

## The basics of irrigation scheduling using ET data from CIMIS

*Presented at*

**Inches to Hours: An Irrigation Workshop for Foothill Wine Grape Growers**  
UC Cooperative Extension-Central Sierra

*April 29, 2014*

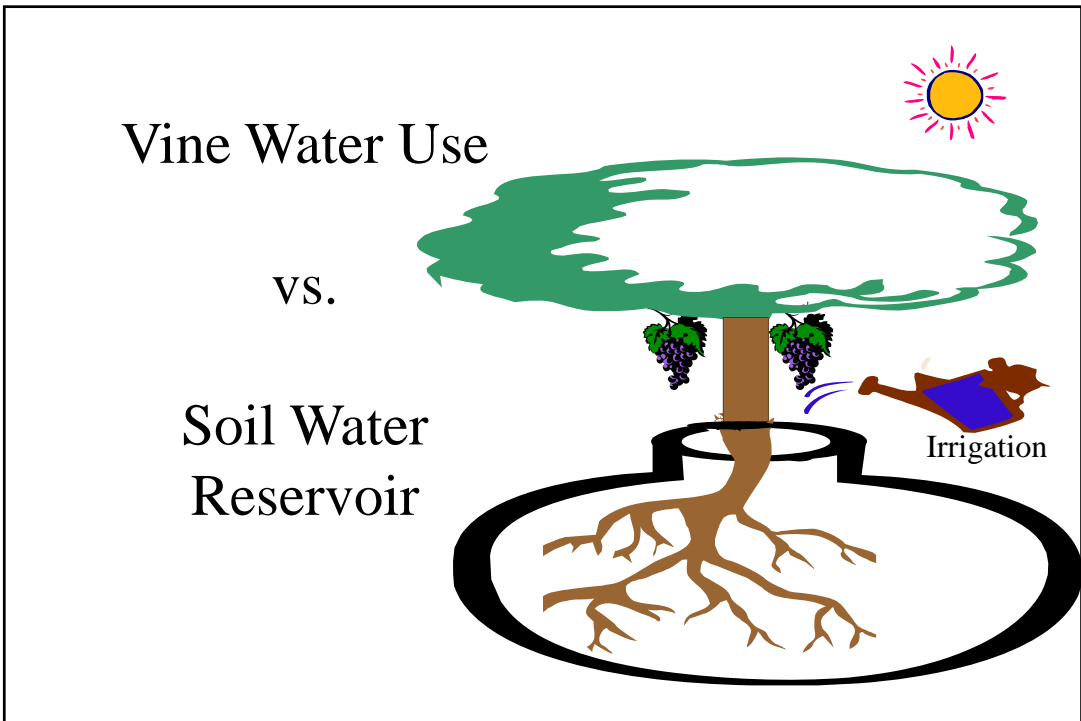
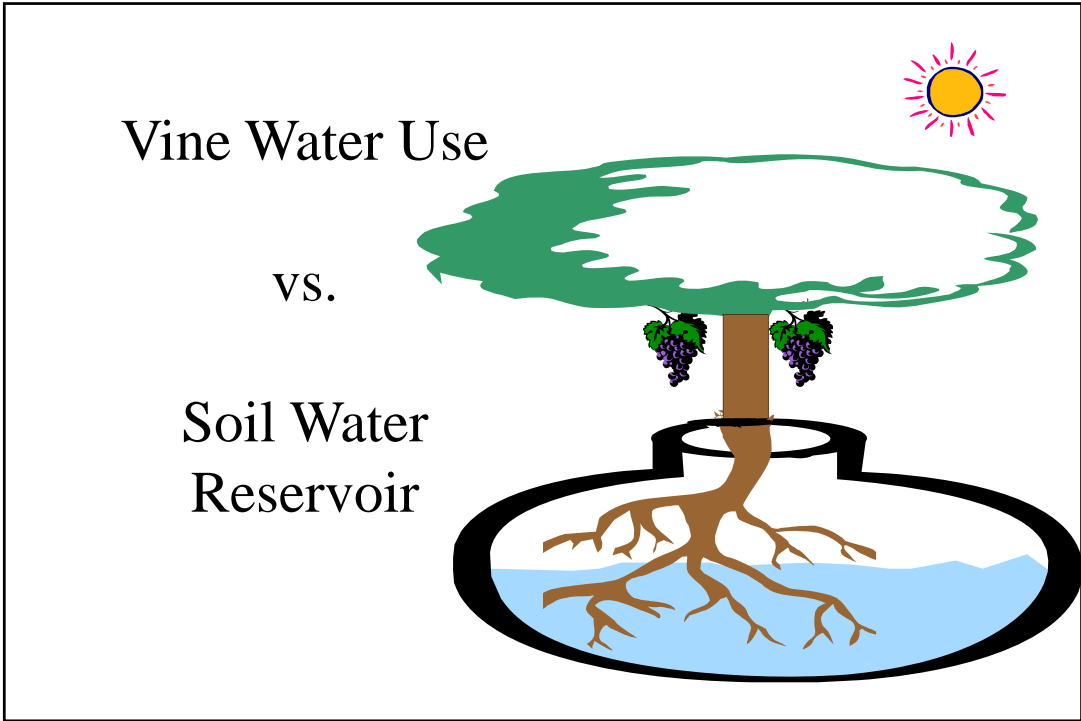
Rhonda Smith  
Viticulture Farm Advisor  
Sonoma County

