Tree Physiology: Young Trees and Orchard Management

December 8, 2016

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Tree Physiology: Young Trees and Orchard Management

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Young Trees and Orchard Management

Ted DeJong (Dept of Plant Sciences)

Reviewing Fundamentals

Katherine Pope (UC ANR – Sacramento, Solano, Yolo, Orchard Systems Advisor)

Developing the Canopy

Ken Shackel (Dept of Plant Sciences)

Managing Irrigation

The Fundamentals:

The overall objective of all cropping systems is **to maximize resource capture** and **optimize resource use** to achieve sustainable economic yields.

What resources are we mainly interested in?

- Light energy
- Carbon, Hydrogen and Oxygen for creating Carbohydrates
- Water
- Mineral Nutrients

Nutrients important for carrying out photosynthesis and developing canopies and almond kernels.

Macro Nutrients

- **Nitrogen**
- Phosphorus
- **Potassium**
- Calcium
- Magnesium
- Sulfur

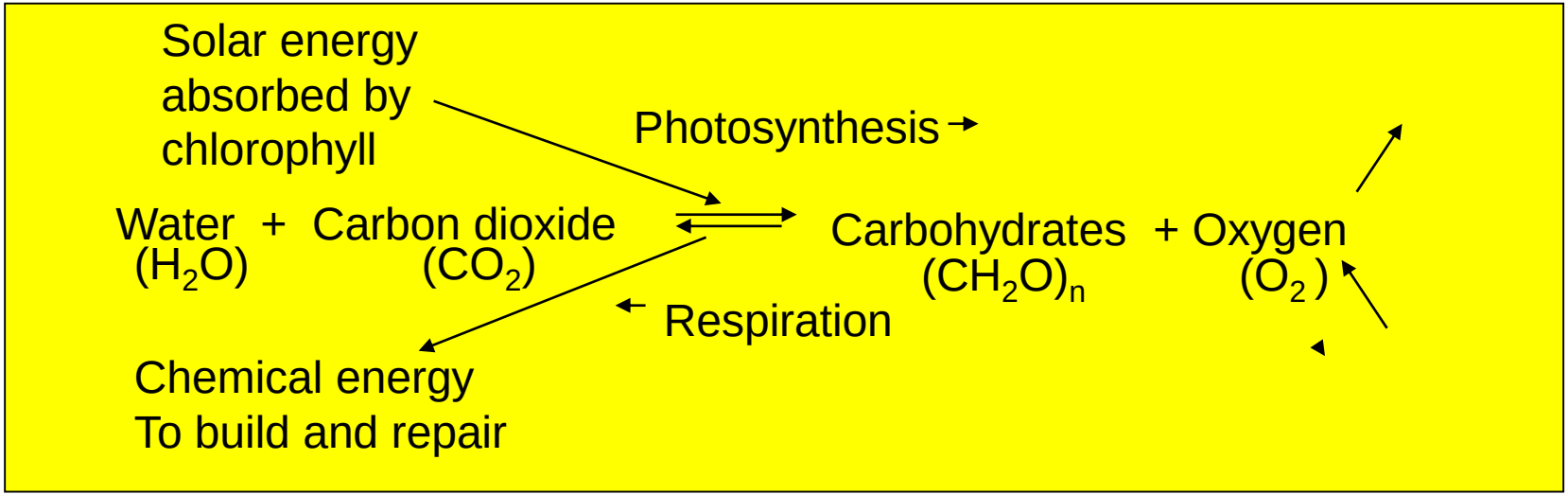
Micro Nutrients

- **Zinc**
- **Iron**
- Boron
- Manganese
- Copper
- Chlorine
- Nickel
- Molybdenum

Where do the Carbohydrates come from?

PHOTOSYNTHESIS!

The basic photosynthesis/respiration reactions
(the most important processes for supporting life on the planet)

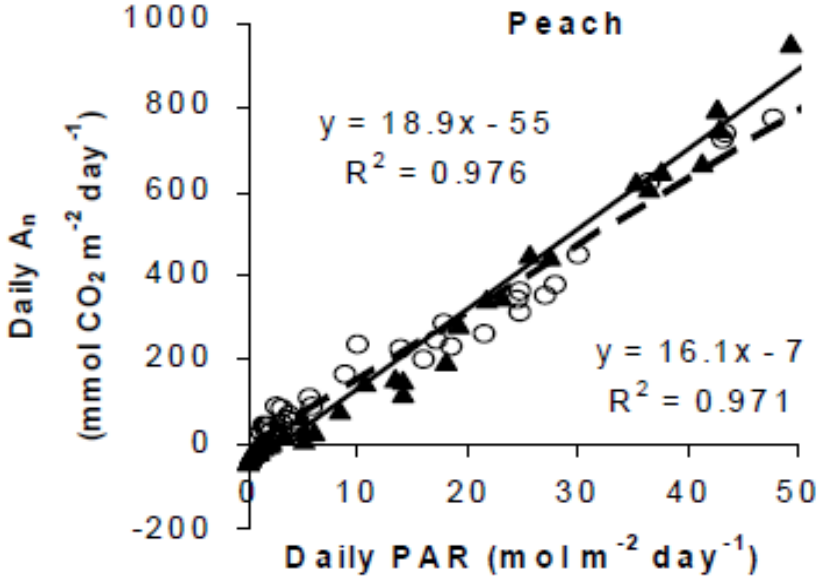


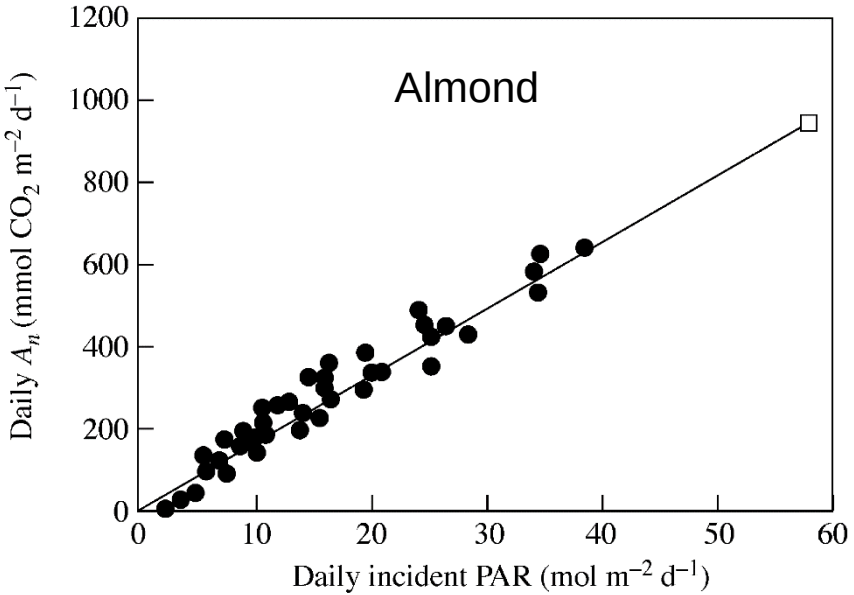
Plants: nature's original solar energy collectors

- What are nature's natural solar energy cells?

➔Chloroplasts

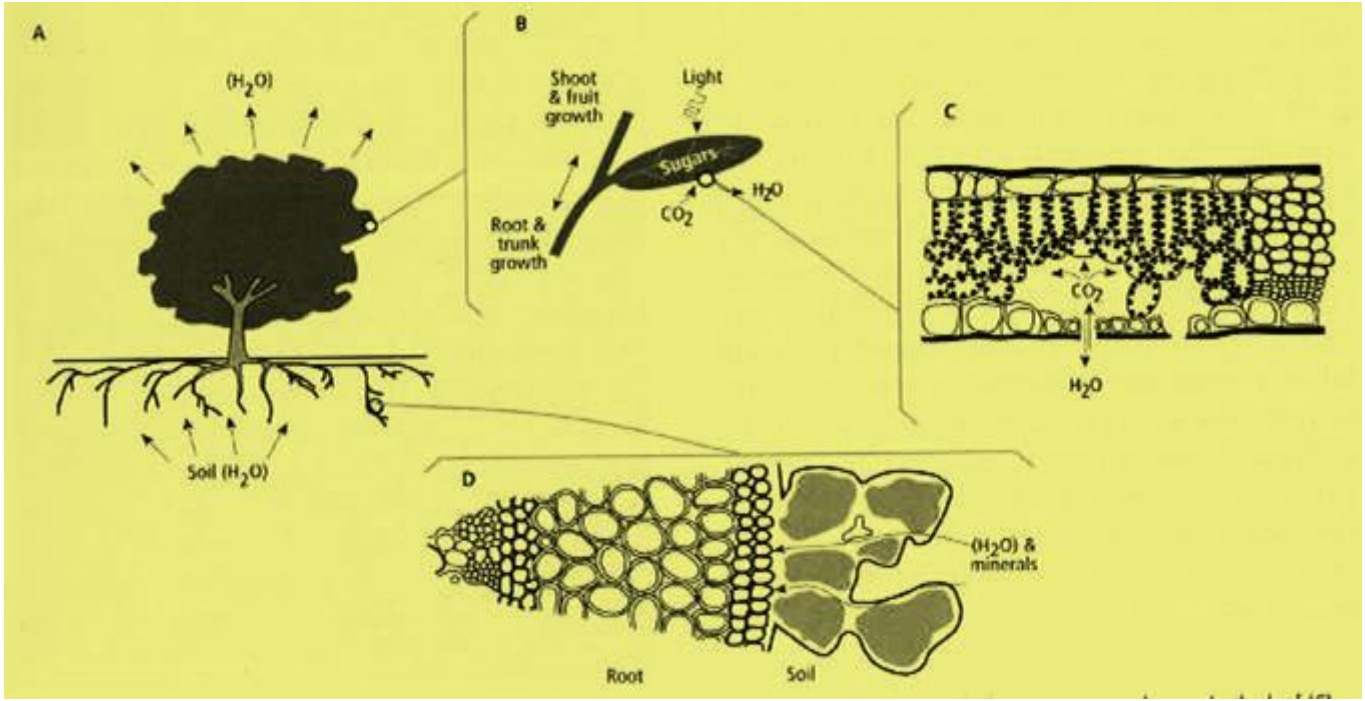
Under non-stress conditions, canopy photosynthesis is a direct function of the light intercepted by the canopy during a day.





