Frost In The Vineyard

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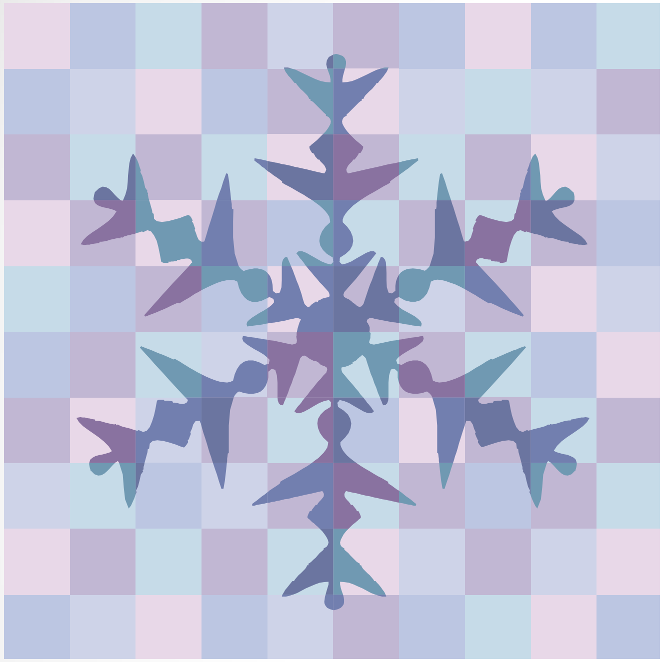

- Basics of Frost Protection…the easy stuff
- Types of freeze and frost events
- Anatomy of Frost
- Frost Monitoring
- Manipulating the landscape
- Protection Mechanisms

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The Question is Not

'How?'

It's

'How Much?'

- It is *possible* to protect crops from most frost events, but other considerations often influence the choice

- Economics:
  - Crop value
  - Expenses
  - Current debt load

- Environment:
  - Resource use
  - pollution

- Horticulture:
  - Long term Physiological/physical effects on crop

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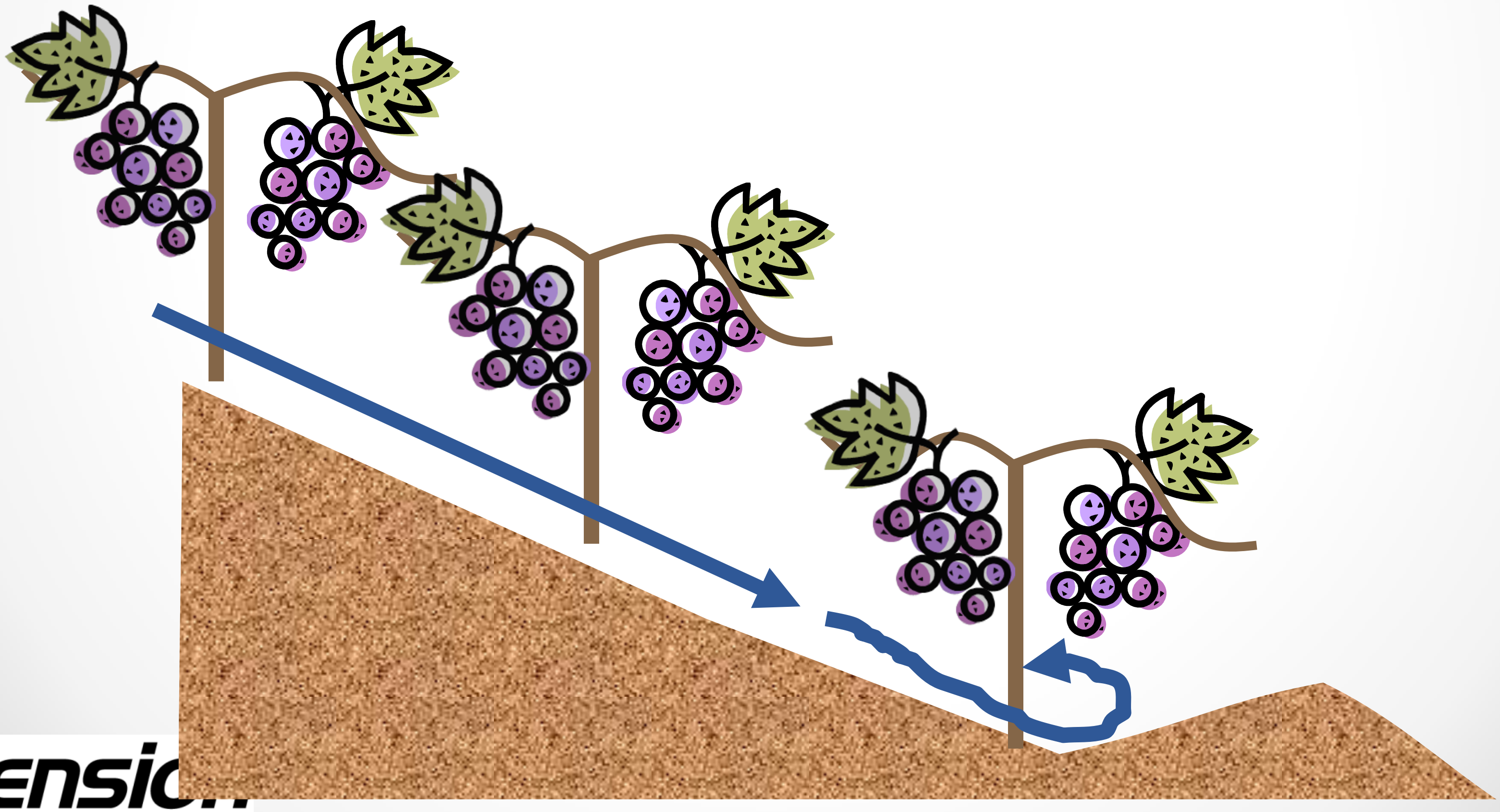
Start with the Easy Stuff…

