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STORM FREQUENCY MAPS OF THE UNITED STATES, 1883–1930

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Storm Frequency Maps of the United States, 1883-1930

By C. J. KULLMER
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The United States is unique among nations in possessing a splendid series of maps of tracks of barometric depressions. These have been published each month from 1874 to the present in the Monthly Weather Review. Nothing similar is available for any other part of the world.

For the 10-year international period from 1878-87 H. H. Dunwoody published in 1893 storm frequency maps for the whole of the Northern Hemisphere. Dunwoody divided the map of the Northern Hemisphere into squares measuring 5° on a side and recorded the number of centers of barometric depressions that crossed each square. In order to determine whether a general shift of the storm track had taken place in an interval of 21 years, I remade the maps of storm frequency in the United States for 1899-1908 according to Dunwoody's plan of 5° squares.[1] A comparison of the two periods showed a slight but definite southerly and westerly shift.

Considering the numerous observed correlations between sun spots and meteorological elements, it seemed worth while to ascertain whether or not Spoerer's latitude shift of sun spots is accompanied by a corresponding latitude shift of the vortexes in the earth's atmosphere. This latitude shift is one of the most striking features of the sun-spot cycle; each new cycle begins at about 25° solar latitude and ends at 10°, with maximum positions of about 30° and 5°.

For such a study it is evident that 5° of latitude, approximately 345 miles, is too large a unit. I have, therefore, chosen a unit area half the size of Dunwoody's, namely 5° in longitude and $2\frac{1}{2}$° in latitude. The series of year maps from 1874-1912 were made in 1913, furnishing comparison material for three solar periods; since then two more

[1] The shift of the storm track. Chap. 16 in Huntington, The climatic factor, Carnegie Inst. Publ. 192, 1914.

solar periods have become available. The year maps from 1874 to 1882 do not extend west of the 100th meridian; the series of storm frequency maps here published begins, therefore, with 1883, the first year that the entire area of the United States was covered. Furthermore, according to the Weather Bureau, the earlier maps are not statistically comparable with the later ones. A more extended network of stations began with the year 1891. Although the year maps are here published for the first time, the material for 1883-1912, assembled by months in 10-year periods, was presented at the Second Pan American Scientific Congress in 1915.[2] It is not the purpose of this paper to discuss the storm frequency of the United States; the maps, made with care according to a uniform technique, are published in order to make the material available to other investigators. How complex the factors involved must be, will be evident from a comparison of the two years 1900 and 1911, both at solar minimum; a similar pair, also separated by 11 years, 2 years after solar maximum, is 1919 and 1930.

THE LATITUDE SHIFT

With these two striking pairs in mind, it is evident that any uniform latitude shift within the 11-year solar period must be masked by other meteorological factors. The method of yearly departures from a mean map suggests itself; I have in manuscript a complete series of such departure maps, which confirm the latitude shift, but illustrate primarily the complexity of the factors involved. The most powerful method of attack seemed to be to add together three years at solar maximum and three years at solar minimum, and compare one set of figures with the other. I have done this for five solar periods:

Maximum 1882-84 versus Minimum 1877-79
Maximum 1892-94 versus Minimum 1888-90
Maximum 1905-07 versus Minimum 1900-02
Maximum 1916-18 versus Minimum 1911-13
Maximum 1927-29 versus Minimum 1922-24

and present the results in Figures 2-6.[3] This method allows for possible difference in recording the tracks of barometric depressions, since the comparisons are with periods separated by only five or six years.

[2] Monthly storm frequency in the United States. Proc. Second Pan Amer. Sci. Congr., Sec. 2, vol. 2, pp. 338-391, 1917.

[3] Preliminary publication of parts of this study appeared in: Huntington, The solar hypothesis of climatic changes. Bull. Geol. Soc. Amer., vol. 25, pp. 477-590, 1914. Huntington, Earth and sun, New Haven, Yale Univ. Press, 1923.

It also allows shifts in longitude to appear; in fact, the longitude shifts are almost as significant as the latitude shifts.

The most striking feature of the resulting maps is that all five maps present the same pattern: 1, a curved area of excess during solar maximum, with a southerly projection (I have drawn a dotted line through this area and its southerly extension); 2, south of this, and on both sides of the southerly projection, areas of deficiency during solar maximum; 3, more variable areas of excess adjacent to the areas of deficiency.

The areas of deficiency are separated from the main area of excess by about 6°-8° of latitude. But the location of the main area of excess is subject to a displacement in both longitude and latitude. In Figure 1 I have assembled the dotted lines drawn through this area of excess and its southerly projection. In the eastern extremity they follow almost a common path. After watching the eastward advance of the southerly projection in periods II, III, and IV, it came as a distinct surprise to find that in period V the whole system had gone back to a position even farther west and south than in period II, and that the large excess in Western Canada had given place to a relatively large deficiency. There seems to be an indication of a cycle of three solar periods: period I has almost the same position as period IV; the periods II, III, and IV seem to show an orderly progression. If these represent a cycle, then period V is the first of the next cycle, and, to make my meaning clear, the coming solar period should occupy the position VI, given by the dotted line.

It should be noted that the maxima are in each case compared with a *preceding* minimum; the approaching solar minimum will give an opportunity to remake these maps for five solar periods to bring out the comparison of maximum with *following* minimum, which is, of course, the true period.

SUMMARY

A latitude shift of the storm track in the United States, corresponding to Spoerer's latitude shift of sun spots, is demonstrated for five solar periods by a comparison of three year maps of storm frequency at solar maximum with three year maps at solar minimum. A uniform pattern of distribution is shown with marked variation in latitude and longitude in the five solar periods.

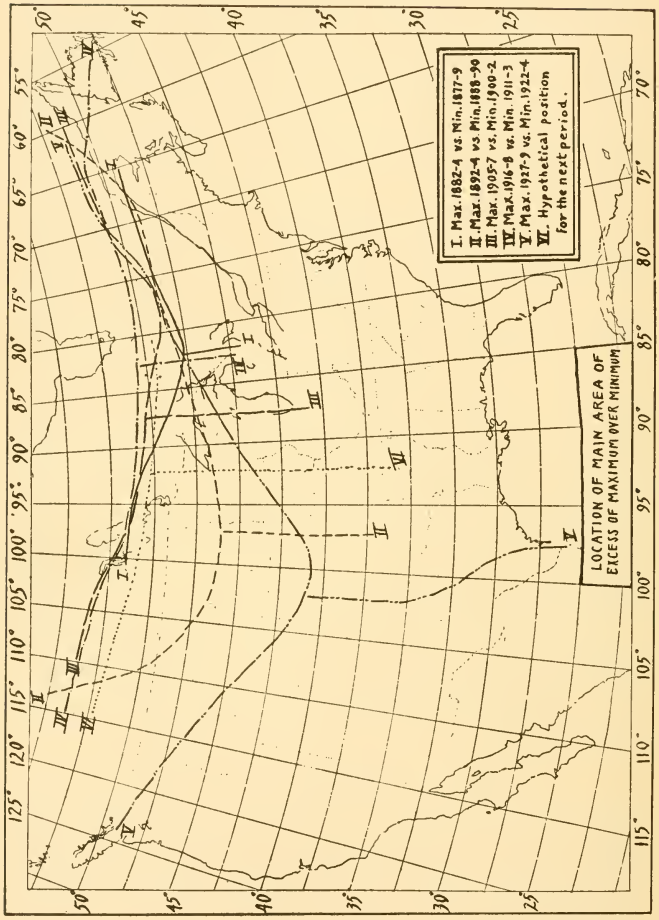

I. Max. 1882-4 vs. Min. 1877-9
II. Max. 1892-4 vs. Min. 1888-90
III. Max. 1905-7 vs. Min. 1900-2
IV. Max. 1916-8 vs. Min. 1911-3
V. Max. 1927-9 vs. Min. 1922-4
VI. Hypothetical position for the next period.
LOCATION OF MAIN AREA OF EXCESS OF MAXIMUM OVER MINIMUM

FIG. 1.

