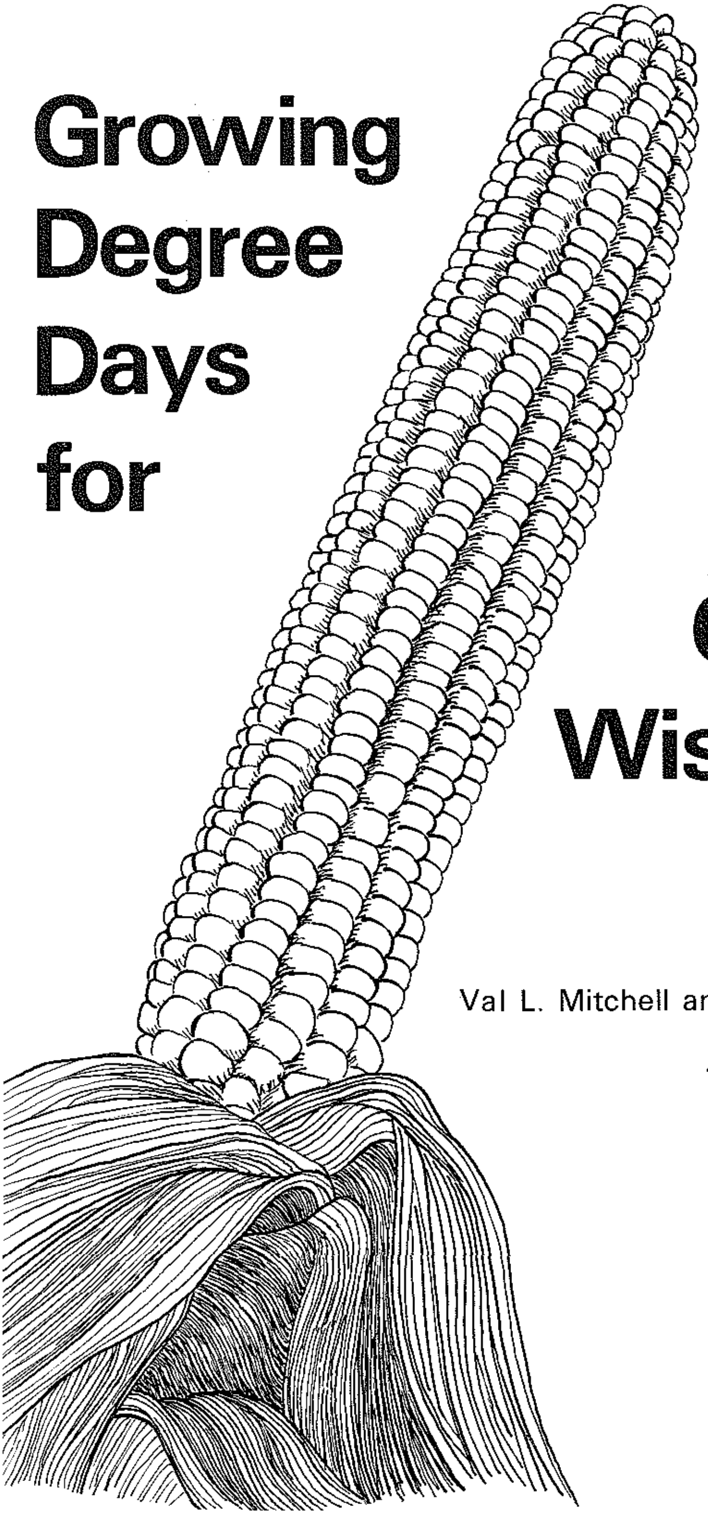
University of Wisconsin-Extension
GEOLOGICAL AND NATURAL HISTORY SURVEY
1815 University Avenue Madison, WI 53706

Growing Degree Days for Corn in Wisconsin



by

Val L. Mitchell and Richard W. Larsen

1981

Introduction

With the introduction of faster maturing corn varieties, corn has become one of Wisconsin's most important crops. Since many corn varieties approach their northern limit of growth in Wisconsin, there are certain temperature related factors that determine how successful a season will be for a particular corn variety.

An important temperature related factor is the accumulation of growing degree days (heat units) during the growing season. A growing degree day (GDD) is defined as the number of degrees by which the average daily temperature exceeds the temperature required for that crop to grow. This factor determines the rate of plant development during the growing season. Growing degree days for corn and their distribution in Wisconsin will be examined more closely in the following sections.

In order that this report may be used for different years, the planting dates are spaced at roughly ten-day intervals for the initial dates which are meant to coincide with approximate planting dates. The dates chosen for this report were suggested by Professor Elwood Brickbauer, agronomist at the University of Wisconsin-Extension, who encouraged preparation of this publication. The dates are not to be treated as absolute in terms of precise dates when corn should be planted. They are chosen because typically, the earliest that corn is planted in the state is about April 20 or 21, depending on soil temperature, and non-temperature related factors such as soil moisture, and operational decisions by the farmer.

The planting of corn may vary from late April to the first of June. It would be the farmer's preference to plant near the end of April or early May in southern Wisconsin and to mid-May in northern Wisconsin, but work conditions do not always allow him to do so. The raininess of the spring, the consequent wetness of the ground and the ability to work the ground to prepare the final seed beds for planting may vary considerably in time from one year to another. Normally, in a work sequence a farmer tries to plant his small grains first. Typically after the small grains and other spring work is done, the corn is planted.

The corn plant goes through certain developmental stages. These again will be dependent upon not only the planting date of the corn but will be dependent on the rate of development of the corn plant itself. Silking and pollination are important in the development of the corn. Silling and denting of the kernels on the ear are part of this developmental stage and at the end of the growing season the corn reaches a stage where the corn plant is physiologically mature as far as any further growth is concerned. Once the corn has reached this stage it is safe from frost. After that date the important thing is the drying process of the kernels on the ear. The more drying that takes place in the field, the less it will cost a farmer for energy to dry the corn with some type of drying equipment.

In the spring, frost is not a problem. Usually by the time planting occurs the season of killing frost is past. This is not always true, but since corn does not germinate until the temperature of the ground is in the vicinity of 50°F, most of the danger of killing frost is past. The light frost that occurs in May quite commonly in Wisconsin may nip a few leaves, but will not usually kill the growing plant itself. The growing portion of the plant is beneath the surface of the soil and therefore is essentially protected from a light frost.

