Designing and Developing a New Orchard

growing ADVANTAGE
The Almond Conference

Designing and Developing a New Orchard

Bob Curtis

Almond Board of California

Designing & Developing a New Orchard

- **Rootstocks, Varieties, Tree Arrangement & Pruning**

Roger Duncan
UC Cooperative Extension
Stanislaus County

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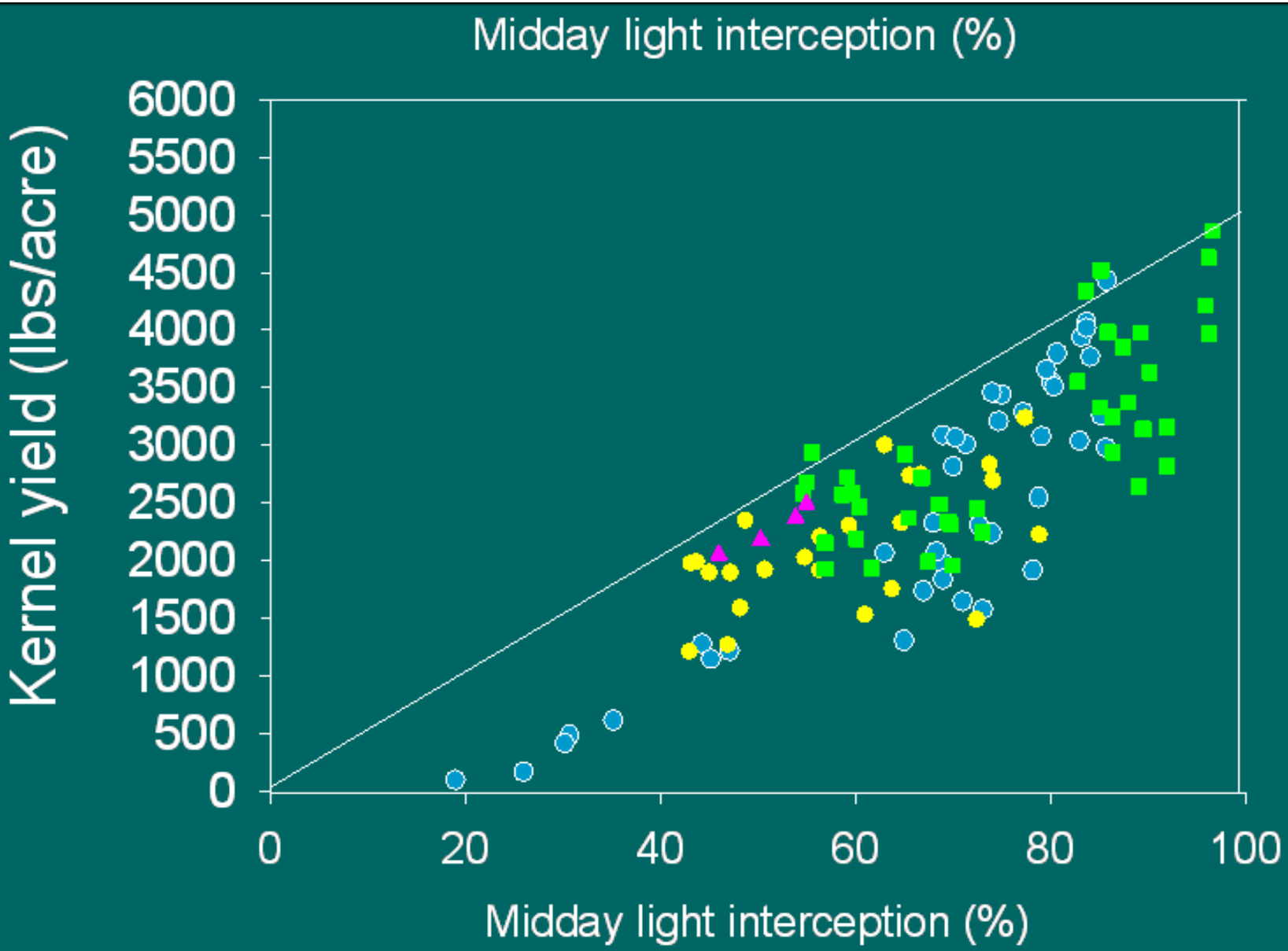
Work by Bruce Lampinen, UCD



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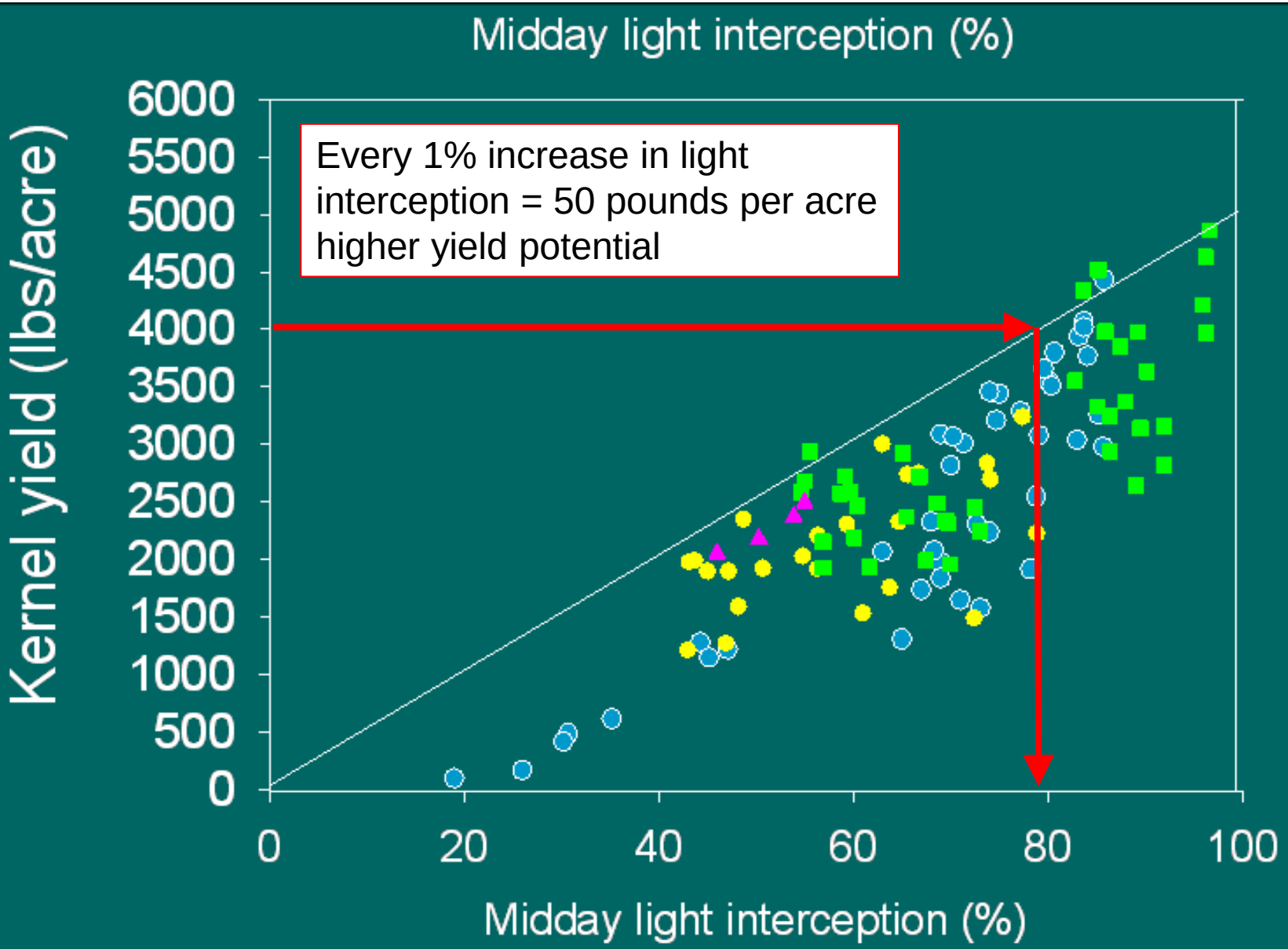
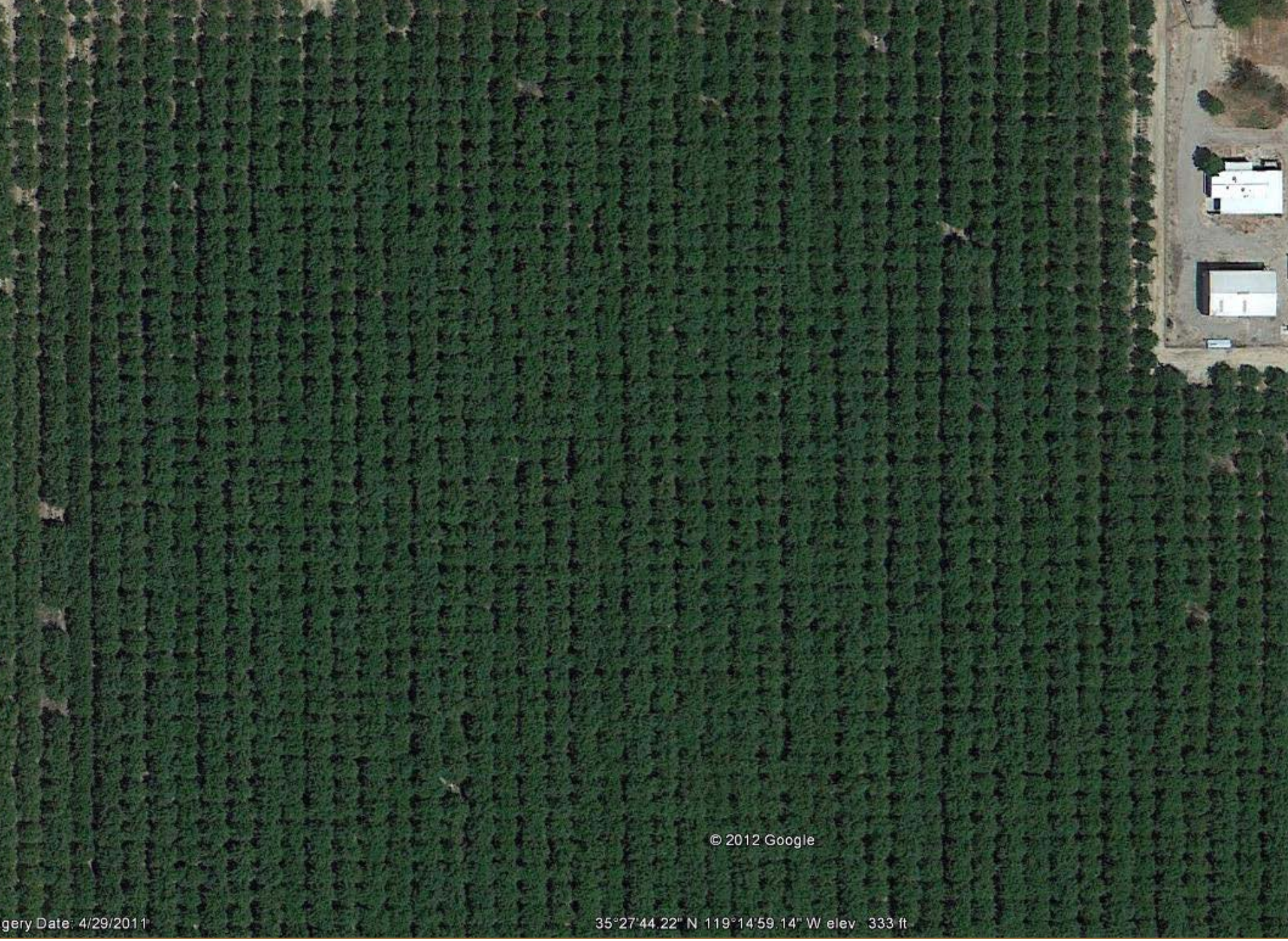
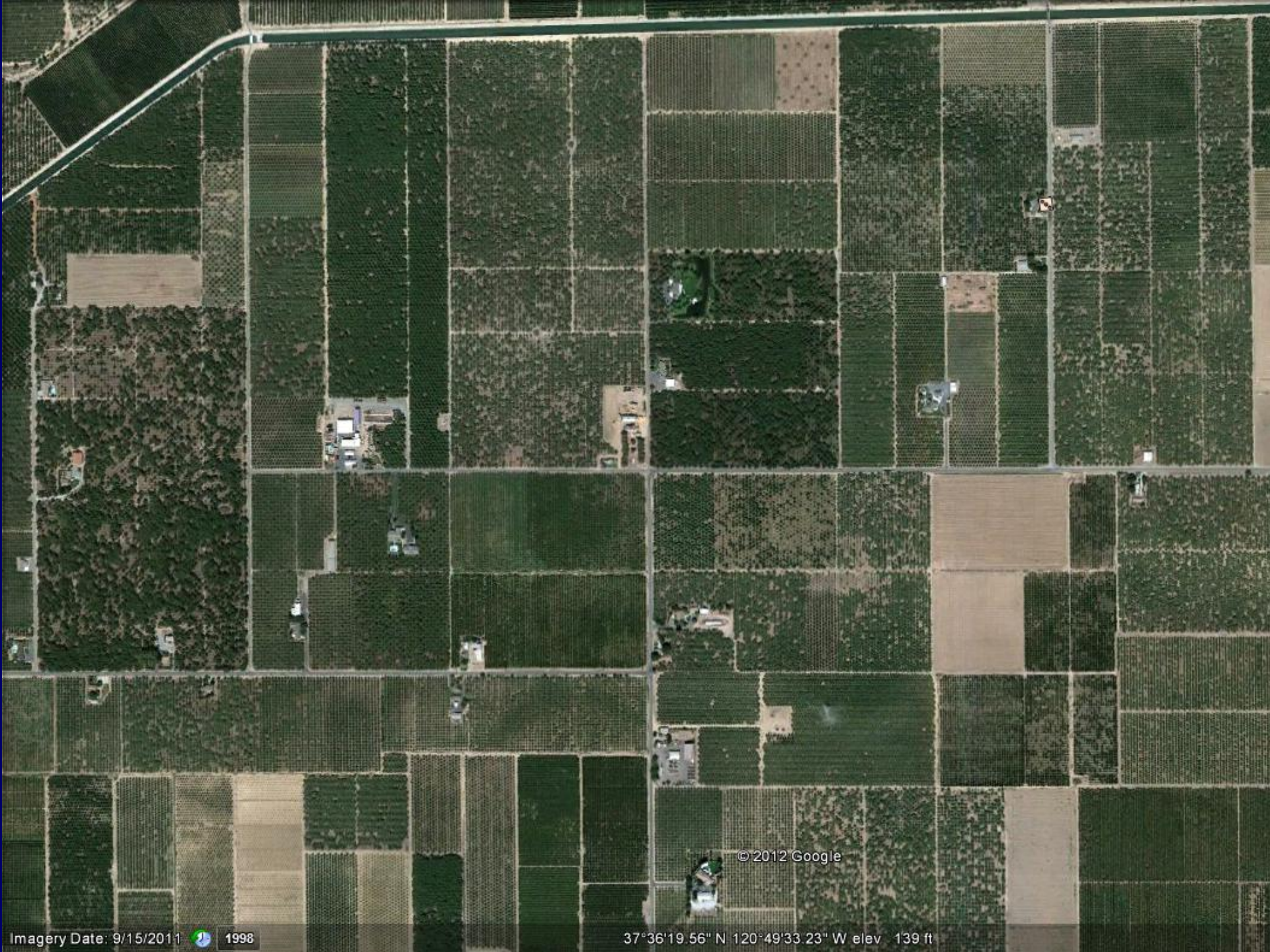



© 2012 Google
gery Date: 4/29/2011
35°27'44.22" N 119°14'59.14" W elev 333 ft


© 2012 Google
Imagery Date: 9/15/2011
1998
37°36'19.56" N 120°49'33.23" W elev 139 ft

Goal: Maximum Light Interception

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Use integration of appropriate rootstock, planting density / tree arrangement & minimal pruning to achieve maximum light interception.

Rootstocks:

The Best Offense is a Good Defense

- Think of the rootstock as your protection against premature orchard decline.

What is the best rootstock?

- Rootstock choice should be site specific
  - Anticipate possible problems with site
  - If no specific biological, chemical or physical soil challenges are present, rootstock choice may not make much difference as long as planting density is appropriate.

Nemaguard

- Advantages
  - “Immune” to rootknot nematode
  - Vigorous rootstock
  - Compatible with all almond varieties
  - Performs well in sandy loam & loam soils
  - “Decent” anchorage
  - Growers are familiar with it

Nemaguard

- Disadvantages
  - *Susceptible to:*
    - Ring & root lesion nematodes
    - Bacterial canker
    - High soil pH / high lime
    - Salt (sodium, chloride, boron)
    - Phytophthora / “wet feet”
    - Oak root fungus
    - Crown gall
    - “Heart” rot / wood decay fungi

Specific Challenges…

- Alkaline / salty soil or water
  - P/A hybrid (not if heavy soil or ring nematodes)
    - Hansen, Nickels, Brights, Paramount,
  - Atlas (not if ring nematodes)
  - Viking
  - Empyrean 1

Salinity Tolerance of P/A Hybrid Rootstocks

Atwater rootstock trial, 2006

	Na (%)	***Cl (%)***
Nemaguard	0.64	0.22
Lovell	0.72	0.26
Hansen	0.17	0.09
Brights	0.20	0.07
Critical level	>0.25%	> 0.3%

Peach / Almond Hybrids

- Includes Hansen, Nickels, Bright's Hybrid Cornerstone, Titan Hybrid, Paramount

- Advantages
  - Very high vigor
  - Tolerant to high lime / high pH soils
  - Tolerant to high boron, sodium & chloride
  - Very good anchorage
  - Resistant to rootknot nematode
  - Perform well in replanted orchards**

Specific Challenges…

- Ring nematodes (bacterial canker)
  - Viking or Lovell

Complex Hybrids

- Viking (peach x almond x plum x apricot)
  - Similar in size to nemaguard
  - Resistant to rootknot nematode
  - Tolerant to ring nematode
  - Bacterial canker tolerance is similar to Lovell but with higher yields
  - More tolerant to high pH, sodium & chloride than peach rootstocks
  - Better anchorage than nemaguard or Lovell
  - *Unknown tolerance to saturated soils
  - **Susceptible to dehydration at planting

Specific Challenges…

- Poor drainage / heavy soil
  - ~~Marianna 26-24~~
  - Krymsk 86
  - Marianna 40
  - ~~Ishtara~~

} More vigorous than M 26-24 with little suckering

Alternative Rootstocks for Almond

Krymsk 86 – Russia

Plum (Myrobalan) x peach

- 80 – 90% size of nemaguard (similar to Lovell)

- Appears to be…
  - Tolerant to heavy soils, Phytophthora root rot.
  - Good anchorage
  - Very little suckering
  - Minor yellow leaf roll issue with Nonpareil & Monterey*

Specific Challenges…

- Oak root fungus
  - Marianna 26-24 is the only known commercially available almond rootstock with ORF tolerance

Alternative Rootstocks for Almond

- Empyrean 1 (Barrier 1) – Italy

Peach

- As vigorous as peach / almond hybrids
- Resistant to rootknot nematode
- So far, very few ring nematodes in local trial
- Evidence of sodium tolerance

2012 Rootstock Trial – West Side Stanislaus County
Heavy soil, marginal water quality

1. Lovell	*P. persica*
2. Nemaguard	*P. persica*
3. Empyrean 1	*P. persica x P. davidiana*
4. Avimag	*P. persica x P. davidiana*
5. HBOK 50	Harrow blood x Okinawa peach
6. Hansen	*P. dulcis x P. persica*
7. Brights #5	*P. dulcis x P. persica*
8. BB 106	*P. dulcis x P. persica*
9. Paramount	*P. dulcis x P. persica*
10. Flordaguard x Alnem	*P. persica* x Israeli bitter almond
11. PAC9908-02	(*P. dulcis x P. persica) x P. persica*
12. HM2 +	Hansen (*P. dulcis x P. persica)* x Monegro (*P. dulcis*×*P. persica*)
13. Viking	P. persica (Nemaguard) x (P. dulcis [Jordanolo] x [P. blireiana = P. cerasifera x P. armeniaca)
14. Atlas	*P. persica* (Nemaguard) x (*P. dulcis x P. blierianna)*
15. Krymsk 86	*P. cerasifera* x *P. persica*
16. Rootpac R	almond x plum

Variety Choice Depends on:

- **Yield**
- **Price**

} Gross income

- **Bloom time (overlap with main variety)**
- **Harvest date**
- **Insect pressure**
- **Disease pressure**
- **Kernel quality**
- **Size of farming operation**
- **Farming style / personal preference**
- **Are you a risk taker?**

Statewide Average Yield Comparison for Nonpareil vs. Butte & Padre (lbs / acre)*

*based on Almond Board of California Almanac

	2000	2001	2002	2003	2004	2006	2007	2008	2009	Avg.
NP	1425	1613	2267	1927	1853	2333	2539	2486	2103	2061
Butte & Padre	1563	1912	2441	2689	2296	1775	2433	2506	2281	2211

Butte & Padre produced 150 lb. per acre more than Nonpareil on average from 2000 - 2009

Average Gross Income for Nonpareil vs. Butte & Padre

	2000	2001	2002	2003	2004	2006	2007	2008	2009	Avg.
NP	$1553	$1694	$2924	$3372	$4466	$5319	$5078	$4425	$4080	$3657
Butte & Padre	$1375	$1683	$2587	$4141	$5005	$3408	$3771	$2932	$2965	$3096
	+$178	+$11	+$337	-$769	-$539	+$1911	+$1307	+$1493	+$1115	+$561

Average Yield per Acre for the Nine Most Commonly Planted Almond Varieties

*based on Almond Board of California Almanac & 2009 prices

	2008	2009	Average	$ / acre
Nonpareil	2486	2103	2295	$4590
Aldrich	2868	1995	2432	$3843
Monterey	2615	2127	2371	$3746
Butte / Padre	2506	2281	2394	$3711
Fritz	2559	1979	2269	$3585
Carmel	2259	1643	1951	$3239
Sonora	2004	1614	1809	$3003
Price	1981	1491	1736	$2743

Full Bloom Time Relative to Nonpareil*

*Data taken from Butte County Variety Trial:

average of 1996 – 2003

Fritz not included in Chico trial

Sonora	-6.4
Sano	- 5.3
Winters	- 3.4
Donna	- 3.3
Aldrich	- 1.4
Jenette	- 0.8
Price	+ 0.4
Carmel	+ 1.4
Wood Colony	+ 1.4
Monterey	+ 1.9
Plateau	+ 2.8
Butte	+ 4.3
2-19E	+ 4.4
Padre	+ 5.1
Livingston	+ 5.6
Mission	+ 6.1
Ruby	+ 9.8

“New” Varieties

- Avalon, Bluegum, Durango, Folsom, Independence, Kochi, Marcona, Sweetheart, Supareil, Winters, 2-19E
- Planting a new variety represents a risk
- Is potential return worth the risk?

