# Annual Chill Unit Accumulation in the U.S.[1]

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The effectiveness of different temperatures in overcoming the wintertime physiologic state of dormancy (rest) of temperate zone fruit plants has been described (2, 3, 6). Through controlled refrigeration experiments, temperatures between 3°C and 10°C were determined to be the most chill efficient, temperatures above 15°C reversed the chilling process, and freezing or near freezing temperatures were ineffectual. The term, chill unit, expresses this time-effective temperature relationship and is defined as: 1 hour × a coefficient of the chilling efficiency of the mean hourly temperature. The optimum temperature has a coefficient of 1.0, ineffective temperatures have a zero coefficient, chill reversing temperatures have a —1.0 coefficient and intermediate temperatures are assigned intermediate, fractional, coefficients. Subsequently, the rest requirement of many deciduous fruit species were defined in terms of chilling units (4, 5).

Using this model (2) and summarized meteorologic data (1), chill unit accumulation maps for the continental United States were plotted (Figures 1-5). No isopleths were plotted in the western mountains due to lack of data and substantial, elevation-dependent, local climatologic variation. Chill accumulation for major mountain cities can be determined by artificially con-

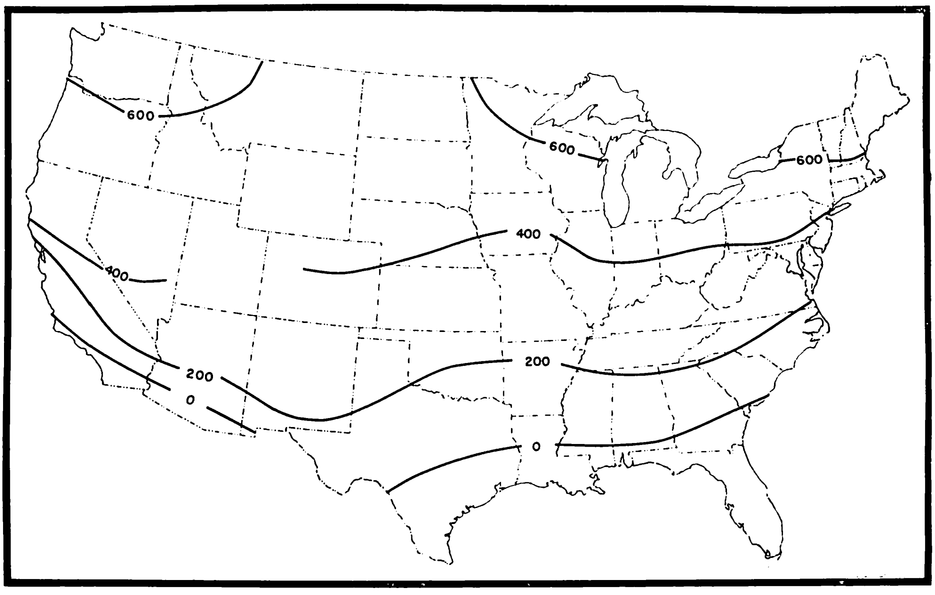


**Figure 1. Chill Unit Accumulation from September 1 through November 30.**

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necting the disjunct isopleths with the shortest line possible and then extrapolating. The model was modified slightly; the optimum chilling range was extended to 2°C (1°C lower) because these temperatures were very efficient at overcoming the rest of apple (6). Temperatures between 10° C and 18°C were assigned values of zero as the slight positive and negative accumulation at these temperatures were compensatory.

Two general effects determined the pattern and total accumulation of chill units for any particular area. The primary effect was due to latitudinal variation. In the south and in coastal regions, chill unit accumulation was determined by the distance from the equator. Almost all stations reported chilling temperatures but, in peninsular Florida and southern Texas, these were offset by chill-negating temperatures. No chill effective temperatures were experienced in San Juan, PR or Honolulu, HI. The secondary determinant of chill unit accumulation was the climate-modifying effects of mountain ranges and large water bodies. Increased elevation in southern areas decreased temperatures and added chill units. In northern areas, mountain temperatures fall below that optimum for chilling for long periods in mid-winter. There, fall and spring chill accumulation was comparable to nearby areas; however, winter accumulation was much reduced. A similar situation occurs when comparing chill accumulation in the northern Great Plains and the Great Lakes. Climatic moderation from the large water bodies results in prolonged cooler weather in fall and spring, and more moderate, above freezing weather in mid-winter. Both conditions result in greater accumulation of optimum chilling temperatures, and almost no chill-negating temperatures. Without temperature modification, large daily

