Sustainable Management of Tree Fruit and Nut Crops in the Face of Climate Change

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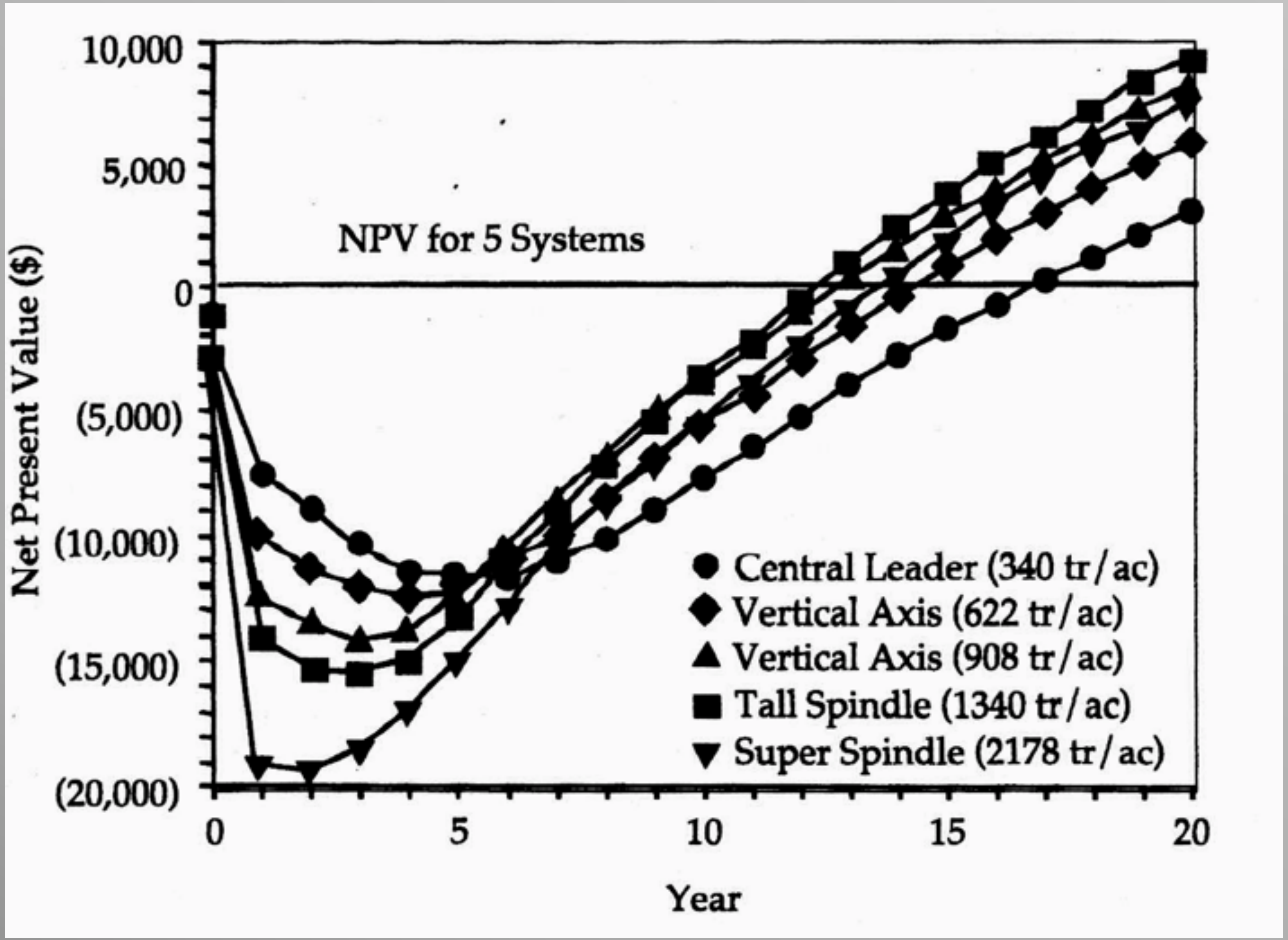
Fruit Trees are "Permanent" Crops

- Cannot take a year off from farming.
- Cannot easily move to a different place.
- Have a long establishment period (years).



Robinson et al., 2007

Effect of Increased CO_2 on Trees

http://face.ornl.gov/expdes.html

FACE Facility at Oak Ridge National Lab, Oak Ridge, Tennesee

- Higher photosynthesis rates
- Reduced stomatal conductance and transpiration.
- Higher light use efficiency and water use efficiency.
- More fruit, thicker trunks, more branches, total biomass.
- Insufficient N uptake (short term?).
- Starch/sugar accumulation→ feedback inhibition of photosynthesis?

