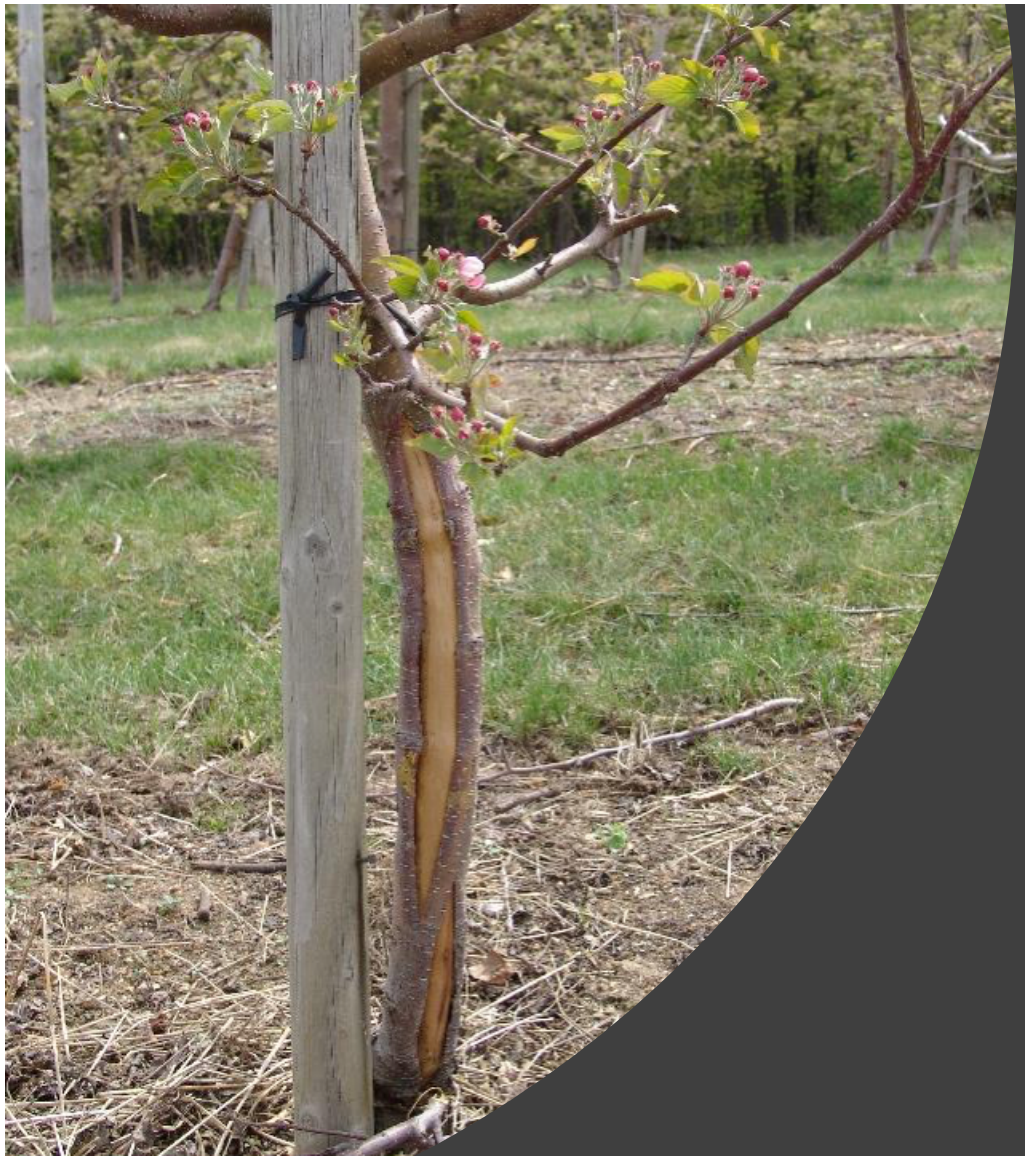

Winter injury – the extension educators answer to everything

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Tree Fruit IPM

What we need to understand

- Acclimation, dormancy, and freezing
- What is cold hardiness anyway?
- Types of winter injury
- What can we do?

Winter injury – cambium vs. floral differences

Dormancy

Ecodormancy	• Growth inhibited by environmental factors, typically temperature but sometimes water and nutrient stress
Paradormancy (ectodormancy)	• Growth inhibited by internal physiological factors outside of the plant organ, such as an apical bud suppressing growth of basal buds (apical dominance); ex., pinching basal to increase branching
Endodormancy	• “True dormancy” where growth is inhibited by internal physiological factors within the organ, such as chilling requirement.

What is cold hardiness?

THE ABILITY OF PLANT TISSUES TO WITHSTAND EXTREMES IN COLD TEMPERATURES.

A COMPLEX PHYSIOLOGICAL PROCESS THAT BEGINS IN EARLY FALL, AND PROGRESSES UNTIL BUD BREAK IN THE SPRING.

Cold hardiness

- Enables plants to withstand winter cold
- Related to dormancy/winter rest (endodormancy)
- Gain hardiness in sub--freezing conditions
- Lose hardiness in warm weather
- Lose hardiness faster than they can regain it!

