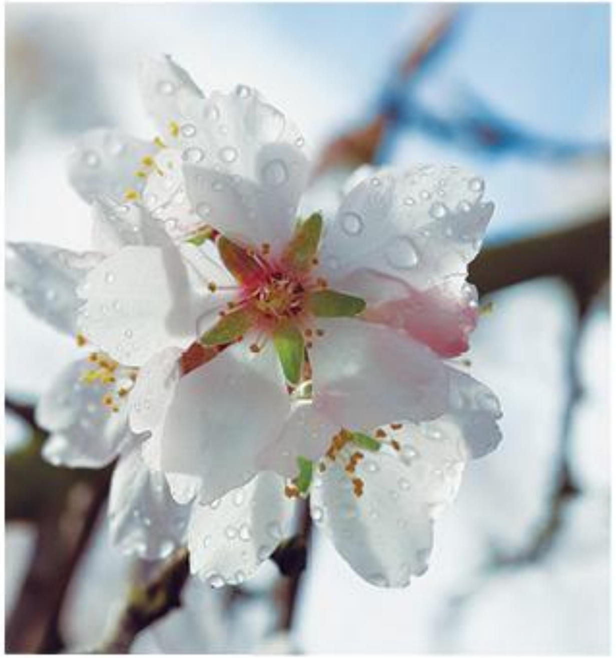
What's New in Nitrogen Management



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What's New in Nitrogen Management

Gabriele Ludwig
Almond Board of California

Emerging Regulations and Nitrogen Management Planning

Joe Karkoski
Program Manager

Central Valley Water Board

Emerging Regulations and Nitrogen Management Planning
Central Valley Water Board

Joe Karkoski
Program Manager

Almond Board
December 12, 2012

Presentation Overview

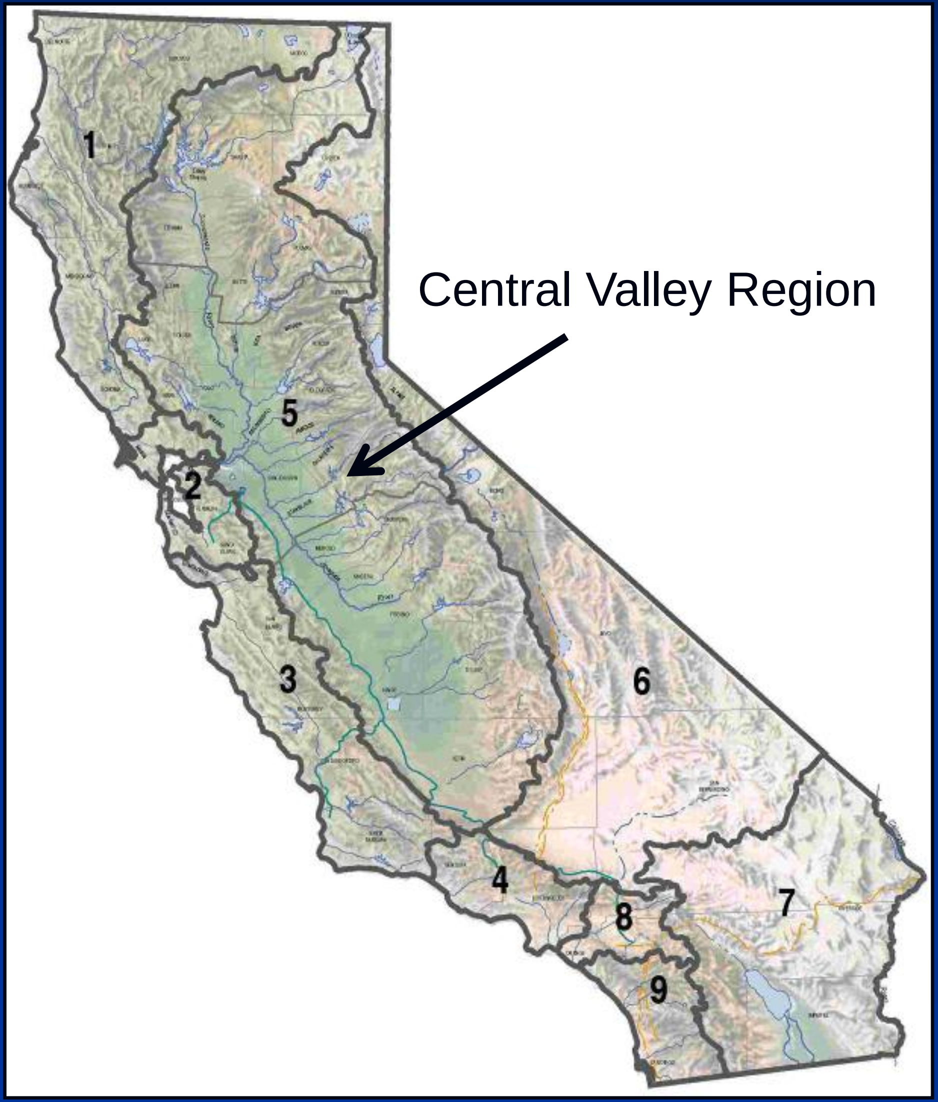
- Background
- Overall Direction
- Current Proposal – Nitrogen Management
- Next Steps

What Are WE Trying to Accomplish?

WE = Water Board, Agriculture, Stakeholders

- Protect water quality for current and future generations
- Ensure any new requirements are consistent with sustaining agriculture in the Central Valley
- Learn and adapt as we move forward

Nine Regional Water Boards



- Implement State and federal water quality laws based on region specific conditions
- Regulate discharges of waste

