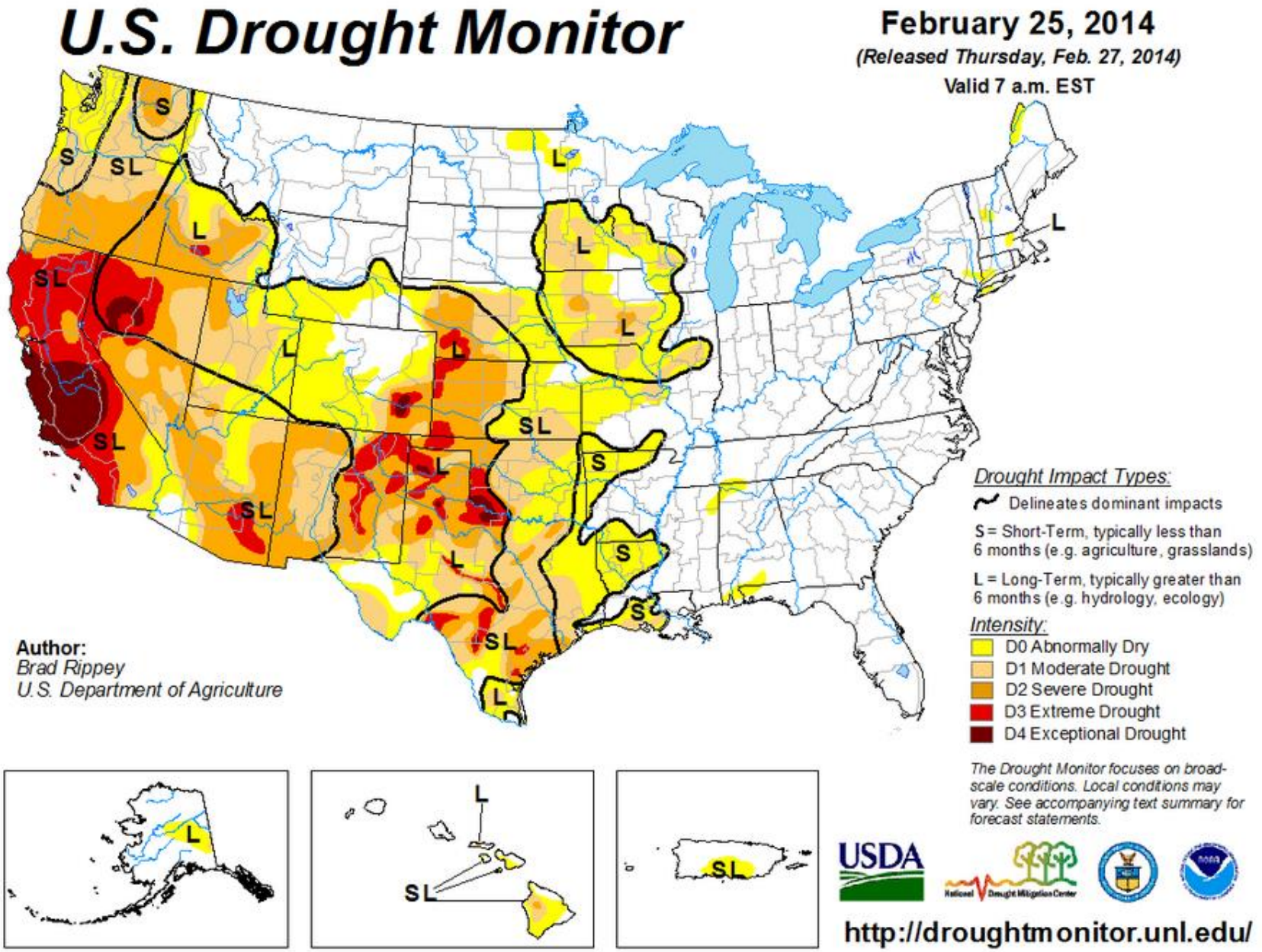
Irrigation management in a drought year

What drought means to the tree, and how best to deal with it

Ken Shackel, Jan/Feb 2014

The current US Drought Monitor



Saving water: some general recommendations

1) Control weeds.

2) Maintain irrigation system and try to improve uniformity.

3) Use a pressure chamber to identify areas of severe stress and adjust your irrigation approach before these areas become a problem.

Recommendations specific to almonds:

1) No evidence that heavy pruning or kaolin/whitewash sprays do any economic good to mitigate drought conditions.

2) Mild to moderate stress at the start of hull split is a good idea to speed up hull split and reduce hull rot.

An issue we don't have much (any?) data on: The need for WINTER IRRIGATION

THE

Agricultural Journal

OF THE CAPE OF GOOD HOPE.

No. 6. JUNE, 1907. VOL. XXX.

Published Monthly in English and Dutch by the Department of Agriculture and distributed gratis to bona fide farmers in the Cape Colony on application through the Resident Magistrate of the District.

Winter Irrigation of Fruit Trees.

"They require only so much moisture from the ground as may serve to keep their tissues in a normal healthy state, and prevent mischief or death by their younger parts transpiring more than they receive."
(E.P., 1907).

University of California Cooperative Extension

SACRAMENTO VALLEY WALNUT NEWS

A Regional Newsletter of the UC Cooperative Extension Walnut Farm Advisors
Sutter/Yuba UCCE, 142A Garden Highway, Yuba City CA 95991
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December 2008 Issue 4: Winter 2008/2009

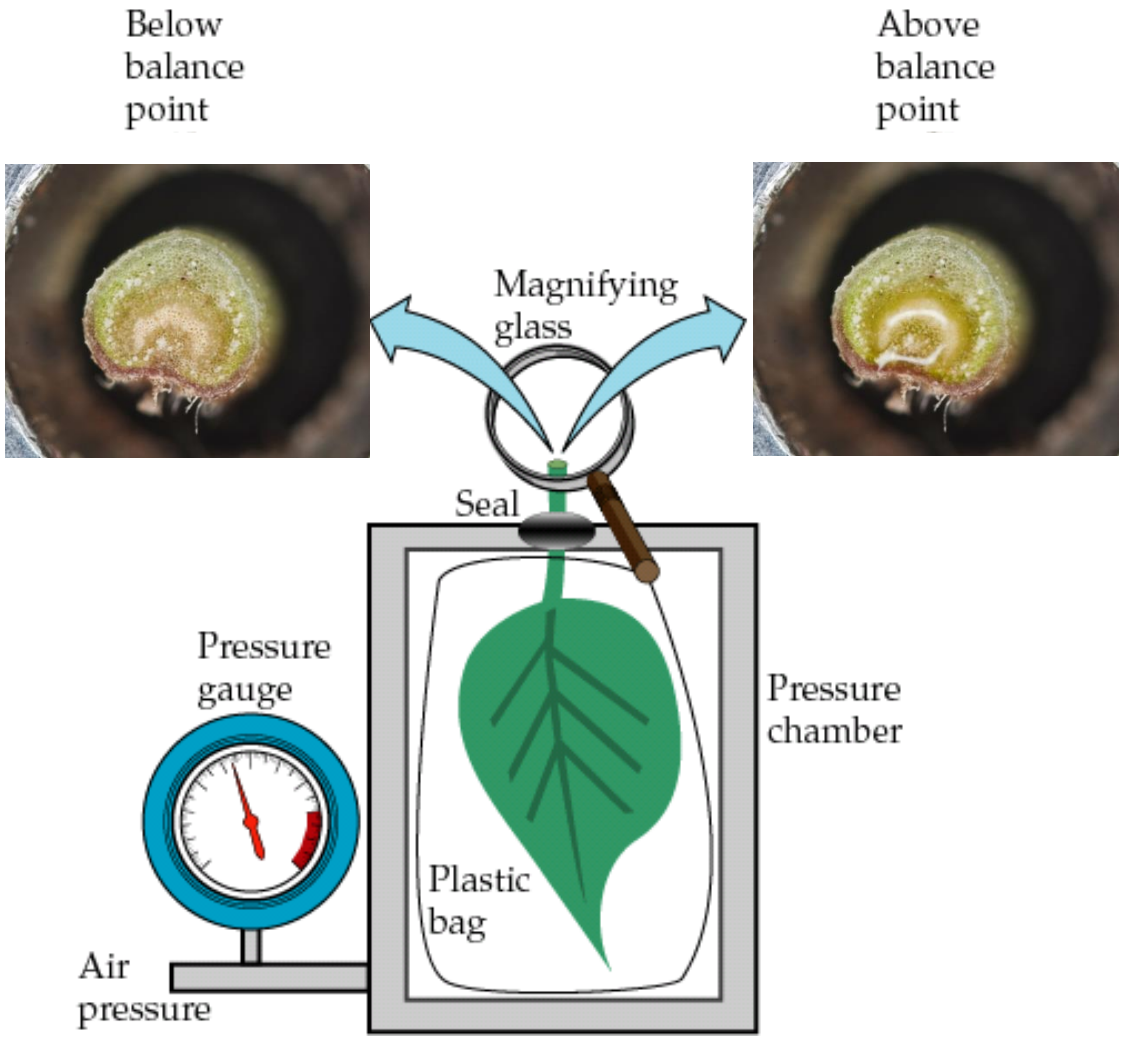
Winter Irrigation During Drought

Joseph H. Connell, UC Farm Advisor, Butte Co.

