly. The most important cause of the variations that exist is differences in elevation.

Variations from the mean temperature. The coldest January on record occurred in 1918 when a mean temperature of 26.5 degrees was registered. The warmest on record occurred in 1890 with a temperature of 50 degrees. The average mean January temperature from 1884 to 1931 was 38.7 degrees. This gives the January mean a variation of 11.3 degrees above, and 12.2

(1) Killibrew, J. B., Op.Cit., page 8.

(2) Huntington and Cushing; Principles of Human Geography, page 82.

degrees below the average. These, however, are the extremes for a 48-year period. The variation usually is only a few degrees from the average of 38.7 degrees which gives Tennessee winters that are not ordinarily severely cold.

Covering a period of 49 years, the hottest July on record was July 1930, with a mean of 81.7 degrees. Only in one other year, 1901, has the mean July temperature reached 81 degrees. Only five times has it reached 80 degrees. The lowest July mean on record was 74 degrees for the years 1883 and 1891. The average July mean was 77.4 degrees.

The annual mean temperatures vary only a few degrees from year to year. The lowest on record is 56 degrees for the year 1885 and the highest 61.8 degrees for 1921, which is the only year with a mean annual temperature of 61 degrees or above. There are only six years (through 1930) which have reached a mean as high as 60 degrees.

"All living creatures seem to need a change. - - - If plants are kept at the optimum temperature day after day they will not grow so well as those which enjoy first a warmer and then a lower temperature. Man is also extremely sensitive in this respect. - - - A combination of frequent changes in both directions does him much more good than uniformity.

"While a cold snap is beneficial, a cold spell is harmful." (1)

Our temperature changes are not the most desirable, since great variations sometimes occur with harmful results. Many of the changes are small and occur frequently, which, according to the authorities quoted above, are favorable.

Seasonal variation: Table 2 and Chart 1 show the winters in this state, with an average of 40.5 degrees, to be relatively mild. Variations

(1) Huntington and Cushing; Op. Cit., p. 252-253.

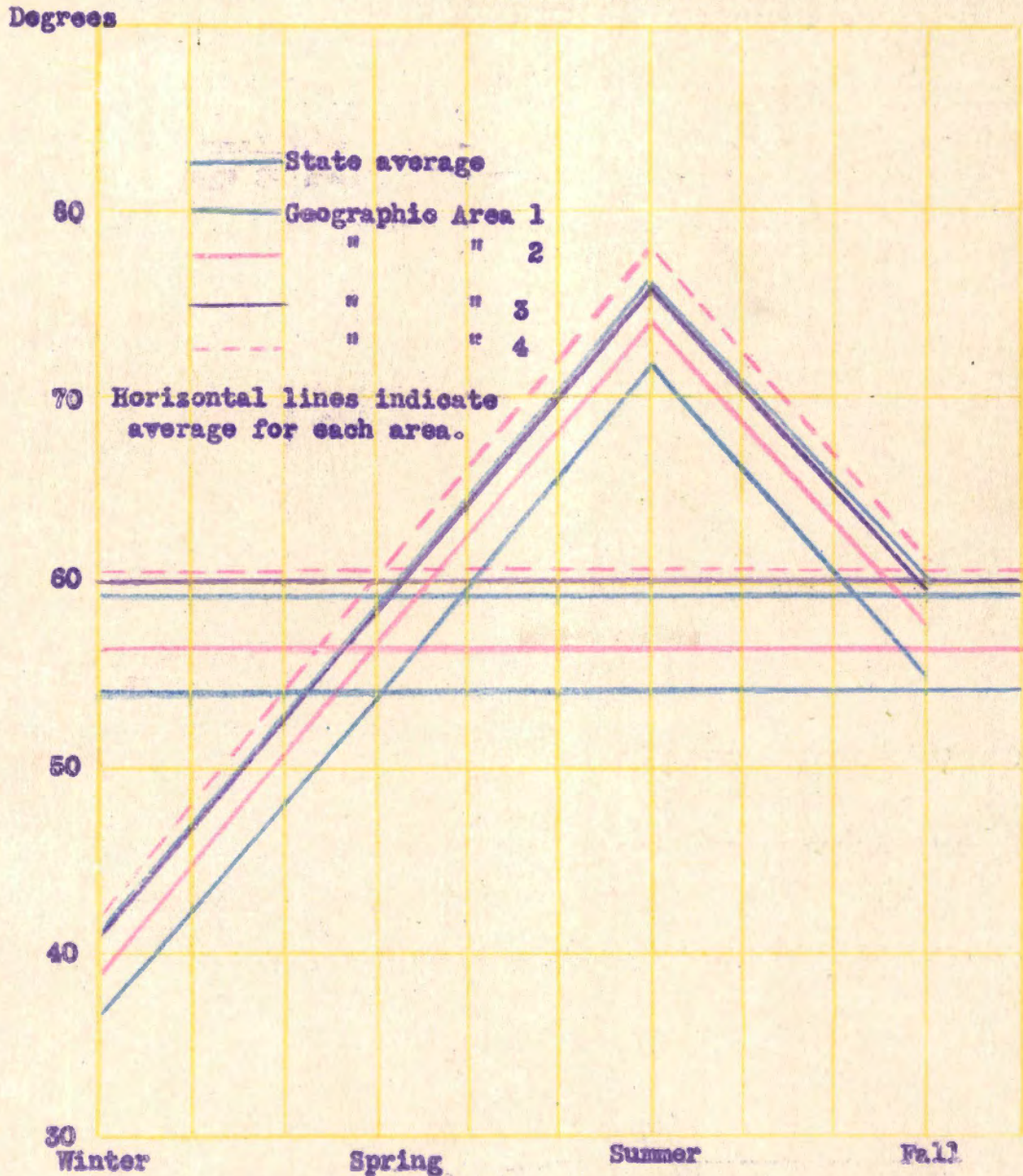
Table 2.

Mean Seasonal and Mean Annual Temperature by Groups
of Stations in Tennessee.

Group	Number Station	Eleva- tion (feet)	Number years record	Degrees Farenheit				
				Winter	Spring	Summer	Fall	Annual
1. North and Central Cumb. Plateau. East and Northeast Tenn. 52 - 55 degrees	4	1774.0	23.5	36.6	53.8	71.5	55.2	54.3
2. Northeast Tenn, Southern Plateau and Northern Rim 56 and 57 degrees	7	1403.7	23.8	39.0	56.6	74.2	57.6	56.8
3. Central Basin, Highland Rim and North- west Tennessee; South and South central East Tennessee. 58 and 59 degrees	29	765.3	27.7	40.8	58.4	76.3	60.0	58.9
4. West Tennessee and Southern part of Middle Tennessee and East Tenn- essee Valley.	13	433.2	28.5	41.8	60.1	78.1	61.5	60.4
State	53	844.3	27.1	40.5	58.2	76.1	59.7	58.6

Chart 1.

MEAN TEMPERATURE IN DEGREES FARENHEIT BY SEASONS AT 53
WEATHER STATIONS, BY GEOGRAPHIC AREAS IN TENNESSEE,
THROUGH 1951.



Source: U. S. Weather Bureau, Climatological
Data, by Section.

within the state range from 36.6 degrees in the extreme Eastern area and the Cumberland Plateau to 41.8 degrees in the Western area.

The summer temperature averages 76.1 degrees for the state. By groups of counties there is a range from 71.5 degrees in the areas with higher elevations in East and Middle Tennessee to 78.1 degrees in the West.

While these temperatures may not be ideal they compare favorably with the ideal optimum temperatures for human health and energy as set up by Huntington and Cushing. They are quoted as follows:

"For physical health, among the white race, the best temperature is an average of not far from 64 degrees Fahrenheit for day and night together. In other words, people's health and strength are greatest when the thermometer drops to about 56 to 60 degrees at night and rises to somewhere between 68 and 72 degrees during the middle of the day.

"For mental activity the optimum temperature appears to be a good deal lower than for physical, being probably about 40 degrees. As a rule, people's minds are most alert and inventive, people do their best thinking and planning and have the best judgment, when the thermometer falls to about freezing at night and rises to perhaps 45 or 50 degrees by day.

"All human progress depends on activity of both mind and body. Hence the best climates appears to be those with an average temperature of not far from 40 degrees during the winter and about 64 degrees during the summer. (But other conditions such as variability, humidity, and rainfall may alter this)." (1)

Tennessee approaches nearer the ideal in winter, with its average of 40.5 degrees, than it does in summer, with its average of 76.1 degrees. The summer temperature is about 8 degrees higher than the ideal.

Area three is almost the same as the mean for the entire state, and much nearer the warmest than the coldest area line. The reason for this is that of the 53 stations represented, 29 are in area three, which would give it more weight.

(1) Huntington and Cushing, Op.Cit., p. 251.

The monthly mean temperature of each of the four areas is shown in Table 3 and Chart 2. January is the coldest month and July is the warmest. The January mean of group 1, the coldest area in the state, is 35.9 degrees; of group 4, the warmest part of the state, 40.2 degrees; and for the state as a whole, 40.5 degrees. For individual stations, as shown in Map No. 2, the mean January varies from 35.9 degrees at Mountain City in the Northeast to 41.5 degrees at Memphis in the Southwest, or a variation of 6 degrees within the state. The effects of both elevations and latitude on temperature is shown clearly. After January the temperature increases consistently through July, slowly in February but more rapidly in the spring months. (Map 2).

The July mean for the state as a whole is 77.5 degrees. (Map 3). This varies from 70.1 degrees at Mountain City in the Northeastern part of the state to 80.9 degrees at Memphis in the Southwest. (Map 3 and Chart 2). As in the mean annual the areas with the higher elevations have slightly lower temperatures. The group 1 counties, those with the highest elevations, have a mean July temperature of 72.7 degrees. (Table 3). The group of counties in Southwest Tennessee have a mean of 79.6 degrees, the highest of any of the groups into which the state has been divided.

After July the monthly mean drops slowly in all areas until the latter part of September, and more rapidly thereafter until January, the coldest month.

• The differences between the low and high temperature areas are greater in summer than in winter. In July there is a variation of 11 degrees as compared with a January variation of 6 degrees. This and a comparison of the isotherms of Maps 2 and 3, keeping in mind the contours of the state, show that the July temperature is affected more than

Table 3.

Monthly and Annual Mean Temperature by Groups of Weather
Stations (1)

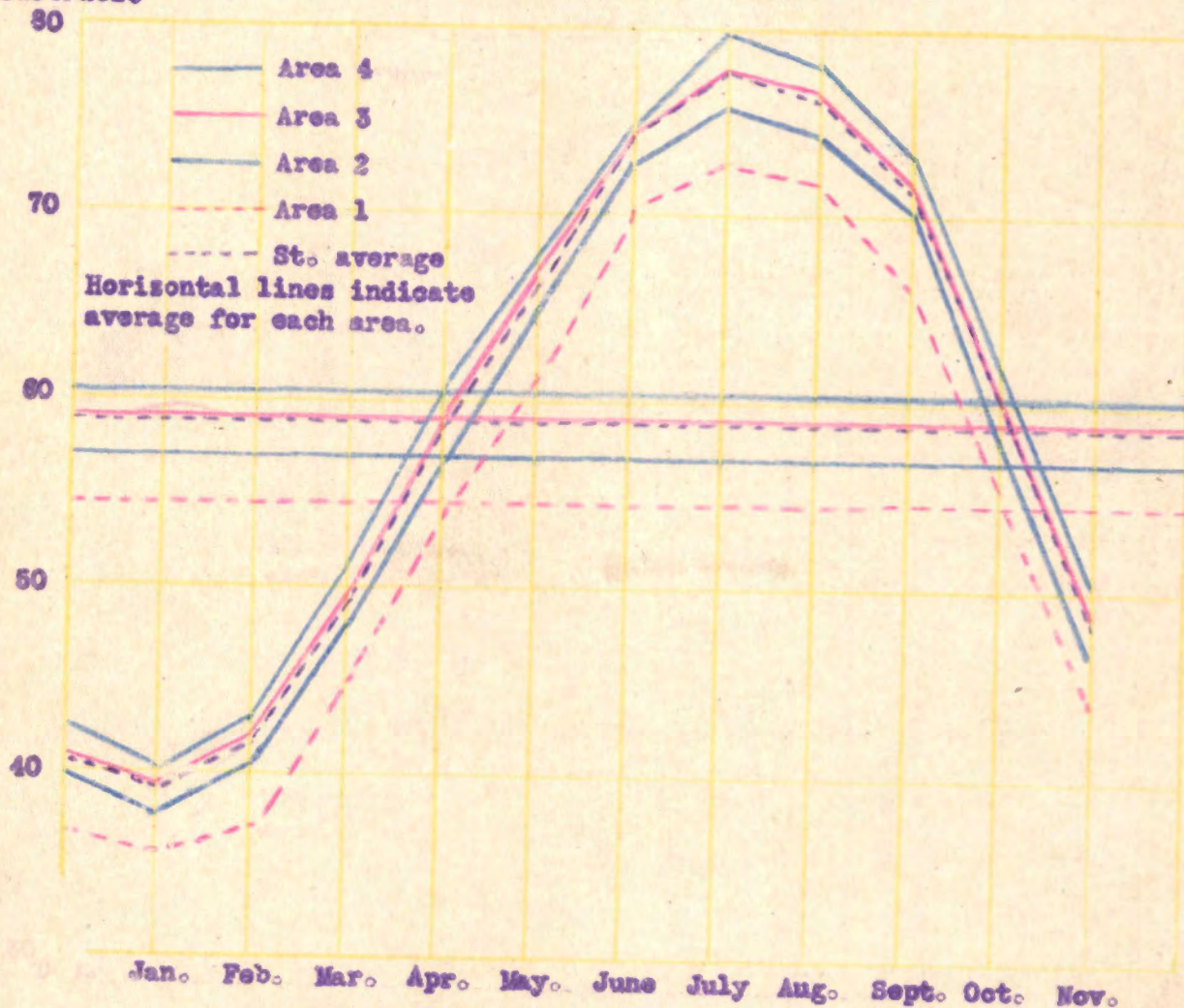
Group	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept	Oct.	Nov.	Year
I.	36.7	35.9	37.2	45.1	54.2	61.4	70.1	72.7	71.7	66.0	55.4	44.1	54.3
II.	38.9	37.6	40.4	48.0	56.8	64.8	72.7	75.6	74.4	69.9	57.8	46.7	56.8
III.	40.8	39.3	42.1	49.6	59.0	66.6	74.7	77.7	76.6	71.6	59.8	48.6	58.9
IV.	42.1	40.2	43.2	51.3	60.6	68.4	74.7	79.6	78.2	73.1	61.1	50.3	60.4
State	40.5	39.0	41.8	49.4	58.7	66.4	74.4	77.5	76.3	71.3	59.6	48.4	58.6

(1) Refer to Table 2 for the location of these areas.

Chart 2

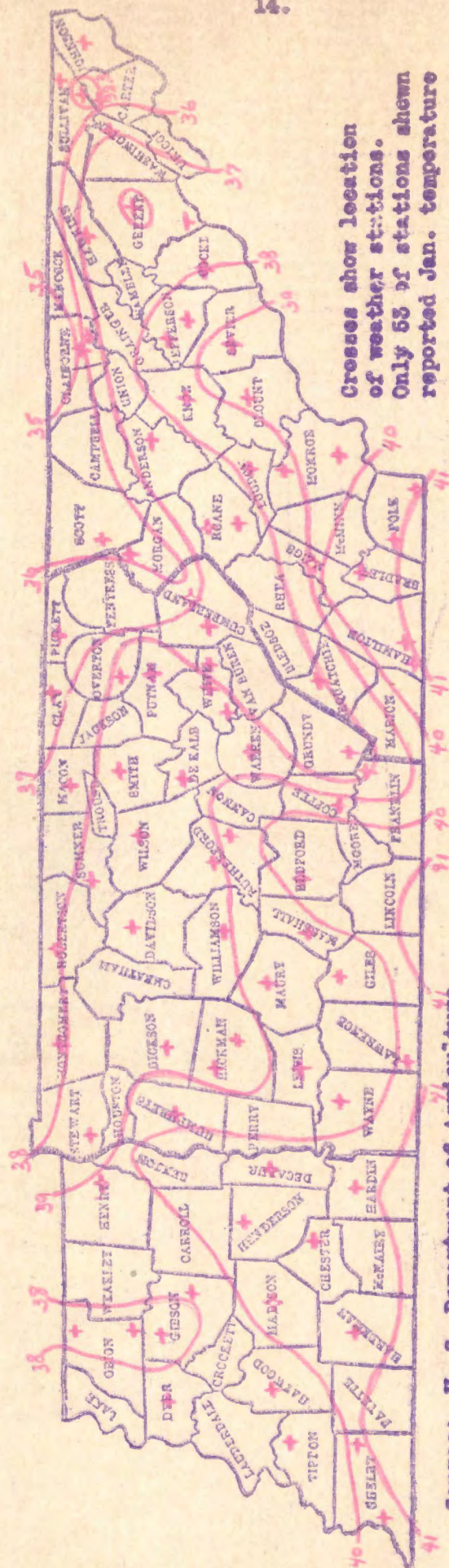
MONTHLY AND ANNUAL MEAN TEMPERATURE BY GEOGRAPHIC AREAS IN
TENNESSEE, THROUGH 1951.

Degrees
Fahrenheit



U. S. Weather Bureau, Climatological
Data, by Sections.

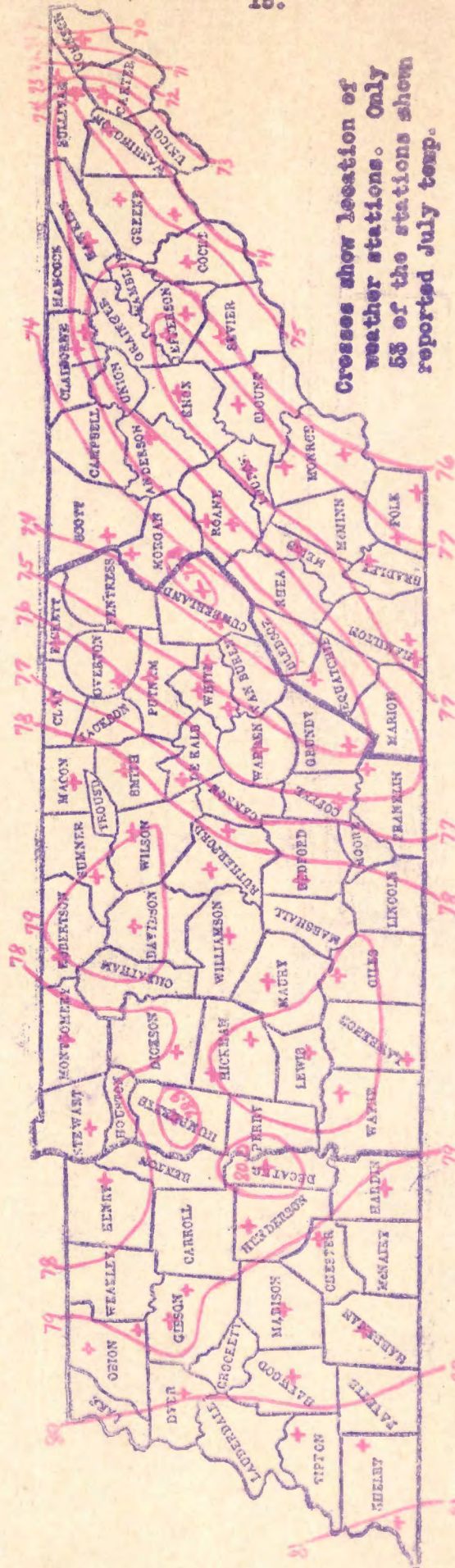
Map 2.
MEAN JANUARY TEMPERATURE OF 53 WEATHER STATIONS



Source: U. S. Department of Agriculture,
Weather Bureau, Climatological Data,
Tennessee Section

Map 3.

MEAN JULY TEMPERATURE OF 53 WEATHER STATIONS THROUGH 1930



Source: U. S. Department of Agriculture, Weather Bureau,
Climatological Data, Tennessee Section.

January temperature by elevation. The higher elevation is largely responsible for the very mild summer temperature in Northeast Tennessee and on the Cumberland Plateau. Of course, all along the Eastern border there are high elevations in the mountains, some as high as 6,000 feet, and over, but there are no weather stations on the mountain peaks but the temperatures there are known to be lower than the adjacent lowlands.

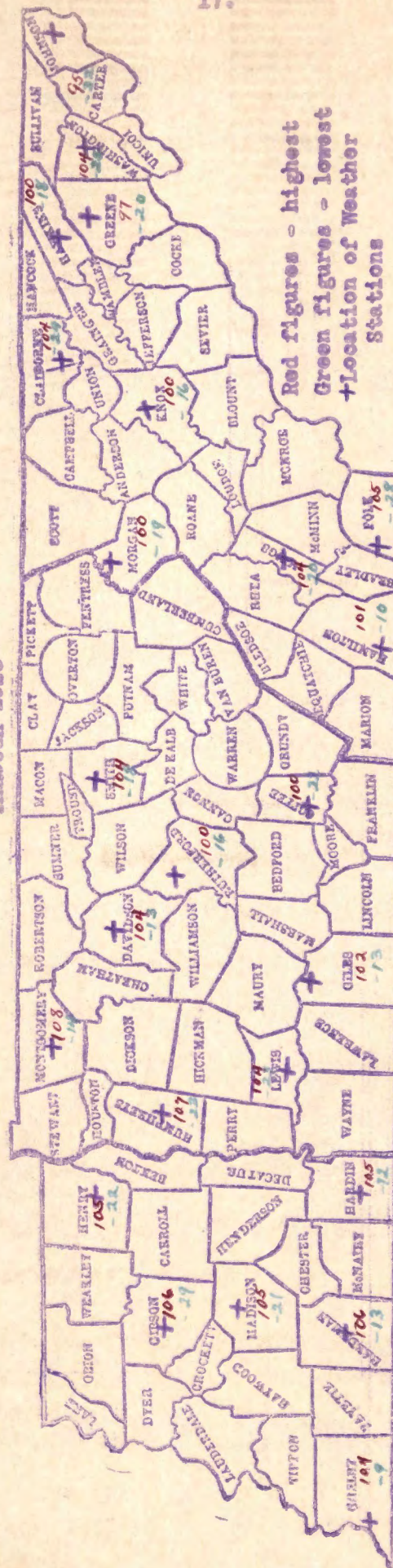
Maximum and Minimum. The highest and lowest temperature occurring any time during the year at any weather station in the state for the years 1884 - 1931 are shown in Table 1. The lowest ever recorded was -32 degrees in December 1917 at Mountain City, in Carter County. The highest temperature on record was 113 degrees, which was registered at Perryville, in Decatur County, July 29, 1930. The average low for the period is -8 degrees and the average high 103 degrees. The extremes are probably better shown in Map 4, which gives the highest and lowest temperature on record through 1920 for twenty-four stations distributed over the state. (1) Temperatures below zero and 100 degrees^{or}/above have occurred at least once at most of these stations. Chart 3 shows the highest and lowest temperature by months of three stations, representing the hottest, the coldest, and the largest intermediate section of the state. This graph shows that there is a much greater variation in the lowest temperature from summer to winter than there is in the highest temperature. There is also a greater difference between the lowest temperature at Memphis and Mountain City than there is between the highest temperature at these two stations.

(1) For table see Appendix.

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HIGHEST AND LOWEST TEMPERATURE EVER RECORDED AT 24 STATIONS IN TENNESSEE

through 1920



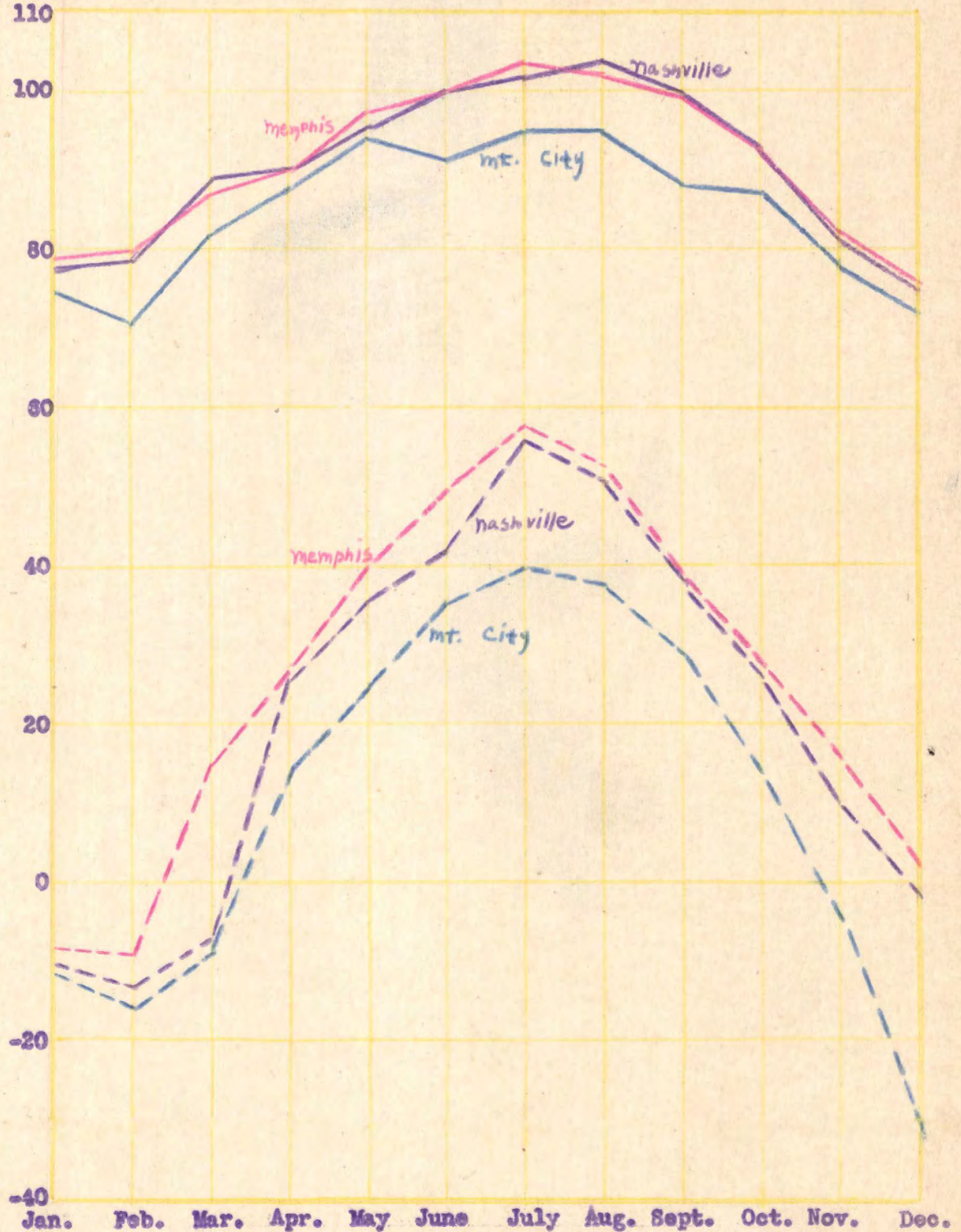
Source: Data from U. S. D. A. Weather Bureau, Climatological Data, Tennessee Sections.

18.

Chart 3.

HIGHEST AND LOWEST TEMPERATURE RECORDED AT THREE WEATHER STATIONS, THROUGH 1920

Degrees
Fahrenheit



Source: U. S. Weather Bureau,
Climatological Data, Tennessee Section.

"It seems that zero temperatures have occurred in Tennessee in each of the winter months. Zero weather, however, is rare for the state generally, but occurs at the mountain stations a few times during almost every winter. Records of 5 to 10 degrees above zero, occur pretty generally over the state on about four or five days during the winter, and zero or below on an average of once in two or three years." (1)

The annual mean maximum and mean minimum temperatures are shown on Map 5. The monthly mean maximum and mean minimum for three stations representing different sections of the state are shown by Chart 4. (2)

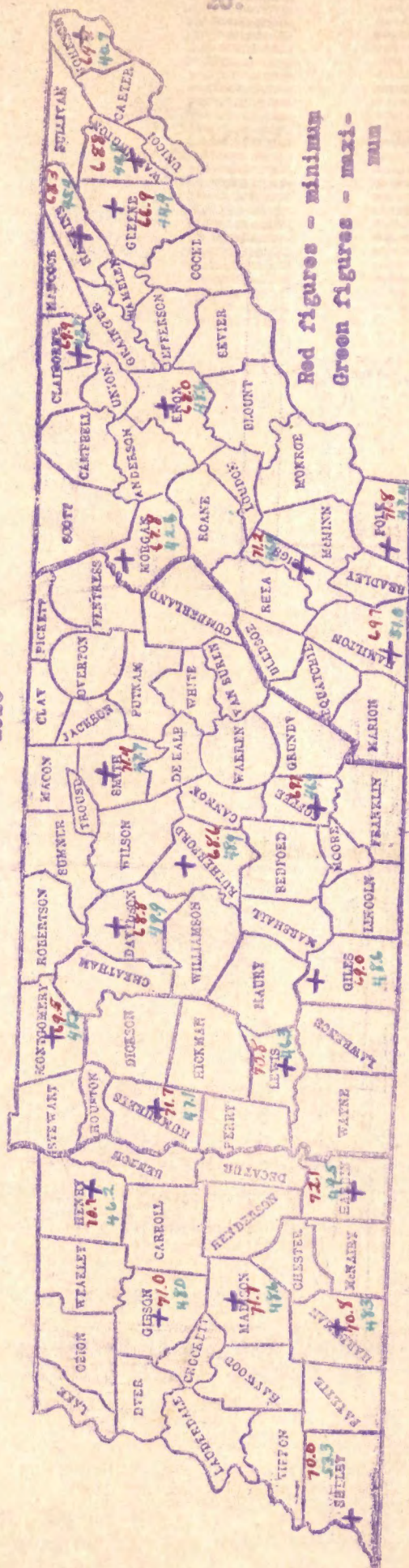
The difference between the mean maximum and mean minimum gives the average daily range. The January daily range varies from 15.1 degrees at Memphis, 16.7 degrees at Nashville, to 21.6 degrees at Mountain City. The colder sections of the state, then, have a wider daily range than the warmer sections, there being a wider difference in the mean minimums than the mean maximums. The July daily range is a little larger than January, being 16.5 degrees at Memphis, 18.8 degrees at Nashville, and 22.2 degrees at Mountain City. This wider summer daily range in the cooler sections of the state area of higher elevation, causes the very pleasant summer nights. Although the cooler sections of the state have a wider daily range than the warmer sections, the difference between the January and July daily range is almost just the reverse. The difference in January and July daily range is .6 degree at Mountain City, 2.1 degrees at Nashville and 1.4 degree at Memphis. There are times, especially during a change of weather, when the daily range of temperature will be more than the monthly average. Tennessee, comparatively, does not have a wide average daily range, and few very rapid changes in temperature, which makes a much more agreeable climate.

(1) Nunn, Roscoe, The Climate of Tennessee,
The Resources of Tennessee, VIII, No. 1, p. 18.

(2) Data in Appendix Table .

ANNUAL MEAN MAXIMUM AND MEAN MINIMUM TEMPERATURE OF 24 WEATHER STATIONS, THROUGH

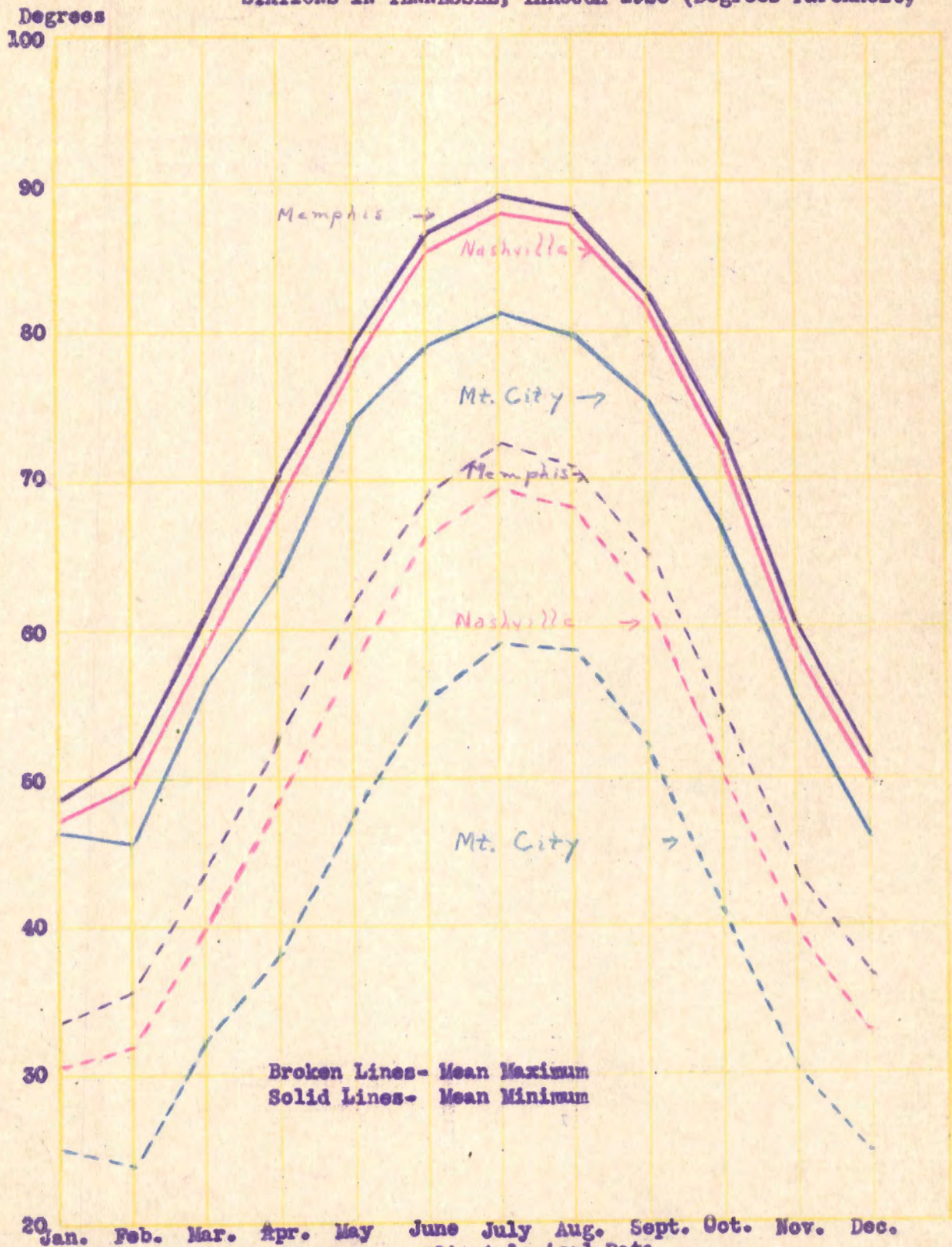
0261



Source: Data from U. S. D. A., Weather Bureau,
Climatological Data, Tennessee Sections

Chart 4.

MEAN MAXIMUM AND MEAN MINIMUM MONTHLY TEMPERATURE OF THREE WEATHER STATIONS IN TENNESSEE, THROUGH 1920 (Degrees Fahrenheit)



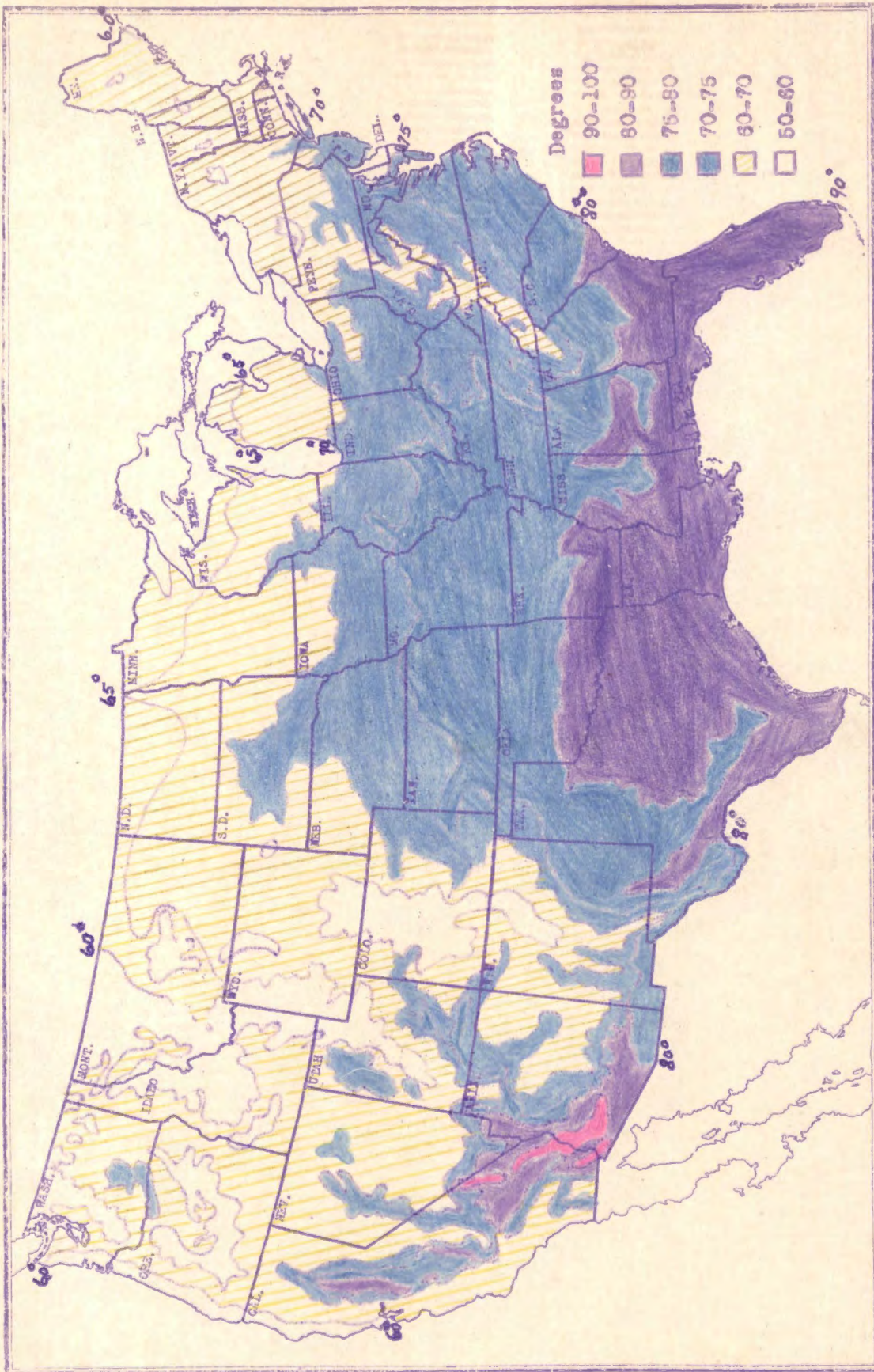
Source: U. S. Weather Bureau, Climatological Data,
Reprint 77 and 78.

Not often having very rapid changes in temperature, extremely low temperatures, or prolonged periods of real cold weather, is of a great advantage to the state of Tennessee from the standpoint of economics as well as comfort. Travel, transportation, and communication are seldom hindered on account of the weather. Telephone and telegraph companies have relatively very small losses from damage caused by ice. The state has to spend very little to keep the highways clear of snow and ice. Since travel, transportation, and communication are hampered very little business and industry are not affected so greatly as in some other areas of the United States. Agriculture is also favored by not having, generally, extremely low temperatures or severely cold winters.

Our Winter and Summer Temperatures Compared with Other Areas. The mountainous area in the extreme northeastern part of the state has a mean summer temperature of approximately 70 degrees or less, which is similar to parts of New York state, Michigan and Wisconsin, as shown in Map No. 6. The Cumberland Plateau and Northern East Tennessee have the same temperature range as most of Ohio, Indiana, and Illinois, 70 - 75 degrees. The Mountain topography shows its effect in lowering the summer temperature in both of these areas below that of the Tennessee areas to the West and of most of North Carolina to the East of them. These areas afford a summer temperature exceeded in mildness only by the extreme North, Northeast and some sections of the Western part of the United States - a condition which is favorable for tourist traffic.

The mean winter temperature of most of Tennessee, ranging from 35 to 40 degrees, is about 10 - 15 degrees warmer than an area including Southern New England, most of Pennsylvania and the Northern half of Ohio and Indiana. (Map 7). In the mountainous areas, particularly at Mountain City, which has a temperature of about 35 degrees, this difference drops

Map 6.
AVERAGE SUMMER TEMPERATURE, JUNE - AUGUST INCLUSIVE (DEGREES FAHRENHEIT)



Source: Atlas of American Agriculture,
Part II, Climate, p. 6-7

MAP 7.
AVERAGE WINTER TEMPERATURE, DECEMBER - FEBRUARY INCLUSIVE. (Degrees Fahrenheit)



Source: Atlas of American Agriculture;
Part II, Climate.

to 5 - 10 degrees. Cape Cod, Massachusetts, is only 5 degrees colder than this station.

Temperature Effects on Plant Life. "Based on temperature requirements, the geographic distribution of different plants where moisture is sufficient may be grouped broadly in latitudinal zones around the world, the several belts in which individual crops dominate being susceptible to more or less definite delineation on a quantitative temperature basis." (1)

So far as the latitudinal belt is concerned, Tennessee is in the Temperate belt and is only about 1.7 degrees of latitude in width. There are, however, areas in Northeast Tennessee that come under the classification of cool zones, as made by the United States Department of Agriculture in an article in the 1924 Yearbook of Agriculture. It states that in the cold zone "the average temperature of the warmest month is between 50 and 72 degrees F.; and the coldest is below 43 degrees F. - - The staple grain crops overlap in this and the Temperate zone, partly because their different varieties permit a rather wide range of temperature and length of growing season. - - - Evergreens, deciduous forests, small grains, and in the warmer portions fruit and corn are found". (2)

With Tennessee lying in the Temperate zone, between the North and the South, and with small areas having temperatures comparable with the warmer parts of the Cold zone, due largely to elevation, it is no wonder that she has often been called the "Transition State" for plant and animal life.

There is a great variety of plants that are suited to the temperature of the temperate belt, which has 4 - 12 months of moderate temperature,

(1) U. S. D. A. Yearbook, 1924, p. 469.

(2) U. S. D. A. Yearbook, 1924, p. 475.

50 - 68 degrees F. - the coldest month below 64 degrees and the warmest month over 72 degrees. From the maps and charts just presented it can be seen that even though Tennessee covers a narrow latitudinal belt that there is considerable variation in temperature in different areas, which is caused largely by the differences in elevation. This makes it possible for an even greater variety of plants to grow in Tennessee.

According to the United States Department of Agriculture, the crops of the United States may be divided roughly into two classes: those considered cool climate crops, and grown principally in the Central and Northern sections of the country, and the warm climate crops, grown chiefly in the Central and Southern states. (1) Among the cool climate crops are potatoes, wheat, oats, rye, buckwheat, flax, and most of the grasses. Among the warm climate crops are cotton, corn, rice, sugar cane, and peanuts. Sweet potatoes also may be classed as a warm climate crop.

Many of the cool climate crops are produced here with a fair degree of success - Irish potatoes in the Cumberland Plateau area, apples in the higher areas, wheat, oats, barley and most of the grasses. Buckwheat, adapted to the mountainous areas of the Northeastern part of the United States, can be grown successfully in the cool sections of the extreme Northeastern part of this state. Other cool climate crops can be grown, but to a lesser extent.

Of crops considered warm climate, cotton, sweet potatoes, peanuts, and corn are produced in Tennessee. Possibly rice and sugar cane could be grown in the extreme Southwestern part of the state. Corn, which is adapted to a wide range in temperature, is grown in all parts of Tennessee.

(1) U. S. D. A. Yearbook, Weather and Agriculture, 1924.

Cotton is grown in West Tennessee. "The Northern limit of successful production of cotton is determined largely by temperature conditions. A mean summer temperature of about 77 degrees F. is the limiting value, which corresponds to about 200 frostless days season." (1) West Tennessee (Map 1) has a summer temperature of 78.1 degrees and area III, the next highest, 73.3 degrees. The cotton territory of Tennessee seems to be limited as given in the quotation above. Area IV and the extreme Western and Southern or warmer part of area III includes practically all of the cotton section. Peanuts and sweet potatoes are also grown commercially in the warmer part of the state. Four types of tobacco are grown in the state.

In the mountains are found a great variety of wild plants and trees within a few miles. On the higher elevations trees are found that grow as far north as Canada. There are approximately 153 varieties of trees and more than 1500 varieties of plants that grow here.

"Tennessee has indeed a double climate - one resulting from latitude and the other from elevation - so interwoven and modified by varieties of soil, position, exposure, trend of mountain ranges, etc., that the characteristics of the climate of every state from Mississippi to may be found in it." (2)

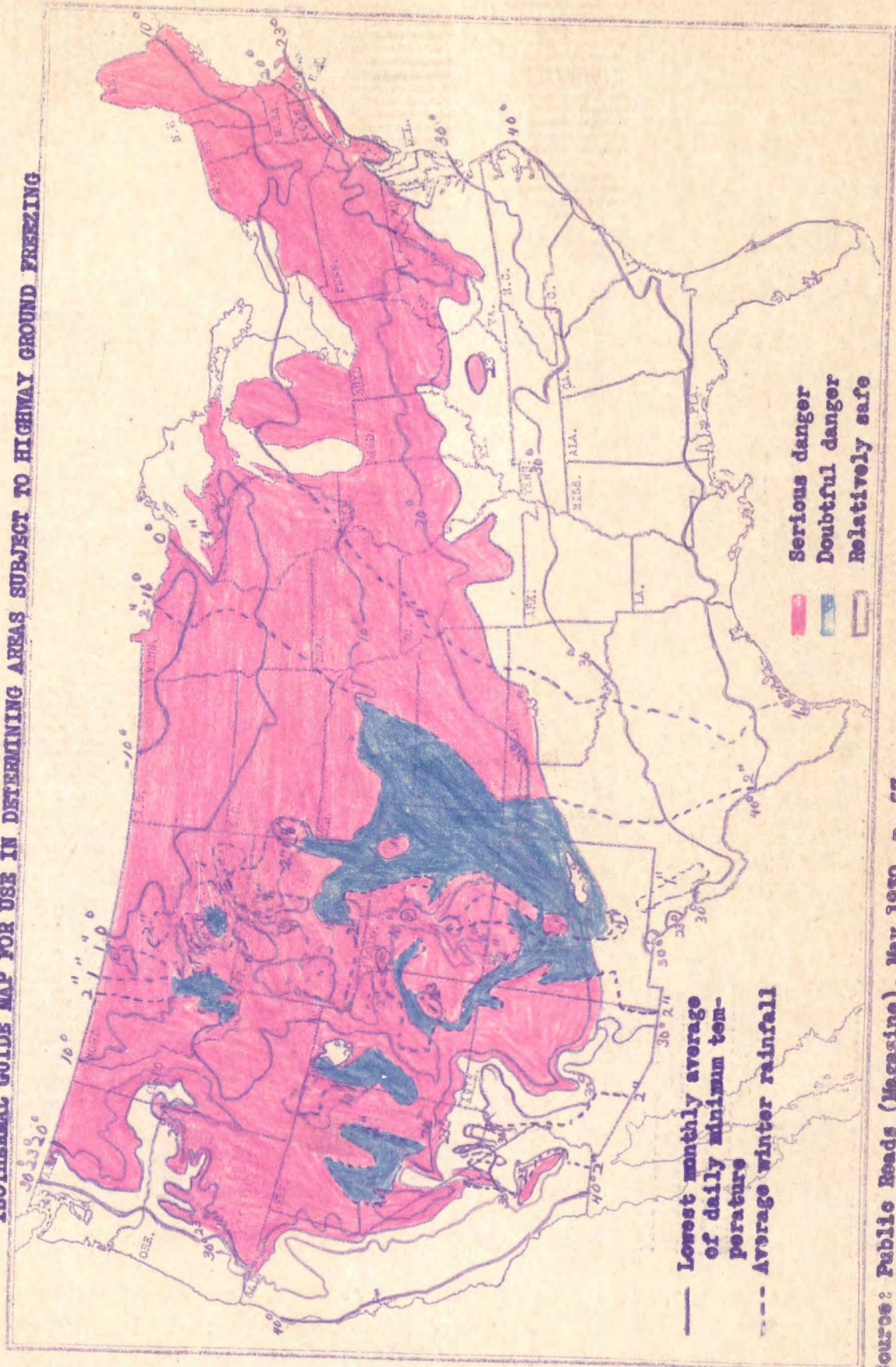
Relation of Temperature to Highway Construction. In some areas of the United States ground freezing presents a serious problem in highway construction and maintenance. Tennessee is in an area that is relatively safe from this danger, according to the information shown in Map 8. In the Northern part of the United States and part of the Southwest there is serious danger of highway ground freezing, while in small areas in the

(1) U. S. D. A. Yearbook, 1924, page 484.

(2) Killibrew, J. B., Introduction to the Resources of Tennessee, First and Second Report of the Tennessee Bureau of Agriculture.

Map 8.

ISOTHERMAL GUIDE MAP FOR USE IN DETERMINING AREAS SUBJECT TO HIGHWAY GROUND FREEZING



Sources: Public Roads (Magazine), May 1930, p. 57.
Data compiled from U. S. Weather Bureau Reports.

West Central states the danger is doubtful.

Temperature was the principal factor considered in determining these areas. The danger free area, which includes Tennessee, has a monthly average daily minimum temperature in excess of 23 degrees. (1)

Precipitation (2)

Mean Annual. Tennessee has had an average annual precipitation of 49.84 inches over a 46 year period. (Table 4). This state is in the North Central part of a region in the United States that is characterized by a relatively large amount of rainfall. Only the Pacific Coast line from West Central California to Canada has a heavier precipitation than this region. (Map 9). Parts of the Northeast near the Atlantic Coast have areas of approximately the same precipitation as the Tennessee region. The greater part of the United States is drier than this state.

The highest yearly precipitation of 59.78 inches occurred in 1929, and the lowest on record for one year is 40.50 inches for 1925.

The mean annual precipitation at 84 stations is shown on Map 10. (3)
The average number of years record is 29.7 but there are a few stations for which there are records for less than 20 years.

The amount of rainfall varies considerably over the state. This is due largely to the differences in elevation and topography, and the differences these cause in the exposure to rain-bearing winds. "Mountains are more cloudy and rainy than plains, for the currents of air that approach them must rise. Hence the air is cooled and its vapor

(1) Article occurring in Public Roads May 30, 1930.

(2) Includes both rainfall and snow.

(3) See Appendix Table for data.

Table 4.

Average Annual Precipitation and Extent of Cloudiness in Tennessee,
1884 - 1931

Date	Average precip. .01 in. or more	Number of days			Prevailing direction of wind	Date	Average precip. .01 in. or more	Rainy (.01 in. or more)	Number of days		Prevailing direction of wind
		Rainy (.01 in. or more)	Clear	Partly Cloudy					Clear	Partly Cloudy	
Aver.	50.06	106	154	101	110	S	1908	98	159	97	S
1884	55.57	108	117	103	146	N	1909	105	148	114	S
1885	44.36	111	121	116	128	SW	1910	106	160	83	S
1886	51.75	119	134	111	120	SW	1911	113	152	84	S
1887	44.97	102	153	106	106	S	1912	112	156	81	S
1888	48.29	101	133	100	133	N	1913	94	170	77	S
1889	45.50	97	145	102	118	NW	1914	97	151	108	S
1890	57.60	107	133	109	123	S	1915	105	164	98	S
1891	52.80	100	153	100	112	S	1916	106	182	88	S
1892	54.17	102	151	105	110	S	1917	110	161	100	S
1893	45.56	93	165	95	105	S	1918	106	159	106	S
1894	42.65	97	160	109	96	S	1919	110	160	99	S
1895	43.10	97	162	102	101	S	1920	114	152	93	S
1896	47.09	94	159	111	96	S	1921	112	152	107	S
1897	50.89	104	158	114	93	S	1922	116	148	102	S
1898	50.45	105	153	112	100	S	1923	121	149	97	S
1899	47.97	103	153	103	109	S	1924	104	175	92	N
1900	51.43	110	149	110	106	S	1925	100	180	89	S
1901	46.96	89	170	104	91	N	1926	113	159	91	SW
1902	49.42	96	150	106	109	S	1927	117	157	98	S
1903	47.23	101	152	116	97	S	1928	115	160	96	SW
1904	40.74	99	157	110	99	S	1929	128	151	96	N
1905	50.85	110	143	107	115	S	1930				
1906	53.86	111	144	102	119	S	1931				
1907	49.14	109	151	94	120	S					

Source: U. S. Weather Bureau, Climatological Data - Vols. 34, 35 and 36.

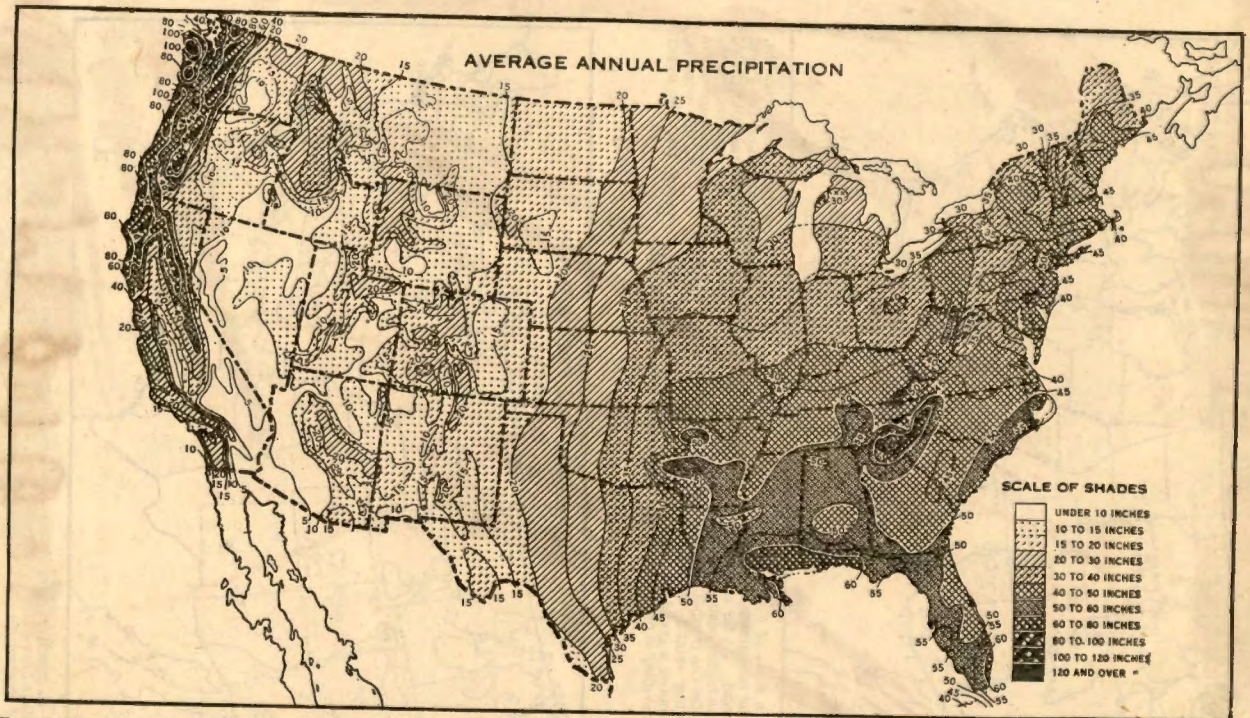
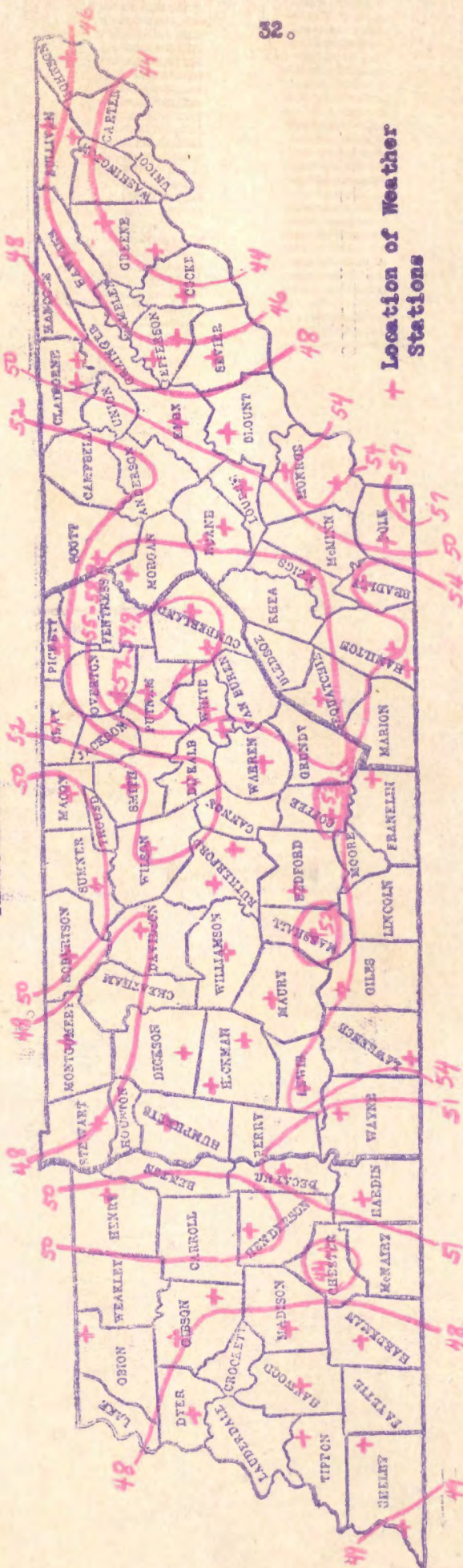
Map 9.