Irrigated Lands Regulatory Program

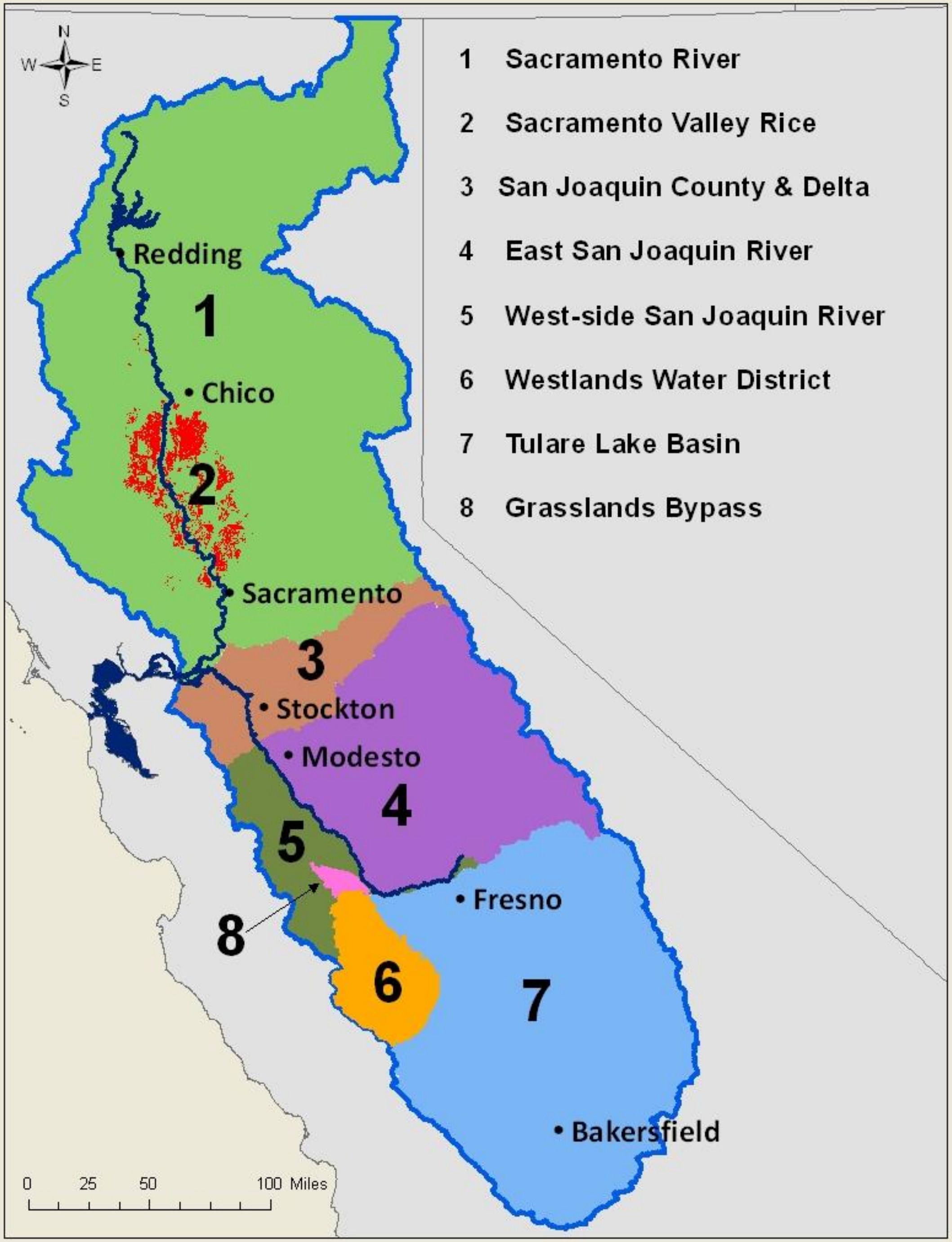
2003 Program

- Surface water protection program only
- Coalition groups provide lead role in interacting with the Water Board
  - 25,000 landowners currently enrolled
  - Five million acres of irrigated land

Direction from Central Valley Water Board, June 2011

- Tailor approach specific geographic areas or commodities
- Include requirements to protect surface and groundwater quality
- Continue with Coalitions (third-parties) as lead to assist growers w/compliance
- General Waste Discharge Requirements (WDRs)

Geographic Areas/Commodities Addressed by WDRs



Porter-Cologne Water Quality Control Act
(The California Water Quality Law)

Applies to:

- "Waters of the state" – ***any surface water or groundwater***
- Discharges of waste to waters of the state

Irrigated Lands Regulatory Program (ILRP)

- Includes commercial operations, managed wetlands, nurseries, and greenhouses
- Surface water discharges
  - surface return flows, storm runoff, tile drainage
- Groundwater discharges
  - Fertilizer/pesticides moving down soil profile, well head, or backflow

Nitrates and Groundwater

- Pollution pathways for nitrates and pesticides are similar
- Nitrates/water soluble pesticides leach through soil to groundwater
- Pathway for nitrates/pesticides
  - Surface runoff
  - Unprotected / improperly sealed wells
  - Over application of nitrogen fertilizer
  - Other conduits to groundwater (e.g., backflow)

Known Nitrate Sources (Regional)

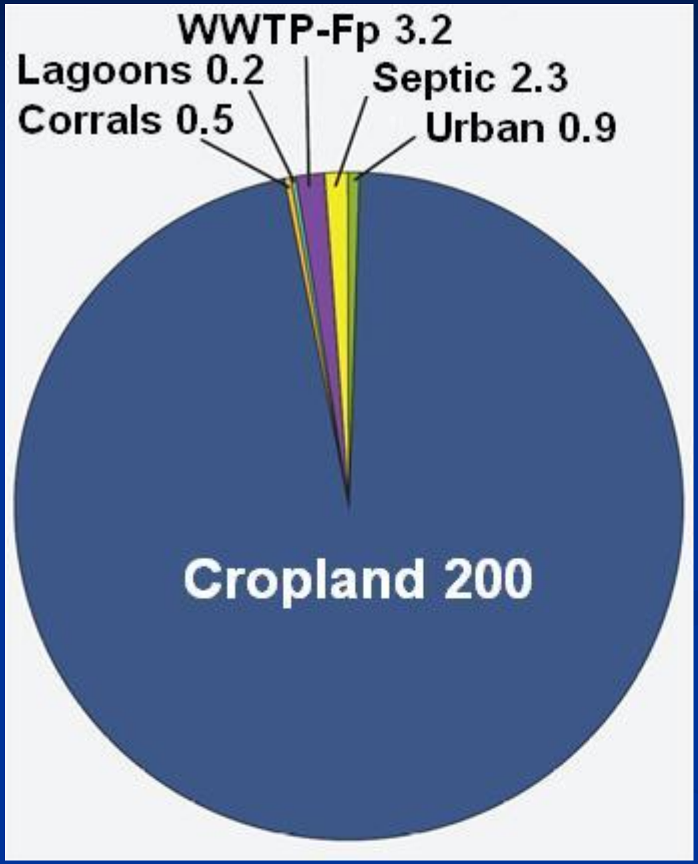


Figure 1. Estimated groundwater nitrate loading from major sources within the Tulare Lake Basin and Salinas Valley, in Gg nitrogen per year (1 Gg = 1,100 t).
http://groundwaternitrate.ucdavis.edu/files/139110.pdf ; Viers, J.H., et al (2012). Nitrogen Sources and Loading to Groundwater

Approach for new ILRP

- Identify high/low vulnerability areas
- Focus requirements and plans on **High Vulnerability** areas
- High Vulnerability areas will be identified by the third-party

