

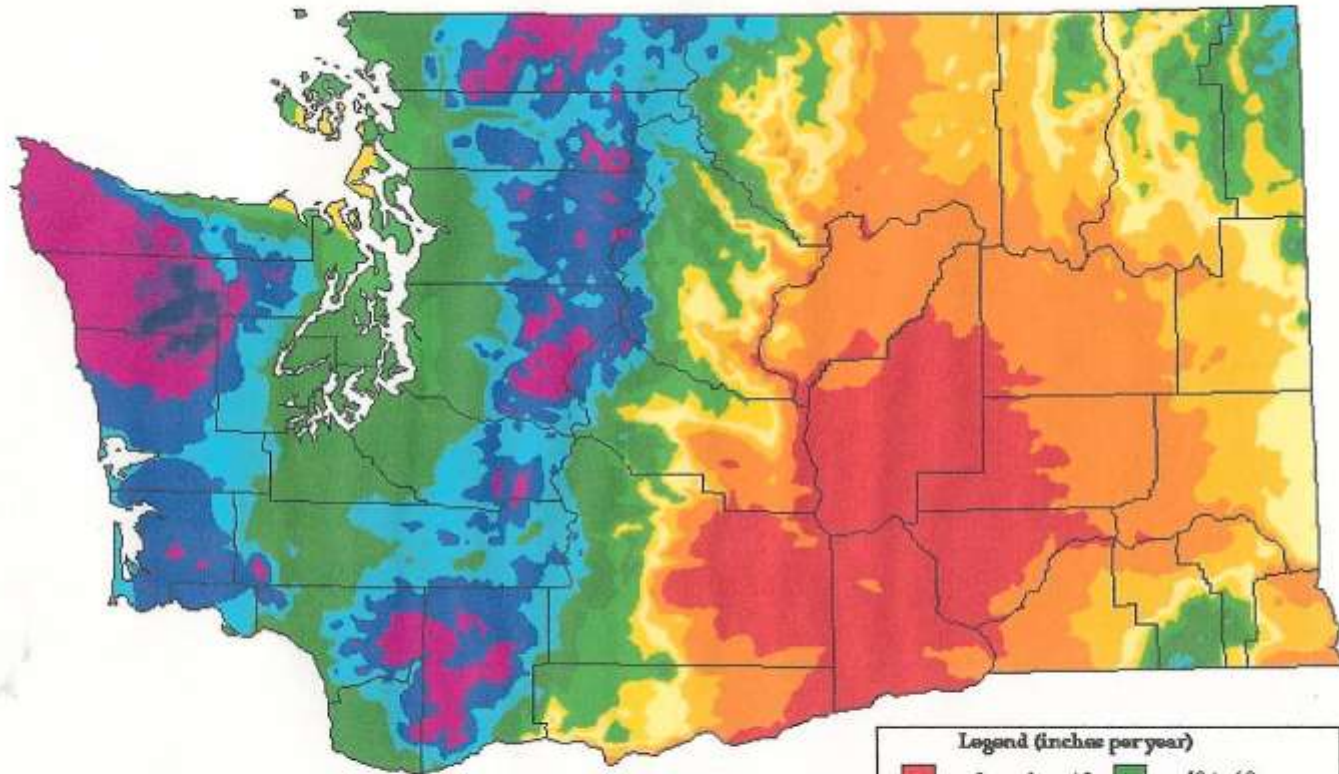
GRAPE COLD INJURY

Causes, Prevention, Assessment, and Compensation

Nevada Grape Growers



Washington Precipitation



Average Annual Precipitation

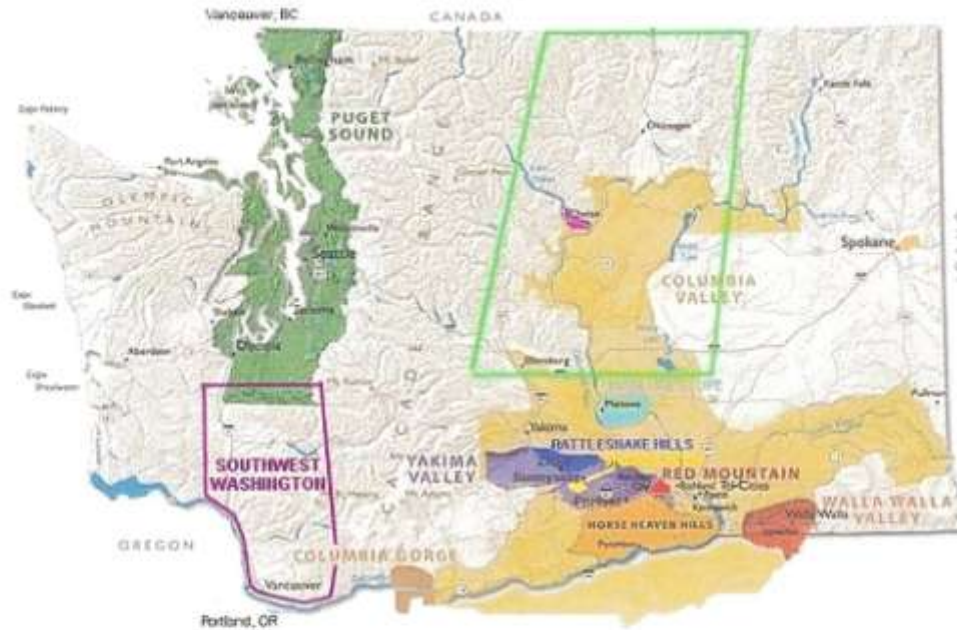
Washington

Period: 1961-1990 Units: inches

Legend (inches per year)

Less than 10	40 to 60
10 to 15	60 to 80
15 to 20	80 to 100
20 to 25	100 to 140
25 to 30	140 to 180
30 to 40	More than 180

Washington AVA'S



Official Appellations/AVAs



Understanding Vine Cold Injury

- # Mechanics of cold injury
- # Avoiding cold injury
- # Prediction and protection methods
- # Injury assessment and compensation
- # Other considerations

Crop-Limiting Effects of Cold Temperatures

- # Low heat units (<1800dd)
