Microclimate Considerations and Frost Protection

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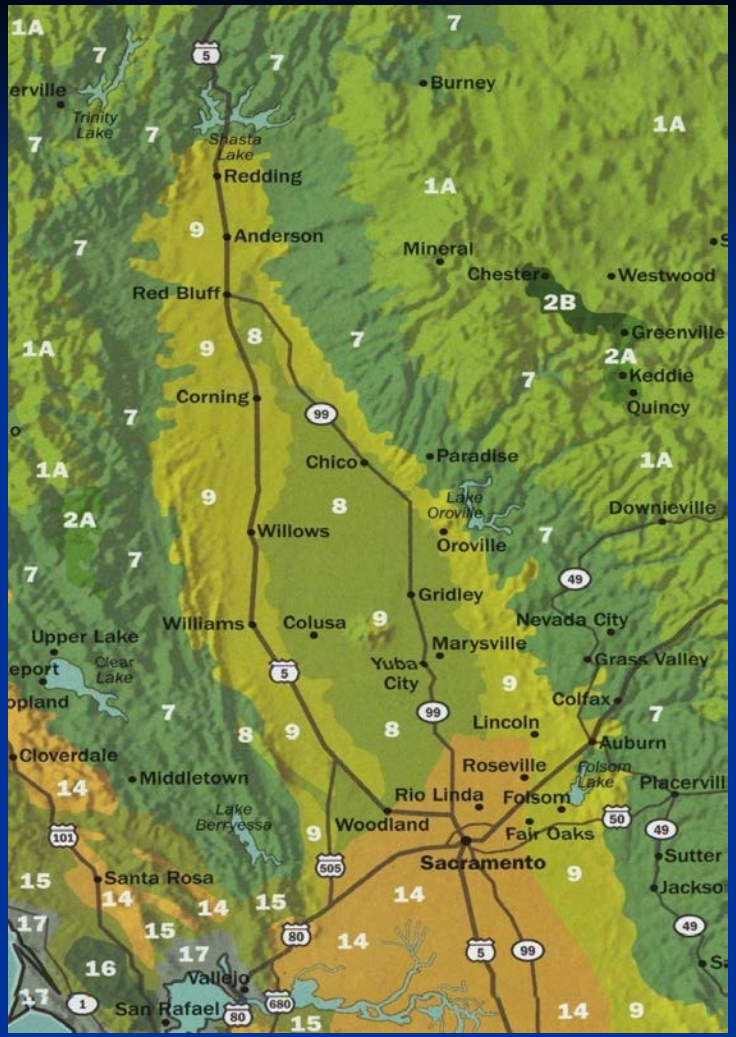
Winter Chilling

- ✓ Required by walnuts to satisfy *rest*
  - Chilling accumulation models are available at: http://fruitsandnuts.ucdavis.edu/Weather_Services/

- ✓ Lack of chilling
  - bud death and drop
  - extended sporadic leafing
  - extended bloom
  - poor nut set



Microclimate:

Three climatic zones in the Sacramento Valley

Zone 8 – valley cold air basin, 820-1200 hours

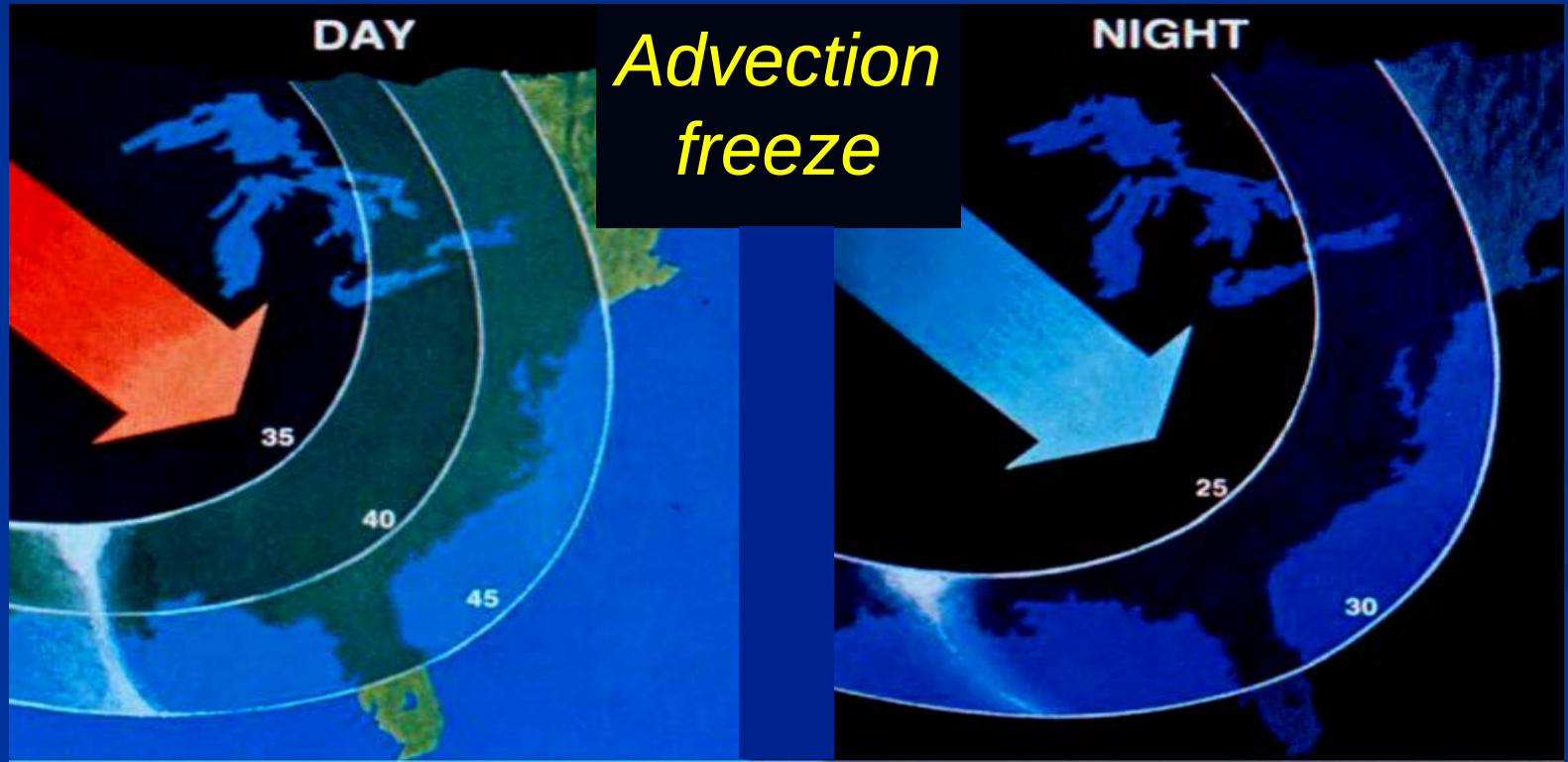
Zone 9 – foothill thermal belt, 500-950 hours

