Methods of Vineyard Frost Protection

Justin Scheiner, Ph.D.

Texas A&M AgriLife Extension

Cold/Freeze/Frost Injury

- **Cold/winter injury:** extreme winter temperatures cause injury to dormant vine buds, canes, cordons, trunks and/or roots.

- **Freeze and frost injury:** freeze or frost after budbreak causes injury to buds and/or young shoots

Acclimation and Deacclimation

Grapevines acclimate in response to decreasing day length and cooler temperatures:

- formation of outer bark (periderm) on shoots
- accumulation of carbohydrates in tissue
- leaf senescence
- tissue dehydration

Mitigating Cold Injury

- Cultivar selection
- Site selection
- Cultural practices
- Mounding soil
- Frost fans
- Heaters

Late Spring Freeze

- Partial to complete crop loss
- Reduction in fruit quality

Frost Avoidance and Protection

Passive

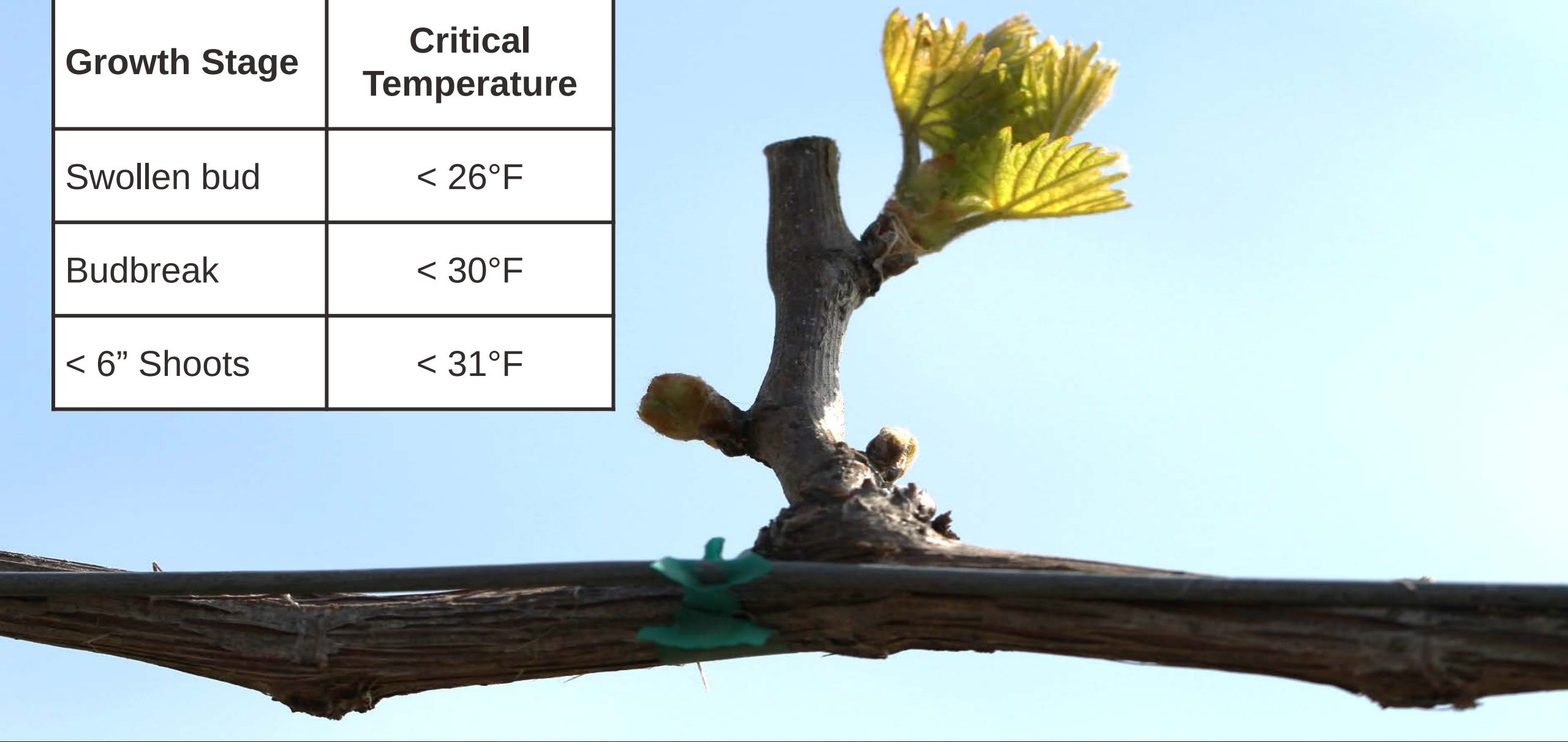
- **Site selection**
- **Cultivar selection**
- **Double/delayed pruning**
- **Floor management**
- **Soil water management**
- **Anti-transpirants**
- **Bactericides**
- **Cryoprotectants**

Active

- **Heaters**
- **Wind machines**
- **Helicopters**
- **Sprinklers**

Tissue Sensitivity to Cold

Growth Stage	Critical Temperature
Swollen bud	< 26°F
Budbreak	< 30°F
< 6” Shoots	< 31°F

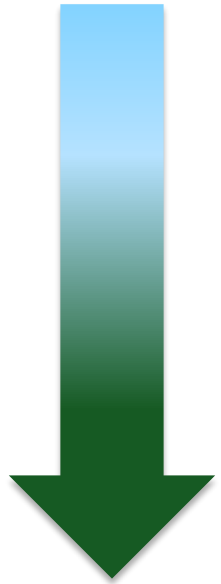


Timing of Bud Break

Relative Dates of Bud Burst of Selected Grape Cultivars	
Cultivar	**Time of Bud Burst (days)***
Chenin blanc, Chardonnay	0
Gewurztraminer, Viognier	1
Pinot gris, Pinot noir, Merlot	3
Petite Verdot, Tannat	5
Riesling, Cabernet Franc, Semillon	6
Grenache, Muscat Ottonel, Rousanne	7
Sauvignon blanc, Syrah, Tempranillo	8
Carignan, Marsanne	10
Cabernet Sauvignon, Mourvedre	14

*adopted and modified from ENTAV-INRA, 1995

More frost prone



Less frost prone

Delayed/Double Pruning

Double pruning: rough prune to long spurs early and follow up after the danger of frost has passed or once basal buds begin to break.