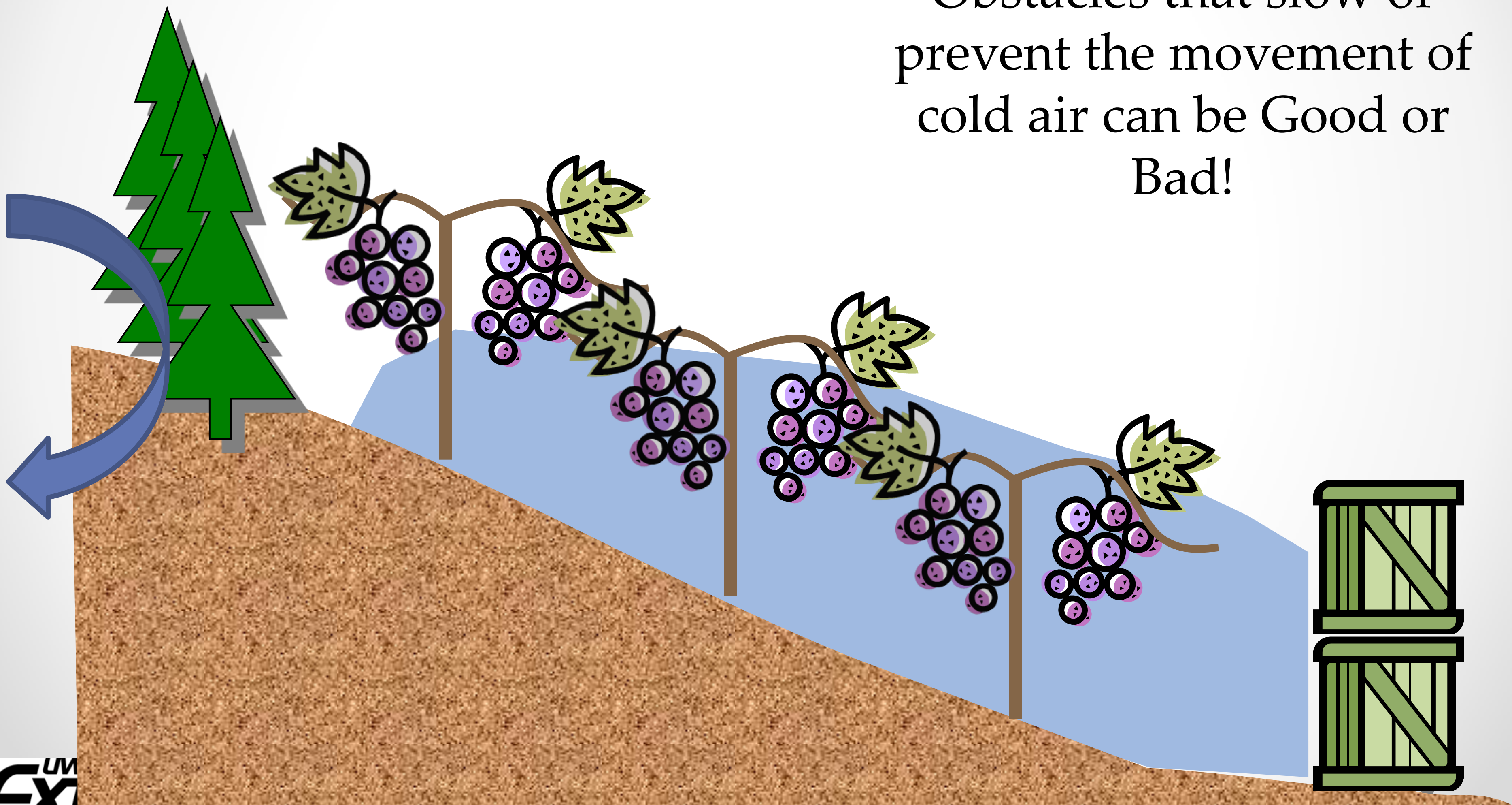
Site Selection

- The best frost protection technique is to choose the right site



Cold Air Drainage:
Wind Breaks and Obstacles

Obstacles that slow or prevent the movement of cold air can be Good or Bad!



Cold Air Drainage

- Prune trees and vines to avoid blocking cold air from draining away from the vines
- Prune out lower portions of windbreaks to allow air to pass through (unless the windbreak is also keeping cold air out)
- Be mindful of where obstructions are placed to ensure they are not blocking movement of cold air

Types of Frost Events

National Weather Service

Frost Advisories

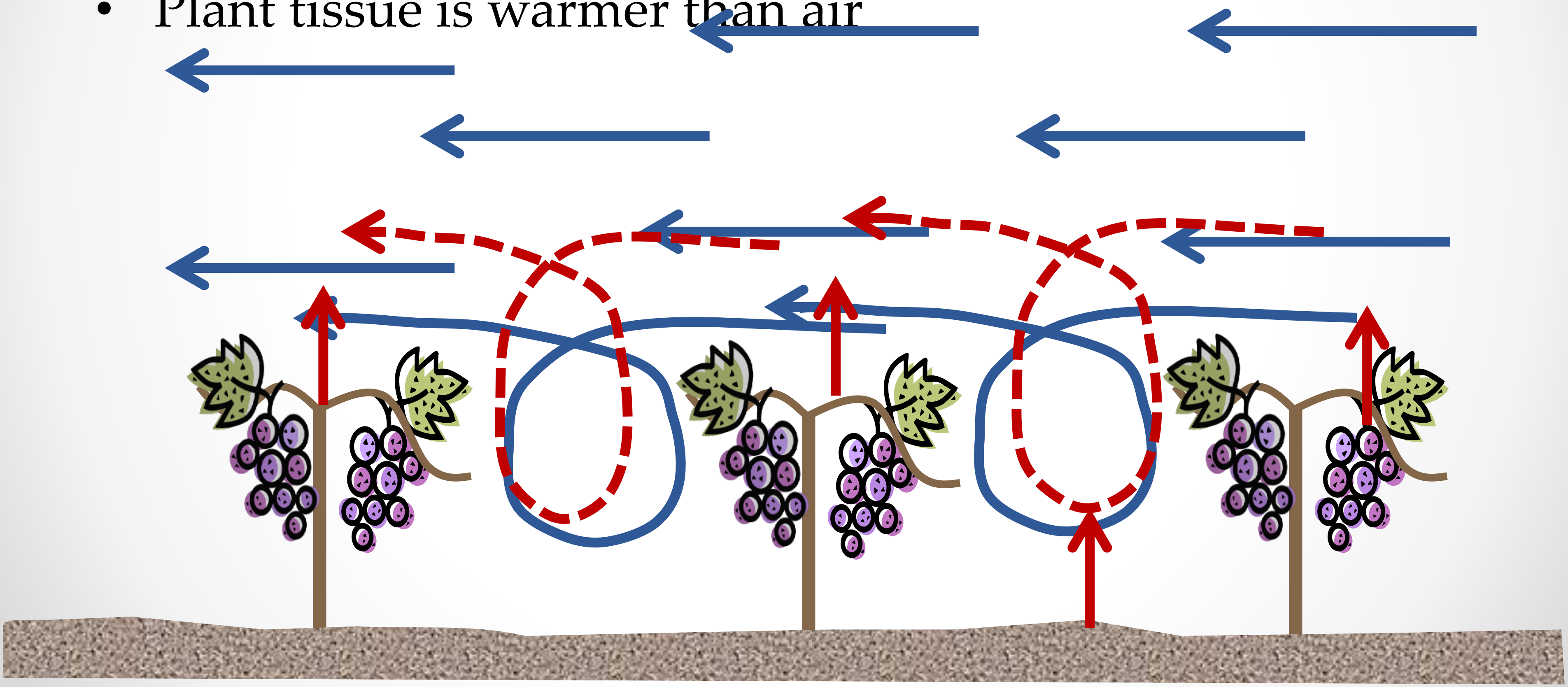
- minimum temperatures of **32-35^0 F** are expected for several hours.

