Nitrogen Management in Walnuts

Katherine Jarvis-Shean
UCCE Sacramento, Solano & Yolo Counties

Nitrogen Management Overview

- Why is nitrogen important
- Nitrogen in soil, plant uptake
- Science → Management

Walnut Nutrient Management Take Aways

1) Minimum 29 lbs N / ton in-shell
2) Divide N evenly over growing season
3) Roots in top 2-3 feet
4) All N *can* turn to nitrate & leach

Why N is Important to Plants

- Most Used Mineral
  - 80% → Proteins
  - Also amino acids, DNA, hormones, chlorophyll, defense compounds

Why N is Important to Plants

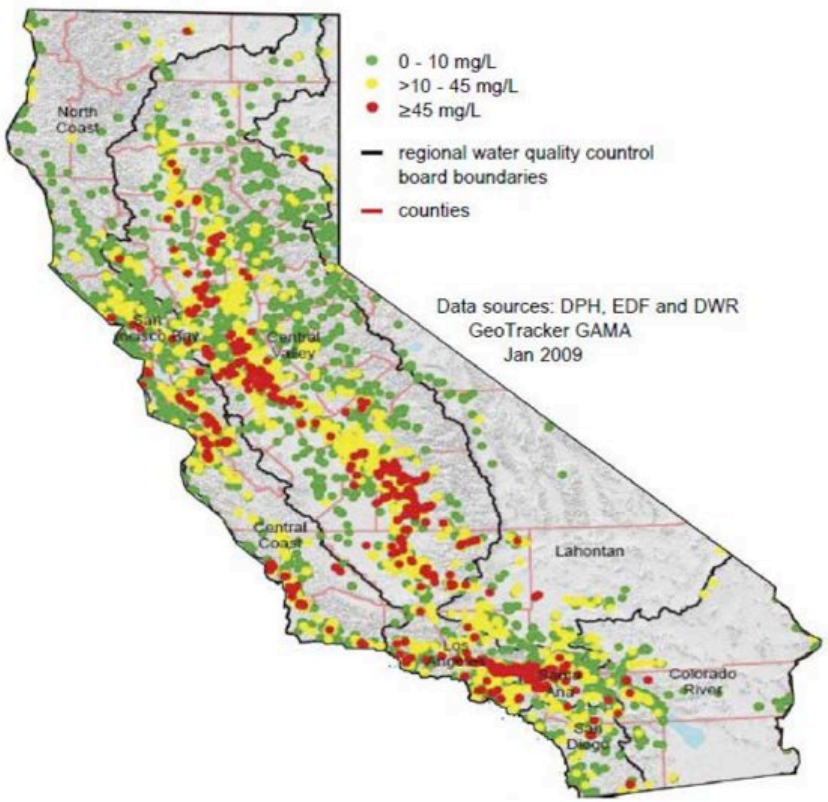
- Deficiency: limits growth, leaf chlorosis
- High N:
  - Excess vegetative growth,
  - Delays leaf drop, dormancy
  - Increases disease susceptibility

Tulare on Paradox seedling.
Photo: B. Lampinen

Darkened cambial tissue damaged by frost. Photo, J. Hasey.

Impacts of Excess Nitrogen

30+% of wells over EPA limits



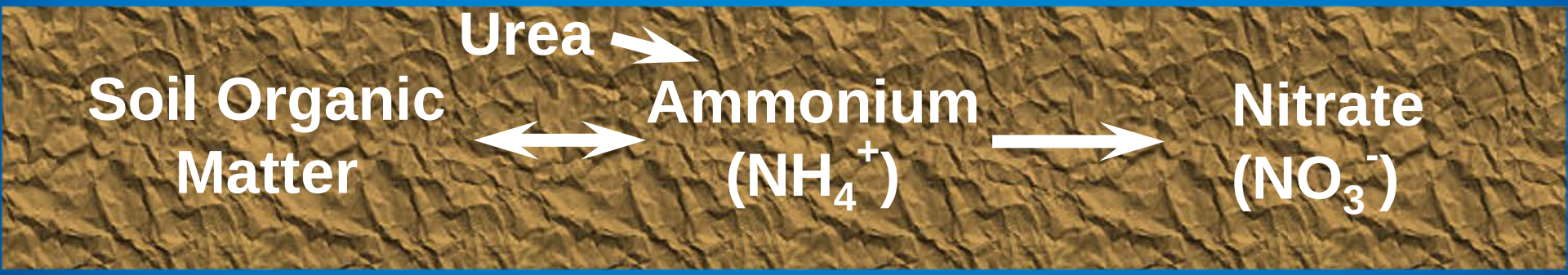
Images: Harter et al, 2012

Photos: WikiHow, wikipedia.org/wiki/Blue_baby_syndrome

To hit Nitrogen sweet spot…
*Right **amount** to trees,*
***When** they need it,*
***Where** they can get it.*

Helps to understand…
*The **Different Forms** of N &*
***How N is Taken Up** by the Plant*

Nitrogen in the Soil

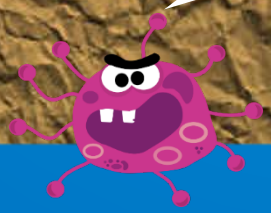


Nitrogen in the Soil

Soil Organic Matter	Ammonium (NH_4^+)	Nitrate (NO_3^-)
N tied up in organic molecules, not available to plants	Roots can take up N as ammonium	Roots can take up N as nitrate
Nutrient storage vault	Positivey charged → Can stick to the soil	Negatively charged → Will not stick to the soil → Can easily LEACH

Nitrogen in the Soil

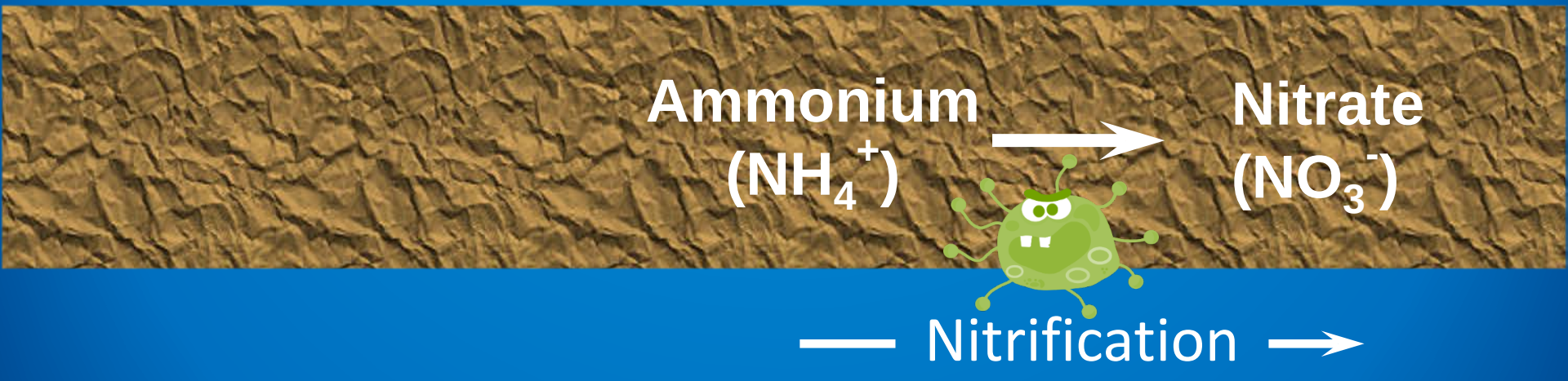
Soil Organic Matter → **Ammonium (NH_4^+)**