- Larger vineyards may be limited by labor

5 - 10 bud spurs

2 bud spurs

Long Pruning

Rough pruning

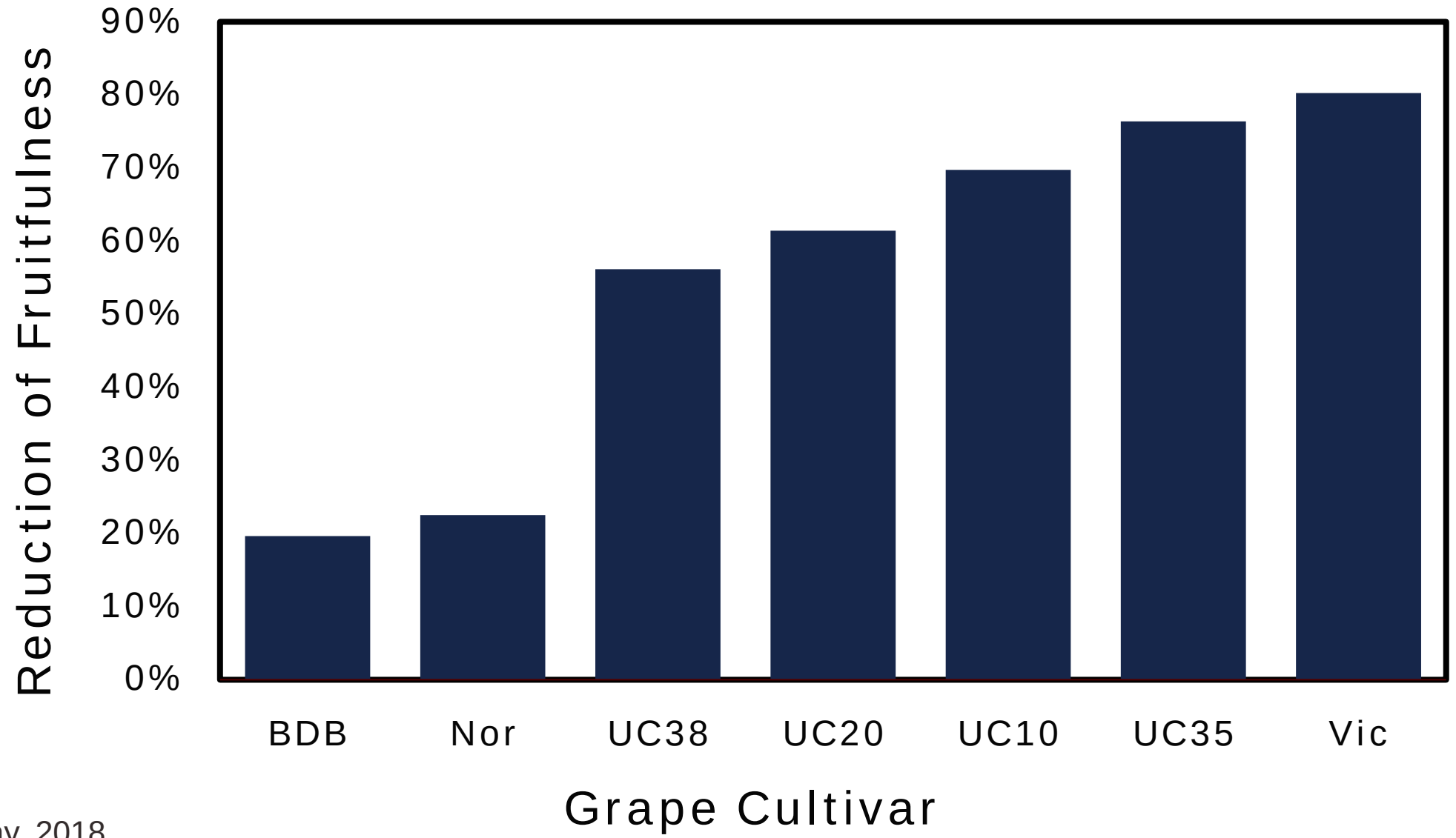
Rough/Trash Pruning

Study #1 – Passive Freeze Protection

Impact of delayed pruning on fruitfulness

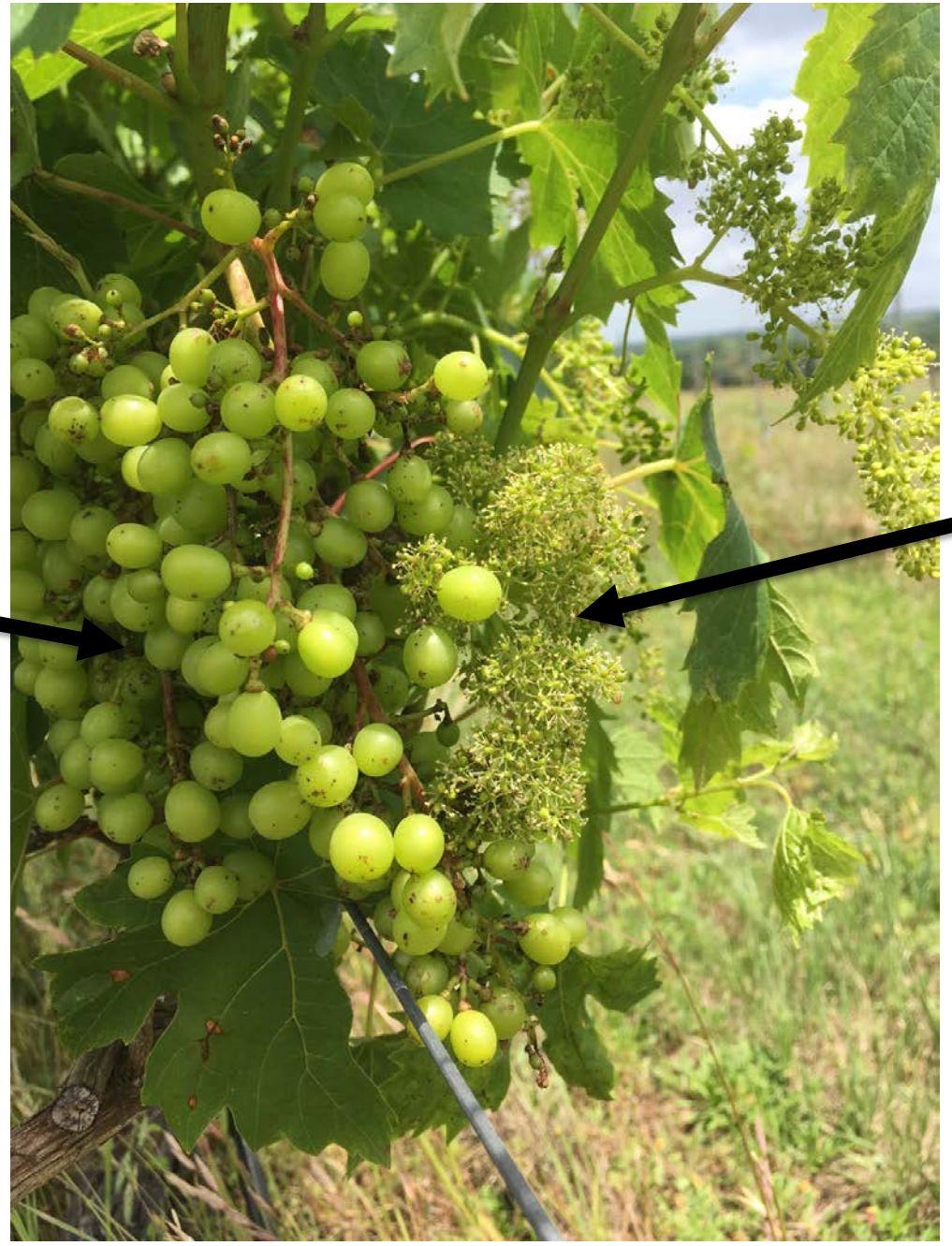
- Timing:
  - Bud break
  - 3 weeks post-bud break

Impact of Delayed Pruning on Fruitfulness



From: Labay, 2018

Pea-sized cluster



Inflorescence

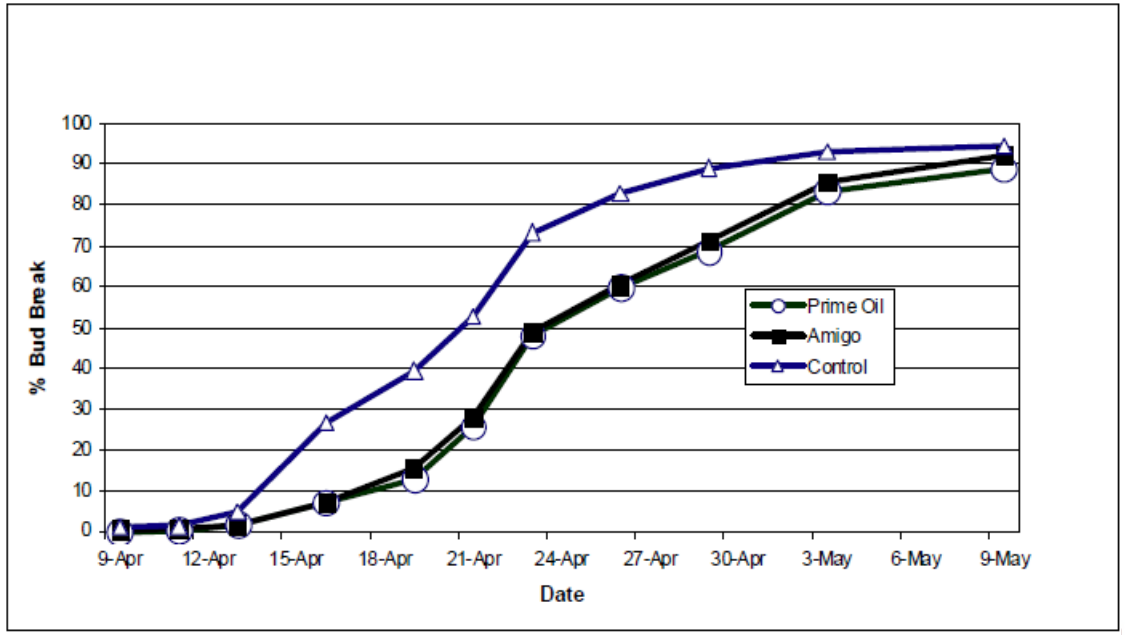
Anti-transpirants

Dormant applications of vegetable and mineral oil have shown to delay budbreak (2 to 19 days) in some grape cultivars.

- Results varied by:
  - Cultivar
  - Application timing
  - Rate

8% v/v soybean oil +
1% v/v spreader sticker
@ 100 gal/acre

Figure 1. Effect of soybean-based oils on bud break and development of Chambourcin.



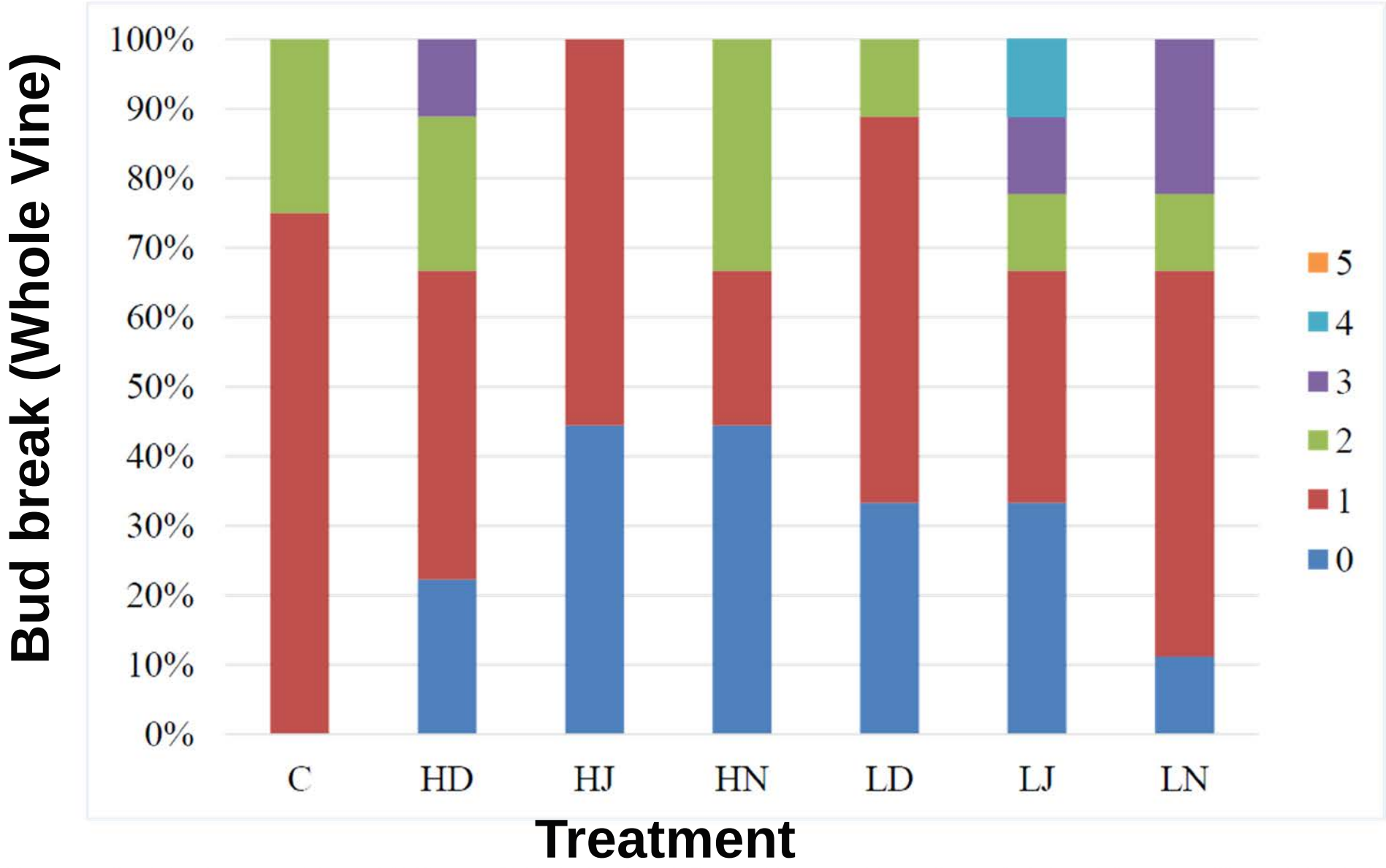
(Dami 2007, Proceedings of Understanding and Preventing Freeze Damage in Vineyards Workshop)

