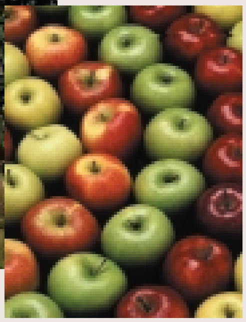

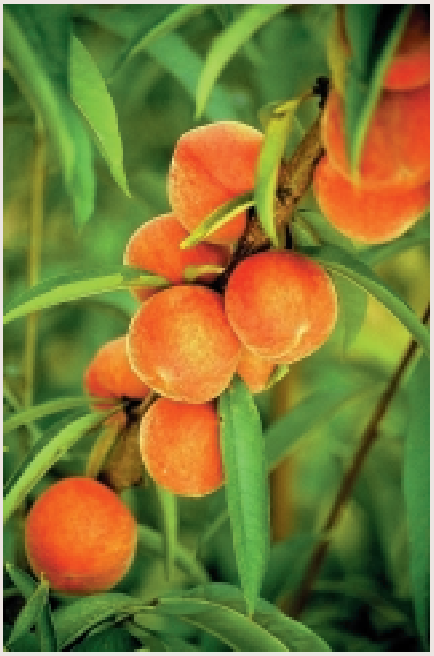

FOCUS

Climate Change and Fruit Production: An Exercise in Downscaling

study conducted by

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Fruit production is a significant commercial endeavor in the Upper Great Lakes region and a primary source of revenue for some local areas. It is extremely vulnerable to damage from temperature extremes, particularly minimum temperature extremes. Hence, most of the fruit-growing areas in the region are located near the shores of the Great Lakes, where the water helps to moderate extremely cold and warm air masses. Deciduous fruit trees normally begin a cold hardening or rest stage in autumn before becoming dormant during the mid-and late winter. As temperatures rise in the late winter and early spring, the trees gradually lose their cold hardiness before becoming actively vegetative. Fruit trees in the Great Lakes region are particularly vulnerable to cold damage during spring bloom when temperatures slightly below freezing may kill flower buds following the loss of cold hardiness. Evaluating the potential for day-to-day temperature extremes along the lakeshores is imperative to understanding the impacts of climate change on fruit production. The principal impacts of projected climate change are more likely to result from changes in the frequency of threshold events and extremes, such as the date of last spring freeze, the length of the growing season, and heat accumulation, than from changes in mean climatic states.

Threshold Events

A climatological threshold event is the exceedence of a variable of interest above or below some predefined level (i.e., "threshold"). Assessing possible future changes is a complex undertaking because relatively small changes in mean temperature may produce large changes in the frequency of threshold events [F7-1], and because observed trends of different temperature threshold parameters at a site or adjacent sites may be uncorrelated. For example, in northern Sweden, the length of the growing season was longer during the cold decade of 1979-1988 than during the much warmer period of 1931-1940 [F7-2]. In the former Soviet Union, there have been no (correlated) changes in the start, end, and duration of the growing season despite the observed warmer conditions during the past 110 years [F7-3]. In Minnesota, mean temperature trends at five stations and the duration of the frost-free period appear to be uncorrelated and in opposition to those for stations in neighboring Wisconsin [F7-4, F7-7]. Only a few observational studies support the anticipated behavior between warming and the occurrence of threshold events. For example, in western Canada, significant warming over the past 100 years at stations has been accompanied by earlier dates of last spring freeze, later dates of first fall freeze, and a longer frost-free period [F7-5]. In western Lower Michigan, the average date of last spring freeze has occurred earlier as springtime temperatures have warmed [F7-6]. The complex relationship between means and threshold events may be the result of concurrent fluctuations in the mean and variance of temperature series. Recent research suggests that the frequency of extreme events is relatively more sensitive to changes in variability than in the mean, and that this sensitivity is greater the more extreme the event [F7-8]. Consequently, a decrease in variability could offset any increase in mean temperature, and conversely, an increase in variability could lead to more frequent occurrences of threshold or extreme events even with little or no change in mean temperature.

