



*the Almond*  
**CONFERENCE**  
2019

# Research Update: Reaching Potential and Sustainable Yields

 **california  
almonds**<sup>®</sup>  
Almond Board of California

# Session Speakers

Sebastian Saa, ABC

Bruce Lampinen, UC ANR

Roger Duncan, UC ANR

Katherine Jarvis-Shean, UC ANR

Franz Niederholzer, UC ANR



A close-up photograph of several green almonds on a branch, with vibrant green leaves. The background is softly blurred, showing more of the orchard. The lighting is bright and natural, highlighting the texture of the almond skins and the veins on the leaves.

# Research Update: Reaching Potential and Sustainable Yields

Moderator, Sebastian Saa, Senior Manager, ABC

# Research Update: Reaching Potential and Sustainable Yields

$$\text{Yield potential } \left( \frac{\text{lbs}}{\text{acre}} \right) = \text{No. of flowers} \times \% \text{ of fruit set} \times \text{kernel weight}$$



# Research Update: Nutrient Management

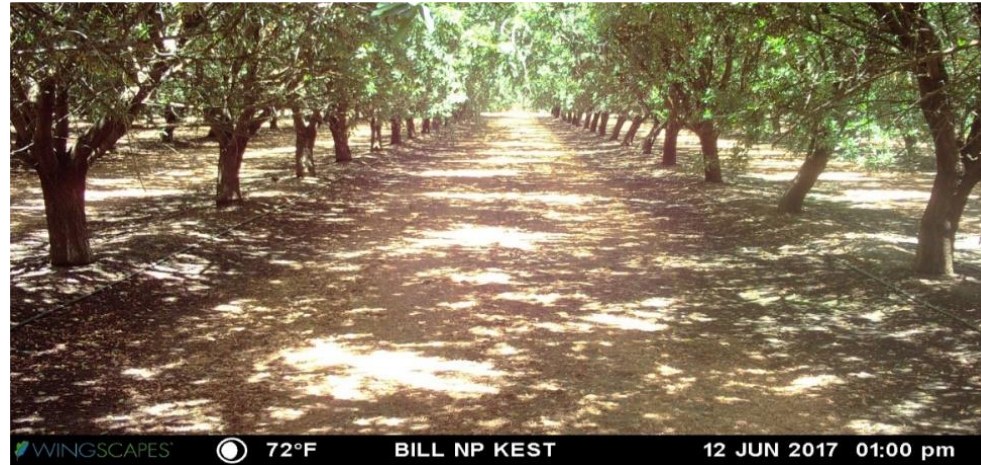
- Bruce Lampinen, Specialist, UC Davis
  - Light interception and yield potential
- Roger Duncan, UC Cooperative Extension
  - Maximizing yield potential in the short and long-term
- Katherine Jarvis-Shean, UC Cooperative Extension
  - Training your orchard for potential and sustainable yields
- Franz Niederholzer, UC Cooperative Extension
  - Maintaining your orchard for best results



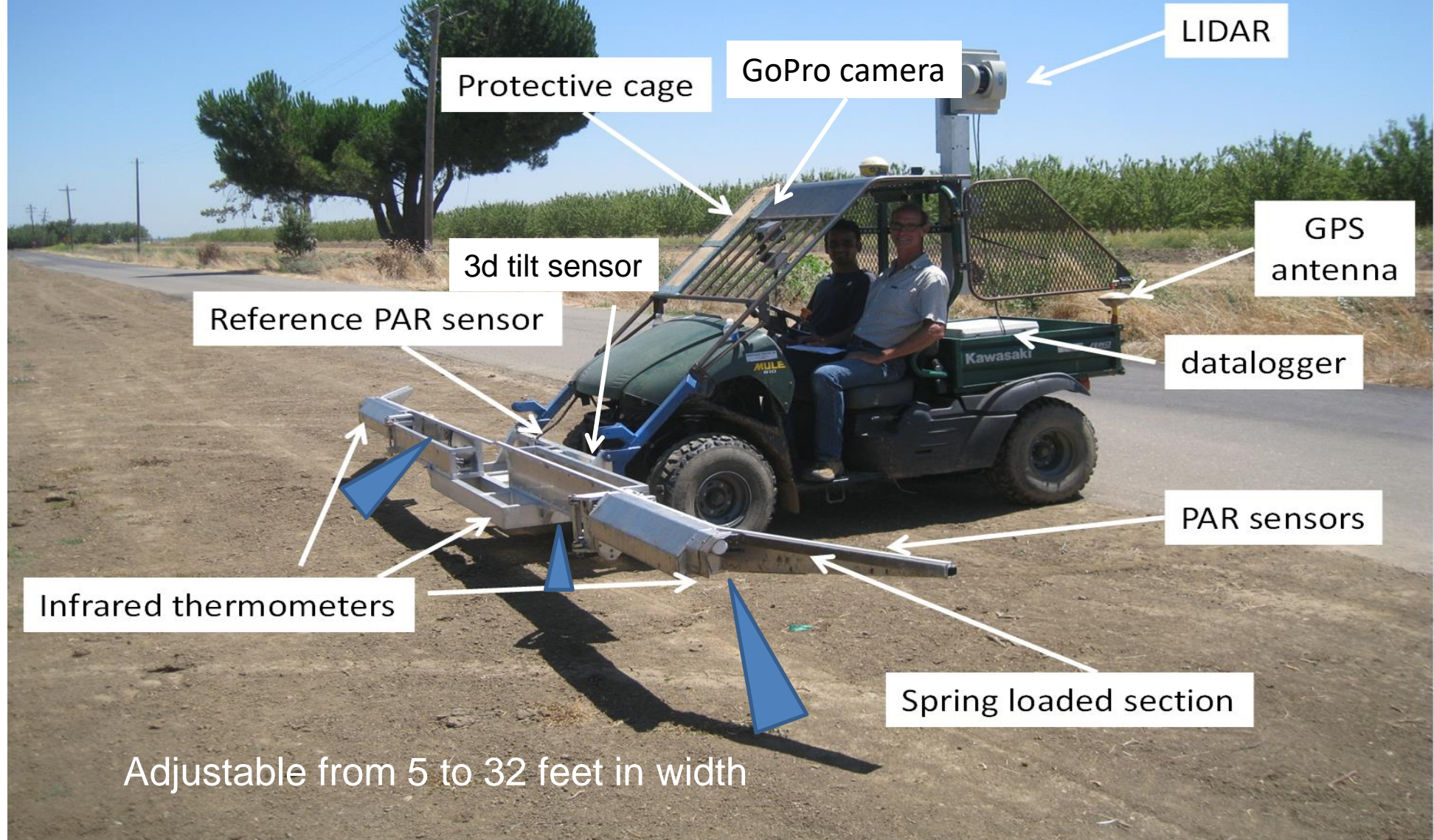
# Reaching Potential and Sustainable Yields

## Light Interception and Yield Potential

Bruce Lampinen, UC Davis Plant Sciences/UCANR



# 2<sup>nd</sup> Generation mule light bar





We set up a portable weather station with temp, RH, windspeed and PAR sensors outside orchard

Normal speed of travel is about 7 mph so we can map about 14 miles within 1 hour of the time the sun is directly overhead



Plots route on Google Earth

PAR = photosynthetically active radiation (in the wavelengths that drive photosynthesis)





Self contained hydraulic system for operating augers, autosampler and elevator



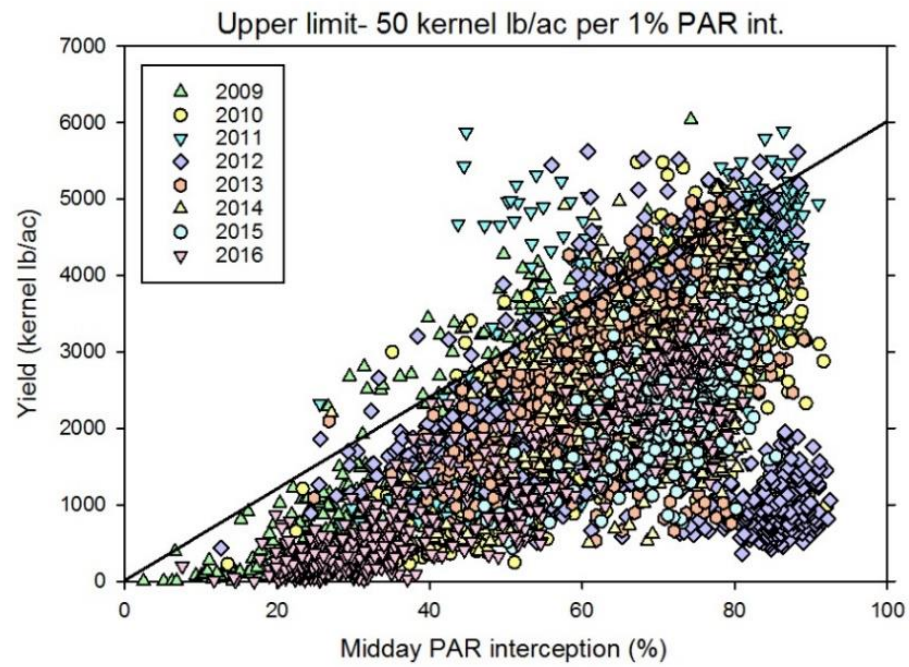
Trimble GPS acts as datalogger to collect continuous yield data



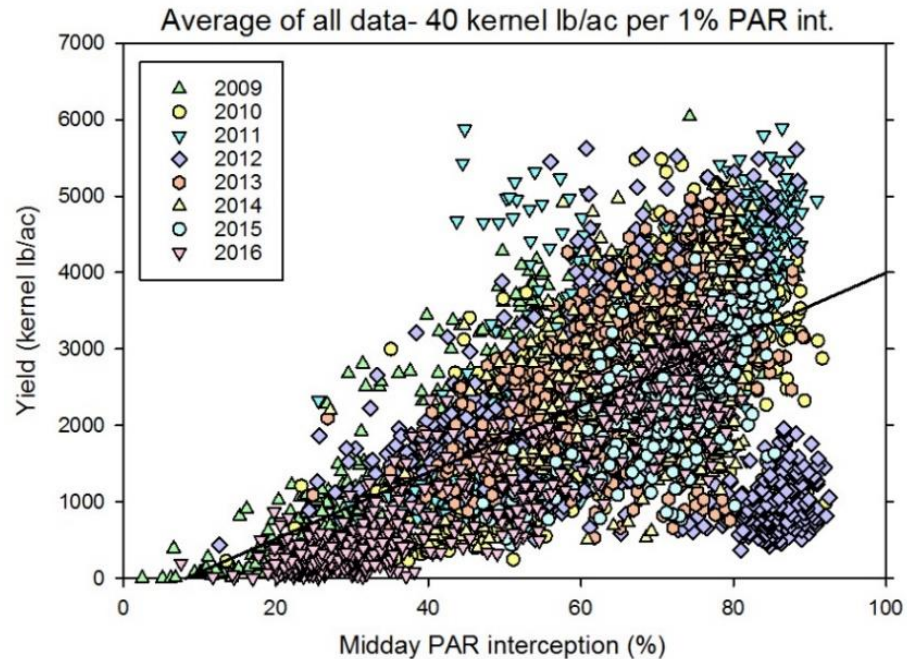
Front skirt to prevent nuts from overflowing as cart fills



Wireless controller for hydraulically operated auto sampler



← We have found the best managed orchards (but very few) can alternate around this line (50 kernel lbs/1% intercepted) after about 5 years of age



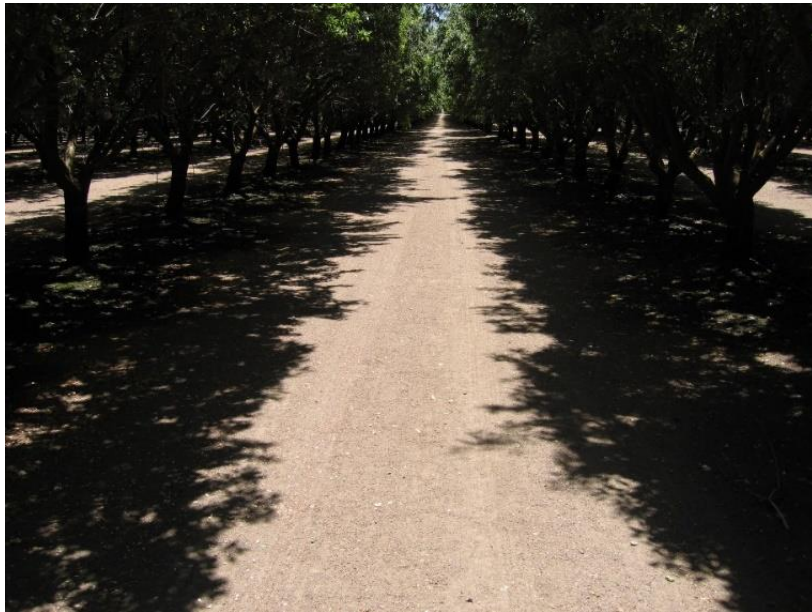
← Regression through all data (40 kernel lbs/1% intercepted)



39% interception (2000 kernel lbs/ac potential



50% interception (2500 kernel lbs/ac potential



80% interception (4000 kernel lbs/ac potential



90% interception (4500 kernel lbs/ac potential



39% interception (2000 kernel lbs/ac potential



50% interception (2500 kernel lbs/ac potential



We do not recommend getting above this level of interception due to food safety concerns

80% interception (4000 kernel lbs/ac potential



90% interception (4500 kernel lbs/ac potential

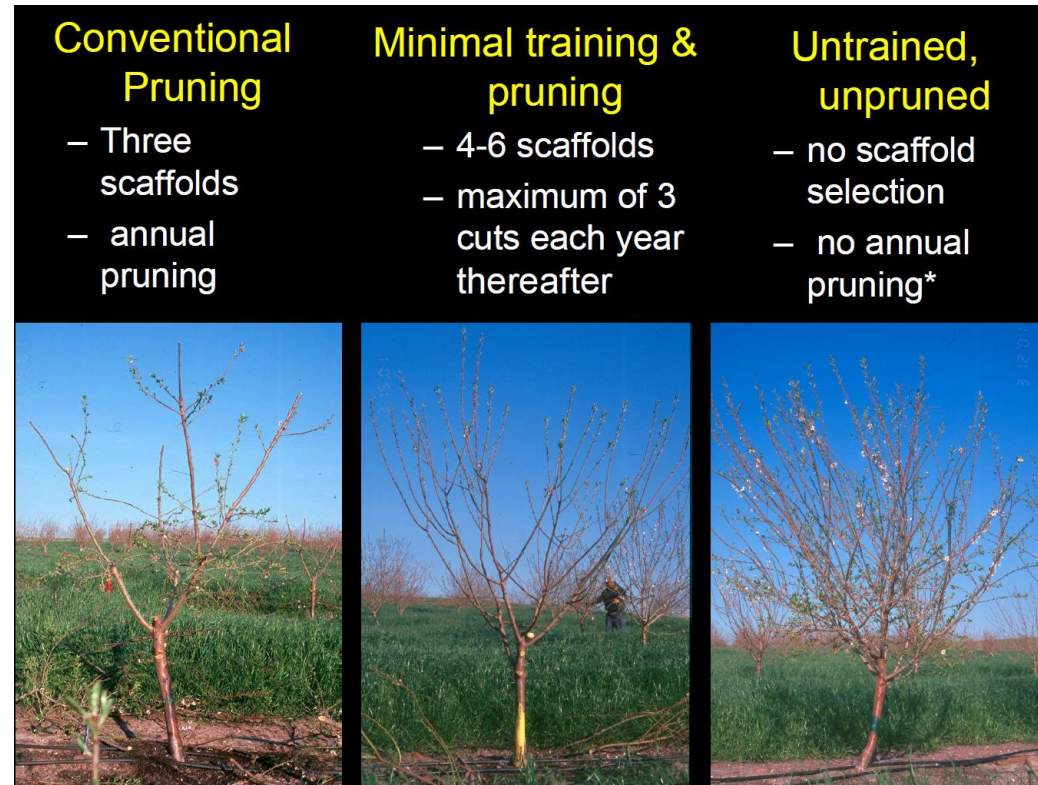
# How does pruning and within tree row spacing influence yield potential?