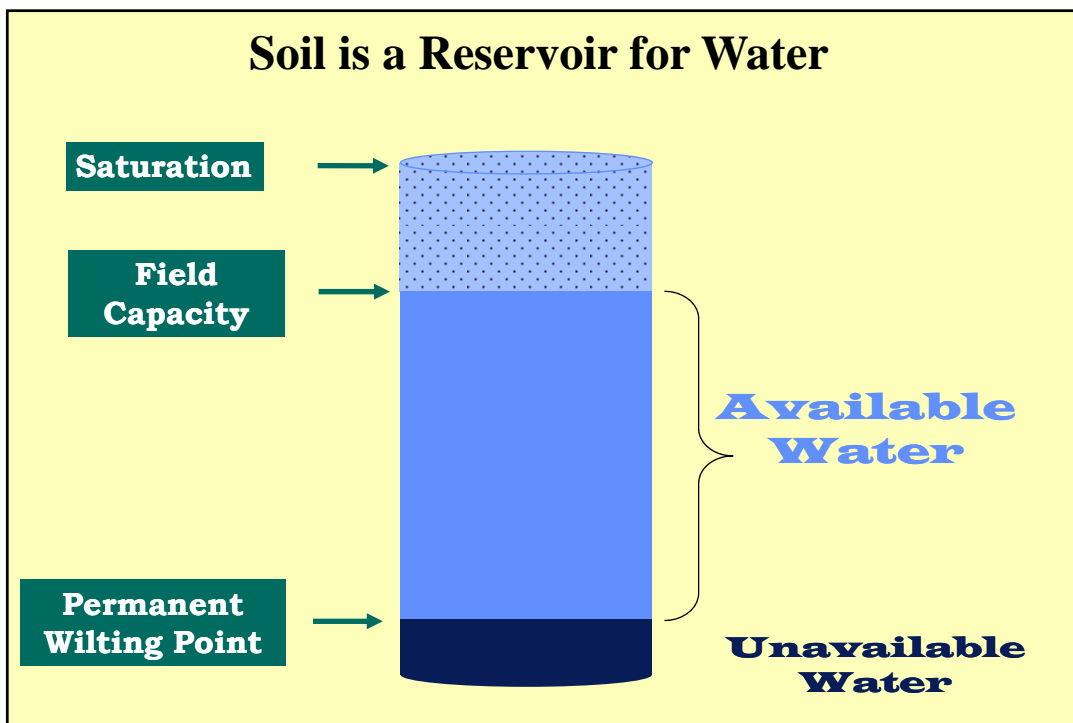
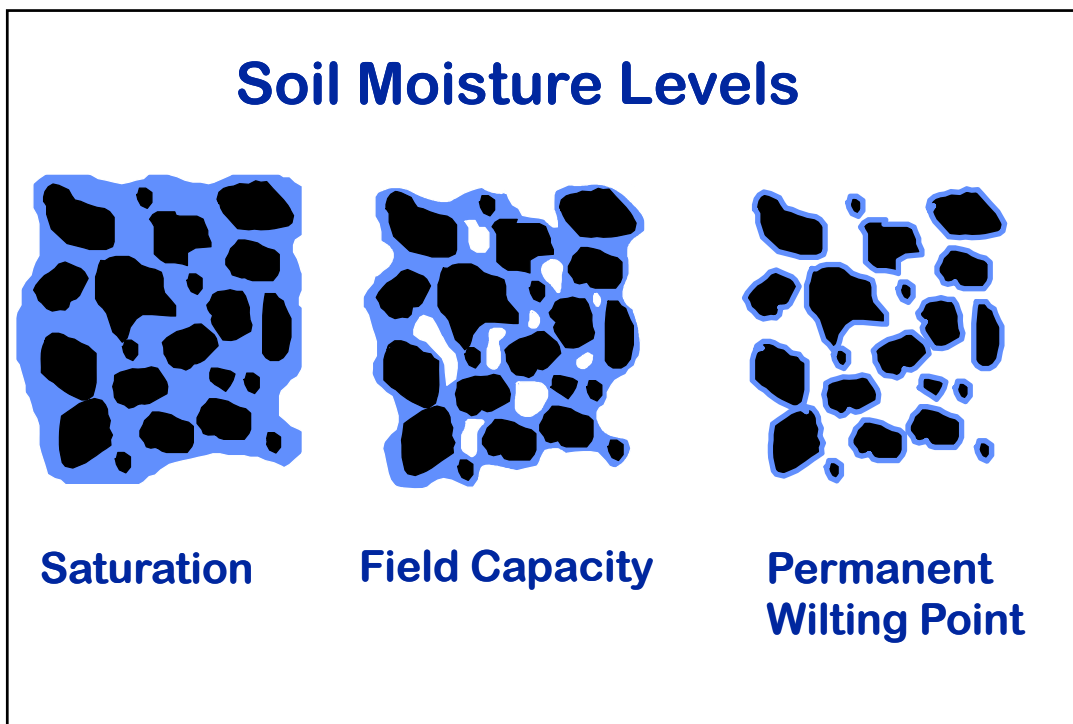
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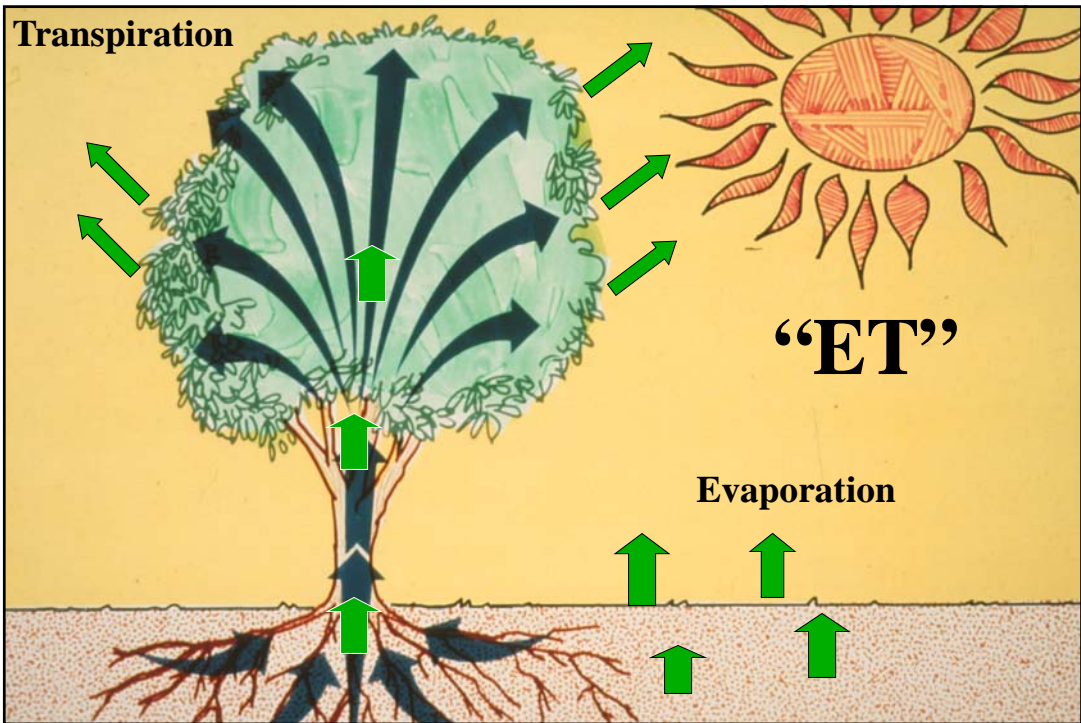
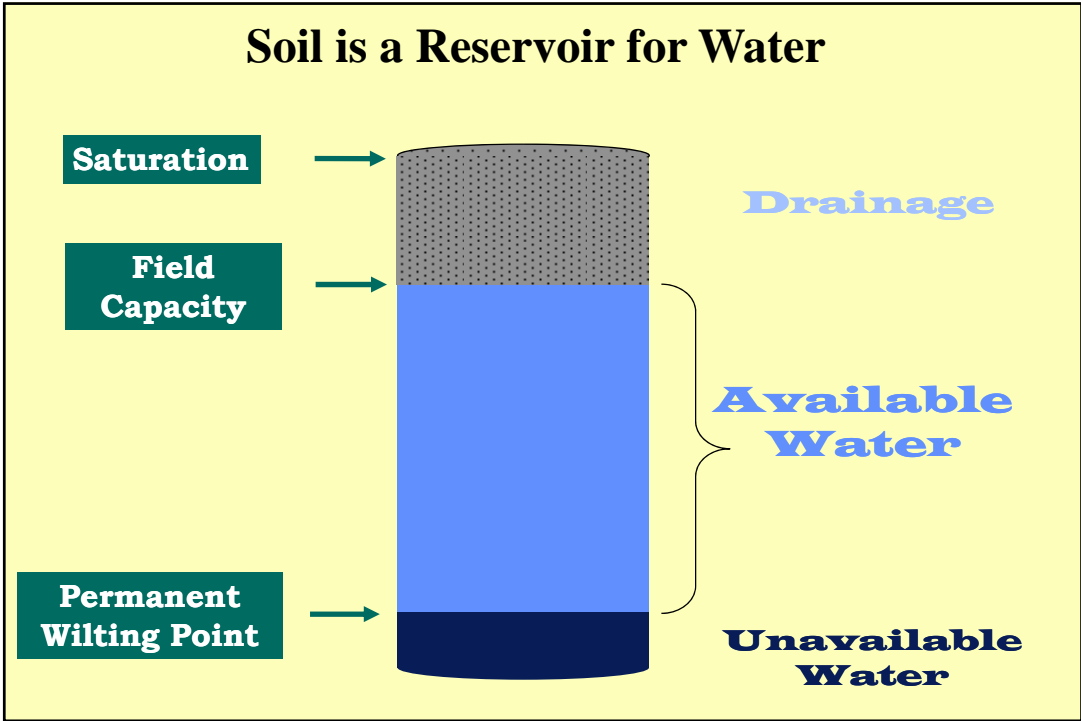
Use plant *and/or* soil-based monitoring tools to determine when to apply water the first time.

