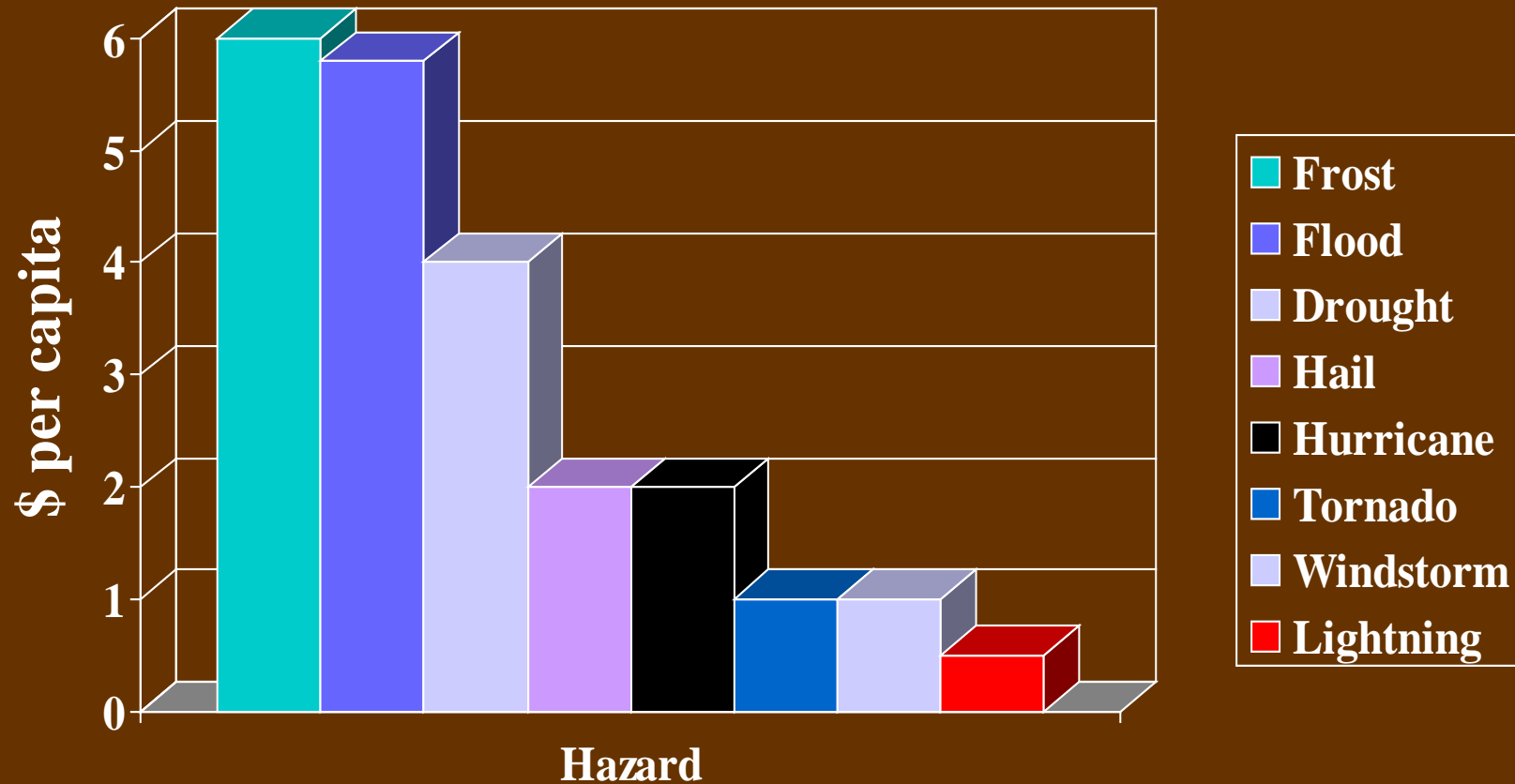


Frost Protection (Almonds)

R.L. Snyder
Biometeorology Specialist

<http://biomet.ucdavis.edu>

Mean Annual Losses to Weather Hazards in the United States



http://lawr.ucdavis.edu/ce_frost_protection.htm

The presentations below will run automatically on your computer, and include recorded audio.

1. [Active Frost Protection: Water](#)
2. [Active Frost Protection: Wind Machines](#)
3. [Passive Frost Protection](#)
4. [Methods of Measuring Temperature](#)

Las presentaciones abajo expuestas se abrirán automáticamente en su computadora, incluyendo sonido grabado.

1. [La protección activa contra las heladas: Agua](#)
2. [La protección activa contra las heladas: Viento](#)
3. [La protección pasiva contra las heladas](#)
4. [Los métodos para medir la temperatura](#)

Mark Battany, Rhonda Smith, Gwen Tindula, Richard Snyder

National Weather Service Forecast Office Sacramento, CA

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- Forecasts
- Forecast Discussion
- Local Area
- Activity Planner
- Aviation Weather
- Fire Weather
- Marine Weather
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- Hurricane Center
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- Hydrology
- Rivers and Lakes
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- Local
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- Drought
- More...
- Climate portal
- Weather Safety
- Preparedness
- Weather Radio
- SkyWarn™
- StormReady
- Weather Spotters

- Additional Info
- Items of Interest
- Other Useful List

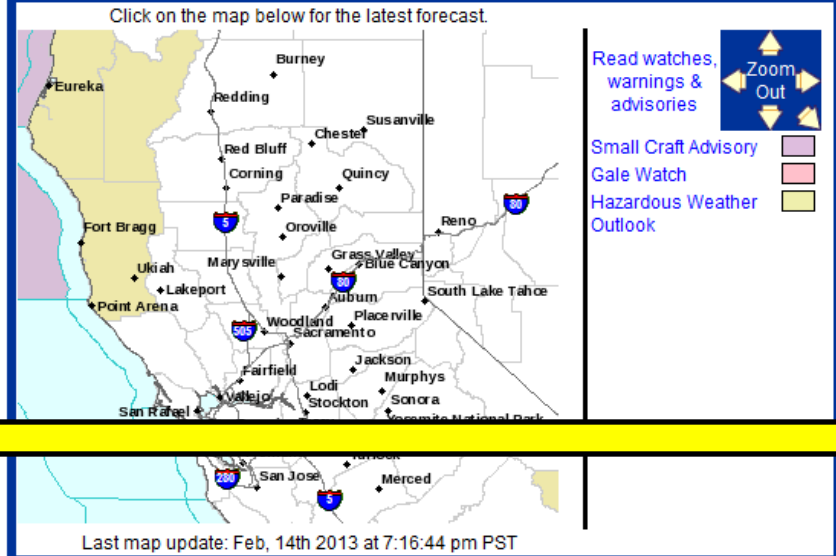
Top News of the Day

Pattern change coming to norcal next week. **NEW**

Last 50 Products Issued Forecast by City

- Watches & Warnings
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North Central California Weather