Rosati, et al. 2002. Acta Hort. 584: 89-94
Rosati, et al. 2004. Annals of Botany 93:567-574

However, carrying out photosynthesis is always a compromise between taking up CO_2 and losing H_20.



Carbon and nitrogen distribution is mainly controlled by the development and growth patterns of individual organs and their ability to compete for these nutrients.

- A tree is a collection of semi-autonomous organs and each organ type has an organ- specific developmental pattern and growth potential.
- Organ growth is activated by endogenous and/or environmental signals.
- Once activated, environmental conditions and genetics determine conditional organ growth capacity.
- Realized organ growth for a given time interval is a consequence of organ growth capacity, resource availability and inter-organ competition for resources.
- Inter-organ competition for resources is a function of location relative to sources and sinks of nutrients, transport resistances, organ sink efficiency and organ microenvironment.

Bottom line: ***The tree does not allocate nutrients to organs, organ growth and respiration takes it from the tree.***

➔***Your job is to insure these nutrients are available for growth.***

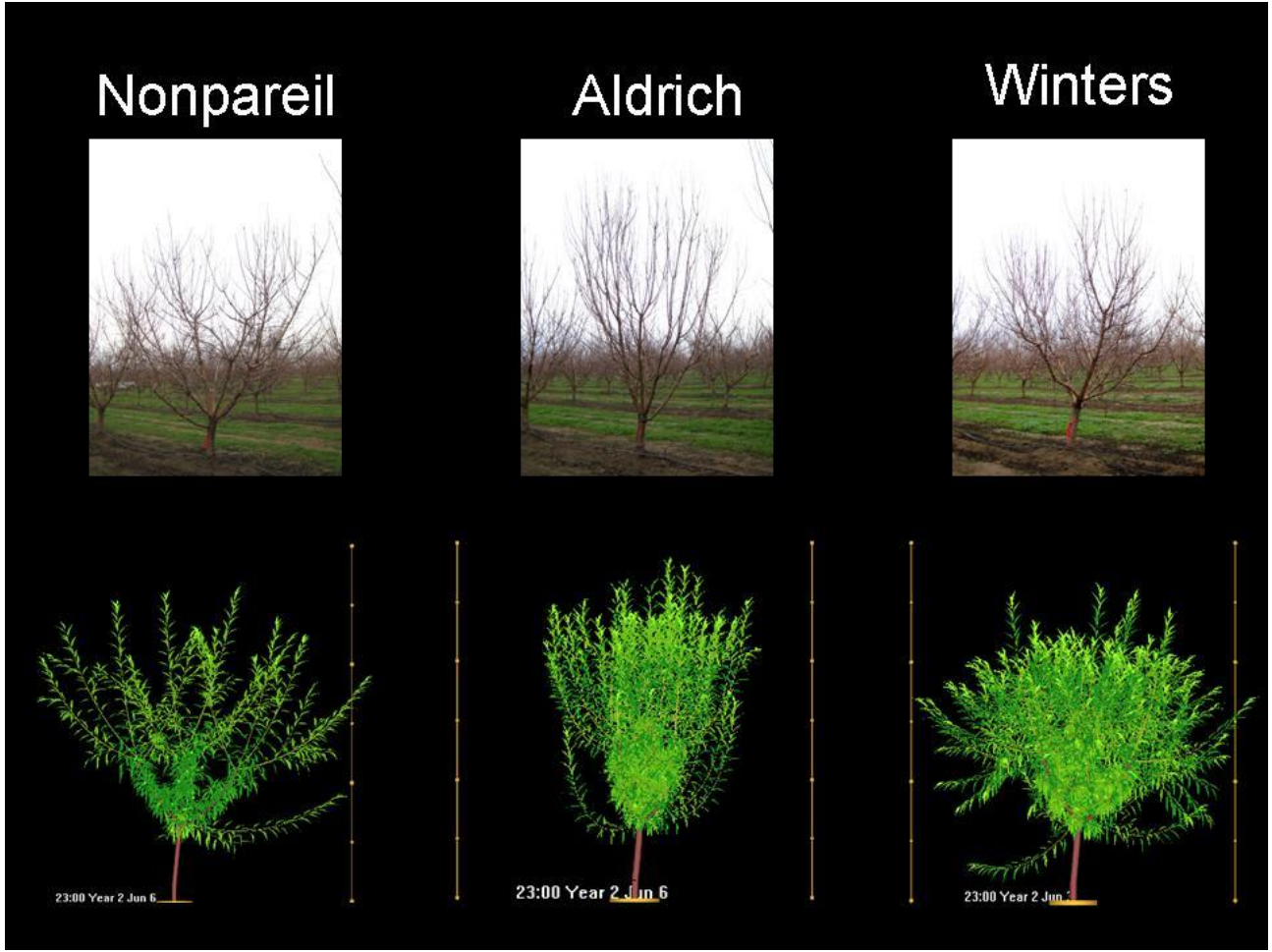
Using these principles to simulate tree growth and productivity over time.

Results from a 3-dimensional computer graphics based simulation model called L-Almond

This model calculates the photosynthesis of each leaf and the uptake of water by the tree, then these resources are distributed around the tree using the previously stated organ development and growth principles.

The growth of three almond cultivars simulated with the L-Almond model.

Note: canopy density is strongly influenced by tree branching habit.



The tree provides resources (CH_2O, H_2O, nutrients) through uptake processes, tree organs use them.

- ***Organ use of resources*** is dictated by ***organ growth and development***.
- ***Organ development and growth*** dictate tree growth and fruit production (**not *vice versa***).

Why does this matter? Growers need to ***manage trees to optimize resource capture*** and to ***manage organs to optimize organ growth to attain high crop yields***.

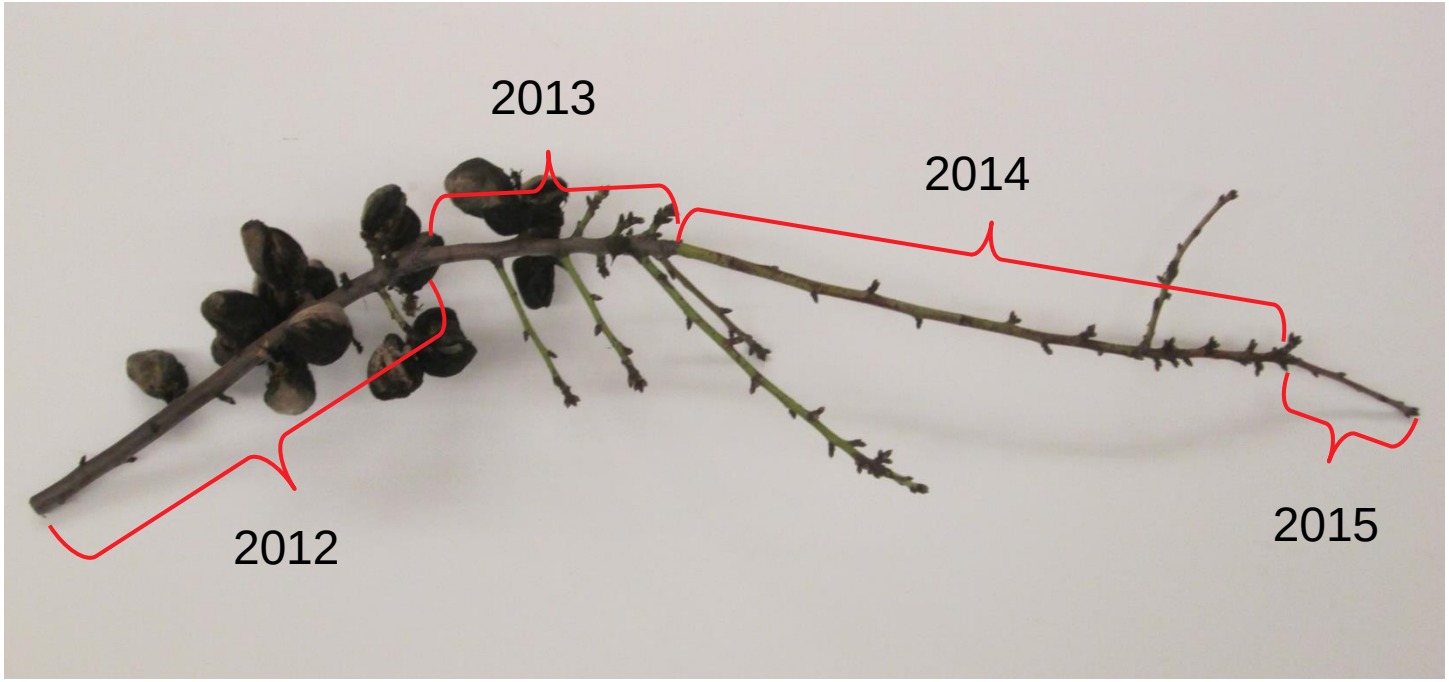
Spurs – the organ of interest
Almond spur population dynamics

- Most of you probably think about growing almonds as managing orchards or trees but I would like to emphasize that growing almonds is really about managing productive spur populations. At orchard maturity most almonds are produced on spurs. So **establishing healthy spur populations is the key to early yields.**

Bearing habit of almond shoots

4-year-old almond branch.

Nuts are primarily produced on spurs on older wood.



Bottom Line

- **Early almond orchard yields are dependent on rapid establishment of large canopies to intercept light for photosynthesis along with healthy populations of spurs for bearing fruit.**

- **However, this needs to be balanced against the need to establish a strong tree framework that can bear large crops and be efficiently managed for the life of the orchard.**

Katherine Pope, UCCE-Yolo, Solano, Sacramento Counties

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Developing the Canopy – Top 3

Top 3 - Principles

1) Keep it clean and sharp!

2) Types of Cuts
   - Thinning → Direct growth, clean out dead wood
   - Heading → Vigorous regrowth just below cut

3) Remember: All pruning is dwarfing

Top 3 – How To

(1st & 2nd Dormant)

1st: Remove obvious losers

2nd: Pick best based on
- ✓ Angle
- ✓ Spacing
- ✓ Orientation

3rd: Head at 42-48” (optional 2nd)

How Pruning Works

- Pruning changes resource and hormone balance
- Response depends on
  - Timing of cut (Growing or Dormant)
  - Type of cut (Thinning or Heading)
- But remember:

  All Pruning is Dwarfing, it's just a matter of *how* dwarfing. Because you are removing nutrients, carbohydrates and sugar-making leaves.