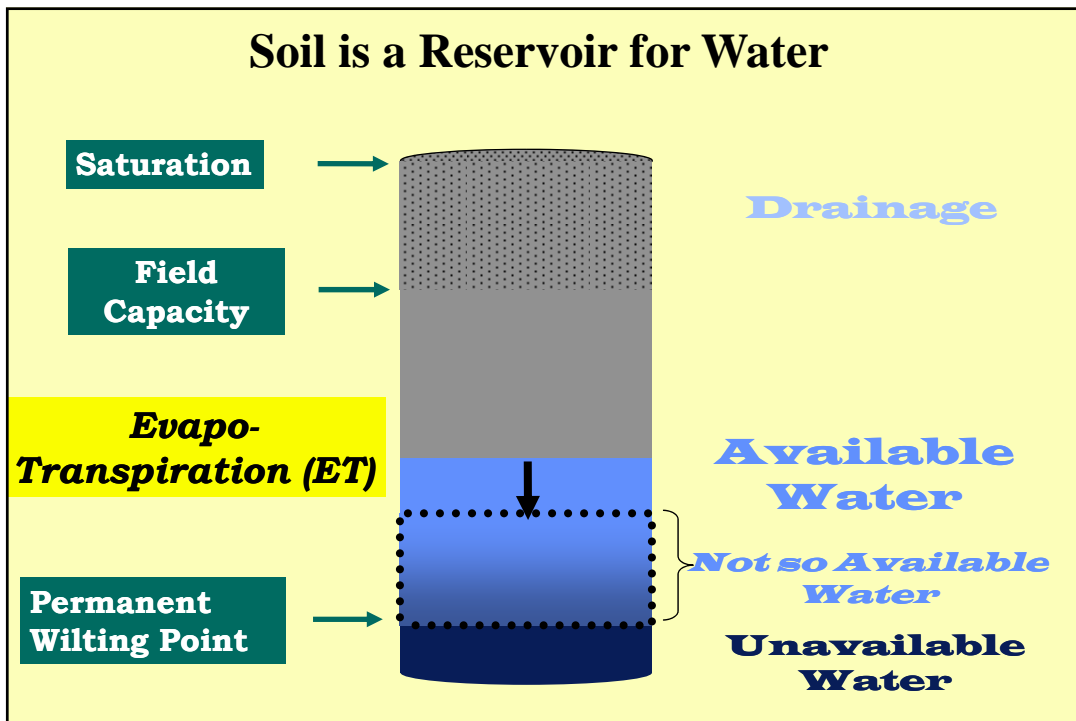
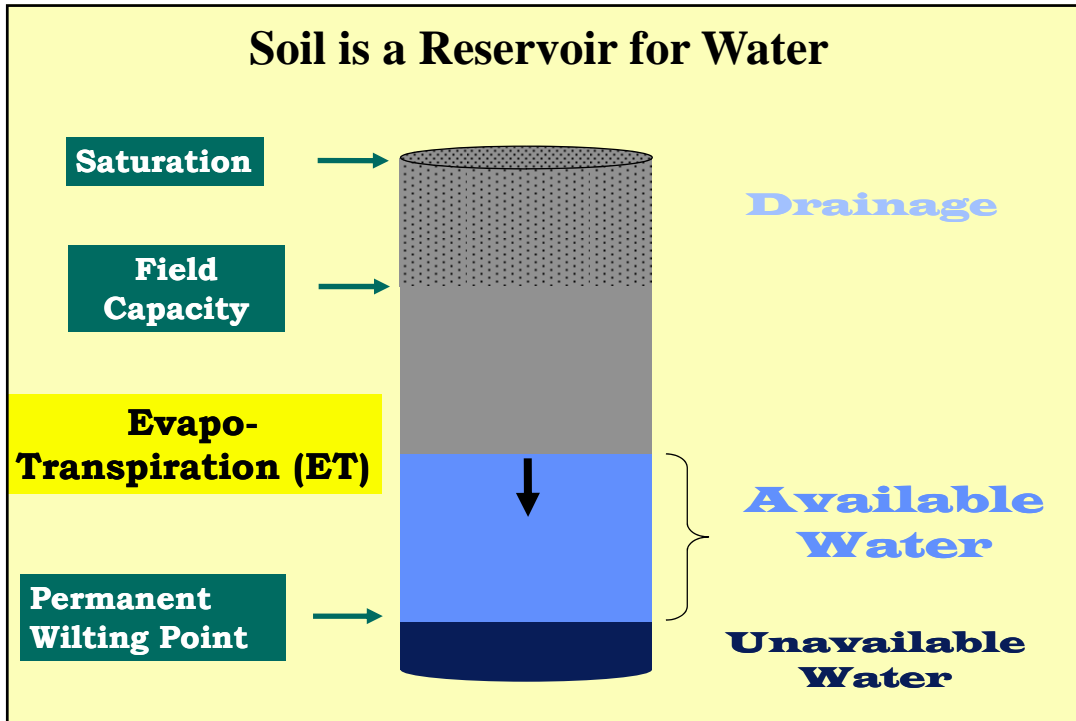
Estimate *evaporative demand* to determine how much water to apply.

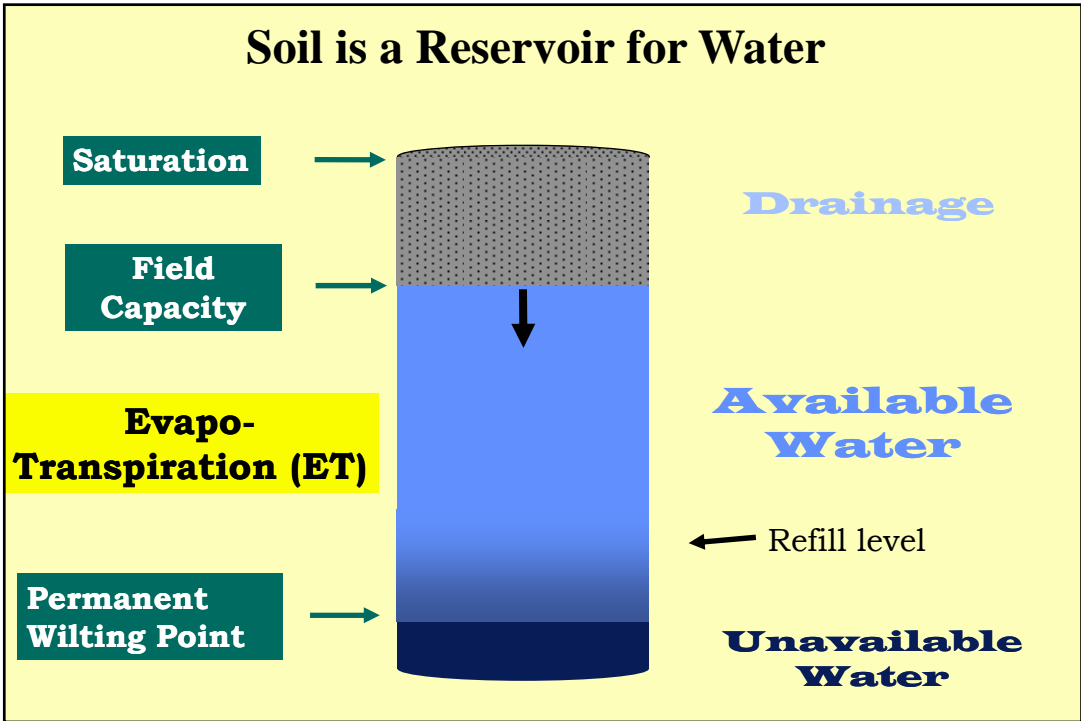
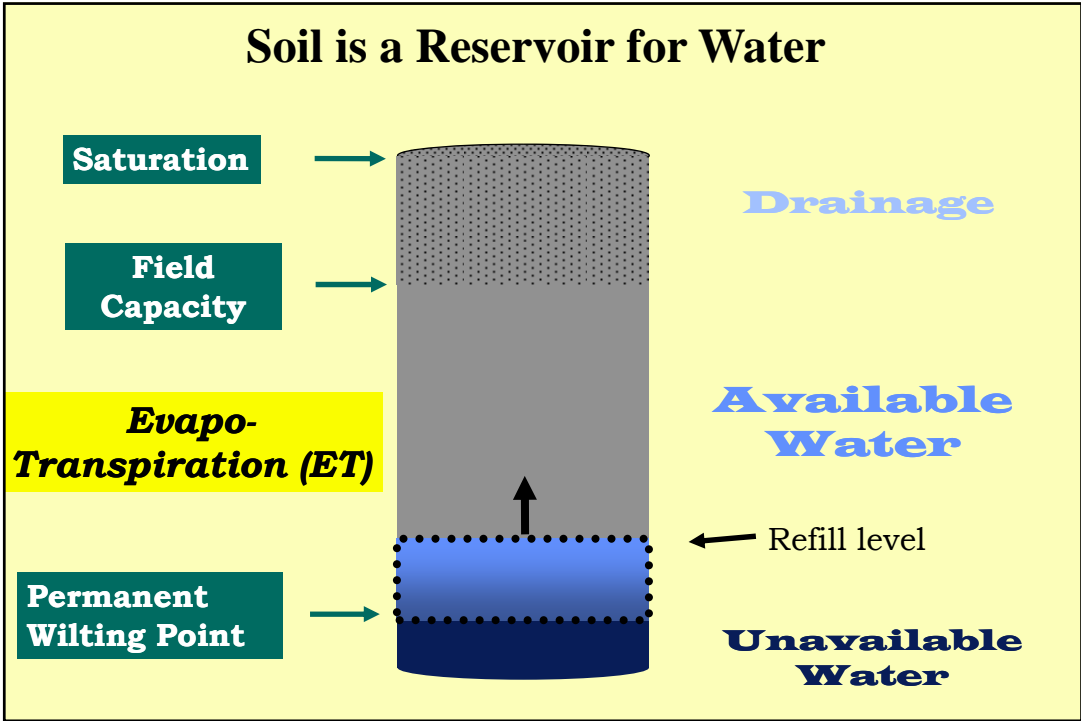
Track plant water stress and/or soil water disappearance to learn how vines respond to each of your subsequent applications.