FIGURE 10.—Precipitation includes rain, melted snow, sleet, and hail. This map and the four seasonal maps preceding are much reduced and generalized from maps prepared by the Weather Bureau and published in the Precipitation and Humidity section of the Atlas of American Agriculture. The map suggests why the United States should be divided agriculturally into an eastern and a western part. However, the division shown in Figure 1 does not follow a line of equal precipitation but advances diagonally across two of the precipitation zones from 14 inches in the northeastern portion of Montana to 24 inches on the south Texas coast, where, because the evaporation is much greater and the rainfall more torrential, more rainfall is required for crop production.

Map 10.

MEAN ANNUAL PRECIPITATION IN INCHES AT 84 WEATHER STATIONS IN TENNESSEE THROUGH 1920



Location of Weather
Stations

Source: Data from U. S. D. A. Weather Bureau,
Climatological Data, Tennessee Sections.

condenses into clouds and rain." (1)

The Cumberland Plateau region has the highest annual precipitation, ranging from 54 to 58 inches. The North Central part of this area is highest with 58 to 60 inches. Relatively high altitude is largely responsible for this comparatively high precipitation. The Southern part of the Highland Rim and extreme Southern part of East Tennessee approach nearest the Plateau region with approximately 54 inches. Immediately adjacent to the Plateau on East and West the precipitation decreases to 51 and 52 inches.

The East Tennessee Valley, Northern part of the Highland Rim, and a narrow section just West of the Tennessee River have an annual average of about 50 inches precipitation yearly. The Central Basin has an annual average of about 48 to 52 inches. In the Southwestern area the average is 48 inches and in the Northwest about 49 inches.

In general the mean annual in the Western part of the state is slightly less than any of the larger areas except the Northeast corner of the state, which is the driest part of the state. This Eastern area, near the Virginia and North Carolina border, has an average about 44 inches, the lowest being 41 inches at Bristol. This area having a high elevation and near the mountains, one would think that the precipitation would be high, but the low average is due to the exposure to the rain bearing winds. (2)

Distribution Throughout the Year. The seasonal and monthly distributions are more significant than the annual precipitation, particularly from an agricultural standpoint. For purpose of analysis from this

(1) Huntington and Cushing; Op. Cit., p. 82.

(2) U. S. Weather Bureau, Reprint of Sec. 78, East Tennessee and Western North Carolina.

angle, the state has been classified into four areas, according to the monthly distribution of precipitation. These are referred to as types of rainfall. The areas covered by each and the average monthly distribution within each type are shown by Map 11. The seasonal and monthly distributions are shown in Tables 5 and 6 respectively. The state as a whole has an almost uniform seasonal distribution, with the exception of a low period in the fall. The four areas or types within the state differ slightly. But each has a low rainfall in the fall.

Type 1 covers West Tennessee and the Northwestern part of the Highland Rim. Here the winter and spring seasons have the heaviest precipitation, with the least in the fall. The rainfall is heavy during December and January, with a decrease in February, then high again during March and April. The trend is downward then until October, which is the driest month of the year.

Type 2 covers most of the Central Basin and a section in North Central East Tennessee. In type 2, as in type 1, the largest amount of rain occurs in the spring months, but in type 2 there is a slightly greater precipitation during the summer months, with slightly less in both spring and winter. But no really significant differences exist between the two types.

Type 3, which represents the wettest parts of the state, is largely on the Cumberland Plateau and in Southern part of the Highland Rim. Its seasonal distribution is characterized by almost uniform amount of precipitation during the winter, spring, and summer seasons; by higher amounts during these seasons than in other areas; and by a relatively low fall precipitation, which is somewhat similar to areas previously mentioned. This plateau area has more rainfall during each spring and

Map 11.

TYPES OF MONTHLY DISTRIBUTION OF PRECIPITATION BY AREAS, IN TENNESSEE (See chart below for four types)

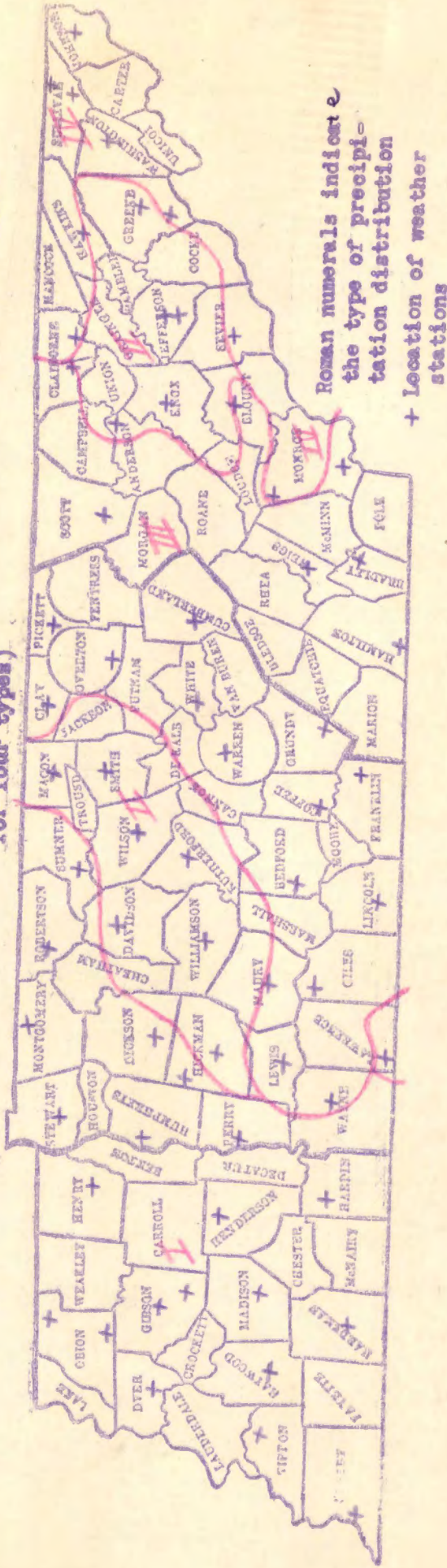
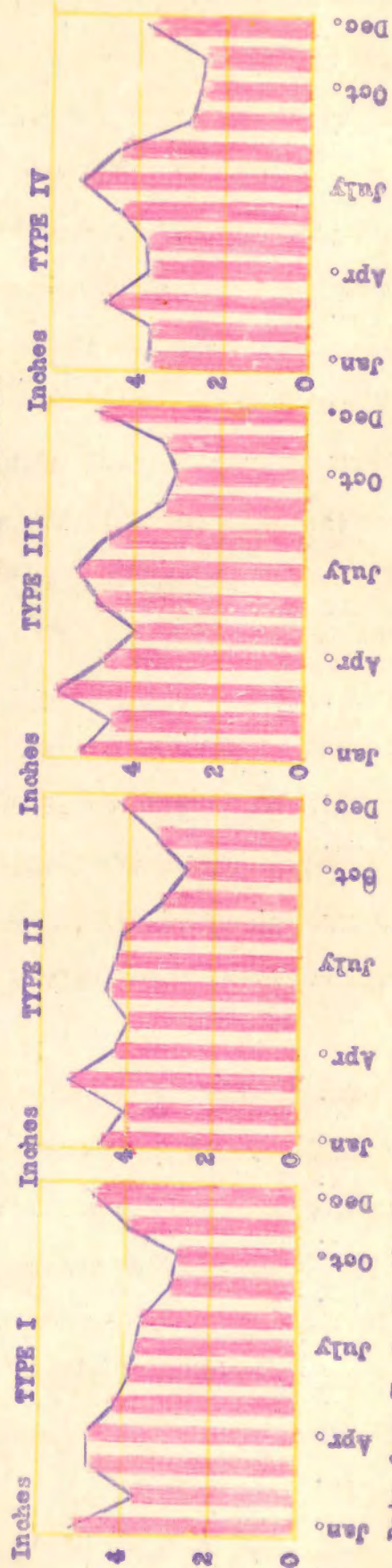


Chart 4A

AVERAGE MONTHLY DISTRIBUTION OF PRECIPITATION BY TYPES IN TENNESSEE



Data from U. S. Weather Bureau, Climatological Data, by Sections, Through 1930

Table 5.

Average Seasonal Distribution of Precipitation by Types in
Tennessee, 1887 - 1920. (In inches)

Type	Winter	Spring	Summer	Fall	Year
1	13.7	14.1	11.3	9.6	48.71
2	12.9	13.7	12.8	9.2	48.61
3	14.6	14.5	14.8	9.8	53.74
4	11.1	12.1	14.2	7.9	45.39
State	13.1	13.6	13.3	9.4	49.8

U. S. Weather Bureau, Summary of Climatological Data, by Sections.

Table 6.

Monthly Distribution of Rainfall by Types in Tennessee,
1887 - 1920. (In inches).

Type	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
1	5.21	3.82	4.84	4.86	4.34	3.93	3.75	3.64	2.89	2.80	3.94	4.69	48.71
2	4.63	4.06	5.39	4.34	4.0	4.38	4.34	4.11	3.16	2.67	3.31	4.19	48.61
3	5.24	4.52	5.81	4.69	4.02	4.86	5.34	4.59	3.32	3.15	3.31	4.87	53.74
4	3.67	3.67	4.68	3.66	3.79	4.44	5.28	4.48	2.80	2.64	2.49	3.78	45.39

Type

1, 23 stations - average 32 years' record.
 2, 13 " " 32 " "
 3, 37 " " 24 " "
 4, 11 " " 22 " "

summer month than any other area. (Table 6). It reaches a peak in March with 5.81 inches; and a summer peak in July with 5.34 inches.

Type 4, in upper East Tennessee, has the lowest annual average precipitation of any area. However, there is no great difference in the mean annual of different areas. The highest rainfall of this section occurs in summer, with 14.2 inches. This is almost equal to the rainfall in the region with the highest average summer rainfall. The low annual mean for this area is due largely to a relatively low fall, winter and spring precipitation. In fact, it shows a lower monthly mean than other areas for all months except June, July, and August. Thus, with the lowest mean annual it has one of the highest rainfalls during the principal crop growing season, when it is most needed.

How Does Tennessee Compare with Other Regions in the United States?

Reference to the series of United States Maps numbers 12 to 15 shows that Tennessee has comparatively heavy rainfall during the growing seasons of spring and summer. Her 11 to 15 inches (Table 5) exceeds the precipitation in the Corn Belt. Apparently this is sufficient for the production of our crops that are also grown in that region.

The average fall precipitation is apparently lower in the majority of the regions of the United States than that of any other seasons. The range in Tennessee of 7 - 9 inches (Table 5) is similar to the amounts in the Eastern half of the Nation. This condition favors the harvesting of corn, cotton, late hay crops, and others. A heavy rainfall at this season would seriously limit the production of these crops.

Our relatively heavy spring precipitation, while favorable to seed germination and the growth of meadows and pastures, often seriously damages the strawberry crop, and sometimes interferes with the planting program.

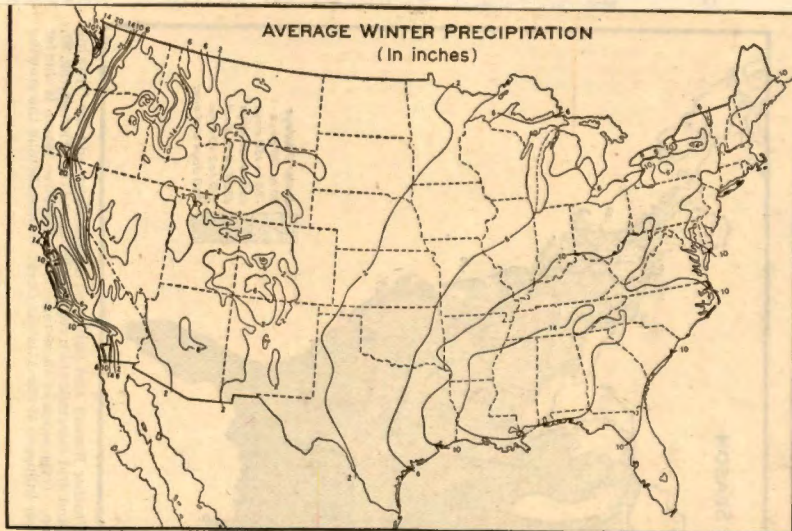
Map 12

FIGURE 6.—West of the Rocky Mountains, except in Arizona, the winters are relatively wet and the summers dry. In the Great Plains region and prairie areas, which together extend from the Rocky Mountains eastward to Minnesota, Illinois, and central Oklahoma, the winters are dry and the summers are relatively wet. In the Northeastern States the precipitation is more evenly distributed through the year, and this is true of the Southeastern States, except that the autumns are slightly drier. Especially significant are the light winter and relatively heavy spring precipitation in the spring-wheat region; the heavy summer rainfall in the Corn Belt, so essential to a large crop; and the light rainfall in the Cotton Belt in the autumn, when the crop is being picked

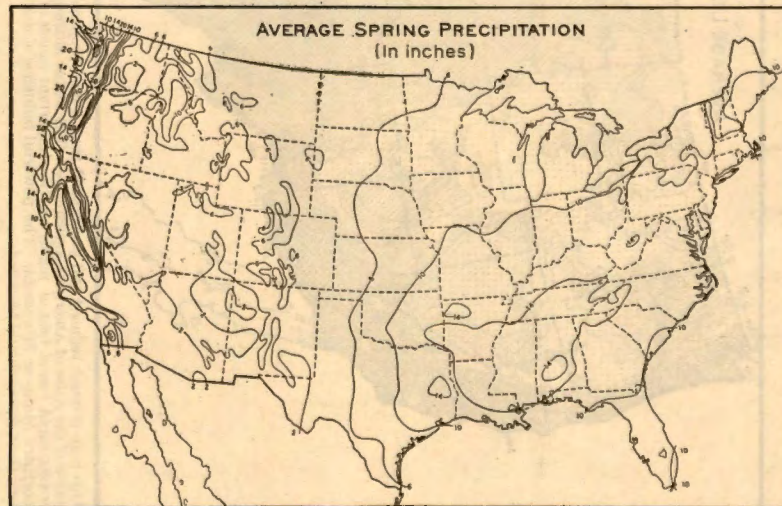
Map 13

FIGURE 7.—The heavy winter rainfall along the Pacific coast continues during early spring, and this is true also of the northern Rocky Mountain region. In the spring-wheat region the rainfall increases markedly in late spring, and this is true also in the western Corn Belt and western Cotton Belt. In the central Cotton Belt the spring rainfall is even heavier than the winter rainfall, and the rainfall is heavier in spring than in winter also in the eastern Corn Belt. In the Northeastern and Southeastern States the spring and winter rains are about equal in amount (10 inches). The local variations in average quantity of spring rainfall in New York State are wider than shown on the map—from about 6 inches to nearly 14 inches

Map 14

A GRAPHIC SUMMARY OF AMERICAN AGRICULTURE

9

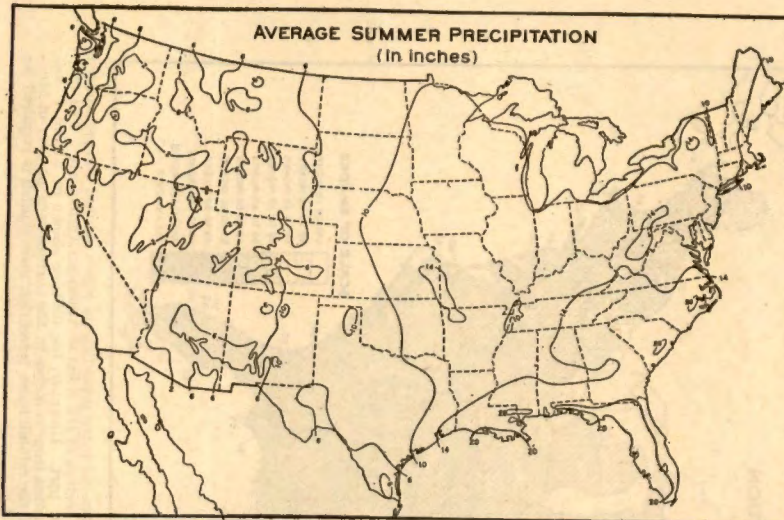


FIGURE 8.—In most of California and Nevada practically no rain falls in the summer months, except in the mountains, and there is very little rain in the Willamette Valley and the Puget Sound lowland. As far east as the crest of the Rocky Mountains the summer rainfall is light, except in the higher mountains. But in the Great Plains region, the Corn Belt, and the South-eastern States the rainfall has now increased to a maximum. It is owing in large part to the heavy summer rainfall, so conducive to heavy corn yields, combined with the dry winters, which promoted a grassland vegetation and conserved the fertility of the soil, that the upper Mississippi Valley is one of the richest agricultural areas in the world

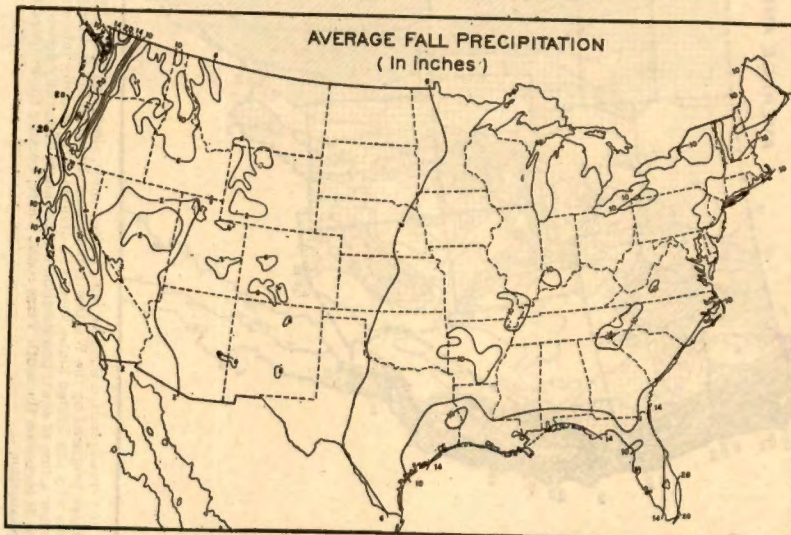
Map 15

FIGURE 9.—In nearly all the Cotton Belt the autumn is the driest season of the year. Where the rainfall is heavy along the Gulf and south Atlantic coast, little or no cotton is grown, partly because of damage to the lint and difficulty of picking, partly because of greater boll-weevil infestation, and partly because of poorly drained or badly leached soils. The autumns are drier than the summers in practically all the rest of the United States east of Idaho and Nevada, and this favors harvesting of corn and of the later cutting of hay, as well as the picking of cotton. Along the Pacific coast the rains begin again in the late fall, and are much heavier north of San Francisco than to the south

The results of the 1931 crop production seems to indicate that timeliness of occurrence of rainfall is more important than the total amount falling within a given season. A serious deficiency existed up to about the middle of July of that year. Some well distributed rains after that time resulted in abundant crops that normally matured in late summer and early fall.

Heavy precipitations are conducive to greater development of plant diseases. In 1930, which was below normal in precipitation, "losses from diseases were generally much less than normal. Outstanding examples are stem rust, leaf rust, scab of small grains, potato blight except in Florida, Septoria blight of tomatoes, apple scab in the drought area, and peach brown rot." (1)

On the other hand "certain diseases showed increased destructiveness. These include, naturally, potato tip burn and blossom-end rot of tomato, and also potato scab, non-parasitic 'rust' of cotton, and others." (1)

Snow (2)

All of Tennessee, except the Northern border, the Cumberland Plateau, and the Northeastern part, is in the Northern part of a belt that has an annual average of 1 - 10 inches of snow. This covers the larger part of the Southern states, except a narrow section extending along the Gulf Coast and up the Atlantic Coast to the central part of the Coast of South Carolina. (3) The narrow strip in Tennessee along the Northern border, and in the Northeast, is in a belt which has an average annual snowfall of 10 - 20 inches. This belt extends Westward from

(1) U.S.D.A., Bureau of Plant Industry (Mimeograph).

(2) Snow is included in the state's annual average precipitation data.

(3) Atlas of American Agriculture - Section on Climate.

Virginia through Kansas. It curves Southward over the mountainous area of Eastern Tennessee and Western North Carolina. Most of Tennessee, then, is in a belt which has next to the lowest snowfall of any section in the United States. The lowest is the sections along the South Atlantic and Gulf Coast, and the Southern Pacific Coast, which have an average of less than one inch. The regions of the heaviest snowfall are in the Sierra Nevada and Cascade Mountains, where the average in some localities is 400 to 500 inches; and the Western slope of the Rockies, which has an annual snowfall ranging from 200 to 300 inches.

Tennessee has snowfall on an average of 1 to 20 days annually - 10 to 20 days in the higher elevations of East and Middle Tennessee and 1 to 10 days in the other areas.

The snow melts soon after falling, as indicated by the figures on the average number of days with snow cover. In the heavier snowfall regions this varies on the average from 10 to 30 days annually; and in the lighter snowfall regions from 1 to 10 days. This offers a great contrast to the North, where snow covers the ground for several months.

Tennessee has approximately the same amount of snowfall, the same number of days with snowfall and snow cover, and the same average date of first snowfall in autumn, as other sections in the same latitude East of the Rocky Mountains. In the Rockies there is a gradual increase in the snowfall with the increase in latitude.

These snow belts, however, are not exactly paralleled with the lines of latitude; the greatest variation occurring in the Appalachian Mountains. ⁽¹⁾ The higher elevations there cause a higher average snowfall than in adjacent areas.

(1) Atlas of American Agriculture, Part 2, Sec. A., p. 42 and 43.

The average monthly and annual snowfall in Tennessee is shown in Table 7. The annual average is also shown on Map 16. Southwest Tennessee, Middle Tennessee except the Northern border, and most of the East Tennessee Valley have an average of 5 to 9.9 inches of snow annually. The heaviest snowfall, over 20 inches, occurs only in the higher elevations of the Cumberland Plateau and extreme East Tennessee. Along the Northern part of the state West of the Cumberland Plateau, and around the Plateau and East Tennessee Valley is a narrow section that has an average of 10 to 14.9 inches of snowfall.

Snow has been recorded at some place in Tennessee, at some time, in all months of the year except June, July, August and September. During April and October only a trace has occurred at most stations. The only stations having as much as one inch during these months are in the higher elevations. January, with 3.3 inches, has the highest monthly average. December and February have an average of 2.4 inches and 2.9 inches respectively.

Having light snowfall and few days with snow cover is of considerable economic importance to Tennessee. The cost of moving snow from highways and streets in states having heavy snowfall is high as compared with this cost in Tennessee. The following quotations give some information on the subject.

"Winter to some people may be disagreeable, but to unemployed in 36 states in the snow belt, winter has brought a spark of cheer in the \$10,000,000 to \$15,000,000 being spent to keep highways clear this year. - - - -"

"Although the cost of road clearing is high, it has been estimated that for every \$100 spent for this purpose, \$1,000 are realized in more efficient transportation and uniform business control brought about by uninterrupted traffic. - - - -"

"Some idea of the commercial value of clear roads in winter is the fact that 3,500,000 busses and trucks carry a large percentage of the short-haul traffic over them.

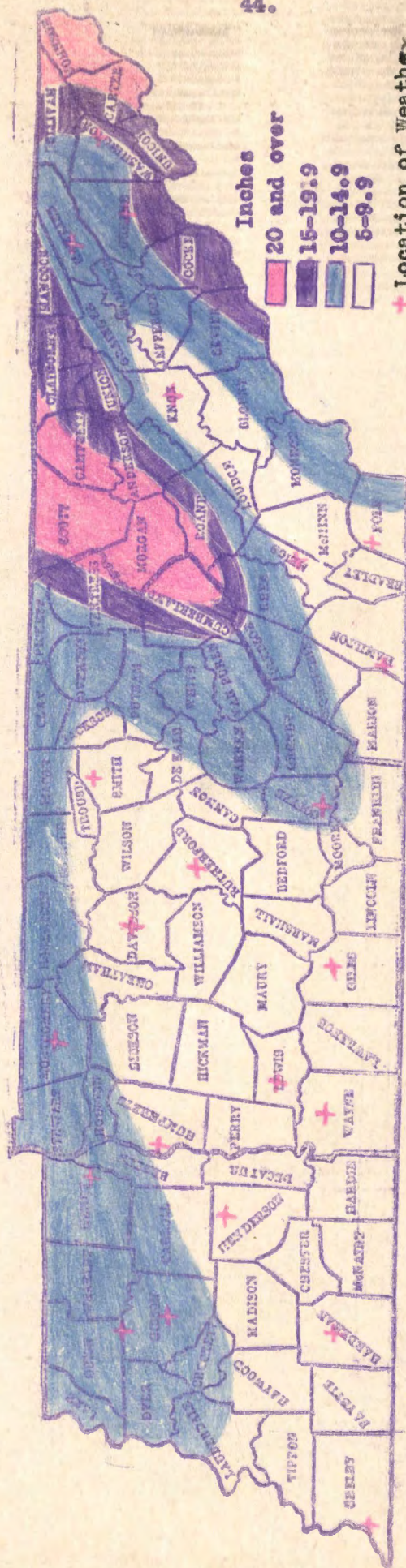
Table 7.

Average Snowfall at 25 Weather Stations in Tennessee, Annual and by Months. (In inches).

Station	County	Eleva- tion (ft.)	Yrs. re- cord	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept	Oct.	Nov.	Dec.	Year
Bolivar	Hardeman	450	25	2.4	2.5	0.7	T	0	0	0	0	0	T	T	3.0	8.6
Benton	Polk	880	21	1.1	1.8	0.8	0.2	0	0	0	0	0	0	0.4	2.2	6.5
Carthage	Smith	500	37	2.7	3.0	1.7	0.2	0	0	0	0	0	T	T	1.2	8.8
Chattanooga	Hamilton	762	42	2.8	2.4	0.6	0.2	0	0	0	0	0	T	0.2	1.5	7.7
Clarksville	Montgomery	500	29	4.4	3.7	2.4	0.2	T	0	0	0	0	0.1	0.3	3.1	14.2
Decatur	Meigs	850	25	2.4	2.8	0.8	T	0	0	0	0	0	T	0.4	1.9	8.3
Florence	Rutherford	560	34	3.2	3.0	1.7	0.1	0	0	0	0	0	T	0.3	1.6	9.9
Greeneville	Greene	1581	25	4.3	3.7	1.6	1.5	T	0	0	0	0	0.1	1.1	4.0	16.3
Hohenwald	Lewis	983	33	2.3	2.5	1.2	T	0	0	0	0	0	T	0.4	2.1	8.5
Johnson City	Washington	1717	10	3.6	2.6	2.5	T	0	0	0	0	0	T	1.0	3.1	12.6
Johnsonville	Humphreys	364	23	3.5	2.5	0.6	T	0	0	0	0	0	T	0.2	1.9	8.7
Kenton	Obion	325	19	5.0	2.4	0.9	0.3	0	0	0	0	0	0.2	0.4	3.3	12.5
Knoxville	Knox	996	35	3.2	2.6	1.1	0.3	T	0	0	0	0	T	0.3	2.5	9.8
Lynville	Giles	744	31	2.5	2.6	1.1	T	0	0	0	0	0	T	0.4	1.4	8.0
Memphis	Shelby	409	36	2.3	1.7	0.9	T	0	0	0	0	0	T	T	1.6	6.6
Mt. City	Johnson	2486	23	6.1	4.6	3.3	1.1	T	0	0	0	0	0.2	1.6	4.6	21.5
Nashville	Davidson	654	36	2.8	3.0	1.8	0.1	T	0	0	0	0	T	0.2	1.5	9.4
Rogersville	Hawkins	1150	35	3.8	2.7	1.1	0.6	0	0	0	0	0	T	0.5	2.7	11.4
Rugby	Morgan	1410	30	5.6	5.5	3.2	0.5	0.1	0	0	0	0	T	1.4	4.0	20.3
Springdale	Claiborne	1058	18	4.6	4.0	1.2	0.5	T	0	0	0	0	T	1.0	2.7	14.0
Springville	Henry	377	18	4.6	2.4	0.9	0.2	0	0	0	0	0	0.1	0.3	2.5	11.0
Trenton	Gibson	345	30	3.7	3.1	0.8	T	0	0	0	0	0	0.1	0.3	2.2	10.2
Tullahoma	Coffee	1075	30	3.3	3.0	1.5	0.2	0	0	0	0	0	T	0.4	2.1	10.5
Waynesboro	Wayne	753	30	2.2	1.9	1.2	0.1	0	0	0	0	0	0.1	0.2	2.1	7.8
Wildersville	Henderson	500	17	1.6	3.8	0.9	T	0	0	0	0	0	T	0.3	2.1	8.7
State Average		856	27.7	3.3	2.9	1.4	.2	T					T	.5	2.4	10.9

T. - Trace.

AVERAGE ANNUAL SNOWFALL IN TENNESSEE THROUGH 1920



Source: U. S. Weather Bureau, Climatological Data, Reprint Sections 77 and 78, through 1920

Millions of persons use the busses as a means of transportation." (1)

Length of Growing Season

The length of the frost free season is very important to agriculture, since frost establishes the seasonal limitations of plant growth. It is the most important factor in determining the geographical boundaries within which certain plants thrive best and on the other hand fail entirely to develop. The length of the growing season determines, to a large extent, the kind of crops that can be successfully grown in any particular area. Due to the differences in altitude, latitude, and other factors, the length of the growing season varies considerably in different sections of Tennessee. This makes possible the production of a large variety of crops.

The length of the growing season as reported by seventy stations is shown on Map 17. (2) The average number of days growing season vary from 167 at Mountain City in the Northeast to 226 at Memphis in the Southwest. This is a difference of 59 days. Upper East Tennessee, parts of Cumberland Plateau and a small area of the Highland Rim have a growing season of 170 to 180 days. The largest portion of the Highland Rim and a strip around the East Tennessee Valley have a frost free season of around 190 days. A large part of West Tennessee, the Central Basin and the lower East Tennessee Valley have a growing season of 200 days while in Southwest Tennessee it is 210 days or more. (Arlington excepted - has 194 days).

The length of the growing season is important, but the percentage

(1) Knoxville News-Sentinel, January 1932.

(2) Table in Appendix, Number

Map 17.



Source: Data from U. S. D. A. Weather Bureau;

distribution of the dates of the last killing frost in the spring and the first in the fall are of greater importance. Frost dates distribution are very important to the truck farmer. He can afford to assume some frost risk if there are chances of higher prices by getting the crop off a few days earlier. Chart 5 shows the percentage of the last killing frosts in the spring that have occurred by weekly periods at seven stations, which represent different geographical areas of the state. (1) This Chart shows not only the earliest and latest dates of the last killing frost in the spring, but also the period or periods in which frost is most likely to occur, or has occurred the greatest number of times. Killing frosts have occurred as late as May 10 - 16 at Rugby, Elizabethton, and McMinnville. The period in which the last killing frost usually occurs is April 19 to May 9 at Rugby, April 5 to 25 at Elizabethton and March 29 to April 25 at McMinnville.

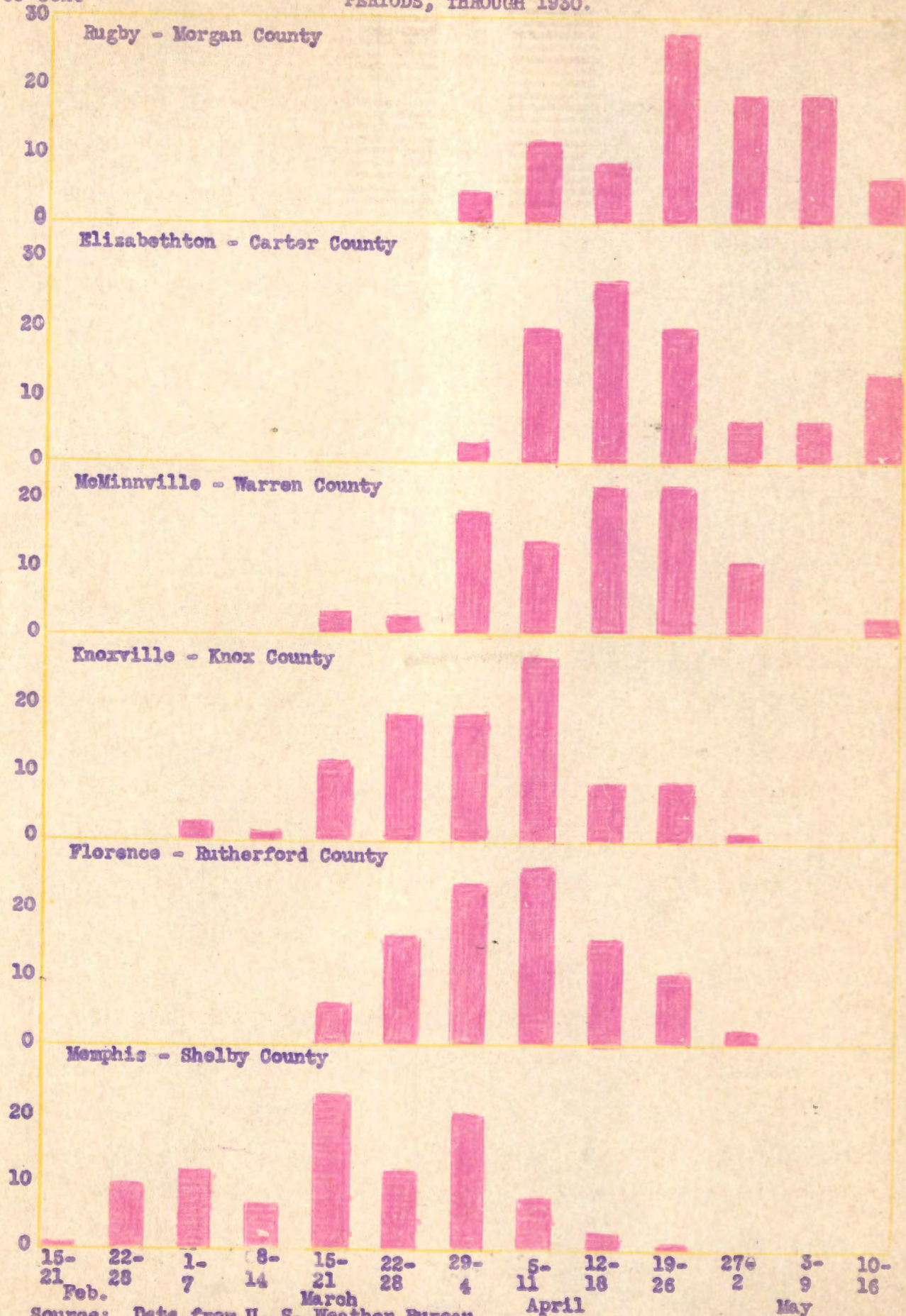
The Central Basin, Northwest Tennessee and Central East Tennessee Valley have approximately the same distribution of the last killing frost. The last date recorded occurred during the week ending May 2. The chances of frost are small after April 18th in these areas. The period during which the last killing frost occurs the greatest number of times is April 5 to 11 at Knoxville and Rutherford, and ~~March 29 to April 4 at Kenton.~~

At Memphis, which has the longest growing season in the state, the date of the last frost is April 19 to 25. This is the same period in which the last killing frost occurs the greatest number of times at Rugby. The last frost occurs the greatest per cent of the time during the period March 15 to April 4. The earliest date of the last killing

(1) Appendix Table

PERCENTAGE OF YEARS THAT LAST KILLING FROST OCCURRED IN SPRING, BY WEEKLY PERIODS, THROUGH 1930.

Per Cent



Source: Data from U. S. Weather Bureau, Climatological Data, by Sections.

frost at Memphis is during the period February 15 to 20, while in the colder areas it is March 29 to April 4. The chances of frost drop below 10 per cent at Rugby May 10 - 16; McMinnville May 3 - 9; Knoxville April 5 - 11; Florence April 26 - May 2; Kenton April 19 - 25; and Memphis April 5 - 11. The season then is approximately one month earlier at Memphis than in the colder areas of the state.

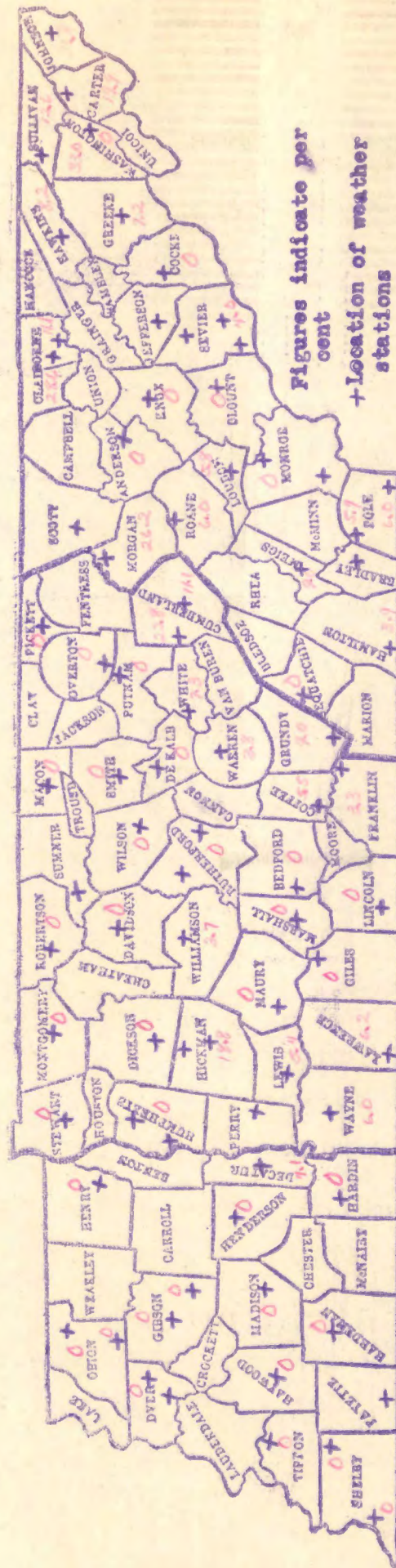
The occurrence of the last killing frost in the spring is shown by Maps 18, 19, 20, and 21. (1) Frost has occurred a few times in some of the colder areas of the Cumberland Plateau and East Tennessee after May 10. Map 18 shows the occurrence of frost after May 2. Most of Middle and West Tennessee is free from frost after this date. Most of the Eastern part of the state has had frost after May 2, but less than 10 per cent of the time, except on the Cumberland Plateau and Northeast Tennessee. After April 25 frost has occurred over practically all of the state at some time. Over the Middle and Western part and part of East Tennessee Valley the chances are that frost will not occur over one year out of ten, except in small area on the Western Highland Rim. On part of the Rim, Southern part of the Cumberland Plateau and some of the Valley, the chances of frost vary from 10 - 20 per cent, while on the Plateau and in the Northeastern part of the state the chances of frost are over 35 per cent.

The chances of frost are less than one out of ten, over a considerable part of West Tennessee, after April 18. (Map 20). In the Eastern half of the state small areas have a 10 - 20 per cent chance of frost and some 20 - 35 per cent, but over a considerable part of it the chances of frost are above 35 per cent with the colder areas being above

(1) Appendix table

Map 28.

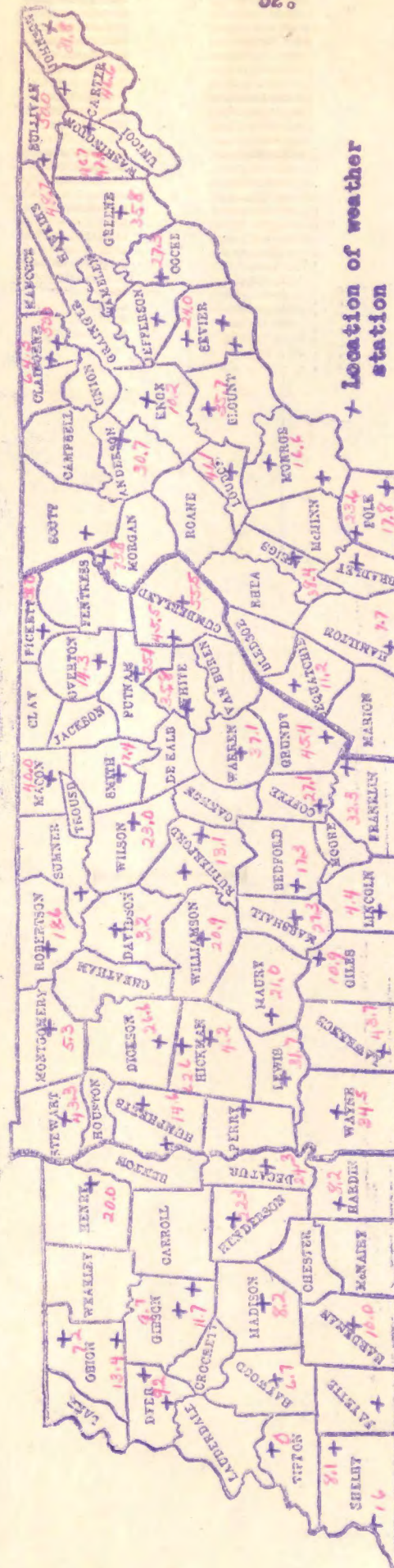
PERCENTAGE OF YEARS THAT KILLING FROSTS HAVE OCCURRED AFTER MAY 2, THROUGH 1920



Source: The data for Maps 18-24 inclusive were calculated from data of U. S. Weather Bureau Climatological Data, by Sections, Reprints 77 and 78.

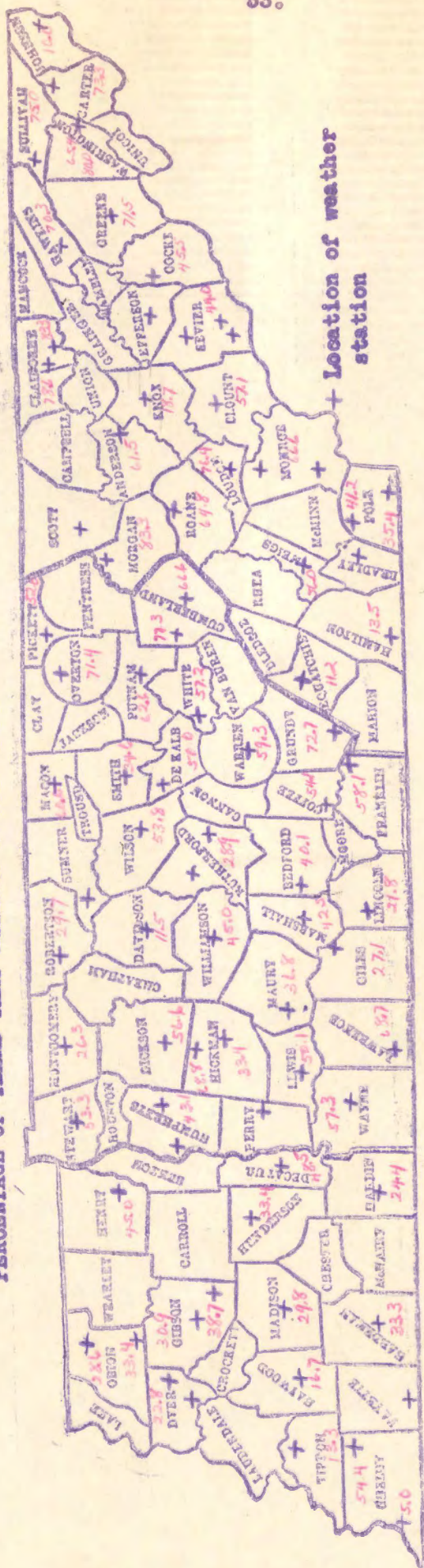
May 20.

PERCENTAGE OF YEARS THAT KILLING FROSTS OCCURRED AFTER APRIL 18, THROUGH 1920



May 21.

PERCENTAGE OF YEARS THAT KILLING FROSTS OCCURRED AFTER APRIL 11, THROUGH 1920



50 per cent. As can be seen from Map 21, the chances of frost after April 11 are rather high for most of the state. There is over a 50-50 chance of frost for most of the Eastern half and the Western Rim. In Western Tennessee the chances of frost after this date are much less, being below 10 per cent at Memphis, but with some other sections as high as 35 to 50 per cent chance. From these maps it can be seen that West Tennessee, Central Basin and East Tennessee Valley are free of frost earlier in the spring than the areas with higher elevation.

The distribution by weekly periods of the first killing frost in the fall are shown in Chart 6 for five stations distributed over the state.⁽¹⁾ At these five stations the date of the first killing frost varies from September 15 - 21 at Erasmus on the Cumberland Plateau to October 6 - 12 at Covington, November 24 - 30 at Memphis. The chances of frost rise to 10 per cent at Erasmus September 22 - 28, Jonesboro October 6 - 12, Franklin October 13 - 19, and Covington and Memphis October 20 - 26. The greater percentage of the first killing frost occurs September 29 - October 6 at Erasmus, October 13 to November 3 at Jonesboro, October 25 - November 10 at Franklin and Covington, and October 27 - November 17 at Memphis. The effects of elevation are reflected in the dates of first frost occurrence, the mountainous areas having naturally an earlier occurrence. Latitude has the lesser influence of the two.

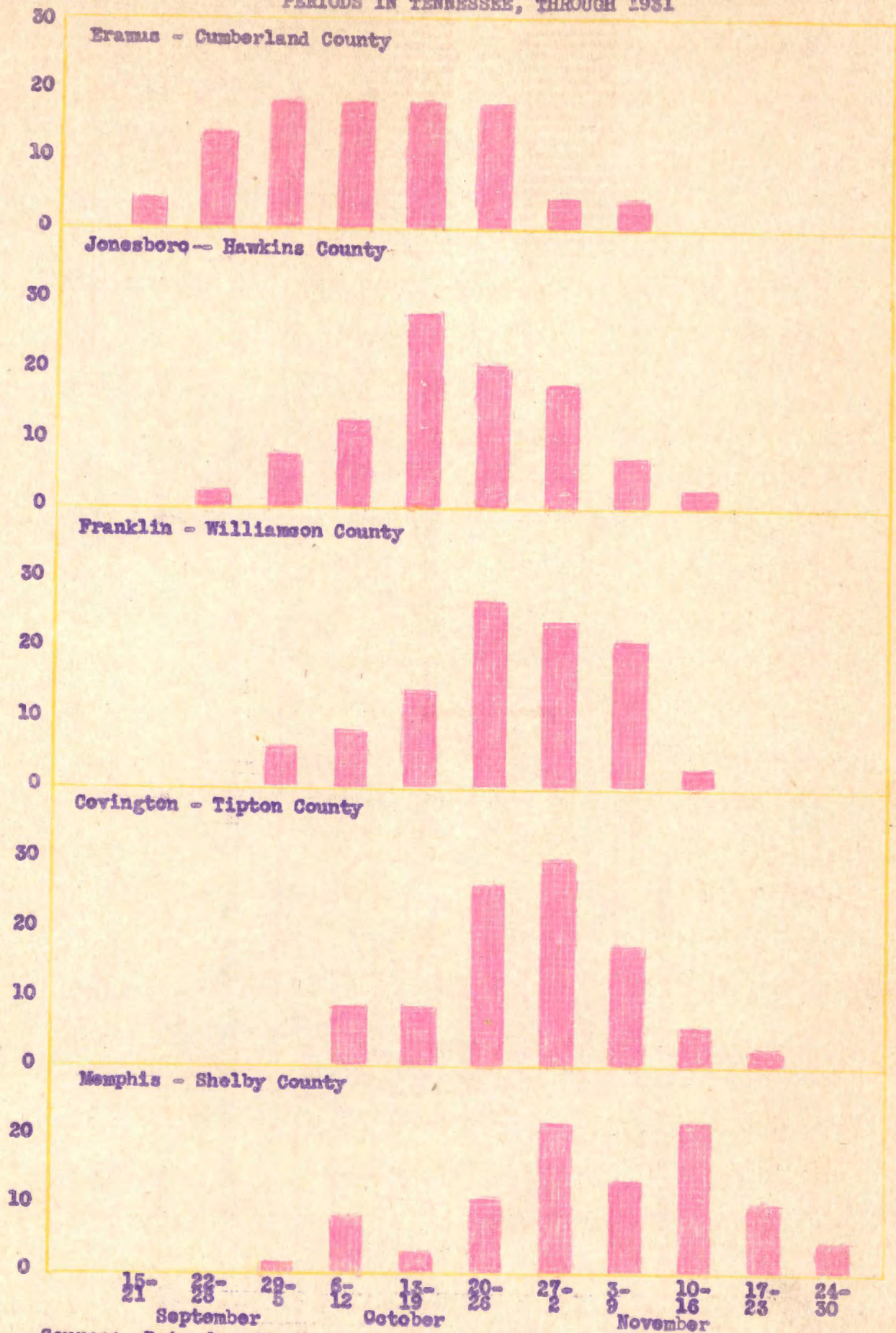
The percentage of frosts that have occurred up to four different dates respectively is shown on Maps 22, 23, 24, and 25. ⁽²⁾ There are only five places that have recorded frost before September 22nd. These

(1) Appendix Table

(2) Appendix Table

Chart 6.

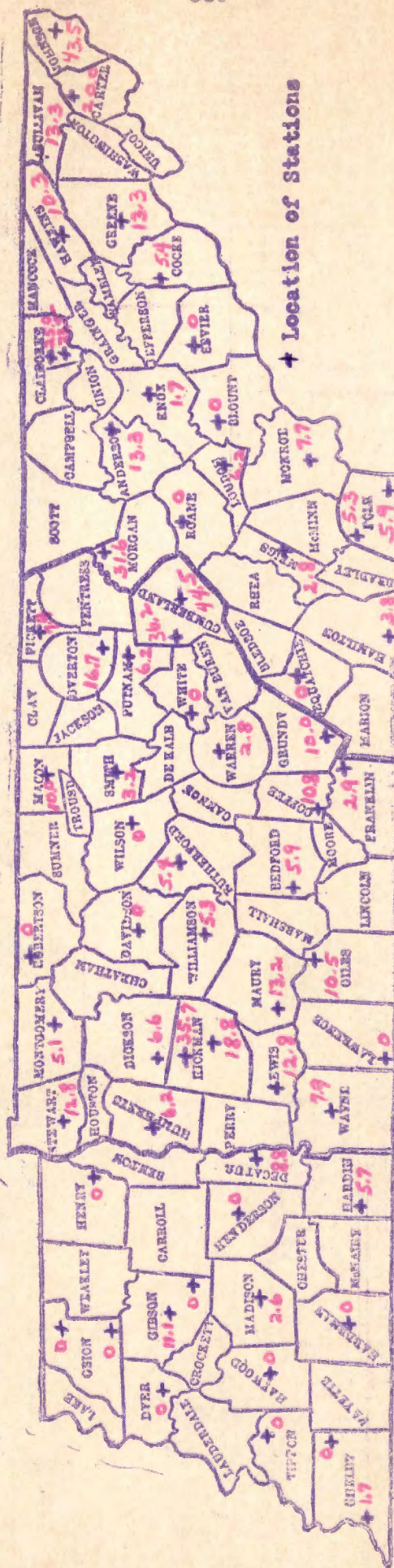
PERCENTAGE OF YEARS THAT THE FIRST KILLING FROST IN FALL OCCURRED, BY WEEKLY PERIODS IN TENNESSEE, THROUGH 1931



Source: Data from U. S. D. A. Weather Bureau, Climatological Data by Sections.

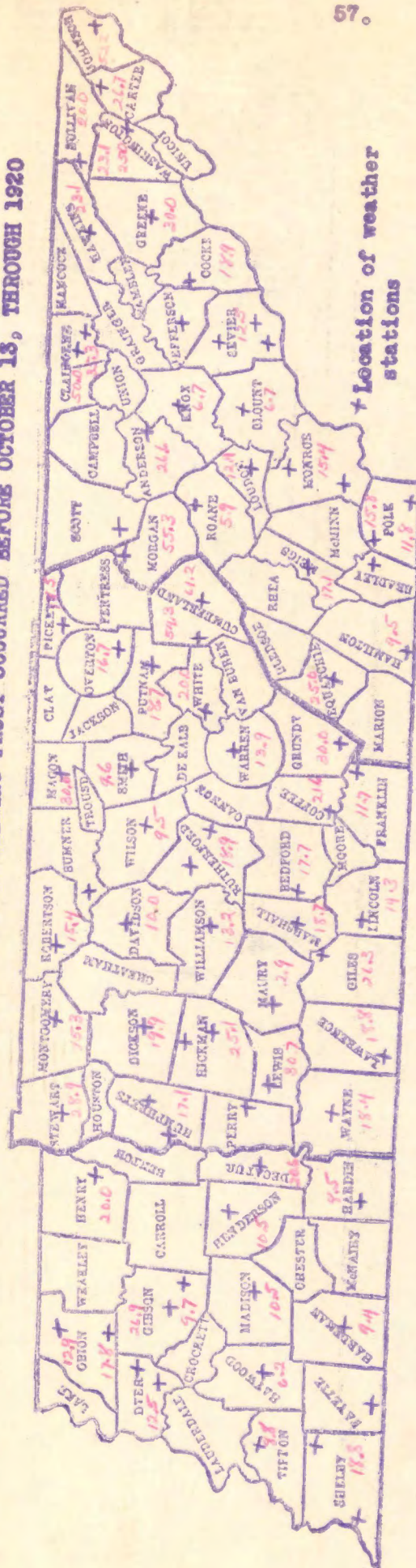
Map 22

PERCENTAGE OF YEARS THAT FIRST KILLING FROST OCCURRED BEFORE OCTOBER 6TH, THROUGH 1920.



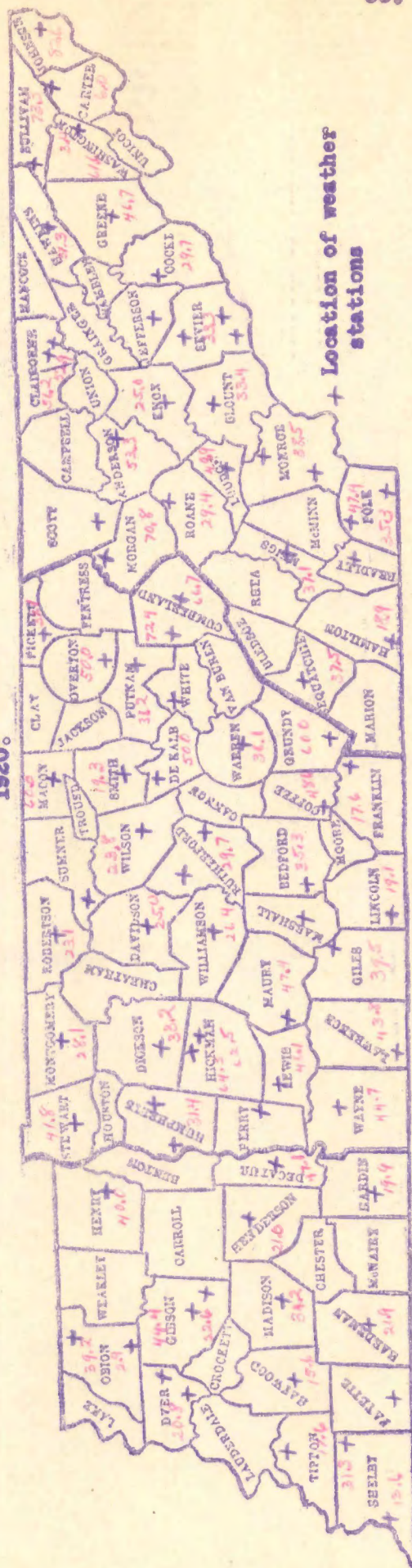
Source: U. S. D. A., Weather Bureau,
Climatological Data, Tennessee Section.