## Stanislaus County Spacing/Pruning Trial (Duncan)

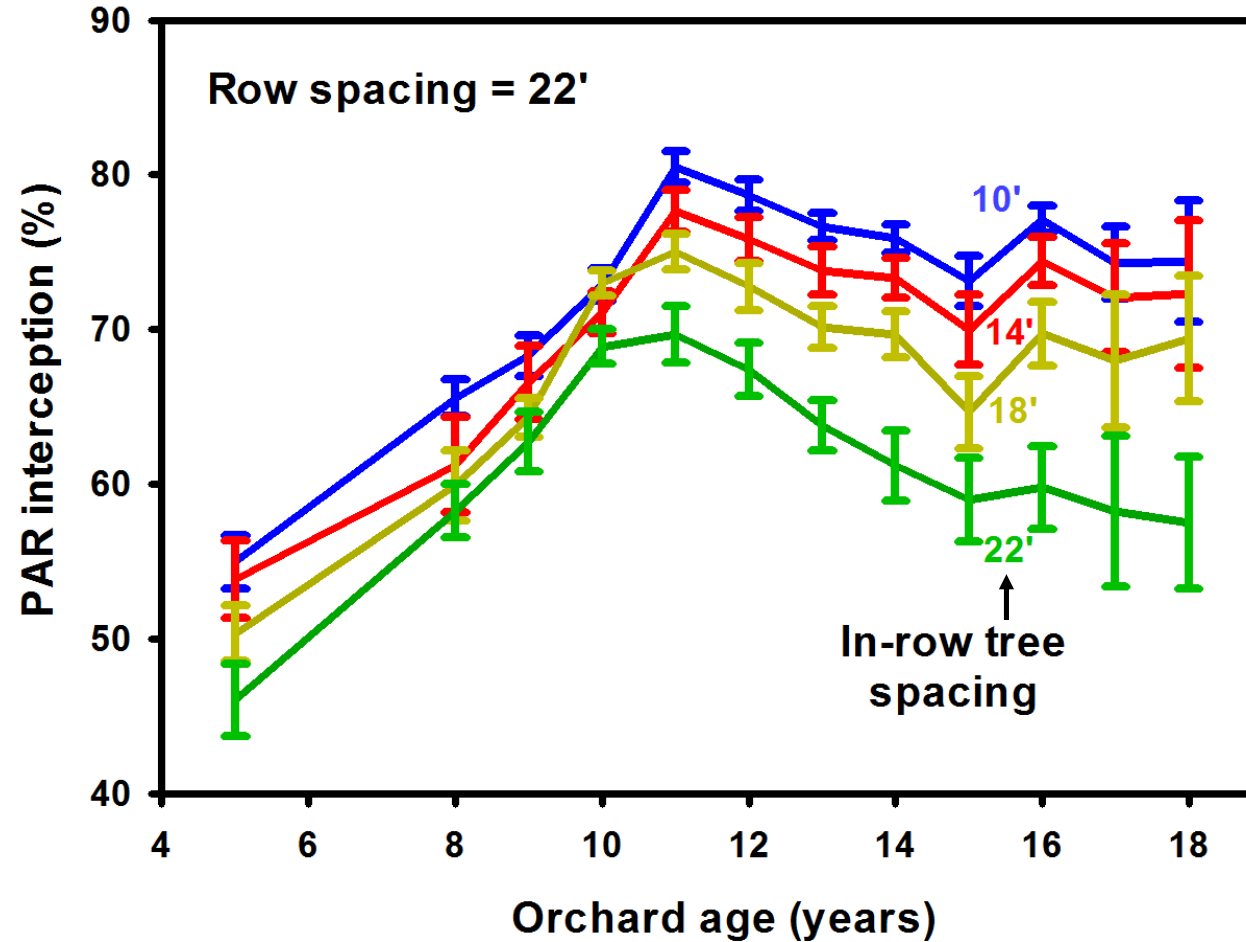
Planted fall, 1999

Four spacings (10' x 22', 14' x 22', 18' x 22', 22' x 22')

Four pruning strategies



Pruning and spacing trial Stanislaus County (Roger Duncan)



The closer the in-row tree spacing, the higher the light interception. Light interception tended to peak at 11 years of age at all in row tree spacings

What about super high density plantings on dwarfing rootstocks- can they be more productive?



Credit: Intemerson/Thinkstock

CROPS > TREE NUTS

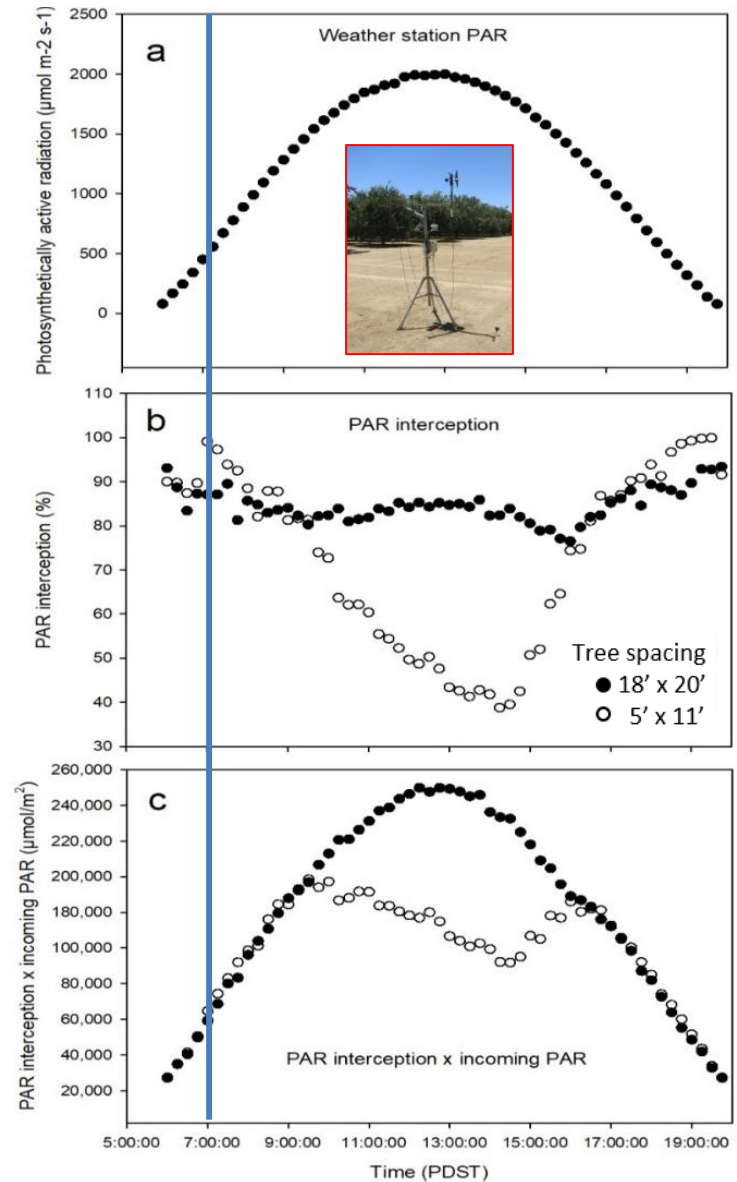
**Grower trial: Super high density almond planting on dwarf rootstock holds promise**

Almond trees blooming in orchard against blue, Spring sky.

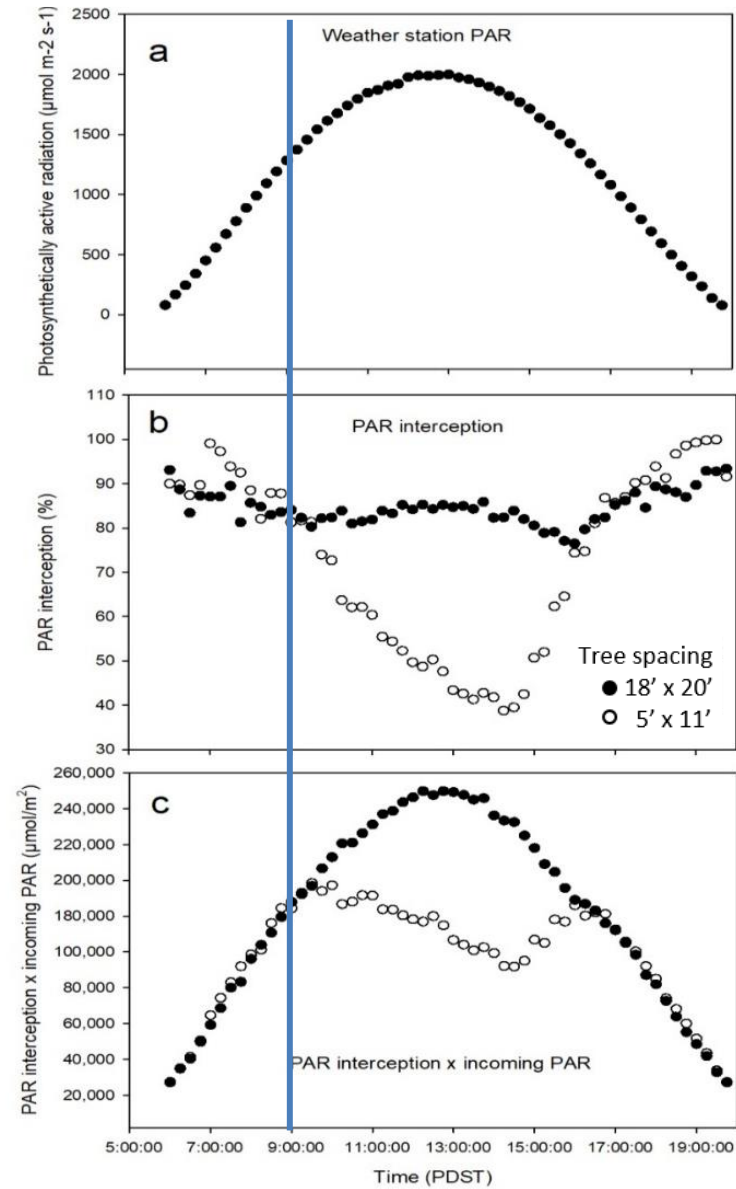
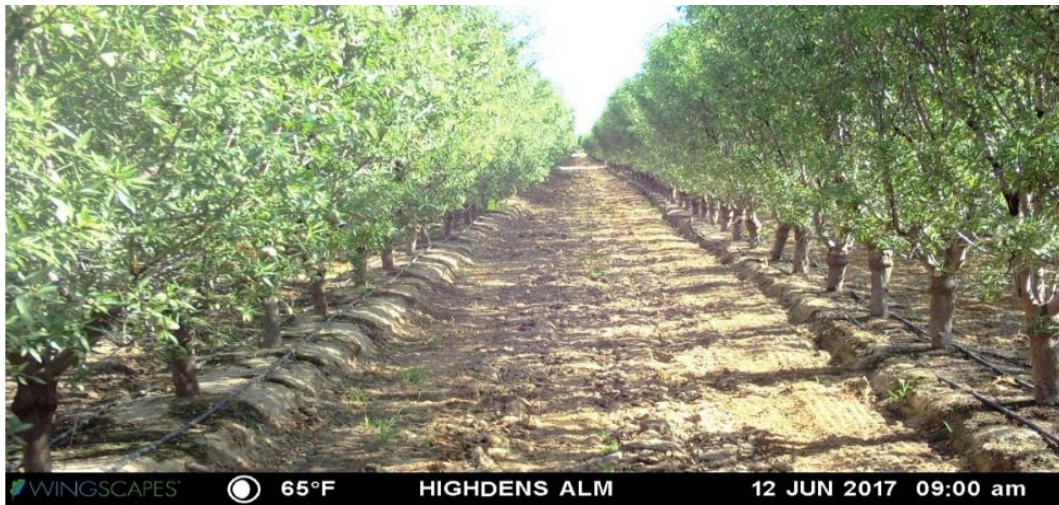
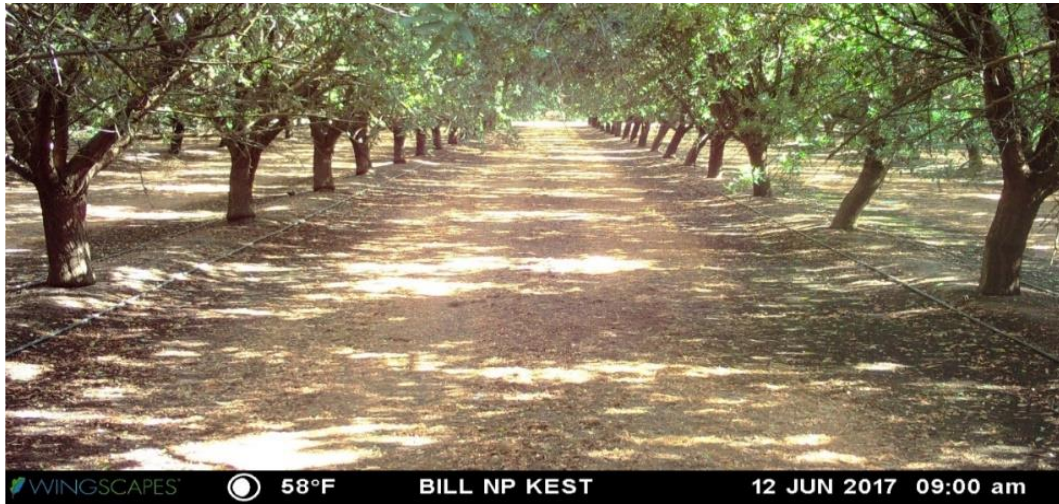
4' x 12'