- # Short growing season (<150 days)
- # Severely cold temperatures

Two Types of Cold Events - Radiation

- # Radiation most common, easiest to control.
- # Exposed objects lose heat to clear night sky.
- # Blossoms, buds, canes, become 1-2 degrees colder than ambient air.
- # Heat rises, replaced by cold air which drifts into low areas.
- # Both radiation heat and drift heat must be replaced.

Frost Events-Radiation(cont.)

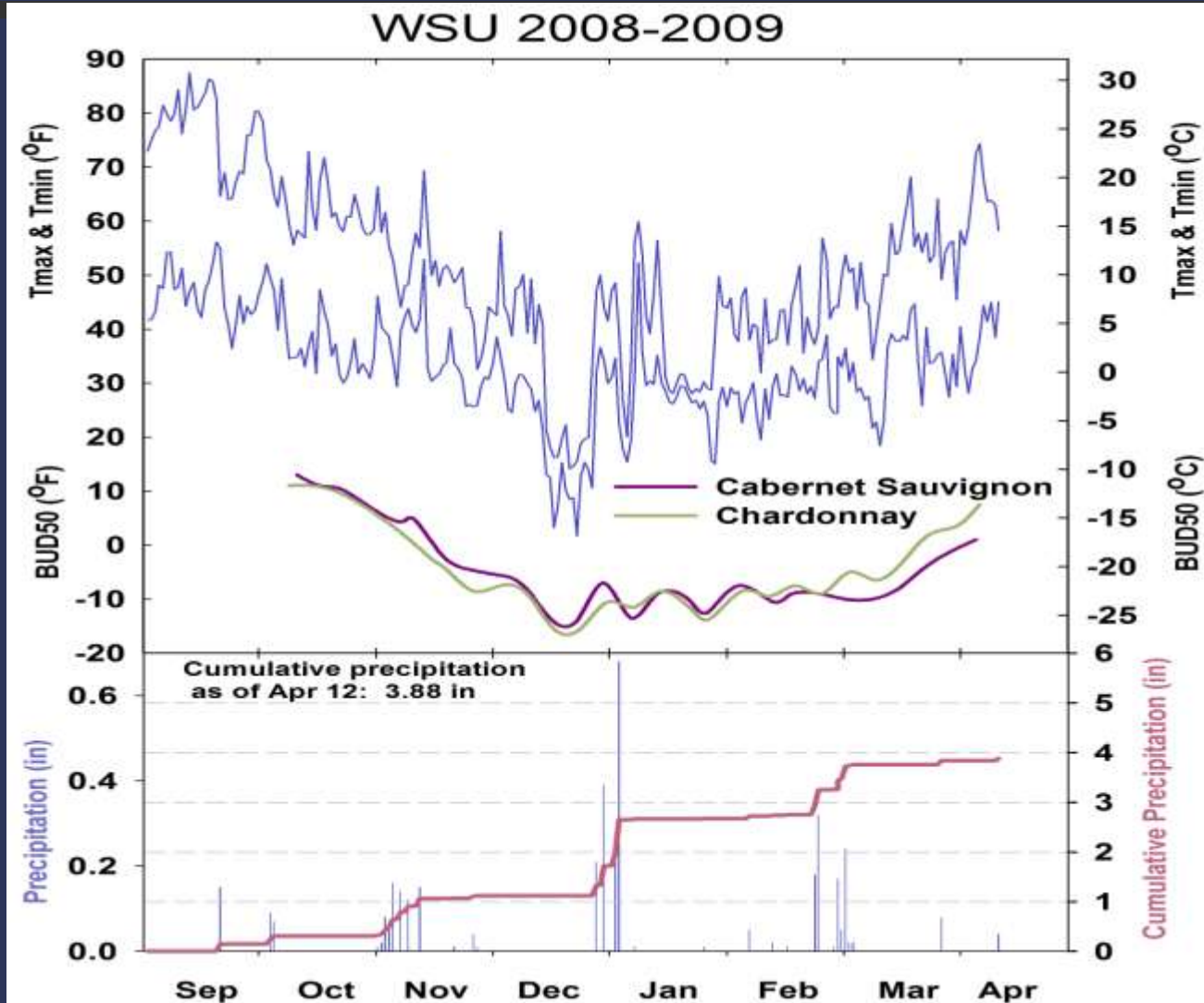
- ❏ Thermal inversion develops 30-60 feet above ground.
- ❏ Temperature loss can be rapid until it reaches the dew point.
- ❏ Dew point is the temperature at which atmospheric water vapor begins condensing from a gas to a liquid.
- ❏ Evolves large amount of heat, slowing temperature drop.