Zone 14 – cold winter valley floor with marine air moderation, 700-1150 hours

Similar in the San Joaquin Valley

Two types of damaging cold events:

- Advection Freezes
- Radiation Frosts



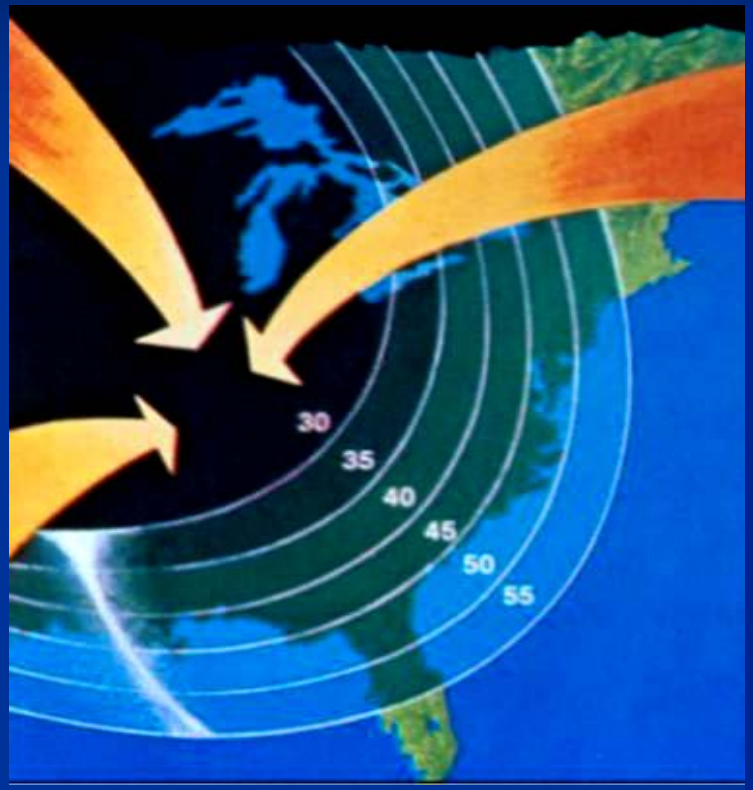
Advection freeze

Early winter advection freezes are more likely to cause limb & branch injury

- Wood is damaged at 22° to 28°F if not fully dormant
- By midwinter dormancy, below 20°F can kill wood