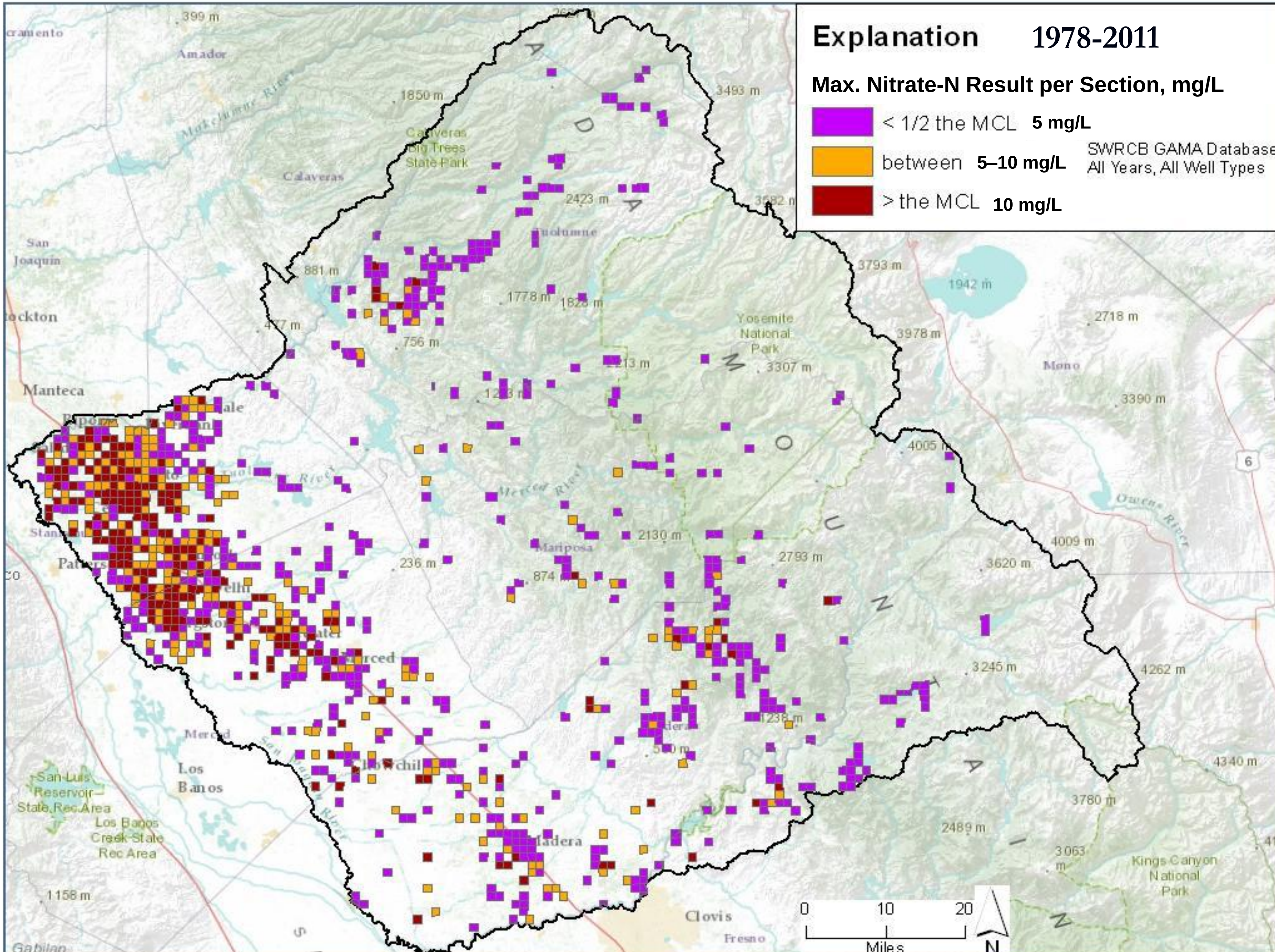
Focus on management practice implementation and reporting

Limited monitoring (compared to other programs)

