Paul Vossen
University of California
Cooperative Extension
Farm Advisor

Dealing with Drought

Value of Water

- Yield
- Fruit Size
- Fruit Quality
- Cover Crop Mgmt.
- Erosion Control
- Frost Control
- Pest Mgmt.
- Nutrition Enhancement

Dry California Hillside

Irrigated Orchard

Dry farmed vs irrigated apples

10 to 20 tons/acre

30 to 60 tons/acre

May – new growth from a feathered tree planted 2 months earlier

2nd year's growth (15 months later)

Yield will be 5 tons per acre

Mission Impossible Without Water

Making it Less Bad

- Save as much soil moisture as possible
- Increase OM content of soil – over time
- Irrigate responsibly – don’t waste water
- Manage deficit irrigation – timing
- Prune appropriately
- Select & time crops that use less water
- Get plants to ‘at least’ survive

January 2014

January 2013

Low Reservoirs

How Bad Was It Here ?

2003 to 2013 - 10 year ave. or 'normal' in inches		2013-2014 rainfall % of 'normal'
Jan	5.24	18%
Feb	4.91	10%
Mar	4.41	45%
April	2.23	51%
May	1.49	0%
June	0.22	0%
July	0.01	0%
Aug	0.04	0%
Sept	0.00	0%
Oct	1.68	0%
Nov	2.95	1%
Dec	7.30	7%
Dec to Jan	30.47	17%

February *** 10-20 inches

Rainfall from Mother Nature

Rainfall 20 – 90" per year

Most of it runs off

Soil Water Holding Capacity

- **Clay = 2.0 to 2.5 inches per foot**
- **Loam = 1.5 to 2.0 inches per foot**
- **Sand = 1.0 to 1.5 inches per foot**

Soil Profiles

Most tree roots are in the top 2 feet = 4”

Deeper in Very Deep Soils

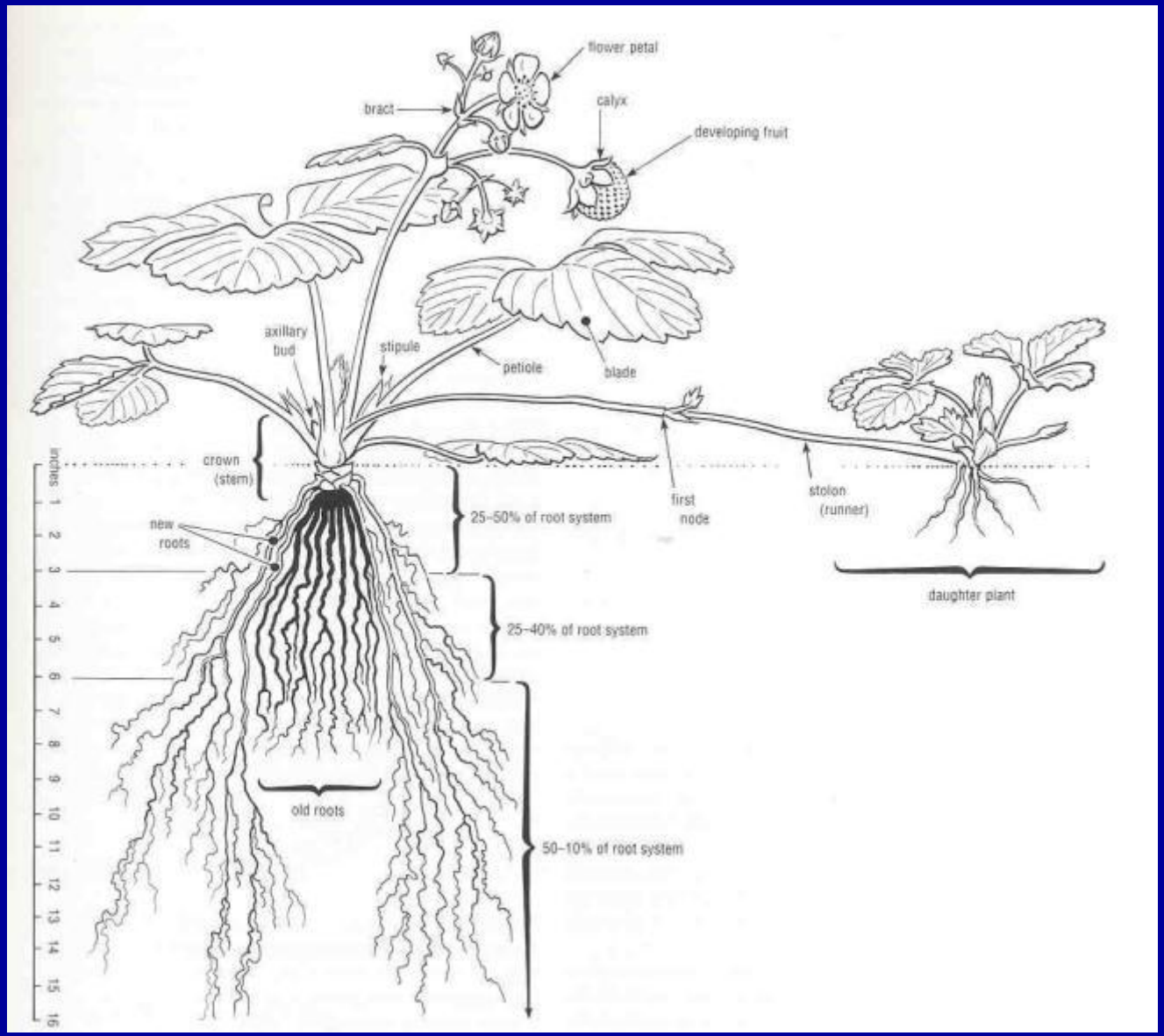
Holding 6-10” of water

Less in Shallow Soils

Holding only 2-3” of water


Sebastopol soil ~ 2 ft. deep
underlain by impervious clay

Soil – Root - Profiles



Vegies and Berries are in the top 1 foot = 2”

Soil Survey

Storie index: 0-100

Capability Unit

Soil Type

Soil Horizons

Rooting Depth

Water Holding Capacity

Site Selection

Investigative Tool

Preserving as much rainfall soil-stored moisture as possible

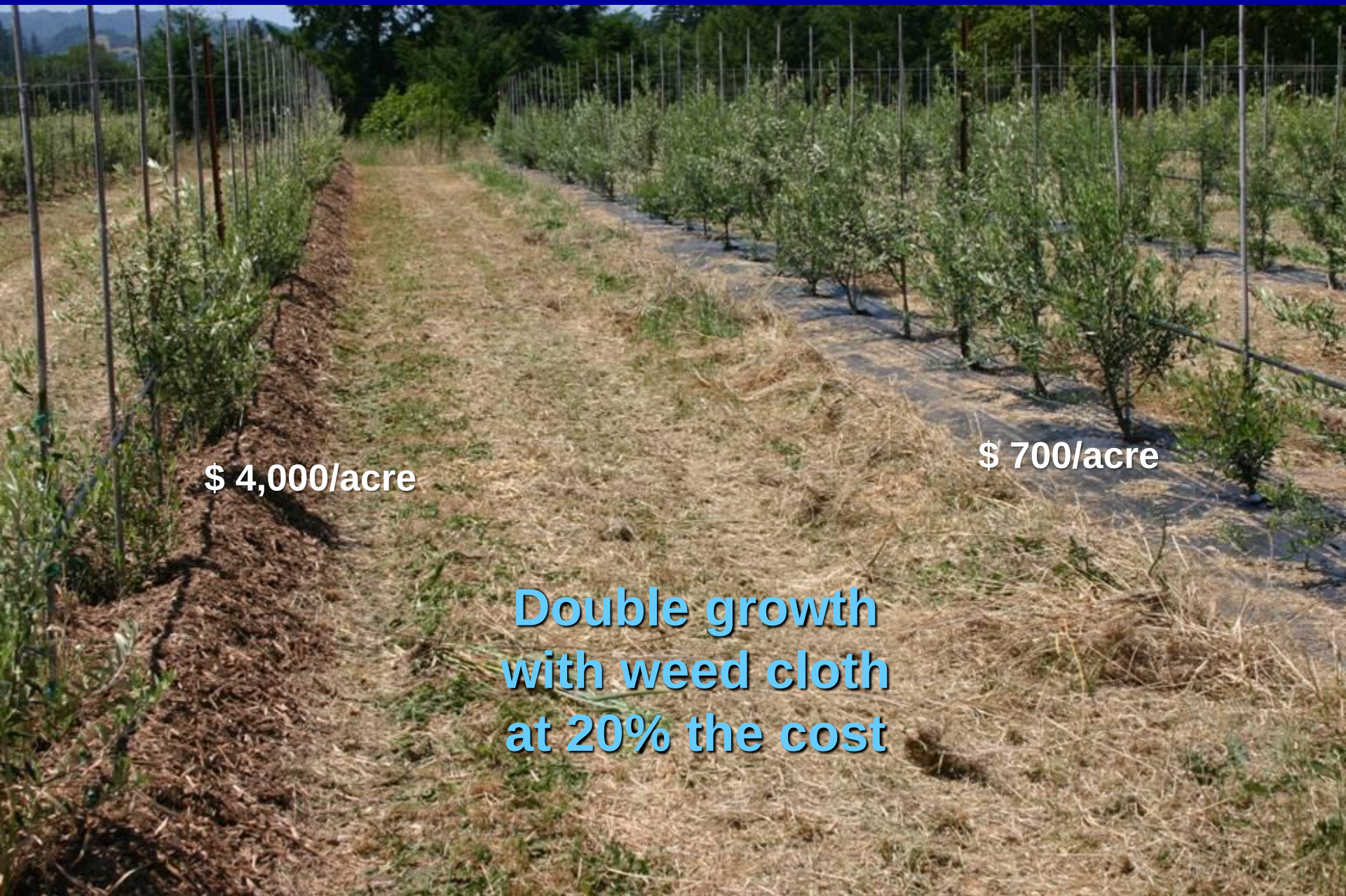
- No weeds
- No cover crop
- Mulch
- Herbicide
- Cultivate
- Add OM
- At least - keep weeds short