Finally,

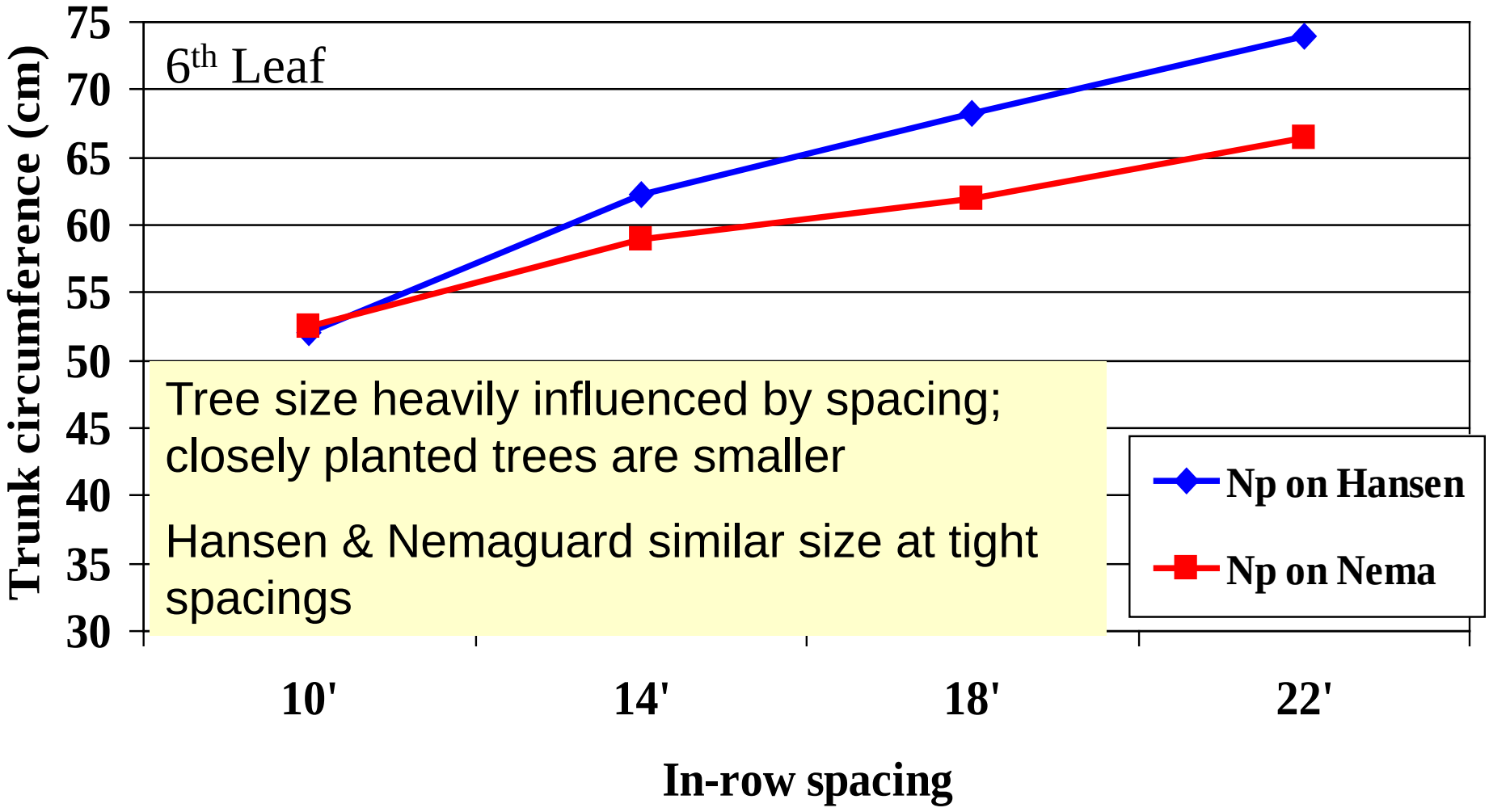
Talk to handlers / sellers

Tree Planting Density

22’ x 22’ 6th leaf

10’ x 22’ 6th leaf

Effect of Tree Spacing & Rootstock on Trunk Circumference.

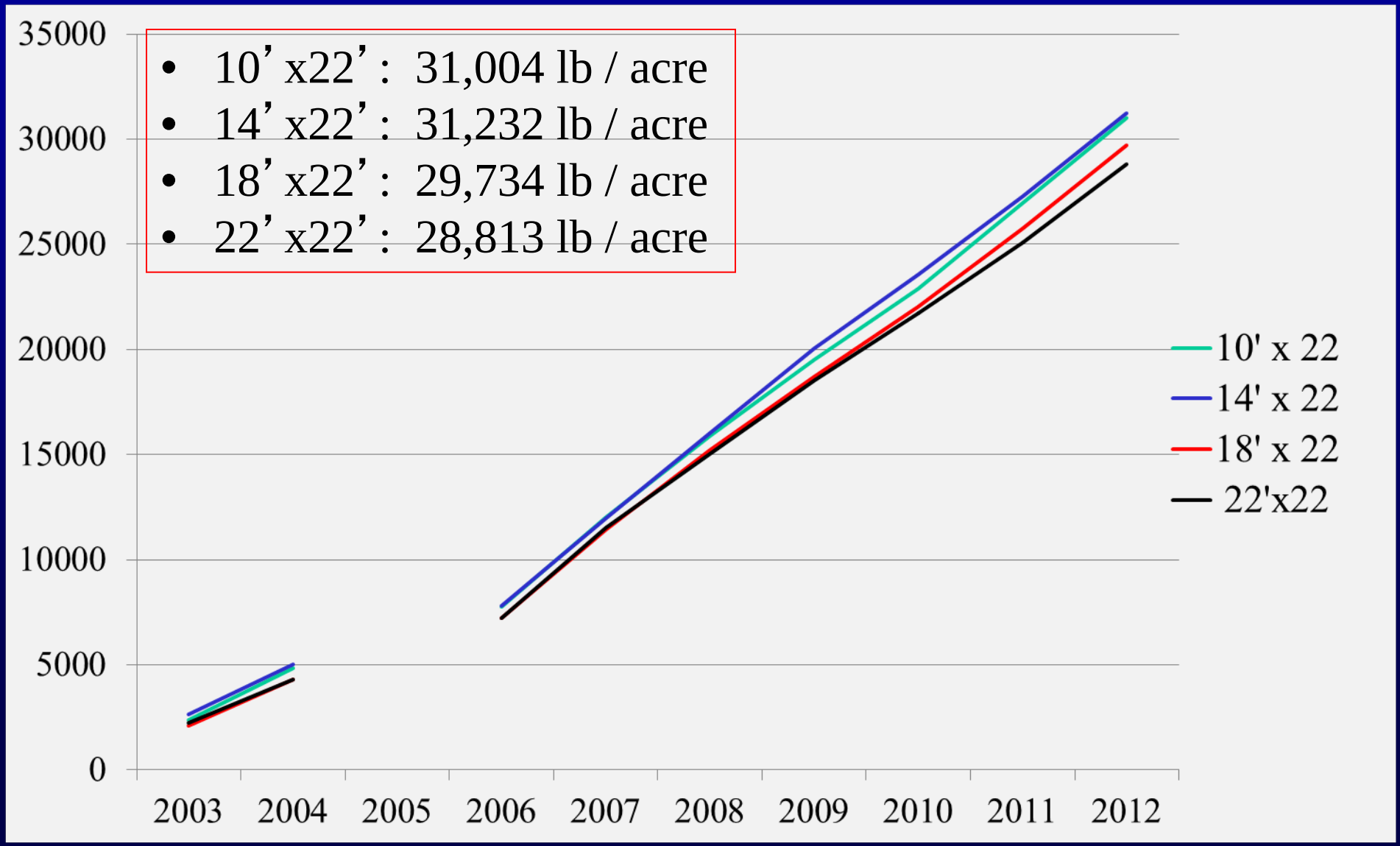


The Effect of Tree Spacing on Height (feet)

	8th Leaf	12th Leaf
10’ x 22’	16.9	21.5
14’ x 22’	17.8	23.1
18’ x 22’	17.6	23.1
22’ x 22’	18.1	24.2

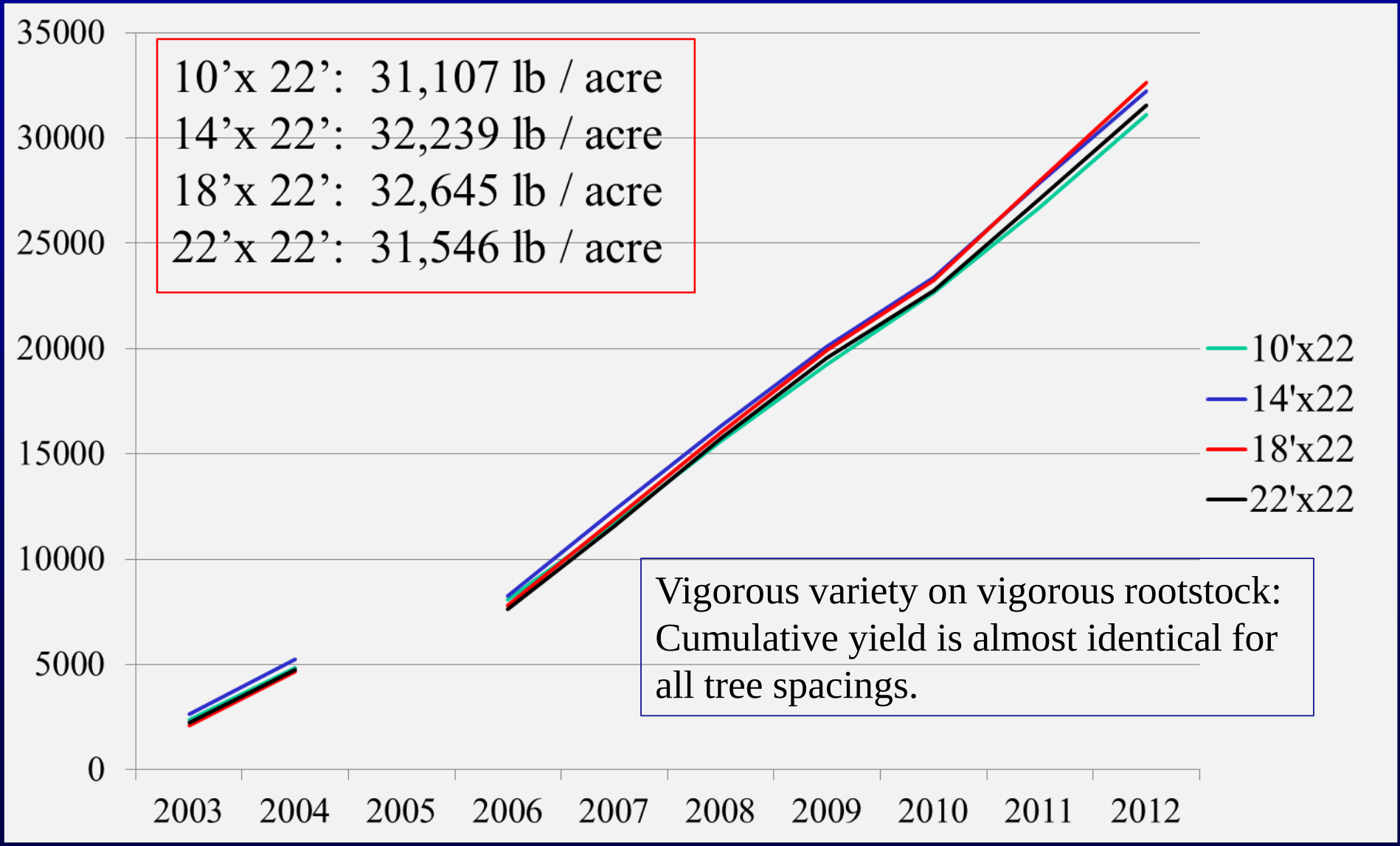
The Effect of Tree Spacing on Cumulative Yield Through 13th Leaf

Nonpareil on Nemaguard



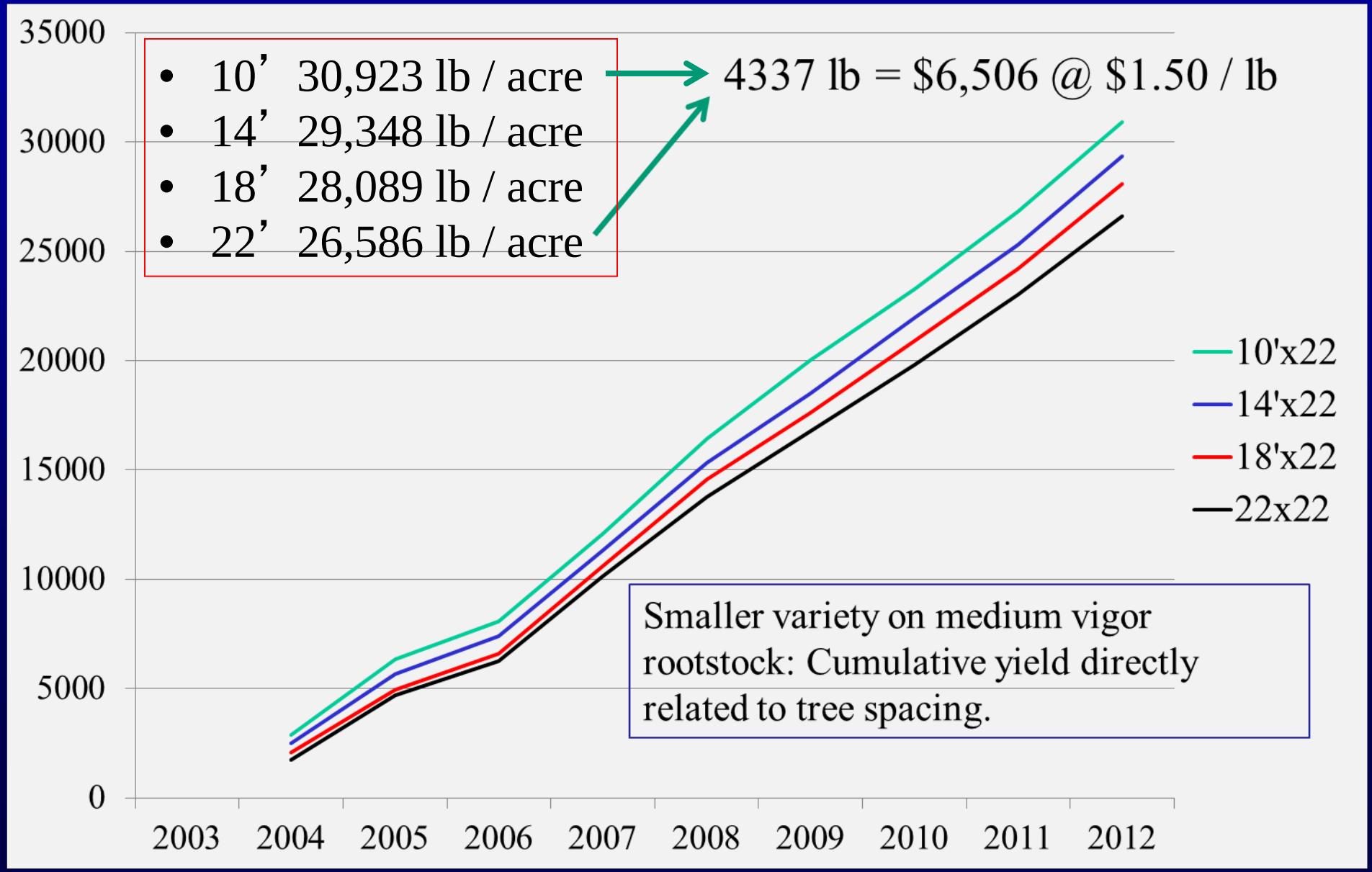
The Effect of Tree Spacing on Cumulative Yield Through 13th Leaf

Nonpareil on Hansen



The Effect of Tree Spacing on Cumulative Yield

Carmel on Nemaguard



The Effect of Tree Spacing on Scaffold Splitting of Almond Trees

The Effect of Tree Spacing on Trunk Shaker Injury

July, 2012. 13th leaf

The Influence of Tree Spacing on Unharvested Nuts (Mummies)

	Mummies per acre January 15, 2010				
	10 x 22	**14 x 22**	**18 x 22**	**22 x 22**	**X**
Standard Pruning	4,297	9,545	12,386	10,845	**9,268**
Trained 2 years, Unpruned	5,207	6,179	10,527	12,276	**8,547**
Minimal training & pruning	5,841	7,650	15,059	13,473	**10,506**
Untrained & Unpruned	3,802	5,090	7,557	9,729	**6,545**
x	**4,787**	**7,116**	**11,382**	**11,581**	

	Mummies per acre February 17, 2012				
	10 x 22	**14 x 22**	**18 x 22**	**22 x 22**	**X**
Standard Pruning	4752	8767	6710	9630	**7,465**
Trained 2 years, Unpruned	6138	4666	4950	7200	**5,739**
Minimal training & pruning	5148	9757	6380	15,750	**9,259**
Untrained & Unpruned	6534	7636	6160	13,590	**8,481**
x	**5,643**	**7,707**	**6,050**	**11,543**	

Costs Associated with Shaking Trees at Different Planting Densities

	Time (minutes) / acre	Cost (Dollars / acre)*
10’ x 22’	54.8	$91
14’ x 22’	45.2	$75
18’ x 22’	44.6	$74
22’ x 22’	49.4	$82

*Cost of shaker is calculated at $100 / hour

Benefits of Closer Spacing (other than yield):

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More closely planted trees are:

- Smaller
- Less likely to have scaffold breakage problems regardless of how they are trained.
- Easier to prune - may need less pruning??
- Easier to shake at harvest – fewer mummies & less shaker injury (longer orchard life?)
- Better spray coverage – less insect & disease pressure?
- May not fall over as easily (longer orchard life?)
- If one tree dies, it effects yield less

Yields in Long-term Almond Pruning Trial

Spacing = 7’ x 22’. John Edstrom, et. al., Nickels Estate (1984 – 1999)

	18th leaf	19th leaf	20th leaf	21st leaf	Cumulative Yield
Annually pruned	2624	2498 a	2494 a	2136	34,176
Unpruned	2833	2680 a	1958 ab	2307	35,082
2 scaffolds	2968	2953 a	2296 a	2483	36,820
Temporary trees removed	2076	2081 b	1757 b	1662	27,861

Yields in Long-term Almond Pruning Trial

Spacing = 7’ x 22’. John Edstrom, et. al., Nickels Estate (1984 – 1999)

	Pruning Costs	Gross Profit / acre	Net Profit
Annually pruned	$3675	$51,264	$47,589
Unpruned	$175	$52,623	$52,448
2 scaffolds	$3675 +	$55,230	$51,555
Temporary trees removed	?	$41,792	?

