Freeze protection of tropical fruit crops in Florida

Jeff Wasielewski, Commercial Tropical Fruits Agent

Miami-Dade County Extension, Homestead, FL

and

Jonathan H. Crane, Tropical Fruit Crops Specialist

Tropical Research and Education Center

Homestead, FL

UF IFAS Extension UNIVERSITY of FLORIDA

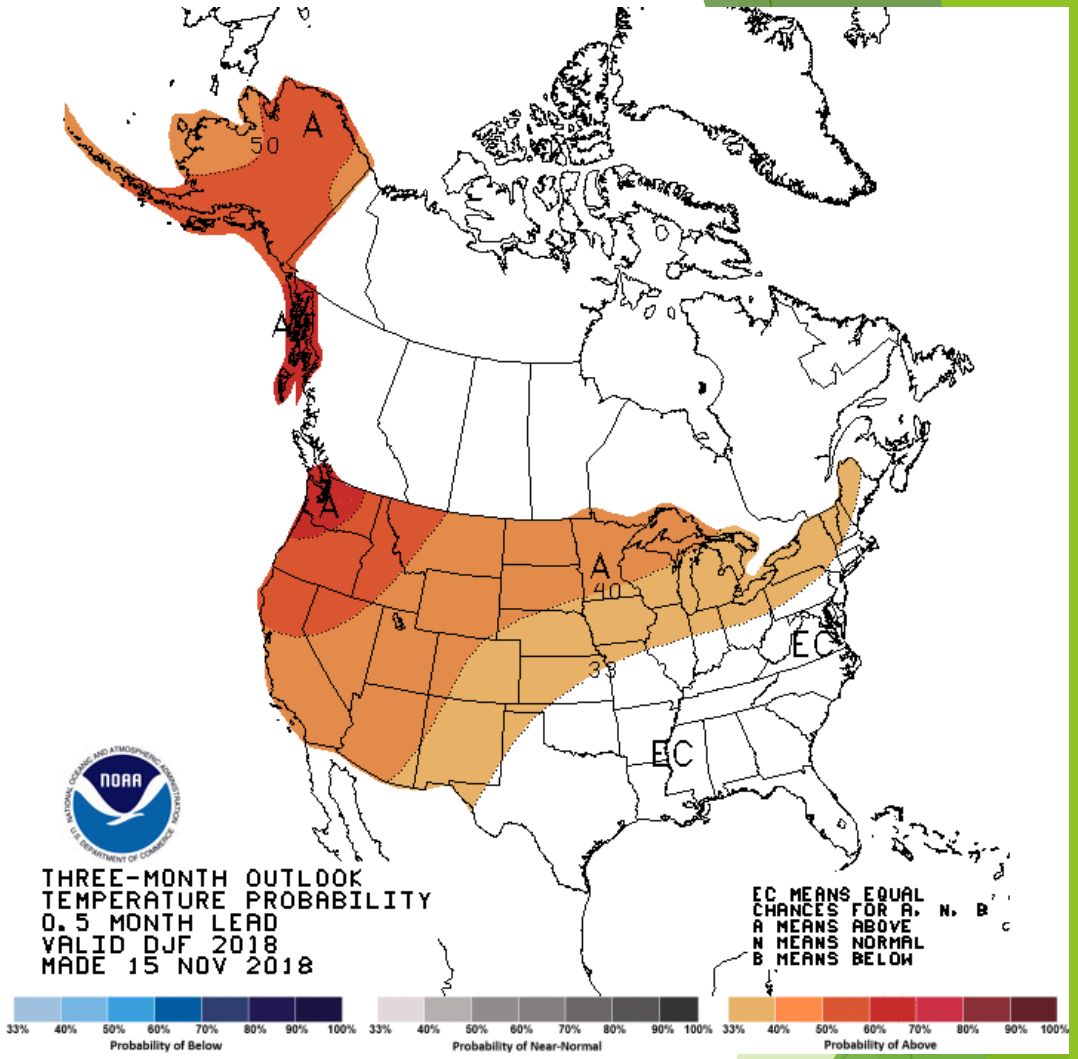
MIAMI-DADE COUNTY

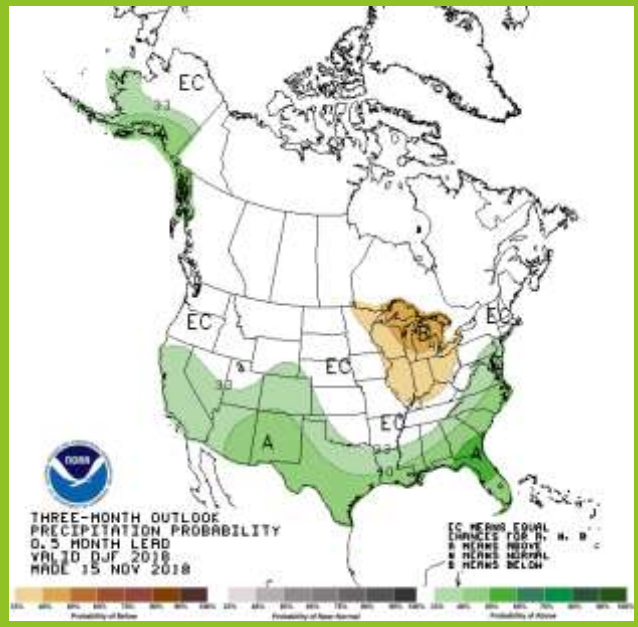
(Miami-Dade County)