Radiation frost

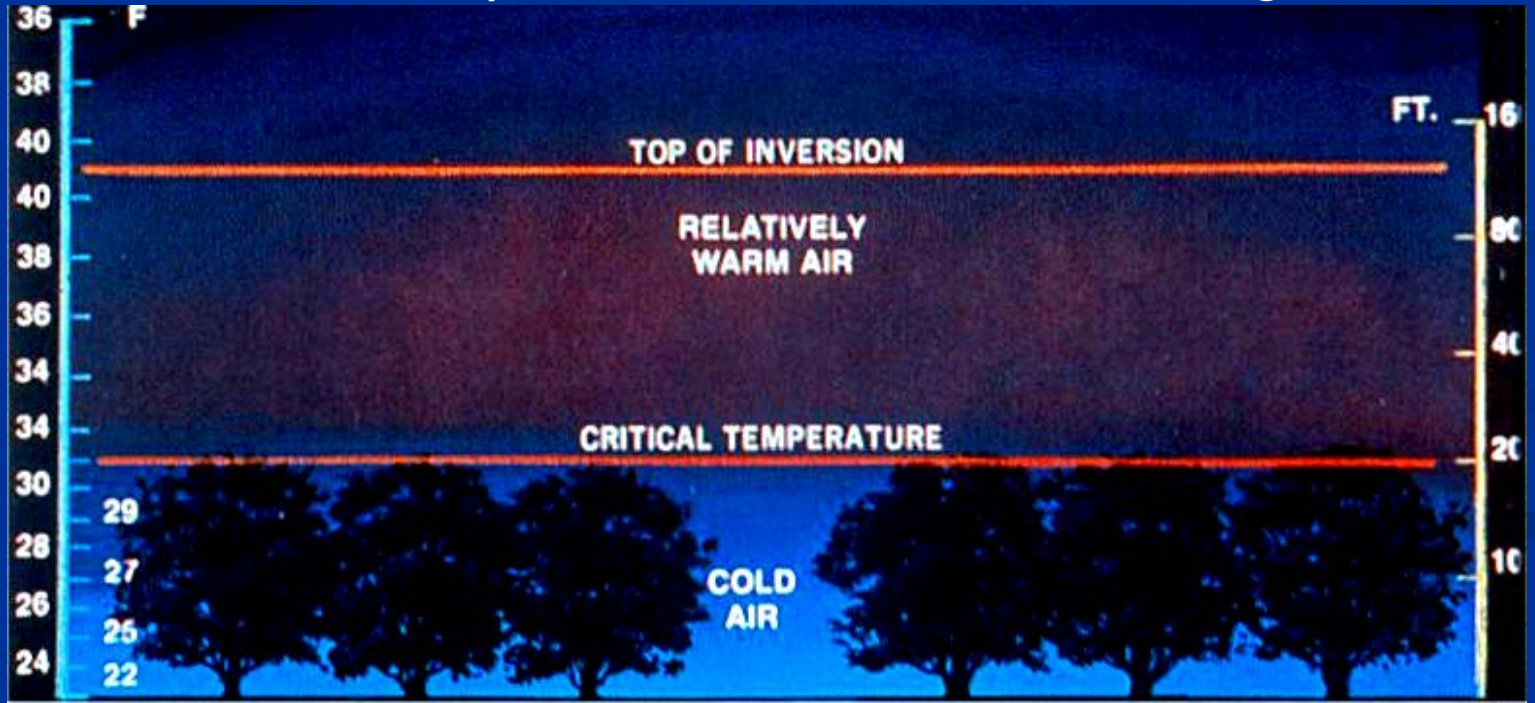
Day

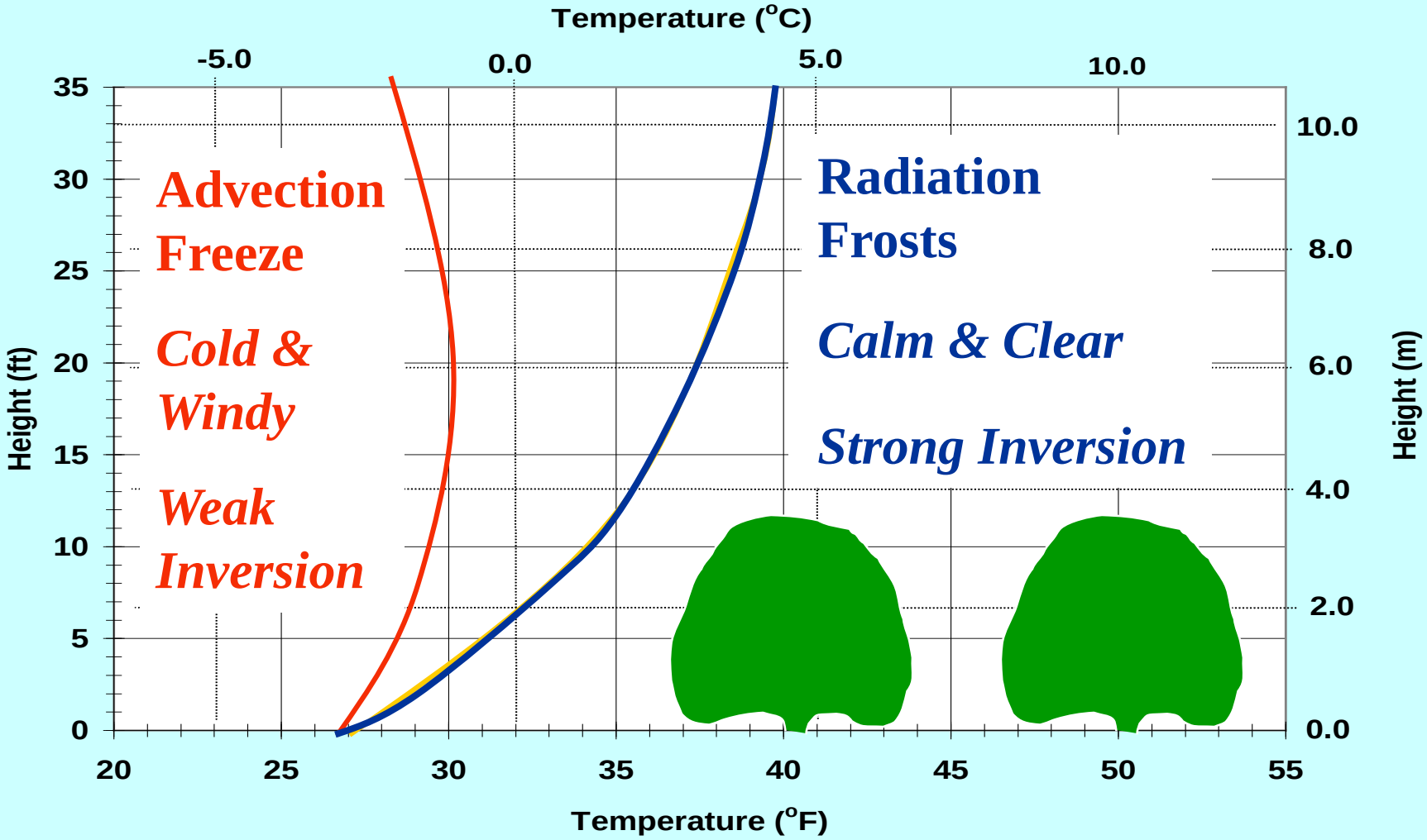


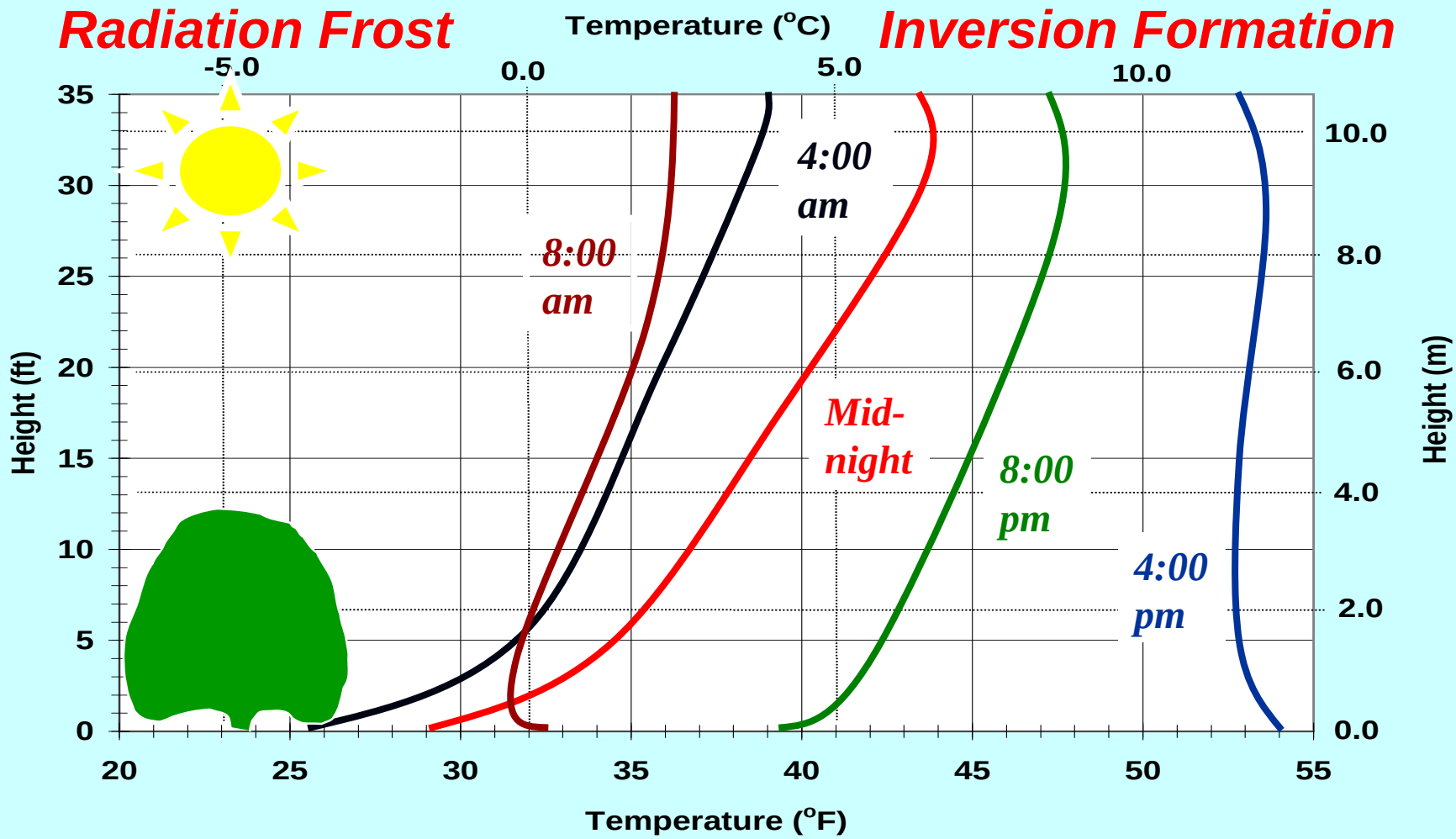
Night

Radiation frosts… strong inversions