Pruning costs @ $175 per acre, including stacking & shredding

Almond price of $1.50 / pound

Cumulative Yields – Kern County through 11th leaf

Pounds per acre

	Nonpareil	Carmel	Monterey
Annual pruning	19,245	21,698	20,841
Pruned every other year	20,585	20,363	21,313
Topped & hedged annually	20,667	22,771	22,153
Mechanical alternate years	20,088	22,561	20,831
Mechanical + hand pruned	18,643	20,248	20,096
Unpruned	21,536	23,577	21,843

Stanislaus County Pruning Trial 200 - 2012

The Effects of Pruning on Current (13th Leaf) & Cumulative Yield

	Nonpareil		Carmel	
	2012 Yield (lb/acre)	Cumulative	2012 Yield (lb / acre)	Cumulative
Training & Pruning				
Trained to 3 scaffolds; Annual, moderate pruning	4209 ab	29,338	3126 b	25,620
Trained to 3 scaffolds; unpruned after 2nd year	4387 a	30,670	3508 ab	27,535
Trained to multiple scaffolds; Three annual pruning cuts	3979 b	28,769	3308 ab	27,080
No scaffold selection; no annual pruning	4220 ab	30,683	3685 a	28,836

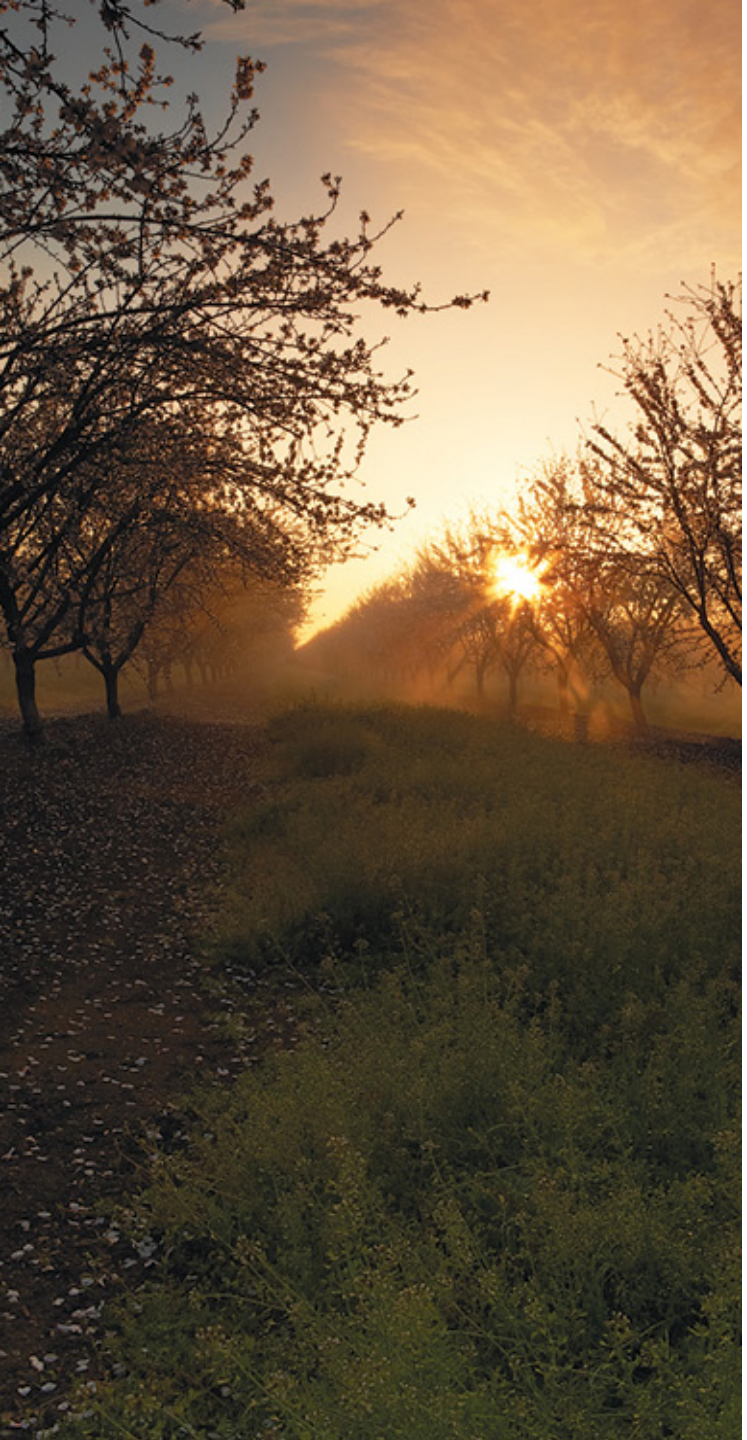
Conservatively, the cost of pruning, stacking brush and shredding every year, plus the value of lost yield would have cost the grower over $7000 per acre to date.

Why Prune Almond Trees?

There are real reasons to prune

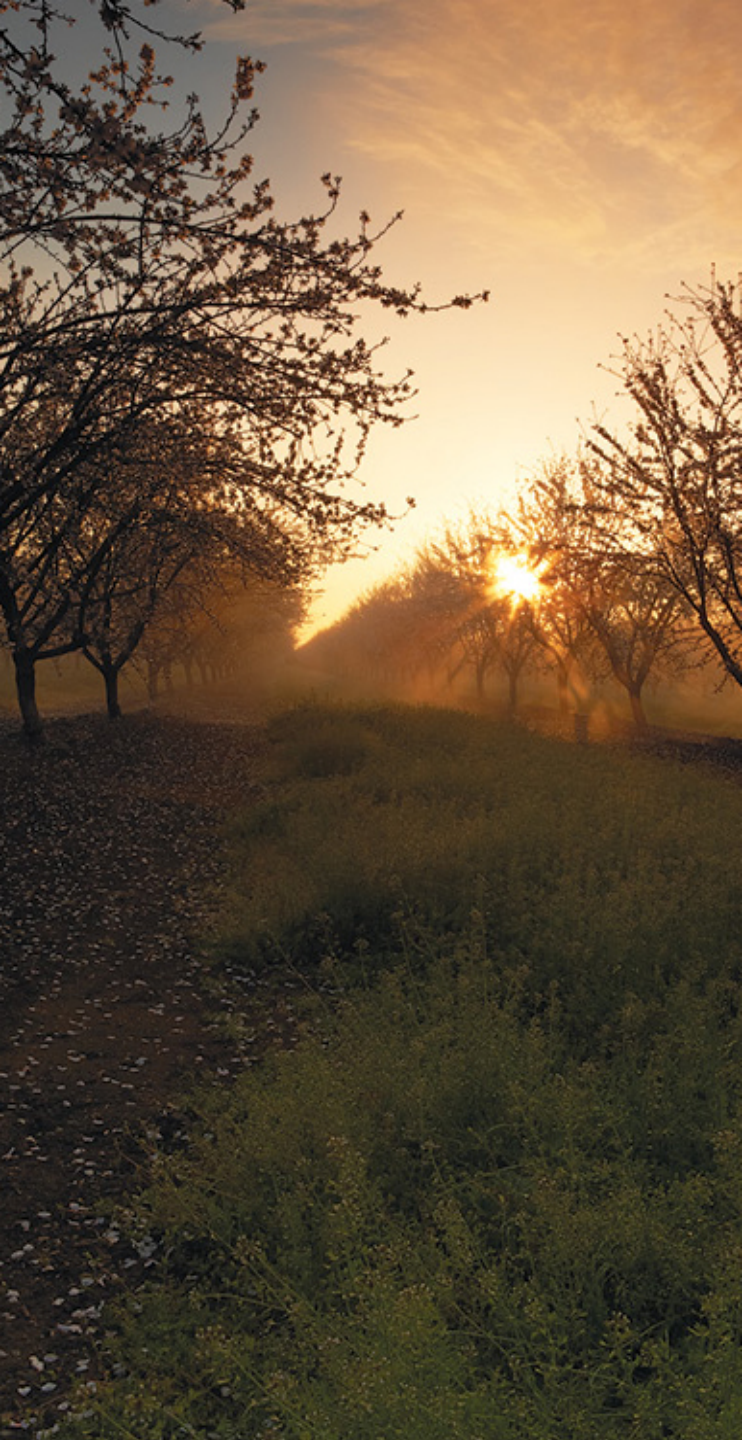
- Allow equipment access (shakers, weed sprayer, etc.
- Safety for tractor driver
- Reduce disease (Alternaria, hull rot, rust, etc.)??
- Sunlight on orchard floor to improve drying
- Remove dead or diseased limbs
- Reduce sticks at harvest

There are many reasons to prune an almond orchard. Yield does not appear to be one of them.



New Orchard Development: Site Evaluation through Planting

David Doll
Farm Advisor
UCCE Merced County



New Orchard Development

1. Site Evaluation
2. Site Sampling
3. Orchard Removal
4. Soil Amended/Modification
5. Soil Fumigation
6. Orchard Planting

Site Evaluation: Soil Differences

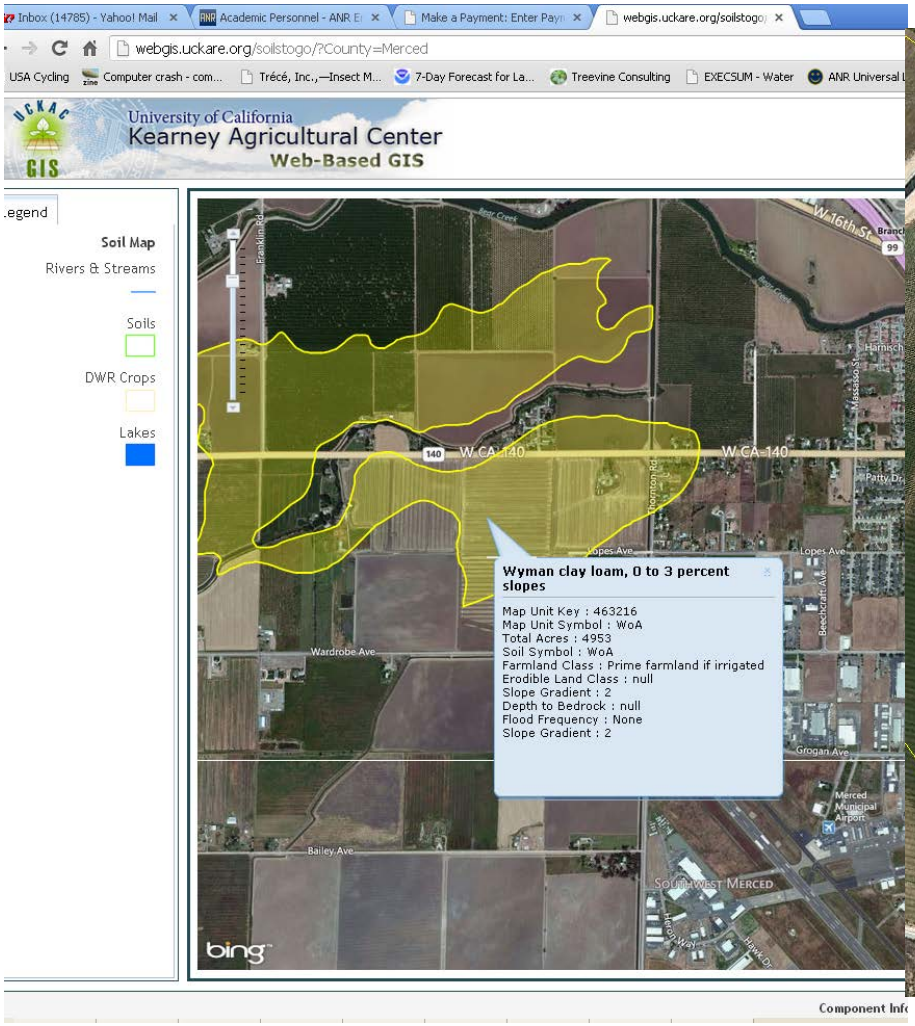
Learn from the old orchard!

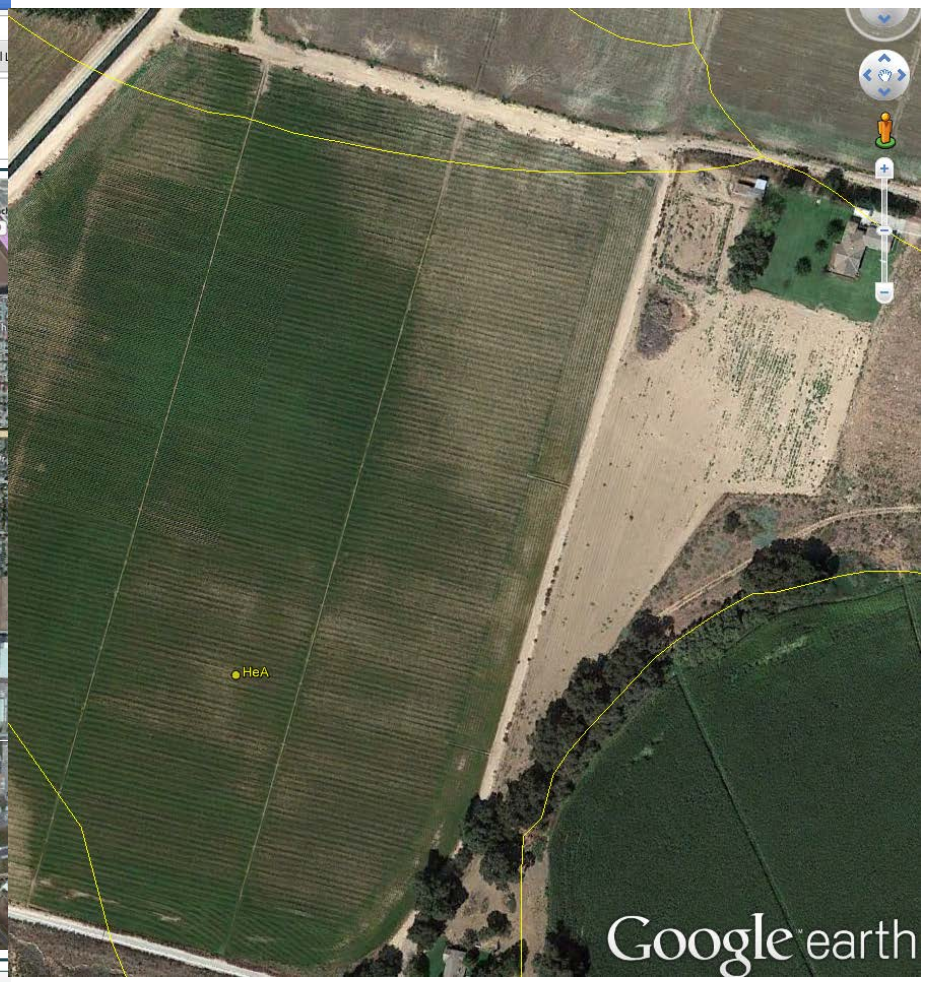
Aerial image through Google Earth, walking the field

Determine areas of variability and address

- Soil Modification – ripping, backhoeing, slip-plowing
- Irrigation system – High volume/low volume
- Rootstocks – Determine options for salinity, boron, alkalinity, high water table, etc.

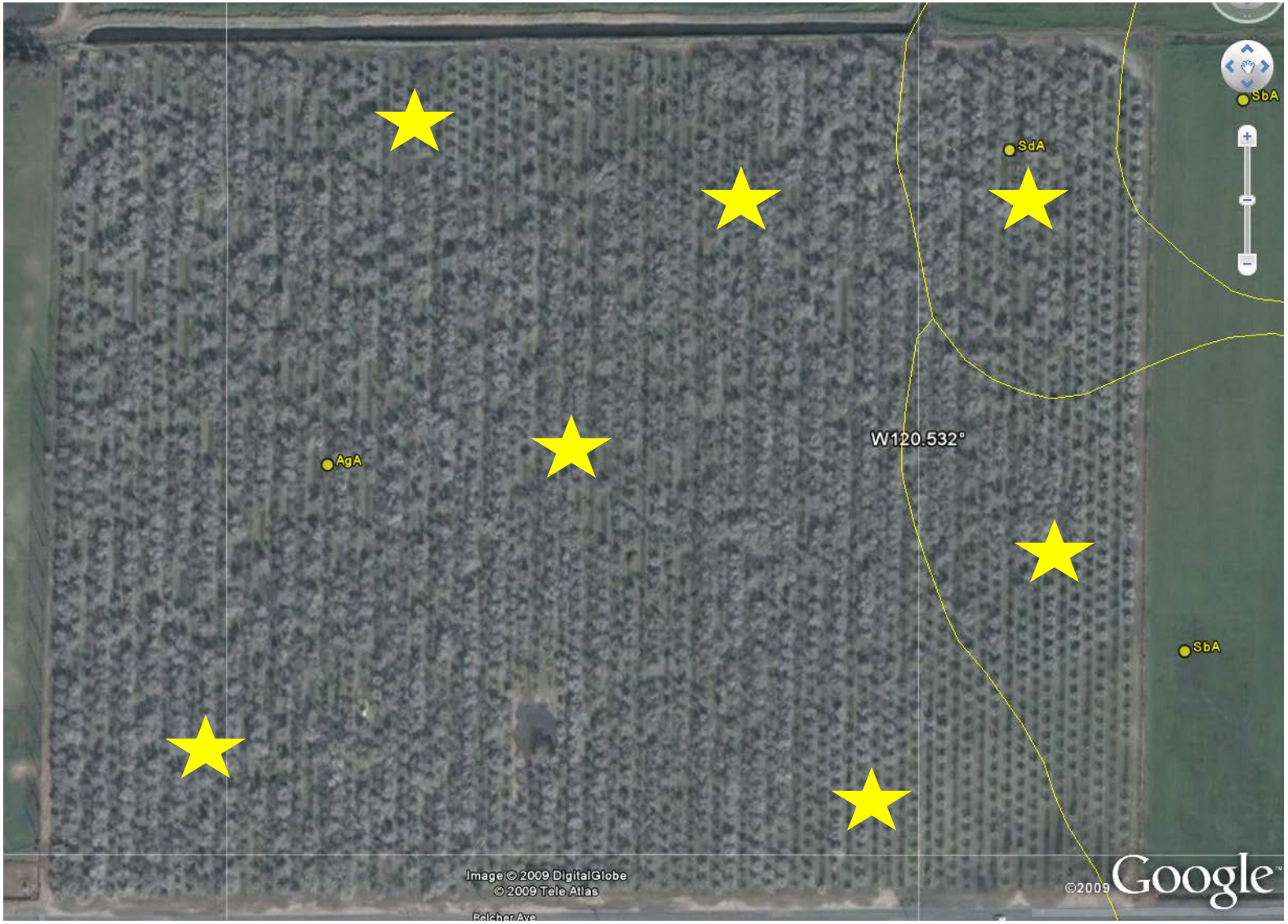
Site Evaluation: Soil Differences





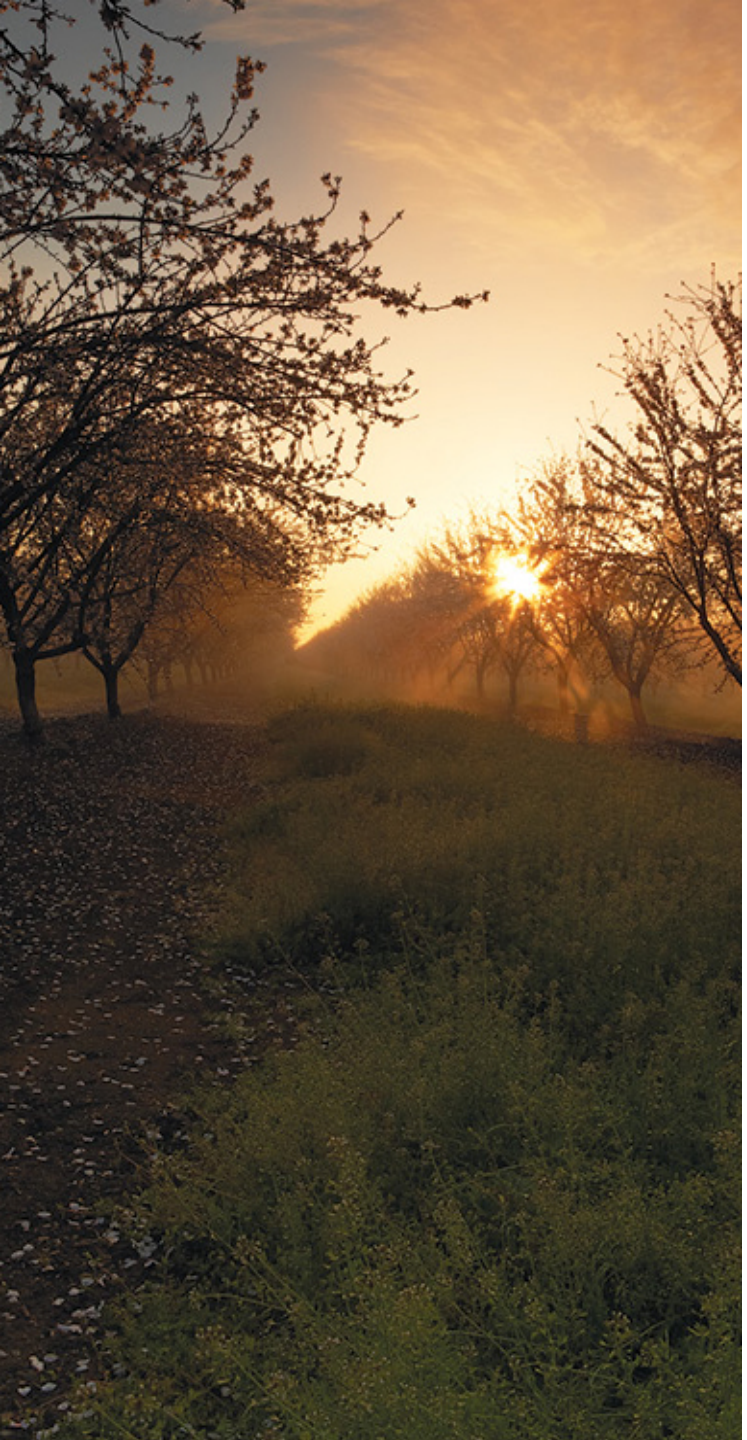
Soil Map: Soils-2-Go, NRCS, Google Earth, etc.