Study #2 – Passive Freeze Protection

Ethephon sprays to delay bud break

- 2 rates
- 3 timings
  - November
  - January
  - February
- 3 locations

Impact of Ethephon on Bud break in ‘Sangiovese’



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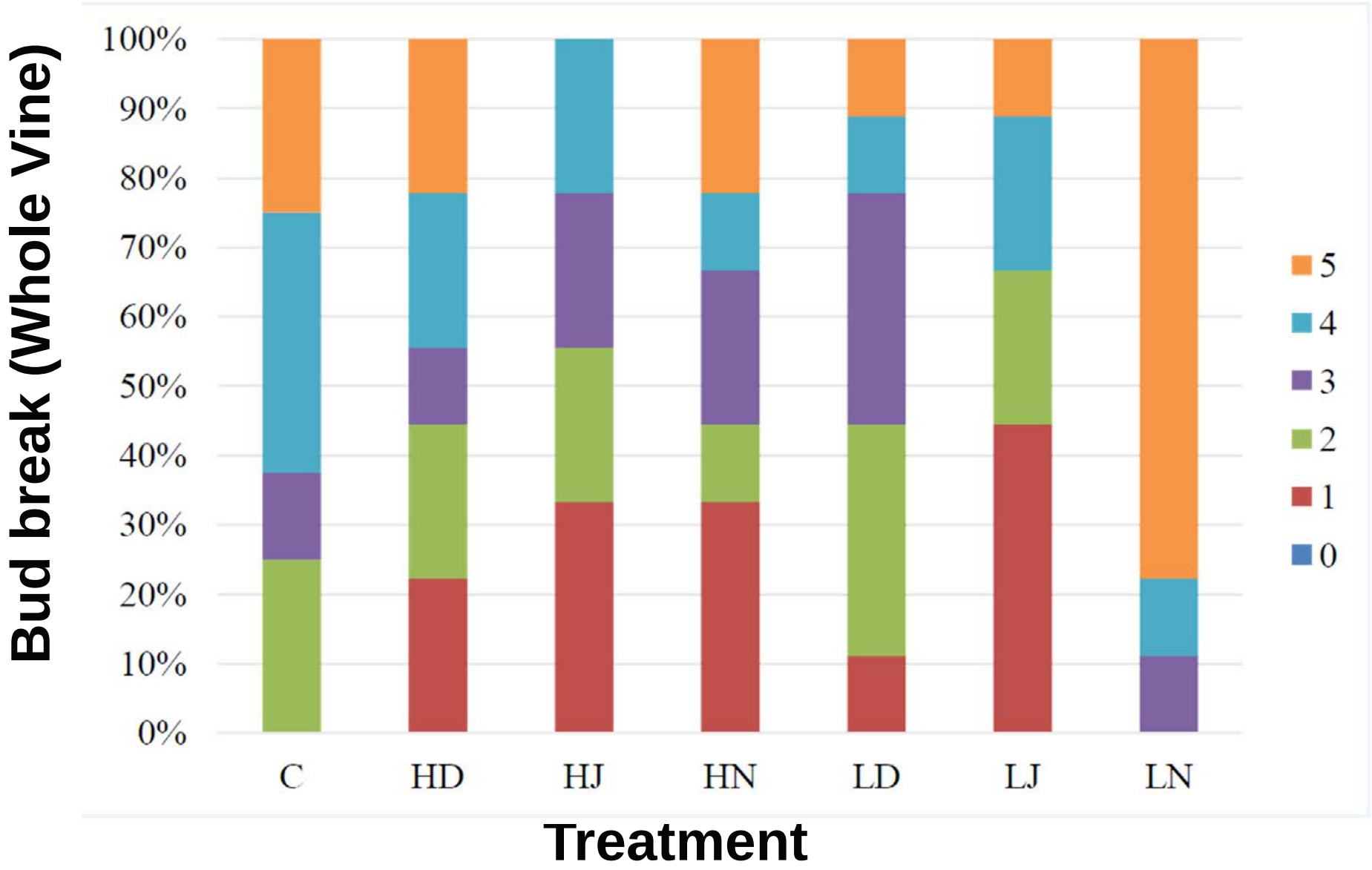


Cryoprotectants

Protect plants by lower the freezing point of tissue or surface.

- Ethylene glycol
- Surfactants
- Potassium dextrolactate

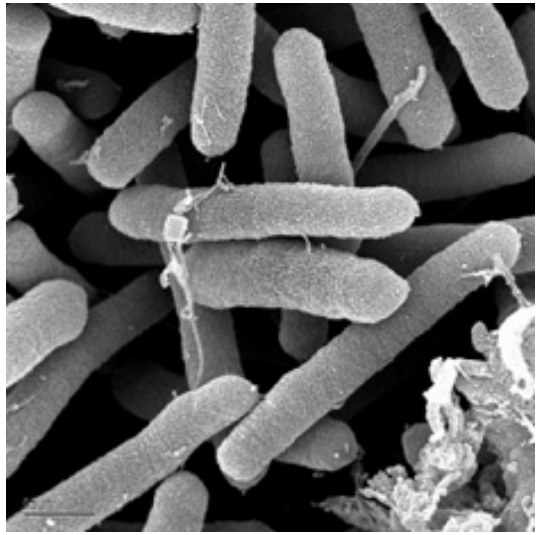
- ex. Glacier, Mega-Fol, Frost Guard

Image from: Ontario Grape IPM, www.omafra.gov

There is a general lack of compelling evidence of efficacy under field conditions.

Ice Nucleation Active Bacteria

- Certain species of bacteria initiate ice formation on the surface of plants.
  - Low populations observed on grapes compared to other crops. More likely to be present on ground cover.



- Copper sprays appear to be most effective in reducing INA bacteria populations.