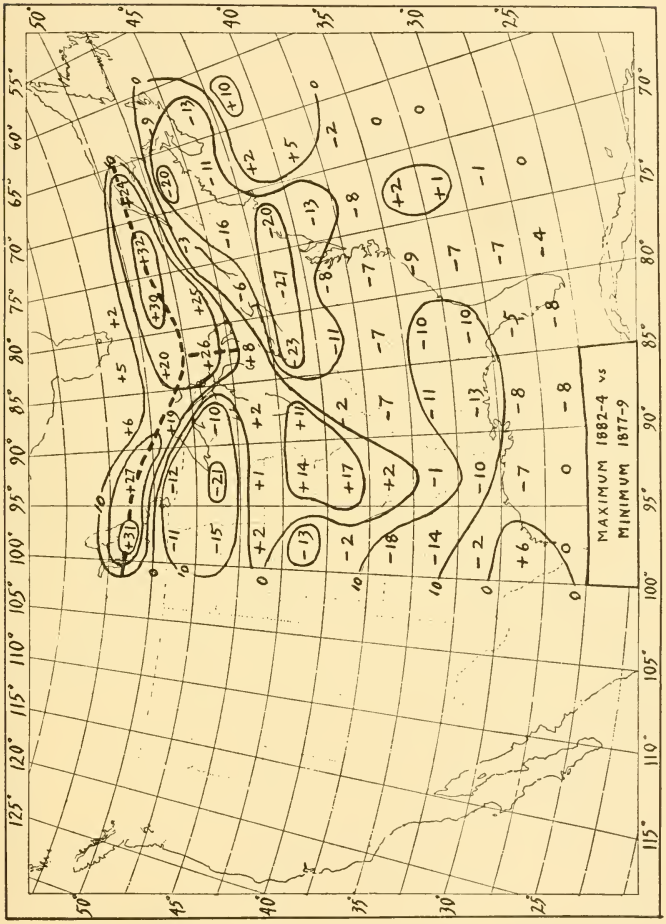


FIG. 2.

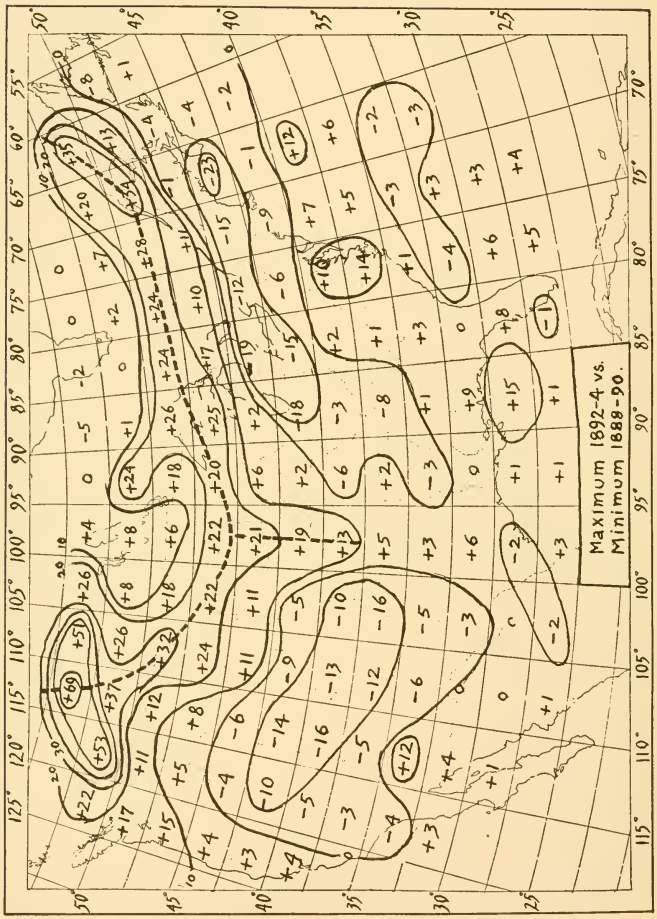


FIG. 3.

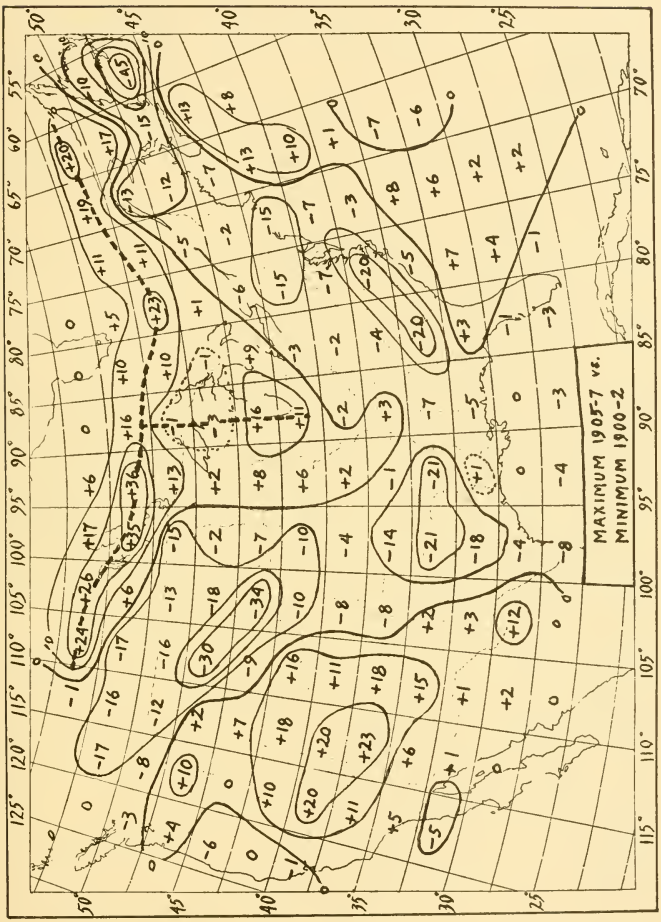


FIG. 4.

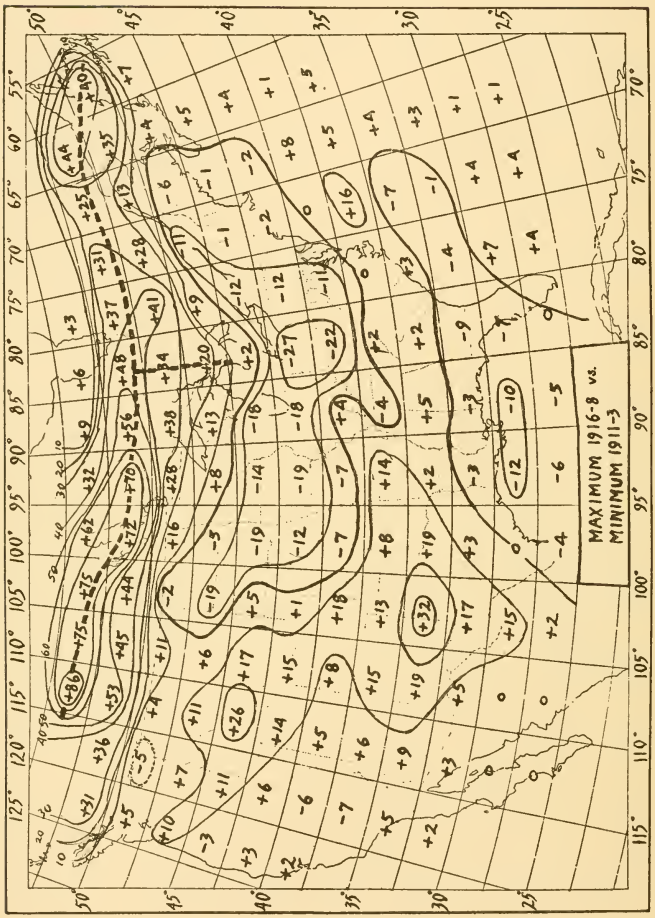


FIG. 5.