Two Types of Cold Events - Advection

- # Mass air movement (cold front).
- # Usually accompanied by wind.
- # Usually low dew points.

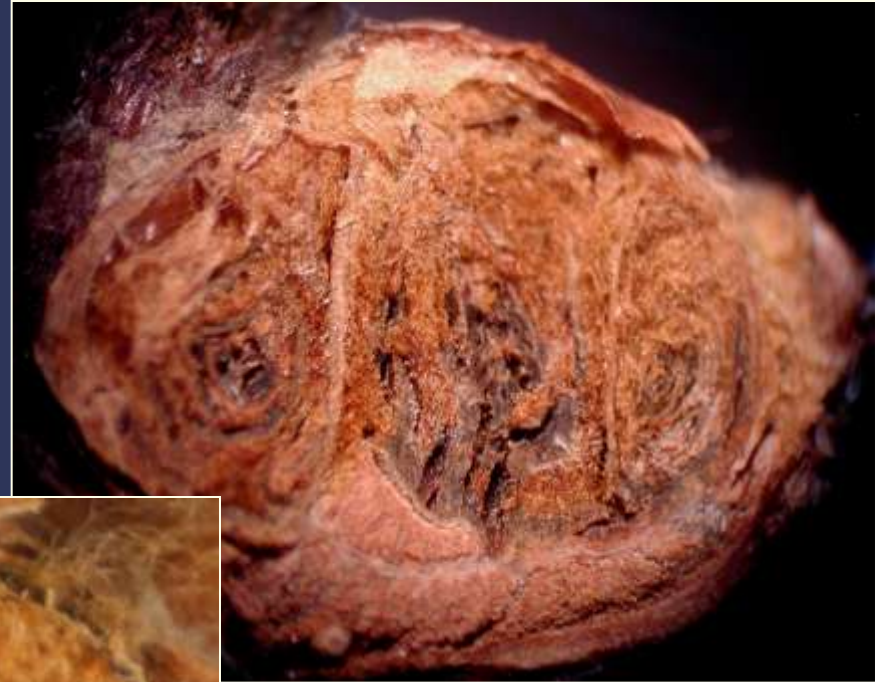
Critical Temperatures



Plant Reaction To Cold

- # Formation of ice crystals
 - # Desiccation
 - # Solutes
 - # Super-cooling
-

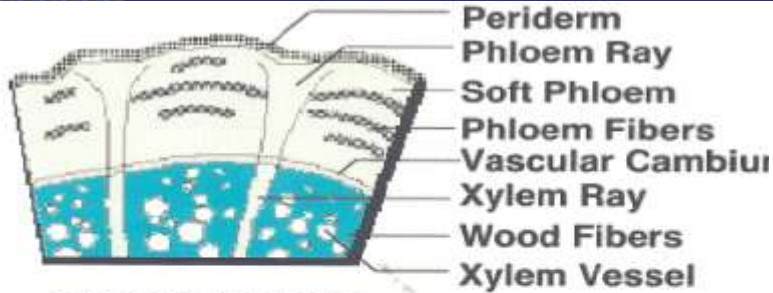
Bud Cold Injury



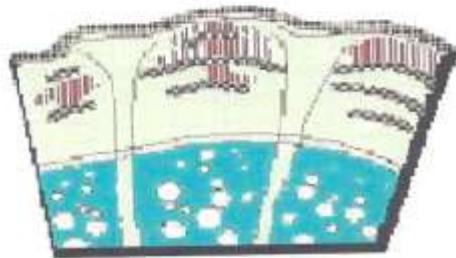
Wood Cold Injury



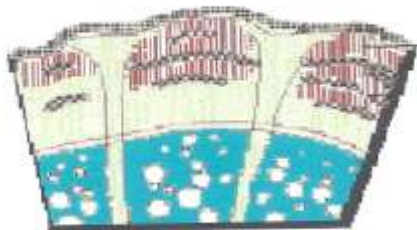
Sequence of Cold Injury to Wood



Stage 1: No Injury



Stage 2: Outer phloem damaged, spotty



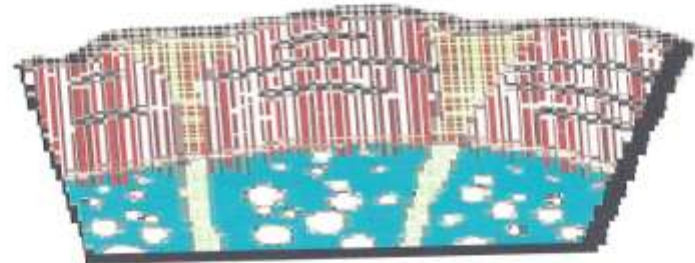
Stage 3: More outer phloem injury; innermost phloem & cambium intact

found on the outer (near the trunk) edge of the phloem bundles. (See colored regions on left)

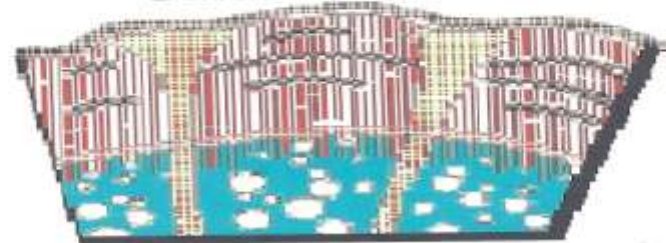
Stage 3 - As cold injury progresses, a greater fraction of the phloem bundles become discolored. For Goftine's stage 3 injury, the inner phloem and the vascular cambium remains uninjured.