<http://www.wrh.noaa.gov/sto/>

Weather Tables

Latest Conditions at Sacramento, CA Choose Your Front Page Site

Feb 14

6:53 pm PST 56 °F (13 °C)

(24 minutes old) Fair

Wind: SW 6 MPH RH: 64% DewPt: 44 °F More Details (KSMF) XML View

Click Images For More Information

Social Media Sacramento Beale Satellite Weather Map

Methods of Heat Transfer

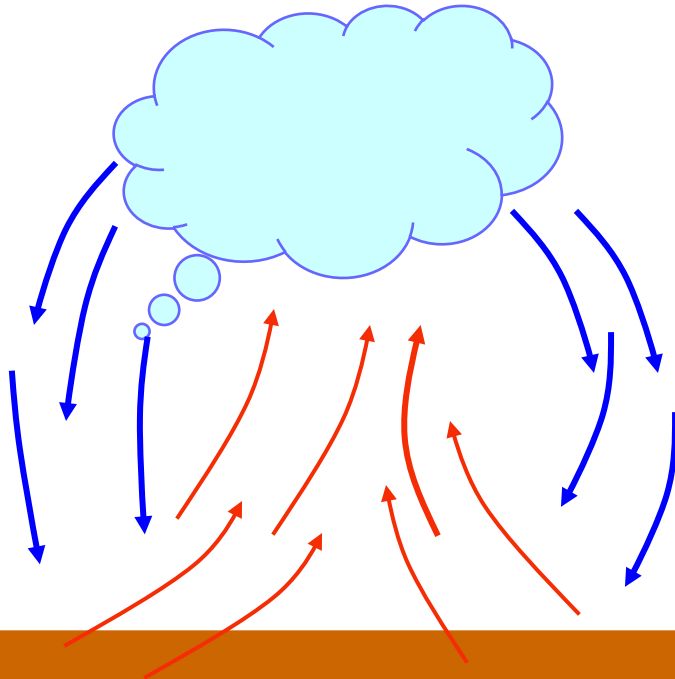
Conduction - from molecule to molecule

Heat Source

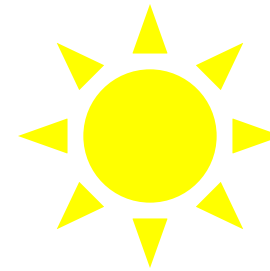


Metal bar

Convection - by movement of heated air

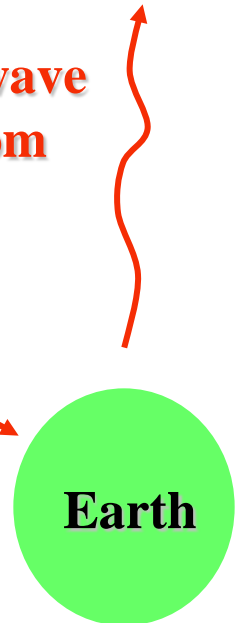


Radiation - energy passing from one object to another without a connecting medium



Short wave gained from the sun

Long wave loss from Earth

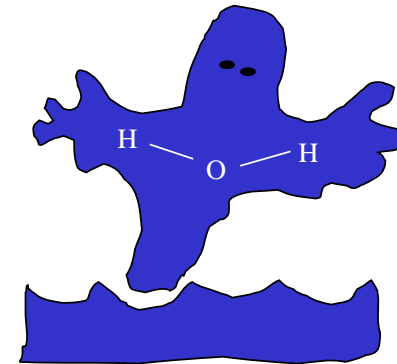


Earth

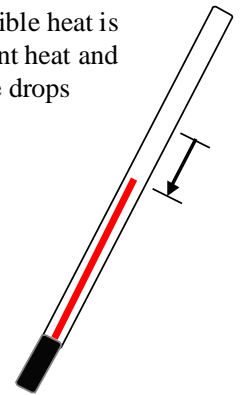
Methods of Heat Transfer

Latent Heat - Chemical Heat

Process	kJ kg^{-1}
20°C to 0°C (68°F to 32°F)	84
Freezing at 0°C (32°F)	335
Evaporation	-2500