- In Calif. soils, SOM → NH_4^+ : Weeks-Months
- Faster when moist, aerated, *warm*
- Organic Matter Amendment → SOM *or* NH_4^+, < 2% N → N into SOM

Elements of the Nature and Properties of Soils, 3/e by N. Brady and R. Well

Nitrogen in the Soil

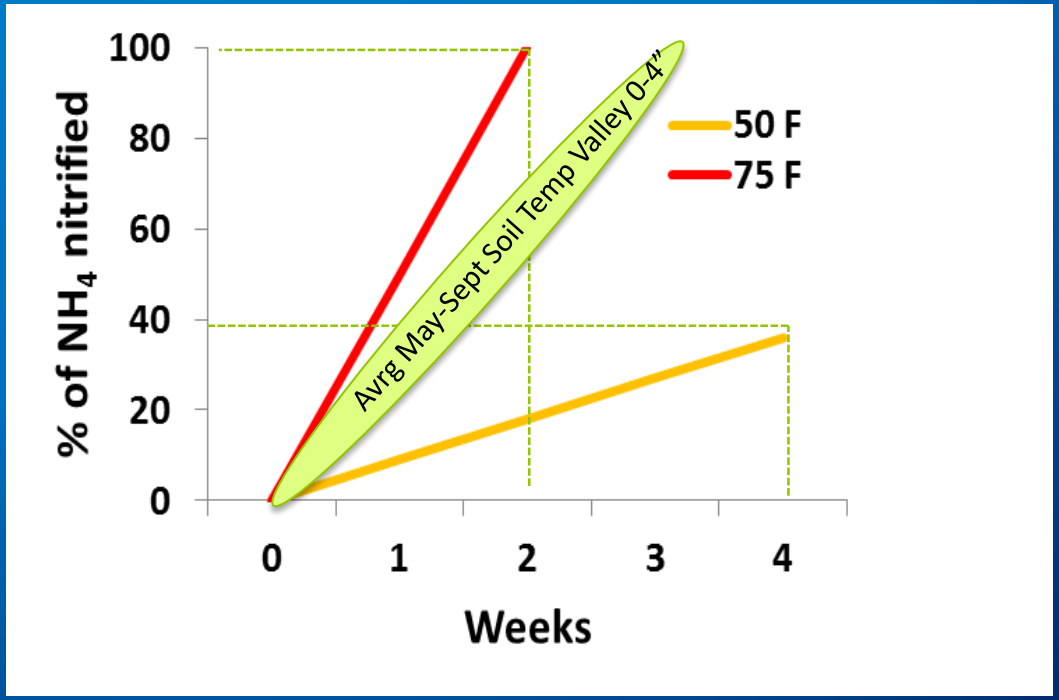


- Rate depends on temperature
- Ammonium → Nitrate: Days-Weeks
- In California soils, *if not taken up, most N eventually turns to nitrate*

Elements of the Nature and Properties of Soils, 3/e by N. Brady and R. Well

Nitrogen in the Soil

Soil Organic Matter → **Ammonium (NH_4^+)** → **Nitrate (NO_3^-)**



Elements of the Nature and Properties of Soils, 3/e by N. Brady and R. Well

Soil Organic Matter

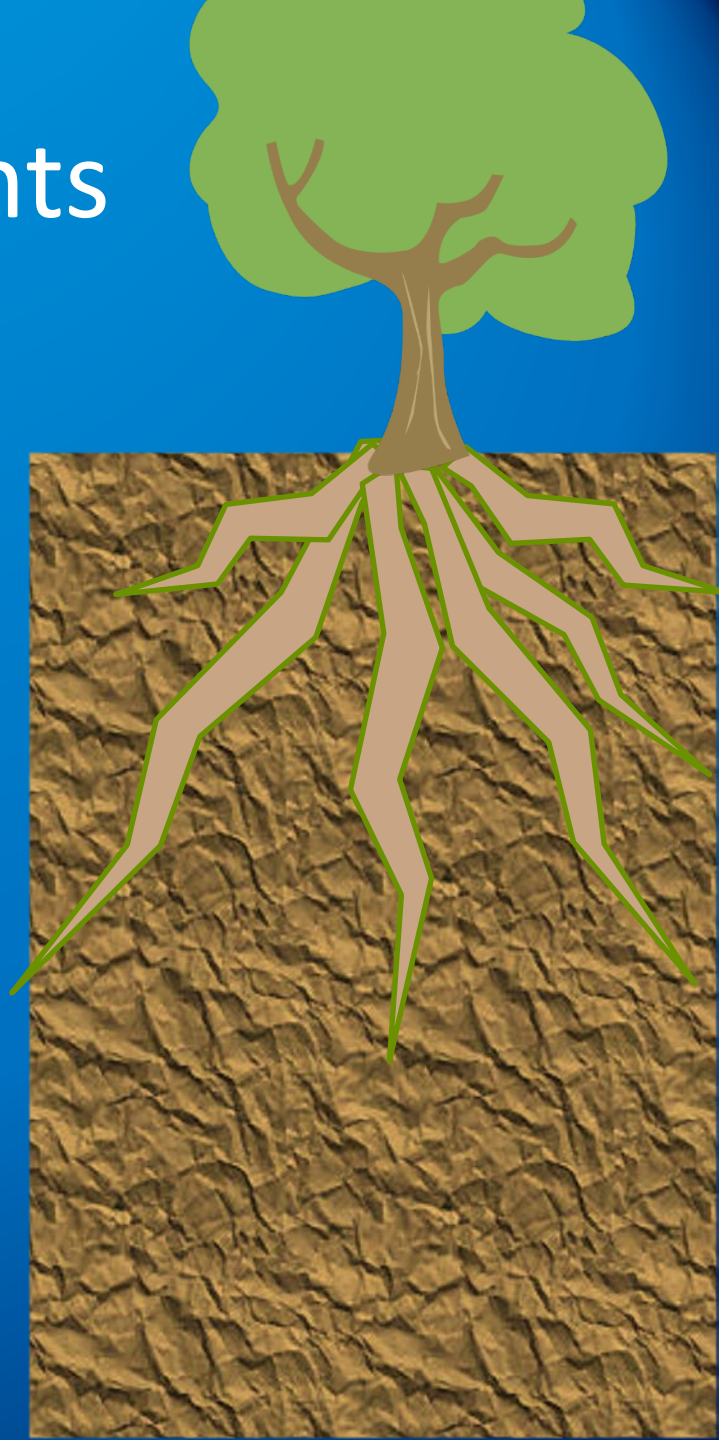
Urea

Ammonium (NH_4^+)