Climate Change and Fruit Trees: Water/Irrigation

- Hotter days and longer seasons → increased evapotranspiration.
- Decreased precipitation → insufficient irrigation→ water stress and salinity

Climate Change and Fruit Trees: Chill Requirements

- Temperate fruit trees require exposure to a certain duration of cold temperatures in order to break "endodormancy".
    - Amount of chilling necessary depends on species and cultivar

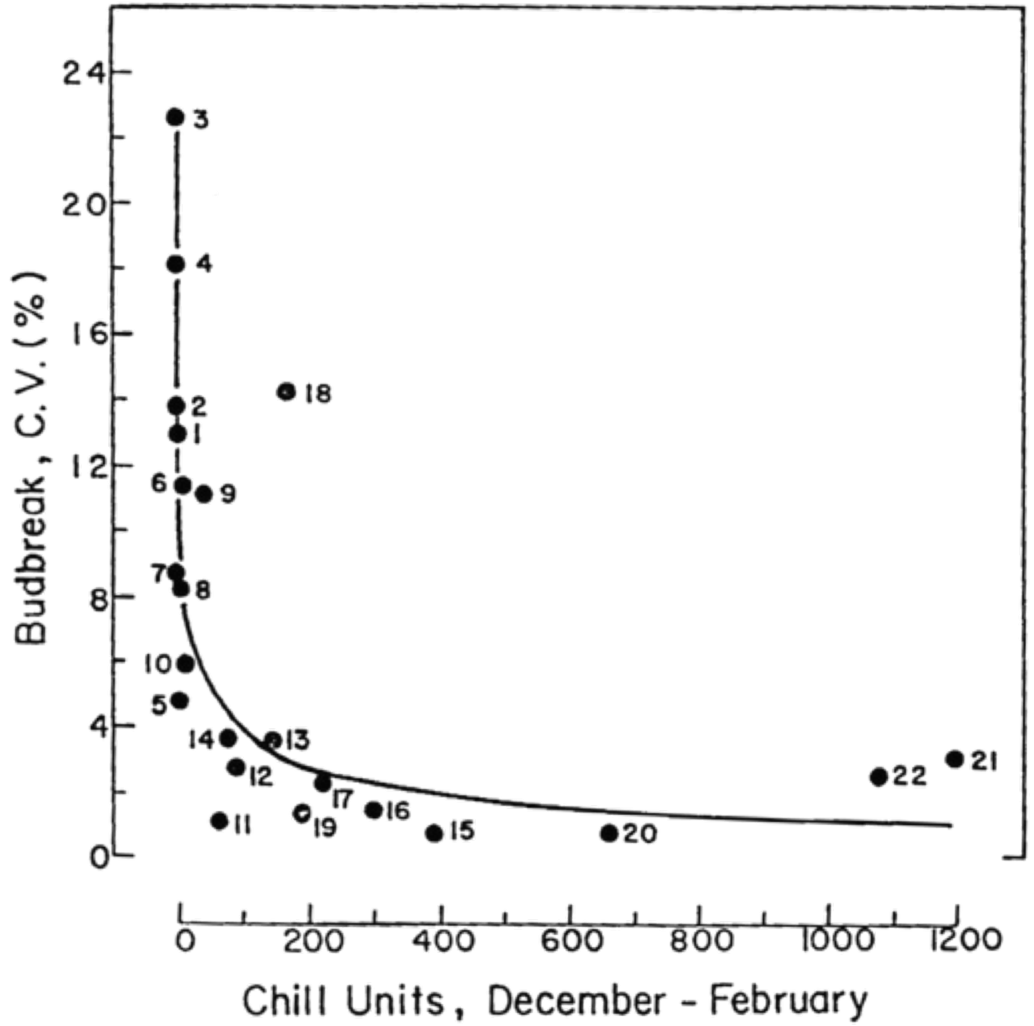


Fig. 2. Variation in budbreak among cultivars at different geographical locations as influenced by amount of chilling received during the preceding winter, base 39°F. The colder the winter, the greater the tendency of cultivars to break together. Variation in budbreak was calculated as coefficient of variation. Numbers within figure designate location and year. 1-4 = Roodeplaat, S. Afr., 1981-1984; 5-10 = Visalia, Calif., 1982-1986, 1988; 11 = Griffin, Ga., 1916; 12-14 = Watkinsville, Ga., 1989-1991; 15 and 16 = Stillwater, Okla., 1972 and 1976; 17 = Sparks, Okla., 1976; 18 = Shreveport, La., 1977; 19 = Stoneville, Miss., 1986; and 20-22 = Lincoln, Neb., 1987-1989. From Sparks (1992b).