Cover crops use water

Organic wood chip mulch

Organic wood chip mulch expensive, biodegradable, & requires annual application

Wood chips – vs – weed cloth



Wall to wall if cost is no issue

100% Herbicide

Europe – *100% herbicide = less erosion than cultivation*

Clean Cultivation

Weeds can steal 2” water

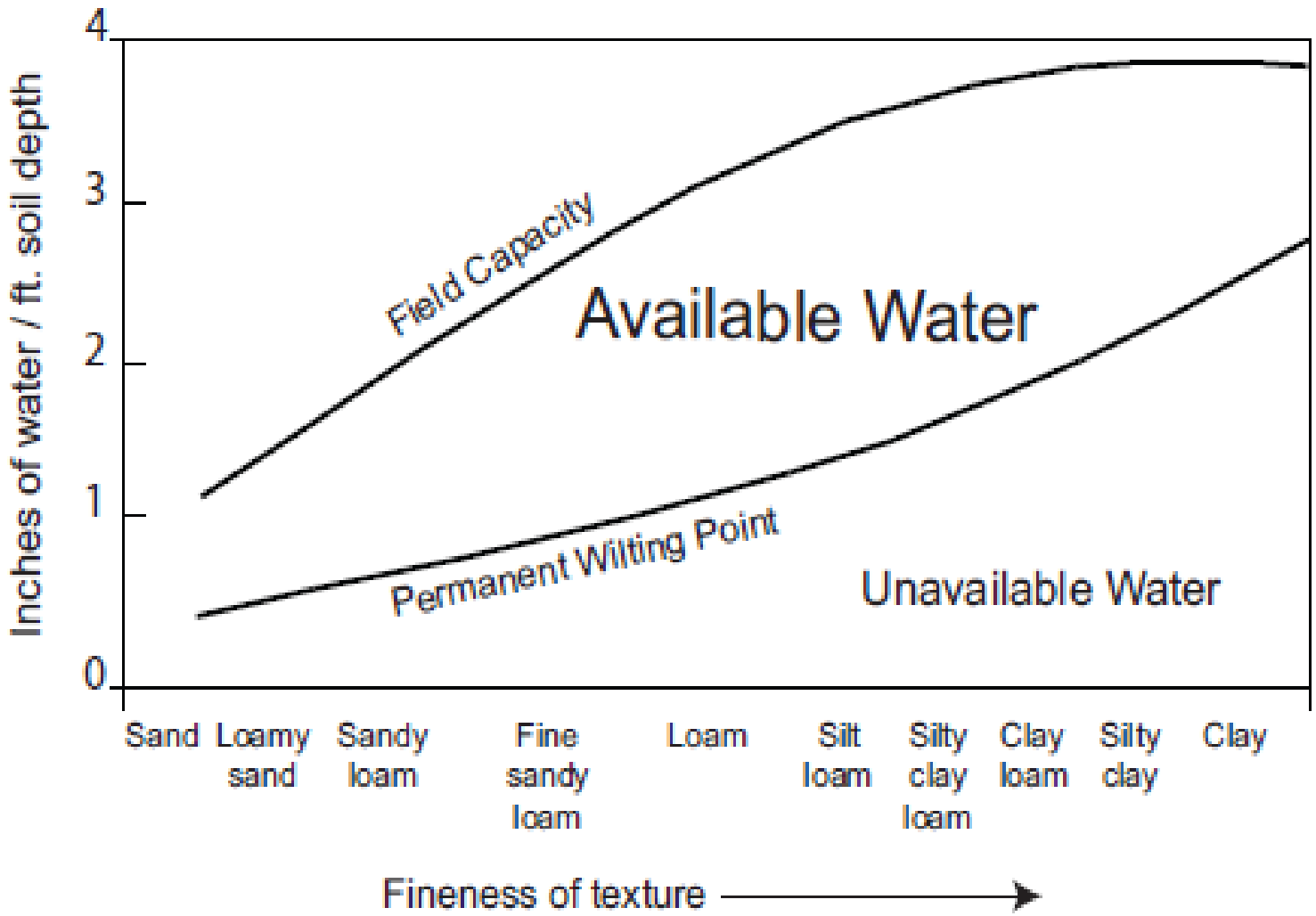


Figure 1. General relationship between soil moisture and texture. Ohio Agronomy Guide, 14th edition, Bulletin 472-05

Cultivation Increases Erosion Risk

Cultivation Reduces Organic Matter

Soil Quality Indicators

Increasing soil OM by 1% increases water holding capacity by about 0.03 ft^3. (0.23 gallons) per ft^3.

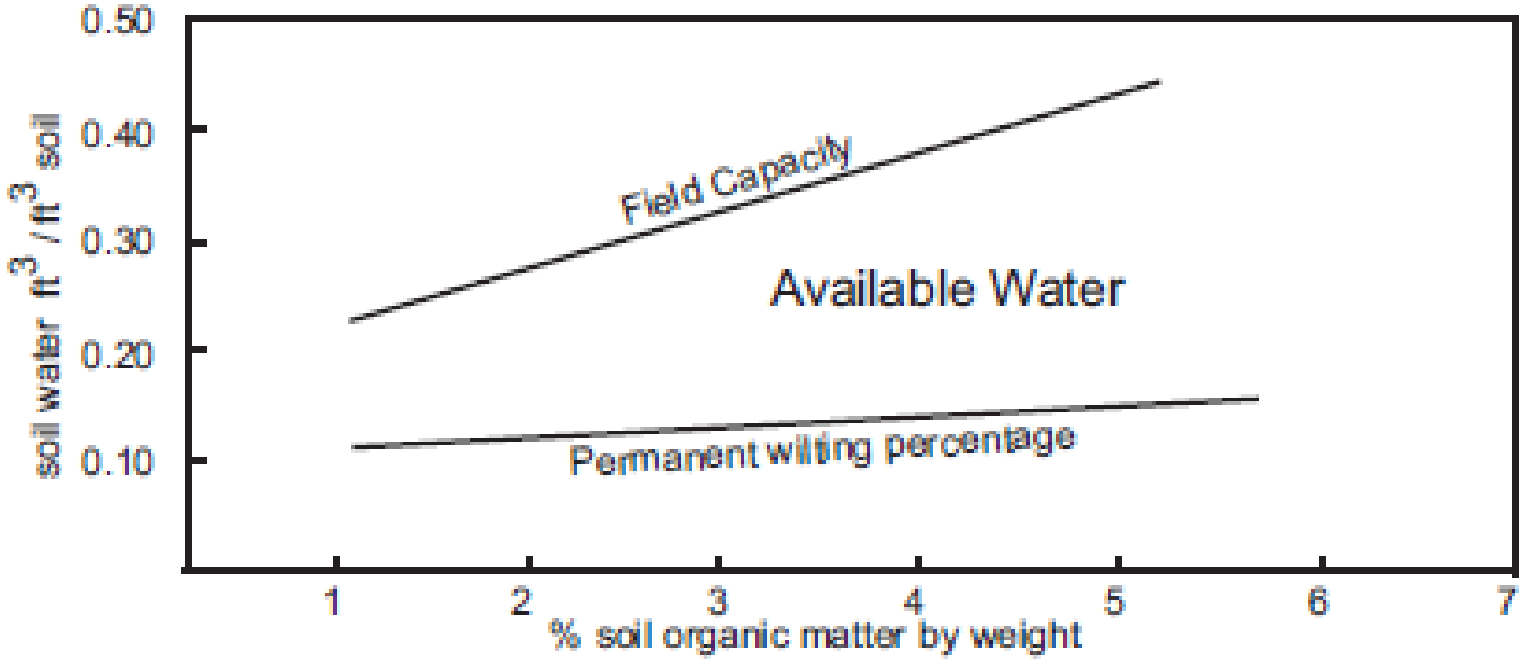


Figure 2. Effect of increasing organic matter on available water capacity of silt loam soils. Adapted from Hudson, SWCS, 1994.