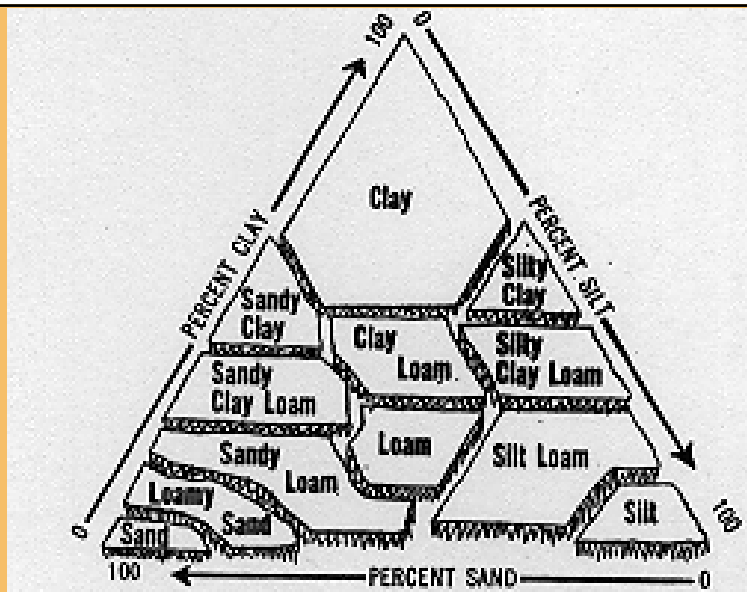








# Soil Textural Classes



1. The texture triangle shows the percentage of sand, silt, and clay in each of the textural classes.

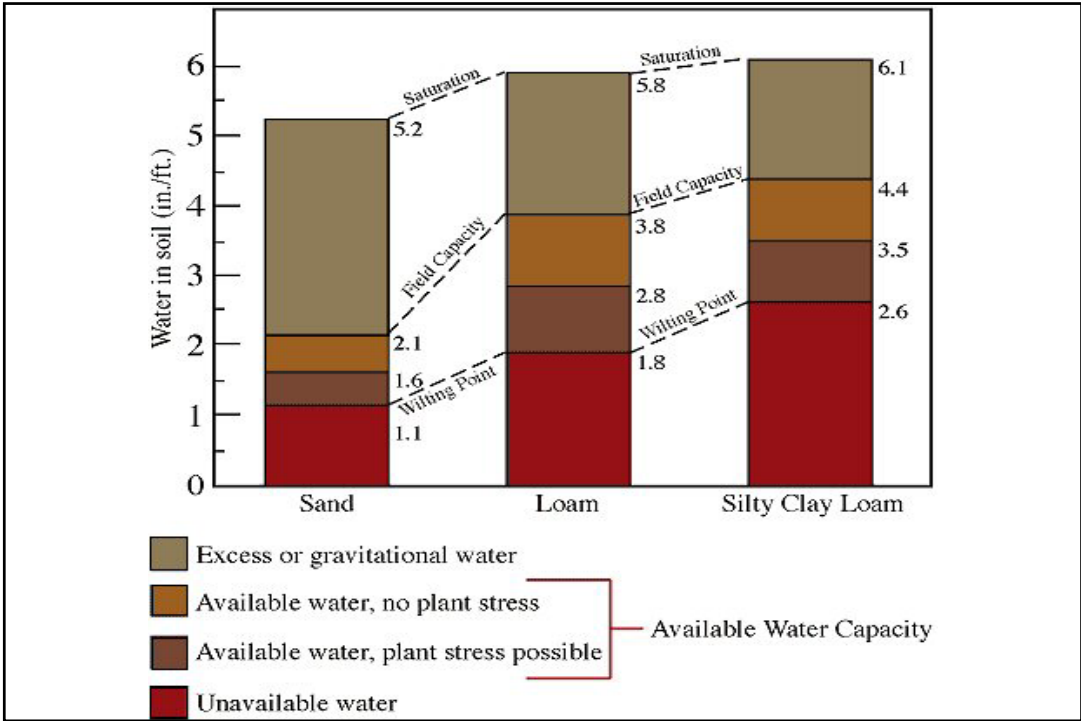
## Units of water: “acre-inch” and “acre-foot”



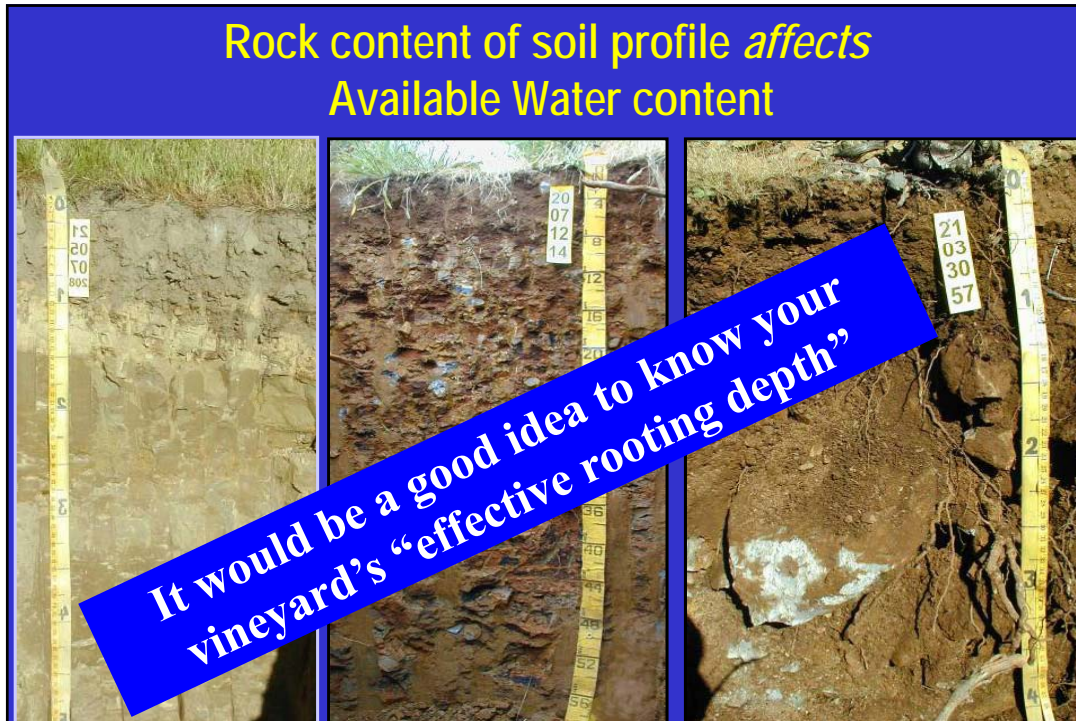
1 acre-inch of water = 27,154 gallons of water



12-inches of water over 1 acre of land = 325,848 gallons of water







## Available Water for Various Soil Types

	Acre-inches/ foot of soil
<b>Coarse textured sandy loams</b>	<b>1.00</b>
<b>Medium textured loams</b>	<b>1.50</b>
<b>Fine textured clay soils</b>	<b>2.00</b>

1 acre-inch = 27,154 gallons

## Vineyard 1: Yolo Clay Loam

- 3-foot effective rooting depth
- Available water is 2.0 inches per foot
- Vines spaced 8' x 12' = 454 vines per acre

**6 acre-inches available water = ~163,000 gallons**  
**359 gallons available water per vine**

1 acre-inch = 27,154 gallons

## Vineyard 2: course rocky shale

- 2.5-foot effective rooting depth
- Available water is 1.0 inch per foot
- Vines spaced 5' x 10' = 871 vines per acre