Freeze Warnings

- minimum temperatures **around 30^0 F (or lower)** are expected for several hours.

Advection Freeze

- Advection- *transfer of heat (or cold, humidity) by the horizontal movement of an air mass*
- Dry, cold air mass moves in
- Plant tissue is warmer than air

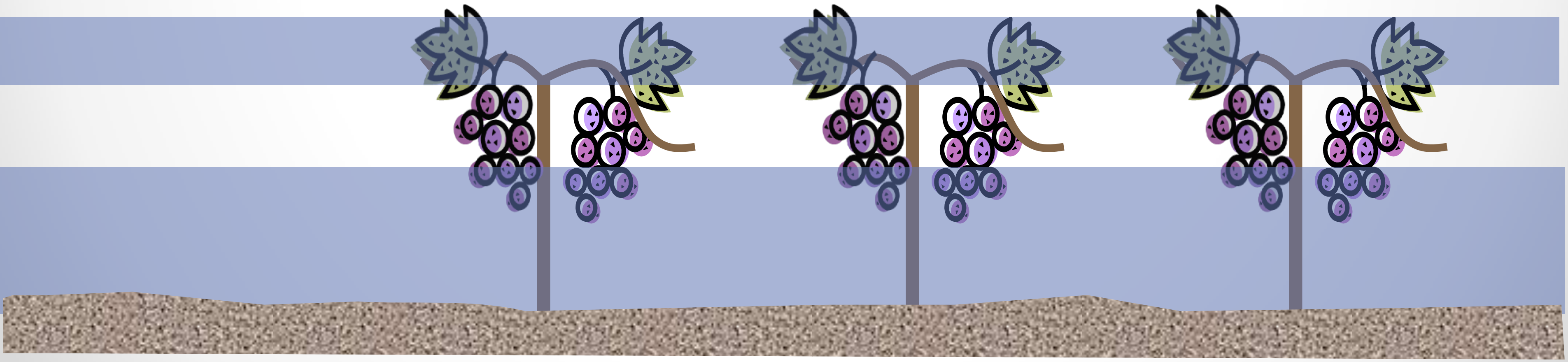


Advection Freeze

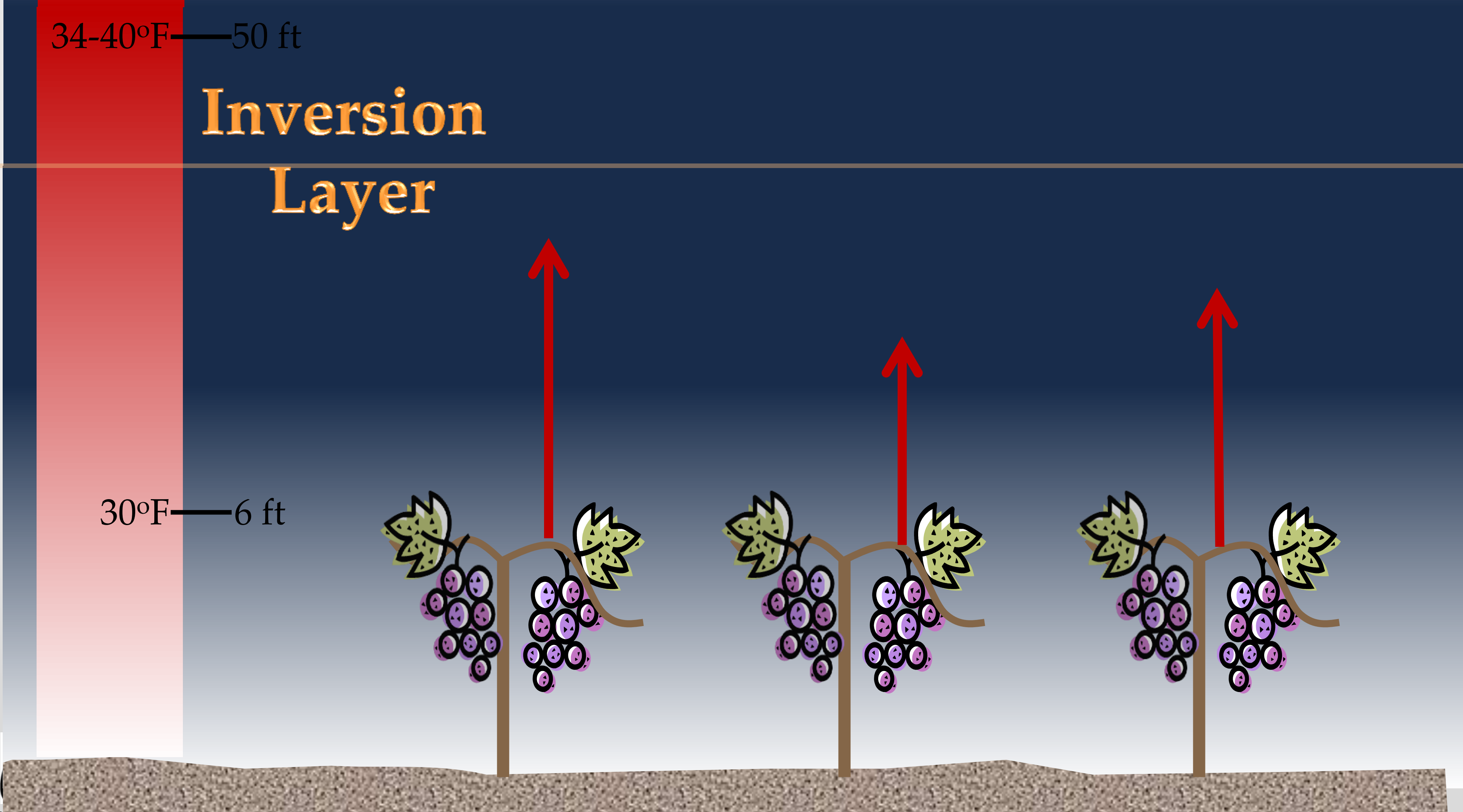
- Very difficult to protect crop
- Any inputs of heat into the vineyard (ie. burners) are quickly blown away
- DO NOT use wind machines!
- Overhead irrigation can be used but MUST supply large volumes of water
    - insufficient water can quickly cause much worse damage that doing nothing at all

