2023
THE ALMOND CONFERENCE
Connecting the Dots
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Optimizing Critical Orchard Practices: Research on Avoiding Pruning, Increasing Fertigation Efficiency and Fine Tuning Orchard Configuration

Moderator: Sebastian Saa (ABC)

Speakers: Roger Duncan (UC ANR), Brian Bailey (UC Davis), Patrick Brown (UC Davis), Thomas Harter (UC Davis), Franz Niederholzer (UC Davis)

Session Details

OPTIMIZING CRITICAL ORCHARD PRACTICES: RESEARCH ON AVOIDING PRUNING, INCREASING FERTIGATION EFFICIENCY AND FINE-TUNING ORCHARD CONFIGURATION

Moderator

Sebastian Saa, ABC, Session Moderator

Speakers

Roger Duncan, UCCE Stanislaus County

Brian Bailey, UC Davis

Franz Niederholzer, UCCE Colusa County

Patrick Brown, UC Davis

Thomas Harter, UC Davis

Optimizing Costs:

Pruning and Orchard Configuration Considerations

Roger Duncan

UC Cooperative Extension, Stanislaus County

To prune or not to prune?

Pruning is a dwarfing process that reduces sunlight capture (carbohydrates), fruit bearing area, and root growth.

Pruning is a yield reducing practice.

The more you prune, the more yield is reduced.

Yields in Long-term Almond Pruning Trial (1980's-90's)

Spacing = 7' x 22'. John Edstrom, et. al., Nickels Estate

	18th leaf	19th leaf	20th leaf	21st leaf	Cumulative Yield
Annually pruned	2624	2498 a	2494 a	2136	34,176
Initially trained, then unpruned	2833	2680 a	1958 ab	2307	35,082
Temporary trees removed	2076	2081 b	1757 b	1662	27,861

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

“Unpruned”

Stanislaus County Pruning Trial

The Effect of Long-term Pruning on 19th Leaf Yield & Cumulative Yield*				
	Nonpareil		Carmel	
	19th Leaf Yield (lb. / a)	Cumulative	19th Leaf Yield (lb. / a)	Cumulative
Trained to 3 scaffolds; Annual, moderate pruning	2998 a	41,326	2461 b	38,851
Trained to 3 scaffolds; Unpruned after 2nd year	3080 a	42,237	2784 ab	41,732
No scaffold selection; No annual pruning	3004 a	42,278	2801 a	43,274

*Average for Nemaguard & Hansen Rootstocks across all tree spacings

Stanislaus County Trial 2000-2021

- Pruning did not increase yield in the short or long term. Pruning either had no significant effect or reduced yield.

- 19 years x $275 / acre pruning, stacking, & shredding costs = $5225

- Decrease in cumulative yield by about 1000 to 3500 pounds = loss of ~$2500 - $9000 / acre
  - Cumulative loss from annual pruning likely $7,500 - $14,000 / acre


After topping, November 2014

Effect of Mechanical Topping 1rst-Leaf Trees on Subsequent Yield - Nonpareil

	2016	2017	2018	2019	Total
Untrained	649 a	2687 a	2924 a	3583 a	9,843 a
Topped no scaffold selection	561 ab	2223 bc	2915 a	3684 a	9,383 b
Medium trained by hand	538 abc	2397 ab	2626 ab	3294 a	8,855 c
Topped + scaffold selection	608 ab	2231 bc	2403 b	3525 a	8,767 c
Short pruned by hand	402 c	1981 c	2779 ab	3513 a	8,675 c

Remarks on Pruning

- Sometimes pruning is needed for safety, equipment access, removing broken and dead branches, limb cankers, etc.
- Best to train trees for good structure and then abandon pruning
- Your reason to prune should justify the expense and potential yield loss

Which Orchard Spacing is Best?

In-Row Tree Spacing Trial
2000 - 2022

10’ x 22’

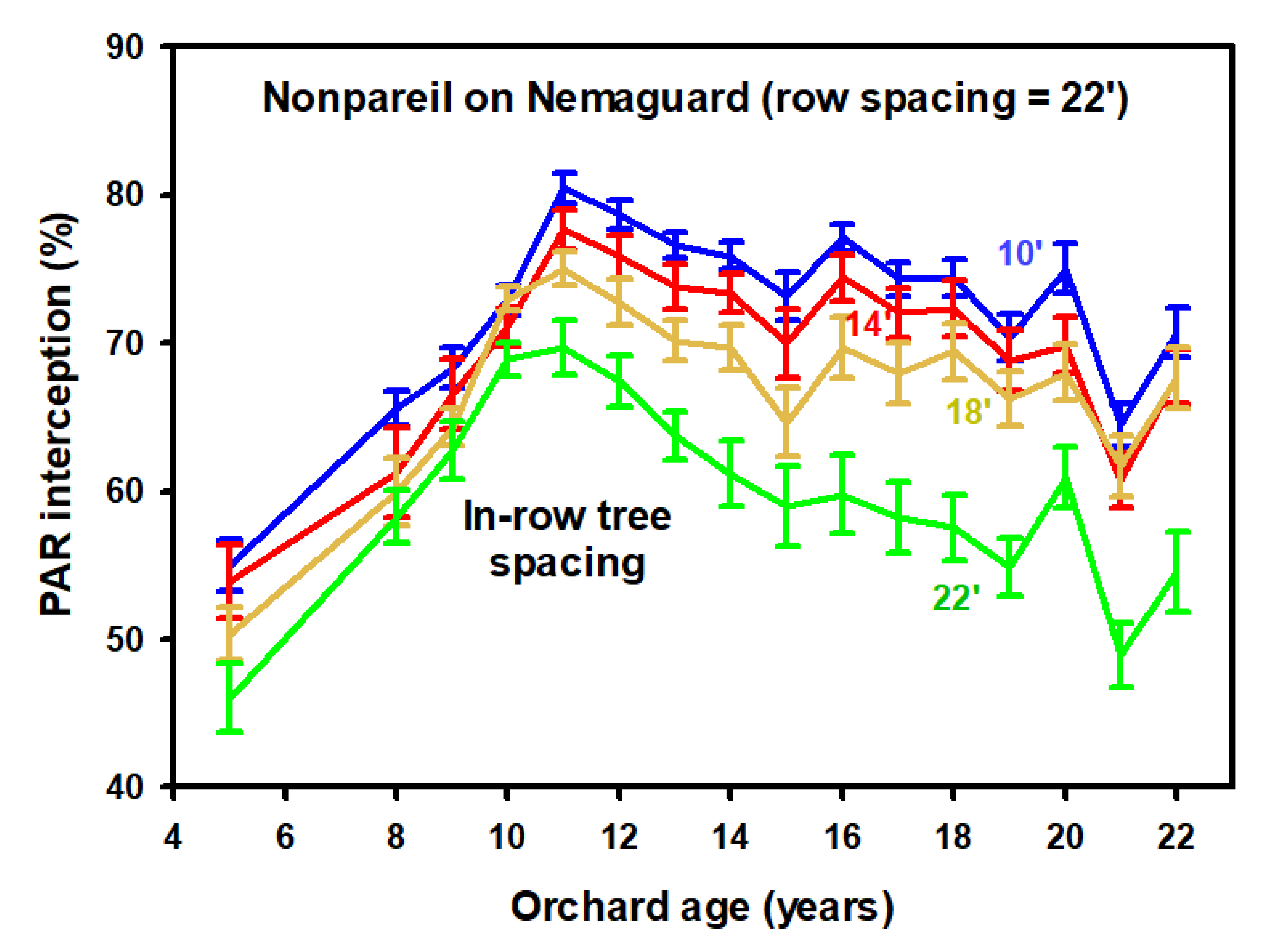
14’ x 22’

18’ x 22’

22’ x 22’

Tighter In-row Spacing = More Sunlight Capture

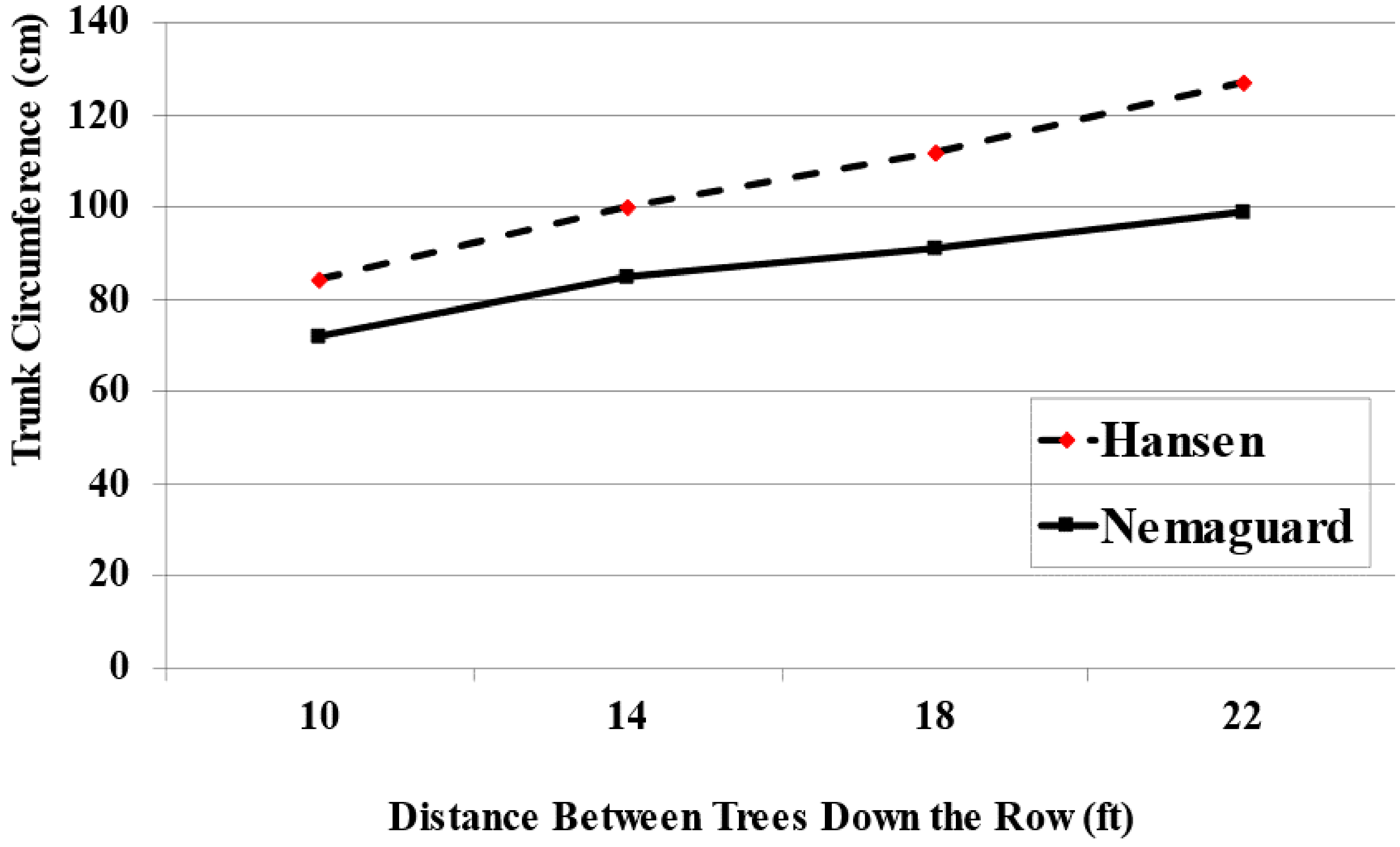
Bruce Lampinen and Sam Metcalf



The Effects of In-row Tree Spacing & Rootstock on Cumulative Kernel Yield Through the 22nd Season. Kg / ha.

	Nemaguard	Hansen
Tree Spacing (m)		
Nonpareil		
10’ x 22’	53,581	55,306
14’ x 22’	53,508	55,479
18’ x 22’	51,006	59,469
22’ x 22’	48,040	53,995
Carmel		
10’ x 22’	58,187	46,367
14’ x 22’	54,701	46,907
18’ x 22’	52,993	45,568
22’ x 22’	49,393	43,300

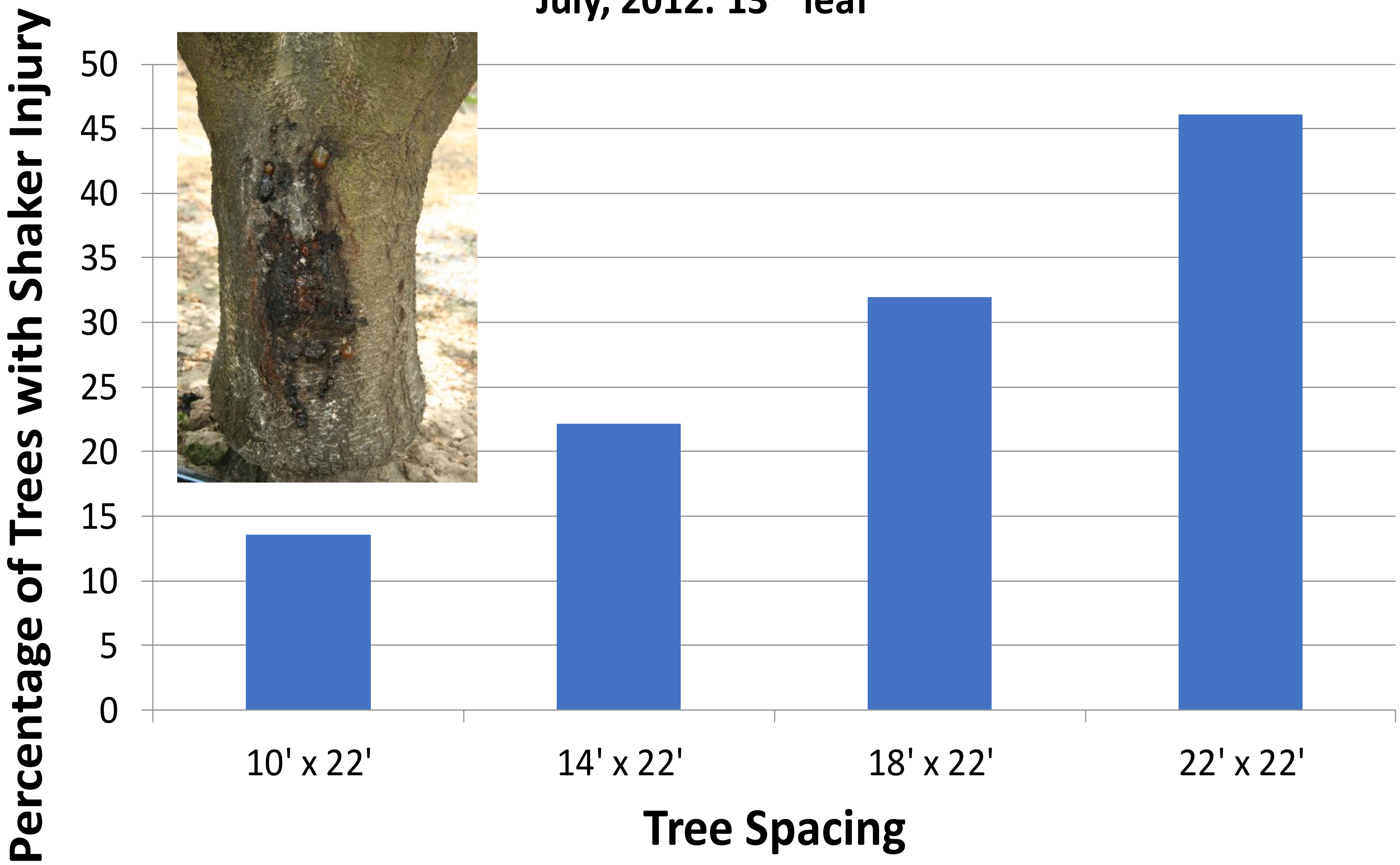
Fig. 4. The Influence of Tree Spacing on Tree Size of 20th -Leaf Almond Trees

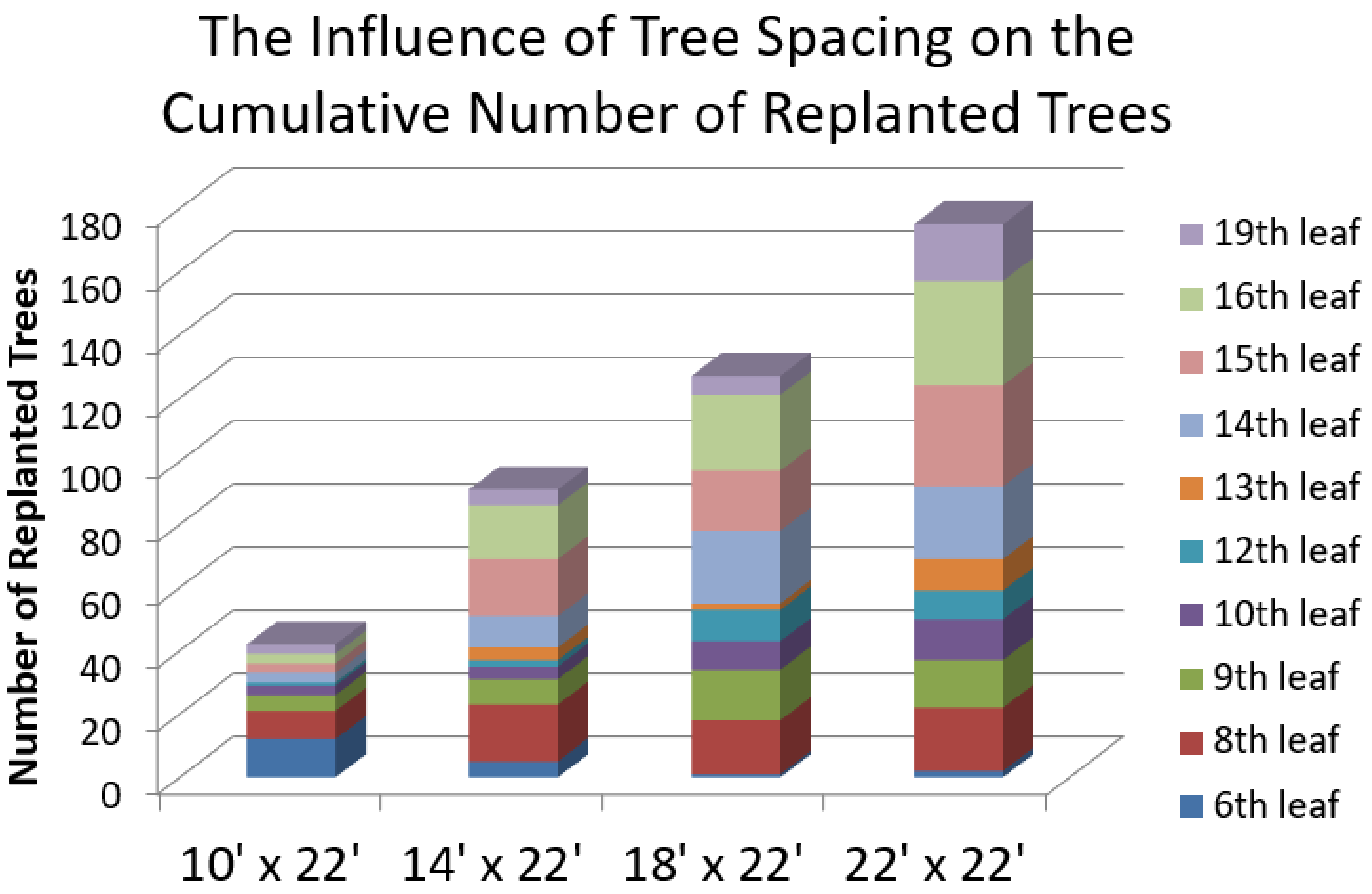


The Effect of Tree Spacing on Scaffold Splitting of Almond Trees - Fifth-leaf

The Effect of Tree Spacing on Trunk Shaker Injury

July, 2012. 13th leaf





The closer trees are planted, the less likely they will fail due to scaffold failure or shaker damage

Tighter In-row Spacing Results in Fewer Mummies

Mummies per acre			
10 x 22	14 x 22	18 x 22	22 x 22
Eleventh Leaf			
4,787	7,116	11,382	11,581
Thirteenth Leaf			
5,643	7,707	6,050	11,543

20th Leaf Carmel and Nonpareil trees on Hansen rootstock

22’ x 22’

10’ x 22’

Benefits of Closer Spacing (other than yield):

More closely planted trees are:

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

Computer-Aided Design and Management of Almond Orchards

BRIAN BAILEY

ASSOCIATE PROFESSOR

DEPARTMENT OF PLANT SCIENCES

UNIVERSITY OF CALIFORNIA, DAVIS

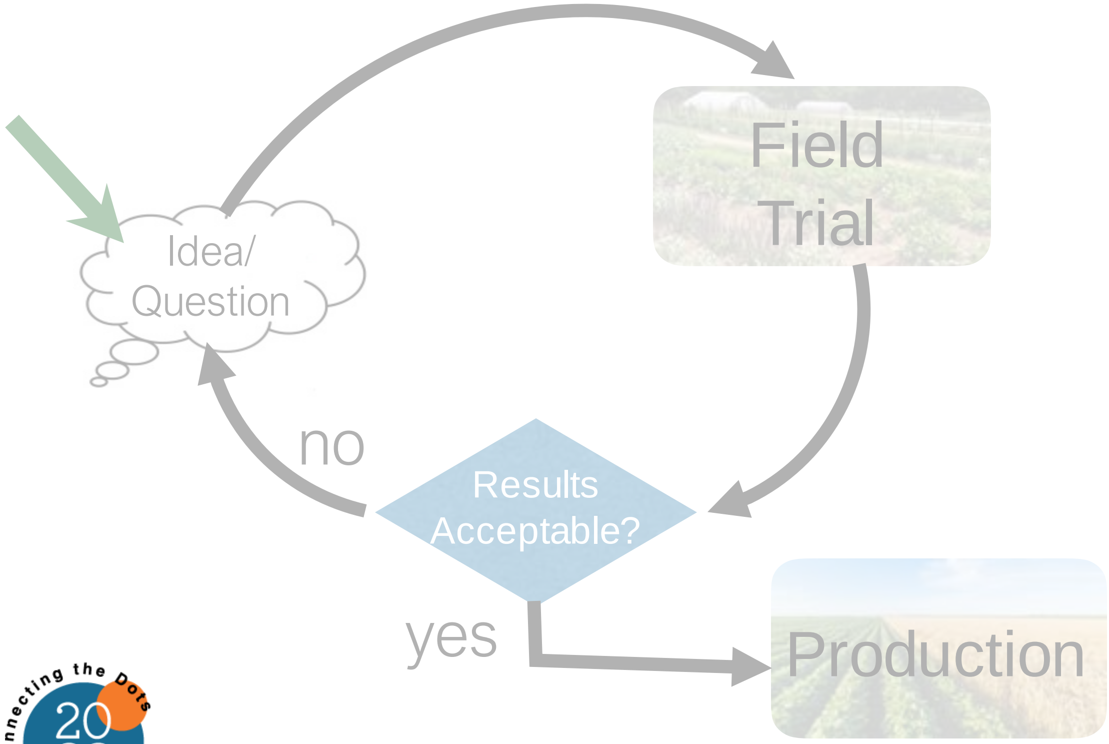
PROJECT PERSONNEL

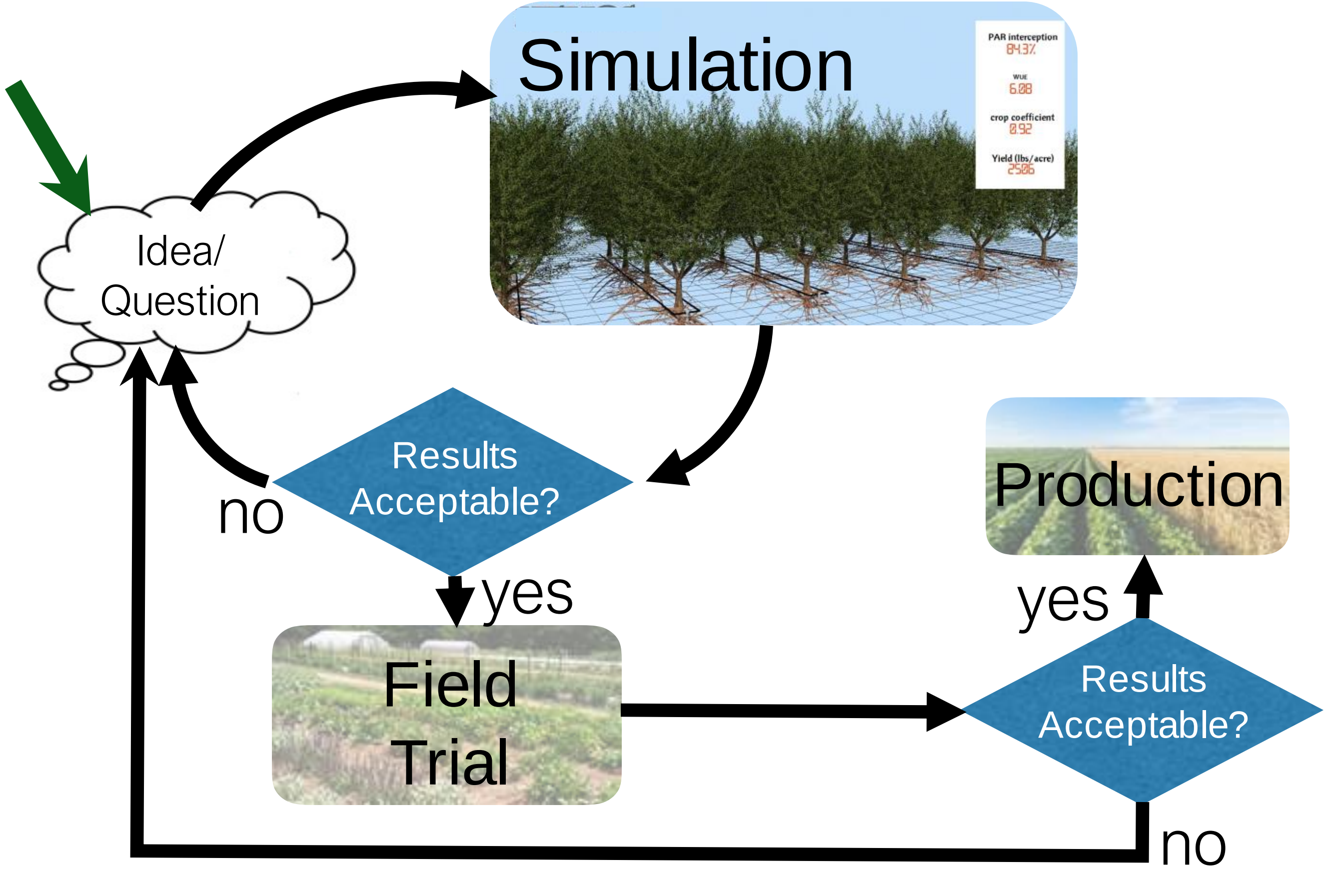
ETHAN FREHNER,

ERIC KENT

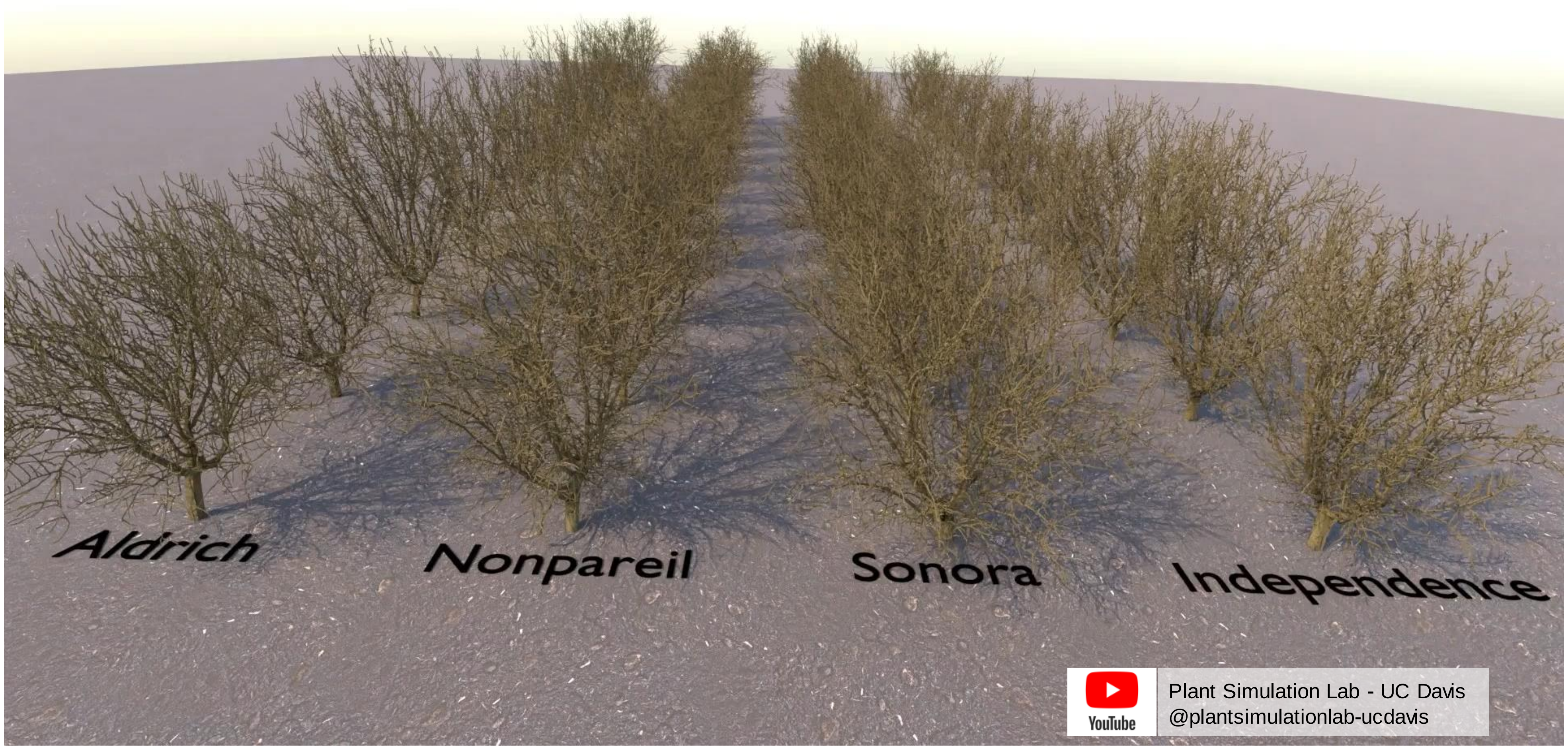
Motivation

Field trials are valuable, yet costly; Models can accelerate the innovation cycle by interpolating and extrapolating available data.





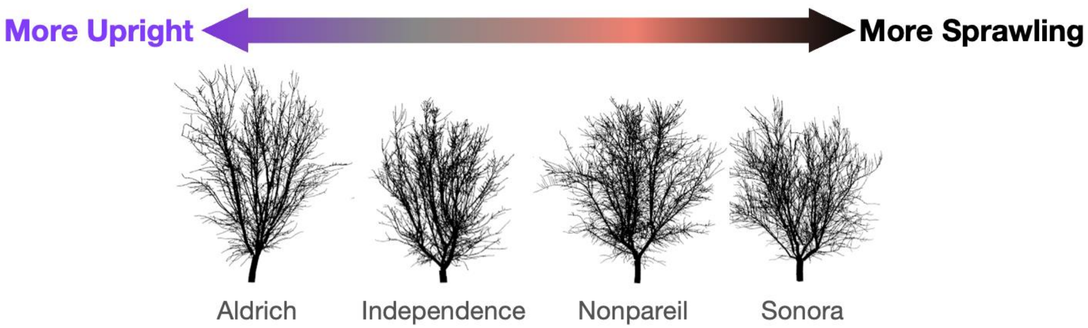
Helios 3D Modeling Framework

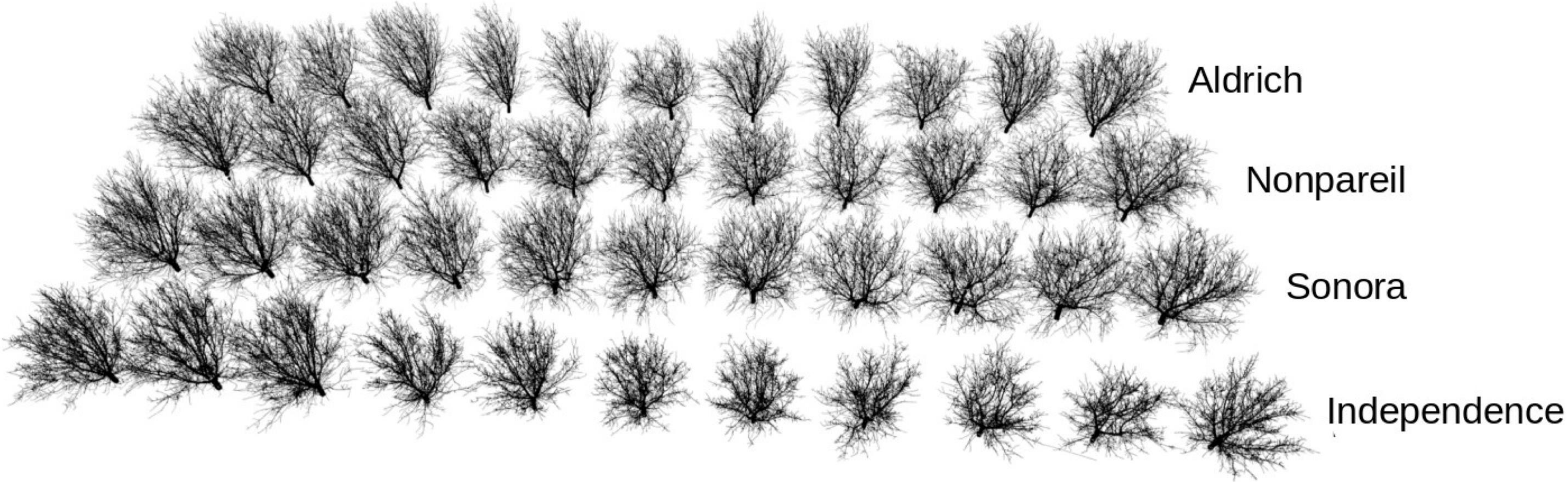


Almond Orchard Reconstruction

NICKELS SOIL LAB

In collaboration with Franz Niederholzer





Viking rootstock
9 years old
20’ x 15’ spacing

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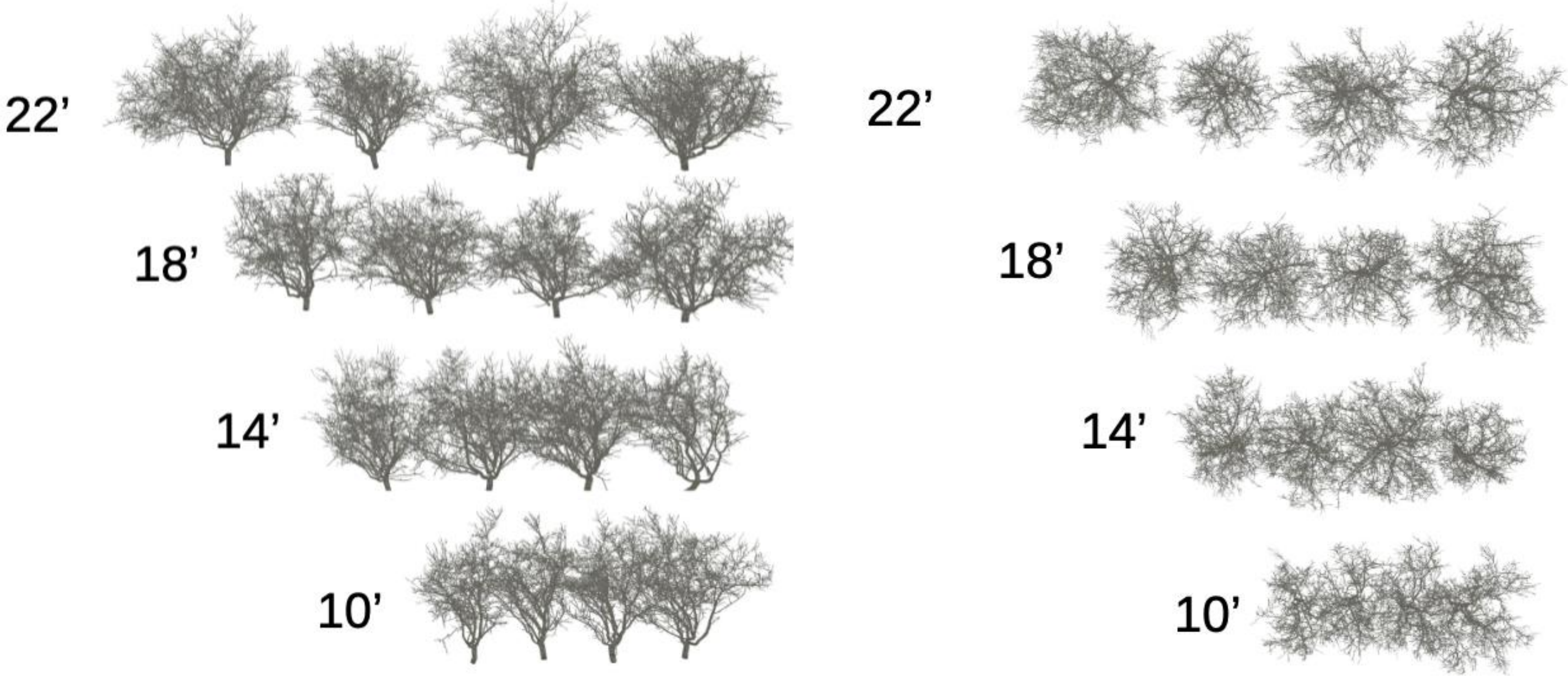
Almond Orchard Reconstruction

CONFIGURATION TRIAL

In collaboration with Roger Duncan



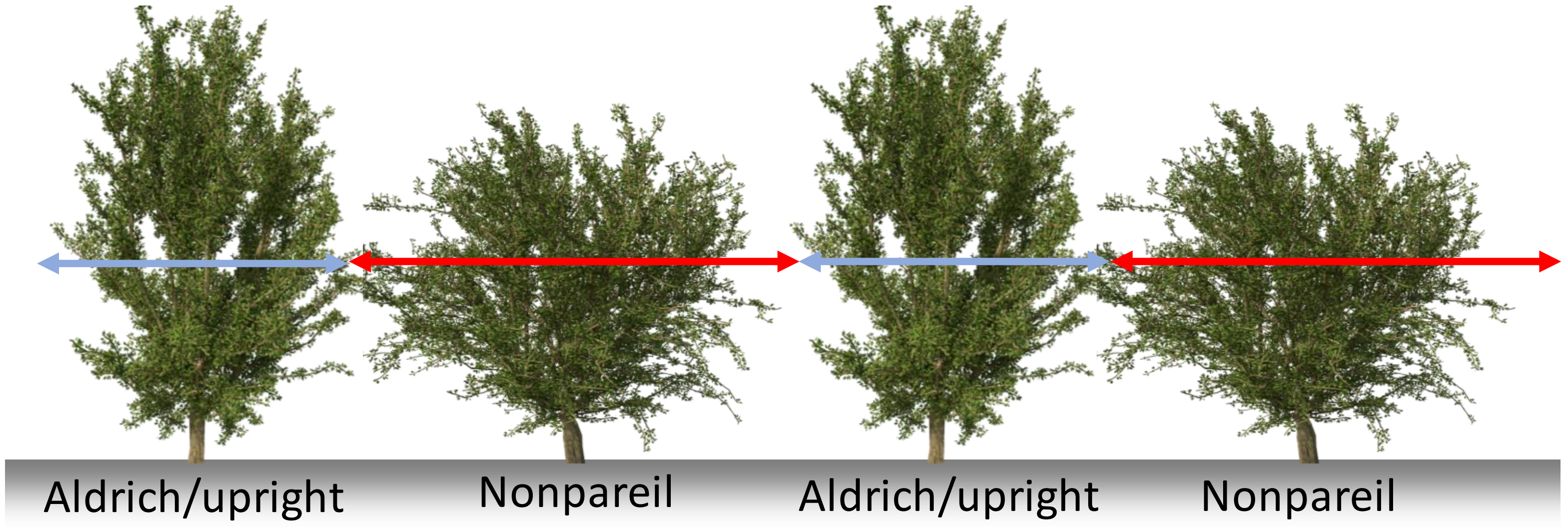
Nonpareil on Nemaguard; variable tree spacing

Potential Applications

The goal is to be able to simulate the impacts of any actions an orchard designer or manager might take

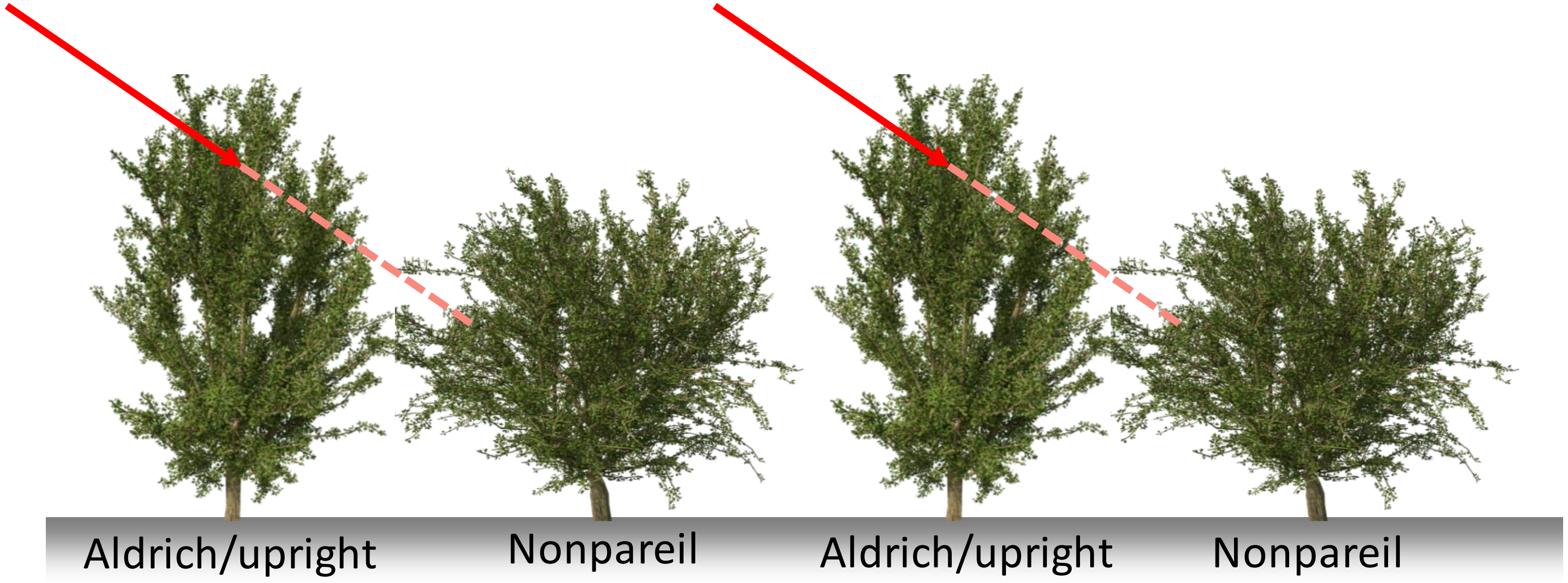
- Orchard configuration design
- Irrigation system design and management
- Pruning/thinning
- “What if?” scenarios and hypothesis testing

Hypothesis 1: Alternating Nonpareil and an upright variety will increase profitability by allowing more space for Nonpareil trees and thus increasing their yield

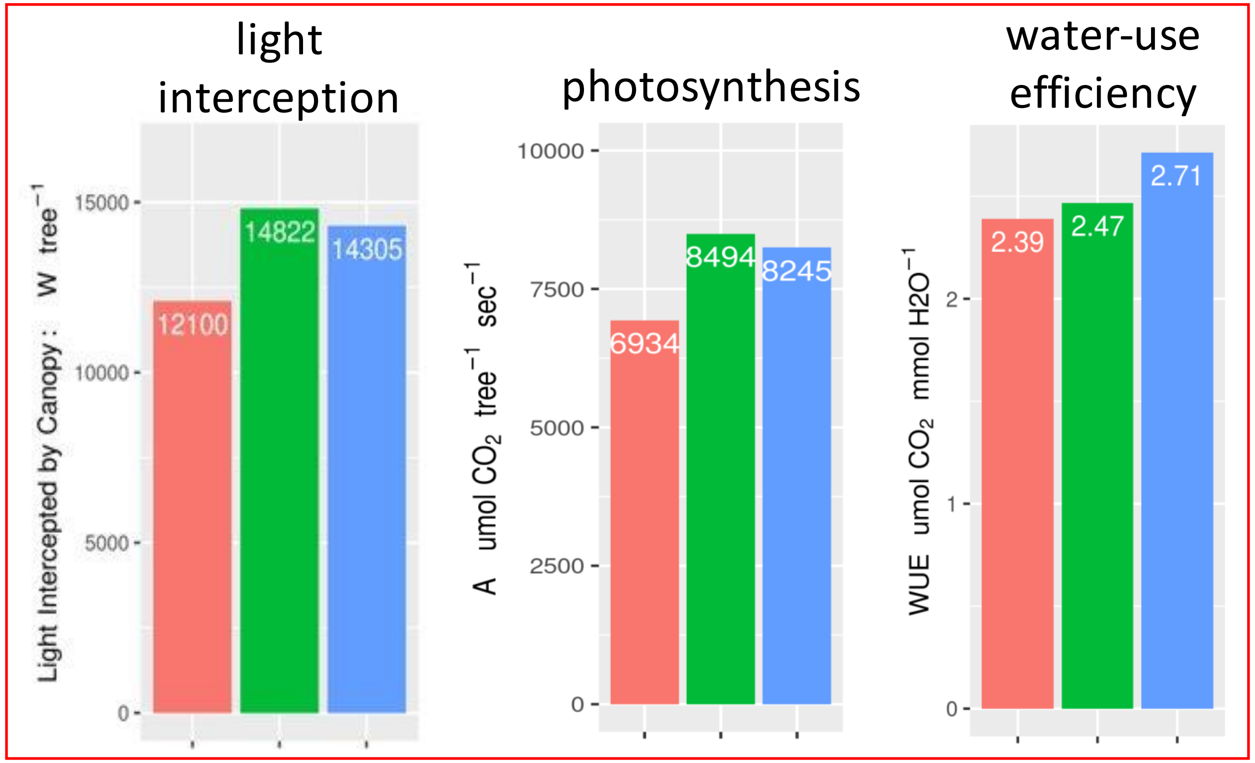


Hypothesis 1: Alternating Nonpareil and an upright variety will increase profitability by allowing more space for Nonpareil trees and thus increasing their yield