Site Evaluation: Backhoe Pits



Backhoeing Soil Pits – Why?

1. Determines soil layering
2. Uncovers the soil's secrets
3. Provides opportunity to sample various depths of soil



New Orchard Development

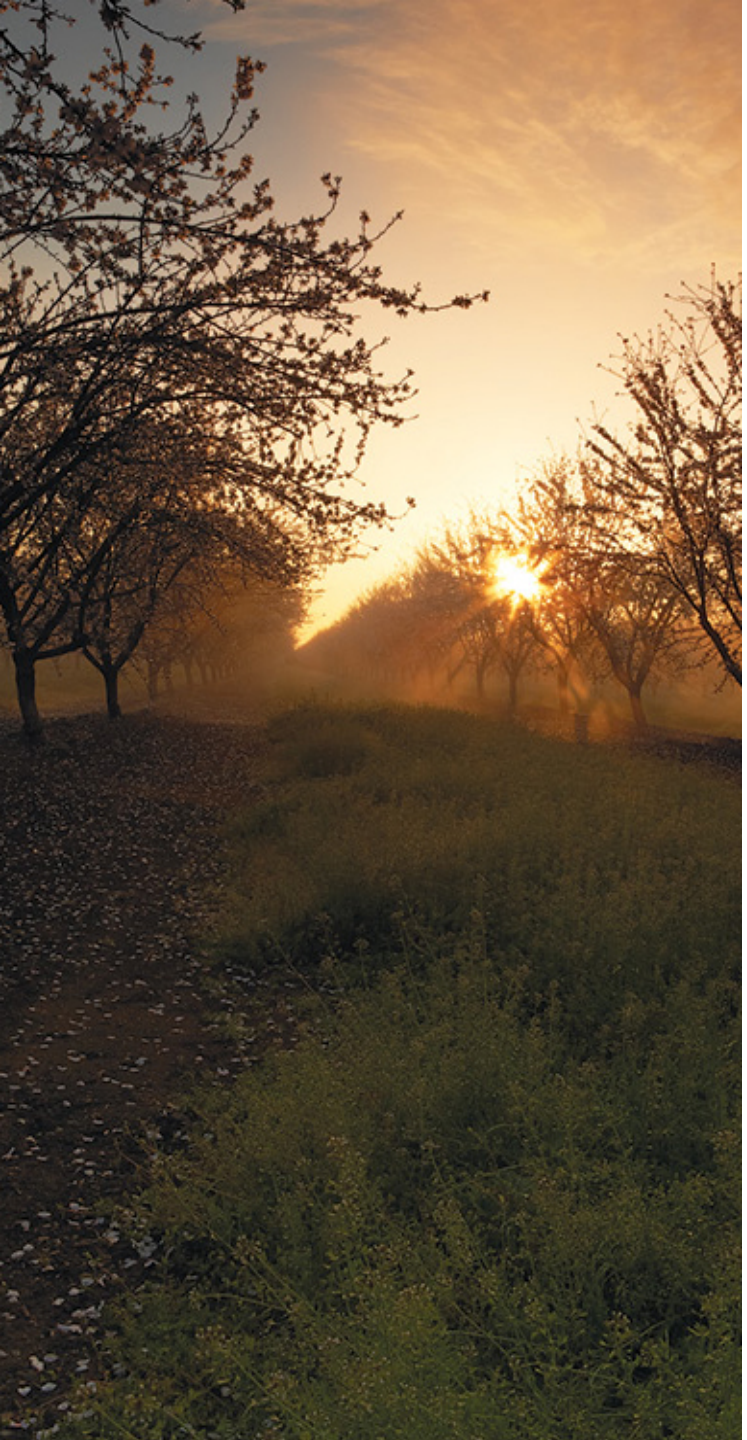
1. Site Evaluation
2. Site Sampling
3. **Orchard Removal**

Orchard Removal

"Iron Wolf"

Orchard Removal - Generalizations

	Stack and Burn	Grind and Haul (Tub Grinders)	Grind, Shred, and Incorporate (Iron Wolf)
Removal Time	Fast	Medium	Slow
Required Permits	Yes – size and county dependent	No	No
Root Ripping/Removal	Yes 3-5 passes	Yes 3-5 passes	No
Soil benefits	Some	Minimal	Increased OM, microbial activity, more??
Growth Issues	Minimal	Some (piles)	Minimal



New Orchard Development

1. Site Evaluation
2. Site Sampling
3. Orchard Removal
4. **Soil Amending/Modification**

Soil Modification

Ripper

Soil Modification - Generalizations

	Ripping	Slip Plow	Backhoe
Strength	Shattering Hardpan	Mixing Layers	Mixing Layers
Cons	Doesn't Mix Layers – tend to reform	Expensive to break hardpans, settling, pulls up "bad stuff"	Expensive, settling
Areas of Use	Hardpan within the first 4 feet	Extensive fine and coarse layering, heavier soils	Area of layering, compaction, lighter soils

Soil Modification – Slip Plow?

1 foot of clay-loam, followed by 1 foot of sandy-loam, 1 foot of clay-loam

2 feet of “good” followed by multiple layers of clay, sand, etc.

Soil Modification – Slip Plow?

2 feet of sandy loam, followed by several feet of sandy clay-loam

3 feet of “good” followed by 3 feet of gravel.

Soil Modification – Slip Plow?

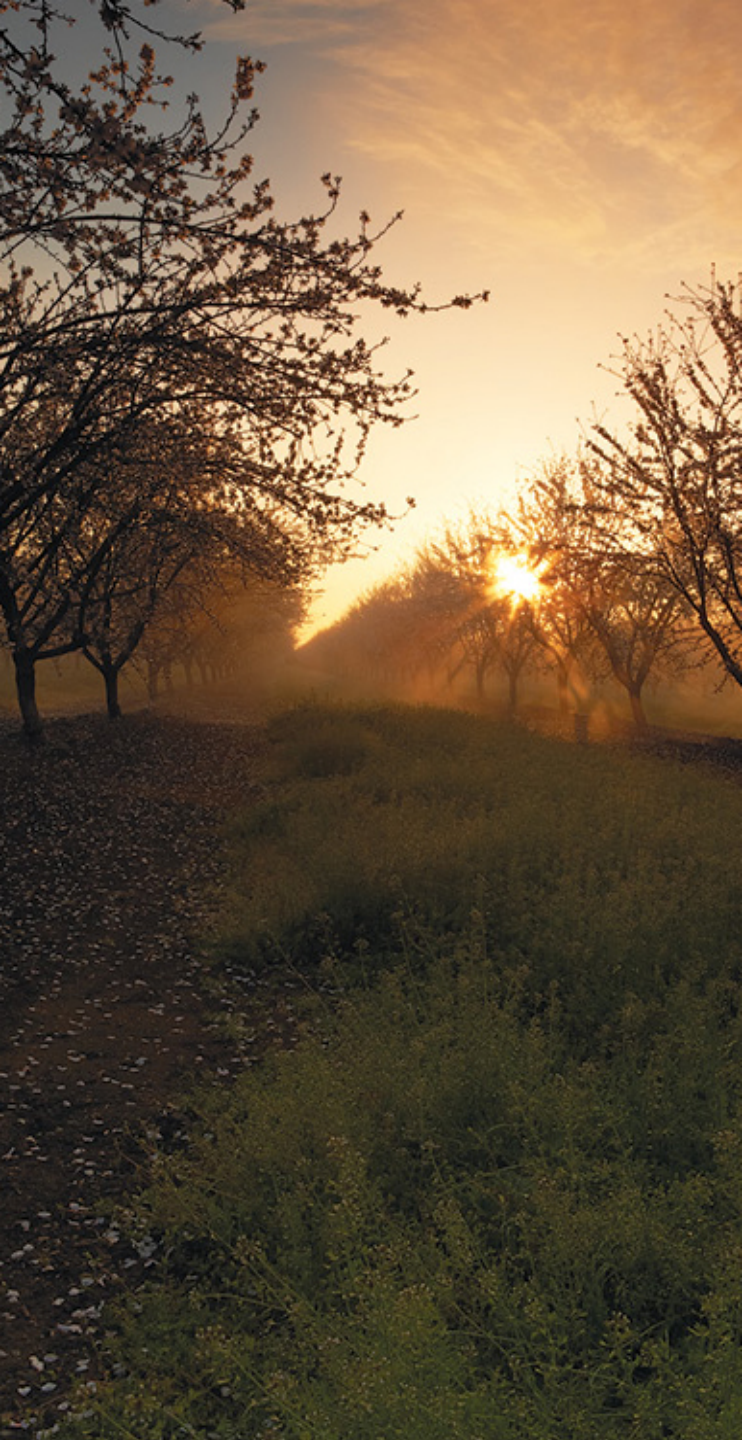
Year	Tree Age (years)	Slip Plowed (lb/ac)	Non-Slip Plowed (lb/ac)
2000	4	894	830
2001	5	1070	1243
2002	6	2725	2761
2003	7	2165	2323
2004	8	1869	1865
2005	9	1548	1841
2006	10	2910	2862
2007	11	2770	2571
2008	12	3771	3686
Cumulative		**19722**	**19982**

Arbuckle Sandy Loam, with clay underlayer, Micro-sprinkler irrigated

Slip-plowing brought rocky layer to surface

Slip Plowing probably still benefits highly layered soils

Edstrom, J., and S. Cutter. 2008. Nickels Soil Lab Projects



New Orchard Development

1. Site Evaluation
2. Site Sampling
3. Orchard Removal
4. Soil Amended/Modification
5. **Soil Fumigation**

Orchard Replanting – Replant Problems

Healthy (L) and replant disease-affected (R) almond trees, Madera County 2007

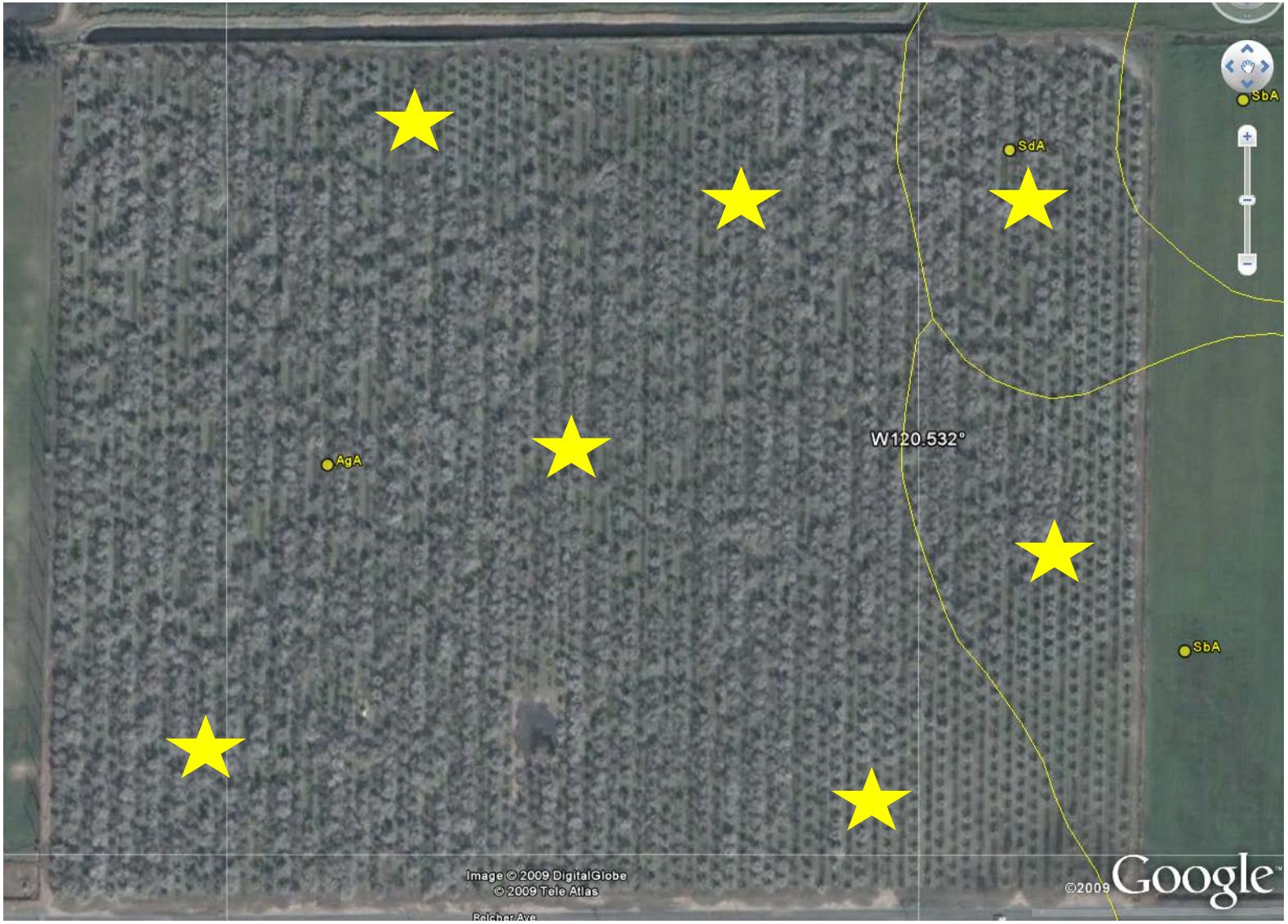
Orchard Replanting – Replant Problems

- **Abiotic factors** (physical, chemical conditions related to previous production)
- **Aggressive pathogens, pests** (*Phytophthora*, *Armillaria*, *Verticillium*, Ten-Lined June Beetle) –localized, not managed completely by fumigation
- **Plant-parasitic nematodes** (ring, lesion, root knot), approx. 35% of almond and fresh stone fruit acreage, 60% of cling peach acreage infested (McKenry)
- **Replant disease (RD)** Microbe-induced growth suppression; incidence nearly universal in *Prunus* after *Prunus,* but severity varies greatly