PERCENTAGE OF YEARS THAT FIRST KILLING FROST OCCURRED BEFORE OCTOBER 13, THROUGH 1920



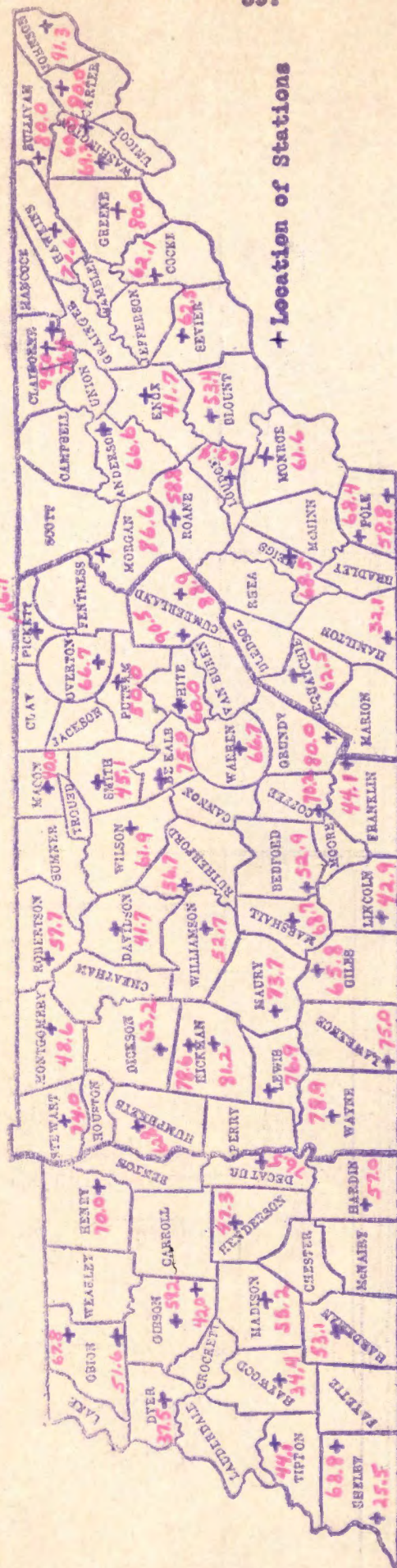
+ Location of weather stations

Map 24.



2

PERCENTAGE OF YEARS THAT FIRST KILLING FROST OCCURRED BEFORE OCTOBER 27th, THROUGH 1920



Source: U. S. D. A., Weather Bureau,
Climatological Data, Tennessee Sections.

are in Hickman, Lewis, Smith, Cumberland and Morgan Counties. Up to September 29 frost has been recorded at several stations in or near the areas of higher elevation, but the chance of occurrence is below 10 per cent except in Cumberland and Morgan Counties. Up to October 6, shown on Map 22, there is still a large percentage of the state which has not had frost, and none except part of the Cumberland Plateau and Northeast Tennessee have had frost over 10 per cent of the time. Frost has occurred over practically all of the state before October 13, but not over 10 per cent of the time for a large part of it, (Map 23), and a rather small part over 20 per cent. However, there are some small areas with the chances of frost above 50 per cent up to this date. Map 24 shows the occurrence of frost up to October 20. The chances of frost occurring before this date are above 20 per cent, except in Southwest and part of the Counties along the Southern border. In the colder sections the chances of frost are above 50 per cent. Map 25 shows that the chances of frost occurrence before October 27 are above 50 per cent for most of the state and above 35 per cent for all of it except Southwest corner and Southern part of the Central Basin and East Tennessee Valley.

Most of Tennessee is favored with a long growing season. The smaller areas with the shorter frost free season are those that are less suitable in other respects for agriculture. The areas with the soil and topography best suited for agriculture have a growing season sufficient for the maturity of a great variety of crops.

Length of Day and Sunshine

The length of the day by months in the Northern and Southern states is given in Table 8 and Chart 7. The time observed was on $32\frac{1}{2}$ degrees latitude in the Southern states and $42\frac{1}{2}$ degrees latitude in the Northern

Table 8.

Length of Day, from Sunrise to Sunset, by Months, Southern
and Northern States. (1)

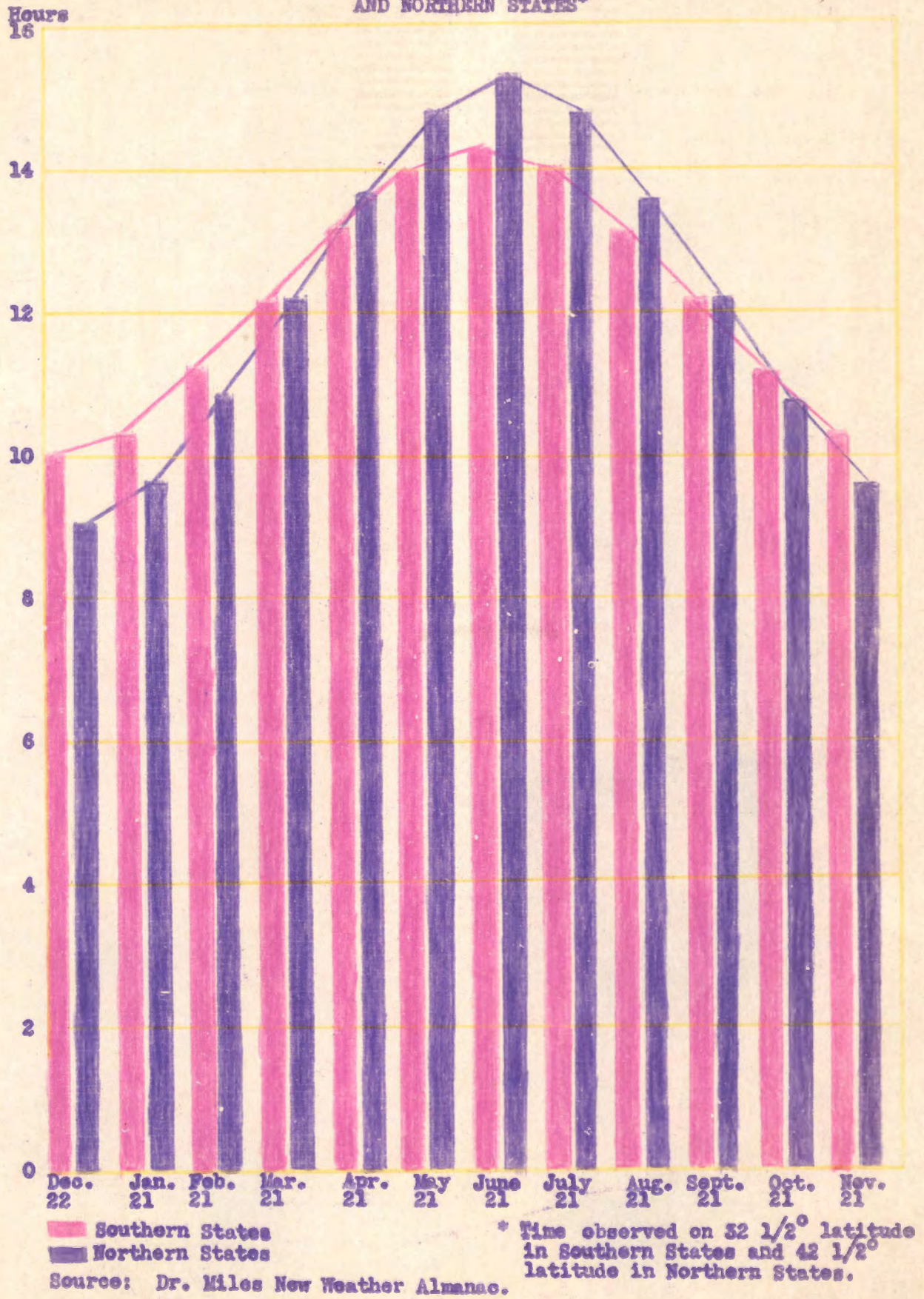
Date	Southern States			Northern States	
	Hours	Minutes		Hours	Minutes
December 22	10	3		9	5
January 21	10	21		9	37
February 21	11	15		10	51
March 21	12	11		12	13
April 21	13	12		13	40
May 21	13	59		14	48
June 21	14	19		15	17
July 21	14	0		14	48
August 21	13	10		13	37
September 21	12	11		12	13
October 21	11	11		10	47
November 21	10	20		9	35

Source: Dr. Miles New Weather Almanac and Hand Book of
Valuable Information, 1932.

(1) Time observed on $32\frac{1}{2}$ degrees latitude in Southern states
and $42\frac{1}{2}$ degrees latitude in Northern states.

Chart 7.

LENGTH OF DAY FROM SUNRISE TO SUNSET BY MONTHS, SOUTHERN
AND NORTHERN STATES*



states, which are medians for the two areas. In June and September the days in the North and South are equal. From April to September the days are longer in the North, while from September to March the South has longer days. In the extreme Southern portion of the country the longest day is about 14 hours in length and the shortest about $10\frac{1}{2}$ hours, whereas in the extreme Northern portion the longest is about 16 hours and the shortest about 8 hours. (Map 26). During clear weather in summer, the sun shines in the extreme Northern portion of the country about two hours longer during the day than in the extreme South. This is an important factor in crop growth in these Northern localities, as the greater amount of sunshine compensates somewhat for the lower temperature. For the year as a whole the possible amount of sunshine is approximately the same throughout the world, or an average of about 12 hours a day. (1)

December 22 in Tennessee is between three-fourths and one hour longer than in the area in the latitude of Lake Michigan. This difference decreases as spring approaches, until after April 21st, when the days in the Northern area are longer than in Tennessee. By June 21st the days in this state are from three-fourths to nearly one hour shorter than in the Lake Michigan area. At the Canadian border the days are about one and three-fourths hours' longer than in the Southern part of Tennessee. (Map 26).

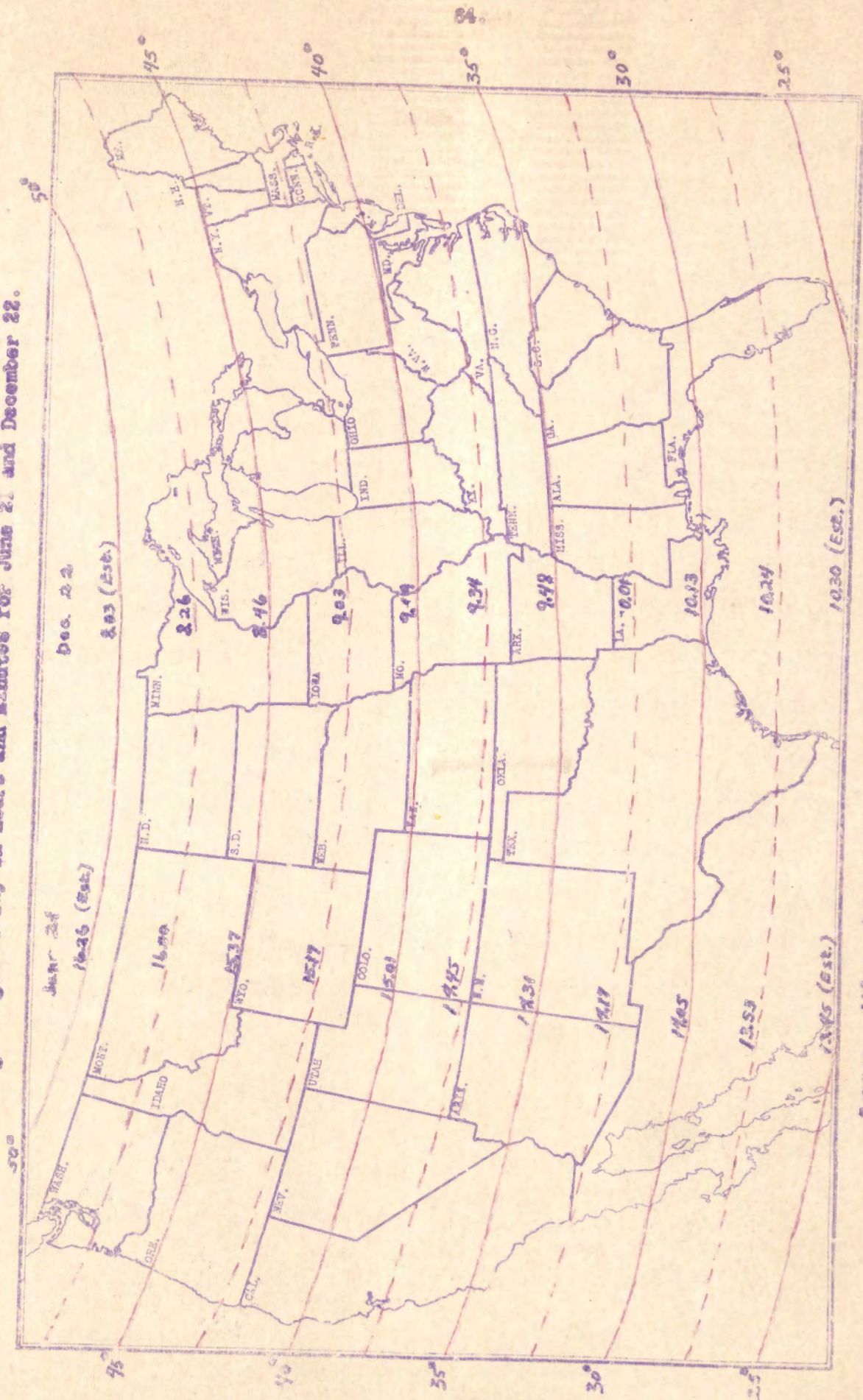
"Sunshine is a very important climatic element, not only from the standpoint of agriculture, but also from its physical effect on man and other animals. Light plays an important part in controlling the plant structure, and the depressing influence on human beings of long periods of damp and cloudy weather is noticeable, even to the casual observer. On the other hand, long periods of successive days with continuous sunshine and high temperature are trying on all animals and most plant life." (2)

(1) U. S. D. A. Yearbook, p. 492, 1924.

(2) U. S. D. A. Yearbook, p. 490, 1924.

Map 23.

Average Length of Day in Hours and Minutes for June 21 and December 22.



Source: Atlas of American Agriculture, Part II, Climate, page 31.

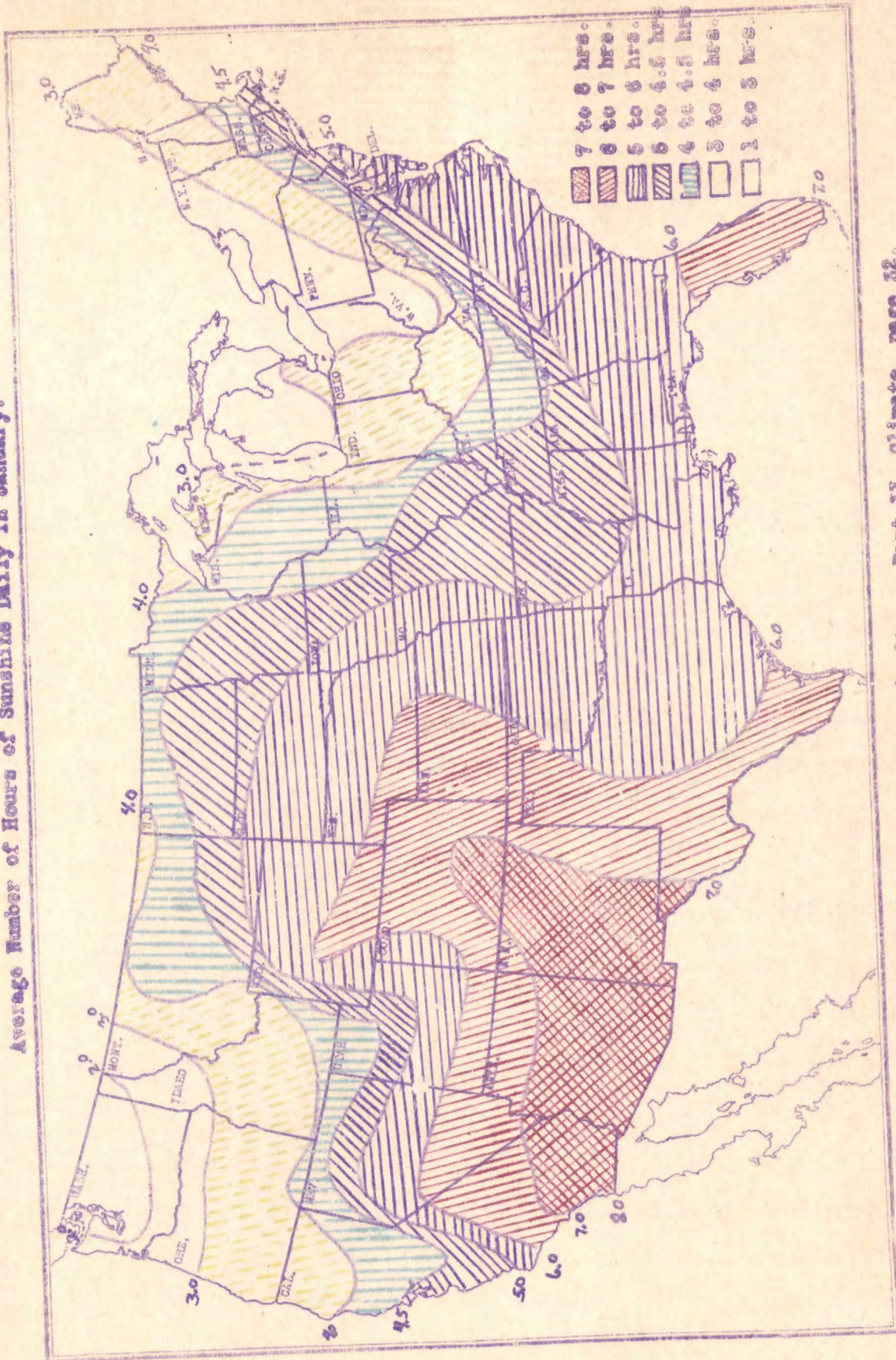
"With an ideal sea level horizon, the amount of sunshine received in any locality, for the year as a whole, would be determined by the prevailing state of the sky as to the presence or absence of clouds and fog, although there is a slight increase with latitude in the possible amount of yearly sunshine. This variation is unimportant, however, amounting in the course of a year to a total of only about $35\frac{1}{2}$ hours between latitudes 25 degrees and 49 degrees N., representing the extreme Southern and extreme Northern portions of the United States." (1)

During January all of Tennessee West of Nashville receives four and one-half to five hours of sunshine per day. (Map 27). The part of the state East of Nashville receives an average of four to four and one-half hours of sunshine daily. Tennessee is similar to an area extending Northeastwardly through Southeastern New York and Southern New England; and Northwest through Illinois and Iowa into Minnesota and North Dakota. Tennessee has one and one-half to two hours more sunshine daily in January than Western New York, Western Pennsylvania, and Michigan. This is partly due to our longer days. The January days in Northern Pennsylvania are one-half to three-fourths hours' shorter than in this state. However, most of the areas South and directly East of Tennessee have more hours of sunshine than this state.

As shown on Map 28 the Western half of Tennessee, including the Central Basin, has from 9 to 10 hours of sunshine daily in July. The extreme Western part of the state has approximately one-half hour more than the Central Basin. This area extends from the Gulf Northeastwardly through the Western part of Maine and also along the Atlantic Coast from Maine to North Carolina. Tennessee, East of the Central Basin, has from $8\frac{1}{2}$ to 9 hours of sunshine daily. This area is similar to most

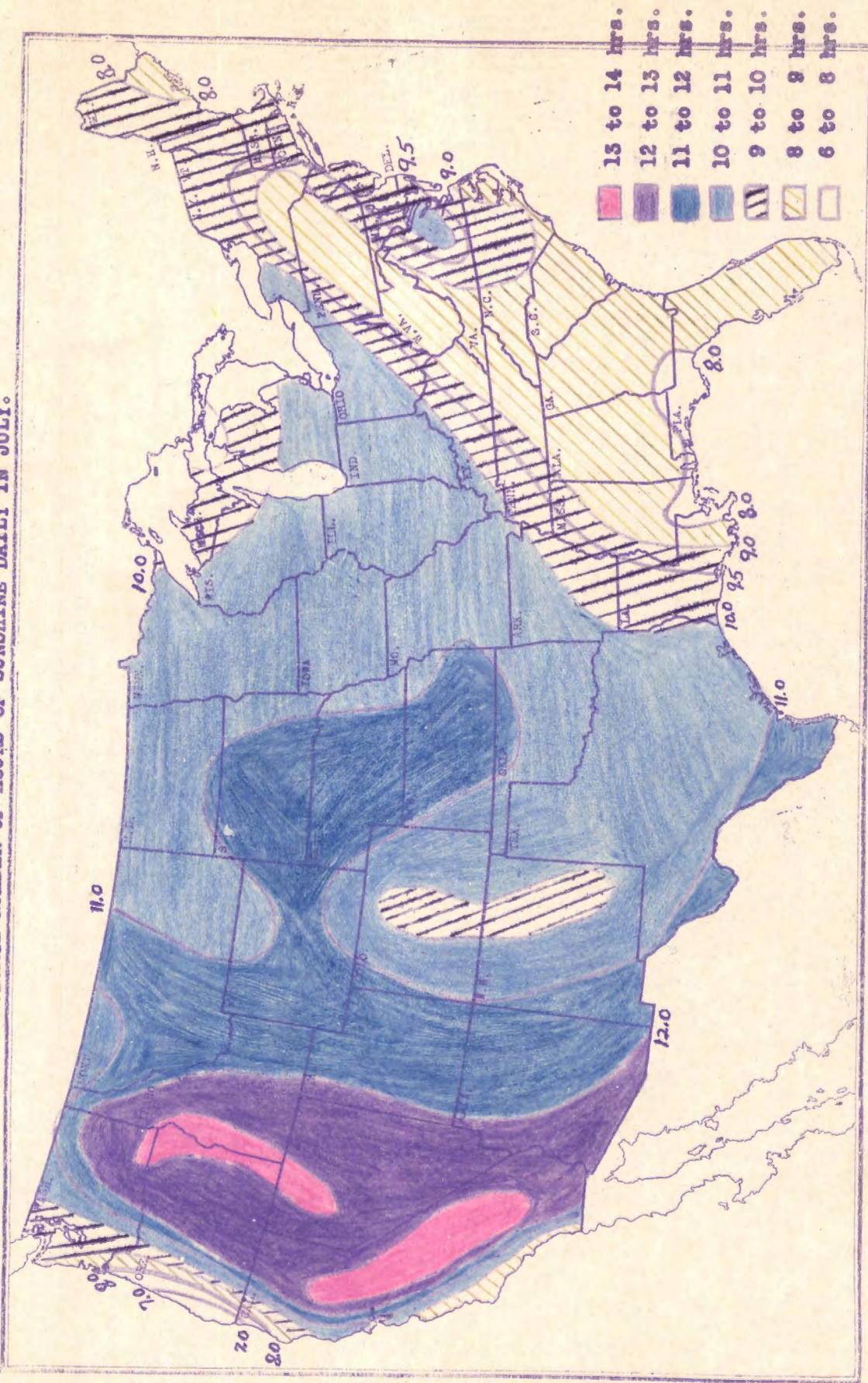
(1) U. S. D. A. Yearbook, page 492, 1924.

Map 27.
Average Number of Hours of Sunshine Daily in January.



Source: Atlas of American Agriculture, Part II, Climate, page 32.

AVERAGE NUMBER OF HOURS OF SUNSHINE DAILY IN JULY.



Source: Atlas of American Agriculture;
Part II, Climate; page 32.

of the South, East of the Mississippi River, and a small area extending into Southern New York. But the summer days in New York are slightly over three-fourths hour's longer than in Tennessee.

Map 29 shows the percentage of possible annual sunshine by states. A narrow strip of West Tennessee is in the area having 60 - 70 per cent. This area covers a large portion of the United States West of the Mississippi. Most of Tennessee is in the area that has from 50 - 60 per cent. This area extends from the Gulf of Mexico Northward to the Great Lakes, Westwardly along the Northern border, and along the Northern part of the Atlantic Coast. Only small areas in the Northeast and Northwest have less than Tennessee.

The percentage of possible monthly and annual sunshine at four stations in Tennessee is shown in Table 9 and Chart 8. Of the four places,

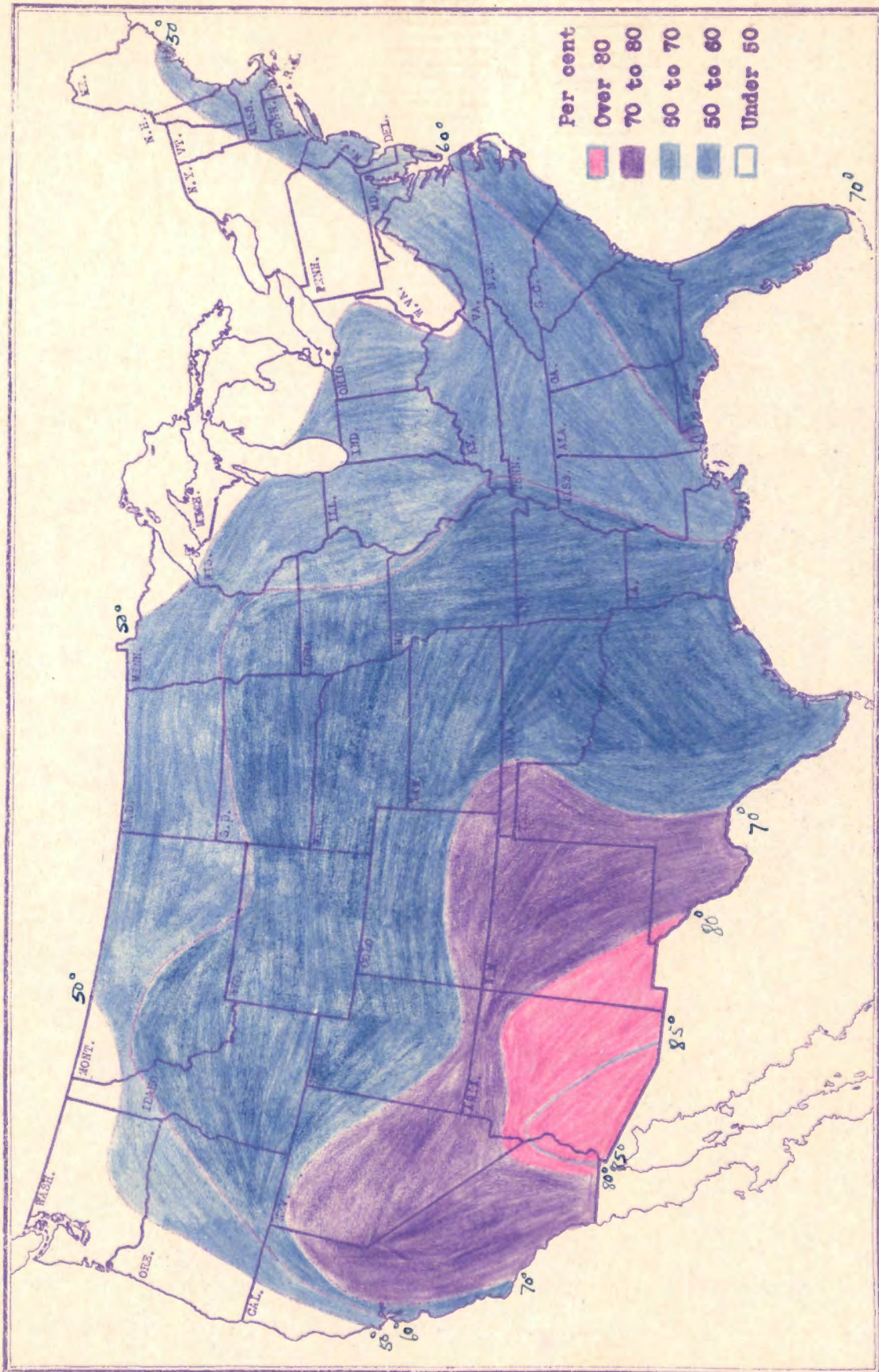
Table 9.

Average Per Cent of Possible Sunshine by Months at Four Stations in Tennessee.

Station	Yrs. Re- cord	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
Chattanooga	24	40	45	48	56	62	62	60	58	63	63	55	41	54
Knoxville	23	41	48	53	56	64	62	62	57	63	64	57	41	56
Nashville	24	43	48	53	61	67	69	70	69	70	65	57	42	60
Memphis	20	46	54	58	64	66	73	73	71	71	69	62	45	63

Chattanooga is the lowest with an annual percentage of 54 and Memphis the highest with 63 per cent. During the winter months, there is not a great difference in the per cent of possible sunshine at the four stations, but during the summer months there is considerable difference. At Chattanooga

MAP 29.
PERCENTAGE OF POSSIBLE ANNUAL SUNSHINE.

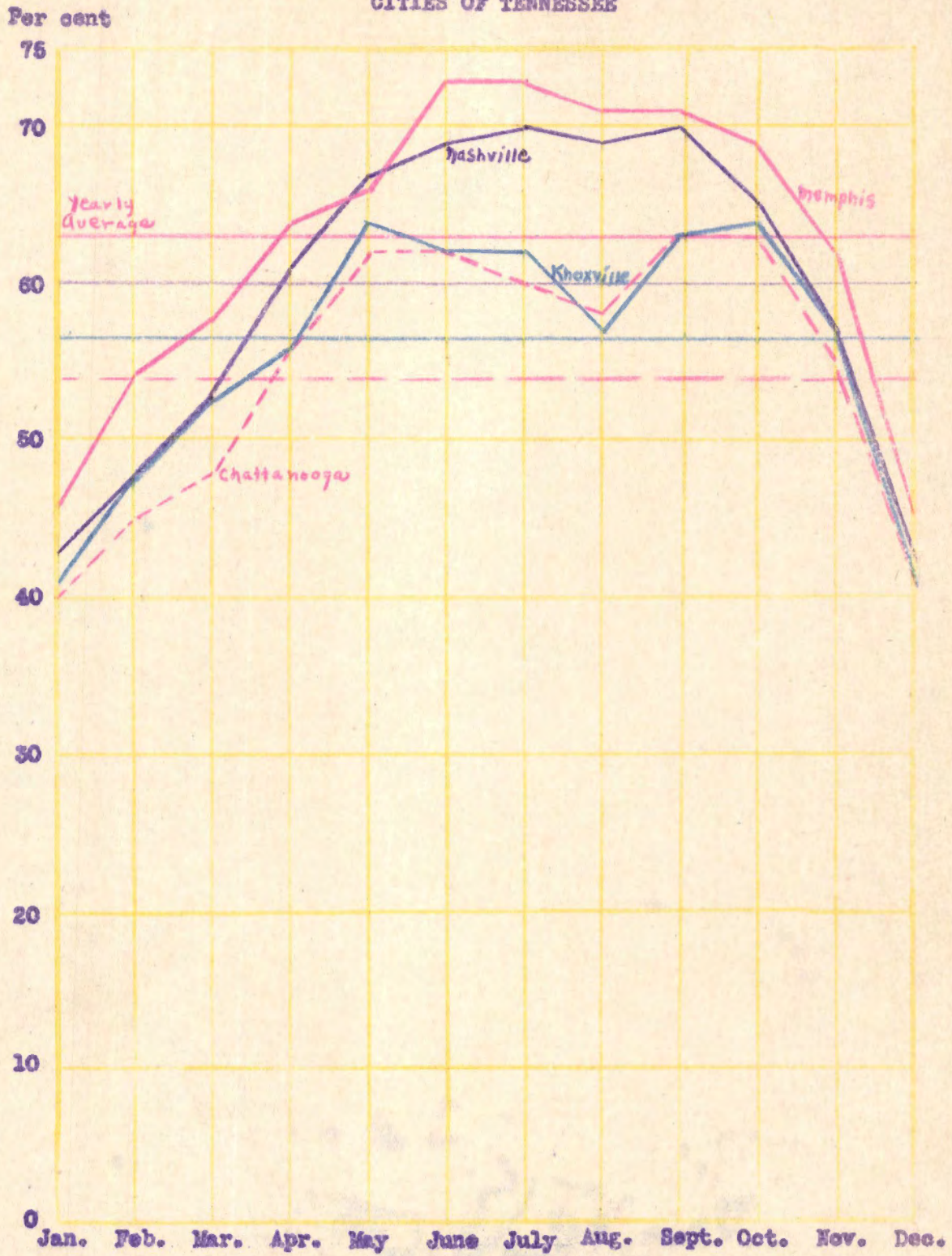


Source: U.S.D.A. Yearbook - 1924, page 493.

Chart 8.

AVERAGE PERCENTAGE OF POSSIBLE SUNSHINE BY MONTHS IN FOUR

CITIES OF TENNESSEE



Source: U. S. Weather Bureau,
Climatological Data,
Tennessee Section.

and Knoxville the highest percentages are in May and October with a considerable decrease during the summer months, the lowest being in August; while at Nashville and Memphis the summer season has a greater percentage of possible sunshine than the other seasons, and a considerably greater percentage than Chattanooga and Knoxville during the summer. This, as well as the maps, shows that West Tennessee has a greater amount of sunshine than East Tennessee.

This state has on the average 154 clear days, or slightly more than two out of five. Of the other 211 days, 110 are cloudy and 101 partly cloudy.

Humidity

"The humidity of the atmosphere is of great climatic importance, not only from the standpoint of its influence on bodily comfort, but also because of its direct relation to plant life and its bearing on commercial activities." (1)

In areas of high temperature, the lower the relative humidity, the less bodily discomfort from the heat. This is true because the lower the humidity, the greater the evaporation, and this has a cooling effect. In cold weather it is also true that a higher relative humidity causes more bodily discomfort because the moisture in the air acts as a conductor, transmitting the heat rapidly away from the body. (2)

The most common measure of atmospheric moisture is relative humidity. "By relative humidity is meant the ratio the amount of moisture present in the atmosphere bears to the amount that could exist without condensation under the same conditions of temperature and atmospheric

(1) Atlas of American Agriculture; Part II, Sec. A, page 451.

(2) (a) Atlas of American Agriculture; Ibid.

(b) U. S. Weather Bureau - Knoxville office.

pressure." (1)

"A comparison of the relative humidity of Tennessee with other areas is difficult because of a difference in local time when observations were made. In most cases the observations were made by Eastern Standard time, which made them earlier in the day farther West." (2)

In January, July and October at 8:00 A.M. there is no great difference in the relative humidity of Tennessee and the country East of the Mississippi. In April at 8:00 A.M. Tennessee is similar to the larger area East of the Mississippi River which has a lower relative humidity than the Gulf Coast, but higher than a narrow section extending from Virginia to Massachusetts. At 2:00 P.M. Tennessee is also similar to the larger part of the Eastern half of the United States. There are some small sections there with lower relative humidity, and a section along the Gulf Coast which is higher than Tennessee. At 8:00 P.M. in April, July, and October, Tennessee is similar to the Eastern section except the Atlantic and Gulf Coast where it is higher. In January Tennessee is included in a narrow strip extending from the West to near the Atlantic Coast and then Northeastwardly to Maine, which is drier than the rest of the Eastern half of the United States. In general, the average relative humidity of Tennessee is lower than the Atlantic and Gulf Coast, about the same as the larger part of the Eastern half of the country, and much higher than the drier West. (3)

The relative humidity - morning, evening, and the average - is given in Table 10 by months for four stations in Tennessee. Chart 9 shows the average at the four stations by months. The morning relative humidity, as in other places, is considerably higher than the humidity in the evening.

(1) Atlas of American Agriculture; Op.Cit., page 45.

(2) Ibid.

(3) Atlas of American Agriculture; Ibid., figures 85-88 and 91-98.

Table 10.

Average Relative Humidity - Annual and by Months. (1)

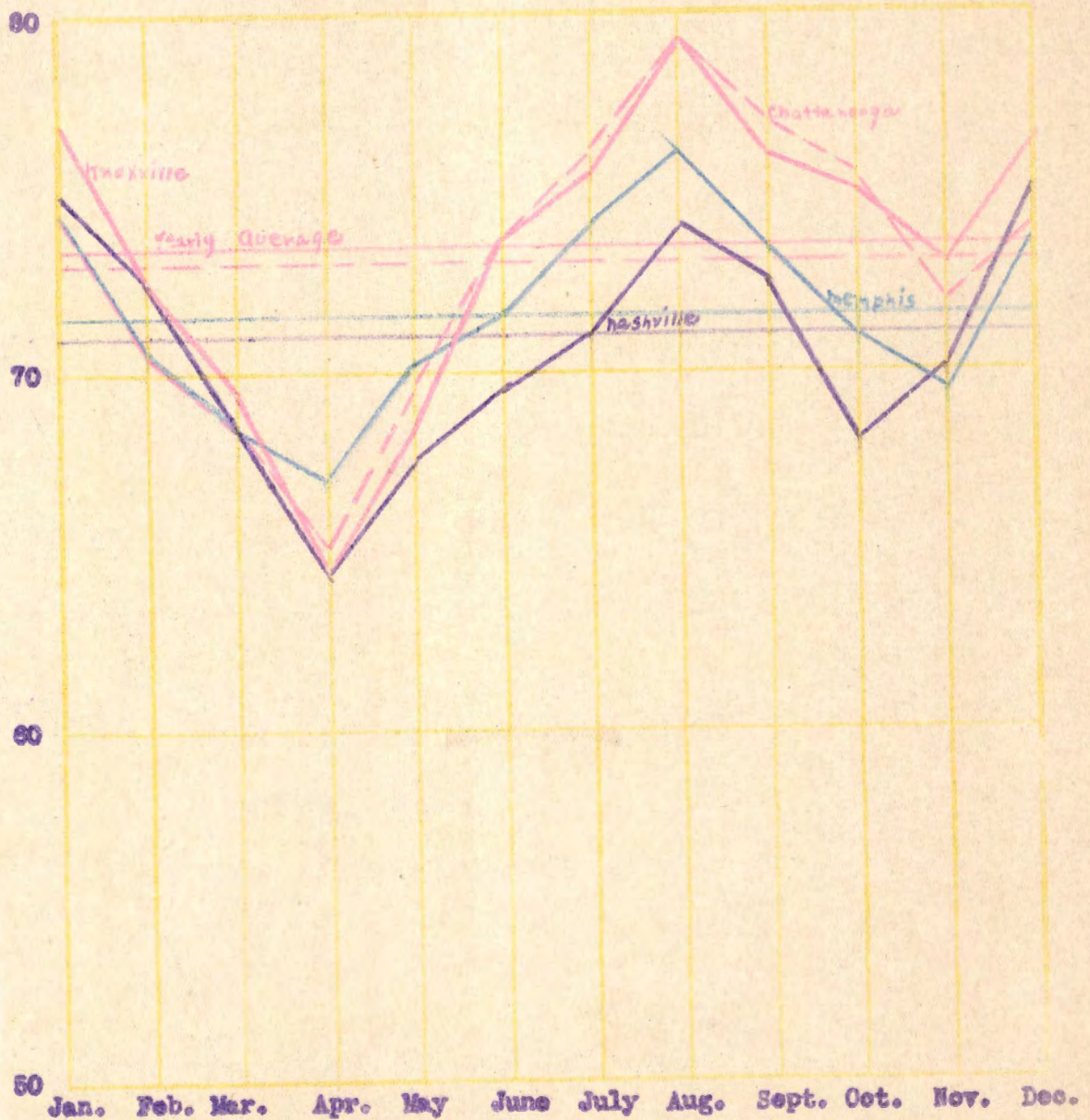
Station	Length of record (yrs.)	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Knoxville 8 A.M. 8 P.M. Average	33 33 33	84 70 77.0	81 64 72.5	79 60 69.5	75 54 64.5	78 59 68.5	81 66 73.5	83 68 75.5	87 71 79.0	85 67 76.0	86 64 75.0	83 63 73.0	84 69 76.5	82 65 73.5
Chattanooga 8 A.M. 8 P.M. Average	42 42 42	80 69 74.5	77 64 70.5	76 61 68.5	74 56 65.0	77 62 69.5	80 67 73.5	82 70 76.0	85 73 79.0	84 70 77.0	84 67 75.5	80 64 72.0	79 69 74.0	80 66 73.0
Memphis 7 A.M. 7 P.M. Average	33 33 33	79 70 74.5	76 65 70.5	74 63 68.5	73 61 67.0	77 63 70.0	78 65 71.5	81 67 74.0	83 69 76.0	81 66 73.5	79 63 71.0	77 62 69.5	79 69 74.0	78 65 71.5
Nashville 7 A.M. 7 P.M. Average	33 33 33	81 69 75.0	80 66 72.5	77 60 68.5	74 55 64.5	77 58 67.5	78 61 69.5	80 62 71.0	84 64 74.0	84 61 72.5	83 58 65.5	80 60 70.0	81 69 75.0	80 62 71.0

(1) See definition of relative humidity, page 71.

Chart 9.

AVERAGE RELATIVE HUMIDITY BY MONTHS IN FOUR
TENNESSEE COUNTIES

Per cent



Source: U. S. Weather Bureau,
Climatological Data,
Tennessee Section.

Generally, the lowest relative humidity in Tennessee is in April and the highest is in August. There is also a low point in October and November, and a high point in January. During winter, spring, and the last part of the fall, there is very little variation in the different parts of the state. During the summer and early fall months Chattanooga and Knoxville are considerably higher than Memphis, and Nashville, with Nashville lower than Memphis. The yearly average for East Tennessee is higher than either Middle or West Tennessee. The latter are approximately the same.

Huntington and Cushing in their discussion of the optimum humidity for human health and energy, state that:

"When the temperature averages about 64 degrees and is therefore close to the optimum for health, the best condition of moisture seems to be a relative humidity of about 80 % for day and night together. - - - - -"

"When the relative humidity at noon falls much below 50% the general conditions of health decline.

"In warm weather, such as we have in summer, high humidity coupled with high temperature is very harmful. On the other hand, extreme dryness is also harmful in summer." (1)

Wind and Storms

Wind may be either beneficial or destructive. According to the Atlas of American Agriculture

"the most important function of wind is the transportation of moisture from the oceans and other large bodies of water to the land, where it is condensed and precipitated in some form of water, for the sustenance of plant and animal life. The surface drift of the wind also has a marked influence on the temperature of many places, especially in localities to the leeward side of large bodies of water."

(1) Huntington and Cushing; Op.Cit., page 251-252.

"In addition to these climatic functions, air movements have an important physiological aspect. They produce a cooling tendency in all conditions of temperature by accelerating the conduction of heat from the body and by increasing the opportunity for evaporation, which is a cooling process. The physical effects of high temperatures are very much modified when accompanied by brisk air movements. But a low temperature which may be even stimulating in a calm becomes unpleasant in windy weather." (1)

Average Annual Velocity. The average annual velocity of the wind in Tennessee is about the same as that of the Eastern part of the United States. The Southeastern and Eastern sections, except along the Atlantic and Gulf Coast, have an average velocity of 6 to 8 miles per hour. Along the Atlantic and Gulf Coast and in the North Central section, the average is 8 to 10 miles per hour. Most of Tennessee is in the area having an average of 6 to 8 miles per hour. The Great Plains Area is highest with 14 to 16 miles per hour. The lowest yearly average is in some of the valleys of the West, where it is only 5 to 6 miles per hour.

The average for this state increases to 8 - 10 miles at 3 P. M. local standard time. This is due to the fact that "the daily march of wind velocity as a rule, except at high elevations, follows closely that of temperature, the minimum occurring soon after sunrise and a maximum in the afternoon near the hour of maximum temperature." (2)

The annual average wind velocity per hour at four places in Tennessee is given by months in Table 11 and Chart 10. Knoxville is lowest with 6 miles. It is followed by Chattanooga with 7, Memphis with 8, and Nashville with 9 miles per hour. The lower velocity at Knoxville and Chattanooga is partly due to the protective influence of the

(1) Atlas of American Agriculture, Part 2, section B., page 31, 1928.
 (2) Ibid., page 34.

Table 11.

Average Wind Velocity by Months at 4 Stations in Tennessee

Station	Yrs. recd.	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Yr.
Knoxville	48	6	7	7	7	6	5	5	4	4	5	5	6	6
Chattanooga	42	8	8	8	8	6	6	6	5	5	6	6	7	7
Memphis	34	10	10	10	10	8	7	7	6	7	7	8	9	8
Nashville	30	10	11	12	11	9	8	7	7	7	8	9	10	9

U. S. Weather Bureau, Summary of the Climatological Data for
United States, Reprint of sections 77 and 78.

mountains. The seasonal changes at the different stations are approximately the same. The highest average wind velocity is from the latter part of winter until the latter part of spring. The velocity is lowest from July to October. The highest monthly average in the state is 12 miles per hour at Nashville during March and the lowest is 4 miles per hour during August and September at Knoxville.

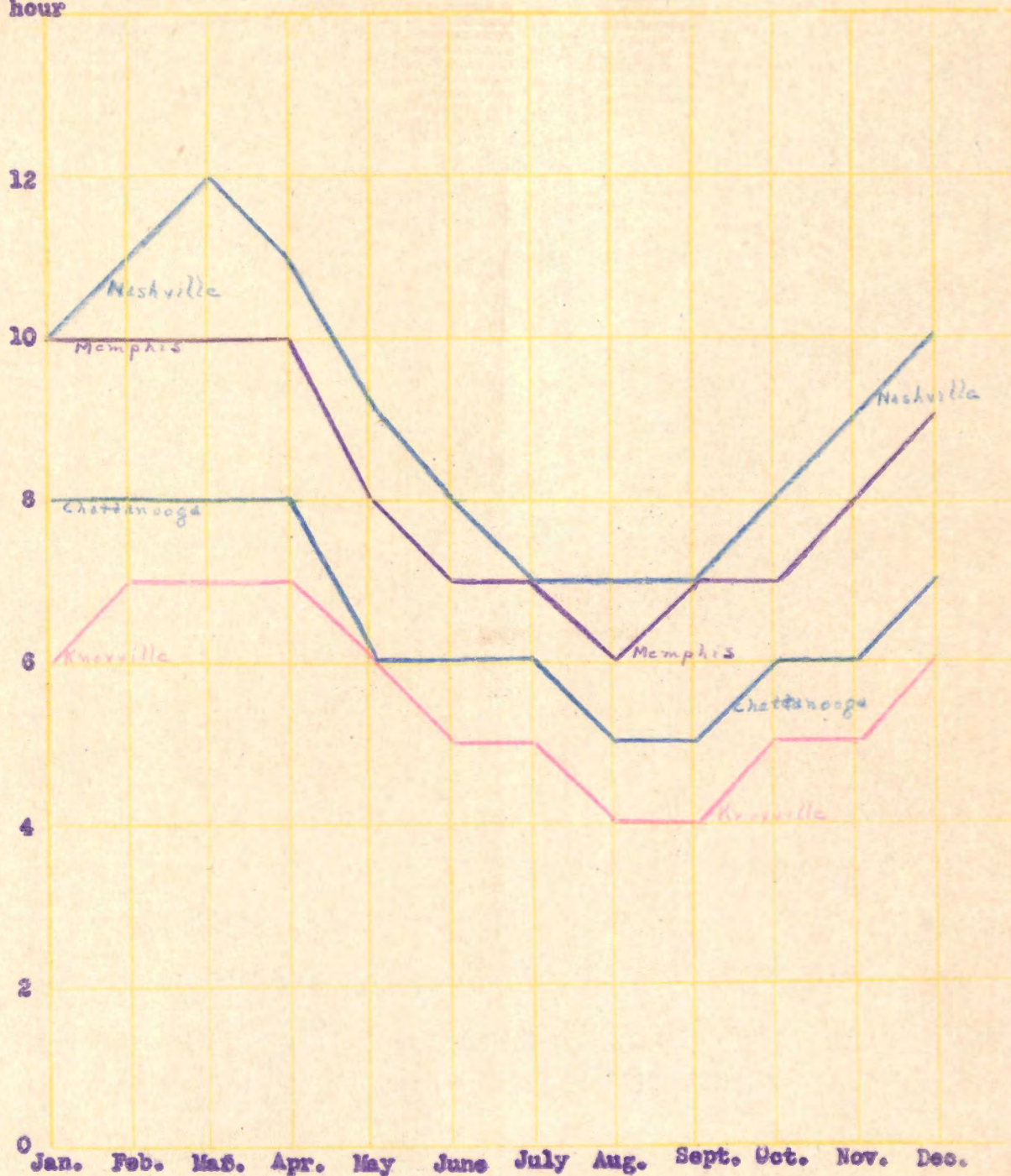
Tornadoes. This type of wind storm is described as "a violent whirling storm of extremely small diameter characterized by a pendant whirling funnel-shaped cloud that progresses rapidly across the country in a rather narrow path that in general is marked by the total destruction of objects in its course. The force of the wind in the vortex of a tornado is too great to measure; trees are uprooted or twisted off and the remnants scattered over the landscape, frame buildings are demolished and those of more enduring construction are severely damaged, heavy objects may be carried up in the funnel cloud only to be dropped to the ground a little farther on." (1)

(1) The World Almanac, 1931, page 86.

Chart 10.

AVERAGE WIND VELOCITY, BY MONTHS, AT 4 WEATHER
STATIONS IN TENNESSEE

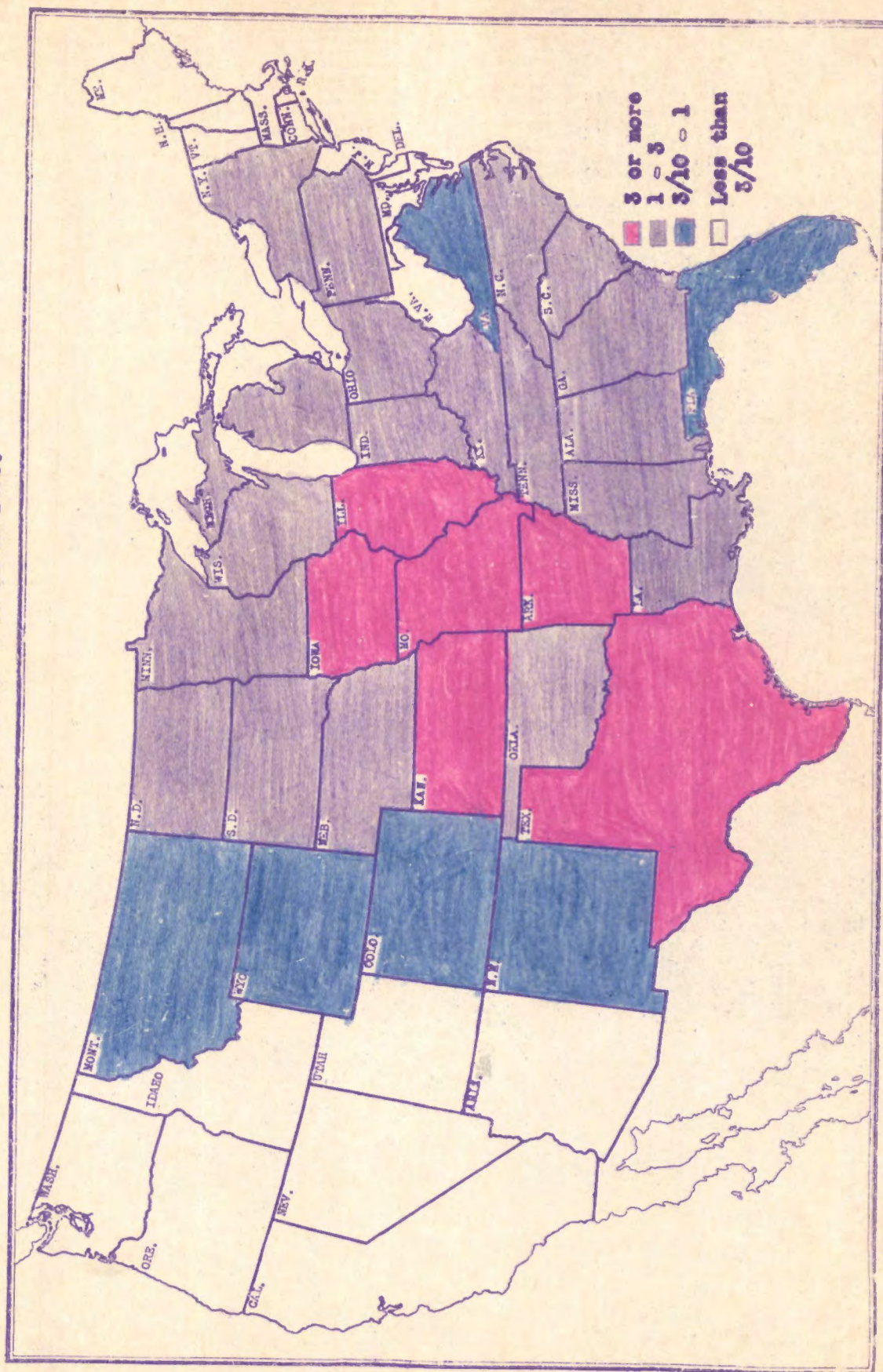
Miles per
hour



Source: U. S. Weather Bureau, Climatological
Data, Reprint of Sections 77 and 78.

Map 30.

AVERAGE NUMBER OF TORNADOES PER YEAR SINCE 1875.



Source: U. S. Weather Bureau, mapped by Associated Press Service for Knoxville Journal, March 29, 1932.

The area of greatest tornado frequency since 1874 is in the Middle Mississippi Valley, west of the Mississippi River, as shown in map 30. (1) An average of 3 or more per year occur in the states of this area, Illinois, Iowa, Missouri, Kansas, Arkansas and Texas. An average of 1 to 3 per year occur in Tennessee, which is in an area of the second highest tornado frequency. This area includes most of the states east of the Mississippi River, and those of the North Central Region. The areas with the fewest tornadoes include the western states from the Rocky Mountains to the Pacific Coast, the New England States and West Virginia.

While Tennessee has had an average of 1 to 3 tornadoes per year considerable annual variations occur. For instance during January, March, and April 1932, there were evidences of eight tornadoes in this state, resulting in the death of thirty-eight persons and more than \$450,000 property damage. (2) Three occurred in West, two in Middle, and three in East Tennessee.

Generally the mountainous areas of the Eastern area of the state are comparatively free from disastrous tornadoes and other wind storms. The United States Weather Bureau explains this in the following quotation:

"The principal weather changes are produced under the influence of storm centers passing along the Gulf Coast, thence up the Atlantic Coast, and those passing from Oklahoma Northeastward to the Great Lakes. This mountain section, therefore, does not lie directly within any of the principal storm tracks that cross the country, and is not subject to such frequent changes as occur, for example, in the Lake region." (3)

(1) The World Almanac, 1931

(1) These figures are not complete, covering only 25 years of the period since 1874.

(2) U. S. Weather Bureau, Climatological Data, Tennessee section, Vol. 37, numbers 1, 3 and 4.

(3) U. S. Weather Bureau, Summary Climatological data for U. S., Reprint, section 78, East Tennessee and Western N. C.

Because of East Tennessee's relative freedom from these destructive winds, the County Mutual Fire Insurance Companies there have insured against property damage by wind without any appreciable loss. However, in Middle Tennessee one county Mutual failed largely because of a disastrous tornado.⁽¹⁾

While tornadoes often render serious damage to areas visited, the probability of a given section being visited is slight. Professor Abbe says that the probability that a given house will be destroyed by a tornado is less than the probability of its being destroyed by either fire or lightning.⁽²⁾

Regarding their seasonal distribution, Nelson's Encyclopedia says that "they may occur in some of the United States in any month of the year. In winter and in early spring months they occur in the Gulf and South Atlantic states only, but with the advance of the season they occur farther and farther to the northward. June is the month of greatest frequency in the Mississippi Valley; February and March in the East Gulf and South Atlantic States; July and August in the Middle Atlantic States and New England." ⁽³⁾

The frequency in the United States was greatest in the spring and early summer, during the period from 1916 - 1930, as shown in Chart 11. Slightly more than 75 per cent occur in March to June inclusive.⁽⁴⁾

(1) Robinson, T. L., Six Types of Cooperation.