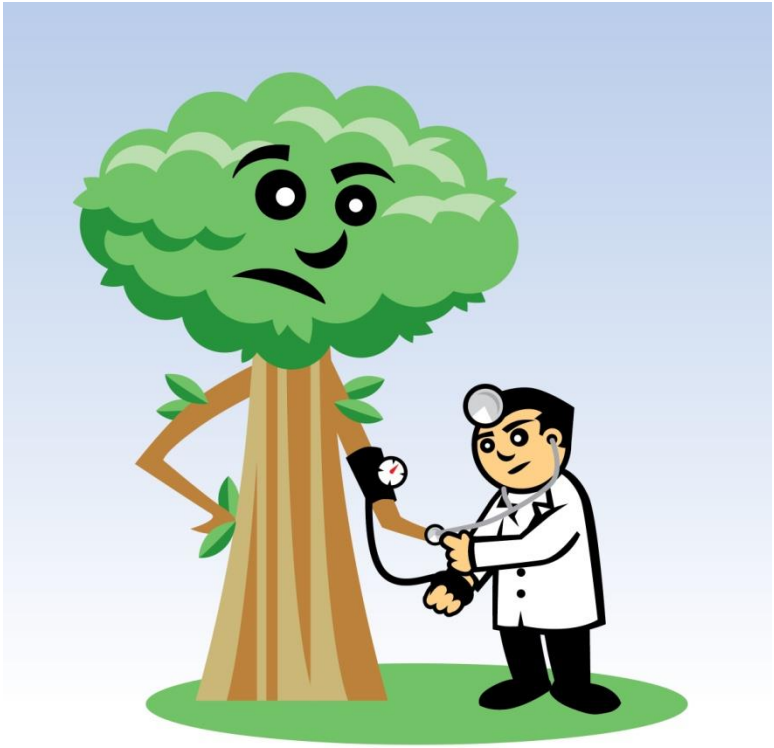
We know that during the winter months walnuts can be hurt by either too much or too little water. …Cutting back on water earlier in the fall slows down the trees growth and helps harden them off. However, drought conditions during winter can make winter kill worse if we get cold temperatures as discussed in Carolyn DeBuse's article on winter freeze injury.

…The ultimate goal is to make sure the soil reservoir is completely refilled either by rain or winter irrigations by the time your walnut trees begin to wake up next March.

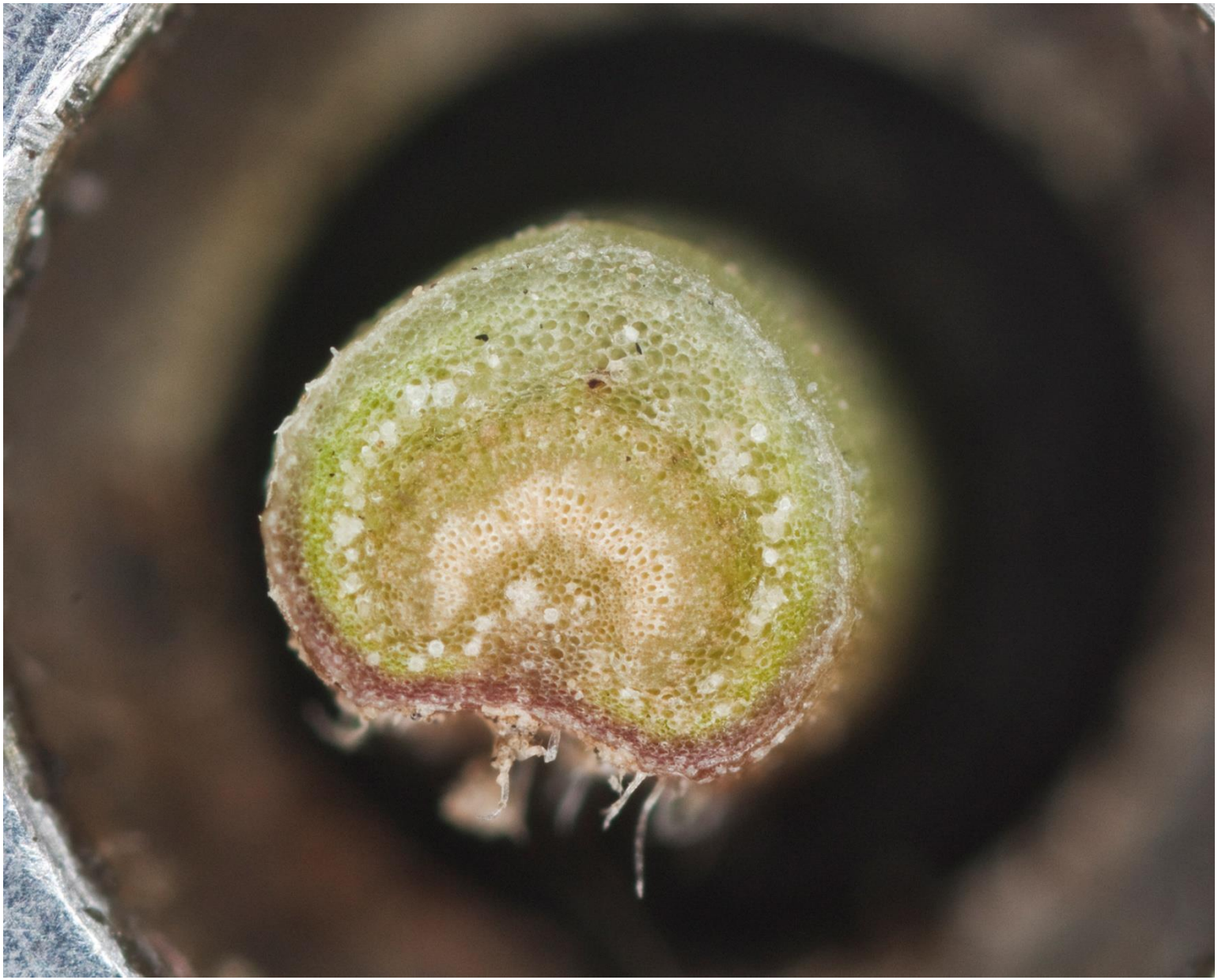
Pressure chamber method for measuring water stress



Like measuring the "blood pressure" of the plant




Stem Water Potential
(SWP)