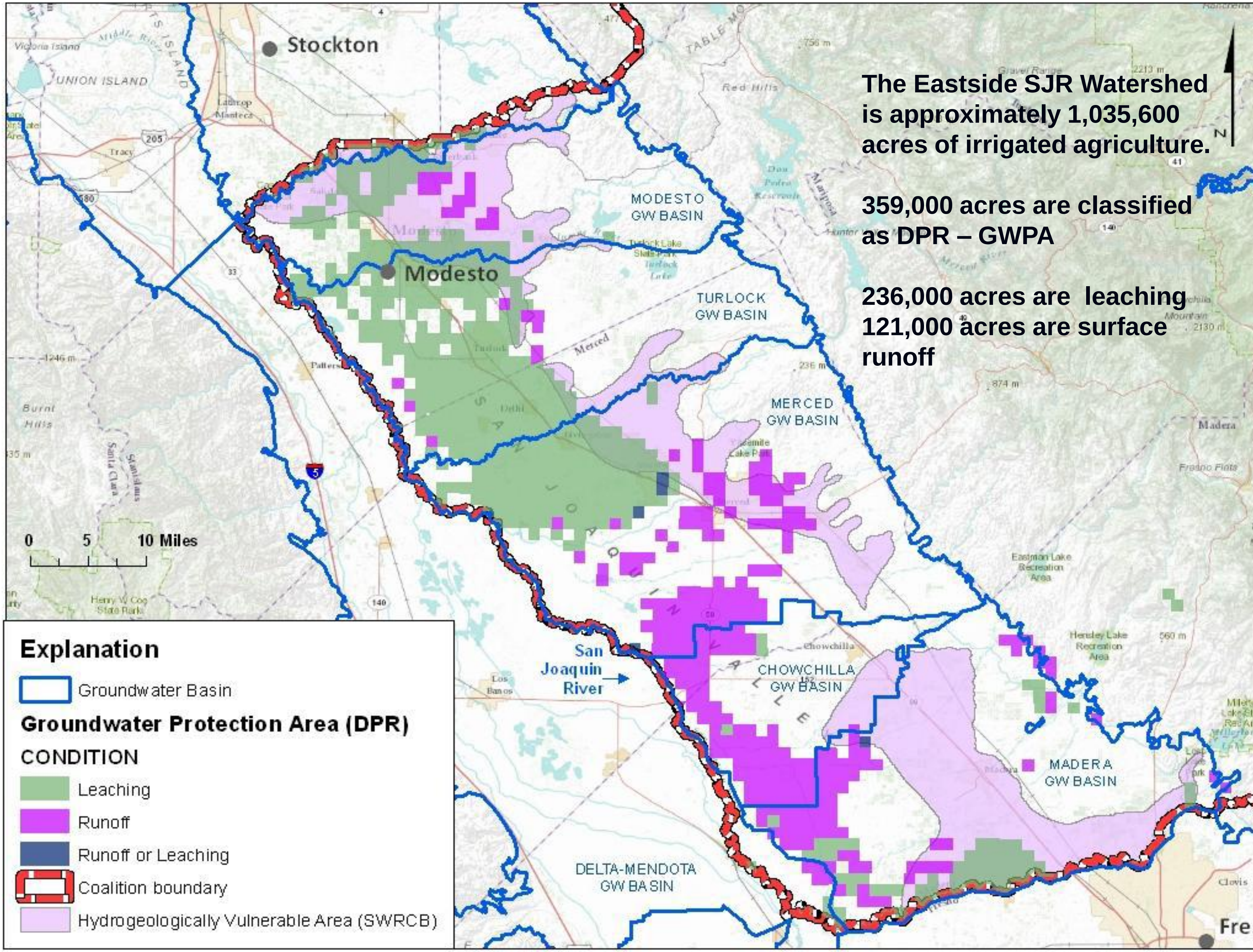
Eastern San Joaquin River Watershed

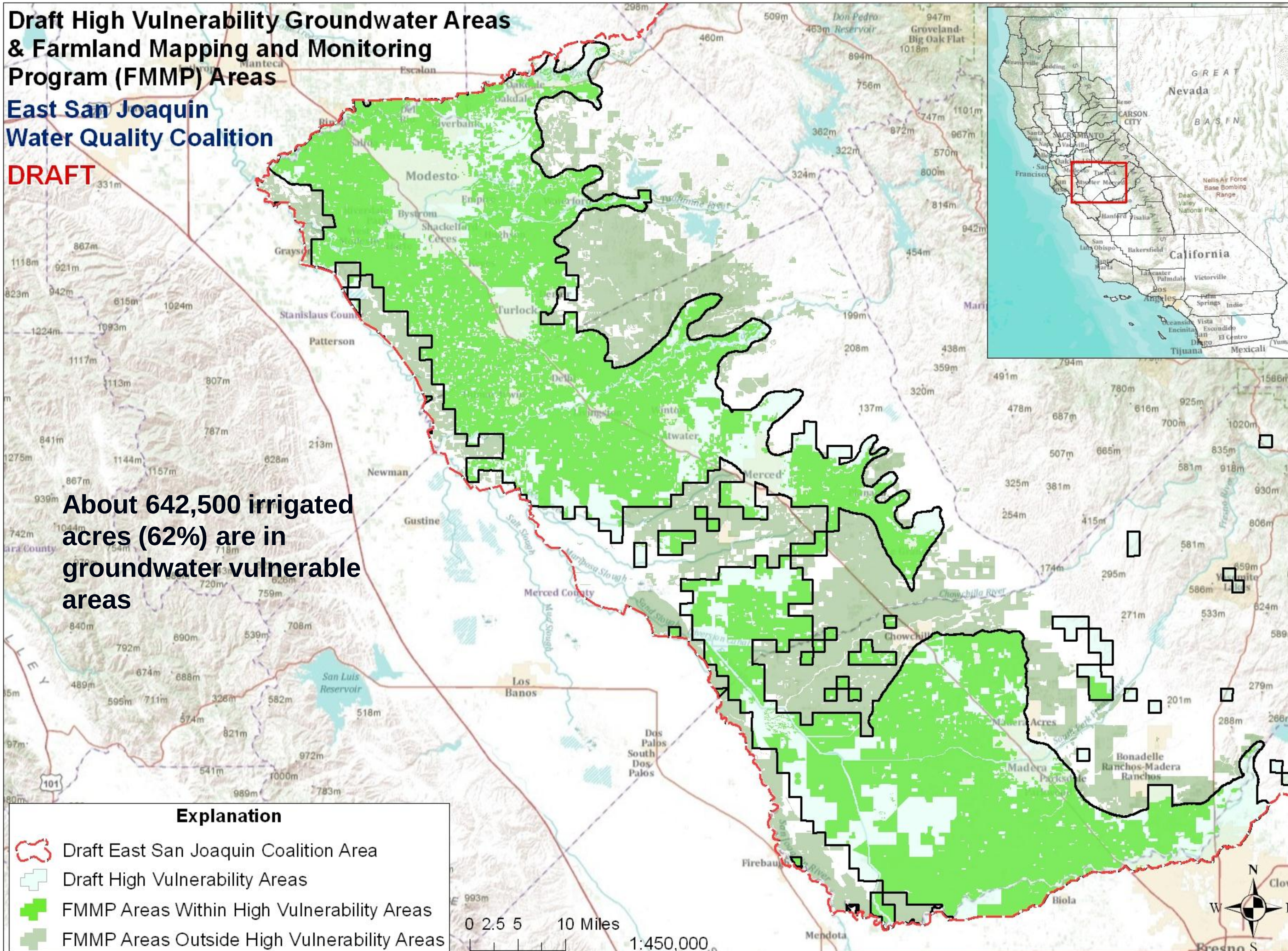
- 1 million+ acres of irrigated lands

- Major crops:
  - almonds
  - hay
  - corn
  - grapes
  - tomatoes
  - pasture
  - wheat
  - cotton
  - walnuts



Explanation
1978-2011
Max. Nitrate-N Result per Section, mg/L
< 1/2 the MCL 5 mg/L
between 5–10 mg/L
> the MCL 10 mg/L
SWRCB GAMA Database
All Years, All Well Types
Yosemite National Park
Manteca
Merced
Madera
Clovis
Fresno
Los Banos
Mono
Calaveras
Tuolumne
Mariposa
Amador
Calaveras Big Trees State Park
San Luis Reservoir State Rec Area
Los Banos Creek State Rec Area
Kings Canyon National Park
Merced River
Owens River
0 10 20
Miles
N


The Eastside SJR Watershed is approximately 1,035,600 acres of irrigated agriculture.
359,000 acres are classified as DPR – GWPA
236,000 acres are leaching
121,000 acres are surface runoff
runoff
Stockton
Modesto
MODESTO GW BASIN
TURLOCK GW BASIN
MERCED GW BASIN
CHOWCHILLA GW BASIN
MADERA GW BASIN
DELTA-MENDOTA GW BASIN
San Joaquin River
UNION ISLAND
N
0 5 10 Miles
Explanation
Groundwater Basin
Groundwater Protection Area (DPR)
CONDITION
Leaching
Runoff
Runoff or Leaching
Coalition boundary
Hydrogeologically Vulnerable Area (SWRCB)


Draft High Vulnerability Groundwater Areas
& Farmland Mapping and Monitoring
Program (FMMP) Areas
East San Joaquin
Water Quality Coalition
DRAFT
About 642,500 irrigated acres (62%) are in groundwater vulnerable areas
Explanation
Draft East San Joaquin Coalition Area
Draft High Vulnerability Areas
FMMP Areas Within High Vulnerability Areas
FMMP Areas Outside High Vulnerability Areas
0 2.5 5 10 Miles
1:450,000
N
S
E
W
Modesto
Turlock
Merced
Chowchilla
Madera
Los Banos
Patterson
Newman
Gustine
Manteca
Escalon
Oakdale
Riverbank
Atwater
Livingston
Delhi
Ceres
Madera Acres
Bonadelle Ranchos-Madera Ranchos
Dos Palos
South Dos Palos
Firebaugh
Mendota
Biola
Fresno
Clovis
San Luis Reservoir
Don Pedro Reservoir
Stanislaus County
Merced County
Nevada
California
GREAT BASIN
Sacramento
San Francisco
Bakersfield
Los Angeles
Tijuana
Mexicali

Nitrogen Management Plans

Key mechanism to minimize nitrogen discharge to surface and groundwater

- High Vulnerability Areas
  - CCA certifies nitrogen plans for members
    - CDFA certification program in development
  - Member self-certification with training
  - Nitrogen Management Plan Summary Reports sent to Third-party
- Low Vulnerability Areas - ?
- Third-party/Ag will develop templates

Nitrogen Management Plans

Potential Components of Plan (from draft template prepared by Coalition)

- Crop Nitrogen Demand
  - Crop type; expected yield; nitrogen crop needs to meet yield
- Nitrogen Supply
  - Total N applied – spring, summer, fall, foliar, manure, compost, other
  - Soil N Credits – from previous legume crop; residual from manure; organic matter mineralization; soil test; amount in irrigation
- N Ratio – Total N Available/Crop Need

Nitrogen Management Plans

Timelines

- Templates from Third-party
  - 90 days after approval as third-party
- High Vulnerability Areas
  - Small Farming Operations (<60 acres)
    - 1 March 2016 – Nitrogen Management Plan
    - 1 March 2017 – N Management Plan Summary Report
  - Other Farming Operations (=> 60 acres)
    - 1 March 2014 – Nitrogen Management Plan
    - 1 March 2015 – N Management Plan Summary Report

Management Practices Evaluation Program

Evaluate whether specific practices are protective of groundwater quality under various site conditions (third-party requirement)

- Required in high vulnerability areas
- Encourages coordinated approach w/all coalitions, commodity groups, others

Representative site conditions

Irrigated ag practice(s)

→ Evaluate effects of discharge

→ Extrapolate to similar sites

What Will the Management Practices Evaluation Program Tell Us?