How Pruning Works: Timing

- Dormant pruning:
  - As early as October.
  - Creates vigorous regrowth in spring near where cut made.
  - Roots, trunk store most energy. When wake in spring, more energy/grow point.
  - So, harder prune → more localized, heavy regrowth
  - But Remember: Regrowth will never be more than the total growth you could have had *without* pruning.

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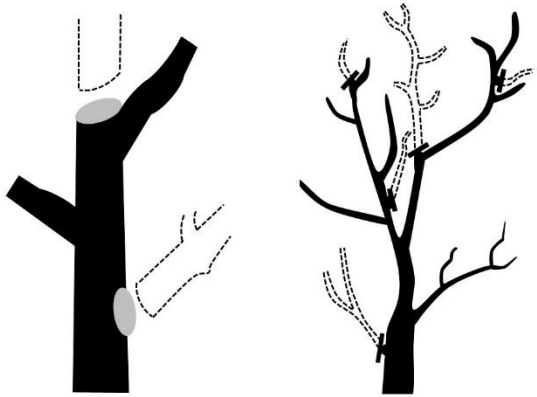
  - But Remember: Regrowth will never be more than the total growth you could have had *without* pruning.
- Summer pruning:
  - More dwarfing than dormant pruning
  - Reduces regrowth
  - Removes energy before it can be sent to reserves
  - Early summer pruning can help direct growth

How Pruning Works: Type of Cut

Thinning Cuts

- Goal: Direct growth; remove dead/diseased wood
- How: Remove limb at point of origin. Leave branch collar



How To: Thinning Cuts

How Pruning Works: Type of Cut

Thinning Cuts

- Goal: Direct growth; remove dead/diseased wood
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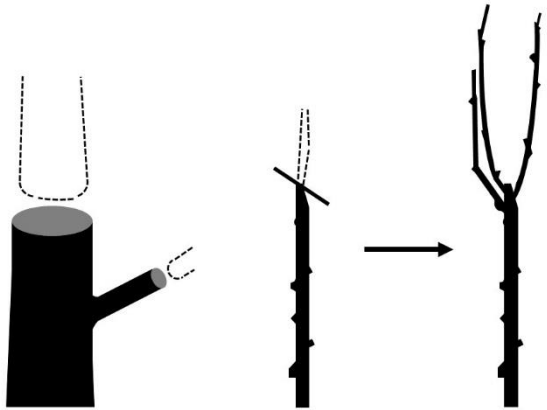
Heading Cuts

- Goal: Encourage regrowth of several vigorous shoots
- How: Removal branch end. Buds below cut will push.



How To: Heading Cuts

Developing the Canopy – Top 3

Top 3 - Principles

1) Keep it clean and sharp!

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3) Remember: All pruning is dwarfing

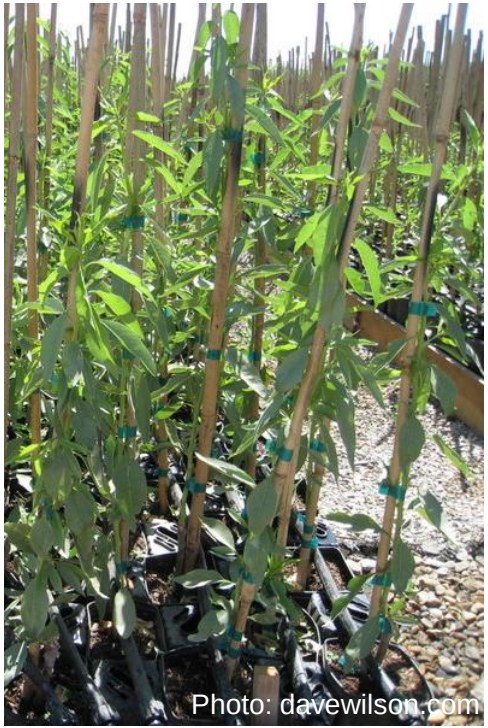
Training Young Trees

- Keep in mind: Vigor, wind, storms, spacing, cultivar, rootstock

- The larger the tree will eventually be, the more critical it is to get training right.

Training Young Trees: At Planting

- Potted: If < 42” of trunk growth, let grow for season, then treat like bare root.



Training Young Trees: At Planting

- Potted: If < 42” of trunk growth, let grow for season, then treat like bare root.
- Bare Root: Top at ~36” at planting (room for shaker head). 42-48” if 5+ scaffolds for spacing.


Photo: youtube.com/watch?v=405GJTRk1Tg

Training Young Trees: 1st Dormant

- Select scaffolds, then head them
- *Selection Goal:* Pick strong, well anchored branches, that won't break or split from trunk with weight of future crops.
- *Heading Goal:* Direct growth of next season's secondary scaffolds
- 1st: Remove obvious losers
- 2nd: Pick best based on angle, spacing, orientation.
- 3rd: Head at 42-48"

Training Young Trees: 1st Dormant

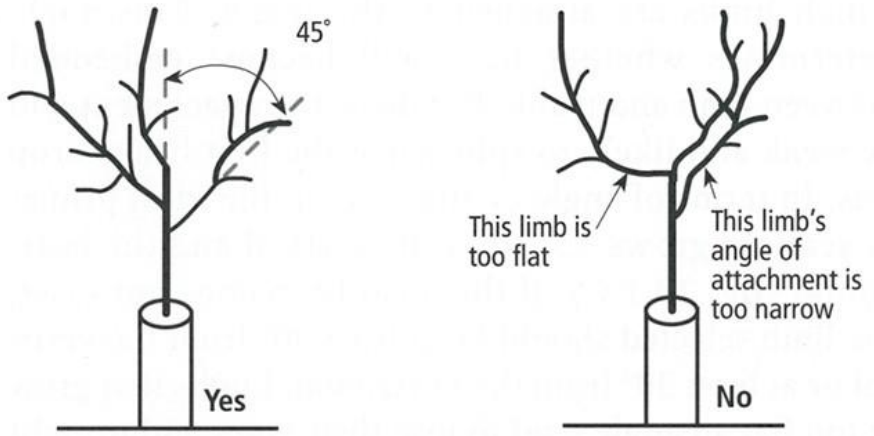
Scaffold Selection

- 1st: Remove obvious losers (cross middle, bad angle)

Training Young Trees: 1st Dormant

Scaffold Selection

- 1st: Remove obvious losers (cross middle, bad angle)
- 2nd: Pick the best of what's left
  - Angle

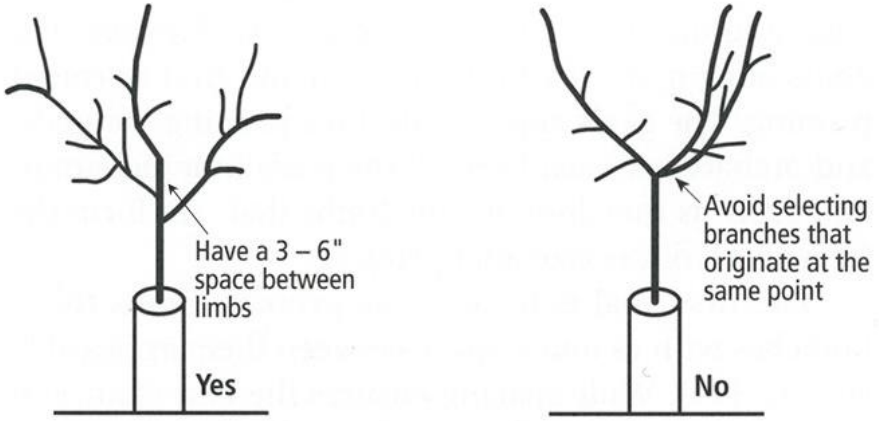


A. Ideally, the angle of branch attachment to the trunk should be close to 45° to be strong and to maintain vigor.

Training Young Trees: 1st Dormant

Scaffold Selection

- 1st: Remove obvious losers (cross middle, bad angle)
- 2nd: Pick the best of what's left
  - Angle
  - Spacing



B. Try to select limbs that have vertical spacing up and down the trunk.

Training Young Trees: 1st Dormant

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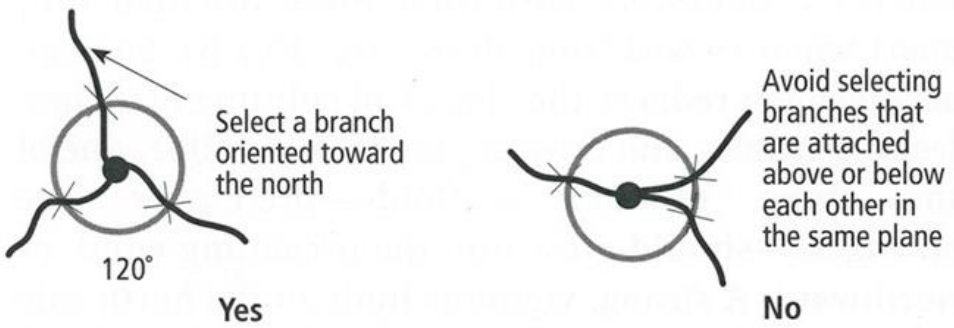