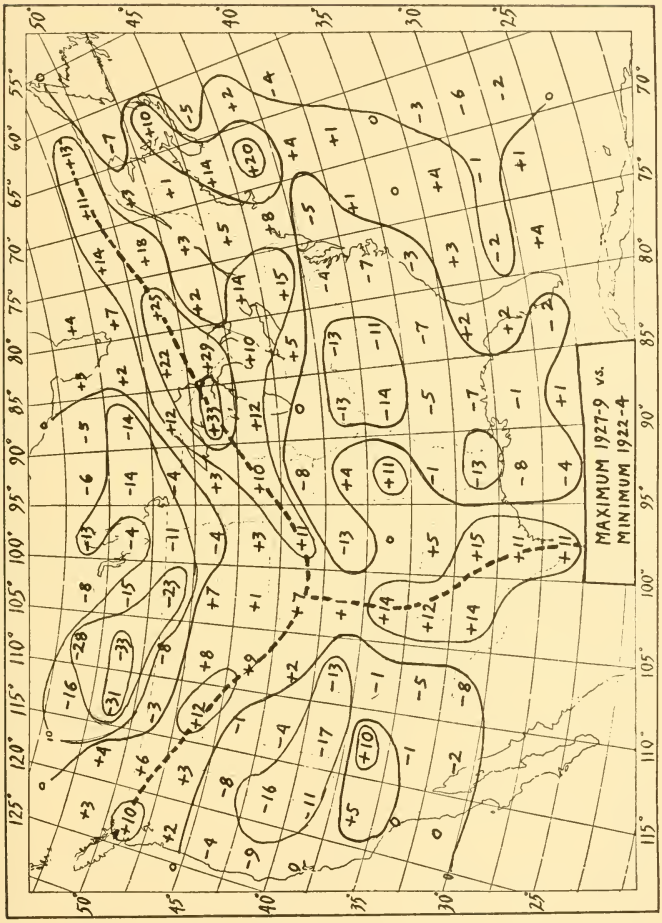
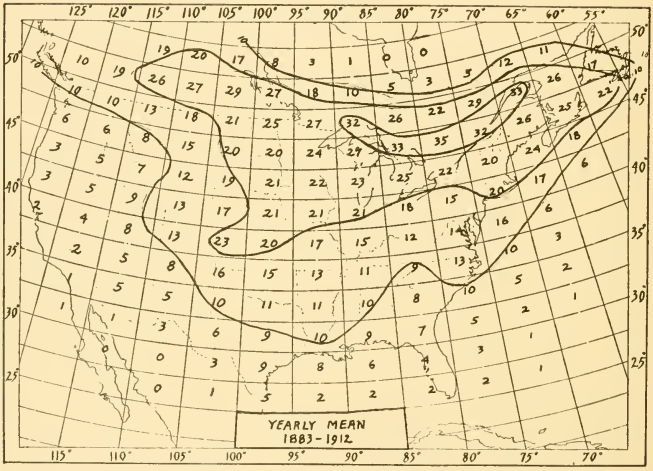
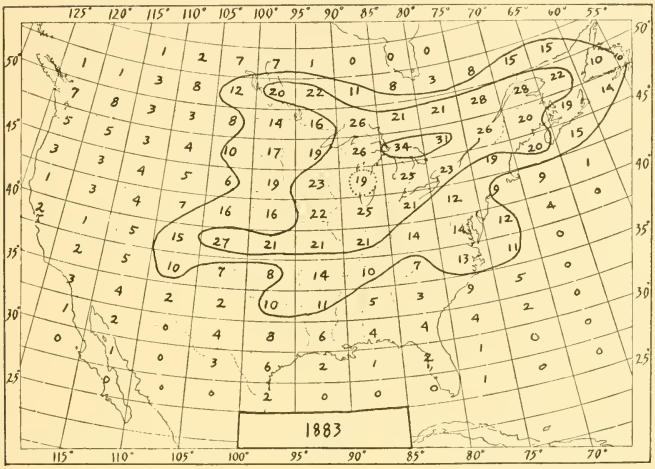


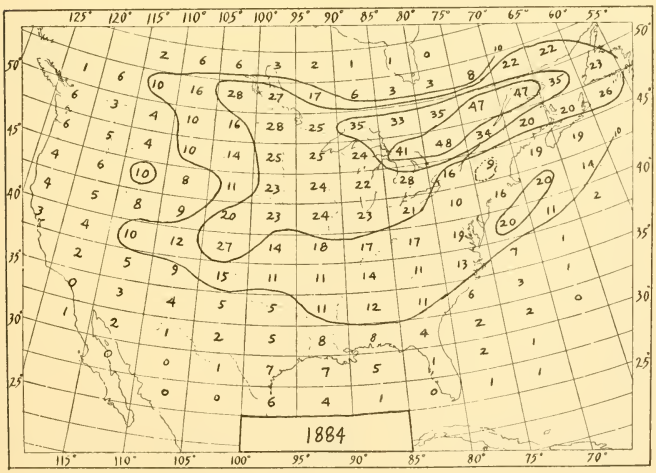
FIG. 6.

Yearly Mean 1883-1912



1883 and 1884





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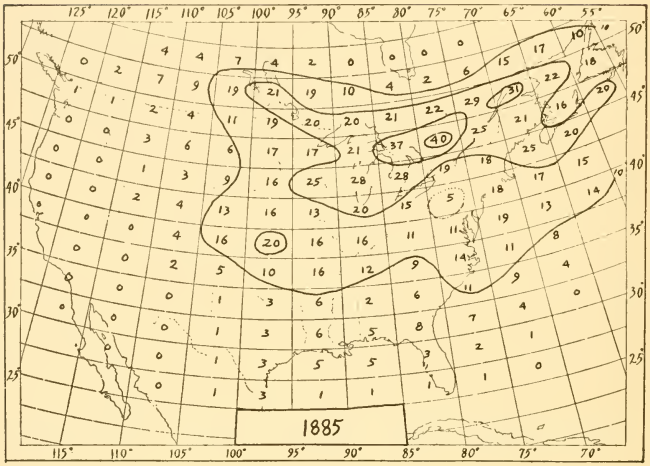
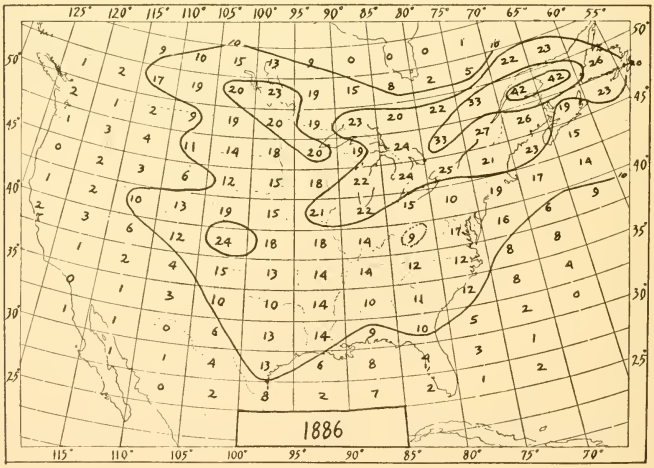
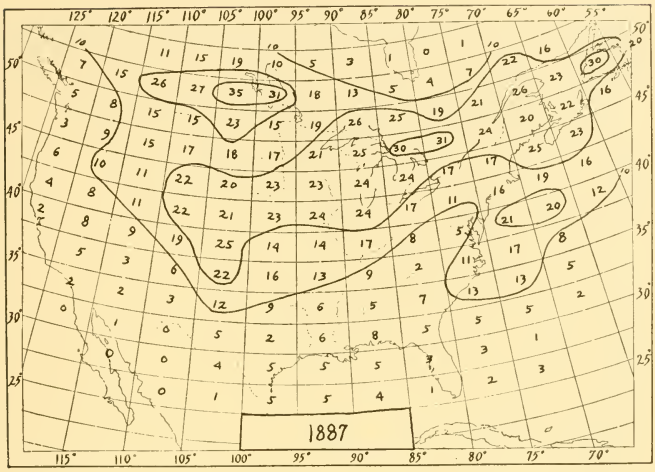
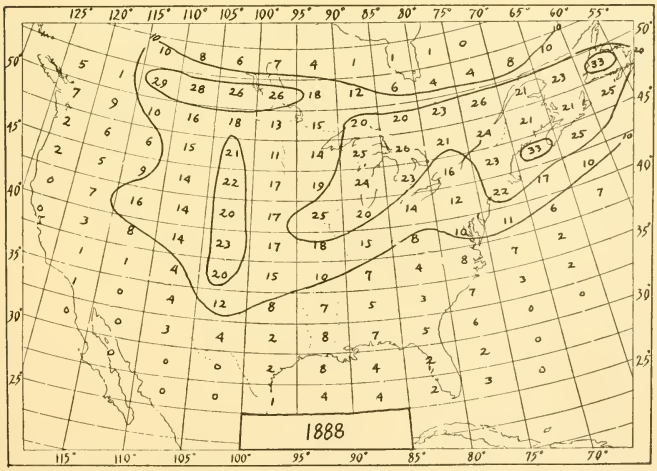