- For example….
  - Flood irrigation of Almonds on sandy soil
    - protective of groundwater, if nitrogen ratio < 1.X
  - Micro irrigation of Almonds on sandy soil
    - protective of groundwater, if nitrogen ration < 1.Y
- Will want to evaluate yield/quality

Member/Grower Requirements
Management Practices

- Implement management practices
  - Practices found protective through management practices evaluation program
  - Implement practices consistent with regional management plans
  - Meet performance standards and discharge limitations

Coalition/Third Party Requirements in WDR

- Assess surface and groundwater in region
- Compile nitrogen reports from members in high vulnerability areas
- Provide members information on management practices to protect surface/groundwater
  - Focus on growers who need to improve practices (e.g., high N ratio relative to similarly situated growers)

What's Next?

Implementation begins with the adoption of the Eastern San Joaquin River Watershed Order

Other geographic areas and rice should have Orders adopted within a year

What Does Everyone Want?

Clean Water!

- Agricultural coalition approach can help meet that goal – Growers, Commodity Groups have been and MUST be actively engaged!
- Water Board recognizes critical importance of agriculture in the Central Valley
- Working together the progress made in surface water will occur in groundwater

Questions?

Adam Laputz – Project Manager

(best person to contact)

awlaputz@waterboards.ca.gov

Joe Karkoski

jkarkoski@waterboards.ca.gov

ILRP information: 916-464-4611

Management of Nitrogen in Almonds

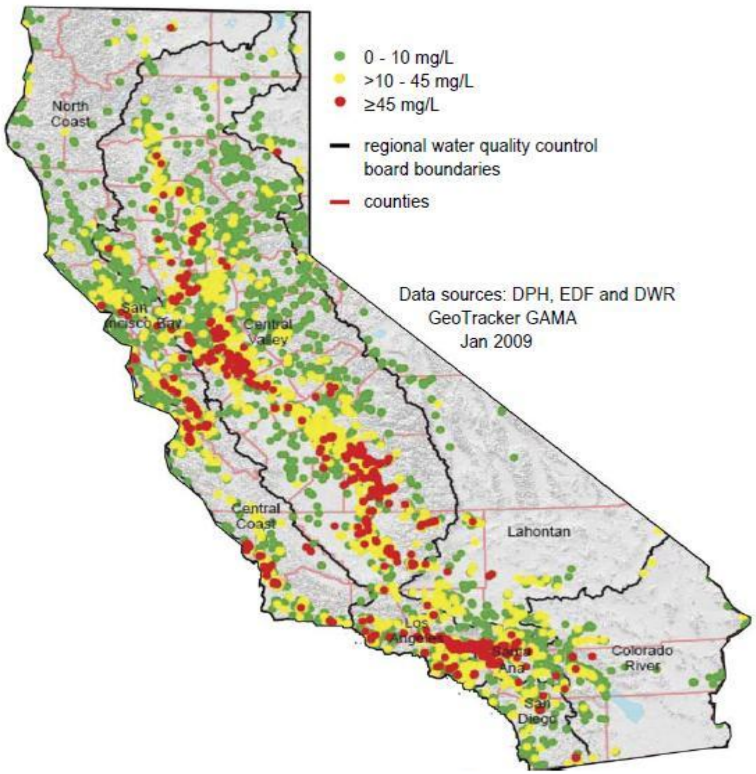
Patrick Brown, Professor,
Department of Plant Sciences
University of California, Davis

Improving the Efficiency of Nitrogen use will Reduce Production Costs and Reduce the Environmental Impact of Nitrogen

- Nitrate concentrations in many California wells exceed state drinking water standards.
- Orchards cover a large area of the Valley

Approaches to improve N use efficiency in Almond:

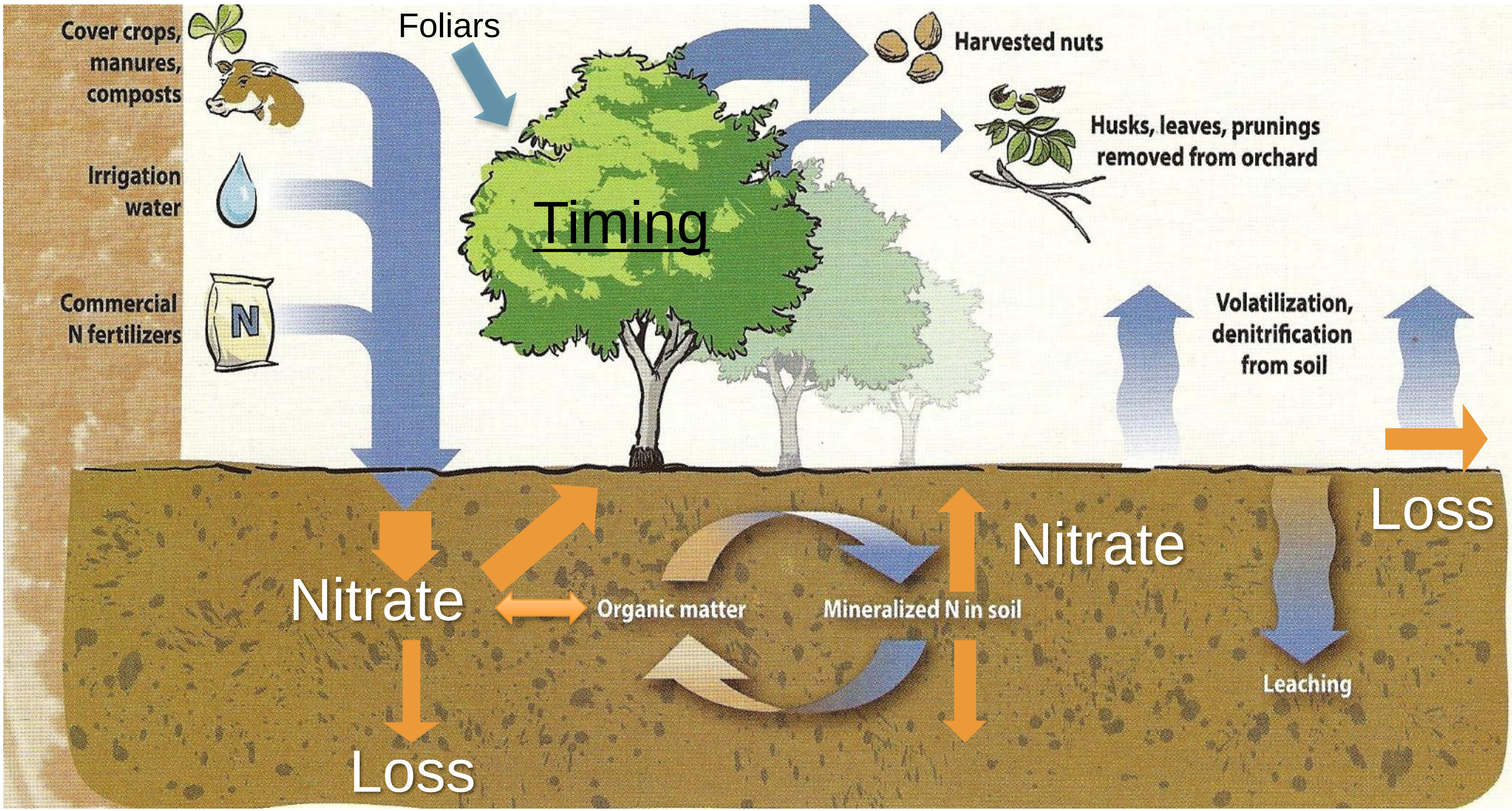
- Improve orchard sampling and monitoring techniques
- Match orchard specific fertilizer rate and application timing with orchard specific demand.
- Avoid losses.
- Develop nitrate monitoring practices that allow growers to adapt and adjust (budgeting, soil and water soil sampling….)