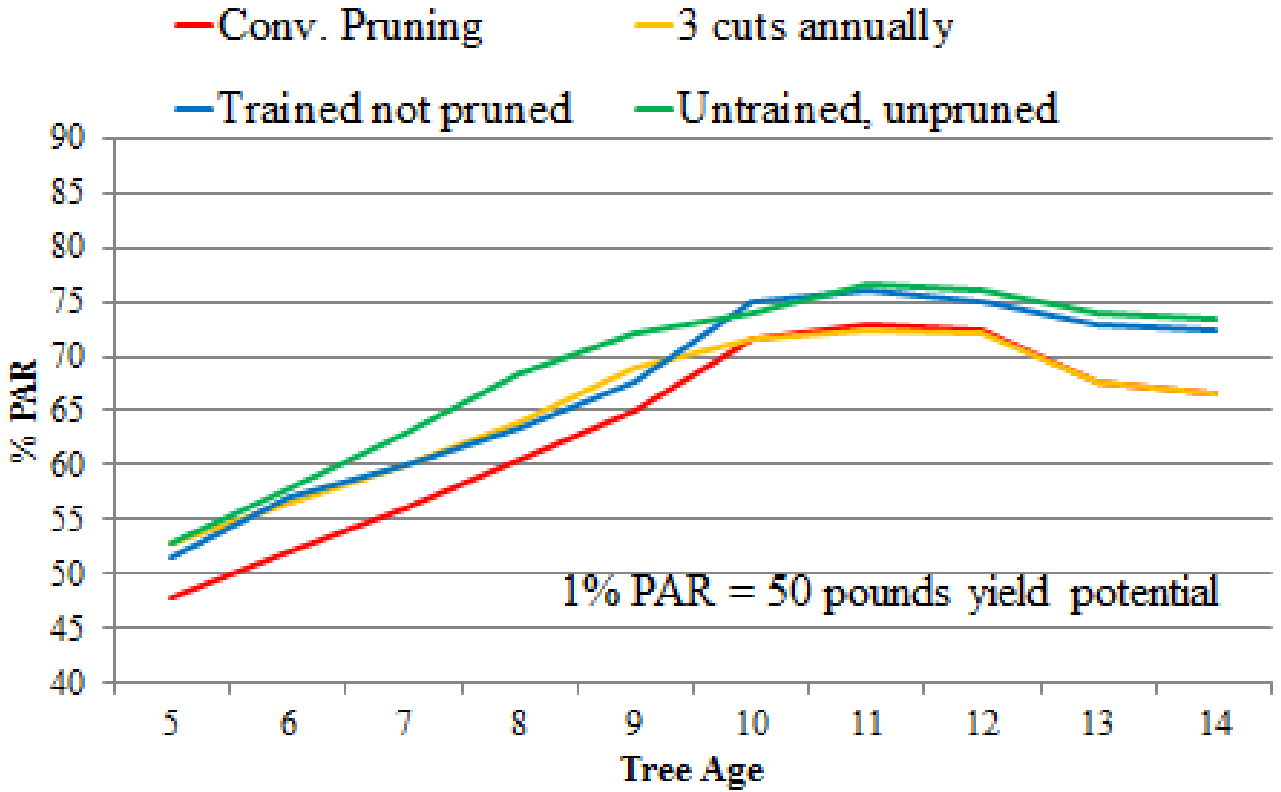
C. Looking downward, select primary scaffolds equally spaced around the tree to provide balance and symmetry.

Training Young Trees: 1st Dormant

How many scaffolds?

- Traditionally, 3-4 primary scaffolds
- Stanislaus & Butte Counties trials:
  - 3 scaffolds vs. 4-6 → No cum. yield diff. after 15 years.
  - 3 with min. pruning in filled in quickly as 4-6 (Stanislaus)

Stanislaus Co. Light Interception of Different Pruning Methods



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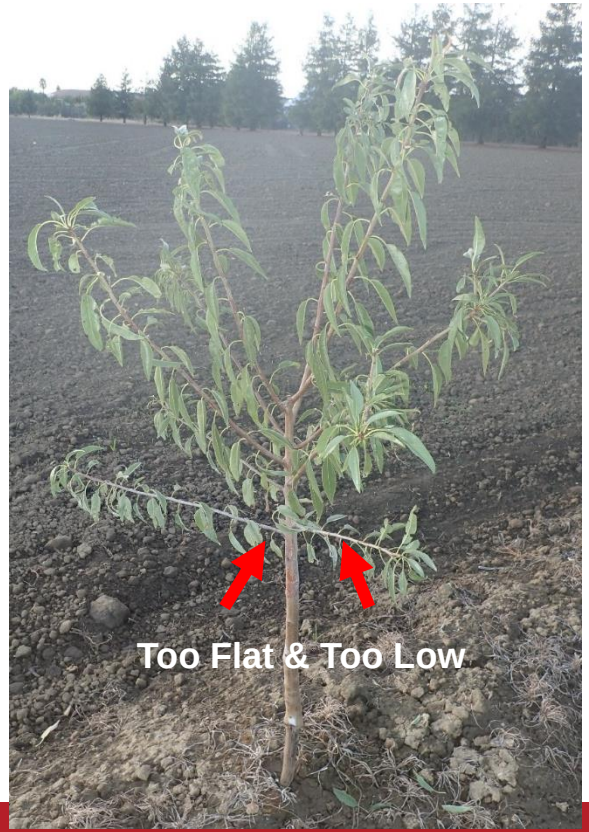
  - 3 with min. pruning in filled in quickly as 4-6 (Stanislaus)
- Potential problems with more than 3-4 scaffolds:
  - Large tree → Blow over
  - Scaffolds too close to scaffold shake, if/when necessary
  - If not well spaced, can have poor branch attachment → splitting → scaffold loss, disease

Training Young Trees: 1st Dormant

Example: 5 Scaffolds

✓1st: Remove obvious losers



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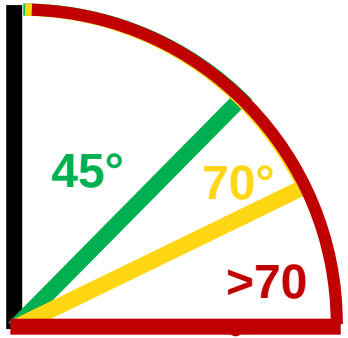

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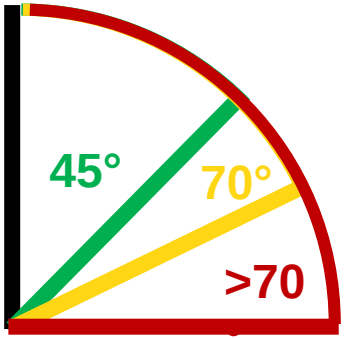

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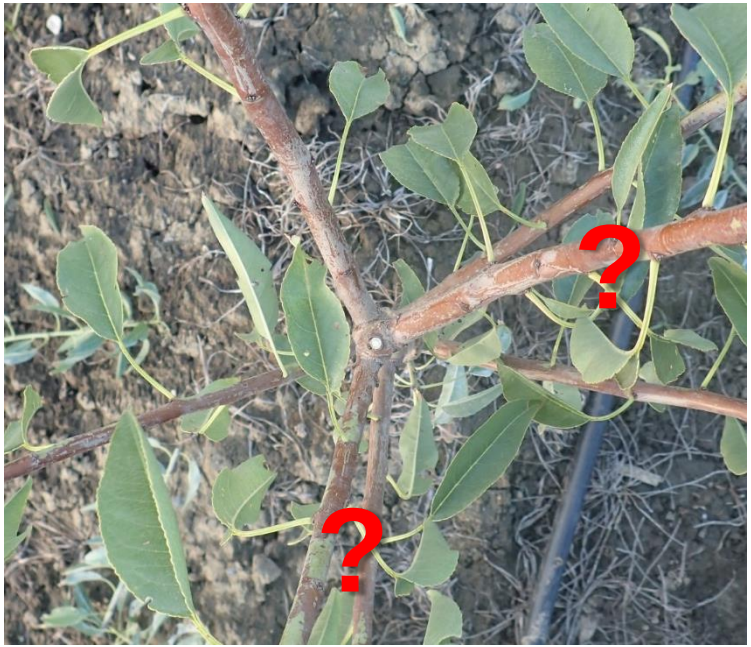

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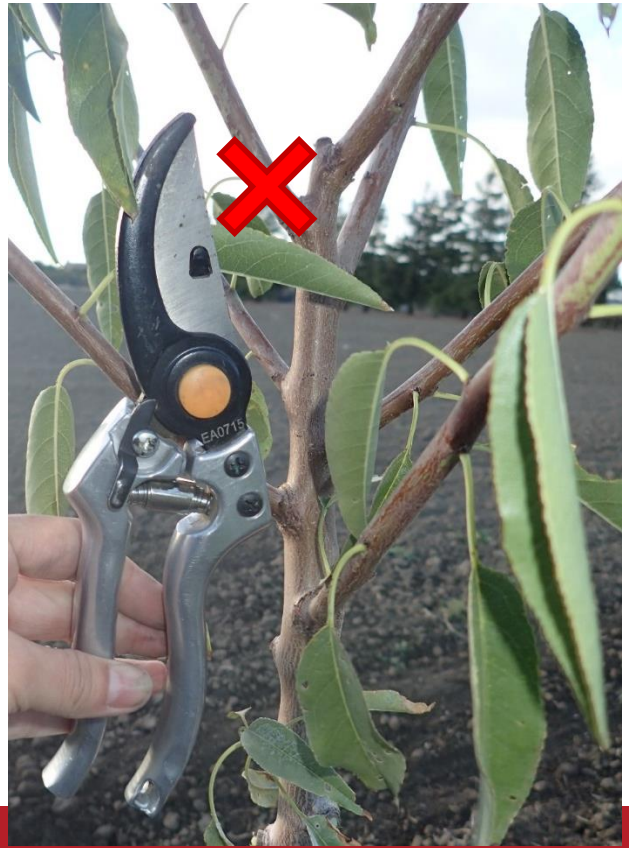

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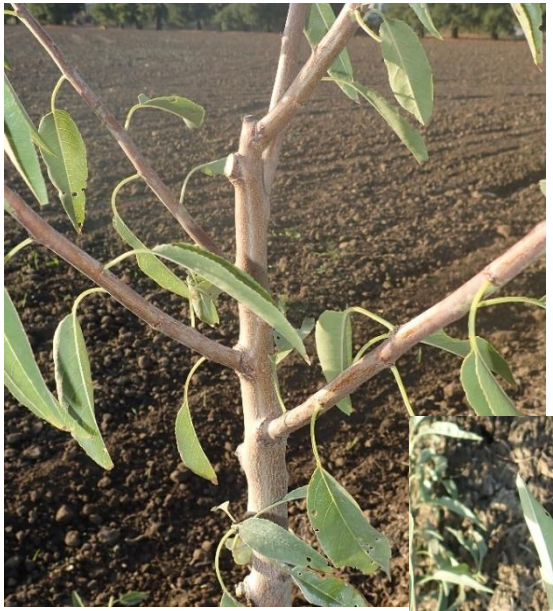

Training Young Trees: 1st Dormant

Example: 5 Scaffolds

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- 3rd: Head at 42-48”

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Before

After

Training Young Trees: 2nd Dormant

- Goal: Continue shaping the structure up and out
- 1st: Remove trouble-makers
  - Crossing branches
  - Central water sprouts
  - Tractor smackers
- 2nd: Select secondary scaffolds from what's left
  - 2-3 branches coming off primary scaffold.
  - Vigorous, growing up and out, well spaced.
  - If upright cv, favor flatter. If spreading cv, pick uprighter.