**2.5 acre-inches available water = ~68,000 gallons**  
**78 gallons available water per vine**

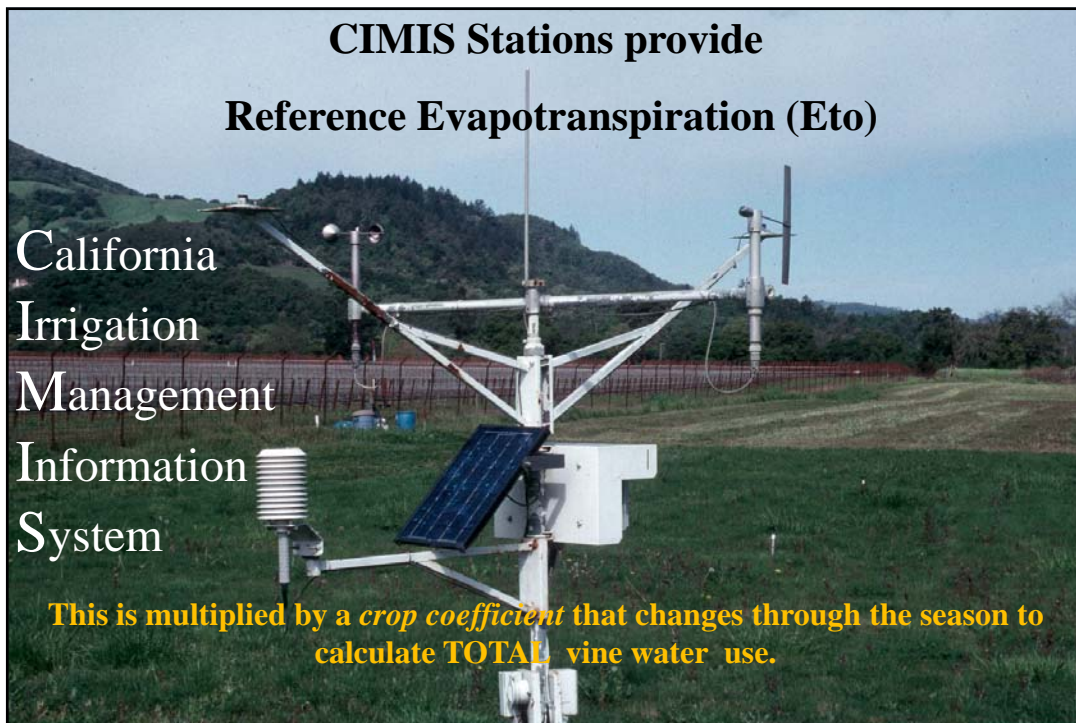
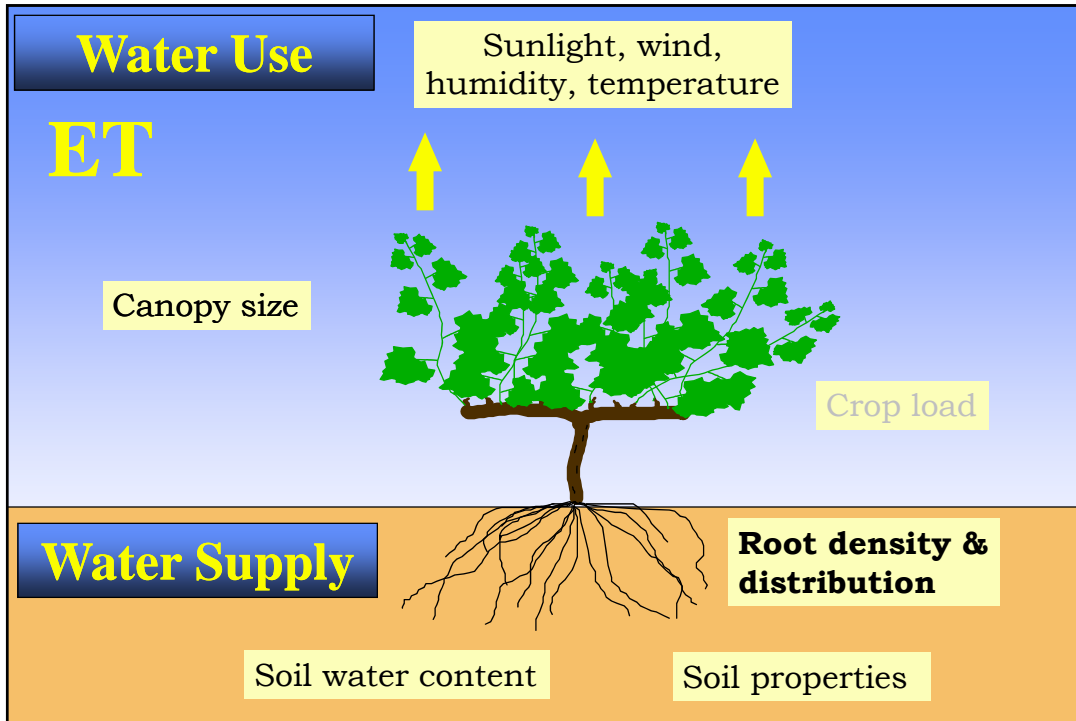
1 acre-inch = 27,154 gallons

## Assessing Water Needs

- Soil-based monitoring
- Plant-based monitoring
- Climate monitoring

## Factors affecting vineyard water use (per land area).

- Evaporative demand ( $ET_o$ )
- Seasonal growth of the vine
- Ultimate canopy size (trellis type)
- Spacing between rows
- Amount of water in the soil profile
- Presence of a cover crop



**CIMIS** stations provide *reference evapotranspiration* (**ET<sub>o</sub>**) which is ET of **grass**.

To determine a crop's ET, you must multiply the reference ET by a "crop coefficient" (**k<sub>c</sub>**). The result is **E<sub>c</sub>** which is ET of the crop.

Vineyard water use will change over the season as canopy expands, therefore **k<sub>c</sub>** changes up until the shoots stop growing.

K<sub>c</sub> is affected by:

Seasonal growth

Canopy size (trellis)