One of the reasons why corn is considered a 50°F plant is that the seed does not germinate and the plant itself does not grow until the soil temperature reaches 50°F. Corn germinates and grows much faster at 60°F than it does at 50°F. If it is convenient for a farmer to plant corn seed when the ground temperature is 45°F, there is usually little problem. The corn seed is treated to prevent fungus growth and other deterioration while it is in the ground. Thus, a well protected seed may remain in the ground two weeks before it germinates. By the time a farmer is finished with the work that precedes the planting of corn, the ground temperature is up to about 50°F.

In those areas where late and early frosts are common, a variety of corn is planted that matures in a relatively short period of time. In those areas of the state where the growing season is a bit longer, a different variety of corn is planted. Usually the faster growing varieties, those that mature more rapidly, do not yield as well as the longer maturing varieties of corn. A farmer would prefer to plant a variety of corn that will give the highest yield possible for the area in which the farm is located.

Degree days have many uses in agriculture and energy related areas. The base temperature will vary with crops. This report deals with corn that has a 50°F base. This is in contrast with peas or small grain in which a 40°F base is used or a 60°F base for sorghum. It can also be used to regulate heating and cooling of structures maintained at 50°F.

Growing Degree Days

Temperature is one of several important atmospheric related parameters that affect plant growth and development. It is one of the two most widely measured weather parameters affecting plant growth; the other being precipitation, which manifests itself in soil moisture.

Because of the availability of daily temperature data, temperature has been used in various ways to estimate plant growth and development. One of the most widely used methods is that of growing degree days.

In the growing degree days concept, the temperature range over which a specific crop grows is considered and the temperatures within that range are calculated for each day. Daily values are computed for a location using the following formula:

$$\text{GDD} = \frac{\text{maximum temperature (Tx)} + \text{minimum temperature (Tn)}}{2} - \begin{array}{l}\text{temperature}\\ \text{base of } 50^\circ\text{F } (T_b)\end{array}$$

In this equation Tx represents the daily maximum temperature, Tn the daily minimum temperature and T_b the base temperature also referred to as the threshold temperature. The expression $(Tx - Tn)/2$ represents the average daily temperature. Only positive values of growing degree days are computed.

After the growing degree days for each day are calculated, they are summed over whatever period is desired, usually from planting date to some developmental stage and ultimately to maturity. While this system is not perfect, it is simple, easy to work with and is widely accepted. The strengths and weaknesses of this system and more complex systems are discussed in the literature and will not be dealt with here.

Growing Degree Days for Corn

Corn requires a temperature of 50°F or higher to grow. It is also accepted that the growth of corn is limited by moisture stress when the temperature is higher than 86°F. Therefore, 50°F and 86°F are used as the lower and upper limits respectively of the growing degree day calculations for corn.

In computing growing degree days using these limits the base temperature, T_b, is set at 50°F and the following procedures are used.

1) If the daily minimum temperature, Tn, is below 50°F it is set to 50°F.
2) If the daily maximum temperature, Tx, is below 50°F it is set to 50°F.

3) If Tx is above 86°F it is set to 86°F.
4) Compute average daily temperature. If the resulting number contains a half degree round up to the nearest whole degree, (i.e., 63.5 is rounded up to 64.0).†
5) Subtract the base temperature, T_b, from the average daily temperature.

The number of growing degree days in a day then range from 0-36. Here are four examples of the resulting growing degree day values following the procedure above.

Tx = 82°F, Tn = 55°F

$$GDD = \frac{(82 + 55)}{2} - 50 = 69 - 50 = 19$$

Tx = 95°F, Tn = 73°F

$$GDD = \frac{(86 + 73)}{2} - 50 = 30$$

Tx = 70°F, Tn = 45°F

$$GDD = \frac{(70 + 50)}{2} - 50 = 10$$

Tx = 90°F, Tn = 46°F

$$GDD = \frac{(86 + 50)}{2} - 50 = 18$$

By using the procedures described above on daily maximum and minimum temperatures reported in an area, a record of growing degree days for the current growing season affecting your crop can be kept. Depending on other environmental factors and the corn variety, developmental stages such as tasseling, silking, and maturity will occur on the average after a certain number of growing degree days have accumulated from the planting date. See your seed dealer or county extension agent for more information on growing degree days and corn development.

Analysis of Growing Degree Days for Corn in Wisconsin

The purpose of the following maps is to present the average distribution of growing degree days across Wisconsin and also to illustrate a measure of the variability of growing degree days that can be expected. These maps are based on growing degree days computed at 20 locations across Wisconsin during the period 1950-1974 using the procedures discussed in the previous section.

Average growing degree day maps of the period 1950-1974 were constructed for 40 periods that correspond approximately to various planting dates for corn and end at various dates until the approximate date of corn maturity. See map index. Contour lines were drawn at 25, 50, and 100 growing degree day intervals depending on the period.

Maps are also presented for 8 periods that show the number of growing degree days that can be expected once in five years, less than average, and 8 periods that show the number of growing degree days that can be expected once in five years, greater than average. These are based on statistical analysis and should be considered as estimates only.

It is important to note that the map data are obtained from 20 weather stations in the state, and that due to differences in terrain or other local effects, the precise growing degree day values for a particular location may differ from the map values. This is particularly true along Lake Michigan where a large range of values occur. The maps should provide a general guide for virtually all areas of the state.

Two large-scale features on all of these maps are worth noting. First, the effect of Lake Michigan that drastically lowers the accumulation of growing degree days from the shoreline to approximately 50 miles inland. The second feature is the southward dip of growing degree day isolines in the north central portion of the state. This dip may be the result of generally higher terrain and the presence of sandy soils. Lower minimum temperatures often occur over these soils.

Map Index

Average growing degree days maps from 1950-1974 averages. The following index gives map numbers for 40 periods.