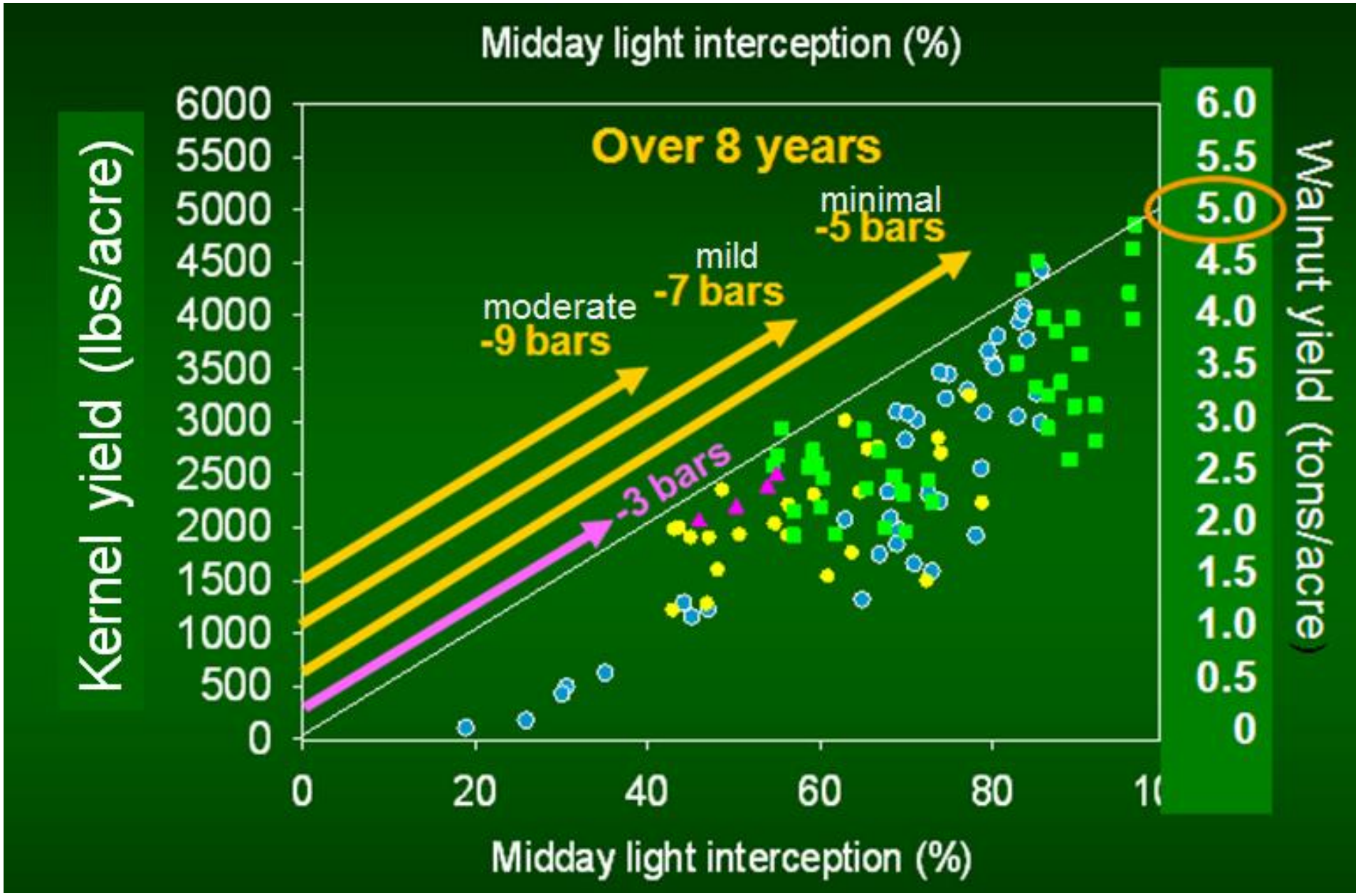


http://www.chlorofilms.org/index.php/crpVideo/display/videoid/27


S10
CHEVROLET
CORNING
California
E034608

Pressure Chamber Reading (- bars)	WALNUT
0 to –2.0	Not commonly observed
-2.0 to –4.0	Fully irrigated, low stress, commonly observed when orchards are irrigated according to estimates of real-time evapotranspiration (ETc), long term root and tree health may be a concern, especially on California Black rootstock.
-4.0 to –6.0	Low to mild stress, high rate of shoot growth visible, suggested level from leaf-out until mid June when nut sizing is completed.
-6.0 to –8.0	Mild to moderate stress, shoot growth in non-bearing and bearing trees has been observed to decline. These levels do not appear to affect kernel development.
-8.0 to –10.0	Moderate to high stress, shoot growth in non-bearing trees may stop, nut sizing may be reduced in bearing trees and bud development for next season may be negatively affected.
-10.0 to –12.0	High stress, temporary wilting of leaves has been observed. New shoot growth may be sparse or absent and some defoliation may be evident. Nut size likely to be reduced.
-12.0 to –14.0	Relative high levels of stress, moderate to severe defoliation, should be avoided.

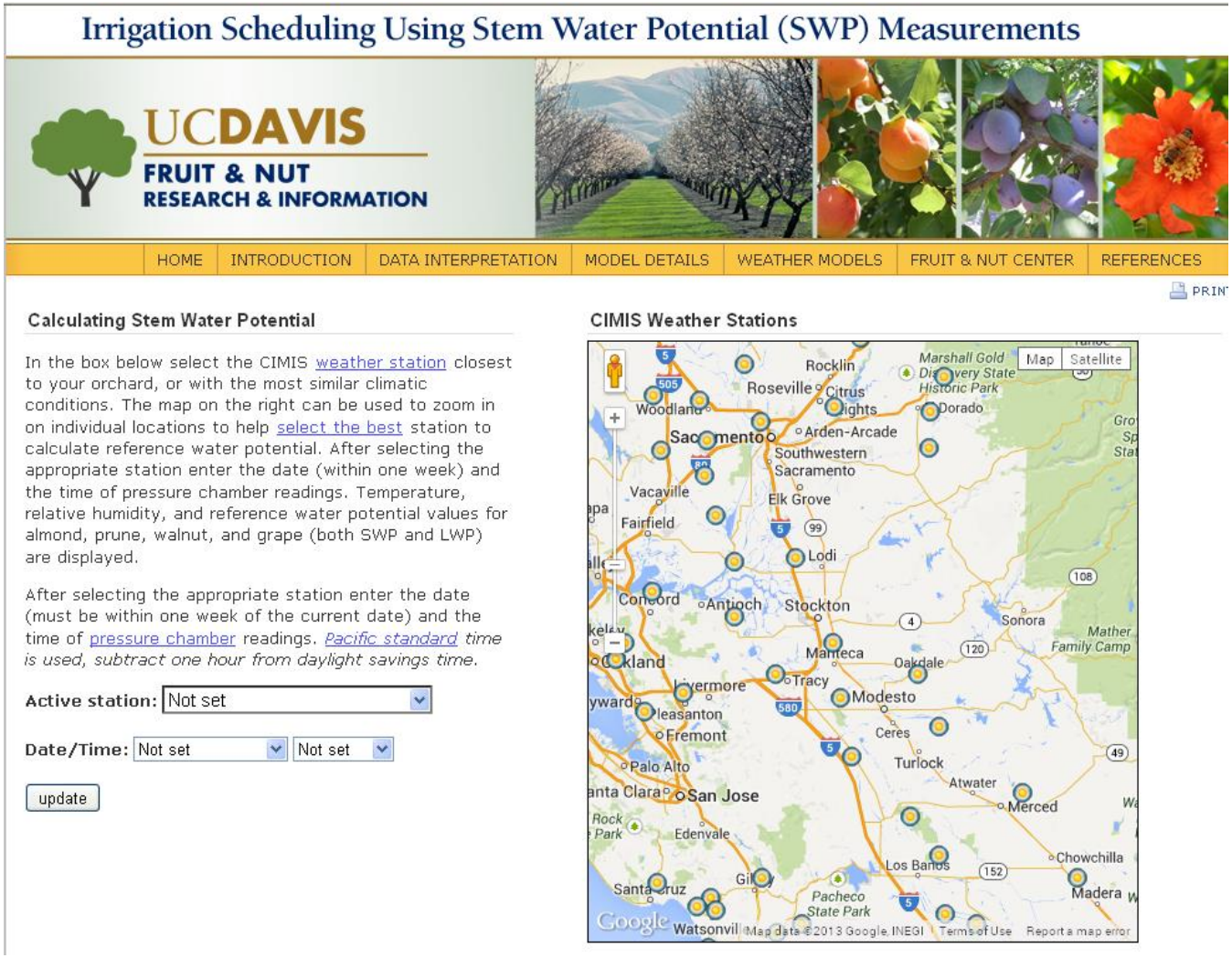
Walnut canopy development effects



Resources to help with the pressure chamber

New ‘baseline’ website:

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



Resources to help with the pressure chamber

New ‘baseline’ website:

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

Active station: 6 - Davis

Date/Time: Wed, 01-15-2014 2:00 PM

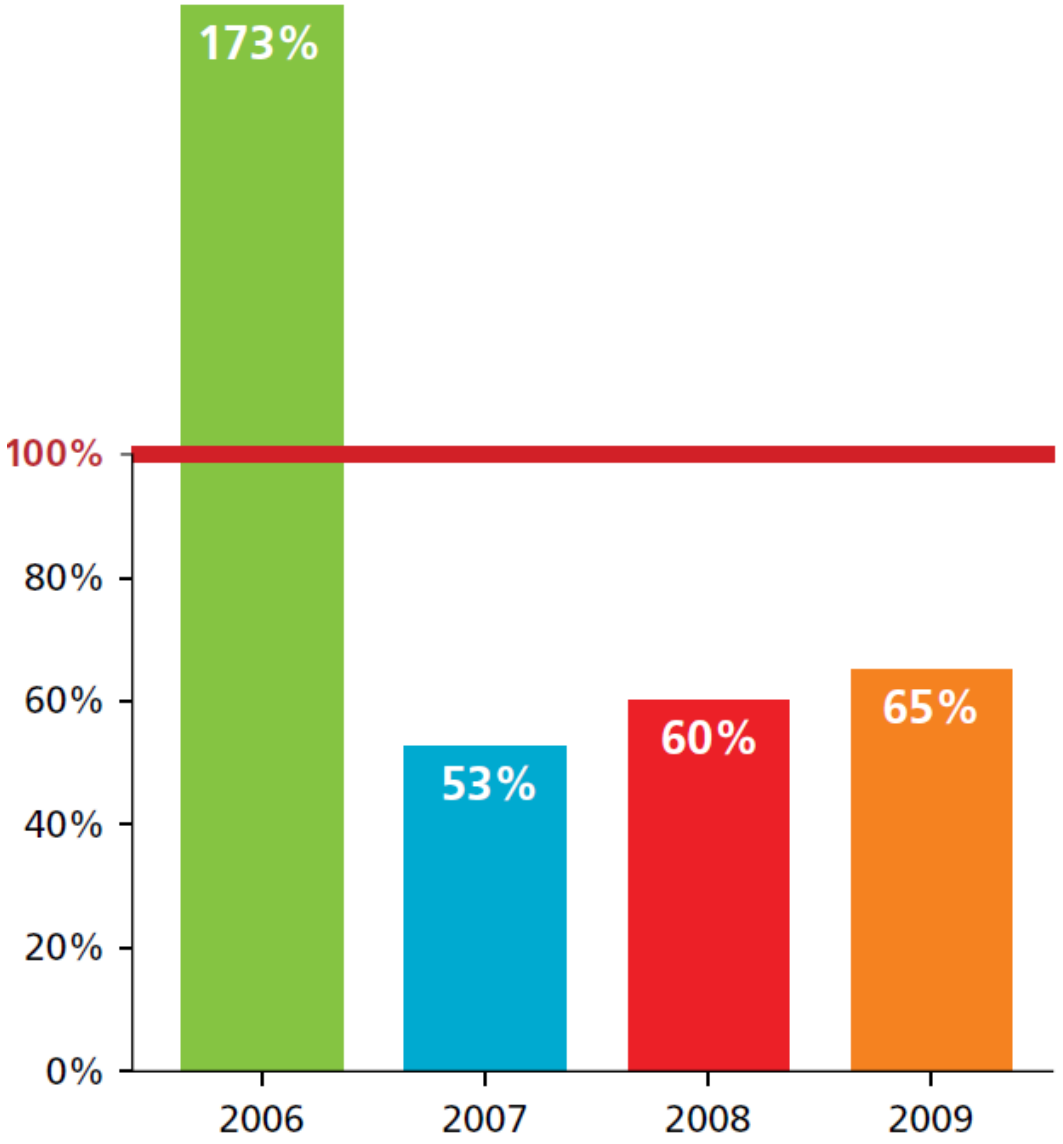
update

Time	Temperature (F)	Relative humidity	Almond/Prune	Walnut	Grape(SWP)	Grape(LWP)
12:00 PM	60.1	33.0	-5.5	-3.5	-3.1	-5.8
1:00 PM	63.5	27.0	-5.9	-3.7	-3.3	-6.1
2:00 PM	65.7	25.0	-6.0	-3.8	-3.4	-6.2
3:00 PM	67.7	24.0	-6.2	-3.9	-3.5	-6.3
4:00 PM	68.6	25.0	-6.2	-3.9	-3.5	-6.3

The drought of 2007-2009

(source: DWR 2010 report)

Percent of statewide average runoff

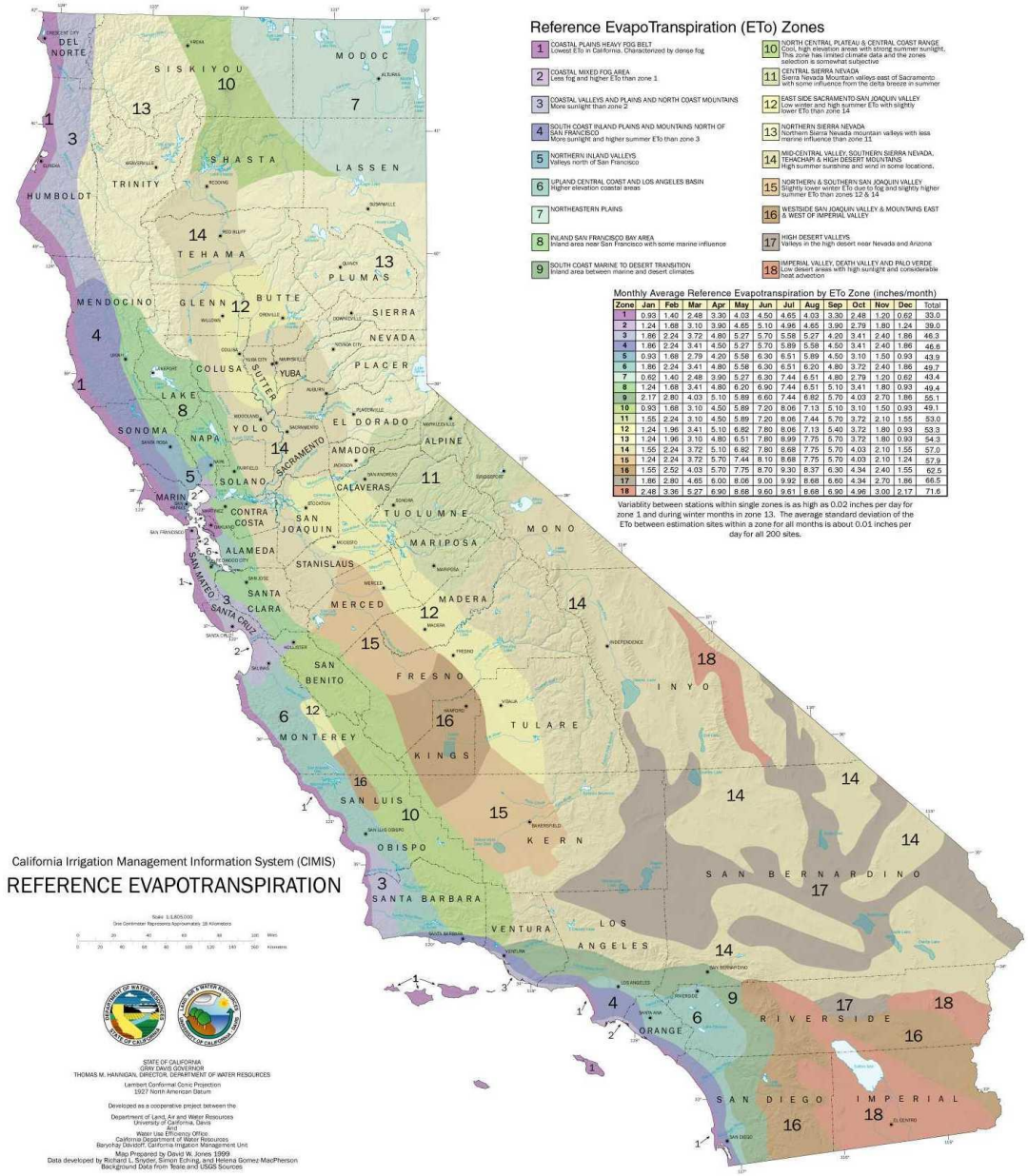


In California, “drought” means low winter rains. We always have dry summers!