Radiation Frost

- Clear, dry air
- Little or no wind
- Plant tissue 'radiates' heat into space and becomes colder (2-4^{o}F colder than air)
  - Plant tissue directly exposed to sky (top of canopy) become coldest
  - Warm air tries to warm plant an becomes colder and settles to the ground



Radiation Frost



Bud Cooling During Radiation Frost

- Rate of plant tissue cooling can be very fast until the temperature approaches the dew point temperature
    - Dew Point Temperature = *The temperature at which condensation of the water vapor in the air first occurs.*

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Heat of Condensation

- The formation of condensation (dew) on the tissue releases heat which temporarily stops/slows the tissue cooling
- At the dew point temperature:
  - The exposed tissue will generally be the same temperature as the air
  - The rate of cooling is much slower because the heat of condensation replaces some of the radiative heat loss

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Rate of Cooling During Radiation Frost

Example 1: Air Temp = 35°F, Dewpoint Temp=33°F

- Temperature will drop quickly until it reaches 33°F when condensation will form on the buds.
- Heat of condensation will compensate for some radiative heat loss and slow the rate of cooling

Example 2: Air Temperature =35°F, Dewpoint= 27°F

- Temperature will drop quickly until it reaches 27°F
- Damage to buds can occur quickly, so protective measures must be started earlier

Dew Point

- Dew point is always lower than or equal to the air temperature
  - If air temperature continues to fall lower than the initial dew point, more water condenses and the dew point is also lowered
- Dew Point Vs. Relative Humidity
  - Relative humidity is a relative measure of air moisture

Temperature (ºF)	Dew Point (ºF)	Relative Humidity
90	80	67%
100	80	47%
110	80	33%

Dew point is the most critical measure to understand when frost protecting

Critical Temperature and Dew Point

- Critical temperature - *the temperature at which buds and/or other plant tissues (cells) will be killed.*

- If dew point is **below** the critical temperature, rate of cooling will be very fast and bud kill will occur quickly
  - No time to ponder the approach…get some protection!
  - If using irrigation for protection, must be sure not to start too late or buds can super cool

- If dew point is **above** the critical temperature, the rate of bud cooling will be slower as it approaches the critical temperature
  - More time to consider and monitor conditions

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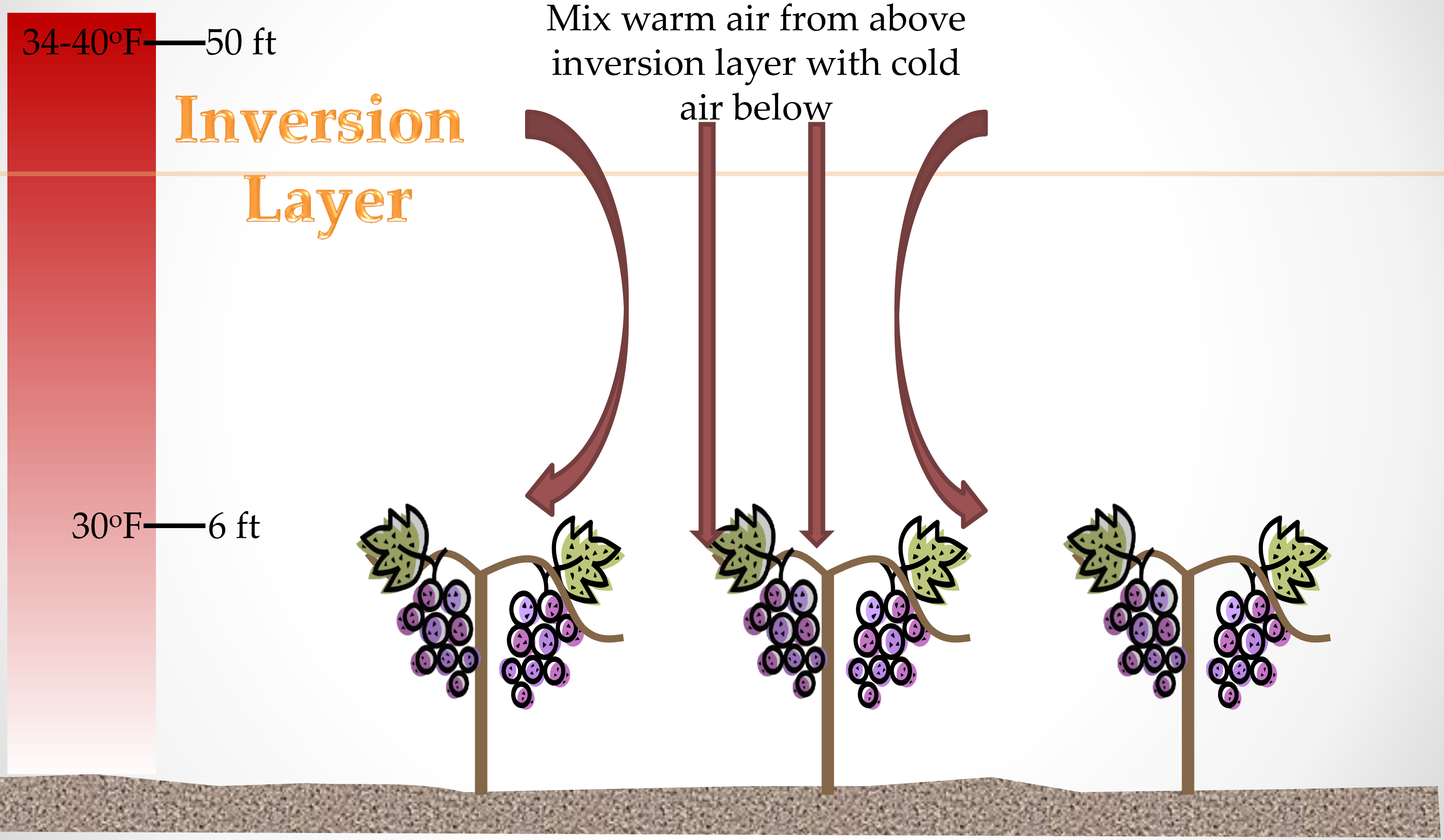
Principles of Protection During Radiation Frost



