Frost & Freeze Protection Strategies

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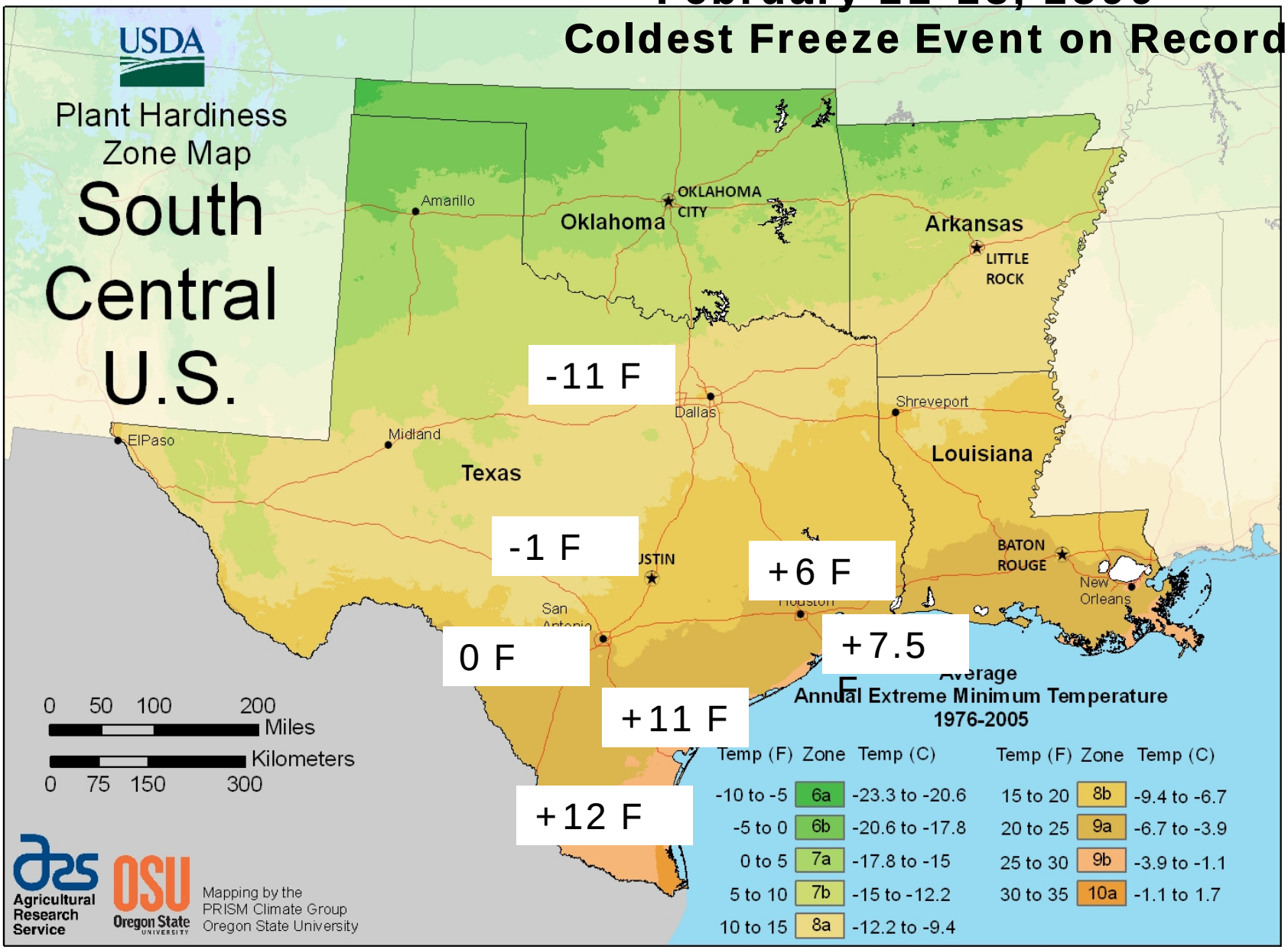
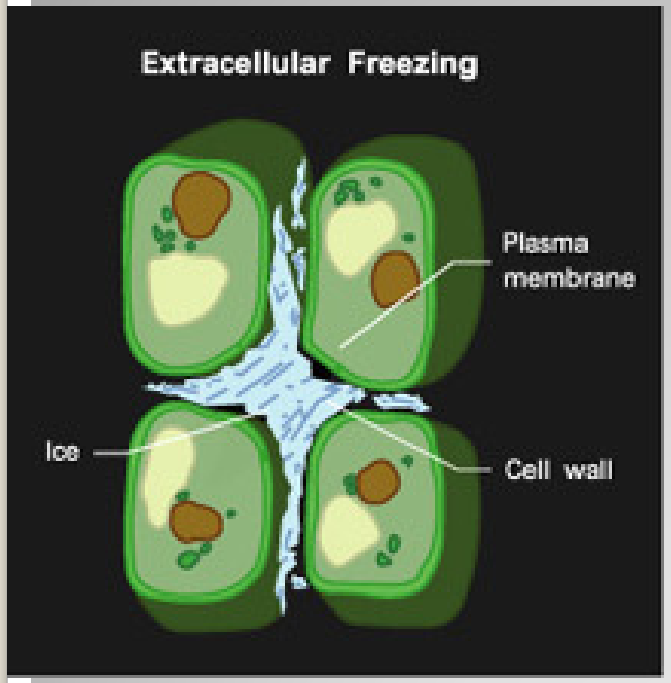
Texas' climate can be uncooperative for fruit production