2018

Freeze potential 2018-2019

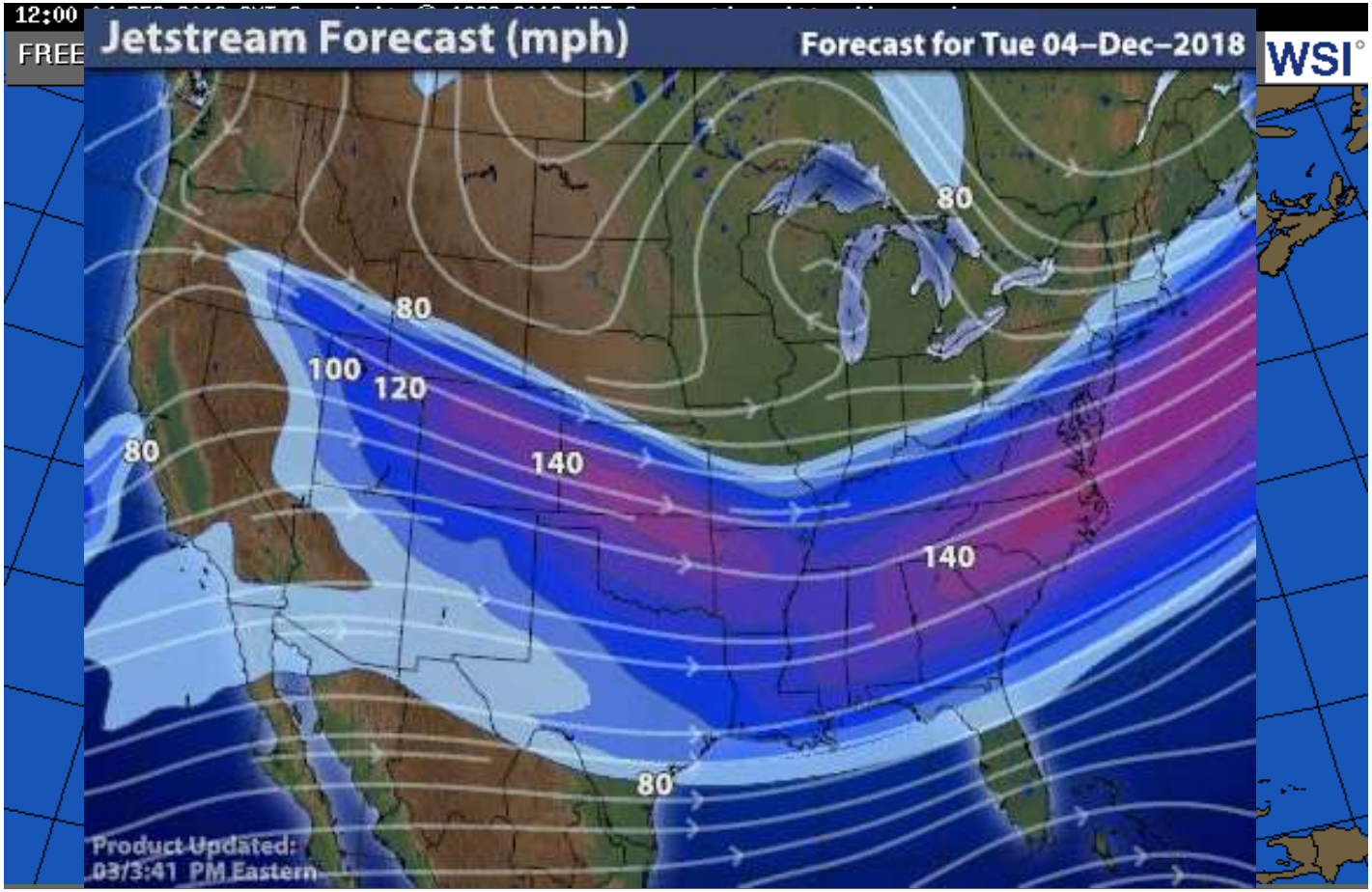
- Neutral to El Niño winter 2018-2019
  - Wet and cool





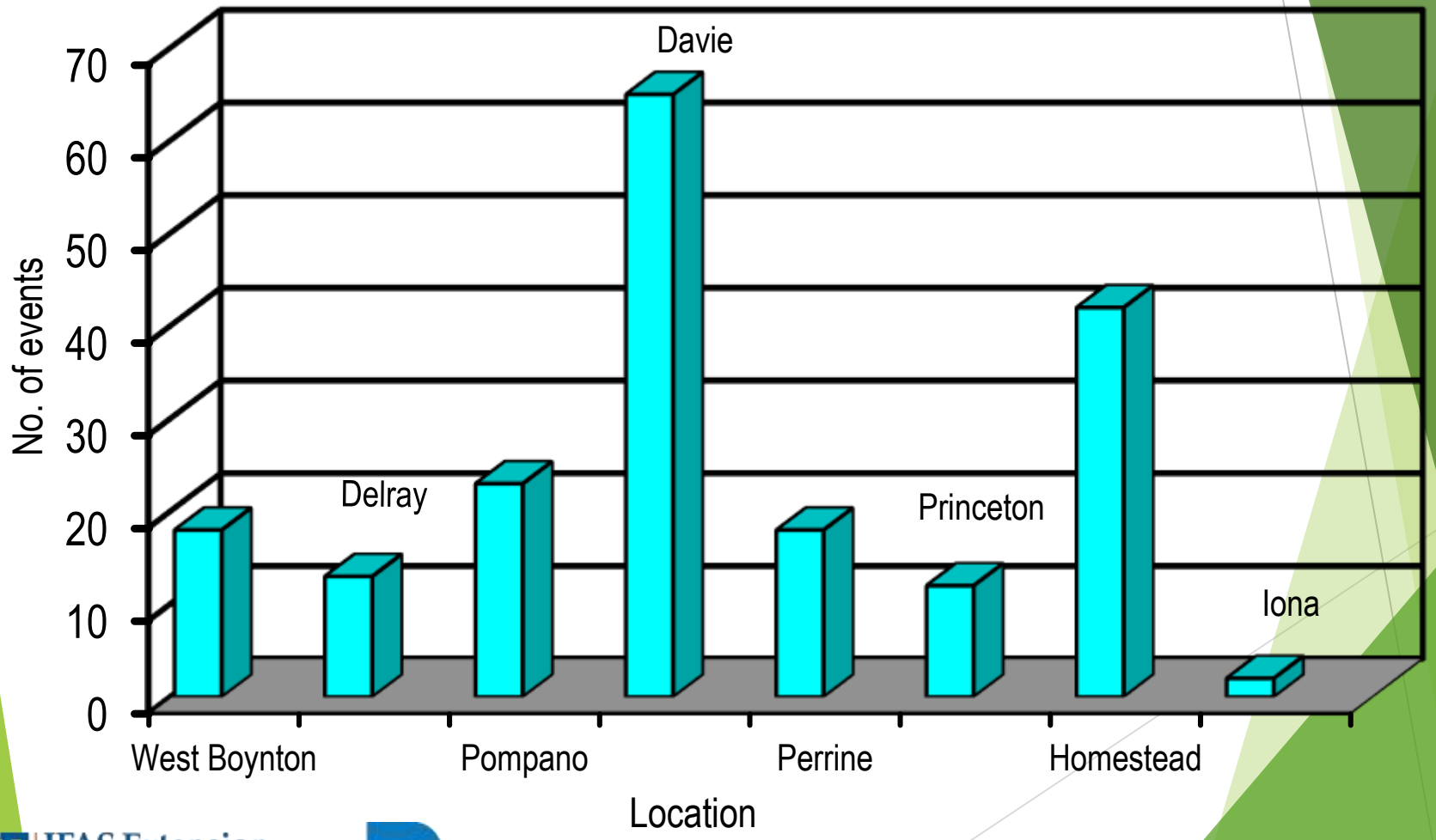
- 50/50 chance mean temperatures above normal/normal/below normal
- Does not mean a freeze event will not occur