Hypothesis 1a (alternate): Alternating Nonpareil and an upright variety will not significantly increase profitability because increased Nonpareil growth will be offset by neighbor shading



per tree basis



whole orchard basis

Mixed: Overall
Nonpareil Only

- Aldrich in mixed orchard
- Nonpareil in mixed orchard
- Nonpareil only orchard

North-South Rows

- In mixed orchard, light interception and photosynthesis went up for the Nonpareil trees and down for Aldrich trees, but for the whole orchard were the same as an equivalent Nonpareil monoculture
- Adding Aldrich trees caused water-use efficiency of the mixed orchard to go down for both the Nonpareil and Aldrich trees

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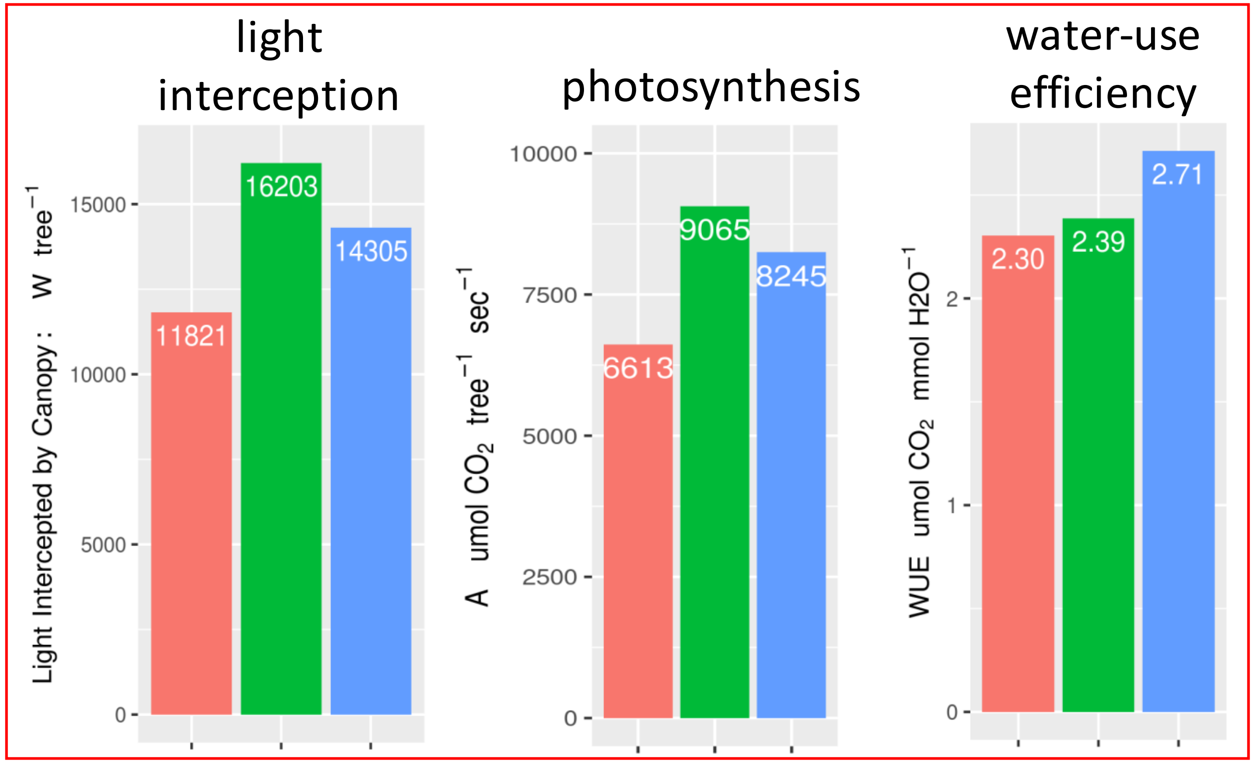
per tree basis



Aldrich in mixed orchard

Nonpareil in mixed orchard

Nonpareil only orchard

whole orchard basis

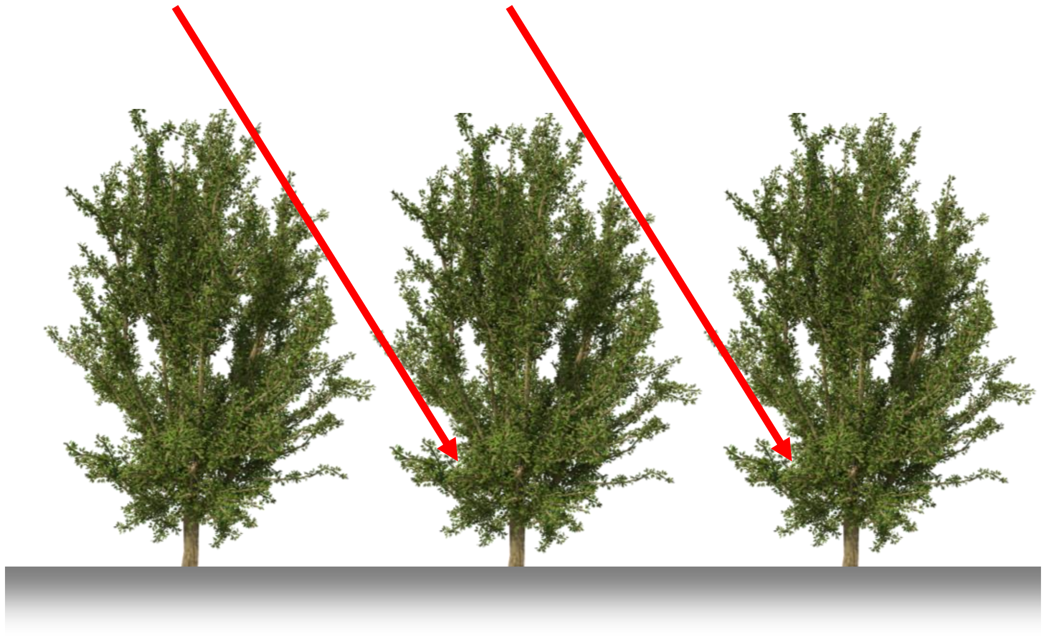
Mixed: Overall

Nonpareil Only

East-West Rows

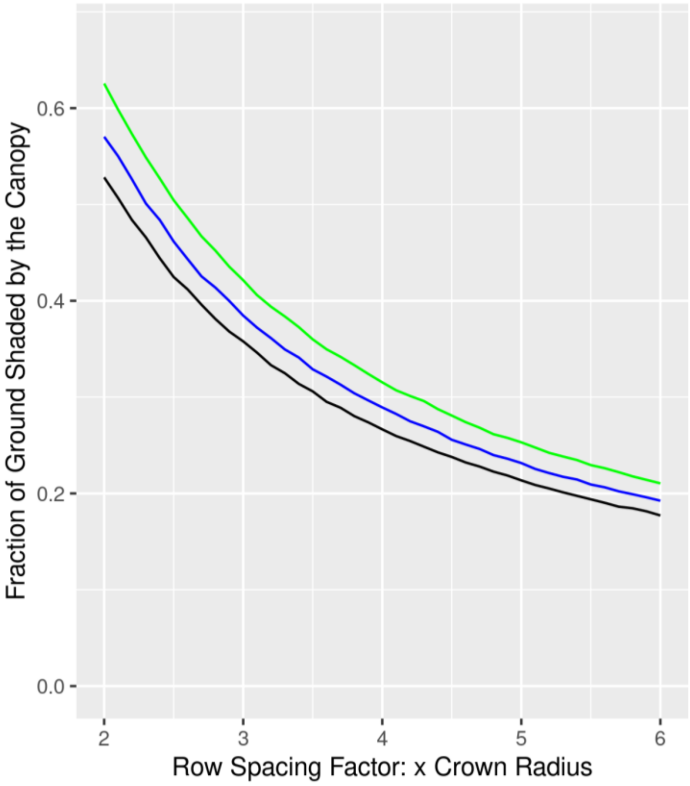
- An East-West row orientation amplified the benefit of the mixed variety orchard

What is the optimal row spacing for an upright/pillar type architecture?

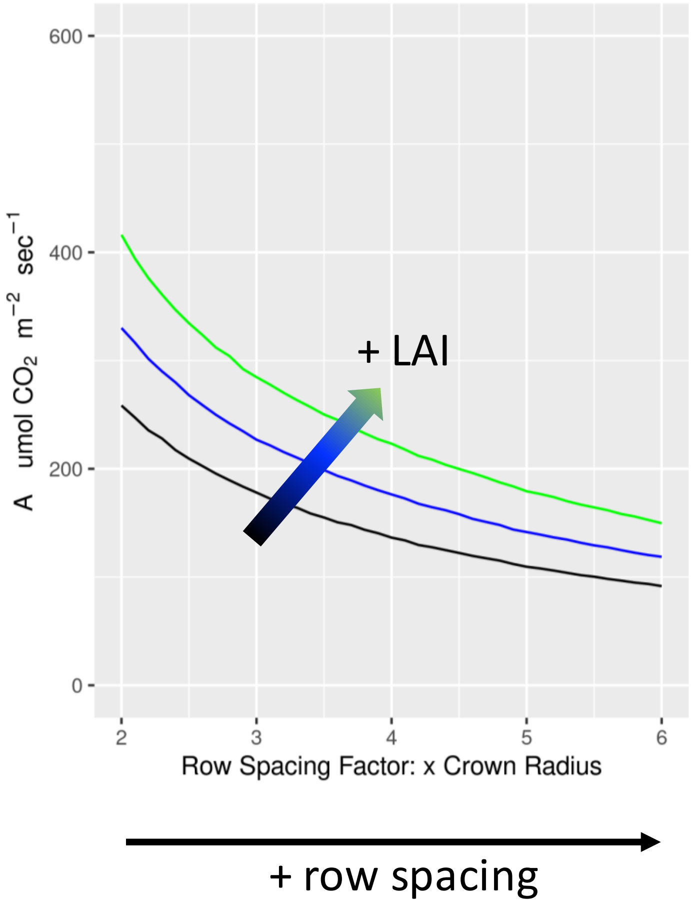


What is the optimal row spacing for an upright/pillar type architecture?

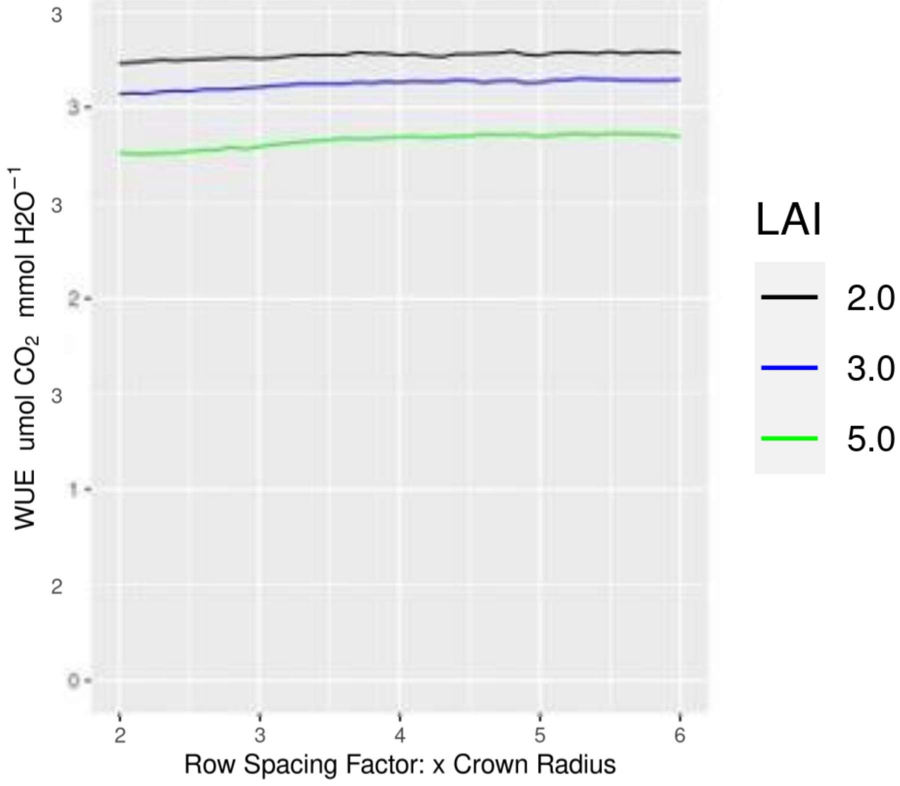
light interception



photosynthesis



water-use efficiency



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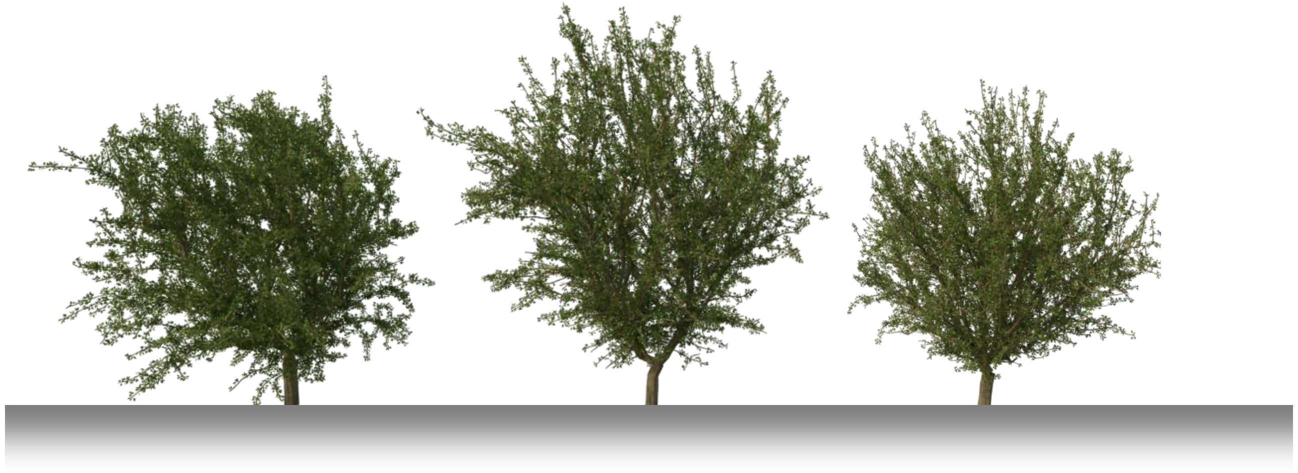
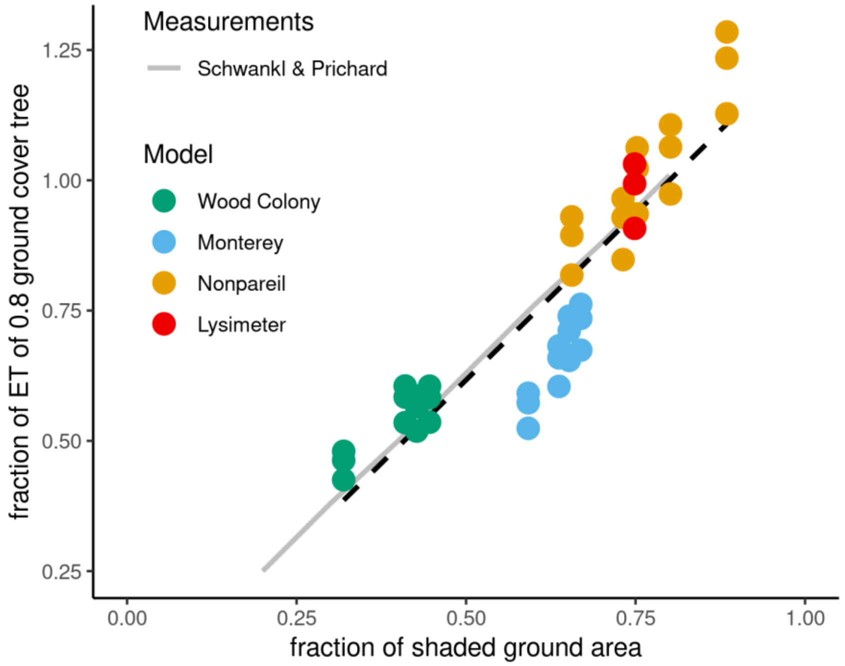
Variety-Specific Irrigation

Should we irrigate differently based on variety?



Variety-Specific Irrigation

Should we irrigate differently based on variety? How much?



For a configuration of 50% Nonpareil, 25% Monterey, and 25% Wood Colony, simulations suggested about 20% water could be saved relative to uniform irrigation based on Nonpareil

Thank you!

Contact:

- bnbailey@ucdavis.edu
- baileylab.ucdavis.edu

GitHub HELIOS

www.github.com/PlantSimulationLab/Helios

YouTube

@plantsimulationlab-ucdavis

Thanks to ABC for funding support of this work

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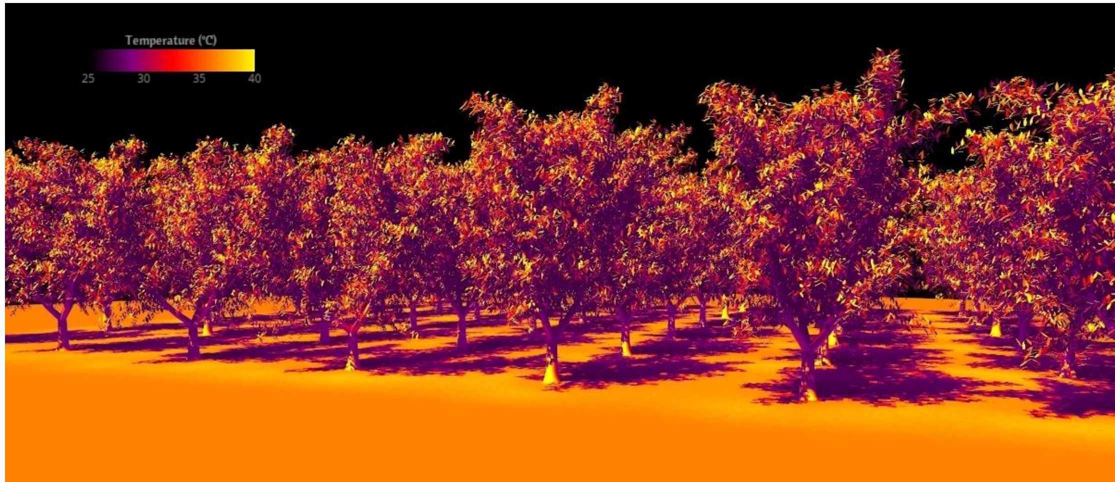

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Nickels Soil Lab Project

Outputs

Nickels Soil Lab Projects

ORCHARD SCALE PROJECTS

- Self-fertile vs Traditional Planting Performance
- Organic Demonstration
- Is there an optimum spacing down the row?
- Which pollinizer combos work best?
- Additional work?

Self-fertile vs Traditional Planting Performance

- Varieties: 100% Independence compared to 50% Nonpareil, 25% Aldrich, and 25% Sonora
- Rootstock: Viking
- Spacing: 15’ x 20’
- Irrigation: Double-lined drip
- Planted in January, 2013 (bareroot trees)

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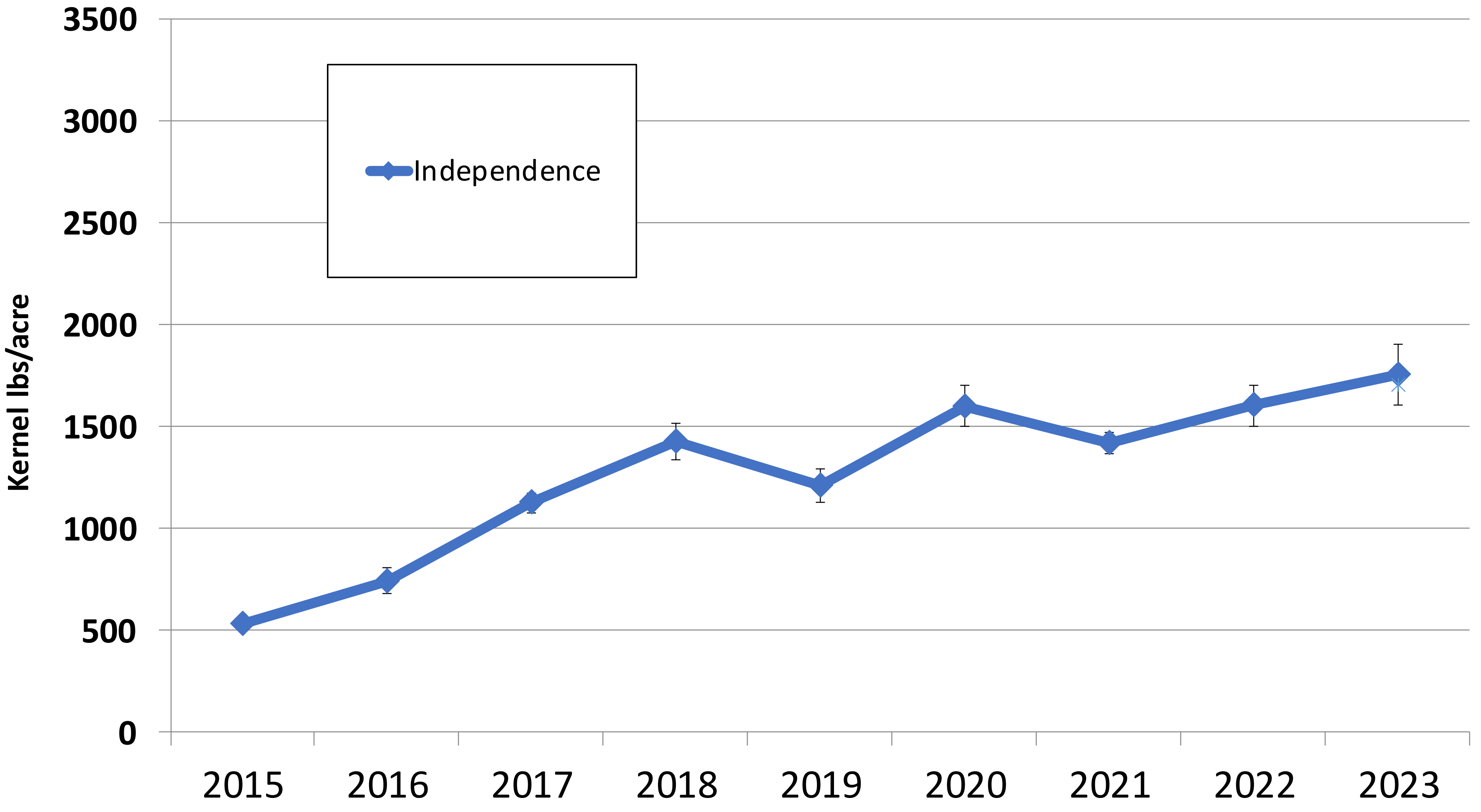
In general, Independence yield is relatively consistent compared to variable production from traditional varieties impacted by bloom/spring weather.