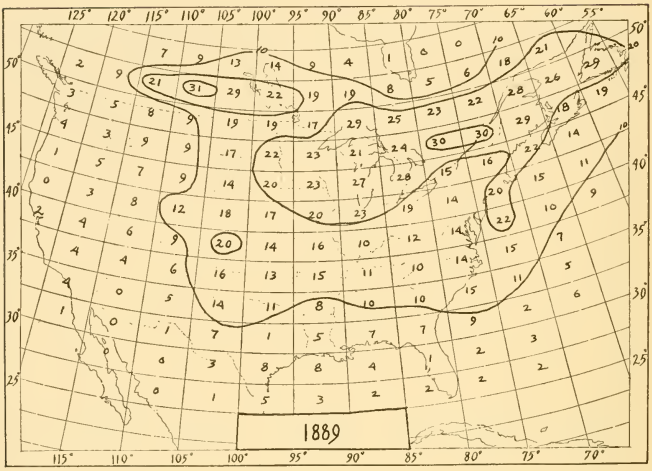


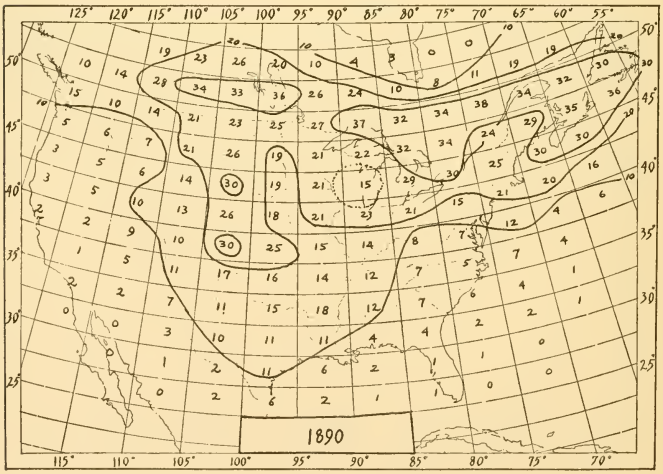
1887 and 1888



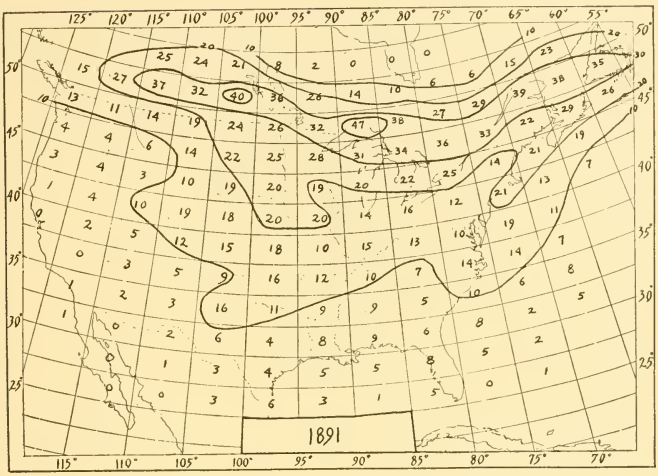


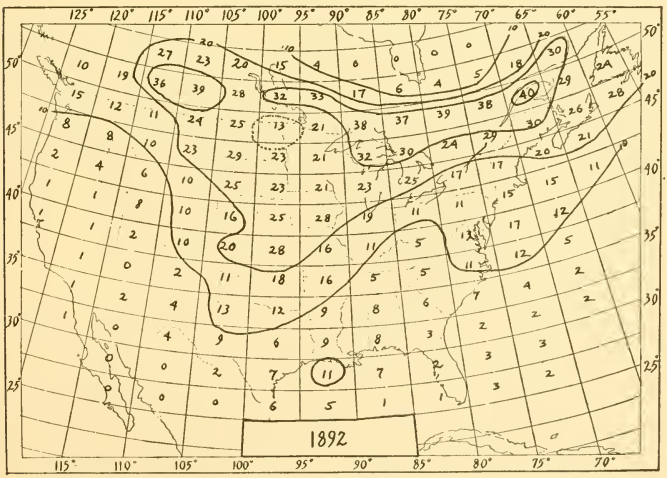
1889 and 1890



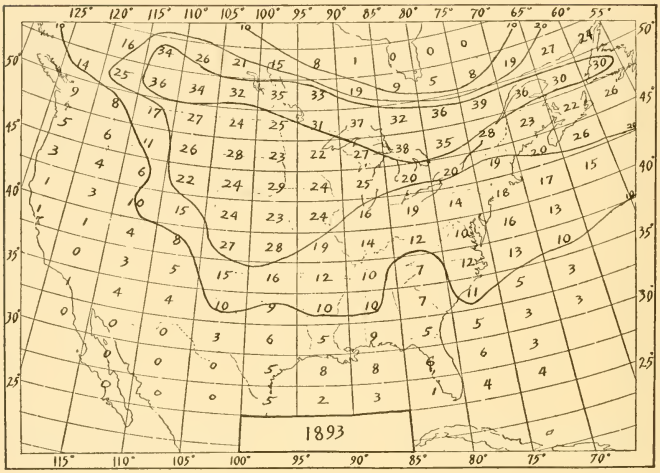


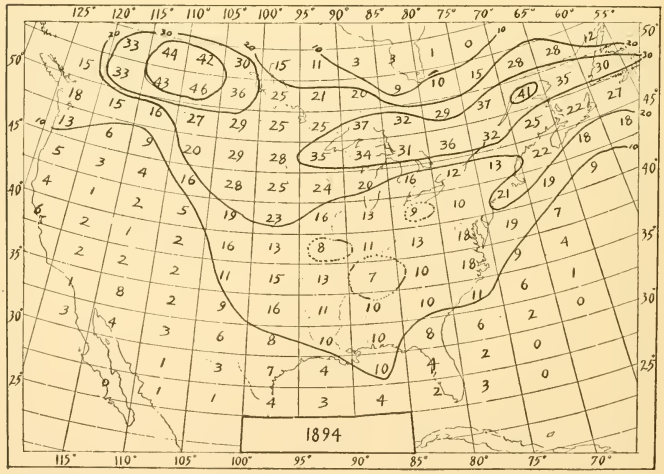
1891 and 1892





1893 and 1894





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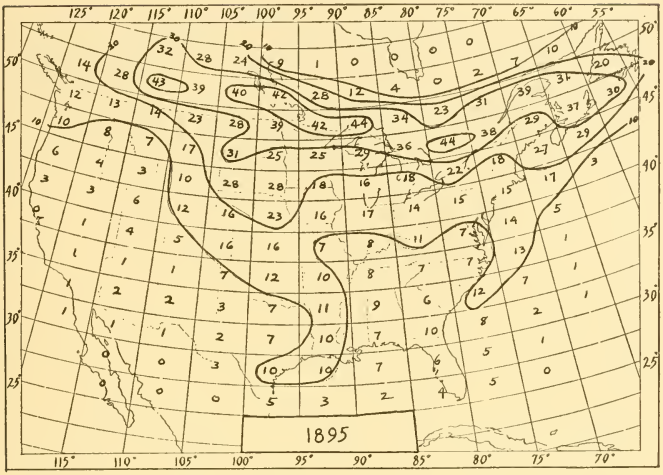