	Beginning Dates				
Ending Dates	Apr 21	May 1	May 11	May 21	Jun 1
Jun 15	Map 1	Map 9	Map 17	Map 25	Map 33
Jun 30	Map 2	Map 10	Map 18	Map 26	Map 34
Jul 15	Map 3	Map 11	Map 19	Map 27	Map 35
Jul 31	Map 4	Map 12	Map 20	Map 28	Map 36
Aug 15	Map 5	Map 13	Map 21	Map 29	Map 37
Aug 31	Map 6	Map 14	Map 22	Map 30	Map 38
Sep 15	Map 7	Map 15	Map 23	Map 31	Map 39
Sep 30	Map 8	Map 16	Map 24	Map 32	Map 40

Maps showing growing degree days that can be expected to be less than or greater than average once in five years, with appropriate average growing degree days map also illustrated.

	Beginning Dates			
	May 1		May 21	
Ending Dates	< average	> average	< average	> average
Jun 30	Map 41	Map 42	Map 48	Map 49
Jul 31	Map 42	Map 43	Map 50	Map 51
Aug 31	Map 44	Map 45	Map 52	Map 53
Sep 30	Map 46	Map 47	Map 54	Map 55

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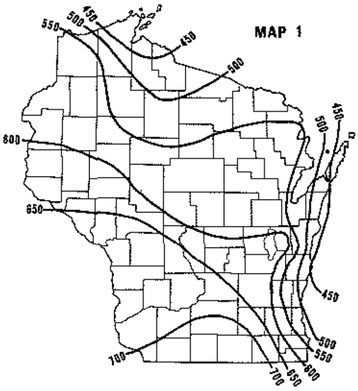
† Historically the National Weather Service has computed the average daily temperature using Tx and Tn and rounded up ½ degrees even though this introduces a positive error in the summation of GDD. All GDD computed in this bulletin are computed using this round up procedure so the values will be consistent with previous GDD studies.

ACKNOWLEDGEMENTS

The authors would like to acknowledge Professor Elwood Brickbauer who made important suggestions and reviewed the maps and the text. We also thank Nancy J. Davis for typing the text, Jim Ramer who made the contour analysis of these maps and Mike Czechanski who did the final cartographic work.



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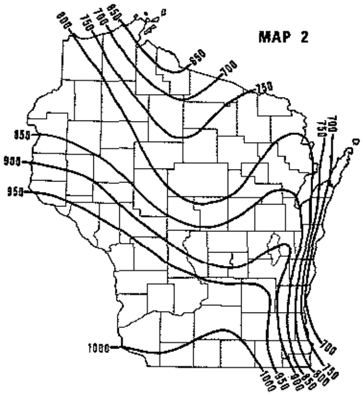
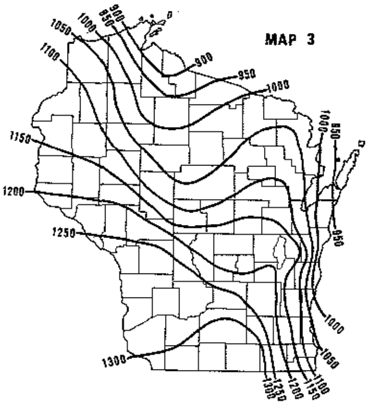


April 21 - June 30



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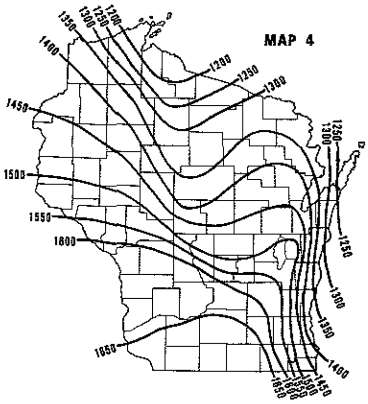
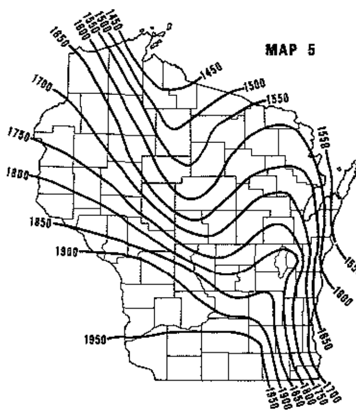


April 21 - July 31

Growing Degree Days (1950–1974 means)



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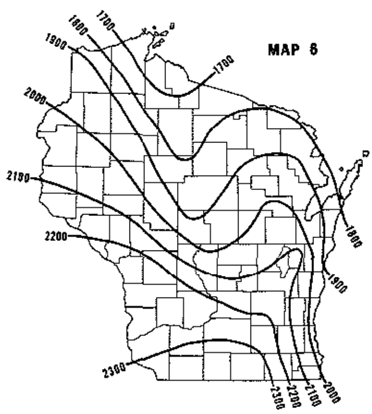

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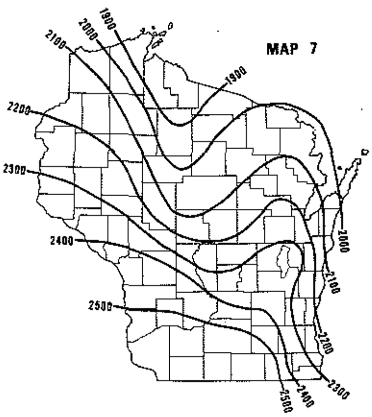

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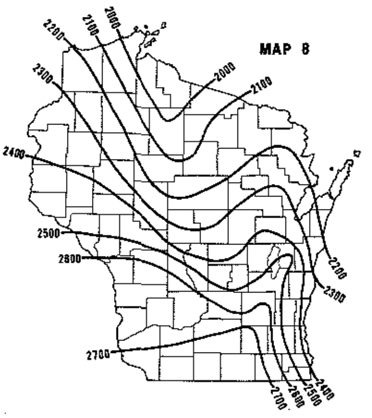

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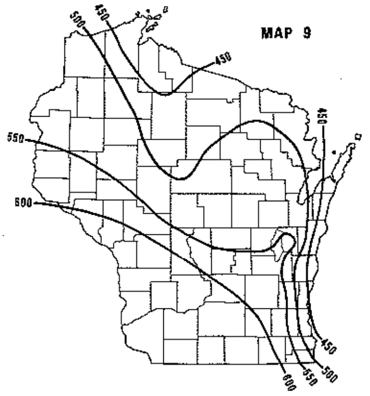