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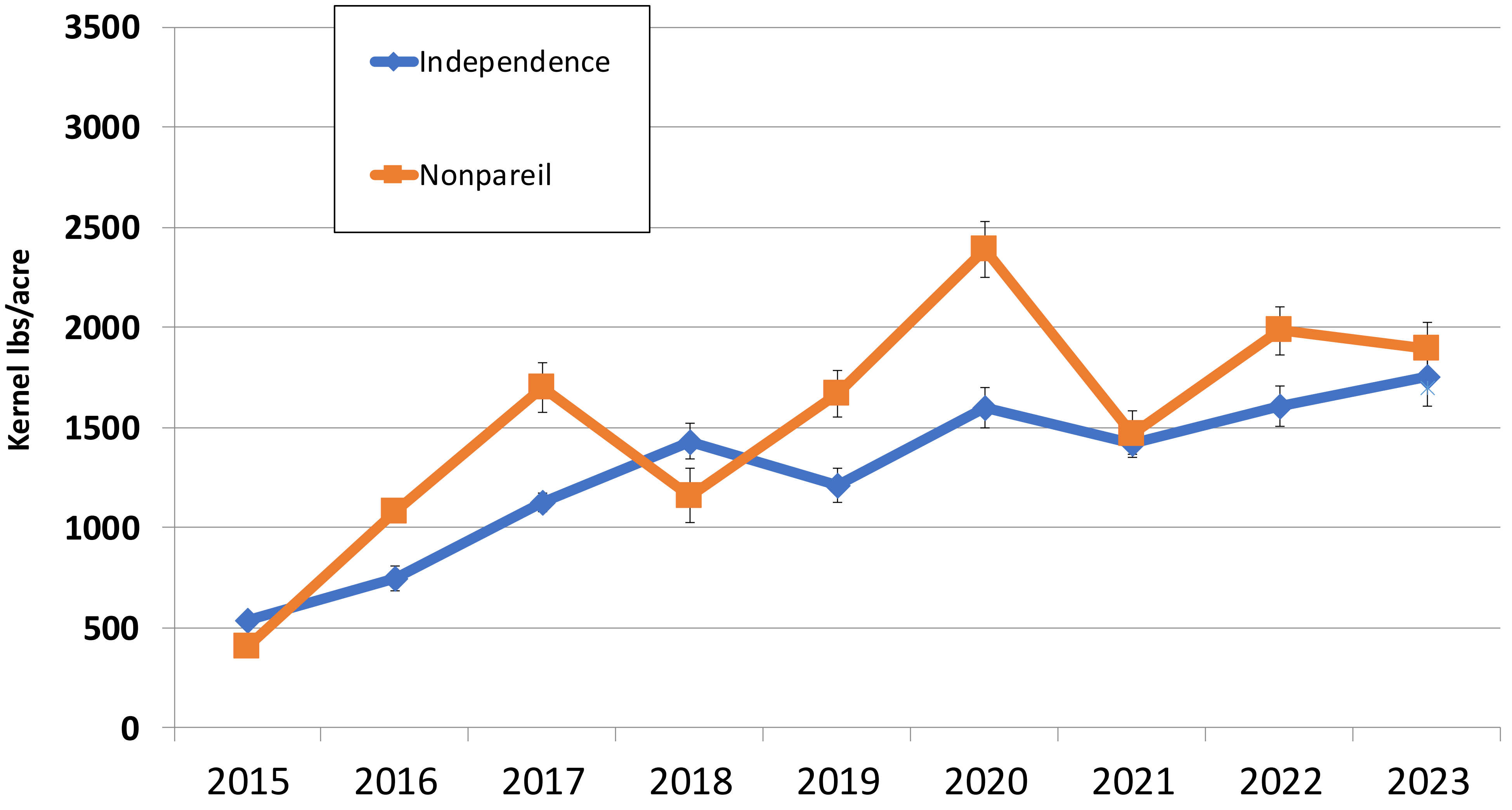

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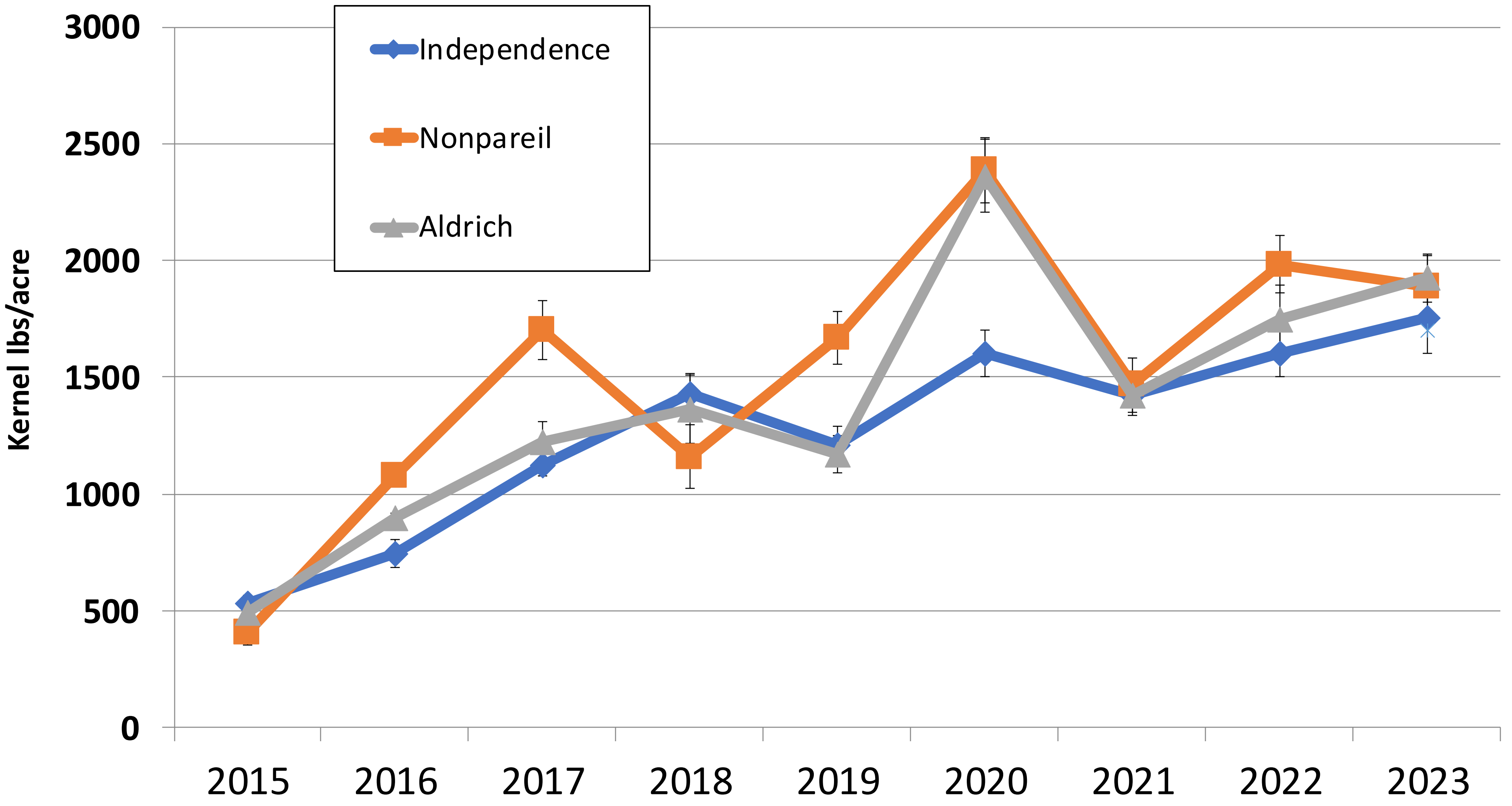

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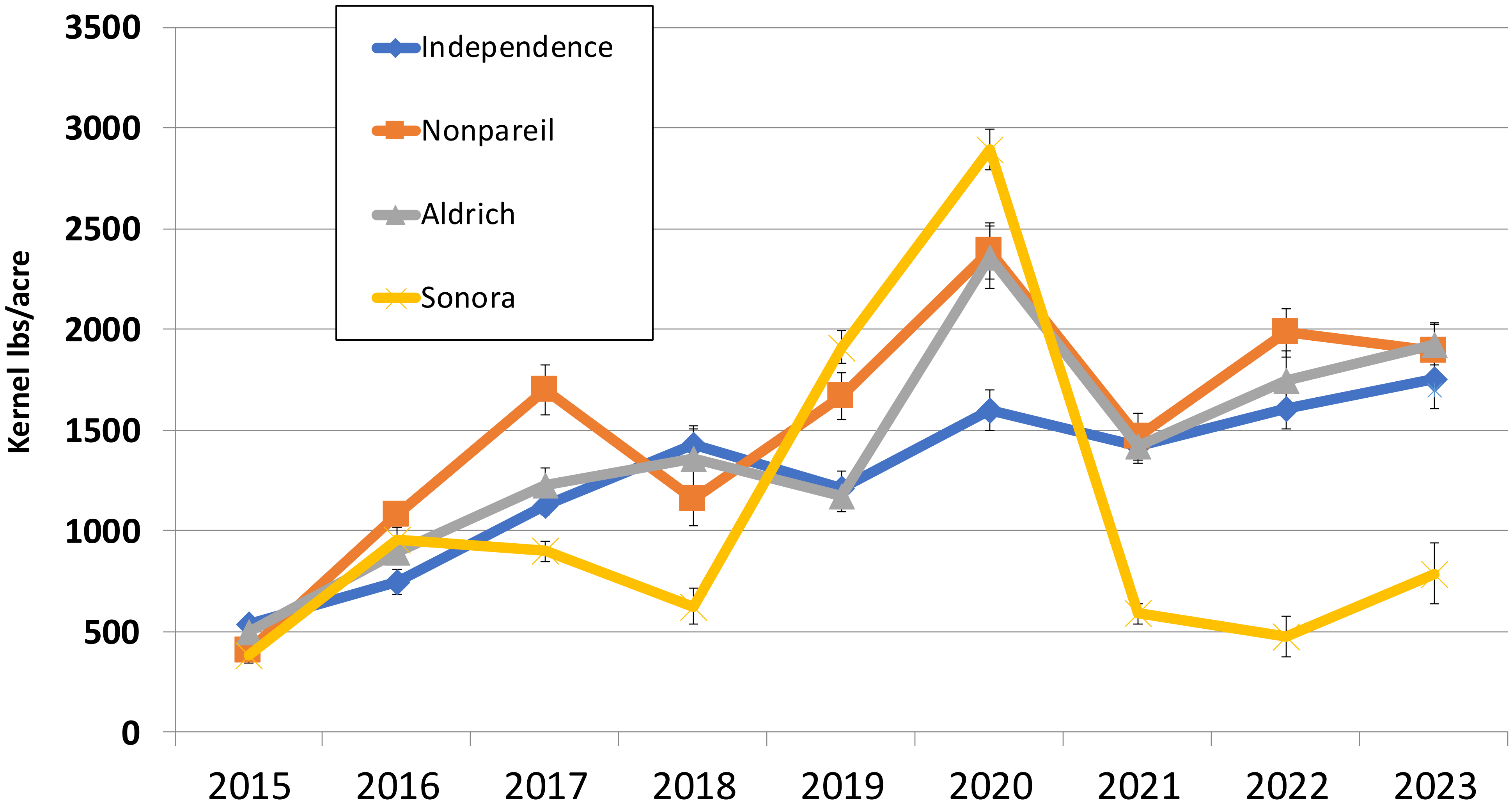
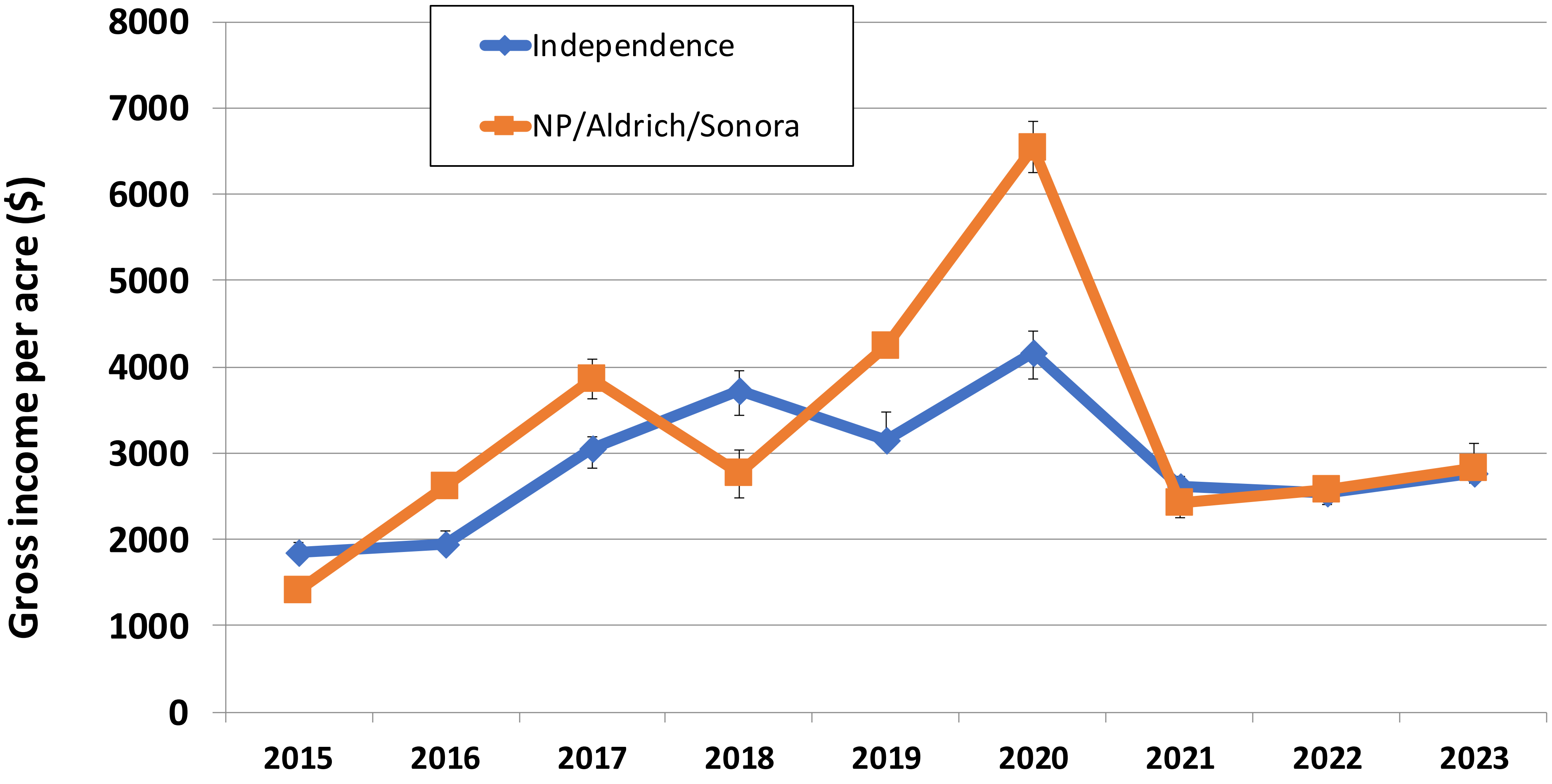
In general, Independence yield is relatively consistent compared to variable production from traditional varieties impacted by bloom/spring weather.



Gross income per acre changed from year with bloom weather and price.



How productive can organic almond orchards be in the Arbuckle District in SW Colusa County compared to conventional plantings?

The same plantings, managed with different tools.

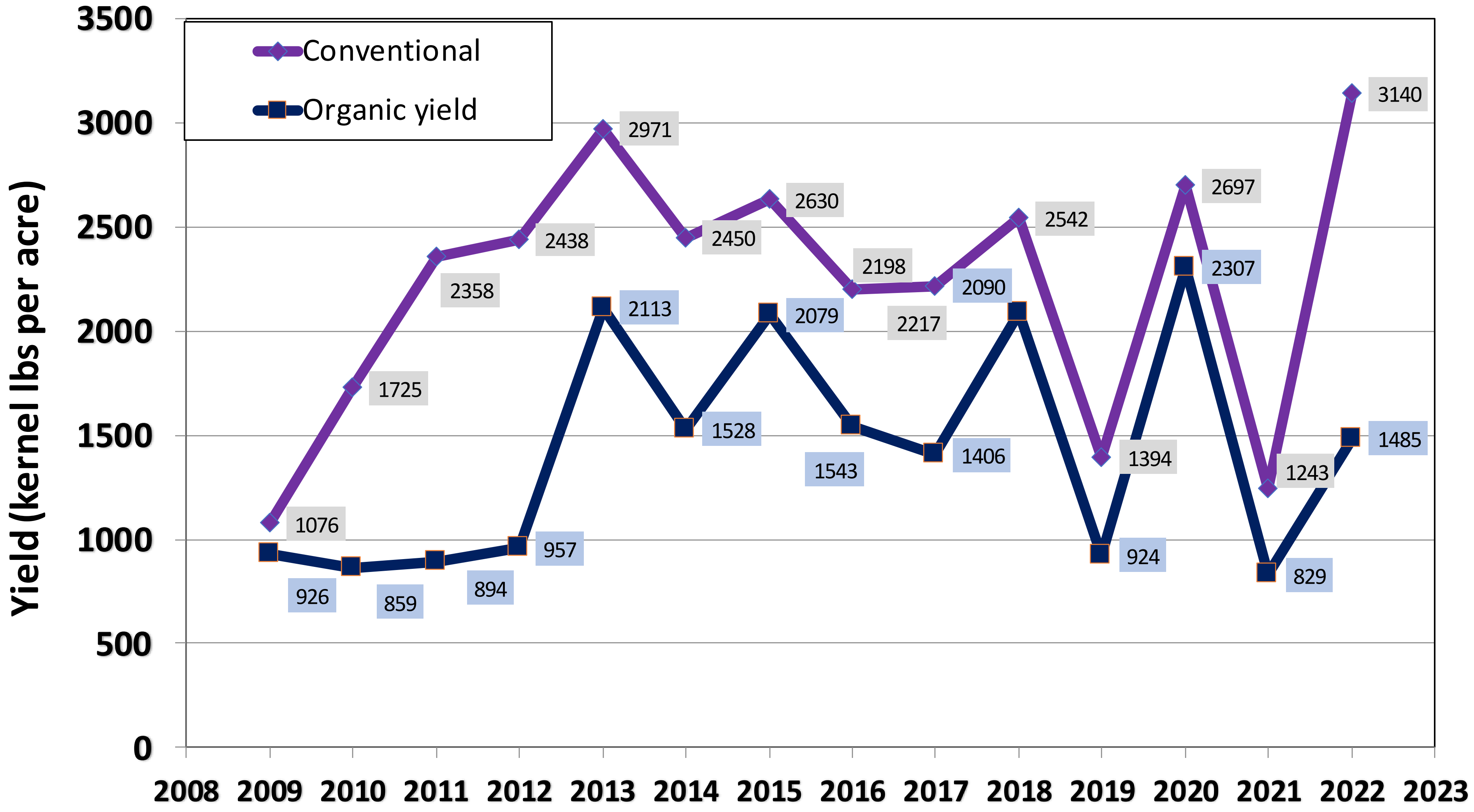
75% Nonpareil, 25 % Fritz

Double-line buried drip

16’ x 22’

Planted in spring, 2006

Organic yield has run 60-80% of conventional once leaf rust was controlled (2012). Low N nutrition hurt 2022 org yield.



Challenges and successes in organic production at Nickels Soil Lab (295' ASL).

Successes:

- Increased production once leaf rust controlled.
- Decent insect & mite control until 2023 (bad NOW)

Challenges:

- Cost effective nitrogen (N) nutrition
- Plugging in irrigation lines.
- Lovell rootstock health later in orchard life
- Covercrop establishment in drought year(s)

“Shanking” in dry organic fertilizer (True 12-0-0).

Catchframe harvesters may have a bigger role in harvesting organic almonds, allowing rougher orchard floor close to the trees without impacting harvest?

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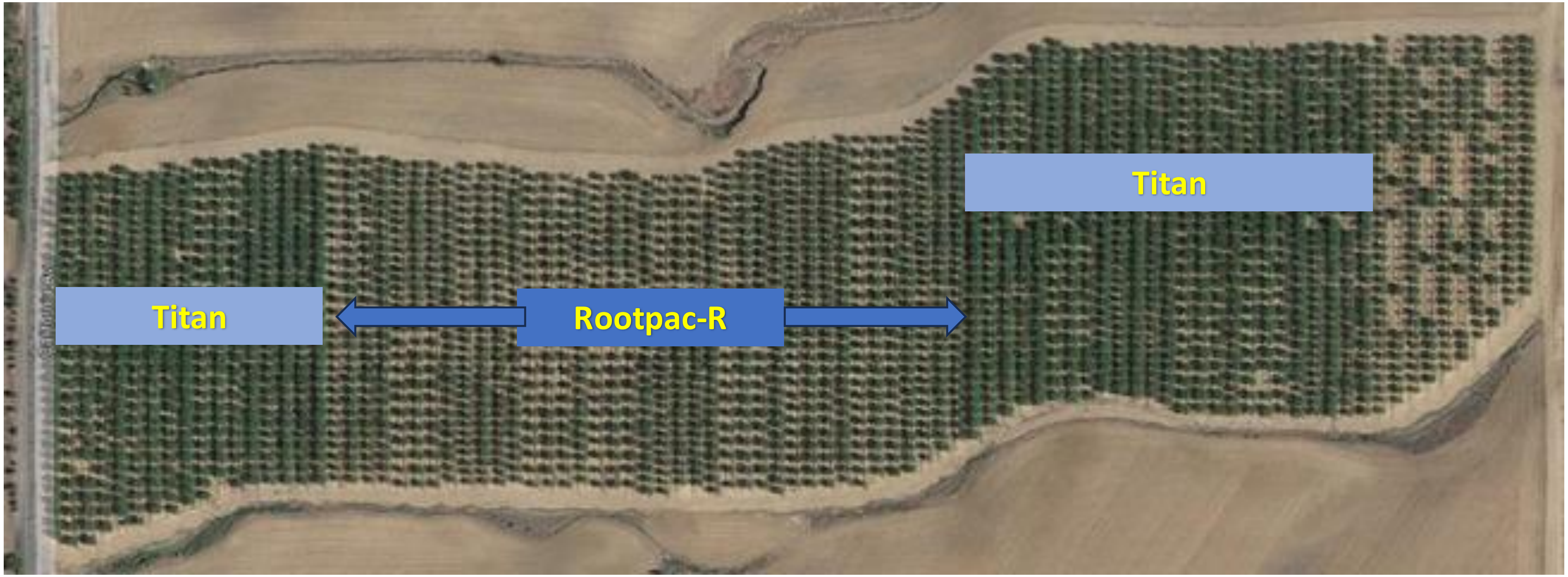
Can planting density down the row (12’, 14’, 16’, or 18’) influence yield with uniform (21’) row spacing?