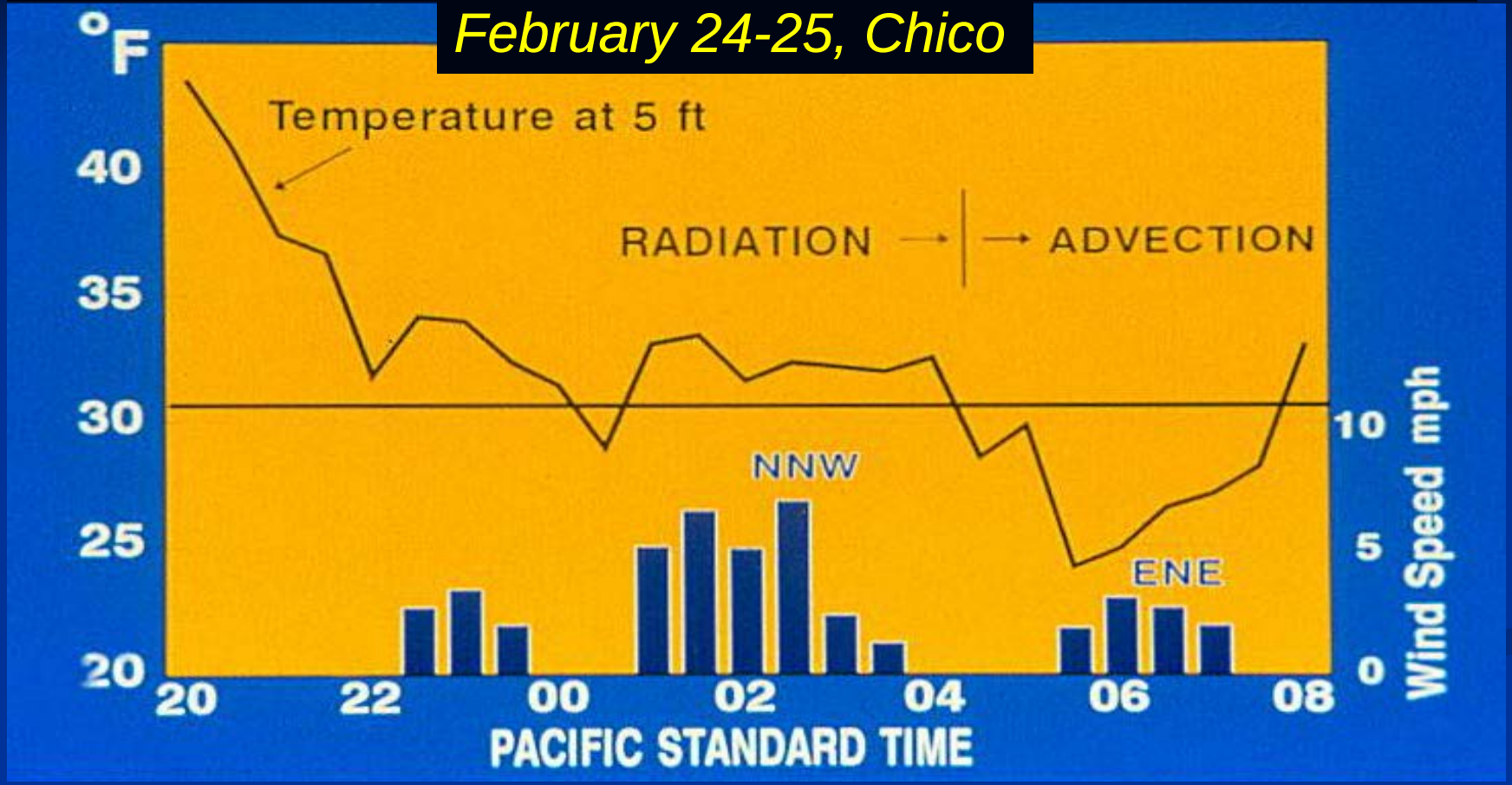
- Of more concern in spring; air near the ground cools more rapidly than the air above
- Observed temperature increases with height