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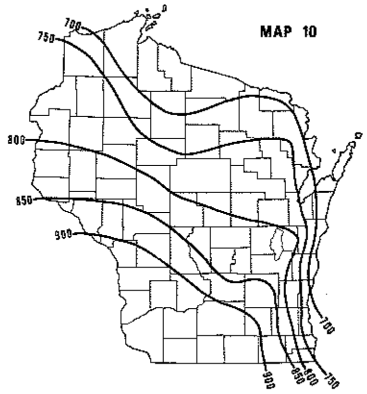

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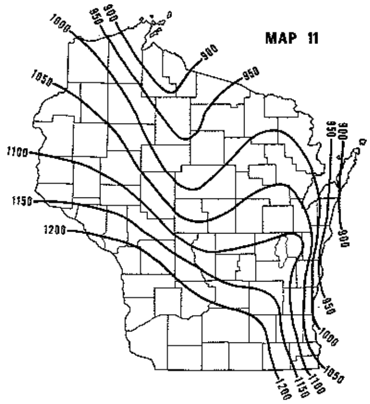

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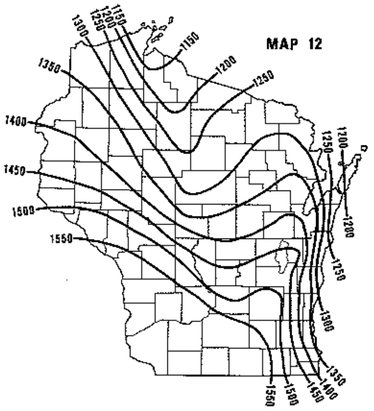

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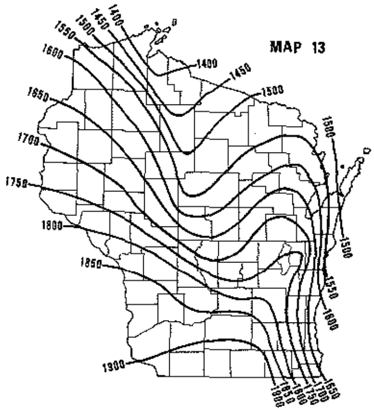

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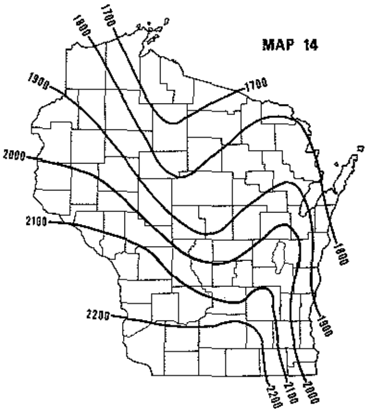

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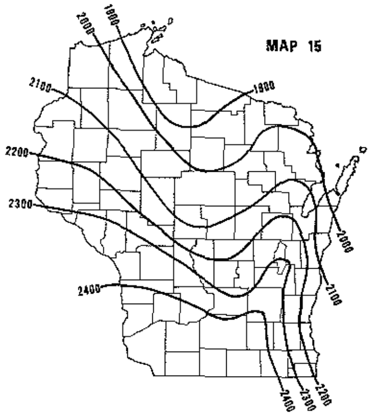

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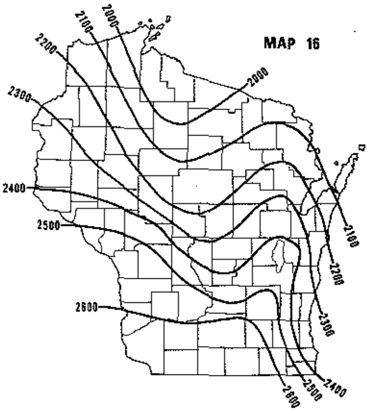

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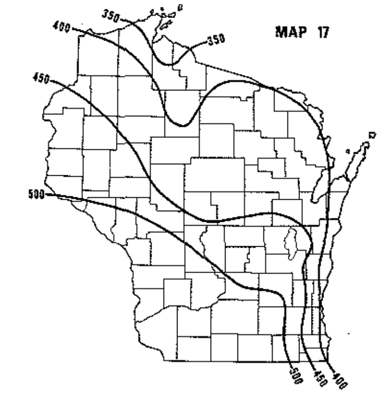

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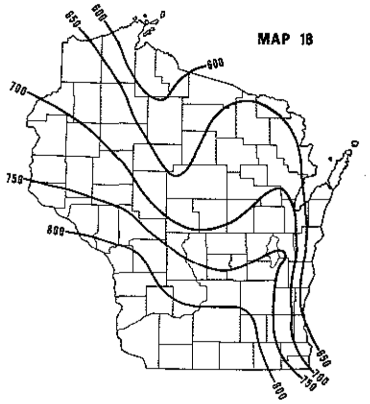

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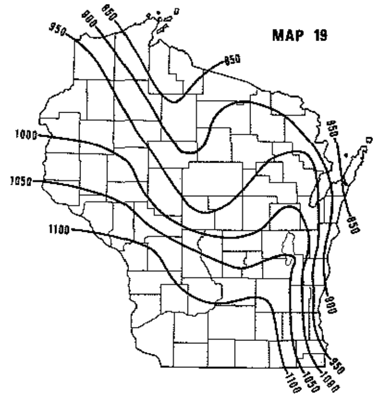

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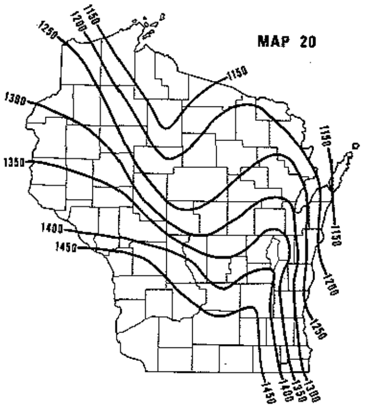

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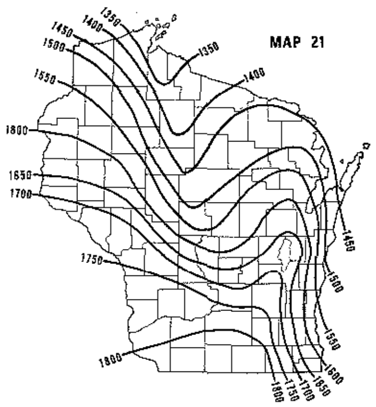