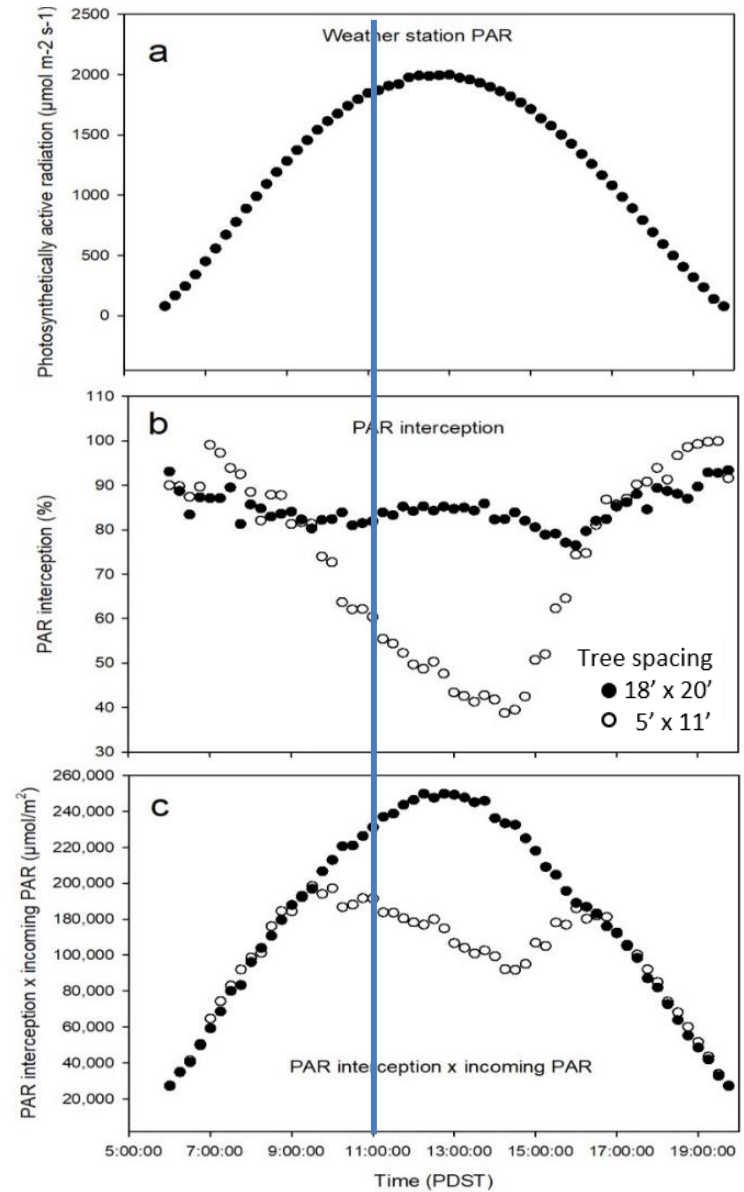
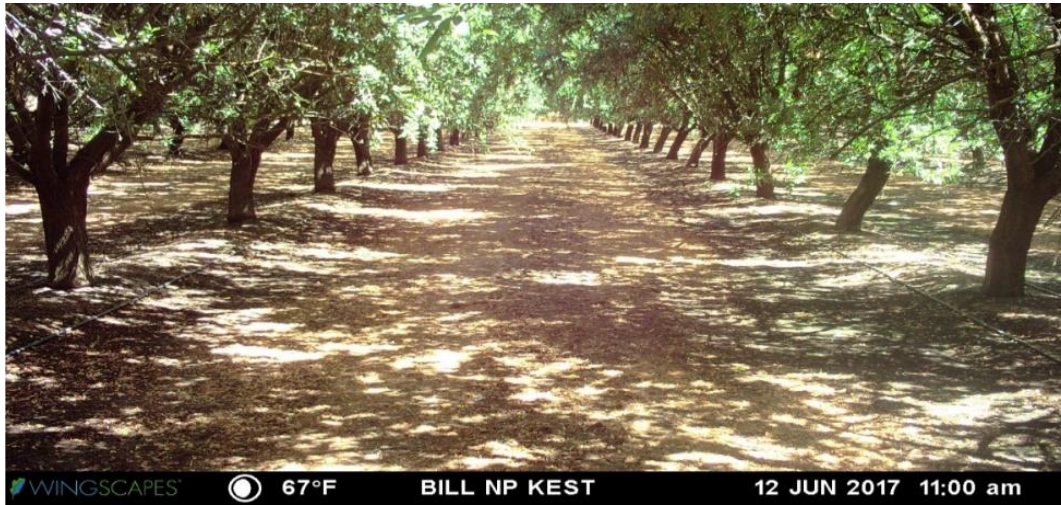
5' x 11'

PAR = photosynthetically active radiation







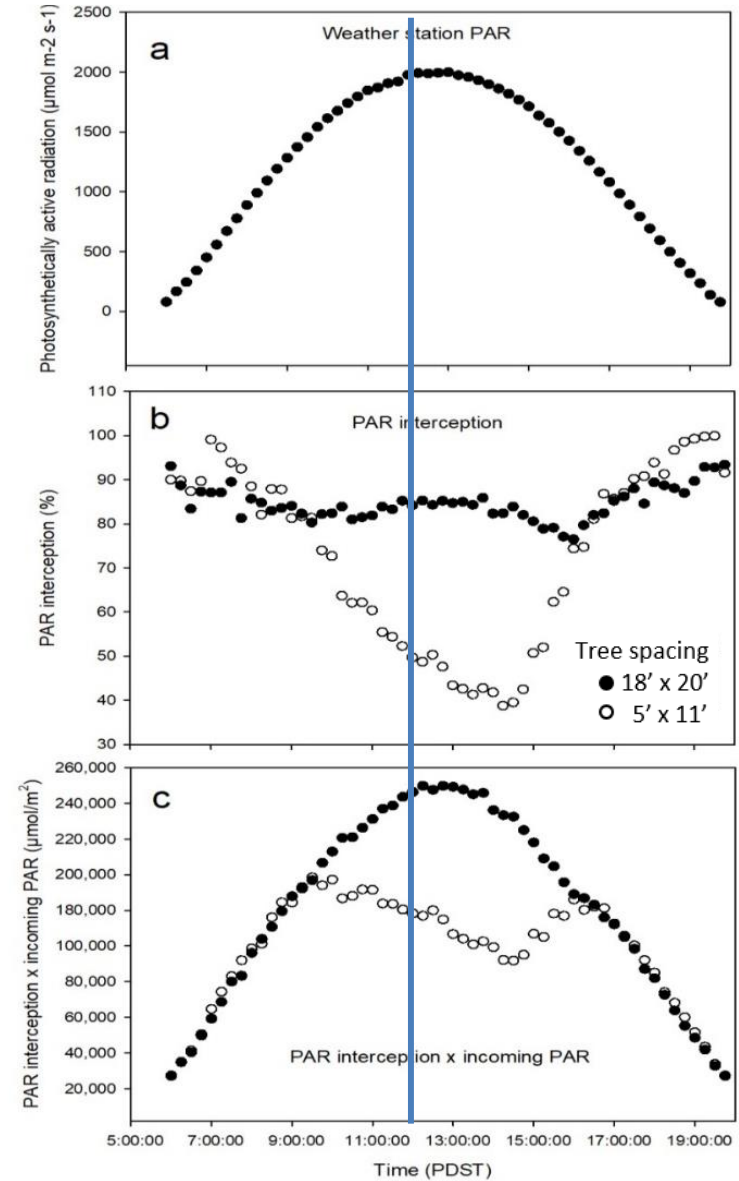




WINGSCAPES 69°F BILL NP KEST 12 JUN 2017 12:00 pm



WINGSCAPES 89°F HIGHDENS ALM 12 JUN 2017 12:00 pm

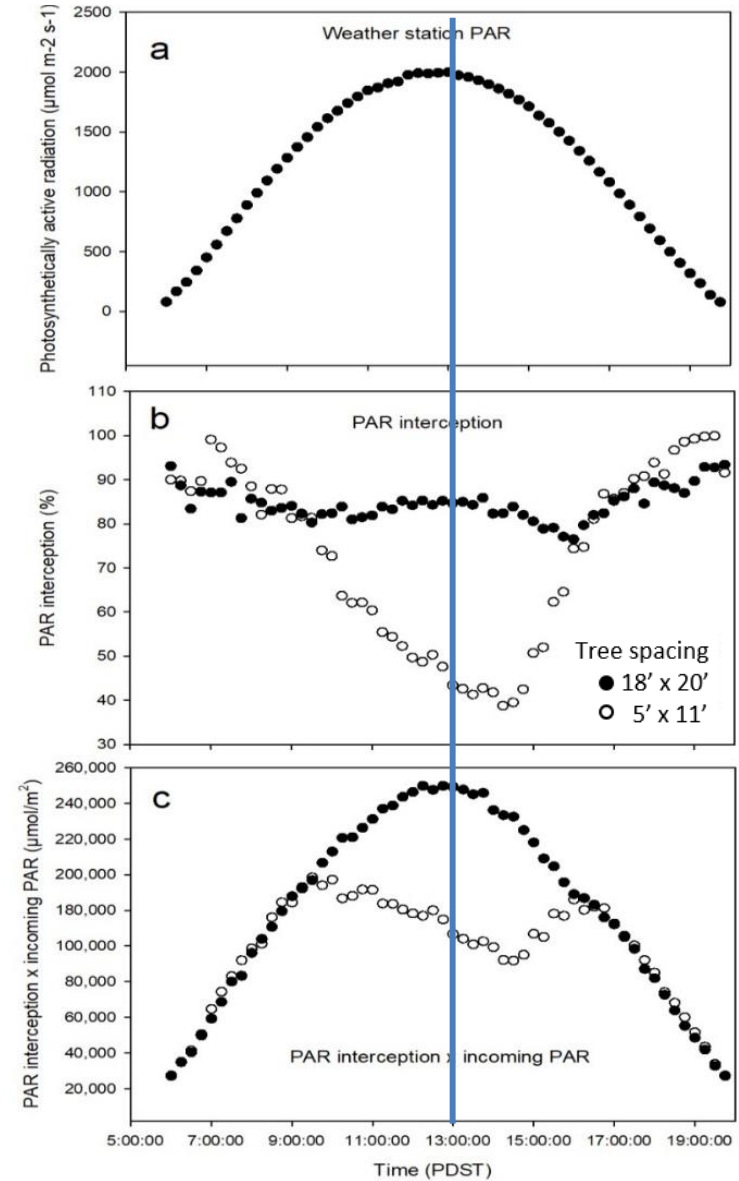


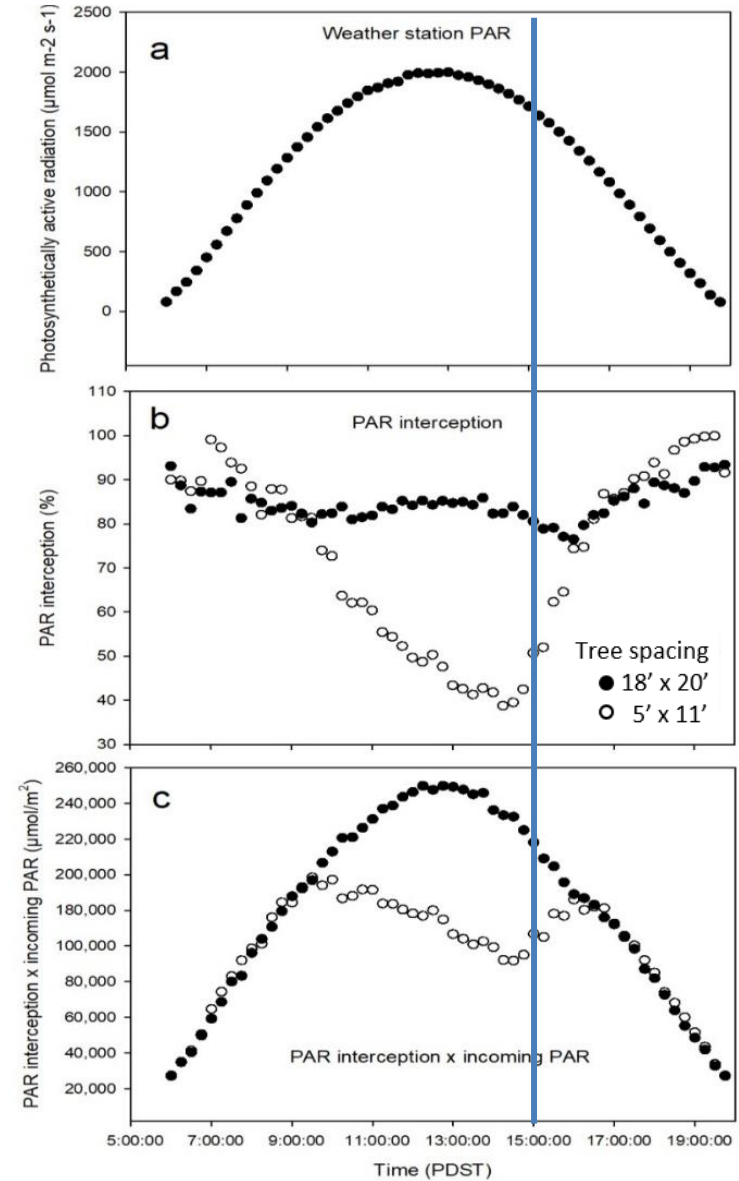


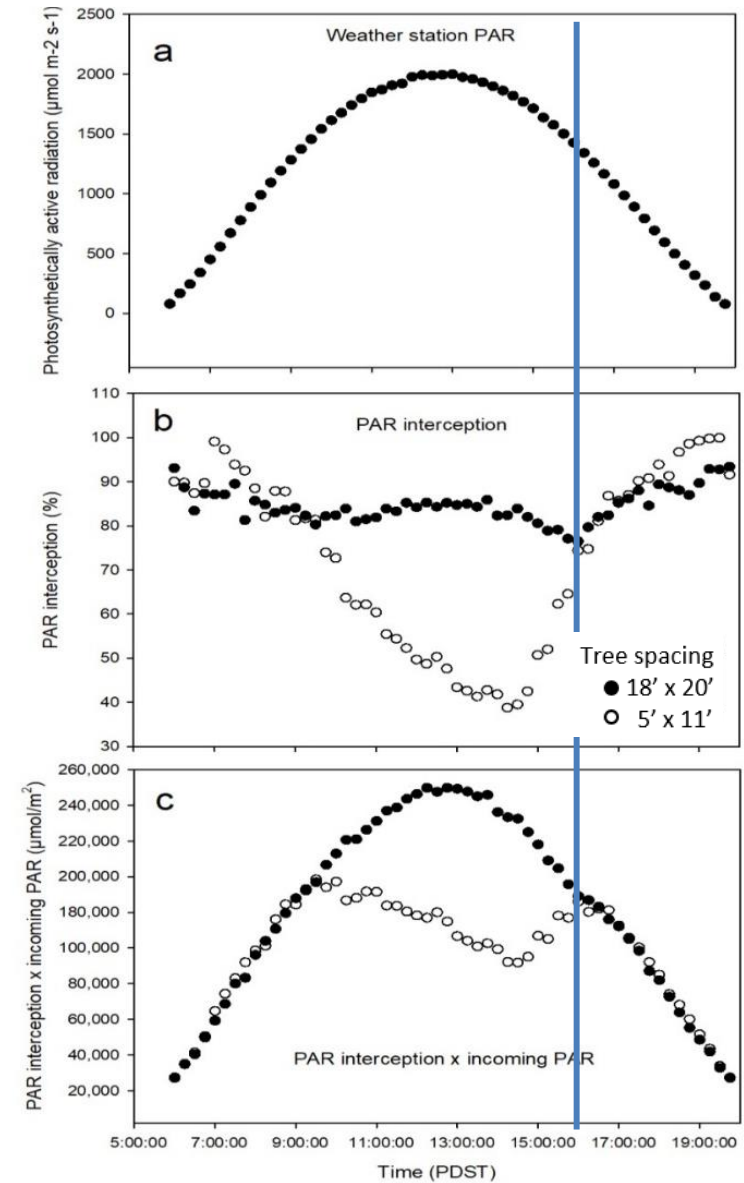
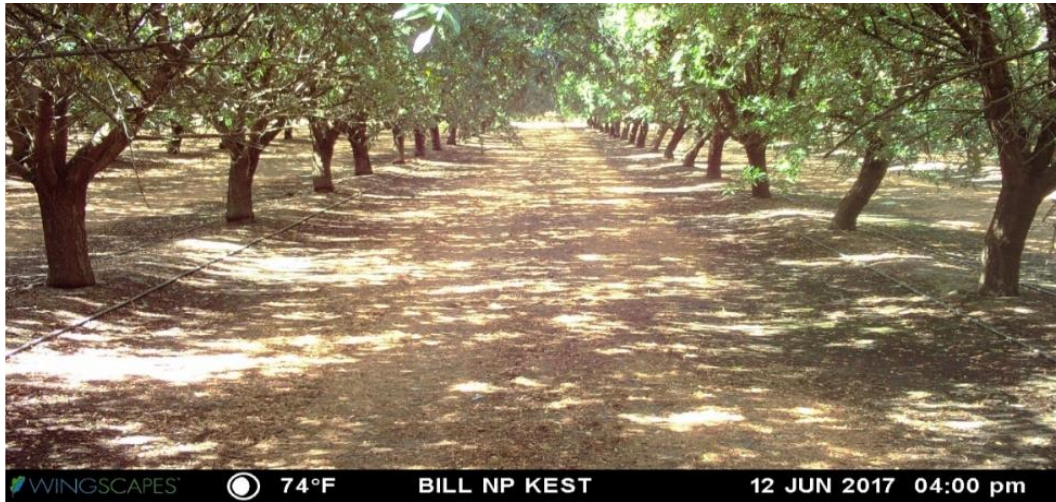
WINGSCAPES 72°F BILL NP KEST 12 JUN 2017 01:00 pm