Current weather



Jet stream

Number of times at or below 32°F (1937-1967; 30-year period)



Cold tolerance of tropical fruit crops - estimated temperatures for freeze damage or death of nonprotected trees

- Atemoya, <32°F
- Avocado,
  - Mexican 18-26°F
  - Guat. 25-28°F
  - West In. 25-30°F
- Banana, 28°F injury, <28°F death
- Carambola, mature 26-28°F, young 27-32°F
- Guava, mature 25-26°F, young 27-28°F
- Jackfruit, <32°F
- Key lime, 32°F

Cold tolerance of tropical fruit crops - estimated temperatures for freeze damage or death of nonprotected trees

- 'Tahiti' lime, mature 22-30°F, fruit 28°F, young 25-30°F
- Longan, mature 24-28°F, young 28-30°F
- Loquat, dormant 10°F, fruit 27-28°F
- Lychee, mature 24-25°F, young 28-32°F
- Mamey sapote, mature 28°F, young <32°F
- Papaya, <30°F
- Passion fruit, <30°F

Cold tolerance of tropical fruit crops - estimated temperatures for freeze damage or death of nonprotected trees

- Pummelo, <32°F
- Sapodilla, mature 26°F, young 30-32°F
- Spanish lime, <32°F
- Star apple, mature 29°F, young 31°F
- Sugar apple, mature 28-29°F, young 30°F
- Tamarind, mature 28°F, young 32°F
- White sapote, 24°F, young 26°F

Factors affecting the susceptibility and recovery of tropical fruit crops to cold damage

- Genetic predisposition
- Site selection (elevation, slope, lakes/ocean)
- Plant vigor and health
- Plant stage of growth
- Tree age or size
- Predisposing environmental stresses
- Cultural practices
  - high fertilizer rates
  - pruning
  - irrigation - drought
- Depth and duration of cold temperatures
- Number of freezing events

Factors, comments and examples - fruit crops to cold damage

#	Factor	Comments
1	Genetic predisposition	Papaya vs avocado
2	Site selection (elevation, slope, nearness to water body)	Establishing new groves
3	Plant vigor and health	Healthy trees withstand and recover better
4	Plant stage of growth	Non-growing trees withstand more cold
5	Tree age or size	Older, larger trees more tolerant to cold
6	Predisposing environmental stresses	Ex. Flood stress prior to freeze stress – more damage

Factors affecting the susceptibility and recovery of tropical fruit crops to cold damage

#	Factor	Comments
1	High fertilizer rates and/or poor timing	More susceptible to cold damage
2	Time of pruning	Fall and winter pruning more of a problem
3	Lack of irrigation – drought stress	Complicated but generally detrimental
4	Depth and duration of cold	Short deep freeze vs long moderate freeze
5	Number of freezing events	Multiple stress, potential for more damage
6	Improper use of or breakdown of cold protection system	Potential for increased damage

Monitoring the weather

- General - local
  - NOAA weather
  - FAWN weather
- Methods
  - radio
  - telephone
  - TV
  - WWW
  - Private services