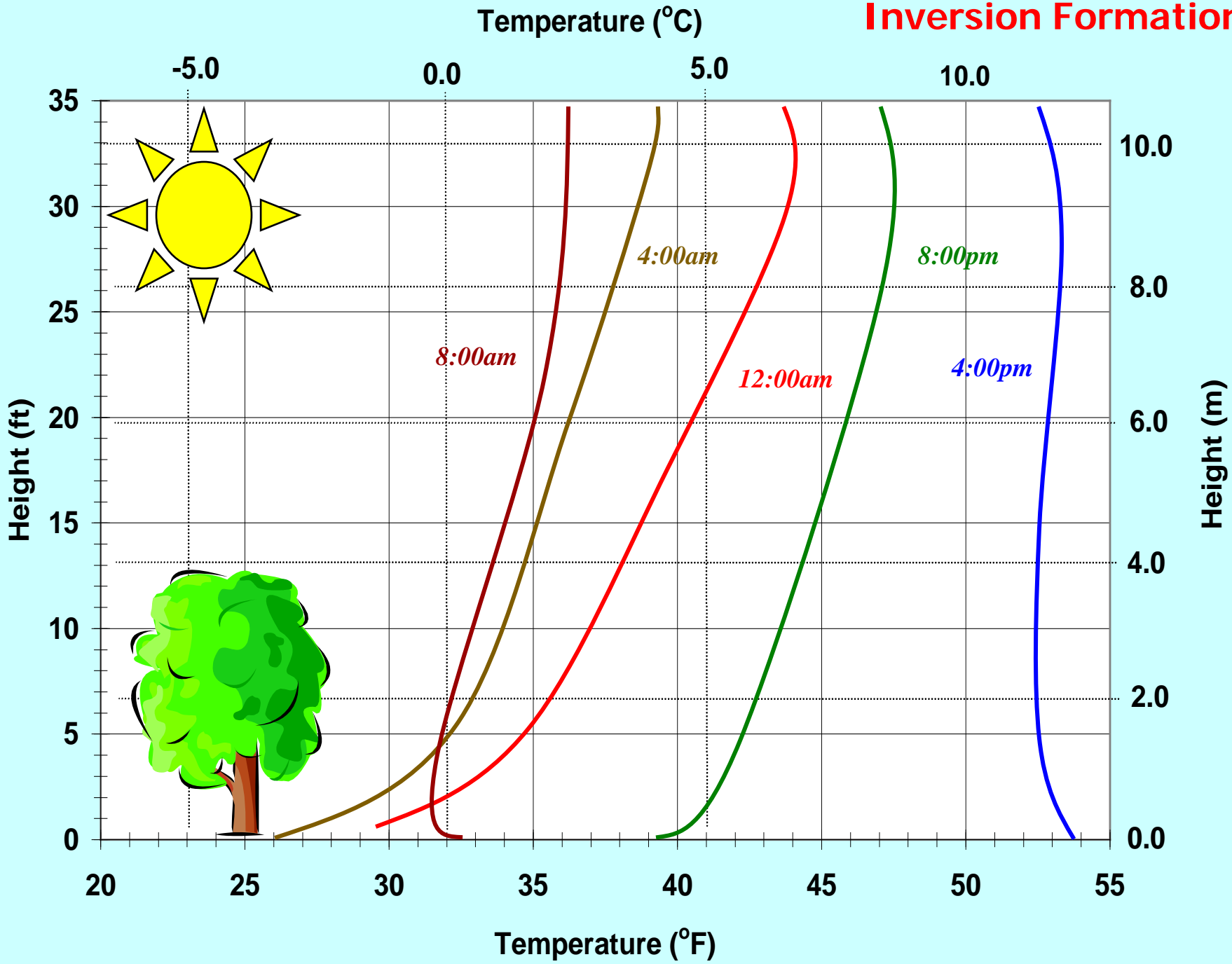


When water molecules evaporate, sensible heat is changed to latent heat and the temperature drops



One must cool and freeze six times as much water as evaporates to gain sensible heat

Inversion Formation



Freeze Injury

1. Intercellular Ice formation
2. Water is drawn out of the cells and condenses on the ice
3. Dehydration causes cell damage

Intercellular Ice Crystal Formation

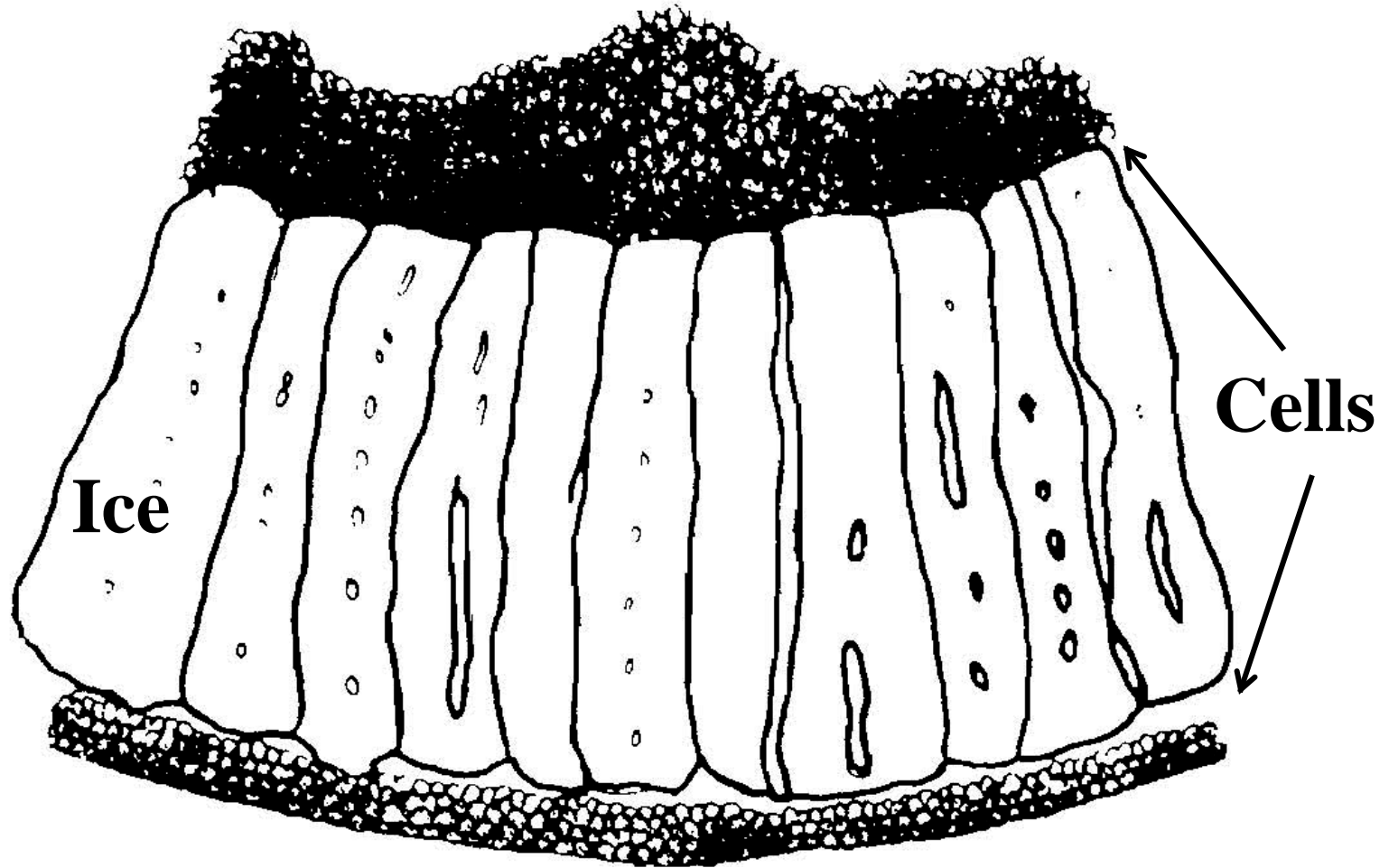


Table of yield loss (%) for given temperatures

Variety	Stage	Temperature °F							
		21.9	23.0	24.1	25.0	26.1	27.0	28.0	28.9
Peerless [F]	Full bloom				100	75	45	25	
	showing pink		100	75	50	25			
Peerless [C]	full bloom				79	50	14	1	
	petal fall						63	14	3
	nut stage						46	45	9
NePlus Ultra [F]	full bloom			100	75	50	25		
Mission [F]	showing pink	100	80	60					
Drake [F]	full bloom		100	75	50	25			
	showing pink	75	50	25					
Nonpareil [F]	full bloom	75	60	40	20				
	showing pink	20	10						
Nonpareil [C]	nut stage						19	14	3
Butte [C]	nut stage					90	45	27	10

F= field observation

C=growth chamber observation

Ice Nucleation

- ❑ Water Freezes below the Melting Point (0°C or 32°F)
- ❑ In the temperature range for Frost Damage, Bacteria cause 99% of Ice Nucleation