Loam soil holds about 1 gallon of water per cubic foot

- Increasing OM by 1% would increase water holding capacity by about 25%
- ~ 10,000 gallons per acre = enough water to last about a week in springtime
- Adding 10 tons of compost per acre (1% of top 8” of soil) every year for many years may slightly increase soil OM

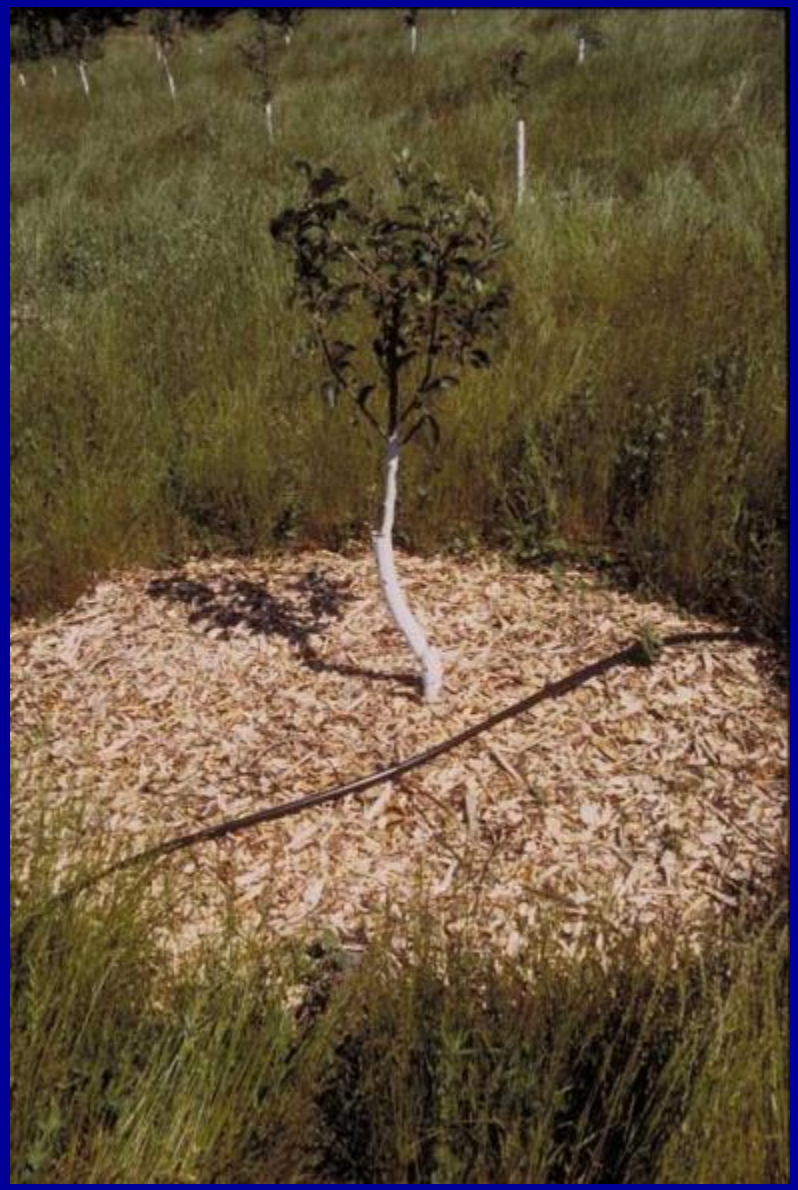
10 tons/acre

20 tons/acre

Applying 2 tons/acre compost

2 tons/acre compost

At least - no weeds near trees



Weed Control Comparisons

Burlap – cheap, biodegradable

Wonder weeder

Wonder weeder

Minimum – keep weeds short

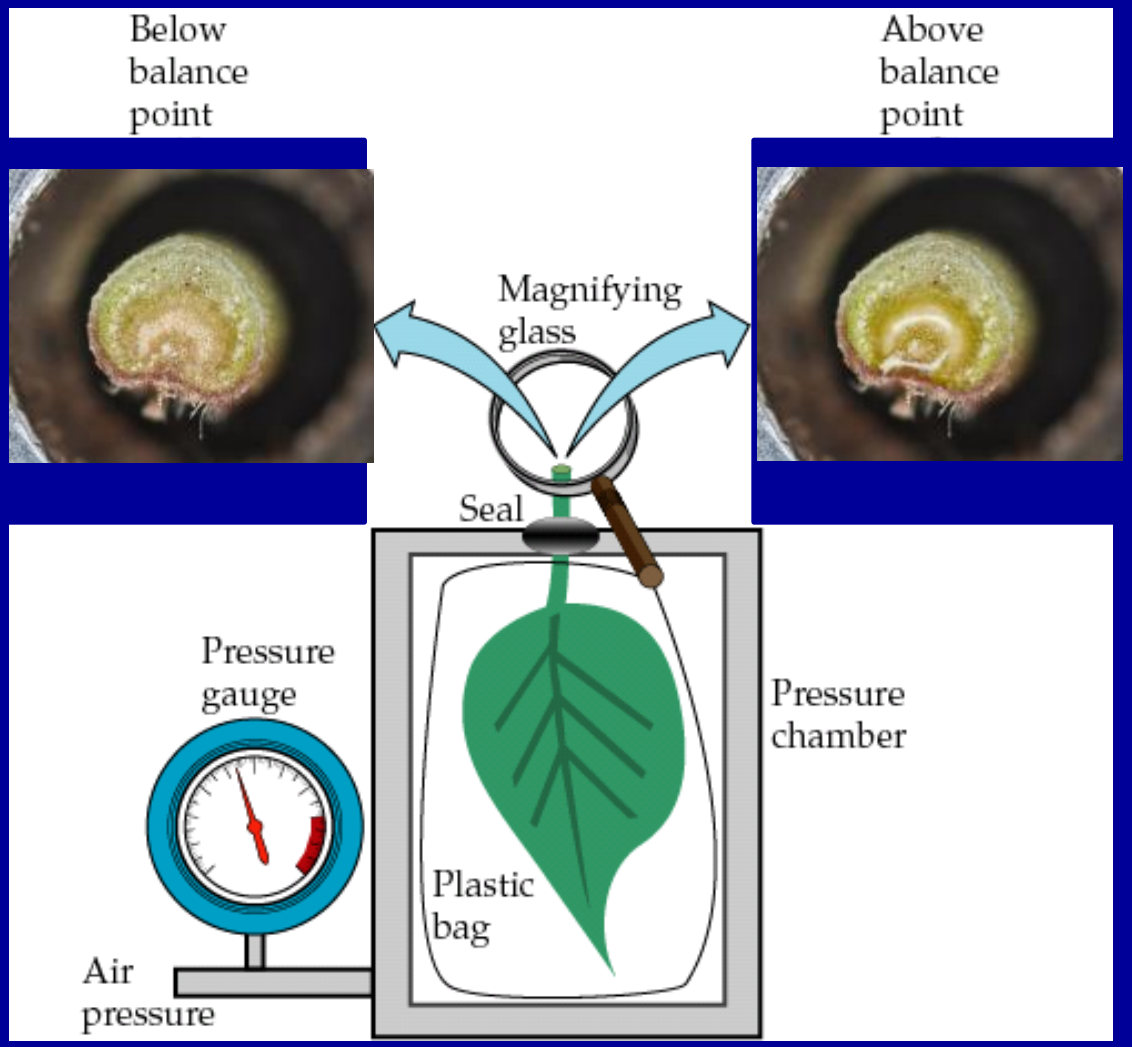
Irrigate Responsibly

- Stop leaks
- Reduce waste (drip)
- Don’t over-irrigate
- Keep it uniform
- Time appropriately
- Right frequency

Measure Stem Water Potential

Ken Shackel

Pressure chamber method for measuring water stress



Like measuring the "blood pressure" of the plant

Ken Shackel

Dry petiole

Wet petiole

Ken Shackel

Pressure chamber

Gauge: in psi or bars

Mid-day Stem Water Potential for Almond

SWP (Bars)

0

-5

(Minimal stress)

Expected range even under fully irrigated conditions

-10

-15

(Mild stress)

Will reduce overall growth of young trees, and shoot growth of older trees, but may also have some beneficial effects on older trees

-20

(Moderate stress)

Interior leaf yellowing and drop usually apparent. Not unusual to find under almond production conditions, but probably reduces tree productivity, particularly if these levels occur regularly