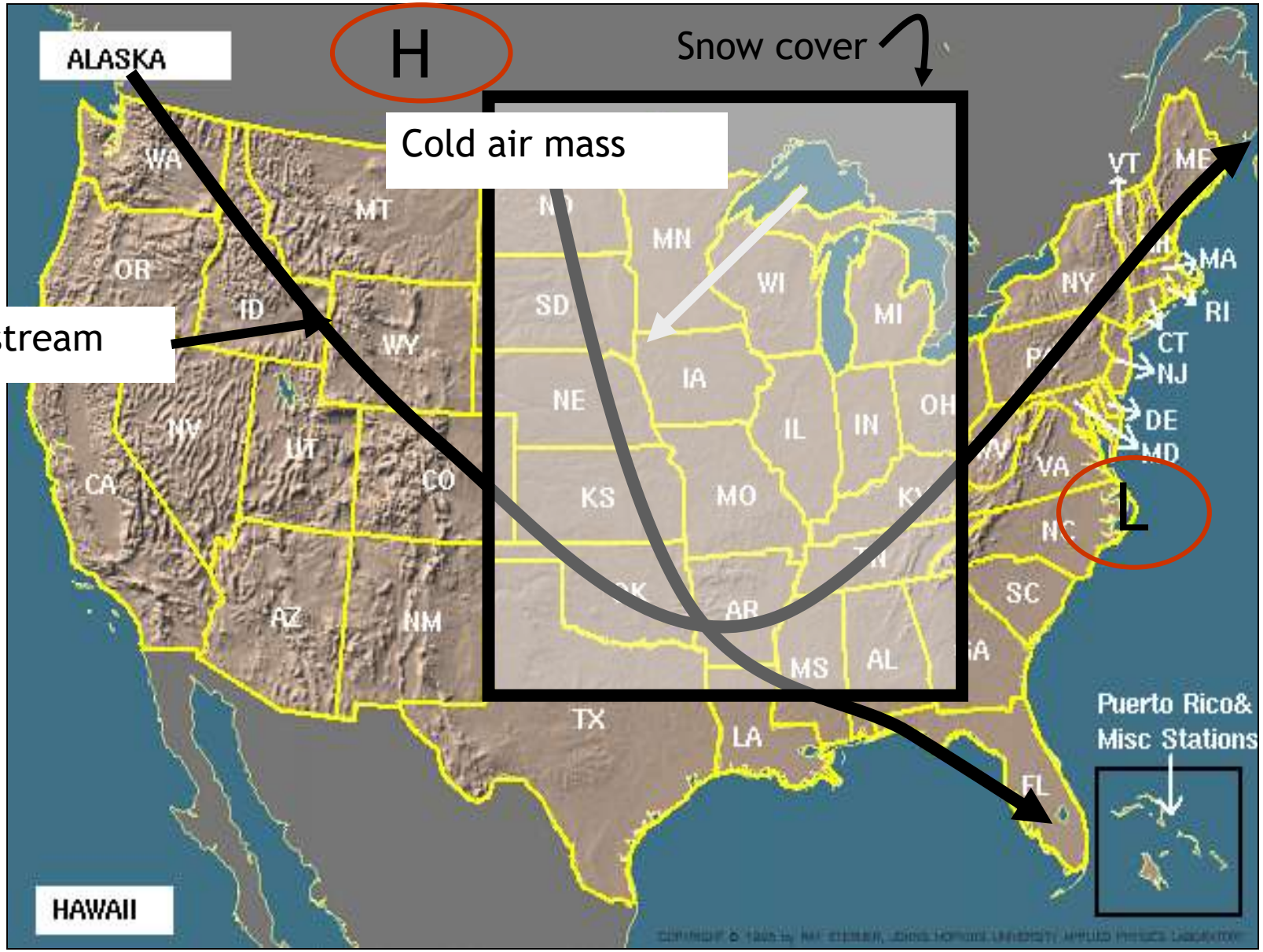
At your grove

- thermometers in shelters
- psychrometers – sling, digital
- automated weather station equipment
- visual and sensorial observation

Is freezing weather on the way?

- Be on the alert from late Nov. through March. Be prepared by mid-Nov.
- Watch the jet stream pattern: moving cold air from NW to SE.
- Is there a low pressure system over the SE, around the Carolinas and W. Virginia?
- Watch for a large Arctic high pressure system - large cold air mass.
- Watch for snow cover over mid-west and central US.
- Is there a high pressure center just west of Minnesota?
- Is there a high pressure center west of Tallahassee, FL?

Is freezing weather on the way?



Is freezing weather on the way or rules of thumb - What to watch for

- In advance of predicted cold weather we experience one or may days when the temperature does not exceed 65°F.
- Days when the temperature is at or below 60°F at 3:00 PM or earlier in the afternoon.
- We experience 2 or more days and/or nights of cold but nonfreezing weather, especially if they are accompanied by wind.
- Snow cover over the northwest, midwest, and middle US.
- The forecast calls for a low night-time dew point temperatures below 30°F or less.

Is freezing weather on the way or rules of thumb - What to watch for

- Cold high pressure systems which move out of Canada to the south. These systems cross the US-Canadian border anywhere from Montana to Wisconsin.
- They take 2-4 days to reach Florida.
- Record low temperatures are reported for the mid-western US states.
- Winds at the surface (low level winds) are blowing from the north-northwest.
- Florida is the predicted target of a cold high pressure system.

What to watch for

- Normally we experience two days (nights) of freezing weather. The first night is usually an advective freeze and the second night an radiation freeze.
- Caution: both types of freeze may occur on the same night.

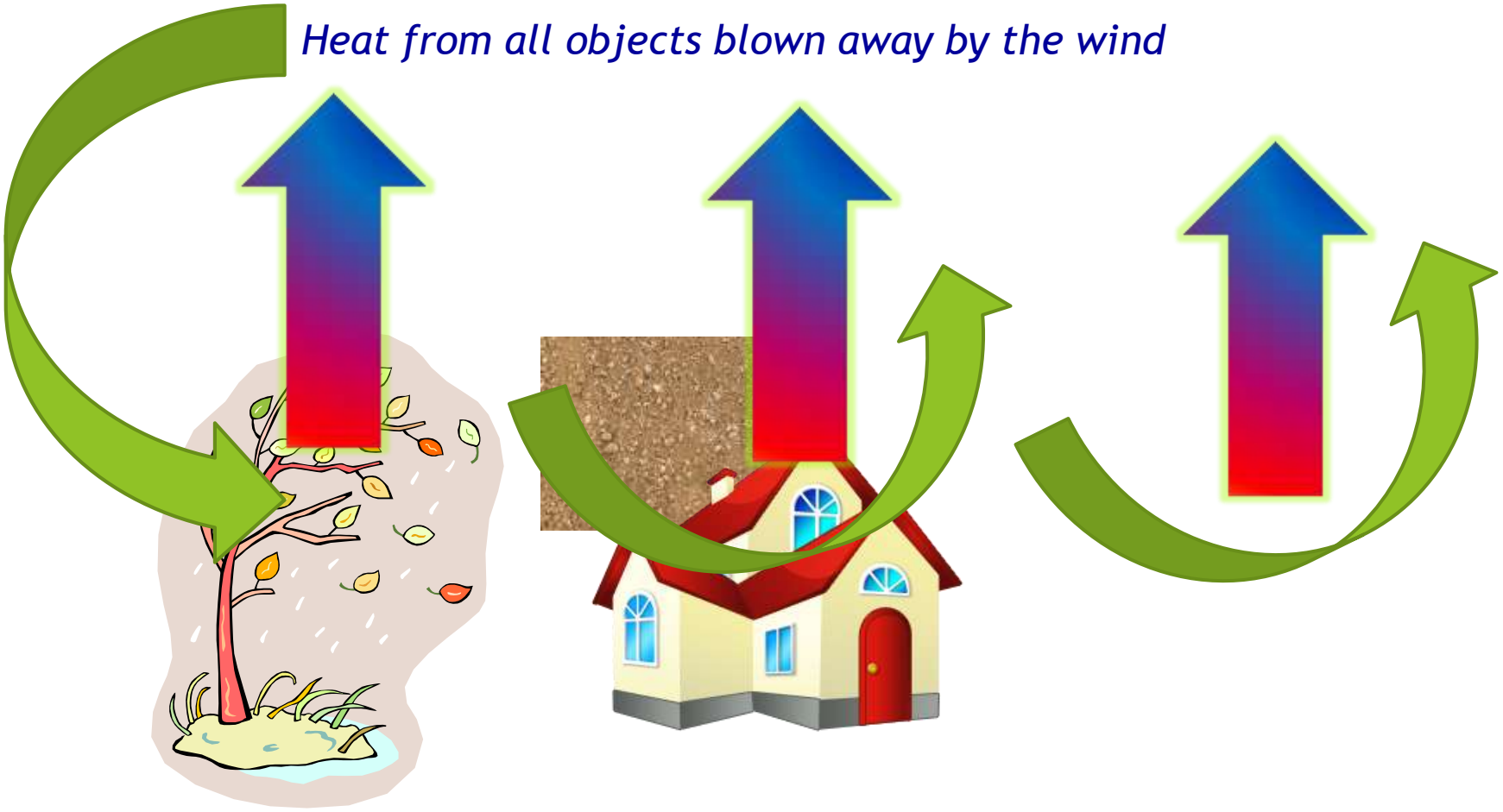
- A fair estimation of the lowest temperature -
  - can be gotten by subtracting 20 degrees off the air (°F) temperature taken at sunset and;
  - the predicted night time dew point low is a fair estimate of the lowest temperature (caution: dry air may cause dew points to fall further)
  - by recording the dew pt and air temperature at sunset and using the minimum overnight temperature tool on FAWN (http://fawn.ifas.ufl.edu/tools/minimum_temperature/)

Advective freezing weather

- Advective freezes are freezes where a large cold air mass brings freezing and subfreezing temperatures to Florida. They are characterized by windy conditions.
- No inversion layer is established.
- The heat from all exposed objects is constantly removed by the windy conditions.
- Is a more difficult type freeze to protect trees from.

