

Plant-Based Irrigation Management in Almonds and Other Orchard Crops

Ken Shackel, UCD Plant Sciences
August 14, 2008

The Water Budget Method of Irrigation

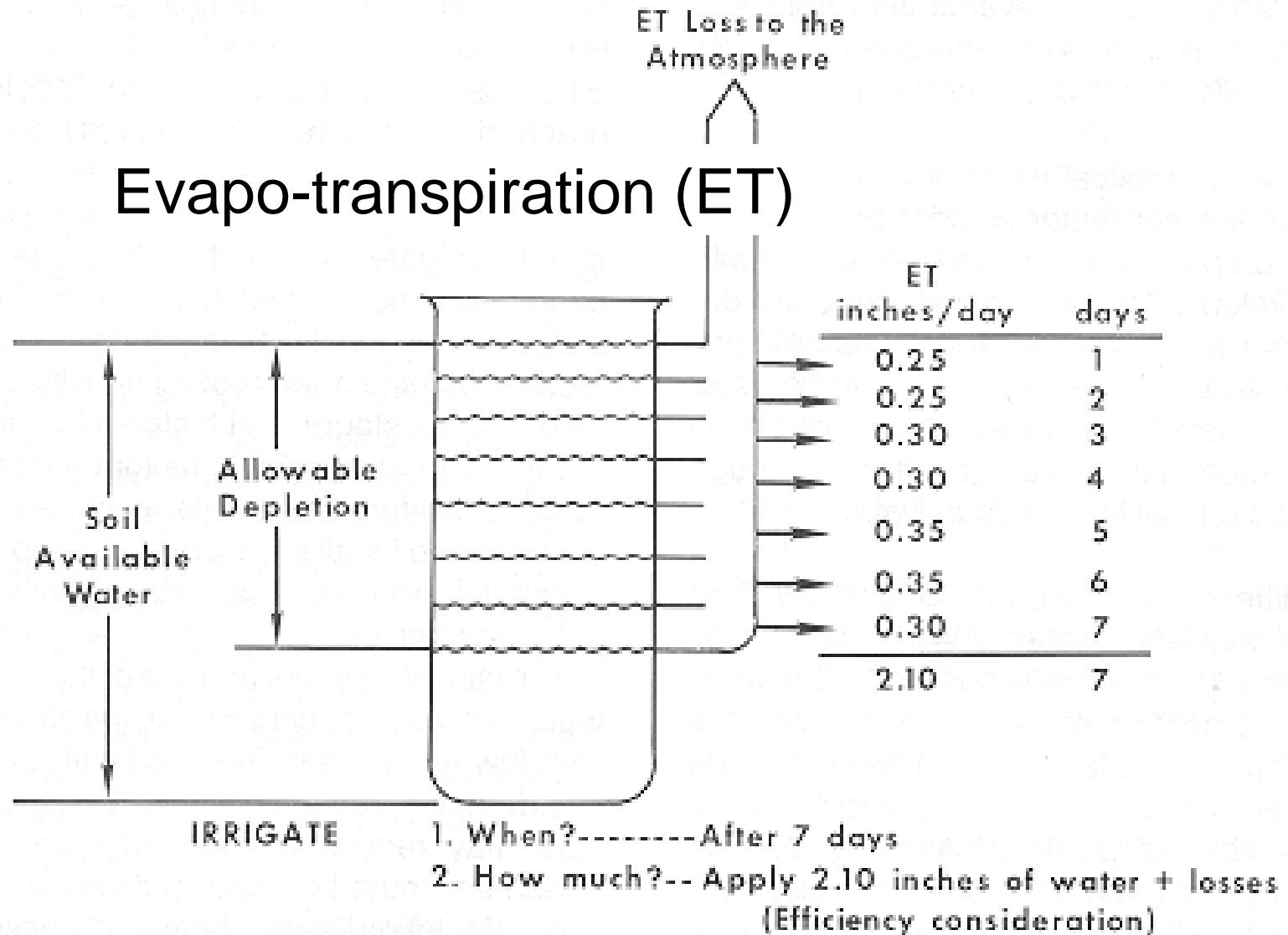
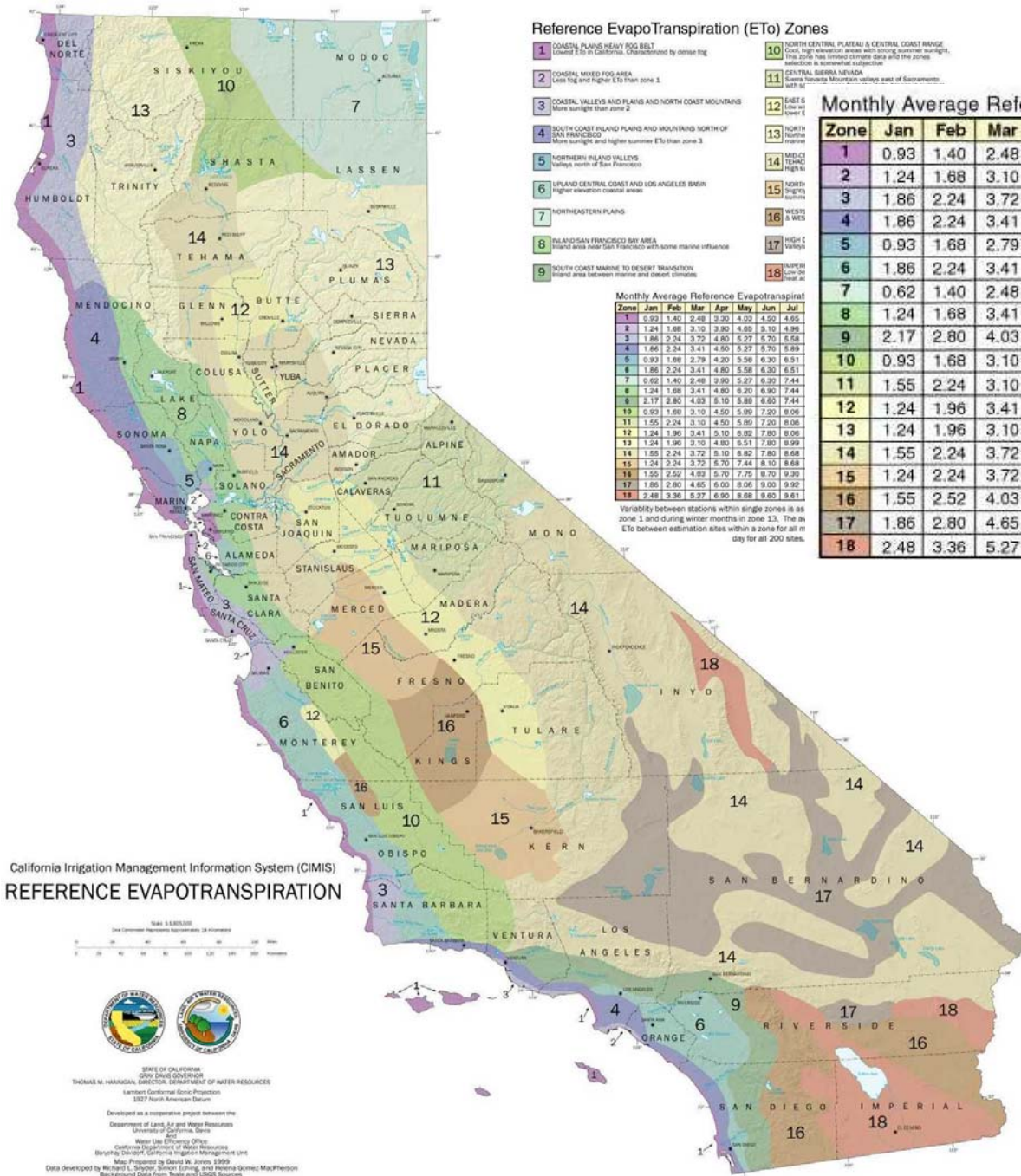


Fig. 2. Water-budget method of irrigation.