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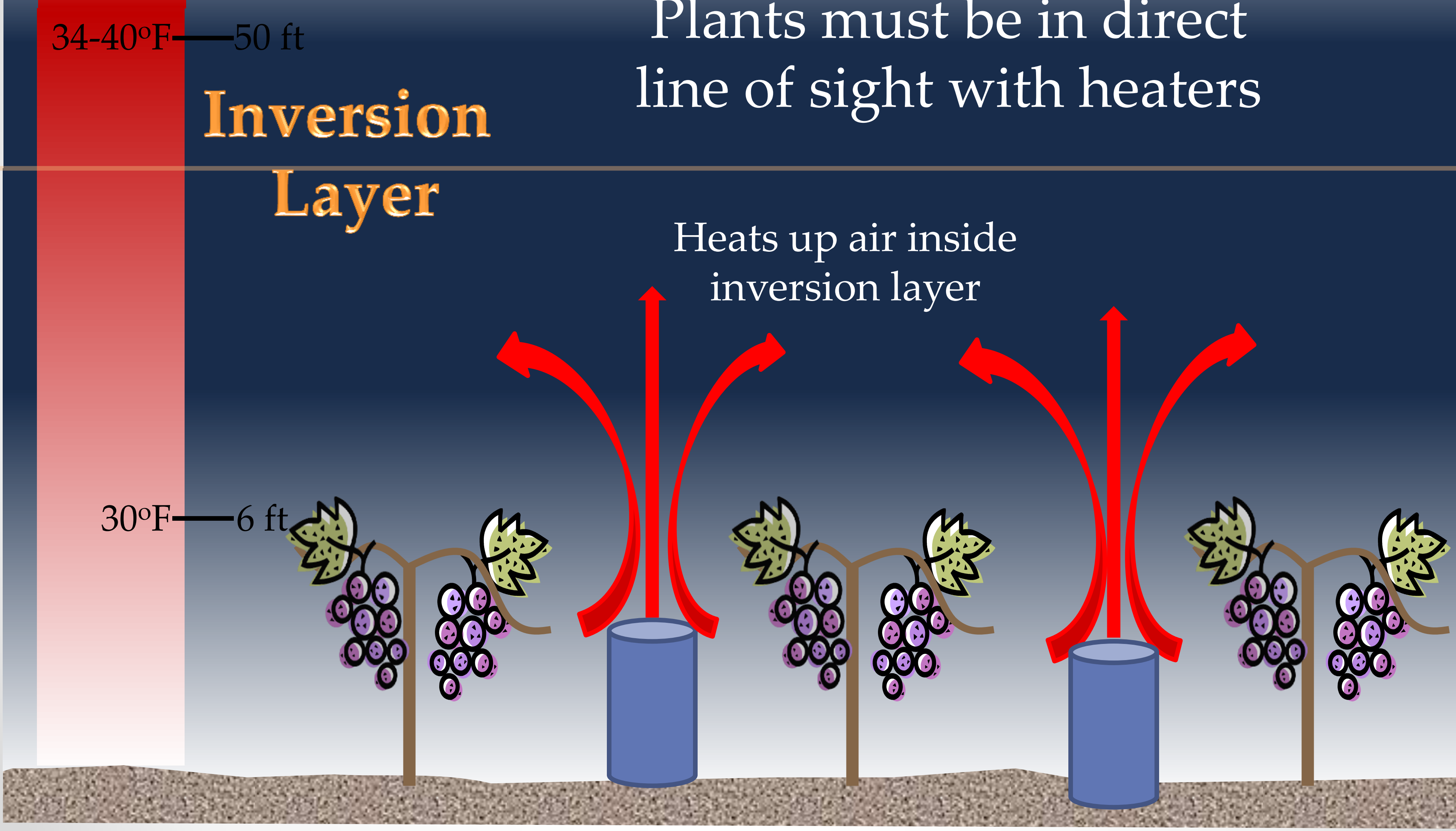
Methods of Protection During Radiation Frost

- Site Selection
- Heat
  - Heaters
- Wind
  - Wind machines
  - Helicopters
- Water
  - Sprinklers
- Covers

Heaters

Plants must be in direct line of sight with heaters

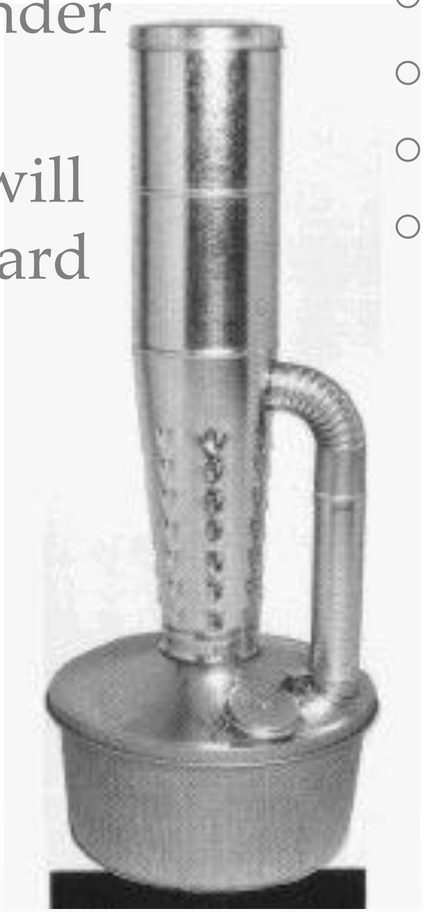


Heaters

- Advantages
  - Can be effective under freeze conditions

  - much of the heat will be blow out of vineyard

- Disadvantages
  - Expensive- need many
  - Fuel
  - Labor intensive
  - environmental