Advective freeze

Heat from all objects blown away by the wind



Plants buildings soil/ground

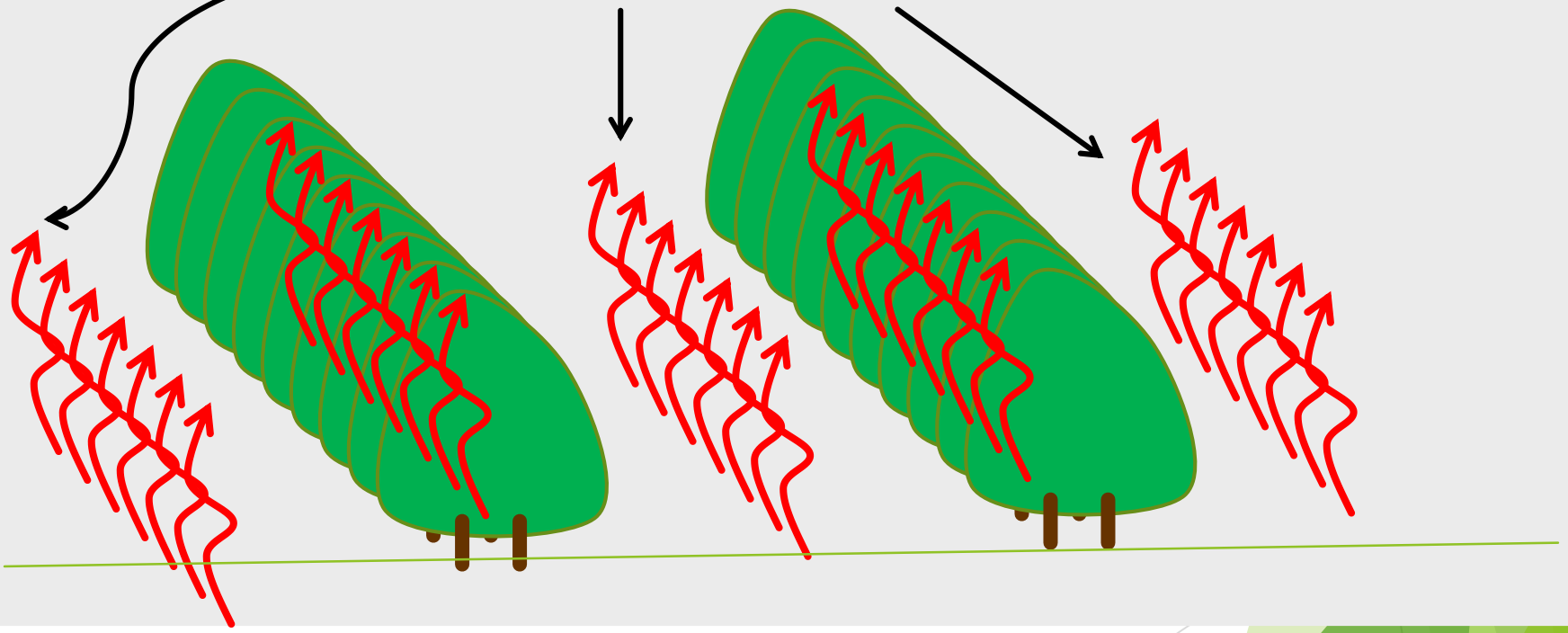
Radiation freezing weather

- Radiation freezes happen when there is little or no cloud cover and little or no wind. Heat from all surfaces radiate to outer space - there is nothing to block the escape of heat waves from the earth's surface.

- A temperature inversion (TI) may occur during a radiation freeze. A TI may occur when a warmer air (usually 30-50 ft up) layer exists above a cold/ freezing layer of air along the ground. When there is a difference of at least 5 degrees between these layers, mixing them can raise the air temperature in the grove.