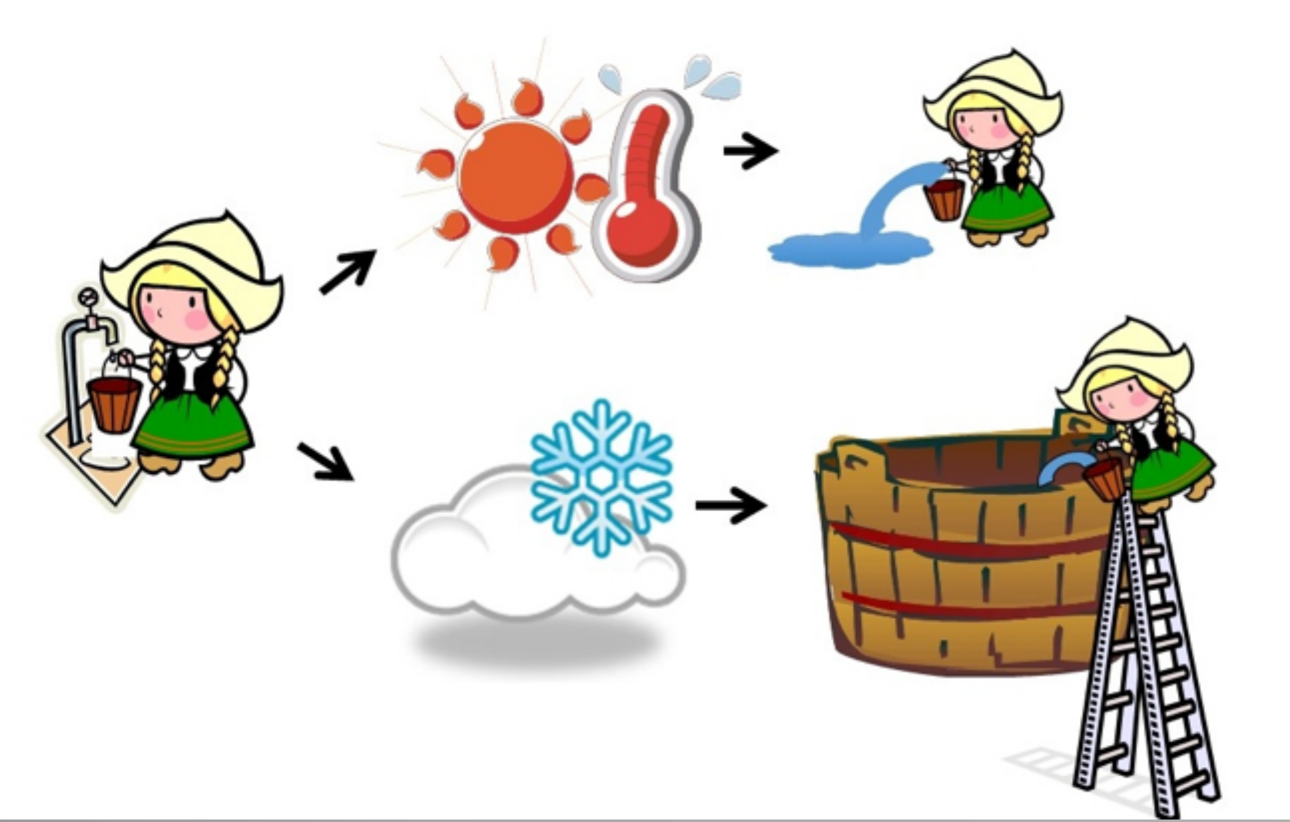
Source: Sparks, 1992.

Chill Requirements:
Models for quantifying winter chill:

- Chilling Hours Model
  - Hours 32-45°F (0-7°C)

- Utah Model
  - 1 hour below 34°F = 0.0 chill unit
  - 1 hour 35 - 36°F = 0.5 chill units
  - 1 hour 37 - 48°F = 1.0 chill units
  - 1 hour 49 - 54°F = 0.5 chill units
  - 1 hour 55 - 60°F = 0.0 chill units
  - 1 hour 61 - 65°F = -0.5 chill units
  - 1 hour >65°F = -1.0 chill units

The Dynamic Model / Chill Portions Model



http://thealmonddoctor.com/wp-content/uploads/2015/01/FillingTheChillTank.jpg

Luedeling et al, 2009

Chill Requirements

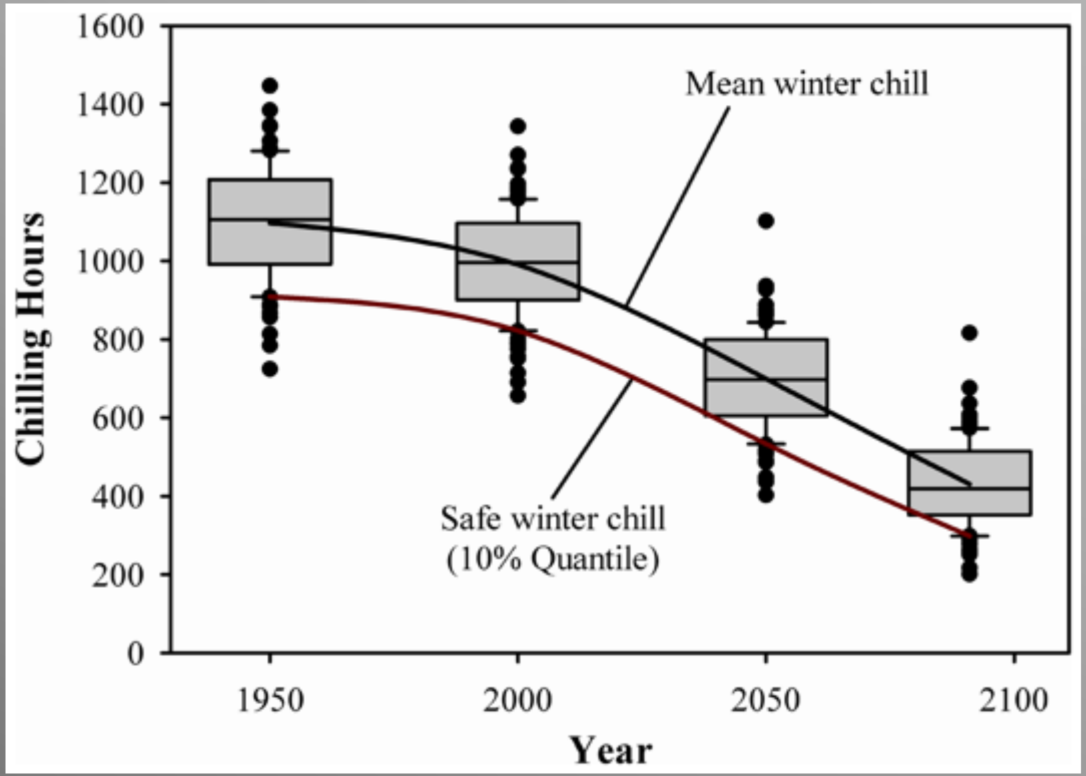


Figure 2. Distribution of annual winter chill estimates (in Chilling Hours) for Davis, CA, based on 100-year synthetic weather records for each point in time.