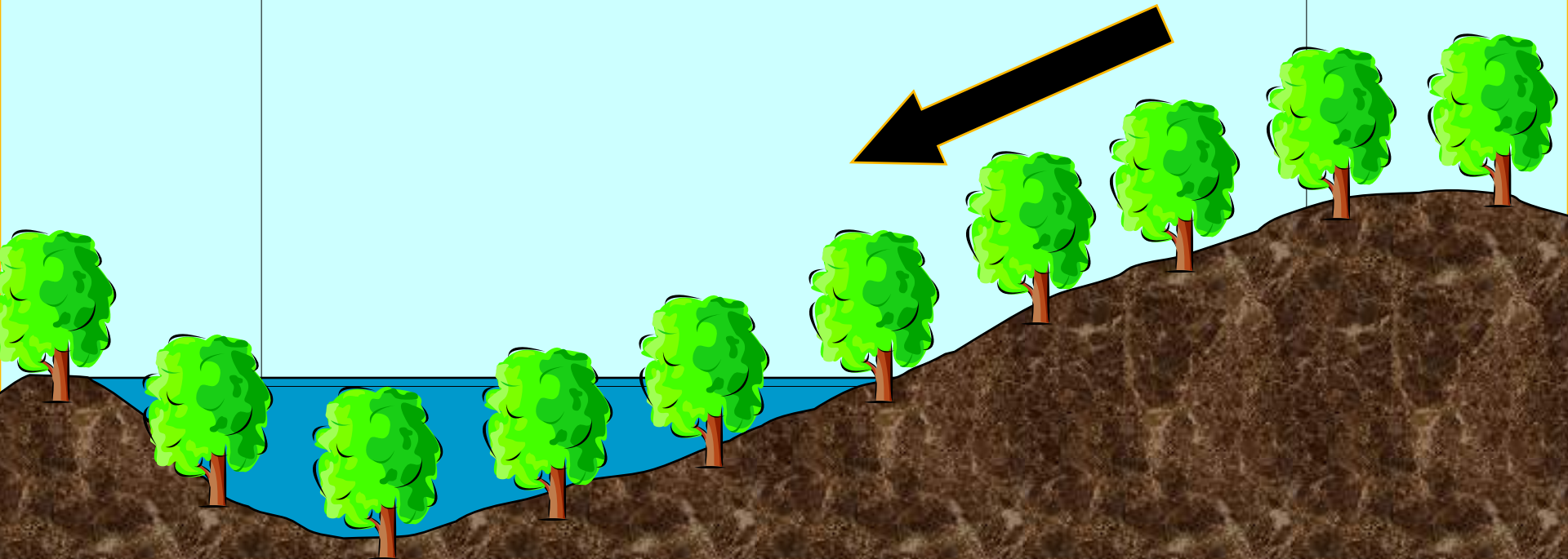
Passive Protection

- INA Bacteria
- Site selection
- Cold air drainage
- Cover crops
- Soil water

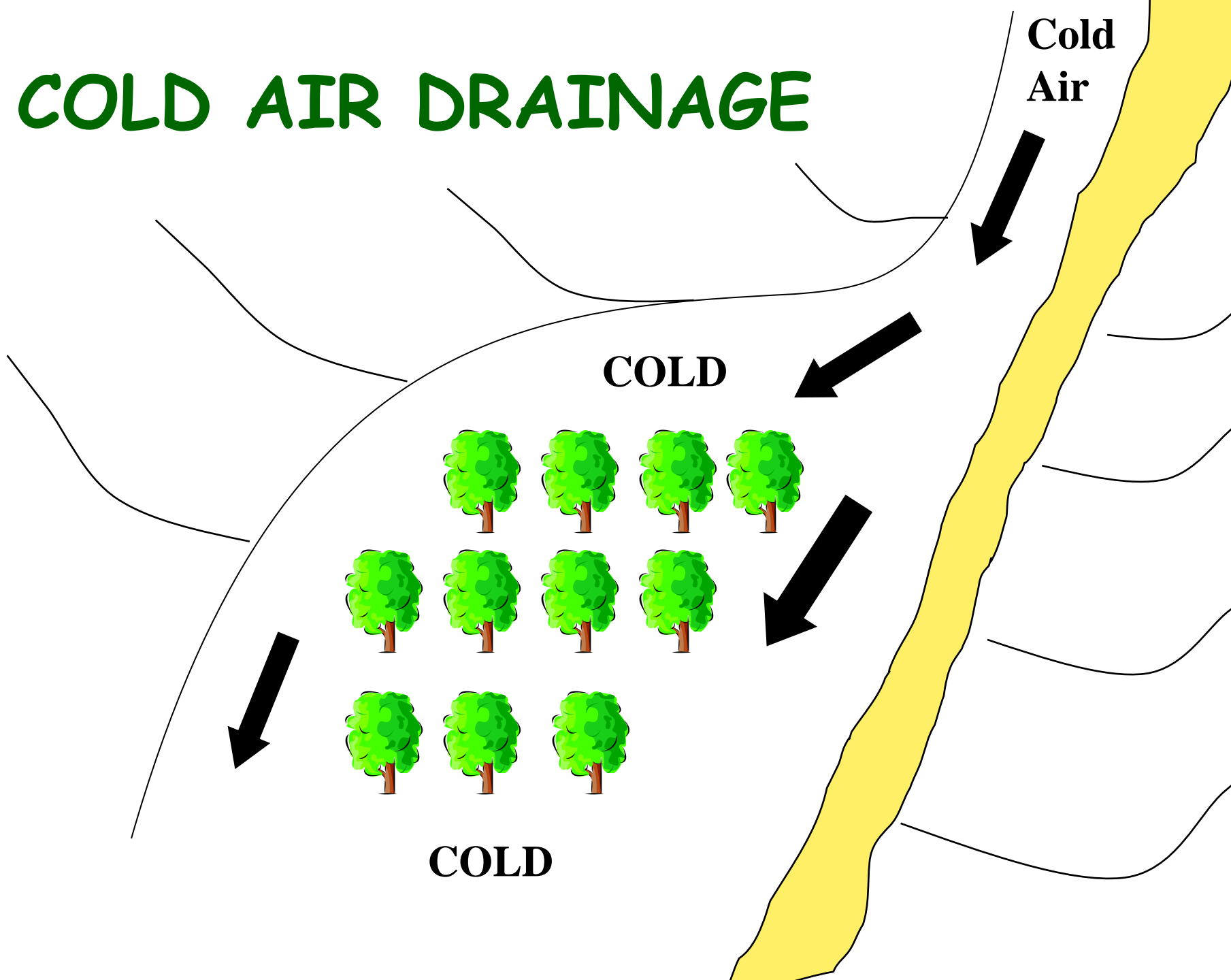
Ice Nucleation

- Kill the Bacteria
- Competitive Bacteria
- Remove Ground Cover