Training Young Trees: 2nd Dormant

Example: 5 Scaffolds

- 1st: Remove trouble-makers
  - Cross, Central, Smackers
- 2nd: Select 2ndary scaffolds
  - 2-3 off primary
  - Angle, Spacing, Orientation
  - Vigorous, up & out
- Heading not generally necessary, unless > ~4’

Training Young Trees: 2nd Dormant

Example: 5 Scaffolds

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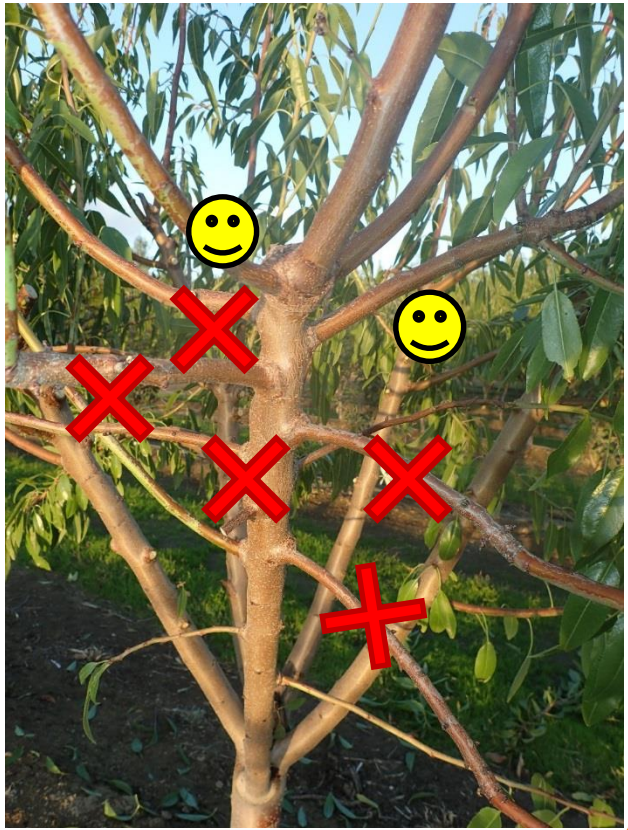

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Before

After

Training Young Trees: 3rd Dormant

- Very minimal pruning required at this stage.
- 1st: Remove crossed limbs, water sprouts.
- 2nd: Remove limbs that will interfere with equipment.
- 3rd: Remove yourself and the pruning crew from the orchard. Most pruning at this point will just delay early yields.

Training Young Trees: 3rd Dormant

- Very minimal pruning required at this stage.
- 1st: Remove crossed limbs, water sprouts.
- 2nd: Remove tractor smackers.
- 3rd: Remove yourself and crew. Most pruning at this point will delay early yields.

Training Young Trees: 3rd Dormant

- Very minimal pruning required at this stage.
- 1st: Remove crossed limbs, water sprouts.

Training Young Trees: 3rd Dormant

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Developing the Canopy – Top 3

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2) Types of Cuts
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3) Remember: All pruning is dwarfing

Top 3 – How To (1st & 2nd Dormant)

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UCDAVIS PLANT SCIENCES

Most textbooks/extension publications emphasize the "Water Balance" approach to irrigation scheduling

BASIC IRRIGATION SCHEDULING

Farmers use numerous ways to schedule irrigations. This leaflet describes two technical procedures. The water budget procedure, which is based on supplying water needs or requirements of the crop, is the most complete. Use of devices which sense water in the soil is also described briefly.

WATER REQUIREMENTS

Water is lost from a cropped field in two ways: direct evaporation of water from the soil surface, and transpiration, which is loss of water vapor from plant leaves. This combination of evaporation from the soil and transpiration by the plant is called evapotranspiration (ET). It is the "crop water requirement"—the amount of water actually used by the growing crop.

However, delivering water to the farm and applying it to the land involves losses by runoff or percolation below the root zone. These losses can be minimized through good conservation practices, but they are difficult to eliminate and must be included to determine the "irrigation water requirement". In general:

Irrigation Requirement = ET − Effective Rainfall − Irrigation System Losses

In the northern and central parts of California, rainfall supplies an appreciable portion of the crop needs in normal years. Some rain may fall after the crop is planted, but most is stored in the soil from pre-season rains. Growers need to estimate the amount of rainfall stored at the beginning of the season, as it is too important to be ignored.

Figure 1 shows water received and potential losses at the farm level during and after irrigation. If losses are kept to a minimum, most of the applied water goes to meet the ET demand.

Evapo-Transpiration "ET"

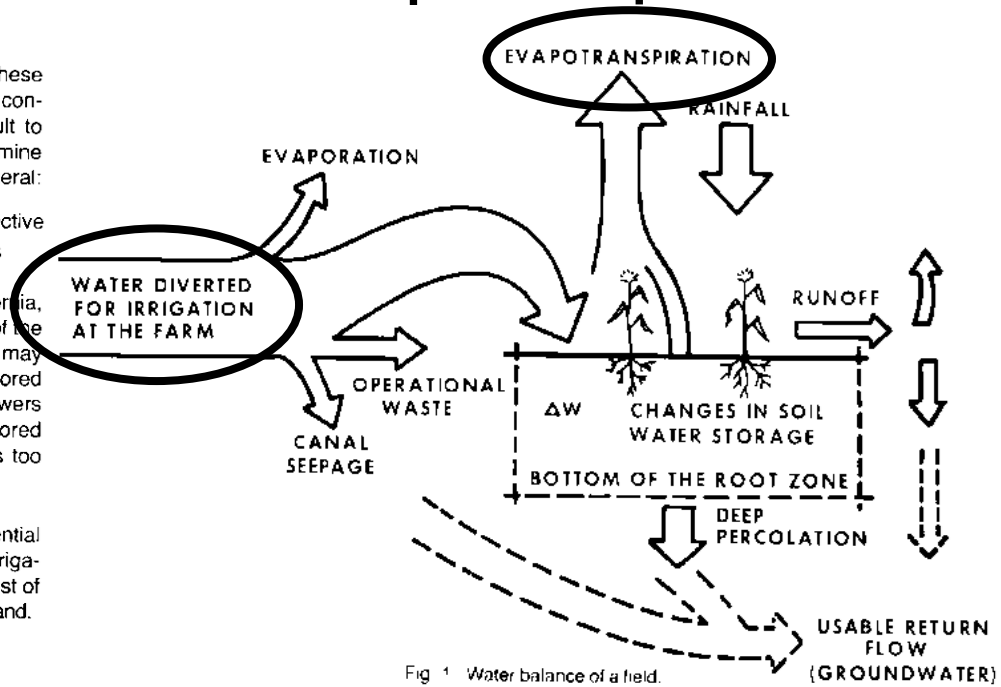
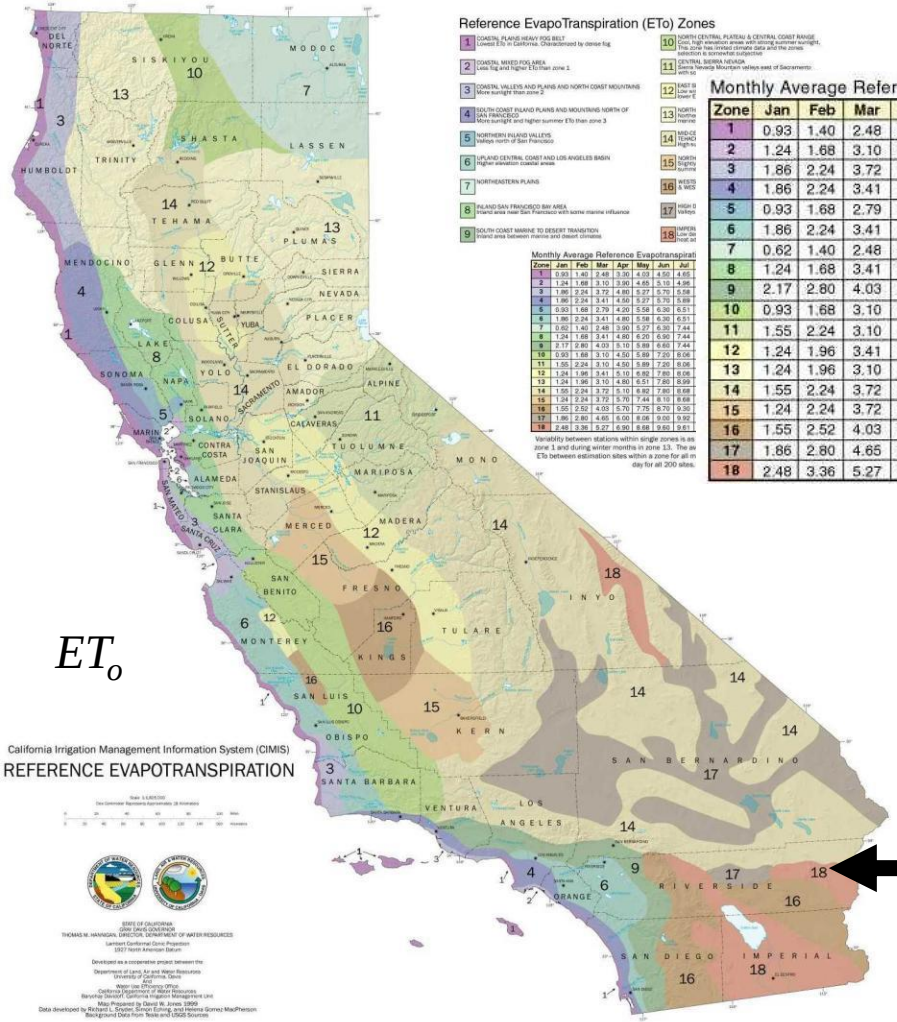


Fig. 1 Water balance of a field.

ET of a <u>mature</u> almond orchard can be calculated from current or historical weather data:

$ET_c = K_c * ET_o$.