Stage 4: All soft phloem and cambium shows some injury: phloem rays OK



Stage 5: Injury begins in outer xylem except



Stage 6: Total injury of all phloem, cambium, outer xylem, including xylem rays

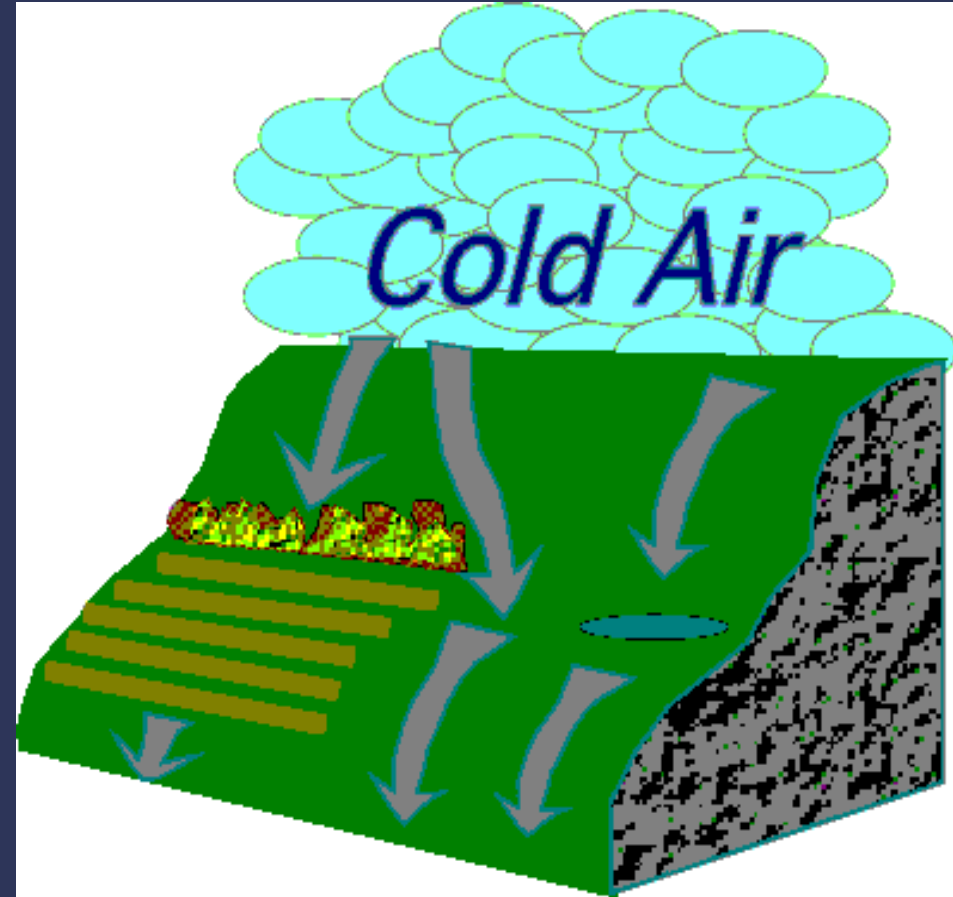
Site Selection

- # Slope
- # Obstructions
- # Aspect
- # Soil
- # Heat sinks
- # Elevation



Cold Air Drainage

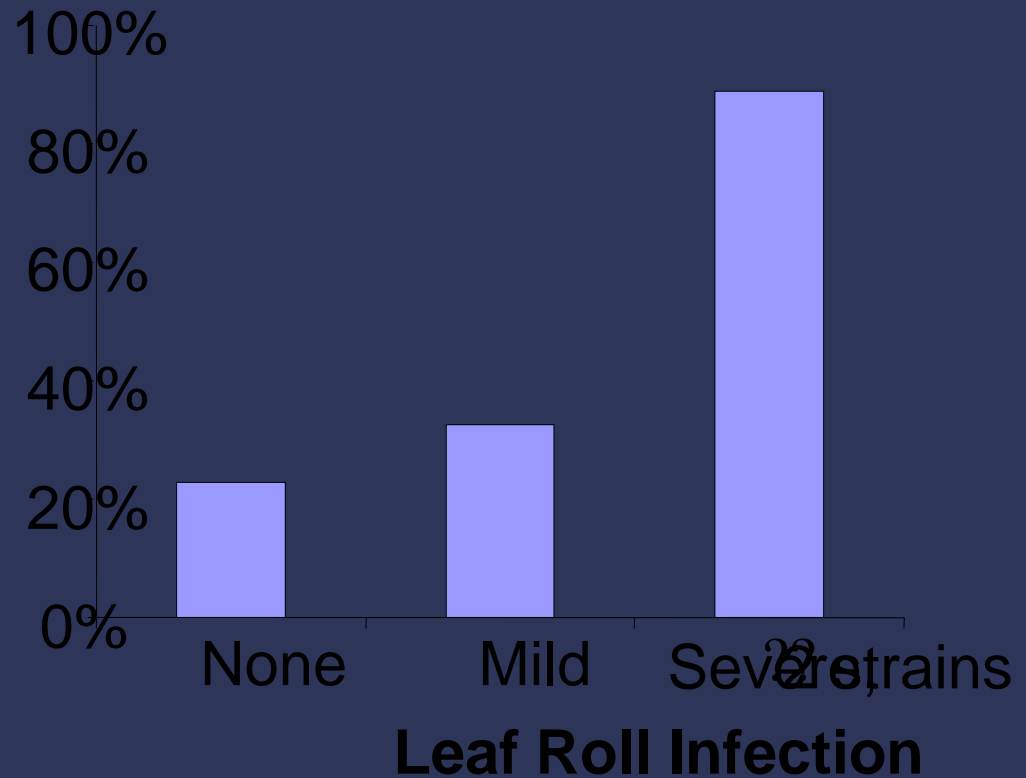
- # Cold air flows like molasses, from higher elevations to lower and pools like water when obstructed



Healthy Vines

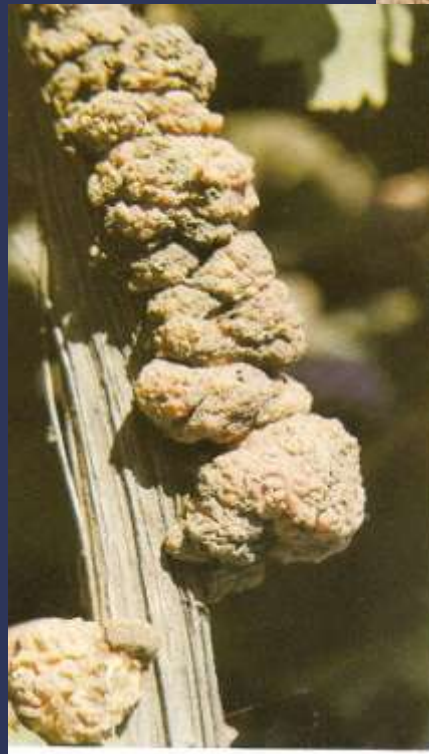
- Viruses
- Stress
- Mildew
- Crown gall
- Other pests

Primary Bud Damage



Crown Gall

- # Large area on permanent wood with growth of soft disorganized tissue.
- # Small ones slough off.
- # Large ones can remain as corky growth(galls) on vine. If girdled, vine will die.



Variety Selection



Relative Cold Hardiness

Low

Moderate

High

Chenin blanc

Sauvignon blanc

Riesling

Merlot

Lemberger

Chardonnay

Sangiovese

Cabernet
sauvignon

Gewurztraminer

Semillon

Cabernet franc

Pinot noir

Syrah

Pinot gris

Viognier

Pinot blanc

Irrigation

- # Deficit
 - # Don't overstress
 - # Post harvest
-

Nutrition

- # “Vines have to struggle to produce high quality grapes”
- # Vines use about 30-40lbsN/a
- # Think nutrient replacement

Crop Load



Pruning and Training

- # Prune for crop and sunlight
- # Keep trellis configuration simple
- # Multiple trunks
- # Fan system
- # Kicker canes
- # Delayed pruning



Bud and Cane Hardiness as Affected By Sunlight Exposure

4).