February 11-13, 1899—
Coldest Freeze Event on Record



NWS Lubbock File Photo, April 8, 2007 (Easter Sunday)



http://ilc.royalsaskmuseum.ca/ilc1/pages/12c/13f/pf13fp2p1.htm

http://www.geraniumsonline.com/freeze4.gif

- Plants have genetic limits to membrane strength, flexibility and their ability to lower intracellular freezing point.
- Enhanced or diminished by weather, vigor, stress.

Freeze Injury is a Physical Process

Critical Temperatures for *Vinifera* Grapes

- 50% bud/shoot destruction, at a given growth stage, are:
- - dormant bud <20 F
- - dormant swollen 26 F
- - burst bud 28 F
- - one leaf unfolded 28 – 29 F
- - two leaves unfolded 29 – 32 F

Source: Tony Wolf, Virginia Tech

Freeze vs Frost

Advective (Freeze)

- Arctic Cold Front
- Wind Speed >4 mph
- Variable Cloudiness
- Cold Air Depth=500 to 5000 ft
- Ground, air and leaves = same temperature.
- May last 24-72 hours
- All portions of plant at risk

Radiational (Frost)

- Cold Front Passed
- Winds <4 mph
- No clouds
- Cold Air Depth=50 to 150 ft (Inversions likely)
- Ground is coldest
- Exposed leaves & buds colder than air temperature
  - 5 degrees possible
- May occur for 1-2 hours
- Outer, top of plants at risk

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EHT-048: Protecting Landscapes and Horticultural Crops from Frosts and Freezes