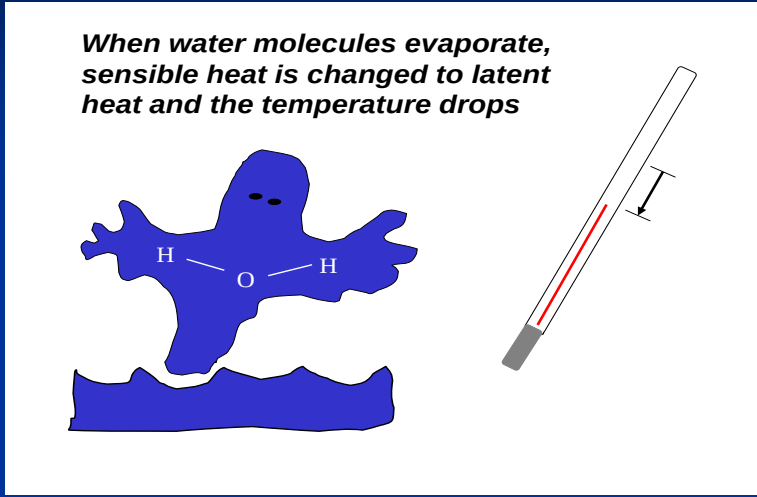

Temperature (°C)
-5.0
0.0
5.0
10.0
Advection
Freeze
Cold &
Windy
Weak
Inversion
Radiation
Frosts
Calm & Clear
Strong Inversion
Height (ft)
35
30
25
20
15
10
5
0
Height (m)
10.0
8.0
6.0
4.0
2.0
0.0
20
25
30
35
40
45
50
55
Temperature (°F)


Radiation Frost
Temperature (°C)
Inversion Formation
-5.0
0.0
5.0
10.0
35
30
25
20
15
10
5
0
10.0
8.0
6.0
4.0
2.0
0.0
Height (ft)
Height (m)
8:00 am
4:00 am
Mid-night
8:00 pm
4:00 pm
20
25
30
35
40
45
50
55
Temperature (°F)

Radiation frost followed by Advection freeze

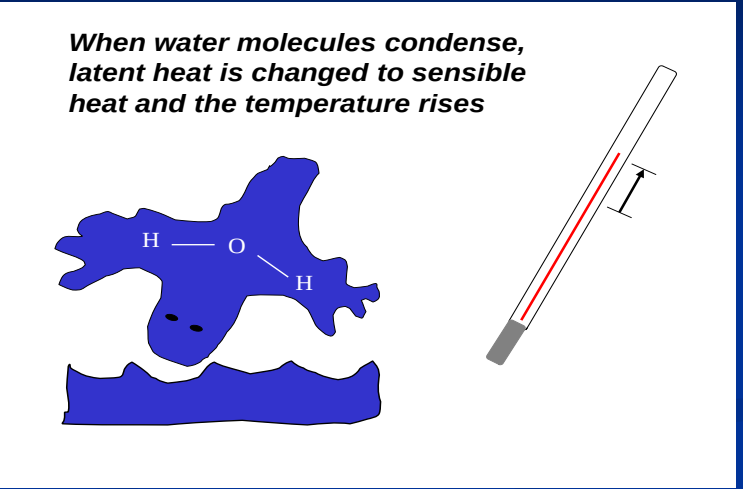


Evaporation



When water evaporates, temperature drops.

Condensation



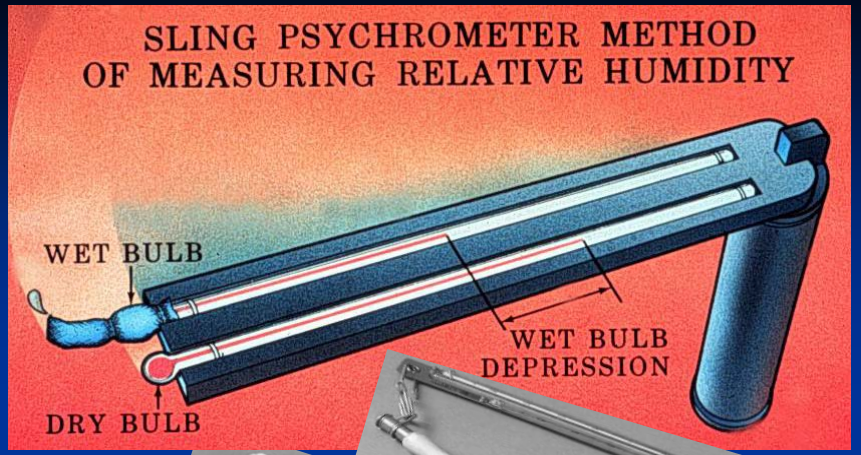
When water condenses, temperature rises.

Dew point temperature

- Temperature when relative humidity = 100 %
- At dew point, condensation (dew) forms on surfaces releasing sensible heat and slowing temperature drop
- To measure dew point
  - ✓ Stir water in a shiny can with a thermometer, slowly add ice to ensure the can and water are the same temperature
  - ✓ When condensation occurs on outside of the shiny can the temperature has reached dew point

Wet-bulb temperature

- A wet plant's temperature can't fall below the wet-bulb temperature
- When water vapor is saturated, a thermometer reads the wet-bulb temperature
- Higher humidity = higher water vapor concentration
- Difference, wet vs. dry temp compared to dry bulb temp gives humidity from a chart