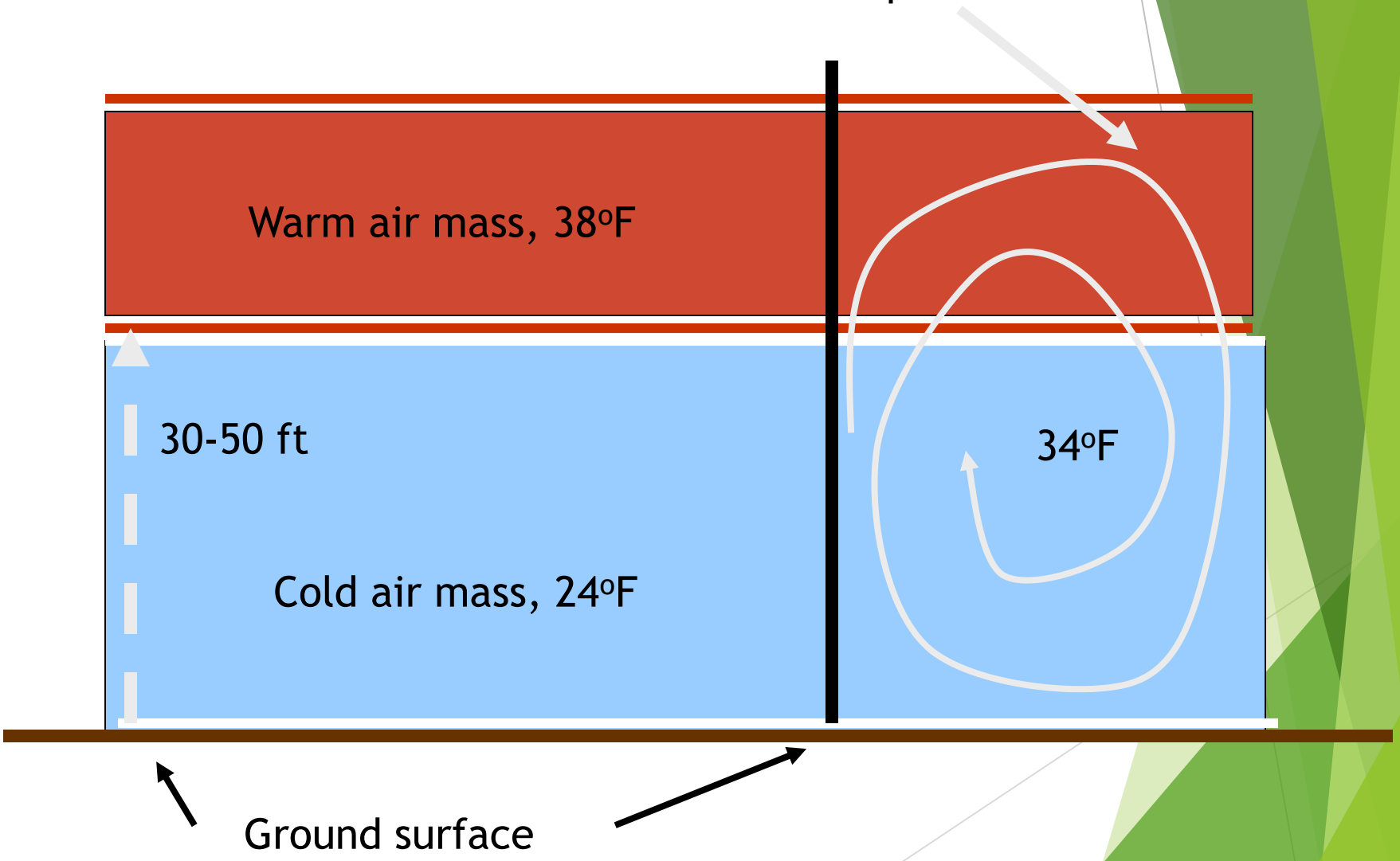
Radiation freeze conditions

Clear sky, little to no wind



Heat loss from ground and all objects

Radiation freeze



Methods of cold protection

- Passive methods
  - site selection
  - clean culture
  - pre-cold irrigation
  - soil banks
  - tree wraps
  - tree covers
- Active methods
  - fuel heaters
  - irrigation
  - mist systems
  - wind machines
  - ditch flooding
  - combinations of passive and active methods

Prefreeze irrigation

- Water has a high capacity to store heat.
- Irrigating the grove **several days prior** to a cold/freeze event will increase the soil's capacity to store and re-radiate heat during freezing temperatures.
- The greater the grove surface area irrigated the greater the soil heat storing capacity.
- Irrigating during the daytime prior to the night of a predicted freeze is not recommended, especially if it is already cold and/or windy.

Young trees and tree wraps

- Tree wraps
  - ✓ only delay heat loss
  - ✓ should be used in conjunction with irrigation
  - ✓ **should be constructed of material with a high insulation value (e.g., fiberglass insulation)**
  - ✓ need to be inspected and possibly removed after winter

Tree wraps

Citrus

Sapodilla

Systems using water

- Mist systems
- Flood irrigation
- Irrigation systems
  - high volume over tree
  - high volume under tree
  - high volume in-tree
  - microsprinkler: ground based
  - microsprinkler: in-tree

Principles of cold protection with above ground irrigation systems

- How it works
  - the sensible (inherent) heat of the water coming out of the ground gives off a little heat as it cools to 32°F (0°C)
  - the heat of solidification (also called fusion) of water as it changes from liquid to solid gives off a lot of additional heat (303 Kcalorie or 1,152 Btu's per gallon water)
- If sufficient water is continually applied to a plant and the plant can withstand 31°-32°F, the heat given off as water changes from liquid to solid maintains the plant at about 31°-32°F - the plant lives.

Principles of cold protection with above ground irrigation systems

Three key components must be in place for irrigation to work in freeze protection.

- 1) The plant must be able to survive 31º-32ºF.
- 2) Sufficient water (0.20 inches/acre/hour or more) must be continuously applied to plant surfaces throughout the period of freezing temperatures.
- 3) Water must completely cover the plant surfaces (not always true for survival of some portion of the tree).

High volume over tree irrigation – now uncommon in Miami-Dade County

- Characteristics
  - metal piping topped with high vol. sprinklers
  - sprinkler height is above trees, sprinklers spaced 40’-60’ apart
  - sixty-100% overlapping spray pattern
- Sprinkler heads make one complete rotation in 1 minute or less.
- Pump pressure of 50-65 psi are needed.
- Apply 0.20 inches of water/acre/hour or more; **more is better**.

High volume over tree irrigation

- Advantages
  - complete land and tree coverage
  - work well for many tree crops
- Disadvantages
  - high pump pressures are required for good water distribution
  - maintenance to irrigation head essential
  - possible wind distortion of sprinkler pattern
  - possibility of limb breakage due to ice loading

High volume overhead irrigation - carambola

High volume overhead irrigation – sugar apple

Sugar apple

Overhead high volume irrigation - damage

Longan

Mamey sapote

High volume under tree irrigation – most common in Miami-Dade County

- Characteristics
  - metal or PVC piping topped with high vol. nozzles
  - sprinklers spaced so there is no more than 2 trees between each sprinkler; either each row or every other row has sprinklers
  - need 70-100% overlapping spray pattern
- Applies water up to about an 8 ft height into the tree canopy.
- Requires a pump pressure of at least 40 psi.
- Sprinkler heads make one complete rotation in 1 minute or less.
- Apply 0.20 inches of water/acre/hour or more; more is better.

High volume under tree irrigation

- Advantages
  - complete land coverage
  - easier to repair than overhead sprinklers
  - potential wind distortion of irrigation pattern less
  - usually less potential for limb breakage due to ice loading
- Disadvantages
  - generally only protects trees to a 7-10 ft height
  - possible for incomplete coverage of trees due to interference
  - increased number of irrigation lateral and heads per acre required for proper coverage

High volume under tree irrigation

Lychee

Guava

High volume in-tree irrigation – uncommon

- Characteristics
  - metal or PVC piping topped with high vol. disks, whiz, or spinner heads
  - one riser with a sprinkler is required for each tree
  - sprinklers are 3 to 8 ft within the tree canopy
- Apply 2-3 gallons of water/minute/tree throughout the tree canopy from inside out.
- Requires a pump pressure of at least 25 psi (40-50 psi may be better).
- Sprinkler heads make one complete rotation in 1 minute or less; spinner heads make rapid rpm.
- Apply 2 gal/min/tree (e.g., 87 trees/acre = 0.38 acre-inch per hour).