Cold hardiness of shoots and buds

- Shoots generally more cold hardy
- Water freezes in shoots/bud scales
  - Ice pulls water from cells
  - Concentrates solution in cells
  - Lowers freezing point of cells
- Eventually, however, cells “freeze” and structure/function damaged

Cold hardiness of flower buds

- Genus and variety dependent
  - Peach -10 F
  - Cherry -15 F
  - Apple and pear -25 to -30 F
- Not as much information on shoot/leaf hardiness
- Flower buds freeze individually, range of sensitivity
- Terminal flower buds more vulnerable than lower

Fruit Type	Critical Temp (F) for flower injury
Apple	-30
Apricot, Pear, Concords	-25
Blueberries	-25
Tart Cherry	-20
Raspberry	-17
Thorny Blackberry	-15
Plum, Sweet Cherry	-15
Peach & Nectarines	-13
European Grapes	-8 to -15

“Cold hardiness” depends…

- When low temperature occurs (early vs. mid-- or late--winter)
- How fast the temperature drops
- Temperatures preceding cold temperature
- Length of sustained cold temperature

How does it happen?

Progressively cooler temperatures in the fall signal the plant tissue to move water from inside their cells into the spaces between cells.

Some of this water is lost through transpiration, but what remains in the intercellular space eventually freezes into ice crystals.

Crystals formed in this space do not damage the cell, but crystals forming inside the cell kills it by destroying the cell membranes.

Initiation of Dormancy

- Cold acclimation
- Process leading to development of freezing tolerance in plants
- Short photoperiod
- Warm days; cool, non-freezing nights
- Exposure to sub-freezing temps (10 degrees F more cold hardy than before freeze)
- Maximum cold tolerance follow exposure to temperatures approaching ZERO degrees F.

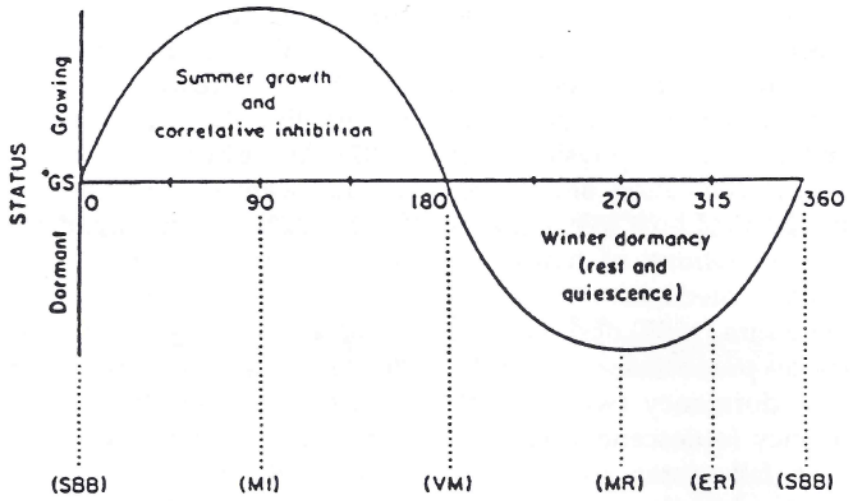
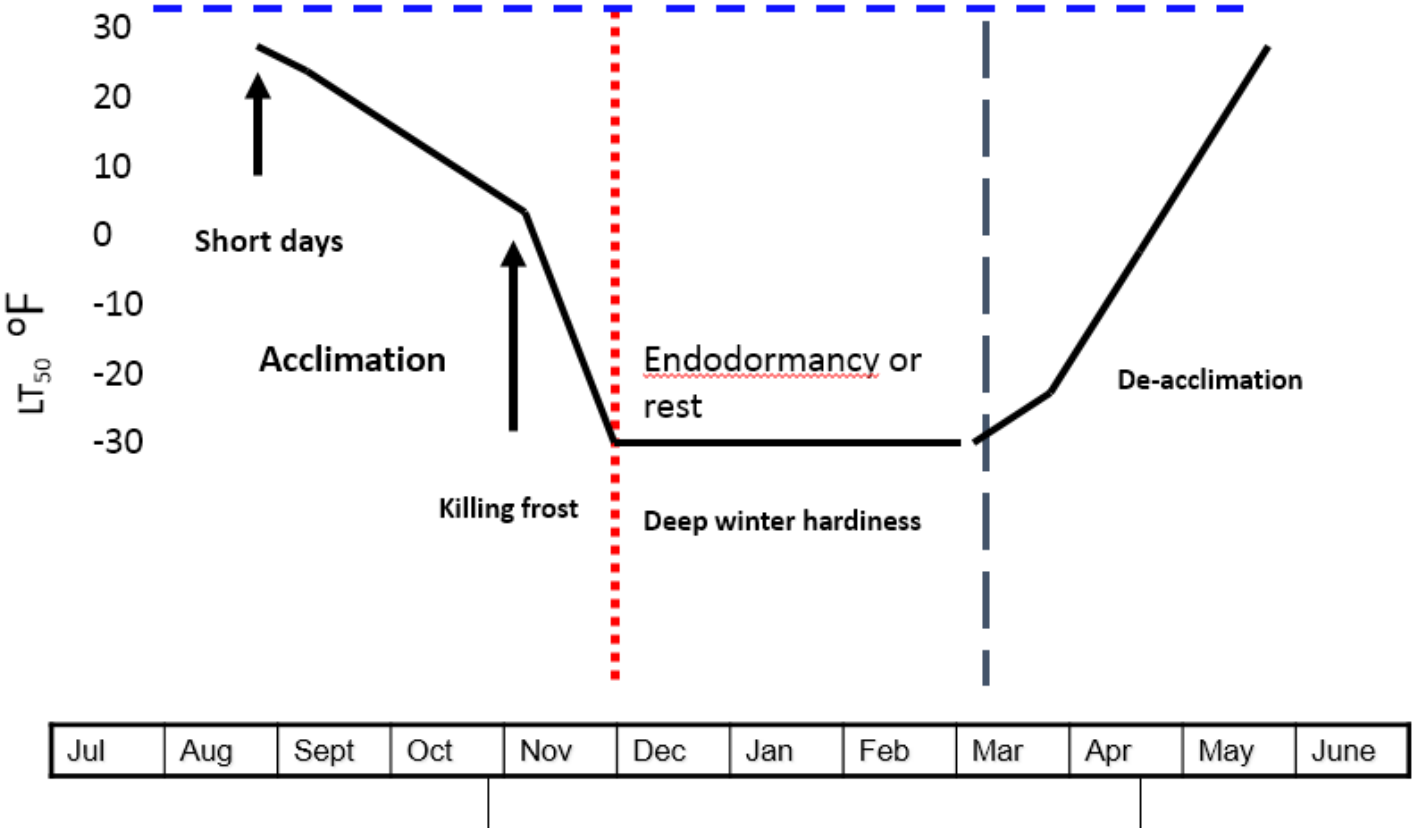