Row Spacing



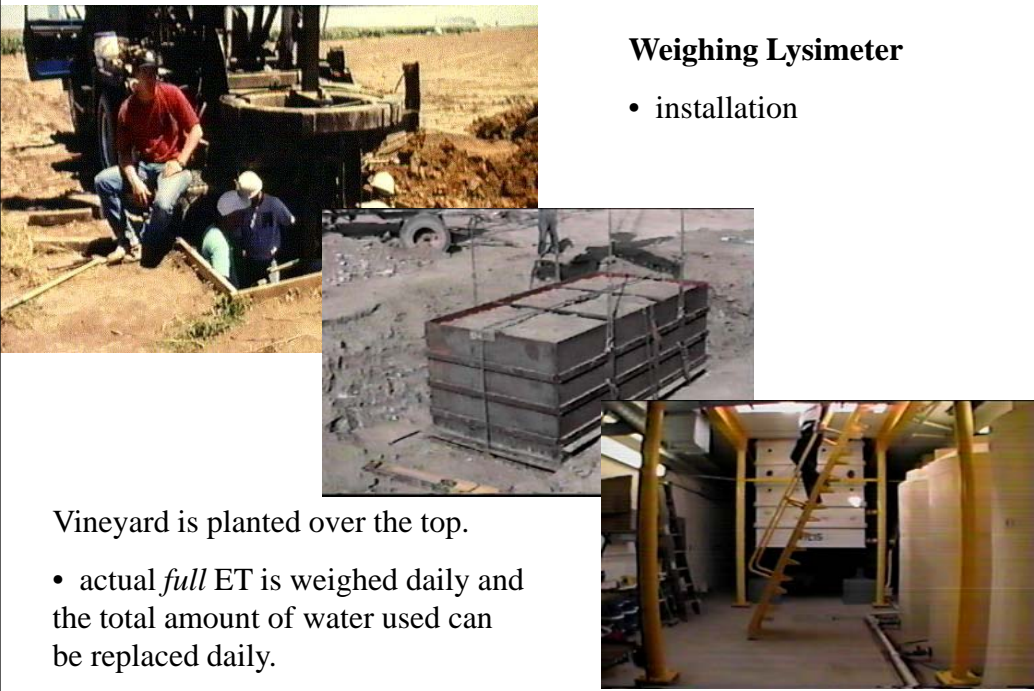


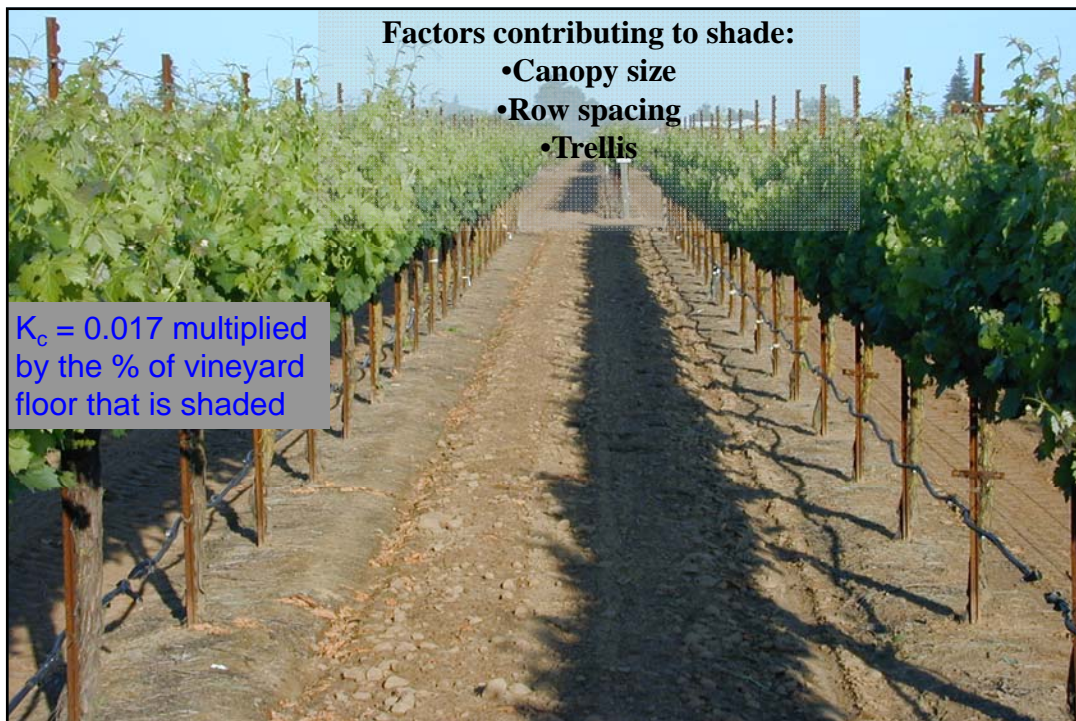
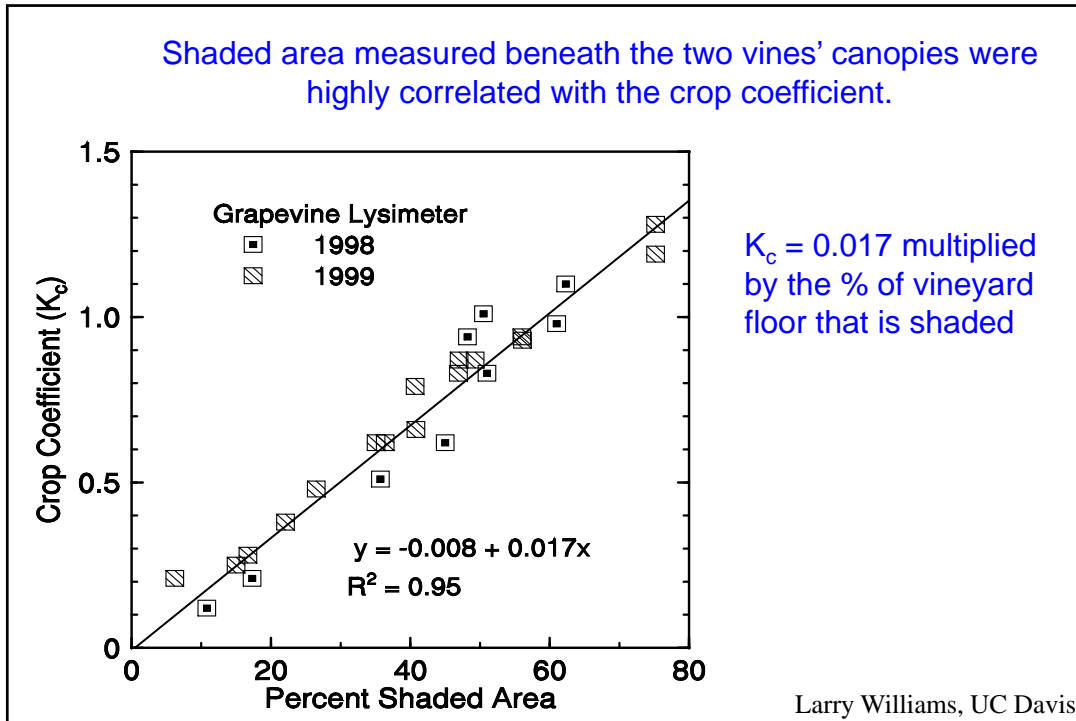
**Weighing Lysimeter**

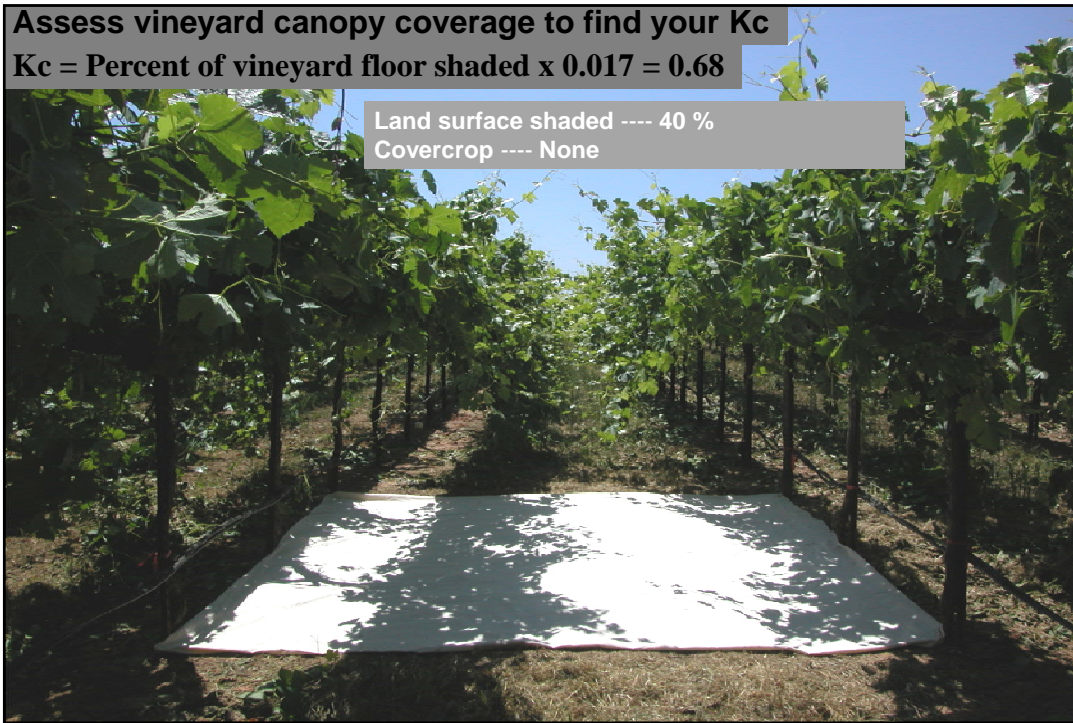
- installation

Vineyard is planted over the top.

- actual *full* ET is weighed daily and the total amount of water used can be replaced daily.







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### Crop Coefficients - Paso Panel

**Using the *Paso Panel* to quickly measure the canopy shaded area and estimate vineyard irrigation crop coefficients**

Introduction

The *Paso Panel* is a simple device which is used to measure the midday canopy shaded area of trellised grapevines. This measurement is of interest because it can be used to calculate the irrigation crop coefficient (Kc). The midday canopy shaded area can also be useful as a quick non-destructive measure of general vine vegetative growth, for example in evaluating the relative growth due to different fertilizer treatments or rootstocks.



### Kc values by row spacing and trellis type

Degree days from bud break

Row spacing

Vertically shoot positioned

Lyre

Sprawl

DD	4	5	6	7	8	9	10	11	12	10	12	10	11	12
0	0.19	0.15	0.13	0.11	0.10	0.09	0.08	0.07	0.06	0.10	0.09	0.12	0.11	0.10
180.00	0.25	0.20	0.17	0.14	0.13	0.11	0.10	0.09	0.08	0.18	0.15	0.21	0.19	0.18
360.00	0.33	0.26	0.22	0.19	0.16	0.15	0.13	0.12	0.11	0.29	0.25	0.34	0.31	0.28
540.00	0.42	0.33	0.28	0.24	0.21	0.18	0.17	0.15	0.14	0.43	0.36	0.49	0.44	0.41
720.00	0.51	0.41	0.34	0.29	0.26	0.23	0.21	0.19	0.17	0.57	0.48	0.63	0.57	0.52
900.00	0.62	0.50	0.41	0.35	0.31	0.28	0.25	0.23	0.21	0.69	0.57	0.74	0.67	0.61
1080.00	0.73	0.58	0.48	0.41	0.36	0.32	0.29	0.26	0.24	0.77	0.64	0.81	0.74	0.67
1260.00	0.83	0.66	0.55	0.47	0.41	0.37	0.33	0.30	0.28	0.81	0.68	0.85	0.77	0.71
1440.00	0.92	0.74	0.61	0.53	0.46	0.41	0.37	0.34	0.31	0.84	0.70	0.88	0.80	0.73
1620.00	1.00	0.80	0.67	0.57	0.50	0.45	0.40	0.36	0.33	0.85	0.71	0.89	0.81	0.74
1800.00	1.07	0.86	0.71	0.61	0.54	0.48	0.43	0.39	0.36	0.86	0.72	0.89	0.81	0.75
1980.00	1.13	0.90	0.75	0.64	0.56	0.50	0.45	0.41	0.38	0.86	0.72	0.90	0.82	0.75
2160.00	1.17	0.93	0.78	0.67	0.58	0.52	0.47	0.42	0.39	0.87	0.72	0.90	0.82	0.75
2340.00	1.20	0.96	0.80	0.69	0.60	0.53	0.48	0.44	0.40	0.87	0.72	0.90	0.82	0.75
2520.00	1.23	0.98	0.82	0.70	0.61	0.54	0.49	0.45	0.41	0.87	0.72	0.90	0.82	0.75
2700.00	1.24	0.99	0.83	0.71	0.62	0.55	0.50	0.45	0.41	0.87	0.72	0.90	0.82	0.75

Veraison

Adapted by Larry Williams, from Tables in  
 "Modeling Grapevine Water Use" by Larry E. Williams  
<http://avf.org/assets/files/articles/87e125d35d5ac0e189659f23da49eee0cd4ea4.pdf>

Et<sub>o</sub> - Reference evapotranspiration

Et<sub>c</sub> - Crop evapotranspiration

K<sub>c</sub> - Crop coefficient (0.2-0.8)

$$Et_c = Et_o \times K_c = \text{full potential water use}$$

**Example:**

- 1.) Vine and row spacing = 6 x 8 ft. (48 ft<sup>2</sup>)
- 2.) Measured shaded area = 12 ft<sup>2</sup>
- 3.) % shaded area =  $12/48 = 0.25 \times 100 = 25$
- 4.) % shaded area x 0.017 =  $K_c$   
 $25 \times 0.017 = 0.425$
- 5.) Assume  $ET_o = 1.2$  inches (~17,500 gal/acre inch)
- 6.)  $ET_o \times K_c = ET_c$
- 7.)  $1.2 \times 0.425 = 0.612$  inches = 16,830 gal/acre
- 8.)  $16,830 \text{ gal}/907 \text{ vines acre}^{-1} = 18.6 \text{ gal/vine}$

From: Larry Williams, Department of Viticulture and Enology, UC Davis and Kearney Research and Extension Center

**The vineyard is using:  
*full* ET vine =  $ET_o \times kc$**

**But how much will you supply?**

**$ET_o \times kc \times \underline{\% \text{ deficit}}$**

## Regulated Deficit Irrigation

The amount of water that is applied is only a percent of full  
Etc.