California Irrigation Management Information System (CIMIS)
REFERENCE EVAPOTRANSPIRATION



STATE OF CALIFORNIA
GOV. DAVID I. WELLS
THOMAS M. HANCOCK, DIRECTOR, DEPARTMENT OF WATER RESOURCES
Lambert Conformal Conic Projection
1927 North American Datum

Developed as a cooperative project between the
Department of Land, Air and Water Resources
University of California, Davis
Water Use Efficiency Office
California Department of Water Resources
Bartlett D. Dwyer, California Irrigation Management Unit
Map Prepared by David W. Jones, 1999

Data developed by Richard L. Snyder, Simon Ewing, and Pamela Gomez MacPherson
Background Data From: Tolls and USGS Sources



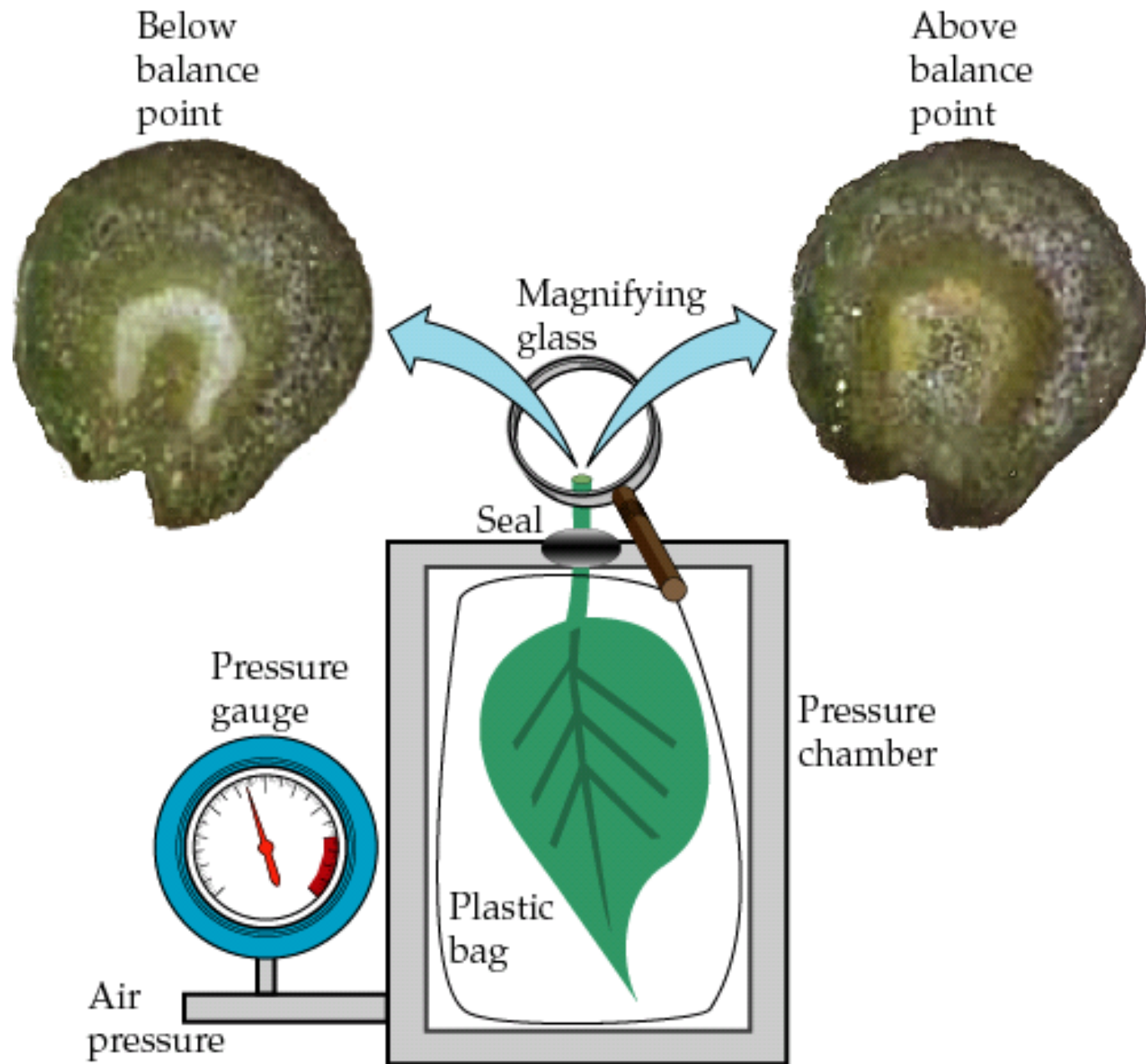
Figure 2-2 Normal (left) and wilted (right) *Coleus* plants. The normal appearance of a plant is dependent upon having sufficient water in the cells to provide turgidity. The wilted plant recovered completely after watering. Note that the youngest leaves on the wilted plant are still quite turgid.