Figure 16-1. Diagram of degree growth stage (°GS) model for identifying developmental stages of terminal vegetative buds of temperate zone woody plants. Growth stages indicated: spring bud break (0–360°GS), maturity induction point (90°GS), vegetative maturity (180°GS), maximum rest (270°GS), and end of rest (315°GS). [After Kobayashi et al. 1983.]

How fast does it happen?

- Accumulation of cold hardiness is a slow process, and as temperatures get colder, tissues increase their cold hardiness.
- The maximum hardiness is reached in mid-January.

Cold Hardiness in Fruit Trees



Winter injury most often occurs…

- Extreme low temperature
- Low temperatures following warm temperatures
- Fall, early hard cold before plants are acclimated
- Warm up during winter (loss of cold hardiness)
- Cold snap after spring warm--up, loss of dormancy and cold hardiness

What are some factors that affect cold hardiness?

- tree health
- temperatures
- species/cultivar
- plant anatomy
- pruning

What are some factors that affect cold hardiness?

Tree health -

- Lack of vigor
- Too much vigor
- Avoid:
  - Moisture stress
  - Overcropping - Heavy crops in particular can reduce reserves (sugars) available and reduce cold hardiness (particularly if incomplete harvest)
  - Late season over-irrigation
  - Excessive or late fertilizer applications
  - Pruning in late fall or immediately before temperatures drop, or
  - Pruning sensitive trees in winter (ie. apricot, peach and nectarine)
- Trees that have undergone recent pruning may be more susceptible to midwinter deep freeze damage - avoid pruning immediately before temperatures drop and delay pruning your most valuable trees until the risk of severe cold is past.