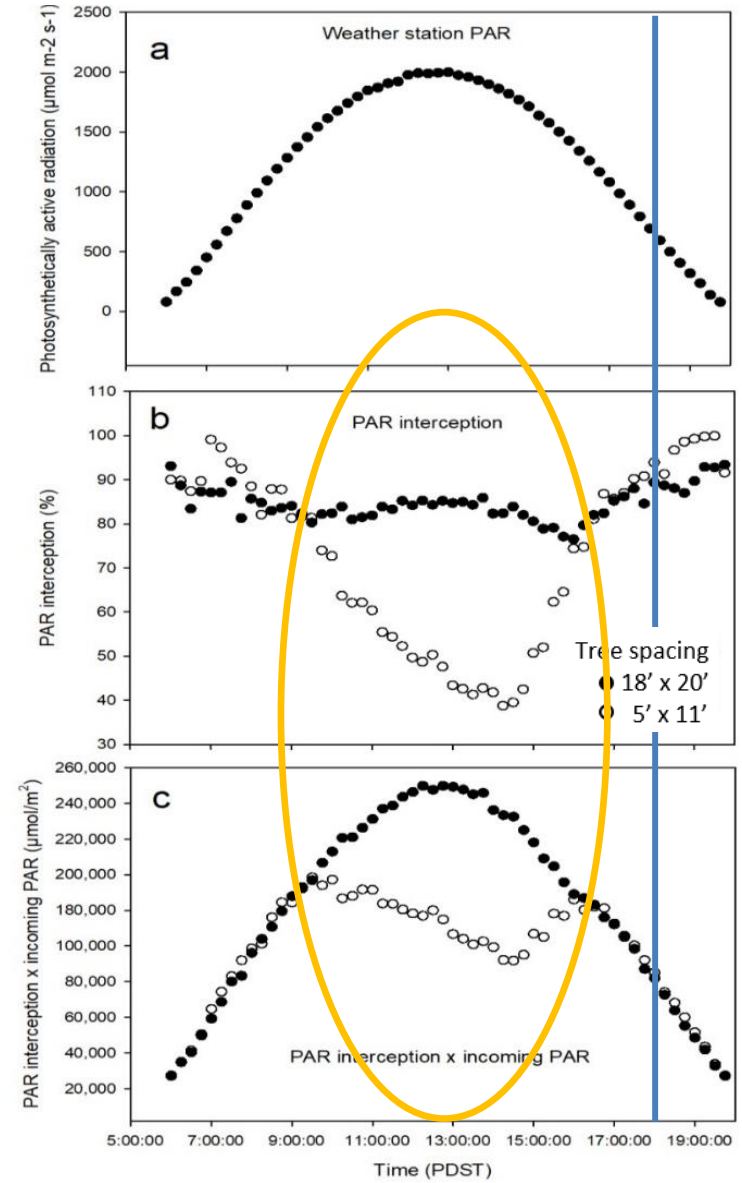
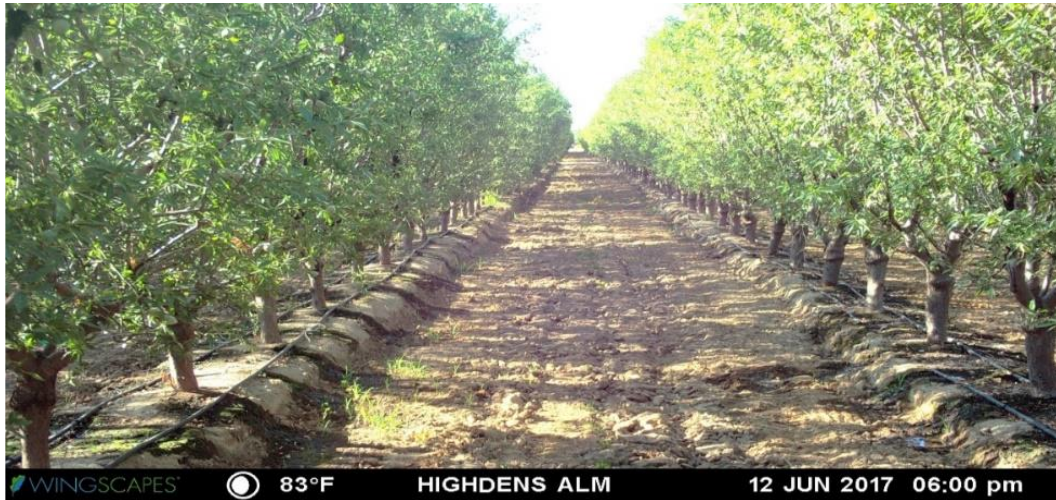
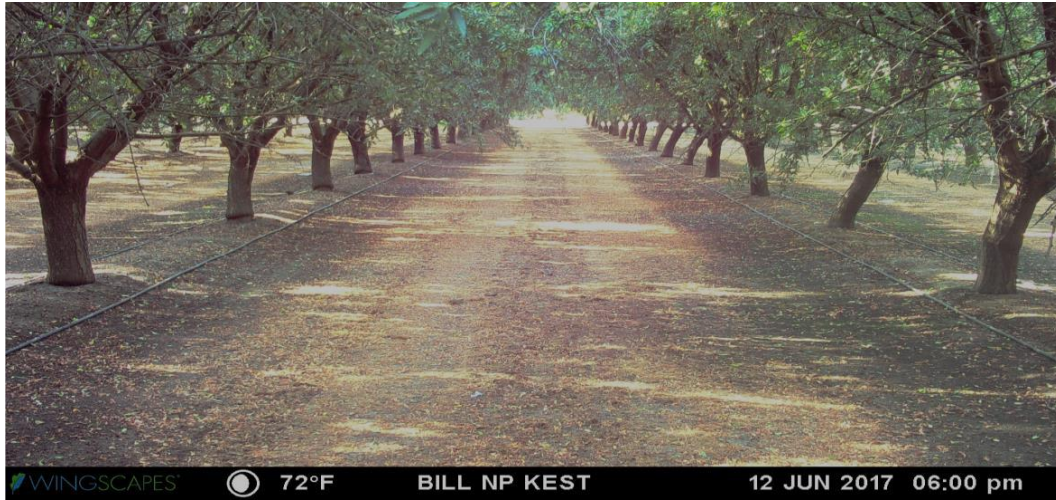


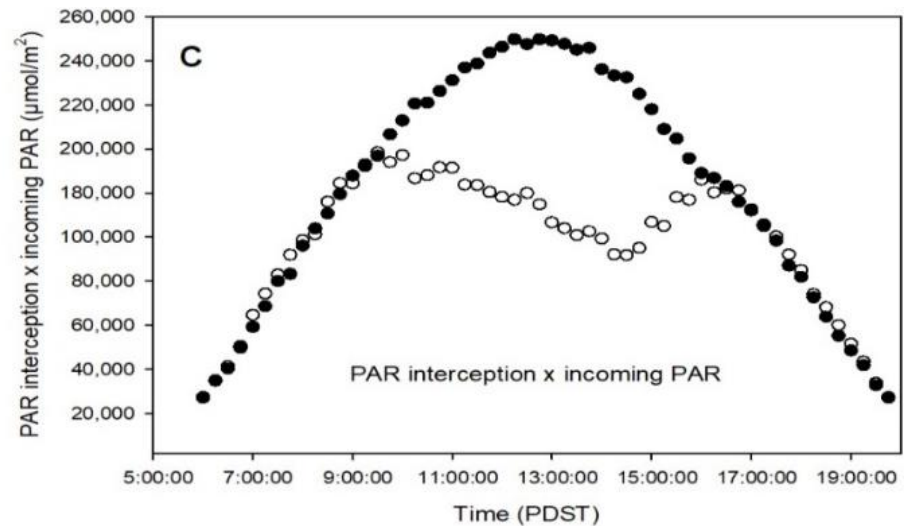
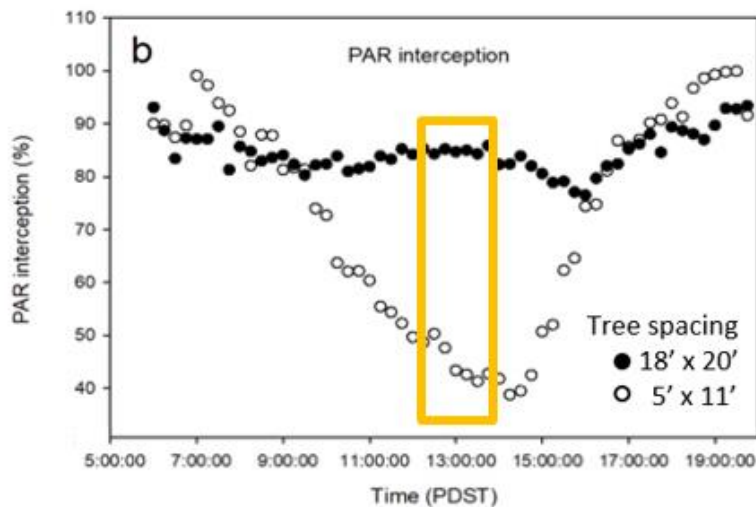
WINGSCAPES 93°F HIGHDENS ALM 12 JUN 2017 01:00 pm











### Yield potential based on midday PAR interception

Planting	Midday PAR int. (%)	Yield potential (kernel lb/ac)	Actual yield (kernel lb/acre)
5' x 11'	44	2200	1324
18' x 21'	83	4150	~3600



Excessive vegetative growth in response to hedging on top and sides

Mechanical and disease damage

side





Repeated hedging cuts leads to increased disease potential and lots of big wood that can cause damage to harvester





Still need to fit an 8' plus wide bankout wagon

$$8' + 2.6' = 10.6'$$



Yield potential for 8' drive row and 2.6'  
canopy width

$$(2.6/10.6)*100 = 24.5 \% \text{ interception}$$
$$24.5*50 = 1,225 \text{ kernel pounds per acre}$$

## Over the row grape harvester



### Advantages

- Eliminates dust generated by sweeping
- Minimizes harvest dust
- Reduces food safety risk since nuts do not touch the ground

### Disadvantages

- Tree size is limited
- All tree surfaces are disturbed by hedging/topping
- Still requires a bankout wagon pulled by tractor in adjacent row
- Nuts still need to be dried

## Wrap around harvester



### Advantages

- Eliminates dust generated by sweeping
- Cleaner windrows
- Half as many windrows to pick up

### Disadvantages

- Nuts still come into contact with ground
- Still requires dusty harvest pickup operation although likely cleaner

## Tenias over the row harvester



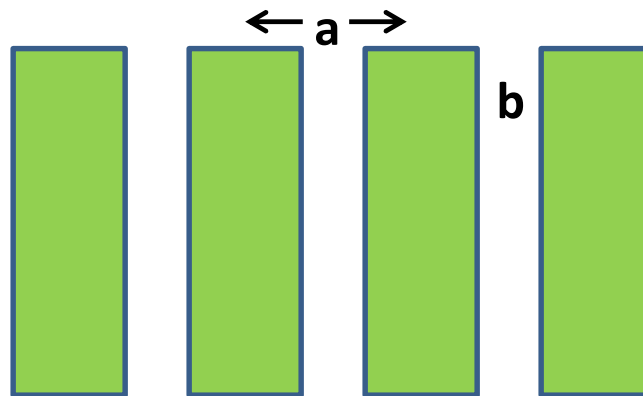
### Advantages

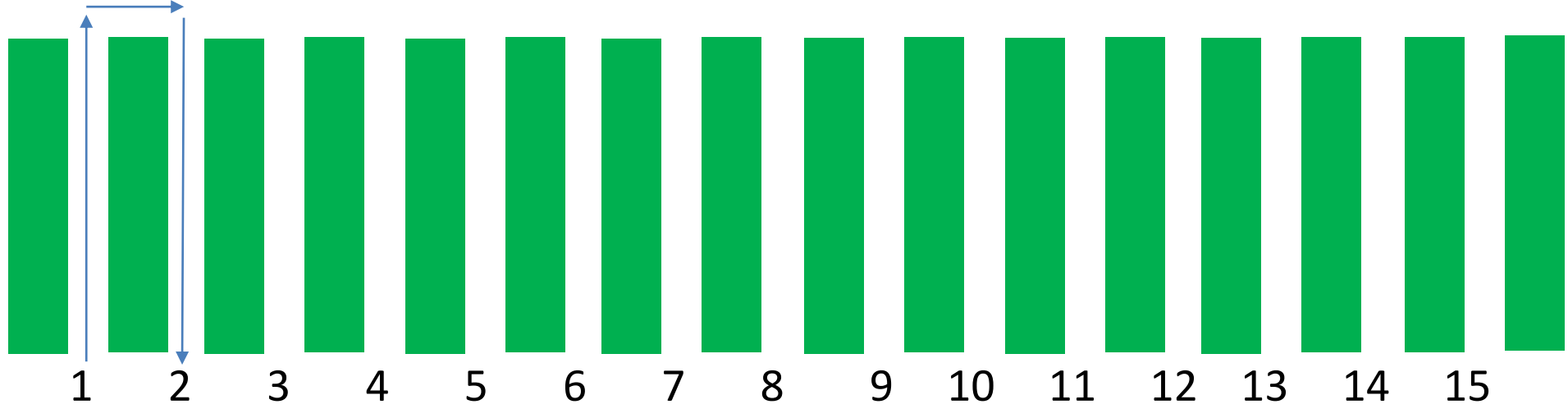
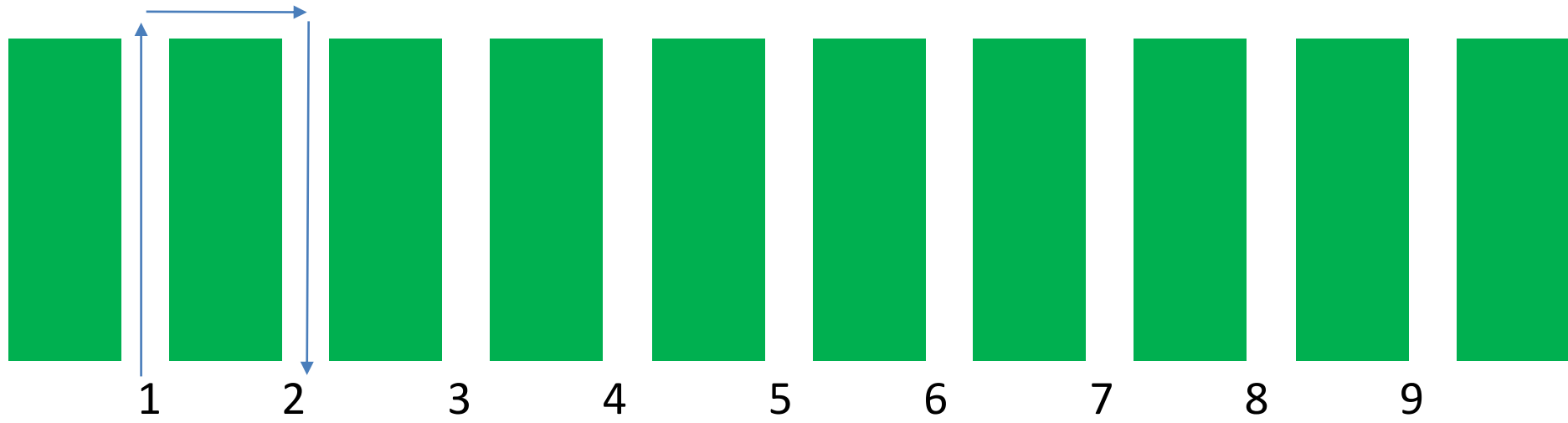
- Eliminates dust generated by sweeping
- Could be scaled up to larger trees
- With all equipment operating over the row, PAR interception could be higher