Nitrate (NO_3^-)

Nitrogen Uptake by Plants

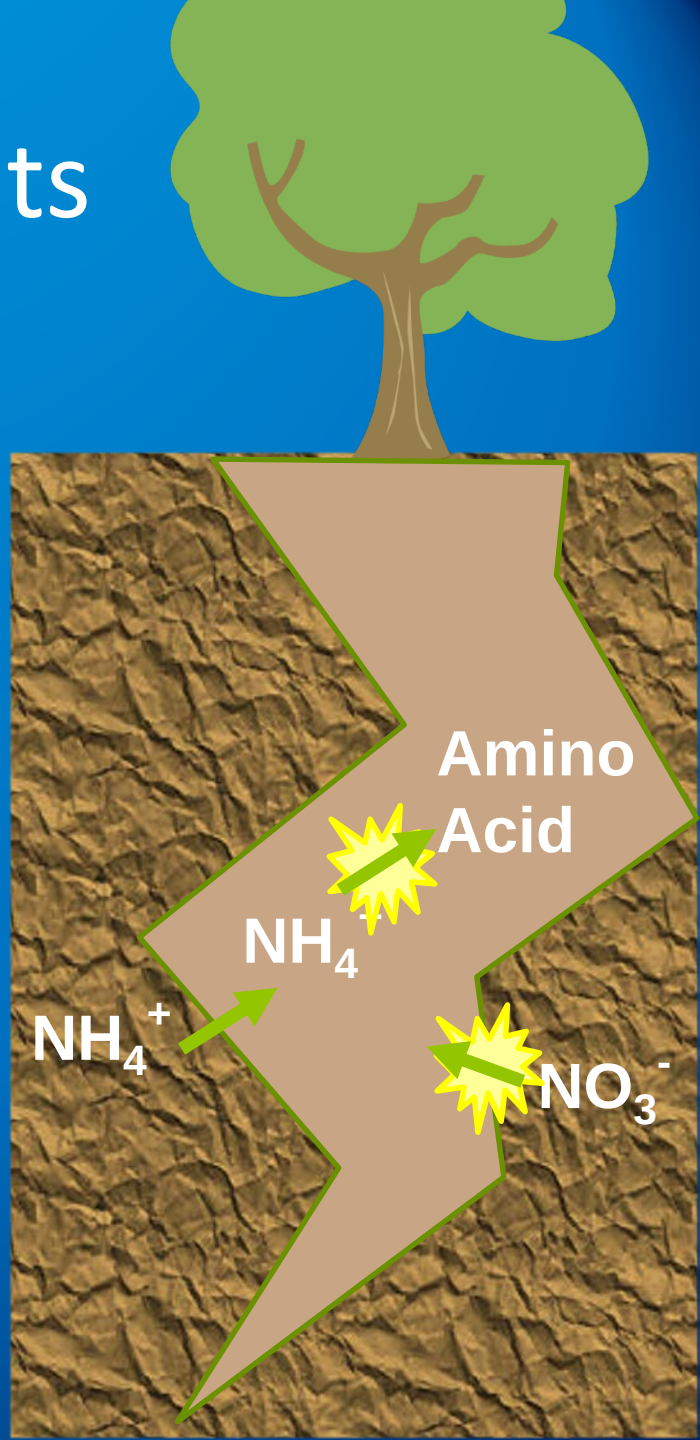
- Most Important to Know:
  - *Nitrogen uptake is regulated because of energy use & transporter bottlenecks*



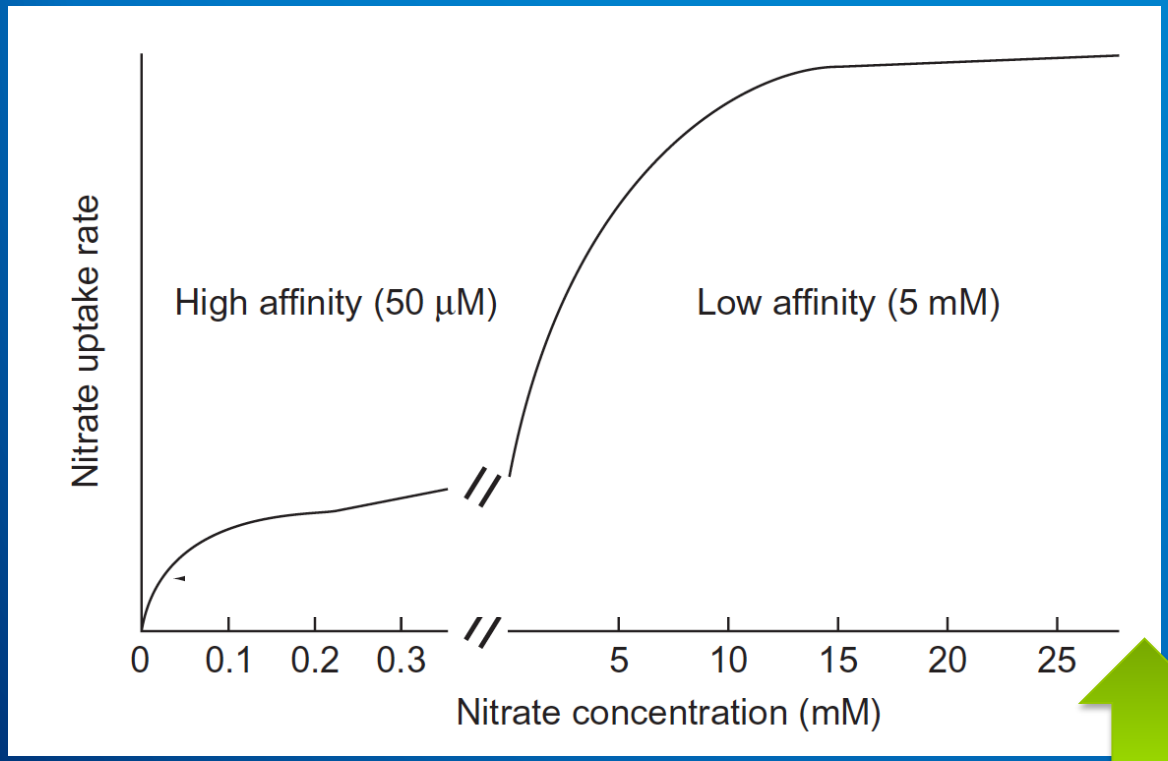
Nitrogen Uptake by Plants

- Ammonium must → amino acids in roots because it's toxic
- Nitrate must be actively transported
- Both processes require energy, highly regulated