Cold Air Drains to Low Spots



COLD AIR DRAINAGE

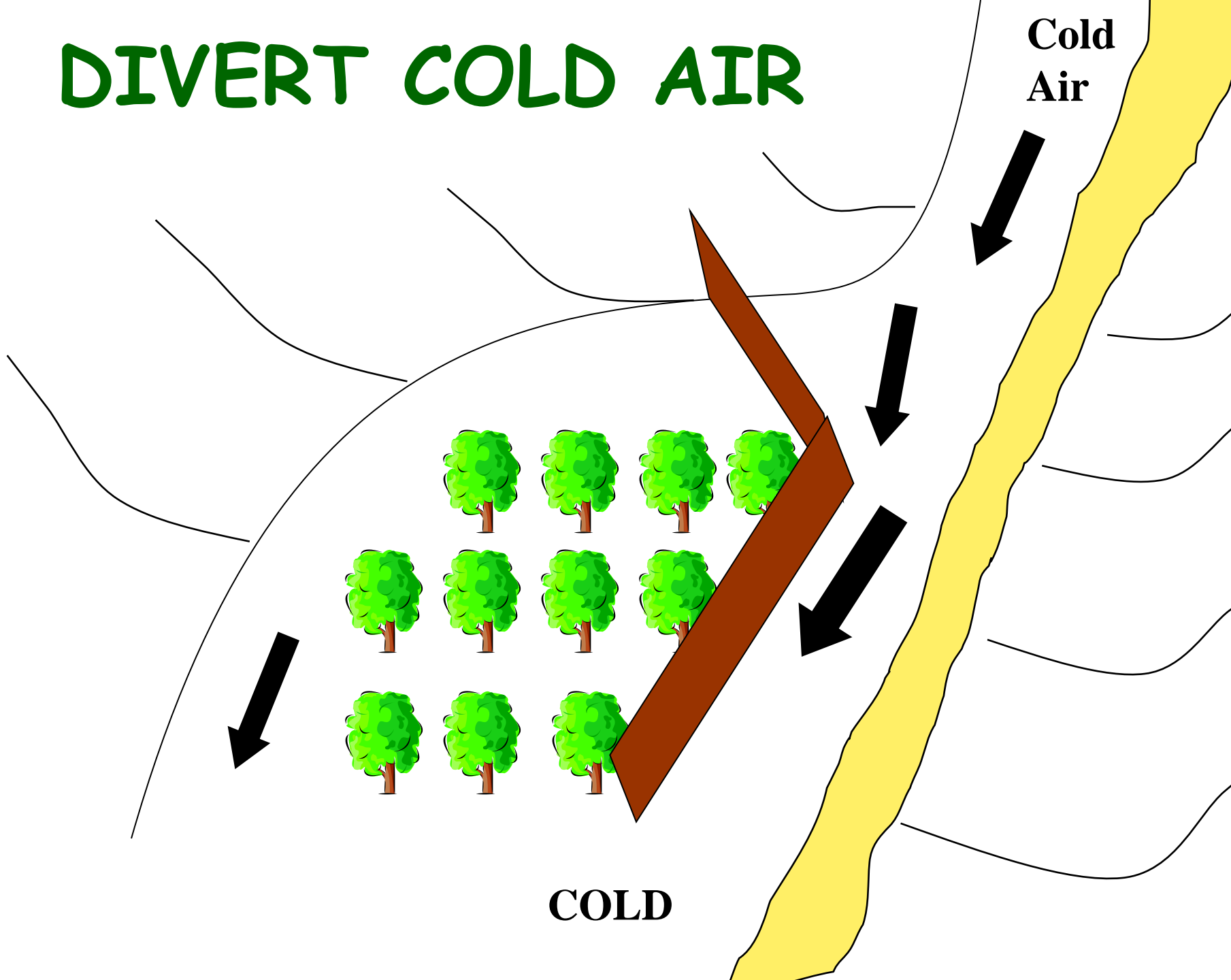


Cold Air

COLD

COLD

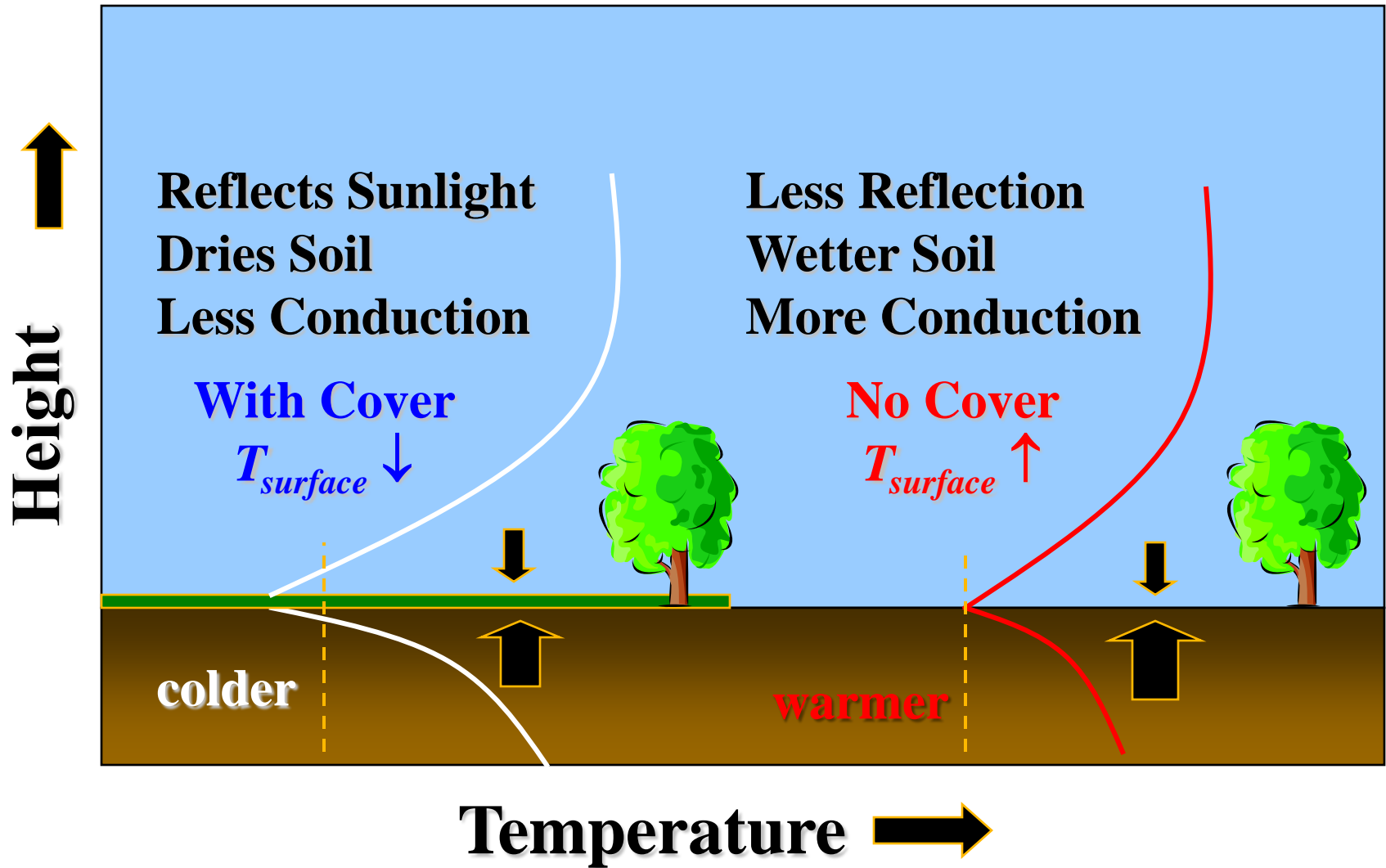
DIVERT COLD AIR



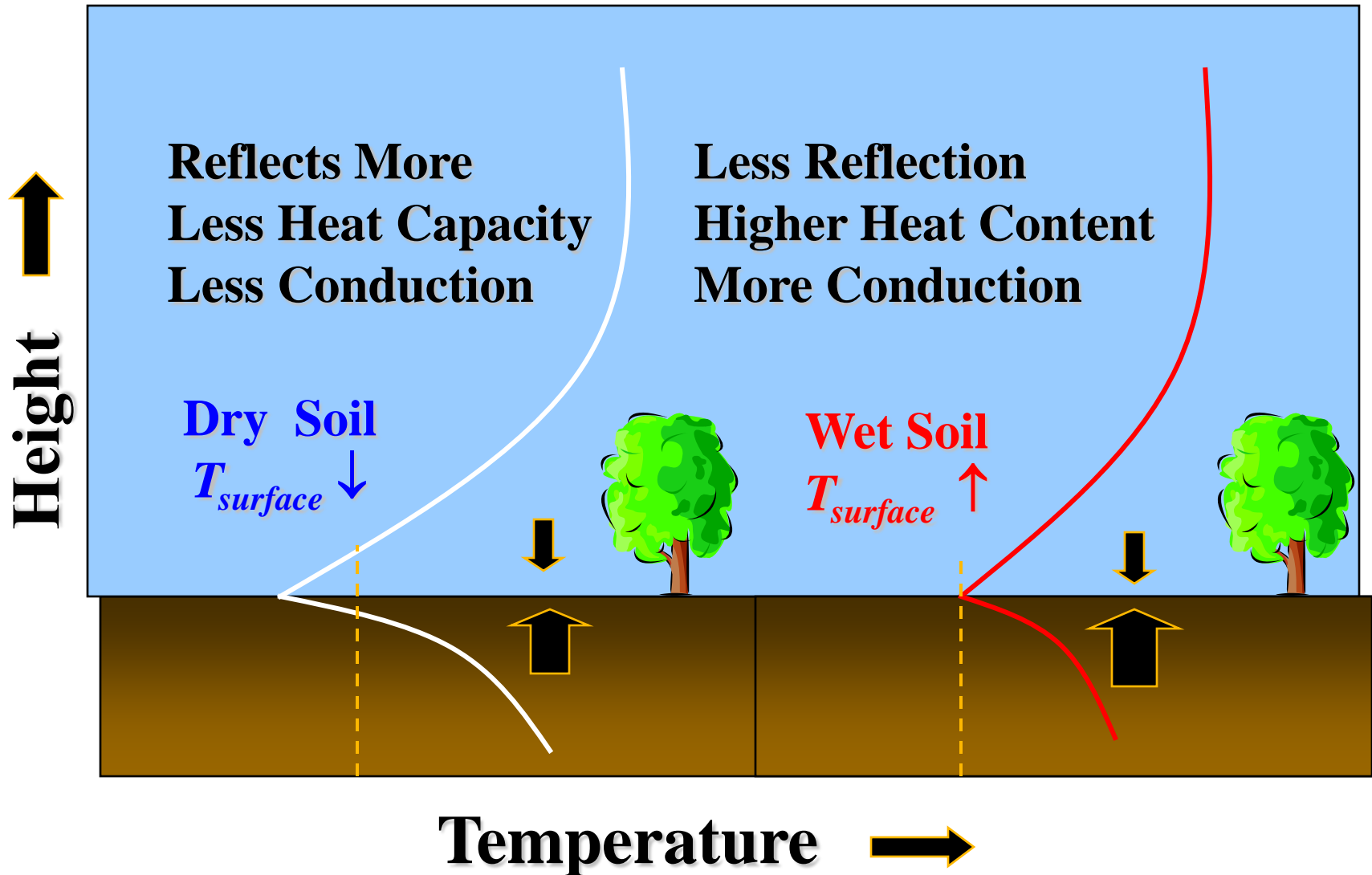
Cold Air

COLD

COVER CROP