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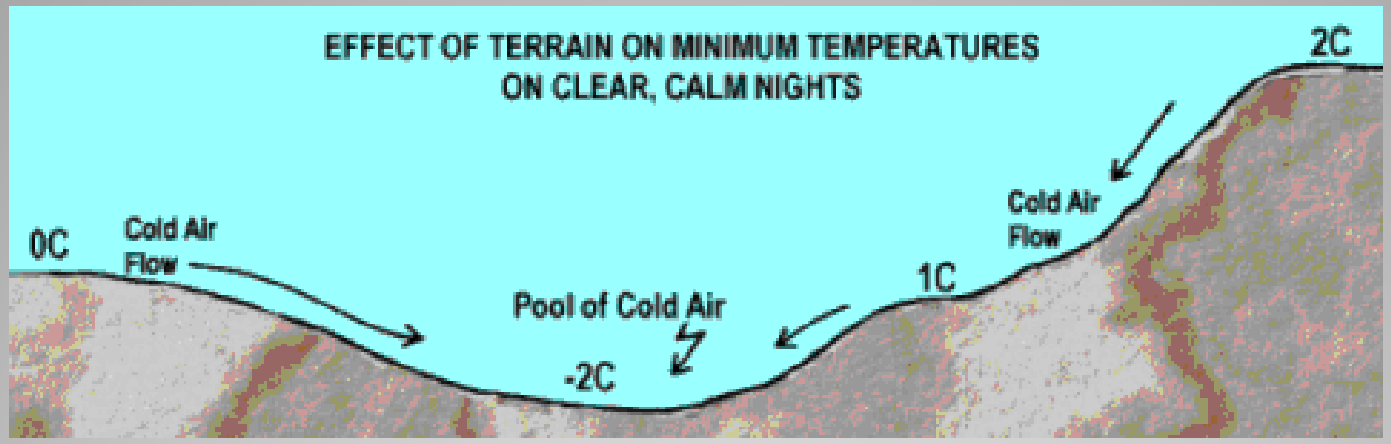
Ground cools quickly from radiation loss
Calm conditions prevent air mixing
“Strong Inversion” means significant temp difference between surface and warm air zone.

Temperature Inversion



Don’t plant in Frost Pocket!

K.C. Heidorn

Cold Air Movement

- Bare ground absorbs and stores more radiant energy than sod.
- Wet, bare ground is even better.
- Maintain a vineyard floor cover in late winter/spring that contributes to greater heat gain.
- Irrigate HEAVILY immediately prior to an event!

Vineyard floor management is important

- Dewpoint Temperature: The temp at which water vapor condenses to liquid, & the temp at which air reaches water vapor saturation.
- High (near 32F) dewpoints slow the rate of temperature decline, especially as fog or moisture in air appears. **Low dewpoints indicate relatively dry air and fast rates of temp decline.**
- Dewpoint temp is considered the basement temp. Dry air has to move in to move the air temp lower than dewpoint.

Weather Factors

Frost

- White Frost or “Hoar Frost”
- Dewpoint higher than 32 F.
- Surface temperature of leaf declines (from radiation loss) to dewpoint.
- Water forms on leaf.
- Water freezes.

- Black Frost or Black Freeze (No visible frost, but plant injury occurs).
- Dewpoint lower than 32 F.
- Temperatures decline to 32 F, with no dew formation.
- Temperatures continue to decline injuring plant tissues.

- Hourly data
- Dewpoint temp.
- Dry bulb temp.
- Wet bulb temp.
- Wind speed
- Cloud/Sky conditions
- Inversion strength

What should you get in your forecast?

Where should you get your forecast?

- Local television meterologists???
- National Weather Service: www.nws.noaa.gov/
- Weather Channel: www.weather.com
- Intellicast, Weather Underground, etc.
- AWIS, Inc.: www.awis.com
  - $200 for 6 months

NWS standard thermometer shelter.

Simple hand-held max/min thermometer—affected by radiation loss

Low cost IR—plant surfacesobjects, not air

Recording dataloggers

Temperature Measurement

Temperature Measurement

Difference Between Dry Bulb & Wet Bulb Temperatures at 30 °F	Relative Humidity
None	100%
0.5°	96%
1.0°	93%
1.5°	89%
9.0°	44%
9.5°	42%
14.5°	19%
15.0°	17%
18.0°	5%

- Sling psychometer—measures wet bulb temperature.

- Vineyard fires
- Prunings
- Many small fires, not large bonfires

- Frost-Dragon
- Mobile heater

Frost Protection Strategies

Return Stack Heaters

- Developed at Univ. of Calif., 1940
- Many small fires concept.
  - 30-40 units/Acre
  - 4.3 Mill. Btu/Acre (Fuel Oil)
  - +6 Deg. Temp increase
- Effectiveness depends on inversion trapping heat.
- Less smoke than reg. smudge pots when maintained.
- Labor needed to light/maintain.

Wind machines

- Disturb the inversion and create currents of warmer air.
- 3-5 degrees protection over 8-10 acres, depending on unit size and cfm.