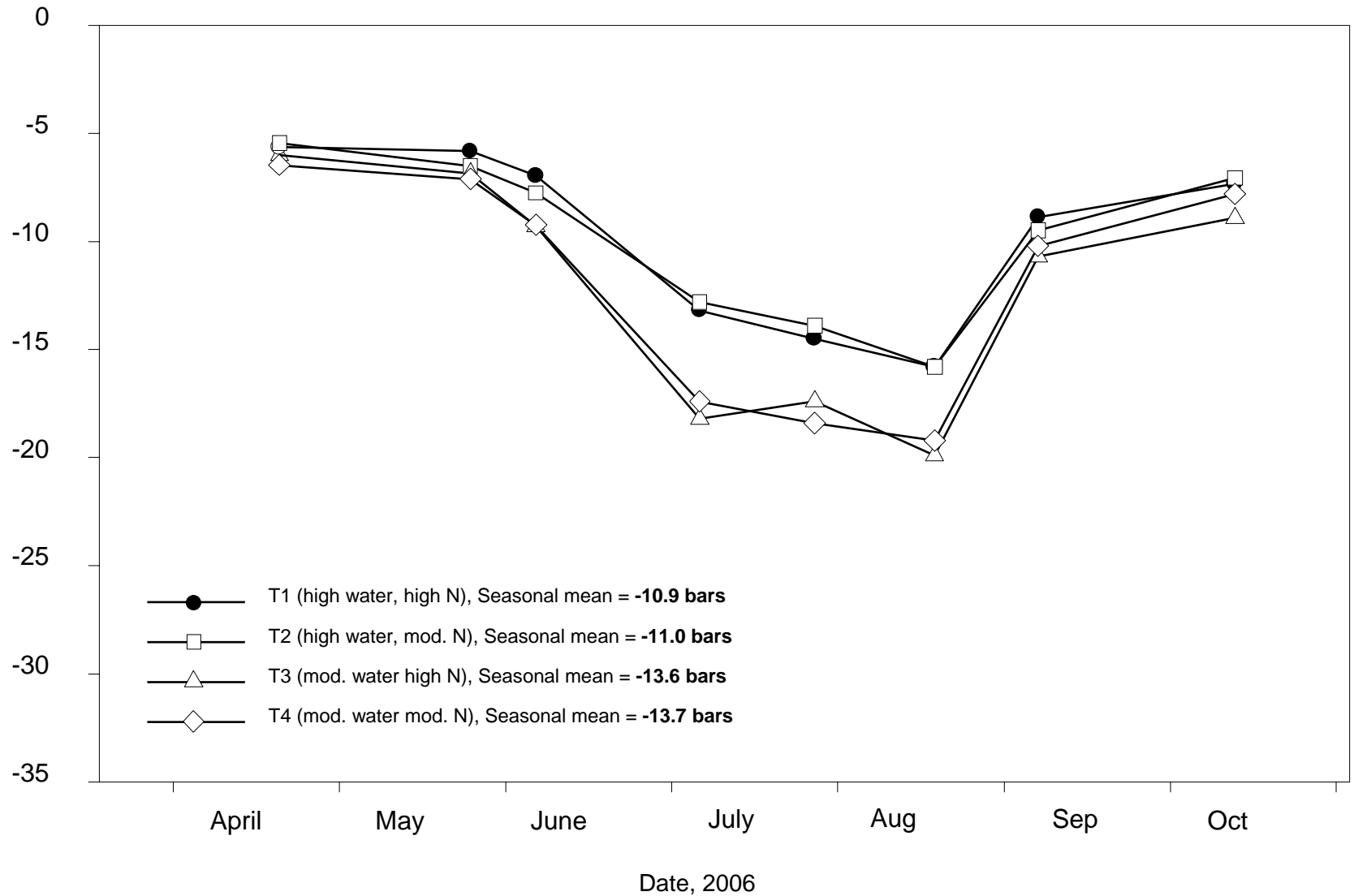








Example: **Midday** stem water potential (bars) in 2006,
Lampinen et al., Spur Dynamics



Almonds, one seasons growth:
Dry treatment (SWP about -15 bars)



Almonds, one seasons growth:
Medium treatment (SWP about -12 bars)



Almonds, one seasons growth:
Wet treatment (SWP about -8 bars)



TENTATIVE GUIDELINES FOR INTERPRETING PRESSURE CHAMBER READINGS (MIDDAY STEM WATER POTENTIAL-SWP) IN WALNUT, ALMOND, AND DRIED PLUM. UPDATED MAY 2007.

Allan Fulton and Richard Buchner, UCCE Farm Advisors, Tehama County, Joe Grant, Farm Advisor, San Joaquin County, Terry Prichard, Bruce Lampinen, Larry Schwankl, Extension Specialists, UC Davis, and Ken Shackel, Professor UC Davis.

Pressure Chamber Reading (- bars)	WALNUT	ALMOND	PRUNES
0 to -2.0	Not commonly observed	Not commonly observed	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.	Low stress, indicator of fully irrigated conditions, ideal conditions for shoot growth. Suggest maintaining these levels from leaf-out through mid June.	Low stress, common from March to mid April under fully irrigated conditions. Ideal for maximum shoot growth.
-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.	↓	Suggested levels in late April through mid June. Low stress levels enabling shoot growth and fruit sizing.
-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.	Mild to moderate stress, these levels of stress may be appropriate during the phase of growth just before the onset of hull split (late June).	Suggested mild levels of stress during late June and July. Shoot growth slowed but fruit sizing unaffected.
-12.0 to -14.0	Relative high levels of stress, moderate to severe defoliation, should be avoided.	↓	Mild to moderate stress suggested for August to achieve desirable sugar content in fruit and to reduce "dry-away" (drying costs).