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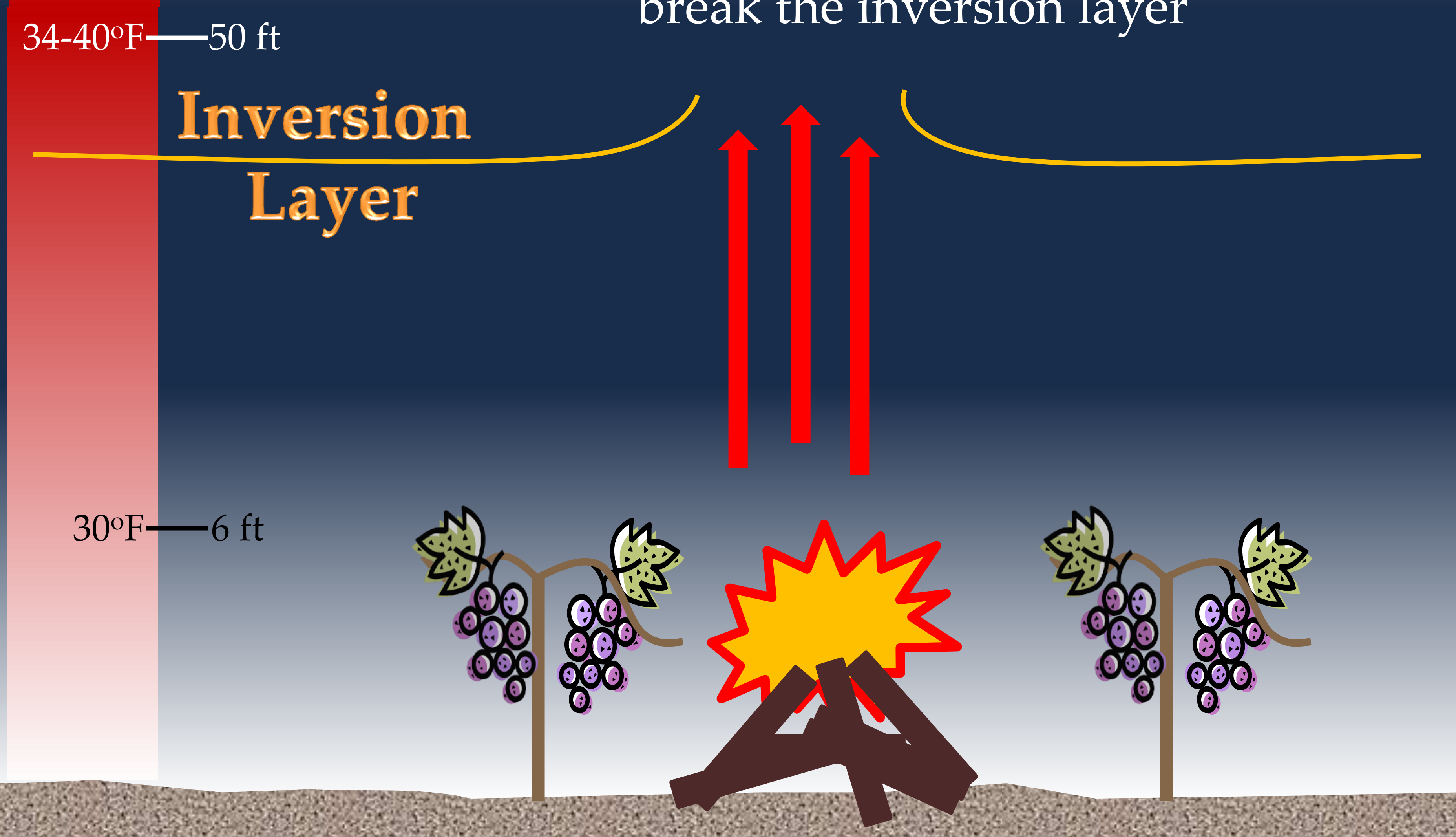
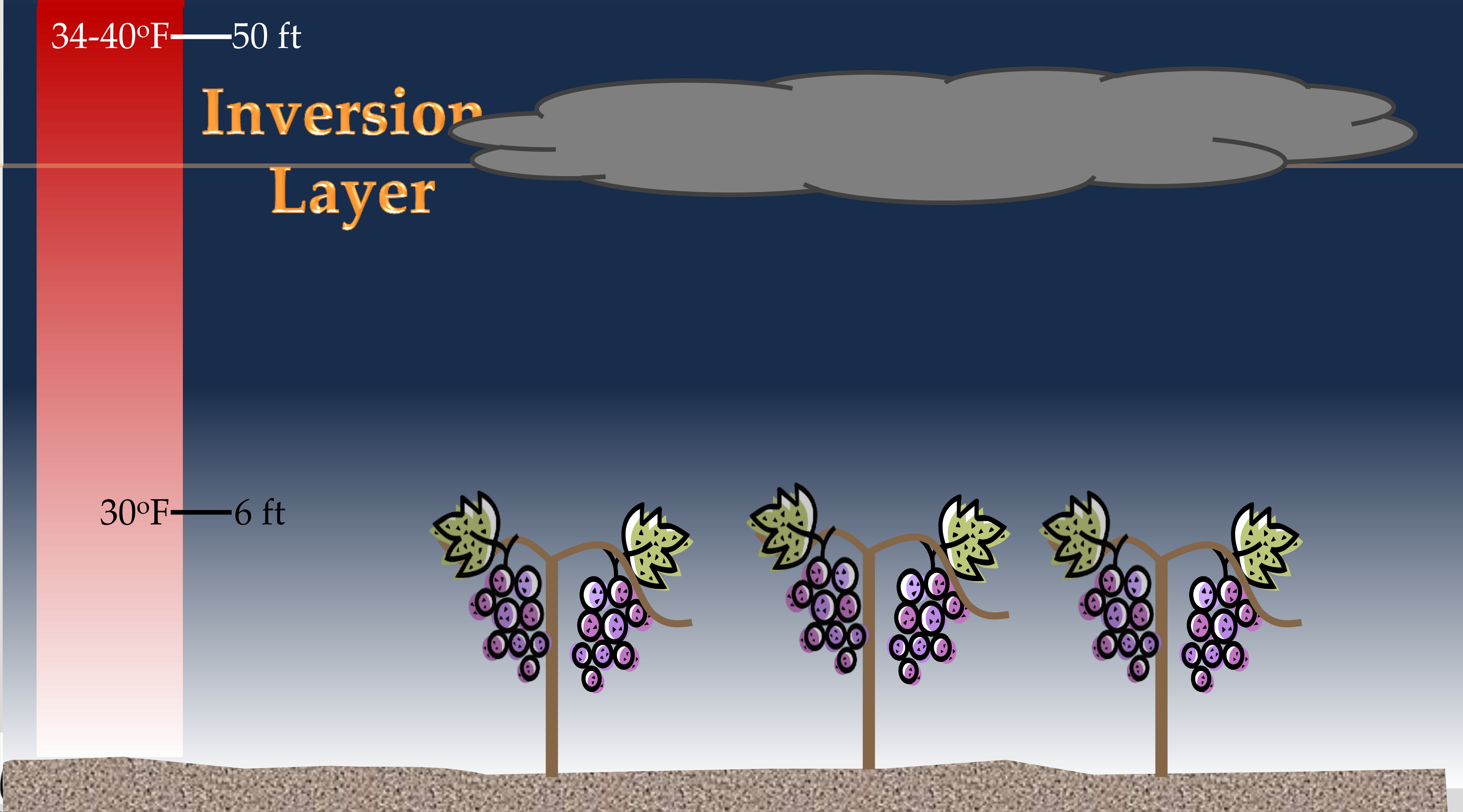
Bonfire