Healthy tree RD-affected tree

Symptoms of replant disease on almond

Orchard Replanting – Replant Problems

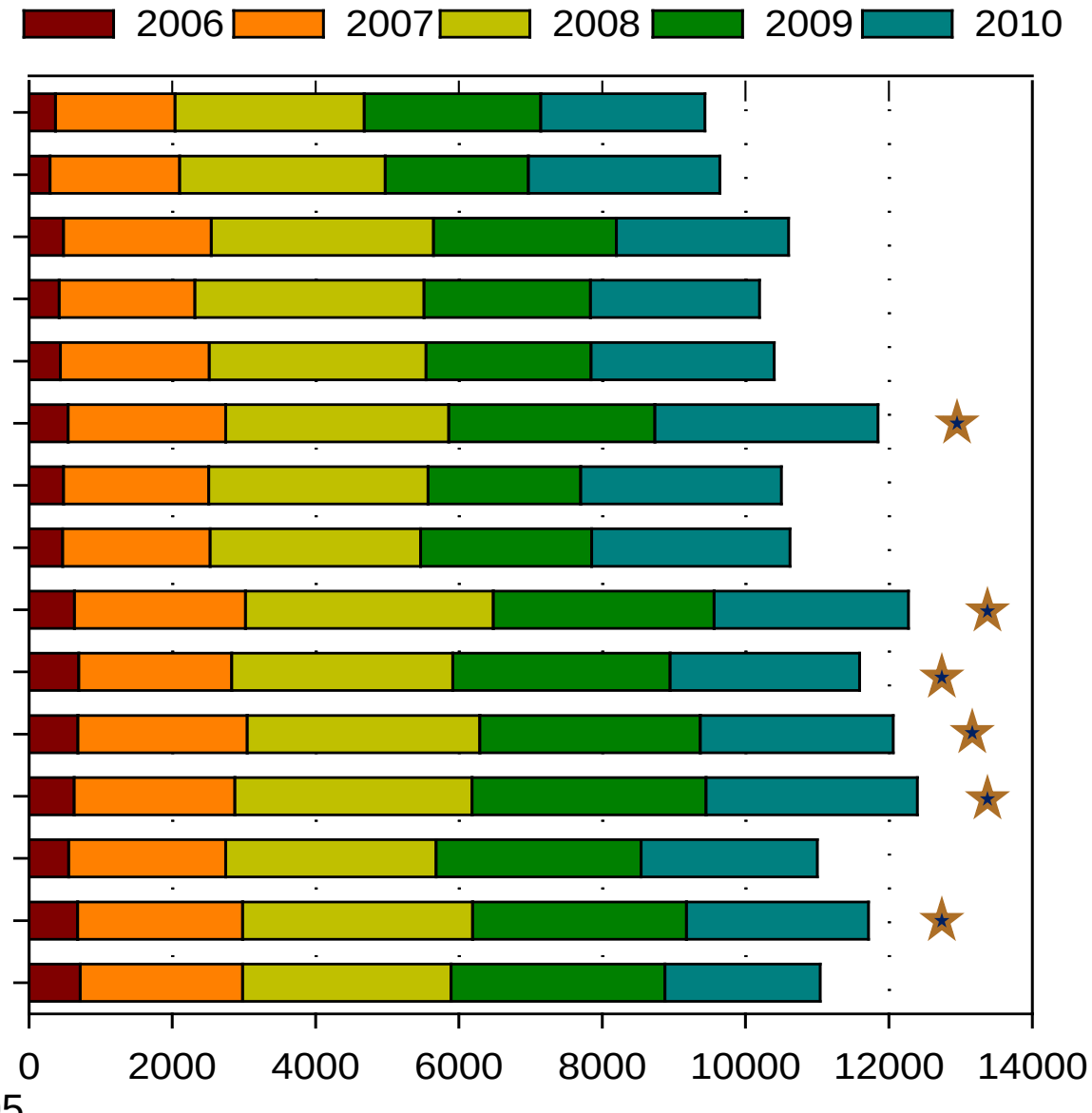


Orchard Replanting – Replant Problems

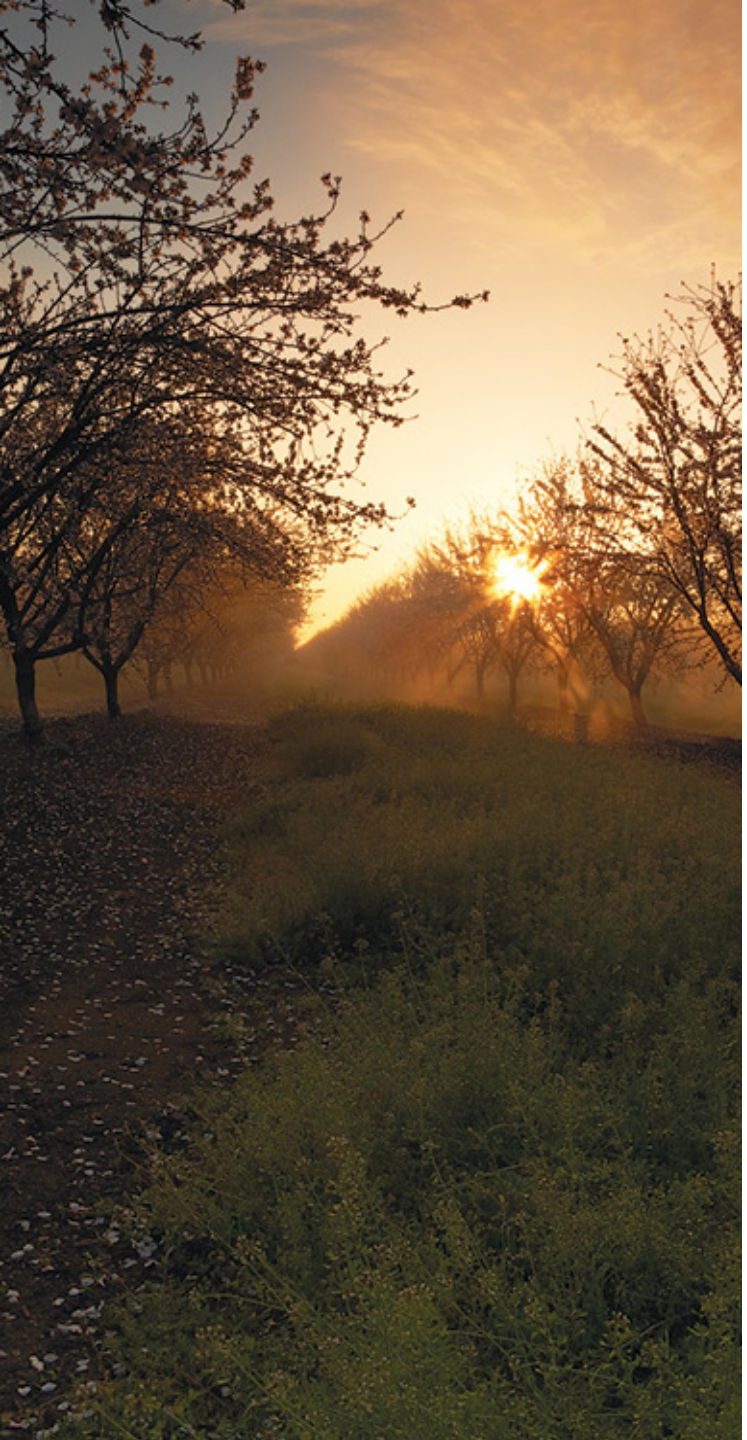
	Not Advised	Broadcast Telone II	Rowstrip C35, Chloropicrin
No Orchard History -Fallow Field, no nematodes	**X**		
No Orchard History – w/Nematodes		**X** – Population dependent	**X** – Population dependent
Orchard History, No Nematodes, Sandy Loams or coarser			**X** – C35
Orchard History, No Nematodes, Silt/Clay Loams or finer	Possible		Some benefit
Orchard History w/Nematodes		**X**- Population dependent	**X**- Population dependent
Orchard History with Aggressive Pathogens			Some benefit

Orchard Replanting – Replant Problems

Fumigant[a]	Treated area[b]	Mulch	lb/treated acre[c]
Control	None	None	0
Control	None	VIF	0
MB	Br. (100%)	None	400
MB	R. strip (38%)	None	400
MB	R. strip (38%)	VIF	400
Telone II	Br. (100%)	None	340
Telone II	R. strip (38%)	None	340
Telone II	R. strip (38%)	VIF	340
Telone C35	Br. (100%)	None	535
Telone C35	R. strip (38%)	None	535
Midas	Br. (100%)	None	400
Midas	R. strip (38%)	None	400
CP	Br. (100%)	None	400
CP	R. strip (38%)	None	400
CP	R. strip (38%)	VIF	400



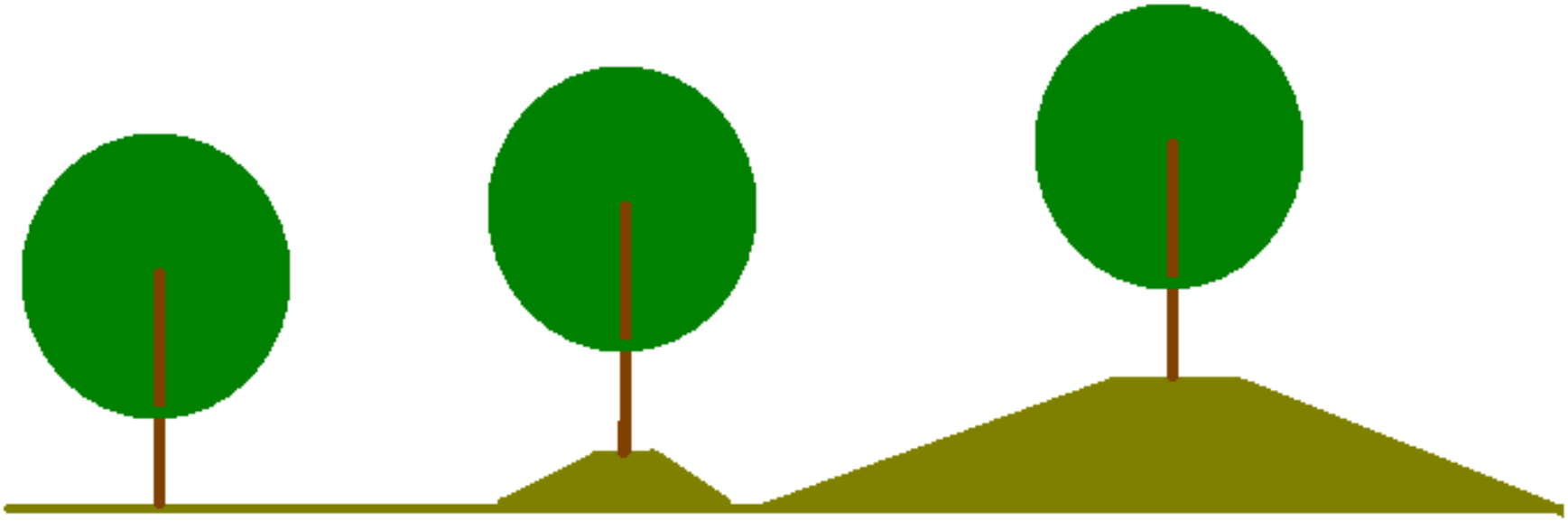
★Significance at p<0.05



New Orchard Development

1. Site Evaluation
2. Site Sampling
3. Orchard Removal
4. Soil Amended/Modification
5. Soil Fumigation
6. **Tree Planting**

Tree Planting: Berms?



Flat:
- Easiest to use with equipment
- Use only in soils with quick drainage (loamy sands-sands)

Standard Berm:
- 8”+ in height, 5’ wide
- Drains water away from crown, keeps roots out of water
- Issues with harvest, weeds, equipment
- Generally recommended

Raised Bed:
- 20”+ in height, 11’ wide
- Possible use in shallow soils
- Increase in yield v/s berm
- Issues with equipment
- Experimental, but feasible

Tree Planting – Method

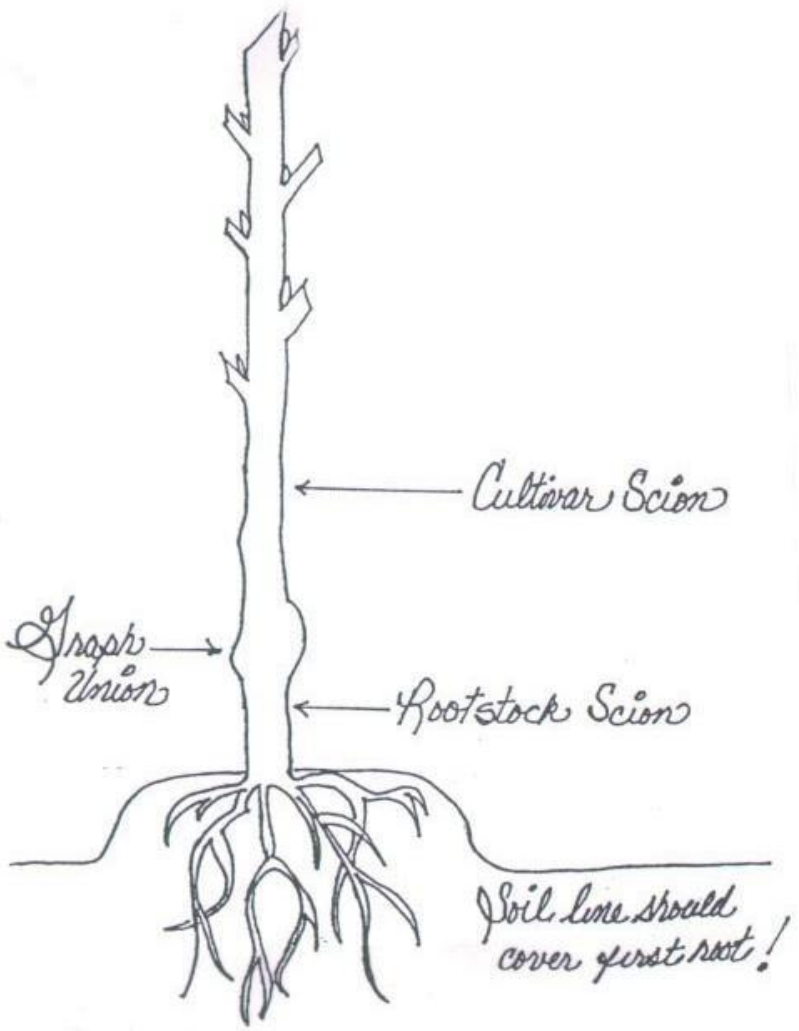
Machine Planting

1. Plants Quickly, Accurately
2. Can create berm as it plants
3. Fewer issues with planting (improper hole size)
4. Limitations on heavy soil and rains?

Hand Planting

1. More control on the planting conditions
2. Can adjust for larger rooting trees
3. No limited on soil types, conditions
4. Possible problems with “scoop, ball, and shove” method on root development

Tree Planting - Method

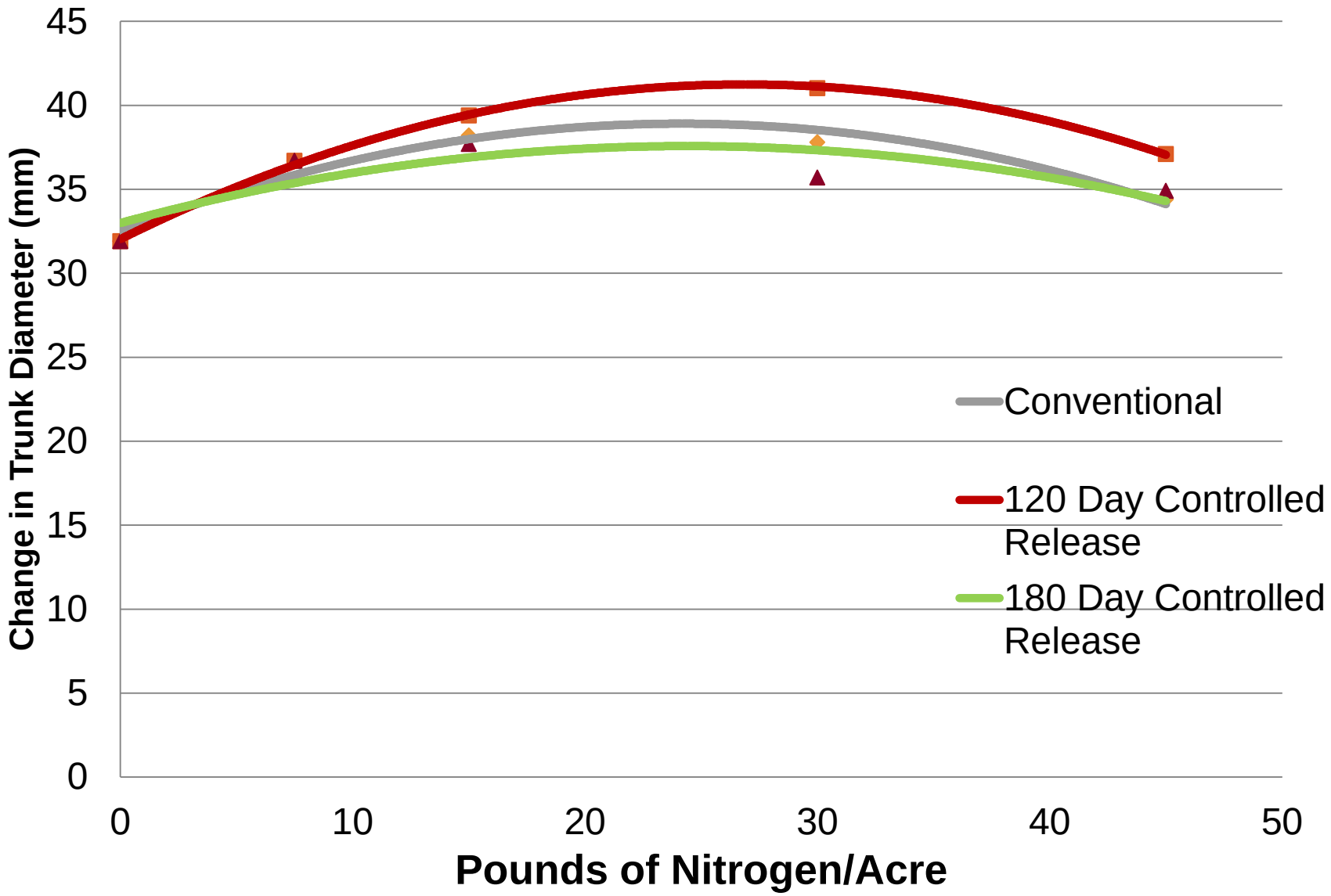


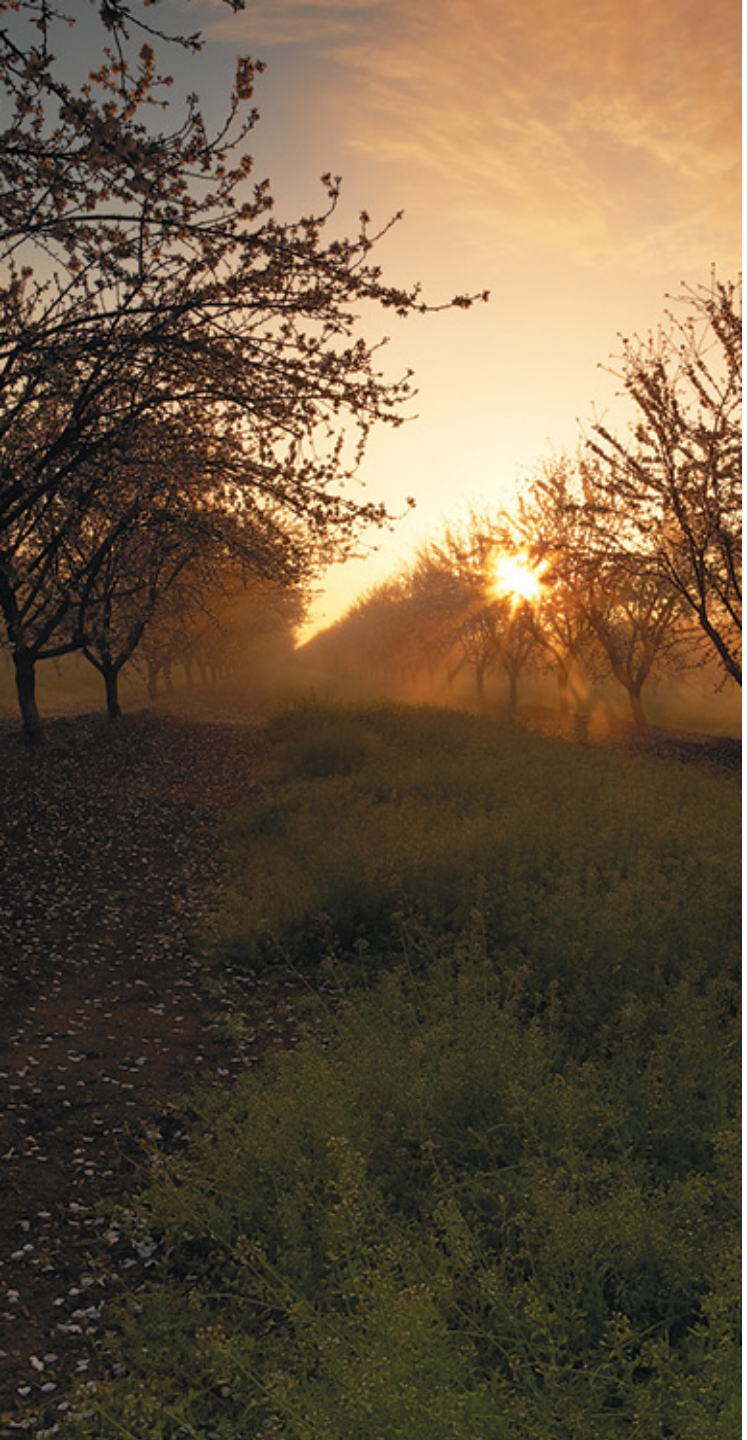
Drawing by Brent Holtz

- Dig a big hole
- Plant high
  - Highest root should be covered with a few inches of soil
  - Graft union must be above soil line
  - Allow 3-4 inches for settling
- Tank in the tree with 3-5 gallons of water
  - Re-tank if needed (i.e. hot weather)
- Trim branches, high heading cut (36”+)

Tree Planting - Problems

Fertilizing First Year Trees





New Orchard Development

Conclusions

Conclusions

“Ounce of prevention is worth a pound of cure”

Only time in the orchards life that soil can be thoroughly evaluated, modified, fumigated.

Pulling berms after planting is a mistake as it often buries the graft union

Planting the tree properly prevents windthrow, crown gall, and increases vigor

Still working on young orchard nitrogen rates!

Designing and Developing a New Orchard: Water Management

Ken Shackel

Plant Sciences/Pomology Professor

UC Davis

With help from: Joe Connell, and Bruce Lampinen.

New Orchards: Water Management

growing ADVANTAGE
The Almond Conference

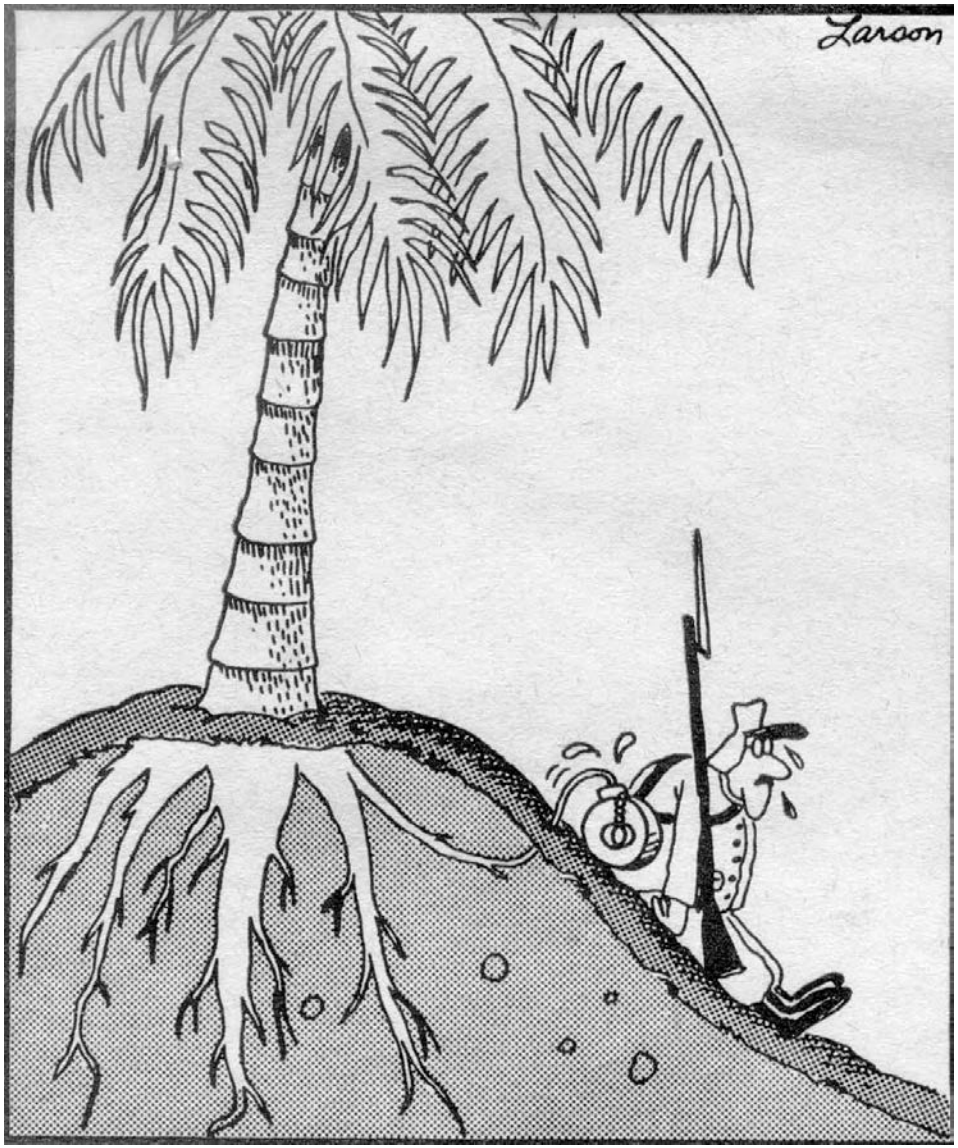
Almonds: very drought resistant, but also very responsive to water inputs.