Almond “full” ETc (inches per month) for two locations in a wet year (2006) and a dry year (2007)

	Tehama		Kings	
Month	2006 (Wet year)	2007 (Dry year)	2006 (Wet year)	2007 (Dry year)
Feb	1.0	0.7	1.1	0.9
Mar	1.6	2.5	1.8	2.7
Apr	3.2	4.0	3.4	4.2
May	6.5	7.1	6.6	7.1
June	8.4	8.9	8.0	8.3
July	9.4	8.9	8.6	8.5
Aug	8.0	8.3	8.0	7.9
Sep	6.1	5.5	5.9	5.8
Oct	3.8	3.2	3.1	3.3
Nov	0.9	1.8	1.3	1.6
Total	**48.9**	**50.9**	**47.8**	**50.3**

Start your plan using ‘average’ year values



Reference EvapoTranspiration (ETo) Zones

1	COASTAL PLAINS HEAVY FOG BELT Lowest ETo in California. Characterized by dense fog	10	NORTH CENTRAL PLATEAU & CENTRAL COAST RANGE Cool, high elevation areas with strong summer sunlight. This zone has limited climate data and the zones selection is somewhat subjective
2	COASTAL MIXED FOG AREA Less fog and higher ETo than zone 1	11	CENTRAL SIERRA NEVADA Sierra Nevada Mountain valleys east of Sacramento with some influence from the delta breeze in summer
3	COASTAL VALLEYS AND PLAINS AND NORTH COAST MOUNTAINS More sunlight than zone 2	12	EAST SIDE SACRAMENTO SAN JOAQUIN VALLEY Low winter and high summer ETo with slightly lower ETo than zone 14
4	SOUTH COAST INLAND PLAINS AND MOUNTAINS NORTH OF SAN FRANCISCO More sunlight and higher summer ETo than zone 3	13	NORTHERN SIERRA NEVADA Northern Sierra Nevada mountain valleys with less marine influence than zone 11
5	NORTHERN INLAND VALLEYS Valleys north of San Francisco	14	MID-CENTRAL VALLEY, SOUTHERN SIERRA NEVADA, TEHACHAPI & HIGH DESERT MOUNTAINS High summer sunshine and wind in some locations.
6	UPLAND CENTRAL COAST AND LOS ANGELES BASIN Higher elevation coastal areas	15	NORTHERN & SOUTHERN SAN JOAQUIN VALLEY Slightly lower winter ETo due to fog and slightly higher summer ETo than zones 12 & 14
7	NORTHEASTERN PLAINS	16	WESTSIDE SAN JOAQUIN VALLEY & MOUNTAINS EAST & WEST OF IMPERIAL VALLEY
8	INLAND SAN FRANCISCO BAY AREA Inland area near San Francisco with some marine influence	17	HIGH DESERT VALLEYS Valleys in the high desert near Nevada and Arizona
9	SOUTH COAST MARINE TO DESERT TRANSITION Inland area between marine and desert climates	18	IMPERIAL VALLEY, DEATH VALLEY AND PALO VERDE Low desert areas with high sunlight and considerable heat advection

Monthly Average Reference Evapotranspiration by ETo Zone (inches/month)

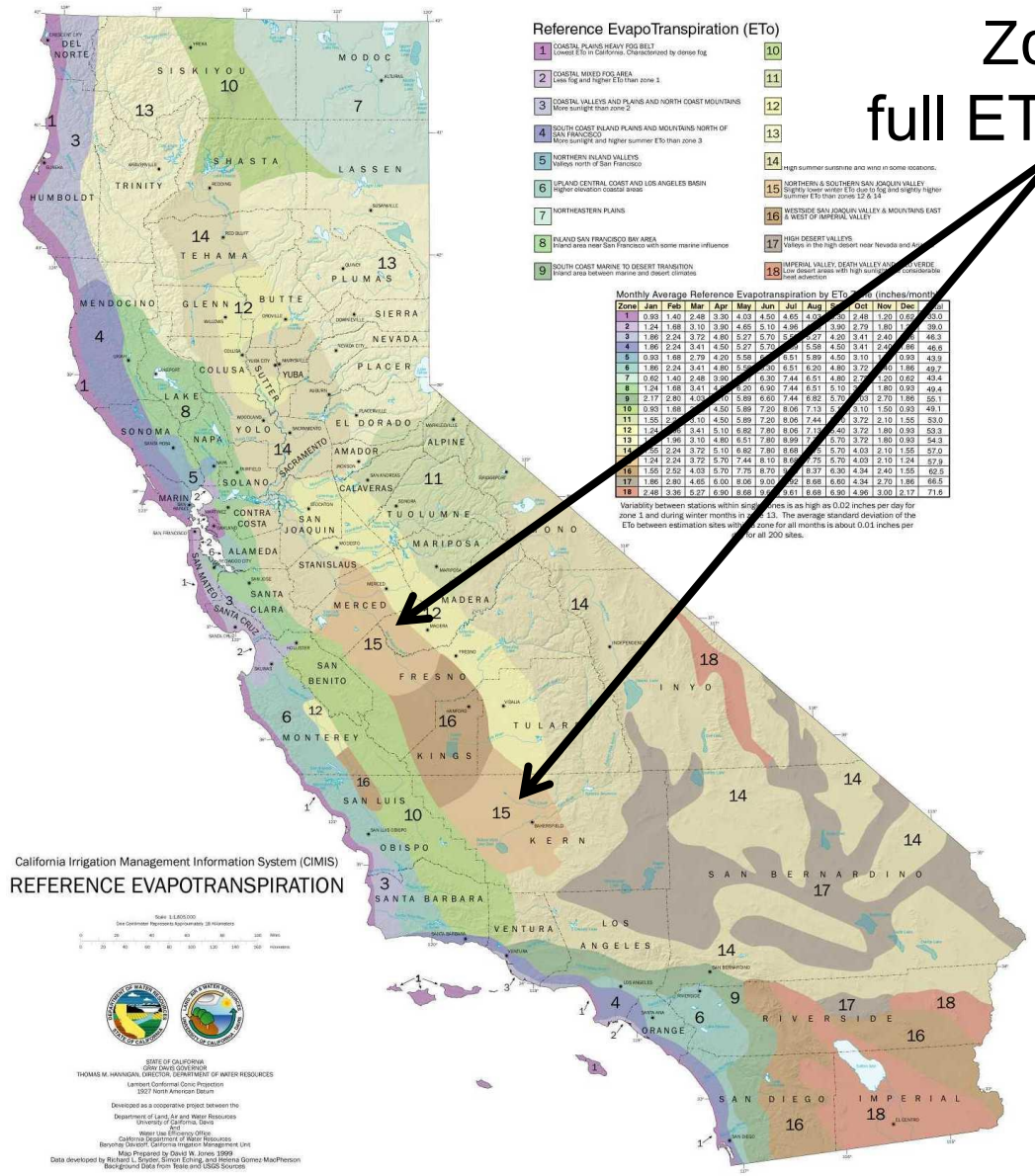
Zone	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1	0.93	1.40	2.48	3.30	4.03	4.50	4.65	4.03	3.30	2.48	1.20	0.62	33.0
2	1.24	1.68	3.10	3.90	4.65	5.10	4.96	4.65	3.90	2.79	1.80	1.24	39.0
3	1.86	2.24	3.72	4.80	5.27	5.70	5.58	5.27	4.20	3.41	2.40	1.86	46.3
4	1.86	2.24	3.41	4.50	5.27	5.70	5.89	5.58	4.50	3.41	2.40	1.86	46.6
5	0.93	1.68	2.79	4.20	5.58	6.30	6.51	5.89	4.50	3.10	1.50	0.93	43.9
6	1.86	2.24	3.41	4.80	5.58	6.30	6.51	6.20	4.80	3.72	2.40	1.86	49.7
7	0.62	1.40	2.48	3.90	5.27	6.30	7.44	6.51	4.80	2.79	1.20	0.62	43.4
8	1.24	1.68	3.41	4.80	6.20	6.90	7.44	6.51	5.10	3.41	1.80	0.93	49.4
9	2.17	2.80	4.03	5.10	5.89	6.60	7.44	6.82	5.70	4.03	2.70	1.86	55.1
10	0.93	1.68	3.10	4.50	5.89	7.20	8.06	7.13	5.10	3.10	1.50	0.93	49.1
11	1.55	2.24	3.10	4.50	5.89	7.20	8.06	7.44	5.70	3.72	2.10	1.55	53.0
12	1.24	1.96	3.41	5.10	6.82	7.80	8.06	7.13	5.40	3.72	1.80	0.93	53.3
13	1.24	1.96	3.10	4.80	6.51	7.80	8.99	7.75	5.70	3.72	1.80	0.93	54.3
14	1.55	2.24	3.72	5.10	6.82	7.80	8.68	7.75	5.70	4.03	2.10	1.55	57.0
15	1.24	2.24	3.72	5.70	7.44	8.10	8.68	7.75	5.70	4.03	2.10	1.24	57.9
16	1.55	2.52	4.03	5.70	7.75	8.70	9.30	8.37	6.30	4.34	2.40	1.55	62.5
17	1.86	2.80	4.65	6.00	8.06	9.00	9.92	8.68	6.60	4.34	2.70	1.86	66.5
18	2.48	3.36	5.27	6.90	8.68	9.60	9.61	8.68	6.90	4.96	3.00	2.17	71.6