-14.0 to -18.0	Severe defoliation, trees are likely dying.	Moderate stress in almond. Suggested stress level during hull split, Help control diseases such as hull rot and alternaria, if diseases are present. Hull split occurs more rapidly	Moderate stress acceptable in September.
-18.0 to -20.0	Crop stress levels in English walnut not observed at these levels.	Transitioning from moderate to higher crop stress levels	Moderate to high stress levels. Most commonly observed after harvest. Generally undesirable during any stage of tree or fruit growth. Most appropriately managed with post-harvest irrigation
-20 to -30	↓	High stress, wilting observed, some defoliation	
Less than -30	↓	Extensive defoliation has been observed	High stress, extensive defoliation

* These guidelines are tentative and subject to change as research and development with the pressure chamber and midday stem water potential progress. This table should not be duplicated without prior consent by the authors.

RDI: “Regulated Deficit Irrigation”

Concept: Mild to moderate levels of water stress, at the correct time, may *benefit* horticultural crop production or quality, or at least save water without reducing production or quality.

Almond hull split



Proposed benefits of RDI for almonds during hull split:

- 1) Speed up Hull Split
- 2) Reduce Hull rot
- 3) Reduce Sticktights (Improve Harvestability)
- 4) Save Water

5-9-02

WEST
(gravel)

EAST
(silt)



% Hull Split, Carmel variety

(East/West difference similar in all varieties)

	Date, 2000					
	10 Aug	16 Aug	22 Aug	31 Aug	6 Sep	14 Sep
East (Average SWP = -8.4 bars)	0%	0%	5%	13%	32%	40%
West (Average SWP = -14.1 bars)	4%	23%	60%	83%	85%	91%