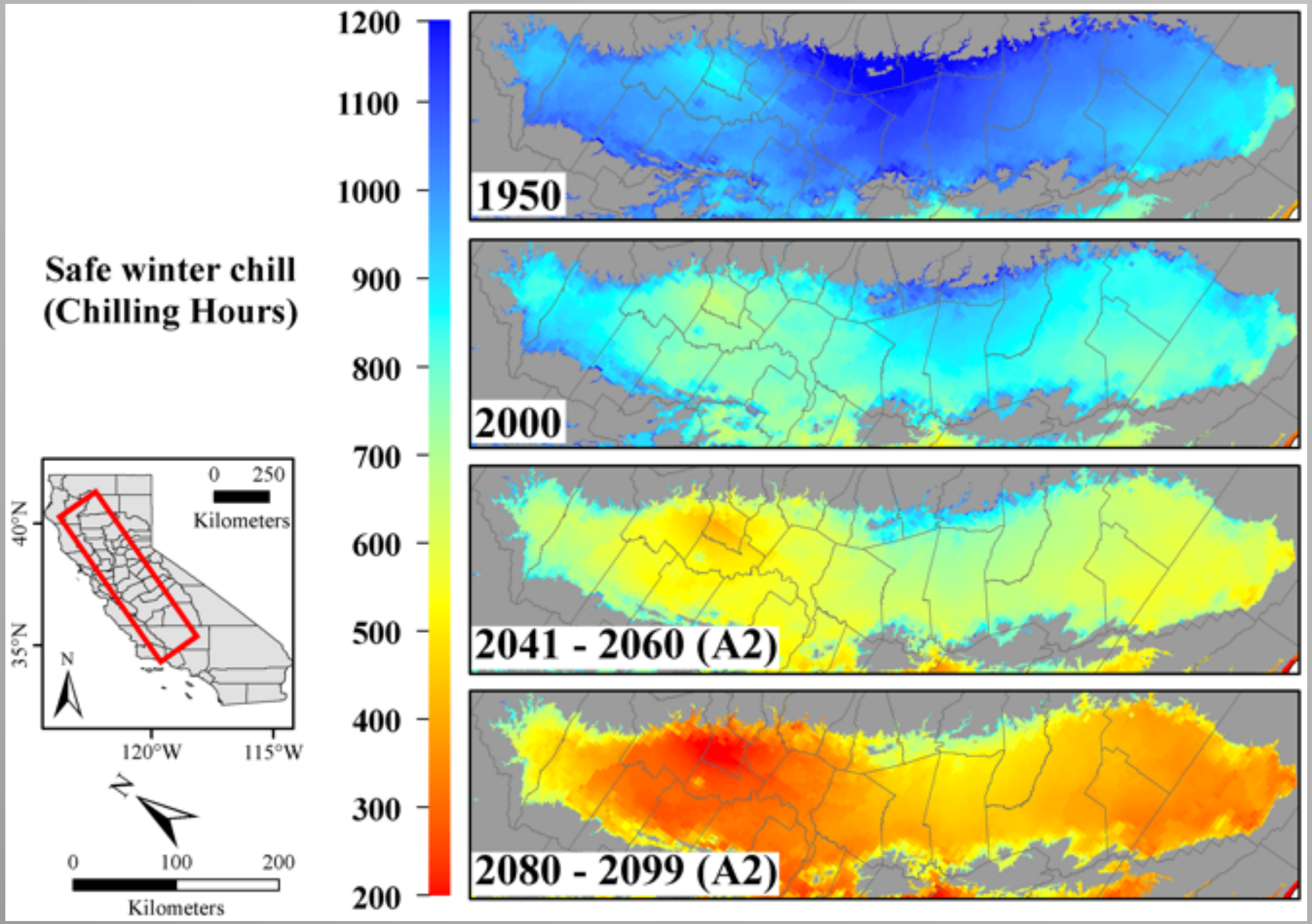


Figure 3. Safe winter chill in California's Central Valley in 1950, 2000, 2041–2060 and 2080–2099, calculated with the Chilling Hours Model.