Variability between stations within single zones is as high as 0.02 inches per day for zone 1 and during winter months in zone 13. The average standard deviation of the ETo between estimation sites within a zone for all months is about 0.01 inches per day for all 200 sites.

Reference ET (ETo) map from DWR
http://wwwcimis.water.ca.gov

“BASIC IRRIGATION SCHEDULING (BIS)” excel file from
http://biomet.ucdavis.edu/irrigation_scheduling/bis/BIS.htm

Apply the same % of full ET across the season to reach your target total



Zone 15:
full ET total = 53”

Month	Full ET "/week	Full ET Hr/wk*	70% ET Hr/wk
Feb	0.25	6	4
Mar	0.60	14	10
Apr	1.15	28	19
May	1.78	43	30
June	2.15	52	36
July	2.40	58	40
Aug	2.15	52	36
Sep	1.50	36	25
Oct	0.90	22	15
Nov	0.35	8	6
Dec	0.13	3	2
Season Total		53"	37"

* At 1”/24h

Simple approach to drought (i.e., a fixed level of deficit all season)

Month	NORMAL Hr/wk	70% Hr/wk
Feb	6	4
Mar	14	10
Apr	28	19
May	43	30
Jun	52	36
Jul	58	40
Aug	52	36
Sep	36	25
Oct	22	15
Nov	8	6
Dec	3	2

Practical issues that may impact the simple approach

1) Frost protection?
   (might allow later start of irrigation in spring)

2) Lack of flexibility in water deliveries, run times, or run days?
   (may cause feast/famine problems)

3) Salinity management?

3 arguments against a ‘simple approach’

1) What about ‘stress sensitive’ stages?
 - bloom?
 - post harvest?

2) Am I ‘wasting water’ if I just give small amounts?

3) Don’t I need to maintain irrigation at 100% ET early on to avoid the depletion of deep soil water?

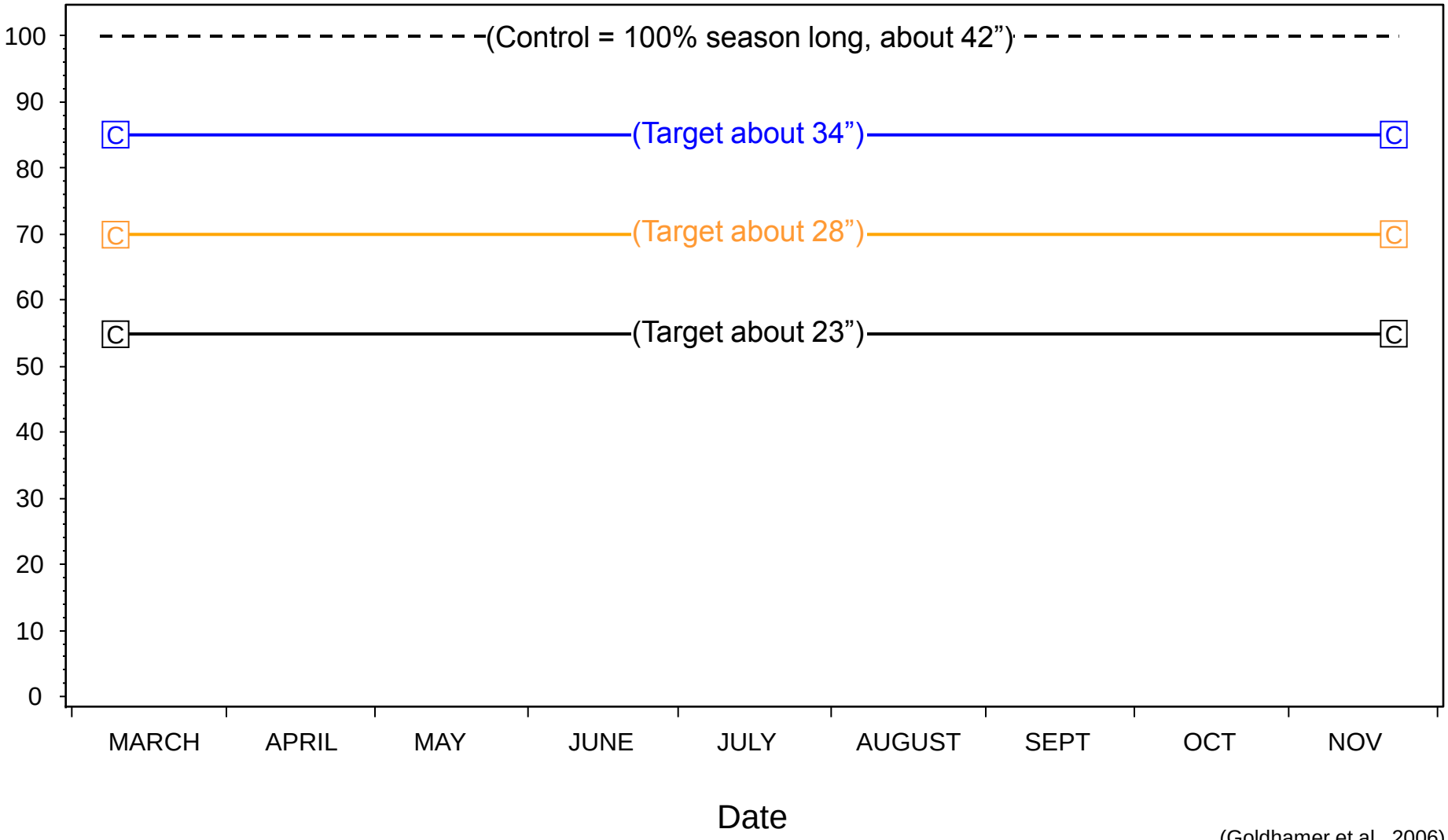
(Specific to cherry: the importance of fruit sizing coupled with a long postharvest period probably means that deficit irrigation should probably focus on the postharvest period)

1) Stress sensitive stages in Almond?

- 1993 -1996 study (Goldhamer et al, 2006), Southern SJV, 18 year-old orchard
- 3’ root zone, 7.5” average rainfall during study (no pre-irrigation)
- Control (100% Etc = 42”)
- 3 levels of irrigation deficit (34”, 28”, 23”) (80%, 67%, 55%)
- 3 patterns of deficit A B C

1) Stress sensitive stages in Almond?