The same plantings, managed with different tools.

50% Nonpareil, 25 % Aldrich, 25% Kester

Double-line drip (same irrigation on all spacings)

12’, 14’, 16’, or 18’ x 21’

Planted in 2017: Titan (spring), Rootpac-R (fall)

So far, no influence of tree spacing on almond yield.

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Thank you

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Patrick H Brown

Department of Plant Sciences

University of California - Davis

The benefits of continuous versus episodic fertigation

Optimizing Nutrient Use in Almond and Preventing Losses.

Supply (Rate) = Demand (Amount and Timing)

How much is needed?

- Rate

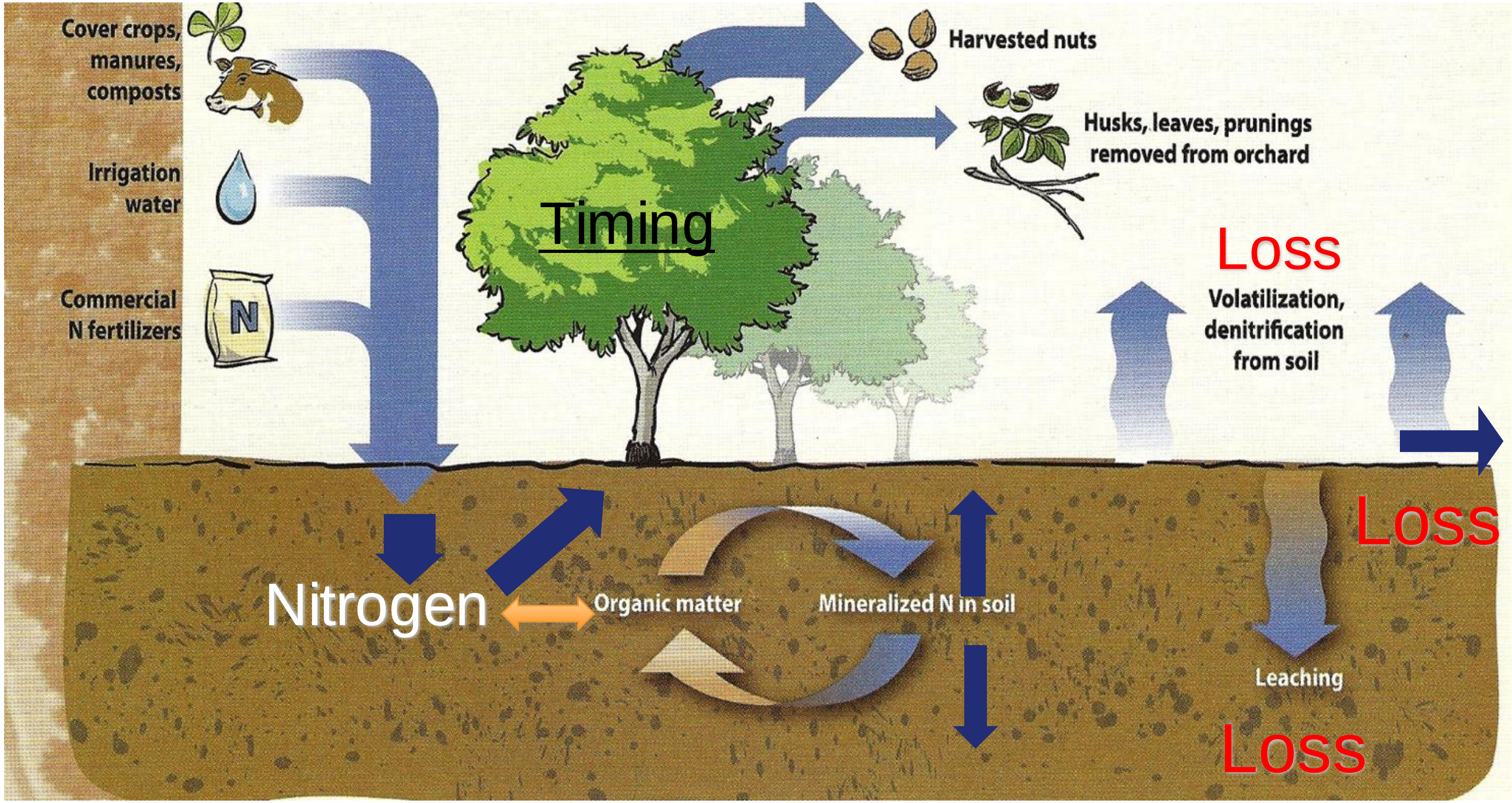
When is it needed?

- Timing

How should it be applied?

- Placement, source, method

How do we prevent losses?



Kathy Kelley-Anderson et al: ANR Pub # 21623

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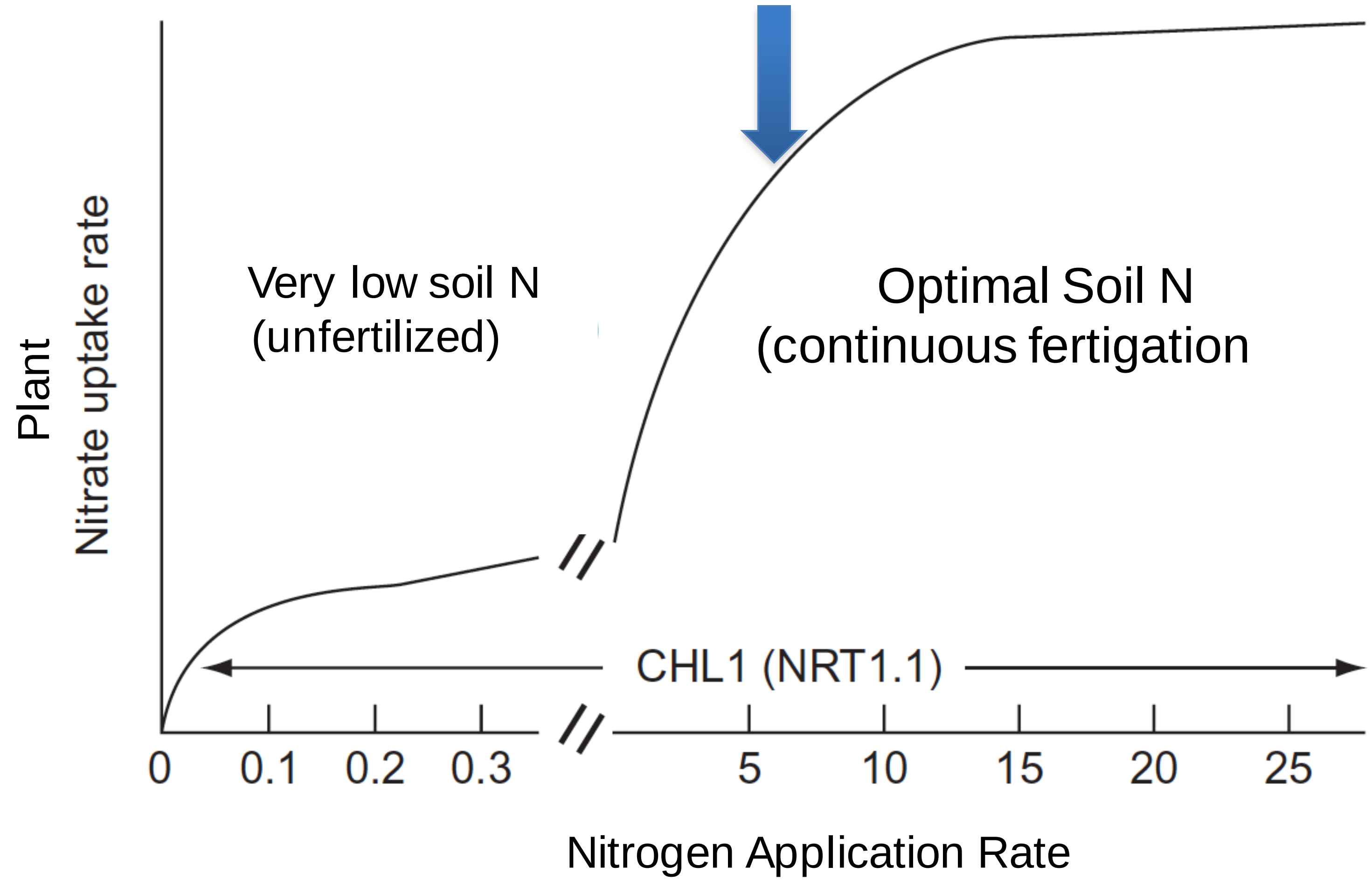
Nitrogen Uptake Rate is Saturated if Fertigation is Infrequent.



Excess Soil N
(Episodic fertigation)

Nitrate leaching
and Greenhouse
Gas Release

Marschner, P. (2012). Mineral Nutrition of Higher Plants. Academic Press. Waltham, MA, USA.

Irrigation Rapidly Moves N into Soil
(Surface applied N Followed by Irrigation (90 mins))

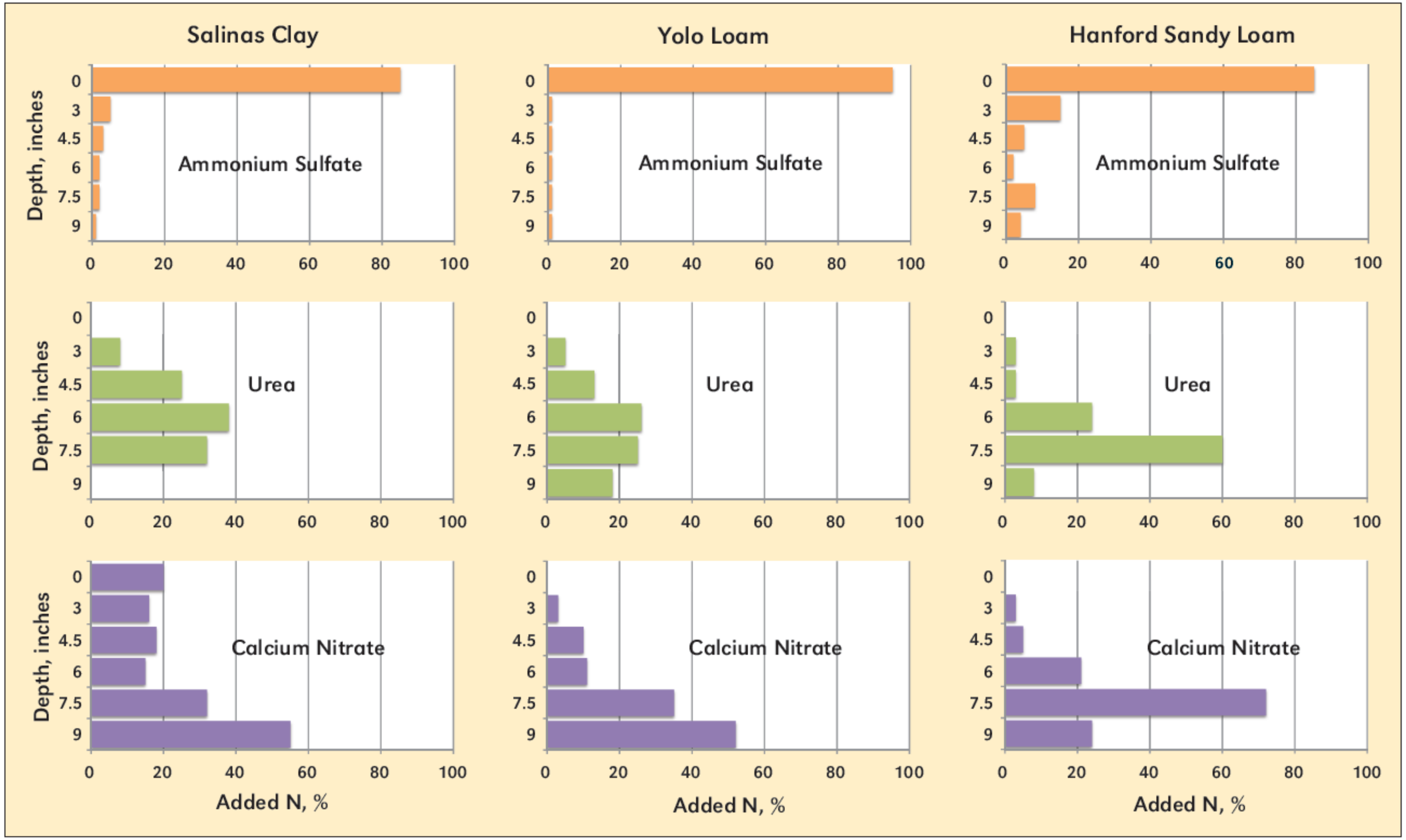


Figure 2. The movement of ammonium, urea, or nitrate in the surface 9 in. of three soils. The urea and calcium nitrate were applied to the soil surface and irrigated with a uniform amount of water. The ammonium sulfate was added as a solution. The soils were sampled 90 minutes after fertilizer and water application. (Broadbent et al., 1958).

Courtesy www.IPNI.org

Optimizing Nutrient Use in Almond and Preventing Losses.

Supply (Rate) = Demand (Amount and Timing)

How much is needed?

- Rate

When is it needed?

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How should it be applied?

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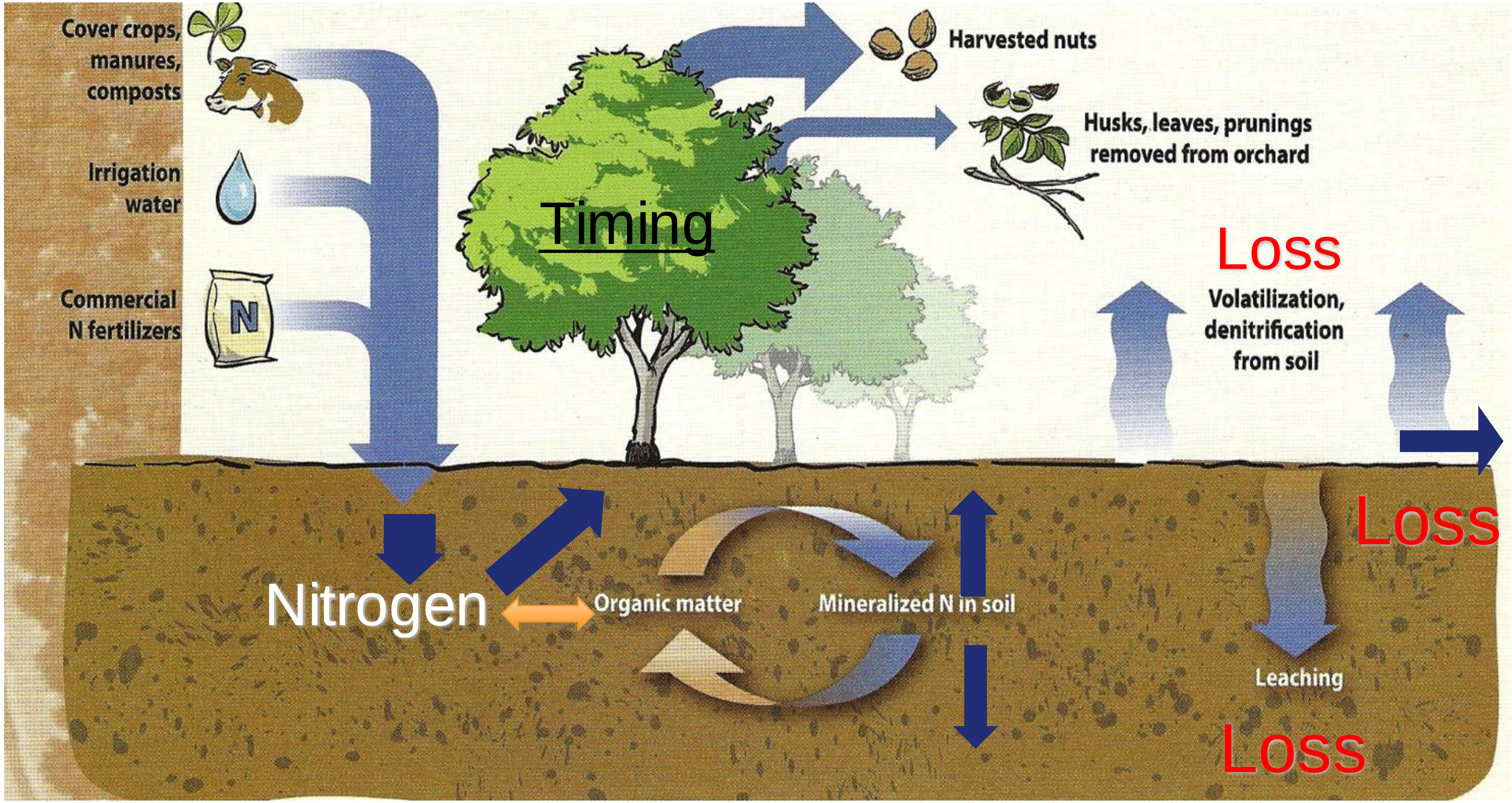

Kathy Kelley-Anderson et al: ANR Pub # 21623

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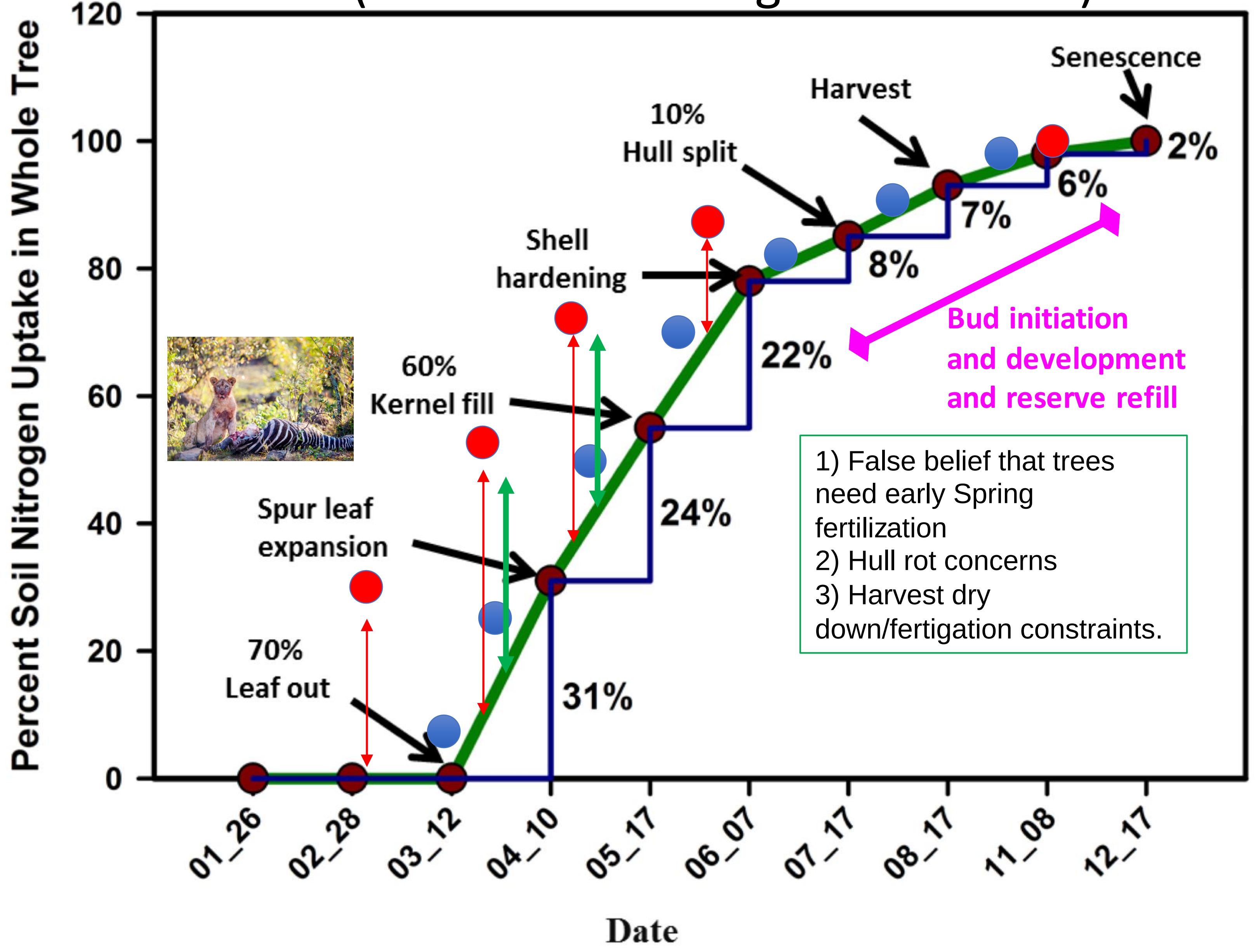
Seasonal Almond Nitrogen Uptake

(2008-2012 Belridge Excavations)



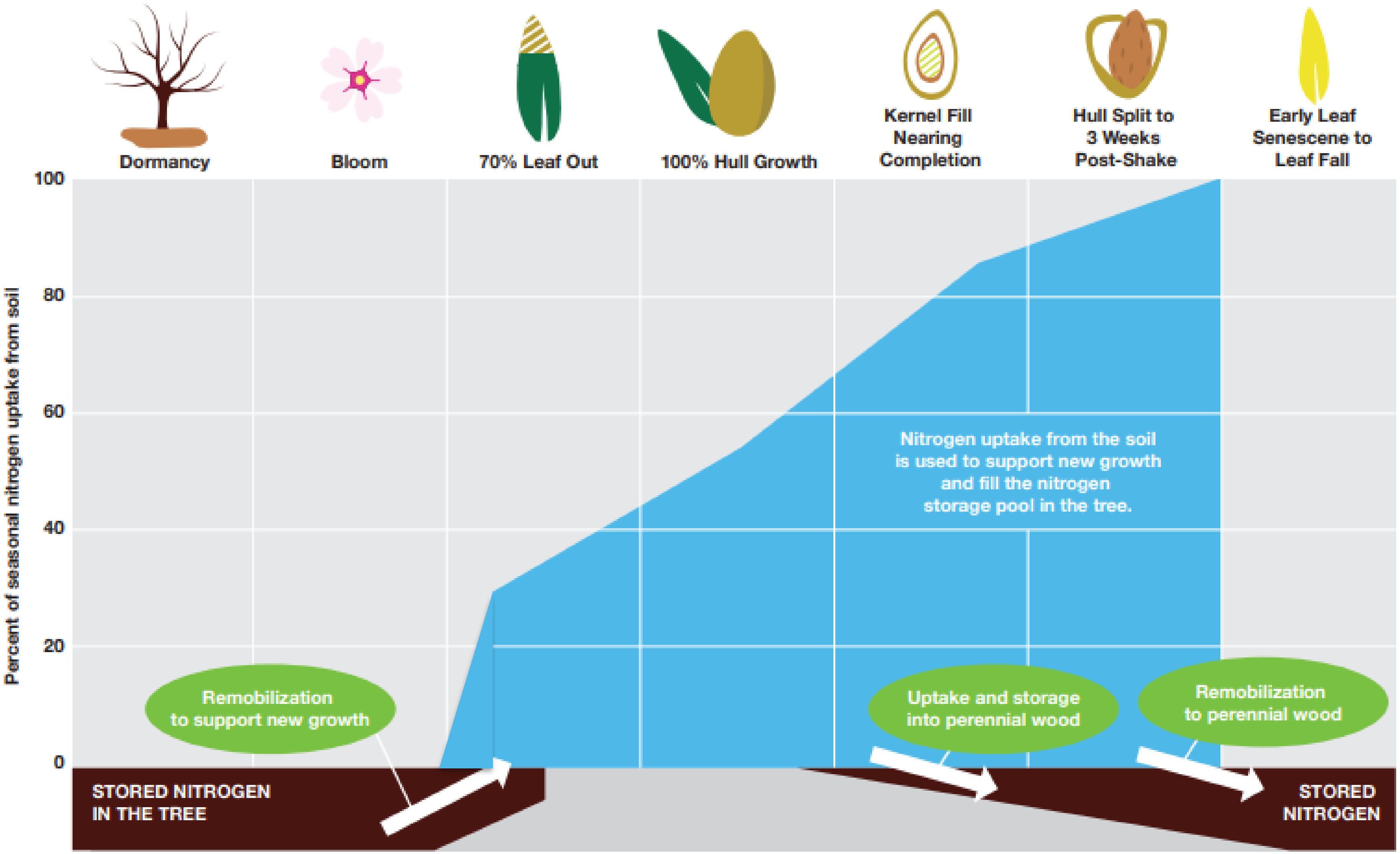
Ideal Fertilization: Multiple Applications in season timed with demand