Table 4. Effect of shoot exposure to sunlight on hardiness (T_{50})^z and water content^y of primary buds and canes of Concord grapevines, 20 September 1979. All samples were from middle node positions (#6-8) on shoots with 3 clusters.

Exposure status	Cane color	Primary bud		Cane	
		T_{50}	H ₂ O	T_{50}	H ₂ O
Exposed	Brown	-13.0a	0.90c	-13.5a	0.91c
Shaded	Lt. brown	-10.5b	1.11b	-11.5b	1.24b
Shaded	Green	-6.5c	1.69a	-7.5c	2.71a

^z °C; separated by Chi² test, $p = 0.05$.

^y g H₂O/g dry wt; separated by Duncan's multiple range test, $p = 0.05$.

Planting

- # Timing
- # Depth
- # Grow-tubes



Other Cultural Practices

- # Rootstocks
- # Cover crops
- # Wind breaks
- # Early harvest
- # Late pruning

Active Frost Protection

- # Efforts to modify temperatures in vine yard
- # Add heat
- # Mix inversion into vine yard
- # Conserve heat



Need to Be Able to Predict Critical Temperatures

- # Temperatures at which cells of a tissue will be killed
- # Usually expressed as T10, T50, or T90; temperatures at which 10, 50, or 90% of buds, tissue are killed



Bud Critical Temperature by Vine Development Stage

Stage of Development	Definition	Critical Temperatures*	
		T ₁₀	T ₉₀
Dormant	Closed bud, inactive	variable	subzero
First swell	Buds increase in size, scales separate to show brown, fuzzy, young leaf tissue	13	-3
Full swell	Buds swell further, young leaves become pink. Still closed around growing point	21	10
Bud burst	Young leaves separate at tip to show the growing point	25	16
1st leaf	First leaf is out of the bud, makes right angle with stem	27	21
2nd leaf	2nd leaf makes right angle with stem	28	22
3rd leaf		28	26
4th leaf		28	27
5th leaf		28	27

Critical Temperatures(cont.)

- # Can be measured in a lab.
- # Usually reported as temperature at which 10, 50, or 90% buds are killed.
- # Temperature range narrows as get closer to bud break.
- # Not absolute but growers can use reports to time protection measures.

Critical Temperature Report

Date	Variety	BUD10 °F	BUD50 °F	BUD9 °F	PHL10 °F	XYL1 °F
Apr 6	<u>Cabernet Sauvignon</u>	+3	-1	-3	+8	-1
Mar 27	<u>Cabernet Franc</u>	+8	+5	+2	+8	0
Apr 10	<u>Merlot</u>	+13	+10	+5	+16	+11
Mar 27	<u>Malbec</u>	+3	+1	-2	+9	-1
Apr 7	<u>Syrah</u>					
Mar 20	<u>Mourvedre</u>	0	-2	-3	+10	+1
Mar 20	<u>Grenache</u>	+4	+2	0	+8	+2
Mar 20	<u>Zinfandel</u>	-2	-3	-4	+4	-4
Mar 20	<u>Sangiovese</u>	+5	+2	-2	+8	-4
Mar 27	<u>Nebbiolo</u>	+8	+6	+1	+10	+2
Mar 20	<u>Tempranillo</u>	+2	0	-3	+3	-4
Mar 27	<u>Barbera</u>	+11	+9	+7	+10	-2
Mar 27	<u>Dolcetto</u>	+4	+2	-3	+9	0
Apr 7	<u>Riesling</u>	+9	+6	0	+13	+6
Apr 7	<u>Chardonnay</u>	+11	+8	+1	+13	+6
Mar 31	<u>Concord</u>	+5	0	-5	+2	-6
Mar 31	<u>Sunbelt</u>	+7	+4	0	+5	-5

Cold Hardiness of Bud and Cane Samples

Unfortunately, at this time, we do not have a large data base with which to compare different cultivars or species of grapevines. As indicated in Tables 4 and 5, some cultivars and species seem to be more susceptible to rapid temperature changes than others. However, we do not know at this time if changes in stem hardiness would occur faster than buds for these plants.