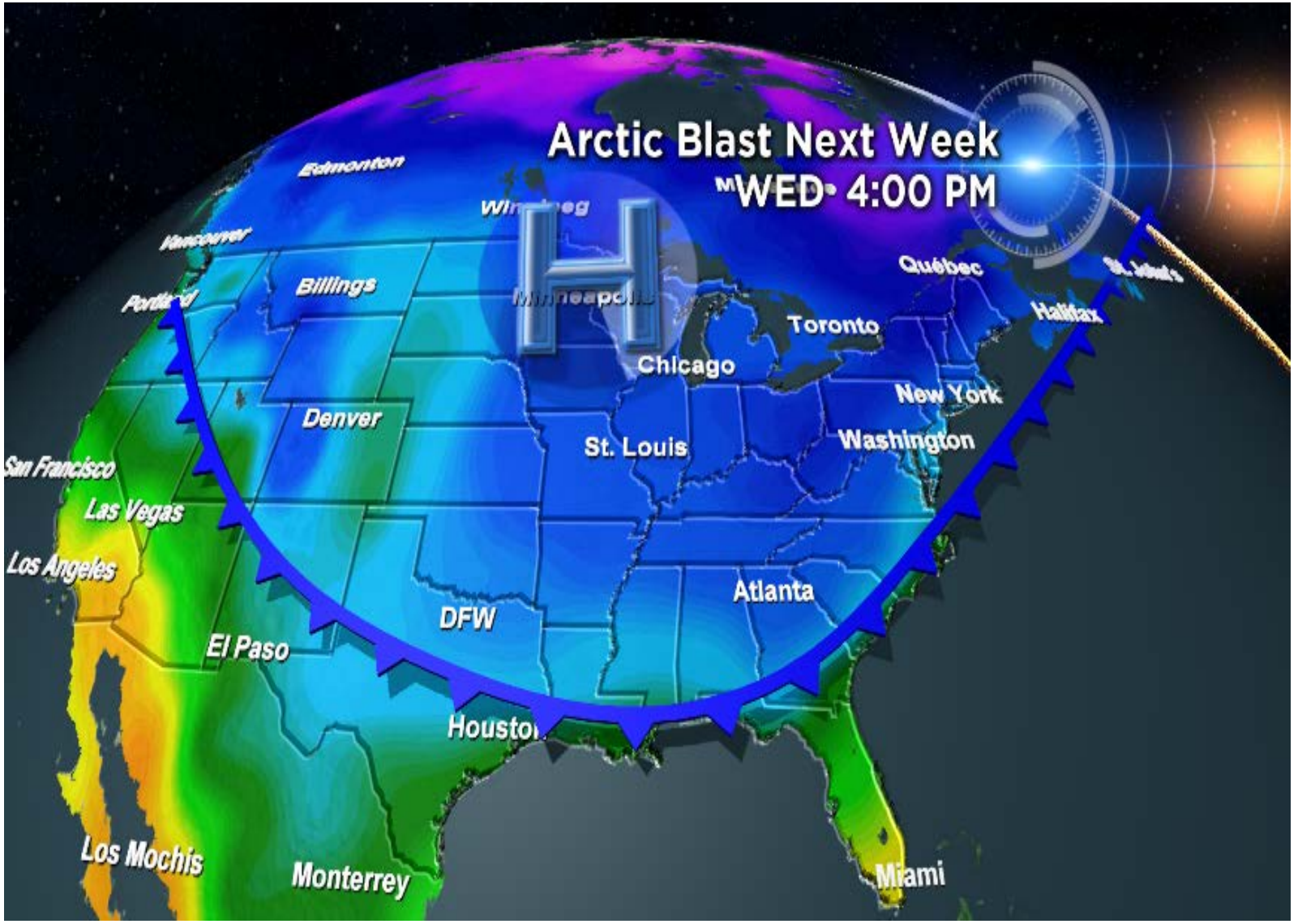
Floor & Soil Moisture Management

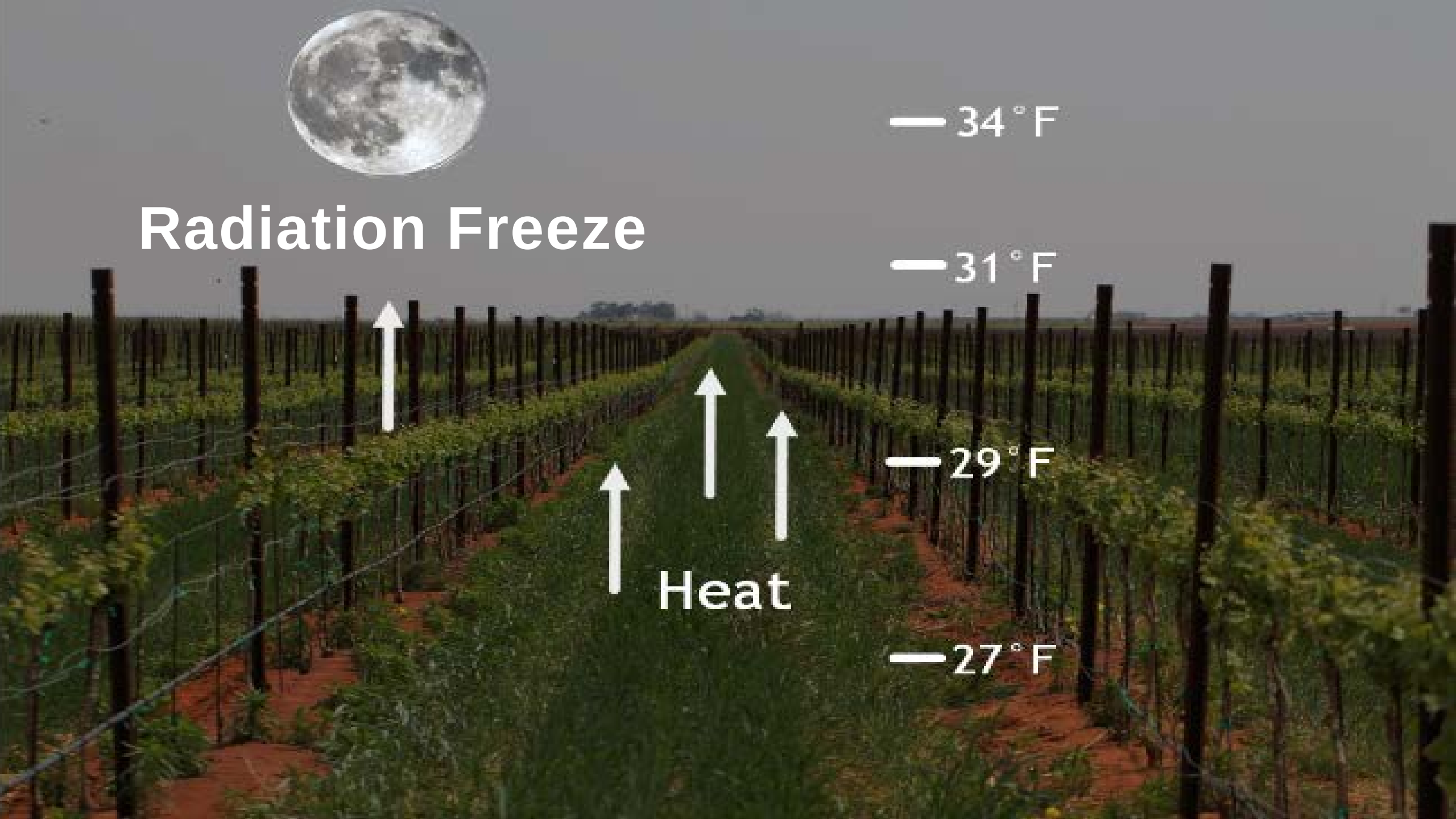
Characteristics	Cooler	Warmer
Soil Texture	Sand	Loam
Soil Water	Dry	Moist
Row Middles	Tall vegetation	Low vegetation
Under Vine	Vegetation	Bare soil

- Moist soil retains heat better than dry soil.
- Tall vegetation insulates the soil from heat transfer and may reduce cold air drainage.

Advection Freeze

- Cold air mass moves into the region, low day and night temperatures
- Wind mixes air in lower layers of the atmosphere




Radiation Freeze
34˚F
31˚F
29˚F
27˚F
Heat

Sprinkler Frost Protection

- Limited by water availability

Sprinklers

As water freezes heat is released; heat is lost with evaporation. Need approximately 8 times as much freezing as evaporation to maintain positive heat balance.

- Must be turned on before critical temperature is reached and remain on until ambient temperatures are above critical
- Overhead vs under vine

Image from:accuweather.com

Overhead Irrigation

- Application rate depends on sprinkler rotation rate, wind speed, and dew point.

Gallons of Water per Acre per Hour Needed for Frost Protection

	Wind Speed	
Temperature	**0 - 1.1 mph**	**2 - 3 mph**
29	2,715	3,259
23	3,530	4,073
26	4,616	5,430

Adopted from: Synder 2000, Principles of Frost Protection

Pulsator microsprinklers – lower water volume (720–900 gph/acre)

Frost (Tower) Fan

- Blend warm air at 30 to 50’ with cooler air near ground
- Gain 25 to 50% of thermal inversion strength
- Coverage: up to 10 to 12 acres
- Cost: $25,000 to $40,000 installed
- Gas, diesel, electric, propane, PTO

- 38°F

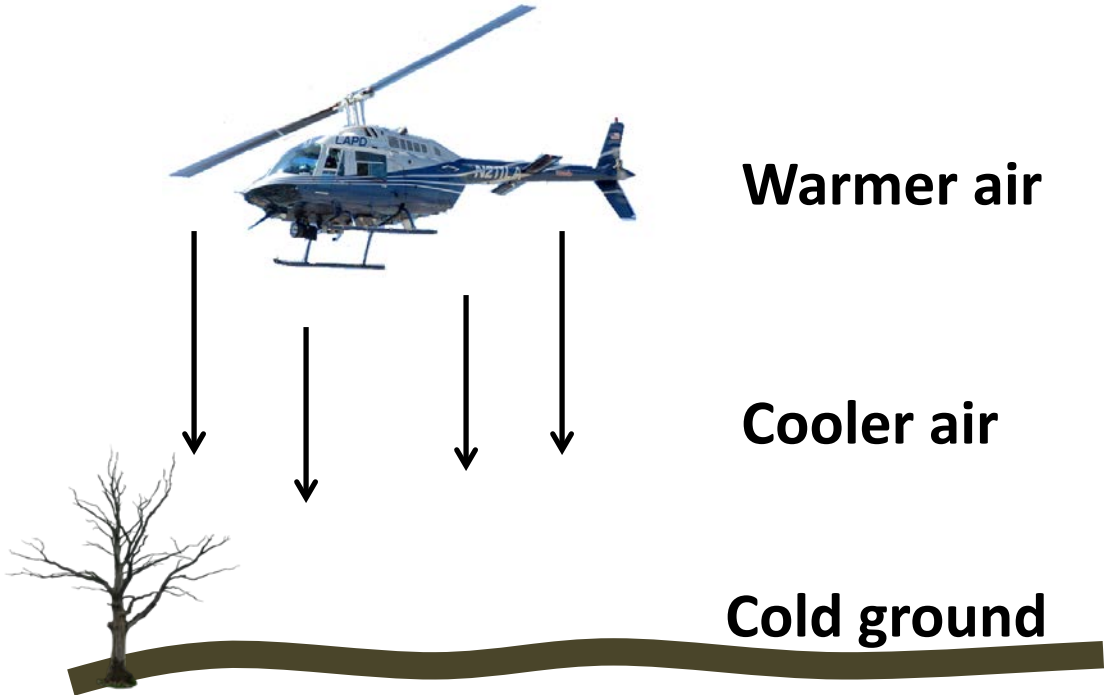
- 35°F

- 32°F

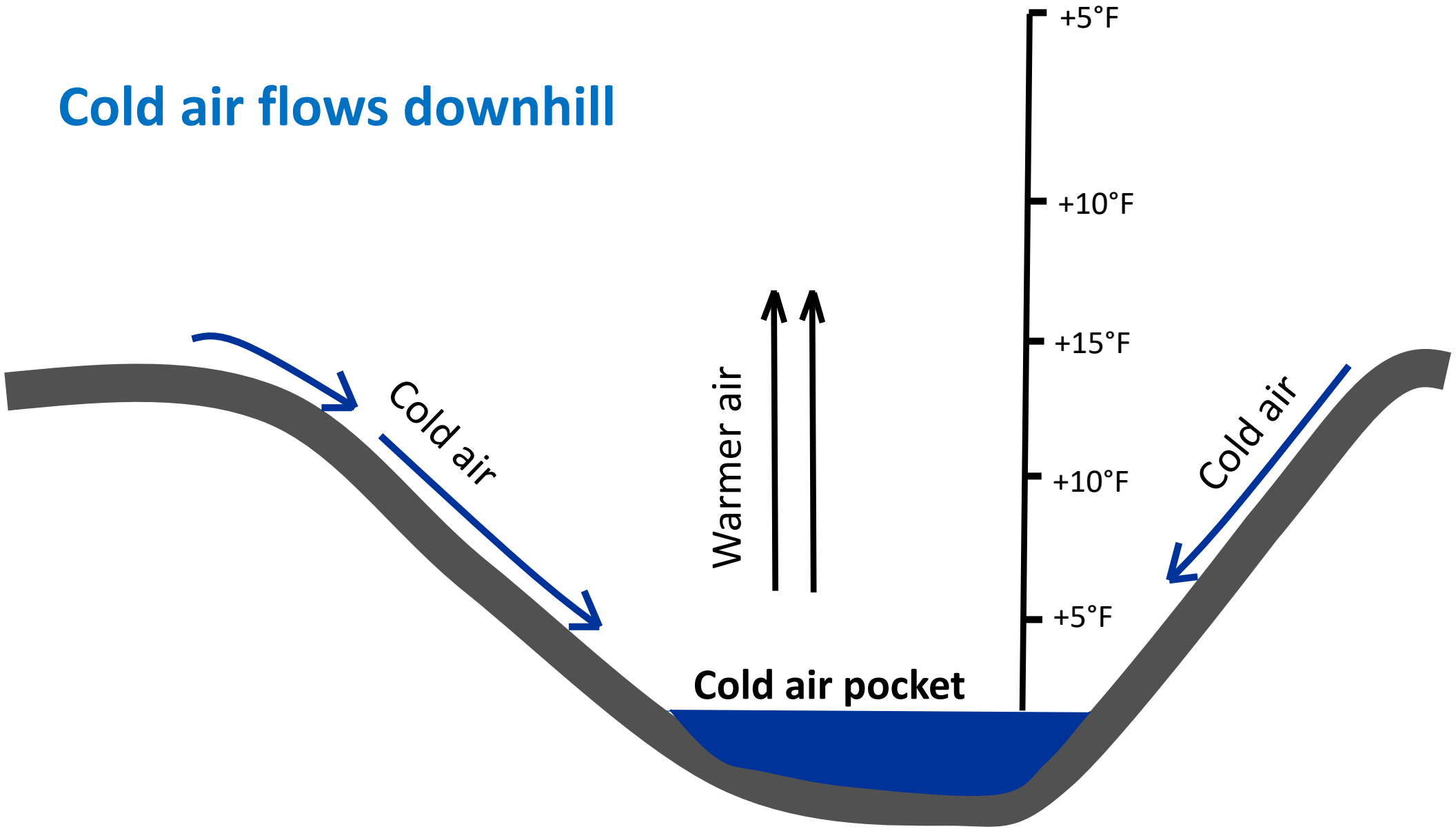
- 30°F

Helicopters

- **Typically cost $700 to $1600 per hour**
- **May protect 25 to 60 acres**
- **Slow passes at 5 to 10mph or hovering**
- **Only effective under inversion conditions**