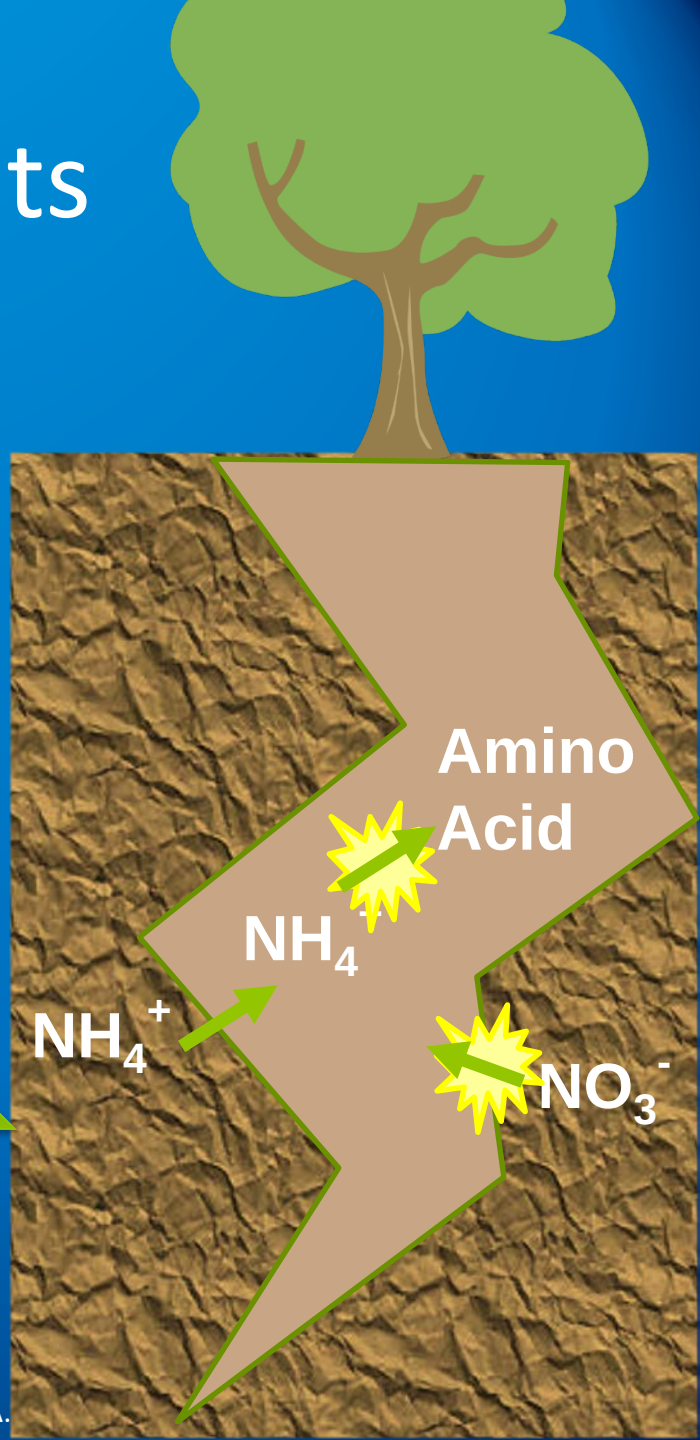
- *Take Away: The tree will limit nitrogen uptake when beyond needs, to not waste energy.*



Nitrogen Uptake by Plants



Nitrate concentration in a typical fertigation event

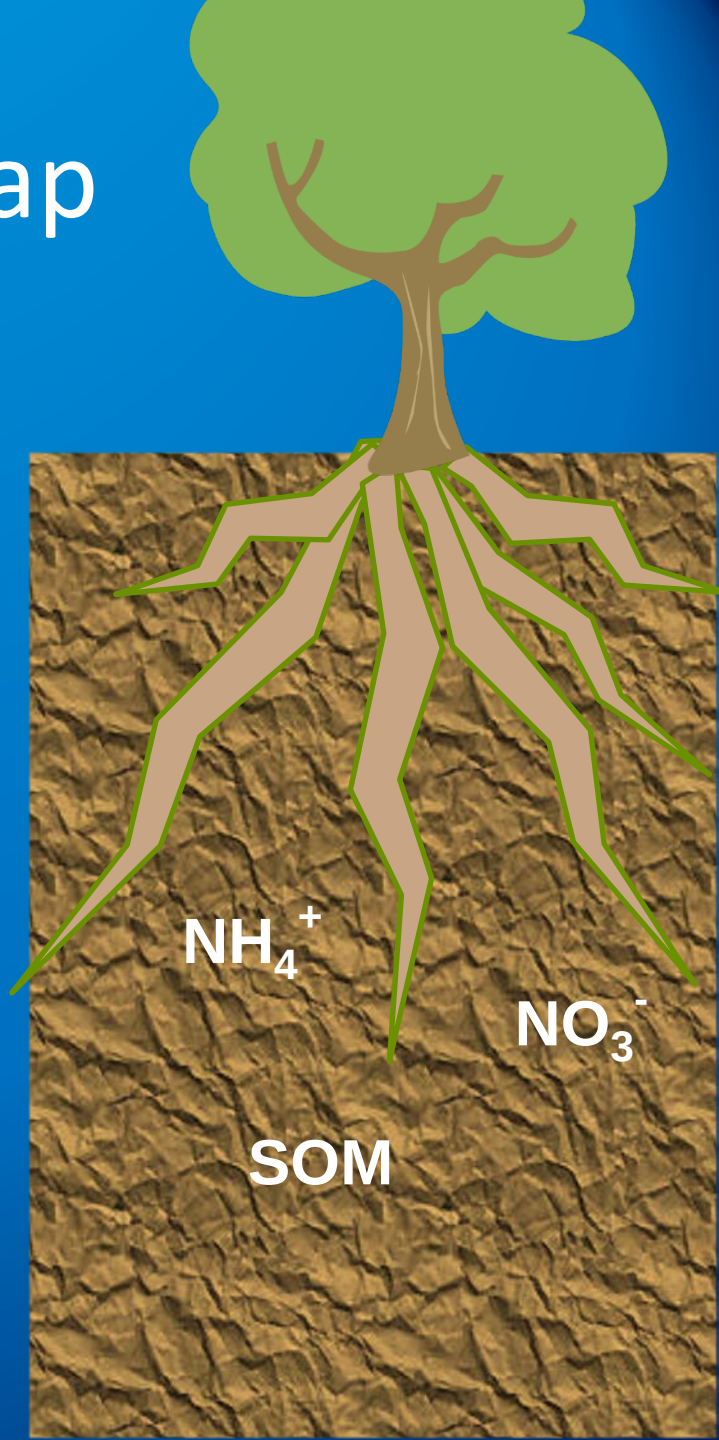


Marschner, P. (2012). Mineral Nutrition of Higher Plants. Academic Press. Waltham, MA, USA.