Irrigating to a 40% RDI means less water is applied than if you irrigated using a 60% RDI

Applied water volume =  $E_{To} \times K_c \times$  "management factor"

## Management factor considerations

- Bud break through set: 70-80% during grand period of growth (if and when you decide you need to apply water)\*
- Set through veraison: 60% down to 35% depending on variety, winery, brand, etc.
- Veraison through harvest: increase % as needed
- Avoid imposing more stress in locations that stress by default.
- Don't stress young vines

\*Be careful - you must support what you "build"!

## Carneros Chardonnay Water Use Starting with young vines in 1991

Year	ET <sub>o</sub> (inches)	ET <sub>c</sub> (inches)	ET <sub>c</sub> (gal/vine)
1991	39	6.9	150
1992	39	9.3	202
1993	39	12.1	271
1994	40	18.1	396
1995	40	18.6	405
1996	39	19.5	425

from Larry Williams

## Weekly or Daily Eto from CIMIS

CIMIS (California Irrigation Management Information System)

**Daily Report**

Rendered in English Units.  
July 1, 2013 - July 7, 2013  
Printed on April 28, 2014

Camino - Sierra Foothill - Station 13

Date	CIMIS ETo (in)	Precip (in)	Sol Rad (Ly/day)	Avg Vap (in/Bars)	Max Air Temp (°F)	Min Air Temp (°F)	Avg Air Temp (°F)	Max Rel Hum (%)	Min Rel Hum (%)	Avg Rel Hum (%)	Dew Pt (°F)	Avg wSpd (MPH)	Wind Run (miles)	Avg Soil Temp (°F)
07/01/2013	0.32	0.00	677	14.1	98.5	74.1	86.0	48	19	33	53.7	5.4	129.4	67.5
07/02/2013	0.32	0.00	652	14.9	97.2	75.8	86.3	50	27	35	55.2	5.4	131.0	68.1
07/03/2013	0.31	0.00	673	15.0	90.8	73.9	85.9	50	20	37	56.3	4.7	114.2	68.8
07/04/2013	0.31	0.00	691	15.2	90.5	74.0	85.5	51	21	30	55.9	0.0	144.2	69.3
07/05/2013	0.31	0.00	718	11.5	87.3	66.1	77.8	58	23	35	48.3	6.2	180.1	69.4
07/06/2013	0.29	0.00	713	11.0	86.3	62.3	74.8	52	26	38	47.2	8.4	130.9	68.7
07/07/2013	0.31	0.00	706	9.5	88.6	63.4	76.6	51	20	30	43.2	8.8	140.6	68.3
<b>Total/Avg:</b>	<b>2.17</b>	<b>0.00</b>	<b>686</b>	<b>13.1</b>	<b>93.0</b>	<b>69.9</b>	<b>81.6</b>	<b>53</b>	<b>25</b>	<b>35</b>	<b>51.4</b>	<b>5.6</b>	<b>134.3</b>	<b>68.6</b>

Flag Legend		
A - Historical Average	I - Ignore	R - Far out of normal range
C or N - Not Collected	M - Missing Data	S - Not in service
H - Hourly Missing or Flagged Data	Q - Related Sensor Missing	Y - Moderately out of range
Conversion Factors		
Ly/day/2.065 = W/sq.m	inches * 25.4 = mm	(F-32) * 5/9 = c
mph * 0.447 = m/s	mBars * 0.1 = kPa	--

# Long Term monthly Eto from CIMIS Camino station (in acre-inches)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1.41	1.88	2.99	4.47	5.91	7.46	9	8.21	6.23	4.19	1.84	1.37	54.96

**UC IPM Online**  
Statewide Integrated Pest Management Program

**How to Manage Pests**  
**California Weather Database: Set Dates and Variables**

Retrieve daily data for CAMINO.A (CIMIS #13, Camino)

Country: U.S. Districts  
Latitude/Longitude: 35 deg 43 min N / 120 deg 44 min W Elevation: 2750 ft  
IPM records begin/end: October 15, 1962 / ongoing Ground cover: Irrigated grass

1. Select a time period  
From: July 1 1999  
Through: October 31 2013

2. Select variables and backup stations

Select variables to retrieve	Actual data from station	Recommendations to fill in data gaps or supply "forecast"		
		Backup station 1	Backup station 2	Long-term averages from
<input checked="" type="checkbox"/> Precipitation	CAMINO.A	PLCKVILLE.C	PLACKROSE.C	PLCKVILLE.C
<input checked="" type="checkbox"/> Air Temperature, max & min	CAMINO.A	PLCKVILLE.C	PLACKROSE.C	CAMINO.A
<input checked="" type="checkbox"/> Soil Temperature, max & min	CAMINO.A	None recommended	None recommended	CAMINO.A
<input checked="" type="checkbox"/> Wind Direction & Speed	CAMINO.A	None recommended	None recommended	None recommended
<input checked="" type="checkbox"/> Relative Humidity, max & min	CAMINO.A	None recommended	None recommended	None recommended
<input checked="" type="checkbox"/> Reference Evapotranspiration	CAMINO.A	None recommended	None recommended	None recommended
<input checked="" type="checkbox"/> Solar radiation	CAMINO.A	None recommended	None recommended	CAMINO.A

3. Select units and output file format

Output Units:  English  Metric

Output File Format:  formatted report (for viewing or printing)  UC IPM data file format (for use with DDG)  Comma-delimited data file (for use with spreadsheets)

4. RETRIEVE DATA

Measurement details about CAMINO.A variables  
Air temperature: Daily max/min measured at 1.5 m (4.92 ft).  
Precipitation: Daily total measured in a 20 cm (8 in) diameter gauge.  
Soil temperature: Daily max/min measured at a 10 cm (4 in) depth.  
Humidity: Daily max/min relative humidity measured at 1.5 m (4.92 ft).  
Evapotranspiration: Calculated from CIMIS hourly values.  
Solar radiation: Daily global radiation measured by solar pyranometer at 2 m (6.5 ft).  
Wind speed & direction: Daily average measured at 2 m (6.5 ft).  
Comments: Located in the northwest corner of a cooler seeding field, south of several utility buildings.

The screenshot displays the UC IPM Online interface for the 'California Weather Data: Report' at station CAMINO.A. The page features a navigation menu on the left and a main content area with a search bar and a table of weather data. The data table includes columns for DATE, TIME, WIND DIR, WIND SPD, REL HGT, and various weather parameters like WIND DIR, WIND SPD, REL HGT, etc.

## Determining the Volume of Water to Apply

- Use HISTORICAL ET<sub>0</sub> to calculate predicted hours to irrigate for a selected period of time.
- Immediately after the period of time has passed, use REAL TIME ET<sub>0</sub> to determine the actual hours of irrigation.
- Adjust the hours of irrigation for the following period of time.