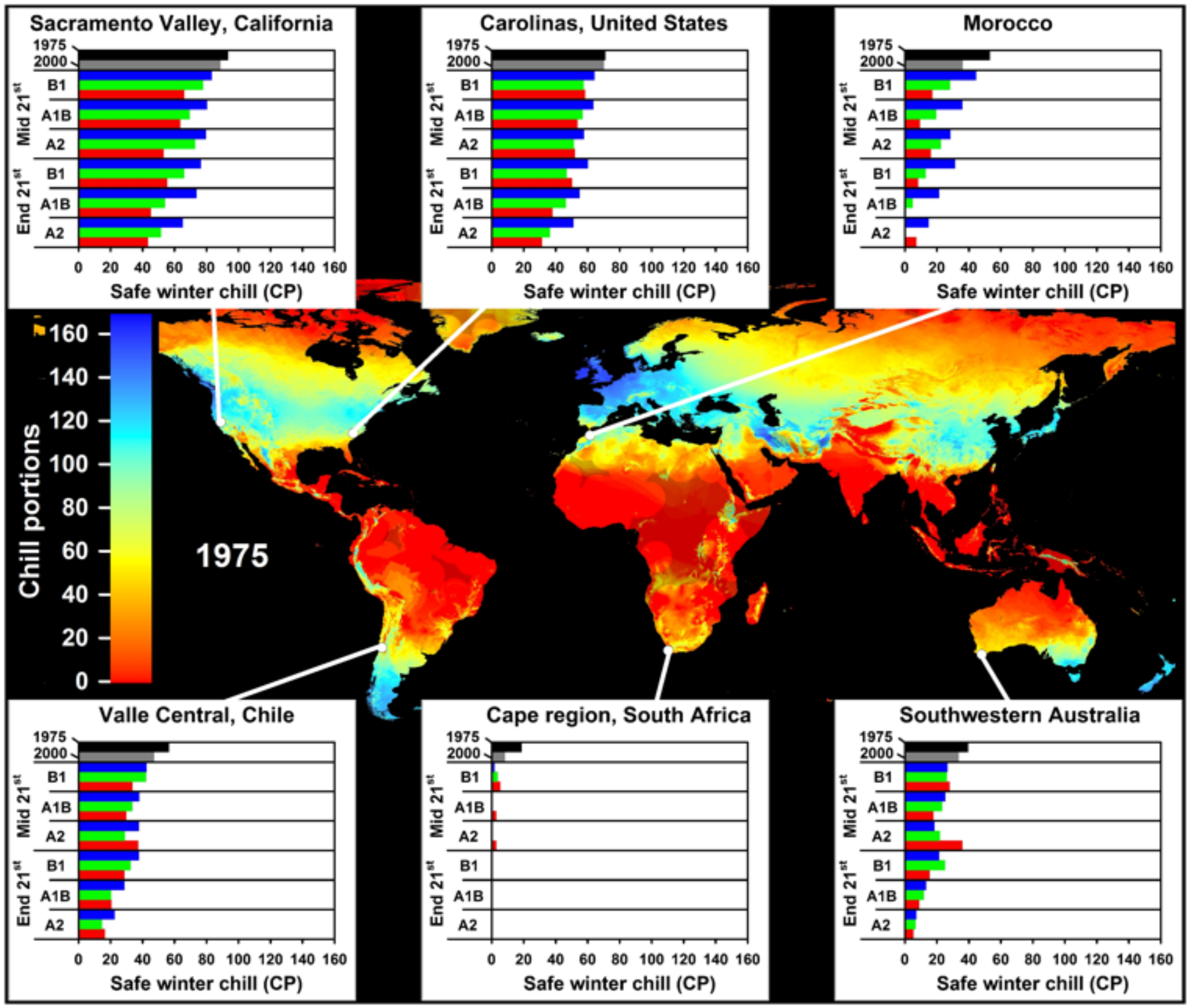


Figure 1. Modeled Safe Winter Chill around the year 1975 (large map), as well as site-specific estimates of Safe Winter Chill for six growing regions and for 20 climate scenarios, representing four points in time (1975, 2000, mid and end 21st century).