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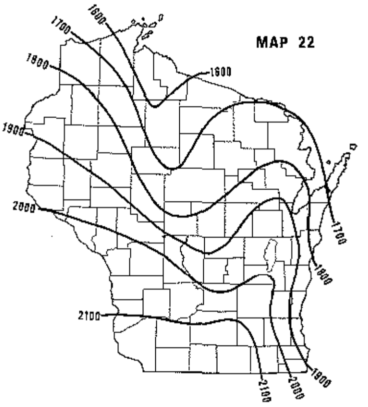

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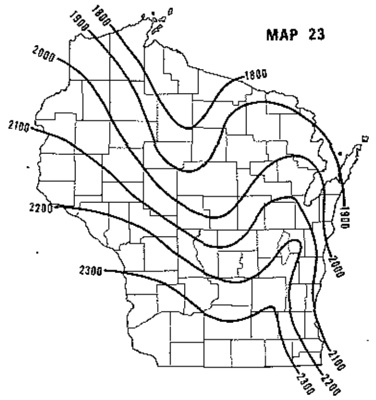

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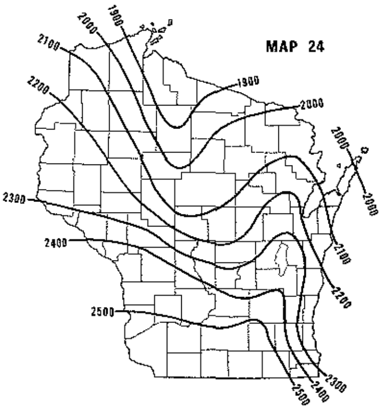

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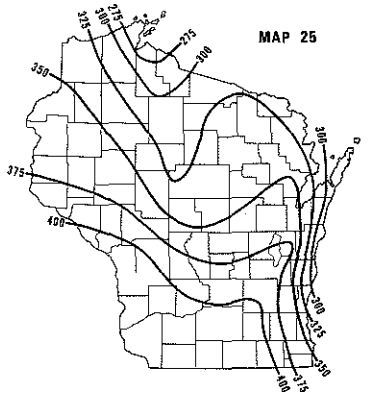

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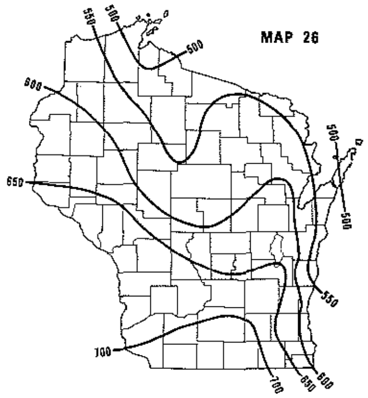

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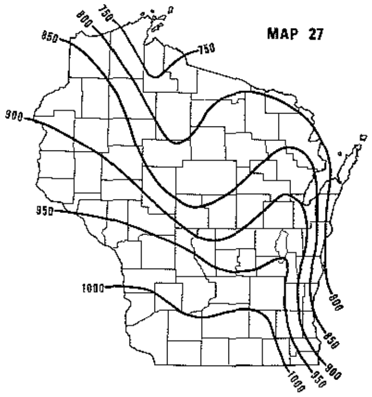

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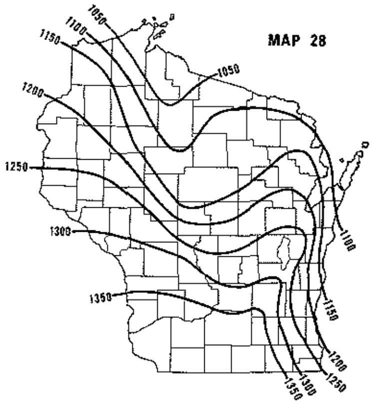

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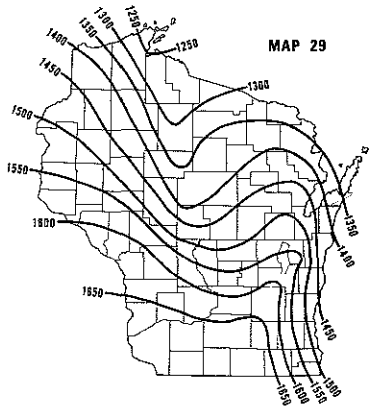

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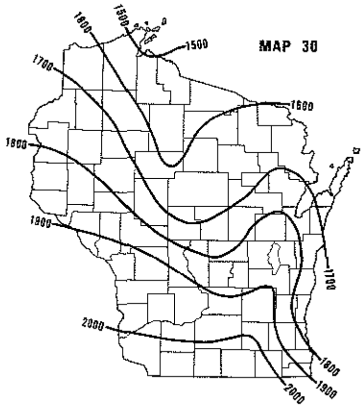

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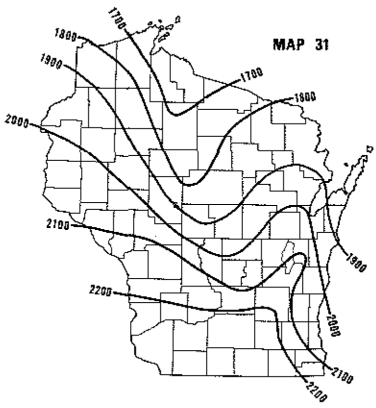

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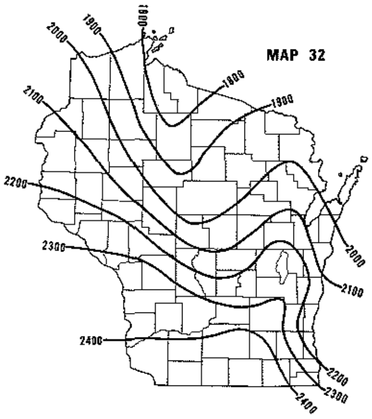