(Ekdahl and others, 2009; Harter Report, 2012)

The Nitrogen Cycle: A balancing act.

Supply Demand



Kathy Kelley-Anderson et al: ANR Pub # 21623

First Principles of Plant Nutrition

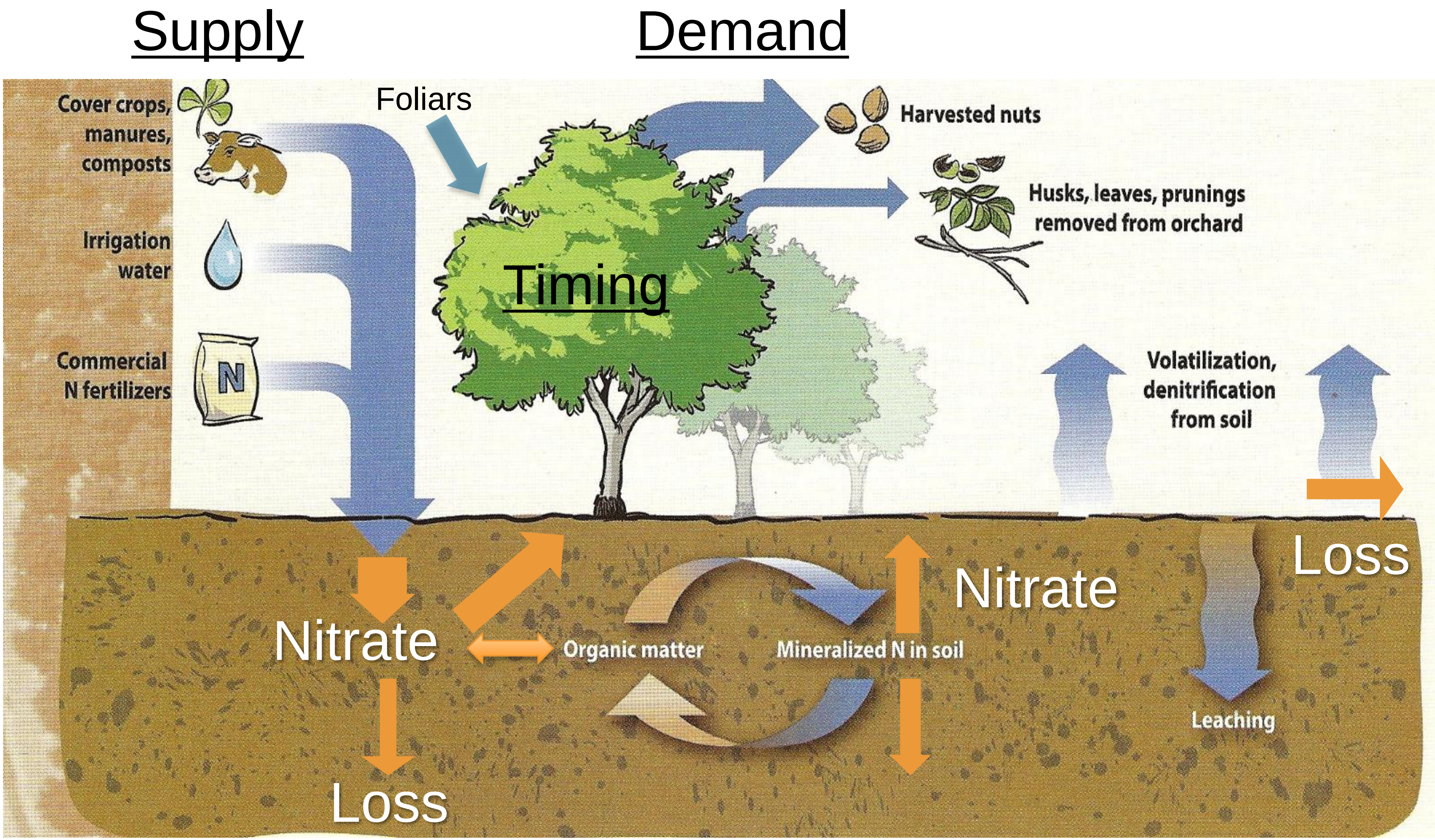
Nutrients are taken up in water only by active roots

- **Active roots are required.**
- **Water, oxygen, suitable temperatures are required for uptake**
- **Leaves are required for nutrient uptake by roots**
- **Uptake is proportional to demand – NOT THE OTHER WAY AROUND!**

Nitrogen fertilizer and groundwater nitrogen is rapidly converted to nitrate in Californian orchards

- **Water movement delivers nitrate to roots**

The Nitrogen Cycle: A balancing act.



Kathy Kelley-Anderson et al: ANR Pub # 21623

Efficient Nitrogen Management
-the 4 R's-

growing ADVANTAGE The Almond Conference

Apply the Right Rate

- Match supply with tree demand (all inputs- fertilizer, organic N, water, soil).

Apply at the Right Time

- Apply coincident with tree demand and root uptake.

Apply In the Right Place

- Ensure delivery to the active roots.
- Minimize movement below root zone

Use the Right Sampling and Monitoring Procedures

The 4 R's are specific to ever individual orchard and every year.

What do we know and how do we manage?

Leaf Sampling and Critical Value Analysis

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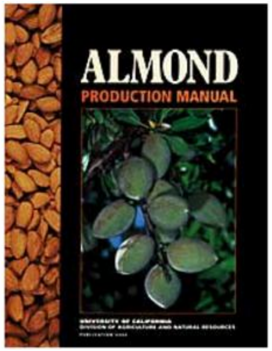
Table 26.2 Critical nutrient levels (dry-weight basis) in almond leaves sampled in July.