Nitrogen Dynamics Recap

- N in many forms in soil – SOM, Ammonium, Nitrate
  - SOM is N storage
  - Uptake as ammonium or nitrate.
  - Nitrate doesn't stick in the soil
- N uptake requires energy, goes through transporters.

More N applied ≠ More N uptake



Nitrogen Management Overview

- Why is nitrogen important
- Nitrogen in soil, plant uptake
- Science → Management

4 R's of N Management

- Apply the ***Right Rate***
  -
- Apply at the ***Right Time***
  -
- Apply in the ***Right Place***
  -
- Using the ***Right Source***
  -

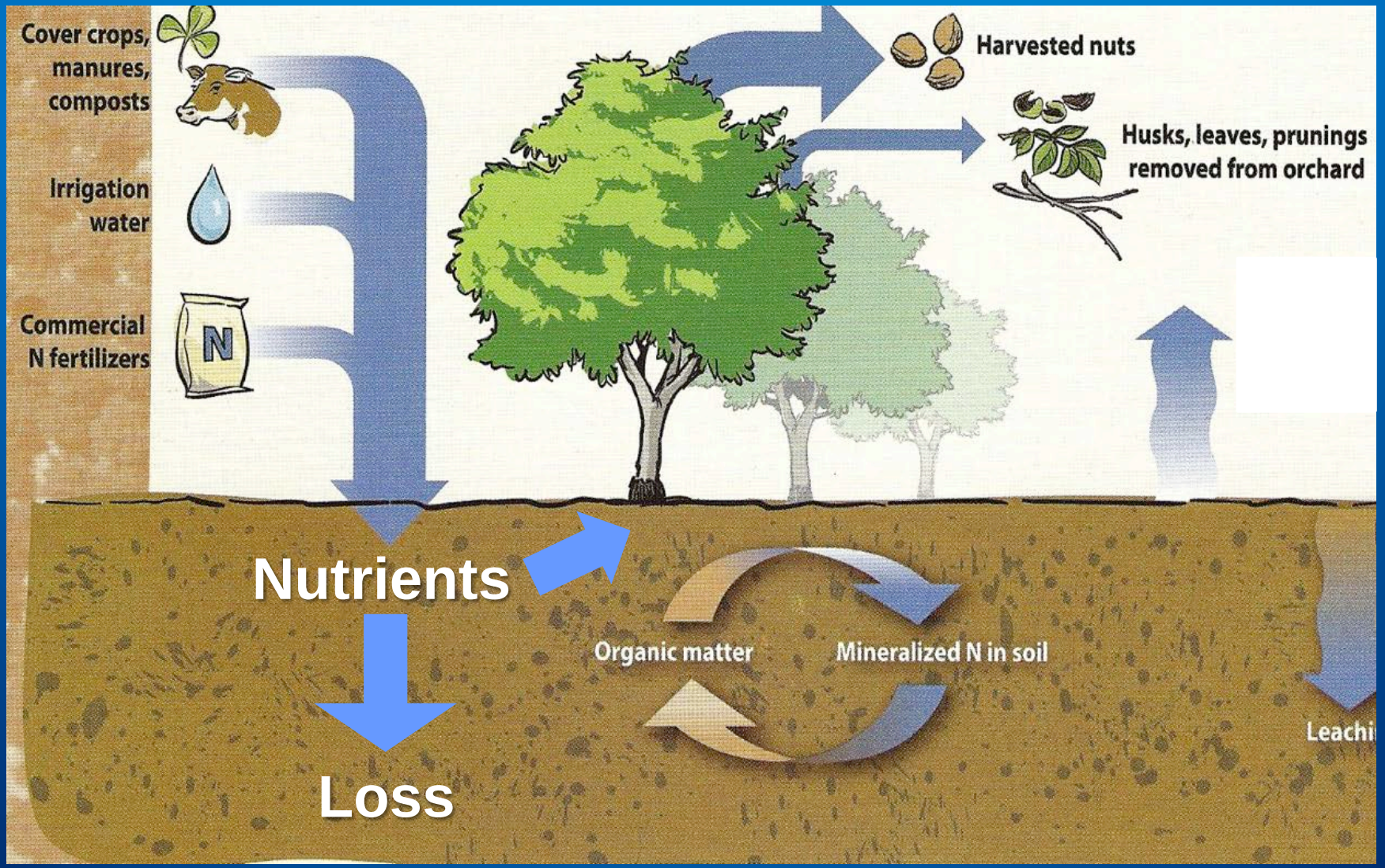
N Management in General

- Apply the ***Right Rate***
  - Trees regulate N uptake
- Apply at the ***Right Time***
  - Trees regulate N uptake
- Apply in the ***Right Place***
  - Keep it where roots can get it
- Using the ***Right Source***
  - Keep it where roots can get it

4 R's of N Management

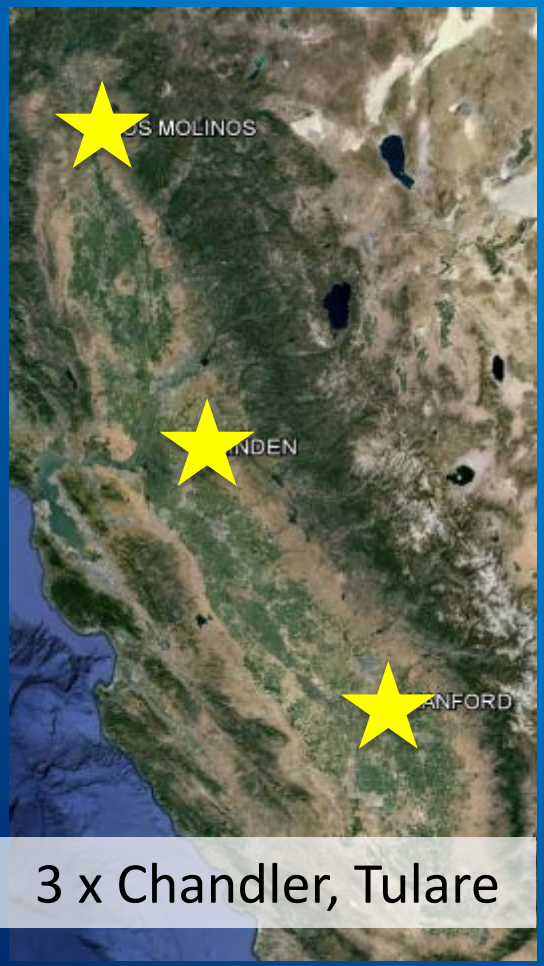
- Apply the ***RIGHT RATE***
  - Match SUPPLY w/ tree DEMAND
    - *Remember, N uptake costs energy. Trees minimize N uptake once N demand is met.*
  - Fertilizer + organic N + water