Photos: J. Scheiner

Cold air drain

- Use irrigation to cool vine temperatures and delay phenology.
- Apply Surround kaolinite??
- Not proven--

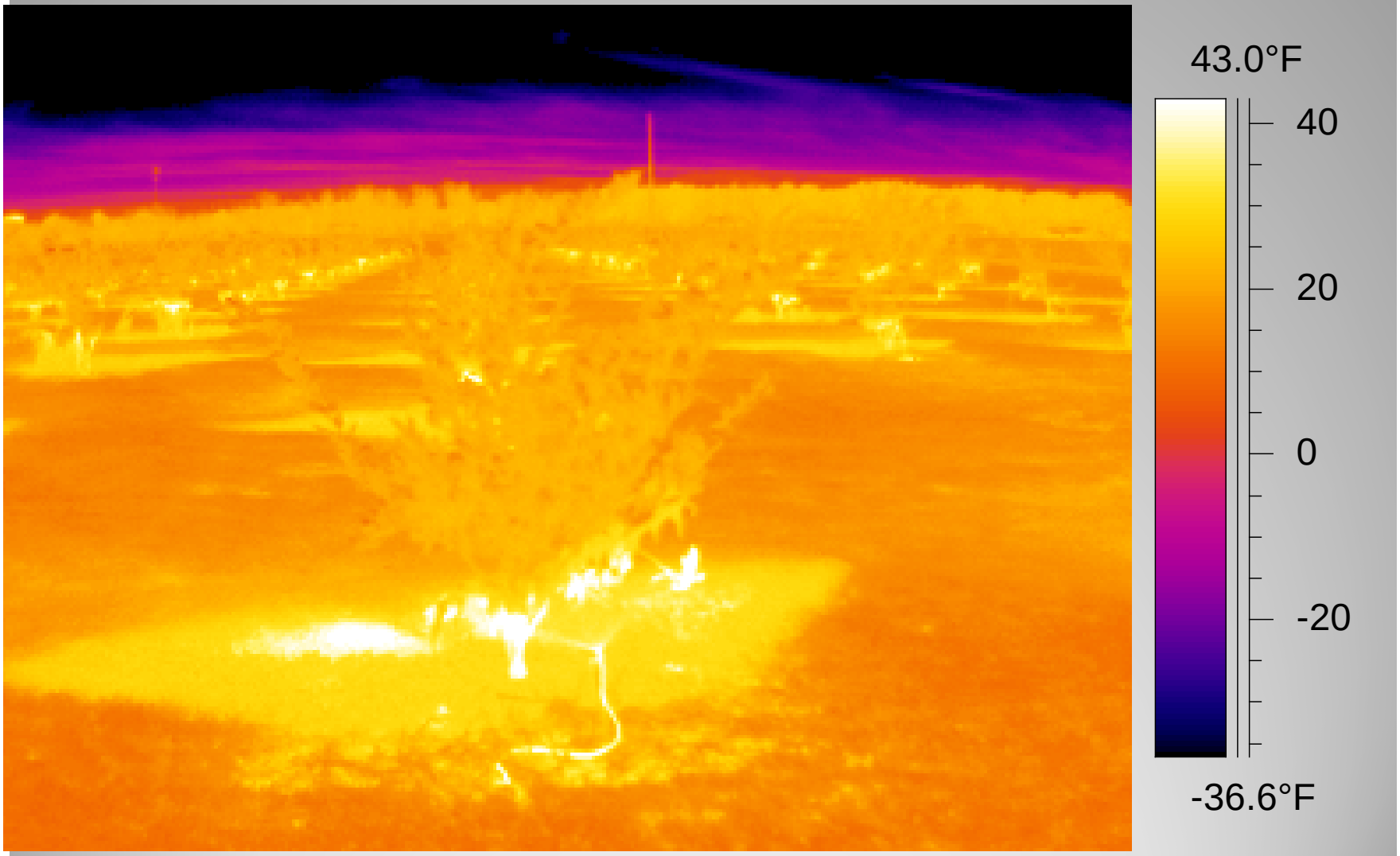
Phenological Manipulation

How irrigation prevents freeze damage

LATENT HEAT OF FUSION

- **Conversion of water to ice releases energy in the form of heat. (144 Btu's of heat per pound of freezing water). + 1 Btu for each degree change in the source water's temperature down to 32.**
  - **1 Gallon water weighs 8.35 lbs, so each gallon frozen yields 1,202 Btu(s).**
  - **1 Gallon water @ 52F = additional 167 Btu(s)**