Low density, rain-fed

High density, irrigated

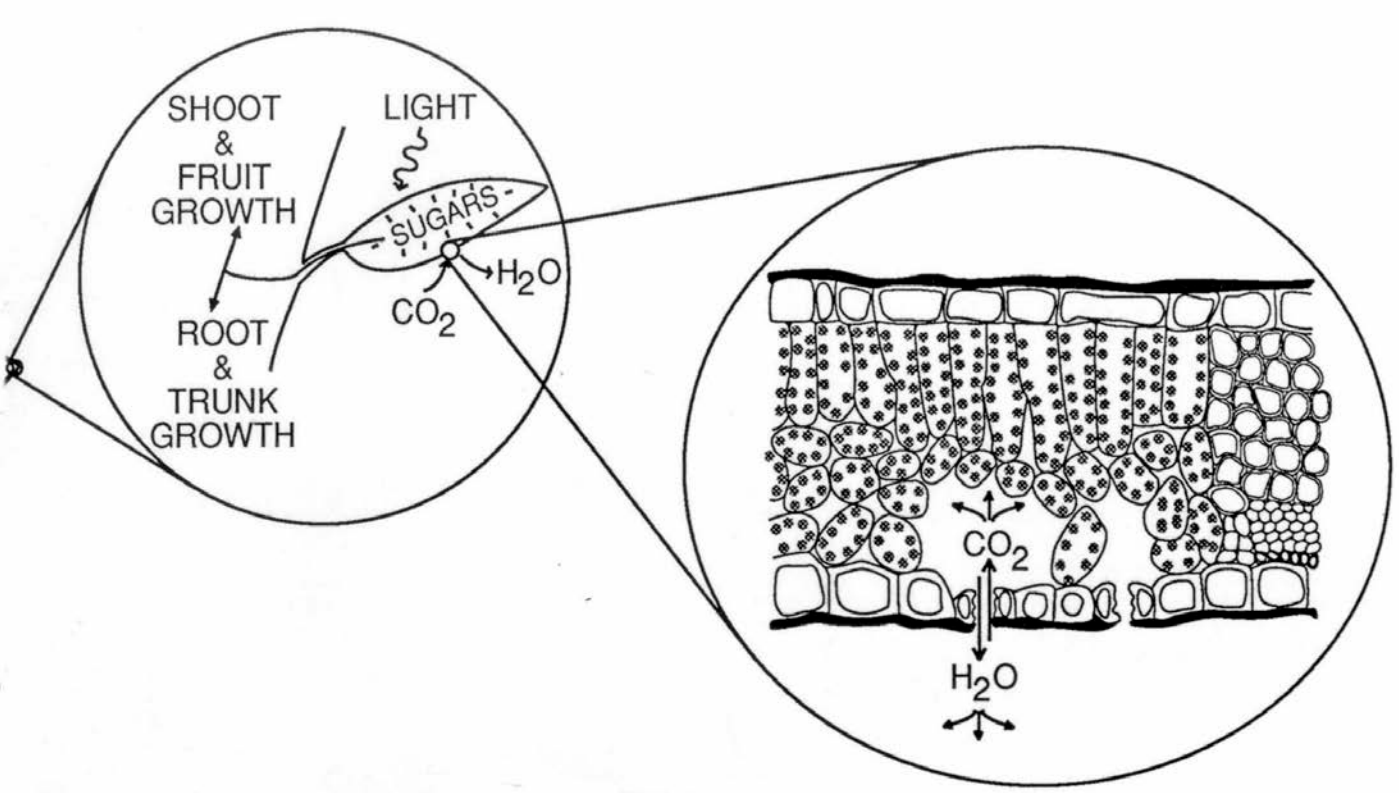
New Orchards: Water Management

Just like us, almond trees need some water to survive, but almond **leaves** need a constant supply of water to be productive.



New Orchards: Water Management

Almond **leaves** are “factories” producing sugars from light and CO_2 (photosynthesis), but in the process, a lot of water is lost to evaporation (around 500 gallons of water per pound of almonds). This is called “evapotranspiration” (ET).



New Orchards: Water Management

The "standard" way to determine almond orchard water requirements is to estimate orchard ET using weather data.

The soil holds water like a bank account, and the orchard uses water from this account.

A "water budget" tells you when the bank account needs refilling, and how much to replace.

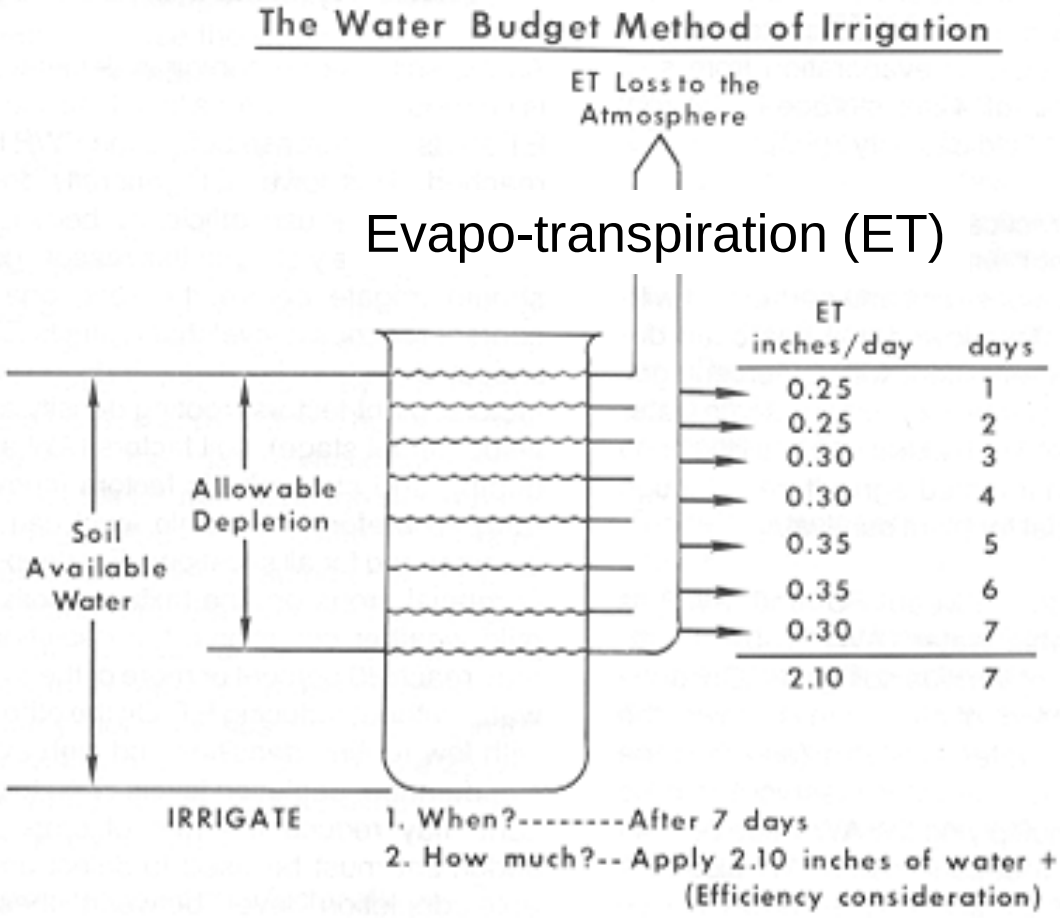


Fig. 2. Water-budget method of irrigation.

New Orchards: Water Management

Of course, there are many other places that water can go besides being stored in the soil, so there are a number of additional practical considerations….

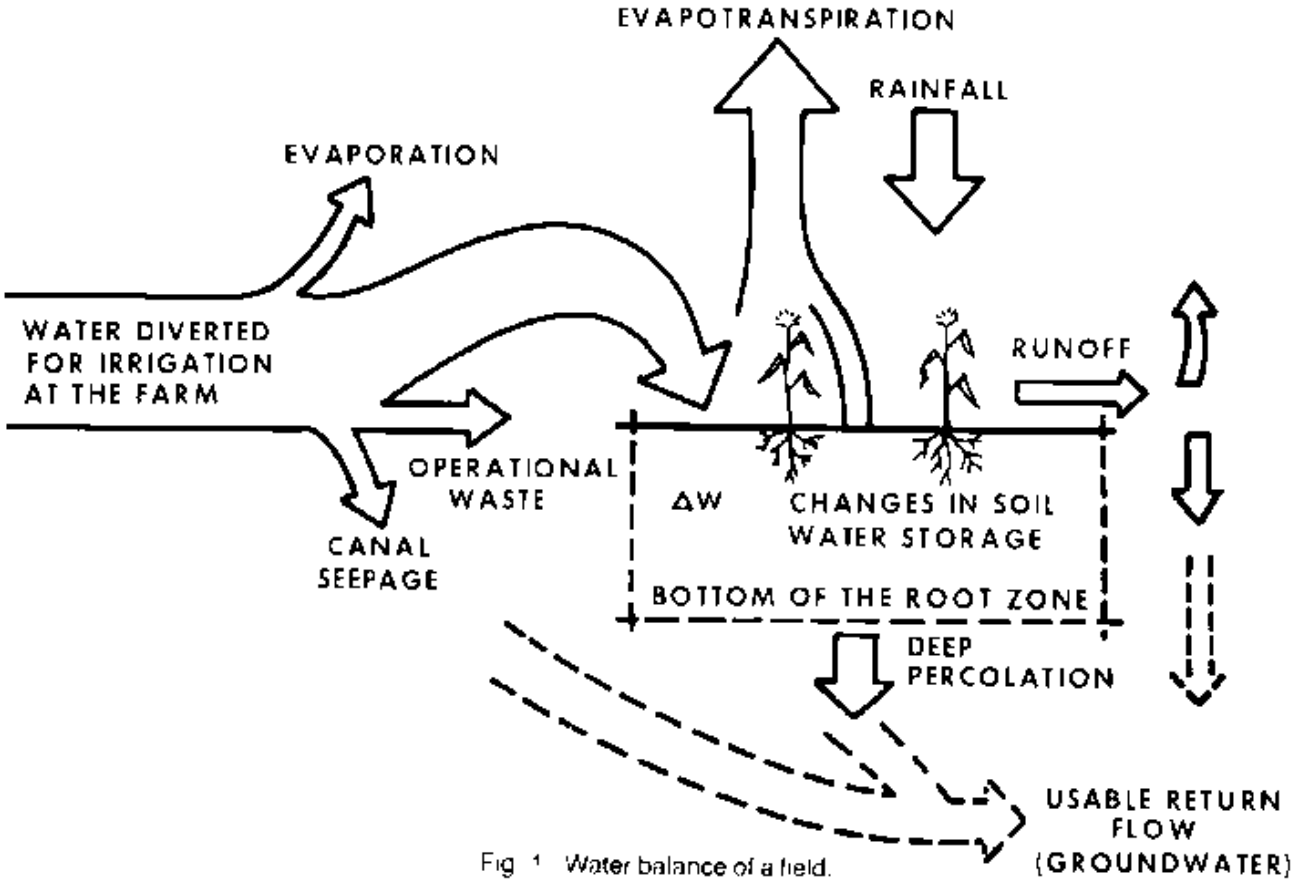
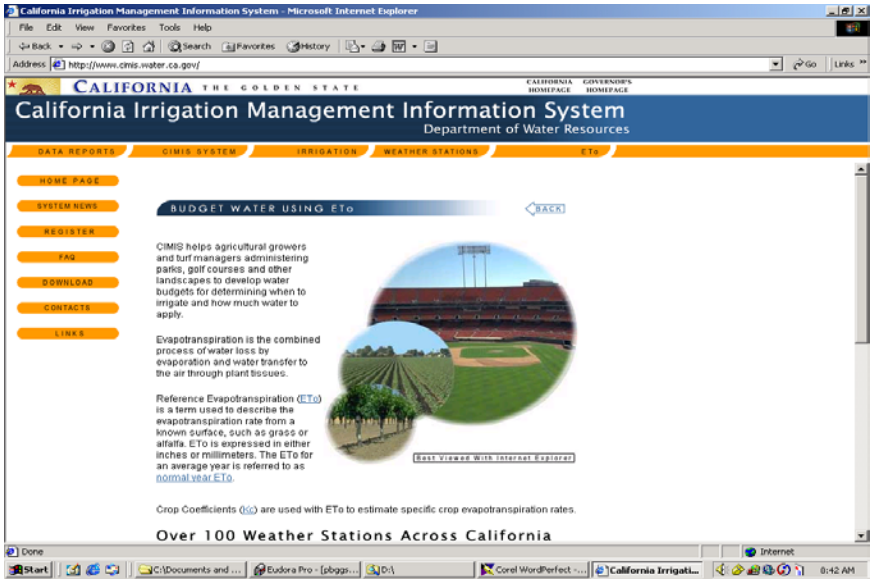


Fig 1 Water balance of a field.

New Orchards: Water Management

But for most crops in California (including almonds), there are many websites to help with all this accounting.

http://www.cimis.water.ca.gov/



http://www.wateright.org/

New Orchards: Water Management

Maximum anticipated orchard ET should already have been considered when your irrigation system was designed.

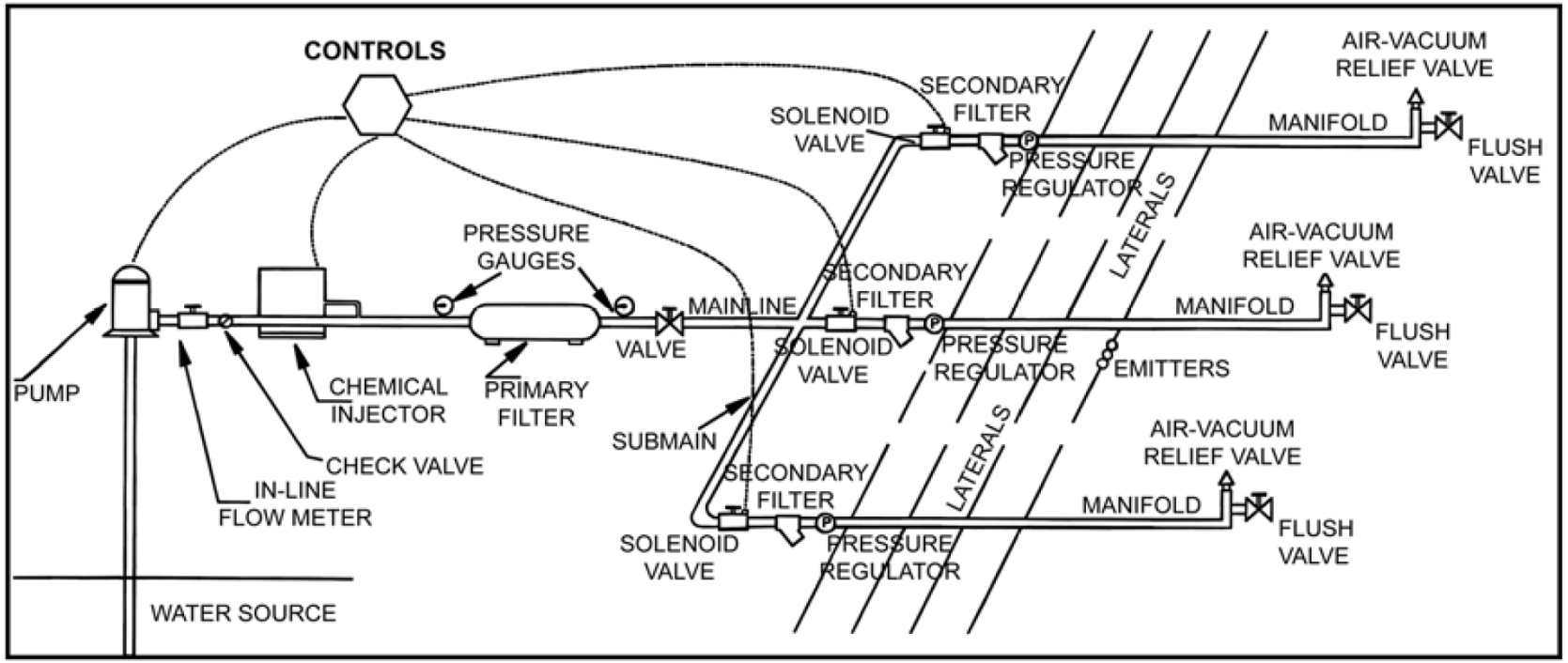


Figure 10. Components of typical drip irrigation system

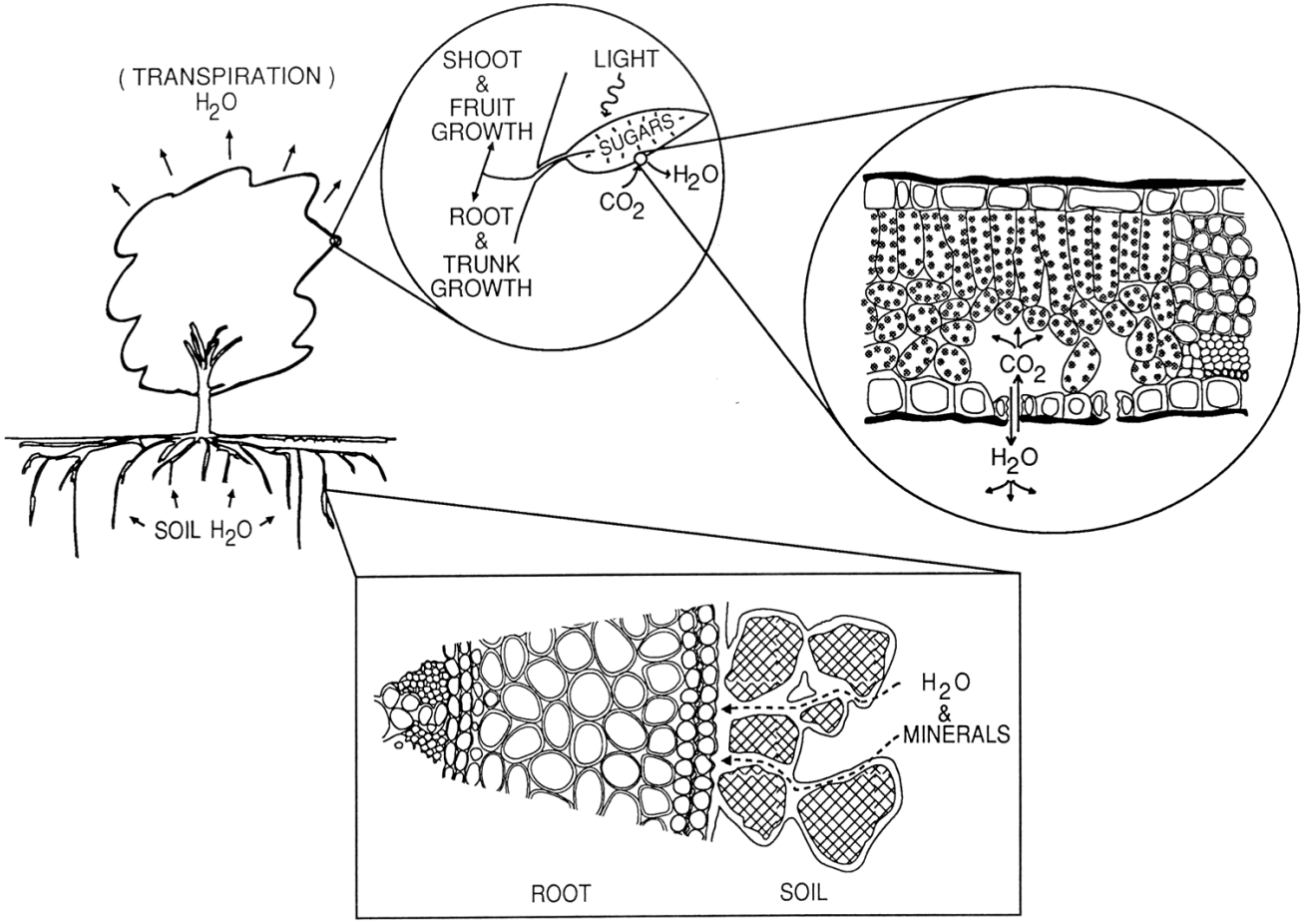
Harrison, K, Univ. Georgia CE

New Orchards: Water Management

But from the trees perspective, there is more to the story than how much is in the bank account: how **hard** is it to get that water?