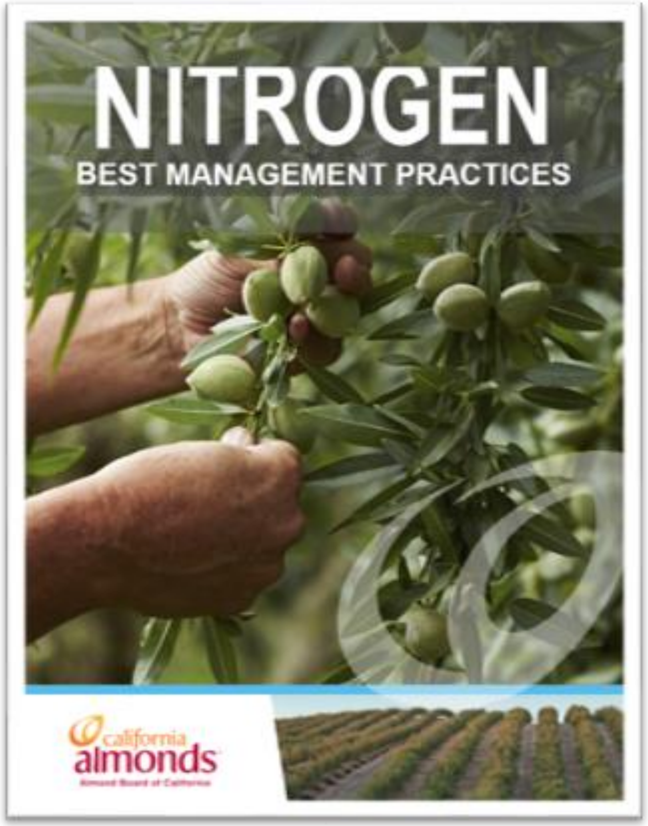
Common Fertilization: 3-4 applications 80-90% complete by June 1 (added complexity in wet years)

Potential for loss of N
-Nitrate in soil/irrigation

Potential for excess canopy vigor
-N uptake in excess of fruit demand

Principles of Sound Fertilization: Right Timing





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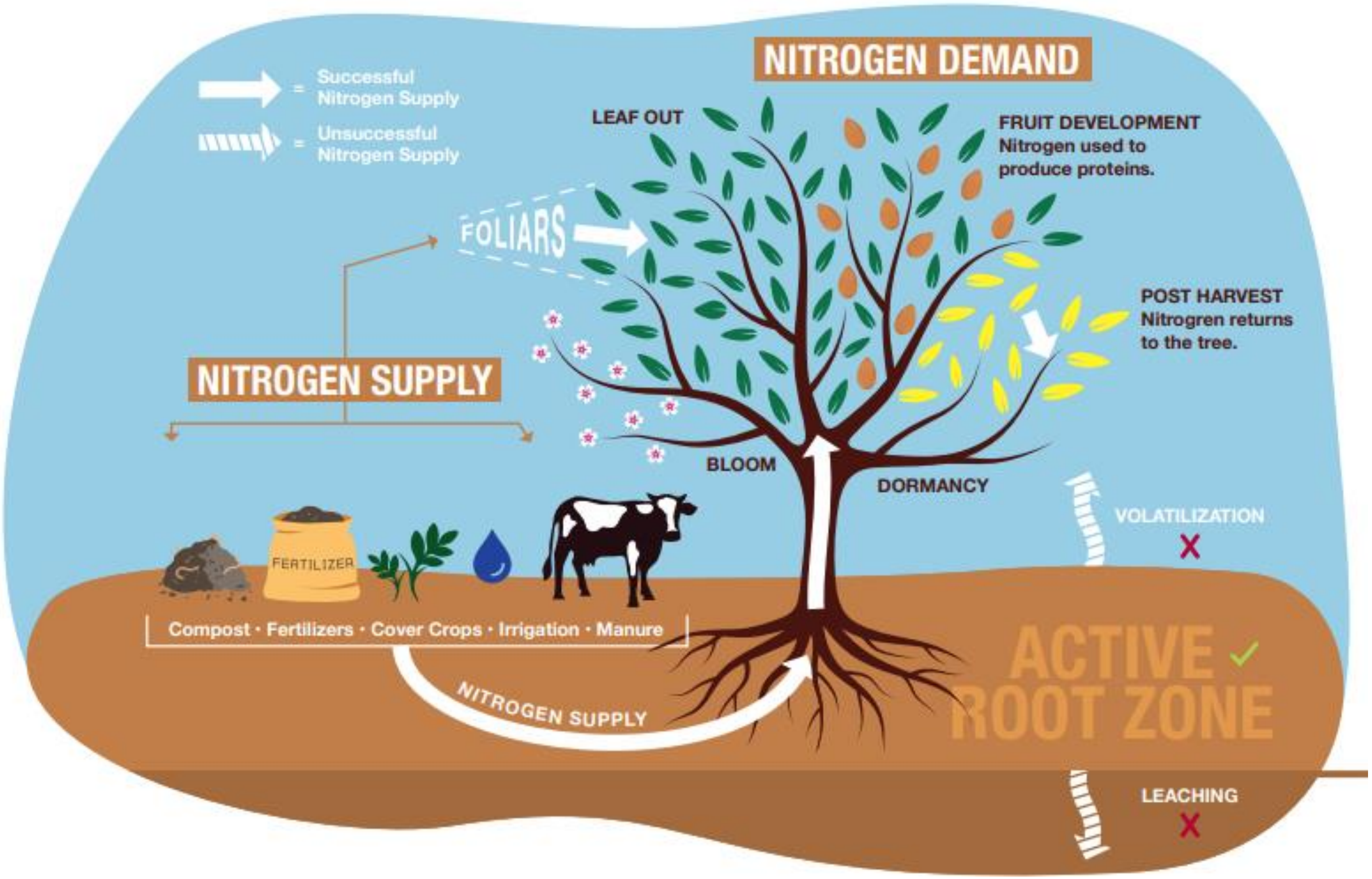
The Basics of Nitrogen in Orchards



Right Place

Nitrogen should be kept within the Active Root Zone

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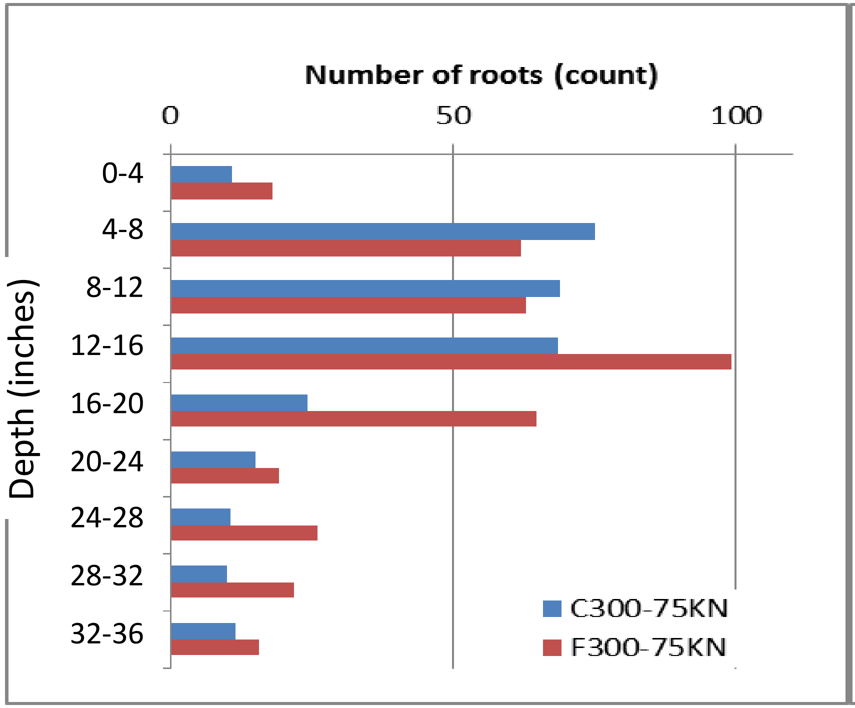
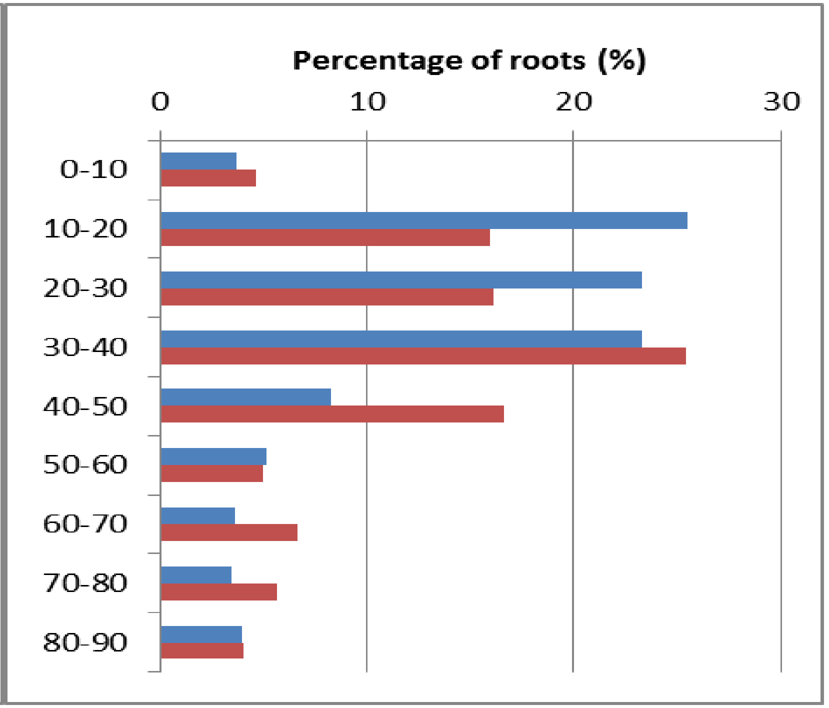
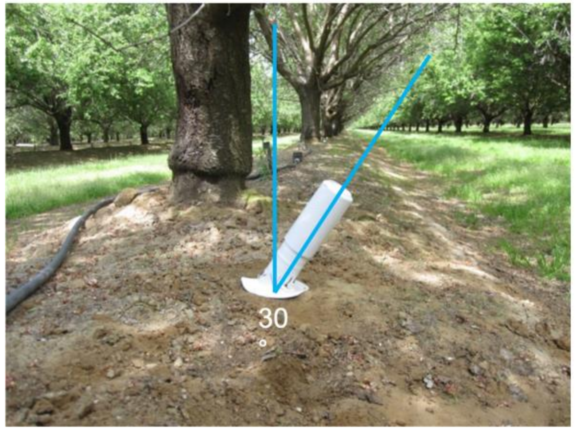
Right Place: Where does N uptake occur?



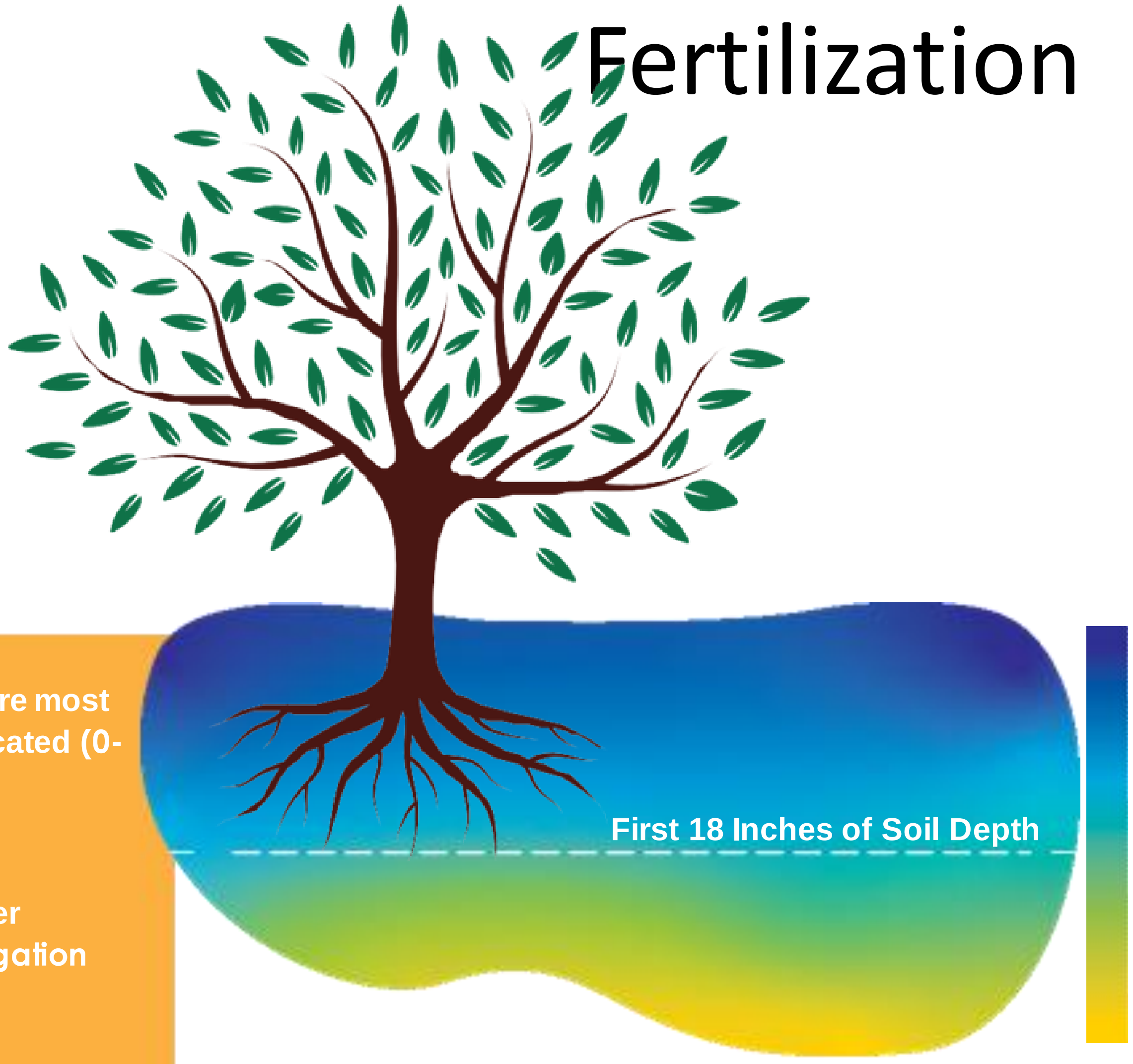




➔In Almonds, the majority of the roots are in the first 18 inches of soil.

Olivos, Unpublished

Efficient Irrigation is Essential for Efficient Fertilization



Goal: Keep nitrogen where most of the active roots are located (0-18 inches).

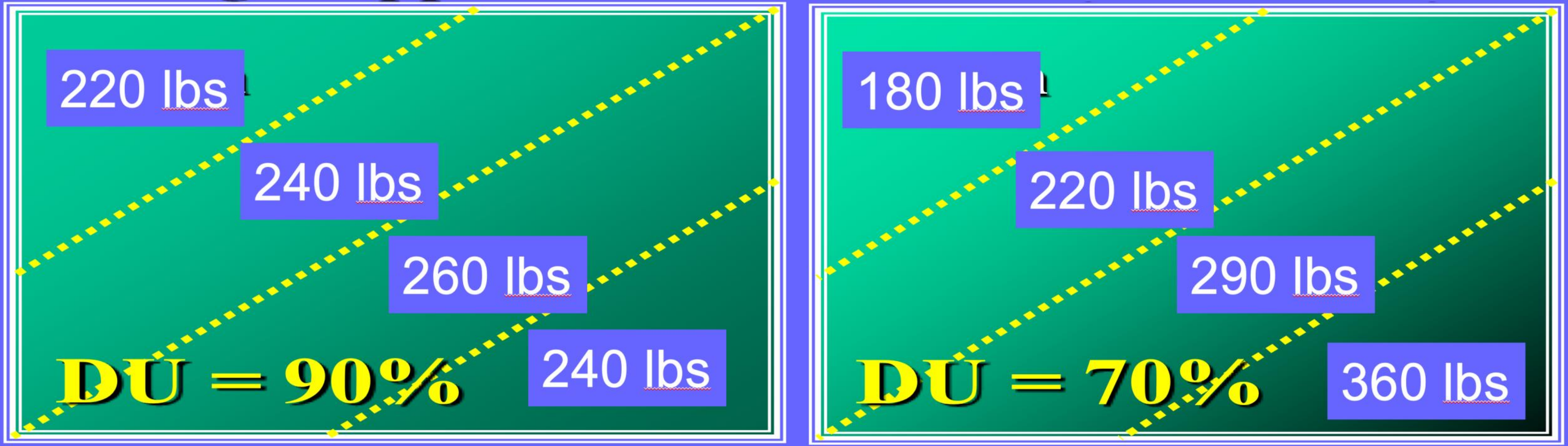
This can be achieved by injecting nitrogen fertilizer toward the end of the irrigation cycle.

Impact of Fertigation Timing on Nitrate Uptake by the Tree

- Nitrogen in the soil moves easily with irrigation water
- Application of nitrogen in a large single dose exposes that nitrogen to loss.
- Smaller applications applied frequently and timed with periods of plant demand limit the potential for nitrogen loss.

Irrigation DU also Determines Nitrogen DU

Target Application = 250 lbs N through Fertigation



Nitrogen Efficiency New ABC BMP

Factors that affect nitrogen use efficiency and the approaches that can be adopted to minimize this risk include:

Application of the Right Rate of nitrogen to meet tree demand

- Accurately calculate tree demand.
- Independently estimate tree demand for each cultivar and manage fertilization.
- Frequently monitor soil, plant and irrigation water nitrogen.

Application at the Right Time

- Apply nitrogen according to tree uptake patterns shown in Fig. 4 on page 12 commencing at 70% leaf out and completing at or soon after tree shaking.

Application in the Right Place

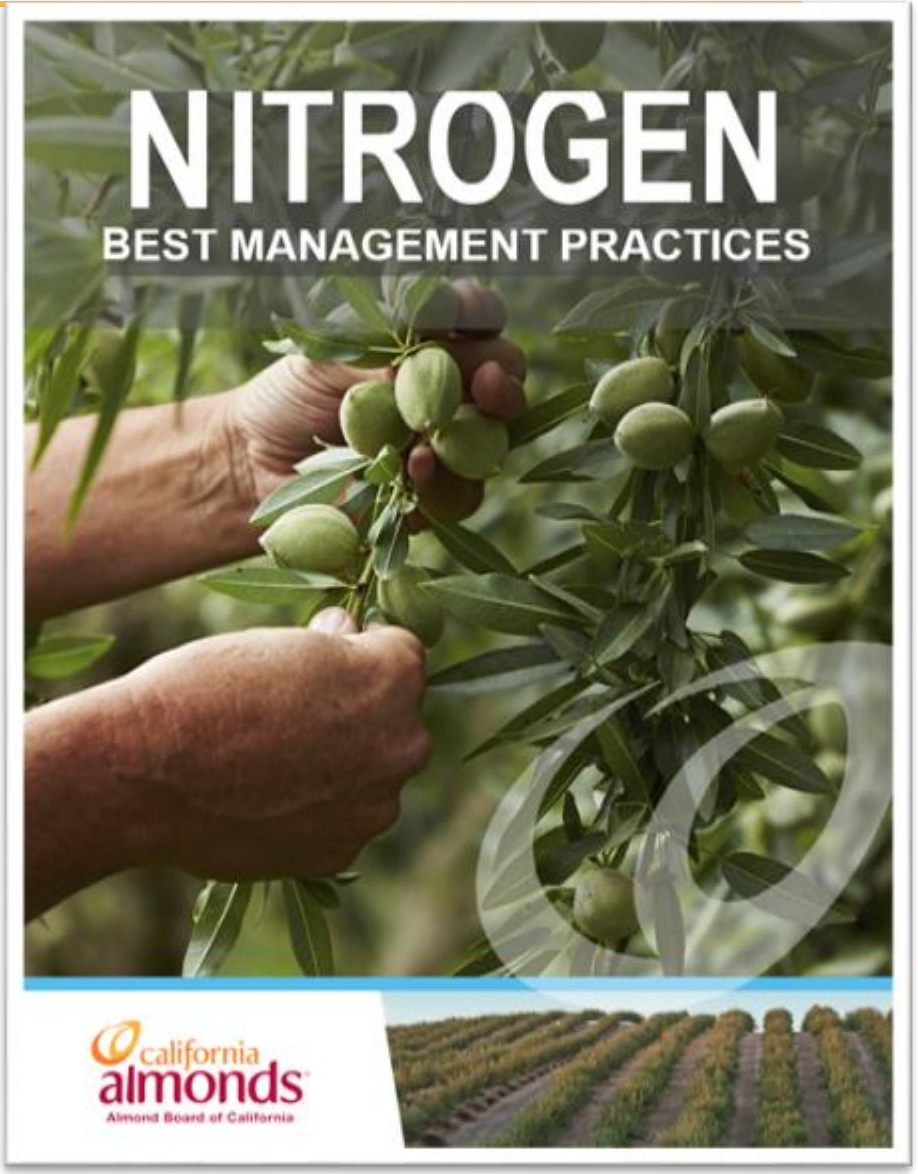
- Time nitrogen application towards the end of an irrigation to ensure nitrogen remains in the active root zone.
- Do not apply nitrogen outside of the active root zone (especially important for young trees).
- Maintain the irrigation system to ensure uniformity of distribution and accuracy of nitrogen and water application rate.