### Disadvantages

- Somewhat slower to operate
- Hulls have value but are left in orchard

	Row width (a)	Drive middle (b)	Potential PAR interception (%)	Yield potential (lbs/acre)	Potential yield increase
With 8' drive row	10'	8'	20	1,000	
	12'	8'	33	1,650	
	14'	8'	43	2,150	
With 4' drive row	10'	4'	60	3,000	+2,000
	12'	4'	80	3,300	+1,650
	14'	4'	86	3,550	+1,400





Costs of trees and irrigation system parts are higher with higher density  
Number of passes required for each orchard operation increases

- Mowing
- Spraying
- Harvest



## Spacing

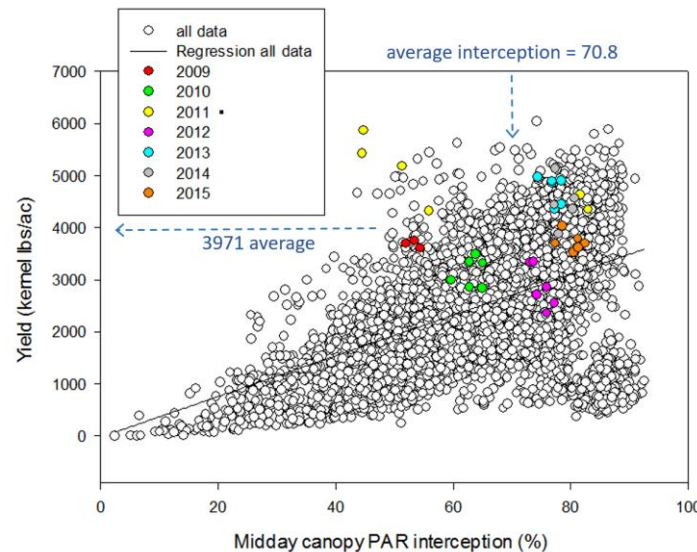
Higher density plantings do not necessarily result in higher yields at some point as row spacing gets closer together since more space is devoted to drive rows.

There is a possibility of getting decent yields with high density plantings if we can:

- Develop effective dwarfing rootstocks
- Conduct all orchard operations with over the row equipment (and/or very small tractors)

We need to research food safety implications of high density plantings

18' x 20' tree spacing



Hard to convince growers to switch to high density plantings when they can get 4000 kernel pounds per acre with current plantings

A photograph of an almond orchard floor covered in fallen almonds and leaves. The almonds are in various stages of ripeness, from green to brown. The orchard rows are visible in the background, with trees that have mostly bare branches, suggesting late autumn or winter. The text "Questions?" is overlaid in yellow, and a thank-you message is overlaid in white below it.

# Questions?

Thanks to the Almond Board of California for supporting this work



# Maximizing yield potential in the short and long-term

**Roger Duncan**  
**UC Cooperative Extension**  
**Stanislaus County**

Maximizing Almond Yield is  
Simple in Theory:

Maximum Light Interception =  
Maximum Yield Potential

Every 1% increase in light interception  
= 50 pounds per acre higher yield potential



© 2012 Google

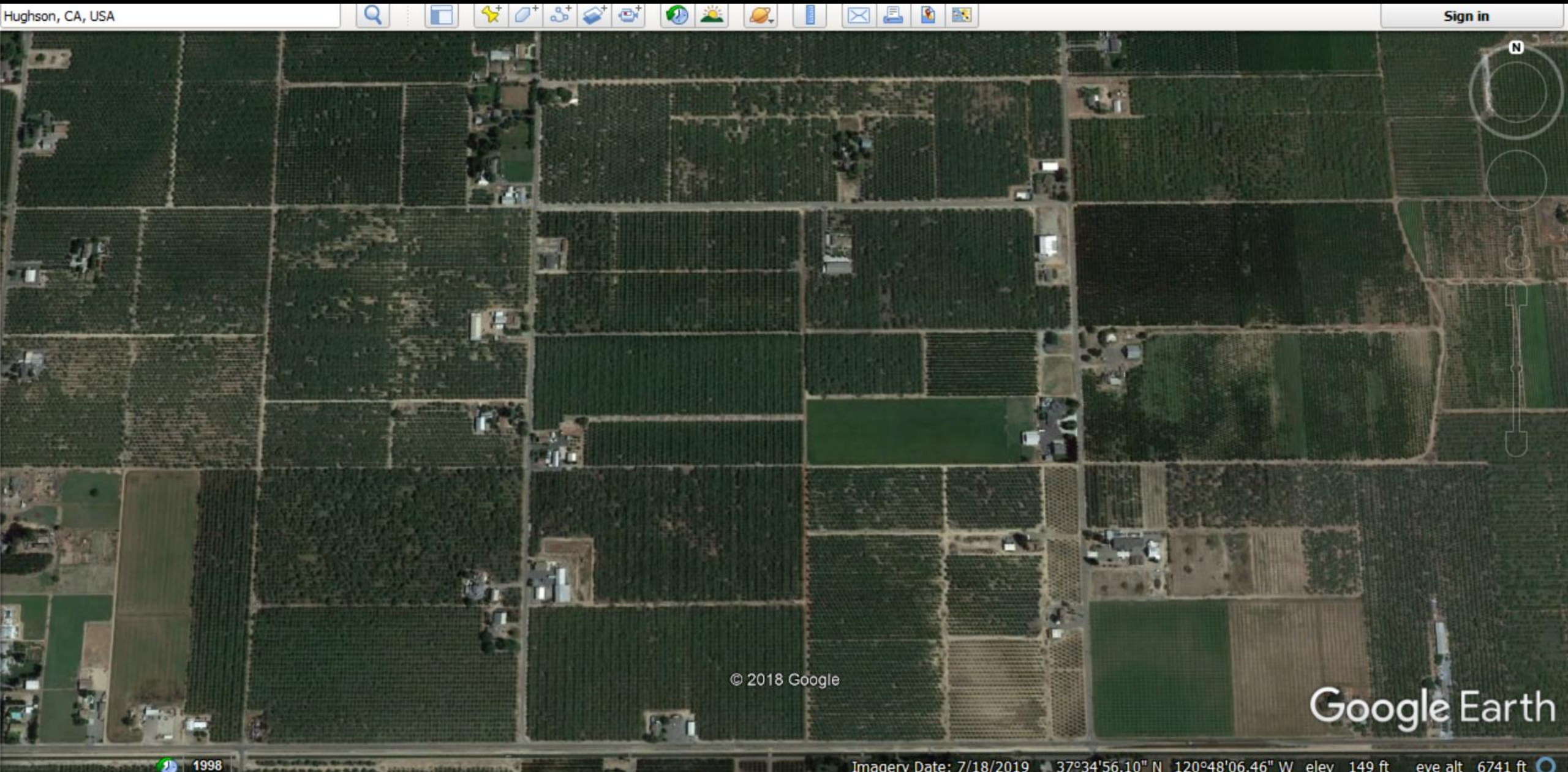
Google earth

Imagery Date: 4/29/2011

35°27'44.22" N 119°14'59.14" W elev 333 ft

Eye alt 157

# Reality



Hughson, CA, USA



Sign in



© 2018 Google

Google Earth

1998

Imagery Date: 7/18/2019 37°34'56.10" N 120°48'06.46" W elev 149 ft eye alt 6741 ft

# How do we develop the problem-free 5000 pound orchard?

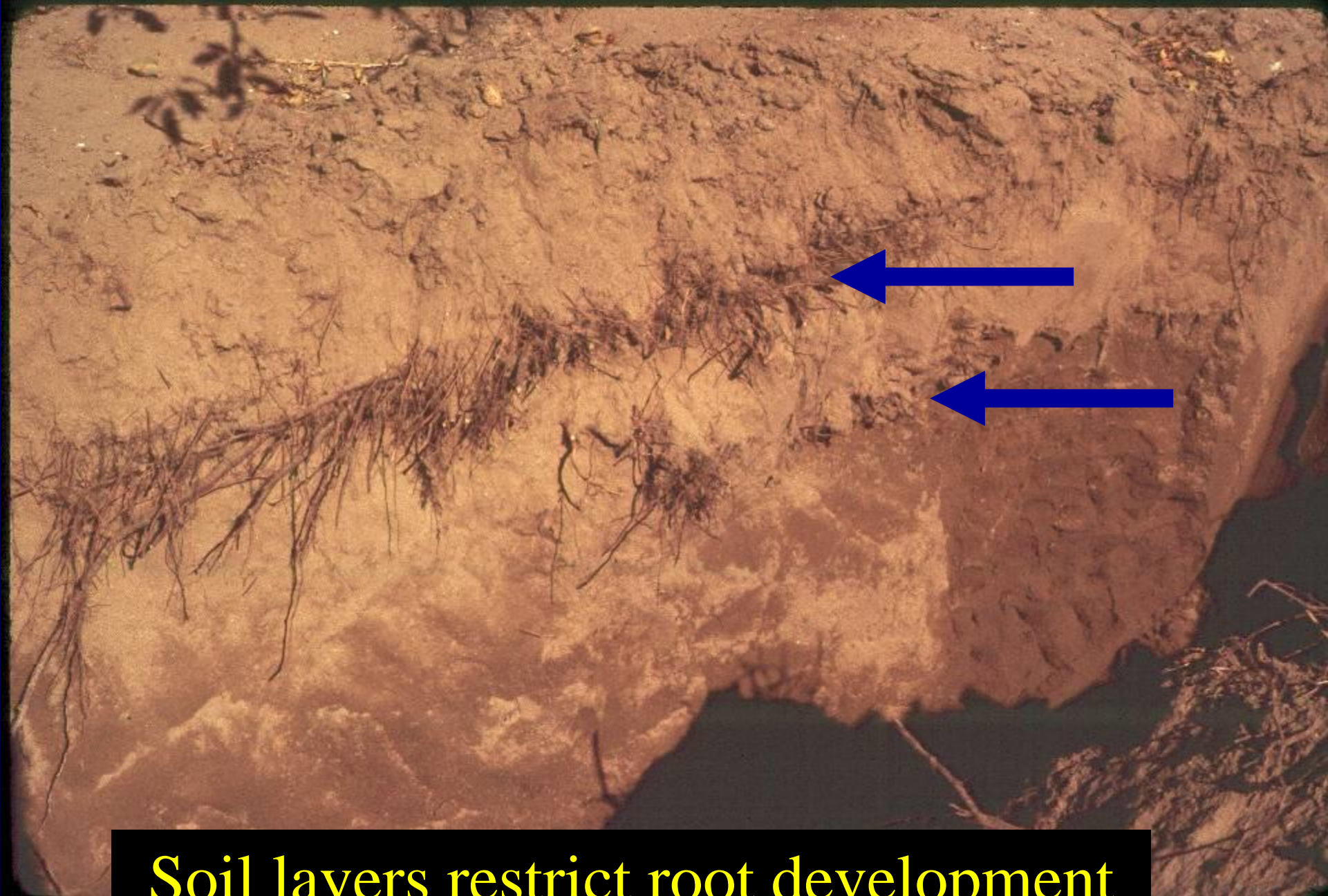
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- Preplant site evaluation and modification
  - Physical, chemical, biological
- Rootstock, variety, tree spacing and proper planting and after planting care (irrigation, fertility, etc.)