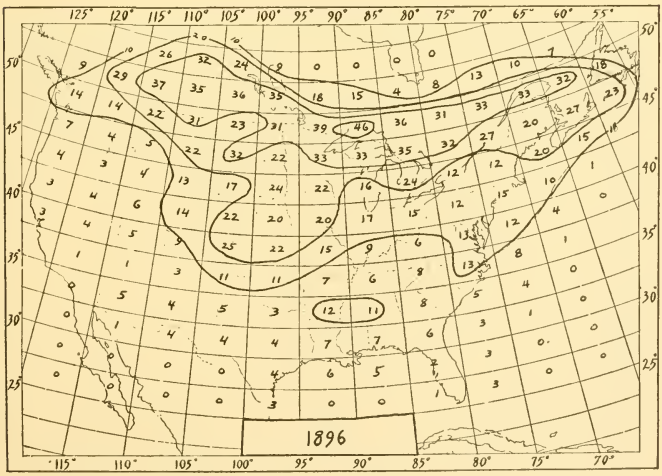
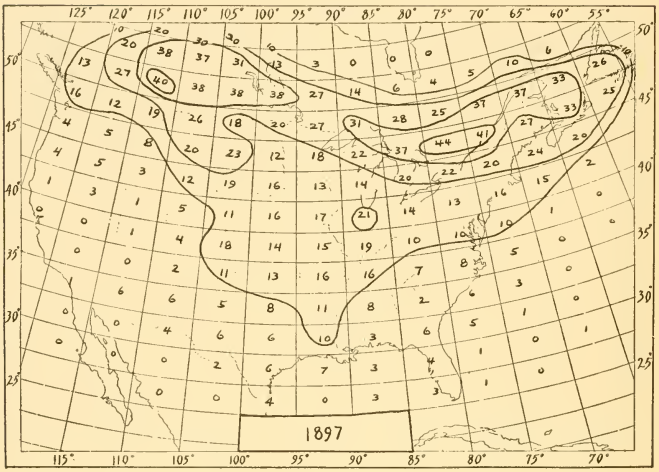
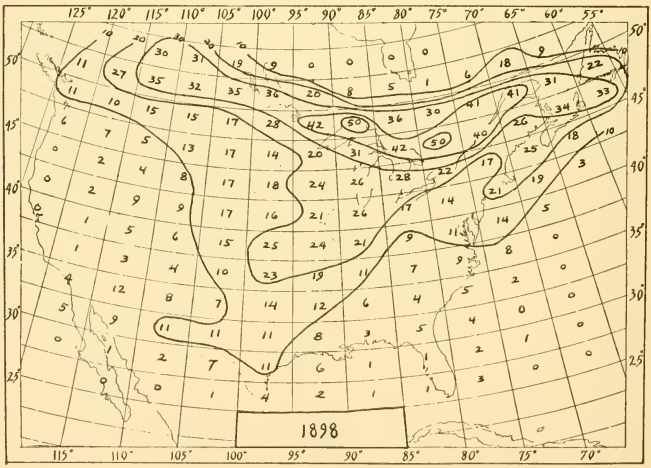


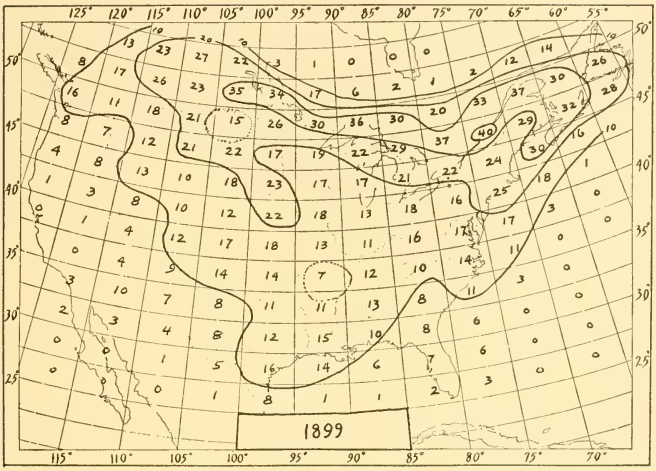


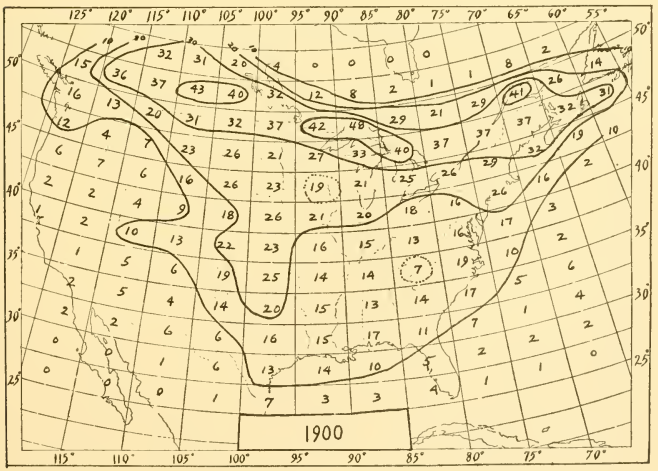
1897 and 1898



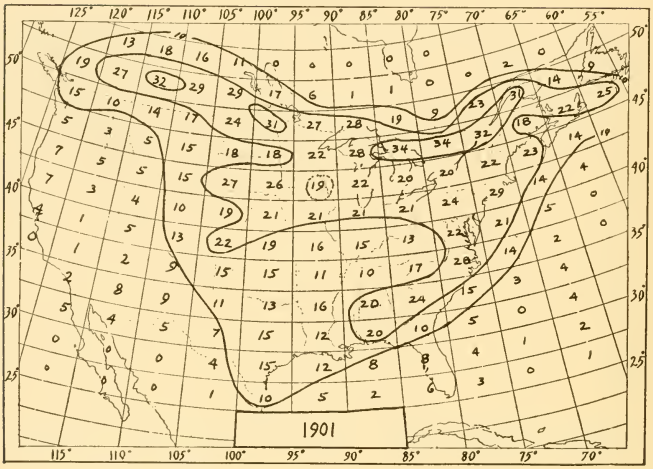


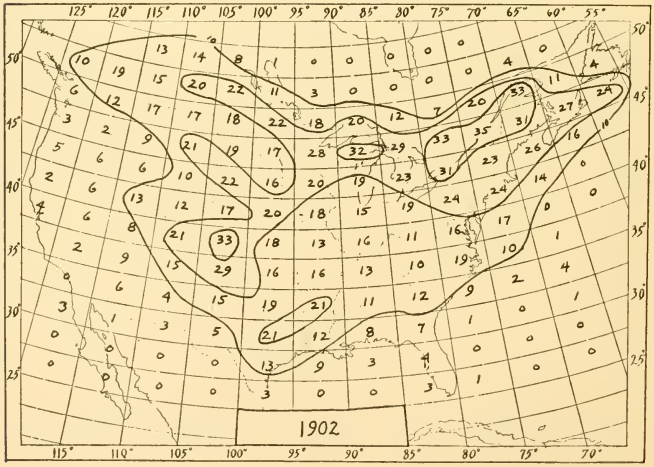
1899 and 1900





1901 and 1902





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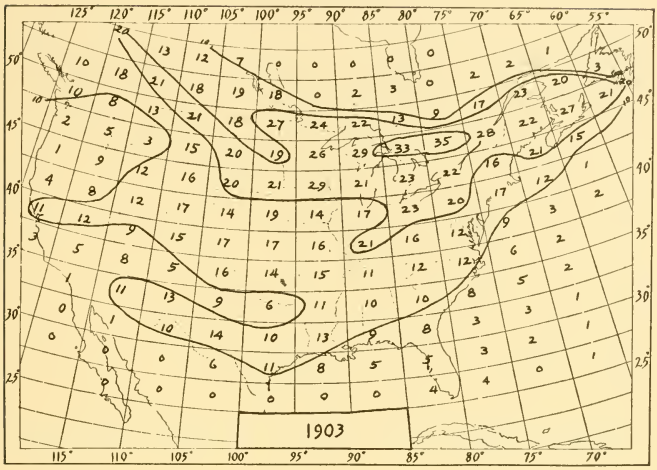