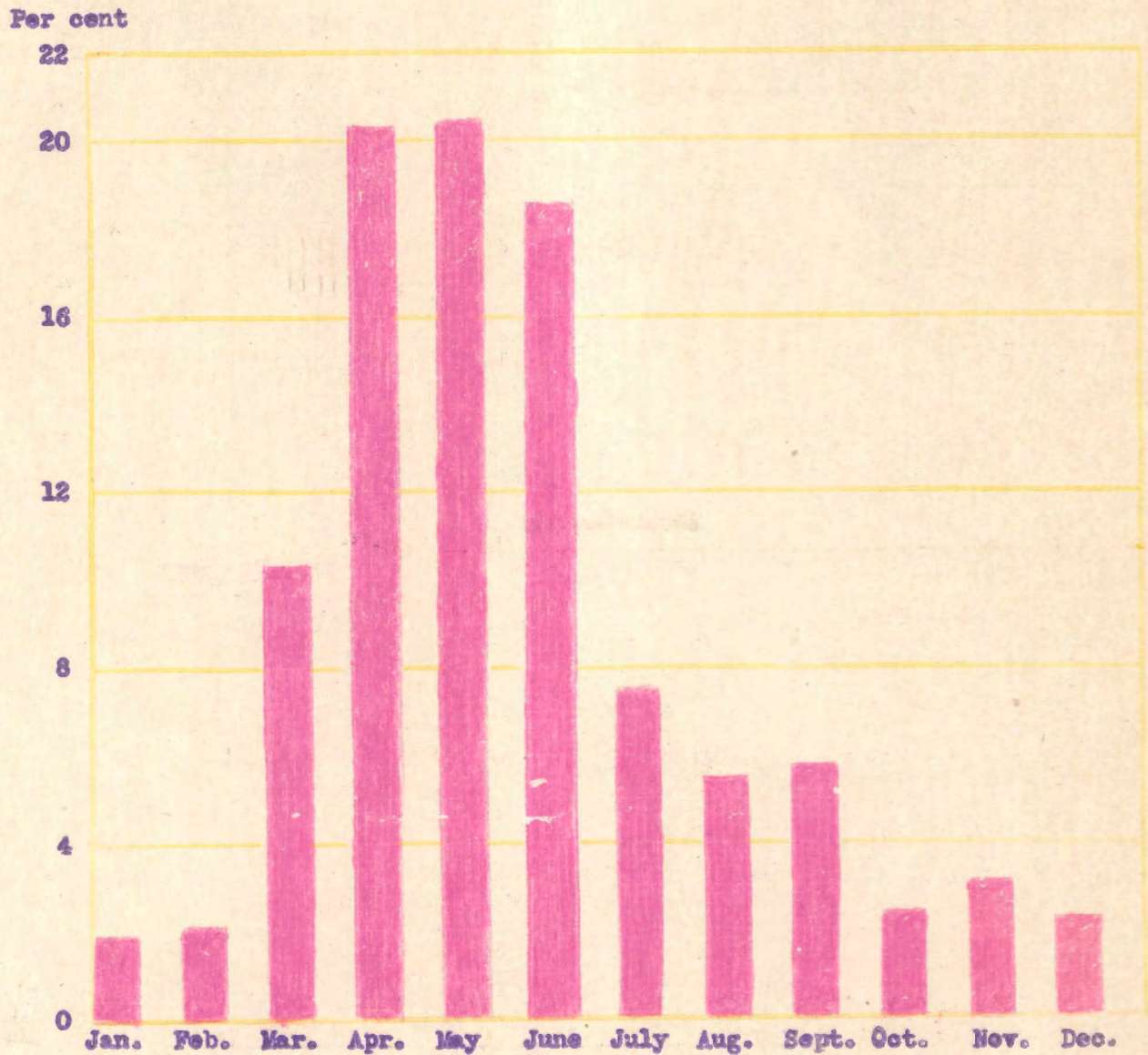
(2) Nelson's Encyclopedia - Volume 12.

(3) Nelson's Perpetual Loose Leaf Encyclopedia, Vol. XII.

(4) Aetna Life Insurance Bulletin, April 1932.

Chart 11.

TORNADO
SEASONAL ~~WINDSTORM~~ FREQUENCY IN THE UNITED STATES, 1916-1930



Source: Aetna Insurance Bulletin, 1932.

Cyclones. This term is frequently applied erroneously to tornadoes, which were described above. "Properly speaking a cyclone is a system of winds, usually moderate, but occasionally very strong, an area of low barometric pressure, and often circular or oval in form." (1)

The cyclonic storms move about a central area of low pressure that include ordinary rain and snow storms. They therefore represent opposite extremes from tornadoes in atmospheric disturbances. They often cover a wide area; (2) sometimes continue for several days; and may travel across the continent. On the other hand tornadoes cover a narrow path, often a few hundred yards, are often less than an hour in duration; and travel for short distances. (3)

Tennessee is visited on the average of four to eight times per year by cyclones. Map 31 shows that from 1892 to 1912 the Western part of the state had from six to eight per year, while Middle and Eastern Tennessee had an average of four to six. The frequency here is exceeded only in the Mid-West and the Western states East of the Rocky Mountains.

"The most advanced parts of the world-----are the regions of cyclonic storms. They have three chief characteristics:

- (1) Rainfall in moderate abundance at all seasons.
- (2) The weather is subject to marked changes every few days. These two characteristics are both due to the frequent passage of cyclones followed by anti-cyclones.

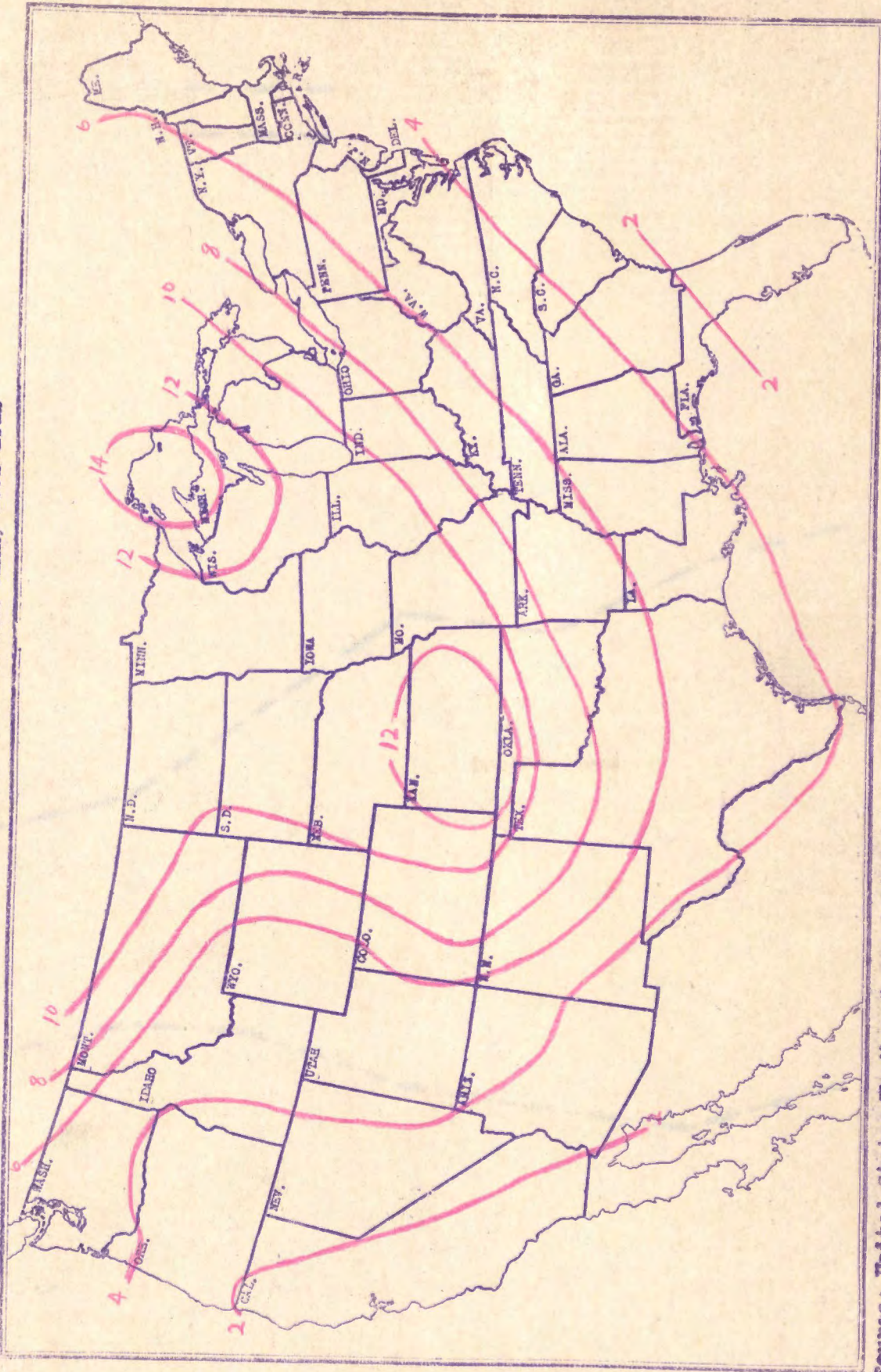
(1) The World Almanac, 1931, page 86.

(2) Those of the temperate zone sometime have diameters of 1,000 miles (1931 World Almanac).

(3) Nelson's Loose Leaf Encyclopedia, Vol. XII.

Map 31.

AVERAGE NUMBER OF CYCLONES PER YEAR, 1892-1912



Source: United States Weather Bureau, Monthly
Weather Review, January 1932, p. 10.

(3) The seasons are strongly pronounced. The winters are cool, or more often cold, and the summers warm or hot, thus the regions of cyclonic storms are particularly favorable not only to agriculture because of the sufficiency of rainfall throughout the year, but to man because of the variations in weather from day to day and from season to season." (1)

These regions form two irregular belts around the world, and include most of the United States and Southern Canada. Tennessee is a portion of one of the world's most favored regions.

Thunderstorms. (2) "There are two recognized classes of thunderstorms, which have been designated "heat" thunderstorms and "cyclonic" thunderstorms. Those of the first-named class usually develop on hot summer afternoons in regions of weak barometric gradient and moist, quiet air; while those belonging to the other class occur under the influence of cyclonic storms----- The breaking up of a long heated period is frequently attended by thunderstorms of rather marked severity which are more or less connected with cyclonic action." (3)

As precipitation during warm or crop growing season in the United States results largely from thunderstorms, these local atmospheric disturbances are of great importance agriculturally.

(1) Huntington and Cushing----Principles of Human Geography, Page 329.

(2) Atlas of American Agriculture, Part II Climate, Section A.

(3) Ibid, Page 44.

Thunderstorms, in the United States, are most frequent in a small section along the central and eastern Gulf Coast where they occur on an average of 80 to 90 days annually. Southern and Western Tennessee is an area that has an average of 60 - 80 days with thunderstorms. This area includes the Gulf States, except Texas, and a part of Arkansas, Georgia, and a small corner of the Carolinas. The North Central and Eastern part of Tennessee has thunderstorms on an average of 40 - 60 days annually, which is the same as that for most of the central part of the country. Along the northern part of the United States the average is only 20 - 40 days and along the Pacific Coast under 20 days.

These storms sometimes result in considerable damage from the heavy rainfall, hail, wind and lightning. The area of destruction is usually not extensive for an individual storm, but several may occur in quick succession on the same day.

Why Storms are Beneficial to Human Health and Energy. Changes in other respects as well as in temperature are highly desirable. For instance, steady sunshine is not nearly so good as a period of sunshine and then one of clouds and rain. But too much cloudiness also leads to ill health and to inefficiency. What is needed is frequent changes of all sorts, not too extreme, but quite frequent. For this reason the countries in the region of cyclonic storms are particularly fortunate. They enjoy changes in weather every few days. Except when very severe the storms of Middle latitudes are a blessing.(1)

(1) Huntington and Cushing---Principles of Human Geography. Pages 253 and 254.

Lightning

Thunderstorms are often accompanied by considerable precipitation, impressive thunder and destructive lightning. In East Tennessee the intensity of the lightning is not great, according to investigations made by Westinghouse Electric and Manufacturing Company in East Tennessee.⁽¹⁾ They report as follows:

"We have reached a tentative conclusion that in this part of Tennessee while the thunderstorms are quite frequent they are not particularly severe, that is to say, the intensities of the lightning strokes did not appear to be very great. It appears that the altitude of the thunderclouds is rather low which will account for low intensity of the lightning strokes, since the cloud discharge to earth will take place at a lower energy content than if the altitude were greater." (2)

The economic value of lightning is indicated by the following quotation:

"Every time the lightning flashes fertilizer is being added to the earth, according to computations made by Dr. W. J. Humphreys, of the U. S. Weather Bureau. Ozone of the lower atmosphere ammonia and oxides of nitrogen are produced by the electrical discharge of the thunderbolt in the atmosphere. All of these synthetic chemicals made by lightning reach with water in the air. The ammonia dissolves in rain, becomes ammonium hydroxide, and serves as plant food. The nitrogen oxides react with atmospheric water to form nitric and nitrous acids carried to earth to form soluble nitrates and nitrites which are good fertilizers. Over 770 million tons of 100% nitrogen fertilizers are thus delivered to the soil each year, at the average of 12 pounds per acre per year. It is thus believed that regions where lightning is frequent and heavy may be more fertile because of this free gift of lightning--made nitrogen compounds." (3)

(1) Investigations were started in 1928 on the transmission lines of the Aluminum Company of America at Chilhowee, near Little River, and on the other side of Chilhowee Ridge near Maryville. These were discontinued in 1930.

(2) Letter from Charles Fortesque, Consulting Engineer, Westinghouse Electric and Manufacturing Company, September 22, 1931.

(3) Science (supplement) January 29, 1932, page 9.

There are three classes of lightning, forked, sheet, and ball.⁽¹⁾ Forked lightning appears to the eye as a single blinding streak of light, and sometimes breaks into one or two branches. It is often a rosy or violet tint. Sheet lightning has no definite form. It is generally of a rosy or red tint and appears in the distant horizon lightning up the clouds, dust, or haze in the atmosphere. Ball lightning appears like a small globe of brilliant light moving slowly through the air at a short distance from the ground, or even rolling along the ground itself. It generally breaks up with an explosion, which, however is not very destructive or dangerous.

There was an occurrence of ball lightning in May 1932 in Union County, near Loyston, Tennessee with some damage reported according to the Knoxville Journal.

"Examination of the ground by the weather bureau men showed that the bolt had struck a cedar tree, from which there was a clearly marked path along a ledge of rock, from which pieces had been chipped.

"But just before the bolt left the rock, a piece of the rock weighing more than 100 pounds was broken off and thrown about 30 feet across a ditch," declared Huff.

A barbed wire fence across the ditch was fused in places and oxidized as though it had been in a fire, another tree was struck, and the bolt had traveled along the wire to still a third tree, where it split in two directions.

It also had struck a woven wire fence around the Stooksbury house and caused four sturdy fence posts to lean."

(1) The New International Encyclopedia.

Hail

Hail occurs in this state an average of 1 to 2 days per year during the growing season. In fact the area East of the Mississippi is relatively free from hail, the occurrence averaging about 1 day per year. The occurrence in the different areas is shown by the following quotation. (1)

"It occurs with much greater frequency in the Plains States and the Rocky Mountains region than in other parts of the country. In central and southern California and along the immediate Atlantic and Gulf Coasts it seldom occurs, and in general, it is infrequent east of the Mississippi, occurring in these districts on the average only about once during each year."

The occurrence of hail does not necessarily result in serious damage to crops, as the fall may be only of small amount, doing no harm. Hail storms are often extremely local in character; great damage may be done on a single farm while others adjoining may escape unharmed.

Fog

"The regions of greatest frequency of dense fogs are found along the Pacific and North Atlantic coasts, over the central and southern portions of the Appalachian Mountain region and along the Western Gulf Coast. The region of least frequency comprises the districts between the Rocky Mountains and the Pacific Coast States, where, as a rule, there are fewer than five foggy days during the year. Fog generally is of infrequent occurrence throughout the interior portion of the country, most of those districts having an annual average fewer than 10 days with dense fog." (2)

(1) Atlas of American Agriculture, Section A, Part II, Page 44.

(2) Ibid.

The eastern part of Tennessee is in the southern Appalachian region where dense fogs occur on an average of 20 - 30 days annually.⁽¹⁾ The southwestern part of the state is similar to the section west of the Mississippi to near the Rocky Mountains areas that have dense fog only 5 to 10 days annually. The central, or the larger part of the state, has dense fog on an average of 10 to 20 days. This is similar to a narrow area in the southern and eastern part of the country, except the high areas of the Appalachian region, West Gulf Coast, and the New England Coast.

(1) Atlas of American Agriculture, Op. Cit.

CHAPTER II

MINERALS AND MINING IN TENNESSEE

Historical Development

Minerals have been important in Tennessee from the time of the early settlers. According to reports, salt was the first of the minerals in the state to be used. A slight fault in the rocks near Nashville permitted salt water to come to the surface. Bones found near this place show that wild animals, some of which are now extinct, and man had gone there for salt. (A body of French moving up the Cumberland River in 1714, found this salt water and settled there.) In 1789 public measures were passed to encourage making salt in Middle Tennessee because at that time the supply had to be brought in from Missouri at a cost of sixteen cents per pound.

Soon after the settlement of East Tennessee began in 1768, minerals, especially iron, was discovered, and before the end of the eighteenth century iron making began.) The first iron mining project in West Tennessee was the building of the Cumberland furnace in Dickson County in 1790 - 95. (In 1802 lime was being made in Knoxville and shipped to New Orleans by boat.) (Caves were searched for niter, which was used in making gun powder, especially during the war of 1812.) This soon stopped, however, after the close of this war. (Lead and marble had been discovered and were being mined in East Tennessee about 1820 - 25.)

Next came a period of organized effort to develop the mineral wealth of the State. In 1831 Dr. Troost, who was State Geologist, knew of the occurrence of zinc, lead, manganese, gold,

marble, and slate, but did not consider these minerals as important as iron and coal.

Gold was discovered in 1830 in the Ocoee District on Coker Creek, and in the Tellico Rivers. In his ninth report in 1850, Dr. Troost described the various zinc deposits of the state and methods of extracting and smelting them, which shows that he must have considered this mineral valuable. Dr. Troost considered the coal, iron, marble, roofing slate, lead, zinc, and other minerals as probably of much value, but he did not regard the gold of East Tennessee nor the lead of Middle Tennessee as having great value.

By 1842 there was a number of iron furnaces and foundries in upper East Tennessee, some marble had been quarried near Rogersville. The U. S. census of 1840 gave Tennessee third rank in the U. S. in iron production. Forty seven furnaces and 92 bloomeries and rolling mills were reported in the state in 1849. According to 1850 census Tennessee was fifth in the U. S. with a production of 30,200 tons of pig iron. In 1854 the production was 40,300 tons worth \$2,000,000, and an estimated production of 50,000 tons in 1856.

(The Ducktown copper deposits were discovered in 1843 in searching for placer gold, and in 1849 some black copper ore was sent to Boston.) By 1853 the production of copper was sufficient to attract attention. In 1859 the sulphide ores were being roasted and smelted. These were producing 40 to 50 per cent copper matter for shipment.

"In a few years immediately preceding and following the Civil War, numerous mining schemes were launched, and the prospectus for each usually contained a geological report on the property. In Tennessee these were usually zinc, copper, coal or iron prospects before the war, but just after it most of the reports were on oil and gas lands.

These numerous reports rarely contained anything of general geological value, and most of the prospects were ill advised and amounted to nothing." (1)

The most important events during the period 1890 - 1900 were the discovery of phosphate, and the geological work of the U. S. survey. (From 1900 to 1910 the prominent events were the development of the phosphate industry, the beginning of modern coal work, and the establishment of the present geological Survey.) Later developments are given in connection with the discussion of each mineral.

Importance of Minerals (2)

The Basic Minerals. Few think of the part minerals play in city life, in the farmer's life and in the country's development in general. It is true that initial prosperity depends on agriculture, and in the past ages the rich agricultural counties were dominant in world affairs. Now conditions have changed and for a country or subdivision to have a dominant place it must be able to produce, in quantity and cheaply, mineral wealth, in addition to purely agricultural wealth. It must have developed and have in reserve the great basic minerals of this age: iron, aluminum, copper and zinc. It must have the power necessary for turning these minerals from the raw ore state into the finished metal ready for the hands of the artisan to fashion, by our intricate machinery and industrial processes, into the major articles of commerce.

Agricultural Wealth. And even our agricultural wealth would be a thing of the past, only existing in areas of virgin soil or

(1) Glenn, A. C., The Growth of Our Knowledge of Tennessee, geology. The Resources of Tennessee, May 1912, Vol. 2, No. 5, Page 193.

(2) State Geology Survey Bulletin Number 25, 1921, page 7 and 8.

river flood plains, if it were not for the mineral fertilizers which come to the farmers aid, phosphate and lime, and nitrogen from the air thru our cheap hydro-electric power possibilities.

Tennessee's Wealth. Is there any other section in the world more blessed in mineral resources and resources of motive power than Tennessee? (We are mining in large quantities the basic minerals necessary in industry, and producing phosphate from one of the largest fields of such in the world, with an additional abundance of limestone for agricultural use. We should with our transportation facilities be one of the richest and best industrial and agricultural regions in the world. That we are not was due, in past, partly to lack of knowledge of our resources, but mostly to lack of consistent advertising. All industries of the state should disseminate accurate information on our advantage from an industrial standpoint due to our diversified interest. That such a diversity of natural resources is advantageous is shown by the per capita purchasing power of the citizens of the state, \$661.00, and particularly the per capita purchasing power of its capital city, Nashville, which amounts to \$898.00, being the highest of any city in the south.

Tennessee's Relative Importance as Mineral Producing State.

In 1929 Tennessee ranked 24th among the states in the value of mineral production, producing 0.79 per cent of the total value for the United States (Table 12). The U. S. average was 2 per cent. While this is a small proportion of the U. S. total, the approximately \$40 million production has a considerable influence on the business and industries of the state.

Among the neighboring states of Tennessee, Kentucky held

Table 12.

Value of Mineral Production, by States: Total in 1929, and Per Cent of U.S. Total in 1929, 1925.

Rank	State	(000 omitted) Total Value		Percentage of U. S.		Rank	State	(000 omitted) Total Value		Percentage of U. S.	
		1929 (1)	1925	1929	1925			1929 (1)	1925	1929	1925
1	Pa.	892,914	17.40	17.29	17.40	25	Virginia	39,753	0.82	0.77	0.82
2	Calif.	554,916	9.97	10.74	9.97	26	N. M.	37,128	0.51	0.72	0.51
3	Okla.	516,685	10.07	10.00	10.07	27	Nevada	36,776	0.53	0.71	0.53
4	Texas	495,820	7.05	9.60	7.05	28	Iowa	35,955	0.77	0.70	0.77
5	W. Va.	346,565	6.69	6.71	6.69	29	Idaho	32,143	0.63	0.62	0.63
6	Ohio	220,061	4.97	4.26	4.97	30	Wisconsin	24,222	0.39	0.47	0.39
7	Ill.	182,791	4.65	3.54	4.65	31	Washington	22,435	0.45	0.43	0.45
8	Ariz.	157,960	2.29	3.06	2.29	32	Maryland	18,470	0.43	0.36	0.43
9	Nich.	151,976	2.45	2.94	2.45	33	Mass.	16,031	0.34	0.31	0.34
10	Minn.	136,350	2.21	2.64	2.21	34	Georgia	15,294	0.33	0.30	0.33
11	Ky.	132,650	2.64	2.57	2.64	35	Florida	14,804	0.33	0.29	0.33
12	Kans.	124,472	2.87	2.41	2.87	36	Vermont	14,603	0.29	0.28	0.29
13	Utah	115,131	2.01	2.23	2.01	37	N. C.	10,964	0.19	0.21	0.19
14	N. Y.	109,361	2.05	2.12	2.05	38	S. D.	8,914	0.16	0.17	0.16
15	Ind.	96,962	2.24	1.88	2.24	39	Conn.	7,053	0.14	0.14	0.14
16	Mont.	93,842	1.59	1.82	1.59	40	Oreg.	6,877	0.13	0.13	0.13
17	Mo.	78,948	1.86	1.53	1.86	41	Maine	6,749	0.12	0.13	0.12
18	N. J.	71,892	1.54	1.39	1.54	42	Nebraska	4,845	0.07	0.09	0.07
19	Ala.	65,402	1.55	1.27	1.55	43	N. H.	3,724	0.07	0.07	0.07
20	La.	62,726	1.21	1.21	1.21	44	S. C.	3,592	0.07	0.07	0.07
21	Colo.	55,532	1.27	1.07	1.27	45	N. D.	3,466	0.05	0.07	0.05
22	Kyo.	51,237	1.58	0.99	1.58	46	Miss.	2,573	0.04	0.05	0.04
23	Ark.	41,325	1.75	0.80	1.75	47	D. C.	1,065	0.02	0.02	0.02
24	Tenn.*	40,720	0.78	0.79	0.78	48	R. I.	940	0.02	0.02	0.02
						49	Del.	467	0.01	0.01	0.01
	Col. Tot.	4,796,037	92.69	92.86	92.69		Col. Total	368,840	6.94	7.14	6.94
	Col. Av.	199,835	3.86	3.87	3.86		Col. Av.	14,754	0.28	0.29	0.28
	Col. Pet.	92.9	92.69	92.86	92.69		Col. Pet.	7.1	6.94	7.14	6.94
	U.S. Tot.	5,164,878	100.00	100.00	100.00		U. S. Av.	105,406	2.04	2.04	2.04

(1) Iron ore, not pig iron, is taken as the basis of valuation of iron, and in the case of other metals mine production (recoverable content of metals) is the basis.

Source: Mineral Resources of U. S. Summary: Bureau of Mine, 1930 and 1926.

11th place in the United States in 1929, Missouri 17th, Alabama 19th, Arkansas 23rd, Virginia 25th, Georgia 34th, North Carolina 37th, South Carolina 44th, and Mississippi 46th. Only four states of this group, Kentucky, Missouri, Alabama, and Arkansas were higher than Tennessee. In 1929 the value of mineral produced in Tennessee was greater than the total production of Oregon, Maine, Nebraska, New Hampshire, South Carolina, North Dakota, Mississippi, District of Columbia, Rhode Island, and Delaware combined (Table 12). The leading states having more than \$200 million value, are Pennsylvania, California, Oklahoma, Texas, West Virginia and Ohio.

The relative importance of Tennessee among the other states in the value of her principal minerals produced is shown in table 13. In the production of coal, Tennessee's most valuable mineral, this state ranked 14th in U. S. and 5th in the South with a production valued at \$9,122,000. In the production of stone valued at more than \$8 million Tennessee was 9th in U. S. and 1st in the South, and was second in U. S. in production of phosphate, Florida being the only state ranking higher. Tennessee was 3rd in U. S. in production of Barite. It can be seen from this table that Tennessee ranks relatively high in the U. S. in production of her principal minerals. Her rank in U. S. ^{is} from second place in production of phosphate, which is fifth in value of minerals produced in the state, to 23rd place in the production of natural gas.

Table 13.

Relative Importance of Tennessee among other states in Value of Her Principal Minerals Produced 1929.

Mineral	Rank of Tennessee in Value in U. S.	Value of Tennessee's Principal Minerals Produced	States That Rank Higher in Order of Pro- duction
Coal	14	\$9,122,000	Pa., W. Va., Ill., Ky., Ala., Ohio, Ind., Colo., Va., Wyo., Utah, Iowa, Oklahoma.
Stone	9 [✓]	8,043,006	Ind., Pa., N. Y., Ohio, Calif., Vt., Mich., Mass.
Cement	12	5,576,235	Pa., Calif., Mich., W. Y., Ohio, Texas, Mo., Ill., Kansas, Iowa, Ala.
Clay Products	17	3,695,837	Ohio, Pa., N. J., Ill., Calif., W. Va., Ind., N. Y., Mo., Ky., Mich., Tex., Ia., Md., Ga., Ala.
Phosphate	2 [✓]	3,097,104	Fla.
Sand & Gravel	18	2,086,535	N. Y., Pa., Ohio, Ill., Calif., Mich., Tex., N. J., Ind., Wyo., Mo., Mass., Wisc., Md., Minn., Ia. W. Va.
Iron, pig	8 [✓]	1,938,238	Pa., Ohio, Ill., Ind., N. Y., Ala., Mich.
Coke	12	1,086,374	Pa., Ind., Ohio, Ill., N. Y., Mich., Ala., Minn., Mass., W. Va., Va.
Lime	9 [✓]	1,036,405	Ohio, Pa., Mo., W. Va., Mass., Ala., Wisc., Va.
Clay, raw	9 [✓]	585,061	Pa., Ga., Mo., N. J., Ohio, S. C., Calif., Ky.
Iron ore, sold to furnaces	9 [✓]	234,827	Minn., Mich., Ala., Wisc., N. Y., Pa., N. J., Mo.
Barite	3 [✓]	181,725	Mo., Ga.
Silver (1)	11	51,246	Utah, Mont., Ida., Ariz., Nev., Ga., Calif., N. M., Texas, Missouri.
Petroleum	19	30,000	Okla., Texas, Calif., Kansas, Pa., La., Wyo., Ark., W. Va., Ohio, Ky., N. Y., Ill., Mont., Mich., Colo., N. M., Ind.
Manganese ore*	9 [✓]	14,235	Minn., Ark., Ga., Va., N. Mex., Mich., Ariz., Nev.
Gold (2)	14	13,500	Calif., S. D., Utah, Colo., Ariz., Nev., Mont., N. M., Ida., Oreg., Wash., Texas, Pa.
Natural gas	23	10,700	W. Va., Calif., Texas, Okla., Pa., Ohio, La. & Kansas, Ky., N. Y., Wyo., Ark., Mont., Mich., Colo., N. M., Ind., Ill., Utah, Mo., S. D., Miss.

* Includes manganese ore (1) Valued at average N. Y. price of bar silver as follows: 1929, 53.3 cents an ounce
 (2) Gold Value, \$20.67 - a troy ounce.

Source: Mineral Resources of the U. S., 1930 (Summary).

Tennessee As a Mineral State.

In 1929 Tennessee held 25th place in U. S. in the value of minerals produced, with a production of 0.79 of U. S. total value (Table 14). In 1920 Tennessee ranked 23rd. During the periods shown in this table, this state's rank has varied from 24th to 26th.

In 1900 Tennessee produced 0.78% of the U. S. total. The greatest percentage total produced by Tennessee during this period was 1.08 per cent in 1910. In no other year did the proportion amount to 1 per cent. In 1915 Tennessee ranked 25th in U. S. and in 1929 24th. The highest place was 22nd in 1921. From this Tennessee seems to be holding its place in the United States with no considerable gain or loss.

Table 14.

Trend in Value of Total Mineral Production in Tennessee and Rank in U. S. 1900-1930.

Date	Total Value	Per Cent of Total U. S.	Rank in U. S.
1930	28,279,832	0.59	
1929	40,719,706	0.79	24
1928	39,216,757	0.82	24
1927	37,874,981	0.77	25
1926	39,296,668	0.71	25
1925	38,869,198	0.78	25
1924	35,354,525	0.67	26
1923	41,553,789	0.69	26
1922	35,146,266	0.85	25
1921	33,754,823	0.81	22
1920	55,023,232	0.79	25
1915	22,166,494	0.92	25
1910	21,396,784	1.08	
1900	8,651,904	0.78	

Source:

- 1900 } 1931 Blue Book of Southern Progress
- 1910 }
- 1915---Mineral Resources of U. S., 1915, Part I
- 1920-1924- World Almanac, 1928, page 356.
- 1925-1929- Mineral Resources in U. S., 1930
- 1930- Estimated by totaling value of products given in Mineral Resources of Tennessee, 1930.

Variety of Minerals in Tennessee.

While Tennessee is not a leading state in mineral production a large variety of minerals have been found in the state. However, only a few are produced in large quantities.

There are several metallic and a large number of the non-metallic minerals found in the state. The metals are, cobalt, copper, gold, iron, lead, manganese, silver, and zinc. The non-metals that have been found are, alum, bauxite, barite, calcite, chert, clay, coal, epsomite, dolomite, fluorite, granite, gravel, greensand, iron ore, lignite, limestone, lithographic stone, marble, mica, mineral water, nitrates, natural gas, petroleum, phosphate, pyrite, quartz, sand, sandstone, shale, silica, slate and tripoli.

Table 61 gives the production and value of the minerals that were mined in 1930 in Tennessee. Of the eight metallic minerals that occur in the state, seven were mined in 1930. Copper ranked first among the metals with a value of over three million dollars, and zinc second with a value of over a million dollars. The total value of all the metals produced was \$4,618,137.

Coal led the non-metallic minerals in the value of the production in 1930, with a value of \$8,577,242. The value of marble and phosphate produced was over two million dollars each, and sand and gravel over a million dollars.

The total value of the non-metallic minerals produced in 1930 was \$16,875,983 , and the value of all minerals was \$21,494,120

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- (1) Does not include production of products made from the original minerals. (See Table 15)
 - (2) Some minerals that have been produced in the past were not mined in 1930. They are discussed separately in another section of this chapter.

Table 15

Mineral Production in Tennessee, 1930⁽¹⁾

	Production	Value
Metallic:		
Copper, pounds	✓ 18,801,177	✓ \$3,309,007 (2)
Silver, fine ounces	26,092	9,340
Gold, fine ounces	251	5,024
Iron ore, tons	23,278	46,566
Manganese, tons	446	10,822
Zinc ore, tons	605,776	1,236,660
Lead ore, tons	29	718
Total metallic		\$4,618,137
Non-metallic:		
Barytes, tons	10,045	67,483
Coal, tons	5,382,607	✓ 8,677,242
Clay, tons (3)	52,105	325,831
Stone, flagging, sq. ft.	316,408)	97,884
rubble, tons	3,169)	
Lime, tons	72,165	477,040
Limestone, tons	1,203,676	982,104
Marble, cubic feet	1,511,789	2,178,387
Phosphate, tons	592,809	2,890,065
Sand and gravel, tons	1,991,544	1,145,433
Crude oil, barrels	21,844	34,514 (2)
Total non-metallic		\$16,875,983
Grand total		\$21,494,120

- (1) Does not include cement, clay products and pottery, pig iron, coke sulphuric acid and mineral paints which are produced from minerals, included in the above table.
- (2) Values calculated by multiplying average price in U. S. in 1929 by the quantity in Tennessee, 1930. (Price from U. S. Mineral Resources, 1930, Summary)
- (3) Includes ball, sagger and wad clays from Carroll, Henry & Weakley Cos.

Source: Mineral Resources of Tennessee, Annual Report of Division of Mines, 1930.

Coal

Use. Coal, according to scientist, is the remains of partially decomposed plants. This exist in the form of anthracite or hard coal, bituminous or soft coal, lignite, and peat. The peat and lignite have little value. Peat makes a low grade fuel, and lignite can be used for making producers gas.

Coal is used principally as fuel for the production of power and heat. It is also used for the manufacture of coke and gas, which in turn are used for fuel. A number of chemical products such as dyes, antiseptic, medicines and drugs are made from the tar and gases from coal. (1)

Coal Regions and Reserves of the World. In 1929 the estimated reserve coal supply of the world was 7,863,556,000,000 metric tons. If this amount were loaded on coal cars, 50 metric tons per car, and hooked up as a train, it would be long enough to extend around the earth (47,650) times at the equator. If the train were traveling at 40 miles per hour it would require 3,390 years for the entire train to pass a given point. (2)

According to Table 16 the North American continent has 66.4 (3) per cent of the world supply of coal. The United States and Alaska alone have 52.3 per cent of world supply. West Virginia

(1) State Geology Survey, The Mineral Resources of Tenn. Vol 3, No. 4.

(2) Factors used in calculation:

(a) Metric ton is equivalent to 22,046 pounds.

(b) Assumed length of freight car, 40 feet.

(c) Capacity of car, 50 metric tons.

(3) World Almanac, 1931, Page 295.

has almost as much as all of Europe including the British Isles; and Pennsylvania has practically as much as West Virginia.

China is the only country, except the United States whose coal supply in metric tons is over 1,000 billions. China had 14 per cent of the world supply. The continent of Asia had a combined supply of 1,900 billion, or 24.2 per cent of the world's total.

The continents of North America and Asia then have approximately 86 per cent of the world's coal reserve. The remainder is divided between Europe, Australasia, South America, and South Africa.

Coal Areas in Tennessee and the United States. The coal bearing area of Tennessee is a part of the Appalachian field which extends for a distance of 875 miles in a southwest direction from the northern part of eastern Ohio and western Pennsylvania into northern Alabama.

The coal area in Tennessee is coextensive with the Cumberland Plateau and covers approximately 5,100 square miles. This and other coal areas of the U. S. are shown on map 32.

The Tennessee field, which is 35-50 miles in width, extends across the state in a northeast and southwest direction.

This area is divided into what is known as the northern field and the southern field. In the former the coal beds are similar to those in Kentucky; and in the latter they are similar to the Alabama coal beds. The Tennessee Central Railway is considered the boundary line between the northern and southern fields; however it is not an exact dividing line.

The southern field includes parts of Bledsoe, Franklin, Grundy, Hamilton, Marion, Putnam, Rhea, Sequatchie, Van Buren,

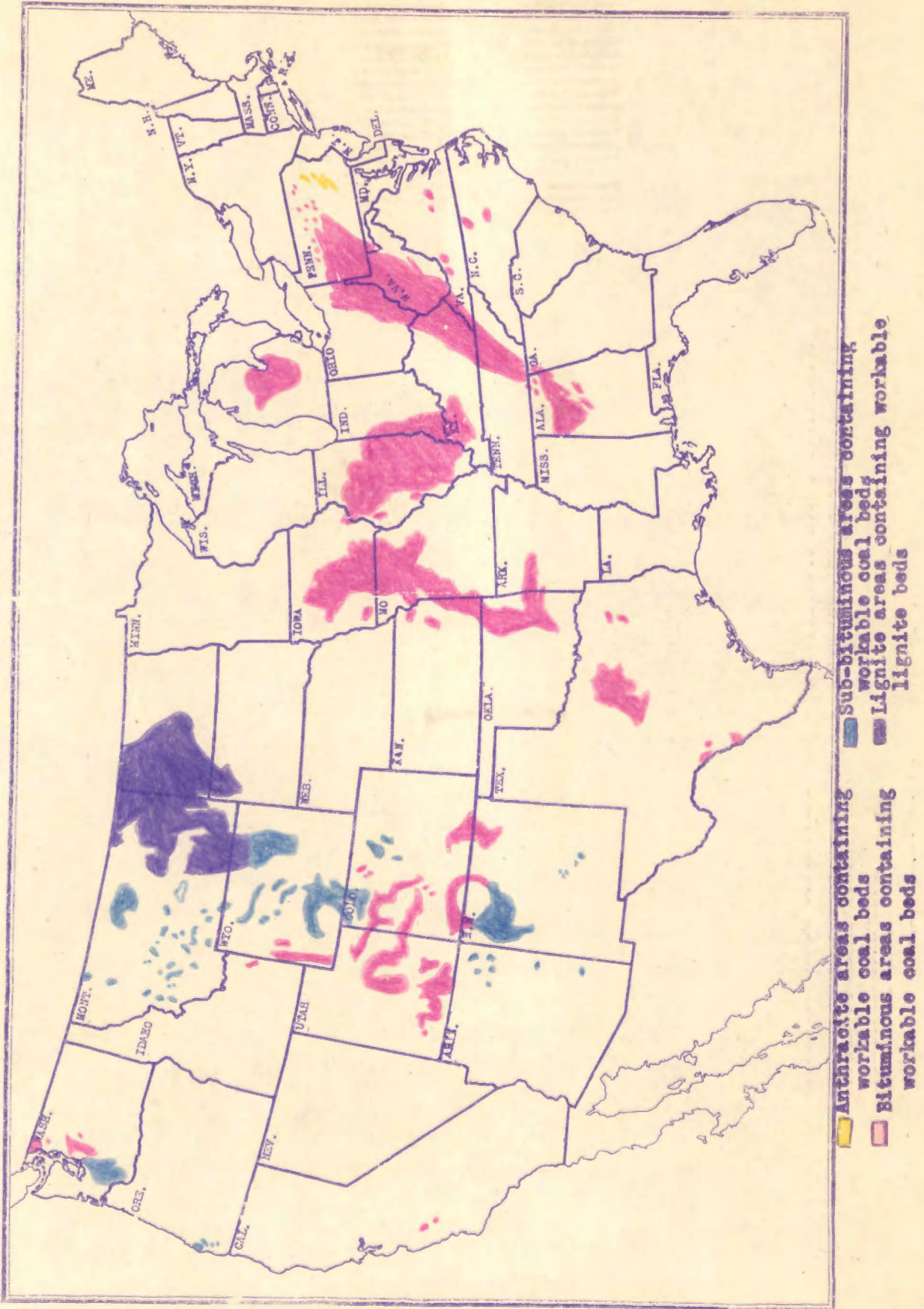
Table 16.Estimated Coal Reserves of the World

Country	Total Metric Tons (Millions)	Per Cent of World Total
North America	4,907,000	62.4
U. S. and Alaska	3,536,000	45.0
Canada	1,361,000	17.3
Mexico and C. America	10,000	0.1
Asia	1,900,000	24.2
China	1,100,000	14.0
Siberia	192,000	2.4
India	87,000	1.1
Indo-China	22,000	0.3
Japan	9,000	0.1
Others	490,000	6.2
Europe	524,950	6.7
British Isles	166,000	2.1
Germany	148,200	1.9
Poland	68,800	0.9
Ukraine	55,600	0.7
Czechoslovakia	24,500	0.3
France	18,600	0.2
Belgium	11,000	0.1
Norway & Spitzbergen	8,750	0.1
Spain	5,500	0.1
Holland	5,000	0.1
Russia in Europe	12,000	0.2
Austria & Hungary	1,000	0.01
Others		
Australasia	200,000	2.5
South America	130,000	1.7
Colombia	30,000	0.4
Brazil, Chile, Peru and Venezuela	100,000	1.3
Union of S. Africa	62,000	0.8
World Total	7,863,556 (1)	100.0

(1) Total as given in the world almanac--The total of the countries listed is 7,723,950 million metric tons.
World Almanac, 1932.

Map 32.

COAL FIELDS OF THE UNITED STATES



Source: The Coal Industry of the World, U. S. Department of Commerce, p. 39.

Warren and White Counties, and all of Cumberland County. (1) This field contains approximately 2200 square miles, but only 1420 square miles of the area contain coal above the Sewanee conglomerate. (2)

The northern field includes parts of Anderson, Campbell, Claiborne, Fentress, Overton, Pickett and Roane Counties; and all of Scott and Morgan Counties. About two thirds or 304 square miles of Campbell County contains coal and has good transportation facilities. There are 875 square miles of coal area in Claiborne County. About $\frac{4}{5}$ of Fentress County is on the Plateau and contains 400 square miles of the coal area, but lacks transportation except in the southwestern area. The total area of Morgan County is 536 square miles, within the coal area, but only the eastern part has easy lines of communication. Overton County has 20 square miles of coal area, estimated. About one fifth of Pickett County is in the coal field. Most of this is in the eastern part of the county. Roane County has a coal bearing area of about 45 square miles. Approximately 10 square miles of this is on the Escarpment, from the crest down to the base, and about 35 square miles back of the crest on the Plateau railroads run parallel to the Escarpment the entire length of the county, and on the plateau the Tennessee Central Railway furnishes the transportation. Scott County's area of 550 square miles is all in the coal area. It has good transportation facilities. Only $\frac{1}{3}$ of Anderson or 114 square miles, exclusive of the upturned rocks of Walden Ridge, is in the coal area. With the upturned rocks of Walden Ridge included the total is 128 square miles. (3)

(1) Division of Geology, The Southern Coal Field, Bulletin 33A, 1925.

(2) State Geological Survey. The Resources of Tenn. Vol. 3, No. 1.

(3) Division of Geology. The Northern Tennessee Coal Field, Bulletin 33B, 1925.

Coal Production by Countries. In 1870 the United States produced 14.07 per cent of the world output of coal while Great Britain produced 52.7 per cent and Germany 16 per cent, as shown in Table 17. In 1920 the United States production had increased to 45.3 per cent and Germany's to 18.4 while Great Britain's production had decreased to 17.7 per cent of the world output. In 1927 the production of the United States was 37 per cent of the world production, Germany 27.1 and Great Britain 17.4 per cent.

It is apparent from this table that the United States and Germany have gained relatively since 1870, while Great Britain, France, and Belgium have decreased. Austria-Hungary has about maintained its 1870 position.

Original Stocks and Total Production to 1929 by States.

The estimated original stock of coal in the United States and the total production to the end of 1929 are shown by states in table 18. Tennessee's original supply, which is all bituminous, was about 26 billion tons as compared with 3,215 billion tons for the United States, or less than one per cent. Counting all classes of coal, Tennessee ranked eighteenth in original supply, but some of the states that ranked higher had a large amount of lignite and sub-bituminous which are of poor fuel quality.

For example, of the 31 billions of the original supply in Texas, 23 billions tons were lignite. Of the eight states adjacent to Tennessee, Alabama, Arkansas, Georgia, Kentucky, Mississippi, Missouri, North Carolina and Virginia, only three, Kentucky, Missouri and Alabama had a larger original supply.

At the end of 1929 Tennessee had mined only 215,852,377 tons of her original supply of 25,665,000,000 tons, or less than one

Table 17.

Per Cent of World's Coal Output Contributed by Leading Countries, 1870-1927.

Year	United States	Great Britain	Germany	France	Belgium	Austria-Hungary
1870	14.07	52.68	15.96	6.26	6.43	3.92
1880	19.59	45.11	17.86	5.85	5.10	4.47
1890	27.90	35.97	17.41	5.08	3.97	5.36
1900	31.86	29.79	19.50	4.35	3.06	5.09
1910	39.20	23.08	19.10	3.29	2.05	4.12
1913	38.53	21.76	20.67	3.04	1.70	4.07
1920	45.30	17.67	18.43	1.91	1.69	2.90 (1)
1921	40.50	14.61	22.85	2.46	1.91	3.73 (1)
1922	35.30	20.68	20.97	2.51	1.73	3.31 (1)
1923	43.90	20.63	13.31	2.83	1.61	2.87 (1)
1924	38.20	20.04	17.98	3.32	1.73	3.47 (1)
1925	38.70	18.36	19.95	3.52	1.70	2.69 (1)
1926	44.90	8.15	21.05	3.80	1.87	2.92 (1)
1927	37.00	17.37	27.07	3.58	1.90	3.67

(1) Includes quota furnished by Austria, Hungary, and Czechoslovakia to world total.

Source: The Coal Industry of the World, U. S. Department of Commerce, page 26.

per cent. Since the first coal was mined over a century ago it seems that the supply in the state would be adequate for many centuries, but all of the supply is not easily accessible. For the United States only 0.96 per cent of the estimated original supply has been mined. This percentage varies from zero in South Dakota to 7.4 per cent in Pennsylvania. The latter state is the principal coal producing state in the United States. None of the other leading producing states have mined more than $1\frac{1}{2}$ per cent of the original supply. The percentages in these states are as follows: West Virginia 1.58, Illinois 1.01, Ohio 1.24, Kentucky 0.71, Indiana 1.12, and Alabama 0.80.

Table 18.

Coal: Total Production to End of 1929 and Original Supplies, by States

State	Original Supply (Millions of tons)	Pro-duction (M. of T)	Per Cent Produc-tion is of ori-ginal supply	Original Supply per sq. mile	State	Original Supply (Millions of tons)	Pro-duction (Millions of tons)	Per Cent Produc-tion is of ori-ginal supply	Original Supply per sq. mile
1 Wyo.	620,723	235	0.04	6.33	25 S. C.	1,020	0	0	0.01
2 Colo.	417,246	339	0.08	4.01	26 Ga.	933	11	1.17	0.01
3 Mont.	381,104	94	0.02	2.59	27 Ida.	700	1	0.14	0.01
4 Ill.	201,400	2,050	1.01	3.55	28 N. D.	600	24	4.00	0.01
5 W. Va.	152,544	2,416	1.58	6.31	29 Oreg.	560	2	0.35	0.01
6 Pa.	133,148	9,901	7.43	2.95	30 N. C.	68	1	1.47	0.001
7 Ky.	123,327	877	0.71	3.03	31 Calif.	43	2	4.65	0.0002
8 Ohio	93,967	1,167	1.24	2.28	32 Conn.	0	0	0	0
9 Utah	93,340	109	0.11	1.09	33 Dela.	0	0	0	0
10 Mo.	84,000	184	0.21	1.21	34 D. C.	0	0	0	0
11 Ala.	67,570	542	0.80	1.29	35 Fla.	0	0	0	0
12 Wash.	63,878	107	0.02	0.92	36 La.	0	0	0	0
13 Okla.	54,951	121	0.22	0.78	37 Me.	0	0	0	0
14 Ind.	53,051	597	1.12	1.45	38 Mass.	0	0	0	0
15 Texas	31,000	52	0.16	0.11	39 Minn.	0	0	0	0
16 Kansas	30,000	210	0.70	0.36	40 Miss.	0	0	0	0
17 Iowa	29,160	281	0.96	0.51	41 Nebr.	0	0	0	0
18 Tenn.	25,665	216	0.84	0.61	42 N. H.	0	0	0	0
19 Va.	21,649	274	1.26	0.50	43 N. J.	0	0	0	0
20 N. M.	20,931	94	0.44	0.17	44 N. Y.	0	0	0	0
21 Md.	8,043	226	2.80	0.65	45 R. I.	0	0	0	0
22 Mich.	2,000	40	2.00	0.03	46 S. C.	0	0	0	0
23 Ark.	1,716	64	3.72	0.03	47 Vt.	0	0	0	0
24 Ariz.	1,151	0	0	0.01	48 Wisc.	0	0	0	0
					U. S. Total	2,715,488	26,126	0.96	1.06
					U. S. Ave.				

Source: World Almanac, 1931.

Tennessee's Relative Position in Coal Production. In 1929

Tennessee ranked eleventh in the United States in the amount of coal produced with a production of 5,405,464 tons and a value of \$9,122,000. (Table 19). In production in 1929, as in amount of original supply, only three of Tennessee's neighboring states were higher while Kentucky, Missouri and Alabama were ahead in original supply. Kentucky, Alabama and Virginia were leading this state in production.

Pennsylvania is by far the outstanding coal producing state, mining more than 217 million tons in 1929, or about one-third of the U. S. total. The other principal producing states are West Virginia, Illinois, and Kentucky.

From the standpoint of production per square mile West Virginia ranks first, with a production of 5760 tons. Pennsylvania is a close second with 4845 tons per square mile. Tennessee ranks 10th in this respect with 130 tons.

The per cent of the U. S. coal production and the rank of each coal producing state is given in Table 20 and Chart 12. Tennessee produced 1.1 per cent of the total U. S. production in 1915 and over 0.9 of it in 1929. Altho the state decreased 0.2 per cent of the total U. S. production from 1915 to 1929 it moved up in rank from 13th to 11th.

There has been very little change in the relative position of any of the states, particularly in the principal producing states. The 3 leading states, Pennsylvania, West Virginia, and Illinois have ranked first, second and third respectively for each of the 3 periods, 1915, 1922 and 1929. But, Pennsylvania has decreased from 46.5 per cent of the U. S. production to 35.7 per cent; while West Virginia has increased from 14.5 per cent to 22.8 per cent. Illinois declined from 11 to 10 per cent.

Chart 12.

PERCENTAGE OF COAL PRODUCTION BY STATES, 1929 and 1915

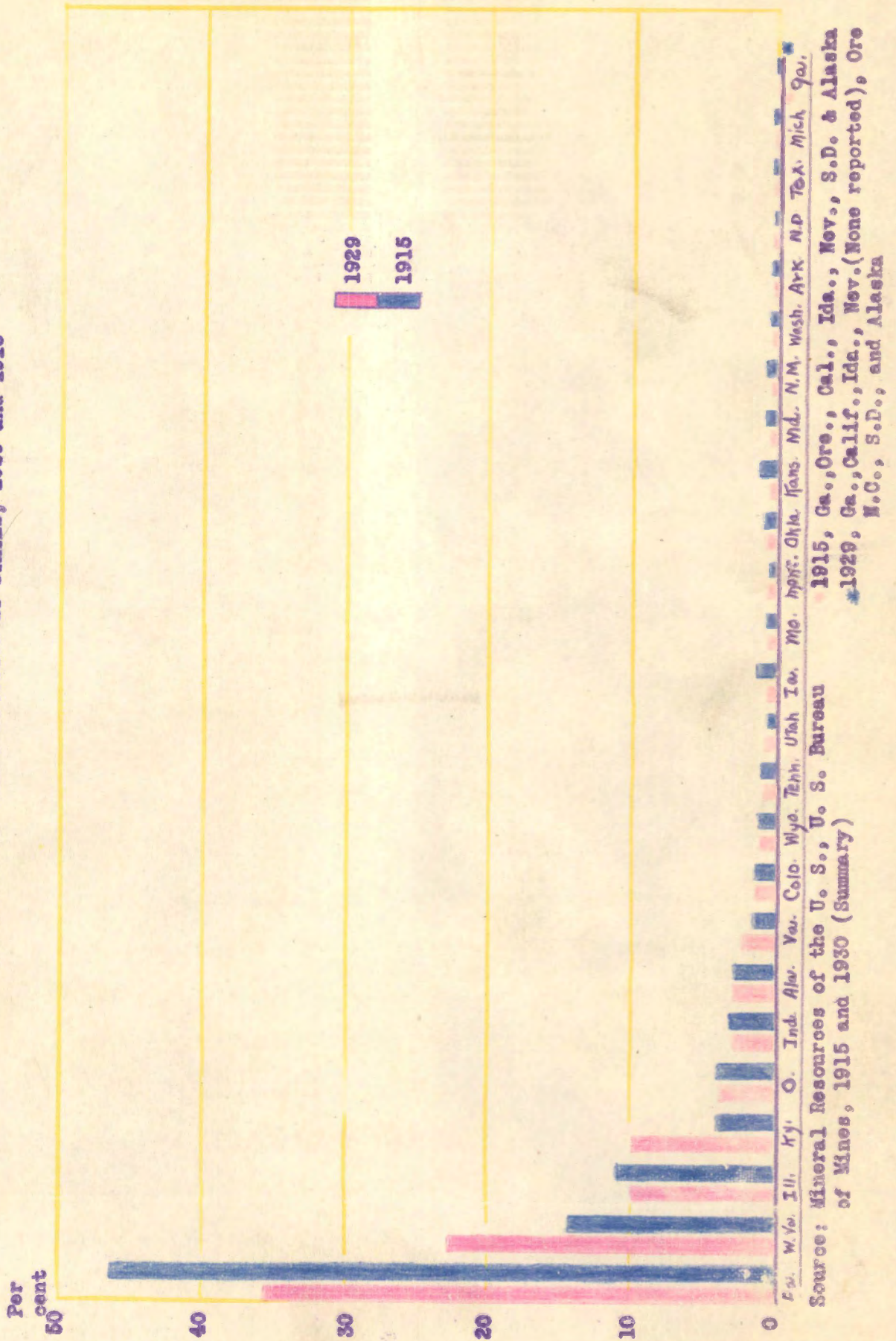


Table 19.

Production of Coal by States, 1929

	State	Tons (short)		Value (000)	State	Total (000)	Tons (short) Per Square Mile	Value
		Total (000)	Per Square Mile					
1	Pennsylvania	217,344	4,845	\$644,250	17 Kans.	2,976	36	6,697
2	W. Virginia	138,519	5,766	215,110	18 Md.	2,649	266	4,640
3	Illinois	60,658	1,082	113,453	19 N. M.	2,623	21	8,314
4	Kentucky	60,463	1,506	93,283	20 Wash.	2,521	38	8,647
5	Ohio	23,689	581	35,733	21 N. D.	1,862	26	3,157
6	Indiana	18,344	509	29,880	22 Ark.	1,695	32	5,624
7	Alabama	17,944	350	37,309	23 Tex.	1,101	4	1,600
8	Virginia	12,748	317	20,942	24 Mich.	805	14	2,904
9	Colorado	9,921	96	26,254	25 N. C.	52	1	177
10	Wyoming	6,705	69	17,052	26 Ga.	45	0.8	136
11	Tennessee	5,405	130	9,122	27 S. D.	13	0.2	38
12	Utah	5,161	63	12,725	28 Calif.	10	0.02	37
13	Iowa	4,241	76	11,948	Idaho			
14	Missouri	4,000	60	9,778	Nev.			
15	Okla.	3,774	54	11,481	Oreg.	10		
16	Montana	3,408	23	7,561	Ariz.		0.1	44
	U. S. Tot.	608,716	205	1,337,896				

Source: U. S. Department of Commerce--Bureau of Mines--Mineral Resources of the U. S., 1930, Summary, page A 55.

Table 20.

Per Cent of and ^{Rank in} Total Coal Production by States,
1915, 1922 and 1929.

State	Rank			Per Cent of U. S. Production	
	1929	1922	1915	1929	1915
Pa.	1	1	1	35.7	46.5
W. Va.	2	2	2	22.8	14.5
Ill.	3	3	3	10.0	11.1
Ky.	4	4	5	9.9	4.0
Ohio	5	5	4	3.9	4.2
Ind.	6	6	6	3.0	3.2
Ala.	7	7	7	2.9	2.8
Va.	8	8	9	2.1	1.5
Colo.	9	9	8	1.6	1.6
Wyo.	10	10	12	1.1	1.2
Tenn.	11	12	13	0.9	1.1
Utah	12	11	18	0.8	0.6
Iowa	13	13	10	0.7	1.4
Mo.	14	16	16	0.7	0.7
Okla.	15	17	17	0.6	0.7
Mont.	16	19	19	0.6	0.5
Kans.	17	15	11	0.5	1.3
Md.	18	21	14	0.4	0.8
N. M.	19	14.	15	0.4	0.7
Wash.	20	18	20	0.4	0.5
N. D.	21	20	24	0.3	0.1
Ark.	22	22	22	0.3	0.3
Tex.	23	23	21	0.2	0.4
Mich.	24	24	23	0.1	0.2
N. C.	25	25	--	(2) 0.04	(1) 0.1
Ga.	26	26	25		
S. D.	27	28	28		
Calif.	(3)28	(4)27	(4)27		

Source: (1) U. S. Department of Interior Geological Survey, Mineral Resources of the U. S. 1915. Part II, non metals, page 359.