Cold hardiness and stress

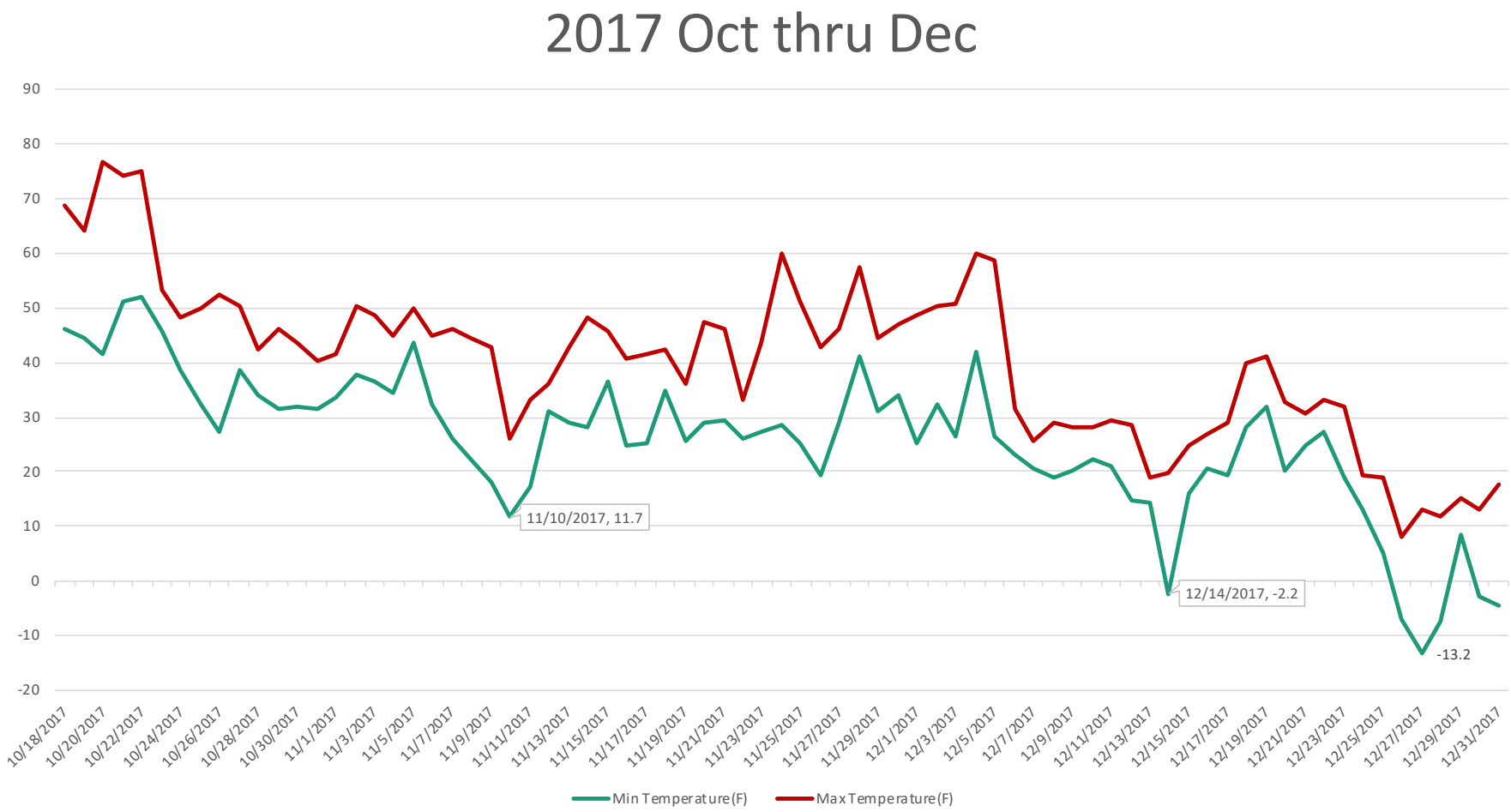
- Stressed plants can gain cold hardiness faster than normal; for example, drought stress
- BUT, stressed plants have less sugars and cannot withstand as much cold

What are some factors that affect cold hardiness?

Temperature -

- Cold hardiness of a plant varies depending on:
  - Severity/duration of the cold event
  - When it occurred
  - How quickly the temperatures dropped
  - How long the temperatures were sustained
  - Temperatures leading up to the cold event
- Every cold event is fairly unique and a tree may be affected differently by different cold events.

Weather Extremes



What are some factors that affect cold hardiness?

Temperature -

- Each tree has a minimum temperature that they can withstand
- Temperatures around -25°C to -28°C (-13°F to -18.4°F) make many growers nervous (especially Asian/Japanese plum, and peach/nectarine).
- Temperatures below -29°C (-20.2°F) worry all fruit growers.
- Widespread extreme winter cold damage doesn't occur frequently, and was last reported with the Michigan fruit industries in 1993/94, when temperatures fell below -29°C.

What are some factors that affect cold hardiness?

Temperature -

- When fruit trees are approaching their chilling requirements, the trees remain hardy as long as the temperatures remain fairly cold.
- In late winter when the chilling requirements for the fruit tree have been satisfied, trees begin to lose their ability to re-acclimate.
- As a result fruit trees may be more susceptible to winter injury following warm periods in mid and late winter when temperatures rise, and this is often when winter injury occurs.

What are some factors that affect cold hardiness?

Temperature -

- If temperatures have remained consistently low in the days leading up to the freeze the trees should have minimal injury, even in cold temperatures.
- Trees are better able to re-acclimate if temperatures gradually return to "normal" following warm weather, but sudden drops of temperature of 6°C (20°F) or more can cause winter injury can occur.
- The worst conditions are when we have several days above freezing followed by a cold snap with temperatures dropping below -17.8 °C (0°F) .

What are some factors that affect cold hardiness?

Species/Cultivar -

- Cold hardiness varies between species and cultivars.
- Trees grown on the northern limits of their climatic zones (e.g. peaches and nectarines, plums), are less cold hardy in general than trees in the central area of their climatic zones (e.g. apples and some pears).
- Cultivars like Loring peach are less cold hardy than cultivars like Redhaven and Harrow Diamond.

What are some factors that affect cold hardiness?

Plant anatomy -

- Different levels of cold hardiness exist for different plant parts.
- Often flower buds are more susceptible to winter cold injury.