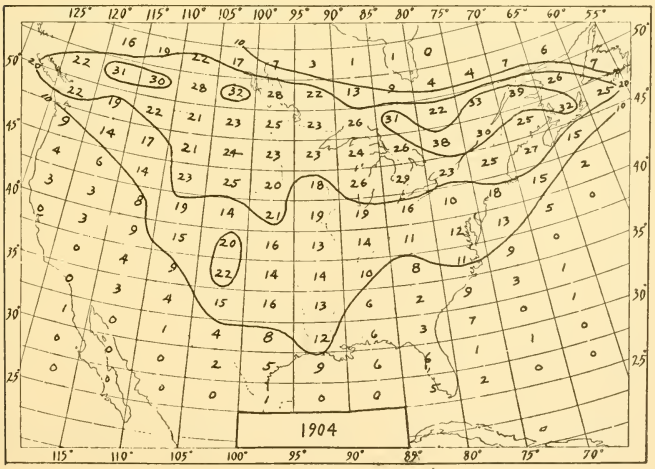

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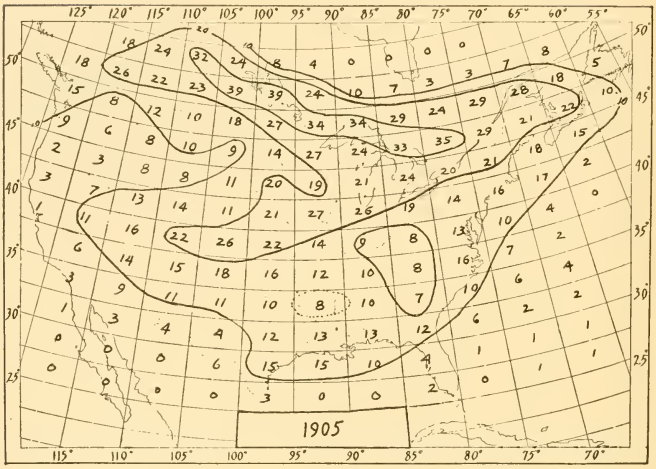
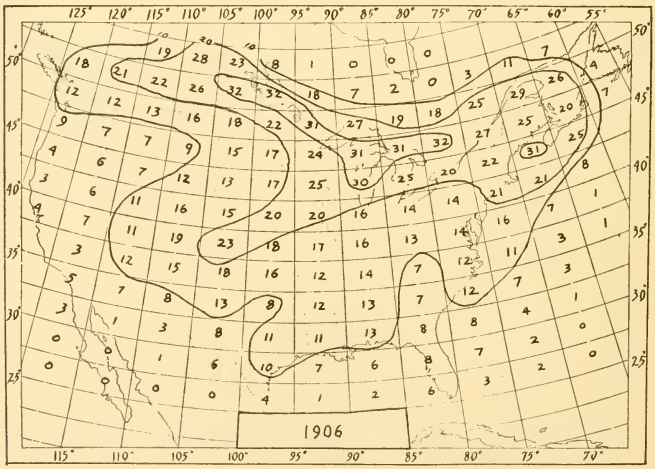
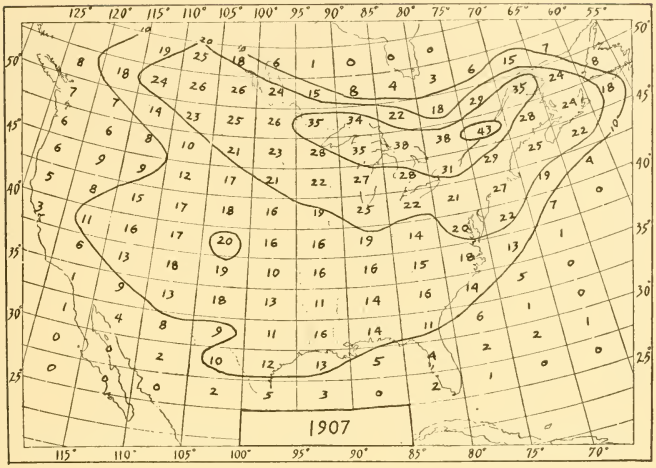
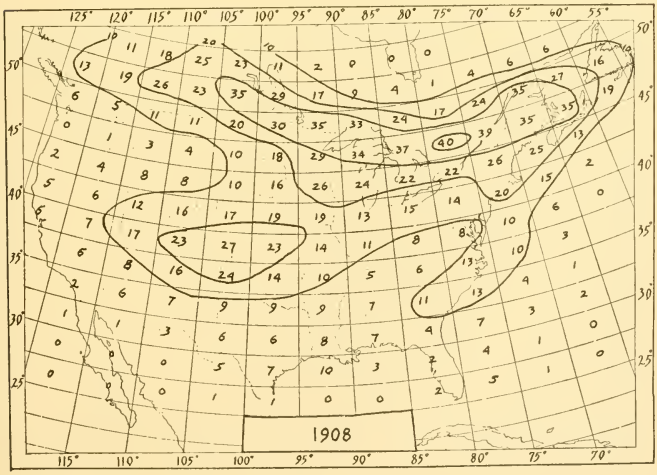




1907 and 1908





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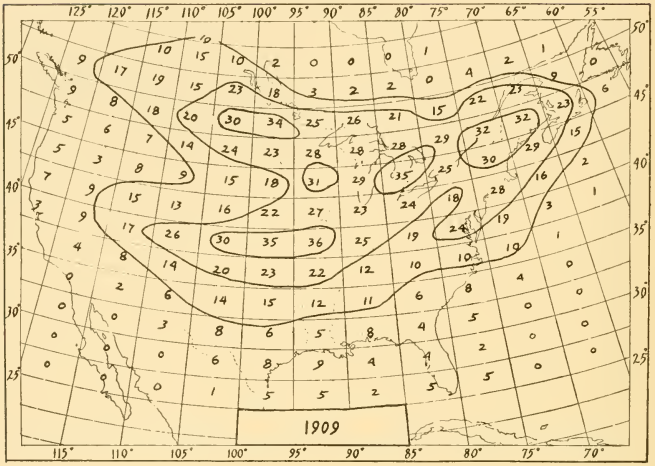
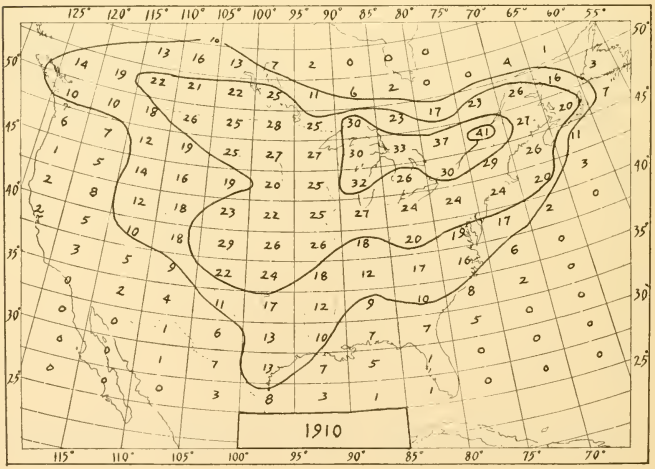
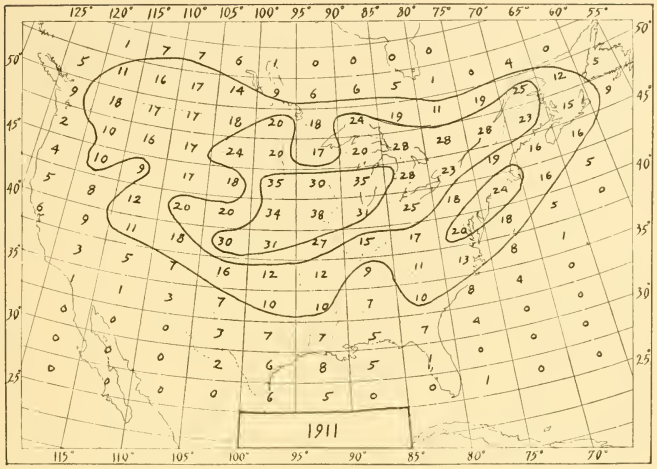
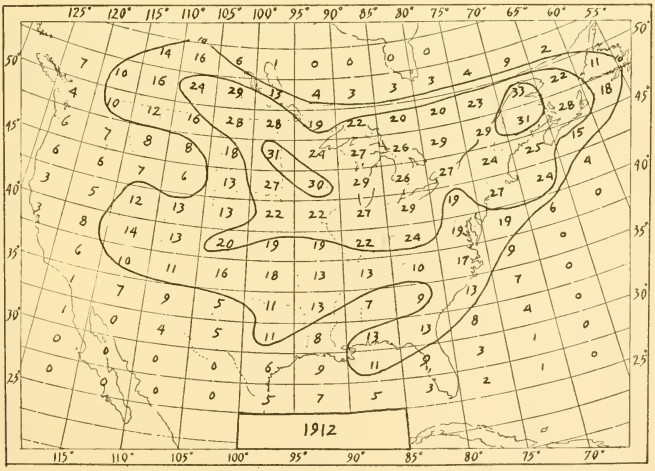