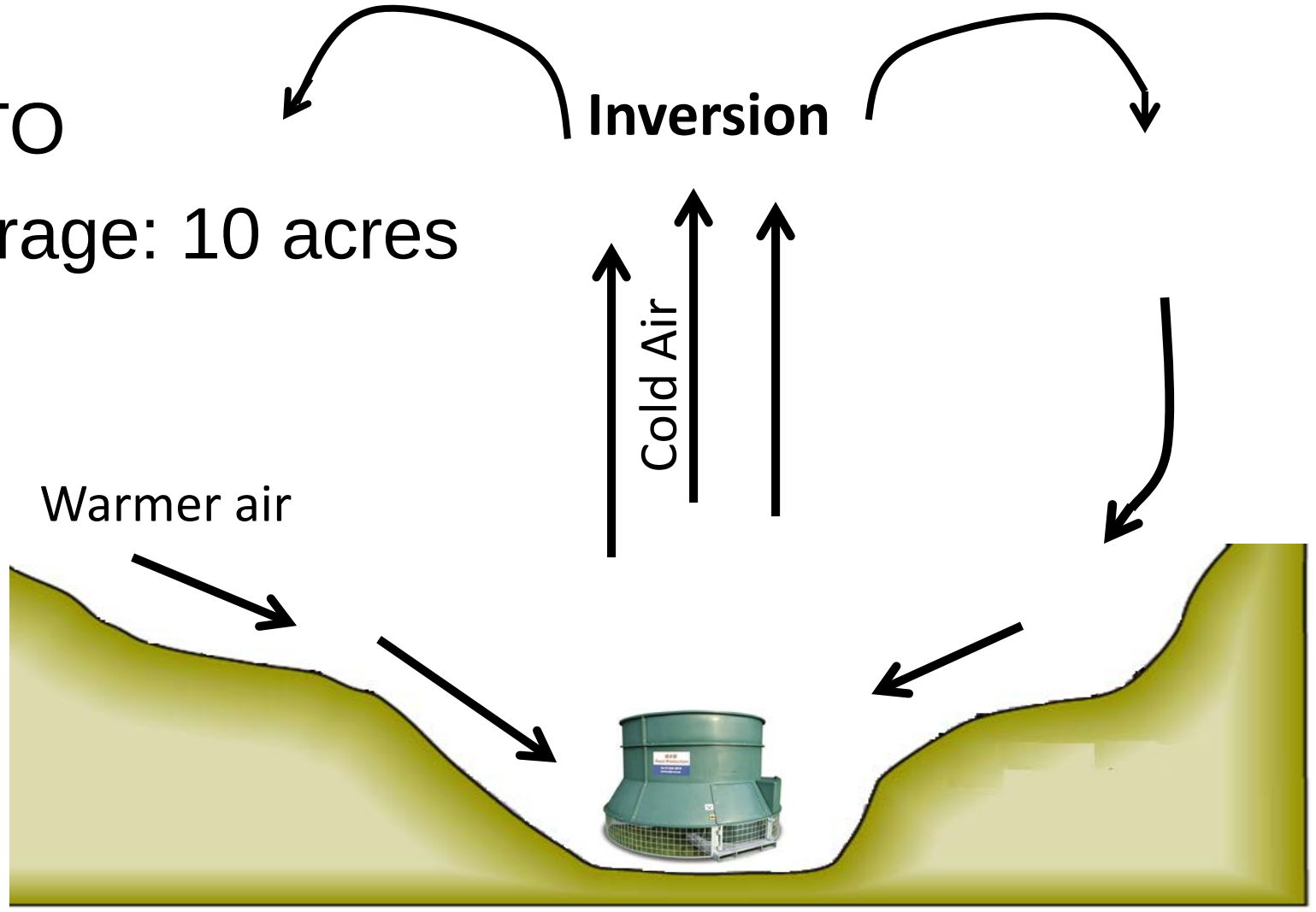
Cold air flows downhill



Cold Air Displacement Systems

- Low spots
- Gas, electric, PTO
- Suggested coverage: 10 acres

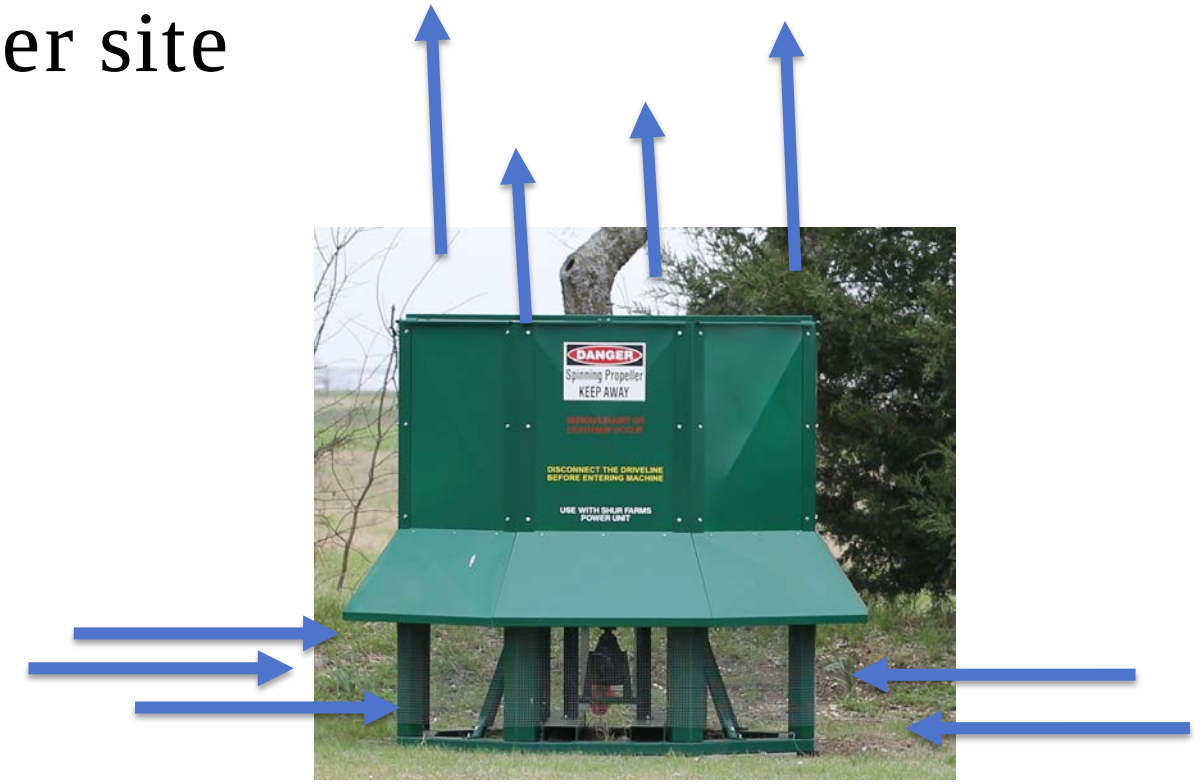
Images from: frostsolutions.com



Study #3 – Active Freeze Protection

Ground based frost fans (Shur Farms Cold Air Drain®)

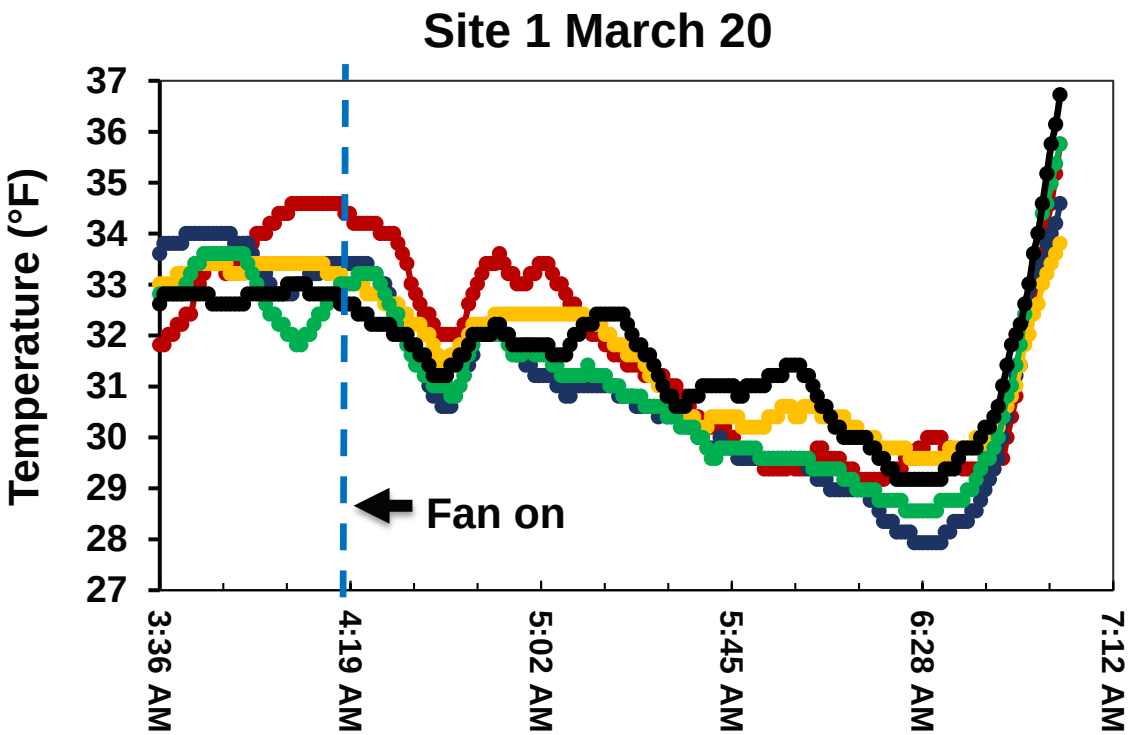
- 2 vineyard sites in North Texas
- 6 temperature data loggers per site
- 2 years