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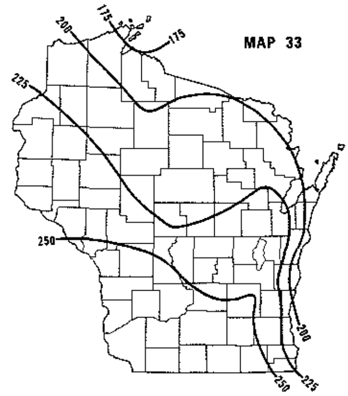

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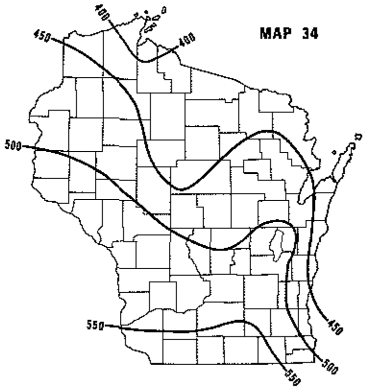

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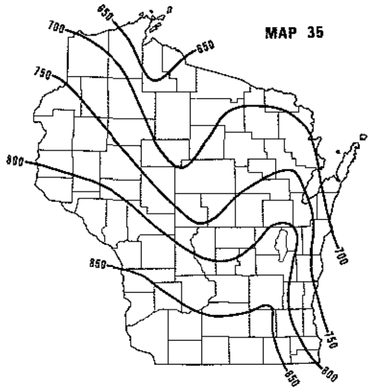

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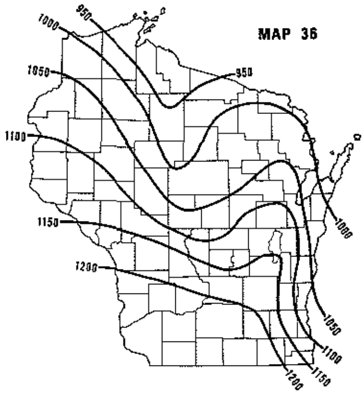

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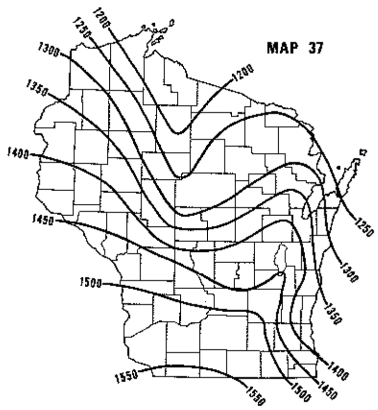

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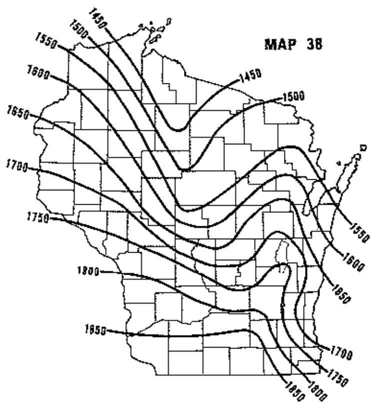

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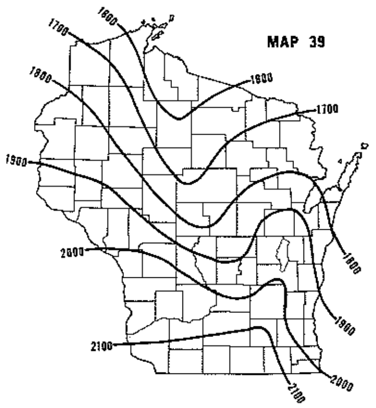

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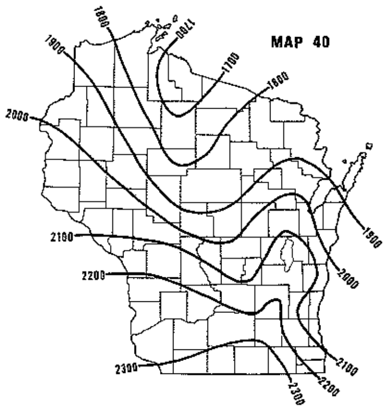

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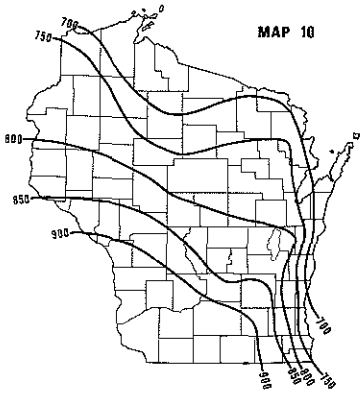
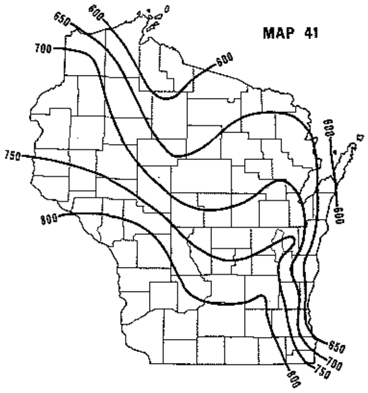


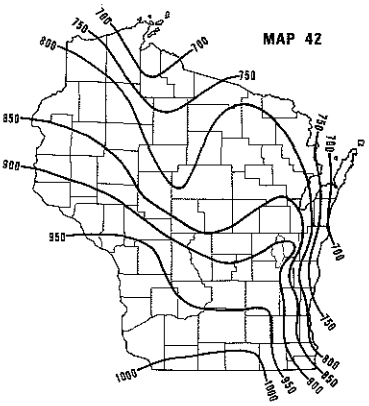
May 1 - June 30

Average Growing Degree Days



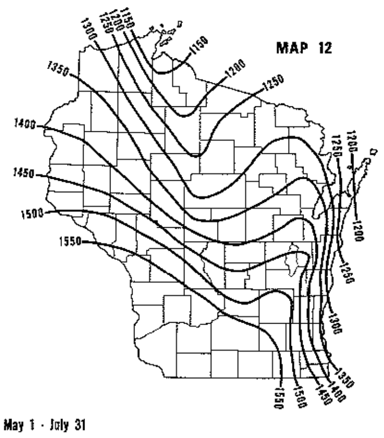
May 1 - June 30

Growing Degree Days that
can be expected to be
less than average
once in 5 years.