Research efforts have not provided much hope for significantly increasing grapevine cold hardiness through management practices. On the other hand, they have shown reductions in cold hardiness due to excessive irrigation and otherwise poor management practices. Thus, it appears that, under generally good management, growers must work with the hardiness

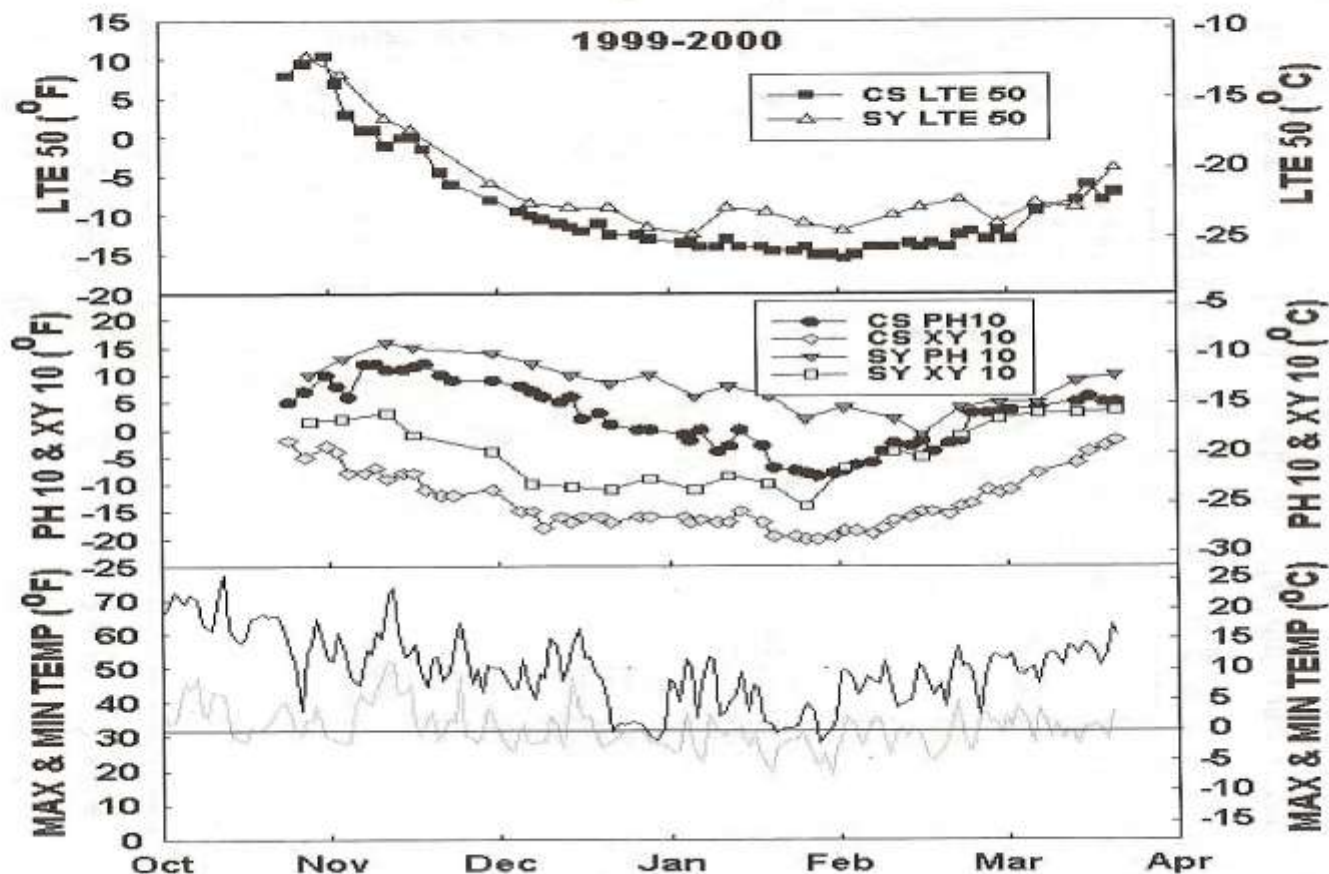


Fig. 8. Cold hardiness of bud and cane samples of Cabernet Sauvignon (CS) and Syrah (SY) during the winter of 1999-2000 collected in Prosser, Washington, at the Washington State University, Irrigated Agriculture Research and Extension Center. Bud hardiness is reported as the temperature at which 50% of the buds would be killed (LTE₅₀). Cane hardiness is reported as the temperature at which 10% of either the phloem (PH) or xylem (XY) tissues would be killed after a short exposure to the indicated temperature. Differences between cultivars and tissue or organ acclimation and deacclimation are reflected in the data.

Protection Measures-Over Vine Sprinkling

- # Warms vineyard by heat of fusion.
- # Requires large amounts of water.
- # Must uniformly cover entire vineyard and keep ice wet. One-third inch/hour.
- # Must have water available. Pond, well?
- # Can create disease, delayed growth problems.

Under Vine Sprinklers

- # Not used much because of interference from posts and vines.
- # Heated water may be new option. 1mm/hr at 100-110 degrees.

Heaters

- # Only about 25% efficient, hot air rises rapidly out of vine yard.
- # Works best when used with wind machines.
- # Perimeter heat best.
- # Smoke won't help reduce radiation.
- # Costly, source of pollution.

Wind Machines

- # Mixes warm air of inversion layer down into vine yard.
- # One machine will cover about 10 acres.
- # Works well with heaters, under vine sprinkling.
- # Don't use with over vine sprinklers.