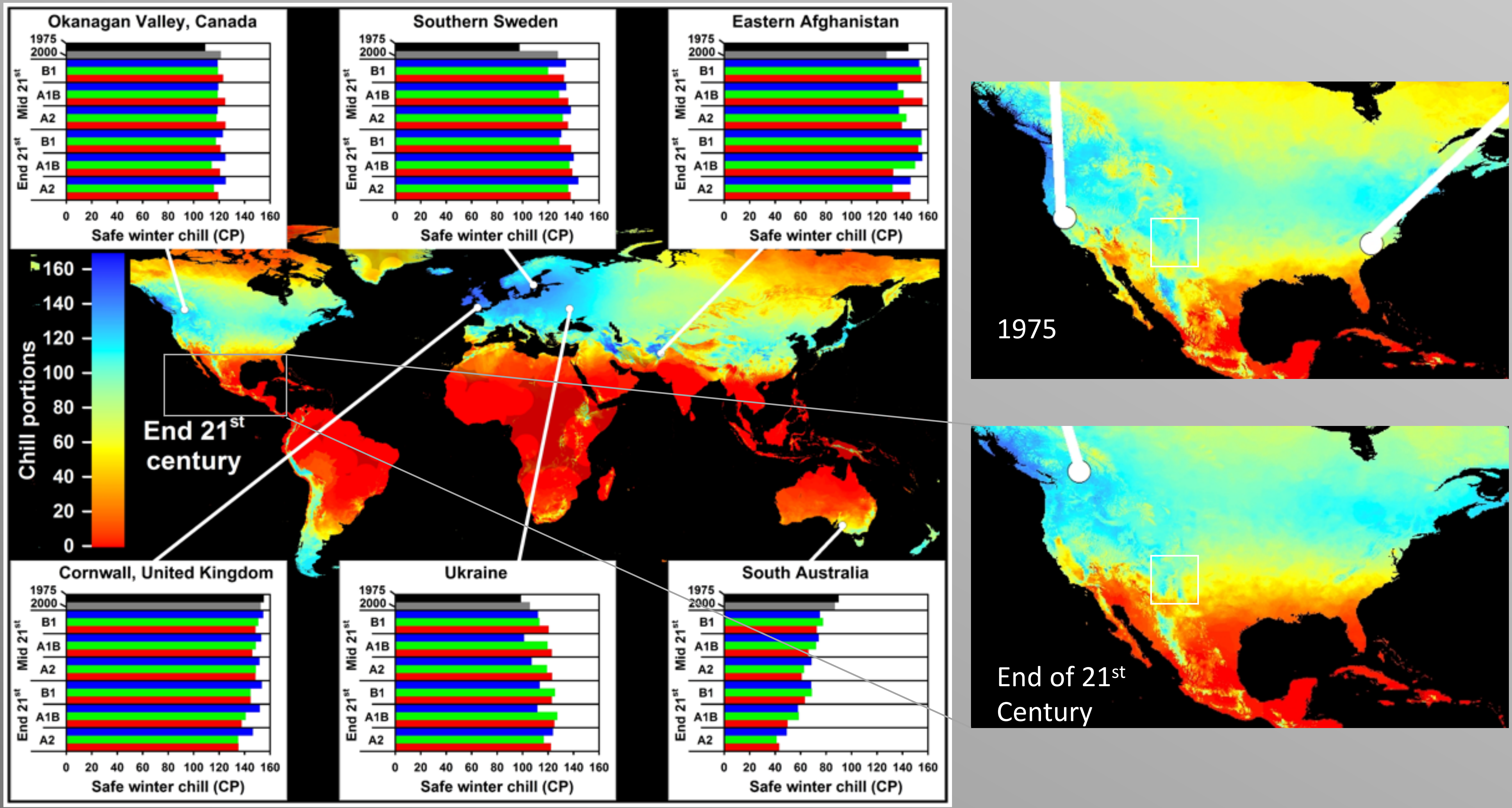
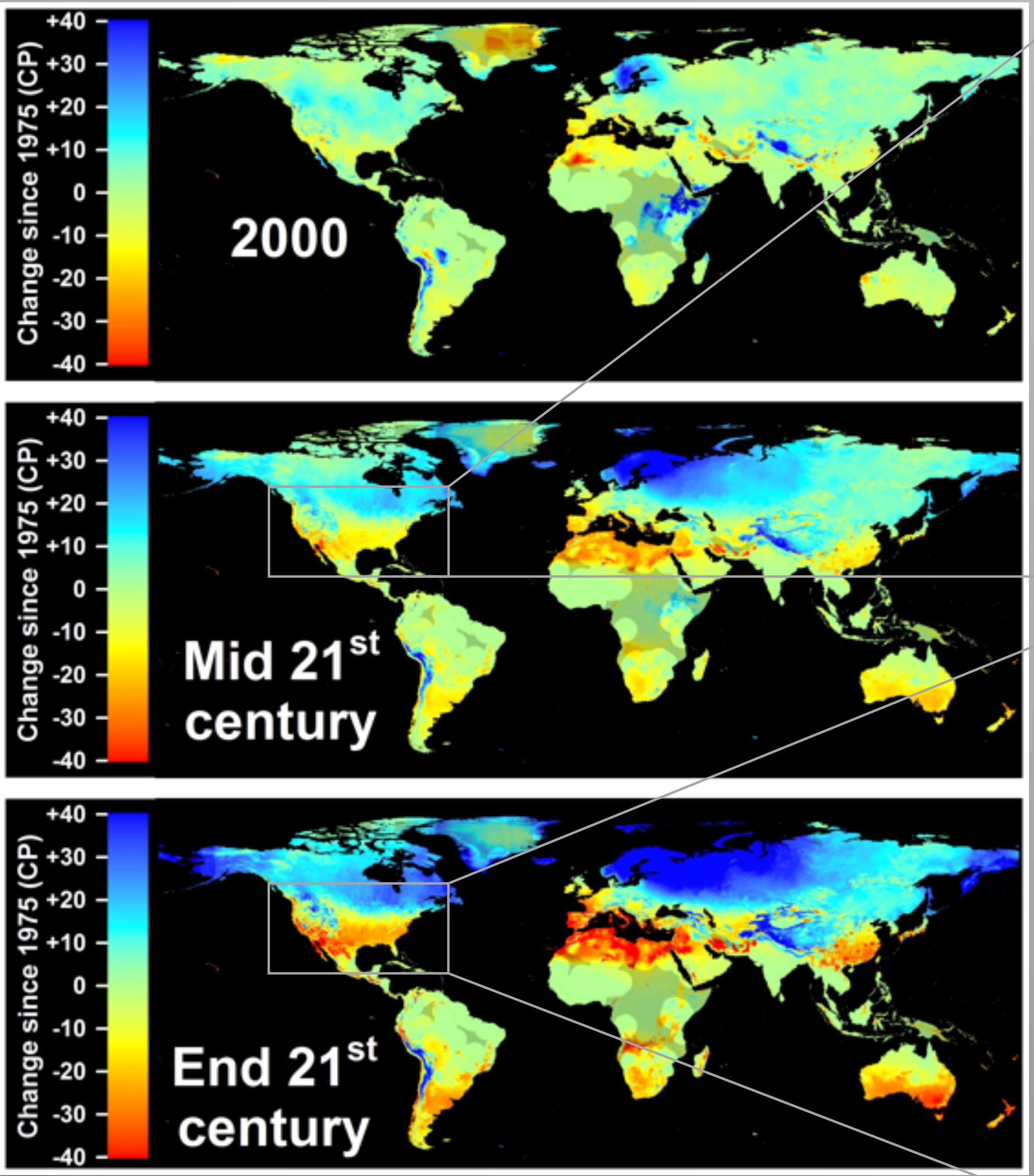