Supply = Demand



Kathy Kelley-Anderson et al: ANR Pub # 21623

Methods – NPK Demand Model



3 x Chandler, Tulare

Senescence

Apr– Nov

May – Sept/Oct

Jan, Apr, May, Jul, Nov

10 trees / site

Right Rate

N / ton of nuts (in-shell, 8% moist)

Site	2013	2014	2015
N Chandler	25	28	28
C Chandler	29	30	34
S Chandler	23	29	32
N Tulare	27	29	23
C Tulare	30	31	31
S Tulare	26	27	35
GRAND MEAN		**29**	

Meat & Shell: 23-35 lbs

Hulls: 0.5-2 lbs

Other Scraps: 0.5-2 lbs (???)

New Growth: 4-8 lbs**(???)

=

28-47 lbs N / ton in-shell

*Letters show dif's w/in cv.

** Based on Weinbaum's 0.13 lb N/tree, 50 trees/acre, 16 year old Hartleys

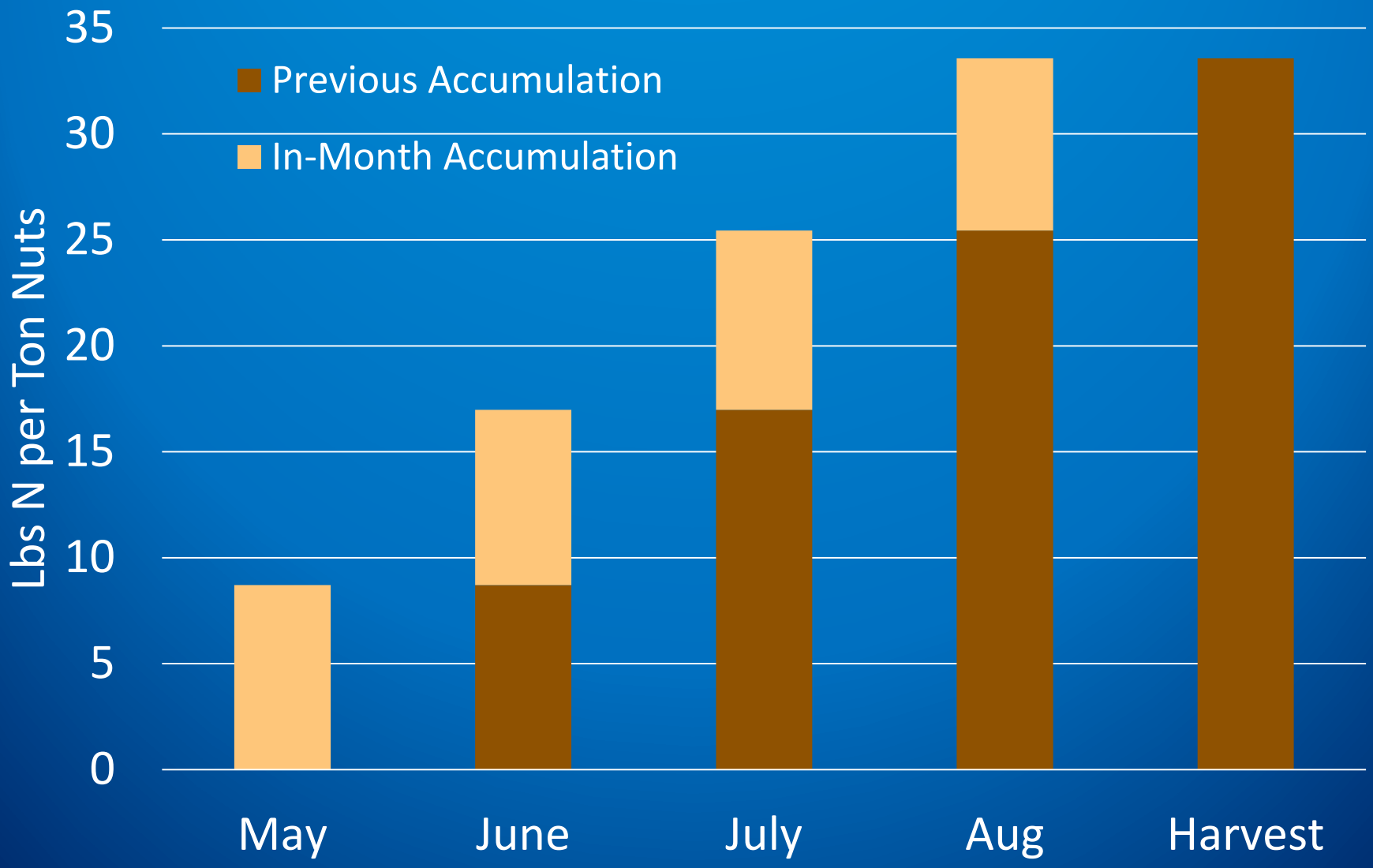
N Management in Walnuts

- Apply the ***RIGHT RATE***
  - ***Minimum 29 lbs/ton****
- Apply at the ***RIGHT TIME***
  -
- Apply in the ***RIGHT PLACE***
  -
- Using the ***RIGHT SOURCE***
  -

4 R's of N Management

- Apply at the ***RIGHT TIME***
  - Match w/ timing of tree demand, root uptake
    - *Remember, limited number of transporters. Bottleneck → Leaching.*
  - Trees take up nutrients most efficiently when it's needed.

Nitrogen Added per Month 2013 - 2015, Chandler & Tulare



N Management in Walnuts

- Apply the ***RIGHT RATE***
  - ***Minimum 29 lbs/ton***
- Apply at the ***RIGHT TIME***
  - ***Even split May-Aug***
- Apply in the ***RIGHT PLACE***
  -
- Using the ***RIGHT SOURCE***
  -

4 R's of N Management

- Apply in the ***RIGHT PLACE***
  - Delivery to active roots
  - N moves w/ water
  - Minimize movement below root zone
    - *Remember, nitrate doesn't stick in the soil. Easily leached.*