Problems with uneven hull split timing:

- Uncertain timing for hull split spray
- Irrigation management problems
- Uneven/delayed harvest

NonPareil variety (Corning) – Hull Split (RDI treatment)

2001:

East (silt)

Date	JUL 13	JUL 20	JUL 27	AUG 1	AUG 13
% HS	2	20	45	70	100

West (gravel)

Date	JUL 13	JUL 20	JUL 27	AUG 1	AUG 13
% HS	2	25	55	75	100

2003:

East (silt)

Date	JUL 29	AUG 7	AUG 15	AUG 22
% HS	29	96	100	100

West (gravel)

Date	JUL 29	AUG 7	AUG 15	AUG 22
% HS	29	88	100	100

Corning location –irrigation summary (RDI)

Soil	2002		2003		2004	
	Water applied	Cutoff date	Water applied	Cutoff date	Water applied	Cutback date
East (silt)	24"	10-Jul	14"	1-Jul	18"	7-Jun
West (gravel)	40"	25-Aug	41"	4-Sep	36"	16-Sep
ETc	43"		40"		42"	

Very long cutoff/cutback OK on East (silt) soil

2001 - 2004 Almond RDI sites:

County	Location	Soil type	Age (yr)	Irrigation
Tehama	Corning(E)	Silt-Loam	9	Microsprinkler
Tehama	Corning (W)	Gravel-Loam	9	Microsprinkler
Butte	Chico	Vina-Loam	9	Solid-set Sprinkler
Colusa	Arbuckle	Gravel-Loam (II)	13	Single line drip
Solano	Dixon	Yolo-S/CLoam	8	Solid-set Sprinkler
Madera	Madera	Dinuba FSL	10	Microsprinkler
Kern	Shafter	Sandy Loam	15	Microsprinkler

Question: Can we use RDI in the same location(s) over many years without reducing yield?