SOIL WATER CONTENT



Active Protection

- Sprinklers
- Surface irrigation
- Helicopters

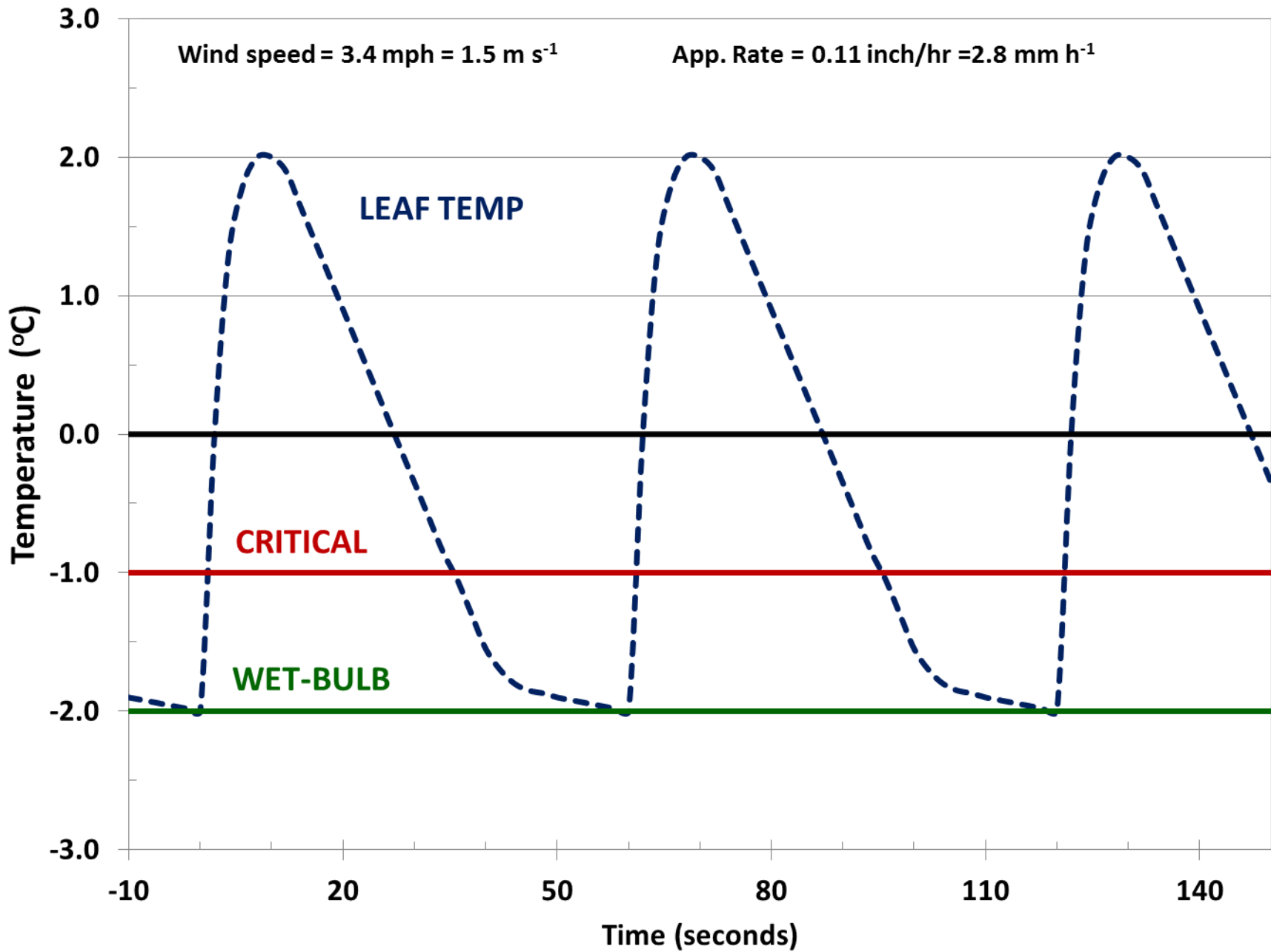
Sprinklers

- Heat from freezing water
- Add more energy from Freezing than lost to evaporation
- Start & stop based on Wet-bulb temperature