Current Assessment

The impact of climate change on fruit production in the Great Lakes region was recently evaluated using VEMAP data from the CGCM1 and HadCM2 models valid at two locations on either side of Lake Michigan: Eau Claire, Michigan and Sturgeon Bay, Wisconsin. The VEMAP datasets from the corresponding coarse GCM output allowed a downscaling approach to determine more location-specific effects. The evaluation focused on low temperature thresholds including:

1) number of days with temperatures ≤32°F during the calendar year
2) date of last spring freeze (defined as ≤32°F)
3) date of the first fall freeze (also defined as ≤32°F)
4) dates at which 270 (base 41°F) growing degree units (GDUs), an indicator of early bud development, and 540 (base 41°F) GDUs, an indicator of mature bud development, are reached
5) the heat accumulation at the time of the last spring freeze
6) percentage of years with freezing temperatures after 270 and 540 GDU accumulations are reached
7) length of the growing season (defined as the period between last spring freeze and first fall freeze)
8) base 41°F and base 50°F GDU accumulation during the growing season

Assessment Decade 2025-2034 Projections

The values at Eau Claire suggest that in 2025-2034 the growing season will increase by 12-20 days. The HadCM2 scenario points to a later date of first fall freeze as the primary contributor to a longer growing season, whereas the CGCM1 scenario indicates that an earlier date of last spring freeze will be responsible. The scenarios also suggest a 10-14 day decrease in the number of days with minimum temperatures ≤32°F. Plants are expected to reach critical growth stages as much as one week earlier in 2025-2034, and seasonal GDU accumulations are projected to be a substantial 11-23 percent larger than current values. The values for both scenarios are smaller at Sturgeon Bay where a 5-10 day increase in the growing season, a decrease of 2-8 days in the frequency of minimum temperatures ≤32°F, a 7-9% increase in seasonal GDU accumulation, and little or no change in the median dates of 270 and 540 GDU accumulation are projected. At both locations considerable ambiguity surrounds the projected changes in the overall susceptibility of fruit trees to damaging low temperatures. The HadCM2 scenarios suggest that susceptibility will be reduced. The CGCM1 scenarios project greater susceptibility. According to the CGCM1 scenarios, the amount of growth (e.g., heat accumulation) at the time of last spring freeze is greater than at present, and there is a higher probability, especially at Sturgeon Bay, of a freeze after reaching sensitive growth stages.

Assessment Decade 2090-2099 Projections

Large changes in the threshold parameters are suggested by the scenarios for the 2090-2099 decade. Projected changes are considerably greater for the CGCM1 scenarios compared to the HadCM2 scenarios. Also, the projected changes are larger at Eau Claire than at Sturgeon Bay. The dates of last spring freeze at the two locations are projected to occur between 17-36 days earlier than at present. The projected change in the date of first fall freeze is somewhat smaller, between 4-23 days, depending on which scenario and location. The HadCM2 scenarios suggest that critical growth stages will occur 11-16 days earlier, whereas the CGCM1 scenarios suggest a 9-27 day change at Sturgeon Bay and a much larger 41-45 day change at Eau Claire. The HadCM2 scenarios project that seasonal GDU accumulations at the two locations will be 20% larger than present-day values, and the CGCM1 scenarios project a 50% increase. Similar to the 2025-2034 period, the projections of overall susceptibility to cold damage are contradictory with the HadCM2 scenarios for the two locations suggesting less susceptibility and the CGCM1 scenarios suggesting greater susceptibility.

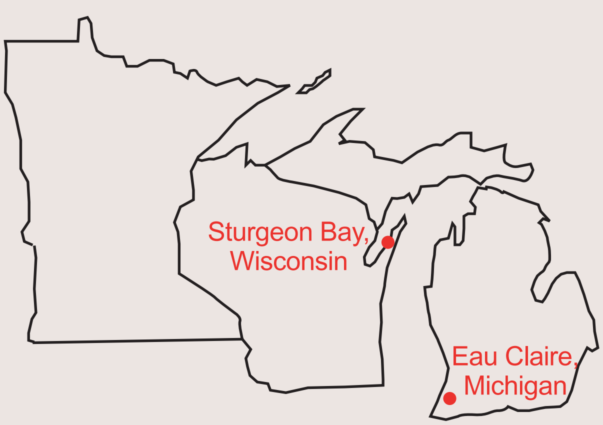

Figure F7.1: Recently evaluated VEMAP data using the CGCM1 and HadCM2 models at two locations: Eau Claire, Michigan and Sturgeon Bay, Wisconsin.

Summary

The analyses presented above for the period 2025-2034 suggest that the fruit-growing regions surrounding Lake Michigan will experience a moderate increase in growing season length and seasonal heat accumulation, and a decrease in the frequency of subfreezing temperatures. In addition, important growth stages will occur earlier in the calendar year than at present. Very large changes in the threshold parameters are projected for the period 2090-2099, especially for the eastern shore of Lake Michigan. However, it is unclear for both periods whether fruit production will be more or less susceptible to damage from low temperatures after critical growth stages are reached. The projected changes in the threshold parameters presented here should be interpreted cautiously as the type of downscaling methodology and the GCM simulation to which the methodology is applied introduce considerable uncertainty into assessment studies. Generally, the projected changes for the stochastically-derived HadCM2 and CGCM1 scenarios are smaller than the changes projected by alternative scenarios [F7-9, F7-10].