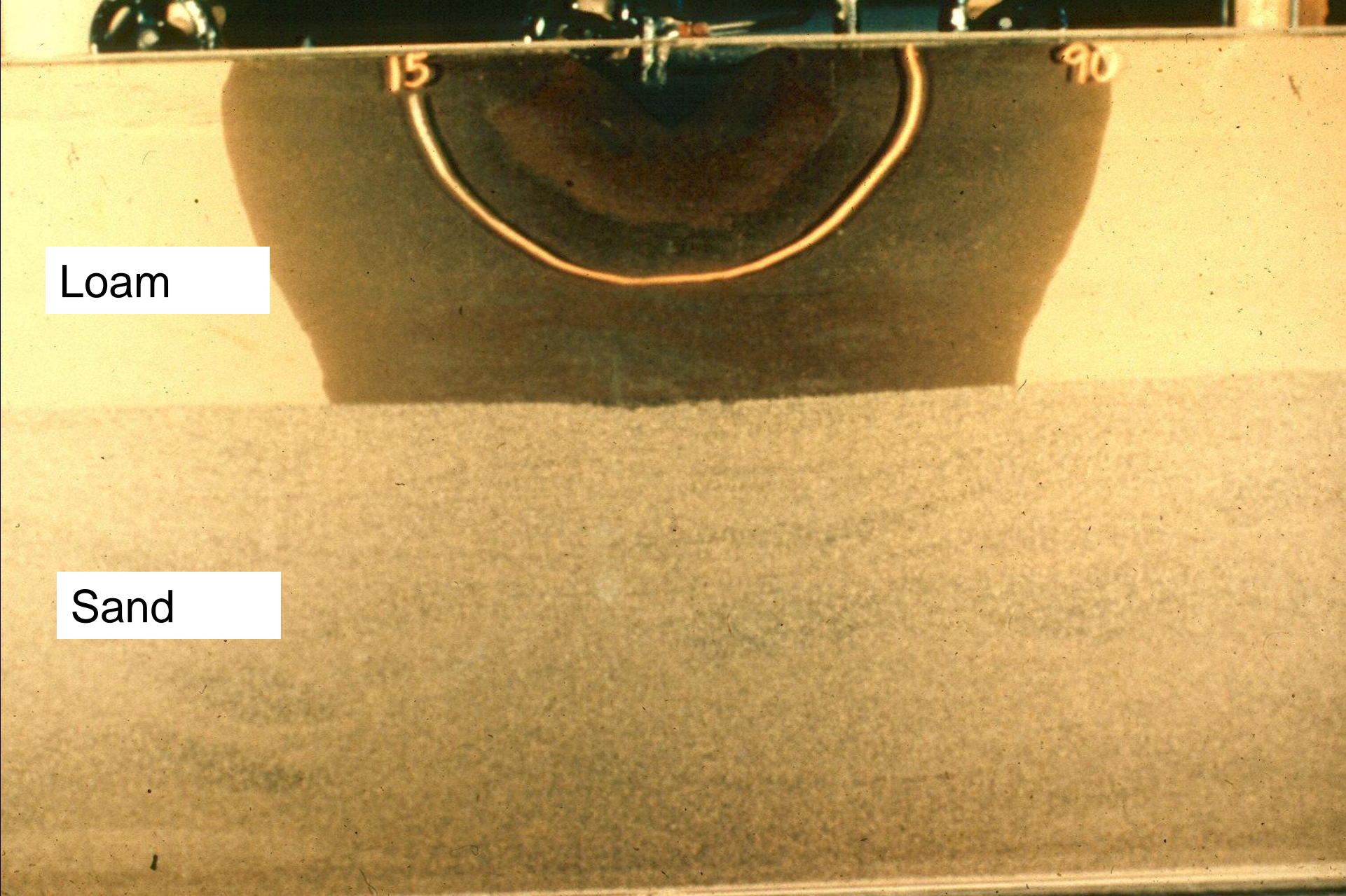


**Stratified sandy loam soil – restricts water movement through soil profile**

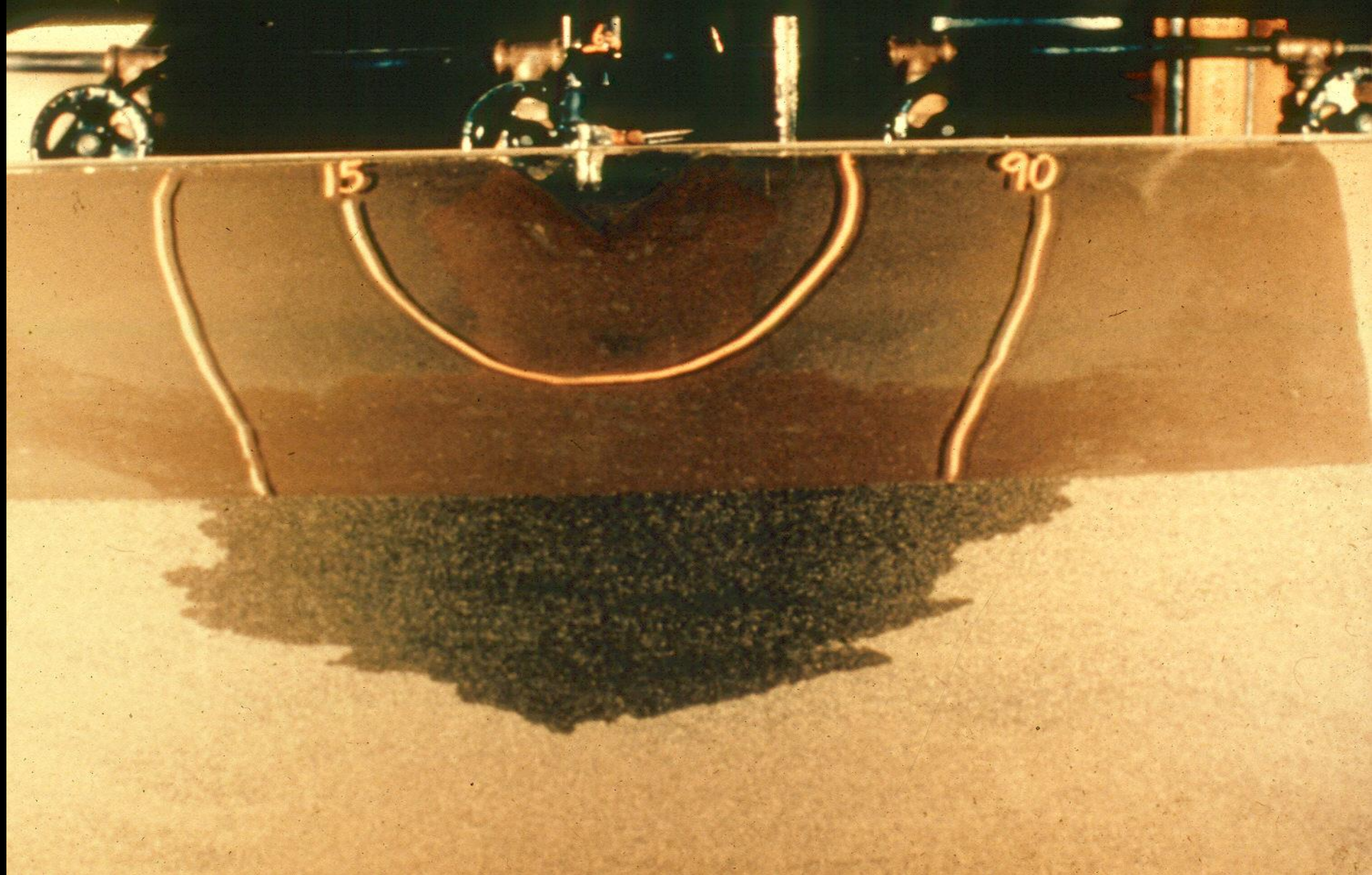




**Soil layers restrict root development  
& water infiltration**



Loamy soil over coarse sand – 90 minute wetting



Loamy soil over coarse sand – water moves through only after upper layer saturated

# Replant Problems of Almonds: Fumigant Option Overview

Problem	Fumigant	Method
High Nematode Parasitism	Telone-II (Chloropicrin)	Broadcast or Row Strip
Low/Medium Nematode Parasitism	Telone-II (Chloropicrin)	Row Strip (Spot?)
Nematode Parasitism +Prunus Replant Disease (PRD)	Telone-II Telone-II C35	Broadcast Rowstrip, Spot
PRD Only	Chloropicrin	Spot, Rowstrip

# Choose Appropriate Rootstock

Think of the rootstock as your  
**DEFENSE** against problems  
which will prevent your orchard  
from obtaining full potential

# *Specific Challenges*

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## High pH / Salt / Alkali



### ➤ **Peach / Almond Hybrids**

- Hansen, Nickels, Brights Hybrid, Titan, Cornerstone

### ➤ **Viking**

### ➤ **Empyrean #1**

# *Specific Challenges*

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## Ring Nematodes / Bacterial Canker



- Viking
- Lovell
- Guardian
- Emphyrean 1

# *Specific Challenges*

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## Heavy Soil / “Wet Feet” / Phytophthora



- Krymsk 86
- Rootpac R
- Marianna 2624





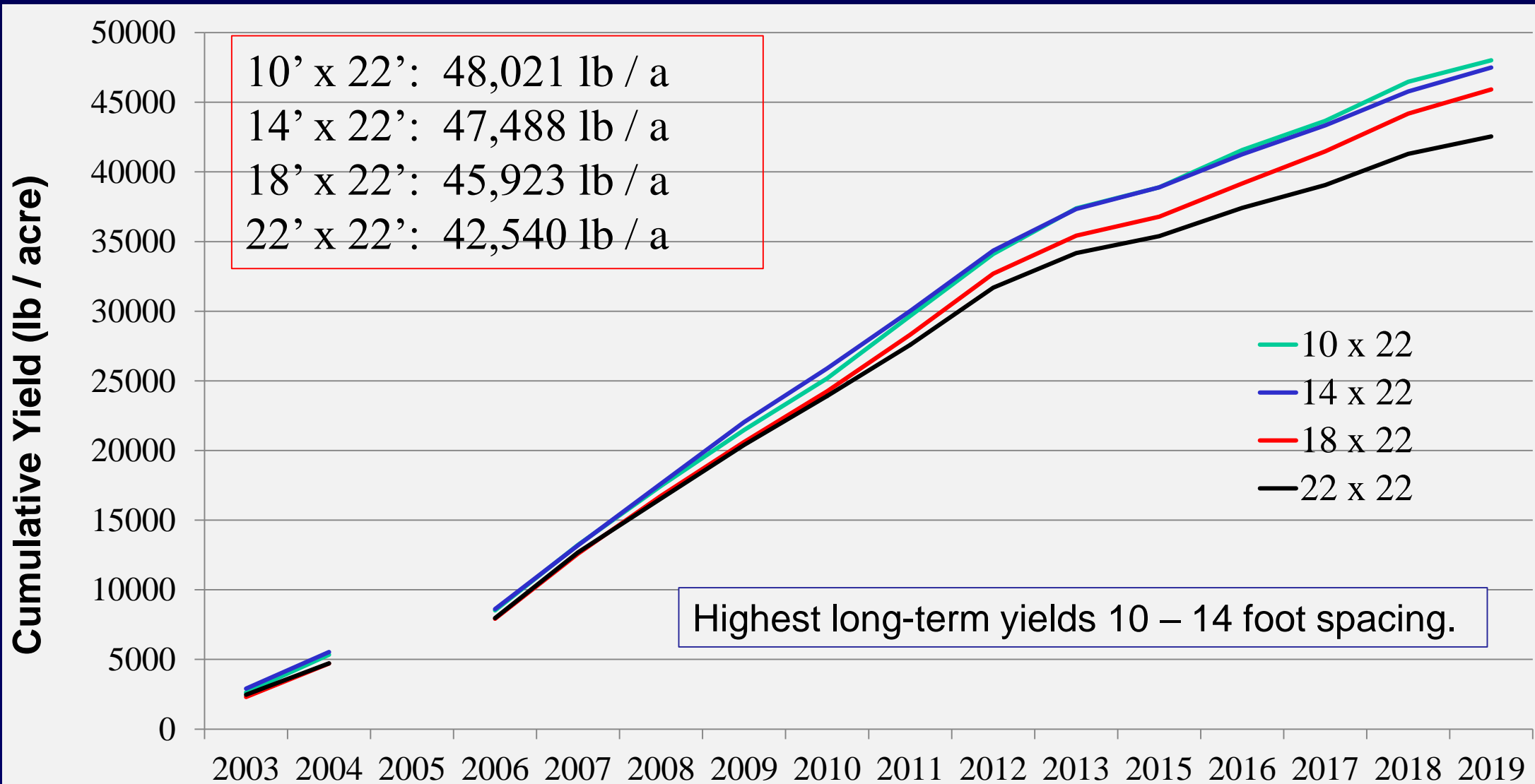


10' x 22' hedgerow

22' x 22' offset

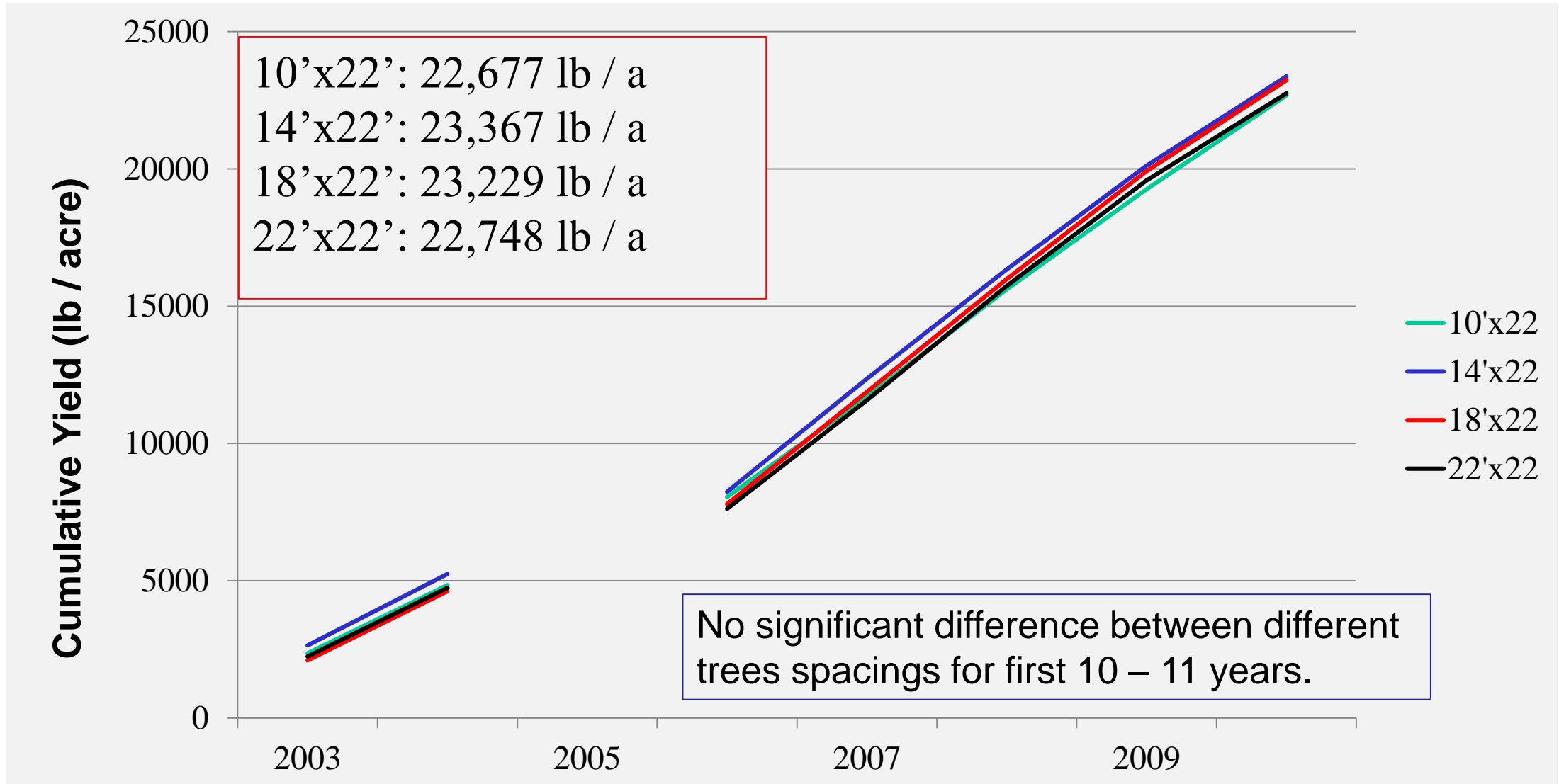
# The Effect of In-row Tree Spacing on Cumulative Yield Through 20<sup>th</sup> Season

## Nonpareil on Nemaguard



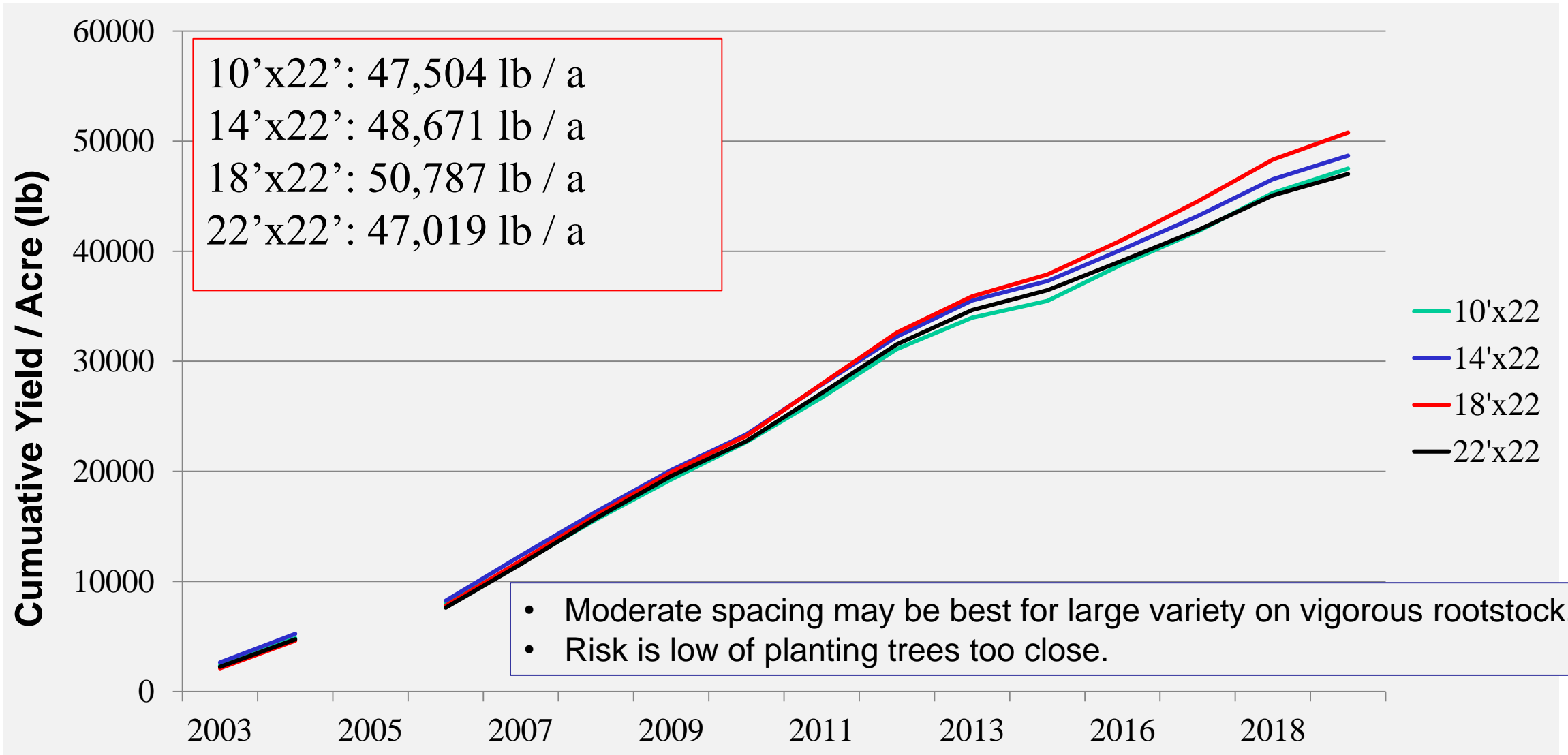
# The Effect of Tree Spacing on Cumulative Yield Through 11<sup>th</sup> Leaf