-25

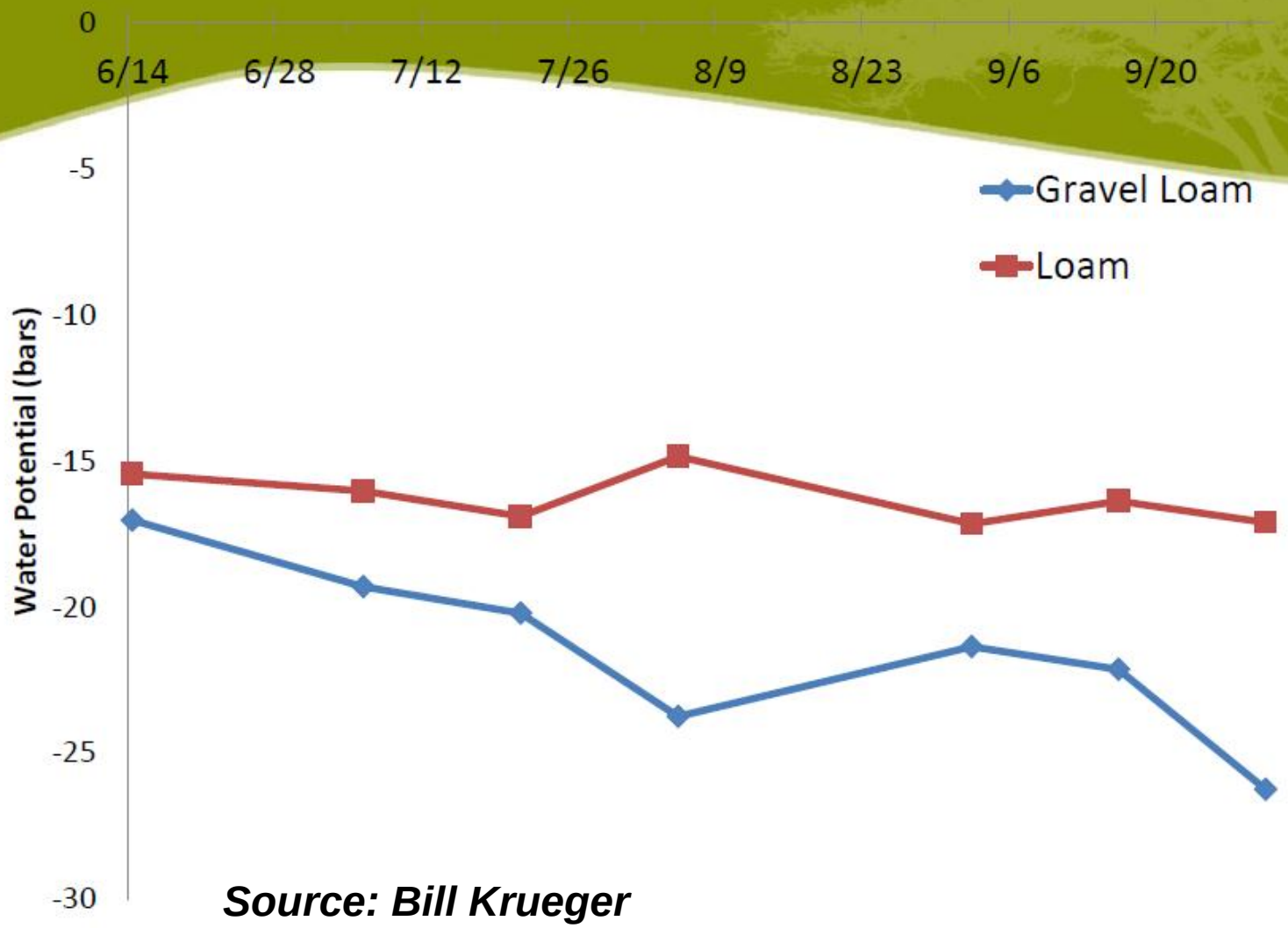
-30

(Severe stress)

Leaf drop, flagging, wilting. Can occur under almond production conditions, particularly around harvest.

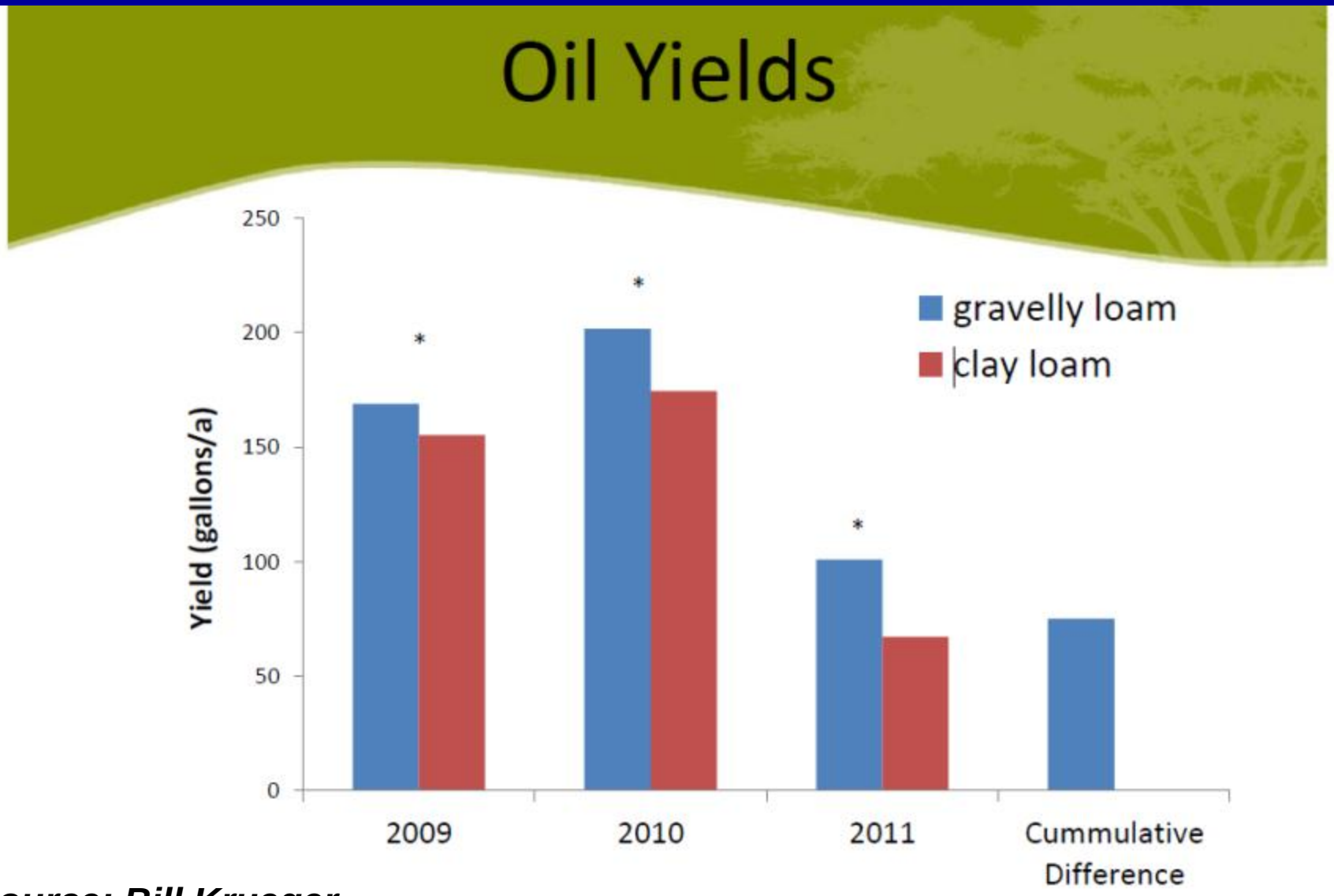
-35

Mid-day Stem Water Potential for Olive



Source: Bill Krueger

Olives produce more oil *& better quality* oil with some water stress



Source: Bill Krueger

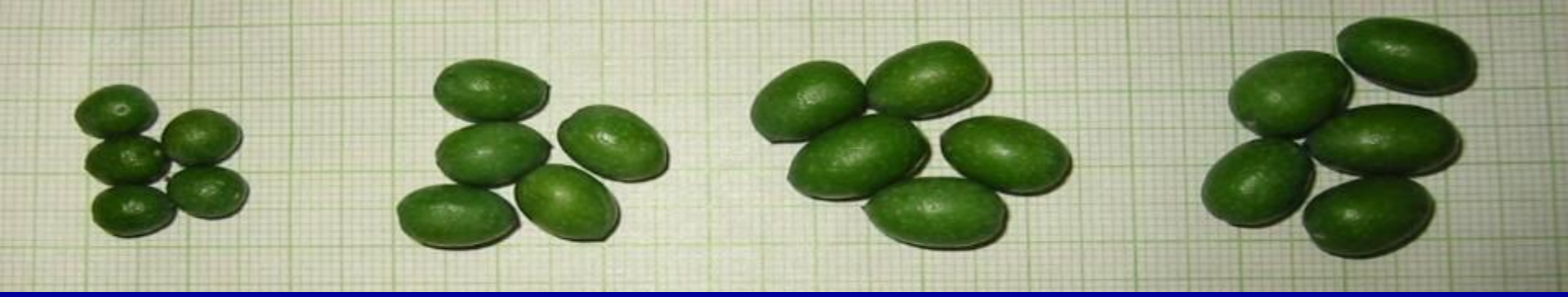
Olive shoot growth at different irrigation rates