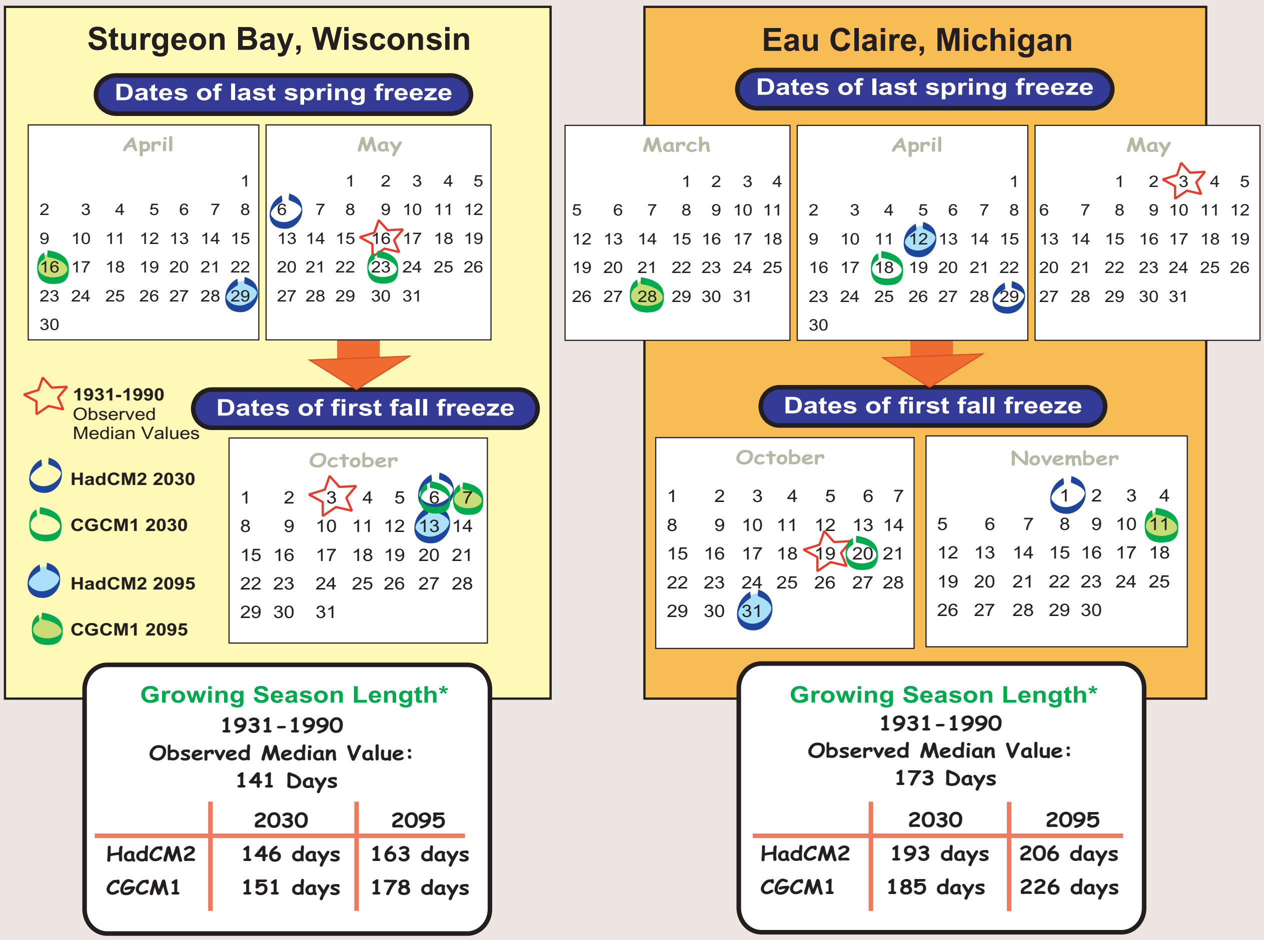

Figure F7.2: Median values of temperature threshold parameters for Sturgeon Bay, Wisconsin and Eau Claire, Michigan for the assessment decades of 2025-2034 and 2090-2099. Differences were calculated between the assessment decades and a control period of 1994-2003. These differences were then compared to the observed median values for 1931-1990.

** Growing season length was calculated for each year separately, and the median value was determined from the values for each year. Consequently, the change in the growing season length does not necessarily equal the sum of the change in the dates of last spring freeze and first fall freeze.*