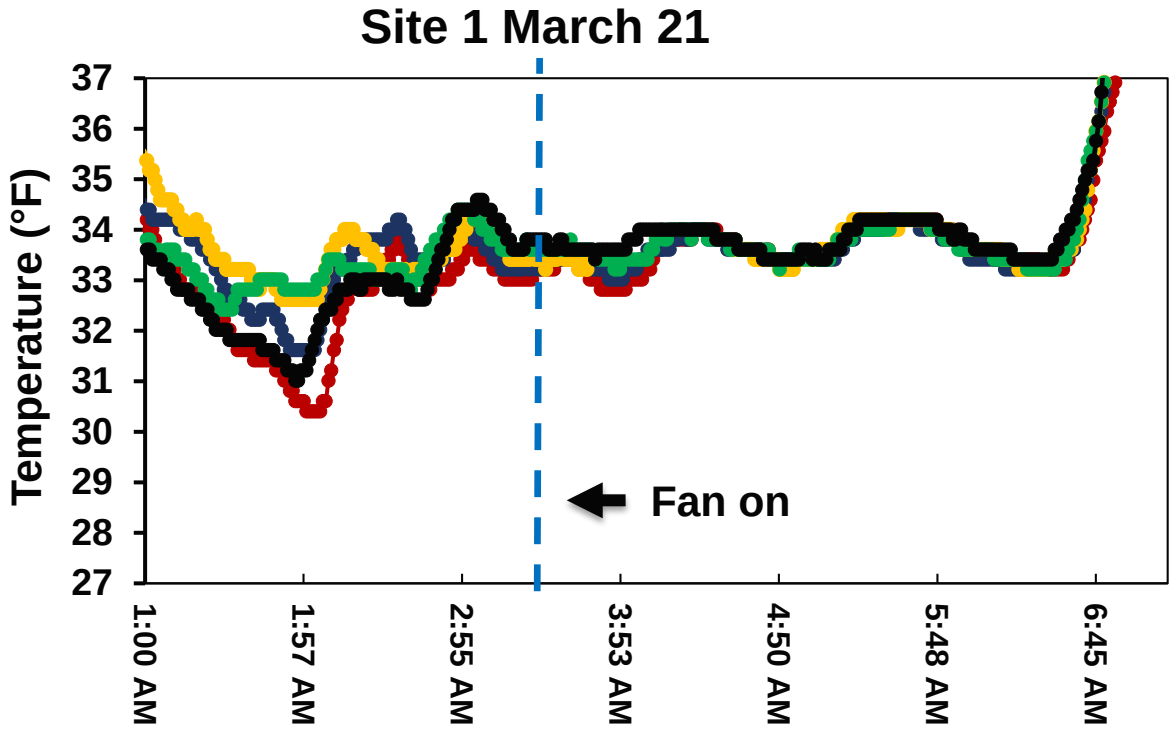


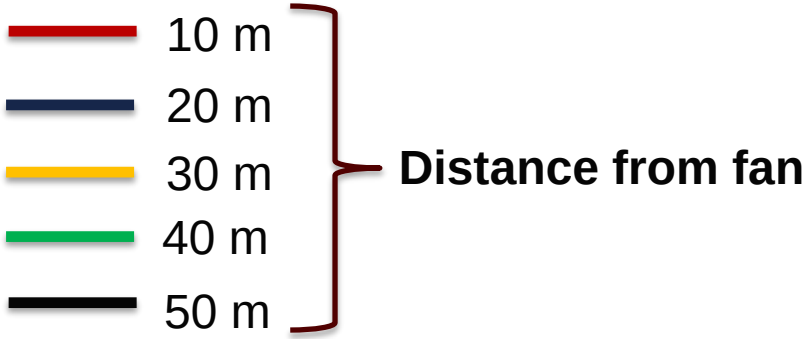
Ground Fan

Positioned in cold air pocket where it blows colder, denser air up to allow warmer air to flow from higher elevations.

Ground Based Fan







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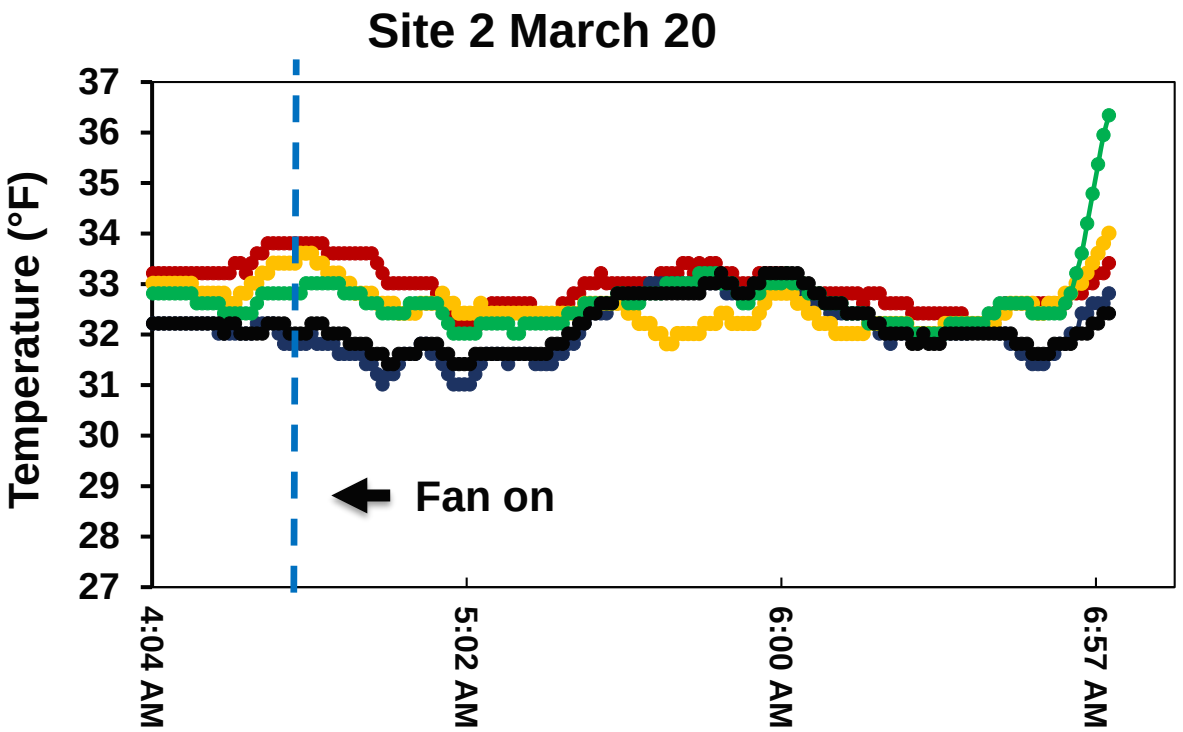
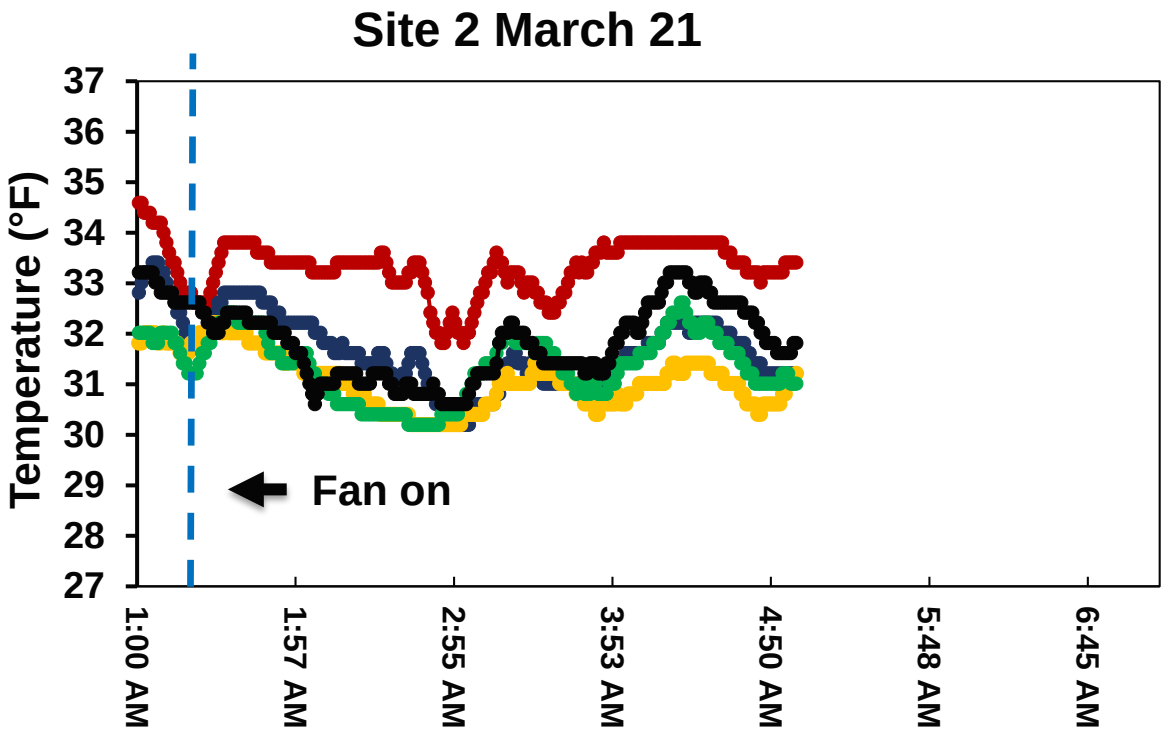
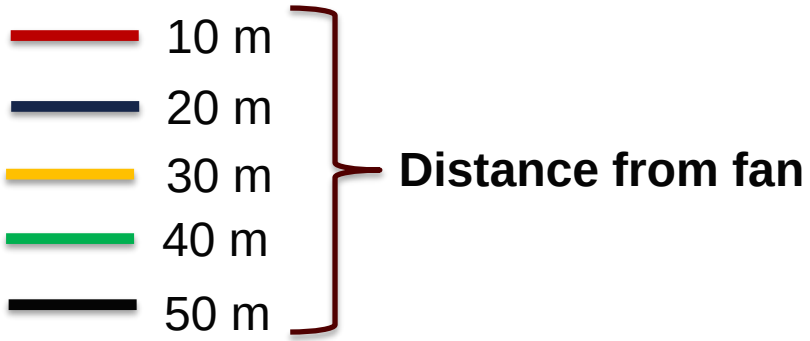