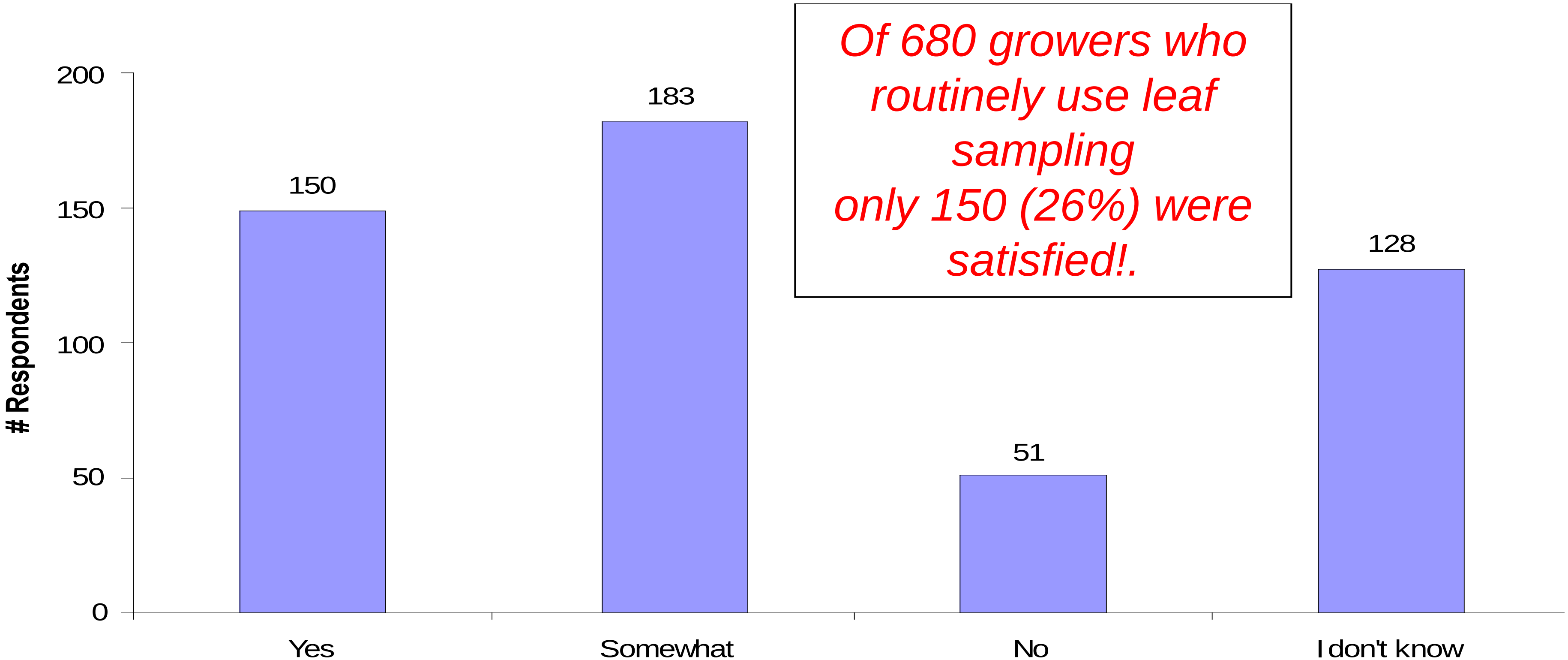


Nitrogen (N)	
Deficient below	2.0%
Adequate	2.2–2.5%
Phosphorus (P)	
Adequate	0.1–0.3%
Potassium (K)	
Deficient below	1.0%
Adequate over	1.4%
Calcium (Ca)	
Adequate over	2.0%
Magnesium (Mg)	
Adequate over	0.25%
Sodium (Na)	
Excessive over	0.25%
Chlorine (Cl)	
Excessive over	0.3%
Boron (B)*	
Deficient below	30 ppm
Adequate	30–65 ppm
Excessive over	300 ppm
Copper (Cu)	
Adequate over	4 ppm
Manganese (Mn)	
Adequate over	20 ppm
Zinc (Zn)	
Deficient below	15 ppm

*Critical values for boron deficiency and toxicity are currently being revised. Hull boron >300 ppm is excessive. Leaf sampling is not effective to determine excess boron.

Is Leaf Sampling and Analysis Trusted?

Are the Current Guidelines for Leaf Testing Adequate to make Fertilization Decisions?



Brown et al, 2007

Reasons for low satisfaction:

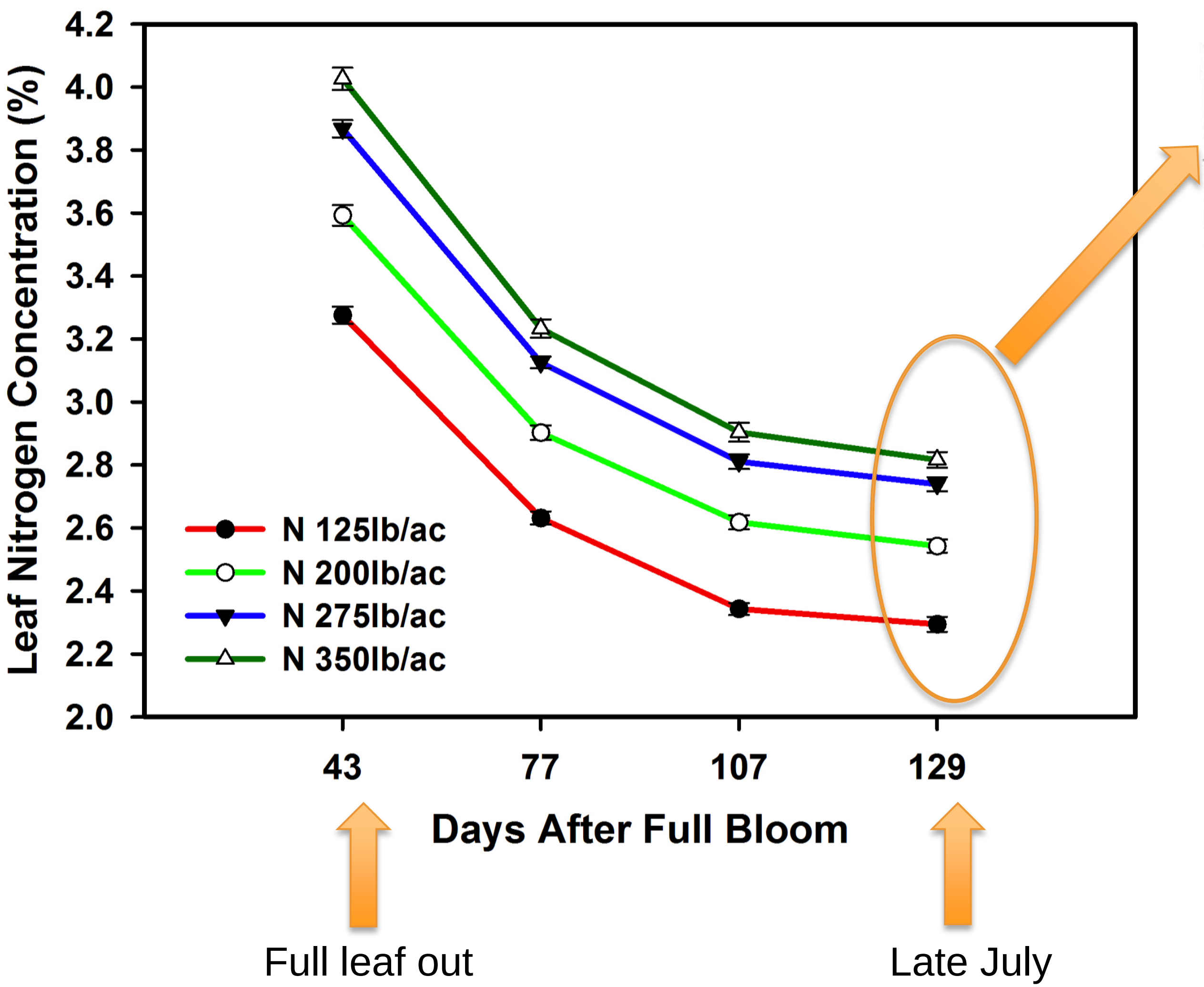
1. Late summer sampling is too late in year to make in-season adjustments.