U. S. Department of Commerce, Bureau of Mines.

(2) Mineral Resources of the United States (Summary) 1923, page 35A; and 1930, page 35A.

(1) Ga., Ore., Calif., Ida., Nev., S. D., Alaska.

(2) Ga., Calif., Ida., Nev., (none reported) Oreg., Ariz., N. C. S. D. Alaska.

(3) Calif., Ida., Nev., (added)

(4) Calif., Ida., Nev., (none reported) Oreg.

The Development of Coal Production in Tennessee. Coal at the present time is one of the states most important minerals, accounting for about 9 million dollars of the states 40 million dollar mineral production in 1929. The first settlers in the coal area must certainly have known of the occurrence of coal, for in many sections there are numerous outcrops. The development of the coal industry in the state is divided into five rather distinct periods which were to a large extent influenced by the developments in transportation in the state. The first period is from the first record of coal being worked in 1814 to 1855 when the Nashville, Chattanooga and Saint Louis Railway was completed. During this period coal was used largely for forges as wood was so plentiful for fuel, and in transportation the coal was difficult. With better transportation the coal industry gained considerable importance during the second period from 1855 to the beginning of the Civil War. (1)

The coal industry made little progress, during the third period which was from the beginning of the Civil War 1861 to 1870. (Table 21).

The fourth period covers a long period from 1869 to 1910. This was generally a period of expansion in the coal industry. According to Table 21 the average production from 1871-1880 of 412,404 tons had increased to 5,564,097 tons 1900-1910.

However there were periods when production decreased. The completion of the Knoxville and Ohio Railroad in 1870 was responsible for the development in the Coal Creek district during this period 1870-1880. The industry expanded again in 1880 when

(1) Tennessee Division of Geology Bulletin 33A.

the Cincinnati Southern Railway was completed and again a few years later when the road was built from Harriman to Clinton. New territory was opened in the Cumberland Mountains in 1899 by the building of the Tennessee Central Railway.

During the fifth period which extends from 1910 to the present, there has not been much expansion, due to some adverse condition for the coal industry. During the year preceding the war there was a decrease probably due to the development of hydroelectric power. The uncertainties caused by the outbreak of the war in 1914 caused further decline from which the industry did not recover until 1918. The strike of 1919, and the business depression of 1921 both affected the coal industry of the state. With these difficulties however the production for the period 1911-1920 was 6,075,436 tons, and 1921-1930, 5,468,890 tons as compared with 5,564,097 tons for the period 1901-1910.

Table 21 shows that Tennessee had declined more rapidly than the U. S. as a whole since 1870. While both have increased at a decreasing rate to 1921, Tennessee increased only 9.2% from 1911, to 1920 while the increase from 1870-1880 was 247 per cent. The rate of increase for this latter period in the U. S. was 119 per cent and in the period 1911-1920, 45.5 per cent. Both showed a decrease from 1921-1930 over the previous 10 year period. Tennessee's decrease was 10% while that of the U. S. was only 0.2%.

Table 21.Trend in Coal Production in Tennessee and United States by
10 Year Periods

Date	Average Production in Tons (Short)		Percentage Inc. over Previous 10 Year Period	
	Tennessee	U. S.	Tennessee	U. S.
1851-1860	111,000	12,513,006	-----	-----
1861-1870	118,842	26,122,011	7.1	108.8
1871-1880	412,404	57,219,993	247.0	119.0
1881-1890	1,491,782	122,844,666	261.7	114.7
1891-1900	2,742,084	202,972,461	83.8	65.2
1901-1910	5,564,097	396,956,010	102.9	95.6
1911-1920	6,075,436	577,777,436	9.2	45.5
1921-1930	5,468,890	576,632,150	-10.0	-0.2

Source:

U. S. Department of Commerce, Bureau of Mines. Mineral Resources
of the United States Summaries. Tennessee Bureau of Mines,
Mineral Resources of Tennessee 1930.

Coal Production in Tennessee Counties. In 1930 coal was being mined in counties, as shown in table 22. The 5 leading counties, Campbell, Claiborne, Anderson, Fentress and Morgan were producing approximately three-fourths of the state total mined that year. The first three counties produced 61.3 per cent of the total. (Table 23). These 5 principal producing counties are located in the Northern coal field.

It is apparent from this that the Southern coal area is of relatively little importance in coal production now. Marion and Grundy Counties are the principal producing counties in this area. They together produced about 12 per cent of the total production in 1930.

Considerable change has occurred in the production by

Table 22.

Production of Coal 1880-1930, by Counties

County	1930 (000 tons)	1915 (000 tons)	1911 (000 tons)	1890 (000 tons)	1880 (000 tons)
Campbell	1,279	1,664	1,704	126	1
Claiborne	1,075	1,141	1,288	0	0
Anderson	946	511	735	582	141
Fentress	394	260	(3)	0	0
Morgan	358	371	458	143	0
Marion	340	479	577	213	43
Grundy	314	306	264	349	200
White	253	0	0	(4) 124	2
Overton	251	(3)	76	0	0
Sequatchie	84	0	0	0	0
Cumberland	54	0	0	0	0
Scott	16	(3)	129	136	0
Hamilton	8	(3)	365	278	50
Van Buren	7	0	0	0	0
Putnam	1	0	0	0	0
Bledsoe	0	(2) 993	(1) 895	0	0
Rhea	0	0	0	211	0
Franklin	0	0	0	0	2
Roane	0	0	0	0	56
Others	0	5	3	4	0
Total	5,380	5,730	6,434	2,166	495

- (1) Bledsoe, Cumberland, Fentress, Franklin, Rhea, Roane, Sequatchie, White.
 (2) Bledsoe, Hamilton, Overton, Scott, Rhea, Roane, Sequatchie and White.
 (3) Included with (1)
 (4) Includes Franklin and Roane.

Source:

1930- Mineral Resources of Tennessee 1930.

1915-1911- U. S. Department of Interior, Geological Survey Mineral Resources of the United States, 1915, Part II.

1890-Annual Report of State Dyst. Ag. Godwin-1892. 1880- Census on Mining, 1880.

counties since 1880. At that time only 3 counties were reported as having mined coal, Table 22. At that time more than one-half of the state's 495,000 ton production was produced in the counties located in the Southern coal area. In 1890 coal was being mined in practically the same counties as in 1880, but the production

Table 23.

Production and Value of Coal by Counties 1930.

County	Production			Value	
	% of Total 1930	Total 1930 (short tons)	5 year Average 1926 - 1930	1930	5 Year Average 1926-30
Campb.	23.77	1,279,480	1,099,526	\$2,164,677	\$2,052,475
Claib.	19.97	1,075,280	1,212,604	1,733,910	2,043,652
Ander.	17.58	946,223	938,594	1,417,861	1,468,172
Fentr.	7.31	393,661	448,090	542,302	709,022
Morgan	6.67	358,567	340,051	494,351	541,738
Marion	6.32	340,299	268,781	661,820	481,959
Grundy	5.84	314,483	402,497	574,554	737,345
White	4.70	253,255	270,762	455,672	476,426
Overt.	4.66	251,558	277,080	370,782	450,331
Sequat.	1.55	83,633	71,049	125,449	112,308
Cumber.	1.00	53,752	35,734	86,003	55,553
Scott	0.29	15,722	86,186	23,583	122,907
Hamilt.	0.16	8,463	153,671	14,975	337,126
Van B.	0.13	7,231	1,446 (1)	9,108	1,822 (1)
Putn.	0.02	1,000	9,974 (2)	2,250	24,718 (2)
Bleds.	0.00	0	1,706 (1)	0	3,026 (1)
Roane	0.00	0	102,313 (2)	0	256,792 (2)
Rhea	0.00	0	3,097 (3)	0	7,108
Tenn.	100.00	5,382,607	5,655,537	8,677,242	9,760,932

- (1) One year only divided by five.
 (2) Four-year total divided by five.
 (3) Three-year total divided by five.

Source:

Tennessee Division of Mines---Mineral Resources of Tennessee 1930

had increased to 2,166,000 tons.

After 1890 the coal production of the state increased rapidly, the majority of the expansion occurring in the counties of the Northern field---principally in Campbell, Caliberne and Anderson. These counties took the lead sometime between 1890 and 1911. Table 22 shows that they were the three leading counties in 1911 and that they have maintained that lead to 1930.

The rapid expansion in coal production in Campbell and Claiborne was due largely to the development of rail transportation there.

The principal producing counties, except Anderson and Fentress have declined in production since 1911 (Table 22). Campbell, the leading county has decreased approximately one-third from 1,704,000 tons to 1,279,000 tons. Claiborne, the second ranking county has decreased about one-sixth, from 1,288,000 tons to 1,075,000 tons. Anderson, the third ranking county, had an increase from 735,000 tons to 946,000 tons during the same period.

Marble

Introduction. Commercially the term marble means any calcareous rock capable of taking a good polish and suitable for ornamental or building purposes. The chemical composition of marble is the same as that of limestone and calcite. The principal difference between marble and limestone is that marble is crystalline and limestone is non-crystalline. In trade however any limestone that will take a polish is considered as marble whether it is crystalline or not. The most common colors are white, gray, pink, black and variagated. ⁽¹⁾

Relative Importance of Value of Marble Production. In the United States the value of marble produced has ranged from 0.2 to 0.3 per cent of the value of all mineral produced from 1921 to 1930, as shown in Table 24. The value of marble production

(1) State Geological Survey, The Resources of Tennessee, Vol. 3, No. 4.

Table 24.

Production and Value of Marble, and Value of all Minerals Produced in the United States 1921-1930

	Marble		Value of all Minerals	Percentage Value of Marble
	Short Tons Produced	Value		
1921	315,400	\$8,580,416	\$4,138,500,000	.21
1922	427,870	10,534,671	4,647,290,000	.23
1923	562,560	12,863,974	5,986,500,000	.21
1924	516,000	13,302,235	5,306,800,000	.25
1925	564,160	13,882,457	5,677,630,000	.24
1926	563,170	14,167,480	5,213,600,000	.27
1927	600,060	15,625,872	5,530,000,000	.28
1928	579,490	16,402,986	5,385,200,000	.30
1929	553,660	16,545,312	5,887,300,000	.28
1930	476,000	12,906,000	4,810,400,000	.27

Source:

U. S. Department of Commerce, Bureau of Mines, Mineral Resources of the United States, Summary 1930, Pages 9 and 82.

has ranged from \$8,580,416 in 1921 to \$16,545,312 in 1929, while the production of all minerals varied from \$4,138,500,000 in 1921 to \$5,887,300,000 in 1929.

Marble is relatively more important in Tennessee than it is in the United States. In 1930 the total state production was valued at \$2,178,387, which was about 5 per cent of the value of the state's mineral production. It ranks fourth in the state in value of product,--coal ranking first with value of \$8,677,242, copper second with value of \$3,309,007, and phosphate third with value of \$2,890,065.⁽¹⁾

(1) Mineral Resources of Tennessee, Annual Report, Division of Mines, 1930.

Early Development of Marble Production. The following quotation from "The Marbles of Tennessee", gives a historical sketch of marble production in Tennessee.(1)

"According to Stafford (2) marble quarrying began in East Tennessee in 1838 with the organization of the Rogersville Marble Company, with headquarters and works at Rogersville, in Hawkins County. The stone was first brought prominently to public attention by its adoption for interior decoration of the United States Capitol Building at Washington. Stone for this purpose was obtained from quarries opened by the government on the banks of the Holston River about nine miles Southwest of Rogersville. These were located on the old Galbraith property and were known for many years as the National Quarries. For many years the entire supply of the so-called "Tennessee Marble" was drawn from quarries in this vicinity, but of late years, during to the more easy accessibility of the stone in Knox and Blount Counties, together with the growing demand for the pinks and gray granular over the variegated varieties, there has been a decided change, and the quarries of Hawkins County produce but a relatively small proportion of the entire output-----."

According to table 25 Hawkins produced none during the period 1926-1930.

Marble Production by Counties. Approximately 80 per cent of the marble produced in Tennessee in 1930 was produced in Knox County; Blount, Loudon, and Union Counties furnished the other 20 per cent. (Table 25). In 1929 Tennessee produced approximately one-third of the marble produced in the United States and for the five years 1926-1930 Knox County produced about 75 per cent of the Tennessee total which gives Knox County approximately one-fourth of the United States production. The marble industry brought to Knox County over two and one-third millions of dollars per year during the period 1926-1930.

(1) Tennessee Geology Survey, The Marbles of Tennessee, Extract D, Bulletin No. 2, 1911.

(2) James M. Stafford, Geology of Tennessee page 508.

Table 25.

Production and Value of Marble by Counties, 1930, and Average 1926-1930

County	Production			Value	
	% of Total 1930	1930 (Cu. Feet)	5 Yr. Ave. 1926-1930 (Cu. Ft.)	1930	5 Yr. Ave. 1926-1930
Knox	79.8	1,206,879	979,149	1,711,882	2,300,436
Blount	9.0	135,575	140,883	336,253	371,152
Loudon	7.1	107,480	(1) 33,571	80,794	41,285 (1)
Union	4.1	61,855	(2) 25,914	49,458	37,365 (2)
Union-Knox	0	0	(3) 140,015	0	136,213 (3)
Tennessee	100.0	1,511,789	1,319,533	2,178,387	2,886,452

- (1) Two years divided by 5.
 (2) Three years divided by 5.
 (3) One year divided by 5.

Source:

Mineral Resources of Tennessee, Annual Reports of Bureau of Mines.

Tennessee's Position Among the States in Marble Production.

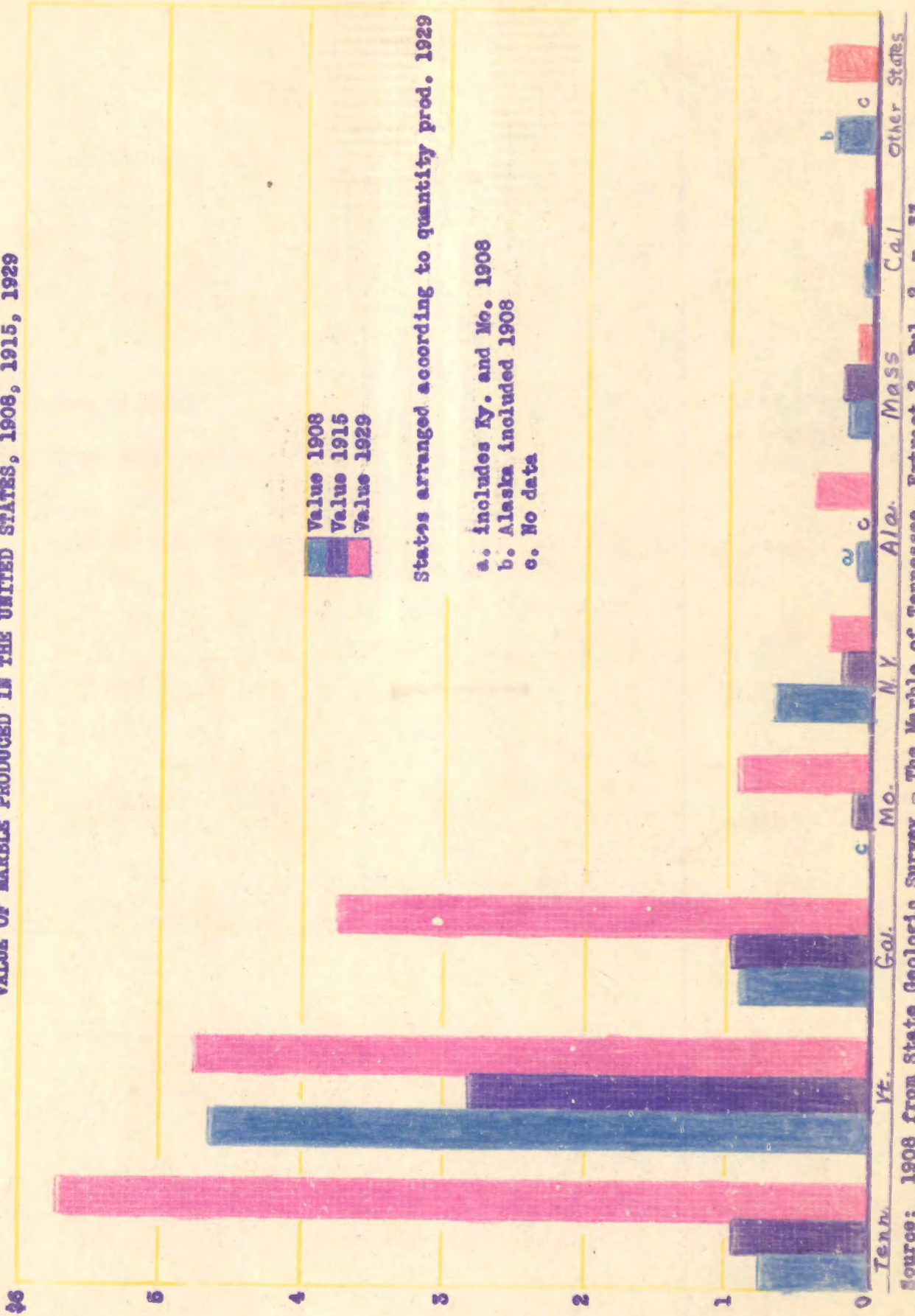
Tennessee is the leading state in the United States in both the quantity and value of marble, produced in 1929. (Table 26).

The value of the marble produced in the principal producing states in the years 1908, 1915 and 1929 is shown in chart 13. In 1908 Vermont was in the lead with Georgia second and Tennessee a close third. From 1915 to 1929 the three leading states, Tennessee, Vermont and Georgia all made large gains, but Tennessee moved from third place to first place. With the three states, Tennessee, Vermont, and Georgia, producing practically eighty per cent of the marble produced in the United States, and Tennessee producing more than either of these, it is easy to see that Tennessee is outstanding in marble production, producing approximately one third of the United States total.

Chart 13.

Millions

VALUE OF MARBLE PRODUCED IN THE UNITED STATES, 1908, 1915, 1929



Source: 1908 from State Geologic Survey - The Marble of Tennessee, Extract 2, Bul. 2, p. 33
1915 and 1929 from Table 2 - Marble Prod. by Principal Producing States.

Table 26.

Marble Production by Principal Producing States 1929 and 1915.

States	Short Tons Produced		Value of Production	
	1929	1915	1929	1915
Tennessee	169,630	44,661	\$5,739,004	\$ 959,037
Vermont	129,940	72,555	4,798,713	2,792,764
Georgia	82,920	92,919	3,777,275	973,605
Missouri	55,420	133,155	932,471	122,238
New York	48,640	67,765	316,962	202,843
Alabama	40,900	not reported	443,519	not reported
Mass.	4,180	20,996	101,452	223,203
Calif.	2,780	2,641	80,834	47,976
Other Sts. (1)	19,250	no data	355,082	no data
Total	553,660	?	16,545,312	6,916,025

(1) 1929: Alaska, Arizona, Arkansas, Colorado, Idaho, Maryland, Montana, New Jersey, North Carolina, Utah, Virginia, and Washington.

Source: Stone in 1929, Mineral Resources of United States, Part II, P. 244. Mineral Resources of the U. S. Part II, 1915, p. 799.

Occurrence in Tennessee. Outcrops of good marble are scattered widely over the East Tennessee Valley. These are known as the Holston beds and are a member of the Chickamauga limestone formation. The marble area of the East Tennessee valley is about twenty miles wide and extends for a distance of 175 miles from near the Virginia line southwestwardly to McMinn County. The outcrops in this area are long narrow belts extending in the general direction of the valley. These belts vary in length from less than 9 mile to seventy-five miles of continuous outcrop. Most of these beds, or outcrops, are less than one-fourth of a mile in width, but in some places they are a mile or more in width. (1)

(1) Tennessee Geologic Survey, Extract D, Bulletin No. 2, 1911.

Practically all of the marble that has been quarried in Tennessee has come from this section.

Red variegated marbles occur in a number of counties in Middle Tennessee, especially in Franklin, Lincoln and Maury Counties. In West Tennessee variegated marbles are found in Benton, Decatur, Henry, Hardin, Perry and Wayne Counties.

- Other deposits said to occur in the state are a fawn-colored marble in Lawrence; dove colored marble in Coffee, Davidson and Wilson Counties; a pale yellow marble, with serpentine veins of red and black dots in Rutherford County; and an olive green marble in Davidson County.

The marbles of Middle and West Tennessee are valuable stone, but are not as good in quality as those of the East Tennessee Valley.⁽¹⁾ Consequently only a relatively small amount of marble has been quarried in the middle and west Tennessee counties.

Uses of Marble. The uses of the marble produced in the principal producing states in 1929 are shown in table 27. Tennessee had more tons used for building and monumental purposes than any other state, and also more consumed by other uses. Tennessee, however, did not have as high percentage of its total production used for building and monumental purposes as Vermont, Georgia and Missouri. Vermont ranked first in this respect with 77.4 per cent as compared with Tennessee's 65.2 per cent; yet Tennessee had 110,680 tons used for this purpose compared with 100,590 tons for Vermont.

(1) Tennessee Geologic Survey, Extract D, Bulletin No. 2, 1911.

Table 27.

Uses of Marble Mined in Principal Producing States, 1929

State	Number Short Tons		Per Cent of Short Tons	
	Building and Monumental (1)	Other Uses	Building and Monumental	Other Uses
Tennessee	110,680	58,950	65.2	34.8
Vermont	100,590	29,350	77.4	22.6
Georgia	56,620	26,300	68.3	31.7
Missouri	39,520	15,900	71.3	28.7
Alabama	4,500	36,400	11.0	89.0
New York	4,480	44,160	9.2	90.8
Mass.	1,670	2,510	39.9	60.1
Calif.	1,210	1,570	43.5	56.5
Other Sts. (2)	4,760	14,490	24.7	75.3
Total	324,030	229,630	58.5	41.5

(1) Found by subtracting short tons in other uses from total.

(2) Alaska, Arizona, Arkansas, Colorado, Idaho, Montana, New Jersey, North Carolina, Utah, Virginia, and Washington.

Source: Stone in 1929, Mineral Resources of U. S., 1929, Part II, p. 245.

Stone Other Than Marble

Variety and Uses. (1) The most important stones found in

Tennessee, other than marble, are limestone, sandstone and granite.

Pure limestone is calcium carbonate but it usually contains some clay, sand, magnesia and other impurities. It occurs in the natural state in a variety of colors, from light gray to dark gray. It is used principally for construction purposes, both building and roads; and in making cement, concrete, and lime.

(1) This section adopted from Tennessee Geology Survey, The Resources of Tennessee, Vol., 3, No. 4.

Sandstone is found in beds. It is found from sand being cemented together by iron oxide, or lime carbonate. Iron oxide gives the stone a red, brown or yellowish color. Sandstone that is soft enough to disintegrate when blasted is used for sand. The harder stone is used for building purposes, curbing riprap, and lining furnace hearths. The pure fine grained sandstone is used for grindstones.

Granite is a rock of igneous origin, composed of crystals of many minerals closely interlocked. It is granular in appearance, the color varying from gray to red. Granite is usually hard and compact, has great strength, resists weathering, and takes a good polish. It is used as building stone, both outside and inside, for monuments, and as crushed stone for a number of uses.

Occurrence in Tennessee.(1) Limestone is the most common rock of East and Middle Tennessee. In 1930 it was quarried in fourteen counties, distributed over East and Middle Tennessee, (Table 29). Sandstone occurs on the Cumberland Plateau and to lesser extent in other parts of Middle and East Tennessee.

Granite occurs along the eastern border of the state.

Relative Position of Tennessee in Production.(2) In the production of all stone Tennessee ranked seventh in 1929. The highest producing states were Indiana, Pennsylvania, New York, Ohio, Michigan and Massachusetts respectively. Tennessee was thirteenth in the production of limestone in 1929. The four leading states were Indiana, Pennsylvania, New York and Ohio.

(1) State Geology Survey, Resources of Tennessee, Vol. 3, No. 4; and State Division of Mines, Annual Report, 1930.

(2) U. S. Department of Commerce, Bureau of Mines, Stone in 1929.

Production in Tennessee. That limestone is an important mineral in Tennessee is shown by the fact that the average value of the production for 1929 and 1930 was over a million dollars. (Table 29). This table also shows that the leading counties in production in order of their importance are Knox, Jefferson, Davidson, Roane and Marion, Williamson and White. The value of the production in these counties ranged from \$96,681 in White County to \$342,783 in Knox County. All producing counties are located in Middle and East Tennessee.

The uses of the limestone quarried in 1930 were, in order of the number of tons used for road construction, 544,329 tons; for use in concrete and cement plants, 451,507 tons; blast furnace flux, etc., 189,205 tons; for agricultural purposes, 10,082 tons; and for railroad ballast, 8,553 tons. (Table 29).

The production of sandstone is relatively unimportant in Tennessee. The total value of the product was only \$97,884 and, only 50 men were employed for which wages amounting to \$43,476 were paid, in 1930. Two companies producing this stone mentioned above/ ^{are located} on Cumberland Mountain, near Crossville in Cumberland County. (1) Other quarries of lesser importance have been operating for several years in providing stone for local construction. While no definite data are available on these small quarries one is known to have operated in Overton County, furnishing stone for local monuments. (2) Others have furnished stone for buildings in Crossville. (3)

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- (1) Annual Report of the Tennessee Division of Mines, 1930, p.122.
 - (2) Allred, C. E., interview.
 - (3) Ibid.

Table 28.
Average Value of the Production of Limestone, 1929-30, by Counties

County	Total Average Value 1929-1930	Value	
		1930	1929
Knox	\$342,783	(1)	\$ 342,783
Jefferson	214,519	214,519	(1)
Davidson	199,804	239,355	160,253
Roane	122,654	116,917	128,391
Marion	112,709	117,192	108,226
Williamson	105,532	86,665	124,399
White	96,681	69,022	124,339
Marshall	35,159	35,159	(1)
Franklin	26,530	28,560	24,500
Carter	23,927	20,864	26,990
Cumberland	22,000	21,000	23,000
Sullivan	15,150	15,150	(1)
Rutherford	15,000	(1)	15,000
Greene	7,500	(1)	7,500
Coffee	7,419	7,381	7,457
Hickman	4,420	4,420	(1)
Dickson	3,100	5,900	300
Total	1,037,621	982,104	1,093,138

(1) None Reported.

Source:

Annual Reports of Department of Labor. (Tennessee).

On the merits of this stone, commonly called flagging and rubble stone, the State Division of Mines says: (1)

"First---The stratigraphy is uniform and the layers range in thickness from three-quarters of an inch to six inches.

"Second---Under laboratory test the stone was found to be suitable for exterior work in fine architectural development. It stands the "withering touch" of time, and the onslaughts of the elements.

"Third---The texture is fine-grained, and the exquisite coloring found in the slab or stones rivals the work of the Persian rug maker. In the last ten years the glory of this stone stands secure. Indeed, it is one of the brightest tents pitched upon the eternal camping ground of architecture.

(1) Tennessee Division of Mines, Annual Report, 1930, page 122.

"Numerous splendid buildings in Nashville and Knoxville have been erected out of this building stone during the past two years. As striking examples, in Nashville we find Scarritt College and the new West End Methodist Church, constructed in their entirety from this stone. In Knoxville a most beautiful building---a poem in stone---the new Methodist Church, was constructed of Crab Orchard sandstone. This building is a monument to the city, and a living credit to the architects.

"This stone was used in the Harkness Dormitory of Harvard University. Special selections of hues and texture in the stone makes this building one of the finest of its kind in the United States. The new buildings of the University of Oklahoma are being erected out of this stone. It has been shipped to far-away Honolulu."

Table 29.

Quantity and Value of Limestone Produced in Tennessee by uses, and by Counties in 1930.

County	Total Value	Quantities used for different purposes (short tons)				
		Agri-cultural	Road Con-struction	Rail-road ballast	Concrete and Cement Plants	Blast Furnace flux, etc.
Carter	20,864	-----	24,772	2,255	-----	-----
Coffee	7,381	-----	-----	-----	8,200	-----
Cumberland	21,000	-----	25,000	-----	-----	-----
Davidson	239,355	4,305	128,222	-----	31,427	53,227
Dickson	5,900	-----	-----	-----	-----	12,110
Franklin	28,560	2,000	28,453	-----	-----	3,492
Hickman	4,420	-----	-----	-----	-----	5,201
Jefferson	214,519	-----	154,281	4,848	-----	99,735
Marion	117,192	-----	-----	-----	338,769	-----
Marshall	35,159	140	37	---p---	35,427	260
Roane	116,917	0-----	122,945	-----	-----	-----
Sullivan	15,150	-----	9,100	-----	1,000	-----
White	69,022	-----	6,730	-----	-----	12,208
Williamson	86,665	3,637	44,789	1,450	36,684	2,972
Total	982,104	10,082	544,329	8,553	451,507	189,205

Source:

Tennessee Department of Labor, Division of Mines, Mineral Resources of Tennessee 1930, Page 128.

Sand and Gravel

Sand is fine particles of quartz which vary in size from what is classed as fine sand up to coarse sand, and then fine or small gravel. The color varies from white to yellow, brown and red, depending partly upon the kind and amount of impurities it contains.

Some of the most important uses of sand are for manufacturing glass, mortar and cement, and sand lime brick. It is also used as an abrasive and for moulding sand in foundaries.

Gravel is hard siliceous rocks composed of quartz and other hard minerals partly or entirely rounded by the action of water in streams and along the seashore. There are many different colors. The size varies from that of peas to the size of cobblestones. It is used for surfacing highways, railroad ballast, making concrete, and many other uses of minor importance.⁽¹⁾

Kind and Occurrence in Tennessee. ⁽²⁾ The two classes of sand found in Tennessee are river sand and pit sand. River sand is found in or along practically all of the larger streams of the state. It is usually not as clean and as good grade as some of the pit sands found in the state.

In the Cumberland Plateau region there are numerous sandstone deposits. Some of these deposits are soft and when blasted disintegrates into clean sand of a good grade. In the Highland Rim sands occur, some of which are valuable, but there are large

(1) The Mineral Resources of Tennessee, Op. Cit. Vol. 3, No. 4.

(2) The Resources of Tennessee, Op. Cit. Vol. 2, No. 10.

quantities of poor value. In West Tennessee sand has been mining extensively.

Gravel is found along many of the streams of the state, some in the clays of the Highland Rim and in the hills between the Highland Rim and the Tennessee River. (Table 31)

Production and Value. In 1929 the total value of the sand and gravel production in the United States was 115 million dollars as compared with a value of 4.8 billion dollars for all minerals, or about $2\frac{1}{2}$ per cent of the total. In Tennessee sand and gravel ranks higher in the value of the production than it does in the United States. Of a total value of 40.7 million dollars for all minerals produced in the state in 1929, the value of sand and gravel produced was over two million dollars, or about 5 per cent of the state total. (1)

Based on the averaged production for the five year period, 1925-1929, Tennessee ranked 23rd, as shown in Table 30. In 1929 Tennessee was twentieth in production and seventeenth in the value of production.

In general the Southern and Western states rank low, and the Middle Atlantic and mid-western states rank high. In fact 8 of the 10 highest ranking states are in these two areas. They had slightly more than one-half of the United States production from 1926-1929. (Table 30). The concentration of population in these areas probably has a big effect on the rank in production by affecting the demand for sand and gravel for construction purposes. (2)

(1) Mineral Resources of the United States (Summary) 1930, P, A8, A9, A115.

(2) Being products of low unit value they will tend to be produced as near the place of consumption as is possible.

Four counties, Shelby, Marion, Humphreys and Davidson produced 31.5 per cent of the state total production of building sand in 1930. Morgan and Roane Counties produced all of the molding sand in 1930, but Davidson and Shelby, especially Shelby, had a higher average for the five year period 1926-1930. Under the classification "other sand and gravel" four counties, Benton, Humphreys, Marion and Davidson produced 31.7 per cent of the state total in 1930. With the exception of the substitution of Benton for Shelby, these are the same counties that led in the production of building sand. (Table 31).

The value of the state's production, as reported by the Tennessee Division of Mines for the period 1926 to 1930, is much smaller than the value of the production for the period 1925 to 1929, as reported by the United States Division of Mines. These differences should not be considered as data are in Tables 30 and 31 from a different source, and for some reason are not comparable.

Phosphate.

There are four kinds of phosphate rock in Tennessee,---brown, blue, white, and nodular. Table 32 gives a description of the phosphate bearing rocks in this state.

Most of the phosphate rock is used in making super phosphates for fertilizer. Some of the ground rock is applied directly to the soil as raw ground rock. (1)

(1) The Resources of Tennessee, Op. Cit. Vol. 3, No. 4.

Table 30.

Sand and Gravel Production: Average Quantity 1925-1929, and Production and Value in 1929, by States.
(all figures in thousands)

	State	Average Production 1925-1929 Short tons	Production 1929 Short Tons	Value of 1924 Production	State	Average Production 1925-1929 Short tons	Production 1929 Short Tons	Value of 1924 Production
1	N. Y.	19,274	21,061	\$14,920	W. Va.	2,523	2,668	\$2,894
2	Ill.	18,257	18,256	9,071	Okla.	2,198	2,906	1,613
3	Mich.	14,687	16,844	7,929	Ark.	2,145	3,992	1,852
4	Calif.	14,632	15,689	8,371	S. D.	2,027	2,729	578
5	Pa.	12,988	12,674	13,658	Va.	1,759	1,729	1,165
6	Ohio	12,947	14,250	9,183	Mont.	1,605	2,446	668
7	Ind.	11,585	10,902	5,529	Fla.	1,326	788	422
8	Wisc.	8,802	10,728	4,574	N. C.	1,236	1,005	1,021
9	Tex.	7,718	9,409	5,766	Wyo.	1,158	-----	-----
10	N. J.	5,407	6,721	5,585	N. H.	1,122	1,977	1,223
11	Mo.	5,198	5,776	4,291	Me.	1,121	2,861	447
12	Wash.	4,768	5,392	2,138	Utah	1,012	1,588	723
13	Minn.	3,841	4,990	2,413	Conn.	861	850	560
14	Mass.	3,566	5,114	3,504	D. C.	852	-----	-----
15	Ia.	3,488	4,044	2,212	Colo.	774	983	493
16	Md.	3,159	3,193	2,854	Ga.	723	605	235
17	La.	2,734	3,139	2,069	S. C.	699	1,068	602
18	Miss.	2,677	2,766	1,278	Nev.	619	1,403	605
19	Kans.	2,619	3,390	1,880	N. D.	473	493	134
20	Ky.	2,614	2,350	1,582	Ida.	371	662	243
21	Ala.	2,575	2,372	1,229	Ariz.	362	395	329
22	Nebr.	2,562	3,371	1,857	R. I.	256	302	154
23	Tenn.*	2,546	3,090	2,087	N. M.	231	338	177
24	Oreg.	2,535	2,257	1,509	Vt.	194	170	59
					Del.	74	78	59
					U. S. Tot.	174,406	222,572	115,000

Source: Mineral Resources of the United States, Summaries, 1926, 1928, and 1930.

Table 31.

Production and Value of Sand and Gravel by Counties, in Tennessee, 1930 and Average 1926-1930.

1. Building Sand:

County	Per cent of total 1930	Production		Value	
		Short tons 1930	5 year Average 1926-1930	1930	5 year Average 1926-1930
Shelby	28.2	141,106	158,692	\$ 49,387	\$ 86,435
Marion	21.7	108,459	21,692 (1)	114,739	22,948 (1)
Humphreys	17.5	87,764	30,602 (2)	40,765	14,884 (2)
Davidson	14.1	70,789	190,219	45,945	75,446
Campbell	6.9	34,600	6,920 (1)	17,147	3,429 (1)
Knox	6.2	31,174	38,735	24,939	32,088
Carter	5.0	25,046	5,009 (1)	14,755	2,951 (1)
Montgomery	0.2	1,228	1,835	2,452	3,560
Roane	0.1	649	1,397 (2)	454	1,338 (2)
Fayette	0	0	20,521 (2)	0	8,611 (2)
Hamilton	0	0	96,783 (2)	0	101,890 (2)
Loudon	0	0	2,000 (3)	0	1,000 (3)
Grundy	0	0	4,000 (1)	0	3,000 (1)
Tennessee	100.0	500,813	578,404	310,583	357,581
(1) One year divided by 5.		(2) Three years divided by 5.	(3) Two years divided by 5.		

2. Molding Sand:

Morgan	53.5	950	2,373	570	1,696
Roane	46.5	826	502 (1)	744	430 (1)
Davidson	0	0	4,000 (2)	0	5,200 (2)
Shelby	0	0	28,717 (2)	0	16,799 (2)
Tennessee	100.0	1,776	35,592	1,314	24,125
(1) Four Years divided by 5.		(2) One year divided by 5.			

3. Other Sands and Gravel:

Benton	47.9	713,059	142,612 (1)	387,598	77,520 (1)
Humphreys	19.4	288,997	192,850 (2)	116,814	104,084 (2)
Marion	12.9	192,358	38,472 (1)	151,851	30,370 (1)
Davidson	11.5	171,057	195,551	121,036	139,135
Shelby	5.5	82,337	252,437	28,818	164,546
Carter	2.2	32,099	6,420 (1)	16,370	3,274 (1)
Knox	0.5	6,804	44,761	8,805	39,951
Montgomery	0.1	2,244	2,686	2,244	2,288
Hamilton	0	0	152,000 (2)	0	172,469 (2)
Loudon	0	0	3,400 (3)	0	2,300 (3)
Roane	0	0	138 (3)	0	84 (3)
Tennessee	100.0	1,488,955	1,031,325	833,536	736,020
(1) One year divided by 5.		(2) Three Years divided by 5	(3) Two years divided by 5.		

Table 32.Description of Phosphate-Bearing Rocks in Tennessee.

Name formation	Thickness	Description
Chattanooga Shale	0-10 feet	A hard black slate, weathering into small angular fragments at the surface, generally with a phosphatic layer at its base, which locally is of economic importance. Also a green shale sometimes occurs at its base. Exposure usually steepened.
Clifton Limestone	0-60 feet	An even bedded, dense, light gray or bluish limestone, often thin bedded, and occasionally slaty in lower portions.
Fernvale Formation	0-40 feet	Soft green and chocolate colored shales, and red ferruginous, crystalline limestones, occasionally phosphatic.
Leipers Formation	0-100 feet	Nearly uniform crystalline limestone, the more granular portions being highly phosphatic. This formation is locally of economic importance.
Catheys Formation	0-100 feet	Shales and knotty limestones usually underlain by thick bedded, almost crystalline limestone, and overlain by fine grained, blue and earthy limestones, separated by thin seams of shale. The basal part sometimes contains granular phosphatic layers.
Bigby Limestone	30-100 feet	Generally a nearly uniform, granular, crystalline limestone; the upper parts often slaty or sandy, the lower parts having beds of slate, but never sandy. This formation is one of the most important phosphate horizons in Tennessee.
Hermitage Formation	40-70 feet	Even bedded, alternating layers of clayed and siliceous limestones and shale in the lower third; siliceous limestones in the upper and middle parts. Sometimes highly phosphatic, but of no economic value as a source of phosphate.

The quantity of domestic phosphate sold for various uses in the United States in 1928 as reported by the producers is shown in Table 33. The second largest use was for making phosphorous and phosphorous chemicals. Some was used for blast furnaces, some for stock and poultry feed, and other uses. Of the 2,603,000 long tons reported in 1928 by the producers, 2,339,000 were reported or used for making super-phosphates.

Table 33.

Domestic Phosphate Rock sold for Various uses in 1928 as Reported by producers, in the United States.

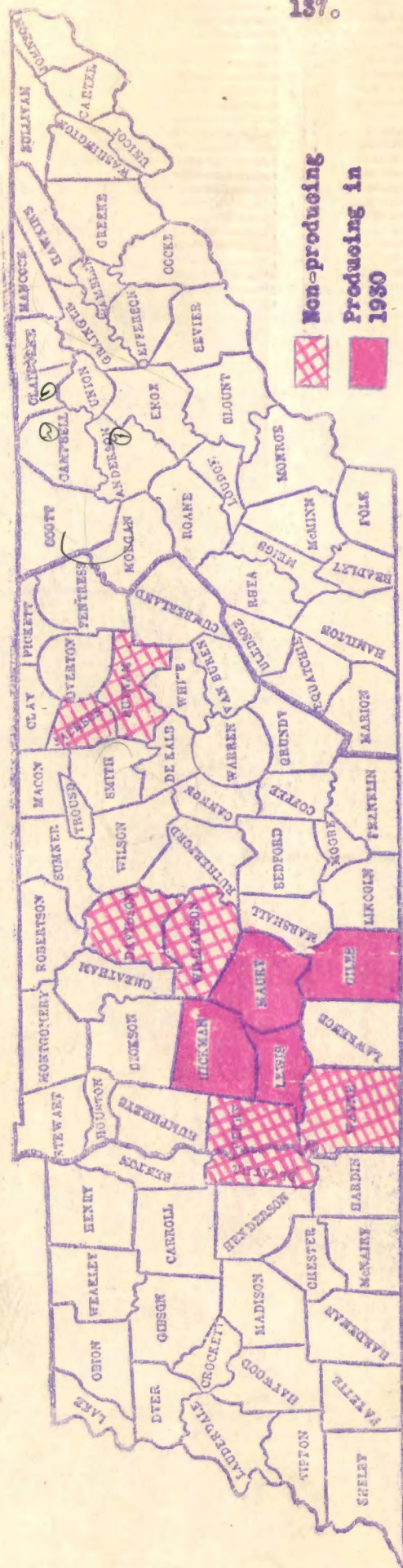
Use	Number Long Tons
For Super-phosphates	2,339,000
For Phosphorous and phos-chemicals	181,000
For direct application to the soil	42,000
For blast furnace	21,000
For stock and poultry feed	5,000
For other uses	15,000
Total	2,603,000

Source: Mineral Resources of the United States, 1928 Op. Cit. Part 2, Page 254.

Occurrence. Phosphate rock deposits are not as numerous in the United States as some of the other minerals. Five southern states,-----Tennessee, Florida, South Carolina, Kentucky, and Arkansas, and four western states,-----Montana, Idaho, Utah, and Wyoming contain practically all of the known phosphate deposits in the United States. (1)

(1) Mineral Resources of the United States, Op. Cit., Part 2, 1928, Page 227, and Plate 2.

OCCURRENCE OF PHOSPHATE BEDS, BY COUNTIES IN TENNESSEE



Source: (1) The Resources of Tennessee, State Geological Survey, Vol. 4, No. 2.
(2) Mineral Resources of Tennessee, Tennessee Division of Mines, 1930

The phosphate deposits of Tennessee occur largely in the Middle Tennessee counties as shown in Map 33. Johnson County has a number of deposits, but none are suitable for commercial production except for local use as ground raw phosphate. (1)

Only four counties produce phosphate commercially. These were Hickman, Giles, Lewis and Maury. The other counties that contain deposits are Williamson, Davidson, Jackson, Putnam, Wayne, Perry and Decatur. The deposits in Perry and Decatur counties are white phosphate.

Tennessee's Position in Production. The value of the phosphate mined in the United States is relatively small as compared with the value of all minerals. There are a number of metallic and non-metallic minerals that had a larger value in 1928 than the phosphate rock. The value of the total phosphate production in the United States in 1930 was \$13,996,830 as compared with over \$50 million for aluminum, \$181 million for copper, \$46 million for zinc, over a billion dollars each for coal and petroleum. (2)

In Tennessee the value of phosphate rock produced ranks higher than in the United States when compared with the value of all other minerals produced. The value of phosphate rock produced in this state in 1930 was third with a value of \$2,890,065. Coal ranked first with a value of over eight million dollars, copper second with over three million dollars, and marble fourth with a value of over two million dollars. (3)

Tennessee ranks second in the production of phosphate rock

(1) Resources of Tennessee, Op. Cit, Vol. VI No. 2 Page 52.

(2) U. S. Department of Commerce, Bureau of Mines, Mineral Resources of the United States, 1930, Summary.

(3) Tennessee Division of Mines, Mineral Resources of Tennessee 1930.

Table 34.

Production and Value of Phosphate, by States, 1891-1929
(All figures in thousands)

Date	Amount Long Tons				Value			
	Florida (a)	Tenn. (b)	S. C.	Ida.	Florida	Tenn.	S. C.	Ida.
1891	112	-----	479	-----	703	-----	2,948	-----
1895	568	39	432	-----	2,113	82	1,411	-----
1899	726	424	357	-----	2,804	1,177	1,078	-----
1903	860	461	259	-----	2,987	1,544	784	-----
1907	1,357	639	257	-----	6,578	3,048	981	-----
1911	2,436	437	169	-----	9,474	1,714	673	-----
1915	1,359	390	83	-----	3,767	1,328	311	-----
1922	2,059	339	2	4	8,348	2,003	8	20
1925	2,930	464	2	66	8,789	2,335	8	289
1929	3,088	634	---	36	9,901	3,097	---	142

(a) Hard rock and hard pebble (1911 and 1915).

(b) Brown rock and blue rock including small amount from Kentucky in 1911, 1915 includes blue and white rock, and small amount from Arkansas.

Source:

The Resources of Tennessee, April 1914, Vol. 4, No. 2, Mineral Resources of U. S., 1915 Part 2. Mineral Resources of U. S. (Prelim. Summary) 1923, 1927, 1930.

in the United States as shown by Table 34 and Chart 14. Tennessee has been second since 1899, when it passed South Carolina. Florida has ranked first since it passed South Carolina in 1894.

Tennessee's production declined from a peak of 638,612 tons in 1907 to a production of 339,027 tons in 1922. Up to 1929 the production had almost reached the 1907 peak. Florida has increased much more rapidly than Tennessee.

Production by Counties in Tennessee. Phosphate was first discovered by chance, near the Hickman-Lewis County line in 1893. This was the blue phosphate. Brown phosphate was first discovered in 1895. (1) White phosphate was first recognized in Perry County in 1896. (2)

(1) Resources of Tennessee, Op. Cit. Vol. IV, No. 2.

(2) Ibid, Vol. V. No. 1, Page 33.

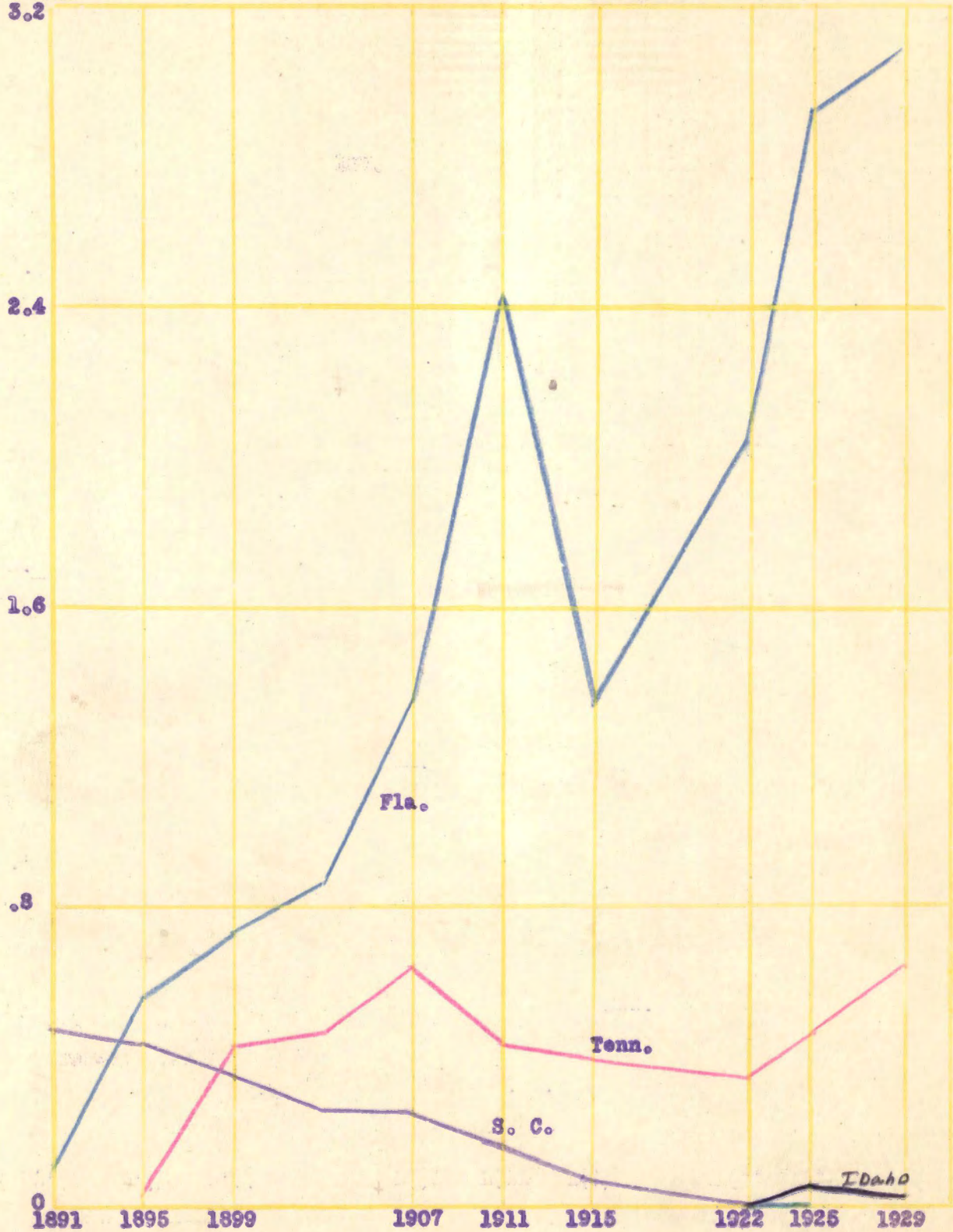
140.

140.

Chart 14.

Million
tons
3.2

PRODUCTION OF PHOSPHATE BY STATES, 1891-1929



Source: Table 3.

In 1930 Maury County produced 79.8 per cent of the state total production. Giles, Lewis, and Hickman Counties produced the other 20.2 per cent. (Table 35). For the years 1926-1930 the average value of the production in Maury County was over two million dollars.

Table 35.

Production and Value of Phosphate by Counties 1930

	Production			Value	
	% of total 1930	Long Tons 1930	5 Yr. Ave. 1926-30	1930	5 Yr. Ave. 1926-30
Maury	79.8	472,938	427,761	\$2,388,648	\$2,153,390
Giles	10.9	64,809	38,554	268,957	174,105
Lewis	7.3	43,336	36,811(1)	170,460	150,900(1)
Hickman	2.0	11,726	14,378	62,000	79,914
Tennessee	100.0	592,809	517,504	2,890,065	2,558,309

(1) Four years divided by 5.

Source:

Tennessee Division of Mines, Annual Report.

During the period 1920-1929, Tennessee produced only brown and blue phosphate rock and a large per cent of the total was brown rock (Table 36). In 1920 the production of brown rock was 542,725 long tons valued at \$8.00 per ton, while the production of blue rock was only 78,671 long tons valued at \$6.59 per ton. The production of blue rock decreased rapidly until in 1923 only 919 tons were produced while the production of brown rock had decreased only about 20 per cent. In 1924 the production of blue rock increased, but its production since that time has been included with that of the brown rock.

Reserves of Phosphate. Tennessee also ranks second in the eastern part of the United States in phosphate reserves, as shown

in Table 37. Florida ranks first. The reserves in the western states are many times larger than those in the eastern area, but the supply is of a lower grade and so far from the main consuming areas that these states had produced very little thru 1929.

Table 36.

Tennessee Phosphate Rock Sold or Used by Producers,
1920-1929

Year	Brown rock			Blue rock			Total		
	Long tons (000)	Value at mines		Long tons (000)	Value at mines		Long tons (000)	Value at mines	
		Total (000)	Ave.		Total (000)	Ave.		Total (000)	Ave.
1920	543	\$4,339	\$8.00	79	\$518	\$6.59	621	\$4,857	\$7.82
1921	239	1,575	6.59	25	146	5.81	264	1,721	6.51
1922	330	1,952	5.91	9	52	5.71	339	2,003	5.91
1923	415	2,249	5.42	1	6	6.14	416	2,255	5.42
1924	367	1,894	5.16	21	82	3.82	389	1,976	5.08
1925	464 ¹	2,335	5.03 ¹	(1)	(1)	(1)	464	2,335	5.03
1926	455 ¹	1,981	4.35 ¹	(1)	(1)	(1)	455	1,981	4.35
1927	482 ¹	2,319	4.81 ¹	(1)	(1)	(1)	482	2,319	4.81
1928	577 ¹	2,857	4.95 ¹	(1)	(1)	(1)	577	2,857	4.95
1929	634	3,097	4.89 ¹	(1)	(1)	(1)	634	3,097	4.89

(1) Blue rock included with brown rock.

Source:

U. S. Mineral Resources, Department of Commerce, Bureau of Mines, 1929, Part II - Phosphate Rock, p. 348, 349, 350.

Table 37.

American Phosphate Reserves
Long Tons--Millions

State	1915	1925
Florida	227	227
Tennessee	88	88
South Carolina	9	1
Kentucky	1	20
Arkansas	20	
Total Eastern States	345	336
Western States--Montana,		
Utah, Ida., Wyo.	5,367	5,367
U. S. Total	5,712	5,703

Source: 1915. U. S. Department of Interior, Geological Survey, Mineral Resources of the United States. Part 2, Page 238.
Utilization of Phosphate Resources--Economic Geography Oct. 1925.

Copper.

Historical Development. Copper was discovered in Tennessee in Polk County in 1849. Some of the first ore mined contained 32 per cent copper and was worth \$192.00 per ton. Up to July 1854 15,569 tons of soft ore had been produced. By 1853 the ore mined contained only seven to ten per cent copper. This ore, with the limited transportation facilities, could not be shipped profitably.

To overcome this economic handicap smelters were brought to the mines. As a result a great industry was soon developed. The development continued until after the Civil War when it began to decline, and then closed in the late seventies largely because of the lower grade ore and to lack of adequate transportation facilities. After the railroad was built thru this section in 1890 the industry soon revived. Heavier machinery was installed, and in 1904 ore containing less than 3 per cent copper was being mined profitably. In 1925 some ore used contained less than 1.6 per cent copper, but the average was three per cent. The profitable use of ore with this relatively low copper content is partly due to the utilization of the by-product, sulphuric acid, for commercial purposes. In 1921 this by-product was worth twice as much as the copper produced. In the earlier years of operation the sulphuric acid fumes were allowed to escape instead of being used in the manufacture sulphuric acid. (1) As a result of their escape the vegetation for several miles adjacent to the Duck Town plant has been killed.

(1) Case, Earl C., The Valley of East Tennessee, Division of Geology, Bulletin 36, 1925

Composition of the Ore, and Uses. Copper is a red, tough, malleable and ductile metal. Two of the most important minerals that contain copper are Pyrite (fool's gold) and Chalcopyrite.⁽¹⁾

Copper is used in the manufacturing of electric wire; it is combined with tin to make bronze and with zinc to make brass; and is also used for making sheet roofing, water tanks, copper plate, engraving, coins, sulphuric acid and for other miscellaneous purposes.⁽²⁾

Based on production, most of the important copper deposits are in the western part of the United States, principally in the Rocky Mountain region. Michigan and Tennessee are the only large copper producing states in the eastern part of the United States.⁽³⁾ The known deposits in Tennessee are in the extreme southeastern corner of the state in Polk County, at Ducktown.⁽⁴⁾

In total value of the production, copper ranked second among the metals and sixth among all minerals in the United States in 1929. Although it is produced in only one county in Tennessee the total value is much greater than that of any other metal mined in the state, and ranks high in value among all of the minerals. The value of the copper produced in Tennessee in 1928 was 2.4 million dollars compared with coal 9.7, stone 7.3, cement 6.3, clay products 4.0, phosphate rock 2.9 and sand and gravel 2.2 million dollars.⁽⁵⁾ ⁽⁶⁾

(1) Resources of Tennessee Op. Cit., Vol. 3, No. 4.

(2) Ibid.

(3) U. S. Dept., of Commerce, Bureau of Mines, Mineral Resources of the United States, 1928, 1928, 1929, 1930.

(4) Tennessee Division of Mines, Mineral Resources of Tennessee, 1928, 1929, 1930.

(5) Case, Earl C., The Valley of East Tennessee Division of Geology, Bulletin 39, 1925.

(6) U. S. Department of Commerce, Bureau of Mines, Mineral Resources of the United States, 1929 (Summary).