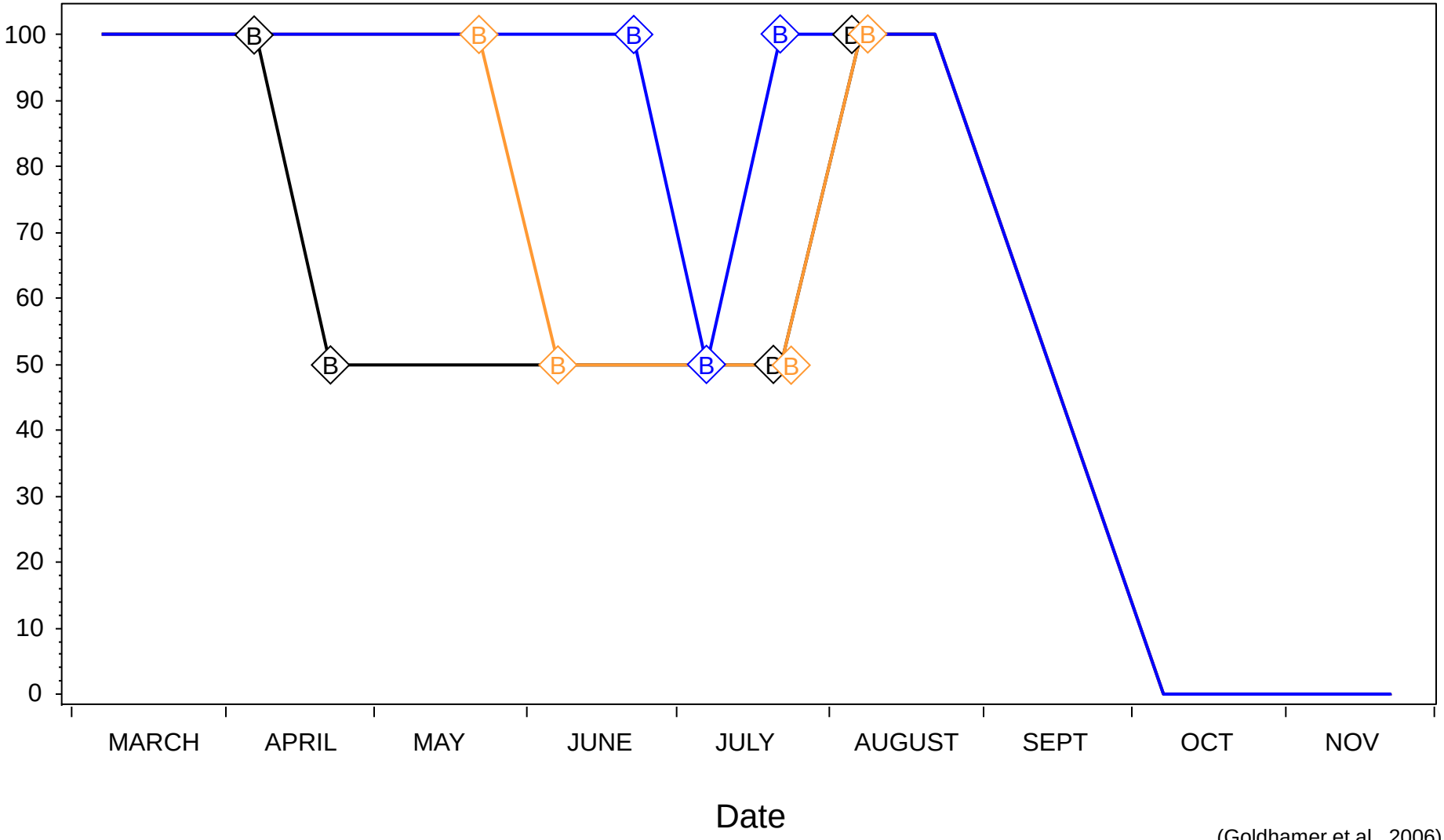
"C" pattern: Equal irrigation deficit all season



(Goldhamer et al., 2006)

1) Stress sensitive stages in Almond?

"B" pattern: Some deficit early, most deficit post-harvest

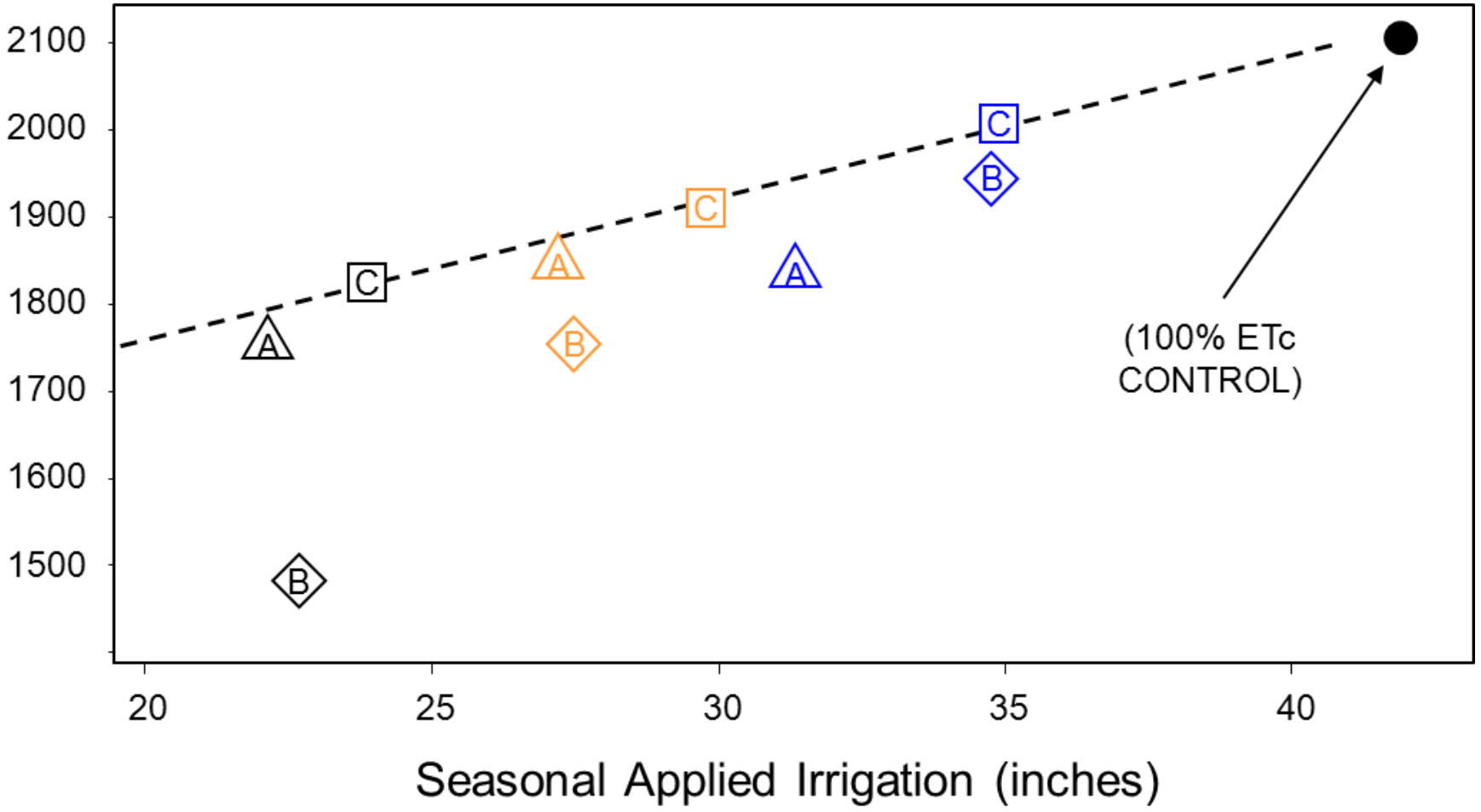


(Goldhamer et al., 2006)

1) Stress sensitive stages in Almond?

Mean Kernel Yield (lbs/ac) 1993-1996

An **even deficit** over the season always gave the best result



(Goldhamer et al., 2006)

2 & 3) Wasting water & deep moisture?

1 year almond drought study, 2009

Water from			
Irrigation	Rain	Soil	Total
0”	2.1”	5.5”	7.6”
3.6”	2.1”	6.7”	12.4”
7.2”	2.1”	5.9”	15.2”
30.8”	2.1”	(?)	(32.9”)

A small amount of irrigation (3.6”) spread evenly over the season resulted in **more use** of deep water than did **no irrigation**.