Intense heat in one area can break the inversion layer



Smoke

Will not help in a frost event
- will show where the inversion layer is



Wind Machines

- Advantages
  - Cost effective
  - Can be effective during radiation frost

- Disadvantages
  - Efficacy is Dependent on inversion characteristics

- Dependent on inversion characteristics

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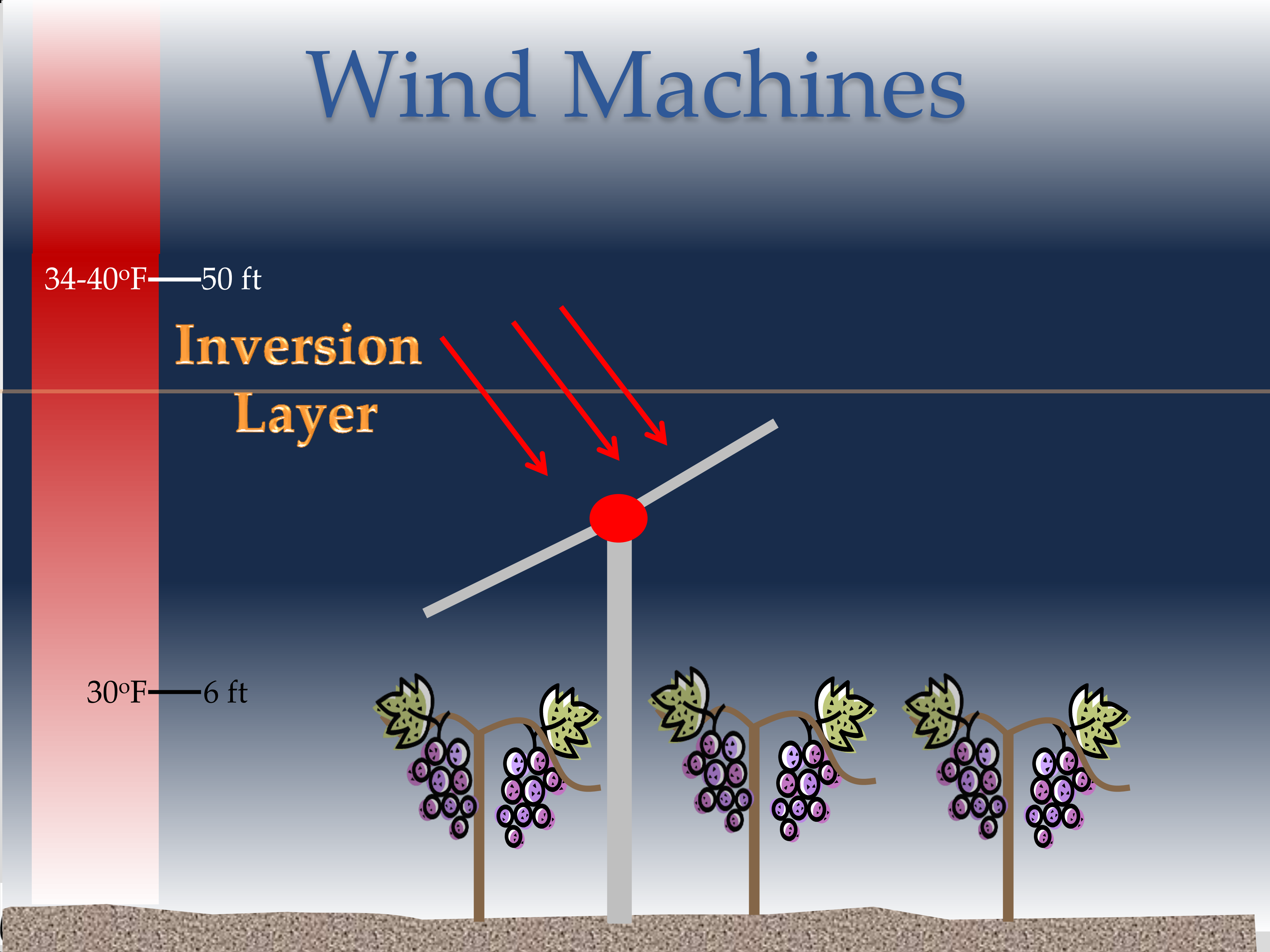
Wind Machines