Table 38.

Production and Value of Copper in the United States, by states, 1924-1928

State	Quantity in Thousand Pounds						Value in Thousand Dollars					
	1928	1927	1926	1925	1924	Average 1924-28	1928	1927	1926	1925	1924	Average 1924-28
Ariz.	732,277	682,190	723,296	713,355	677,752	705,774	105,448	89,367	101,291	101,296	88,786	97,232
Utah	293,235	256,933	257,464	236,487	242,138	257,252	42,226	33,658	36,045	33,581	31,720	35,446
Mont.	248,262	223,493	255,373	268,911	249,152	249,038	35,750	29,278	35,752	38,185	32,639	34,321
Mich.	178,443	177,538	175,382	155,157	135,663	164,436	25,696	23,257	24,553	22,032	17,772	22,662
Nev.	158,877	120,259	101,828	79,300	73,805	106,814	22,878	15,764	14,256	11,261	9,668	14,765
N. M.	89,855	74,252	81,642	76,428	74,691	79,374	12,939	9,277	11,430	10,853	9,785	10,857
Cali.	25,151	27,133	33,466	46,865	52,107	36,944	3,622	3,554	4,685	6,655	6,826	5,068
Term.*	16,374	14,941	18,607	19,788	18,336	17,609	2,358	1,957	2,606	2,810	2,402	2,426
Col.	8,595	5,671	3,404	2,361	2,713	4,549	1,238	743	477	335	355	630
N. C.	8,207	5,443	1,469	(1)	(1)	5,040	1,182	713	206	(1)	(1)	700
Penn.	4,978	1,736	1,019	1,036	1,115	1,977	717	227	143	147	146	276
Idaho	2,072	2,173	1,337	3,297	2,739	2,324	298	285	187	468	359	319
Wash.	1,177	1,686	1,352	1,159	928	1,260	170	221	189	165	122	173
Texas	448	21	13	(1)	(1)	161	64	43	2	(1)	(1)	23
Oreg.	358	488	296	106	768	404	52	64	42	15	101	55
Mo.	65	451	1,077	12	183	358	9	59	151	2	24	51
Wyo.	3	(1)	(1)	(1)	(1)	3		(1)	(1)	(1)	(1)	
U. S.	1,825,900	1,684,041	1,739,622	1,674,870	1,532,091	1,691,305	262,930	220,609	243,547	237,832	200,704	233,124
					(2)						(2)	

(1) None given in Report (2) Sum of the column.

Source: U. S. Department of Commerce, Bureau of Mines, Mineral Resources of the United States, Summaries 1926, 1928, 1929.

In 1928 Tennessee ranked eighth in the United States in the amount of copper produced, as shown in Table 38. There were nine states producing copper that ranked lower than Tennessee. Of the United States total production of 1,825,900,393 pounds in 1928 Tennessee produced 16,374,261 pounds.

Table 39 shows the amount of copper produced in Tennessee from 1911-1930 inclusive. During this period the production has varied from 13 million pounds to 19 million pounds. The period of low production occurred from 1916 to 1923, and again in 1927, when from 13 million to 17 million tons were produced.

Table 39.

Copper Production in Tennessee 1911-1930

Year	Quantity in tons	Year	Quantity in tons	Year	Quantity in tons
1911	18,850,276	1917	16,033,749	1924	18,240,150
1912	18,483,173	1918	14,799,680	1925*	19,788,234
1913	19,390,750	1919	15,623,589	1926*	18,606,664
1914	18,737,656	1920	16,567,159	1927*	14,940,595
1915	18,046,010	1921	15,021,549	1928*	16,374,261
1916	14,679,794	1922	13,979,031	1929	18,476,826
		1923	18,948,969	1930	18,801,177

Tennessee Division of Mines, Mineral Resources of Tennessee, 1922, 1924, 1930.

* U. S. Department of Commerce, Bureau of Mines, Mineral Resources of the United States. (Preliminary Summary), 1926, 1928, 1929.

Iron

Composition and Use. (1) Since most of the iron ores are oxides pure iron is rarely found in nature because of the process of oxidation. In order of their commercial importance the iron ores are: hematite, (Fe_2O_3) which is 70 per cent iron, and 30 per cent oxygen; limonite, ($2\text{Fe}_2\text{O}_3 \cdot 3\text{H}_2\text{O}$), which is 59.8 per cent iron, 25.7 per cent oxygen and 14.5 per cent water; magnetite, Fe_3O_4 , which is 72.4 per cent iron and 27.6 per cent oxygen; and carbonate and sulphate of iron.

The ores are converted by blast furnaces into pig iron. From the pig iron, cast iron, wrought iron and many different grades of steel are made.

Occurrence. There are three regions in Tennessee that contain iron ore deposits. The eastern iron belt extends North and South thru the state among and along the western border of the Unaka Mountains. The Dyerstone Region skirts the eastern base of the Cumberland Plateau or Waldens Ridge, beginning in the northern part of Georgia, below Chattanooga, and extending northwardly to the Kentucky and Virginia lines. This belt in places extends out laterally into the valley of East Tennessee from ten to twenty miles and includes the Sequatchie and Elk Valleys.

The Western iron region occupies a belt of the Western Highland Rim contiguous to the West Tennessee Valley and forms a part of the valley. This belt extends across the state from Alabama to Kentucky. (2)

(1) State Geological Survey. The Resources of Tennessee Vol. III, No. 4.
 (2) State Geological Survey. The Resources of Tennessee, Vol. II, No. 10, Page 370.

The chemical character of the different iron ores is given in Table 40. The iron ores in the eastern belt are magnetic. There are three kinds of this magnetic ore found; (1) magnetite, (2) a mixture of magnetite and some mineral containing titanium, and (3) a mixture of magnetite and hematite. Now, with modern methods of smelting only non-titaniferous magnetites are of economic importance. Yet, at one time only titaniferous ores were mined.

Most of the ore in the deposits in the belt along the eastern base of the Cumberland Plateau is red ore, or hematite, (Fe_2O_3), with such impurities as silica- (SiO_2), alumina- (Al_2O_3), calcium- (MgCO_3), sulphur, phosphorous and manganese, red hematite, containing as high as seventy per cent. Metallic iron, has been mined at Rockwood, but the average for 1929 was 34 per cent. (1)

The ore in the western iron region of Tennessee is Limonite but it is also called brown hematite. (2)

Table 40.

Chemical Character of the Iron Ore Minerals in Tennessee					
Ores	Mineral	Chemical formula	Chemical Composition		
			% Iron	% Oxygen	% Water
Anhydrous oxides of iron	Magnetite	Fe_3O_4	72.4	27.60	None
	Hematite	Fe_2O_3	70.0	30.00	None
	Turgite	$2\text{Fe}_2\text{O}_3 \cdot 2\text{H}_2\text{O}$	62.93	26.97	10.10
Hydrous	Goethite	$2\text{Fe}_2\text{O}_3 \cdot \text{H}_2\text{O}$	66.29	28.41	5.30
	Limonite	$2\text{Fe}_2\text{O}_3 \cdot 3\text{H}_2\text{O}$	59.80	25.70	14.50
	Anthosiderite	$2\text{Fe}_2\text{O}_3 \cdot 4\text{H}_2\text{O}$	57.12	24.48	18.40
Carbonate of Iron	Siderite	FeCO_3	48.20	51.80 CO_2	None

Source: State Geological Survey. The Resources of Tennessee Vol. 3 No. 2, Page 84.

(1) State Geological Survey--The Red Iron Ores of East Tennessee, Bulletin 16.

(2) State Geological Survey--The Resources of Tennessee, Vol. 5, No. 3.

Production and Value of Iron Ore, by States. Iron ranks high among the minerals in production in the United States. In 1930 its total value was much greater than that of any other metallic mineral and was third in all minerals, petroleum and coal being the only ones having a greater value.⁽¹⁾

In Tennessee iron production does not rank as high compared with the other minerals as it does in the United States. In 1930 the value of copper and of zinc mined in Tennessee was greater than that of iron. There were a number of non-metallic minerals that had a greater value than did iron.⁽²⁾

In 1929 Tennessee ranked eleventh in the United States in the total amount of iron ore mined, as is shown in Table 41. Minnesota was first with over thirty-seven million tons; Michigan second, with over thirteen million tons; Alabama third, with over six million tons; while the production in Tennessee was only 128,928 tons, ranking the state 11th.

In three of the four leading states all of the ore produced was hematite and in Alabama, the 4th ranking state, approximately ninety per cent was hematite, and ten per cent brown ore. In Tennessee, of the total 128,928 tons produced, 45,266 tons, or approximately 35 per cent, was brown ore. The largest amount, or about 65 per cent, was hematite.

Production of Pig Iron by States. In the amount of pig iron produced in 1929, Tennessee ranks twelfth, or just one place lower than it did in the amount of iron ore mined, (Table 42). There is

(1) Mineral Resources of the United States, Op. Cit. 1930, Summary, Pages A7 and A8.

(2) Mineral Resources of Tennessee, Annual Report of Division of Mines. 1930.

Table 41.

Iron Ore Mined by Principal Producing States, 1929

State	Total (Tons)	Hematite (Tons)	Brown Ore (Tons)	Magnetite (Tons)	Carbonate (Tons)
Minnesota	37,564,005	37,564,005	0	0	0
Michigan	13,676,984	13,676,984	0	0	0
Alabama	6,307,844	5,668,493	639,351	0	0
Wisconsin	1,284,592	1,284,592	0	0	0
Pennsylvania	1,023,870	0	0	1,022,080	1,790
New York	712,757	(1)	0	712,757(1)	0
Wyoming	491,280	491,280	0	0	0
Utah	320,655	320,655	0	0	0
New Jersey	250,332	0	0	250,332	0
New Mexico	184,623	0	0	184,623	0
Tennessee *	128,928	83,662	45,266	0	0
Missouri	94,899	94,899	0	0	0
Georgia	73,052	0	73,052	0	0
Colorado	52,713	0	52,713	0	0
Virginia	27,902	23,287	4,615	0	0
Montana	1,640	0	1,640	0	0
Washington	1,012	0	0	1,012	0
Total	62,197,088	59,207,857(1)	816,637	2,170,804(1)	1,790

(1) Some hematite included with magnetite.

Source: Iron Ore, Pig Iron and Steel in 1929, U. S. Bureau of Mines, Part I, Page 7.

a considerable change in rank however, among some of the heavier producing states. Pennsylvania ranks first in pig iron production, but ranked fifth in the total amount of iron ore mined, Minnesota, which ranked first in the amount of iron ore mined, ranked tenth in the amount of pig iron produced. The cause of this is probably the fact that both iron ore and coal are required to produce pig iron and if both are not found in the same section, one of them must be transported to the other. Tennessee has both coal and iron ore which probably accounts for the fact that it holds almost the same rank in the amount of iron ore mined and in the amount of pig iron produced.

Table 42.

Pig Iron Produced by States, 1929

State	Tons Produced (Exclusive of Ferro-Alloys)	Metals consumed per Ton Iron made.
Pennsylvania	14,008,831	1.880
Ohio	9,708,425	1.876
Illinois	4,358,555	2.144
Indiana	4,277,759	1.977
Alabama	2,704,733	2.549
New York	2,635,675	1.924
Maryland	1,117,228	1.843
Michigan	807,856	1.808
West Virginia	665,584	1.868
Minnesota	379,162	1.972
Kentucky	196,417	1.784
Tennessee *	118,213	2.077
Virginia	11,921	2.439
Undistributed (1)	771,129	2.053
Total	41,761,488	1.964

(1) Includes Colorado, Massachusetts, and Utah.

Source:

Iron Ore, Pig Iron and Steel in 1929, Op. Cit. p. 15.

Production by Counties. The amount of iron ore mined in Tennessee in 1928 was 128,928 tons, in 1929, 102,171 tons and in 1930, 23,278 tons. (Table 43). (1) In 1928 and 1929 Hamilton and Roane Counties produced a large per cent of the state total.

The number of producing counties decreased from five in 1928 to four in 1929, and to one, Hickman, in 1930. The five year average 1926-1930, production and value is shown in Table 44. During this period the greater part of the ore mined was hematite, mined near Rockwood, in Roane County. The second highest ranking county during

(1) Mineral Resources of Tennessee, Op. Cit., 1930, Page 123.

Table 43.

Iron Ore Mined in Tennessee, 1928 and 1929, by Counties

County	1928		1929	
	Active Mines	Gross Tons	Active Mines	Gross Tons
Dickson	2	8,898	2	8,880
Hickman	1	23,095	1	24,536
Lawrence	1	13,273	0	0
Hamilton	1}	83,662	1}	68,755
Roane	1}		1}	
Total	6	128,928	5	102,171

Source:

Iron Ore, Pig Iron, and Steel in 1929, Op. Cit. Page 23.

Table 44.Production and Value of Iron Ore by Counties, 1930

County	Production			Value	
	% of Total 1930	Tons 1930	5 Yr. Ave. 1926-1930	1930	5 Yr. Ave. 1926-30
Hickman	100.0	23,278	21,313	\$46,556	\$50,585
Roane	0	0	61,801(1)	0	93,930(3)
Lawrence	0	0	985(2)	0	3,645(2)
Lewis	0	0	2,655(2)	0	10,618(2)
Dickson	0	0	6,855(1)	0	23,277(1)
Tennessee	100.0	23,278	93,609	46,556	182,056

- (1) Four year total divided by 5.
 (2) One year total divided by 5.
 (3) Three year total divided by 5.

Source:

Annual Report of State Division of Mines, 1930.

this period, and the only one producing in 1930, was Hickman. Brown ore is produced in this county.

Pig iron was produced in only two counties in 1930, Hickman pro-

ducing 75.9 per cent of the state total and Roane 24.1 per cent. During the five year period 1926-1930 Roane County produced the larger per cent of the state's total production of pig iron.

Trends in Production. In East Tennessee before 1870 the production and use of iron was widespread. There were several causes of this: (1) the long distance to producing or importing centers; (2) an abundance of local deposits; (3) a plentiful and cheap supply of labor, charcoal and waterpower; and (4) the availability of water transportation. By 1870 almost every county had a blast furnace, forge or bloomery. Part of the iron produced was used locally in making wagon tires, horse shoes, hines, nails, harrow teeth, etc. (1)

In the western belt, iron has been mined since 1832. In 1854 in this belt 31 furnaces made 37,283 tons of iron, four bloomerics made 91 tons of iron, 13 refineries made 6,808 tons of blooms, and a few tons of iron. (2)

In the last half century the numerous small furnaces have given way to a few large ones. In 1922 there were only two operating in East Tennessee. These two were at Lafollette and Rockwood. One at Johnson City had just closed down but it was operated again later. In 1930 pig iron was produced only in Hickman and Roane² Counties and 75.9 per cent of the total was produced in the former county, (3)

Table 45.

(1) Case, Earl C., Op. Cit.

(2) The Resources of Tennessee, Op. Cit., Vol. 5, No. 3.

(3) Case, Earl C., Op. Cit.

Table 45.Production and Value of Pig Iron by Counties, 1930

County	Production			Value	
	% of Total 1930	Tons 1930	5 Yr. Ave. 1926-1930	1930	5 Yr. Ave. 1926-1930
Hickman	75.9	9,741	1,948 (1)	\$225,000	\$ 156,437 (2)
Roane	24.1	3,100	58,863	43,400	1,071,147
Maury	0	0	3,729 (2)	0	340,573 (2)
Wash.	0	0	10,258 (3)	0	238,437 (3)
Tenn.	100.0	12,841	74,798	268,400	1,806,594

Source:

Annual Report of Division of Mines, 1930.

Tennessee has declined rapidly in iron ore production since 1910, as shown in Table 46. At that time 732,000 tons were produced as compared with 284,185 tons 5 years later, and 102,000 tons in 1929. Meanwhile the trend in production in the United States has been upward from about 27½ million tons in 1900 to about 73 million tons in 1929.

Table 46.

Trend in Iron Ore Mined in Tennessee and United States, 1900-1930

Date	Number Tons in Tennessee	Number tons in U. S.
1900	594,000	27,553,000
1910	732,000	56,890,000
1915	284,185	55,526,430
1921	25,219 (1)	
1925	164,073 (1)	63,924,763
1926	138,307 (1)	69,292,832
1927	121,220 (1)	61,232,473
1928	128,478 (1)	63,432,826
1929	101,796	75,602,734
1930		55,201,221

Mineral Resources of the United States, (Summaries) Op. Cit.

(1) Sold to furnaces.

Table 47.

Trend in Pig Iron Production in Tennessee and United States 1900-1930
686

Date	Number Tons in Tennessee	Number tons in U. S.
1900	362,000	13,789,000
1910	398,000	27,304,000
1915	177,729	29,916,213
1921	21,972	36,688,126
1925	95,186	36,884,702
1926	113,029	38,181,053
1927	87,971	34,866,644
1928	102,718	38,303,699
1929	104,985	41,549,161
1930	12,841	29,905,355
1931		

Mineral Resources of the United States, 1930 (Summary) Op. Cit.,
except 1930 Tennessee data, which are from Annual Report of
Tennessee Division of Mines, 1930.

Like iron ore the production of pig iron has declined since 1910 in Tennessee. From a production of 398,000 tons at that date there was a decrease to 177,729 tons in 1915. In 1929 the production had declined to 104,980 tons---the previous 15 year period witnessing violent fluctuations. On the other hand the production in the United States has been increasing almost consistently since 1900---with the exception of the depression period beginning in 1929.

Zinc

Composition and Use. Zinc is a bluish white metal that is brittle at ordinary temperature, but may be hammered or rolled into sheets when heated to 100°. When heated to above 200° it becomes brittle again and if heated in air, it burns with a bluish flame. Zinc soon tarnishes when exposed to air, but this forms a film on the surface which protects it from further corrosion.

Zinc is not found in the pure state, but combined with other elements in ores. The principal ores containing zinc are: sphalerite, (ZnS) , (Zn 67 per cent, S 33 per cent); smithsonite, $ZnCO_3$ (ZnO 64.8 per cent, O_2 35.2 per cent); and calamine, $(ZnOH)_2 SiO_3$, (ZnO 67.8 per cent, SiO_2 25 per cent, H_2O 25 per cent).

Zinc is used to galvanize sheets, tubes, wire and wire cloth. It is used also in an alloy with copper to make brass, and with copper and nickel to make German silver. Zinc is also used in electric batteries and for making zinc white and other paints. Since 1926 a considerable amount has been used in the United States for die castings.⁽¹⁾

Occurrence. The zinc ores, sphalerite and smithsonite have been found in Middle Tennessee, but not in sufficient amounts to make zinc mining profitable. Sphalerite, smithsonite, and calamine all occur in the East Tennessee Valley, especially in the northeastern part. Most of the mining, however, has been done in the East Tennessee Valley north of Knoxville.

Regarding the areas of occurrence the Tennessee Division of Mines say:

"The area of zinc ores lies in the Great Valley region of East Tennessee, and extends from Virginia to Georgia. Much prospecting has been done within this territory in the following counties: Unicoi and Claiborne, in the New Prospect district; Claiborne County in the Straight Creek district; Hancock County, in the Evanston district; Grainger and Hancock, in the Copper Ridge district; Sullivan County, in the Falls Branch district; Greene County, in the Greenville district; Jefferson County, in the Mossey Creek district; Jefferson County, in the Mossey Creek district; Jefferson County, in the New Market district; Knox County, in the Mascot district; Blount County, in

(1) The Resources of Tennessee, Op. Cit., Vol. 3, No. 4.

the Friendsville district; Monroe County, in the Eve Mills district; Bradley County, in the Cleveland district; Carter County, in the Watauga district; Washington, Unicoi and Jefferson Counties, in the Embreeville district." (1)

Production. In 1929 the total amount of zinc ore produced in the United States was 7,193,000 short tons compared with a total production of copper ore of 68,442,000 short tons.

The value of the primary zinc produced in the United States increased from less than 20 million dollars in 1921 to over 84 million dollars in 1925, or from 198,232 tons to 555,631 tons, (Table 48). The value decreased from 1925 until 1929 when the value was less than 80 million dollars, and in 1930 less than 47 million. Due to the decline in prices the value decreased more than did production, but the latter decreased from 612,136 tons in 1929 to 489,361 tons in 1930. (2)

The production in Tennessee increased from 15,000 tons in 1928 to 17,000 tons in 1929. The value of the production decreased from \$1,243,865 in 1929 to \$1,236,660 in 1930. (Table 49). This is a very small decrease compared with that of the United States. There is no record of the production in Tennessee prior to 1912. The production for the years 1912 to 1930 inclusive are given in Table 49. Production increased rapidly from 1912 until 1917 when the peak of 883,341 short tons of ore were mined. This rapid increase was due largely to operations in the Mascot district. The production declined to 319,764 tons in 1921, but has been increasing since that time. In 1924 it reached 718,175 tons, the second largest production since 1912. By 1930 it had decreased to 605,776 tons.

(1) Mineral Resources of Tennessee, Tennessee Division of Mines, 1930 Page 138.

(2) Mineral Resources of the United States, Op. Cit. 1930, Summary.

Table 48.Primary Zinc Produced in the United States from Domestic Ores
1921-1930

Year	Short Tons	Value
1921	198,232	\$19,823,000
1925	555,631	84,456,000
1928	591,525	72,166,000
1929	612,136	80,802,000
1930	489,361	46,979,000

Source:

Mineral Resources of U. S. Op. Cit. 1930 Summary, Page A90.

Table 49.

East Tennessee Zinc Production 1912-1930 (1)

Year	Mine Production (crude ore) Short tons	Zinc Produced (Tons)	Value of Product
1912	32,347	(1)	(1)
1913	171,392	(1)	(1)
1914	357,437	(1)	(1)
1915	525,829	(1)	(1)
1916	702,326	(1)	(1)
1917	883,341	(1)	(1)
1918	598,742	(1)	(1)
1919	649,844	(1)	(1)
1920	598,742	(1)	(1)
1921	319,764	(1)	(1)
1922	411,484	(1)	(1)
1923	579,022	(1)	(1)
1924	718,175	(1)	1,157,873
1925	(1)	25,710	1,328,311
1926	(1)	12,000	1,089,772
1927	(1)	11,000	
1928	(1)	15,000	751,388
1929	670,213	17,000	1,243,865
1930	605,776	(1)	1,236,660

(1) Total Production confined to East Tennessee.

(2) Data not available.

Source:

- (1) 1912-1923 data, from Zinc Deposits of East Tennessee, Division of Geology, Bulletin 31 (1924).
- (2) Tons Zinc Produced from, unpublished manuscript by George M. Hall, Professor of Geology, University of Tennessee.
- (3) All other data from Annual Reports of Tennessee Division of Mines.

The mining of zinc began in Tennessee with the discovery of zinc on Mossy Creek, Jefferson County in 1856. The finding of the oxidized ore soon led to the discovery of the sulphide ore in limestone. There was no large scale production of zinc until 1911 when the American Zinc Company began operation at Mascot. (1) The small scale production prior to that time is indicated by the \$14,821 value of the production in 1907. (2)

"Near Mascot is located the largest zinc mine in the United States producing zinc ore for the manufacture of zinc white. After separating the zinc from the lime, the latter is sold as fertilize." (3)

Lead

Composition and Use. Lead is a bluish white, soft, heavy metal. It is acted on slowly by most natural waters, sulphuric acid, and hydrochloric acid, but it is not soluble in nitric acid. The lead ores are: Galena, (PbS), which is 86.6 per cent lead and 13.4 per cent sulphur; Cerussite "dry bone", ($PbCO_3$) which is 83.5 per cent PbO and 16.5 per cent CO_2 ; and Anglesite, $PbSO_4$, which is 73.6 PbO and 26.4 per cent SO_3 .

Lead is used in the manufacture of white lead for paint, the alloys, pewter, solder, type metal and organ pipe metal, making shot, water pipes, fusible alloys for electric fixtures and covering electric cables are other important uses for lead. (4)

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- (1) Zinc Deposits of East Tennessee, Op. Cit.
 - (2) Annual Report of Tennessee Division of Mines, 1924.
 - (3) Case, Earl C., Op. Cit. Page 83.
 - (4) The Resources of Tennessee, Vol. 3, No. 4, Op. Cit.

Occurrence and Production. There are lead deposits in a large number of the states. The principal producing regions of the United States are, the Atlantic Coast, Mississippi Valley, the Rocky Mountain and Pacific regions.⁽¹⁾ The leading producing states in 1929 were Missouri, Utah, Idaho, Oklahoma, Colorado, Kansas, Montana, Nevada, and New Mexico.⁽²⁾ Although Tennessee is not one of the leading producing states it does have considerable lead deposits.

Lead has been mined or located in several of the East Tennessee counties, some of the Middle Tennessee counties and small amounts located in the southern part of the Cumberland Plateau region. While scattering deposits are found over a large part of East Tennessee, most of the mining has been done in the Northern part of this section.⁽³⁾

In the United States the value of the lead produced in 1930 was high as compared with the other metallic minerals. Iron and copper are the only metallic minerals having a greater value. Aluminum and zinc ranked next to lead in value of the production in 1930.

The United States production of lead in 1930 was over one half million tons valued at over 57 million dollars. (Table 50). Nine states each had a production exceeding a million dollars in value. These states and the value of their production in million dollars

(1) The Resources of Tennessee, Vol. 2, No. 3, Op. Cit.

(2) Mineral Resources of the United States, 1930 Summary, Op. Cit.

(3) The Resources of Tennessee, Vol. 2, No. 3, Op. Cit.

Table 50.

Refined Primary Lead Produced in the United States from Domestic Ores, 1921-1930

Year	Short Tons	Value
1921	398,222	\$35,840,000
1922	468,746	51,562,000
1923	543,341	76,138,000
1924	566,407	90,625,000
1925	654,921	113,956,000
1926	680,685	108,910,000
1927	668,320	84,208,000
1928	626,202	72,639,000
1929	672,498	84,735,000
1930	573,740	57,374,000

Source: Summary Mineral Resources of the United States, 1930, Page A57.

were as follows: Missouri, 25; Utah, 18; Idaho, 18; Oklahoma, 5; Colorado, 3; Kansas, 3; Montana, 2; Nevada, 1; and New Mexico, 1. Tennessee produced 770 tons in 1926 and in 1930 produced only 29 tons valued at \$718. (1)

Lead production is relatively unimportant in Tennessee. The number of tons produced for the years stated are: (1)

1925	436 tons
1926	770 tons
1927	19 tons
1930	29 tons

These quantities are almost negligible in comparison with the 573,740 ton production in the United States in 1930.

The production in 1930 was valued at only \$718. (2)

Since an early date, lead deposits were known in East Tennessee. In 1779 the settlers in the Nashville vicinity mined lead from what is now Carter County. Lead was mined also during the Confederate War, and is said to have been mined during the war of 1812. (3)

(1) Annual Reports of Tennessee Division of Mines.

(2) Ibid, 1930.

(3) State Geological Survey, The Resources of Tennessee, Op. Cit., Vol. 2, No. 3.

Manganese

Composition and Use. Pure manganese is a hard, brittle, grayish white metal. It is not found pure, but in ores which are oxides mixed with varying percentages of iron, sulphur, carbonic acid, and earthy matter.

Large amounts of the black oxide of manganese are used for obtaining oxygen gas used in manufacturing bleaching powder and liquors. Manganese is used as an alloy in making steel and as a drying agent in paints and varnishes. It is used as a decolorizer of glass, and also in coloring glass, bricks, and pottery. It is used in the manufacturing of electric dry cells.(1)

Occurrence. There are large deposits of manganese in East Tennessee and some in Middle Tennessee in Wayne, Hickman, and Lawrence Counties. Some of the more important deposits in East Tennessee are in Johnson, Carter, Unicoi, Sevier, and Blount Counties. Most of these deposits of ore contain a high percentage of manganese, averaging from 40 to 58 per cent. Some ore has also been reported in Greene, Cocke, Hamblen, Grainger, Jefferson, Knox, Anderson, Loudon, Monroe, McMinn, and Bradley Counties. (2)

The first manganese mined in the United States was mined in Tennessee in 1837. Since that time very little has been done to develop the deposits here. (3) However, it ranked ninth in the United States in 1929 in the production of manganese ore, containing 35 per cent or more of manganese, and 13th in total production of manganese and manganiferous ore.

(1) State Geological Survey, Resources of Tennessee, Vol. 3, No. 4.

(2) The Resources of Tennessee, Op. Cit. Vol. 8, Nos. 1,3,4; and Mineral Resources of Tennessee, Op. Cit. 1930.

(3) Ibid.

Table 51.

Manganese and Manganiferous Ore (Exclusive of Fluxing Ore)
Shipped from Mines, 1929

State	Total (a) Long Tons	Ore containing 35 per cent or more of manganese	Total number of Shippers
Minnesota	1,009,841		6
New Mexico	70,527	2,969	4
Montana	57,992	42,327	6 (1)
Michigan	49,112		3
Arkansas	18,082	4,308	6
Colorado	17,770		2
Georgia	7,831	2,521	9
Utah	6,030	88	4
Virginia	3,131	3,051	10 (2)
Arizona	2,700	2,655	4
Nevada	2,407		5
Idaho	1,364	1,326	4
Tennessee	764	523	6
California	569	569	4
Alabama	475		3
Texas	42	42	1
Total	1,248,637	60,379	76

(a) Total of ore containing 35 per cent or above manganese ore, 10 to 35 per cent ore, and 5 to 10 per cent ore.

(1) Figures represents mills through which all shipments were made; individual producers not counted.

(2) One producer in Virginia shipped both metallurgical and chemical ore.

Source: Summary of Mineral Resources of the United States, 1930, p. A63.

This state's production in 1929 was only 764 tons in comparison to the production in the United States of 1,248,637 tons, or less than one-tenth of one per cent of the total amount. Table 51. Only 3 producing states, California, Alabama and Texas produced less than Tennessee. By 1930 Tennessee's production had declined to 446 tons. (1)

(1) Annual Report of Tennessee Division of Mines, 1930.

Minnesota is the outstanding state in production, with 1,009,-841 tons reported in 1929, or about one-half of the United States total. (1) New Mexico, Montana, and Michigan rank next in order. Arkansas, Georgia and Virginia are the high producing states in the South.

Statistics on production by areas in Tennessee prior to 1924 are incomplete. The Annual Report of the Tennessee Division of Mines for 1924 says regarding manganese:

"The above is the first report we have undertaken to publish of the manganese production for some few years owing to the fact that the production was so small the Division of Mines has not undertaken to inspect and gather statistics of this one." (2)

In 1924 only one mine operating was in Monroe County. (3) The production was 425 long tons valued at \$11,250. In 1925 and 1926 the amount produced was 350 and 250 tons respectively. In 1930, the 446 ton production was reported from Carter County. (4)

Bauxite

Composition and Use. Bauxite, ($\text{Al}_2\text{O}_3 \cdot 2\text{H}_2\text{O}$), is a hydrate of alumina, (Al_2O_3), and is white to gray when pure, but due to impurities is commonly brown to red. Pure bauxite contains 73.9 per cent water. Analyses show the per cent of water to vary from 30.3 to 76.0 bauxite, containing 79.3 per cent alumina, contains 39.2 per cent of the metal aluminum. (5)

(1) Minnesota reports no ore with manganese content of 35 per cent and over.

(2) Mineral Resources of Tennessee, Op. Cit. 1924, p. 137.

(3) Ibid.

(4) Mineral Resources of Tennessee, Op. Cit. 1930.

(5) The Resources of Tennessee, Op. Cit., Vol. 3, No. 4, and Vol. 4, No. 2.

"In amount, aluminum is the third most important element in those rocks of the earth which are accessible, being exceeded only by oxygen, and silica. The approximate amounts of these are aluminum, 7.84 per cent; silica, 28.00 per cent; oxygen 47.17 per cent." (1)

Bauxite is used in the manufacturing of bauxite brick, alum and calcium aluminate. It is also used in the manufacturing of abrasives and is practically the only source of the metal aluminum. The per cent of aluminum in bauxite and other minerals is shown in Table 52.

Table 52.

Per Cent of Aluminum in Specified Minerals

Mineral	Per Cent Aluminum
Common clay	11.10
Cryolite	12.89
Kaolin	17.61
Bauxite	31.21
Corundum	53.03

Source:

The Resources of Tennessee, April 1914, Vol. 4, No. 2,
Page 89.

Production. Based on the production of bauxite in the United States, 1921 to 1930, four states, Arkansas, Georgia, Alabama and Tennessee contain the principal deposits. Arkansas produced much more than the total of the other three states. Table 53. There are a number of the metallic minerals that rank higher in the value of the production than bauxite, yet it is important. The value of the United States production in 1929 was over two million dollars and in 1930 about two million dollars. (2)

(1) The Resources of Tennessee, Op. Cit. Vol 4, No. 2, Page 87.

(2) Mineral Resources of the United States, Op. Cit. 1930 Summary.

Table 53.

Bauxite Produced in the United States, 1921-1930.

Year	Georgia, Alabama, and Tennessee		Arkansas		Total	
	Long tons	Value	Long tons	Value	Long tons	Value
1921	14,700	\$124,400	124,850	\$755,400	139,550	889,800
1922	42,810	329,440	266,790	1,682,890	309,600	2,012,330
1923	28,810	176,030	493,880	2,980,580	522,690	3,156,610
1924	19,940	156,990	327,630	1,981,000	347,570	2,137,990
1925	20,220	109,800	296,320	1,878,450	316,540	1,988,250
1926	20,680	116,650	371,570	2,298,550	392,250	2,415,200
1927	17,110	95,920	303,830	1,892,860	320,940	1,988,780
1928	14,190	80,668	361,256	2,193,230	375,426	2,273,898
1929	14,723	84,480	351,054	2,181,158	365,777	2,265,638
1930	15,339	104,908	315,273	1,823,389	330,612	1,928,297

Source:

Summary, Mineral Resources of the United States, 1930.

Bauxite has been mined in Tennessee near Chattanooga, in Hamilton County, and near Elizabethton, in Carter County. Deposits have been reported near Hixon, in Hamilton County. Since bauxite is hard to recognize, even by a geologist, there may be other deposits in East Tennessee. (1) No production of bauxite has been reported in Tennessee since 1928, when the production was 460 long tons. (2)

The mine near Chattanooga opened in 1906 and was in operation in 1925. The one near Elizabethton opened in 1906 but was not operating in 1925. None of the bauxite mined in Tennessee was used for making aluminum but was used for making alum, refractory brick and abrasives. (3)

(1) Case, Earl C. Op. Cit.

(2) Mineral Resources of the U. S. Op. Cit. 1929, (Summary) Page All4.

(3) Case, Earl C. Op. Cit.

There has been a rapid growth in the United States of the production and consumption of aluminum, most of which is made from bauxite. In 1883 the production was 83 pounds; in 1912 it was 65,607,000 pounds; and in 1930 it had increased to 229,035,000 pounds. (1)

Gold

Gold in the native state is yellow, heavy, soft and malleable, and is usually alloyed with silver. It is used principally in making coins and jewelry. It is also used in dentistry and medical. (2)

The only known deposits of gold in Tennessee are in the southeastern part of the state, in Blount and Monroe Counties. The richest deposits have been found in the Colser Creek Valley in the southeastern part of Monroe County. Gold has also been reported in Blount County, east of Montvale Springs and back of the Chilhowee Mountains. All of these localities are practically in a straight line north 4° East. The length of this belt is about 50 miles long. This does not include Ducktown where some gold is recovered from the copper ore. (3)

Gold is a very valuable mineral, but the value of the gold mined in the United States each year is smaller than that of several of the other metallic minerals. The value of all of the metallic minerals mined in the United States in 1930 was over 982 million dollars while the value of the gold mined was only 47 million dollars. The value of aluminum was over 50 million dollars,

(1) Resources of Tennessee, Op. Cit. Vol 4, No. 2; and Mineral Resources of the United States Op. Cit. 1930 Summary.

(2) The Mineral Resources of Tennessee, Op. Cit. Vol. 3, No. 4, page 200.

(3) The Resources of Tennessee, Op. Cit. Vol. 1, No. 3.

copper over 181 million dollars and pig iron over 512 million dollars. (1) The United States however, ranked second among the countries of the world in 1929, 1924 and 1914 in the production of gold, as shown in Table 54. Out of the \$261,715,000 produced in 1929 Africa produced \$235,346,900 which is approximately 90 per cent of the world production.

In 1929 Tennessee ranked fourteenth among the states of the United States in the production of gold. (Table 55). Altho Tennessee's production of 653 fine ounces worth \$13,500 looks very small compared with California's production of 409,020 fine ounces worth \$8,455,200, Tennessee produced more than any of its neighboring states. During the period 1831 to 1854 the greatest value of gold produced in any one year in Tennessee was \$7,161 in 1848. The year of the second highest value during this period was 1833 when the value was \$7000.(Table 56).

That there were gold deposits in the southeastern part of Tennessee appears to have been known by the Indians. It was first discovered by white man in 1827. The first gold sent from Tennessee to a mint was \$1000 worth sent to Philadelphia in 1831. The value of the gold mined from 1831 to 1854 is given in Table 56. It has been reported that the most active work did not begin until 1856 to 1860.(2)

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- (1) Mineral Resources of the United States, 1930, Summary.
 (2) The Resources of Tennessee, Op. Cit. Vol. 1, No. 3.

Table 54.

Value of World Production of Gold by Principal Producing Countries, 1929, 1924, 1914

Country	1929	1924	1914
Africa	\$235,346,900	\$219,579,700	\$217,639,599
U. S.	(2) 42,514,300	50,570,300(2)	99,714,800 (2)
Canada	39,861,700	31,532,400	18,936,971
Russia	20,671,800	19,805,100	28,586,392 (3)
Mexico	13,475,400	16,480,100	6,559,275
Australasia	12,096,400	16,536,800	49,397,797
India, British	7,521,800	8,193,200	11,522,457
Japan	6,905,600	5,054,300	5,385,917
Philippine Is.	3,320,400	1,651,500	1,320,900
Chosen	2,928,500	2,772,700	3,739,477
Peru	2,524,800	2,459,000	1,109,891
Netherland	2,230,500	214,000	449,054
Brazil	2,219,800	2,990,700	2,424,515
Rumania	1,470,800	871,300	?
Ecuador	1,391,800	800,000	545,674
France	1,116,500	409,400	1,400,000
Cent. America	1,100,000	1,800,000	2,970,271
Colombia	1,000,000	2,000,000	5,453,148
China	1,033,600	2,218,000	2,804,692
All others (1)			
Total	\$261,715,000	\$239,484,700	\$470,466,214

- (1) Argentina, Bolivia, Chile, British Guiana, French Guiana, Netherland Guiana, Venezuela, Czechoslovakia, Germany, Great Britain, Greece, Italy, Spain, Sweden, Yugoslavia Federated Malay States, Ido-china, Sarawok, Taiwan, Turkey.
- (2) Philippine Islands excluded.
- (3) Russia and Finland.

Source:

1929 and 1924: Gold and Silver in 1929 (general report)
 1914: Mineral Resources, 1915--Part I.

Table 55.

Value and Production of Gold by States, 1929

State	Number five ounces	Value (1)
California	409,020	8,455,200
South Dakota	312,328	6,456,400
Utah	237,221	4,903,800
Colorado	220,285	4,553,700
Arizona	211,108	4,364,000
Nevada	158,941	3,285,600
Montana	55,854	1,154,600
New Mexico	33,026	682,700
Idaho	19,597	405,100
Oregon	17,657	365,000
Washington	3,972	82,100
Texas	1,263	26,100
Pennsylvania	745	15,400
Tennessee *	653	13,500
North Carolina	174	3,600
Georgia	58	1,200
Wyoming	48	1,000
Alabama	10	200
Total	1,681,960	34,769,200

Value and Products of Gold by Possessions, 1929

Alaska	374,669	7,745,100
Philippine Is.	151,757	3,137,100
Total	526,426	10,882,200
Total for states and possessions	2,208,386	\$45,651,400

(1) Gold valued at \$20.67 - a fine ounce.

Source: Gold and Silver in 1929 (general Report) U. S. Bureau of Mines p. 1.

Table 56

Value of Gold Produced in Tennessee

Years	Value	Years	Value	Years	Value
1831	\$1,000	1839	\$ 300	1847	\$2,511
1832	1,000	1840	104	1848	7,161
1833	7,000	1841	1,212	1849	5,180
1834	3,000	1842		1850	1,507
1835	100	1843	2,788	1851	2,377
1836	300	1844	2,240	1852	750
1837	1,500	1845	3,202	1853	149
1838		1846	2,642	1854	
	Total				\$46,023

Source:

Killebrew, J. B., Introduction to Resources of Tennessee,
p. 266.

Silver

Pure silver is a white lustrous metal that takes a good polish and is the best known conductor of heat and electricity. It is found alloyed with gold, copper, and bismuth. Silver is used in making coins, tableware, jewelry. It is also used as an alloy with gold and copper, and in medicine and photography. (1)

The United States in 1929 and 1924 ranked second among the countries in the production of silver. (Table 57). Mexico ranks highest, with Canada third.

Tennessee ranked eleventh in the United States in 1929, with a total production of 96,146 fine ounces valued at \$51,246. Table 58.

(1) The Resources of Tennessee, Op. Cit. Vol. 3, No. 4.

The production given above is a by-product of the copper ore from the copper mines at Copper Hill and Ducktown.

Table 57.

Production of Silver in Fine Ounces by Principal Producing Countries, 1929 and 1924.

States	1929 (Troy ounces)	1924
Mexico	108,700,400	91,486,100
U. S. (1)	61,233,300	65,366,800
Canada	23,143,300	19,736,300
Peru	21,496,200	18,717,100
Australasia	10,434,000	10,769,900
Burma	7,273,300	5,284,200
Germany	5,512,800	3,753,000
Japan	5,144,900	3,542,300
Bolivia	4,816,200	4,857,600
Gen. America	2,796,900	2,686,200
Spain	2,659,200	2,880,000
East Indies,		
Netherland	1,967,900	2,083,300
Chile	1,436,700	3,357,700
Transvaal, Cape		
Colony, Natal	1,031,800	1,396,900
All others (2)		
Total	261,715,000	239,484,700

(1) Philippine Islands excluded.

(2) Argentinian, Brazil, Colombia, Ecuador, Guina (S. A.), Venezuela, Austria, Czechoslovakia, France, Great Britain, Greece, Italy, Norway, Poland, Rumania, Russia, Sweden, Yugoslavia, China, Chosen, India (British), Indo-China, Philippine Islands, Taiwan, Turkey, Algeria, Bechuanaland, Belgia Congo, East Africa (Portuguese), Rhodesia, Tanganyika.

(3) Bolivia and Chile reported together.

Source:

Gold and Silver in 1929 (general report)-1929 and 1924.
1914-World Almanac, 1916, p. 328.

Table 58.

Value and Production of Silver by States, 1929.

State	Number Fine Ounces	Value (1)
Utah	17,844,657	\$9,511,202
Montana	12,613,580	6,723,038
Idaho	9,533,327	5,081,263
Arizona	7,840,321	4,178,891
Nevada	4,746,750	2,530,018
Colorado	4,415,838	2,353,642
California	1,194,651	636,749
New Mexico	1,060,494	565,243
Texas	1,042,273	555,531
Missouri	146,638	78,158
Tennessee *	96,146	51,246
S. Dakota	84,465	45,020
Washington	51,639	27,524
Oregon	37,840	20,169
Michigan	17,899	9,540
N. Carolina	14,414	7,683
Pennsylvania	5,616	2,993
Illinois	4,146	2,210
Vermont	3,633	1,936
Georgia	13	7
Wyoming	8	4
Total	60,754,348	32,382,067

Value and Production of Silver by Possessions, 1929

Alaska	478,973	255,293
Philippine Islands	94,547	50,394
Total	573,520	305,687

Total for states and possessions	61,327,868	32,687,754
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(1) Silver valued at 53.3 cents a fine ounce. Average New York price of bar silver.

Source:

Gold and Silver in 1929 (general report), P. 1.

This is only about 0.15 per cent of both the U. S. production and value. Practically all of the gold is produced in the Western States--principally in Utah, Montana, Idaho, Arizona, Nevada and

Colorado. Tennessee, Georgia and North Carolina are the only producing southern states east of the Mississippi River. Tennessee produces 7 times as much as Georgia and North Carolina combined.

Cement

"For structural uses, cement is any mixture that will set, or harden. The chief ingredient of most of these mixtures is lime, and, hence, the term applied to these,-----calcareous cements. Contrasted with these are certain mixtures, whose setting properties are due to the formation of oxychlorides, and hence called oxychloride cements. These are of limited use structurally." (1)

Cements are divided into two classes, known as simple cements and complex cements. The simple cements are those which on hardening reassume the chemical composition of the materials from which they were made, and the complex cements are those in which the set cement differs in chemical character from the raw materials or mixture from which it is made. The classification of cements is given in Table 59. The silicate cements are characterized by the property to set when mixed with water, or even under water. This is the reason for their being called hydraulic cements. The complex silicate or hydraulic cements commonly known as Portland cements are used more than the other classes. The essential elements of the Portland cements are, lime, silica, and alumina. A little alumina is always replaced by iron oxide and some lime by magnesia.

(1) Resources of Tennessee, Op. Cit. Vol. 1, No. 2, Page 58.

Table 59.Classification of Cements"I. Simple Cements.

1. Hydrate cements or plasters. Derived from gypsum by driving off the water contained in the rocks. Setting properties due to reabsorption of water.
Plaster of Paris,
Cement plasters,
Hard-finish plasters,
Dead-burnt plasters.
2. Carbonate cements or limes. Derived from limestone or magnesite by driving off the CO_2 . Setting properties due to reabsorption of carbon-dioxide.
High-calcium limes
Magnesium limes
Magnesia

II. Complex Cements.

1. Silicate cements. Setting properties due to formation of silicates during the process of manufacturing or use. Known as Hydraulic Cements.
Hydraulic lime,
Natural cements,
Pozzolana cements
2. Oxychloride cements. Setting properties due to formation of oxychlorides.
Sorel-stone, etc." (1)

"Good cement is supposed to have from 58 to 67 per cent lime; 19 to 25 per cent of silica; 5 to 10 per cent of alumina; usually less than 5 per cent iron oxide; and not to exceed 4 per cent of magnesia." (2)

There are a number of combinations of the raw materials that may be used to make cement.

- "1. Argillaceous hard limestone (cement rock) and pure limestone.
2. Pure hard limestone and clay (or shale).
3. Soft (chalky) limestone and clay (or shale).
4. Marl and clay (or shale).
5. Alkali waste and clay.
6. Slag and pure limestone." (3)

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- (1) Resources of Tennessee, State Geological Survey, Vol. 1, No. 2, Page 59.
 - (2) Resources of Tennessee, Op. Cit. Vol. 1, No. 2, Page 61.
 - (3) Resources of Tennessee, Op. Cit. Vol. 1, No. 2, Page 63.

In locating cement plants the problems are to find two kinds of deposits, limestone and clay or shale of the right composition, near together, and also near coal and adequate transportation. Tennessee has practically an unlimited supply of limestone and clay, and also a good supply of coal and fairly adequate transportation.

The Holston marble which is almost pure calcium carbonate is excellent for making Portland cement. Near Knoxville, north and south, are suitable materials for making this product. There are several locations along the eastern part of the Cumberland Escarpment where the materials used in cement occur and coal is found. Some of these locations are Cumberland Gap, Lafollette, Coal Creek, Oliver Springs, Harriman, Rockwood and Chattanooga. There is also good material for cement manufacture along the Louisville and Nashville railroad between Clarksville and Paris.⁽¹⁾

The value of the cement produced in the United States in 1930 was fifth as compared with the value of other minerals. The four minerals having a greater value than cement were iron, coal, natural gas and petroleum. In Tennessee in 1930, cement ranked third in value--only coal and stone having a greater value.⁽²⁾

Of the thirty-five states producing cement Tennessee ranked twelfth in the amount, produced in 1929 and 1930 (Table 60). The number of barrels produced in 1929 was 4.4 million and in 1930, 3.8 million. The value of the shipments in 1929 were over 5.5 million dollars in and 1930 over 5.3 million dollars.

(1) Resources of Tennessee, Op. Cit. Vol. 1, No. 2.

(2) Mineral Resources of the United States, Op. Cit, 1930, (Summary) Page 115A.

Table 60.

Portland Cement Produced and Value of , 1929 and 1930, by States.

State	Active Plants		Production		Value of Shipments	
	1929	1930	Barrels in Millions		1929	1930
			1929	1930	Value	Value
Pa.	27	27	39,354	37,844	\$55,601	\$52,712
Mich.	14	14	13,749	11,511	18,917	14,897
N. Y.	10	10	10,761	10,373	15,598	15,381
Calif.	12	12	13,092	10,124	22,806	15,241
Ohio	10	10	9,427	8,632	13,428	11,956
Ill.	4	4	8,243	7,935	11,135	10,519
Missouri	5	5	8,113	7,809	11,558	11,471
Iowa	6	6	6,373	7,088	9,781	10,048
Texas	9	9	7,374	6,782	11,806	10,782
Kansas	7	7	6,740	6,012	10,041	8,254
Alabama	6	6	5,006	4,821	5,911	5,830
Tenn.	6	6	4,442	3,875	5,576	5,316
All others (1)	47	47	37,971	38,393	59,997	56,312
Total	163	163	170,646,000	161,197	252,154	228,720

(1) Arkansas, Colorado, Florida, Georgia, Idaho, Indiana, Kentucky, Louisiana, Maine, Maryland, Minnesota, Montana, Nebraska, New Jersey, Oklahoma, Oregon, South Dakota, Utah, Virginia, Washington, West Virginia, Wisconsin and Wyoming.

Source:

Mineral Resources of the U. S. 1930, Op. Cit. Summary, p. A29.

Cement was produced in six counties in 1930. These were, Knox, at Knoxville, Marion, at Richard City, Hamilton, at Chattanooga, Davidson, at Nashville, Franklin, at Cowan, and Sullivan, at Kingsport. Table 61. In 1925 cement plants were in operation at each of these places except Knoxville. (1)

(1) Resources in Tennessee, Vol. 1, No. 2.

Table 61.

Production and Value of Cement by Counties, 1930

County	Production			Value	
	% of total 1930	Barrels 1930	3 Yr. Ave. 1928-1930	1930	3 Yr. Ave. 1928-1930
Knox	21.9	852,306	677,296	\$1,303,675	\$ 901,403
Marion	21.5	835,623	1,104,490	681,418	712,360
Hamilton	17.7	688,755	761,197	964,011	1,032,047
Davidson	14.3	556,131	727,044	406,503	722,436
Franklin	12.8	497,016	487,729	747,015	668,031
Sullivan	11.7	454,480	587,777	433,741	472,802
Tennessee	100.0	3,884,311	4,345,532 4,519,441(1)	4,536,363	4,509,079 5,606,997 (1)

(1) Average for 5 years, 1926-30.

Knox County ranked first in 1930 with 852,306 barrels, or 21.9 per cent of the state's production. The lowest was Sullivan County with 454,480 barrels, or 11.7 per cent of the total. (Table 61).

Portland cement was first made by a brick layer, Joseph Aspin, of Leeds, England in 1824. He made it by burning and grinding together a mixture of clay and limestone. He called it Portland because the limestone resembled the Oolite limestone near Portland, England. It was first made in the United States by the Coplay Cement Company of Coplay, Pennsylvania in 1875. This cement was first used in the Eads jetties along the Mississippi River. The Drexel Building in Philadelphia is the first "skyscraper" in which American Portland Cement was used.(1)

(1) State Geological Survey, The "Resources of Tennessee, Vol. 1, No. 2, Op. Cit.

Clay and Clay Products

"Clay is a term applied to those earthy materials occurring in nature whose prominent property is that of plasticity when wet and that of a hardened mass when dry. Clays are composed of many different minerals in a fine state of division, of which kaolinite is the most characteristic." (1)

The term clay then covers a large number of different grades or classes of material. It, as commonly used, applies to all grades from soil to the rarest and purest clays used in making china ware. This fact makes it difficult to get comparable data on the production of clay and clay products.

The purest clays are used to make china ware, porcelain, electric porcelain ware and electrical insulators, sanitary and enamel ware, and for making pots in which optical glass is melted. Some other grades of clay are used in making earthenware, stoneware and crockery. Lower grade clays are used in making building brick, drain tile and terra cotta. A better grade of clay is used in making fire brick. (2) (3)

Clay is one of the important non-metallic minerals in the United States. In 1929 clay products ranked fourth in value among the non-metallic minerals and ranked fifth in value among all minerals. In Tennessee clay products ranks fourth, in value, following coal, stone, and cement. (4)

Some form of clay, that can be used commercially, is found in practically every state in the United States. In 1929 the leading states in the production of brick and tile, with a value

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- (1) Tennessee Division of Mines, Mineral Resources of Tennessee 1930, Page 115.
 - (2) Ibid.
 - (3) State Geology Survey, The Resources of Tennessee, Vol. 3, No. 4.
 - (4) U. S. Bureau of Mines, Mineral Resources of the United States (Summary) 1930.

Table 62.

Clay Products Manufactured, by States, 1929 (1)

	State	Value (000)		Number of Establishments Reporting	State	Value (000)		Number of Establishments Reporting
		Total	Brick and Tile			Total	Brick and Tile	
1	Ohio	81,797	46,372	329	25 Minn.	2,086	1,584	19
2	Pa.	49,674	41,478	266	26 Conn.	2,039	2,038	22
3	N. J.	39,418	19,112	183	27 Ark.	2,024	1,961	12
4	Ill.	27,391	21,427	120	28 Okla.	1,893	1,893	17
5	Cali.	22,734	18,173	133	29 S. C.	1,253	1,231	24
6	W. Va.	20,490	4,783	45	30 Miss.	1,189	1,144	22
7	Ind.	18,503	14,596	84	31 Utah	1,028	1,028	9
8	N. Y.	17,662	11,072	84	32 Nebr.	914	914	16
9	Mo.	14,995	14,934	49	33 N. H.	900	900	12
10	Ky.	7,062	6,935	42	34 Oreg.	709	636	20
11	Mich.	6,217	3,076	35	35 Me.	641	641	16
12	Tex.	6,010	5,801	59	36 La.	584	584	17
13	Ia.	5,770	5,770	43	37 Ariz.	506	506	9
14	Md.	5,116	2,456	26	38 Mont.	353	353	9
15	Ala.	4,002	3,969	39	39 Fla.	282	282	7
16	Ga.	3,718	3,691	28	40 Dela.	230	230	6
17	Tenn.	3,696	2,732	32	41 D. C.	(3)195	195	4
18	Kans.	3,280	3,280	24	42 N. D.	175	175	5
19	N. C.	3,197	3,140	64	43 Wyo.	173	173	5
20	Colo.	3,117	2,790	37	44 N. M.	155	155	5
21	Va.	2,948	2,948	45	45 Ida.	151	151	6
22	Wis.	2,801	1,043	32	46 Nev.	(2)	(2)	1
23	Mass.	2,572	2,127	32	47 R. I.	(2)	(2)	1
24	Wash.	2,467	2,521	29	48 S. C.	(2)	(2)	1
					49 Vt.	(2)	(2)	1
					U. S. Tot.	373,409	261,390	2,062
					Undistributed	1190	803	

(1) Figures obtained through cooperation with Bureau of the Census. (2) Included under undistributed (3) Exclusive of pottery, value of which is included under ("Undistributed").

Source:

U. S. Bureau of Mines, Mineral Resources of the U. S. (summary) 1930- p. 33.

of ten million dollars or more, were California, Illinois, Indiana, Missouri, New Jersey, New York, Ohio and Pennsylvania, as shown in Table 62. Tennessee ranked 17th, with a value of \$2,732,166. The states producing the greatest amount of pottery, with a value of five or more million dollars, were Illinois, New Jersey, New York, Ohio, Pennsylvania and West Virginia. In this Tennessee ranks 20th with a value of \$963,671.

Clay suitable for making brick and tile is found in practically every county in Tennessee. Clay that is well adapted to making building brick is found along the Cumberland and Tennessee Rivers. Pottery is made from clay in Davidson, Henry and Unicoi Counties. The finer grades of clay are found in West Tennessee, principally in Henry, Carroll and Weakley Counties. (Table 63).

The 1930 production was 52,105 short tons and the five year average from 1926 to 1930 was 90,407 short tons. The 1930 value was \$325,831 and the five year average \$464,722. (Table 63.).

Table 63.

Production and Value of Clay Produced in 1930 by Counties

County	Production			Value	
	% of total 1930	Short tons	5 Yr. Ave. 1926-1930	1930	5 Yr. Ave. 1926-1930
Henry-Carroll	80.5	41,925	(1)	\$280,588	(1)
Henry-Weakley	19.4	10,134	(1)	45,106	(1)
Carroll	0.1	46	(1)	137	(1)
Tennessee	100.0	52,105	90,407	\$325,831	464,722

(1) Not averaged because of distribution between counties.

Source:

Tennessee Division of Mines, Mineral Resources of Tennessee,
1930, Page 118.

Lime.