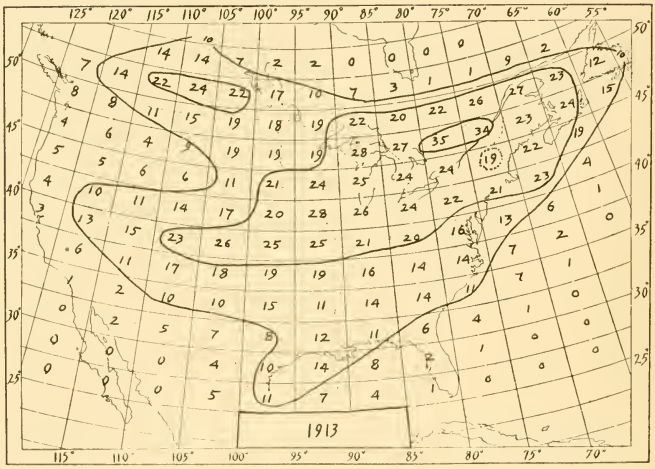


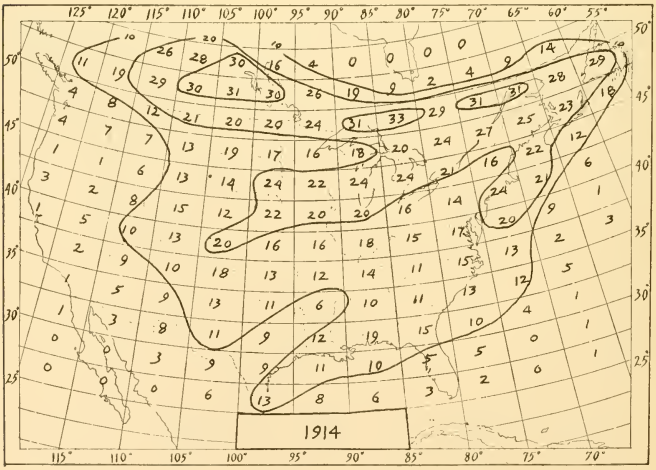
1911 and 1912





1913 and 1914





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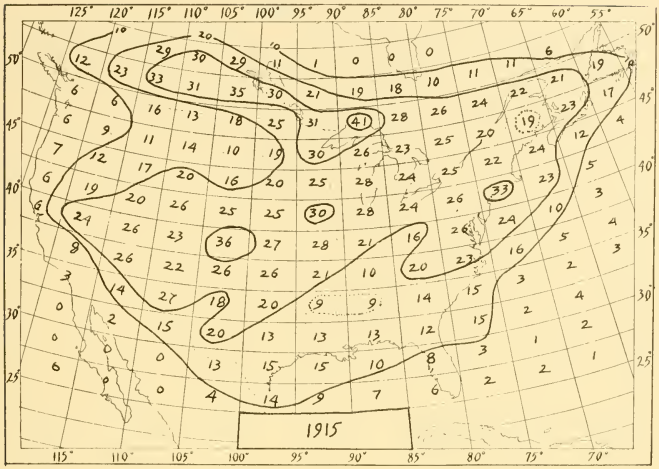

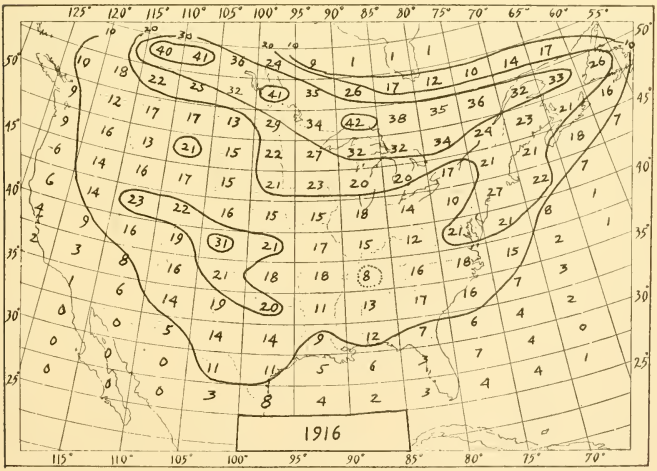

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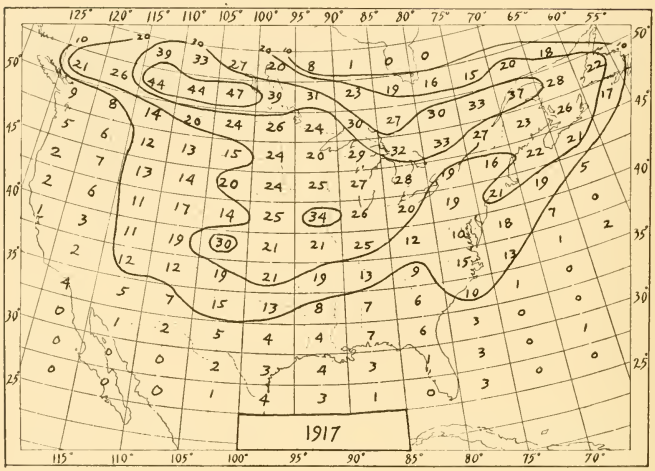