Burning Hay Bales or Brush

- **How effective? How much to burn?**
- **Time and cost to set out and clean up**

Propane Heaters

- **Stationary or tractor mounted**
- **Circulate hot air and modify moisture**
- **Coverage: variable up to 25 acres**

Frost Guard

Image from: AFCOtec.com

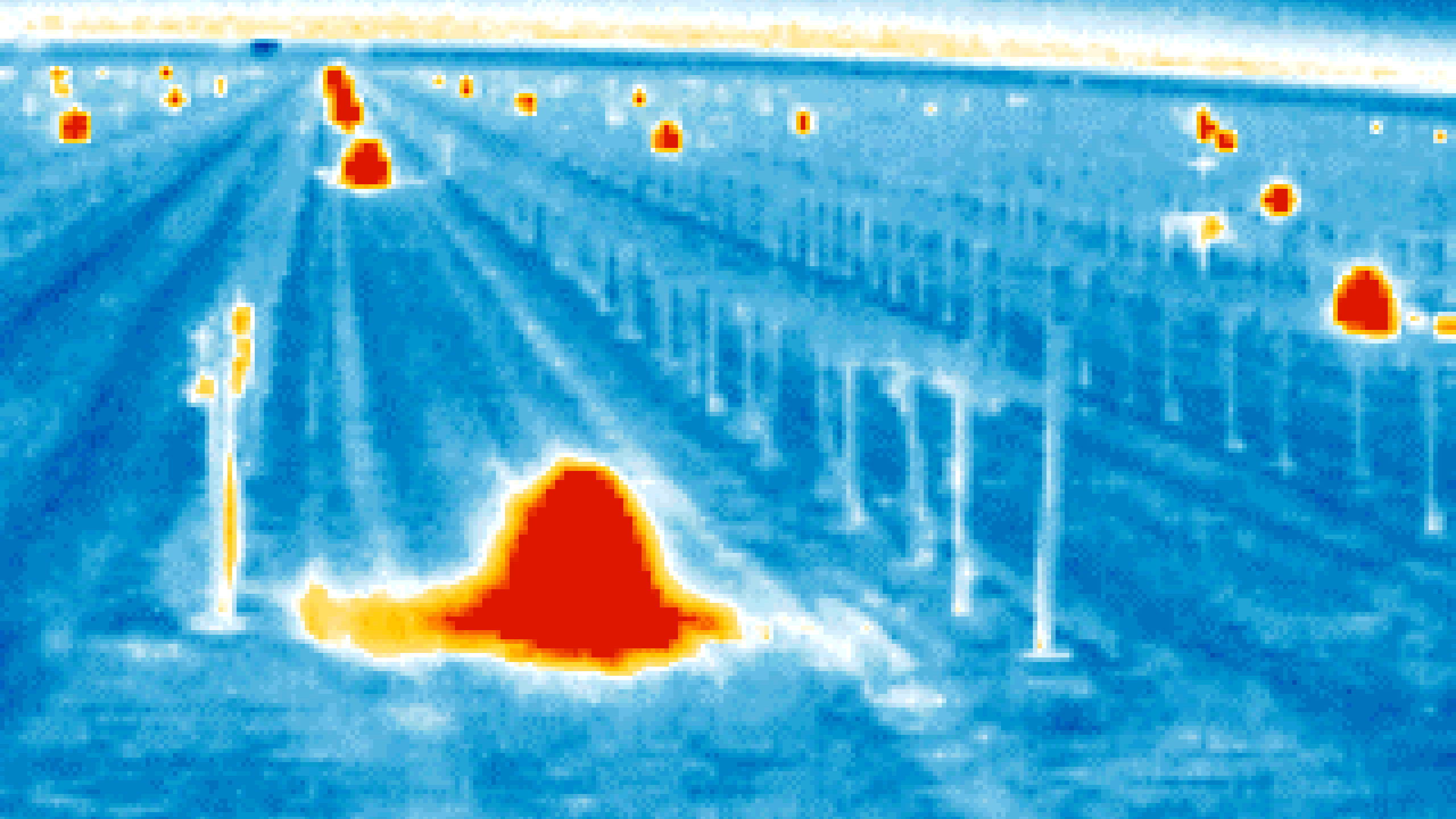
Frost Dragon

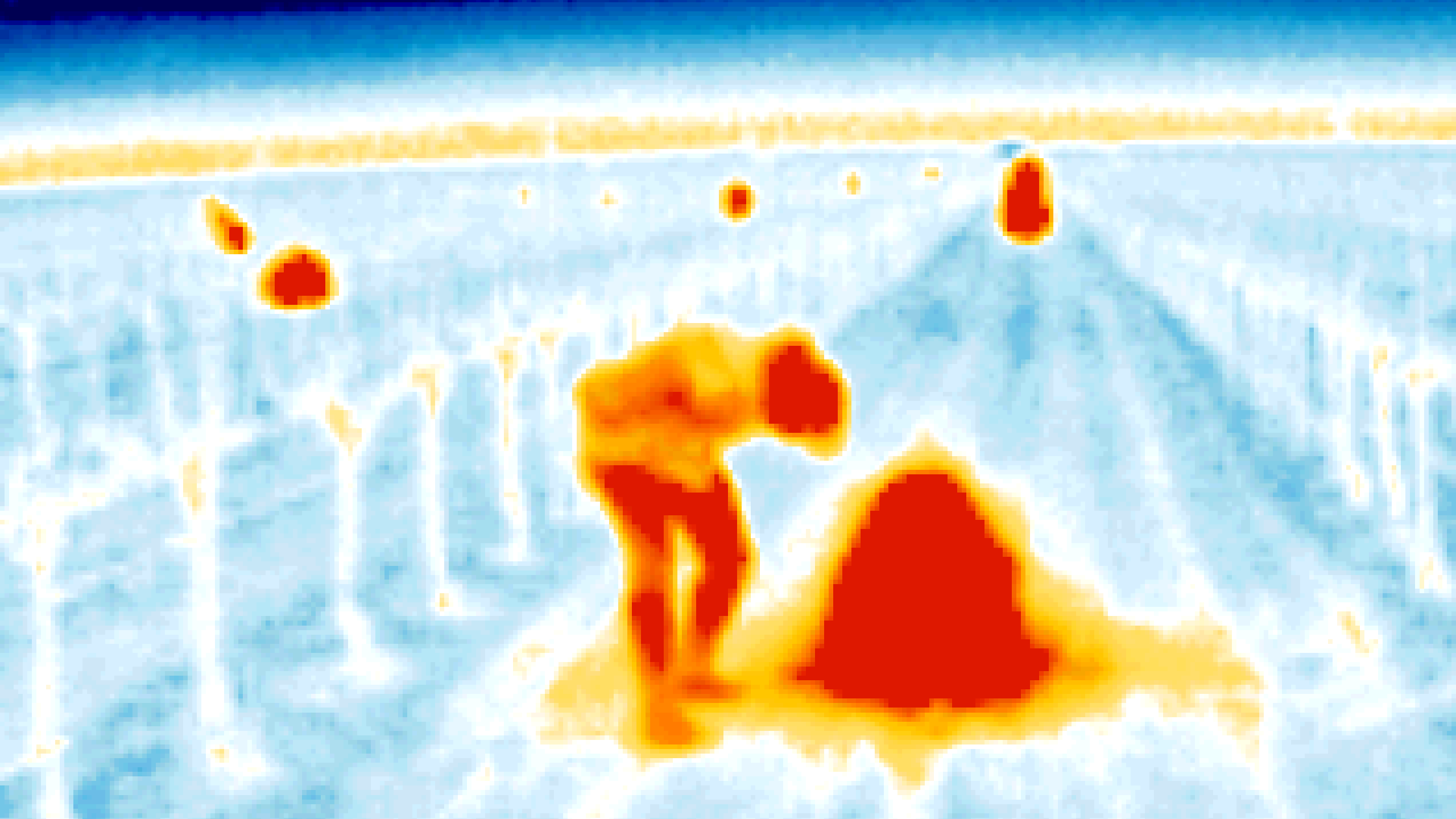
Image from:paigeequipment.com

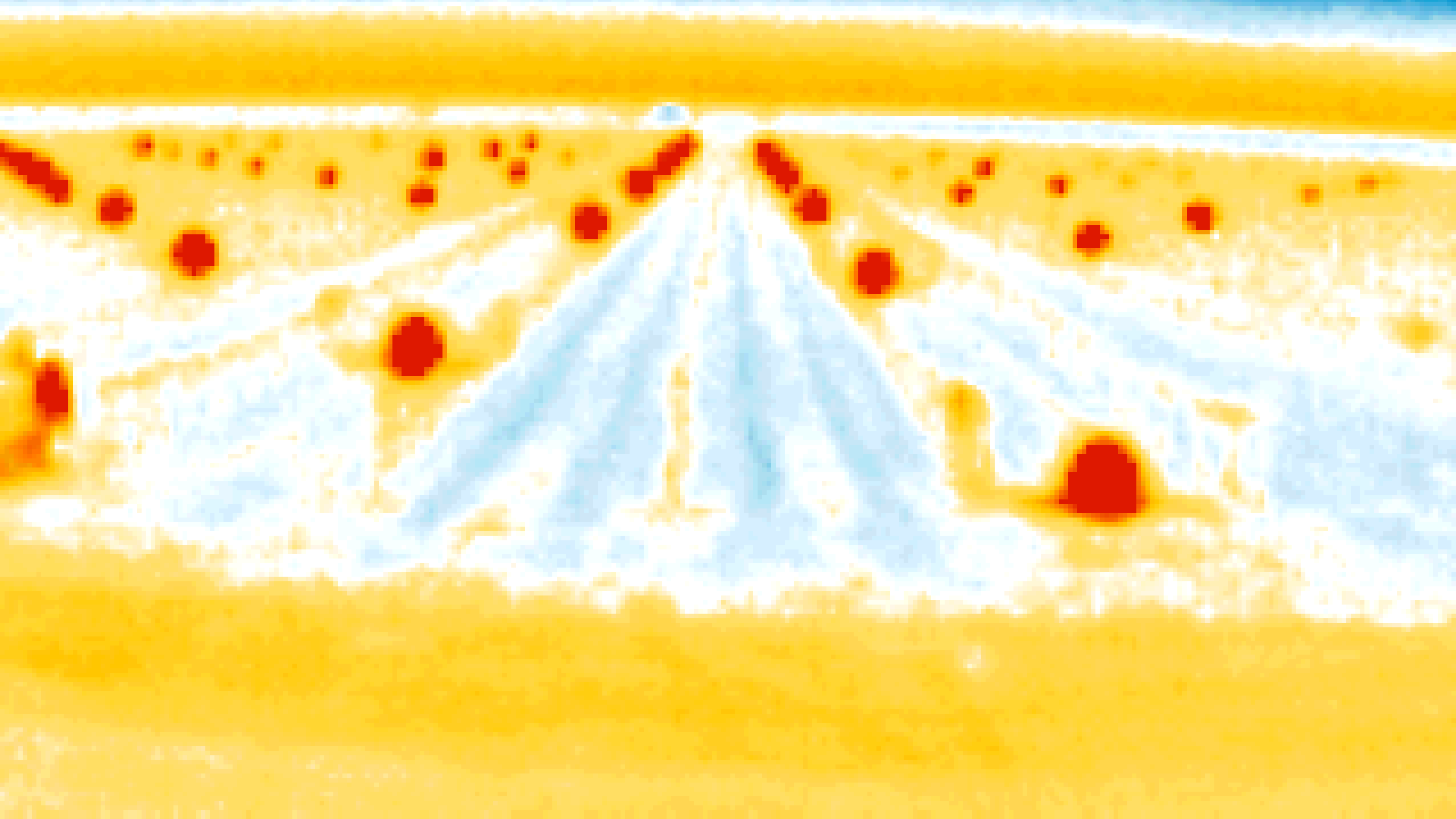
Study #4 – Active Freeze Protection

Propane heaters

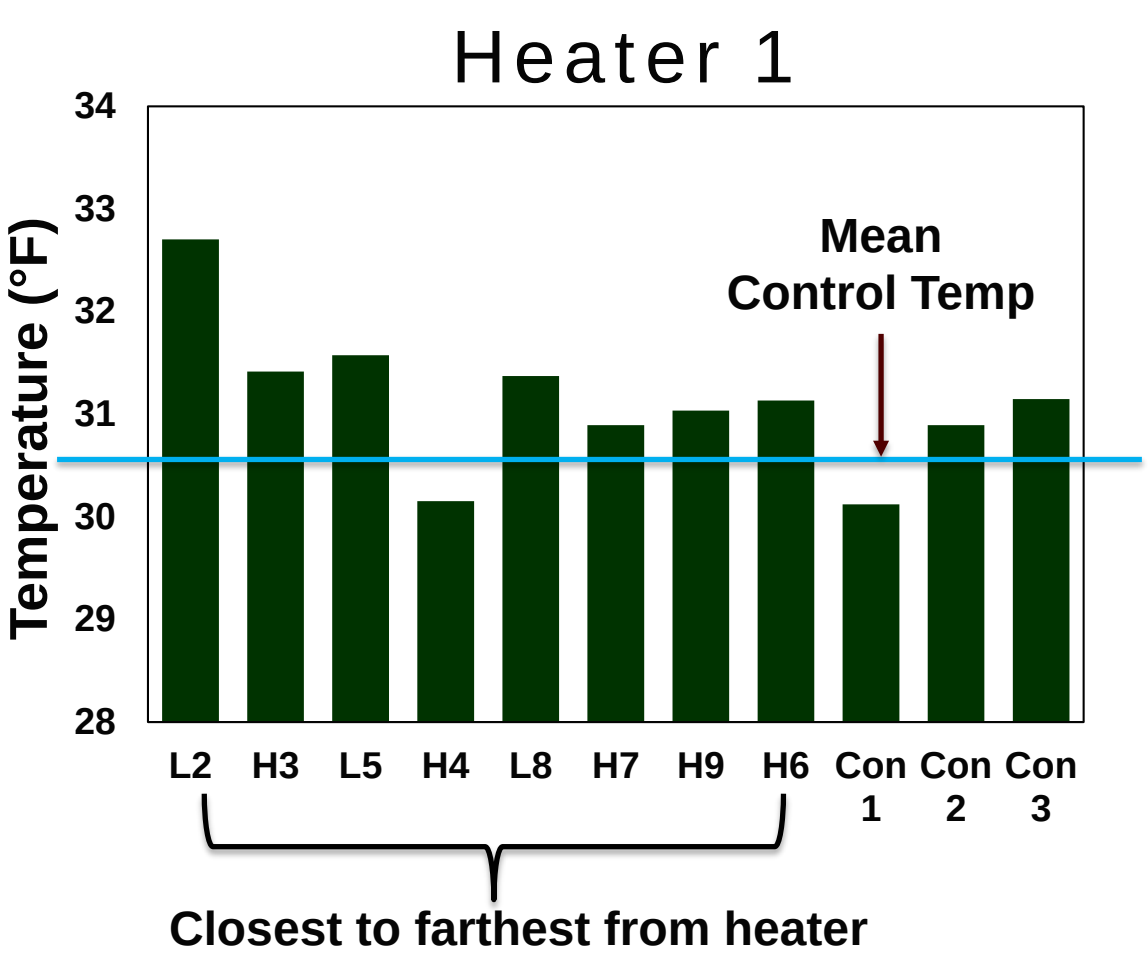