May 1 - June 30

Growing Degree Days that
can be expected to be
greater than average
once in 5 years.



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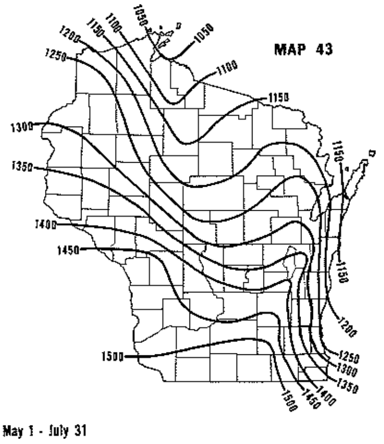
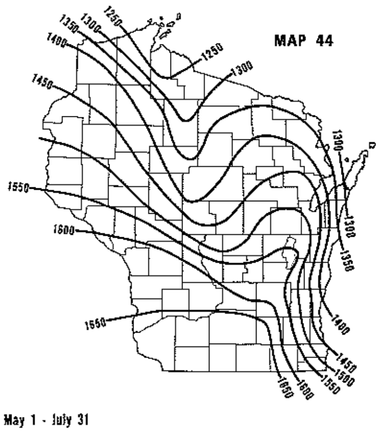
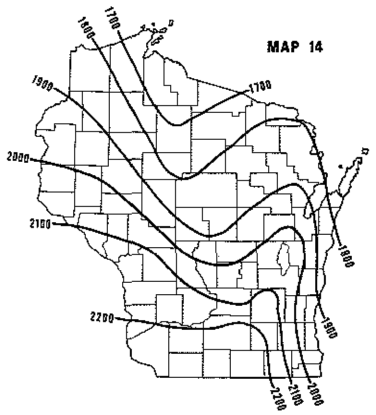


Growing Degree Days that can be expected to be less than average once in 5 years.

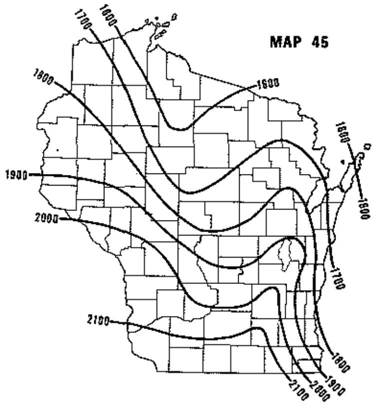


Growing Degree Days that can be expected to be greater than average once in 5 years.



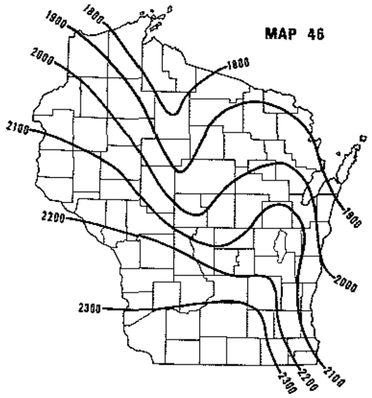
May 1 - August 31

Average Growing Degree Days



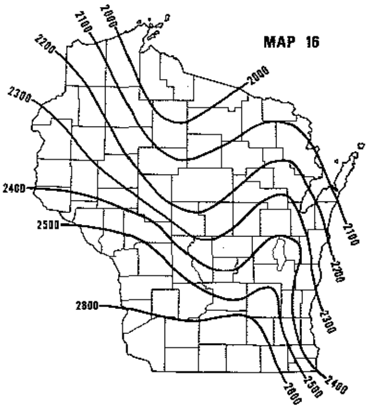
May 1 - August 31

Growing Degree Days that can be expected to be less than average once in 5 years.



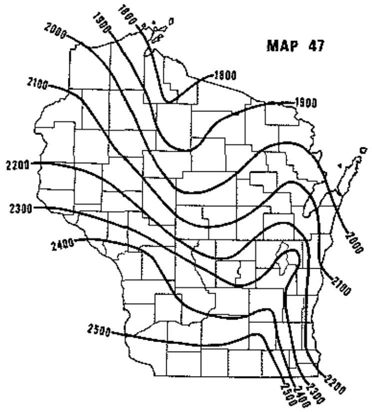
May 1 - August 31

Growing Degree Days that can be expected to be greater than average once in 5 years.



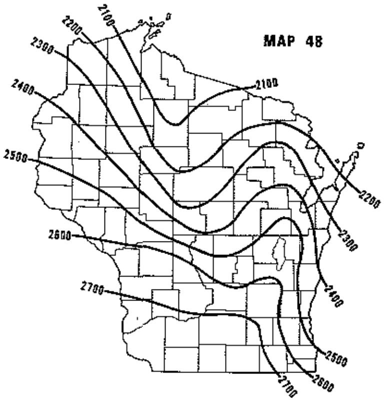
May 1 - September 30

Average Growing Degree Days



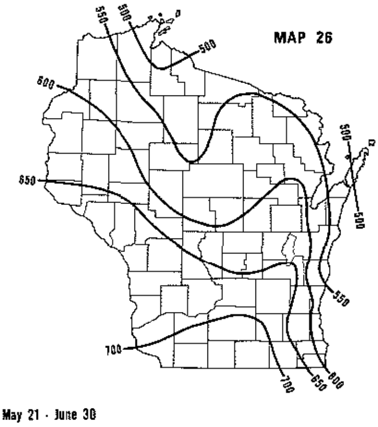
May 1 - September 30

Growing Degree Days that can be expected to be less than average once in 5 years.

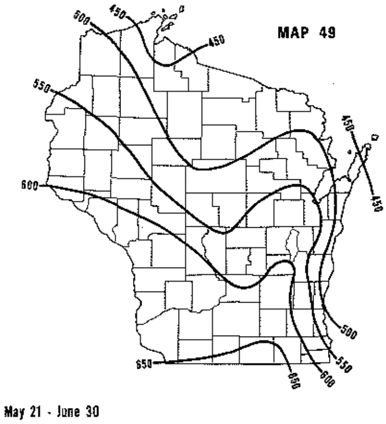


May 1 - September 30

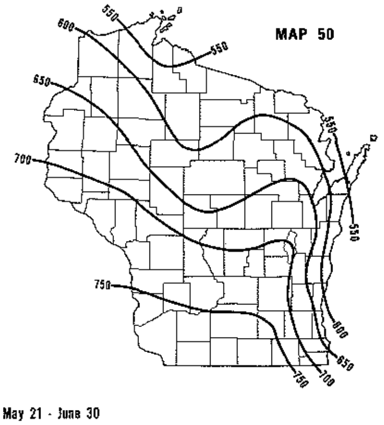
Growing Degree Days that can be expected to be greater than average once in 5 years.