Figure 4. Modeled Safe Winter Chill around the end of the 21st century averaged over three greenhouse gas emissions scenarios and three Global Climate Models (large map), as well as site-specific estimates of Safe Winter Chill for six growing regions and for 20 climate scenarios, representing four points in time (1975, 2000, mid and end 21st century).

Luedeling et al, 2011



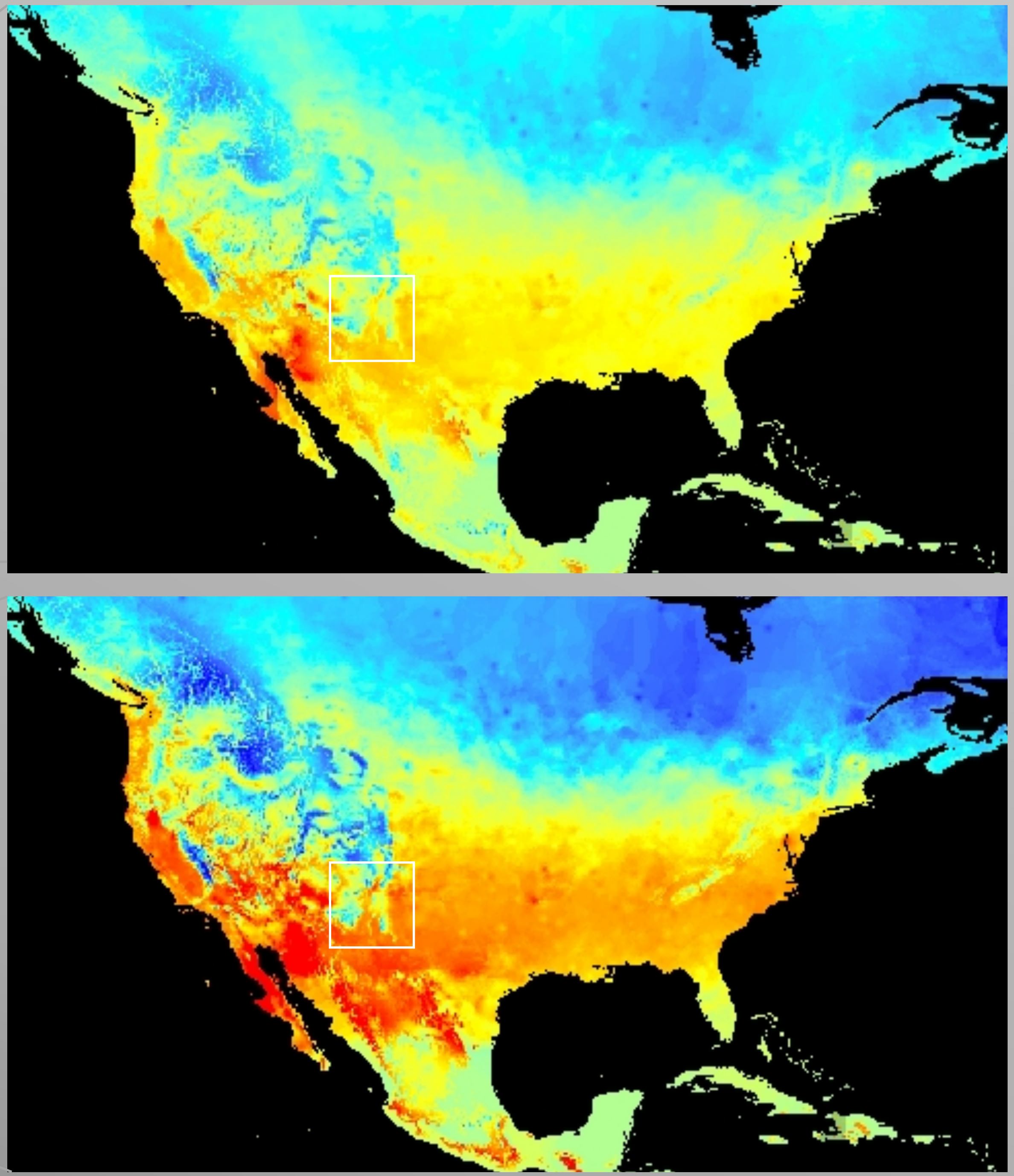


Figure 5. Modeled and projected losses in Safe Winter Chill compared to 1975 for the year 2000 (top), the middle of the 21st century (middle), and the end of the 21st century (bottom).