- **Water contacted tissues stay at or above 32 F if water is continually applied. (Ice is poor insulation)**

How irrigation prevents freeze damage


43.0°F
40
20
0
-20
-36.6°F

LATENT HEAT OF VAPORIZATION

- Heat loss is approximately 1070 Btu(s) per pound of water evaporated.
  - 8935 Btu(s)/gallon evaporated.

- Water must be applied at a rate 7.5 times higher than the evaporation rate to balance heating against evaporation loss.

Evaporative Cooling

Existing fruit is often damaged. Blooms may or may not be saved, depending on stage and low temp.

Water Delivery Options

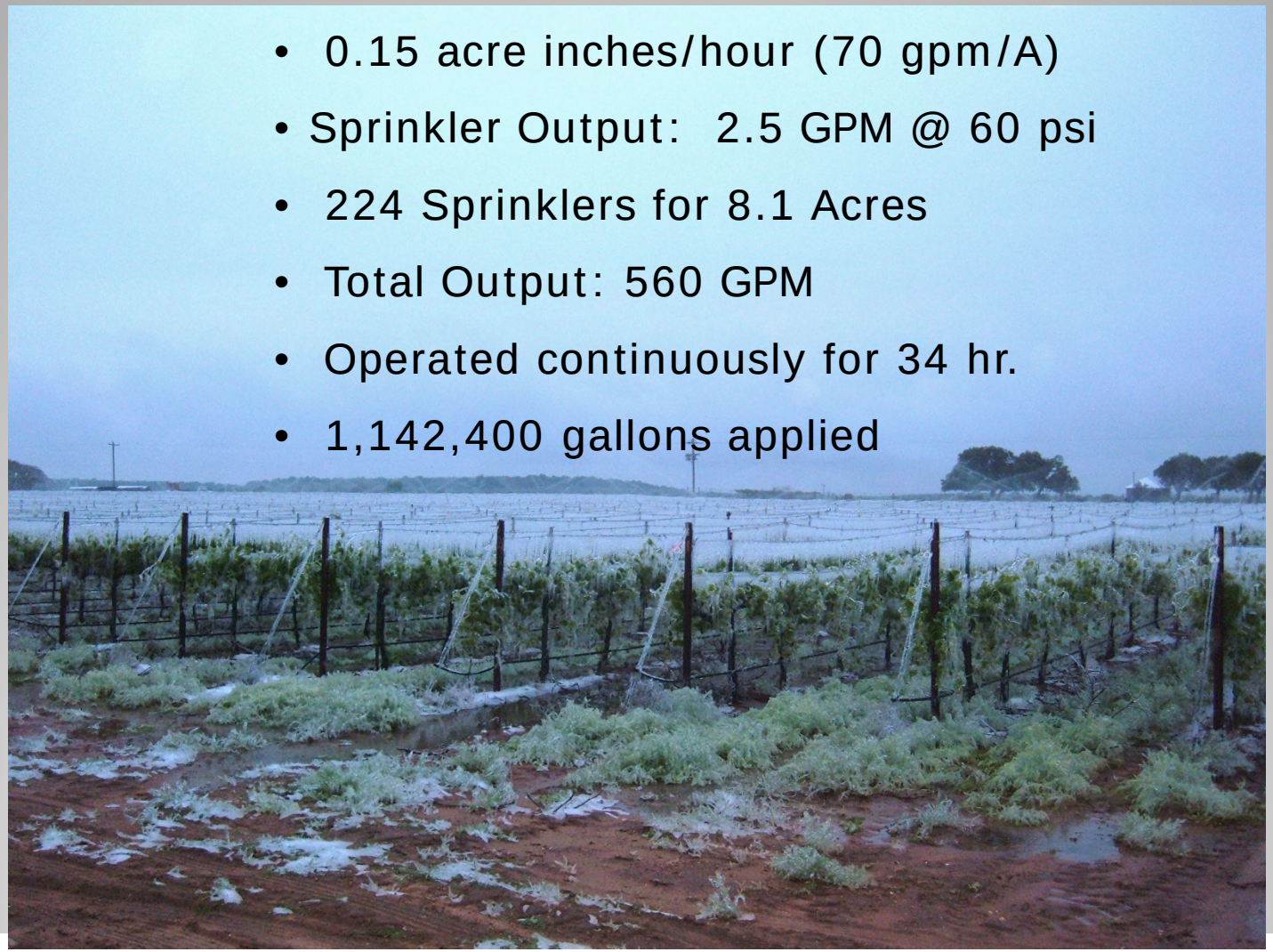
- Overhead
- Under-Tree (Under-Vine)
- Directed or Targeted