**ET<sub>o</sub> X K<sub>c</sub> =  
FULL POTENTIAL VINE WATER USE (Etc)**

Assumptions				
1. Leaf Water Potential trigger was reached July 1.				
2. Harvest Date was October 1.				
Date	A = Historical Eto	B = Crop Coefficient <sup>b</sup>	C = A x B: Potential Water Use	D = RDI coefficient
Period	Inches/Period	Kc	(in)	Kr <sub>di</sub>
July 1-7				
July 8-14				
July 15-21				
July 22-28				
July 29 to August 4				
August 5-11				

**Full Potential Water Use x RDI**

Assumptions				
1. Leaf Water Potential trigger was reached July 1.				
2. Harvest Date was October 1.				
Date	A = Historical Eto	B = Crop Coefficient <sup>b</sup>	C = A x B: Potential Water Use	D = RDI coefficient
Period	Inches/Period	Kc	(in)	Kr <sub>di</sub>
July 1-7				
July 8-14				
July 15-21				
July 22-28				
July 29 to August 4				
August 5-11				

## Determine Regulated Deficit % (RDI %)

- RDI % experiences:
  - 60% is conservative
  - 35% is risky
- Full Potential Water Use (ET<sub>c</sub>) X RDI%

## Scheduling Inputs

- E<sub>To</sub> (Reference ET)
- K<sub>c</sub> (Crop Coefficient)
- E<sub>Tc</sub> (Full Potential Vine Water Use)
- RDI% (Net Water Volume Needed)
- Soil water contribution between the start of the irrigation season and harvest
- In-season effective rainfall
- Emission Uniformity
- Application rate of drippers



<b>E = Soil Contribution</b>	<b>F = Effective Rainfall<sup>c</sup></b>	<b>G = [(C x D) - E - F]: Net Irrigation Requirement</b>	<b>H = Emission Uniformity<sup>d</sup></b>	<b>I = G/H:Gross Irrigation Amount</b>
(in)	(in)	(in)	(%)	(in)

$E \times RDI\% \text{ minus soil water contribution minus effective rainfall} = \text{NET IRRIGATION REQUIREMENT}$

<b>E = Soil Contribution</b>	<b>F = Effective Rainfall<sup>c</sup></b>	<b>G = [(C x D) - E - F]: Net Irrigation Requirement</b>	<b>H = Emission Uniformity<sup>d</sup></b>	<b>I = G/H:Gross Irrigation Amount</b>
(in)	(in)	(in)	(%)	(in)

<b>G =</b> <b>[(C x D) - E - F]:</b> <b>Net Irrigation Requirement</b>	<b>H =</b> <b>Emission Uniformity<sup>d</sup></b>	<b>I =</b> <b>G/H:Gross Irrigation Amount</b>	<b>J =</b> <b>Vine Spacing</b>	<b>K =</b> <b>(I x J x .623):</b> <b>Gallons per Vine/ Period</b>	<b>L =</b> <b>Average Application Rate</b>	<b>M =</b> <b>(K/L):</b> <b>Hours of PREDICTED Irrigation Time</b>
(in)	(%)	(in)	(sq feet)	(gal/week)	(gph/vine)	(hours)

<b>G =</b> <b>[(C x D) - E - F]:</b> <b>Net Irrigation Requirement</b>	<b>H =</b> <b>Emission Uniformity<sup>d</sup></b>	<b>I =</b> <b>G/H:Gross Irrigation Amount</b>	<b>J =</b> <b>Vine Spacing</b>	<b>K =</b> <b>(I x J x .623):</b> <b>Gallons per Vine/ Period</b>	<b>L =</b> <b>Average Application Rate</b>	<b>M =</b> <b>(K/L):</b> <b>Hours of PREDICTED Irrigation Time</b>
(in)	(%)	(in)	(sq feet)	(gal/week)	(gph/vine)	(hours)
	92		48		0.96	

	<b>M = (K/L): Hours of PREDICTED Irrigation Time</b>	<b>Must be entered by hand (should be column R same week.): Hours of ACTUAL Irrigation Time</b>	<b>Linked from 'real time Eto' sheet: Hours of irrigation based on REAL TIME Eto</b>	<b>columns O-P previous week. Net diff of ACTUAL and REAL TIME hours PREVIOUS WK</b>	<b>columns N-Q same week. Actual Hours of irrigation after previous week's adjustment</b>
	(hours)	(hours)	(hours)	(hours)	(hours)
	8.1	8.1	7.2		
	7.3	6.4	9.2	0.9	6.4
	6.2	9.0	9.0	-2.8	9.0
	5.9	6.0	5.6	0.0	6.0
	6.3	5.9	6.1	0.4	5.9
	5.5	5.7	5.9	-0.2	5.7
	5.8	0.0	8.5	-0.2	6.0
	5.1	13.6	8.0	-8.5	13.6
	4.5	4.5		5.6	-1.1

1 Sonoma County Cooperative Extension  
2 Vineyard Irrigation Scheduling Worksheet Version 1.2, January 2009  
3 Complete Fields Shaded in Blue Press TAB key to move between cells

Developed By: Rhonda Smith, Viticulture Farm Advisor, Sonoma County Cooperative Extension  
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Larry Schwankl, Irrigation Specialist, UC Davis and Kearney Agricultural Center  
John Vase, Senior Agricultural Program Assistant, Sonoma County Cooperative Extension

Vine Spacing (feet) \_\_\_\_\_ Emitters per Vine \_\_\_\_\_  
Vine / Acre \_\_\_\_\_ Emitter Discharge (gph) \_\_\_\_\_  
Estimated soil moisture contribution from root zone between irrigation start & \_\_\_\_\_ inches  
Soil moisture contribution from the root zone of the soil profile is the water volume present at the first irrigation minus the water volume at harvest  
The soil moisture contribution from the root zone for this time period ranges from 2" to 5" for deep loamy soils to 1" for shallow rocky or sandy

Start of First Irrigation Interval  
Month \_\_\_\_\_ Day \_\_\_\_\_  
Estimated Harvest  
Month \_\_\_\_\_ Day \_\_\_\_\_

Emission Uniformity: \_\_\_\_\_ %  
Emission Uniformity is a function of differences in emitter discharge throughout an irrigation block. It can be calculated as the average discharge of all emitters divided by the average discharge of the 25% lowest flowing emitters. A Microsoft Excel worksheet is available from UCCE, Sonoma to determine emission uniformity.

Emission Uniformity Criteria:  
Excellent Greater than 90%  
Good 80% - 90%  
Fair 70% - 80%

Select Nearest CIMES Station  
Widener CIMES Station #1037 p p vq 2004-2008

**Drop down menu of historical Eto data from CIMIS**

Irrigation Interval Date Range				Historical Average Eto	Previous Irrigation Interval Actual Eto From CIMIS or UC IPM Website	Shaded Ground At Soaker Mass	Crop Coefficient (Kc)	Net Potential Water Use (Eto)	Regulated Deficit Irrigation Percentage (Eto)	Total Risked Deficit Irrigation Interval	Deficit Irrigation Requirement	Predicted Actual Gallons / Vine	Predicted Irrigation Hours (from historical Eto)	Actual Hours Applied	Actual Irrigation Requirement (from correct gross Eto)	Difference between Actual Irrigation Requirement and Actual Hours Applied Previous Week	Adjusted hours to apply based on history of Eto in correct week and compensated hours								
From Month	From Day	To Month	To Day	Inches	Inches	%	Inches	%	Inches	Inches	Inches	Gallons	Hours	Hours	Hours	Hours to Compensate	Hours								
0	0																								
Total:													0.00	0.00		0.00	0.00	0.00	0.0				Actual	Predicted	Corrected
													Cumulative Gallons per vine =	0.0	1.0	1.0									
													Cumulative Hours of Irrigation =	0.0	0.0	0.0									
													Cumulative Inches of water =	0.00	0.00	0.00									

This worksheet is online on two UC Cooperative Extension county websites. See next slides for instructions and addresses.

## Online Irrigation Scheduling Worksheets - important stuff -

- Remember that on each website, the worksheets automatically access historical Eto data from CIMIS stations that are in or near the UC Viticulture Farm Advisor's county. Those data are linked to the worksheets. You can choose which data set you wish to use by using the **drop down menu** (see previous slide).

Continued on next slide

## Online Irrigation Scheduling Worksheets (continued)

- The historical CIMIS data options on each county's worksheet were calculated for you by the farm advisors.
- To use more relevant CIMIS data:
  - Select the last option on the drop down menu "User entered Eto data".
  - Follow directions on Lynn Wunderlich's website to access a local CIMIS station and request Eto data for a particular week in 2013.
  - Back on the Scheduling worksheet, open the "Eto Data" tab at the bottom of the worksheet and enter your Eto values into the first column.

## Online Irrigation Scheduling Worksheets - web addresses -

- Sonoma County
  - [http://cesonoma.ucanr.edu/viticulture717/Vineyard\\_Irrigation/](http://cesonoma.ucanr.edu/viticulture717/Vineyard_Irrigation/)  
In the left menu, select “Excel irrigation scheduling worksheet” and scroll down to see links to the sheet.
- San Luis Obispo County
  - [http://cesanluisobispo.ucanr.edu/Viticulture/Water\\_and\\_soils/](http://cesanluisobispo.ucanr.edu/Viticulture/Water_and_soils/)  
Look at the section headings in the center of the page and find “Irrigation Scheduling Calculators”

Use plant *and/or* soil-based monitoring “tools” to determine when to apply water the first time.

Estimate *evaporative demand* to determine how much water to apply.

Track plant water stress and/or soil water disappearance to learn how vines respond to each of your subsequent applications.