Orchard Management Options with Insufficient Chilling: Species/Cultivar Choice

Species with low typical chill requirements



http://aces.nmsu.edu/pubs/_h/H310/welcome.html


Very Low Chill Apple Varieties

'Ein Shemer'

'Anna'

https://www.willisorchards.com/product/ein-shemer-apple-tree#.WDwyHlesniA

https://www.willisorchards.com/product/anna-apple-tree#.WDwy81esniA

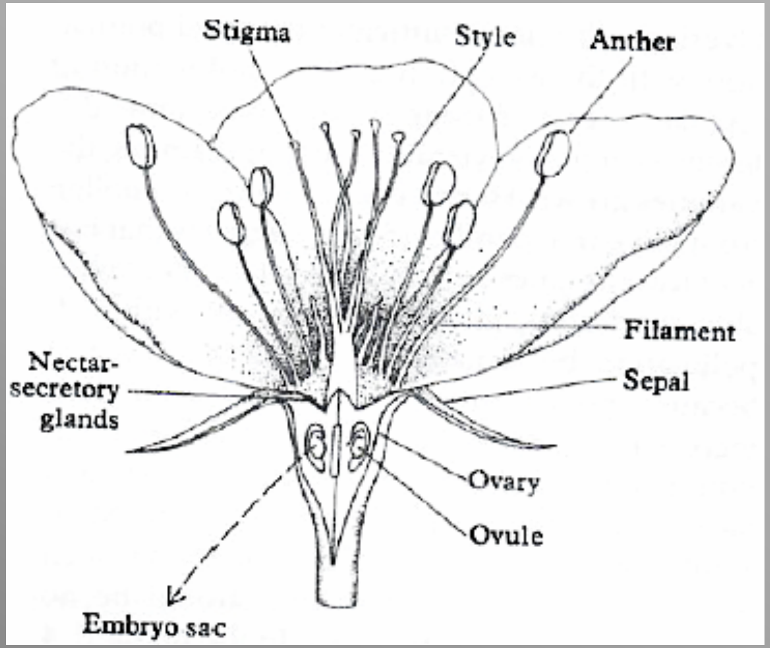
Orchard Management Options with Insufficient Chilling: Rest-Breaking Chemicals

- Hydrogen cyanamide (Dormex). Treatments are applied about 1 month before normal bud break. Can advance bloom as much as two weeks. Labeled for apples, grapes, blackberries, cherries, and peaches. Used in low-chill areas of Mexico (not New Mexico!) for pecans.
- Calcium ammonium nitrate (CAN 17) and potassium nitrate. CAN17 used in cherries. Less effective in than Dormex.
- Spray oils. Much less effective than other available materials.
- Garlic paste and garlic oil (Kubota and Miyamuki, 1992)– research in grapes
- Cyanogenic glycosides– research?

Orchard Management Options with Insufficient Chilling: Kaolin Clay

- Spraying dormant tree with kaolin clay (Surround).
  - White color reduces heat absorption by buds.

Pollination and the Effective Pollination Period

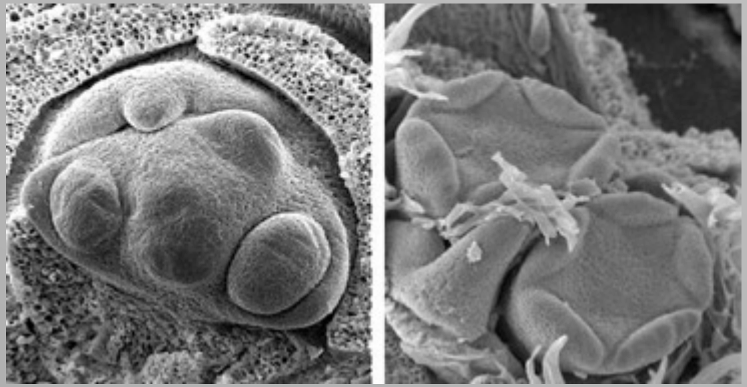


Westwood, 1993.

- Temperatures may affect pollinizer cultivars differently than main varieties.
- Temperatures affect the activity of pollinator insects in orchards.
- Increased temperatures decrease the receptive period of stigma and ovule receptivity, but increase the growth rate of pollen tube growth.

Fruit Doubling and Spurring in Cherry

- Hot weather during cherry flower differentiation period (July-August), leads to increased doubles and spurs



http://www.goodfruit.com/the-causes-and-cures-of-doubling/

- Managed through cultivar selection, over-tree cooling (sprinkling), or Surround.

http://www.goodfruit.com/cooling-can-reduce-cherry-doubles/

Pre-Germination (Vivipary) in Pecan

- High temperatures in autumn increases pre-germination.
- Managed by “green-harvest”.

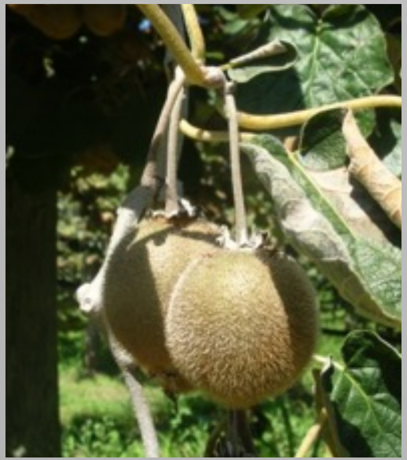
Pests & Diseases

- Shift in occurrence and duration
  - Timing and number of generations (e.g., codling moth and pecan nut casebearer)
- Change in severity of certain diseases.
  - Both temperature and rainfall may be factors (e.g., fireblight)

Questions?







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