Winter injury – cambium vs. floral differences

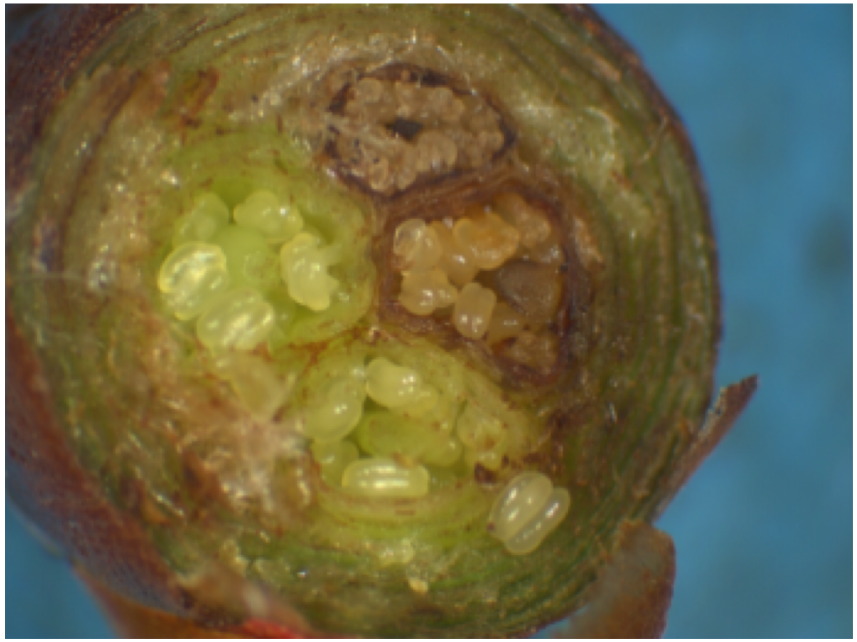


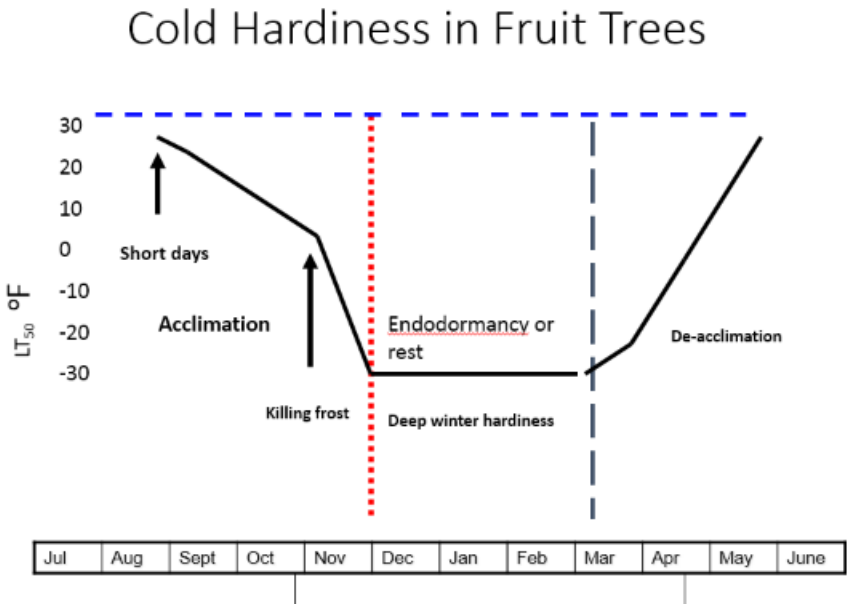
Table 5. Critical temperatures during spring bud development in tart cherry

Bud Stage (a)	Temperature (°F)	
	Possible injury	Severe injury
0 Dormant	-25 to +15 (b)	-30 to 0 (b)
1 First swelling	15	0
2 Side green	24	10
3 Green tip	26	20
4 Tight cluster	26	22
5 Open cluster	28	24
6 First white	28	24
7 First bloom	28	24
8 Full bloom	28	24

(a) See Fig. 4
(b) Wide range, depending on time of year.

How much time does it take for plants to re-acclimate after a warm spell?

- Plants can re-acclimate to the cold - takes longer once they have lost some cold hardiness.
- Cold hardiness can be totally lost over a few warm days
  - process to re-acclimate is much slower
  - achieving only a degree or two of hardiness with each cold day.



What are the symptoms of winter injury?

- Blackheart
- Cambium Injury
- Crotch injury
- Crown or collar injury
- Sunscald
- Trunk splitting (SW)
- Killing back of shoots
- Injury to leaf/flower buds
- Killing of roots

Blackheart

- Fairly common
- Pith killed and heartwood darkened
- Gumming occurs with cell death
- Found in apple, peach, cherry, plum, pear
- Young and nursery trees more affected
- Weakens trunk and branches, but recovery can be rapid in healthy trees

Cambium injury

- Stone fruit/ fast growing apples
- Exacerbated by warm temperatures preceding and fact that cambium is last to harden off
- Results in weakening of tree, secondary infection by fungi, canker
- Gumming often a symptom

Crotch injury

- May be last area to harden off
- Upright limbs with narrow crotch angles most likely to be cold injured
- Injury may extend up and down the limb
- Cultivar susceptibility??

Crown/collar injury

- Winter killing of bark near ground
- May be late hardening off
- Cultivar/Rootstock sensitivity

Winter sunscald

- Commonly known as southwest injury
- Trunk heats during sunny day, followed by rapid drop in temperature with sunset
- Peach with lower branches may be less at risk (vs. apple)
- White latex paint is advised

Trunk splitting

- More common on sweet cherry and apple
- Occurs most often in late fall, early winter with rapid temperature drop
- Splitting/cracking can extend all the way to pith
- May or may not close up/heal over
- “Beginning of the end” with stone fruit

Shoot death/die-back

- Most likely with very cold weather when tree has not fully acclimated/hardened-off
- Seen more often in young trees
- Watch nitrogen fertilization, late pruning
- Effect similar to a heading cut

When do symptoms appear?