Trees use suction to get water from soil.

The dryer the soil, the more the suction.

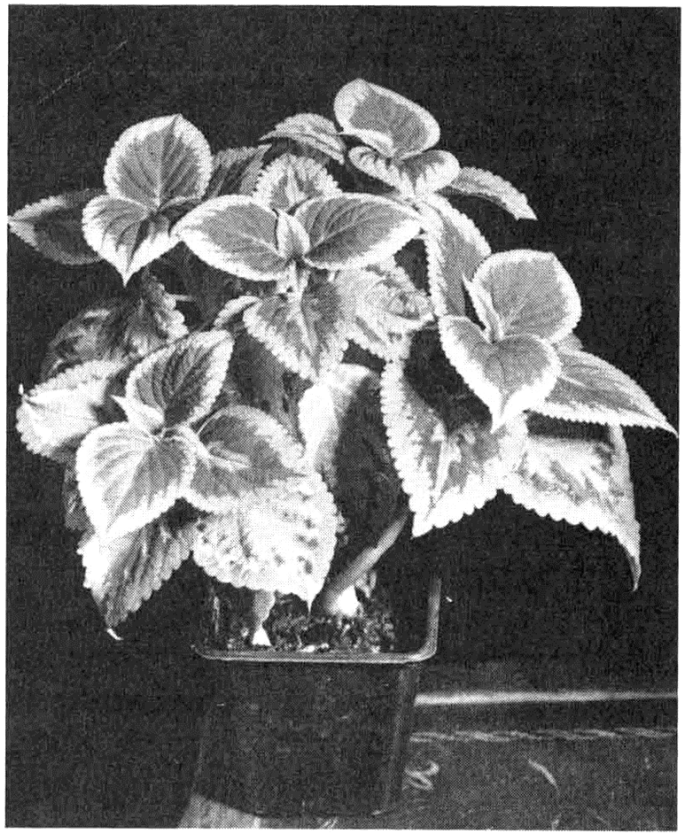


New Orchards: Water Management

When water suction gets too high, water is sucked out of cells, and for some pants, leaves loose turgidity and visibly wilt. The suction in a plant is called its “water potential.”

But long before this visible symptom of water stress, growth slows.

Luckily, we have a device that can measure water stress in almonds.



Salisbury & Ross, Plant Physiology (1992)

New Orchards: Water Management

The "Pressure Bomb" was developed in the early 1960's to extract water from leaves.

But it was later found that the pressure required to push water out of the leaf was actually measuring leaf water potential!

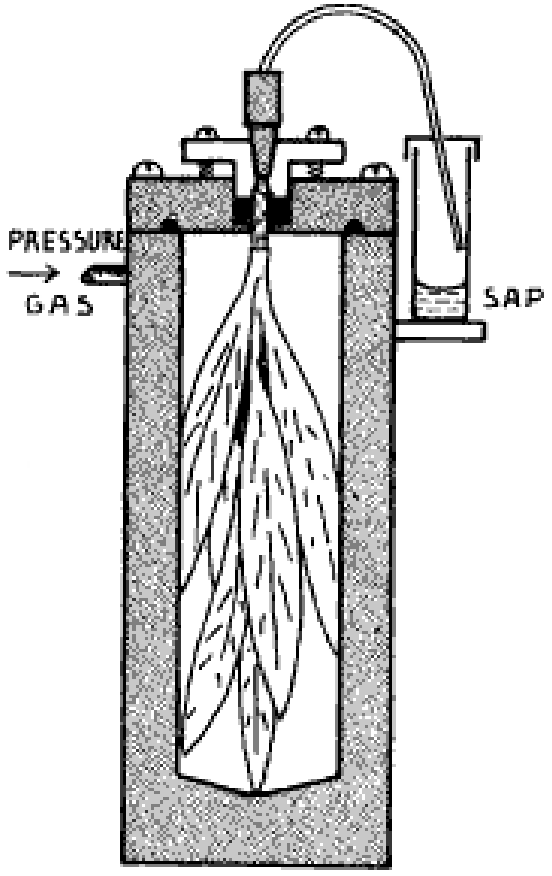
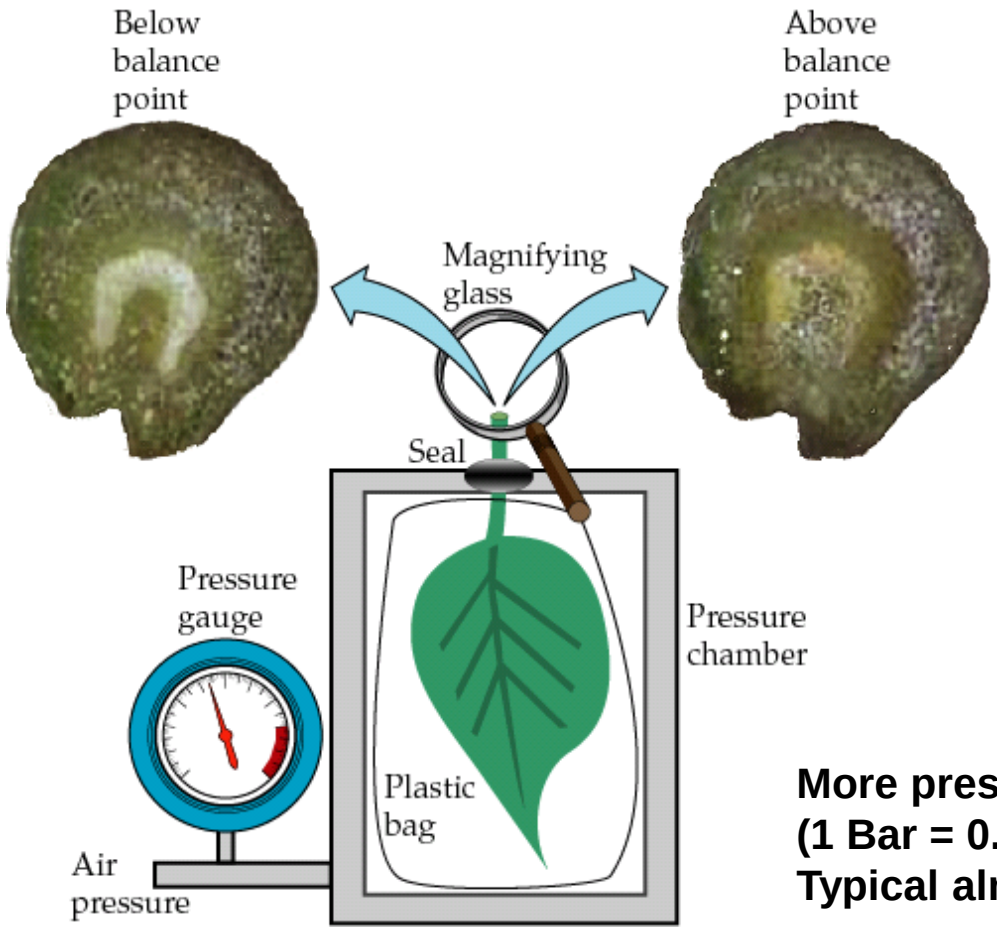


FIG. 3.—Pressure bomb with leafy twig, rubber compression gland, and plastic capillary for collection of sap.

Scholander et al, 1964

New Orchards: Water Management

Now we use it routinely to measure the “blood pressure” of the plant.



More pressure = lower water potential = more stress.
(1 Bar = 0.1 MPa = 14.5 psi)
Typical almond values range from -7 to -30^{+} bars.

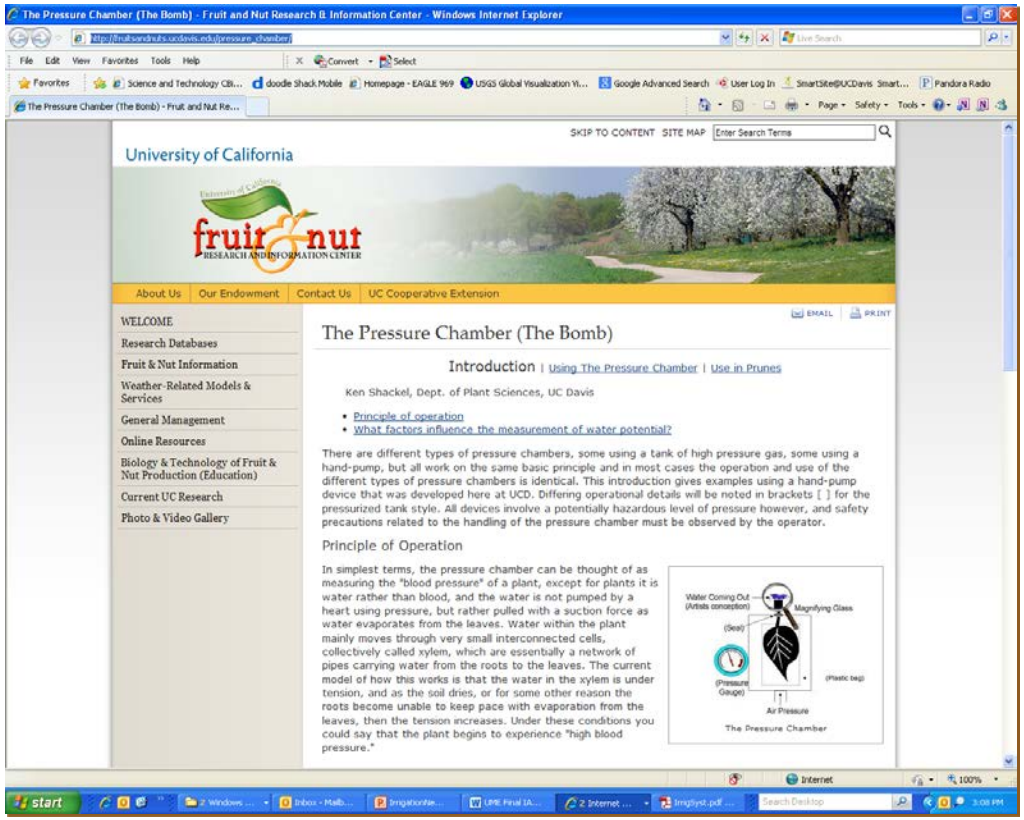

S10
CHEVROLET
CORNING
California
E034608


Stem water potential
(SWP)

New Orchards: Water Management

Resources to find out more about the pressure bomb/pressure chamber.

http://fruitsandnuts.ucdavis.edu/pressure_chamber/



Wikipedia!

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.

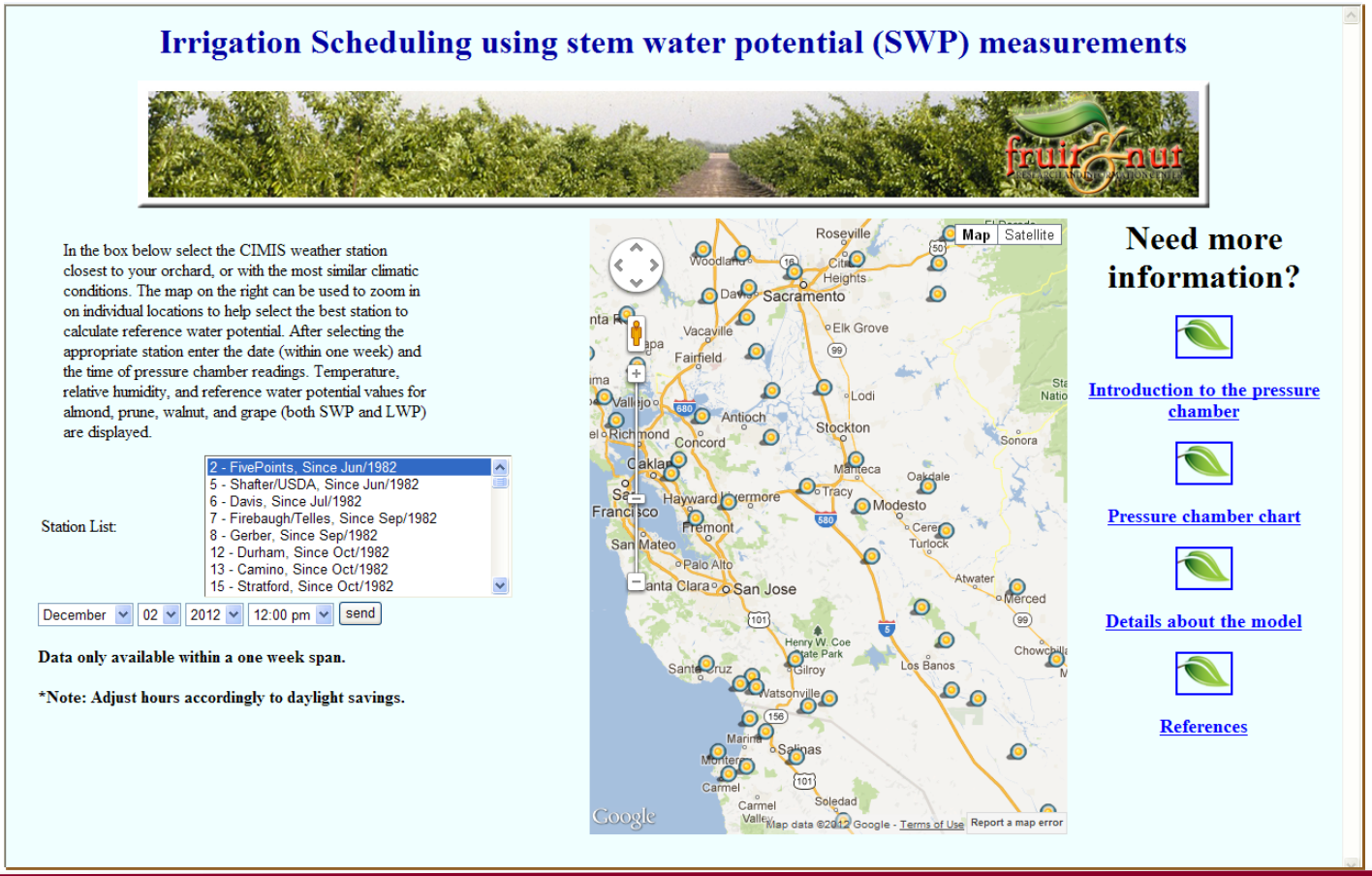
New Orchards: Water Management

Under fully irrigated conditions (no limitation in soil water), the value of SWP will depend on the weather. This is called a "baseline" SWP value.

Air Temperature (F)	Air RH (%)		
	20	40	60
70	**-6.5**	**-5.9**	**-5.3**
80	**-7.5**	**-6.6**	**-5.8**
90	**-8.7**	**-7.6**	**-6.4**
100	**-10.4**	**-8.8**	**-7.2**
110	**-12.6**	**-10.4**	**-8.3**

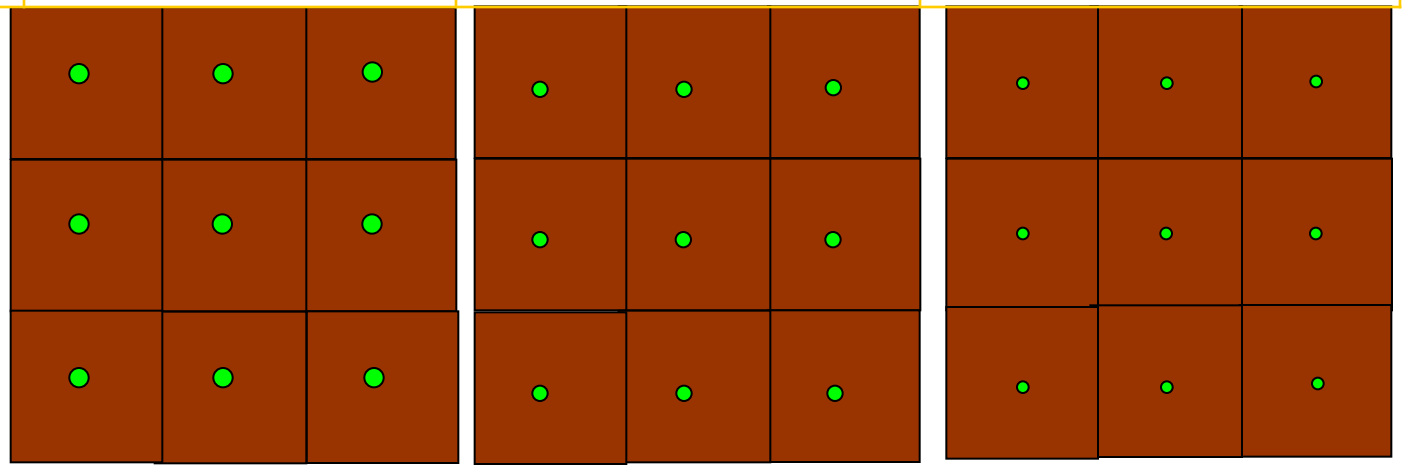
New Orchards: Water Management

The fruit and nut center at UCD is developing a website linked to CIMIS that will give this information for your location and date/time.