But what about a <u>young</u> orchard?



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	4.0	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	4.4	.40	1.55	62.5
17	1.86	2.80	4.65	6.00	8.06	9.00	9.92	8.68	6.60	4.3	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	4.9	3.00	2.17	71.6

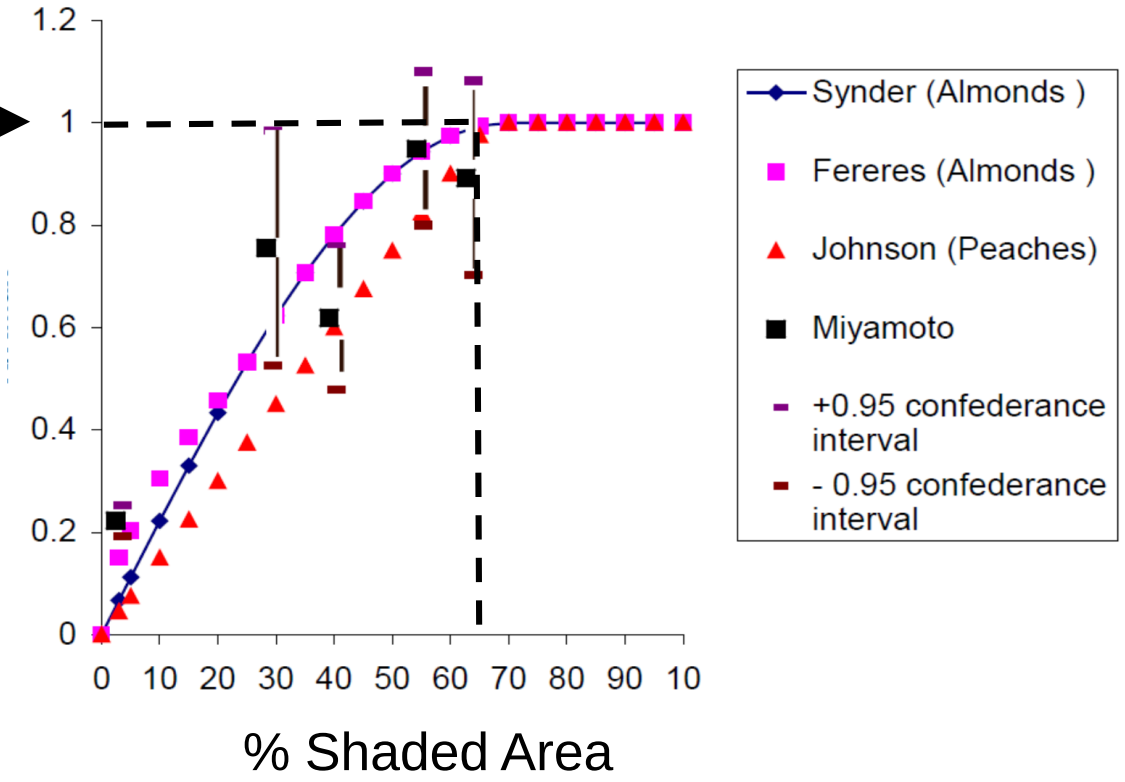
ET_o

Tables of average monthly weather conditions (reference ET, 'ET_o')

Maps of CA weather zones

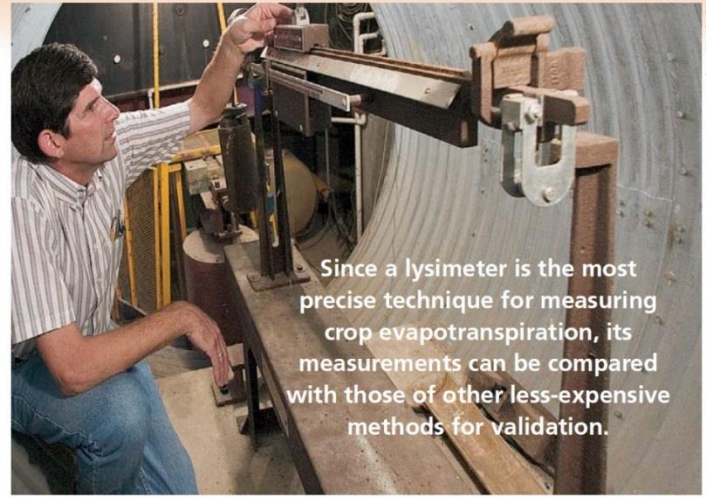
100 % of mature ET

The current approach is to relate the ET of a young orchard to the ET of a mature orchard, based on the mid-summer, midday, % shaded area on the orchard floor.



Sammis, T. W., Allan Andales, and Luke Simmons. 2004. Adjustment of Closed Canopy Crop Coefficients of Pecans for Open Canopy Orchards. Pecan Conference proceedings March 7-9 Las Cruces NM pp 28-33

Scott Johnson study: Weighing lysimeter to measure ET



Young tree (peach) ET model of Johnson et al, 2004.

Based on ET_o and % shaded area.

% shaded area is very important because it determines water loss from both tree and wetted area.

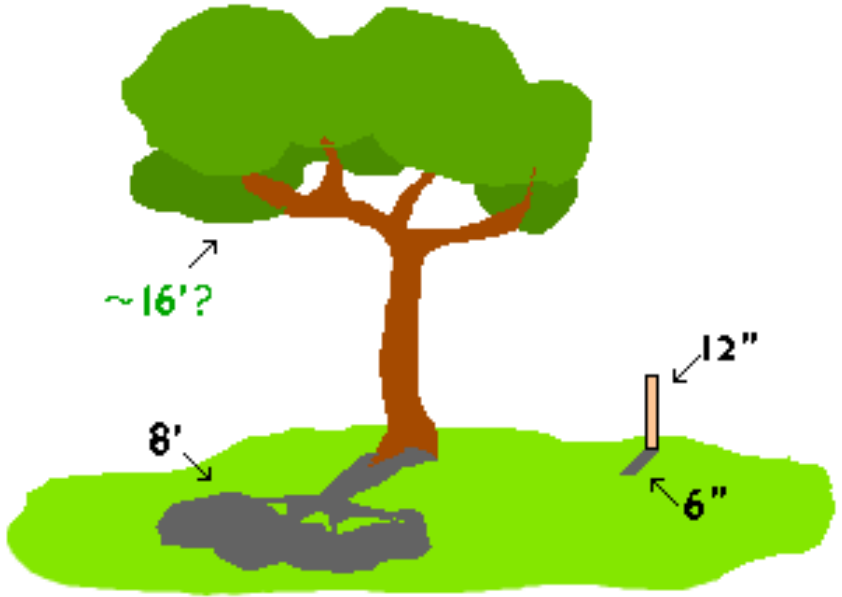
Water loss from:

Shaded area depends on:

1) Tree size
2) Sun angle (time of day and year)

Not easy to measure shaded area, especially for small trees, but photographs+image analysis can work.

Johnson's simplified method: just measure tree dimensions (height, width N/S, E/W).



Problems:

1) Young almond trees don’t shade the same area as young peach trees, even when the canopy dimensions are similar.

2) How do you schedule irrigation in the spring, when you need to wait to mid summer to measure % shaded area?

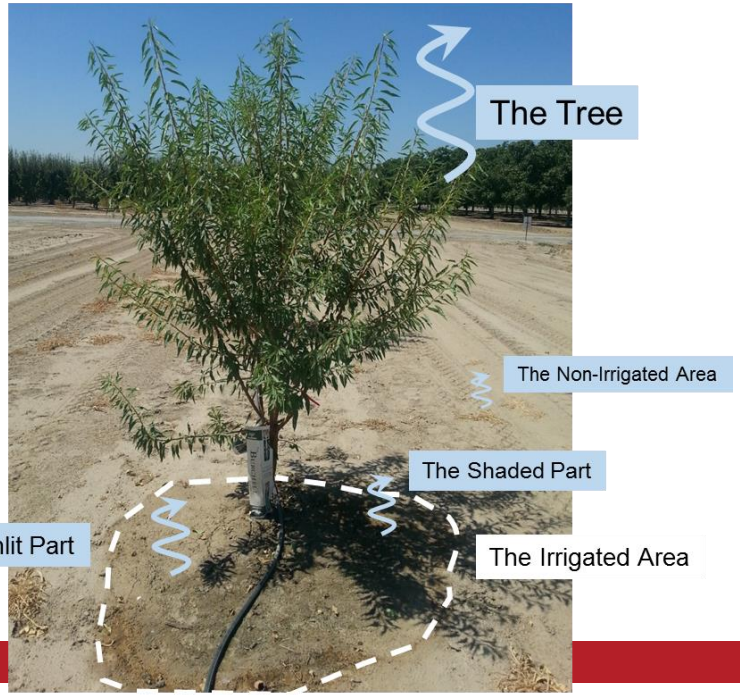
2015: Weighing lysimeter used to measure almond ET