- When temperatures rise above freezing and tissues thaw.
- Summer heat and water stress

Xylem tends to be the weak link in most temperate zone tree fruit species

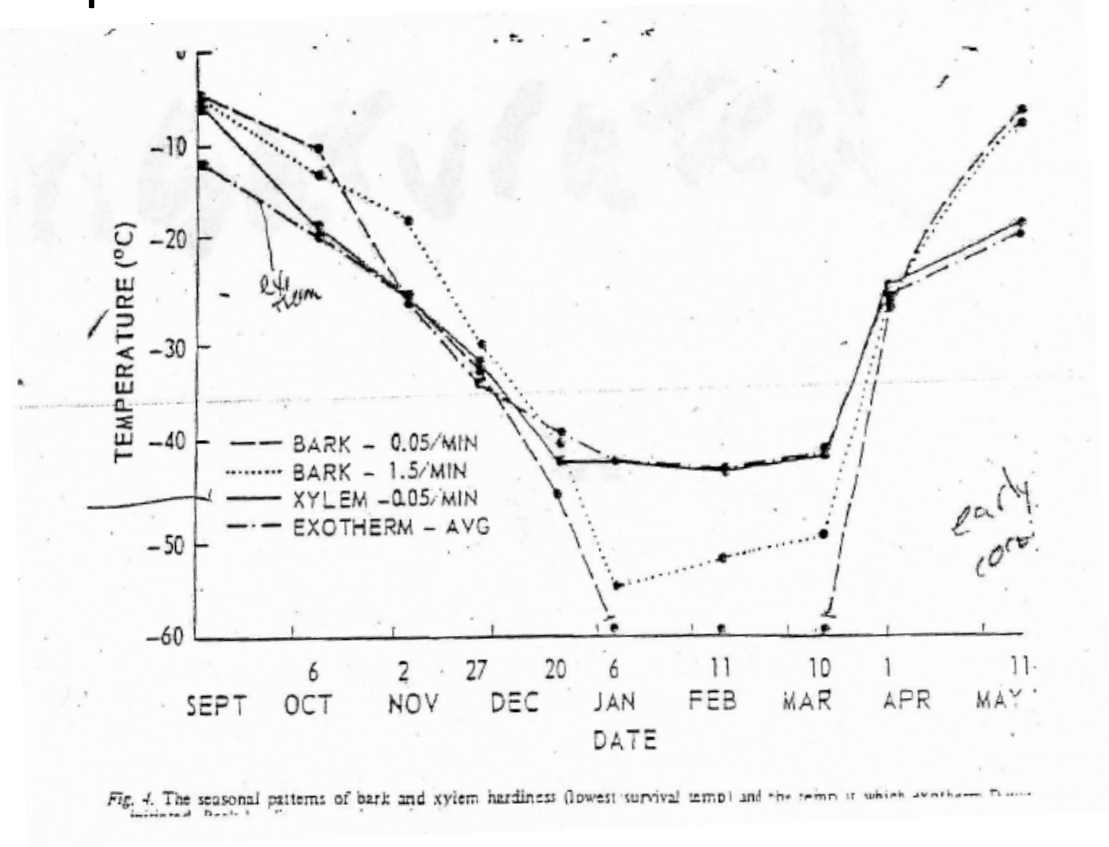


Fig. 4. The seasonal patterns of bark and xylem hardiness (lowest survival temp) and the temp at which exotherm [illegible]