Psychrometers

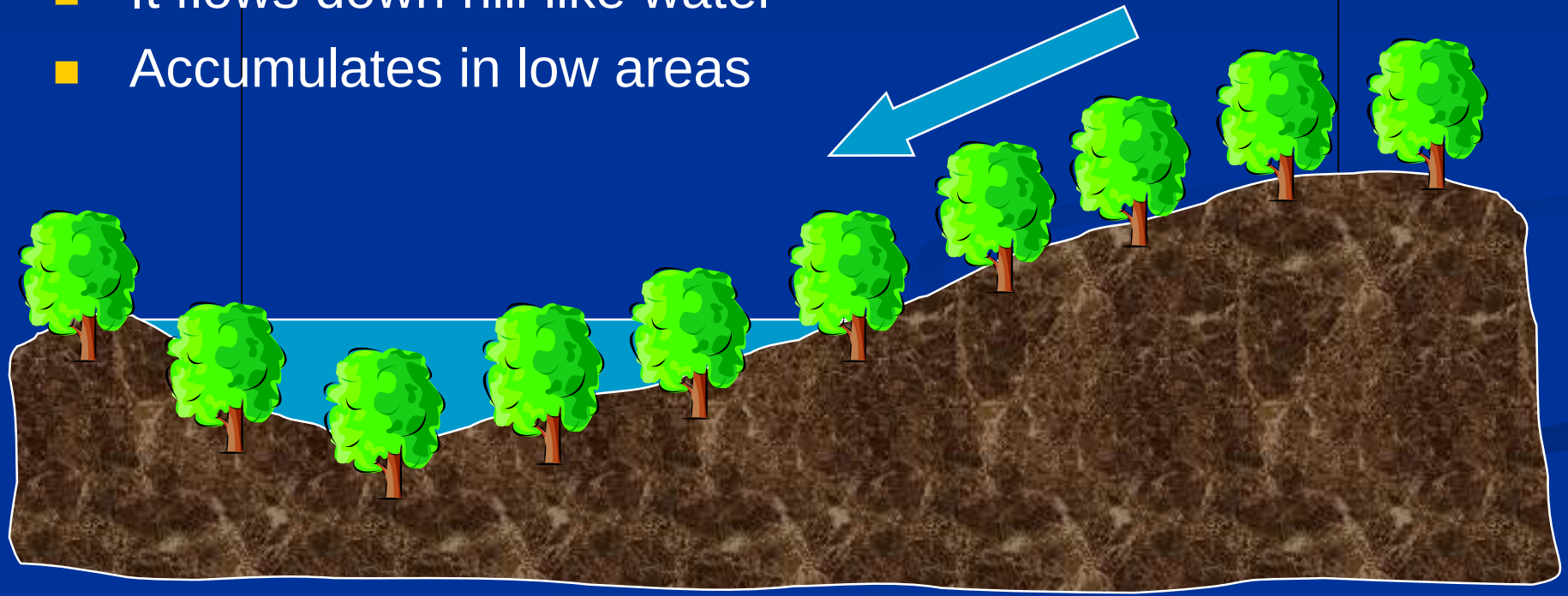
- Traditional sling
- Battery aspirated
- Digital

Elements of passive frost protection

- Site Selection
- Ground Cover
- Soil Water Content

Site selection -- cold air drainage

- Cold air is heavier (more dense) than warm air
- It flows down hill like water
- Accumulates in low areas



Citrus freeze along Highway 65, Porterville, CA

Colder in the lowest areas

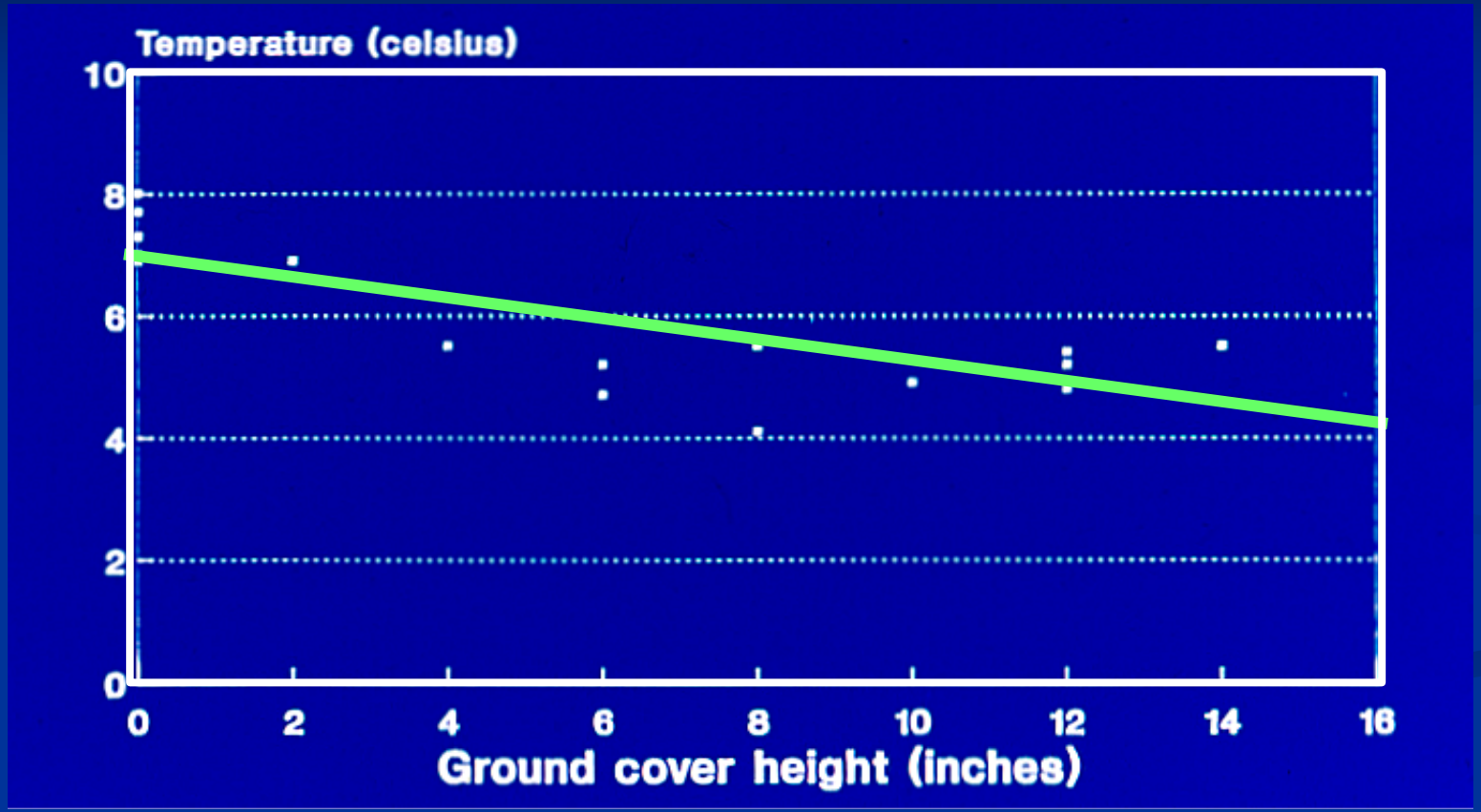
Give consideration to site selection…

- Assess the risk of freeze damage
- Be aware of low (cold) sites
- Consider air drainage from the site