Lime is a compound of calcium and oxygen produced by heating some form of calcium carbonate or nitrate. As lime is a very active base, it is never found free in nature. The forms of calcium carbonate most used in the manufacture of lime are limestone, marble, and sea shells. The calcium oxide, that is formed after burning is referred to as quick lime, burned lime and dehydrated lime. If quick lime comes in contact with water or is exposed for some time to the moisture of the air the hydroxide (Ca (OH)_2) or slake lime is formed. (1)

The three important uses of lime are, agricultural, building and chemical. Lime is used for mortar and for making sand-lime bricks. There are a number of chemical uses some of which are, in manufacturing alcohol, alkali works, bleaching powder and liquid, coke and gas manufacture, insecticides, sugar refineries, and water purification. (2)

Limestone and the other materials from which lime can be made are found over a large part of the United States. Thirty nine states are reported as having one or more lime plants in operation in 1929. Most of the leading states are in the eastern half of the United States. (Table 64). "Limestone is the most common rock of the East Tennessee Valley and Middle Tennessee." (3) This gives Tennessee an almost unlimited supply of lime material.

(1) New International Encyclopaedia.

(2) Mineral Resources of the United States, Part 2, 1928.

(3) Resources of Tennessee, Vol. 3, No. 4, Page 211.

Table 64.

Lime Sold by Producers: Quantity, Value, and Number of Plants Operating, by States, 1929

State	Quantity (Short tons)	Value (000)	Number of Plants Operating	State	Quantity (Short tons)	Value (000)	Number of Plants Operating
1 Ohio	962,415	7,936	27	20 Ariz.	42,971	397	4
2 Pa.	782,915	5,897	116	21 Conn.	35,180	387	4
3 Mo.	316,579	2,320	13	22 Ark.	33,647	296	4
4 W. Va.	308,600	1,866	13	23 Wash.	31,598	325	4
5 Ala.	209,260	1,224	10	24 Ga.	10,757	77	1
6 Tenn.	172,936	1,036	10	25 Colo.	7,046	77	4
7 Va.	153,170	1,061	29	26 Oreg.	2,486	40	3
8 Mass.	133,644	1,444	7	27 R. I.	1,885	24	1
9 Wisc.	130,902	1,094	18	28 N. J.	1,644	15	1
10 Ill.	119,382	973	8	29 Fla.	(1)	(1)	2
11 Ind.	116,395	787	8	30 Ida.	(1)	(1)	1
12 N. Y.	104,614	906	12	31 Iowa	(1)	(1)	1
13 Tex.	97,332	838	6	32 Ky.	(1)	(1)	1
14 Me.	92,428	772	4	33 Minn.	(1)	(1)	3
15 Mich.	91,468	844	6	34 Mont.	(1)	(1)	2
16 Md.	54,029	405	12	35 Nev.	(1)	(1)	1
17 Vt.	53,128	505	7	36 N. M.	(1)	(1)	2
18 Calif.	49,753	526	9	37 N. C.	(1)	(1)	1
19 Utah.	46,581	365	10	38 Okla.	(1)	(1)	1
20				39 S. D.	(1)	(1)	2
				U. S. Total	4,253,270	33,270	368
				Undistrib.	90,125	830	

Source:

Mineral Resources of the U. S. 1930 Summary.

(1) Included under "Undistributed."

The fact that the value of the lime produced in the United States in 1930 was almost 25 million dollars, shows that lime is not an unimportant mineral. However, there were several non-metallic minerals with a value of the 1930 production greater than, and some of them several times as great as, lime. These minerals were coke, coal, cement, natural gas, natural gasoline, petroleum, salt, stone and sulphur.

Lime production in Tennessee as compared with other minerals ranks higher than it does in the United States. It is one of the ten leading mineral products. In 1930 the value of the lime produced was over a million dollars while the value of all minerals was approximately 40.7 million dollars.⁽¹⁾

In 1929 Tennessee ranked sixth among the states of the United States in the amount of lime sold by producers with a total of 172,936 short tons and a value of \$1,036,405. The five states that produced more lime than Tennessee were Ohio, Pennsylvania, Missouri, West Virginia and Alabama which ranked in the order named. (Table 64). Tennessee had 10 plants in operation while Ohio, the leading state had 27 and Pennsylvania reported 116, which was the largest number reported by any state.

Of the five counties reporting lime burned in 1930, Franklin produced more than the other four combined. These four were Coffee, Knox, Cumberland and Dickson. (Table 65). The total amount of lime burned in these five counties in 1930 was 72,165 short tons. This does not compare so well with the 1929 state total of 172,936 short tons, of lime sold as given in Table 64.

(1) Mineral Resources of the United States, 1930 Summary ,
Page A115 (Op. Cit.)

Table 65.Quantity and Value of Lime Burned by Counties, 1930

County	Quantity Burned			Value	
	% of total 1930	Short tons	5 Yr. Ave. 1926-1930	1930	5 Yr. Ave. 1926-1930
Franklin	62.6	45,174	55,354	\$312,000	\$436,369
Coffee	12.5	9,000	8,701	68,245	63,741
Knox	11.9	8,591	19,373	49,795	108,565
Cumber.	6.9	5,000	2,000 (2)	25,000	11,000(2)
Dickson	6.1	4,400	8,351 (3)	22,000	56,391(3)
Houston	0	0	1,449 (1)		11,000(1)
Tenn.	100.0	72,165	95,228	477,040	687,066

- (1) One year divided by 5 (2) Two years divided by 5.
 (3) Four years divided by 5.

Source:

Mineral Resources of Tennessee, Op. Cit. 1930, Page 127.

These data however are probably not comparable as the county totals are for "lime burned" and the state totals given in table 64 are for "lime sold by producers." Also table 65 may not include all of the lime burned in Tennessee in 1930.

The average production and value for the five year period 1926-1930 was larger than for the year 1930.

Barite.

Characteristics and Uses. Barite, or barytes, sometimes referred to as heavy spar, is sulphate of barium. It is a white opaque to translucent crystalline mineral, about as hard as calcite, four and one-half times as heavy as water, and inert when treated with acid.

Barytes is used in the adulteration of white lead in manufacturing paint. The barytes makes the paint more opaque and less subject to damage from sulphuric vapors. "It is also used very extensively in the refining of sugar, enameling iron, oil-cloth, wall paper, cement, and many others." (1)

Occurrence. There are probably deposits of barite in the United States that are not being mined, but the principal producing states, from 1926 to 1930, were Missouri, Georgia, Tennessee, California, Virginia and Nevada. (Table 66.) Barite deposits occur in the limestone area of East and Middle Tennessee, but it is workable in only a few places. It has been mined in Greene, Bradley, Washington, Loudon, McMinn, Monroe, and Jefferson Counties.

Barite deposits of commercial importance may be found as bedded and fissure veins, as irregular bodies in replacement of beds of limestone, and as lumps and masses overlying residual clays, derived from the decay of dolomitic limestone. In the Sweetwater area it occurs as bedded veins or shattered zones in the Knox Dolomite and as lumps and masses overlying the residual.

Clays. The unaltered veins are not worked because of the difficulty in separating the ore from the limestone. The total production in the state is from the residual clays. (2)

Production. Compared with the value of other minerals produced in the United States barite is of minor importance. The value of the total production in 1930 was only a little over one and one-half million dollars. In Tennessee barite ranks higher in value of production as compared with other minerals than it

(1) Mineral Resources of Tennessee, Op. Cit, 1930, Page 108, and State Geological Survey. The Resources of Tennessee Vol. 3, No. 4, Vol. 8, No. 8.

(2) The Resources of Tennessee, Vol. 8, No. 1.

Table 66.

**Crude Barite Sold or Used by Producers, by States, 1930, and
Average 1926-1930**

State	Production in short tons		Value	
	1930	Ave. 1926-30	1930	Ave. 1926-30
Missouri	132,640	120,315	938,812	896,472
Georgia	41,746	83,255	230,769	486,730
Calif.	19,517	17,485	114,310	93,294
Tenn.	17,006	20,971	111,981	146,084
Virginia	10,250	10,250	73,168	73,168
Nevada	2,647	1,733	19,457	12,921
Other Sts. (1)	11,126	14,388	49,674	90,587
Total	234,932	252,171	1,538,171	1,695,717

Source:

Summary Mineral Resources of the United States, 1930.

does in the United States, but it is not one of the most important minerals, (Table 66).

For the five year period, 1926-1930, Tennessee ranked third in the amount and value of barite produced. (Table 66.) Missouri and Georgia were the two leading states. Tennessee was fourth in 1930 producing 17,006 tons of the United States total of 234,932 tons, or about 7 per cent. (1) In 1915 Tennessee produced 25,074 tons or about 25 per cent of the United States production of 108,547 tons. (2)

Tennessee's total production was mined in Monroe County in 1930. In 1927 both Monroe and Loudon Counties reported production. In 1926 only Monroe County was reported as producing. In 1874

(1) The Mineral Resources of Tennessee, Op. Cit. 1930, Page 108.

(2) The Resources of Tennessee, Op. Cit. Vol. 8, No. 1.

shipments were reported from the following places: (1)

Fullens-Greene County	455,663 pounds
Greenville-Greene County	125,498 pounds
Midway	184,847 pounds
Morristown	197,835 pounds

Pyrite.

Pyrite or "fool's gold," which is a sulphide of iron (FeS_2), is a hard, brittle, brass-colored mineral. It is sometimes found in the form of beautiful cubic crystals.

Pyrite is used in the manufacture of sulphuric acid which is used mainly, with phosphate rock, to manufacture acid phosphate for fertilizer.

Pyrite is one of the common minerals, but it is rarely found in sufficient quantities to be of value. It is usually found in small crystals scattered thru the rocks. Most of the sulphuric acid manufactured in Tennessee is made as a by-product of copper ores, one of which contains pyrite. (2)

In 1930 the total production of sulphuric acid in Tennessee was 604,260 short tons, and the total value was \$3,203,687. (3) The total United States production, for the same year, from copper and zinc smelters was only 1,188,316 short tons and the total value \$9,544,283. Tennessee then produced over one third of the commercial sulphuric acid produced in the United States from copper and zinc smelters. (4)

(1) Killebrew, J. B., Resources of Tennessee,

(2) The Resources of Tennessee, Op. Cit, Vol. 3, No. 4.

(3) Mineral Resources of Tennessee, Op. Cit. 1930, P. 121.

(4) Mineral Resources of the United States, Op. Cit. 1930, Summary, Page A8.

Miscellaneous Sand and Stone.

Calcite. Calcite, (CaCO_3) when found pure, is white or colorless, but due to impurities it is found in gray, black, pink, yellow, and purple colors. Calcite is soft enough to be scratched with a knife. When burned it produces lime and will effervesce when treated with hydrochloric acid. Some calcites are known as cave onyx and marble onyx.

Calcite is used in making ornamental products, soda fountains, clock frames, paper weights, and as interior finish for fine buildings.

Deposits of calcite are found in most all parts of Middle and East Tennessee. It is found in veins, caves, and as beds of marble. The most common occurrence of calcite in Tennessee is in the form of marble. (1) (2)

Dolomite. This mineral when pure, is a carbonate of lime and magnesia, but it frequently contains iron and other impurities. It occurs in crystalline beds--dolomite marble--and noncrystalline beds--dolomitic limestone. The uses are practically the same as the uses for limestone. Too much magnesia in limestone makes it undesirable to use in the manufacturing of cement and lime, but experiments have been made which indicate that ground dolomitic limestone, because of the magnesia it contains, is a good fertilizer for bright tobacco, while the calcitic limestone, limestone not containing magnesia, is not. (3)

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- (1) State Geological Survey. The Resources of Tennessee, Vol.3, No. 4.
(2) Winston-Salem, North Carolina, Part 3, Page 32.
(3) The Resources of Tennessee, Vol. 3, No. 4.

Chert. This is one of the hardest rocks. It cannot be scratched with a knife, It is more impure than flint, and is usually gray but may be black. The best use for chert is road building, especially if it is used with crushed limestone. Chert may be found in deposits many feet thick or in thin layers, and also as scattered fragments in the soil. Large amounts of it are found in the soils of the Highland Rim. (1) (2)

Slate. This is any rock that has the property of parting along parallel planes developed to the extent that it may be split into thin plates with even surfaces. Shale is often mistaken for slate. The color of slate varies, but the dark color is most common.

Slate is used for roofing, mantels, lavatories, flooring, blackboards, and switch boards. (3)

The value of the slate produced in the United States in 1930 was almost eight million dollars. (4) Slate is not being produced commercially in Tennessee at the present time, but it has been reported to occur in commercial quantities in some of the southeastern counties.

Shale. This occurs as hardened beds of mud, which are made up of thin layers. As shale may contain practically no sand or lime, or a large per cent of either or both, there is a gradual gradation from shale to sandstone or limestone. There is a wide

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- (1) State Geological Survey, The Resources of Tennessee Vol 3, No. 4.
 - (2) Winston Salem, North Carolina, Part 3, Page 32.
 - (3) The Resources of Tennessee Op. Cit. Vol. 3, No. 4.
 - (4) Mineral Resources of the United States, Op. Cit., 1930, Summary.

variation of colors, but dark is the most common.

Shale that contains a large per cent of sand makes a good road dressing, when suitable, it is used in manufacturing cement, oilcloth, linoleum, and cheap paint. Some shales that contain a large per cent of carbonaceous matter are distilled and the oil and residue used for paint. A small amount of black shale in Middle Tennessee is used for this purpose. At Kingsport, Johnson City and Bristol, shale is being used, or has been used, to make brick for building purposes. (1)

"Shale is one of the common rocks of the Cumberland Plateau and less common in East Tennessee. A bed of shale known as the "black shale" occurs around the rim of the Central Basin." (2)

Lithographic Stone. What is known as lithographic stone is a porous, even textured, fine grained limestone. It must be soft enough to work with engravers tools, free from veins and hard parts, and sufficiently free of joints to permit its being taken out in blocks large enough for lithographs as it is used in printing for making lithographs. It has been reported that this stone occurs near Algood, in Putnam County, Tennessee. (3)

Silica. Silica as used by prospectors does not mean pure silica, but applies to bodies of white fine-grained sand which may contain more or less kaolin. This material may be used as tripoli; and if not too fine-grained, for making glass. Deposits have been reported in different places west of the Central Basin, the most important one being in Hickman County. (4)

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- (1) Tennessee Geological Survey-The Resources of Tennessee, Vol. 3, No. 4, Page 226.
 (2) Case, Earl C. Op. Cit.
 (3) The Resources of Tennessee, Op. Cit. Vol. 3, No. 4.
 (4) Ibid.

Greensand. This is a loose, or unconsolidated material, of greenish color due to glauconite, a silicate of iron, potash, and water. It usually contains some lime and phosphoric acid. The potash, lime, and phosphoric acid contained in greensand, if in sufficient amounts, makes it valuable as a fertilizer.

There are beds of greensand west of the Tennessee River, in McNairy, Chester, and Henderson Counties. (1)

Quartz. Quartz, SiO_2 (Si 46.7%, O 53.3%), is one of the hardest of minerals.

"It usually occurs in six sided crystals, some of which are very beautiful, either from their transparency and brilliancy, or their color. This varies from colorless through black, pink, rose, red, purple, or violet. The transparent variety is commonly known as "rock crystal", and the purple and violet are amethyst. Chalcedony, agate, jasper and flint are varieties of quartz that do not occur in crystals." (2)

"Quartz is ground and used as an abrasive, either as quartz sand or sandpaper; as an acid flux in smelting and in the manufacture of pottery. The clear crystals are used for cheap jewelry and to some extent for spectacles lenses. Agate, jasper and chalcedony are polished and used for ornaments. The best varieties of amethyst are highly prized for gems." (3)

Quartz, occurring in small cavities or veins, is found in many of the rocks of Tennessee. It is used in copper smelting in the southeastern part of the state. (4)

Flint, which is one form of quartz, was quarried in Tennessee during 1915-1918, from several localities near Iron City and St. Joseph. This flint was shipped to large copper companies in Michi-

(1) The Resources of Tennessee, Op. Cit. Vol. 3, No. 4.

(2) Ibid.

(3) Ibid.

(4) Ibid.

gan to be used as lining for tube mills in which copper ore was treated. Flint for this purpose is usually obtained from Belgium, but during the War the supply from this source was cut off. Although the Tennessee flint was only 60 per cent as efficient as the Belgian flint, it proved to be a satisfactory substitute. If the well established source is ever again cut off, Tennessee flint may again be used.

Shipments of the American Flint Company, the principal shipper, are given in Table 67.

Table 67.

Production and Value of Flint by American Flint 1916-1918

Year	Shipments of Short Tons	Value
1916	784	\$15,680
1917	2,000	40,000
1918	1,335	25,034

Source:

State Geological Survey 1921, Bulletin 26--Mineral Resources of the Waynesboro Avadrangle State Geology Survey, Bulletin 26, page 132 1921.

Cobalt

Cobalt is a hard, white, tough, and somewhat magnetic metal. It is much like nickel. The two metals are usually found together in ore containing sulphur and arsenic.

Cobalt is used in chemistry, as pigment for blue paint, and for coloring glass and porcelain.

Traces of black cobalt oxide have been found at a number of points near Centreville, in Hickman County. None of this ore, however, has analyzed over 2 per cent of cobalt while ore found

in South Carolina, and Missouri contains 25 per cent and 40 per cent cobalt respectively. (1) (2)

Fluorite

Fluorite, or fluorspar, is translucent to transparent, and in colors of green, pink, purple, yellow, violet and sky-blue. It is one of the most beautiful minerals and is sometimes made into ornamental objects, but because of its softness it is rarely cut for gems. It is used as a flux in smelting iron; and in the manufacture of opalescent glass, hydrofluoric acid, and enamel for cooking utensils.

In 1930, 95,849 short tons of fluospar valued at \$1,746,643 was shipped from mines in the United States. The largest per cent of this was from Illinois and Kentucky, and the other from Colorado, New Mexico and Nevada. In Tennessee small amounts of fluorite were shipped from Smith, Trousdale, and Wilson Counties, from 1902 to 1906. (3)

Alum

Alum is the name given to a large number of compounds, but what is commonly known as alum is a sulphate of potash and aluminum.

Alum is used in tanning, dyeing, hardening, plaster of paris, sizing paper and as a medicine especially in the practice of veterinary medicine. The aluminum sulphate is used to clarify the water supply of cities.

(1) State Geological Survey, The Mineral Resources of Tennessee, Vol. 3, No. 4.

(2) Winston-Salem, North Carolina, Part 3, Page 32.

(3) The Resources of Tennessee, Op. Cit. Vol. 3, No. 4.

A common source of alum is bauxite. Alum may be made by treating clay with sulphuric acid, (H_2SO_4). Natural alum is found in Alum Cave in Sevier County. It could be prepared from the black shale which occurs on the border of the Central Basin. (1)

Epsomite.

Epsomite, or epsom salt, occurs in the water of many wells and springs and in much underground water. "Natural epsom salt has but little or no use except as a constituent of medicinal water. The supply for commerce is obtained chiefly as a by-product in the manufacture of common salt by evaporation." (2) Epsom salt is found on the floor and rocks of the roof of many limestone caves in Tennessee. Alum Cave in Sevier County was reported to contain considerable quantities. (3)

Lignite

Lignite is an impure form of coal, which more or less distinctly shows the grain of the wood from which it was derived. It is brown in color. It burns with a smoky flame and has low heating power. It contains a considerable amount of water and falls to pieces when exposed to the air.

Because of its tendency to smoke and fall to pieces lignite is of very little economic importance. It can be used, however, to make producers gas.

Lignite is found in some of the clays of East Tennessee. (4)

(1) The Resources of Tennessee Op. Cit. Vol. 3, No. 4.

(2) Ibid.

(3) Ibid.

(4) Ibid.

Tripoli.

Tripoli, in a strict sense, is a fine grained material composed of the siliceous skeletons of microscopic plants and animals, but the term as used by the trade means any fine-grained, siliceous, or flint like, material that can be used for polishing and scouring. The true tripoli is white, but commercial tripoli may be white, brown, yellow, or cream colored.

Tripoli is used for polishing wood and metal; in manufacturing, scouring soaps; by jewelers in cleaning and polishing; in making water filters; and as packing material for safes, steam pipes, and steam boilers.

Tripoli has been mined in Sullivan County, and doubtless there are other deposits within the state. (1)

Mica.

Of the several varieties of mica, muscovite and phlogopite are the only ones of any economic importance. Phlogopite is produced in North America only in Canada, consequently, muscovite is the only one of importance produced in the United States. All of the micas are easily split into very thin sheets.

The principal use of muscovite is for insulators in electric dynamos, electric motors, and electric switchboards. It is also used to make transparent doors for stoves and for safety lamps. Scrap mica is ground and used to give luster to wall paper, to make fancy paints, and is molded into electric insulators. Finely

(1) The Resources of Tennessee, Op. Cit. Vol. 3, No. 4.

ground mica mixed with oil makes a good lubricant.

The value of the sheet mica produced in the United States in 1930 was \$177,307 and the value of the scrap mica was \$109,100.(1) No mica of commercial importance is produced in Tennessee, but deposits of commercial importance may occur in the counties among the eastern border of the State.(2)

Nitrates

There are three nitrates occurring in nature: potassium nitrate (KNO_3), which is commonly known as salt peter or niter; sodium nitrate, or soda niter (NaNO_3); and calcium nitrate, or lime nitrate ($\text{CaN}_2\text{O}_8 - n\text{H}_2\text{O}$).

The nitrates are used principally for fertilizer, but they are also used in manufacturing gun powder and nitric acid. Soda niter is used in making iodine. Since these nitrate compounds are soluble in water, they are found in nature only in dry regions, or dry caves.

"Many of the limestone caves of Tennessee are reported to have produced lime nitrate from which powder was made during the War of 1812 and the Civil War." (3)

Mineral Paint

The term "mineral paint" as commonly used has a rather broad meaning. Included in classifications of mineral paints are, ocher, metallic paint, shale and slate, mortar colors, and other pigments which includes barytes, and soap stone. Ocher is a low

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- (1) Mineral Resources of the United States, 1930, Summary.
 - (2) The Resources of Tennessee, Vol. 3, No. 4.
 - (3) Ibid.

grade earthy iron ore. It is usually red hematite, or yellow limonite.

Metallic paint which consist chiefly of red and brown oxides is produced by grinding natural iron oxide or by roasting natural iron carbonate. (1)

The United States Bureau of Mines classifies mineral paints as natural pigments, and zinc and lead pigments which are made, in a large part, direct from ores, and includes sublimed blue lead, sublimed white lead, leaded zinc oxide, and zinc oxide.

The chief deposits of metallic paint materials in the United States are the beds of Clinton hematite in Tennessee, New York and Georgia, the red hematite in northern Michigan and the gray siderite in Pennsylvania. There are deposits in Tennessee suitable for making mineral paint in Bradley, Cheat-ham, Davidson, Hamilton, Monree, and Wayne Counties. (2) Table 69.

Table 68.

Production and Value of Mineral Paints by Classes,
1929 and 1930

Material	Amount Produced short tons		Value	
	1929	1930	1929	1930
Ocher	425	227	17,244	4,994
Metallic Paint	993	549	30,386	6,578
Other Pigment (in- cluding Barytes and Soap stone)	153	571	12,196	3,701
Total	1571	1,147	59,826	15,273
Shale Slate, Mortar colors	2,099	1,676	82,103	42,085
Grand Total	3,070	2,823	141,929	57,358

Source:

Mineral Resources of Tennessee, 1930, Tennessee Division
of mines.

(1) Mineral Resources of Tennessee, Op. Cit, 1924, 1930.

(2) Tennessee Division of Mines, Mineral Resources of Tennessee
1926, 1927.

Table 69.Production and Value of Mineral Paints by Counties 1930

	Production			Value	
	% of total 1930	Short tons 1930	5 yr. Ave. 1926-1930	1930	5 yr. ave 1926-1930
Hamilton	50.8	851	4,024	\$25,530	\$104,636
Davidson	49.2	825	(1) 539	16,555	13,777
Cheatham	0.0	0	(2) 340	0	6,440
Tenn.	100.0	1,676	4,903	42,085	124,853

(1) Three years divided by 5. (2) Two years divided by 5.

Source: Annual Report of Tennessee Division of Mines.

While mineral paint is not one of the most important minerals in Tennessee, it is of considerable importance. The value of the mineral paint produced in 1929 was \$141,929. This decreased to \$57,358 in 1930, but the quantity produced decreased only from 3070 tons to 2823 tons, (Table 68). In 1930 Hamilton and Davidson were the only two counties that reported production (Table 69). During the five year period, 1926-1930, Hamilton, Davidson and Cheatham were the producing counties, Hamilton being the largest producer.

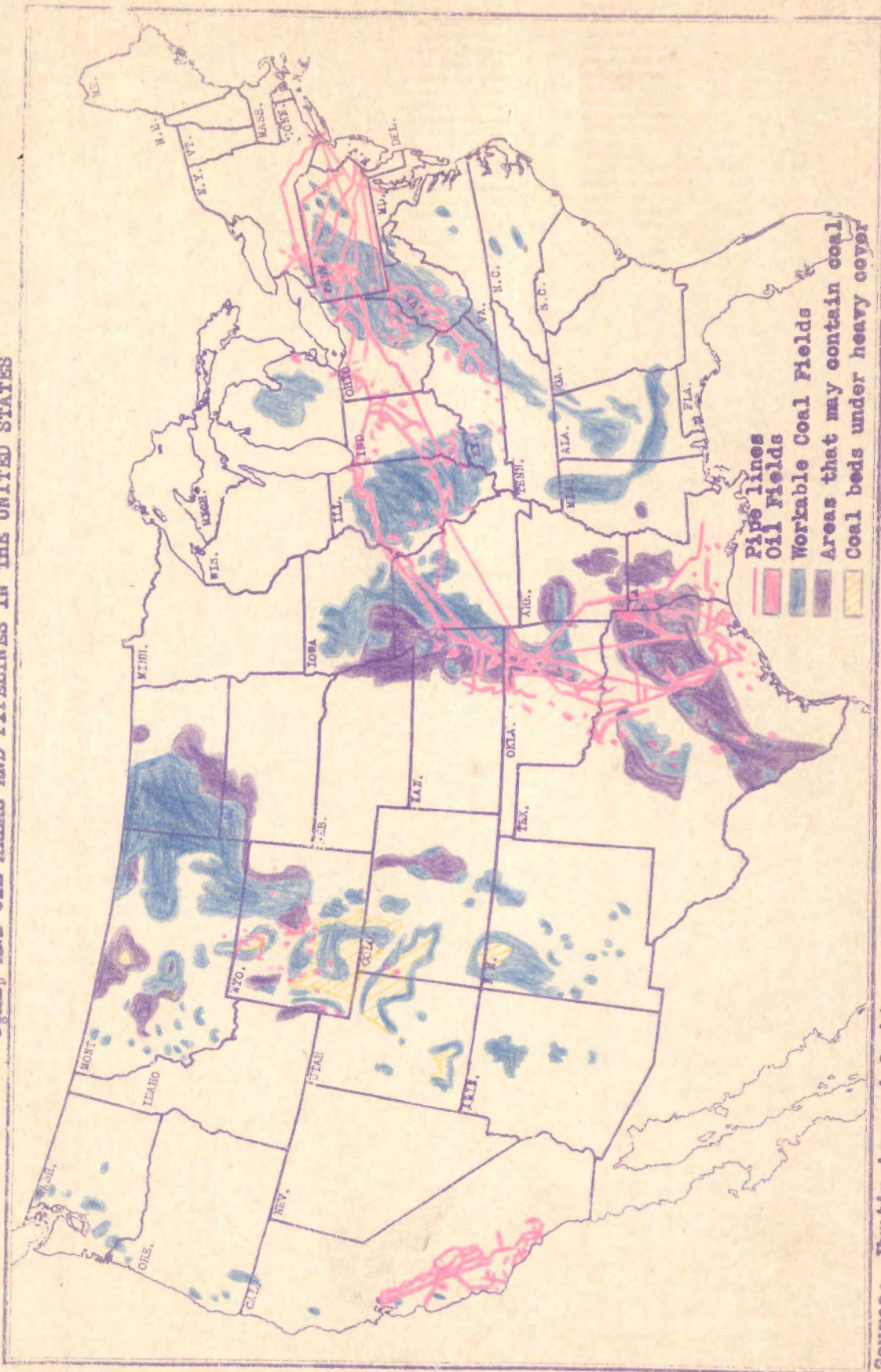
Petroleum.

The largest known gas and petroleum deposits in the United States are in Texas, California, Oklahoma, Kansas, Louisiana, Arkansas, Wyoming, Pennsylvania, Kentucky, Ohio, Illinois, and West Virginia as shown in Map 34 and Table 72. A number of other states have some known oil and gas deposits.

The prospective oil and gas lands in Tennessee occupy a comparatively small area north and east of the Nashville dome. This area covers 3,248 square miles or 8.1 per cent of the area of the

Map 34.

COAL, AND OIL AREAS AND PIPELINES IN THE UNITED STATES



Source: Huntington and Cushing, Principles of Human Geography, p. 190.

Table 70.

Summary of Classification of Tennessee for oil and gas, Jan. 1, 1929

Classification of land	Area Sq. mi.	Per cent	Remarks
Impossible	415	1.0	Small irregular belt along extreme eastern border.
Unfavorable	36,348	90.0	Most of Tennessee except comparatively small area in central north.
Prospective	3,248	8.1	Comparatively small area north and east of Nashville dome.
Proved	11 ^a	^z	Small, isolated patches north and east of Nashville dome.
Total	40,022 ^b	100.0	

^zLess than 0.1 per cent.^aOil area, 10 square miles; gas area, 1 square mile.^bWater area, 335 square miles.

Arnold , Ralph and Keninitzer, W. J. Petroleum in the United States and Possessions.

state, as shown in Table 70. The proved oil and gas area covers only 11 square miles (oil 10 and gas 1), or less than 0.1 per cent of the total area of the state. The proved areas occur in small isolated patches north and east of the Nashville dome. Table 70. This table shows that 90 per cent of the area of Tennessee is unfavorable for oil and gas, but that only 1 per cent of the area is impossible.

In the United States the annual production of petroleum has a much greater value than any other mineral, metallic or non-metallic. The value of the 1930 petroleum production was \$1,046,400,000, natural gas, \$412,000,000, and natural gasoline \$126,000,000, a total of almost 1.6 billion dollars. The total value of the metallic mineral products was only 0.98 billion dollars, the total approximate value of non-metallic mineral products was 3.8 billion or a grand total (approximate) of 4.8 billion

dollars for all mineral products produced in the United States in 1930. (1)

The United States is producing a large per cent of the world's supply of petroleum, having produced 67.9 per cent in 1929 and 63.3 per cent in 1930. (Table 71). No other country produced as much as 10 per cent. Venezuela with a production of 9.7 per cent, and Russia, with a production of 9.5 per cent, were the only other countries in 1930 producing as much as four per cent of the world's supply.

The value of the natural gas and oil produced in Tennessee is small compared with the value of some of the other minerals produced in the state. The value of the natural gas produced in 1930 was only \$10,700 and the value of the petroleum was \$30,000, making a total for both \$40,700. (2)

Tennessee ranked seventeenth among the states of the United States in the production of crude oil in 1930, but her production of 19,000 barrels is small compared with that of the three leading states, Texas, California, and Oklahoma. These states had a production of over 200 million barrels each. (Table 72). Tennessee has one refinery of 500 barrels per day capacity, but on January 1, 1931 it was not operating. (Table 73).

Production in Tennessee by Counties. Only four counties, Morgan, Clay, Scott and Pickett produced oil in 1930. The per cent of the state total produced by each of these counties was, Morgan 56.4,

(1) Mineral Resources of the United States 1930, Summary, Page A7 and 8.

(2) Mineral Resources of the United States, 1930, Summary, Page A115.

Table 71.

World's Production of Petroleum, by Countries, 1930 and 1929.
(Figures in Thousands of Barrels of 42 U. S. Gallon)

	1930 (1)		1929	
	Quantity	Percentage of total	Quantity	Percentage of total
United States	898,000	63.3	1,007,323	67.9
Venezuela	137,675	9.7	137,472	9.3
Russia	135,165	9.5	(2) 99,507	6.7
Persia	(3) 45,420	3.2	(3) 42,145	2.8
Roumania	41,680	3.0	34,689	2.3
Netherlands E. Indies	40,150	2.8	38,072	2.6
Mexico	39,530	2.8	44,688	3.0
Colombia	20,346	1.5	20,385	1.4
Peru	12,458	0.9	13,422	0.9
Trinidad	9,120	0.7	8,716	0.6
Argentina	8,910	0.6	9,391	0.6
India, British	8,280	0.6	8,366	0.6
British Borneo (Sarawak)	5,830	0.4	5,279	0.4
Poland	4,840	0.3	4,988	0.3
Japan and Taiwan	1,950	0.1	2,010	0.1
Egypt	1,910	0.1	1,864	0.1
Sakhalin Russian	1,670	0.1	1,076	0.1
Ecuador	1,559	0.1	1,350	0.1
Canada	1,550	0.1	1,121	0.1
Germany	1,161	0.1	711	
Iraq	750		798	
France	520		497	
Czechoslovakia	150	0.1	93	0.2
Italy	63		44	
Bolivia	56			
Other Countries	30		34	
Total	1,418,723	100.0	1,484,041	100.0

- (1) 1930 figures are subject to slight revision.
 (2) Production for fiscal year ended September 30; calendar year 1929 production estimated at 103,000,000 barrels; 1928, 87,800,000 barrels.
 (3) Net production; actual production less oil returned to structure.

Source:

American Petroleum Institute Petroleum Facts and Figures, P. 7.

Clay 33.1, Scott 9.5, and Pickett 1.0. These counties hold the same rank for the average of the three year period 1928-1930. Table 74.

Table 72.

Production of Crude Oil in the United States by States

(Thousands of barrels of 42 U. S. gallons)

State	1930	1929	1920
Texas	289,965	296,875	96,868
California	228,099	292,534	103,377
Oklahoma	215,227	255,004	106,206
Kansas	41,617	42,813	39,005
Louisiana	23,107	20,554	35,714
Arkansas	19,663	24,917	
Wyoming	17,846	19,314	16,831
Pennsylvania	12,797	11,820	9,956
Kentucky	7,345	7,775	8,738
Ohio	6,519	6,743	7,400
Illinois	5,699	6,319	10,744
West Virginia	5,092	5,574	8,249
New York	3,802	3,377	906
Montana	3,139	3,980	340
Colorado	1,657	2,358	111
Indiana	991	981	945
Tennessee	19	19	14
Others	13,681	6,365	13

Source:

Petroleum Facts and Figures, The Petroleum Institute, 1931,
Page 110.

The development and trend in Tennessee. The historical review
of petroleum production is given by Arnold and Kemnitzer as follows: (1)

"Crude oil was produced commercially in Tennessee in 1860 and continued to be produced through 1907. From 1907 to 1915 inclusive, there was no yield, but since 1916 a small output has been uninterrupted. Natural gas has been produced commercially since 1902. No natural-gas gasoline has been produced.

(1) Arnold, Ralph, and Kemnitzer, W. J. Op. Cit.

The year of maximum crude-oil output was 1927, with approximately 60,000 barrels. During 1929, approximately 30,000 barrels of crude oil were produced. During 1927, the output of natural gas amounted to 9,000 M cubic feet. In view of the enormous national outputs, the production of crude oil and natural gas in Tennessee is almost negligible.

Oil and gas have been known to exist in Tennessee since about 1820. About this time, the first white settlers took notice of the numerous natural seepages in the northern-central part of the State, and oil and gas are said to have been encountered in water wells drilled by them. Only passing note was made of the petroleum resources of Tennessee until after the Civil War. In 1866, several wells were drilled in Dickson and Overton Counties. A small amount of oil was produced on Spring Creek in Overton County, but the Dickson County well did not develop production of commercial consequence.

The Spring Creek field, Overton County, was the first oil pool to be developed in Tennessee. For 10 years following 1866, a mild interest and development took place in that vicinity, but the remoteness of the district from suitable markets, the small amount of oil obtained, and the difficulties of transportation soon caused interest to lack, and by 1877 development and production were at a standstill.

Between 1877 and the early 1890's, there was little activity in developing the oil and gas resources of Tennessee. Occasionally a well or two was drilled, but interest as a whole was lacking, and there was no production.

Beginning in 1890 interest revived. Several wells were drilled about 8 miles north of White Bluff in Dickson County, and oil was reported in some of them. In 1892 oil was discovered at Spurrier in Pickett County. Considerable development and exploratory work followed, and, by 1896, some 50 wells had been drilled in northern-central Tennessee, but only one was producing. Production was maintained until 1906, when the field at Spurrier went to water and ceased to produce.

Between 1906 and 1916, little or no interest was manifest in oil and gas resources of Tennessee, but in the later year a revival of interest came with the discovery of oil near Glenmary in Scott County. The modern development of the oil and gas industry may be said to date from that discovery. Since then, although production has been extremely small, the output has been fairly regular, and though little elaborate exploratory work has been carried on by the larger companies, the smaller operators have shown a continued interest in the State, and persistent effort has been made to uncover new fields."

Table 73.

Number and Capacity of Petroleum Refineries, by States, January 1, 1931

State	Number			Capacity (barrels per day)			
	Operating	Shut down	Building	Operating	Shut down	Building	Total
Arizona	-	1	-	-	1,000	-	1,000
Arkansas	8	1	-	46,000	1,500	-	47,500
California	55	14	-	871,430	35,750	-	927,180
Colorado	3	-	2	4,100	-	2,500	6,600
Georgia	1	1	-	5,000	4,000	-	9,000
Illinois	10	1	-	137,700	3,500	-	141,200
Indiana	5	-	-	187,000	-	-	187,000
Iowa	1	-	-	2,000	-	-	2,000
Kansas	14	2	-	141,000	5,000	-	146,000
Kentucky	8	-	-	27,750	-	-	27,750
Louisiana	10	3	-	193,200	33,000	-	226,200
Maryland	2	2	-	42,000	14,000	-	56,000
Massachusetts	2	-	-	42,000	-	-	42,000
Michigan	5	1	-	14,700	1,500	-	16,200
Missouri	2	-	-	21,500	-	-	21,500
Montana	13	6	1	19,650	4,830	1,500	25,980
New Jersey	7	-	-	307,000	-	-	307,000
New Mexico	5	2	-	6,300	300	-	6,600
New York	4	-	-	40,500	-	-	40,500
Ohio	9	3	4	82,580	3,100	32,000	117,680
Oklahoma	45	13	1	316,900	29,700	2,500	349,100
Pennsylvania	37	12	1	238,250	13,280	5,000	256,530
Rhode Island	2	-	-	11,500	-	-	11,500
South Carolina	1	-	-	15,000	-	-	15,000
Tennessee	-	1	-	-	500	-	500
Texas	75	22	1	795,600	63,775	1,500	860,875
Utah	2	2	-	7,000	500	-	7,500
Virginia	1	-	-	1,500	-	-	1,500
W. Virginia	6	-	-	16,100	-	-	16,100
Wyoming	13	2	-	113,350	840	-	114,190
Total	346	89	10	3,706,610	236,075	45,000	3,987,685

Source: Petroleum Facts and Figures, The Petroleum Institute, p. 124.

Table 74.

Production of Crude Oil in Tennessee Counties

	Production 1930		3 yr. Average 1928-1930
	% of state total	Barrels	
Morgan	56.4	11,844	11,122
Scott	9.5	2,000	2,735
Clay	33.1	6,944	14,892
Pickett	1.0	202	500
Tenn.	100.0	20,990	29,249

Source:

Mineral Resources of Tennessee, 1930, 1929, 1928.

Table 75.Chronological List of Oil and Gas-Field Discoveries in Tennessee,
1866-1928

Year	Field	County	Year	Field	County
1866	Spring Creek	Overton	1916	Glenmary ¹	Scott
1892	Spurrier	Fentress	1923	Willow Grove	Clay
1896	Riverton	Pickett	1924	Tinsleys	Jackson-
1900	*(Franklin Co.)	Franklin		Bottom	Clay
			1924	Bone Camp ²	Morgan
			1925	Celina ³	Clay
			1925	Clark	Clay

*Producing gas only or principally

¹Also known as Oneida²Also known as Sunbright.³Also known as Peterman Bend.

From 1915 to 1929 the total production in Tennessee was 282,047 barrels of crude oil with a total value of \$551,469. Since 1906 a total of 2,023,825 thousand cubic feet of natural gas has been produced, valued at \$386,308, (Table 76). The trend in crude oil production is upward, but is characterized by wide fluctuations. The 1930 production was 21,030 barrels as compared with 46,000 in 1928.

Table 76.

Production and Value of Crude Oil and Natural Gas Produced in
Tennessee 1860-1929

Year	Production		Value	
	Crude oil (Barrels)(1)	Natural gas (M. Cu. Ft.)	Crude oil	Natural gas
1860-75	Included in Pennsylvania and N. Y. Combined; crude oil insignificant; natural insignificant; natural gas none.			
1875-89				
1889-00				
1901				
1902	Included in Ky.-crude oil little			\$300
1903				300
1904				300
1905	1 ^x			300
1906	Inc. in Ky.	2,200		300
1907	crude oil	2,200		300
1908	none.	2,200		350
1909		2,200		350
1910		1,200		300
1911		1,200		300
1912		1,500		375
1913		2,400		600
1914		1,200		300
1915	0	1,600		400
1916	677	2,000	\$1,317	1,150
1917	12,196	10,900	28,448	2,450
1918	8,374	1,826,725 ?	21,704	361,140
1919	15,000	77,000	37,000	5,700
1920	14,000	15,000	50,000	3,000
1921	12,000	11,000	21,000	2,600
1922	9,800	3,000	17,000	333
1923	8,000	4,100	14,000	300
1924	10,000	1,200	18,000	110
1925	24,000	8,500	53,000	800
1926	43,000	11,500	100,000	1,150
1927	60,000	9,000	90,000	800
1928	46,000	-	70,000	-
1929	19,000	25,000	30,000	2,000
Total				
Pct.	282,047	2,023,825	551,469	386,308

(1) In barrels of 42 U. S. gallons.

Sources- Geological Survey, Dept. of Interior; Bur. of Mines, and Bureau of the Census, Dept. of Commerce; and the Oil and Gas Journal. Taken from Petroleum in the U. S. and Possessions by Arnold and Kemnitzer.

Table 77.

Petroleum Wells Developed in Tennessee---1915-1929

Year	Number New Wells drilled				Old Wells	
	Oil	Gas	Dry	Total	Producing(1)	Abandoned(2)
1915	4	1	7	12	4	0
1916	2	0	7	9	2	4
1917	8	3	0	11	4	6
1918	14	3	6	23	6	12
1919	9	0	4	13	8	7
1920	7	0	8	15	10	5
1921	17	1	3	31	13	14
1922	16	1	15	32	15	14
1923	12	1	41	54	17	10
1924	3	6	19	28	17	3
1925	19	4	35	58	24	12
1926	26	1	0	35	60	10
1927	49	2	16	67	70	39
1928	41	7	18	66	75 ^x	36 ^x
1929	7	0	1	8	35 ^x	47 ^x
Total	234	30	198	462		199
Pct.	50.6	6.5	42.9	100.0	14.9	85.1

(1) Producing oil wells on December 31, 1928.

(2) Abandoned and shut-in wells on December 31.

x Estimated.

From 1915 thru 1929, inclusive, a total of 462 new wells were drilled in Tennessee. Of this total, 198 or 42.9 per cent were dry, 30 or 6.5 per cent produced gas, and 234 or 50.6 per cent produced oil. Table 77.

While there have been considerable variations in the number of wells drilled from year to year the trend has been upward to 1928, when 66 were drilled. In 1929 only 8 were drilled, the smallest number since 1915.

Of the 296 wells drilled in proved areas, 218 produced oil, 30 produced gas, and only 48 or 16.2 per cent were dry.

The wildcat wells ranged in depth from 100 feet to 2983 feet with an average depth of 1195 feet, and an average cost of \$5,680. The proved wells ranged in depth from 52 feet to 1400 feet with an average depth of 885 feet, and an average cost of \$2,870. The state average cost per well was \$3,484 with an average returns of only \$1,995 per well, 1866-1928.

The total investments in wildcat wells, thru 1928, was \$897,440, in proved area wells \$849,520 or a total of \$1,746,960. This gave a total return of \$905,777. (Tables 77, 78, 79).

Future Possibilities. The future possibilities of the petroleum industry has been reviewed by Arnold and Kemnitzer as follows: (1)

"The petroleum resources of Tennessee were intermittently exploited from 1860 to 1915. Since 1915, exploitation has been continuous. The geologic data at hand indicate the original prospective area to have comprised about 3,395 square miles or 8.1 per cent of the State, all in northern-central Tennessee. Up to January 1, 1929, or after 14 years of continuous development during which time 454 wells were drilled, approximately 11 square miles, or 0.32 per cent of original prospective area, proved productive - 10.1 square miles or 0.30 per cent productive of oil, and 0.8 square mile, or 0.02 per cent, productive of gas.

The petroleum resources are estimated about 30 per cent developed. The chances for future discoveries of significance are, however, poor. A number of small spotted discoveries will be made with extraordinary difficulty, but the ultimate productive area will probably never reach much more than 1 per cent of the original prospective area. Showings of oil and gas have been found throughout the whole sequence of Paleozoic rocks from the Pennsylvanian down to and including the Cambro-Ordovician but adverse regional conditions of diastrophism together with a paucity of source rocks are believed to preclude the existence of important accumulations. The younger rocks of western Tennessee are believed to offer practically no chances for future discoveries.

The production of crude oil is so small - less than 30,000 barrels in 1929- as to be entirely insignificant in relation to national demand. Neither future discoveries nor improvements in present production methods can be expected to greatly improve the present situation."

(1) Arnold, Ralph, and Kemnitzer, W. J. Op. Cit.

Table 78.

Areas	Summary of Oil Wells - Number Drilled, Depth, and Costs: 1860-1928						
	Drilled, 1860-1928			Present Status		Depth (feet)	Cost
	Oil	Gas	Dry	Total	Per cent		
Wildcat	9	2	149	158	dry		
Proved	218	30	48	296	94.3	1195	\$5,680
Whole					16.2	885	2,870
State	227	30	197	454	43.4	993	3,848

1 Producing oil wells on December 31, 1928

2 Abandoned and shut-in wells on December 31, 1928.

3 Areas at least a mile outside proved production.

Sources: Compiled mainly from data published or furnished by the Geological Survey, Department of the Interior; Bureau of the Census, and Bureau of Mines, Department of Commerce; the Oil and Gas Journal; and various companies, and individuals. Taken from Arnold and Kennitzer, Op. Cit.

Table 79.

Approximate Investment in the Drilling of Oil Wells in Tennessee, 1866-1928			
Class of drilling	Number of Wells	Drilling investment (cost)	
		Total amount	Per well drilled
Wildcat wells	158	\$897,440	\$5,680
Proved-area Wells	296	849,520	2,870
Total	454	\$1,746,960	
Average			\$3,848

Source: Arnold and Kennitzer, Op. Cit.

Table 80.Revenue Derived from the Sale of Crude-petroleum Products in Tennessee,
1866-1928

Product	Period	Revenue derived		Year 1928		Return per well drilled (1)
		Period 1866-1928 Total	Per cent	Total	Per cent	
Crude oil	1866-1928	\$521,469	57.6	\$70,000	98.9	\$1,149
Natural gas	1889-1928	384,308	42.4	x750	1.1	846
Nat. gas				0	0.0	
gasoline	-	0	0.0	0	0.0	0
Total		\$905,777	100.0	\$70,750	100.0	\$1,995

1 Total number of wells drilled 1866 to 1928 inclusive, equals 454.

- Never produced.

x Estimated

Source:

Arnold and Kemnitzer, Op. Cit.

Mineral Water

Mineral waters, in the strict sense, is water that contains an appreciable amount of mineral matter in solution. In this sense the water of practically all wells and springs is mineral water; but, as the term is usually used, mineral water means water containing minerals of medicinal value.

The principal use of mineral water is for medicinal purposes. Where the climatic and scenic conditions are favorable resorts, which are used for rest, recreation, and health, have been established. (1)

The sales of natural mineral water in the United States in 1923 was 44,430,998 gallons valued at \$6,493,177. Since 1923 this information has not been collected. (2) Tennessee has a large number of mineral springs which are well distributed over the state.

(1) State Geological Survey, The Resources of Tennessee, Vol. 3, No. 4.

(2) Mineral Resources of the United States 1930, Summary.

Recent data on the operation of these springs are not available. In 1911 there were 19 commercial springs in operation as shown in Table 81. This number had increased to 23 in 1915, but the amount of water sold had decreased. The total value of the water sold decreased from \$72,475 to \$39,304, part of which was due to the decrease in the price.

The following 22 springs reported sales in Tennessee in 1915.⁽¹⁾

Bright Sunrise Spring, near Ashland City, Cheatham County.
 Bush Epsom Lithia Springs, Davidson County, near Nolensville.
 Darnell Well, Clarksville, Montgomery County.
 Eagle Bluff Springs, Jacksboro, Campbell County.
 Eastbrook Spring, Eastbrook, Franklin County.
 Faulkner Springs, near McMinnville, Warren County.
 Fernwood White Sulphur Spring, near Morristown, Hamblen County.
 Galbraith Epsom Lithia Springs, Mooresburg, Hawkins County.
 Hamilton Spring, near Lebanon, Wilson County.
 Horn Springs, Horn Springs, Wilson County.
 Larkin Spring, Madison, Davidson County.
 Montvale Spring, Maryville, Blount County.
 Neubert Spring, Neubert, Knox County.
 Paris Wells, Paris, Henry County.
 Pioneer Lithia Spring, Near Nashville, Davidson County.
 Red Boiling Springs, Red Boiling Springs, Macon County.
 Rhea Springs, Rhea Springs, Rhea County.
 Richardsons Lockeland Spring, near Nashville, Davidson County.
 Tate Spring, Tate Springs, Grainger County.
 Thompson Spring, near Nashville, Davidson County.
 Willow Brook Spring, Craggie Hope, Cheatham County.
 Wright's Epsom-Lithia Spring, Mooresburg, Hawkins County.

Table 81.

Mineral waters sold in Tennessee, 1911-15.				
Year	Commercial Springs	Quantity sold	Value	Average price per gallon
		Gallons		Cents
1911	19	1,073,115	\$72,475	7
1912	21	796,568	53,560	7
1913	23	1,088,034	64,905	6
1914	23	943,502	56,741	6
1915	23	703,566	39,304	6

Mining As An Industry In Tennessee.

Comparison with Agriculture and Manufacturing. Mining is the third most important industry in Tennessee. Manufacturing ranks first and agriculture second (Table 82). In the United States these three industries rank in the same order as they do in Tennessee, but the ratio of one to the other is not the same. Mining is relatively of less importance in Tennessee, as compared with manufacturing and agriculture than it is in the United States. The ratio of cash farm income to the value of mineral production in Tennessee is over 4 to 1 while the United States is a little less than 2 to 1; and the ratio of gross farm income to the value of mineral production in Tennessee is 7 to 1 while in the United States it is just a little over 2 to 1. (See footnote (a), Table 82). In Tennessee the value of the mineral production is 12.6 per cent of the value added by manufacturing, and in the United States it is 18.5 per cent.

Tennessee compared with 8 Southern States 1920. Although Tennessee is not one of the leading mineral producing states of the United States, it one of the leading states in the South in this respect. Five measures of the importance of mineral production of eight Southern states in 1920 are shown in Table 83. (1) Among these States Tennessee ranked second in the number of enterprises,

(1) Similar data were not available for 1930.

Table 82.

Relative Importance of Agriculture, Manufacturing and Mining
in Tennessee and U. S. 1929.

Tennessee		United States
Value Added by Manufacturing (d)	322,898,000	31,843,928,000
Gross farm income (a)	239,356,000	11,983,258,000
Cash farm income	168,681,000	10,205,467,000
Value of Minerals production (b)	40,719,706	5,887,300,000 (c)

Sources:

Farm income data, State Summaries of Income Estimates 1929-1930. U. S. Bureau of Ag. Economic, U. S. Department of Agriculture.

Mineral data- U. S. Mineral Resources, Summary 1930, U. S. Division of Mines.

Manufacturing data- Bureau of Census on Manufacturing, 1929 Department of Commerce.

- (a) Gross farm income--cost income and value of the product consumed in The household or the farm where commodities were produced.
- (b) Iron ore taken as basis of iron valuation, and in the case of other metals mine production (recoverable content of metals) is the basis.
- (c) Value of shipments rather than of total production.
- (d) Value added by manufacturing is total value of product less cost of material.

and in the number of people employed. In horsepower employed and in the total value of the minerals produced Tennessee held third place. In one measure, capital employed (1) Tennessee ranked fourth. Considering all measures, the 3 leading states in this

(1) Mineral Resources of the United States, Op. Cit. 1930, (Summary).

Table 83.

Mining in 8 Southern States in 1920.

	Number of Enter- prises	Capital Employed	Number of People Em- ployed	Horsepower Employed	Value of Product
Ala.	264	\$84,000,000	32,500	146,000	\$59,800,000
Fla.	36	58,000,000	3,300	45,000	8,900,000
Ga.	74	6,000,000	2,300	13,000	4,000,000
La.	137	82,000,000	5,200	79,000	40,000,000
Miss.	-	-	-	-	-
N. C.	102	2,000,000	1,800	5,000	2,700,000
S. C.	20	3,000,000	900	5,000	1,300,000
Tenn.	203	51,000,000	14,400	57,000	23,200,000

Bureau of Census, 1920.

group are Alabama, Louisiana and Tennessee. These three states hold this same rank in the value of the mineral production in 1929.⁽¹⁾ Tennessee ranked 24th in the U. S. in this respect in 1929.

The growth of mining in Tennessee. Four factors are used here to show the growth in mining, number of wage earners, horsepower used, amount of wages paid, and the value of the products mined. While each of these factors is subject to more or less serious limitations, an analysis of their trends should give a fair indication of the growth in mining.⁽²⁾ The changes in amount of production of individual minerals were shown in connection

(1) Mineral Resources of the United States, Op. Cit. 1930, (Summary).

(2) These limitations are mentioned in connection with the discussion of each factor.

with the previous discussion relating to these minerals.⁽¹⁾

Using the number of wage earners as a measure of growth in mining, Tennessee lost 12 per cent during the period 1919-1927, which gave her twenty-eight place in the United States (Table 84). During this period 21 states made a gain in the number of wage earners. These included Kentucky, West Virginia, and Illinois, four principal mineral producing states. North Dakota made a 73 per cent gain during this period, which was the largest percentage gain made by any state. In 1927 only 15 states had a larger number of wage earners engaged in mining than Tennessee.

From 1909 to 1919, Tennessee lost 11 per cent in the number of wage earners. The United States lost 1 per cent from 1919-1927 and gained 1 per cent from 1909-1919 (Table 84). It seems, then, that Tennessee has had a more rapid decline than the United States as a whole.

From 1909 to 1919, Tennessee gained 76 per cent in the amount of wages paid in the mining industry, which gave this state twenty-second place in the percentage gained. The highest ranking state was Texas which gained 639 per cent. From 1902 to 1909 Tennessee gained 51 per cent and 167 per cent from 1902 to 1919. The percentage gain for the United States was 121 from 1909 to 1919, 59 from 1902 to 1909, and 250 from 1902 to 1919.

(1) The best measure of growth is physical production, or amount produced. Such data were available for most of the minerals produced in Tennessee and were presented in the previous sections dealing with each mineral. Since these minerals differ in relative importance and in units of measure, to show the growth of mining as a whole by using physical production, it would be necessary to calculate a composite index for each state and for each year.

Table 84.