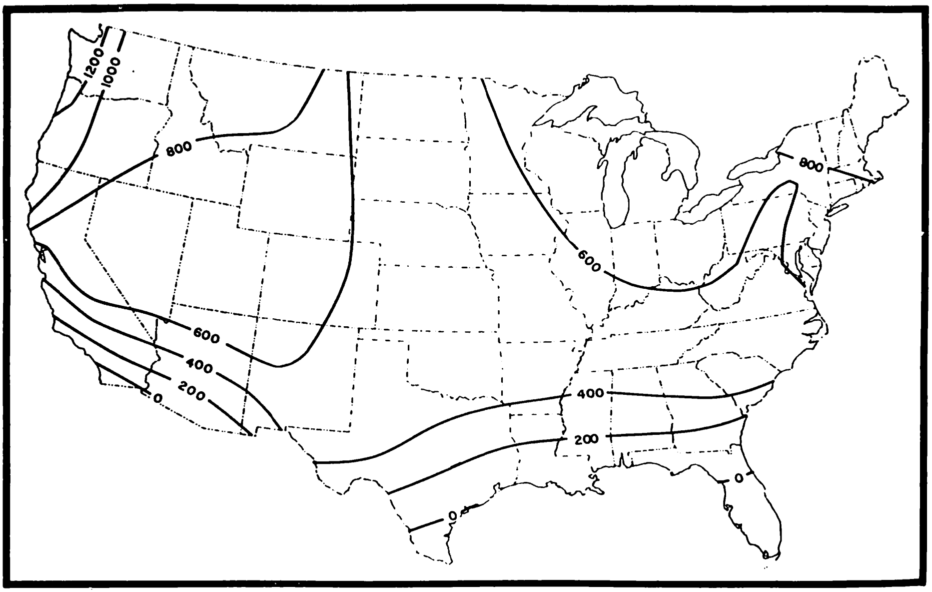


**Figure 2. Chill Unit Accumulation from September 1 through December 31.**

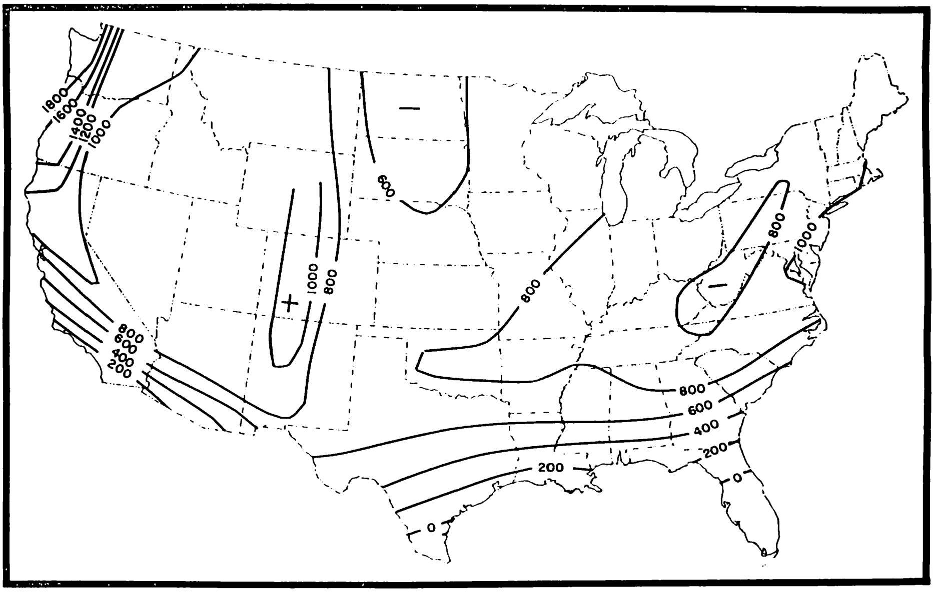


Figure 3. Chill Unit Accumulation from September 1 through January 31.