## Nonpareil on Hansen



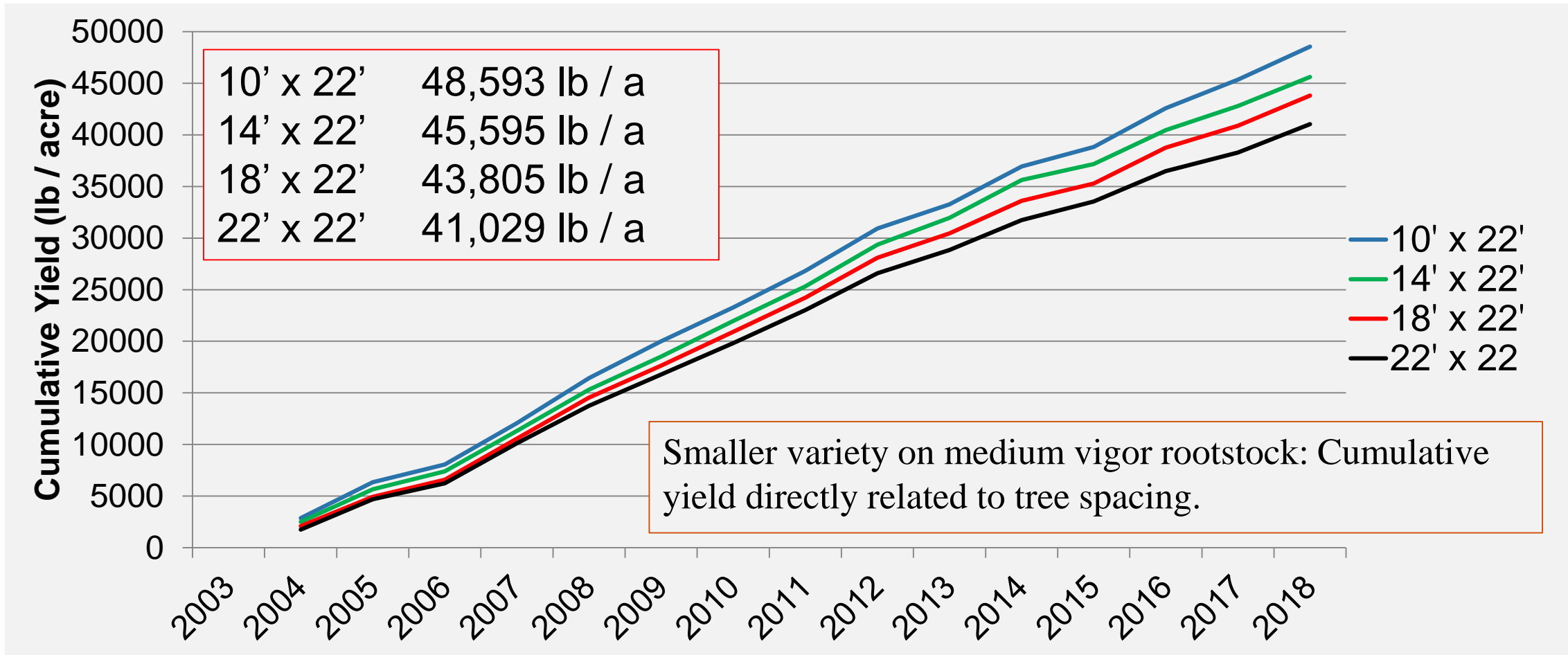
# The Effect of Tree Spacing on Cumulative Yield Through 20<sup>th</sup> Leaf

## Nonpareil on Hansen



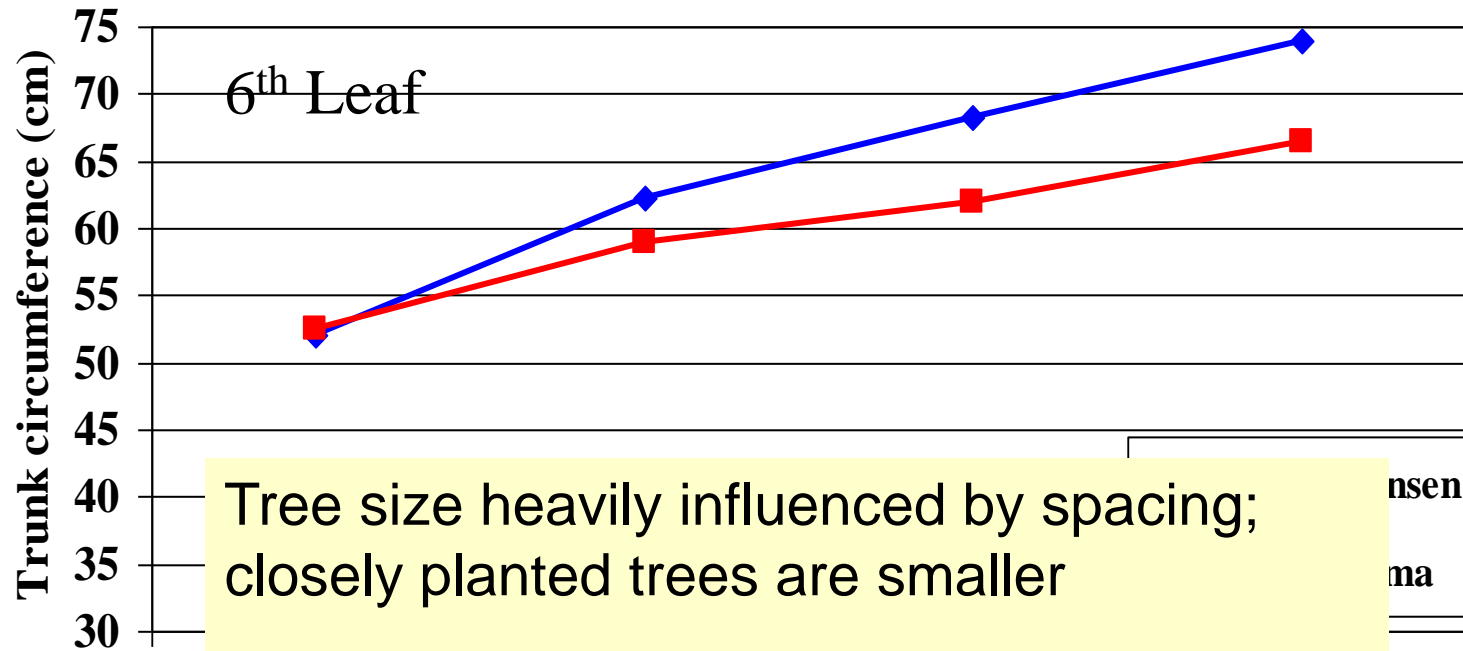
# The Effect of Tree Spacing on Cumulative Yield Through 19<sup>th</sup> Season

## Carmel on Nemaguard



Roughly 5.8% increase in cumulative yield for each 4' decrease in in-row tree spacing

# Effect of In-row Tree Spacing & Rootstock on Tree Size.



Tree size heavily influenced by spacing;  
closely planted trees are smaller

Hansen & Nemaguard similar size at tight spacings

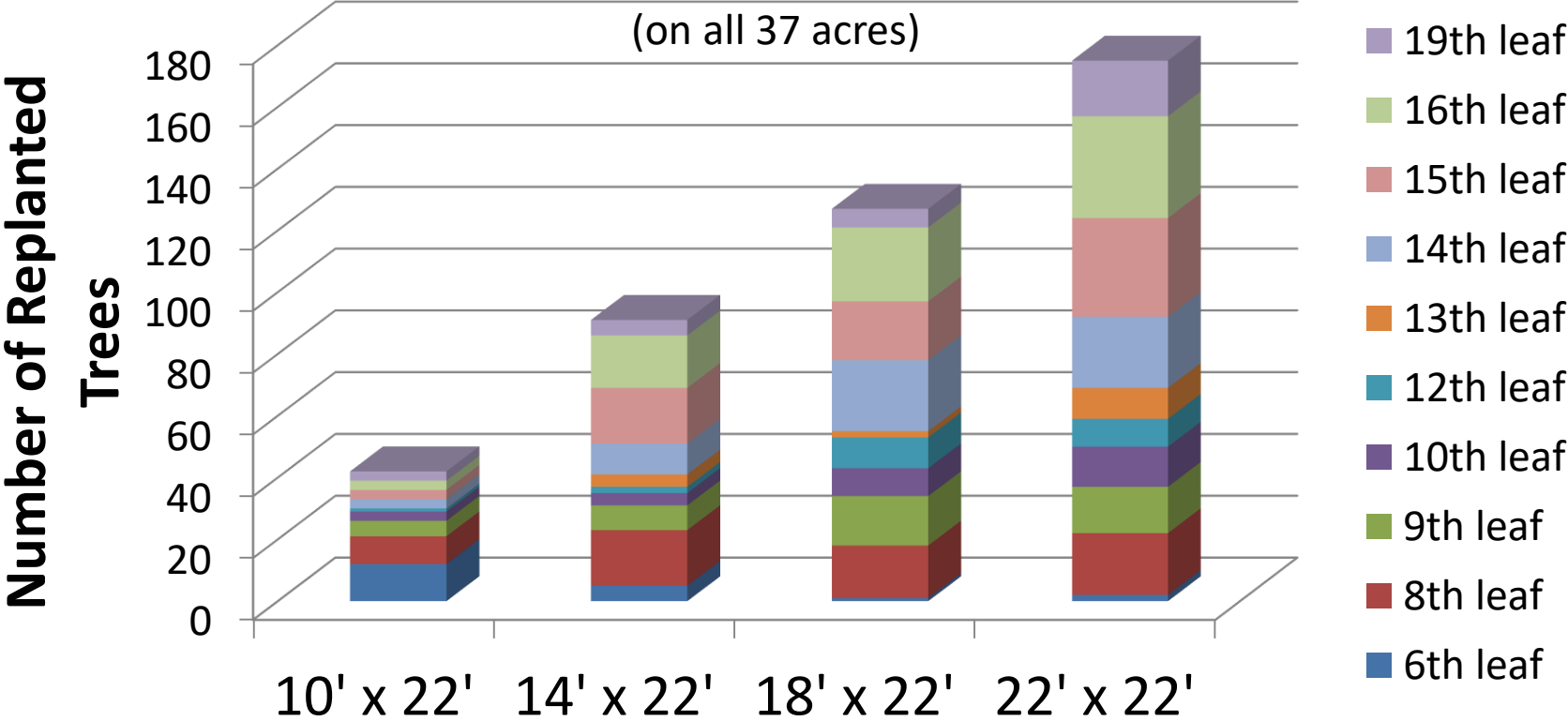
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# The Effect of Tree Spacing on Scaffold Splitting of Almond Trees



# The Influence of Tree Spacing on the Number of Replanted Trees





## Costs of Higher Density

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- For every one foot reduction in row width (e.g., 22' to 21'), many costs are increased by 5%
  - Strip fumigation, mowing, spraying, herbicides, irrigation hoses, sprinklers, etc.
  - Planting trees closer down the rows does not increase most on-going costs

# Summary

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Spend your money prior to planting to keep your orchard growing uniformly

- Preplant soil modification & disinfestation
- Proper rootstock and planting configuration
  - If in doubt, choose more vigor and higher density
- “Proper” irrigation & fertility



# Thank you for your attention

Roger Duncan

209-525-6800

[raduncan@ucdavis.edu](mailto:raduncan@ucdavis.edu)

[cestanislaus.ucdavis.edu](http://cestanislaus.ucdavis.edu)

 **University of California**  
Agriculture and Natural Resources

# Almond Tree Training

Katherine Jarvis-Shean

UCCE Orchard Systems Advisor

Sacramento, Solano & Yolo Co.s



# Goal of Training (Years 1-3)

Create structure to support crop weight



Minimize cuts that decrease early yields



Minimize infection: Avoid rain, January for fastest healing,  
Protect with appropriate fungicide

# Heading At Planting: Most important cut in tree's life

**Goal:** Room for 4-6 scaffolds above ~22" for shaker head.

- If ideal is 6" per Scaffold → Ideal = +24-36" above shaker head zone

**Potted:** If < 42" of trunk growth...

- If fall planted, let it grow, then top like new bare root when dormant.
- If winter or spring planted, tip if untipped, let it grow and scaffold select at first dormant.



**Bare Root:** Top at 42-48" for scaffolds spacing.

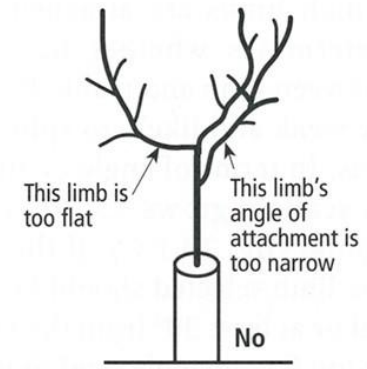
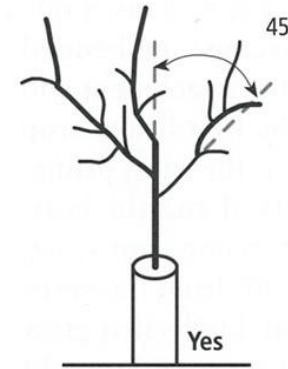


# Training Young Trees:

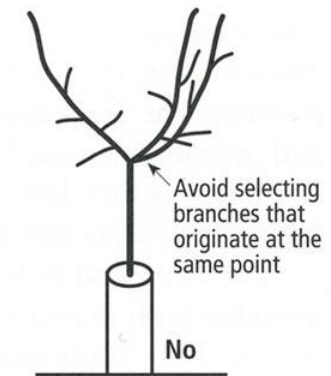
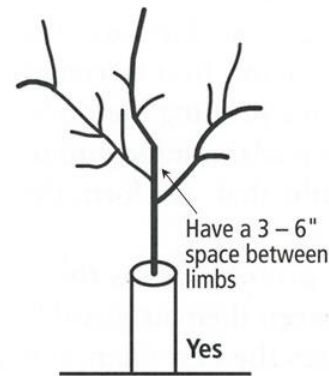
## 1<sup>st</sup> Dormant – Scaffold Selection

*Selection Goal:* Strong, well anchored branches that won't break or split from trunk with future crop weight.