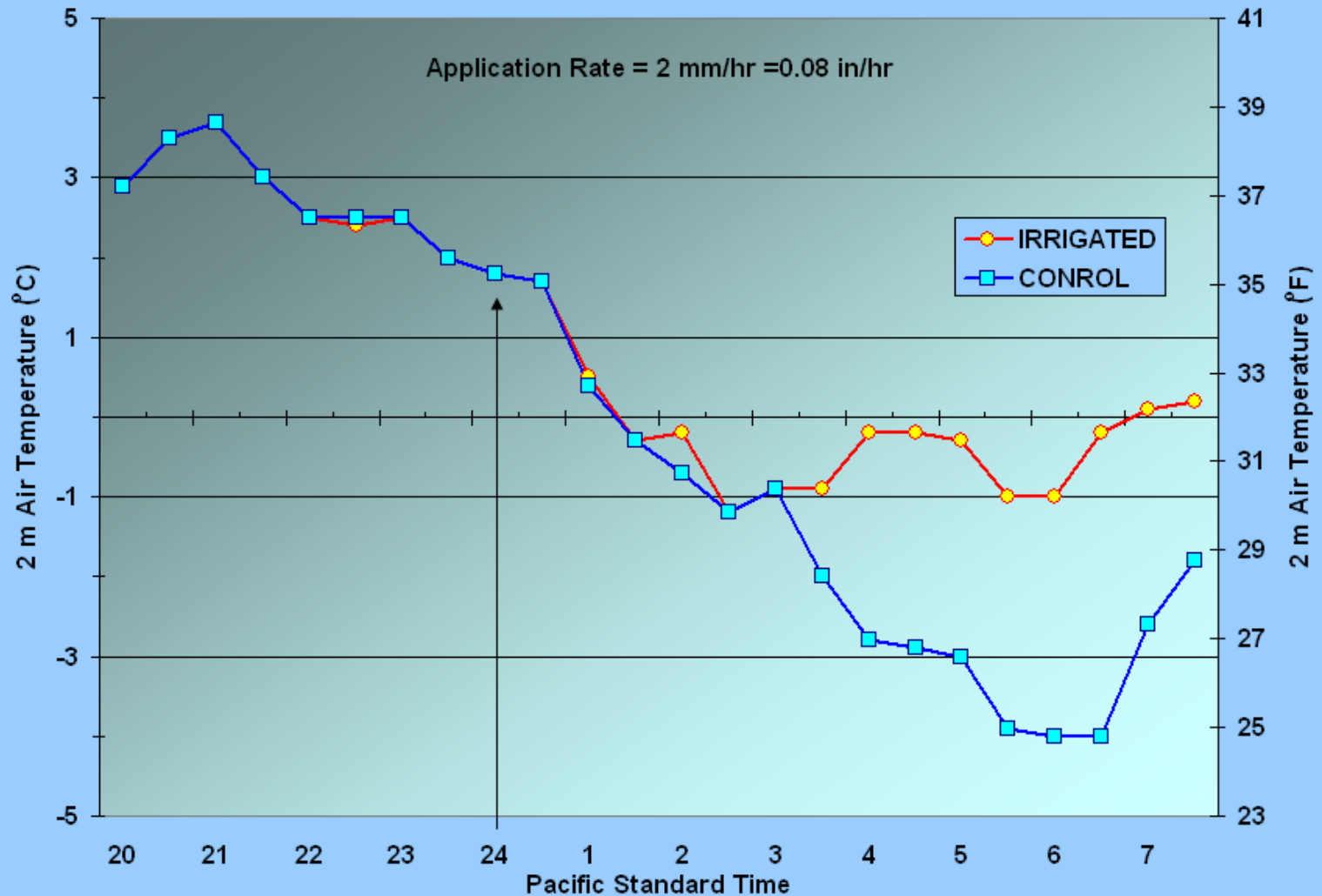
STARTING AND STOPPING

1. Air temperature initially drops to the wet-bulb temperature
2. If sprinklers stop, soil surface temperature drops to the wet-bulb
3. Between wetting, wet plant tissue cools to the wet-bulb