Application of the Right Source

- The C:N ratio of organic nitrogen sources influences nitrogen availability with limited availability from 17 to 25, immobilization at greater than 30 and only in-season availability at a C:N ratio equal to or less than 13.
- Compost best practices include application as a surface mulch on the tree berm, and spreading post-harvest, before the first rainfall, to maximize breakdown prior to the subsequent harvest.
- Cover crops planted in the orchard may include a combination of legumes and grasses, and provide benefits such as improved water infiltration, soil microbial diversity and habitat for pollinators and other beneficial insects.

- Field variability in soil type and tree productivity.
  - Yield varies across all fields as a consequence of differences in soils, environment and irrigation uniformity, among others. The selection of a single uniform nitrogen rate to satisfy the average yield of the entire orchard will result in the under fertilization of many trees and overfertilization of the remainder.
    - Consider managing trees in zones of relative productivity by designing irrigation systems to provide cultivar and site (soil)-specific fertigation control and fertilizing at a rate to provide sufficient nitrogen for the majority of trees. Then supplement the highest performing trees with foliar or local surface applications.
- Deficiencies of other tree nutrients, areas of saline or sodic soils, soils with poor penetration of drainage or other local factors can reduce tree production and compromise nitrogen uptake. Optimizing management of all variables will increase the efficiency of nitrogen use.
- Avoid applications of nitrogen preceding a period of potential rain.

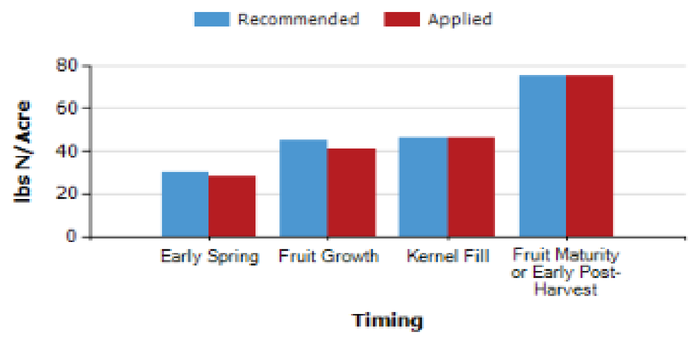
*These guidelines are based on extensive research conducted in four high-yielding orchards across California from 2008-2013, and as such are considered to be representative of good growing practices. The applicability under all growing circumstances, however, cannot be predicted with certainty — **grower judgment remains critical.***

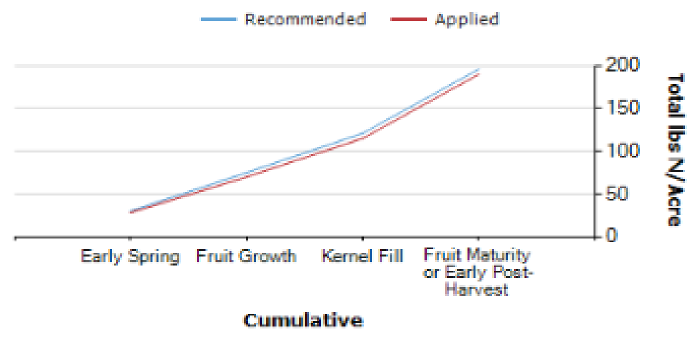


Nitrogen Management Tool

SustainableAlmondGrowing.org

Crop Year: 2018 | Orchard: Gratton Ranch | Organization: AA | ABC Orchards | Business: ABC Orchards





KERNEL YIELD | IRRIGATION N-CREDIT | MANURE N-CREDIT | COMPOST N-CREDIT | COVER CROP N-CREDIT | OTHER N-CREDITS | FERTILIZER APPLICATION | LEAF FACTOR | WATER COALITION INFORMATION

Previous Tab | Save Budget | Close Budget | Delete Budget | Next Tab

FERTILIZER APPLICATION ?

Add | Delete | Clone

	Edit	Timing	Date	Product Name	Prod. App Rate	N	P_2O_5	K_2O	App Method
		Early Spring		UAN 32 32-0-0	8 gal	28	0	0	
		Fruit Growth	5/25/2020	CAN-17 17-0-0 +8.8Ca	20 gal	41	0	0	Fertigation - Micro Sprinkler
		Kernel Fill		CAN-17 17-0-0 +8.8Ca	22 gal	46	0	0	Fertigation - Micro Sprinkler
		Fruit Maturity or Early Post-Harvest		CAN-17 17-0-0 +8.8Ca	36 gal	75	0	0	Foliar Spray

REPORTS

Show PDF Summary

Download CSV File

Show Nitrogen Management Plan Report

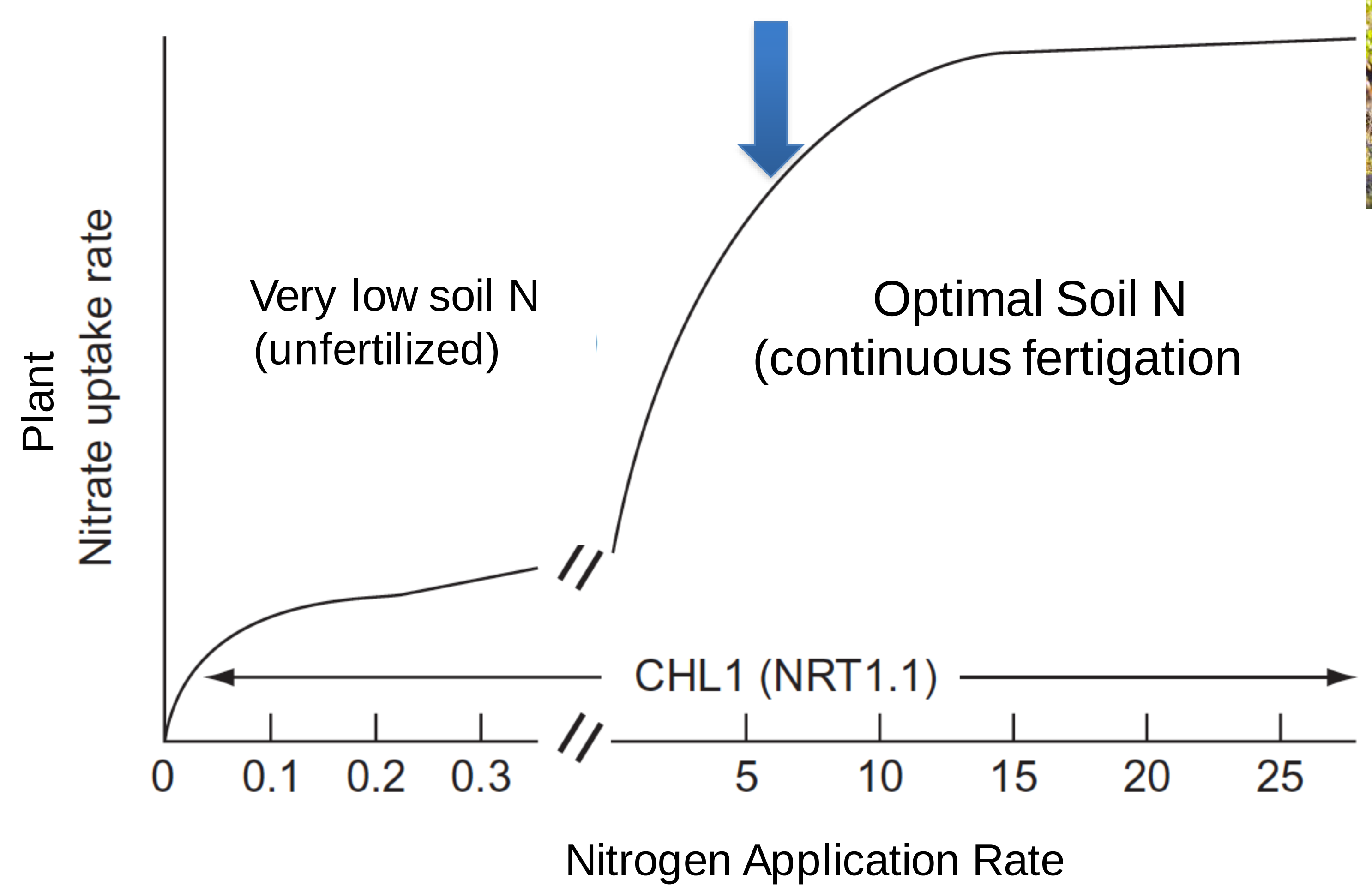
CALCULATIONS

Refresh Calculations

Kernel Yield

Pre-Application Predicted	2733 lbs/Acre
Pre-Harvest Estimated	lbs/Acre
Post-Harvest Actual	3400 lbs/Acre

Nitrogen Uptake Rate is Saturated if Fertigation is Infrequent.



Excess Soil N
(Episodic fertigation)

Nitrate leaching
and Greenhouse
Gas Release

Marschner, P. (2012). Mineral Nutrition of Higher Plants. Academic Press. Waltham, MA, USA.

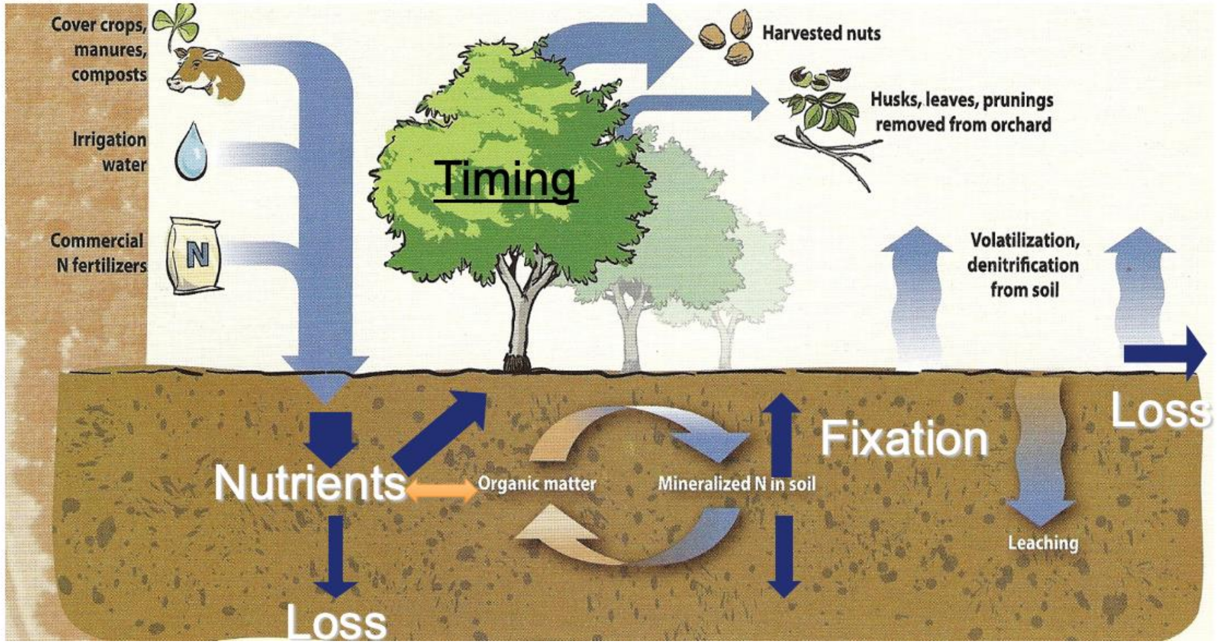
Contrasting the Greenhouse Production Potential of Episodic Fertigation (5 fertigation events) with Continuous Fertigation (Fertigation in every irrigation)

Year	Treatment	Cummulative N_2O (g ha^{1-})
2015	Episodic	1000.4
2015	Continuous	474.6
2016	Episodic	445.2
2016	Continuous	95.9

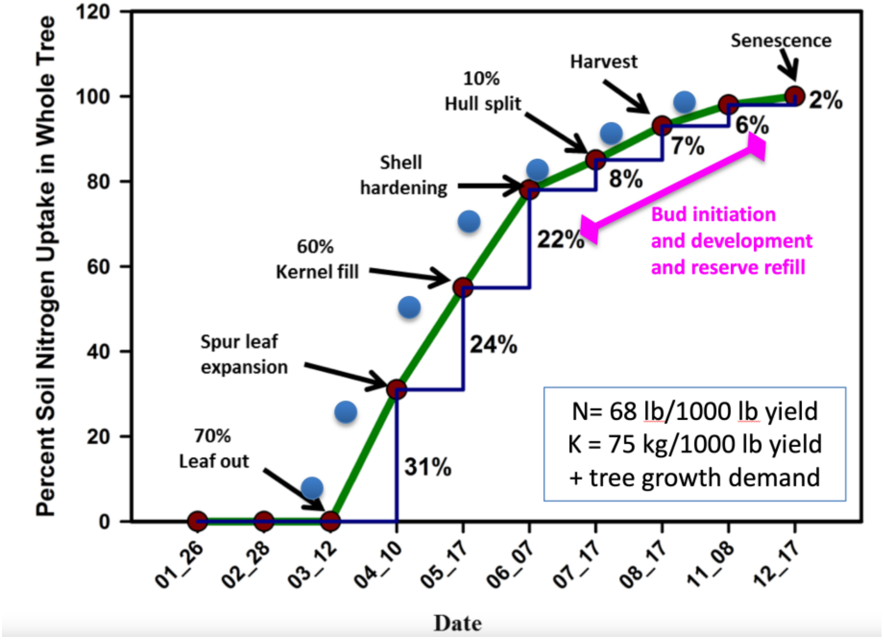
Patrick Nichols, in Press

Summary Tree Crop 4 R's

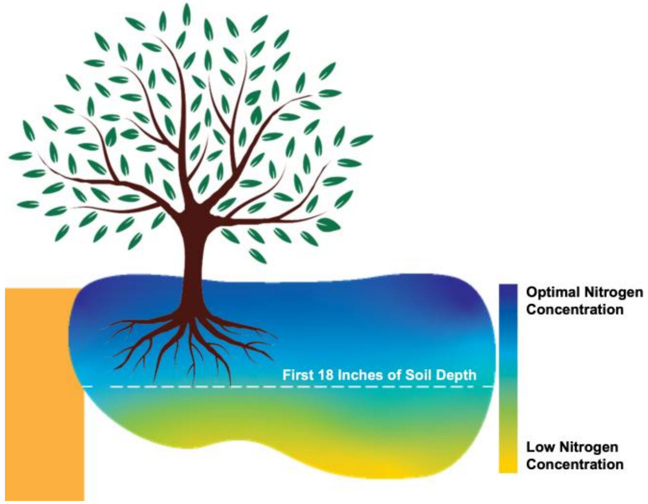
Supply (Rate) = Demand (Amount and Timing)



Right Rate Right Time



Right Place



Minimize Losses

Contrasting the Greenhouse Production Potential of Episodic Fertigation (5 fertigation events) with Continuous Fertigation (Fertigation in every irrigation)

Year	Treatment	Cummulative N_2O (g ha^{1-})
2015	Episodic	1000.4
2015	Continuous	474.6
2016	Episodic	445.2
2016	Continuous	95.9


california almonds
Almond Board of California
Thank you

2023

THE ALMOND CONFERENCE

Connecting the Dots

GROWERS // HANDLERS // CUSTOMERS // CONSUMERS

Continuous Fertigation and Recharge Promise Improved Groundwater Quality

2023

THE ALMOND CONFERENCE

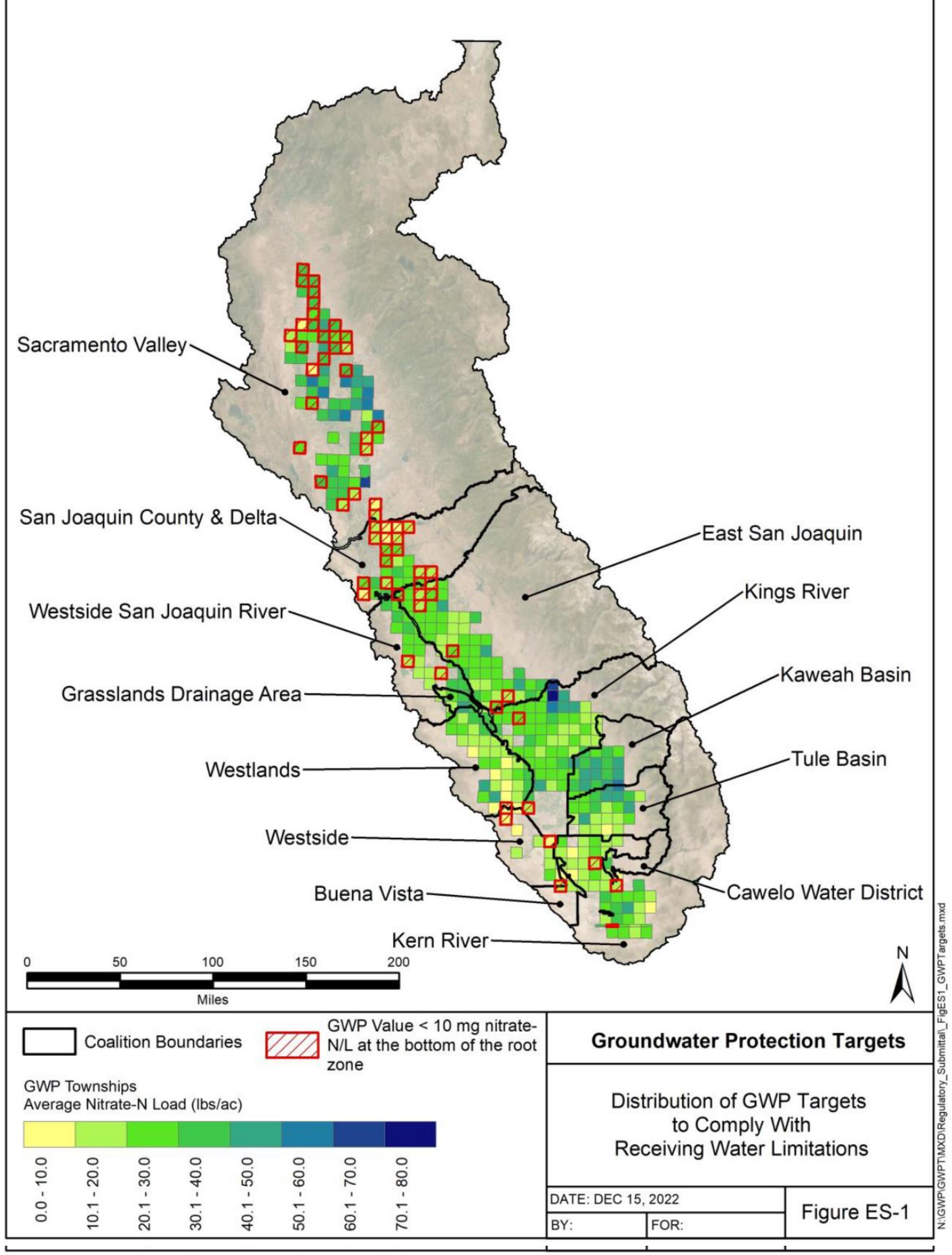
Connecting the Dots

GROWERS // HANDLERS //
CUSTOMERS // CONSUMERS

Spencer Jordan, Will Lennon, Teena Stockert, Thomas Harter / UC DAVIS

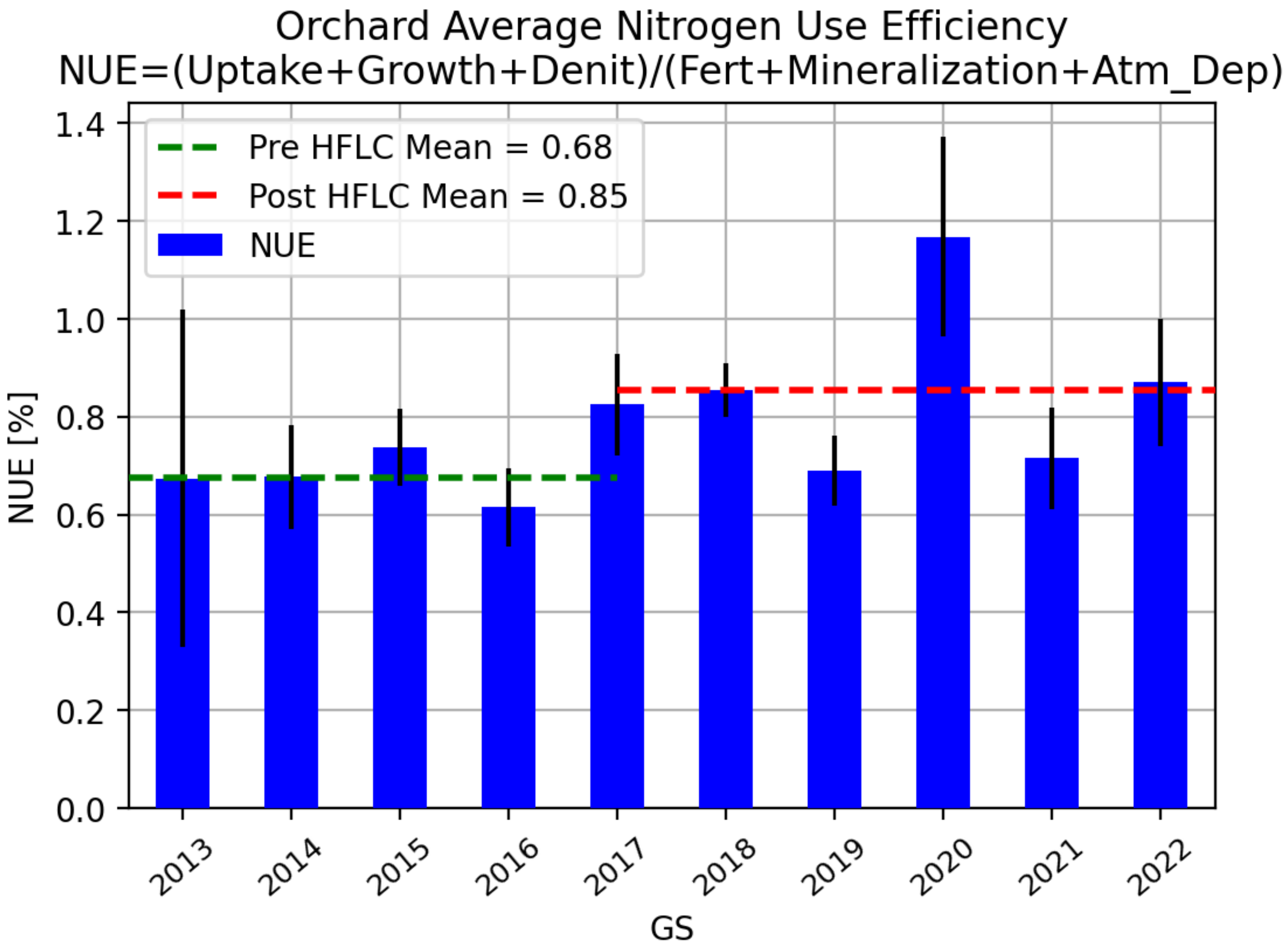
Targets for N Losses

Developed by Ag Water Quality Coalitions to comply with Irrigated Lands Regulatory Program (ILRP)