15% ET

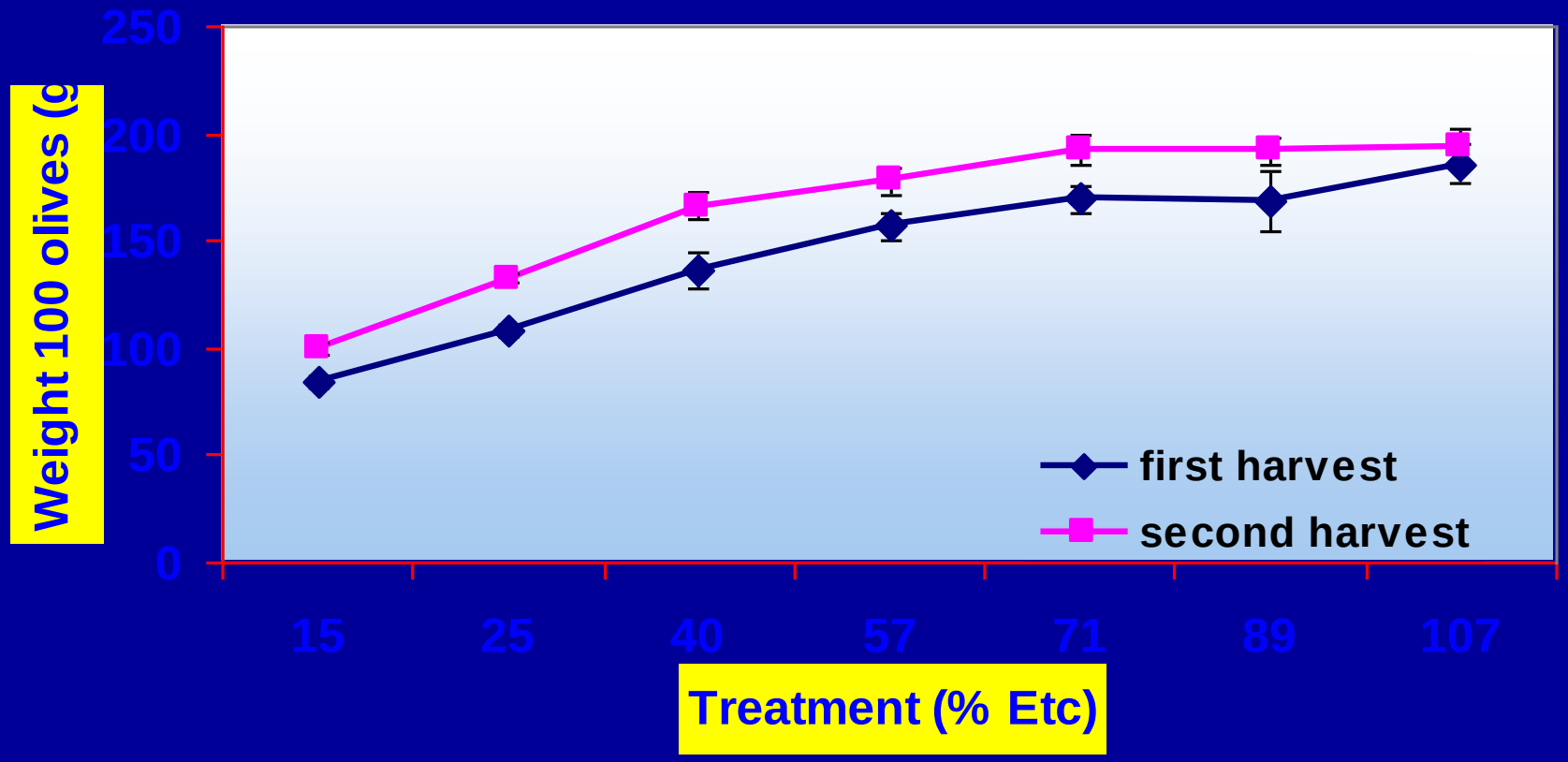
40% ET

89% ET

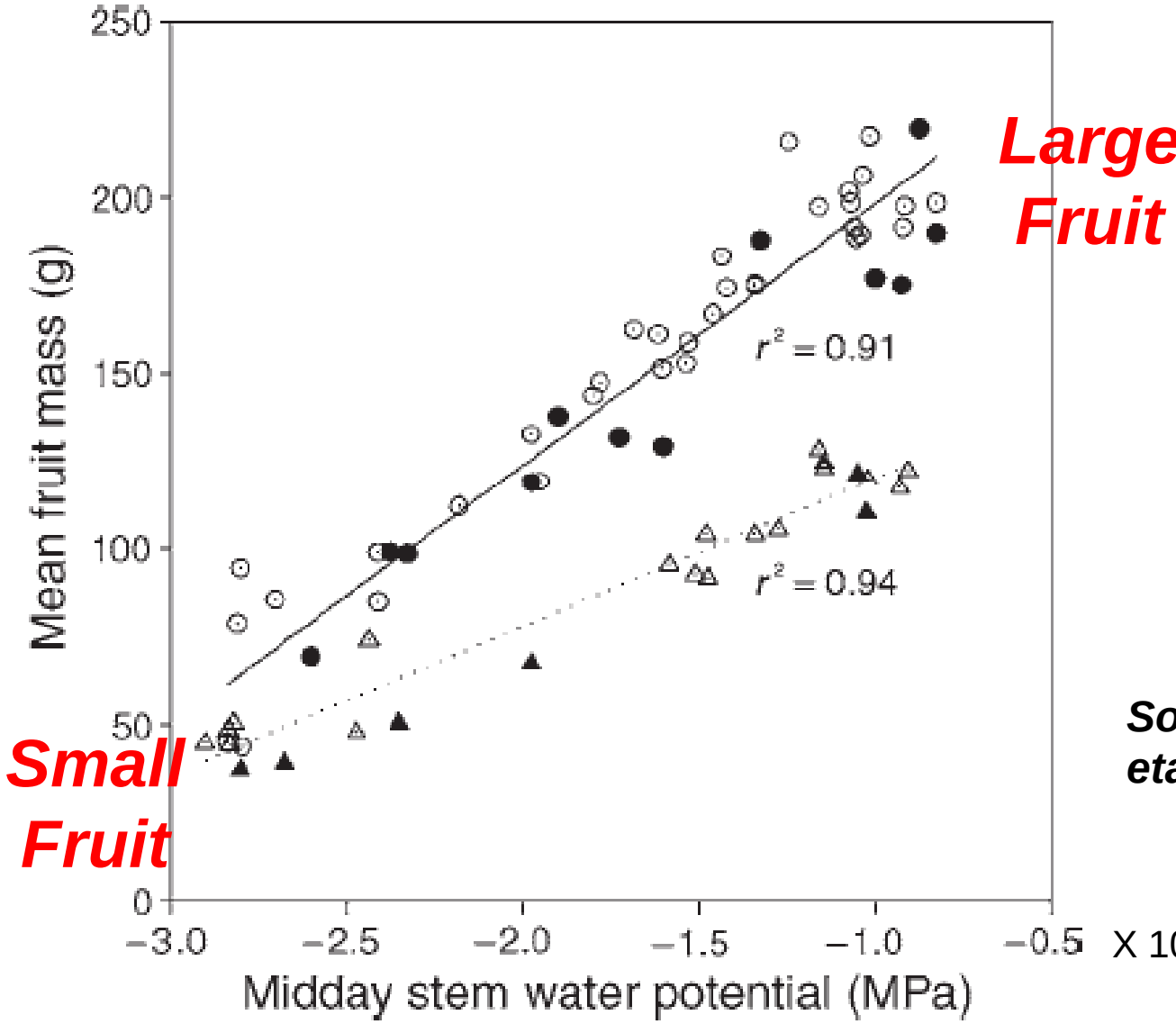
107% ET



15% ET 40% ET 71% ET 107% ET



Mid-day Stem Water Potential for Apple



X 10 = bars

Source: Naor etal 2008

http://informatics.plantsciences.ucdavis.edu/Brooke_Jacobs/index.php

HOME | INTRODUCTION | DATA INTERPRETATION | MODEL DETAILS | WEATHER MODELS | FRUIT & NUT CENTER | REFERENCES

PRINT

Calculating Stem Water Potential

In the box below select the CIMIS weather station closest to your orchard, or with the most similar climatic conditions. The map on the right can be used to zoom in on individual locations to help select the best station to calculate reference water potential. After selecting the appropriate station enter the date (within one week) and the time of pressure chamber readings. Temperature, relative humidity, and reference water potential values for almond, prune, walnut, and grape (both SWP and LWP) are displayed.