Roots in Top 3 Feet

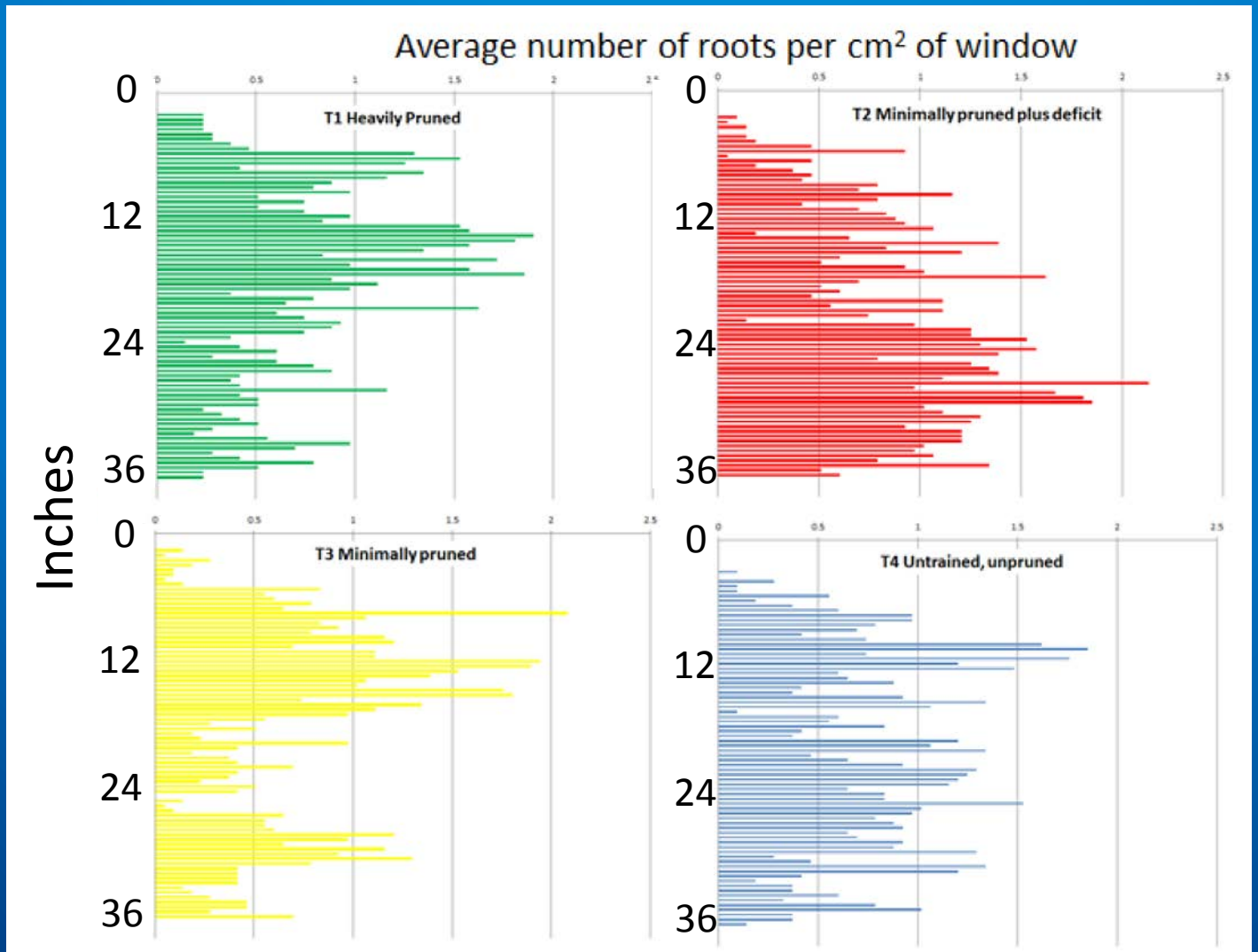


Fig. 3. Total number of roots per cm^2 of window area for the 2012 season by treatment.

Lampinen et al

N Management in Walnuts

- Apply the ***RIGHT RATE***
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- Apply at the ***RIGHT TIME***
  - ***Even split May-Aug***
- Apply in the ***RIGHT PLACE***
  - ***Roots in top 3 feet***
- Using the ***RIGHT SOURCE***
  -

4 R's of N Management

- Using the ***RIGHT SOURCE***

Fertilizer	Nitrogen (%)	Urea	Ammonium	Nitrate	Leaching Potential	Soil Acidifier	Comments
Ammonium Nitrate	34%		✓	✓	Medium	Medium	Nitrate N immediately available. Ammonium N half delayed.
Ammonium sulfate	21%		✓		Low	High	Source of sulfur
Calcium ammonium nitrate (CAN-17)	17%		✓	✓	Medium	Medium	
Calcium nitrate	16%			✓	High	No	Source of calcium
Urea	45%	✓		✓	Low	Low	
Urea Ammonium Nitrate (UN-32)	32%	✓	✓	✓	Medium	Medium	Nitrate N immediately available. Remainder of N delayed.

N Management in Walnuts

- Apply the ***RIGHT RATE***
  - ***Minimum 29 lbs/ton***
- Apply at the ***RIGHT TIME***
  - ***Even split May-Aug***
- Apply in the ***RIGHT PLACE***
  - ***Roots in top 3 feet***
- Using the ***RIGHT SOURCE***
  - ***Most becomes Nitrate with time.***