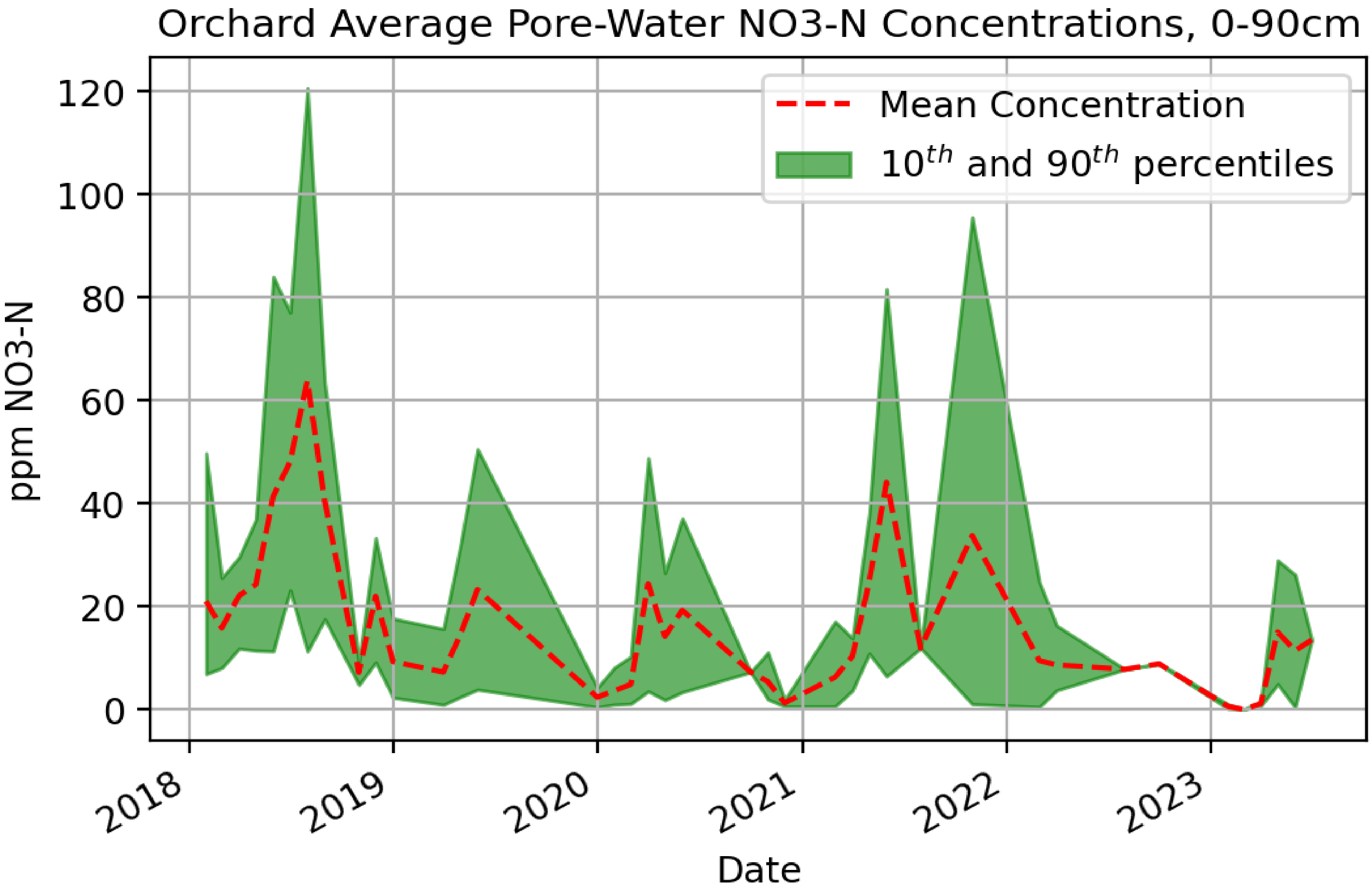


Field Monitoring Site: 140 Acres

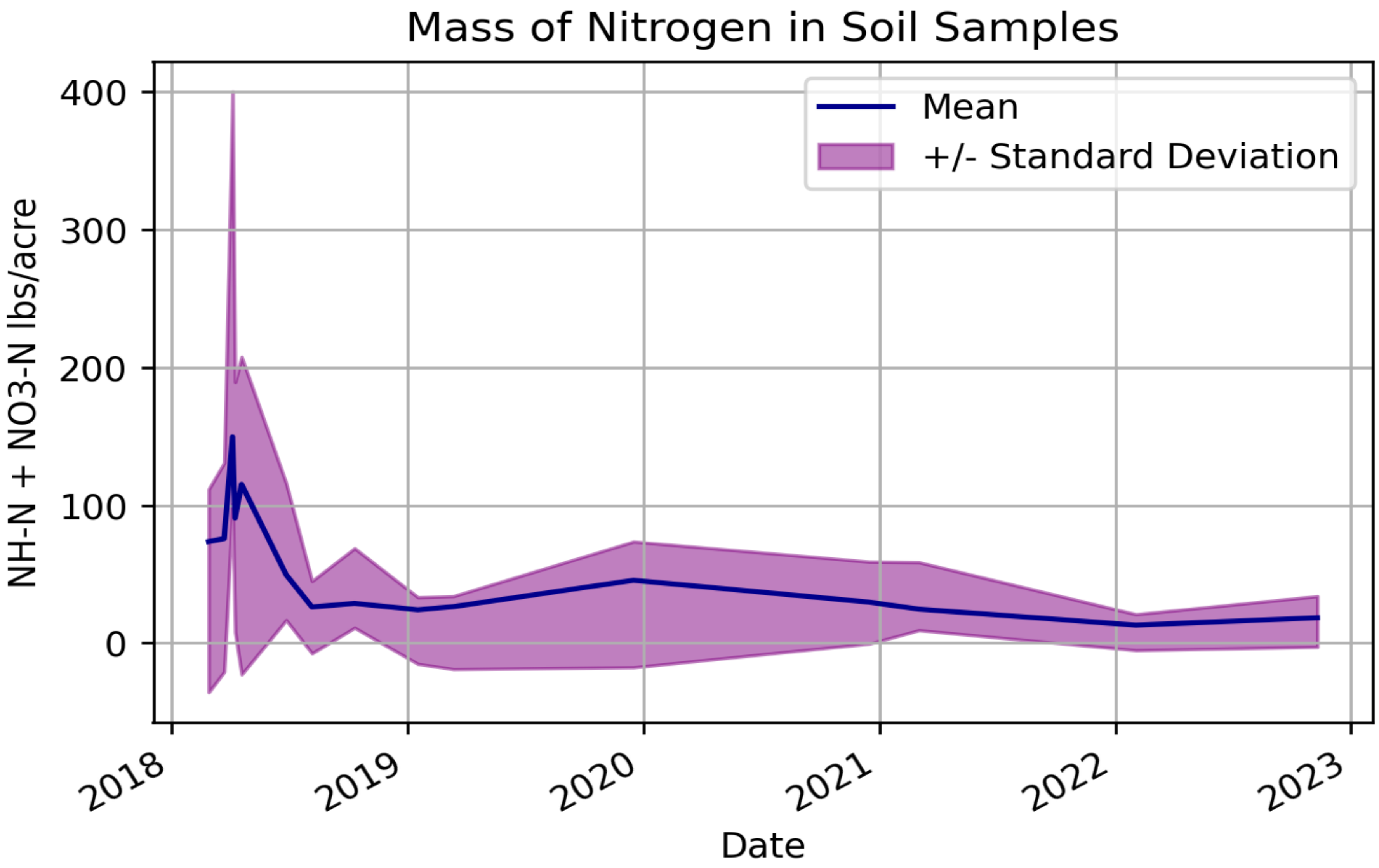
HFLC Increases Nitrogen Use Efficiency



HFLC Reduces End-of-Season Soil N Concentration

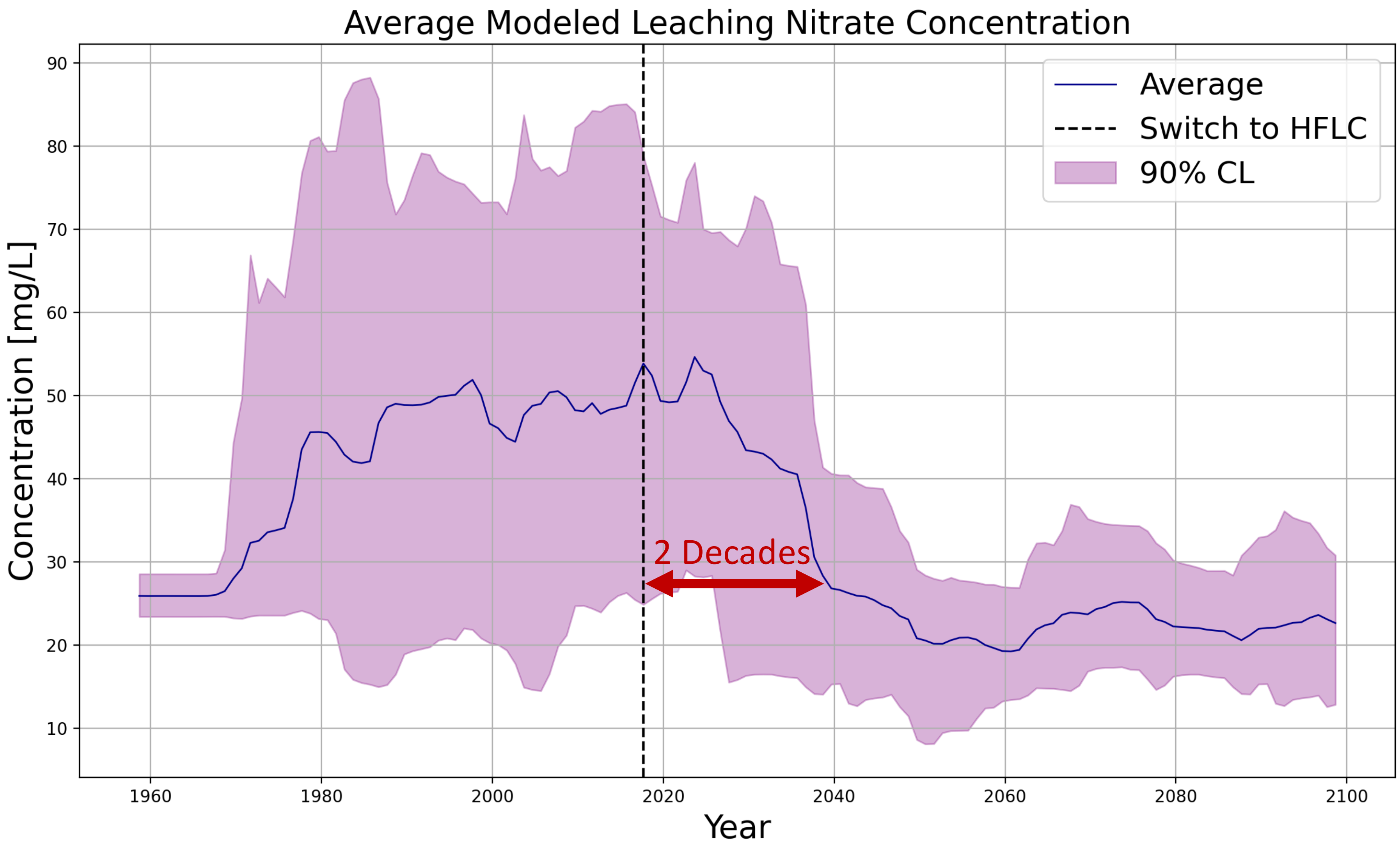


HFLC Reduces End-of-Season Soil N Residual Mass

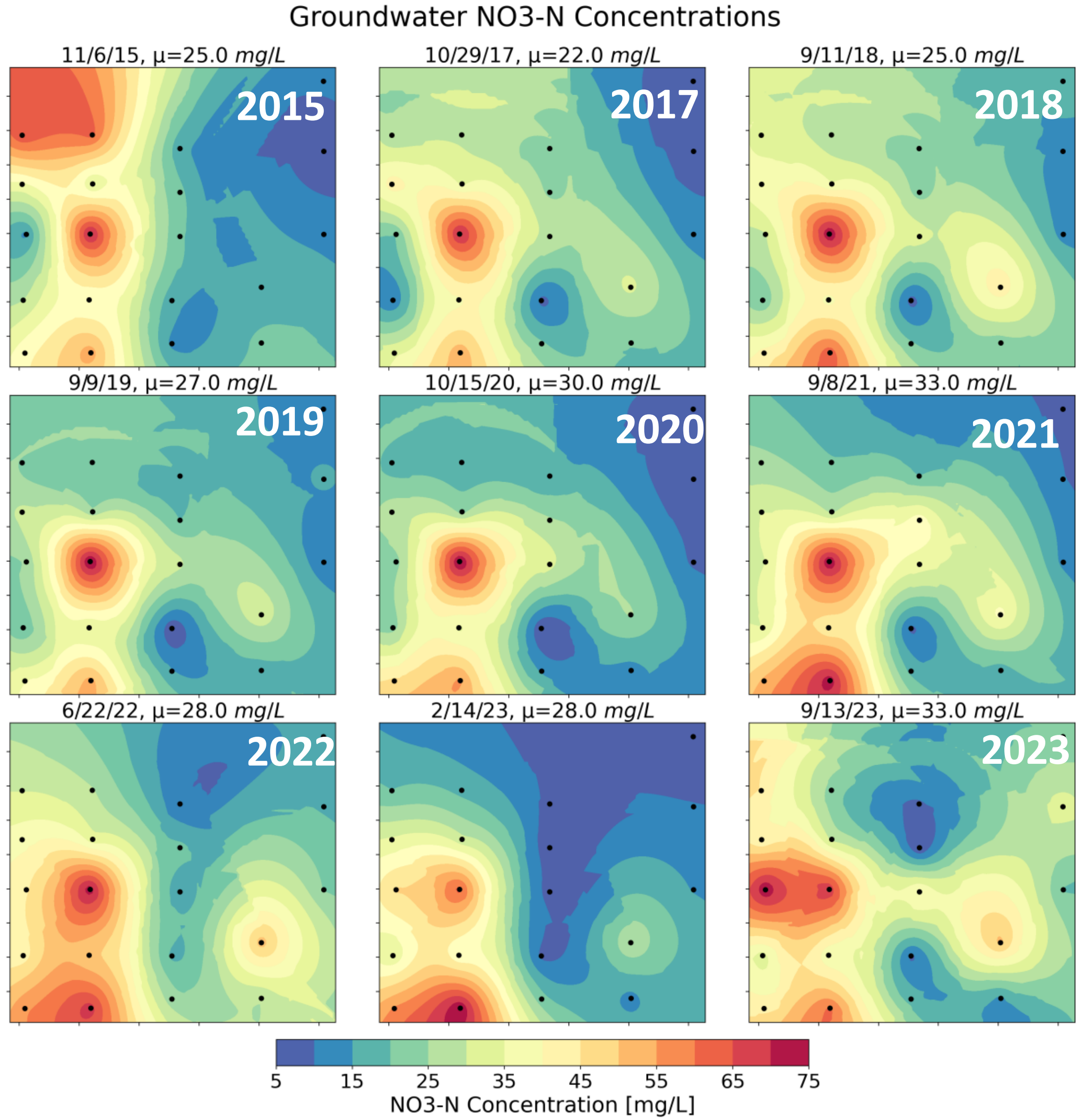


Excellent Irrigation Efficiency & Megadrought Means

Long Travel Time to Water Table



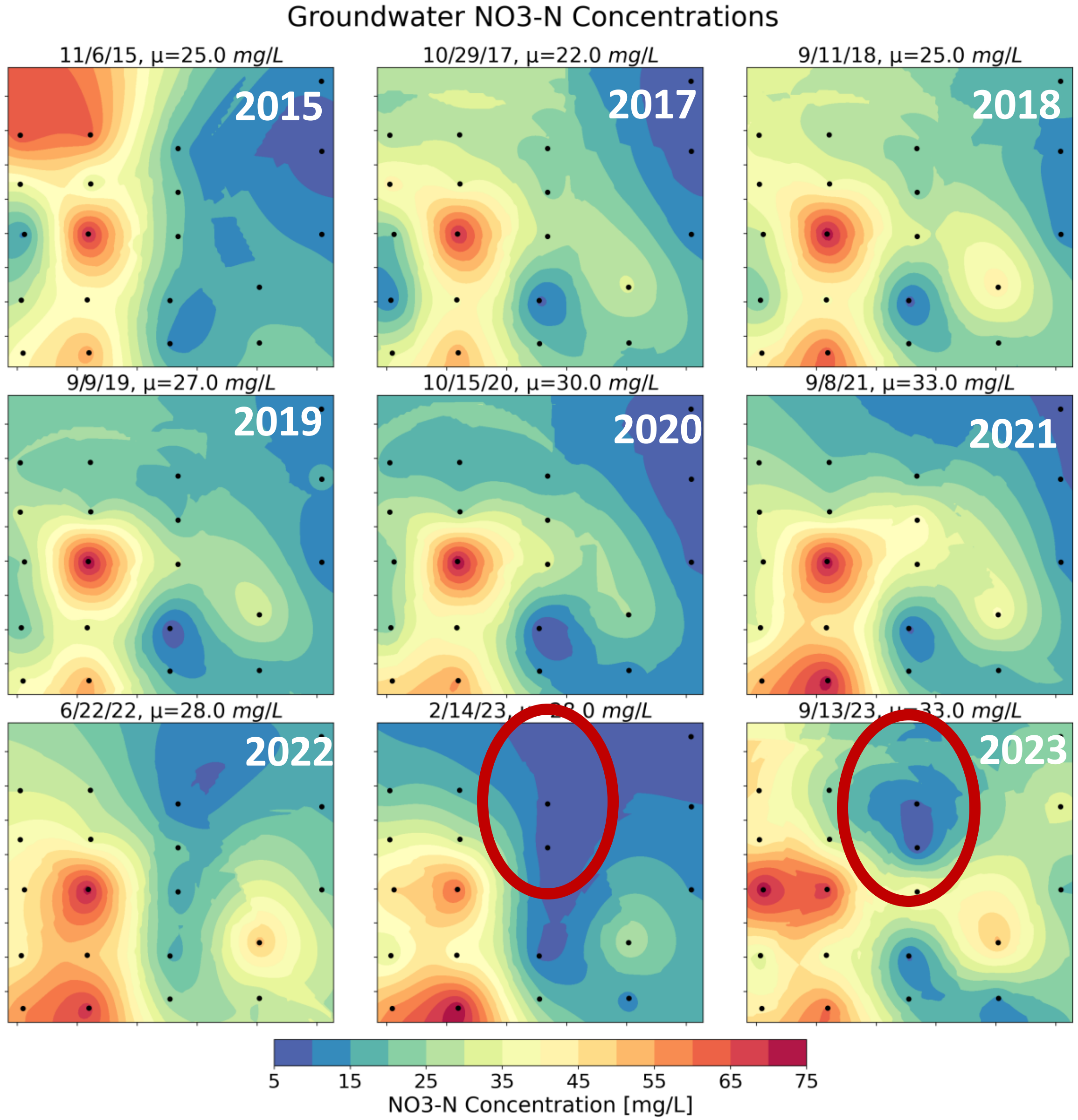
Groundwater Quality Changes Not Expected for Some TIme!



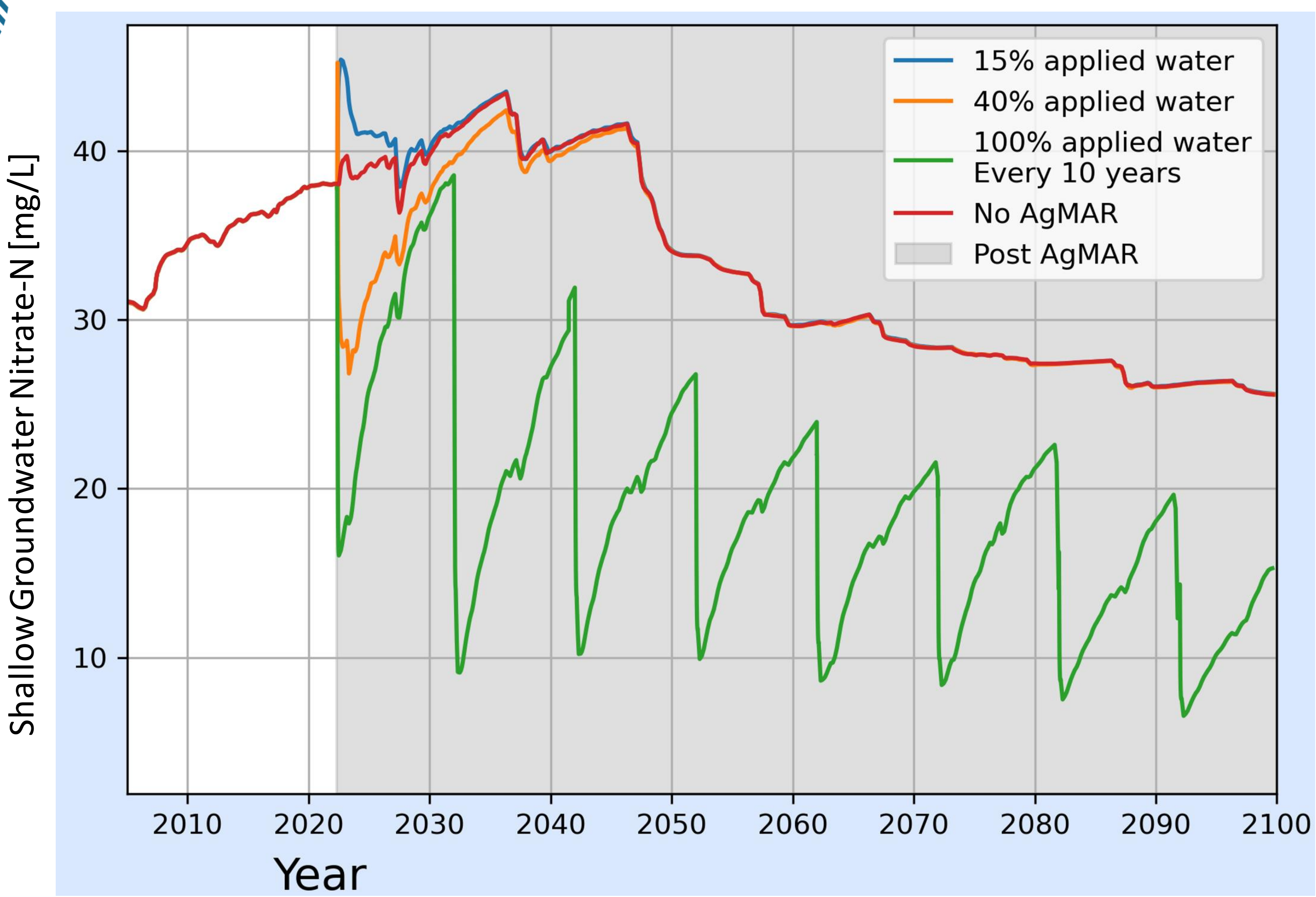
AgMAR Leads to Rapid Improvement!

Late Spring 2022:

30 feet of intentional recharge over 30 days



HFLC & AgMAR are Promising Tools, Especially when Combined



Connecting the Dots 2023

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Thank you