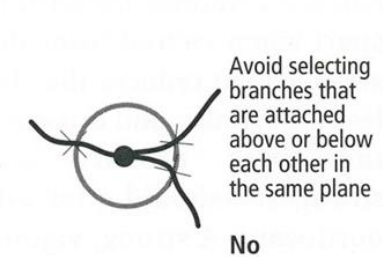
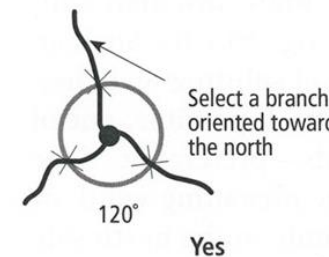
- 1<sup>st</sup>: Remove crosses, shaker blockers
- 2<sup>nd</sup>: Pick the best of what's left
  - Angle, Spacing, Orientation
- 3<sup>rd</sup>: Head back ~20-30%
  - Longer → Potential roping



Angle



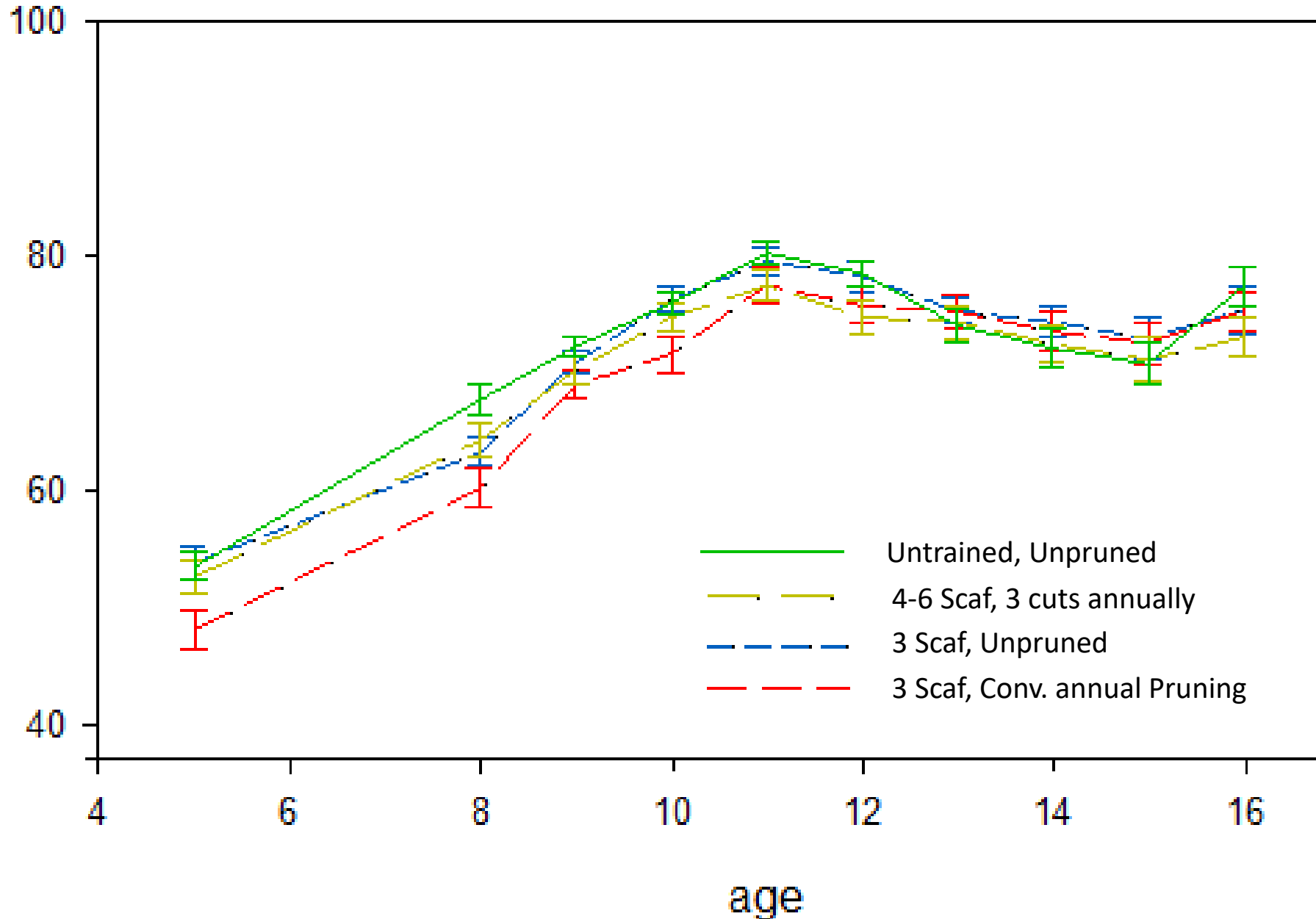
Spacing



Orientation

# How Many Scaffolds? Stanislaus Co.

Photosynthetically Active Radiation (PAR)





*Before*



*After*



# Training Young Trees: 2<sup>nd</sup> Dormant

Example: 5 Scaffolds

- ✓ 1<sup>st</sup>: Remove trouble-makers
  - ✓ Cross, Central, Smackers
- ✓ 2<sup>nd</sup>: Select 2ndary scaffolds
  - ✓ 2+ off primary
  - ✓ Angle & Spacing
  - ✓ Vigorous, up & out, well spaced.
- Heading not necessary

*Before*



*After*



# Training Young Trees: 3<sup>rd</sup> Dormant

- Minimal-to-no pruning required at this stage.
- 1<sup>st</sup>: Remove crossed limbs.
- 2<sup>nd</sup>: Remove tractor smackers.
- 3<sup>rd</sup>: Remove yourself and crew. Most pruning at this point will delay early yields.



Franz Niederholzer,  
UC ANR



**Once its built, strong & complete, maintain the orchard for best results.**



**Orchards are like kids. You can set them up but shouldn't try to make it happen.**



HOWARD MCWILLIAMS



**The goal is  
consistent  
production.**

# **The objectives are:**

- **adequate pollination/nut set**
- **careful irrigation & nutrition**
- **protect the canopy**



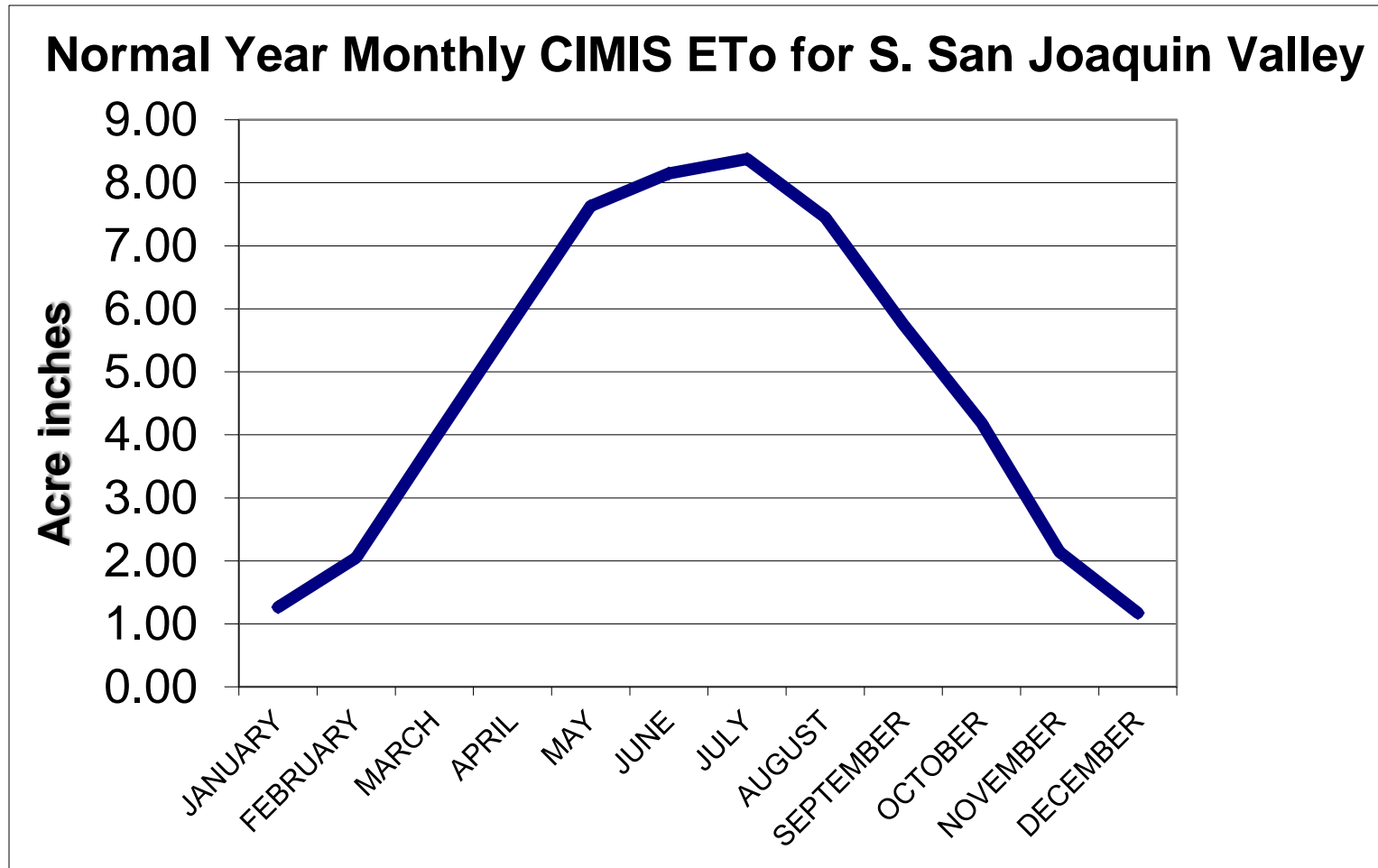
**Good bee activity + adequate boron = good nut set. All hives are not equal.**

<b>Frames/hive</b>	<b>Pollen collected (lb per hive)</b>
<b>4</b>	<b>0.51</b>
<b>5</b>	<b>0.67</b>
<b>6</b>	<b>1.17</b>
<b>8</b>	<b>1.70</b>

**Good bee activity + adequate boron = good nut set.**

Hull boron (ppm)	Boron status
<b>&lt;80</b>	<b>Deficient</b>
<b>80-120</b>	<b>Could use +B</b>
<b>120-200</b>	<b>Adequate?</b>
<b>&lt;300</b>	<b>Toxic</b>

# Careful irrigation to match orchard water use.



**With the crop set, feed it. Focus on nitrogen, don't ignore potassium.**

**Leaf N target 2.4-2.5%**

**Leaf K target 1.4% (deficient <1%)**

**Check leaf levels in spring and summer.**

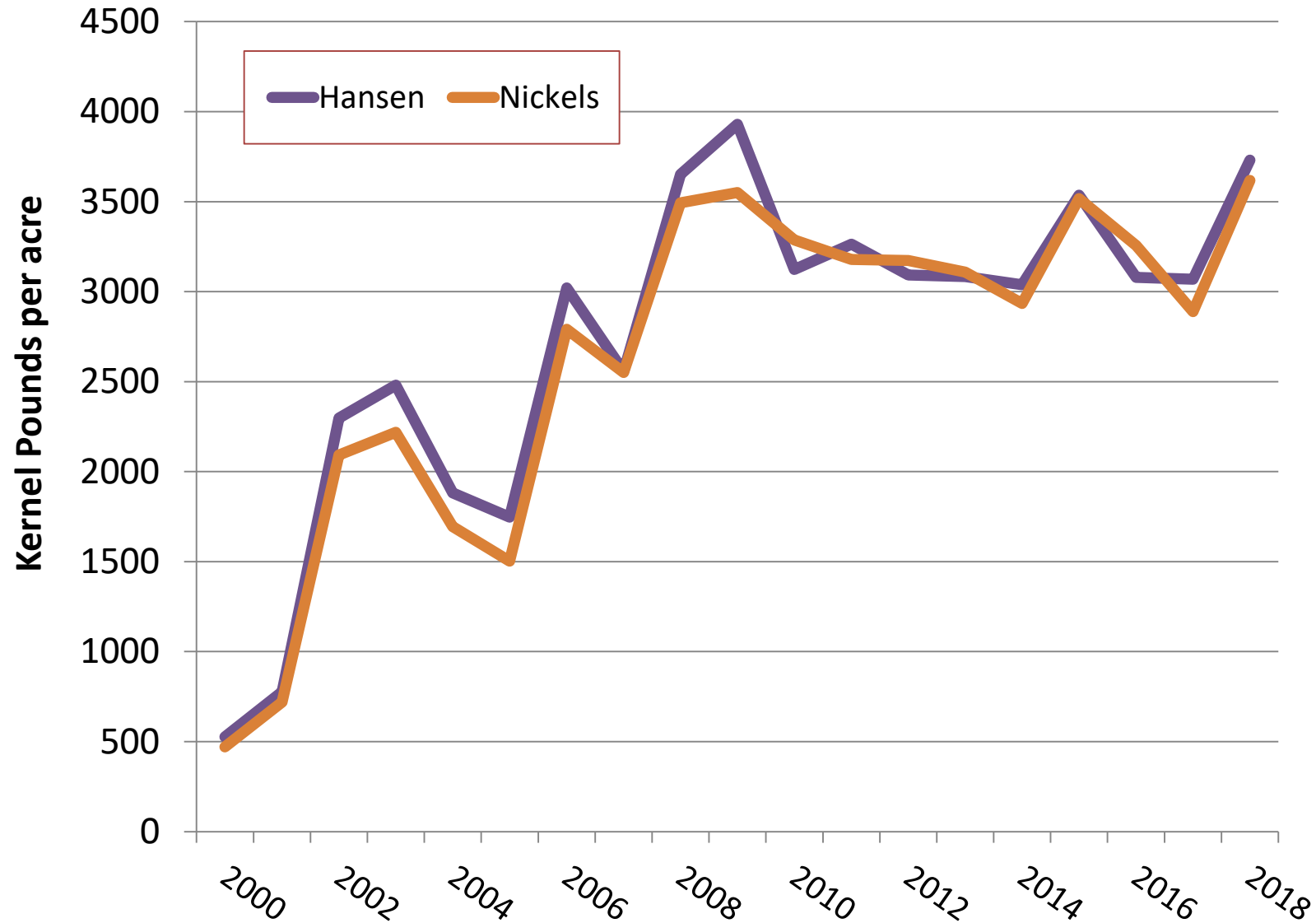
**Use the 4-Rs**

**Multiple applications better than bigger "shots"**

# **Maintain a healthy canopy. Keep the motor running smoothly.**

- **Irrigation (previously noted, but worth repeating)**
- **Disease control**
  - **Monitoring (Weather & Crop)**
  - **Materials/Rotation**
  - **Coverage**
- **Mite control**
  - **Monitoring (Weather & Crop)**
  - **Materials/Rotation**
  - **Coverage**

# Opinion: Don't try to out smart Nature (AKA Don't plan your kids' lives).



# Session Review

A landscape photograph showing a dirt road winding through a field. The road is in the foreground, leading towards a line of trees in the distance. The sky is filled with dramatic, layered clouds, with some light breaking through near the horizon. The overall tone is warm and somewhat somber due to the lighting.

**Thank you!**