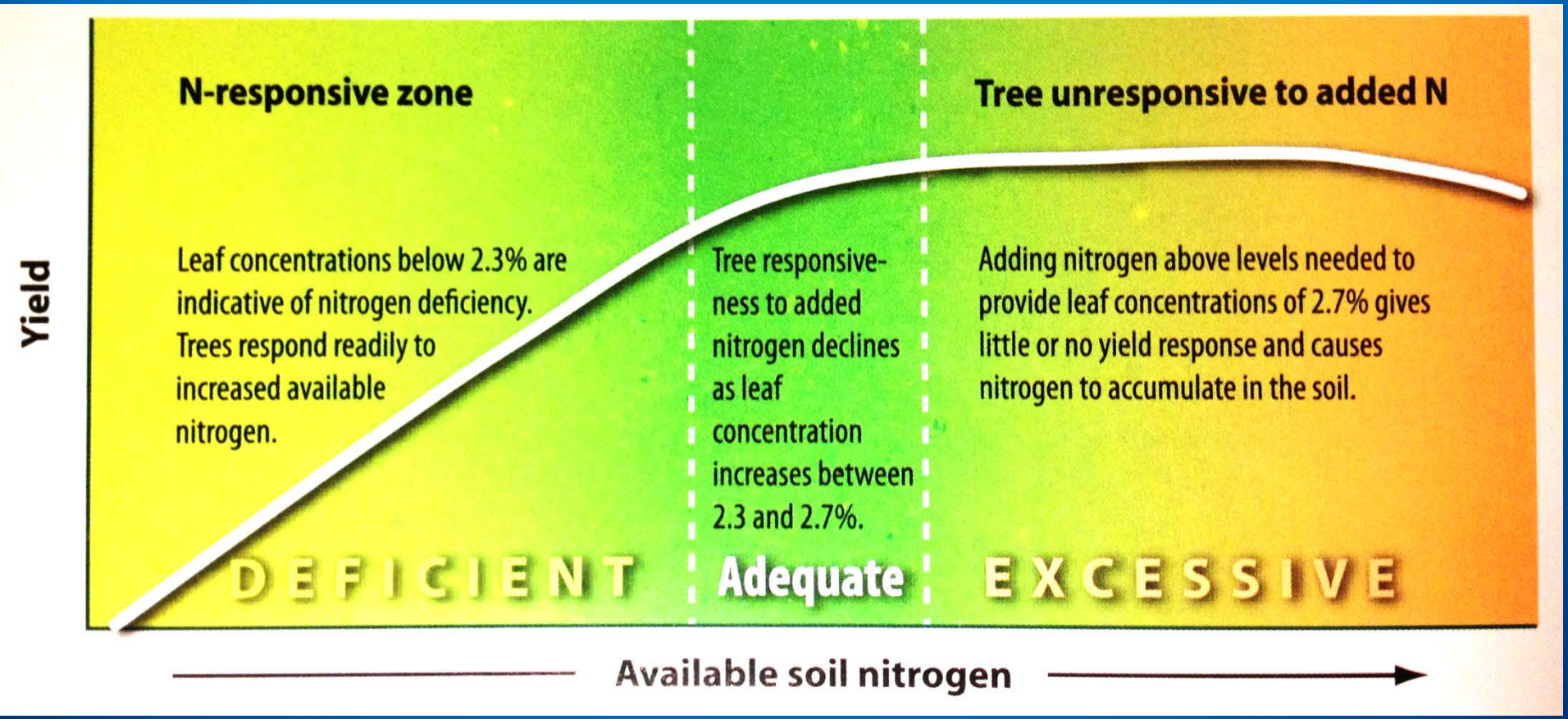
N Management in Walnuts

If based on yield history, this year's condition, you expect 3 ton crop,
assuming 70% of N will get into the tree…

	Rate	Time	Place	Source
May	3 x 29 ÷ 0.7 = **124 lbs** for whole season	31 lbs*	Manage irrigation to keep in top 3'	What works for your system? Remember, it can all → nitrate
June		31 lbs*		
July		31 lbs*		
August		31 lbs*		

*Nitrate in water,
N from compost,
+ synthetic N

Leaf Sampling



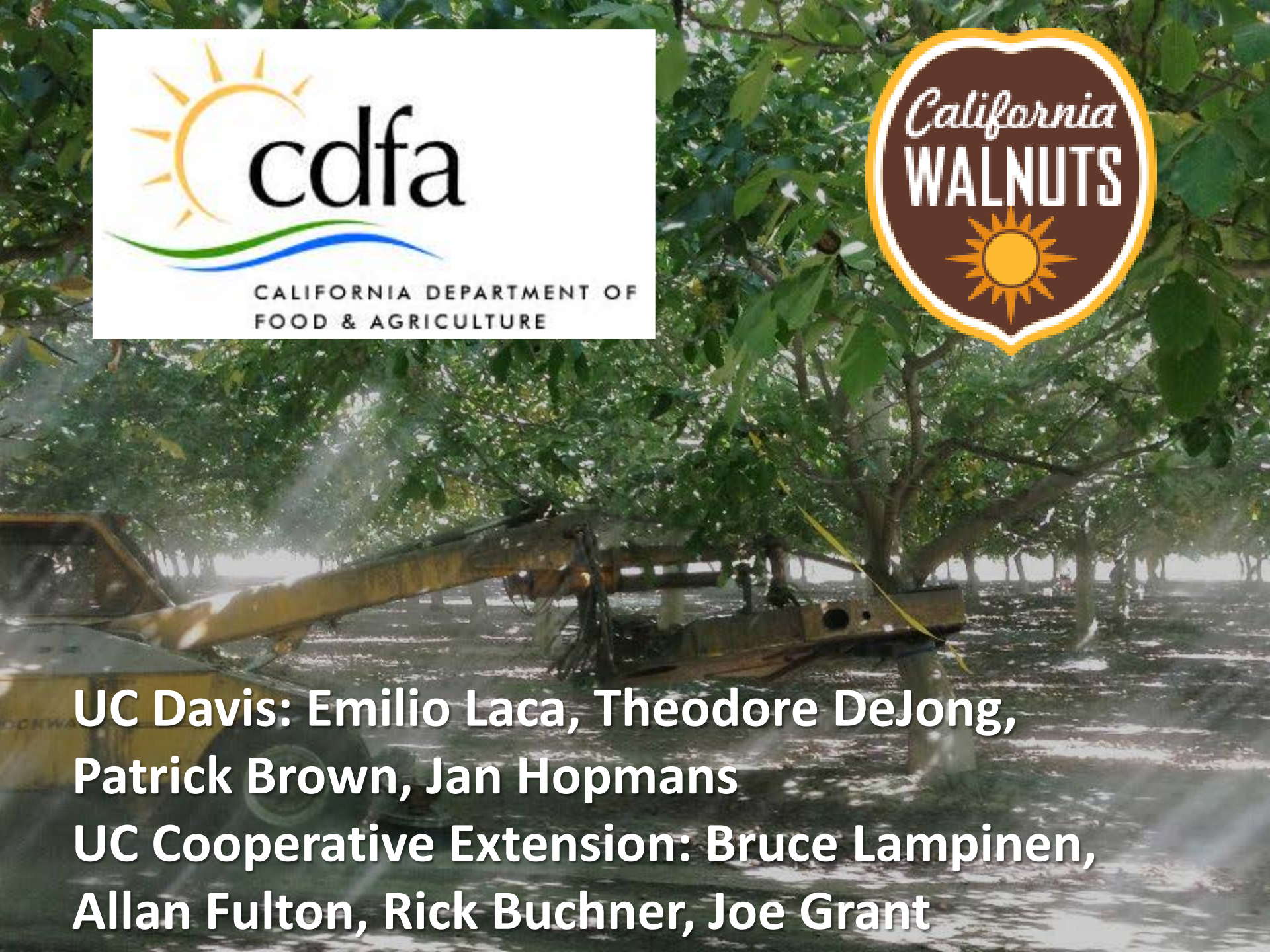
Leaf Sampling

- Sample trees at least 30 yards apart
  - Closer are *likely* not independent (need tighter grid experiment to be sure)
- Sample 29 trees per block, assuming similar soil type throughout block
  - Achieves test results within 0.1% of the true orchard N status 95% of the time

Image: Kelley Anderson et al., 2006

Walnut Nutrient Management Take Aways

1) Minimum 29 lbs N / ton in-shell
2) Divide N evenly over growing season
3) Roots in top 2-3 feet
4) All N *can* turn to nitrate & leach



UC Davis: Emilio Laca, Theodore DeJong, Patrick Brown, Jan Hopmans
UC Cooperative Extension: Bruce Lampinen, Allan Fulton, Rick Buchner, Joe Grant