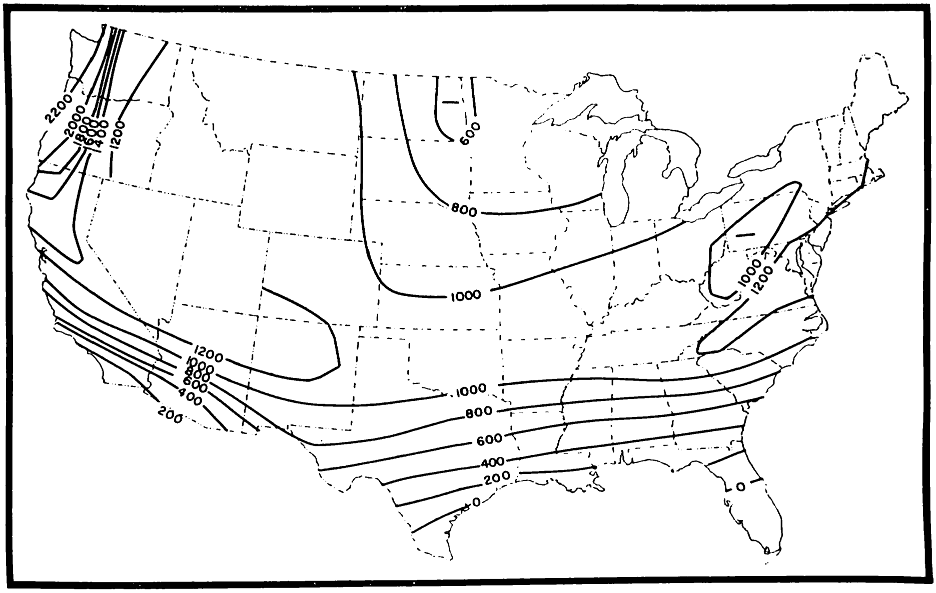


Figure 4. Chill Unit Accumulation from September 1 through February 28.

temperature fluctuations during the fall and spring result in a slightly decreased accumulation of chilling units. In addition, mid-winter temperatures in the Dakotas and surrounding states seldom exceed the freezing level and little chilling is accumulated in January and February. Thus, chill unit accumulation in Atlanta, GA exceeds that of Fargo, ND. Annual accumulation of similar stations reporting ≤ 1500 chilling units and north of 35° parallel, typically have this bimodal, fall and spring pattern of accumulation. In coastal areas, the accumulation is less distinctly bimodal as chilling units accumulate in mid-winter. In the Pacific northwest, as in the south, accumulation inversely parallels the movement of the mean daily temperature.

## Literature Cited


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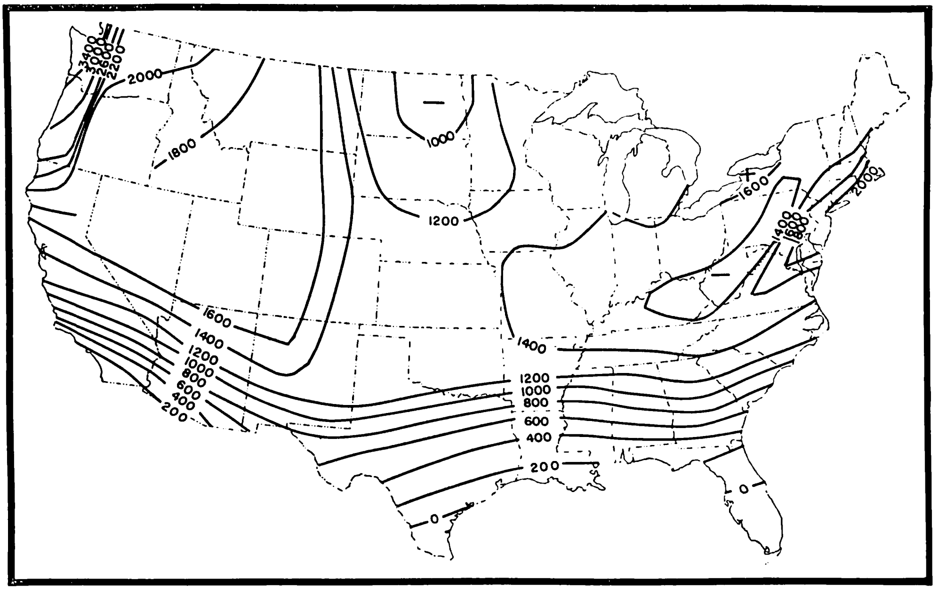


**Figure 5. Annual Chill Unit Accumulation for the United States. Fairbanks AK. = 997 units, Anchorage AK. = 1897 units.**