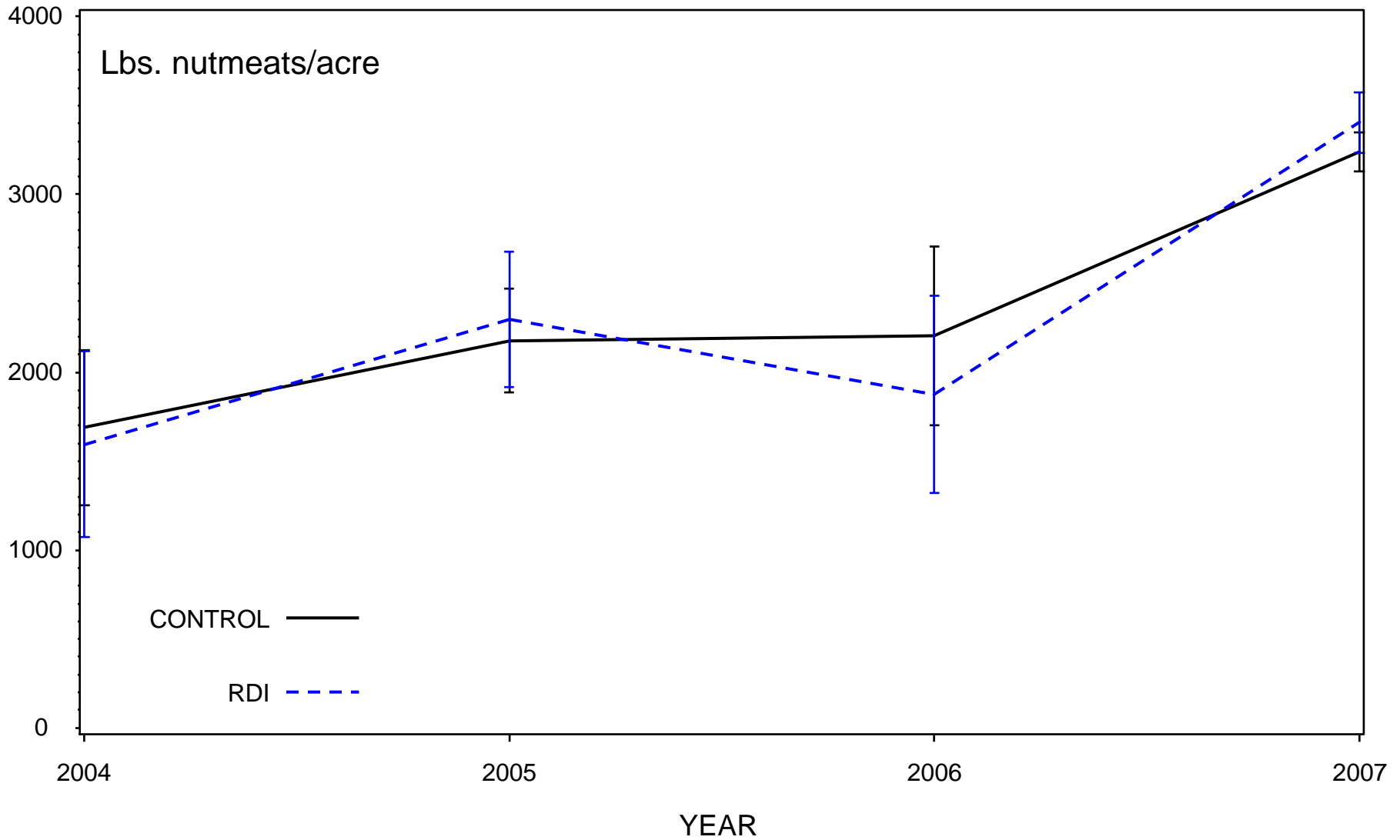
Four year yield summary

(lbs. nutmeats per acre)

	2001	2002	2003	2004
<u>Treatment</u>	<u>(2 sites)</u>	<u>(7 sites)</u>	<u>(7 sites)</u>	<u>(7 sites)</u>
Grower	2,400	3,170	2,860	2,650
RDI	2,430	3,080	2,660	2,680

Magnum Ranch, Lassen Land co. RDI study.

Nutmeat yields, 2004 - 2007



Benefits of RDI (mild stress)
for almonds during hull split:

- 1) Speed up Hull Split (use water as a management tool)
- 2) Reduce Hull rot
- 3) Reduce Sticktights (Improve Harvestability)
- 4) Save Water
- 5) No negative impact on yield