High volume in-tree irrigation

- Advantages
  - only covering canopy surface area
  - little wind distortion of irrigation pattern
  - usually less potential for limb breakage due to ice loading
- Disadvantages
  - higher initial investment because each tree has a riser plus sprinkler
  - uses very high volume of water per acre (need for large pump capacity)
  - may only protect trees to about a 7 to 10 ft height (depends upon height of riser and tree)

Lychee

High volume in-tree irrigation

UF IFAS Extension UNIVERSITY of FLORIDA

MIAMI-DADE COUNTY

Low volume microsprinkler systems

- Characteristics
  - apply 10-30 gallons per sprinkler per hour or more
  - recommended 2,000 gallons/acre/ hour rate
  - use polyethylene tubing for laterals along the soil surface
  - use hard plastic spray heads
- Require pump pressures high enough (~30 psi) to get between 20-30 psi at the sprinkler head.
- Ground based systems have been used to successfully protect young citrus and sapodilla.
- Micro-sprinkler in-tree systems have been used to protect citrus trees up to 5 years old; during calm freeze 10-15 ft trees protected to 8 ft height.

Low volume microsprinkler systems

- Ground based
  - place microsprinkler on the NW side of trees
  - spray or fan sprinkler patterns are more effective than spoke patterns; 90° or 180° pattern more effective than 360° patterns
- In-tree based
  - placed 2 to 3 ft up into tree canopy along the trunk
  - 360° spray or fan sprinkler patterns are more effective than 90° patterns and spoke spray patterns

Low volume microsprinkler systems

- Advantages
  - less pumping capacity/size needed
  - lower volume of water per acre needed
  - may be easier to maintain and repair than high volume systems
- Disadvantages
  - higher wind distortion potential
  - less water applied = less potential cold protection
  - orange/tangerine/grapefruit trees are much more cold hardy than tropical fruit crops
  - Little experience with these systems and tropical fruit crops; if the system fails your trees will be damaged or killed

Low volume microsprinkler

Sapodilla

Crops with special issues

Pitaya

- Tolerance to chilling and freezing temperatures is species and clone dependent
- Sensitive to chilling injury
  - ≤ 41°F (5°C)
    - Photodamage
    - Bleached epidermis
    - Photoinhibition
- Potential damage at ≤ 29°F (-1.5°C)
- Damage to death at 24°F-26°F (-3 to -4°C)

Considerations

- Irrigation – high volume?
  - Over head – potential stem breakage
  - Under plant – less damage
- Microsprinkler
  - Effectiveness?
- Plastic stem barriers at base of plant to prevent water hitting the stems directly
- High insulation wraps at base of post?
- Pre-freeze and immediate post-freeze white-wash of sky-exposed stems

Pitaya cold damage - Photoinhibition - sunburn

Crops with special issues

Passion fruit

- Cold tolerance is species and hybrid dependent
- Tolerates 40-55˚F (5-13˚C)
- Hybrids ?
- Purple –
  - Tolerates brief exposure to frost
  - Tolerates down to 28˚F (-1.5˚C) and light frosts

Considerations

- Irrigation – high volume
  - Over head – potential stem breakage
  - Under plant – less damage
- Microsprinkler
  - Effectiveness?
- Plastic stem barriers at base of plant to prevent water hitting the stems directly
- High insulation wraps at base of plant (potential) (J. Morton)

Passionfruit – high volume overhead

Crops with special issues

Banana

- ≤68˚F (20°C) – slow growth
- 50-57˚F (10-14˚C) – growth
- stops
- 51-55˚F (11-13˚C) – chilling injury
    - Photodamage
    - Bleached epidermis
    - Photoinhibition
    - Choking
- ≤32˚F (0˚C) – freeze damage to plant death
- ~32-34˚F (0-1˚C) – frost damage to leaves

Considerations

- Success of freeze protection varies
- Plants killed to ground generally re-grow from corm
- Generally 4 healthy leaves required to mature a young banana bunch
- A nearly mature bunch may mature after leaf death
- A newly emerged or 50% developed bunch will not mature
- Wait to see how many functional leaves remain on mature plants that have not flowered

Banana plant freeze damage

Crops with special issues

Papaya

- ≤68˚F (20˚C) – slow growth
- ≤ 54˚F (12˚C) – growth stops
  - Chilling injury
  - Photodamage
  - Bleached epidermis
  - Photoinhibition
- ≤30˚F (-1.1˚C) – freeze damage
- ≤ 28˚F (-2.2˚C) - plant death
- ~32-34˚F (0-1˚C) – frost damage to leaves

Considerations

- Irrigation
  - Over head – potential leaf breakage
  - Under plant – less damage
- Height of plants
- Pre-freeze irrigation (heat loading soil)

Papaya freeze protection and damage

How to prepare for a freeze

- Install a cold protection system and maintain it.
- Test your system, repair any problems and have it ready by 15 November.
- Periodically test the system for several hours every week during the cold season.
- Keep the diesel or gas tank at least 2/3 full.
- Purchase one or more grove thermometers and build shelters.
- Purchase a weather radio and/or view the Internet weather sources.

- Install one or more temperature gauges in the grove.
- Perhaps purchase a psychrometer.

A freeze is predicted !

- Closely monitor the weather - both predictions and what is occurring in your area (remember the signs).
- Remember: most weather forecasts are for urban areas and most NWS temperature gauges are located at airports or in urban areas - these places are always warmer!
- Watch/listen to more than one weather source and get a handle on how much colder your site usually is compared to adjacent urban areas.
- Test your system!
- Pre-freeze irrigate grove floor several days ahead.

Watch out for

- The temperatures dropping very rapidly (4-10 degrees in about 1-2 hours) into the 30s within an hour to several hours right after sunset (usually in winter that is between 5:30PM-6:00PM).
- This may occur when we have low dew points (at or below 32°F), low relative humidity conditions (for So. Fla. that means below ~40%), and clear skies during the day light hours prior to the night-time freeze event. When the air mass (atmosphere) is dry we get rapid cooling after sunset.

It's freeze time! Assuming you are properly prepared - when do you start your high-volume irrigation system?

- Wind speeds 10 mph or less
  - If your pump engine has a clutch turn it on at 3-5 degrees above freezing (35-37°F)
  - turn on irrigation 3-4 degrees above freezing (35-36°F)
  - Once the system is on do not turn it off until air temperatures are at or above 40°F and/or above the wet bulb temperature
- Wind speeds above 10 mph (high volume systems)
  - Overhead systems use caution, wait until wind speeds die down
    - It may be better not to irrigate
  - For under-tree and in-tree systems; these may be turned on because of lower wind speeds (not always) inside mature groves

It’s freeze time! Assuming you are properly prepared - when do you start your microirrigation system?