Average Growing Degree Days



Growing Degree Days that can be expected to be less than average once in 5 years.



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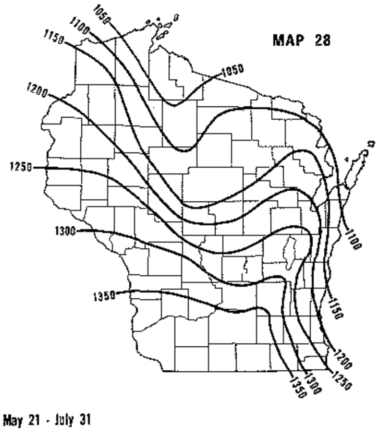
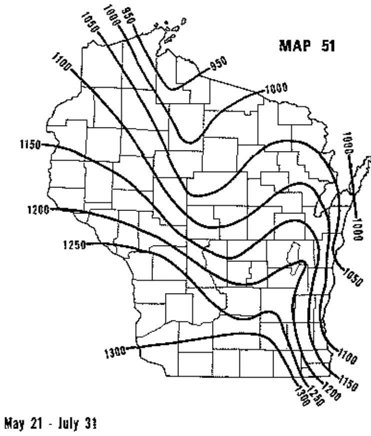


Average Growing Degree Days



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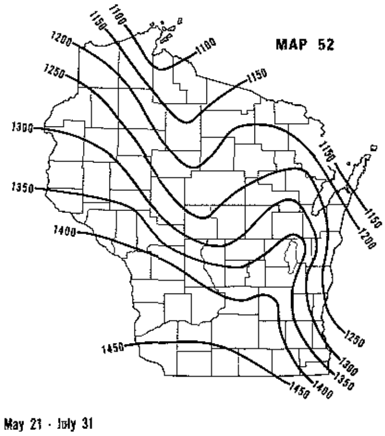
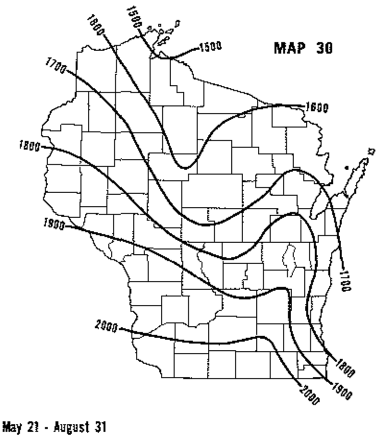
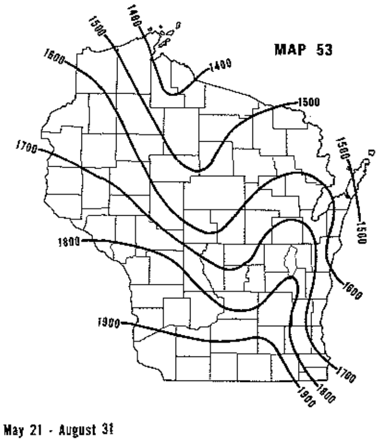


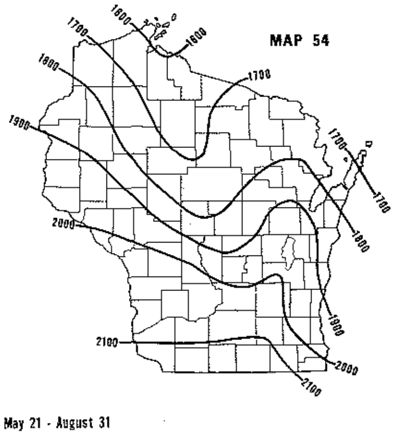
Growing Degree Days that can be expected to be greater than average once in 5 years.



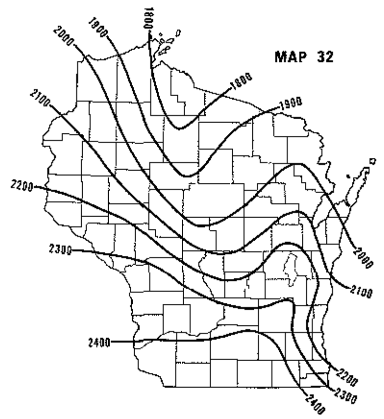
Average Growing Degree Days



Growing Degree Days that can be expected to be less than average once in 5 years.

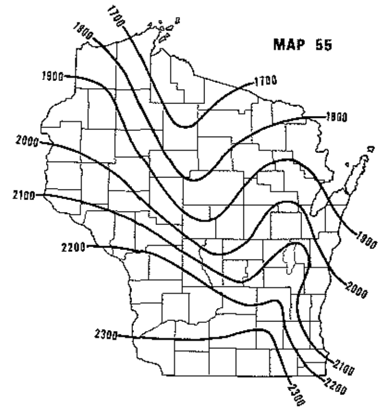


Growing Degree Days that can be expected to be greater than average once in 5 years.



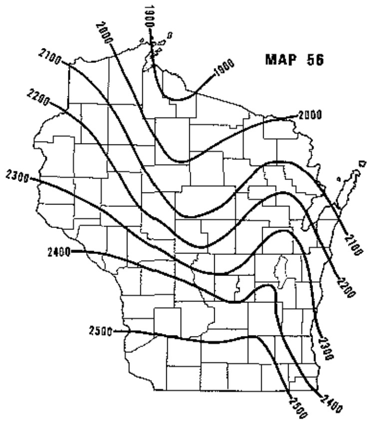
May 21 - September 30

Average Growing Degree Days



May 21 - September 30

Growing Degree Days that can be expected to be less than average once in 5 years.



May 21 - September 30

Growing Degree Days that can be expected to be greater than average once in 5 years.

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