Ground covers

- Reflect sunlight
- Dry the soil & evaporate water
- Reduce soil heat storage & conduction
- Result in colder minimum temperatures

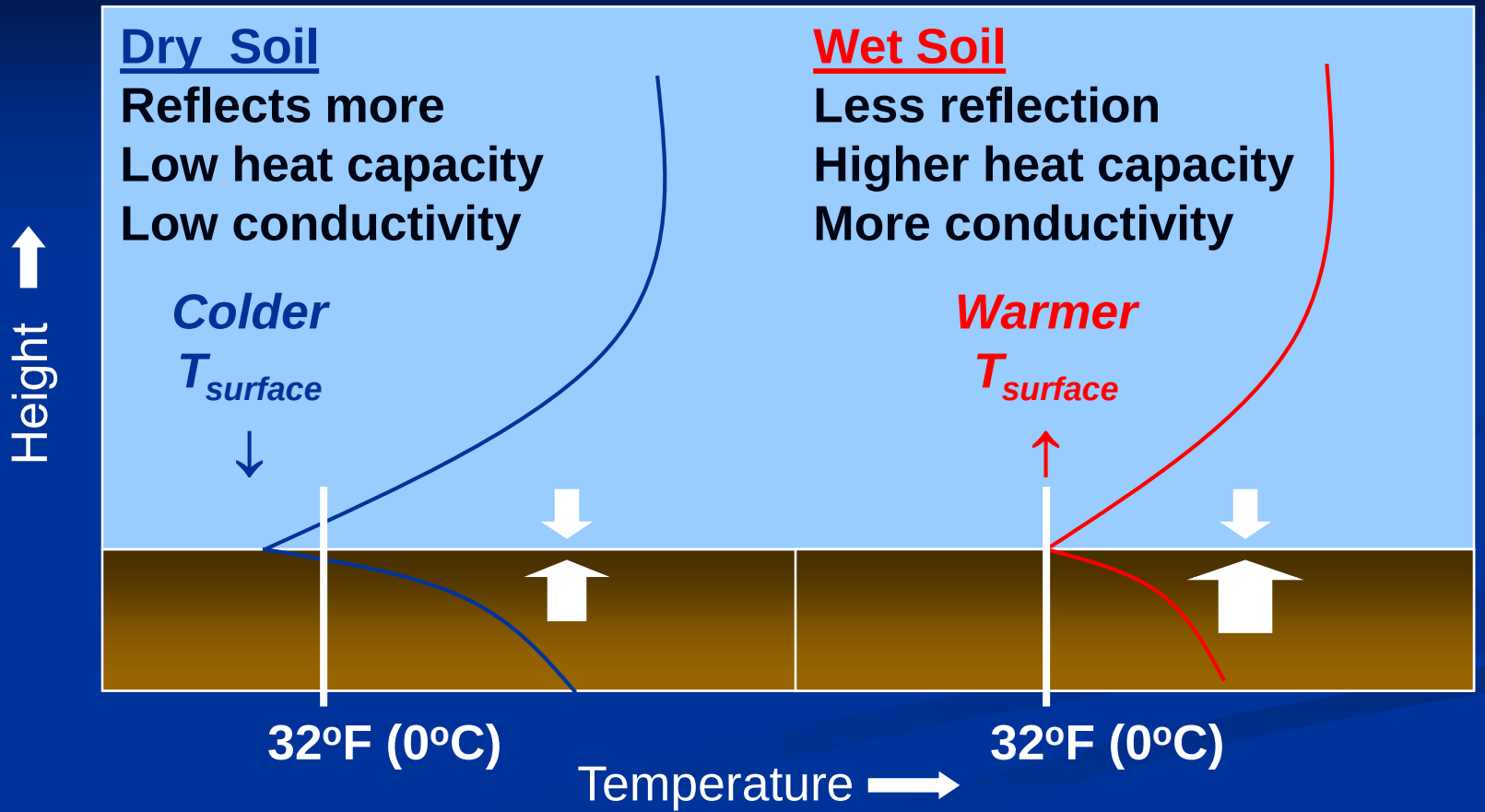
As ground cover height increases, surface temperature is colder



Ground covers

- The surface radiates its temperature to the crop
- When the ground surface is warmer, the crop is warmer
- Bare, firm, moist soil is warmest
- Cut covers short, mow to 2 inches or less
- Re-wet dry soil
- Don’t cultivate

Soil water content



Soil water content = heat storage

- Wet the entire surface & the top foot
- Soil moisture should be near field capacity
- Water dry soil 1-2 days ahead of a freeze to improve soil heat storage

Coldest… is dry, loose, recently cultivated soil

Active methods of frost protection

- Heaters
- Wind machines
- Helicopters
- Sprinklers
- Surface water

Start with a good orchard thermometer in a proper thermometer shelter

Critical temperature for radiation frost damage in spring is 30°F for new leaves, shoots and nutlets