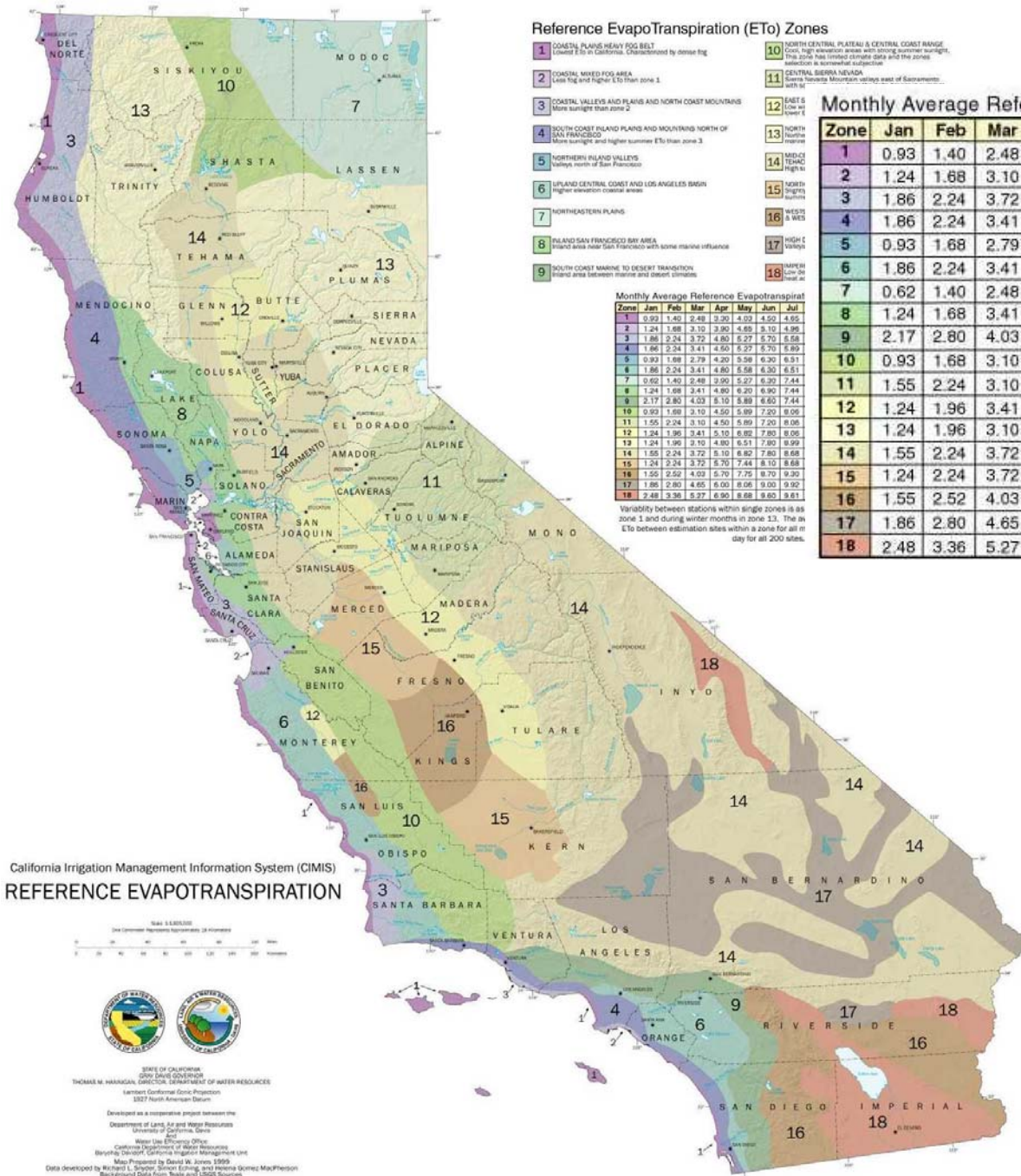
Benefits of RDI in Prunes:

- 1) Increase fruit sugar concentration
- 2) Decrease fruit water content and drying costs
- 3) Increase flower density and yield
- 4) Save Water

Tehama county (Vina) prune irrigation record

(monastery site, 1999, normally irrigated every 2 weeks)

Date	Recommended	Observed	(Fully irrigated value)
April 29	-8 to -10	-6.5	(-6.8)
May 6		-7.2	(-6.4)
May 12		-8.5	(-7.3)
May 18		-8.6	(-5.7)
May 20	IRRIGATE		
May 25	-8 to -10	-5.5	(-6.7)
June 4 (rain June 2)		-5.4	(-5.5)
June 10 (...June 24)		-7.4	(-8.2)
July 1	-10 to -12	-10.4	(-9.4)
July 2	IRRIGATE		
July 13 (...July 27)	-10 to -12	-8.4	(-9.2)
August 2	-12 to -14	-10.1	(-7.2)
August 5	IRRIGATE		
August 9 (...August 23)	-12 to -14	-8.0	(-8.0)
August 30		-10.5	(-6.7)
Mid-September	HARVEST		
September 24	IRRIGATE		
September 27	-14 to -18	-6.7	(-6.7)



California Irrigation Management Information System (CIMIS)
REFERENCE EVAPOTRANSPIRATION



STATE OF CALIFORNIA
GOV. DAVID I. BECKWITH
THOMAS M. HANCOCK, DIRECTOR, DEPARTMENT OF WATER RESOURCES
Lambert Conformal Conic Projection
1927 North American Datum

Developed as a cooperative project between the
Department of Land, Air and Water Resources
University of California, Davis
Water Use Efficiency Office
California Department of Water Resources
Beverly D. Davis, California Irrigation Management Unit
Map Prepared by David W. Jones, 1999

Data developed by Richard L. Snyder, Simon Ewing, and Pamela Gomez MacPherson
Background Data From: NOAA and USGS Sources