- Microirrigation systems
  - Monitor air temperatures at 1-2 ft because the irrigation lines are on the ground and where young trees are most vulnerable
  - If winds are 5 mph or more, not recommended you turn on – evaporative cooling potential high
  - If wind are <5 mph start irrigating prior to 32°F at about 35-37°F (partly to prevent the water in the polytubes from freezing)

It’s freeze time

- Throughout the night
  - Monitor temperatures
  - Cloud cover
  - Weather forecasts
  - Wind direction and speed
  - Monitor and repair any broken or clogged sprinkler heads
  - Go outside!
- Many times our freezing weather comes in twos - in other words two nights of freezing weather - be prepared (e.g., fuel, parts, etc.)!

Using the Internet

- National Weather Service - steps
  - Zip code
  - Detailed Point Forecast map
  - Additional Forecasts and Information
    - Hourly Weather Graph
- http://www.weather.gov
- http://www.weather.gov/mfl/#

- AgroClimate
  - Ag focus
  - Short to long-term weather conditions
  - Prediction tools
- http://agroclimate.org

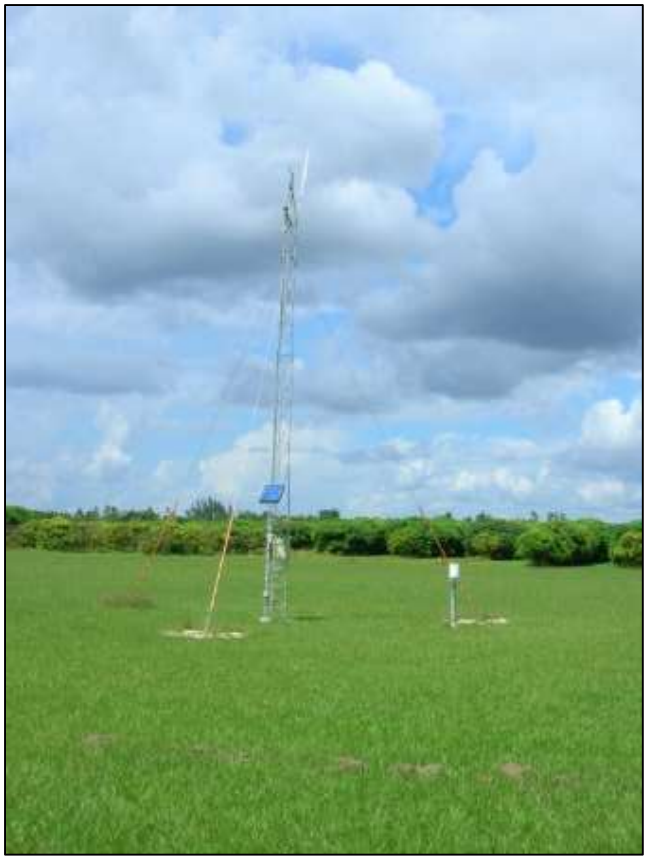
- Florida Climate Center
- http://climatecenter.fsu.edu/

Using the Internet

- Intellicast
  - Similar to NWS
  - Some better maps, cloud coverage and movement
- http://www.intellicast.com

- Weather Underground
  - Similar to NWS
  - Some better maps, cloud coverage and movement
- http://www.wunderground.com

University of Florida, IFAS FAWN (http://fawn.ifas.ufl.edu/)



- Real time tracking
- Tools
  - Critical temperatures
  - Forecasts

Other local weather sites

- Miami-Dade County Cooperative Extension Service (http://miami-dade.ifas.ufl.edu/)
  - Weather Issues
    - Weather Stations
- Homestead General Airport
  - Phone only at 305-247-2791
- Homestead Air Reserve Base (http://rap.ucar.edu/weather/surface/)
  - *Go to* Retrieve text format METARs
  - *Insert* khsp
  - *Hit* Translated
  - Retrieve

Common freeze damage plant symptoms

- Leaves
  - leaf wilting, water soaking, browning, death
  - dead leaves persistently hanging on stems
  - leaf drop
- Flowers and fruit
  - water soaking, browning, shriveling, and drop

Note: Leaf drop may be a good sign after a freeze as it indicates the stem tissue was alive. If leaves are dead and hanging on, there is some stem damage.

Common freeze damage plant symptoms

- Wood
  - twig, limb, and trunk discoloration
  - water soaking, browning and death of wood
- Trunk area and major limbs
  - bark splitting
  - sap exudation
  - death

Post freeze tree care - trees with no visible twig or limb damage

- **Do not prune immediately after the freeze!**
  - you cannot tell what is dead at this time and you may prune live wood
  - there may be another freeze and even dead leaves will provide some barrier to heat loss
- if you do prune immediately after the freeze you may not remove all the dead wood and you'll have to prune again later
- wait 2-6 months before pruning - it takes awhile to see the damage
- prune to live wood

Post freeze tree care – trees with limb and trunk breakage

- Prune only jagged limbs, trunks, etc. to major crotches or top or stump if there is total damage.
- Spray cooper onto the entire tree at labeled rates, one time.

Post freeze tree care - irrigation

- Groves or tree with little leaf damage should be irrigated normally during dry periods.
- Groves or trees with moderate leaf damage have less leaf area and therefore irrigation rates and frequencies should be reduced.
- Groves or trees with little to no leaves should not be irrigated until signs of new shoot and leaf growth appears. Irrigating leafless trees may lead to root rot problems.

Post freeze tree care - fertilization

- Groves or trees with little leaf and wood damage should be fertilized at normal rates and frequencies.
- Groves or trees with moderate leaf loss should be fertilized frequently at reduced rates when new growth begins.
- Groves or trees with complete leaf loss should be fertilized frequently at slightly higher rates when new growth begins.
- Groves or trees with severe leaf loss plus wood damage should be fertilized at a reduced rate in proportion to the percent of canopy lost.

Note: If we have an early season freeze it may be best to wait until warmer weather to fertilize.

Post freeze tree care - weed control

- Weeds need to be controlled because they compete with trees for water and nutrients and light (especially vines).
- Weeds may be a fire hazard in groves after a freeze and should be cut down to minimize their use as a fuel in case of fire.

Recommendations

- Be prepared by mid-November
- Monitor the weather, nationally, regionally, locally and in your grove

- Good luck!