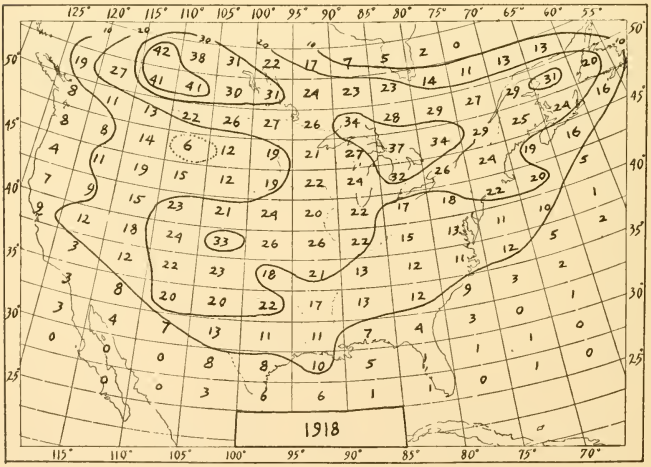

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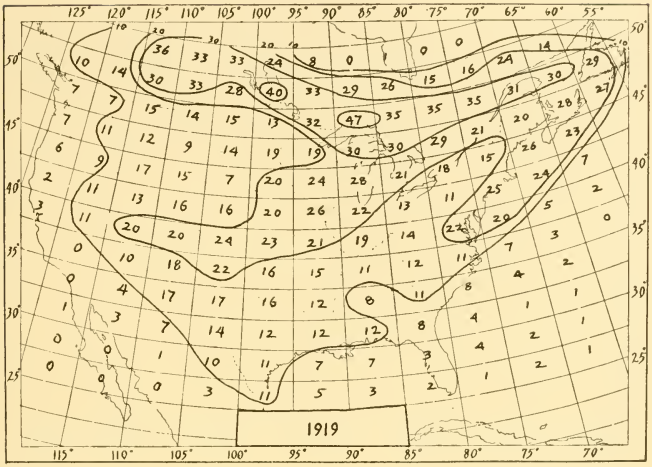
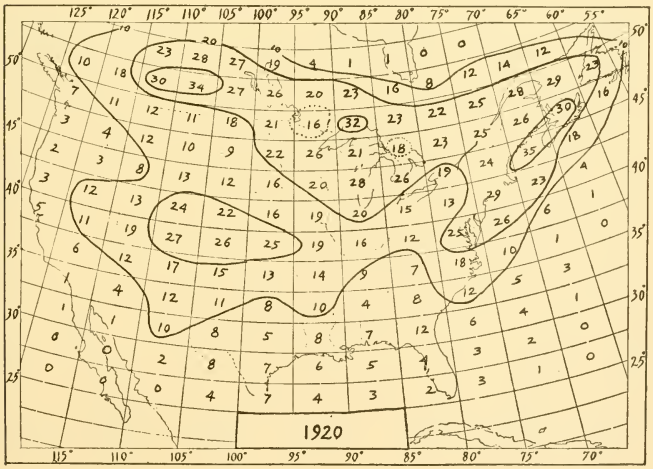
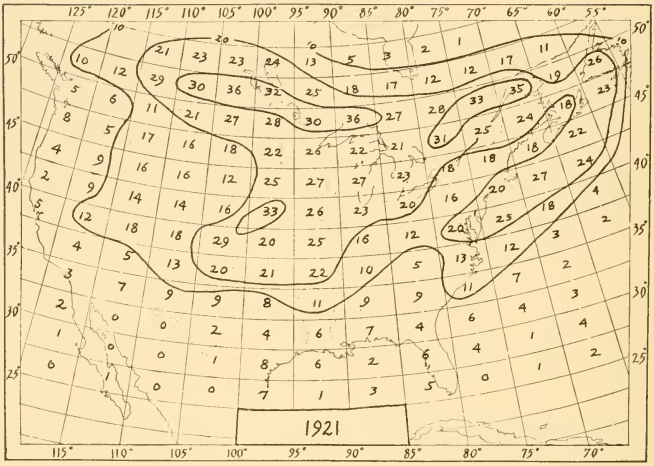
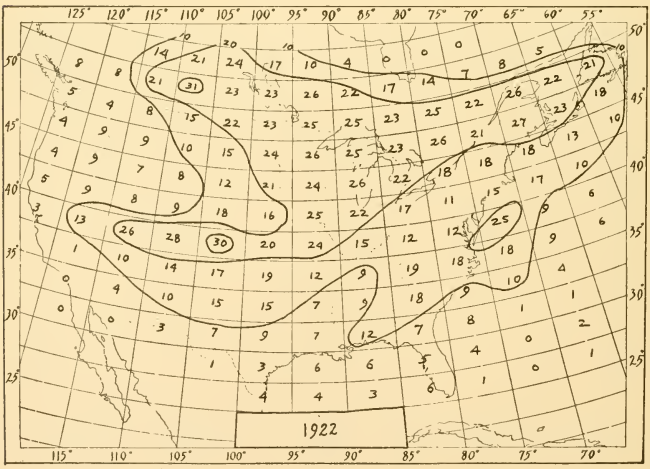


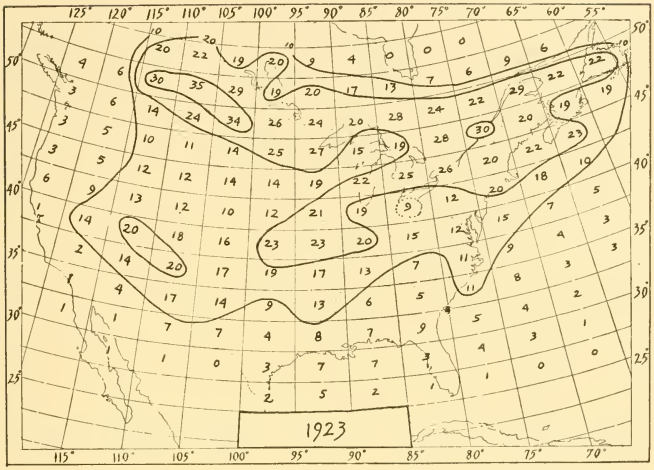


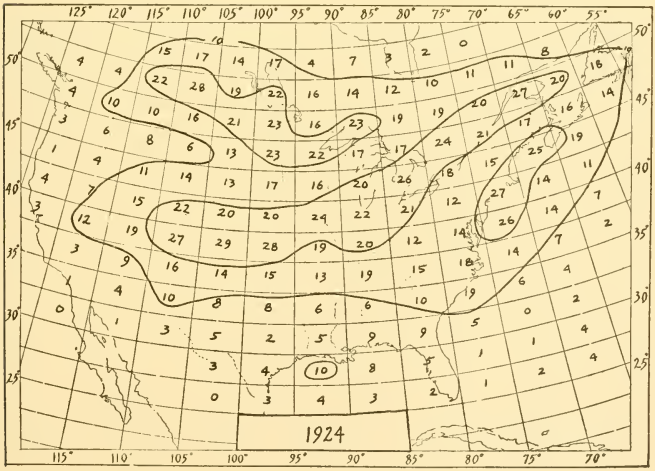
1921 and 1922



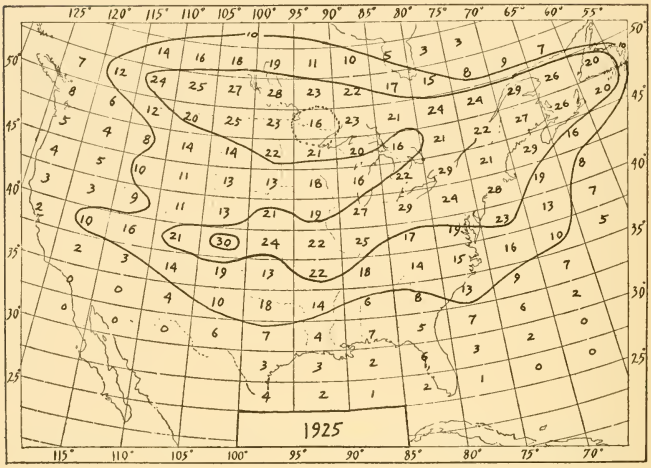


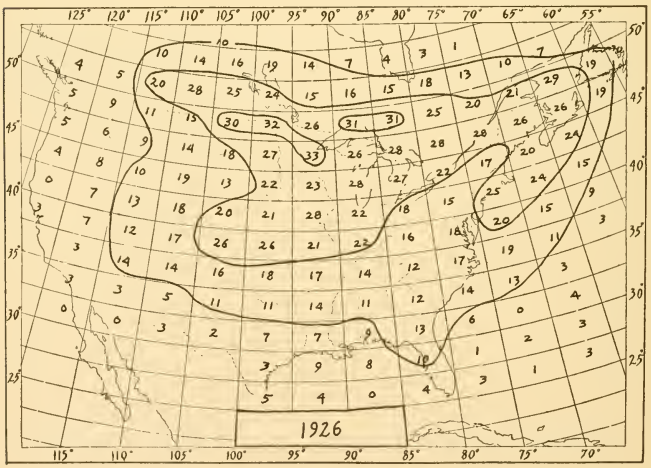
1923 and 1924



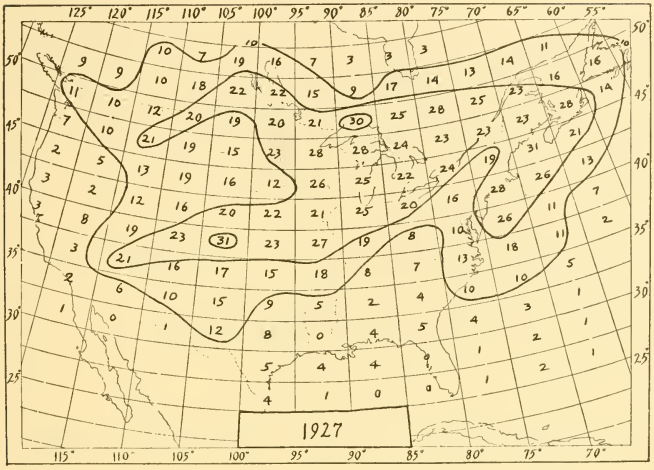


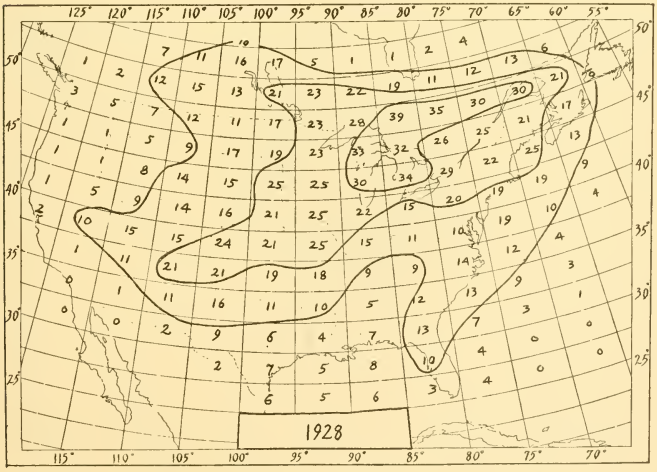
1925 and 1926





1927 and 1928





1929 and 1930