Percentage Change in Number Wage Earners Engaged in Mining 1919-27, and 1909-19; and Number Engaged in 1927, by States

State	Percentage Change		Number Wage Earners in 1927	State	Percentage Change		Number Wage Earners in 1927
	1919-27	1909-19			1919-27	1909-19	
1 N. D.	73.2	37.7	1341	25 Oreg.	-9.8	-13.9	668
2 Ne.	72.8	-54.3	1692	26 Md.	-10.2	-21.7	5052
3 Ida.	67.2	-24.4	4106	27 S. D.	-10.4	-48.4	1599
4 Vt.	58.0	-63.9	4639	28 Tenn.	-12.4	-11.4	12105
5 Ky.	53.2	138.1	67048	29 Ohio	-14.2	-2.5	42209
6 Conn.	52.5	-60.3	828	30 Wash.	-14.9	-26.8	4300
7 Mass.	49.1	-48.2	2541	31 N. H.	-15.1	39.0	6026
8 Ga.	40.9	-29.1	3378	32 Minn.	-16.4	4.1	14433
9 N. Y.	32.0	-33.3	8190	33 Ariz.	-20.0	18.9	12224
10 W. Va.	20.6	337.3	121585	34 Nev.	-21.2	-8.9	3333
11 Ark.	19.3	-26.4	4331	35 Mont.	-25.7	-14.4	11989
12 Va.	16.0	-4.7	16878	36 Kans.	-30.6	12.5	11191
13 Ind.	11.5	11.8	29345	37 Mich.	-32.7	-20.1	21048
14 W. C.	10.3	-14.7	2094	38 R. I.	-32.8	-44.5	248
15 Ala.	9.9	15.2	36810	39 N. J.	-33.2	-21.5	3055
16 Wisc.	9.2	-24.7	3875	40 Wyo.	-33.5	25.3	6454
17 Ia.	6.3	-31.6	10569	41 Cal.	-37.2	-5.7	12154
18 Utah	6.2	-2.4	10454	42 Fla.	-38.3	-38.1	2082
19 Pa.	4.4	-10.4	337544	43 Okla.	-64.1	190.9	12180
20 N. H.	3.5	-31.9	706	44 Tex.	-64.5	134.7	5718
21 Ill.	2.8	9.8	81371	45 S. C.	-68.6	-48.6	293
22 Colo.	-2.2	-21.8	16421	46 La.	(1)		495
23 Febr.	-4.3	-53.6	155	47 Miss.	-90.4	477.0	495
24 Mo.	-9.0	-36.6	13517	48 Dela.	(2)	-76.5	(2)
			U. S. Total		-1.4	1.4	967,780

Source: (a) 1909 and 1919 data from Statistical Abstract of the U. S. 1931, Page 771.

(b) 1927 data from Market Data Handbook of the United States, Bureau of Commerce,

pages 164 - 208.

(1) Data for Louisiana and Mississippi combined for 1919. Data for 1909 and 1927 for Louisiana only, Mississippi not reported.

(2) No data for 1927.

Table 85.

Percentage Change in Amount of Wages Paid in the Mining Industry, 1909-1919, 1902-1909, and 1902-1917;
and Amount of Wages in 1919.

State	Percentage Increase		Amount of Wages paid (000) 1919	State	Percentage Increase		Amount of Wages paid (000) 1919
	1909-19	1902-09			1909-19	1902-09	
1 Miss. (1)	760.0	2457.6	7,506	25 N. Y.	58.9	-7.5	7,497
2 Tex.	639.3	76.7	29,668	26 Ga.	57.8	17.8	2,017
3 Ky.	533.1	50.7	49,551	27 Wisc.	64.2	56.0	4,750
4 Okla.	502.0	1196.1	46,809	28 Ark.	51.1	55.6	4,573
5 W. Va.	232.3	106.0	119,518	29 Oreg.	40.8	31.2	993
6 Va.	208.0	51.2	16,108	30 Colo.	37.6	-2.2	25,406
7 N. M.	197.4	114.3	10,494	31 Fla.	32.2	117.3	5,108
8 N. D.	182.7	94.8	1,029	32 Wash.	26.7	57.7	7,466
9 Ala.	154.1	37.8	36,230	33 Nev.	24.9	391.3	7,401
10 Minn.	146.8	86.3	29,383	34 Mont.	20.4	80.8	25,724
11 Wyo.	132.6	32.6	14,576	35 Mo.	16.3	64.4	16,777
12 Kans.	127.8	69.6	21,949	36 Ia.	14.7	80.0	12,466
13 Pa.	125.4	73.0	445,219	37 S. C.	8.6	-29.8	680
14 Ohio	117.1	15.3	58,110	38 Mass.	5.2	-32.1	2,069
15 N. J.	110.4	5.5	5,893	39 Ida.	3.8	3.6	4,202
16 Ind.	104.2	37.8	30,193	40 Neb.	-2.4	77.1	166
17 Ill.	103.1	71.9	94,179	41 R. I.	-2.5	5.7	400
18 Ariz.	94.0	166.9	28,193	42 N. H.	-10.8	14.9	826
19 Utah	91.4	76.6	17,197	43 Conn.	-11.4	-9.8	647
20 Md.	84.2	-32.8	6,152	44 Me.	-21.0	-61.7	1,052
21 Mich.	82.2	37.6	50,406	45 S. D.	-22.8	-4.5	2,497
22 Tenn.	76.5	61.3	12,967	46 Vt.	-31.6	42.9	3,042
23 N. C.	72.5	66.6	1,489	47 Dela.	-37.6	-2.2	136
24 Calif. (2)	66.6	72.4	51,748				

Source: (a) Abstract of the Twelfth Census 1900, Page 429.

(b) Statistical Abstract of the United States, 1931, Page 771.

(1) Includes Louisiana only for 1902 and 1909.

(2) Includes 2 operators in Alaska and Hawaii.

(3) Includes D. C.

Only 19 states paid a greater total for wages in 1919 than Tennessee. (Table 85).

Neither the number of wage earners nor the total amount of wages paid are perfect measures of the growth of mining. The increased use of machinery has had a considerable affect on the number of people employed. The changing price level or wages scale greatly affects the total amount of wages paid. These measures, however, are suitable for making comparisons of relative growth in mining in the different states.

Tennessee gained 64 per cent in the number of horsepower used in mining during the period 1909 - 1919, and 372 per cent during the period 1902 - 1919 (Table 86). In the percentage gained from 1909 to 1919, Tennessee ranked eighteenth and from 1902 to 1919 only eight states made a larger percentage gain. This state made a larger percentage gain during these periods than the United States, which made a gain of 46 per cent from 1909 to 1919 and 152 per cent from 1902 to 1919. (Table 86).

The correlation between the increase in the use of horsepower and the increase in mining no doubt is not perfect because, to a certain extent, machinery has been taking the place of man power. Therefore, the use of horsepower tends to overestimate the growth while the number of wage earners tends to underestimate it.

In the value of mineral products, Tennessee gained 76 per cent from 1919 - 1929, 84 per cent from 1902 - 1929 (Table 87). For these same periods the United States gain was 86 per cent, 155 per cent, and 663 per cent respective. Compared with the growth in other states, Tennessee ranked 29 in the percentage gain from 1919 - 1929, 22 from 1909 - 1919, and 26 from 1902 - 1929.

Table 85.

Percentage Change in Primary Horsepower Used in Mining, by States 1902-1919, and Amount Used in 1919.

State	Per Cent Increase		Horsepower Used 1919	State	Per Cent Increase		Horsepower Used 1919
	1909-1919	1902-1919			1909-1919	1902-1919	
1 La. (1)	320	1940	86,135	26 Pa.	24	79	1,999,422
2 Miss	371	(b)	448,173	27 Mich.	23	83	3,537,882
3 Okla.	303	1186	129,036	28 Ga.	22	39	13,026
4 Tex.	273	(a)	59,876	29 Ida.	19	67	31,239
5 N. H. (2)	251	40	166,091	30 Colo.	18	40	116,351
6 Ariz.	180	697	148,893	31 N. H.	15	66	4,336
7 Ky.	127	524	1,947	32 Ohio	14	65	337,611
8 Nebr.	107	(a)	62,757	33 Vt.	10	88	28,119
9 Wyo.	100	667	133,984	34 Wisc.	6	123	26,766
10 Kans.	93	350	313,213	35 Fla.	6	334	44,969
11 Col.	89	(a)	50,876	36 Md.	3	50	18,660
12 Nev.	88	161	33,901	37 N. D.	1	143	2,037
13 N. J.	84	221	38,193	38 Minn.	-5	406	406
14 Wash.	82	(b)	86,131	39 Mo.	-9	116	100,160
15 Utah	69	193	704,279	40 N. Y.	-10	43	91,339
16 N. Va.	67	272	57,880	41 N. C.	-17	34	5,039
17 Va.	64	372	56,685	42 Mass.	-17	12	12,498
18 Tenn.	59	431	145,775	43 Mont.	-18	(a)	1,847
19 Ala.	52	190	21,365	44 Oreg.	-22	67	6,264
20 Ark.	41	260	318,231	45 Me.	-23	-10	6,277
21 Ill.	37	119	32,171	46 S. D.	-24	-3	11,844
22 Iowa	36	8	129,663	47 S. C.	-33	(b)	4,656
23 Ind.	35	7	8,520	48 Dela.	-55	-53	660
24 Conn.	28	(b)	3,000	49 (x)			
25 U. S. Total				U. S. Total	46	152(3)	6,725,786

(x) Mississippi and Louisiana combined.

Source: (a) Mines and Quarries, Bureau of Census, Vol. II, 1910. (b) Statistical Abstract of the United States, 1931, Op. Cit. Page 771.

(1) Data for 1902 and 1909 for Louisiana only--none reported for Mississippi. (2) Arizona 1902 includes New Mexico, Montana, Utah and Wyoming. (3) Oklahoma, S. C., E. I., and D. C. are included in U. S. total for 1902.

Table 87.

Percentage Change in Value of Mineral Products 1919-1929, 1909-1919 and 1902-1929--by States.

State	1919-1929	1909-1919	1902-1929	State	1919-1929	1909-1919	1902-1929
1 Neb.	1553.6	-9.0	5173.6	25 Ind.	83.5	140.9	260.5
2 N. J.	672.3	-11.5	1678.6	26 Okla.	83.3	999.6	2663.0
3 Ark.	391.7	82.6	1355.1	27 N. D.	79.9	241.1	963.2
4 N. Y.	335.2	88.4	1029.5	28 Ariz.	78.5	281.1	1310.7
5 Conn.	327.7	19.8	414.1	29 Tenn.	74.8	83.5	339.4
6 N. C.	300.6	101.4	1085.3	30 Vt.	70.7	4.1	147.3
7 Mass.	283.8	20.4	256.3	31 Wash.	68.3	26.5	315.9
8 Ga.	274.6	42.0	396.5	32 S. D.	67.4	17.4	33.1
9 Me.	270.2	-11.3	84.6	33 Fla.	64.9	1.4	402.8
10 Oreg.	264.8	58.3	229.4	34 Ohio	64.0	111.0	290.6
11 Cali.	238.8	158.4	1839.5	35 Mich.	46.3	53.4	216.5
12 Tex.	209.2	85.1	7258.6	36 Kans.	37.8	382.5	1206.6
13 Utah	177.4	88.0	830.0	37 Va.	35.4	233.8	533.0
14 Ida.	171.5	36.9	291.3	38 Ky.	34.7	713.9	1497.0
15 S. C.	165.9	7.8	95.8	39 W. Va.	23.3	287.5	516.6
16 N. H.	137.6	19.8	216.8	40 Wyo.	22.2	296.6	801.4
17 Mo.	136.6	5.4	289.3	41 Ala.	9.2	145.8	279.2
18 Wis.	123.2	45.5	468.8	42 Pa.	9.0	134.8	294.0
19 Nev.	103.7	22.4	945.4	43 Colo.	8.0	12.1	36.6
20 N. M.	96.7	237.7	1282.3	44 Minn.	4.6	122.3	432.2
21 Ia.	94.6	33.1	272.2	45 Ill.	2.3	133.1	389.0
22 Dela.	91.4	52.7	4.2	46 R. I.	-1.3	6.1	21.3
23 Md.	90.4	67.7	157.9	47 Miss.	-93.6	511.2	822.2
24 Mont.	88.0	-9.2	229.2	U. S. Total	86.4	155.0	663.1

Source: (a) Mines and Quarries, Bureau of Census, Vol. II, 1910. (b) Statistical Abstract of U. S. 1931 Op. Cit. P. 771. (c) Mineral Resources of the U. S. 1930 (Summary) Op. Cit. (d) Data for Arizona, Montana, Nevada, New Mexico, Utah and Wyoming for 1902 taken from the Abstract of the 12th Census, 1900, Page 429.

Table 88.

Trend in Development of Mining in Tennessee 1902 - 1929.
(All dollar figures in thousands)

	1902	1909	1919	1927	1929
1. Total in Tennessee					
Value of Product, (dollars)	9,768	12,692	23,292		40,720
Number of Wage- earners	10,890	16,338	14,470	12,105	(1)
Primary Horsepower Used	12,007	34,523	56,685		(1)
Wages paid (dollars)	4,864	7,359	12,987		(1)
2. Per Cent Tennessee is of United States					
Value of Product	1.2	1.02	0.74		0.69
Number of Wage- earners	1.9	1.7	1.5	1.5	
Primary Horsepower	0.45	0.76	0.84		
Wages Paid	1.3	1.3	1.0		
Capital invested			51,000		

(Table 87).

Because of the changing price level, value of the mineral production is not an adequate measure of the growth of mining, unless adjustment is made for price changes. It may be used, however, to show Tennessee's relative changes.

In summarizing these factors for Tennessee, it is noted that the value of mineral products produced in Tennessee have increased consistently from \$9,268,000 in 1902 to 40,720,000 in 1929. (Table 88). The number of wage earners increased from 10,890 in 1902 to 16,338 in 1909, but decreased to 14,470 in 1919 and to 12,105 in 1927.

The primary horsepower used and the amount of wages paid both made large increased 1902-1919, the latest date for which data are available. These measures indicate that the quantity of minerals produced have made a steady growth; that the increased use of machinery has been a principal cause of the decrease in number of employees; and that the amount of wages paid has increased partly because of a higher wage scale.

Relative to the United States, Tennessee has declined in the value of minerals produced from 1.2 per cent in 1902 to 0.69 per cent in 1929; in number of wage earners from 1.9 per cent in 1902 to 1.5 per cent in 1927; and amount of wages paid from 1.3 per cent in 1902 to 1.0 per cent in 1919; but has increase relatively in the primary horsepower used from 0.45 per cent in 1902 to 0.84 per cent in 1919. (Table 88).

Table 2

Source: Climatological Data by sections, Reprints, 77 and 78.

Table 3

Mean Maximum and Mean Minimum Temperature, by Months and by Weather Stations in Tennessee,
Through 1920 (Degrees Fahrenheit)

Weather Stations	No. Yrs.	Mean	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Benton	17	Max. 52.4 Min. 31.2	52.4	52.4	64.2	70.6	81.3	87.7	89.6	89.8	85.5	74.3	61.9	51.6	71.8
Chatta.	17	Max. 49.7 Min. 33.1	49.7	52.3	40.9	45.7	54.5	62.2	65.8	65.4	59.8	46.6	35.2	30.9	47.4
Decatur	42	Max. 50.4 Min. 29.5	50.4	51.8	62.9	71.5	79.0	85.5	87.5	86.5	81.8	71.9	60.0	50.8	69.7
Greeneville	25	Max. 46.6 Min. 26.7	46.6	46.8	60.1	65.9	77.6	83.3	85.9	85.1	82.4	51.3	41.7	34.5	51.0
Johnson City	10	Max. 48.3 Min. 27.8	48.3	49.5	57.8	69.1	79.1	85.1	87.8	86.4	85.4	74.4	61.6	50.0	71.2
Knoxville	10	Max. 47.3 Min. 30.6	47.3	49.8	59.1	68.6	77.8	84.2	86.7	85.7	81.0	70.4	57.9	47.5	68.0
Mtn. City	46	Max. 46.7 Min. 25.1	46.7	45.7	56.8	63.8	74.3	79.2	81.2	79.7	75.3	66.5	55.2	45.6	64.2
Rogersville	22	Max. 48.0 Min. 28.0	48.0	48.9	60.5	68.7	77.9	83.4	86.0	85.4	81.9	72.4	59.1	47.6	68.3
Rugby	25	Max. 47.2 Min. 26.2	47.2	47.7	59.7	67.4	77.7	83.8	86.8	85.8	81.4	71.3	58.2	46.9	67.8
Springdale	24	Max. 48.7 Min. 26.9	48.7	49.2	62.9	69.1	81.4	86.5	89.1	88.6	84.1	72.3	59.4	47.6	69.9
Bolivar	14	Max. 48.8 Min. 29.6	48.8	50.3	62.4	71.2	80.4	87.7	89.8	89.7	84.8	73.4	61.3	49.6	70.8
Carthage	26	Max. 50.5 Min. 29.9	50.5	50.9	63.2	71.1	80.9	87.6	90.3	90.1	85.6	75.2	61.8	49.8	71.4
Clarksville	21	Max. 47.7 Min. 29.4	47.7	48.1	60.7	68.9	78.7	86.6	89.9	88.8	83.7	72.7	60.0	47.8	69.5
	24	Max. 47.7 Min. 29.4	47.7	48.1	60.7	68.9	78.7	86.6	89.9	88.8	83.7	72.7	60.0	47.8	69.5
	24	Max. 47.7 Min. 29.4	47.7	48.1	60.7	68.9	78.7	86.6	89.9	88.8	83.7	72.7	60.0	47.8	69.5

Table 3 (continued)
 Mean Maximum and Mean Minimum Temperature, by Months and by Weather Stations in Tennessee,
 Through 1920 (Degrees Fahrenheit)

Weather Stations	No. Yrs.	Mean	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Florence	24	Max.	49.0	49.1	60.7	68.2	78.1	84.7	86.9	85.5	82.1	70.6	59.8	48.7	68.6
	24	Min.	31.0	30.4	40.8	47.5	57.0	65.0	68.2	67.4	60.8	49.3	38.3	31.4	48.9
Hohenwald	24	Max.	50.4	51.4	63.1	71.0	79.7	86.7	89.2	88.8	84.3	73.7	61.7	50.0	70.8
	23	Min.	31.2	28.4	39.2	45.6	53.7	61.1	64.2	63.6	57.6	45.8	35.5	29.6	46.3
Jackson	17	Max.	50.0	52.0	62.6	70.8	80.9	88.5	91.2	90.6	86.1	75.1	62.8	50.3	71.7
	22	Min.	30.9	31.4	41.6	48.2	56.9	61.3	67.4	66.7	60.4	48.4	38.2	31.4	48.6
Johnsonville	24	Max.	50.4	51.3	63.7	71.7	81.2	88.0	91.1	90.5	85.7	74.9	62.4	50.0	71.7
	24	Min.	28.9	28.8	39.4	46.1	55.3	62.9	66.5	65.9	59.0	46.9	36.0	29.5	47.1
Lynnville	23	Max.	48.5	48.8	60.9	68.3	78.4	85.7	87.6	86.8	82.6	72.4	59.9	48.4	69.0
	23	Min.	31.2	30.4	40.4	46.7	56.4	64.5	67.4	66.8	60.5	48.8	37.9	31.7	48.6
Memphis	46	Max.	48.7	51.5	61.1	70.6	78.9	86.3	89.0	87.8	82.4	72.2	60.2	50.8	70.0
	46	Min.	33.6	35.6	44.2	53.2	61.6	69.2	72.5	71.0	64.9	54.1	43.4	36.2	53.3
Nashville	46	Max.	47.4	49.8	59.3	69.0	78.1	85.5	88.4	87.4	81.9	71.4	58.5	48.9	68.8
	46	Min.	30.7	32.2	40.4	49.2	57.9	66.1	69.6	68.1	61.6	50.3	39.7	32.8	49.9
Savannah	23	Max.	51.3	52.4	64.0	71.5	80.7	88.3	90.7	91.0	85.9	75.5	63.1	51.3	72.1
	23	Min.	32.0	32.0	42.2	48.2	57.2	64.8	68.3	67.6	60.6	48.9	38.8	32.8	49.5
Springville	18	Max.	49.5	50.9	62.4	70.6	79.1	86.8	89.9	89.4	84.6	73.7	61.8	49.5	70.7
	18	Min.	28.2	28.4	38.2	45.6	54.4	61.9	65.7	64.9	57.9	45.4	34.8	28.9	46.2
Trenton	25	Max.	49.3	50.2	61.9	70.0	79.9	87.4	90.5	90.3	86.0	75.2	61.7	49.1	71.0
	23	Min.	29.2	29.8	40.5	48.0	57.3	63.8	66.8	66.3	59.4	47.4	37.2	30.1	48.0
Tullahoma	24	Max.	49.8	50.6	62.4	69.7	79.8	85.2	87.5	87.1	83.1	72.8	60.0	49.3	69.7
	24	Min.	30.0	29.7	39.6	45.6	54.2	62.1	65.4	64.9	58.4	46.7	35.9	30.4	46.9

(1) Mean monthly maximum and minimum temperatures are the averages of the daily maximum and minimum temperatures respectively.

Source: Climatological Data, by Sections, Reprints 77 and 78.

Table 4.

Mean Precipitation by Months and by Types (1) Through 1920.

(Precipitation figures in inches)

Type I	Station	County	Length of Period in Years	Dec.	Jan.	Feb.	Mar.	April.	May	June	July	Aug.	Sept.	Oct.	Nov.	Annual
	Memphis	Shelby	61	4.35	4.88	4.40	5.21	5.10	4.25	4.01	3.27	3.41	2.98	2.83	4.14	48.81
	Dyersburg	Dyer	38	4.81	5.30	3.63	4.34	5.23	4.13	3.96	3.42	3.58	2.93	2.88	4.37	48.58
	Covington	Tipton	38	4.55	4.95	3.93	4.63	4.68	4.35	3.88	3.46	3.79	2.66	2.71	4.24	47.73
	Brownsville	Haywood	39	4.76	5.06	3.56	4.65	5.04	4.00	3.77	3.39	3.25	2.57	2.73	3.94	46.74
	Bolivar	Hardeman	38	4.60	4.79	3.96	5.16	5.17	4.01	3.72	4.02	2.96	2.80	2.68	3.73	47.60
	Arlington	Shelby	39	2.91	6.74	3.50	5.75	4.45	4.38	4.04	3.81	3.61	2.46	2.41	4.40	48.46
	Clarksville	Mont.	63	4.59	4.51	4.07	4.96	4.74	4.24	3.99	3.86	3.37	2.83	2.54	3.96	47.66
	Dover	Stewart	23	4.49	5.43	3.47	4.60	4.64	4.25	3.62	3.08	3.96	3.00	3.04	3.99	47.57
	Jackson	Madison	32	4.80	4.56	3.26	4.62	5.27	4.15	4.23	4.23	3.43	2.83	2.77	3.74	47.69
	Kenton	Obion	19	5.20	5.49	3.69	4.44	5.06	4.05	3.61	3.79	3.54	2.79	3.32	3.95	48.99
	Union City	Obion	26	4.61	5.42	3.83	4.91	4.64	4.71	3.76	3.70	3.70	3.20	3.00	4.16	49.84
	Trenton	Gibson	42	4.38	5.44	4.06	4.81	4.74	4.02	3.90	3.15	3.53	2.98	2.90	4.35	48.26
	Milan	Gibson	39	4.11	5.51	4.17	4.20	4.98	4.52	4.11	3.76	3.75	2.83	2.75	4.25	48.74
	Cedar Hill	Robert.	23	4.79	5.46	3.83	5.33	4.89	4.74	4.28	4.11	3.75	3.02	2.85	3.78	50.83
	Springville	Henry	19	5.09	5.38	3.65	4.58	4.90	5.14	3.28	3.78	3.77	3.50	3.06	3.92	50.05
	Dickson	Dickson	29	4.55	5.36	4.00	5.10	4.82	4.48	3.92	3.97	3.77	2.58	2.54	3.80	48.89
	Wildersville	Anderson	23	5.13	5.50	3.61	4.62	4.65	4.87	3.76	3.91	4.55	2.95	2.87	3.66	50.08
	Worsham	Sumner	19	4.99	5.08	3.72	4.98	4.58	4.50	4.00	4.23	3.98	3.11	3.06	3.35	49.58
	Center Point	Chester	16	5.55	3.48	3.80	3.95	4.38	3.92	3.96	3.08	2.99	2.75	2.50	3.65	44.01
	Perryville	Decatur	25	5.03	5.32	3.85	5.98	4.85	4.14	4.21	3.98	3.53	2.78	3.04	4.06	50.77
	Savannah	Hardin	38	5.08	5.04	5.55	5.44	4.74	4.30	4.43	4.47	3.49	3.15	2.46	3.73	50.98
	Pinewood	Hickman	15	5.20	6.10	3.43	4.29	5.32	4.66	3.93	3.48	4.12	2.66	2.87	3.35	49.41
	Johnsonville	Humphreys	38	4.36	4.96	4.04	4.62	4.81	4.22	4.02	4.23	3.94	3.27	2.64	4.06	49.17
	Average		32	4.89	5.21	3.82	4.84	4.86	4.34	3.93	3.75	3.64	2.89	2.80	3.94	48.71
Type II																
	Iron City	Lawrence	22	5.81	5.04	4.95	6.40	4.96	4.30	4.38	4.41	4.36	3.61	2.47	3.27	53.96
	Munnely	Hickman	19	4.46	4.35	4.07	6.26	4.37	3.86	4.22	3.60	4.04	3.37	1.92	3.85	48.37
	Nashville	Davidson	58	3.82	4.84	4.18	5.00	4.43	3.92	4.26	4.06	3.64	3.62	2.58	3.58	47.93
	Greeneville	Greene	36	2.98	3.65	4.01	5.01	3.48	3.89	4.72	4.65	4.65	2.26	2.60	2.36	44.17
	Franklin	William.	33	4.72	4.87	4.12	5.41	4.99	3.98	4.21	3.83	3.49	3.19	2.60	3.56	49.03
	Ashwood	Maury	48	4.11	5.09	4.39	5.30	4.72	4.01	4.03	4.41	4.03	3.41	2.75	3.63	49.88
	Dandridge	Jefferson	16	4.37	4.03	3.54	4.68	3.74	3.88	4.58	4.73	4.30	2.59	3.16	2.24	45.81
	Newport	Cocke	31	3.56	3.59	3.93	5.06	3.59	4.20	4.20	4.60	4.13	2.49	2.24	2.55	44.14
	Florence	Ruther.	39	4.14	4.84	4.33	5.32	4.29	4.05	4.05	4.42	3.82	3.31	2.65	4.48	48.70
	Carthage	Smith	36	4.08	4.73	4.28	5.27	4.32	3.89	4.54	4.50	4.38	3.08	2.83	3.66	49.57
	Lebanon	Wilson	15	4.30	5.30	3.24	4.69	4.94	4.80	6.11	4.82	4.87	2.97	3.68	3.66	52.38
	Lafayette	Macon	12	3.94	5.08	3.17	6.46	4.16	3.67	4.25	4.07	3.75	4.36	2.64	3.95	49.47
	Knoxville	Knox	55	4.21	4.79	4.57	5.18	4.48	3.77	4.40	4.33	4.07	2.84	2.61	3.22	48.47
	Average		32	4.19	4.63	4.06	5.39	4.34	4.01	4.36	4.34	4.11	3.16	2.67	3.31	48.61
Type III																
	Byrdstown	Pickett	29	4.35	4.96	4.15	5.42	4.57	4.25	4.65	5.49	4.39	3.26	3.10	3.79	52.36
	Celina	Clay	18	4.66	5.35	3.73	5.14	4.31	4.68	4.58	4.96	4.51	3.75	3.71	3.64	52.72
	Yukon	Lincoln	25	5.42	5.27	4.72	6.27	4.64	4.29	4.06	4.82	4.25	3.30	3.00	3.65	53.69
	New River	Scott	13	4.56	6.03	3.93	5.33	5.05	4.22	4.97	5.10	5.39	2.94	3.04	2.36	52.94
	Clinton	Anderson	37	4.67	5.07	5.10	5.75	4.43	3.54	4.86	5.59	4.59	2.80	2.65	3.07	52.11
	Oak Hill	Overton	7	4.27	5.26	6.45	7.72	5.97	3.57	5.82	5.83	4.48	3.14	3.44	4.82	60.77
	Loudon	Loudon	31	4.56	4.94	4.75	5.10	4.52	3.94	4.46	5.18	4.00	3.42	2.88	3.01	50.76
	Decatur	Meigs	26	5.65	4.73	3.02	6.30	5.03	4.06	5.01	5.48	4.80	3.30	3.37	3.22	55.99
	Chattanooga	Hamilton	42	4.86	5.28	4.93	5.83	4.78	3.79	4.17	4.25	4.05	3.25	2.92	3.16	51.27
	Charleston	Bradley	37	4.81	4.98	5.13	5.86	4.57	4.25	5.54	5.13	4.27	3.32	3.11	3.04	54.01
	Maryville	Blount	22	4.91	4.46	4.78	5.65	4.27	3.78	5.01	5.04	4.08	3.08	2.47	3.23	50.77
	Lookout Mt.	Hamilton	12	5.02	5.41	4.86	5.07	3.87	4.03	4.28	6.26	5.05	3.67	3.90	3.04	54.46
	Halls Hill	Ruther.	18	4.48	4.92	3.87	5.15	4.54	4.11	5.26	5.22	4.32	3.22	3.30	3.17	51.56
	Waynesboro	Wayne	37	4.92	4.90	4.30	5.70	4.86	4.11	4.39	4.66	4.26	3.11	2.55	3.57	51.33
	Hoehemald	Lewis	38	5.44	5.38	4.77	6.19	5.08	4.45	4.42	4.42	4.24	3.85	2.64	4.02	54.64
	Lynnville	Giles	35	4.80	5.01	4.99	5.79	4.73	4.42	4.58	5.54	4.17	3.64	2.95	3.33	53.95
	Lewisburg	Marshall	27	4.74	5.13	4.47	5.95	4.52	4.03	4.18	4.86	4.71	3.44	3.14	3.16	52.36
	Palmetto	Bedford	31	4.75	5.18	4.28	5.56	4.59	4.31	4.29	5.36	5.76	3.39	2.98	3.01	51.44
	Tullahoma	Coffee	34	5.41	5.46	4.49	6.07	4.81	3.86	4.26	5.19	4.19	3.27	2.97	3.42	53.40
	Liberty	DeKalb	22	4.00	5.42	4.36	5.91	4.36	3.89	4.66	5.19	4.50	3.04	3.28	3.55	52.16
	McMinnville	Warren	44	4.63	5.10	3.94	5.66	5.00	3.74	4.60	5.25	4.01	3.30	2.90	3.42	51.55
	Tracy City	Grundy	13	6.18	4.53	5.09	5.82	5.05	3.72	4.56	4.98	5.06	3.32	3.22	3.50	55.03
	Cookeville	Putnam	7	4.86	7.72	2.43	4.84	4.80	4.91	5.04	5.31	5.64	3.46	5.45	3.72	59.18
	Tazewell	Claiborne	25	4.66	4.64	4.16	5.47	4.29	4.03	4.43	4.49	5.31	3.20	3.00	2.83	50.51
	Sparta	White	15	4.69	4.98	3.15	4.84	4.16	4.10	5.03	6.07	4.21	3.95	2.97	2.90	51.06
	Walling	White	17	4.68	5.17	3.71	5.64	4.42	4.46	5.32	5.90	4.32	4.16	3.30	2.88	53.96
	Grace	White	9	4.71	4.97	4.73	6.61	4.60	4.21	6.75	5.67	6.23	2.75	2.64	4.19	58.06
	Sewanee	Franklin	28	4.73	5.17	4.69	5.85	4.68	4.16	5.03	5.46	5.00	3.08	3.28	3.49	54.62
	Erasmns	Cumber.	23	5.38	5.85	4.60	6.72	5.55	4.37	5.55	6.07	5.00	3.73	3.46	3.48	59.76
	Crossville	Cumber.	9	5.02	7.10	3.46	6.57	4.72	4.05	5.13	5.36	5.59	3.67	3.91	2.83	57.41
	Dunlap	Sequatchie	15	5.69	5.34	4.75	5.03	4.95	3.44	5.10	5.94	4.85	4.21	3.26	3.25	55.81
	Rugby	Morgan	35	4.64	5.53	4.80	6.12	4.93	4.21	4.90	5.52	4.83	3.48	2.98	3.43	55.37
	Benton	Polk	33	4.49	4.76	4.84	5.67	4.19	4.09	5.45	4.75	3.90	3.06	2.59	2.93	50.59
	Copper Hill	Polk	7	6.01	7.23	6.44	6.78	4.91	2.88	4.77	5.93	5.64	2.68	3.91	2.36	57.54

Table 4 (Continued)
 Mean Precipitation by Months and by Types (1) Through 1920.
 (Precipitation figures in inches)

Type III Station	County	Length of Period in Years	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Annual
Tellico Plains	Monroe	14	4.60	3.72	4.86	6.41	4.38	3.49	5.52	5.94	5.02	3.11	2.52	3.59	53.16
Harriman	Roane	21	4.69	4.20	4.74	5.72	4.91	3.70	4.32	5.95	3.62	3.03	2.78	3.51	51.17
Kingston	Roane	37	4.42	4.89	4.94	5.59	4.51	3.73	4.49	5.09	3.90	3.38	2.92	2.95	50.81
Average		24	4.37	5.24	4.52	5.81	4.69	4.02	4.86	5.34	4.59	3.32	3.15	3.31	53.74
Type IV															
Bluff City	Sullivan	26	3.34	3.34	3.38	4.72	3.28	3.59	4.29	5.21	4.49	3.00	2.53	2.26	43.43
Bristol	Sullivan	15	3.27	2.79	3.39	4.57	3.06	4.31	5.69	4.19	2.28	2.00	2.72	2.72	41.06
Elizabethton	Carter	30	3.18	3.38	3.22	4.37	3.39	4.03	5.45	4.75	4.42	2.86	2.38	2.01	43.43
Mountain City	Johnson	24	3.60	3.74	3.44	4.51	3.64	4.03	4.76	5.82	5.21	3.13	2.71	2.21	46.80
Springdale	Claiborne	24	3.97	4.00	4.93	4.83	4.08	3.76	4.15	5.42	4.53	2.78	2.46	3.37	48.31
Rogersville	Hawkins	38	3.69	3.97	4.14	4.93	3.65	3.74	3.91	3.91	4.18	2.71	2.60	2.63	45.06
Sevierville	Sevier	15	4.31	4.07	3.69	4.92	3.75	4.25	5.13	5.11	4.77	2.92	2.96	2.50	48.38
Jefferson City	Jefferson	11	4.28	4.57	3.63	4.45	4.04	3.66	3.77	5.72	4.71	2.29	3.21	2.19	46.52
Birds Bridge	Greene	10	3.79	3.01	2.96	4.20	3.91	3.92	4.26	5.42	4.17	3.16	2.41	2.04	43.25
McGhee	Monroe	16	4.83	4.31	4.16	4.98	4.16	3.76	4.40	5.29	4.18	3.07	3.27	2.77	49.18
Johnson City	Wash.	30	3.38	3.25	3.42	4.99	3.53	3.84	4.40	4.72	4.48	2.65	2.48	2.70	43.84
Average		22	3.78	3.67	3.67	4.68	3.66	3.73	4.44	5.28	4.48	2.80	2.64	2.49	45.39

(1) See Chapter I, Section on precipitation.

Source: Summaries of Climatological sections by Sections, Reprints 77 and 78, U. S. Weather Bureau.

Table 5

Average Length of Growing Season in Days, Per Year, By Weather Stations
in Tennessee, Through 1920 (1)

Station	County	Average Number of Days	Elev- ation (feet)	Num- ber Yrs. Record	Station	County	Average Number of Days	Elev- ation (feet)	Num- ber Yrs. Record
1 Memphis	Shelby	226	409	49	Johnson City	Washington	194	1717	10
2 Cheatham	Hamilton	217	762	42	Maryville	Blount	193	1150	14
3 Covington	Tipton	210	311	21	Tellico Plains	Monroe	192	900	12
4 Brownsville	Haywood	209	361	18	Harriman	Roane	192	841	17
5 Dyersburg	Dyer	209	310	19	Benton	Polk	191	880	17
6 Nashville	David.	208	654	50	Decatur	Meigs	191	850	25
7 Knoxville	Knox	208	996	50	Byrdstown	Pickett	191	1026	25
8 Copper Hill	Polk	207	1600	7	Dickson	Dickson	191	825	19
9 Bolivar	Hard.	203	450	24	McMinnville	Warren	191	1038	22
10 Savannah	Hardin	203	442	24	Oak Hill	Overton	191	1000	6
11 Milan	Gibson	201	448	19	Palmetto	Bedford	191	770	25
12 Barthege	Smith	201	500	20	Liberty	DeKalb	190	672	7
13 Florence	Ruther.	201	560	27	Sparta	White	190	920	14
14 Franklin	William.	201	730	27	Anderson	Anderson	189	1167	13
15 Jackson	Madison	201	440	26	Tullahoma	Coffee	189	1075	27
16 Hildersville	Hender.	201	500	17	Waynesboro	Wayne	188	753	25
17 Tukon	Lincoln	200	850	21	Rogersville	Hawkins	187	1150	27
18 Clarksville	Montg.	200	500	28	Dover	Stewart	187	500	19
19 Sevierville	Sevier	200	900	15	Perryville	Decatur	187	577	23
20 Trenton	Gibson	199	345	26	Jonesboro	Washington	186	1740	12
21 Dunlap	Sequat.	199	746	7	Iron City	Lawrence	186	600	16
22 Loudon	Loudon	198	816	7	Greeneville	Greene	185	1581	14
23 Cedar Hill	Roberts.	198	625	16	Munnely	Hickman	185	620	6
24 Kenton	Obion	198	325	17	Hohenwald	Lewis	185	983	27
25 Lebanon	Wilson	198	522	11	Lafayette	Macon	184	1000	9
26 Lynnville	Giles	198	744	25	Elizabethton	Carter	181	1575	15
27 Sevanee	Frank.	198	1850	20	Bristol	Sullivan	181	1675	15
28 Union City	Obion	198	360	19	Crossville	Cumberland	180	1850	9
29 New Port	Cocke	196	1100	26	Tracy City	Grundy	180	1900	9
30 Johnsonville	Humph.	195	364	25	Springdale	Claiborne	179	1058	15
31 Lewisburg	Marsh.	195	195	22	Tazewell	Claiborne	175	1350	9
32 Arlington	Shelby	194	273	11	Rugby	Morgan	173	1410	28
33 Ashwood	Maury	194	725	28	Pinewood	Hickman	172	520	9
34 Cookeville	Putnam	194	1117	6	Erasmus	Cumber,	170	1695	22
35 Springville	Henry	194	377	18	Mountain City	Johnson	167	2486	21

(1) The growing season is considered here as the period between the last killing frost in Spring and first killing frost in fall.

Source: Climatological Data by Sections, Summaries, Reprints 77 and 78.

Table 6

Number and Percentage of Years that Last Killing Frosts in the Spring Have Occurred,
by Weekly Periods and by Weather Stations in Tennessee through 1920.

Station (1)	County	Length of Period Years	February				March				April				May			
			15-	20	22-	1-	8-	14	15-	22-	5-	12-	19-	26-	3-	10-	17-	
			%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
Mountain City	Johnson	22										18.2	36.4	13.6	13.6	18.2		
Greeneville	Greene	14								7.1	21.4	35.7	28.6			7.1		
Elizabethton	Carter	15								6.7	20.0	26.7	20.0	6.7	6.7	13.3		
Bristol	Sullivan	16								6.2	18.8	25.0	31.2	6.2		12.5		
Johnson City	Washington	19								10.5	26.3	15.8	31.6	15.8				
Rogersville	Hawkins	37								13.5	16.2	21.6	27.0	13.5	2.7	5.4		
Springdale	Claiborne	18								11.1	5.6	33.3	33.3	5.6	5.6	5.6		
Tazewell	Claiborne	14									21.4	14.3	7.1	28.6	7.1	21.4		
Andersonville	Anderson	13									30.8	30.8	30.8					
Crossville	Cumberland	18							11.1	5.6	16.7	11.1	11.1	33.3	11.1	13.6	4.5	
Erasmus	Cumberland	22							7.1	4.5	18.2	31.8	9.1	13.6	4.5	7.1		
Sparta	White	14								21.4	14.3	21.4	7.1	21.4		7.1		
Rugby	Morgan	42								4.8	11.9	9.5	28.6	19.0	19.0	7.1		
Munnelly	Hickman	9							11.1	11.1	44.4	22.2		11.1				
Pinewood	Hickman	16								6.2	25.0	6.2	25.0	18.8		18.8		
Jonesboro	Washington	15								13.3	6.7	33.3	26.7	6.7	6.7			
Hohanwald	Lewis	38							2.6	26.3	18.4	18.4	18.4	7.9		5.3		
Benton	Polk	17							5.9	17.6	35.3	17.6	11.8	5.9		5.9		
Copper Hill	Polk	17							17.6	29.4	17.6	17.6	5.9	5.9				
Tellico Plains	Monroe	12								16.7	16.7	50.0	16.7					
Maryville	Blount	14								14.3	28.6	21.4	35.7					
Newport	Cocke	22							9.1	22.7	22.7	18.2	13.6	13.6		5.9		
Harriman	Roane	17								17.6	17.6	17.6	29.4	11.8		5.9		
Decatur	Meigs	34							5.9	17.6	17.6	17.6	20.6	8.8		8.8		

Table 6 (continued)

Number and Percentage of Years that Last Killing Frosts in the Spring Have Occurred,
by Weekly Periods and by Weather Stations in Tennessee, through 1920.

Station (1)	County	Length of Period Years	February		March				April				May			
			15- 20 %	22- 29 %	1- 7 %	8- 14 %	15- 21 %	22- 28 %	29- 4 %	5- 11 %	12- 18 %	19- 25 %	26- 2 %	3- 9 %	10- 16 %	17- 23 %
Ashwood	Maury	38				7.9	5.3	26.3	23.7	15.8	18.4	2.6				
Burdstown	Pickett	25				4.0	4.0	24.0	16.0	16.0	24.0	12.0				
Carthage	Smith	29					3.4	3.4	27.6	31.0	17.2	13.8	3.4			
Cookeville	Putnam	16					6.2		25.0	6.2	37.5	25.0				
Dickson	Dickson	30					6.7		26.7	10.0	30.0	20.0	6.7			
Dover	Stewart	30					3.3	6.7	20.0	16.7	20.0	13.3				
Dunlap	Sequatchie	9						22.2	22.2	44.4		11.1				
Iron City	Lawrence	16							18.8	12.5	25.0	22.5	25.0	6.2		
Lafayette	Macon	10							10.0	30.0	30.0	30.0	10.0			
Liberty	DeKalb	8							12.5	37.5	50.0			3.7		
McMinnville	Warren	27					3.7	3.7	18.5	14.8	22.2	22.2	11.1			
Oak Hill	Overton	7							14.3	14.3	57.1	14.3				
Palmetto	Bedford	35					2.8	8.6	22.8	25.1	22.8	11.4	5.7			
Perryville	Decatur	33			3.0		6.1	6.1	15.2	24.2	24.2	6.1	9.1	3.0		
Springville	Henry	20					5.0	10.0	20.0	20.0	25.0	10.0	10.0			
Tracy City	Grundy	11					2.7	10.8	18.9	13.5	27.3	27.3	9.1	5.4		
Tullahoma	Coffee	37					2.8		22.8	17.1	22.8	17.1	11.4	2.8		
Waynesboro	Wayne	35						20.0	20.0	40.0	20.0					
Lookout Mtn.	Hamilton	5														
Johnsonville	Humphreys	35					5.7	8.5	25.6	17.1	28.5	8.5	5.7			
Lewisburg	Marshall	33					6.1	3.0	24.2	24.2	15.2	21.2	6.1			
Knoxville	Knox	59			3.4	1.7	11.9	18.6	18.6	27.1	8.5	8.5	1.7			
Loudon	Loudon	17					5.9	5.9	5.9	5.9	35.3	23.5	11.8	5.9		
Sevierville	Sevier	25					8.0	4.0	28.0	16.0	20.0	8.0	12.0	4.0		
Cedar Hill	Robertson	27					3.7	7.4	33.3	25.9	11.1	14.8	3.7			
Clarksville	Montgomery	38			2.6		13.2	13.2	21.0	23.7	21.0	4.5	5.3			
Dyersburg	Dyer	22			4.5		13.6	27.3	18.2	13.6	13.6	4.5	4.5			
Florence	Rutherford	38					5.3	15.8	23.7	26.3	15.8	10.5	2.6			
Franklin	Williamson	29			3.4		13.8	10.3	17.2	10.3	24.1	13.8	3.4	3.4		
Jackson	Madison	37		2.7	2.7		16.2	13.5	18.9	16.2	21.6		8.1			
Kenton	Obion	28			3.6		14.3	10.7	25.0	17.8	21.4	3.6	3.6			

Table 6 (continued)

Number and Percentage of Years that Last Killing Frosts in the Spring Have Occurred, by Weekly Periods and by Weather Stations in Tennessee, through 1920.

Station (1)	County	Length of Period Years	February				March				April				May		
			15-20 %	22-29 %	1-7 %	8-14 %	15-21 %	22-28 %	29-4 %	5-11 %	12-18 %	19-25 %	26-2 %	3-9 %	10-16 %	17-23 %	
Lebanon	Wilson	13						7.7	30.8	7.7	30.8	15.4	7.7				
Lynnville	Giles	37					2.7	8.1	29.7	32.4	16.2	8.1	2.7				
Milan	Gibson	31					12.9	12.9	19.4	16.1	29.0	6.4	3.2				
Nashville	Davidson	60					16.7	20.0	26.7	21.7	8.3	3.3					
Savannah	Hardin	37					8.1	10.8	24.3	24.3	16.2	2.7	5.4				
Sewanee	Franklin	31					3.2	6.4	12.9	19.4	25.8	16.1	12.9				
Trenton	Gibson	26					11.5	19.2	19.2	15.4	19.2	3.8	7.7				
Union City	Obion	30					6.7	13.3	20.0	23.3	20.0	10.0	3.3				
Wildersville	Henderson	18					11.1	11.1	22.2	22.2	11.1	5.6	16.7				
Yukon	Lincoln	23					8.7	13.0	21.7	34.8	17.4	4.3					
Covington	Tipton	30					20.0	16.7	30.0	13.3	13.3						
Arlington	Shelby	11						9.1	18.2	18.2	36.4	9.1	9.1				
Brownsville	Haywood	30					10.0	16.7	26.7	20.0	10.0						
Bolivar	Hardeman	30					10.0	16.7	23.3	16.7	23.3	3.3	6.7				
Chattanooga	Hamilton	52					19.2	19.2	17.3	13.5	5.8	3.8					
Memphis	Shelby	59	1.7	10.2	11.9	6.8	23.7	11.9	20.3	8.5	3.4	1.7					

(1) The stations are arranged in the approximate order of their rank in mean annual temperature--lowest to highest.

Source: Calculated from Climatological Data by Sections, Reprints, 77 and 78, op. cit.

Table 7.

Number and Per Cent of Years that First Killing Frosts Have Occurred, by Weekly Periods
and by Weather Stations in Tennessee Through 1920.

Station	County	Length of Period Years	September					October					November				Dec.	
			1-7	8-14	15-21	22-28	29-5	6-12	13-19	20-26	27-2	3-9	10-16	17-23	24-30	1-6		
			%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
Mountain City	Johnson	23	0	0	0	8.7	34.8	38.7	30.4	8.7	4.3	4.3	0	0	0	0	0	0
Greeneville	Greene	15	0	0	0	0	13.3	6.7	26.7	33.3	13.3	6.7	0	0	0	0	0	0
Elizabethton	Carter	15	0	0	0	0	20.0	6.7	33.3	20.0	13.3	6.7	0	0	0	0	0	0
Bristol	Sullivan	15	0	0	0	0	13.3	6.7	53.3	6.7	13.3	6.7	0	0	0	0	0	0
Johnson City	Willi.	20	0	0	0	5.0	5.0	15.0	5.0	30.0	20.0	10.0	10.0	0	0	0	0	0
Rogersville	Hawkins	39	0	0	0	2.6	7.7	12.8	28.2	20.5	17.9	7.7	2.6	0	0	0	0	0
Springdale	Claiborne	17	0	0	0	0	23.5	11.8	17.6	23.5	17.6	5.9	0	0	0	0	0	0
Tazewell	Claiborne	16	0	0	0	0	25.0	25.0	6.2	18.8	18.8	6.2	0	0	0	0	0	0
Andersonville	Anderson	15	0	0	0	0	13.3	13.3	26.7	13.3	13.3	20.0	0	0	0	0	0	0
Crossville	Cumberland	18	0	0	0	16.7	27.8	16.7	5.5	22.2	5.5	5.5	0	0	0	0	0	0
Erasmus	Cumber.	22	0	0	4.5	13.6	18.1	18.1	18.1	18.1	4.5	4.5	0	0	0	0	0	0
Sparta	White	15	0	0	0	0	0	20.0	13.3	26.7	33.3	0	6.7	0	0	0	0	0
Rugby	Morgan	38	0	0	2.6	13.2	15.8	23.7	15.8	15.8	7.9	5.2	0	0	0	0	0	0
Munnelly	Hickman	16	0	0	0	0	18.8	6.2	37.5	18.8	12.5	6.2	0	0	0	0	0	0
Pinewood	Hickman	14	0	0	7.1	0	28.6	14.3	14.3	14.3	14.3	0	7.1	0	0	0	0	0
Jonesboro	Wash.	13	0	0	0	0	15.4	7.7	38.5	7.7	7.7	15.4	7.7	0	0	0	0	0
Hohenwald	Lewis	39	0	0	5.1	5.1	2.6	17.9	15.4	30.8	10.2	15.4	2.6	0	0	0	0	0
Benton	Polk	19	0	0	0	0	5.3	10.5	31.6	21.0	21.0	10.5	0	0	0	0	0	0
Copper Hill	Polk	17	0	0	0	0	5.9	5.9	23.5	23.5	23.5	5.9	11.8	0	0	0	0	0
Tellico Plains	Monroe	13	0	0	0	0	7.7	7.7	23.1	23.1	15.4	23.1	0	0	0	0	0	0
Maryville	Blount	15	0	0	0	0	0	6.7	26.7	20.0	20.0	26.7	0	0	0	0	0	0
Newport	Cocke	37	0	0	2.7	2.7	2.7	13.5	10.8	32.4	21.6	10.8	2.7	0	2.7	0	0	0
Harriman	Roane	17	0	0	0	0	0	5.9	23.5	29.4	17.6	11.8	5.9	0	5.9	0	0	0
Decatur	Meigs	35	0	0	0	0	2.8	14.3	20.0	31.4	20.0	8.6	2.8	0	0	0	0	0
Ashwood	Maury	38	0	0	0	0	13.2	15.8	18.4	26.3	7.9	15.8	2.6	0	0	0	0	0
Byrdstown	Pickett	27	0	0	0	0	7.4	11.1	18.5	29.6	25.9	7.4	0	0	0	0	0	0
Carthage	Smith	31	0	0	3.2	0	0	6.4	9.7	25.8	32.2	19.4	3.2	0	0	0	0	0
Cockeville	Putnam	16	0	0	0	0	6.2	12.5	12.5	18.8	12.5	25.0	12.5	0	0	0	0	0

Table 7 (continued)
 Number and Per Cent of Years that First Killing Frosts Have Occurred, by Weekly Periods
 and by Weather Stations in Tennessee Through 1920.

Station	County	Length of Period Years	September				October				November				Dec.	
			1- 7 %	8- 14 %	15- 21 %	22- 28 %	29- 5 %	6- 12 %	13- 19 %	20- 26 %	27- 2 %	3- 9 %	10- 16 %	17- 23 %	24- 30 %	1- 6 %
Dickson	Dickson	30	0	0	0	0	6.6	13.3	13.3	30.0	16.7	16.7	3.3	0	0	
Dover	Stewart	31	0	0	0	6.4	6.4	16.1	12.9	32.2	12.9	9.7	3.2	0	0	
Dunlap	Sequat.	8	0	0	0	0	0	25.0	12.5	25.0	25.0	12.5	0	0	0	
Iron City	Lawrence	16	0	0	0	0	0	18.8	25.0	31.2	12.5	12.5	0	0	0	
Lafayette	Macon	10	0	0	0	0	10.0	20.0	30.0	30.0	0	10.0	0	0	0	
Liberty	DeKalb	8	0	0	0	0	12.5	0	37.5	25.0	25.0	0	0	0	0	
McMinnville	Warren	36	0	0	0	0	2.8	11.1	22.2	30.6	11.1	13.9	8.3	0	0	
Oak Hill	Overton	6	0	0	0	0	16.7	0	33.3	16.7	16.7	16.7	0	0	0	
Palmetto	Bedford	34	0	0	0	0	5.9	11.8	17.6	17.6	17.6	23.5	2.9	0	0	
Perryville	Decatur	34	0	0	0	2.9	5.9	11.8	26.5	29.4	14.7	2.9	5.9	0	0	
Springville	Henry	20	0	0	0	0	0	20.0	20.0	30.0	25.0	0	5.0	0	0	
Tracy City	Grundy	10	0	0	0	0	10.0	20.0	30.0	20.0	10.0	10.0	0	0	0	
Tullahoma	Coffee	37	0	0	0	2.7	8.1	10.8	27.0	21.6	10.8	16.2	2.7	0	0	
Waynesboro	Wayne	38	0	0	0	2.6	5.3	10.5	26.3	34.2	13.2	5.3	2.6	0	0	
Lookout Mtn.	Hamilton	4	0	0	0	0	0	0	0	50.0	25.0	0	0	25.0	0	
Johnsonville	Humph.	35	0	0	0	2.8	5.7	8.6	14.3	31.4	20.0	14.3	2.8	0	0	
Lewisburg	Marsh.	32	0	0	0	0	6.2	12.5	12.5	37.5	9.4	18.8	3.1	0	0	
Knoxville	Knox	60	0	0	0	0	1.7	5.0	18.3	16.7	21.7	18.3	10.0	3.3	0	
Loudon	Loudon	16	0	0	0	6.2	0	6.2	12.5	37.5	12.5	12.5	12.5	0	0	
Sevierville	Sevier	24	0	0	0	0	0	12.5	20.8	29.2	16.7	20.8	0	0	0	
Cedar Hill	Robert.	26	0	0	0	0	0	15.4	7.7	34.6	23.1	15.4	3.8	0	0	
Clarksville	Montg.	39	0	0	0	0	5.1	10.2	12.8	20.5	33.1	25.6	2.6	0	0	
Dyersburg	Dyer	24	0	0	0	0	0	12.5	8.3	16.7	29.2	12.5	20.8	0	0	
Florence	Ruther.	37	0	0	0	0	5.4	13.5	10.8	27.0	13.5	24.3	5.4	0	0	
Franklin	William.	38	0	0	0	0	5.3	7.9	13.2	26.3	23.7	21.0	2.6	0	0	
Jackson	Madis.	38	0	0	0	0	2.6	7.9	23.7	21.0	26.3	13.2	5.3	0	0	
Kenton	Obion	28	0	0	0	0	0	17.8	21.4	28.6	21.4	7.1	3.6	0	0	
Lebanon	Wilson	21	0	0	0	0	0	9.5	14.3	38.1	19.0	14.3	4.8	0	0	
Lynnville	Giles	38	0	0	0	2.6	7.9	15.8	13.2	26.3	18.4	13.2	2.6	0	0	
Milan	Gibson	31	0	0	0	0	0	9.7	12.9	19.4	32.2	19.4	6.4	0	0	

Table 7 (continued)

Number and Per Cent of Years that First Killing Frosts Have Occurred, by Weekly Periods
and by Weather Stations in Tennessee Through 1920.

Station	County	Length of Period Years	September					October					November					Dec.	
			1- 7	8- 14	15- 21	22- 28	29- 5	6- 12	13- 19	20- 26	27- 2	3- 9	10- 16	17- 23	24- 30	1- 6	%		
Nashville	David.	60	0	0	0	0	0	10.0	15.0	16.7	25.0	18.3	8.3	3.3	1.7	1.7			
Savannah	Hardin	35	0	0	0	0	5.7	2.8	11.4	37.1	17.1	14.3	8.6	2.8	0	0			
Sewanee	Frank.	34	0	0	0	0	2.9	8.8	5.9	26.5	14.7	23.5	11.8	2.9	2.9	0			
Trenton	Gibson	27	0	0	0	0	11.1	18.5	14.8	14.8	25.9	11.1	3.7	0	0	0			
Union City	Obion	31	0	0	0	0	0	12.9	16.1	22.6	19.4	19.4	6.4	3.2	0	0			
Wildersville	Hender.	19	0	0	0	0	0	10.5	10.5	26.3	26.3	26.3	0	0	0	0			
Yukon	Lincoln	21	0	0	0	0	0	14.3	4.8	23.8	33.3	19.0	4.8	0	0	0			
Covington	Tipton	34	0	0	0	0	0	8.8	8.8	26.5	29.4	17.6	5.9	2.9	0	0			
Arlington	Shelby	16	0	0	0	0	0	18.8	12.5	37.5	25.0	11.0	6.2	0	0	0			
Brownsville	Haywood	32	0	0	0	0	0	6.2	9.4	18.8	34.4	15.6	12.5	0	3.1	0			
Bolivar	Harde.	32	0	0	0	0	0	9.4	12.5	31.2	18.8	12.5	12.5	3.1	0	0			
Chattanooga	Hamilton	53	0	0	0	0	5.8	5.7	9.4	13.2	13.2	15.1	13.9	13.2	7.5	0			
Memphis	Shelby	59	0	0	0	0	1.7	8.5	3.4	11.9	22.0	13.6	22.0	10.2	6.6	0			

Counties are arranged in the approximate order of their rank in mean annual temperature--lowest to highest.

Source: Calculated from data from Climatological Data, by Sections, Reprint 77 and 78.

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