Water Delivery Options

Overhead: advective & radiational events

- **Proposed Sprinkling Rates**
- **0.12 acre inches/hour** — **54 Gal/min/A**
- **0.25 acre inches/hour** — **113 Gal/min**
- **0.35 acre inches/hour** — **158 Gal/min**

Cartwright Vineyard – Mason, Texas April 8, 2007



Slide: E. Hellman

Cartwright Vineyard – Mason, Texas April 10, 2007

2 Days Later

Slide: E. Hellman

System design & operation

- **For successful outcomes, rotation time of heads must be short (30-60 seconds) and system output must be capable of offsetting volatilization losses in wind.**
  - **More sprinklers is better.**
- System start-up must be made in consideration of dewpoint or wetbulb temp.

- Wet bulb temperature should be factored at the time a decision to run water is made.
- Plant temperatures will decline from dry bulb to wet bulb temp instantly when water is applied.

Projected Low Dewpoint Temp	System Start Temp	
28 F	33 F	
25 F	35 F	
20 F	37 F	
18 F	38 F	
Using Wet Bulb Temp		
Start	32 F	Exposed emitters may freeze up before air temp of 32F in radiational events.
Stop	34 F	Higher Stop temp is needed when conditions favor heat vaporization

System start & stop

- Only protects canopy in radiational frosts with little to no wind.
  - Advective, low dewpoint conditions detrimental
- Protects lower trunk well.

Under-Tree/Vine Frost Protection

- Individual vine microsprinklers
- Constant application to target (buds &/or leaves on cordon)
  - Use with shields & netting?
- Efficient use of water volume.

Wade Rain Inc., Fresno, CA

Targeted Frost Protection

- In situations where water is limiting, a directed system allows portions (1/3, ½) of the vineyard or orchard to be protected and prevent total crop loss.

Water Limiting?

Overhead or Targeted Delivery

Radiational (Frost)

- Cold Front Passed
- Winds <4 mph
- No clouds
- Cold Air Depth=50 to 150 ft (Inversions likely)
- Ground is coldest
- Exposed leaves & buds colder than air temperature
- May occur for 1-2 hours
- Outer, top of plants at risk

Best Application: Grapes

- Water volume must support multi-day freeze/frost events.
- System failure (electrical, filtration) can cause greater damage than with no irrigation.
  - ICED-up plants in high winds can/will be colder than if no water were applied.
- Marginally damaging frost events can lead to difficult decisions of whether to run water or not.
- Trellis and branch damage may occur under excessive ice loading.

Considerations & Concerns

Final Thoughts

- Know Your site
  - Topography—Mesosite
  - Local radiational heating/cooling patterns
  - Compare to surrounding monitored sites
- Know varietal phenology & differences in cold hardiness.
- Monitor vine phenology
- Track weather closely during critical stages.
- Check system operation regularly.
- Consider and integrate every weather factor in each event.

Contact

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