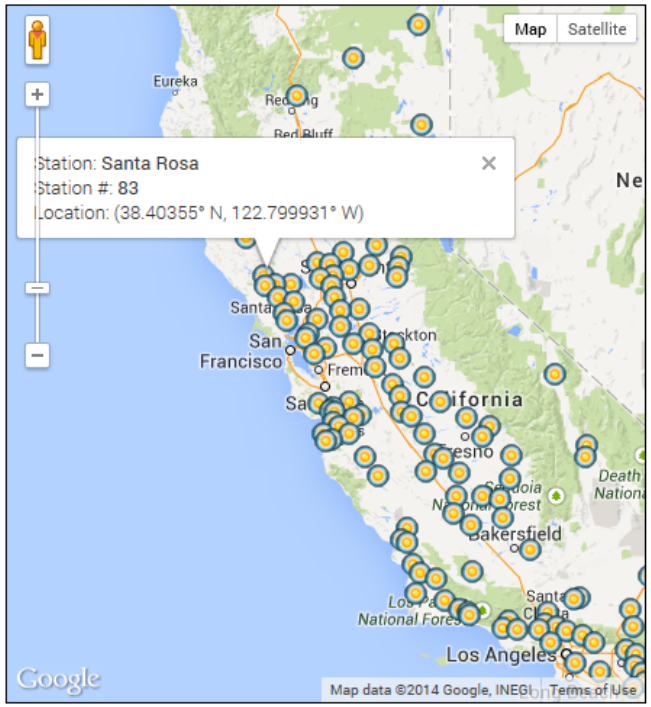
After selecting the appropriate station enter the date (must be within one week of the current date) and the time of pressure chamber readings. *Pacific standard time is used, subtract one hour from daylight savings time.*

Active station: 83 - Santa Rosa

Date/Time: Wed, 02-19-2014 1:00 PM

update

CIMIS Weather Stations



Time	Temperature (F)	Relative humidity	Almond/Prune	Walnut	Grape(SWP)	Grape(LWP)
11:00 AM	57.0	57.0	-4.9	-3.2	-2.8	-5.4
12:00 PM	59.2	49.0	-5.2	-3.3	-2.9	-5.6
1:00 PM	61.1	47.0	-5.3	-3.4	-3.0	-5.7
2:00 PM	63.2	44.0	-5.4	-3.5	-3.0	-5.8
3:00 PM	64.1	41.0	-5.5	-3.6	-3.1	-5.9

University of California Agriculture and Natural Resources | UCDAVIS College of Agricultural and Environmental Sciences | UCDAVIS Department of Plant Sciences

IRRIGATION

How much - how often - how long ?

SPRINKLERS

- Plant Use Rate (ET)
- Application Rate
- Rooting Depth
- Soil Water Holding Capacity

DRIP IRRIGATION

- Plant Use Rate (ET)
- Plant Size (Area in Ft^2)
- Application Rate (Emitter Spacing and Size)

Plant - USE RATE

How Much Water Plants Use

Evapo - Transpiration (ET)

- <u>Evaporation</u> from soil surface = 10%
- <u>Transpiration</u> = 90% cooling of the leaves

EVAPOTRANSPIRATION (ETo)

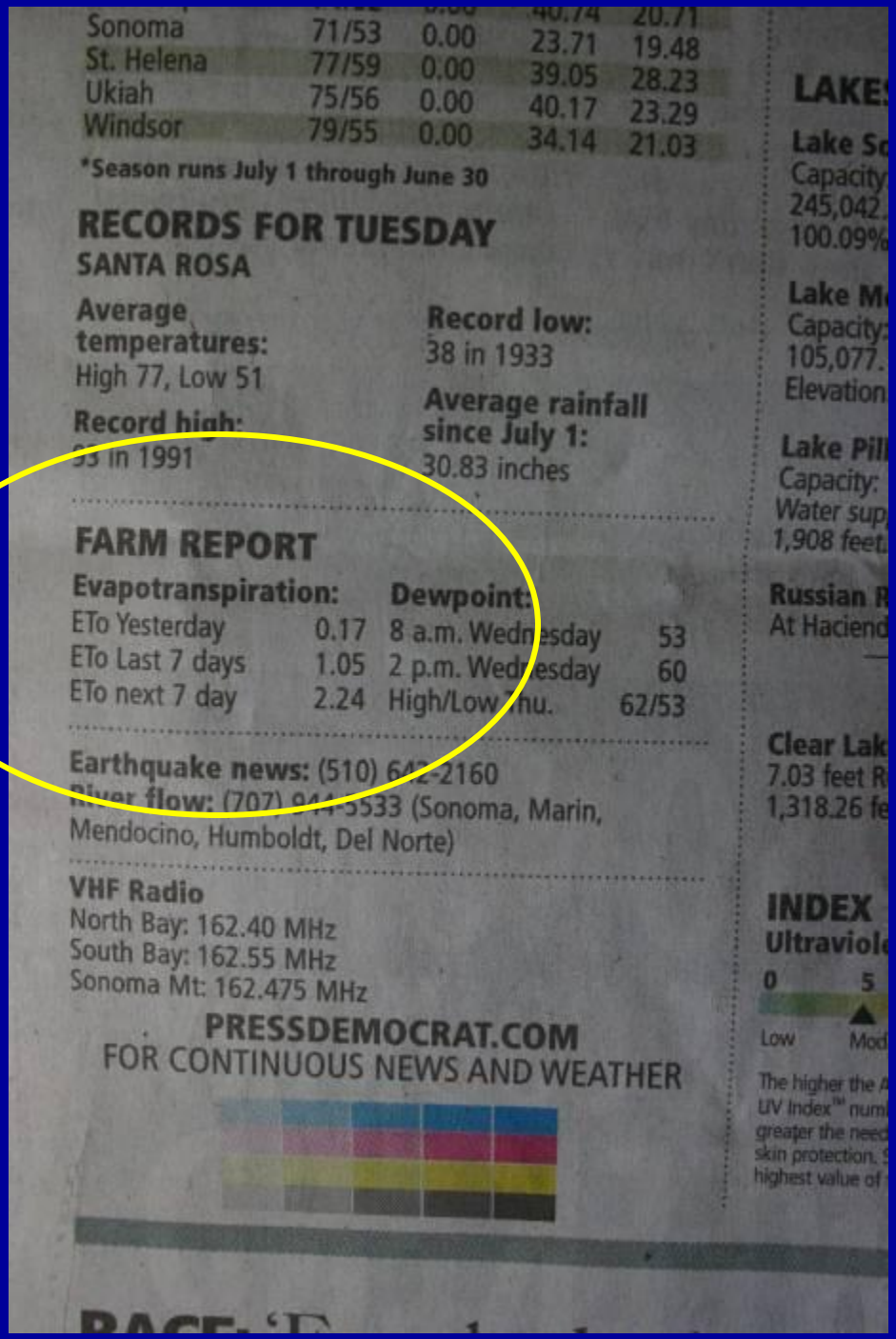
REFERENCE

Temperature

Relative Humidity

Wind

ETo Rates in the Press Democrat



Sonoma	71/53	0.00	23.71	19.48
St. Helena	77/59	0.00	39.05	28.23
Ukiah	75/56	0.00	40.17	23.29
Windsor	79/55	0.00	34.14	21.03

*Season runs July 1 through June 30

RECORDS FOR TUESDAY
SANTA ROSA

Average temperatures: High 77, Low 51

Record high: 93 in 1991

Record low: 38 in 1933

Average rainfall since July 1: 30.83 inches

FARM REPORT

Evapotranspiration:		Dewpoint:	
ETo Yesterday	0.17	8 a.m. Wednesday	53
ETo Last 7 days	1.05	2 p.m. Wednesday	60
ETo next 7 day	2.24	High/Low Thu.	62/53

Earthquake news: (510) 642-2160
River flow: (707) 944-5533 (Sonoma, Marin, Mendocino, Humboldt, Del Norte)