- 30,000 BTU
- 42/acre
- 22 temperature loggers
- Infrared imaging

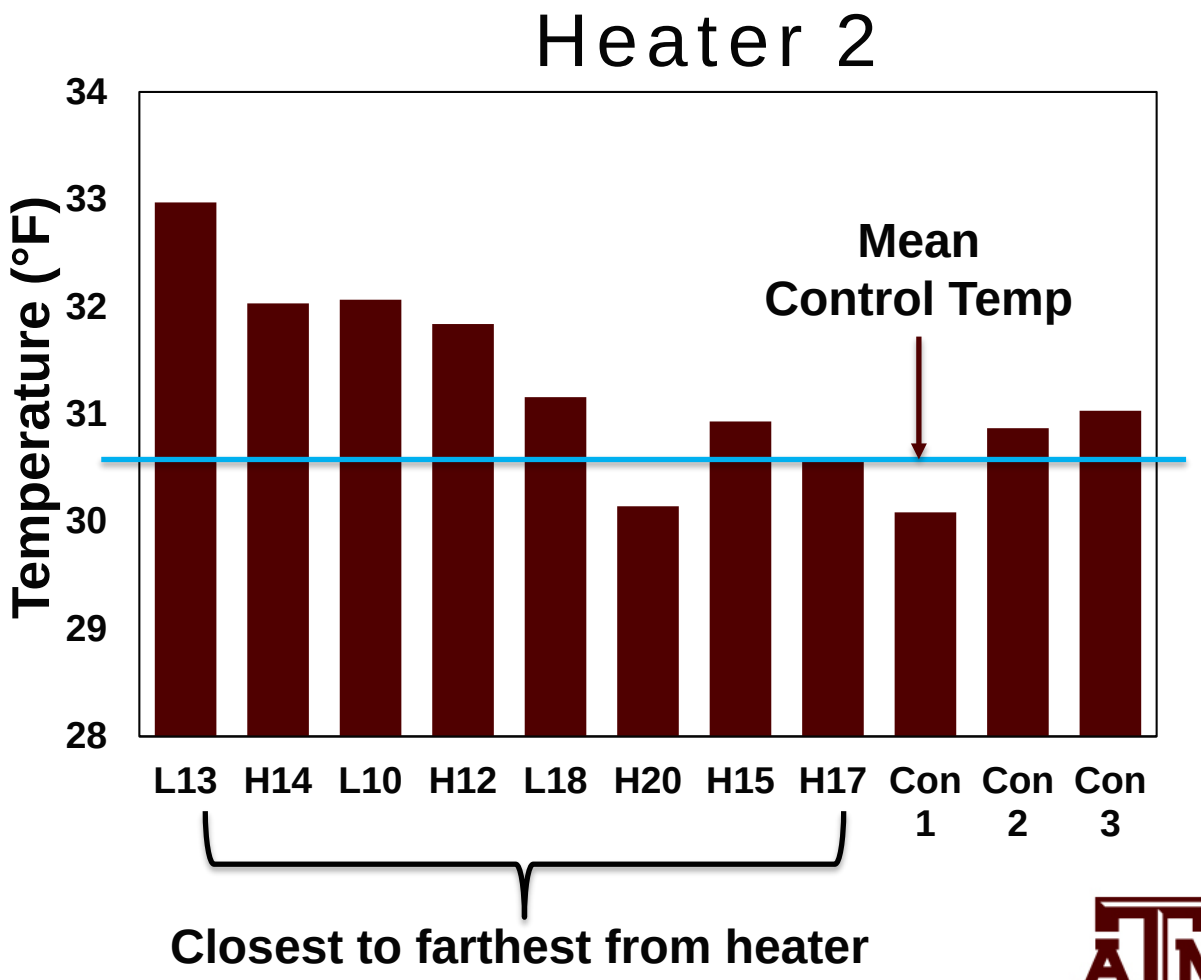






Average Temperature During Freeze Event





Cost of Propane Heater System

- Heaters: $1,000-$1,500/acre
- Hardware: $2,500/acre
- Propane: $11.92/hr/acre (wholesale); $33.52/hr/acre (residential)

Breakeven yield @ $2,000/ton and 12 hours run time:

1.82 tons/acre to 1.95 tons/acre

Summary

- Active frost protection methods are more expensive, but offer protection after bud break and may also be used to mitigate winter injury.