Estimated Costs(2000)

Method	Estimated costs/ha/hr
Return Stack Oil Heaters (100/ha)*	\$ 93.08
Standard Propane Heaters (154/ha)*	103.98
Wind Machine (130 BHP propane)	33.36
Overcrop Sprinkling	4.10
Under Canopy Sprinkling	4.25
Frost-free site	0.00

* equal total heat output

Combination Best

- # Use both passive and active methods to minimize cold damage.

How to Deal With Cold Injured Vineyards

- # Assessment
- # Compensation
- # Adjustment

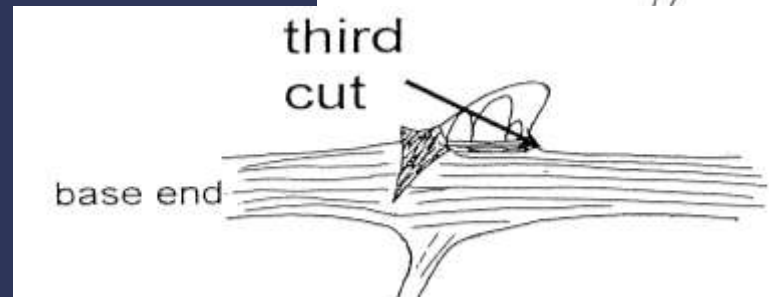
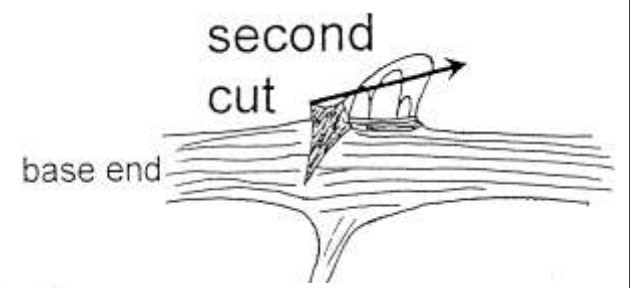
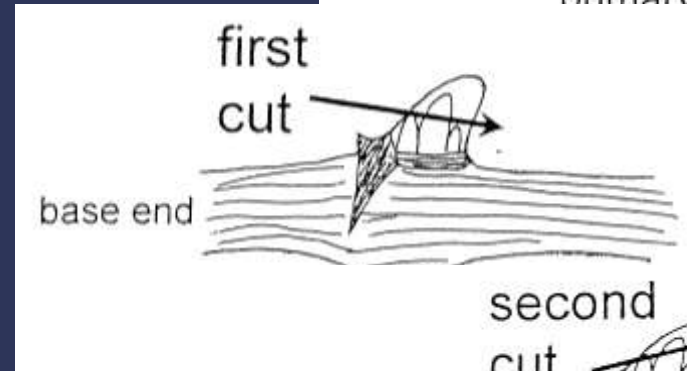
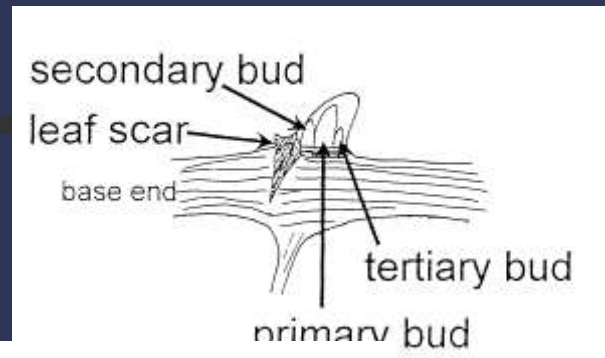


Damage Assessment

- # Prune as late in the spring as possible
- # Assess damage before pruning
- # Examine vines representative of the vineyard
- # Tissue may have to be warmed to indicate damage

Bud Compensation

- # 25% Injury - Add 50% more buds
- # 50% Injury - Double bud number
- # 75% Injury - Triple bud number
- # Above 75% injury - Wait and hedge



Trunk Injury

- # Phloem
- # Xylem
- # Southwest injury



When To Renew Trunk

- # Temperatures below – 10 degrees
- # Xylem injury
- # Over 75% bud mortality



Sucker Management For Trunk Renewal

- # Leaving existing vine and renewing trunk usually results in poor bud break
- # 4-6 Canes to disperse vigor
- # Training suckers along wires best



Bottom Line

- # Vines at lower end of 75-100% bud kill usually do OK
- # Be prepared to thin (especially in 25-50% bud kill range)
- # Hedge prune with high bud mortality



Cultural Practices for Cold Injured Vines

- # Use standard cultural practices for moderate injury
- # Use vigor reducing practices for severely damaged or renewed vines, i.e. reduced N fertilizer, cover crop, maintain sucker growth
- # Don't over-crop

Other Considerations

- # Build cold injury into budget
 - # Build into wine distribution
 - # Acreage vs tonnage contracts
 - # Insurance
-