Chilling Requirement

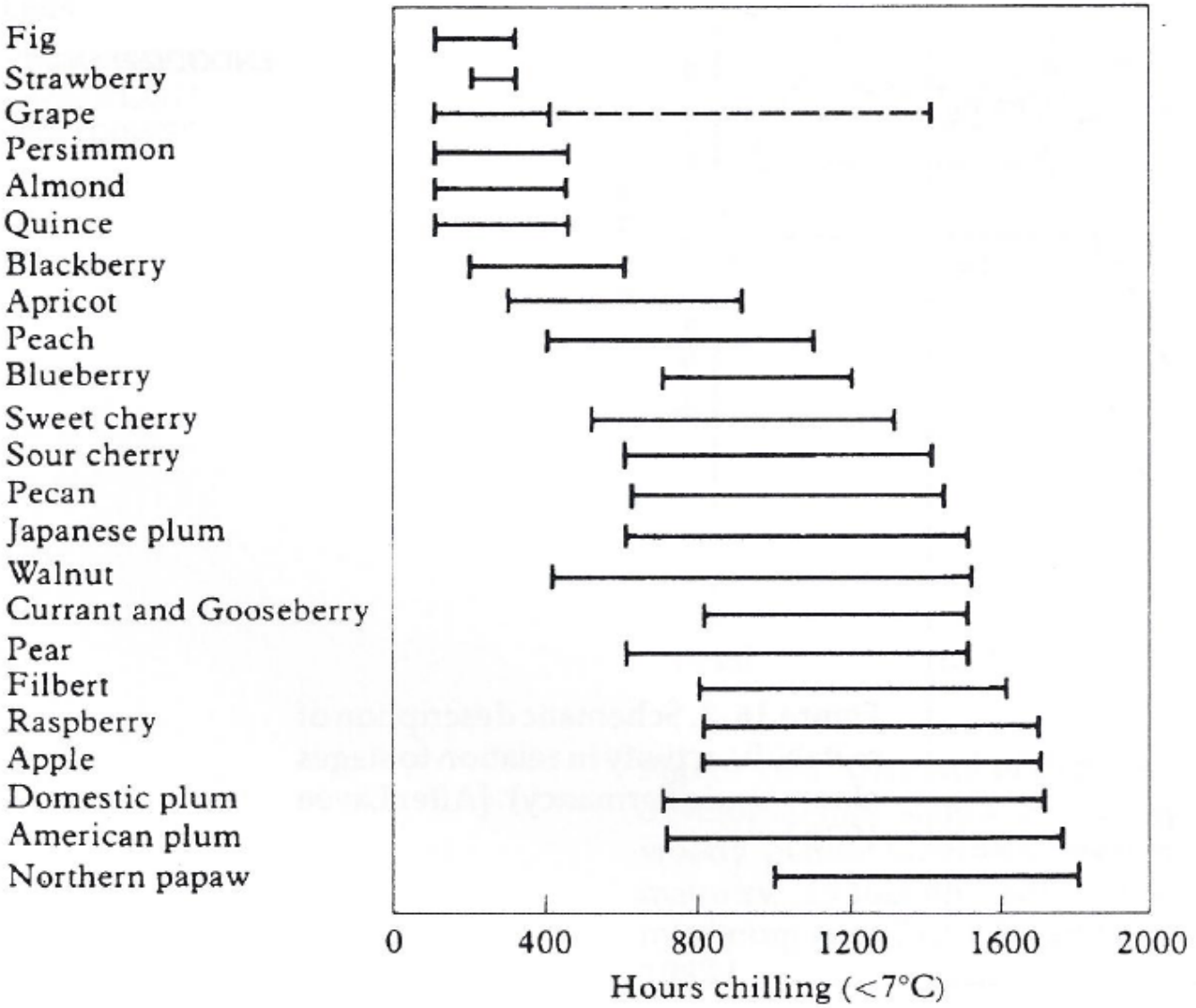
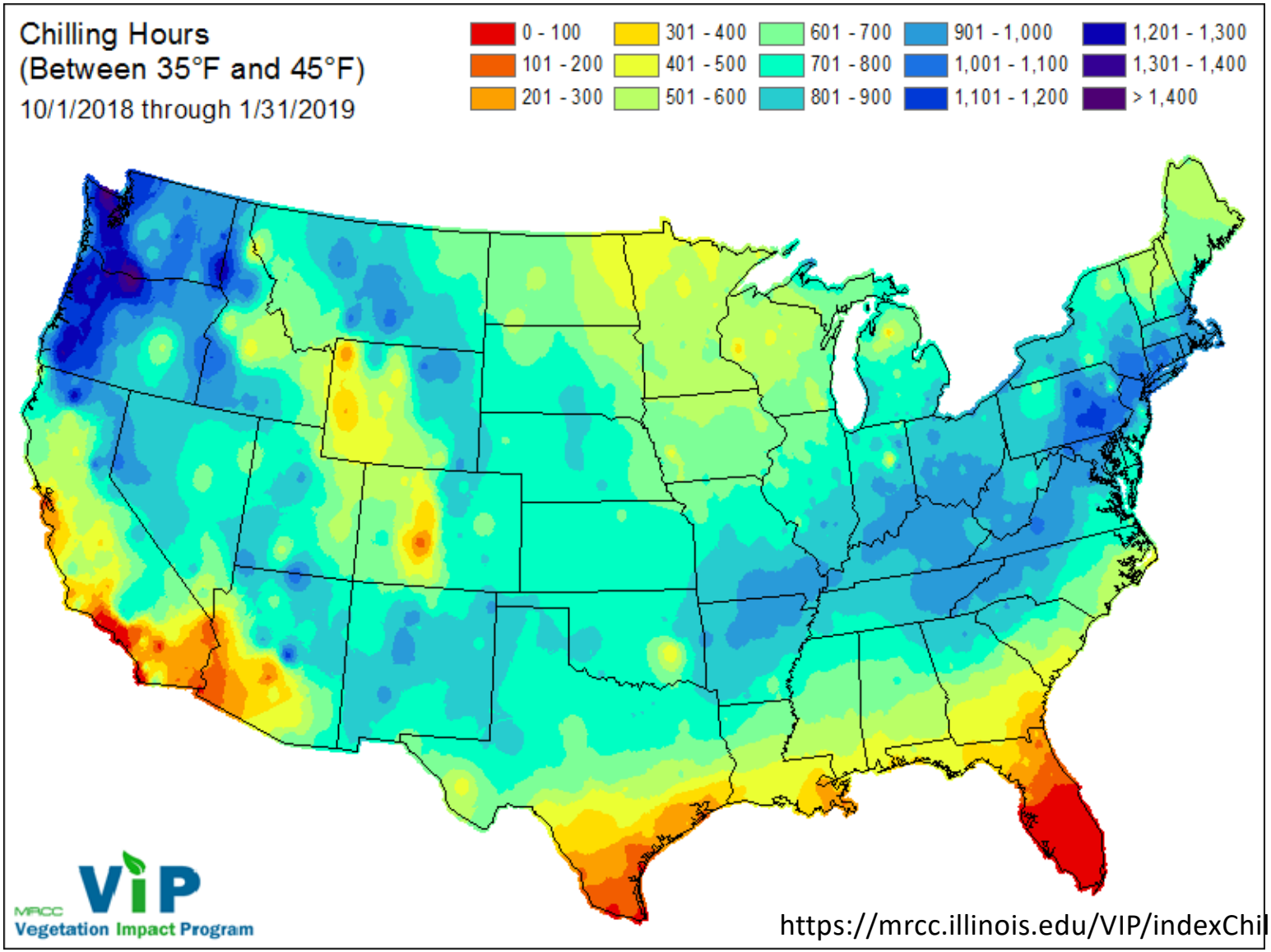