Photo courtesy Janine Hasey

Photos courtesy Francisco Paredes

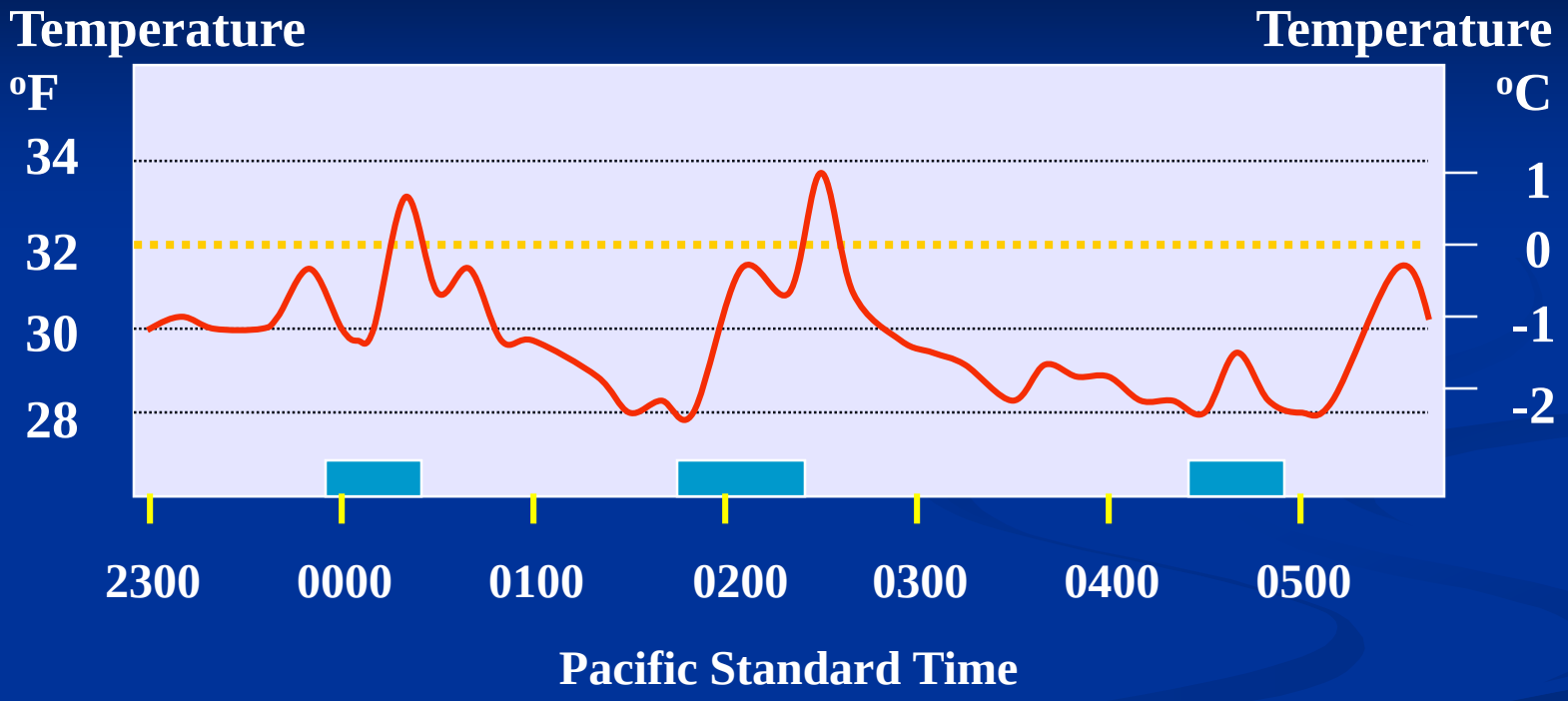
Frost damage April 20th (27.5°F in Durham), note new shoots re-growing by May 21st

Injury varies with timing of frost and a variety's stage of development

Helicopters… similar to wind machines

- Push warm air from inversion down into the crop
- An inversion is required
- Load with water
- Frequent passes
- Monitor temperature & use marker lights
- Talk to the pilot

Helicopter raised temperature with fly-over



After Miller et al. (1951)

Sprinkler frost protection

- Heat gain is due to the release of latent heat from freezing water
- Systems should be engineered to provide a flow rate of 40 gpm/acre
- Start and stop based on the wet-bulb temperature (crop’s critical damage temperature) and the dew point

Sprinklers can provide 2º- 4º F of frost protection

Photo courtesy Rick Buchner

Photo courtesy Rick Buchner

Micro-sprinklers must be started early enough with a sufficient flow rate to keep micro tubes from freezing up

At flow rates below 30 gpm/acre micro tubes may freeze

Turn on Temperatures for Sprinklers

Dew-point Temperature	Wet-bulb Temperature (°F)										
°F	22	23	24	25	26	27	28	29	30	31	32
32											32.0
31										31.0	32.7
30									30.0	31.7	33.3
29								29.0	30.6	32.3	34.0
28							28.0	29.6	31.2	32.9	34.6
27						27.0	28.6	30.2	31.8	33.5	35.2
26					26.0	27.6	29.2	30.8	32.4	34.0	35.7
25				25.0	26.5	28.1	29.7	31.3	32.9	34.6	36.3
24			24.0	25.5	27.1	28.6	30.2	31.8	33.5	35.1	36.8
23		23.0	24.5	26.0	27.6	29.1	30.7	32.3	34.0	35.6	37.3
22	22.0	23.5	25.0	26.5	28.1	29.6	31.2	32.8	34.5	36.1	37.8
21	22.5	24.0	25.5	27.0	28.5	30.1	31.7	33.3	34.9	36.6	38.2
20	22.9	24.4	25.9	27.4	29.0	30.6	32.1	33.7	35.4	37.0	38.7
19	23.4	24.9	26.4	27.9	29.4	31.0	32.6	34.2	35.8	37.5	39.1
18	23.8	25.3	26.8	28.3	29.8	31.4	33.0	34.6	36.2	37.9	39.5
17	24.2	25.7	27.2	28.7	30.2	31.8	33.4	35.0	36.6	38.3	39.9
16	24.6	26.1	27.6	29.1	30.6	32.2	33.8	35.4	37.0	38.7	40.3
15	25.0	26.4	27.9	29.5	31.0	32.6	34.2	35.8	37.4	39.0	40.7

When to turn off sprinklers?

- Turn off when the wet-bulb temp upwind of the protected orchard is above the crop's critical damage temperature
- Or, when all the ice melts

Of frost protection options available today, the most effective and practical…

- Passive: a non-tilled orchard floor with either bare, firm, moist soil or a short mowed cover
- Active: using under tree sprinkling
  - Solid set irrigation, movable pipe, or micro- sprinklers
  - Application rate of 40 gpm/acre is effective in most California radiation frost conditions

Thank you!

Dr. Richard Snyder, Cooperative Extension Biometeorologist Emeritus, UC Davis LAWR Dept., was my frost research colleague for decades.

For more information, visit the LAWR web site:

http://lawr.ucdavis.edu/cooperative-extension/frost-protection

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