March 26, 2015

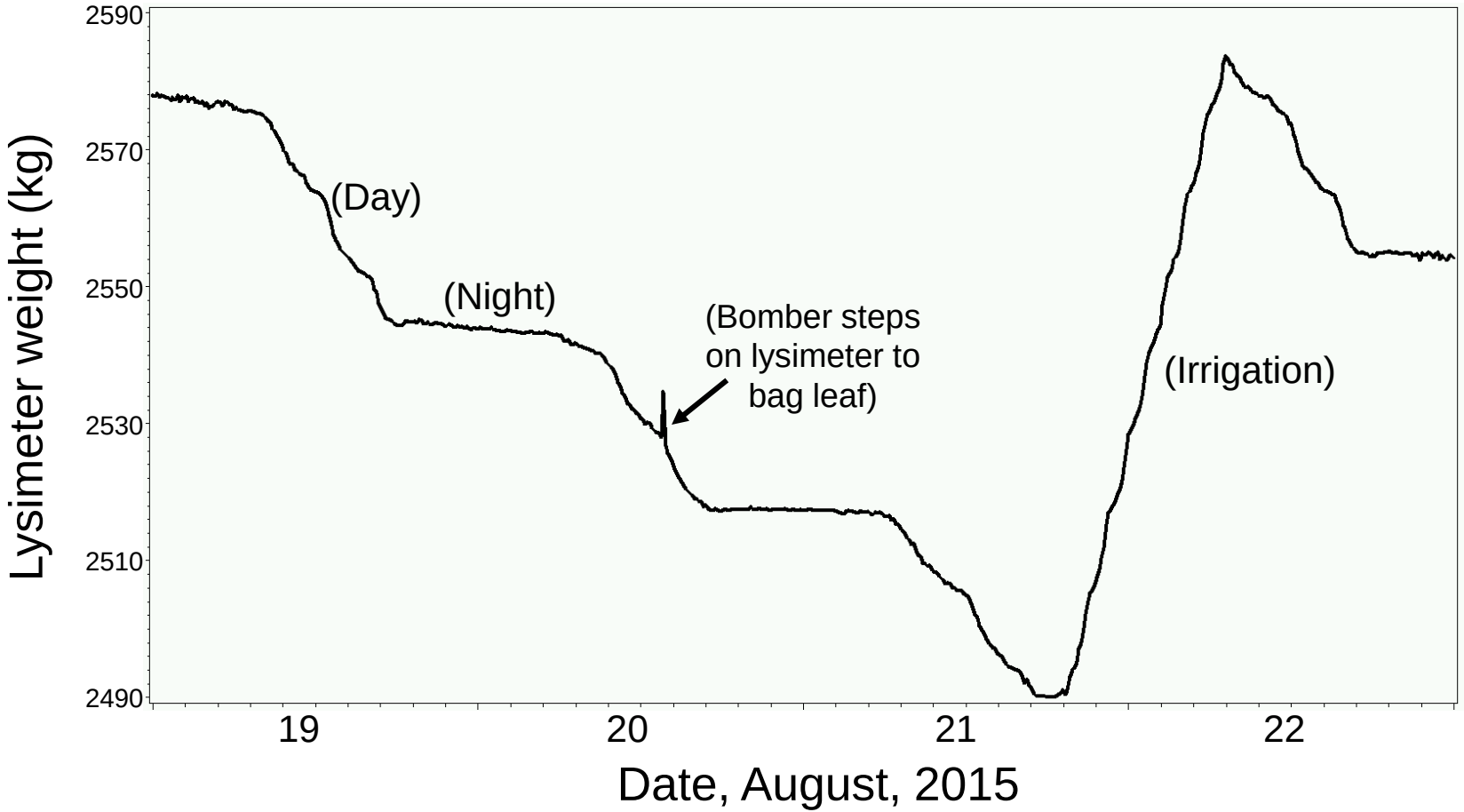

July 6, 2015

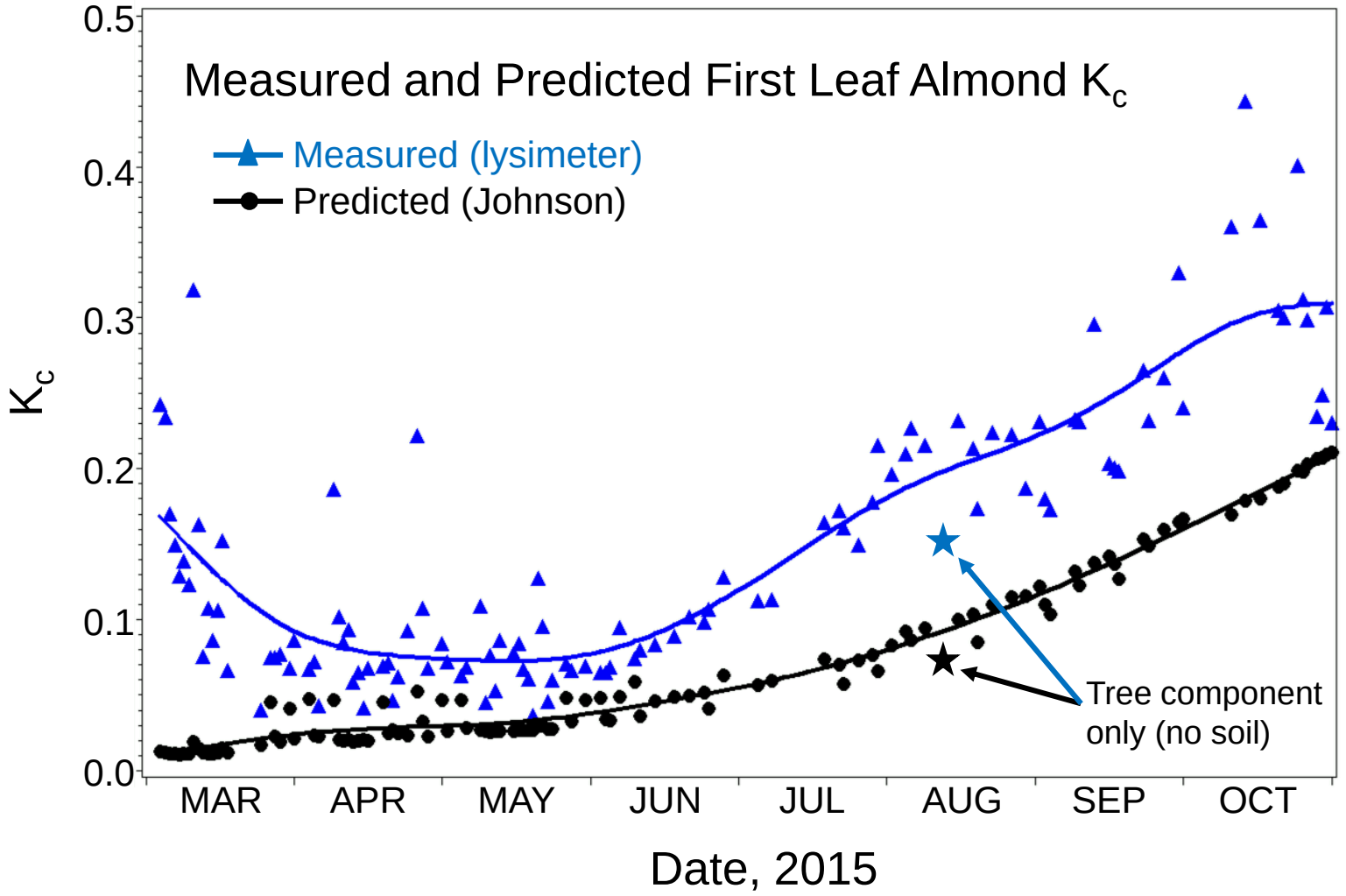
Lysimeter tree August 26, 2015

Measured shaded area over the season and compared Johnson ET (calculated) to observed ET.



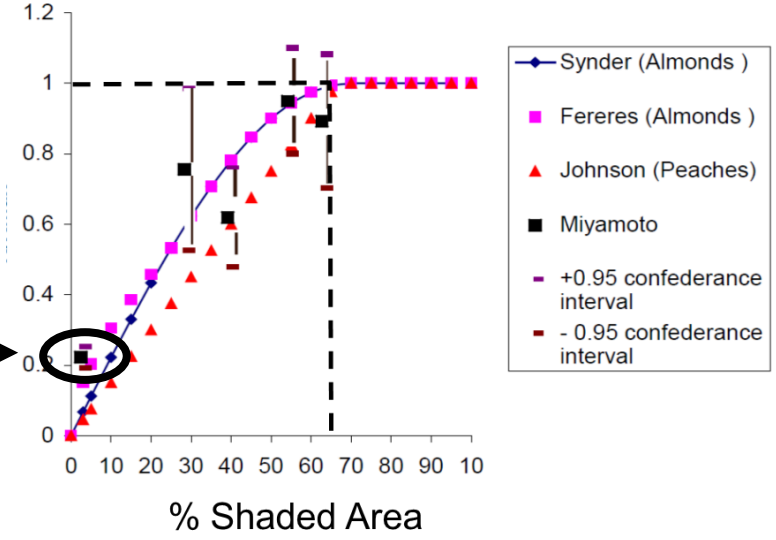
Example Lysimeter Weight Data, 19-23 August, 2015




Measured and Predicted First Leaf Almond K_c
Measured (lysimeter)
Predicted (Johnson)
K_c
0.5
0.4
0.3
0.2
0.1
0.0
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
Date, 2015
Tree component only (no soil)

Conclusion:
First year almonds may be closer to having the highest reported Kc's

"Outliers?"

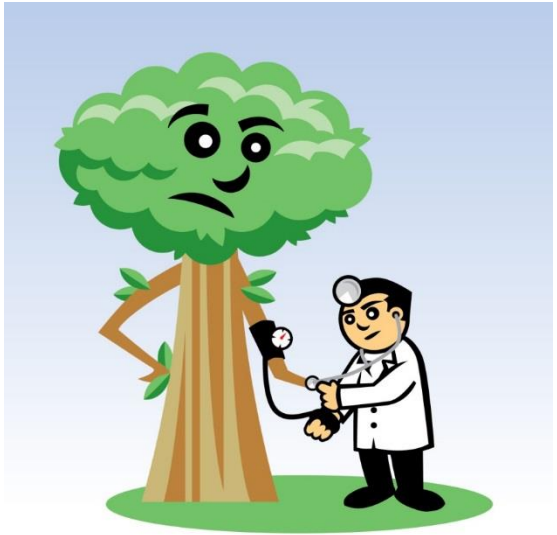


But there are many other questions that are difficult to answer for young tree irrigation management:

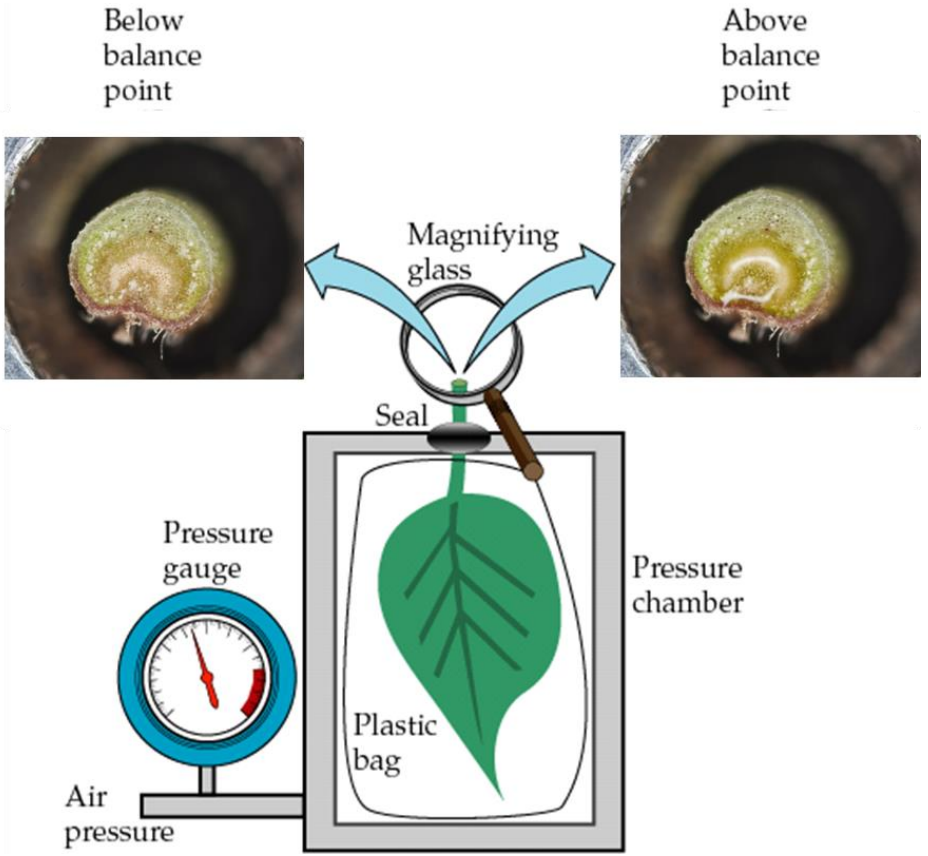
1) Where is the root zone, and how wet does it need to be?
2) How big is the soil evaporation component?
3) …Etc.

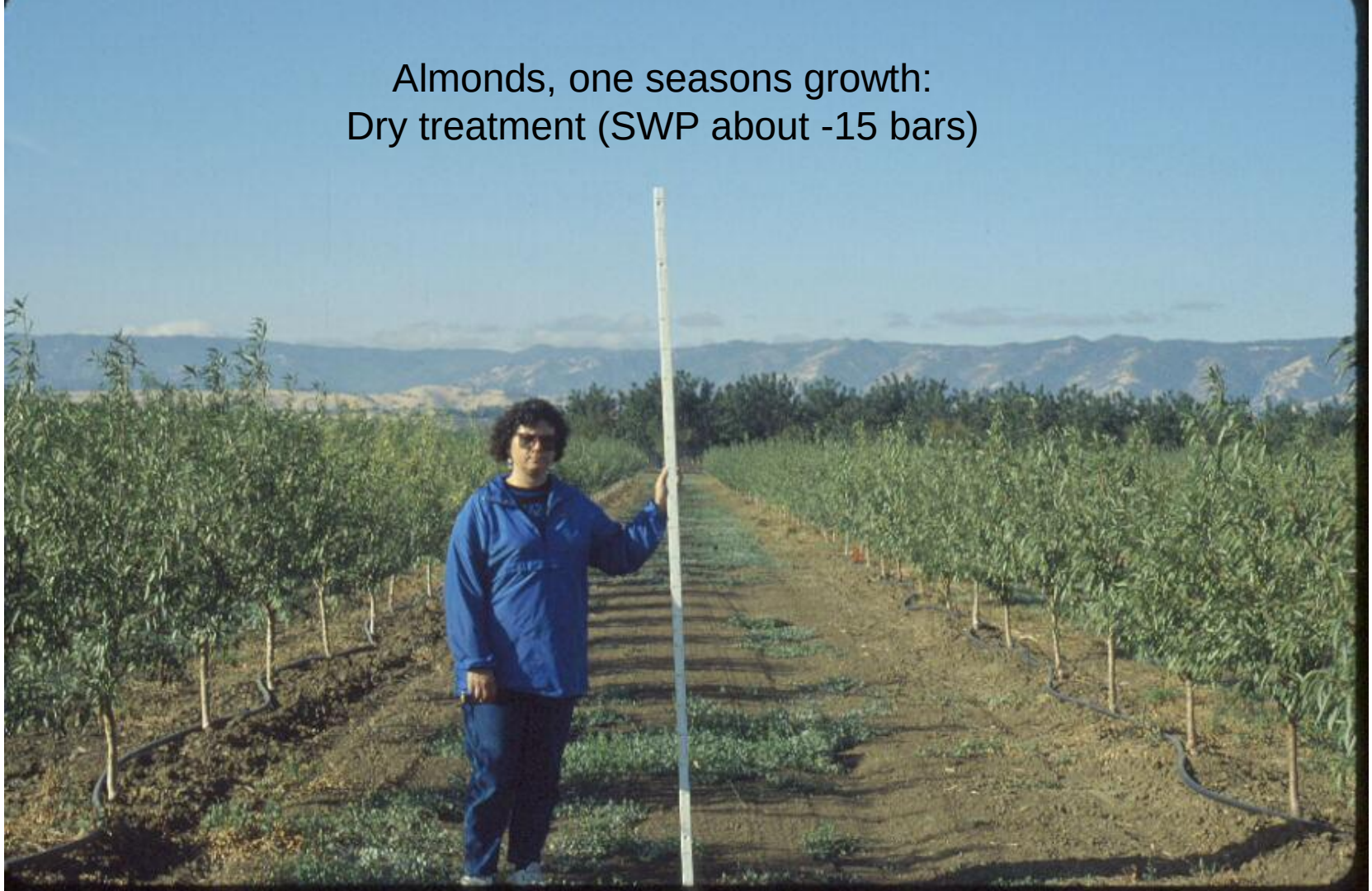
Bigger question: is Kc the only tool that we have to manage young tree irrigation?

No, we also have the pressure chamber.

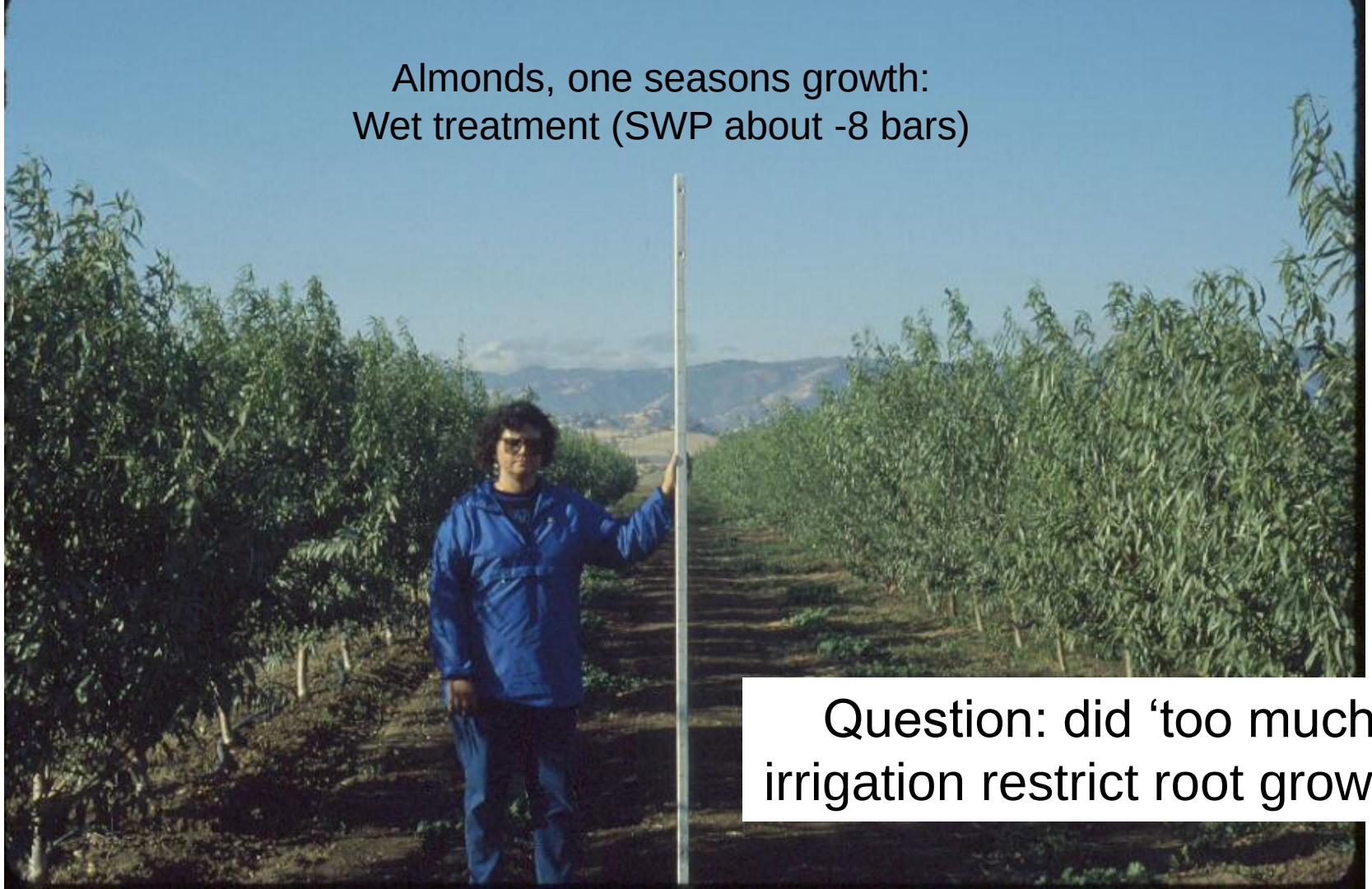


Measure the “blood pressure” of the plant




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)
Question: did ‘too much’ irrigation restrict root growth?

“Hydraulic excavation” to inspect intact root systems

Typical ‘WET’ plant root system:
Big top, big roots.


Typical ‘DRY’ plant root system:
Small top, small roots.

Conclusions

- **ET is a good planning tool, but depending on it to schedule irrigation for young orchards requires making a number of important assumptions, including many “known unknowns” and “unknown unknowns.”**
- **Make a plan based on anticipated ET, but make periodic “Goldilocks” checks with the pressure chamber to see if:**
- **Your irrigation system is getting water to the active root system, and your irrigation interval is not too long (too much stress at the end of the cycle) or too short (trees remain close to baseline SWP all the time), but just right (current guess: near baseline just after irrigation, about 5 bars below baseline before the next irrigation).**