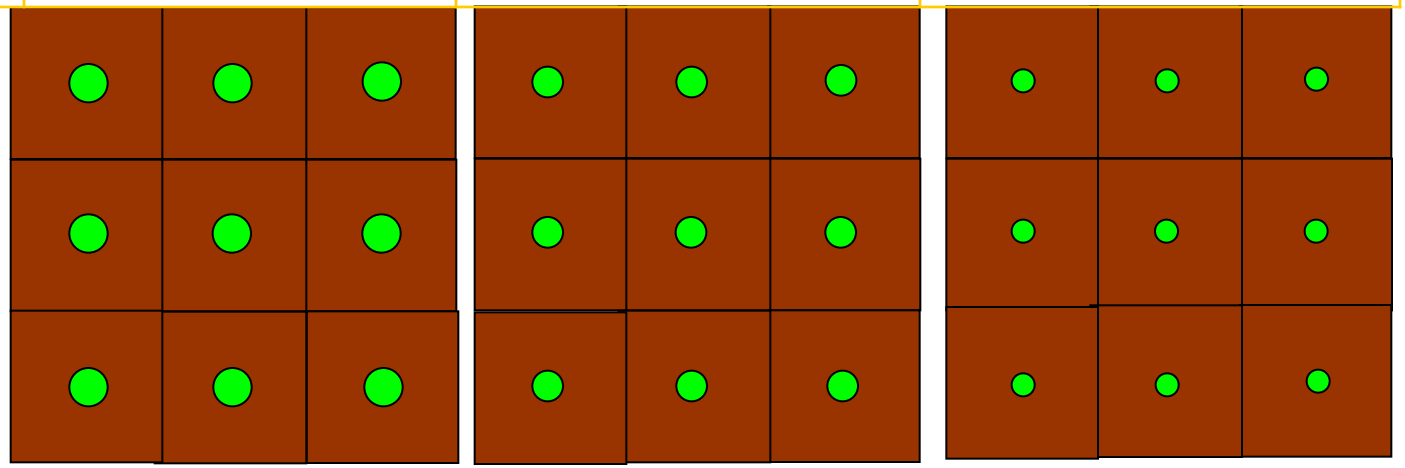
After one year at seasonal average midday stem water potential of:

	-8 bars	-12 bars	-16 bars
Yield (lbs/ac)	500	400	300
Cum. yield	500	400	300
Cum. dollars	$1000	$800	$600
Per acre loss		-$200	-$400



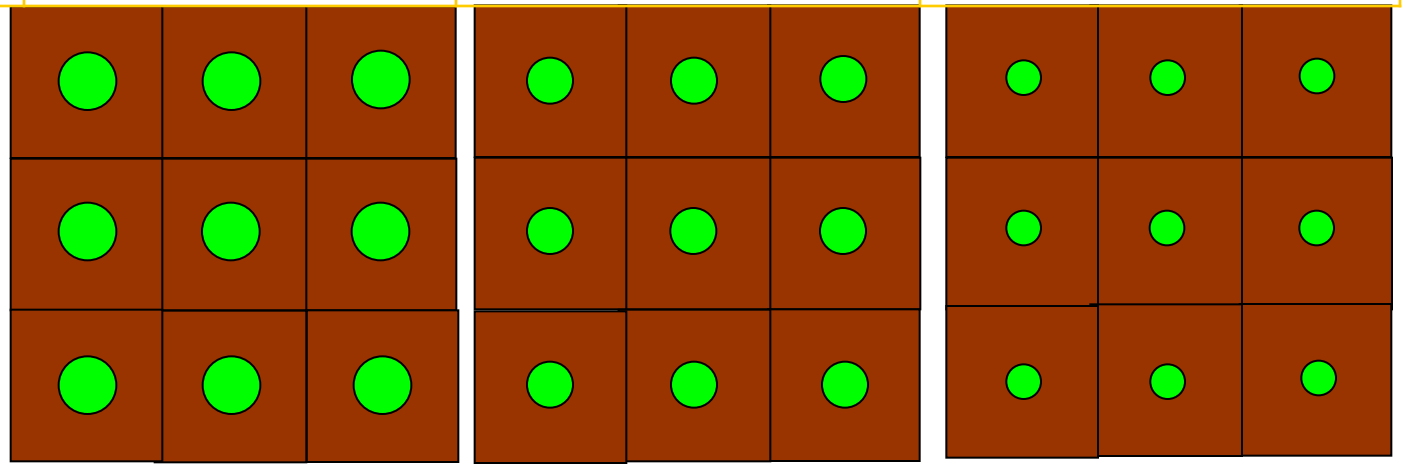
After two years at seasonal average midday stem water potential of:

	-8 bars	-12 bars	-16 bars
Yield (lbs/ac)	1,000	800	600
Cum. yield	1,500	1,200	900
Cum. dollars	$3,000	$2,400	$1,800
Per acre loss		-$600	-$1,200



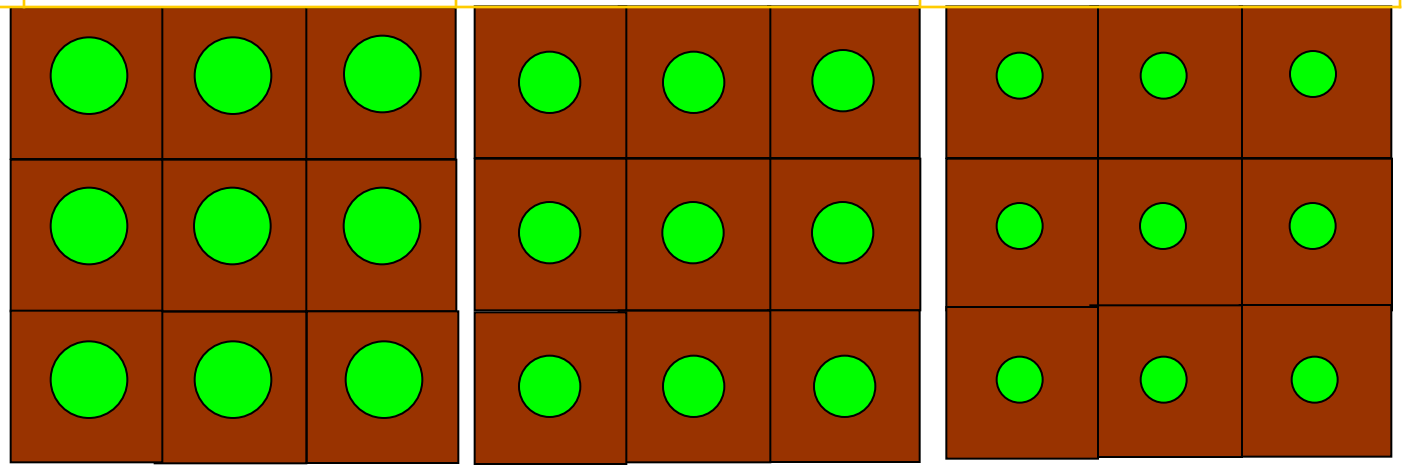
After three years at seasonal average midday stem water potential of:

	-8 bars	-12 bars	-16 bars
Yield (lbs/ac)	1,500	1,200	900
Cum. yield	3,000	2,400	1,800
Cum. dollars	$6,000	$4,800	$3,600
Per acre loss		-$1,200	-$2,400



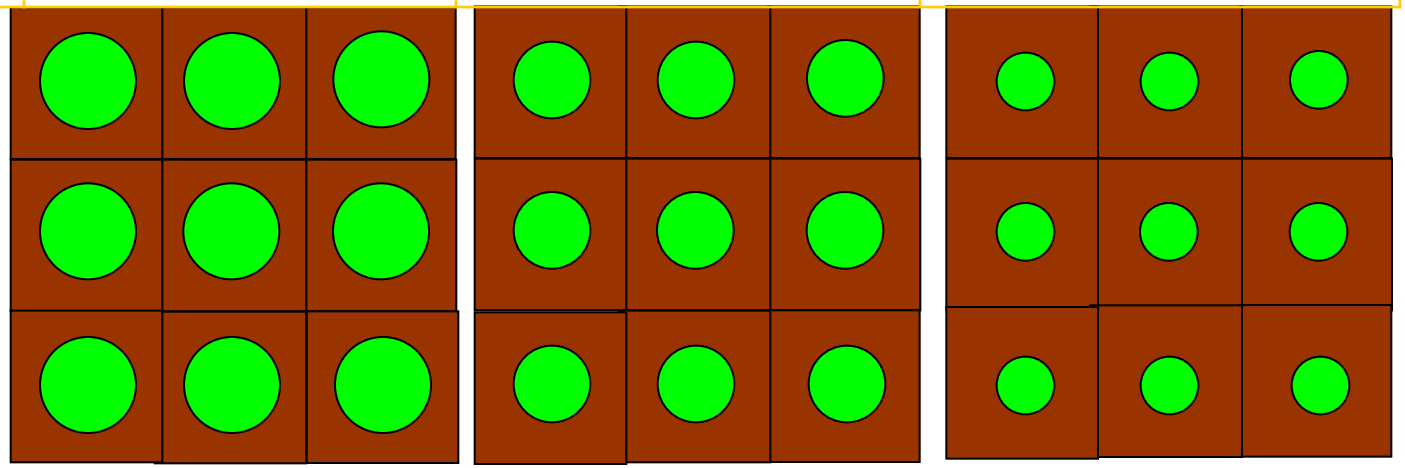
After four years at seasonal average midday stem water potential of:

	-8 bars	-12 bars	-16 bars
Yield (lbs/ac)	2,000	1,600	1,200
Cum. yield	5,000	4,000	3,000
Cum. dollars	$10,000	$8,000	$6,000
Per acre loss		-$2,000	-$4,000



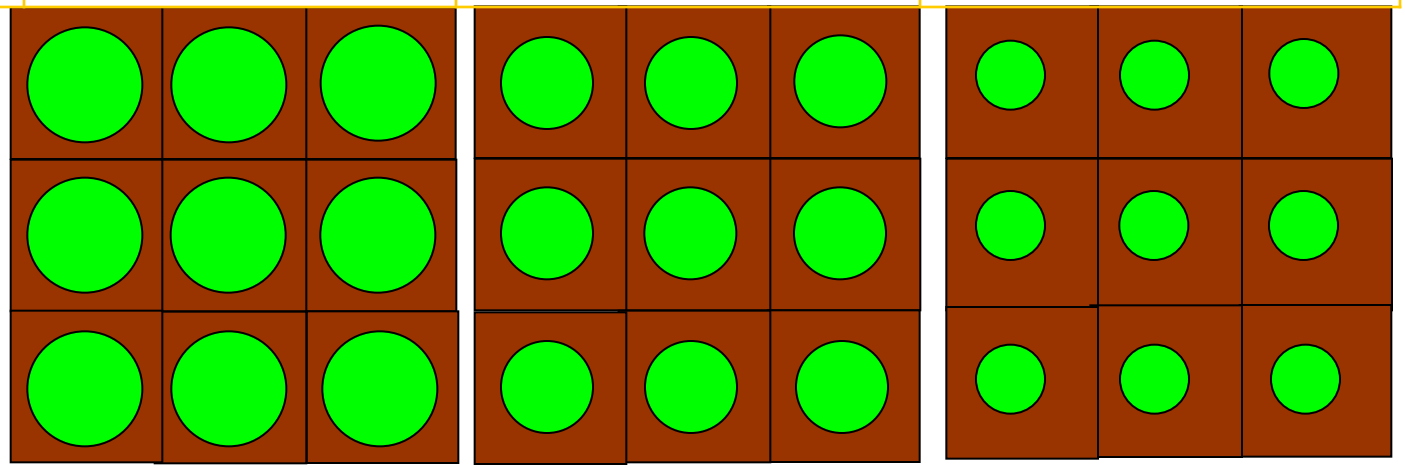
After five years at seasonal average midday stem water potential of

	-8 bars	-12 bars	-16 bars
Yield (lbs/ac)	2,500	2,000	1,500
Cum. yield	7,500	6,000	4,500
Cum. dollars	$15,000	$12,000	$9,000
Per acre loss		-$3,000	-$6,000



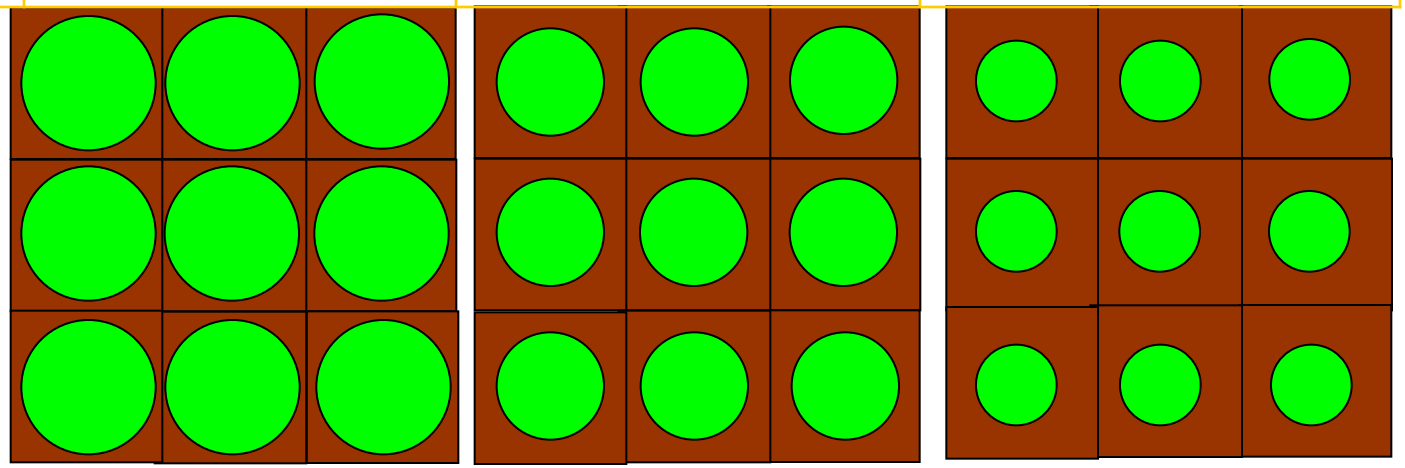
After six years at seasonal average midday stem water potential of:

	-8 bars	-12 bars	-16 bars
Yield (lbs/ac)	3,000	2,400	1,800
Cum. yield	10,500	8,400	6,300
Cum. dollars	$21,000	$16,800	$12,600
Per acre loss		-$4,200	-$8,400



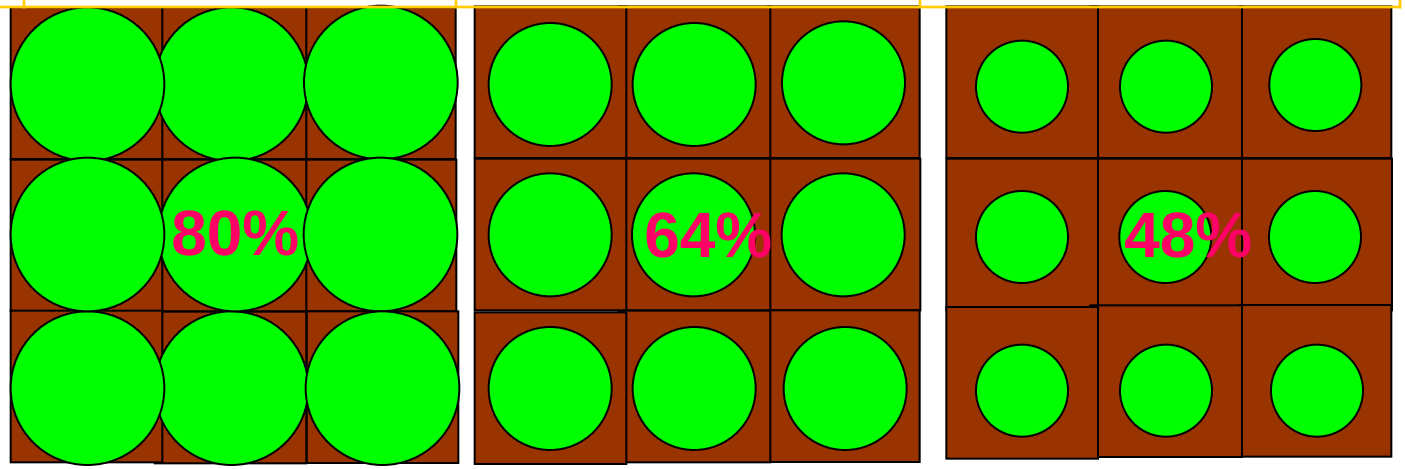
After seven years at seasonal average midday stem water potential of:

	-8 bars	-12 bars	-16 bars
Yield (lbs/ac)	3,500	2,800	2,100
Cum. yield	14,000	11,200	8,400
Cum. dollars	$28,000	$22,400	$16,800
Per acre loss		$5,600	$11,200



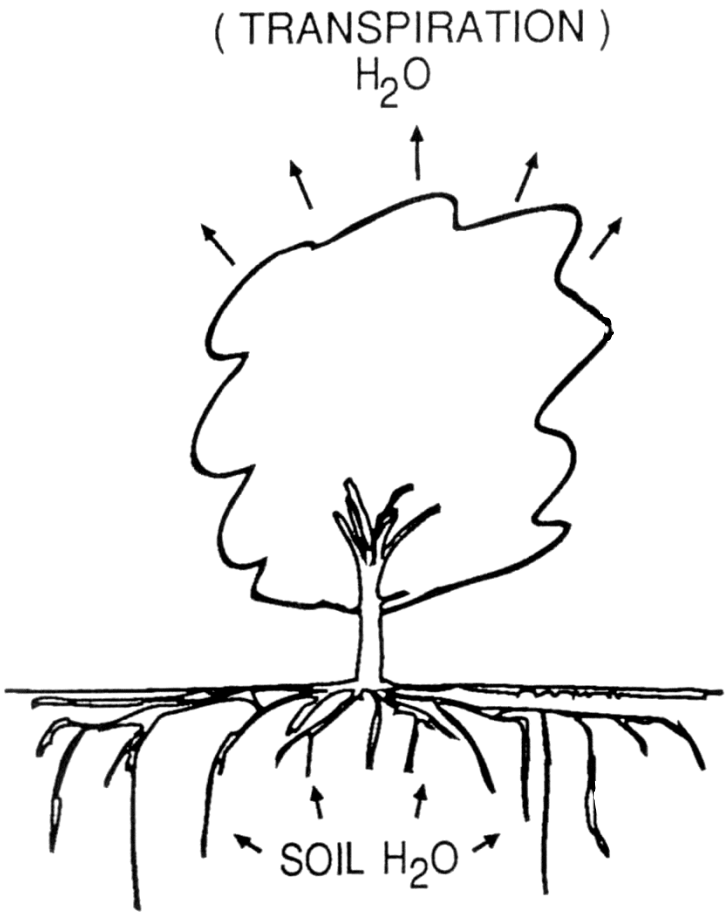
After eight years at seasonal average midday stem water potential of:

	-8 bars	-12 bars	-16 bars
Yield (lbs/ac)	4,000	3,200	2,400
Cum. yield	18,000	14,400	10,800
Cum. dollars	$36,000	$28,800	$21,600
Per acre loss		-$7,200	-$14,400



New Orchards: Water Management

Irrigation management: factors to consider



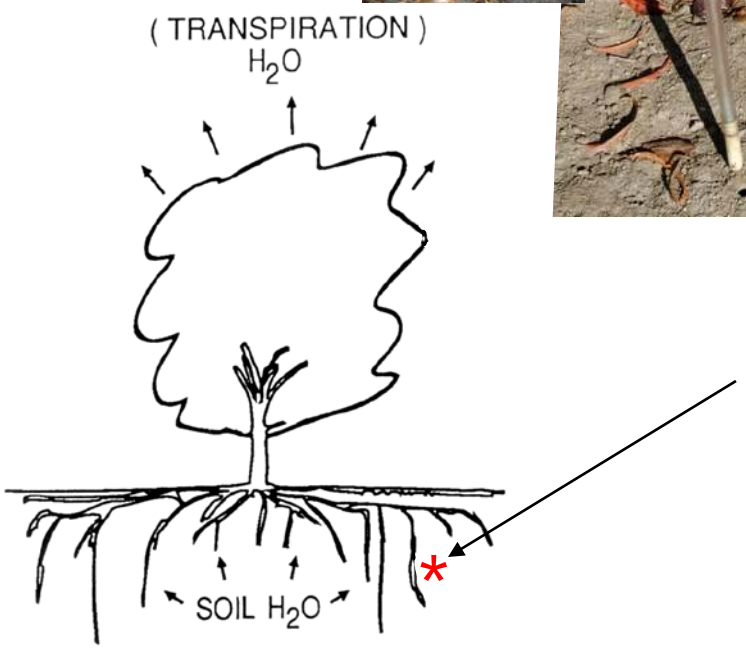
The weather (ET)

The plant (SWP)

The soil (wetness)

New Orchards: Water Management

Methods to measure soil moisture: simple & cheap to complex & expensive…

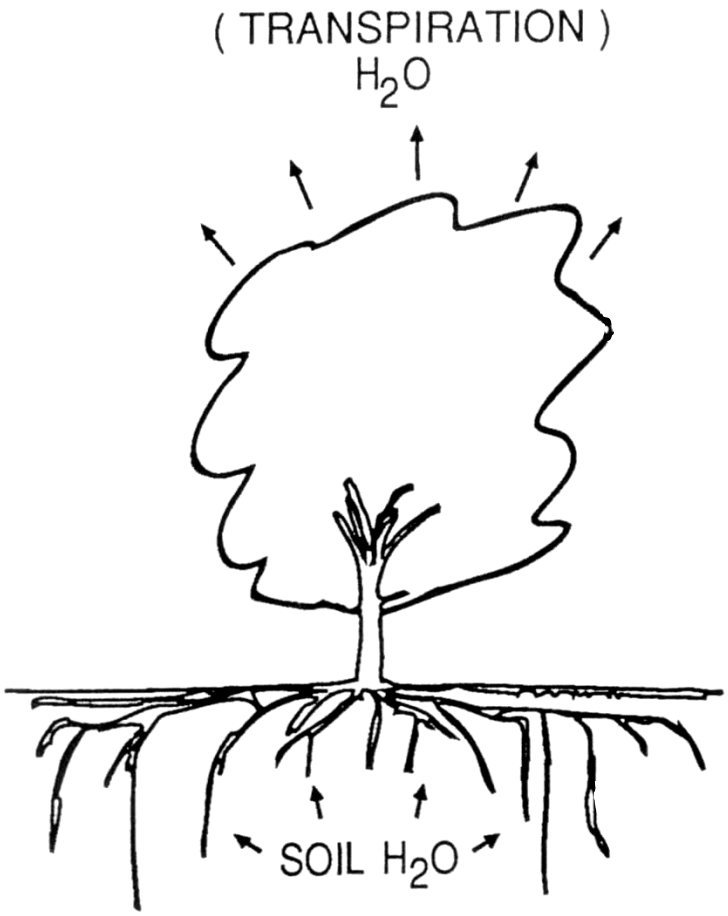


All have one key limitation: only a small fraction of the root zone can be measured

The solution –
measure many locations and depths, 24/7

New Orchards: Water Management

Irrigation management tools: what each one tells you



The weather

Can tell you **how much**, but not **when.**

The plant (SWP)

Tells you that something is **wrong**, but not **why**.

The soil

Tells you about the **supply**, but only for a **small portion** of the root zone.

Bottom line:

using the tools and paying close attention to irrigation management in young orchards, will set the stage for maximum yield later on!

Questions