Wind Machines

- Must be turned on before freezing temperatures are reached
- Can cover a 10A area – head rotates to cover area
  - Area of protection is not circular due to wind drift
- Highly dependent on temperature inversion
- Placement should be done by a professional
- Power source: gas, diesel, electric, PTO
- Can cause more damage during an advective freeze
- Cost ~ $30,000 for new

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Helicopters

- Operate on the same principle as the wind machines
- Not as sensitive to temperature inversion and height
- Expensive > $500/hr
- Must be able to return to areas every 6-8 mins to ensure air stratification do not reoccur

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Forced Air Displacement System

- Force cold air up into atmosphere
- Cost effective
- PTO or Gas operated models

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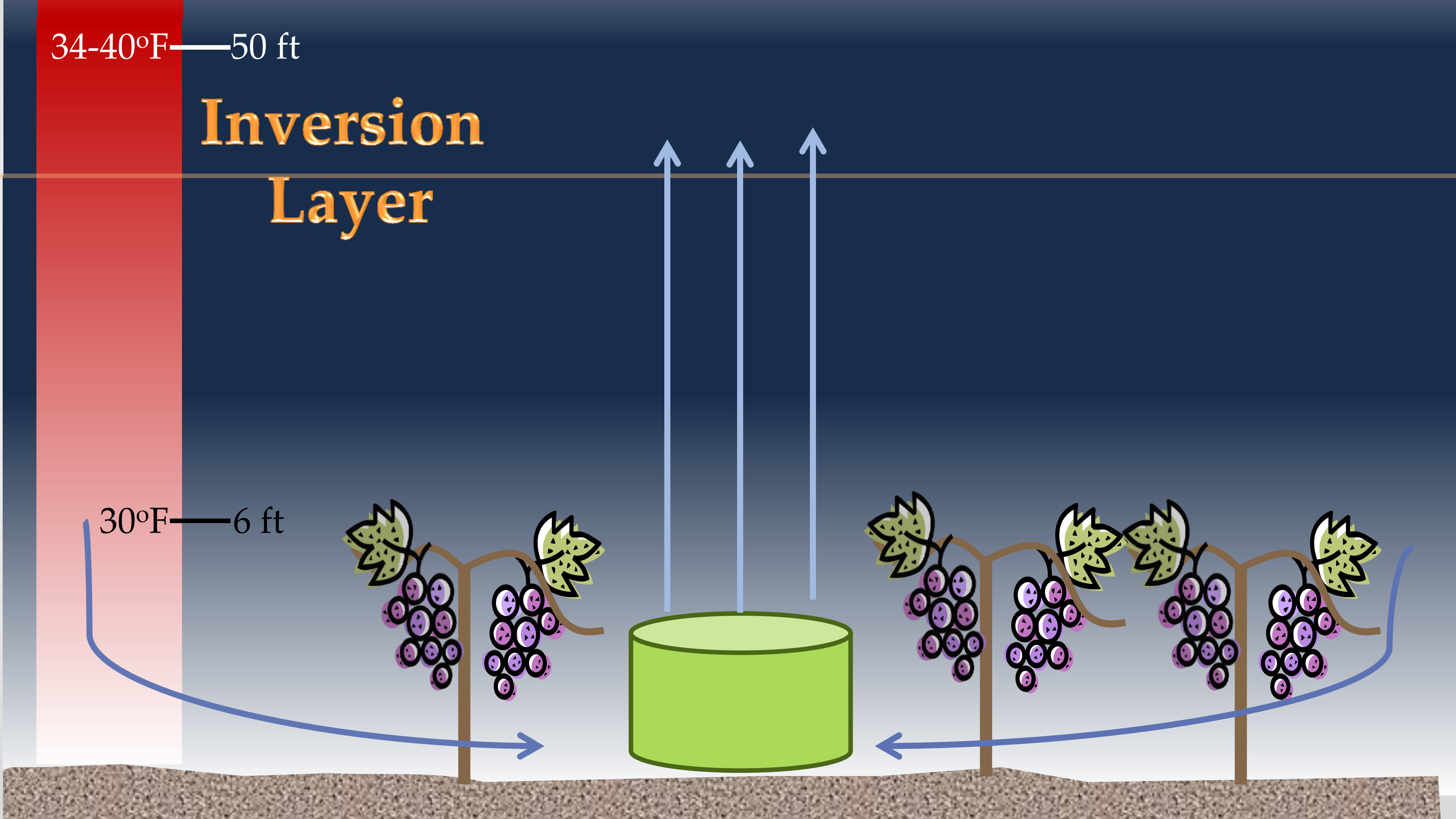
Forced Air Displacement



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Sprinklers

- Warm water gives up heat on contact with cold air and tissue
- **Latent heat of fusion-** heat released when ice is formed

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Sprinklers

- Cost effective
- Set Up Options:
  - Overhead
    - Better frost protection
    - More ice build up
    - Increased leaf wetness if used for irrigation
  - Micro Sprinklers
    - Less frost protection
    - No issues with ice build up
    - More efficient for irrigation

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Considerations for Sprinkler Use

- Water quantity
  - Irrigation *must* run during the *entire* frost event

- Irrigation turned on for frost protection when irrigation not necessarily needed
  - Consider soil characteristics
  - Heavy soil – low output sprinklers

- Weight of ice on vines can cause damage

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Dew Point and Sprinkler Use

- In dry conditions (dew point 5ºF below predicted low air temperature):
  - water applied to tissue will evaporate causing evaporative cooling of tissue
  - Tissue can become colder than surrounding air- more damage than doing nothing at all

Other Frost Protection Methods

- Covers
  - Several types: spunbonded fabrics, plastic
  - Can be effective during advective freeze due to wind protection
  - During radiative frost- tissue touching poly film may be more damaged
- Spray
  - Ice nucleating bacteria sprays, nutrient and hormonal sprays, etc.
  - No conclusive evidence of their efficacy

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Summary

- Choose your site and design your vineyard wisely!
- Understand the forecast
  - Advective freeze (pray) OR Radiation frost
- Understand the dew point!
- Install temperature monitoring equipment
  - Inversion pole
  - Thermometers throughout the vineyard
- Consider economics