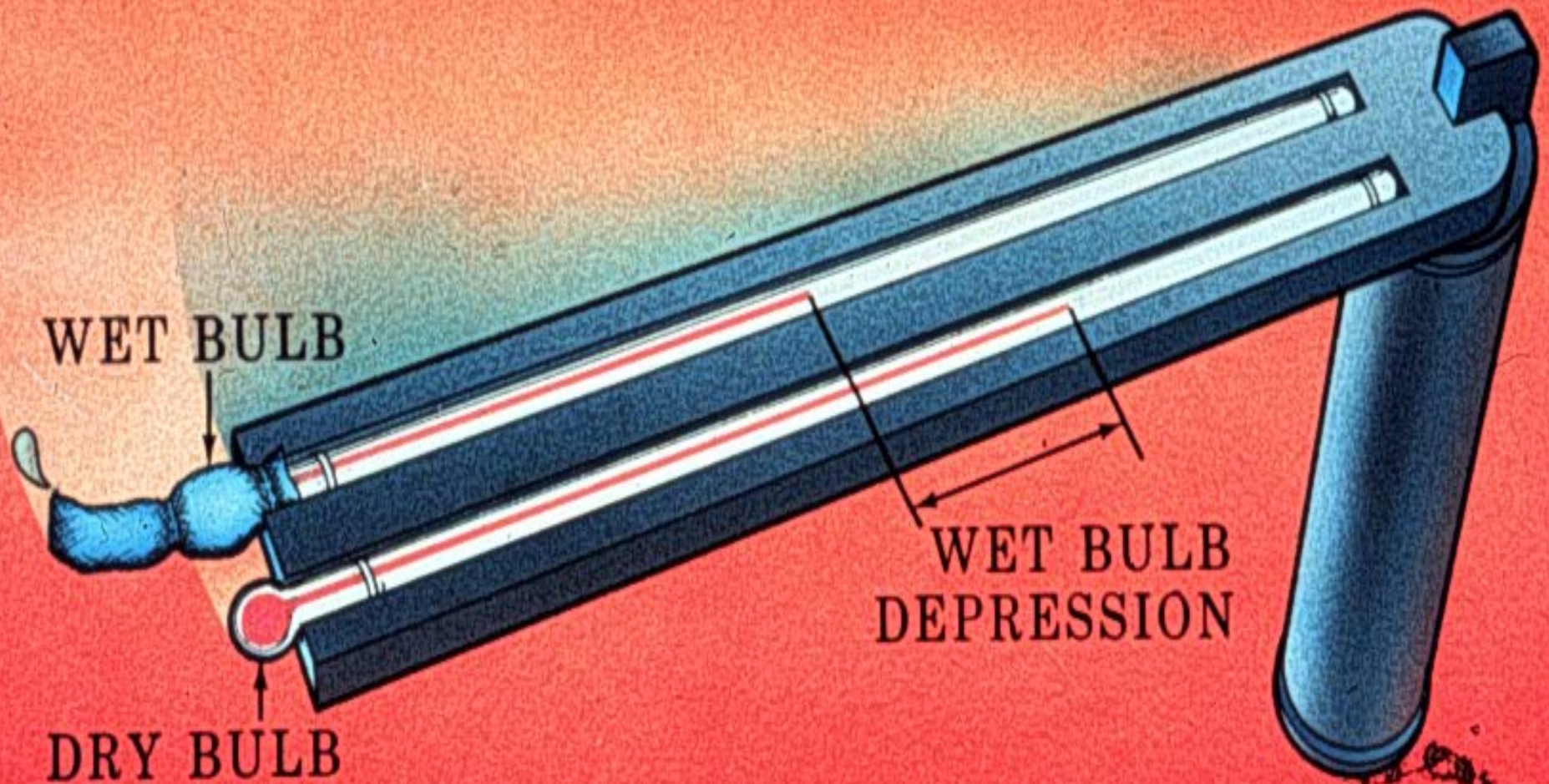




Under-tree Sprinklers



SLING PSYCHROMETER METHOD OF MEASURING RELATIVE HUMIDITY



When to Start and Stop Sprinklers

Elevation: ft
 Barometric Press: in Hg

Elevation: m
 Barometric Press: kPa mbar

Dew point °F	Wet-bulb Temperature (°F)											$e_s(T_d)$ kPa	
	22.0	23.0	24.0	25.0	26.0	27.0	28.0	29.0	30.0	31.0	32.0		
32.0												32.0	0.6108
31.0											31.0	32.7	0.5865
30.0										30.0	31.7	33.3	0.5631
29.0								29.0	30.6	32.3	33.9	0.5406	
28.0							28.0	29.6	31.2	32.9	34.6	0.5188	
27.0						27.0	28.6	30.2	31.8	33.5	35.1	0.4978	
26.0					26.0	27.6	29.1	30.8	32.4	34.0	35.7	0.4776	
25.0				25.0	26.5	28.1	29.7	31.3	32.9	34.6	36.2	0.4581	
24.0			24.0	25.5	27.1	28.6	30.2	31.8	33.4	35.1	36.7	0.4393	
23.0		23.0	24.5	26.0	27.6	29.1	30.7	32.3	33.9	35.6	37.2	0.4212	
22.0	22.0	23.5	25.0	26.5	28.1	29.6	31.2	32.8	34.4	36.1	37.7	0.4037	
21.0	22.5	24.0	25.5	27.0	28.5	30.1	31.7	33.3	34.9	36.5	38.2	0.3869	
20.0	22.9	24.4	25.9	27.4	29.0	30.5	32.1	33.7	35.3	37.0	38.6	0.3708	
19.0	23.4	24.8	26.3	27.9	29.4	31.0	32.5	34.1	35.8	37.4	39.1	0.3552	
18.0	23.8	25.3	26.8	28.3	29.8	31.4	32.9	34.5	36.2	37.8	39.5	0.3402	
17.0	24.2	25.7	27.2	28.7	30.2	31.8	33.3	34.9	36.6	38.2	39.9	0.3258	
16.0	24.6	26.0	27.5	29.1	30.6	32.1	33.7	35.3	36.9	38.6	40.2	0.3119	
15.0	24.9	26.4	27.9	29.4	31.0	32.5	34.1	35.7	37.3	38.9	40.6	0.2986	
14.0	25.3	26.8	28.3	29.8	31.3	32.9	34.4	36.0	37.7	39.3	40.9	0.2857	
$e_s(T_w)$	0.4037	0.4212	0.4393	0.4581	0.4776	0.4978	0.5188	0.5406	0.5631	0.5865	0.6108		

Starting and Stopping

First night - Start before the wet-bulb temperature falls to the critical damage temperature.

Subsequent nights – Start before the wet-bulb falls to 0°C.

Mornings - Stop when the sun is shining and the wet-bulb temperature is greater than 0°C.

SURFACE IRRIGATION

- Start early enough
- Do not reuse cold water
- Run water near tree skirts
- Maximize the area
- Good flow rate

HELICOPTERS

Frequent passes

Talk to Pilot

Load with water

Use Marker lights

Monitor

Temperature

Thanks!