VHF Radio
North Bay: 162.40 MHz
South Bay: 162.55 MHz
Sonoma Mt: 162.475 MHz

PRESSDEMOCRAT.COM
FOR CONTINUOUS NEWS AND WEATHER

LAKES

Lake Sonoma
Capacity: 245,042 ... 100.09%

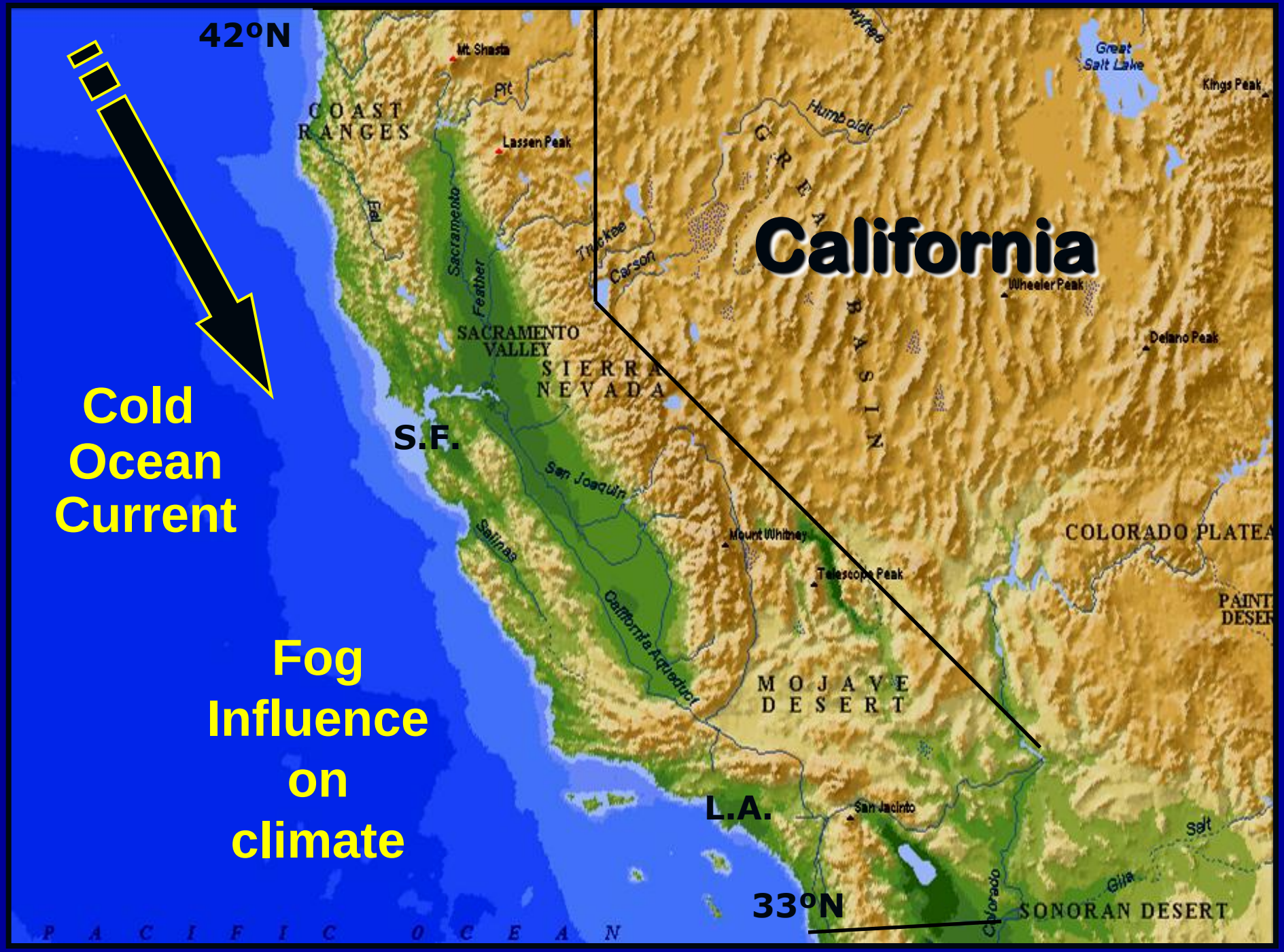
Lake Mendocino
Capacity: 105,077 ... Elevation

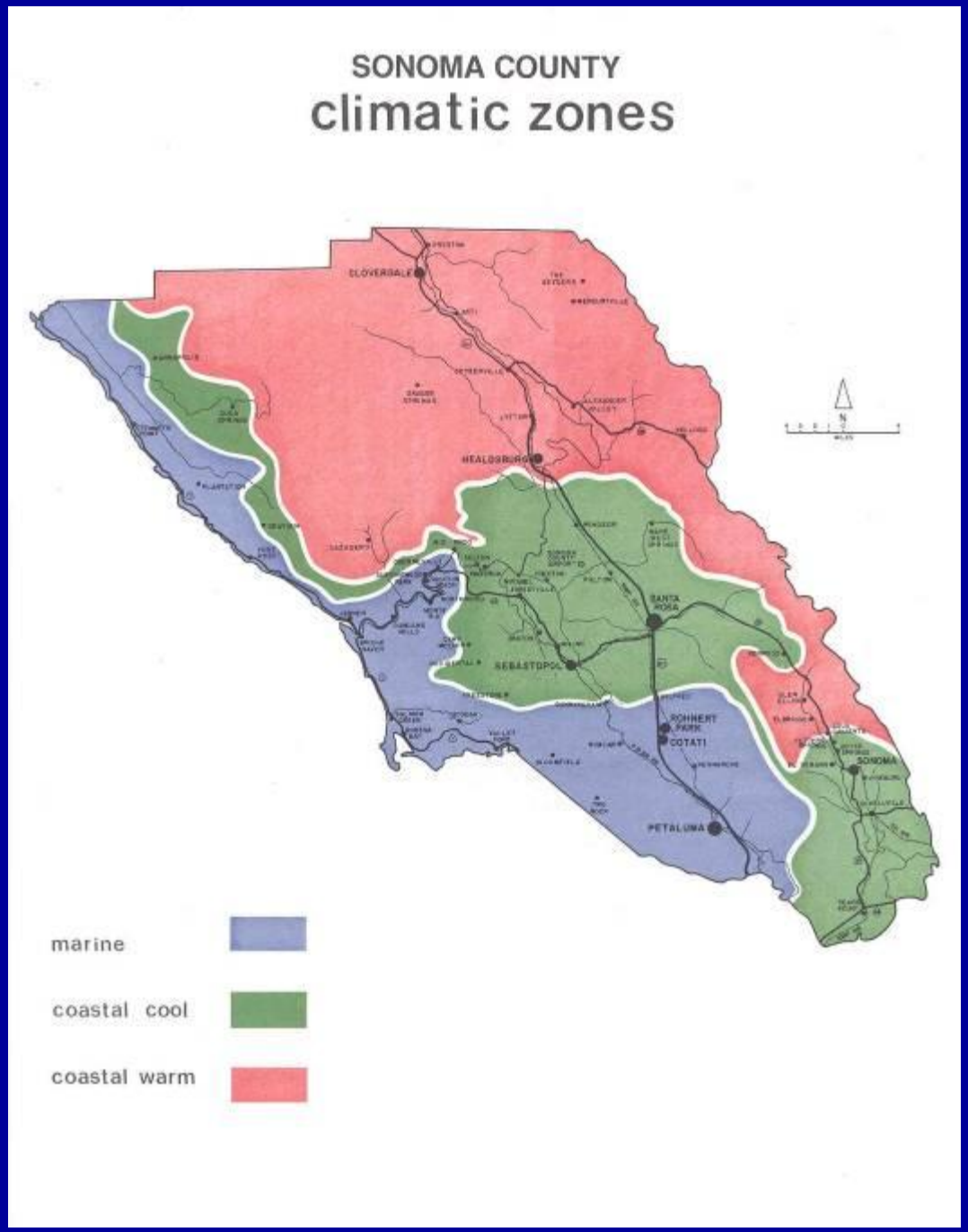
Lake Pillsbury
Capacity: Water sup... 1,908 feet

Russian River
At Hacienda

Clear Lake
7.03 feet R... 1,318.26 fe...

INDEX
Ultraviolet
0 5
Low Mod...
The higher the A... UV Index™ numb... greater the need... skin protection. S... highest value of ...


42ºN
Cold Ocean Current
Fog Influence on climate
California
S.F.
L.A.
33ºN
Mt. Shasta
Pit
Lassen Peak
COAST RANGES
Eel
Sacramento
Feather
SACRAMENTO VALLEY
SIERRA NEVADA
Truckee
Carson
Humboldt
GREAT BASIN
Great Salt Lake
Kings Peak
Wheeler Peak
Delano Peak
San Joaquin
Salinas
California Aqueduct
Mount Whitney
Telescope Peak
COLORADO PLATEA
PAINT DESER
MOJAVE DESERT
San Jacinto
Salt
Gila
Colorado
SONORAN DESERT
PACIFIC OCEAN



Marine

Coastal Cool

Coastal Warm

Seasonal Water Requirement

April - October (30 yr. average in inches) (Sonoma County)

	Marine	Coastal Cool	Coastal Warm
April	2.8	4.0	4.5
May	2.9	5.8	6.9
June	2.8	5.6	7.0
July	3.4	6.1	7.9
August	3.1	5.2	6.8
Sept.	3.1	4.4	5.7
Oct.	3.1	3.3	3.7
TOTAL	21.2	34.4	42.5

Climatic Zones

Marine: Foggy, windy, cool

- 2,185 degree days (1,800-2,800)
- Water use ~ 20-22”

Coastal Cool: Intermediate – some fog

- 2,582 degree days (1,900-3.600)
- Water use ~ 30-34”

Coastal Warm: Warm – little fog

- 2,920 degree days (2,100-4,200)
- Water use ~ 36-42”

Max Potential Water Use (May-October)

	ET (inches)	Gal/Acre	Gal/Min	Gal/1,000ft^2
Marine	20	543,080	2.04	12,464
Coastal Cool	34	923,236	3.50	21,195
Coastal Warm	42	1,140,468	4.22	26,181

Typical water use patterns ETo - Inches per day

- Spring or fall with short cool days = 0.1
- Warm summer days with fog = 0.15
- Hot summer days with some fog = 0.20
- Hot summer days - no fog = 0.25
- Very hot days and windy = 0.30

Water Use in Gallons / Day

ETo →	0.1"/day	0.2"/day	0.25"/day	0.3"/day
1 ft^2	0.062	0.125	0.156	0.187
10 ft^2	0.62	1.25	1.56	1.87
36 ft^2	2.25	4.50	5.61	6.73
100 ft^2	6.20	12.5	15.6	18.7
200 ft^2	12.4	25.0	31.2	37.4
300 ft^2	18.6	37.5	46.8	56.1
1 acre	2,715	5,431	6,788	8,146

Plant Size

4 gpm X 60 min/hr X 24 hrs/day = 5,760 gallons per day

Deficit Irrigation
Less than maximum

- Reference ETo is maximum
- Young plants use more due to surrounding heat, but they are smaller
- Immature plants use ~ % of surface coverage
- Mature crops use about 75-80%

"Crop Coefficient"

Sprinklers

Sprinkler Irrigation

- Typical Rain-bird Sprinkler
- Applies 0.20” per hour
- 5 hours = 1” water applied
- 1” water soaks down about 6 in

SPRINKLER IRRIGATION for Vegies

- Rooting depth 12” = 2” total water in soil
- Allowable depletion = 1”
- Water use (Eto = 0.2”/day x 75% = 1.05”/ week
- Sprinklers apply 1” in 5 hours
- Water for 5 hours every 7 days

Berry Irrigation

Applies

½” per hour

Run 2 hrs.