June 29, 2009

Control tree

- 9 bars SWP

June 29, 2009

10” tree

- 25 bars SWP

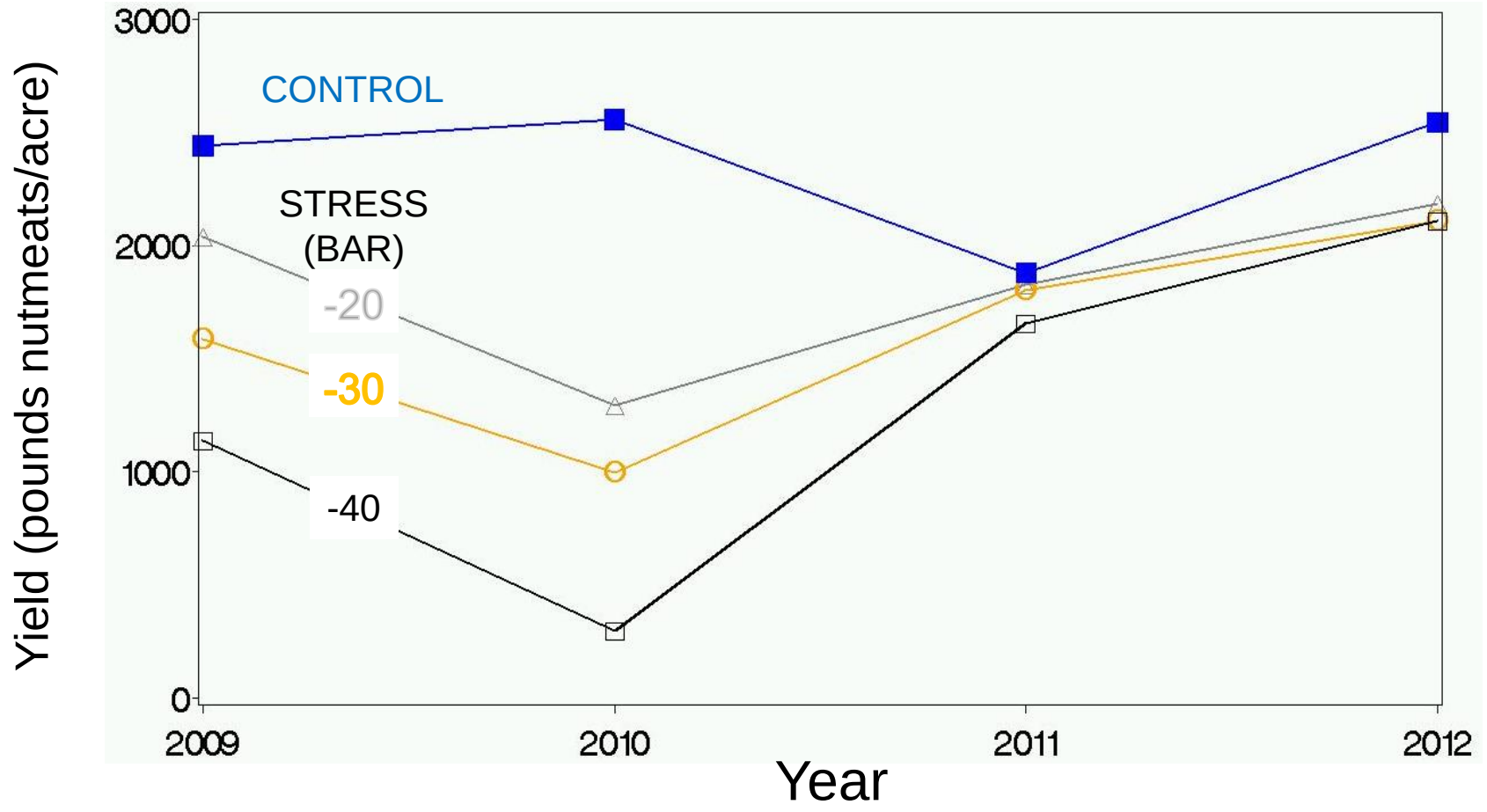
June 29, 2009

0” tree

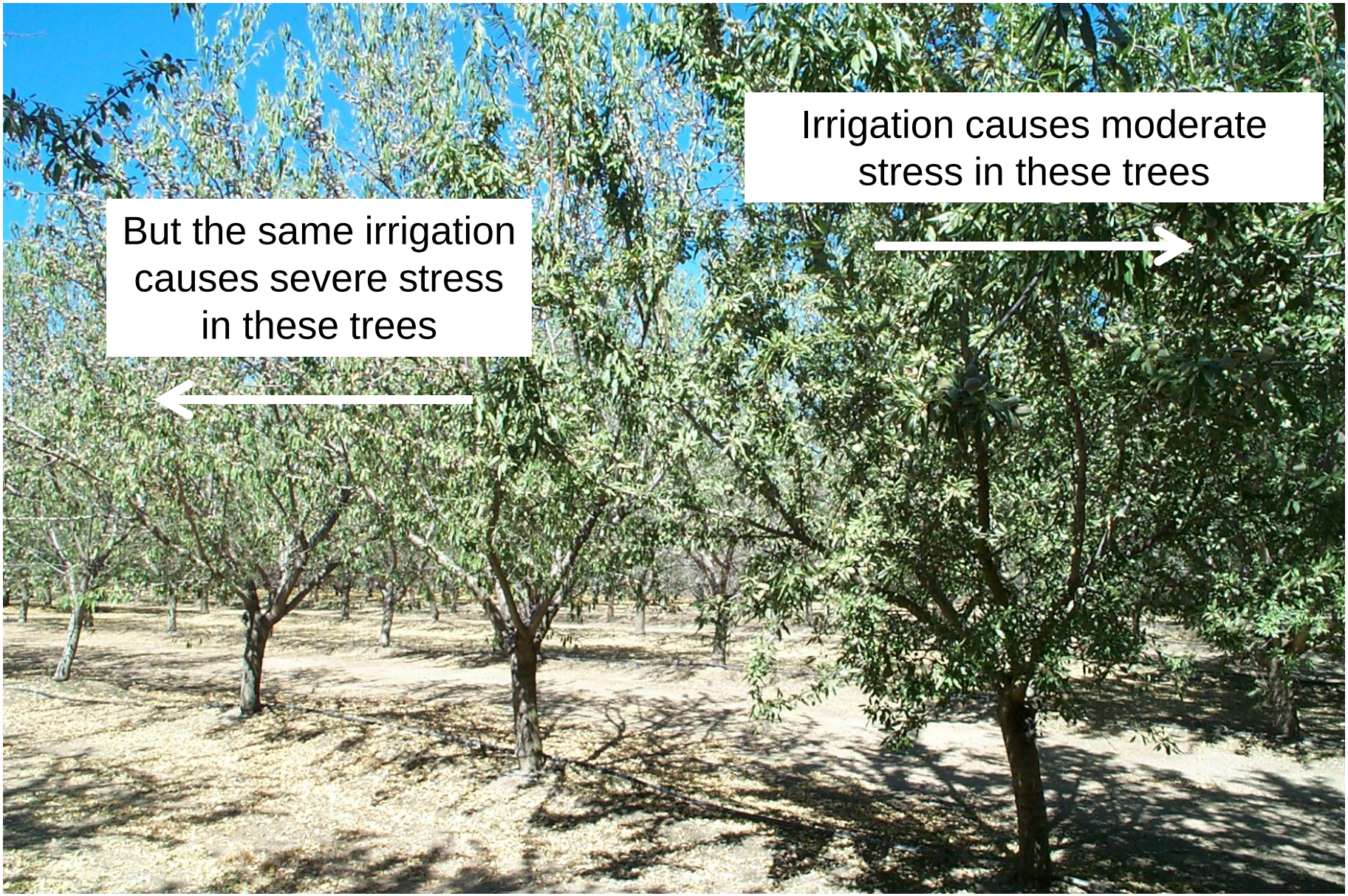
- 40 bars SWP

This tree had reached -63 bars on July 14, 2009, and by July 28 was completely defoliated. But notably, did not die!

Yield: The biggest reduction occurred in the year <u>following</u> the stress (i.e. carryover effect)



Example of field variability in a hull rot deficit irrigation test



Bottom line - conclusions

1) Control weeds, maintain irrigation system and irrigate at a proportion of ‘normal’ (best to use full ETc as ‘normal’) throughout the season.
2) Under deficit irrigation, expect to see differences due to soils.
3) Use the pressure chamber to determine when to start irrigating (tentative: wait for at or below baseline values before starting) and for ‘early warning’ from soils which will present a significant problem later on.
4) Expect a reduced nut/fruit size this year, and reduced bloom and set next year, depending on the degree of deficit.

Thanks for your attention, and thanks to funding and/or cooperation from:

Almond Board of California
USDA-SCRI
Nickels Estate

Colleagues: Bruce Lampinen, Larry Schwankl, Allan Fulton, Sebastian SaaSilva, Patrick Brown, Andres Olivos, Gerardo Spinelli, Hector Munoz, and anybody else I forgot!