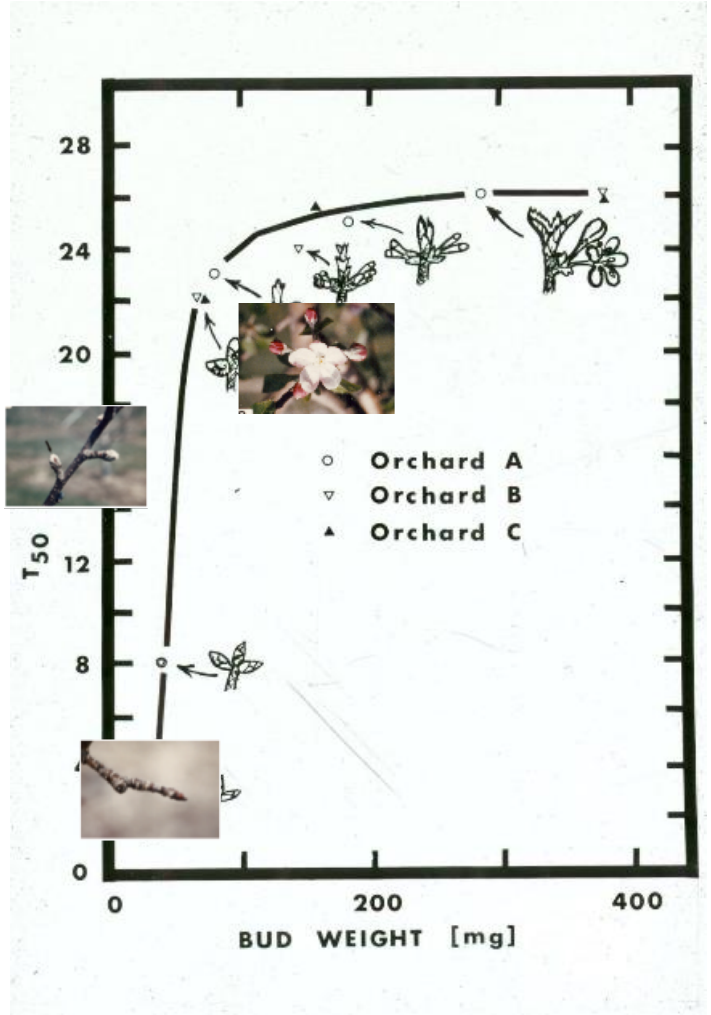
Figure 16-4. Approximate chilling requirements to break winter rest for fruit and nut species. The ranges shown for each species indicate the differences between low- and high-chilling varieties within the species. Grape will grow with very little winter chilling, but will grow much faster after long chilling. [Partial data from Chandler et al. 1937.]

(From: M. Westwood, Temperate-zone Pomology, Timber Press, 1993)


Chilling Hours
(Between 35°F and 45°F)
10/1/2018 through 1/31/2019
0 - 100
101 - 200
201 - 300
301 - 400
401 - 500
501 - 600
601 - 700
701 - 800
801 - 900
901 - 1,000
1,001 - 1,100
1,101 - 1,200
1,201 - 1,300
1,301 - 1,400
> 1,400
MRCC
Vegetation Impact Program
MRCC
Midwestern Regional
Climate Center
https://mrcc.illinois.edu/VIP/indexChillHours2.html

After Rest (Endodormancy)

- Development is driven by GDH
- Accumulation of heat units begin well before any visible signs of growth by the bud.
- The buds lose hardiness as they begin to develop.
- Therefore freezing injury occurs at an ever increasing temperature



Cold Hardiness in Dwarf Trees vs. Standard

- Biologically no different
- Culturally, VERY different

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Cold Hardiness in Dwarf Trees vs. **Standard**

- Biologically no different
- Culturally, VERY different

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- Grow the structure
- Less vigor
- No irrigation
- High N = green fruit (lack of sunlight)
- Dormancy reached faster (less vigor)

Cold Hardiness in **Dwarf Trees** vs. Standard

- Biologically no different
- Culturally, VERY different

- Get to the top wire ASAP (high N)
- Fill the space; set the box
- Fruit size a must - irrigation
- Early production = ROI
- More vigor going into fall
- Dormancy reached last

onapples.com

What we need to understand

- Acclimation, dormancy, and freezing
- What is cold hardiness anyway?
- Types of winter injury
- What can we do?

Tree protection from S.W. Injury in Winter

- White latex paint reduces damage due to rapid temperature fluctuations in trunks due to sunlight in mid winter
- Provides additional protection against damage by contact herbicides
- Plastic tree guards & paper cartons

Need to remove in summer to avoid excess moisture (Pseudomonas injury) &/or borer damage under wrap

Find the Balance

Tree health -

- Vigor
- Irrigation
- Crop load
- Pruning