Every 4 days

Convert to Drip & save ~ 20%

Berries: *solid moisture*

Drip Irrigation

- Water plant daily – lightly – shallow
- Give the plant what it needs/wants
- Need is determined by ETo + coefficient
- Exact an acceptable amount of stress
- Soil water holding capacity is not important

Water Use in Gallons / Day

	0.1"/day	0.2"/day	0.25"/day	0.3"/day
1 ft^2	0.062	0.125	0.156	0.187
10 ft^2	0.62	1.25	1.56	1.87
36 ft^2	2.25	4.50	5.61	6.73
100 ft^2	6.20	12.5	15.6	18.7
200 ft^2	12.4	25.0	31.2	37.4
300 ft^2	18.6	37.5	46.8	56.1
1 acre	2,715	5,431	6,788	8,146

4 gpm X 60 min/hr X 24 hrs/day = 5,760 gallons per day

FRUIT TREE DRIP IRRIGATION

- Warm summer day: Use is 0.25 Inches
- Tree occupies 100 ft^2 = 16 Gallons / Day
- 4 One-gallon per Hour Emitters per Tree
- Water for 4 Hours Every Day

Fruit tree – water stress

- Shoot Growth Slows - Stops
- Fruit Size Reduced
- Leaf Burn
- Trunk Sunburn
- Xylem Damage
- Bud Development Influenced
- Severe Stunting and Death

Little or no influence on flowering or fruit set

Reducing fruit tree stress

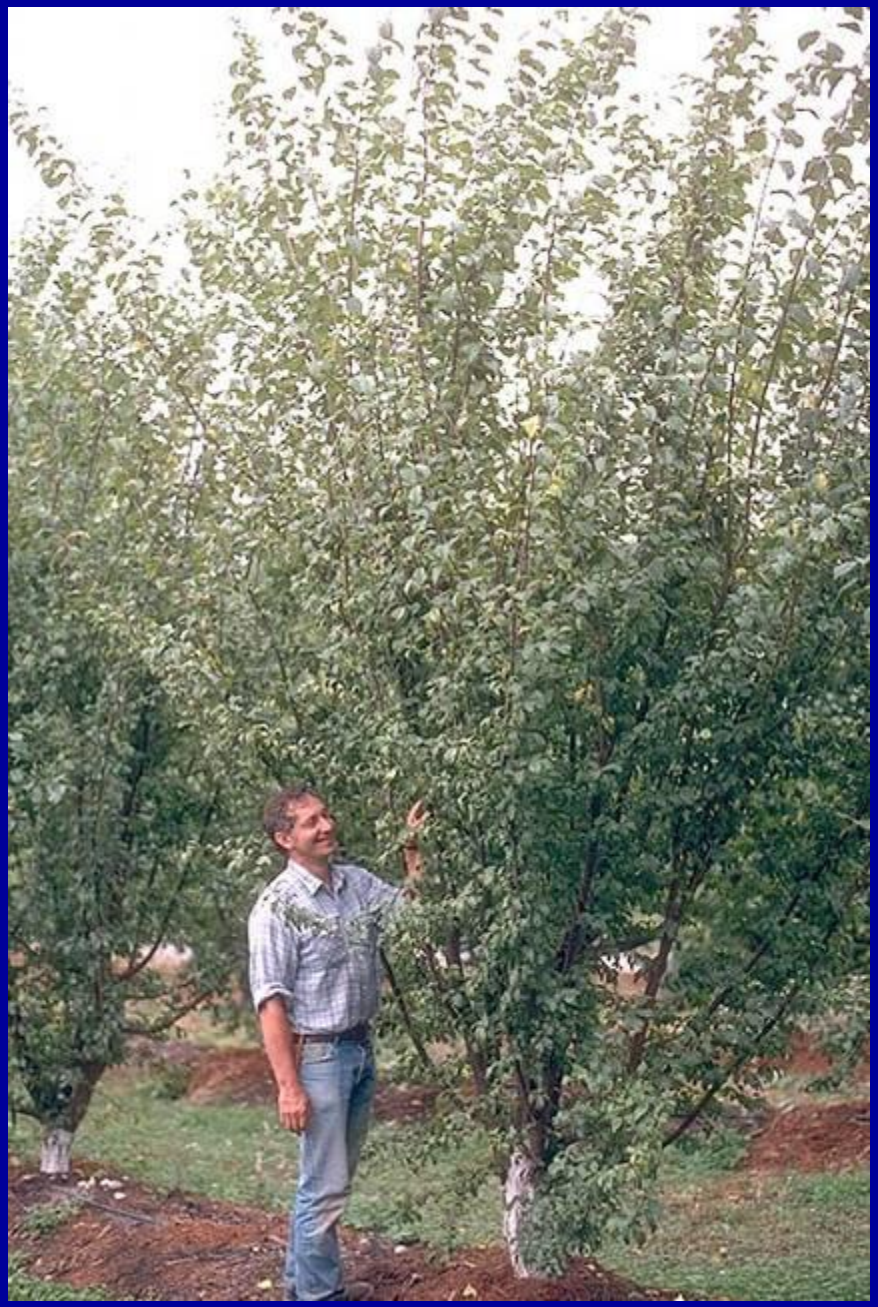
- Prune moderately when dormant
- Only thinning cuts when dormant
- Summer prune (May-June)
- Reduce crop load (apple & peach)
- Paint SW trunks white
- Time most stress toward summer and autumn – not spring growth stage

Heavy Dormant Topping

Heavy Dormant Topping

Thinning Cuts to open up the tree

Thinned and Un-pruned




Summer prune
to reduce
foliage – stunt
growth

Before Summer Pruning

After Summer Pruning

Summer pruning reduces foliage

What NOT to Grow

- Plants that sunburn and die from water stress
- Plants where fruit size is important (fresh)
- Plants that have shallow root systems
- Late maturing varieties
- Plants that need heat and water

- -

Strawberry, raspberry, blueberry, blackberry, table olive, table grape, peach, nectarine, pear, asparagus, pepper, eggplant, squash, cutting greens, spinach, watermellon, corn, beans, summer onion

What to Grow

- Plants that have been successfully dry farmed
- Plants that are deep rooted
- Plants where fruit size does not matter (processed)
- Plants that naturally tolerate water stress
- Plants that mature in winter & spring
- Short season varieties (early maturing)

- -

- Oil olives, wine grapes, processing apples, some pears, plums, prunes, apricots, potatoes, tomatoes, cole crops, radishes, peas, winter greens, winter alliums, bunch lettuce, melon - -

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California Drought Resources

As we enter 2014 in the midst of historic drought, California's academic institutions serve as a tremendous resource both in offering everything from near-term management advice to farmers and ranchers to the innovative work being carried out by researchers on a vast array of issues from drought resistant crops to snow sensors to climate change.

These pages are being continuously updated as we work to bring the resources of the state's universities and colleges to a broad range of communities.

- Drought-related events
- Drought information and resources
- Drought experts list
- Media coverage featuring our experts
- Story highlights

http://ciwr.ucanr.edu/California_Drought_Expertise/

University of California
UC Drought Management

Crop Irrigation Strategies

Individual Crop Deficit Irrigation Information

For some crops, primarily perennial crops, there may be growth periods when the crop can be deficit irrigated with minimal impact on yield and quality. Taking advantage of these periods, irrigation systems such as micro precise systems can apply precise irrigations to deficit irrigate without overly stressing the crop.

Click below on your crop of choice for information on irrigation strategies. Each section provides detailed information on irrigation management for crops under drought conditions, as well as a list of resources.

Almonds

Pistachios

Stone Fruit

Walnuts

Alfalfa

Olives

Winegrapes

Corn

Thanks! – Questions?

pmvossen@ucanr.edu