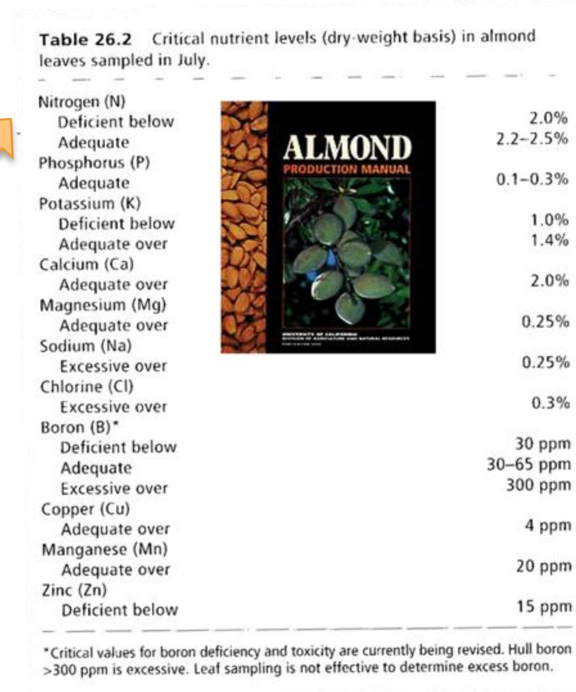
2. Samples collected do not always represent the true nutrient status of the orchard as a whole.

3. Leaf sampling is useful for detection and monitoring but provides no guideline on how to fertilize!
    1. Leaf analysis can indicate a shortage or excess but cannot define how to respond.
    2. No guidance on Rate, Timing, or Placement (NO R's)

4. Provides no estimate of efficiency of N use

Problem 1: Sampling is too late to adjust fertilizer for current crop load.





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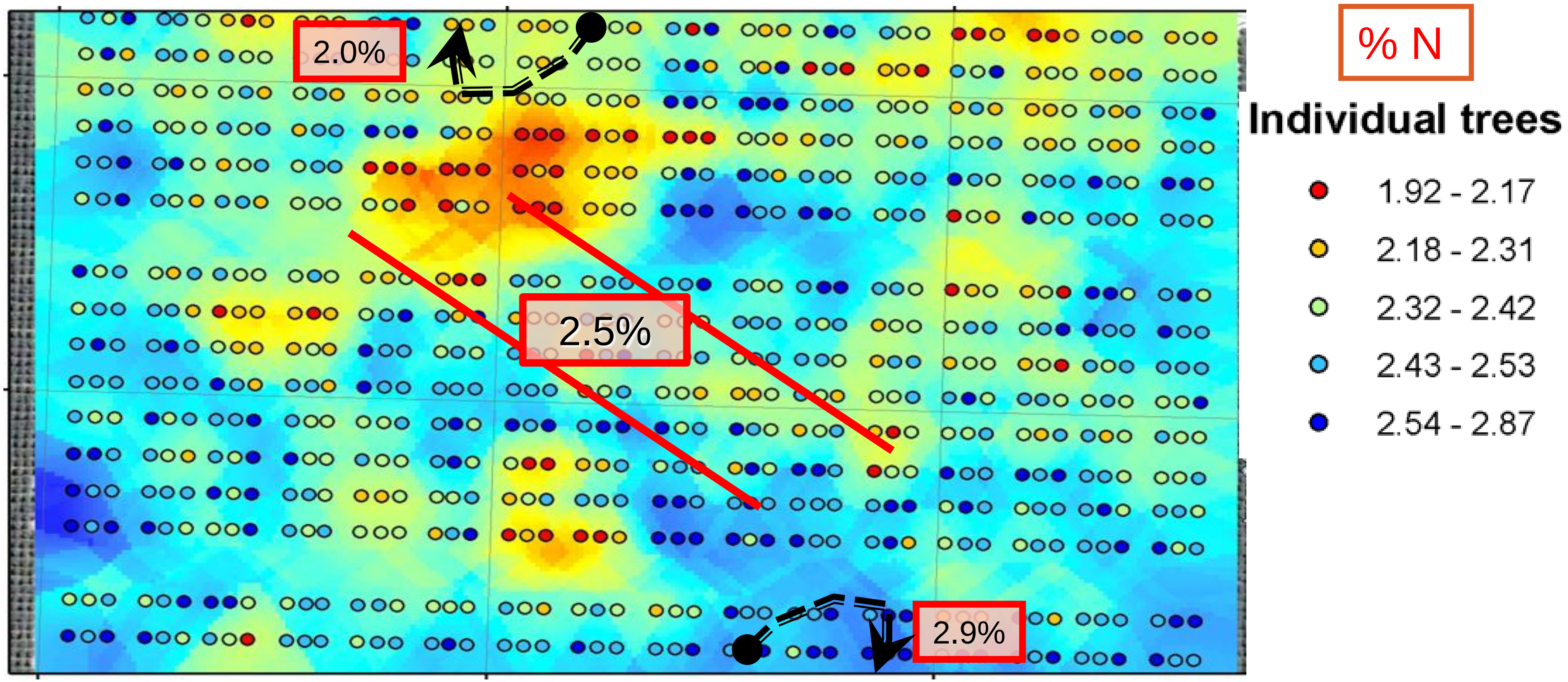
Problem 2: Field Variability

Common Sampling Practices are Inadequate:



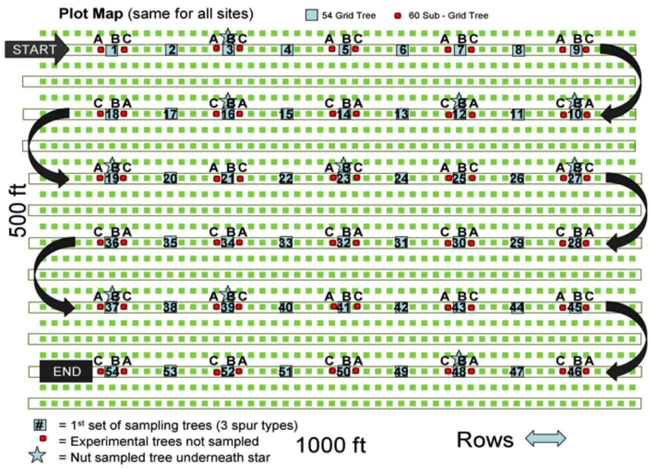
What is the average nutrient concentration and how much variability is there?

Improved Tissue Sampling and Interpretation:

- **Develop methods to sample in spring and relate that number to summer critical value.**
- **Develop sampling methods that accurately predict average field nutrient concentration AND variability.**
- **Provide an integrated grower friendly method:**
  - **recognizing that typical practice is to collect only 1 sample per field.**

Experimental Design:

California Wide Sampling



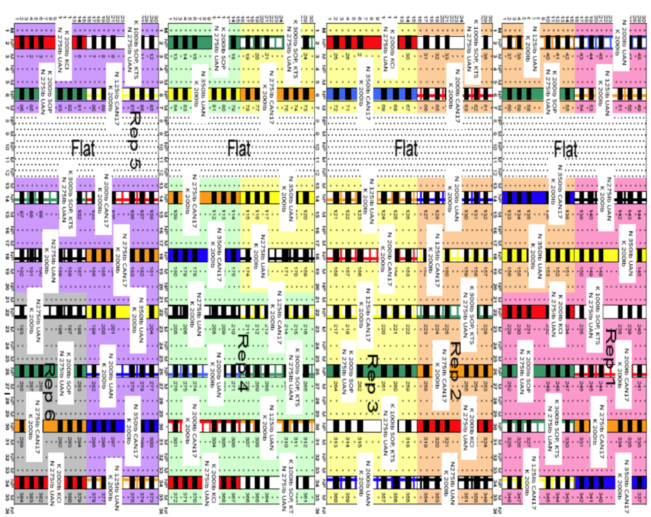
- 100 acre x 4 Sites x 4 years.
- Multiple California Locations

(About 1,130 data points)

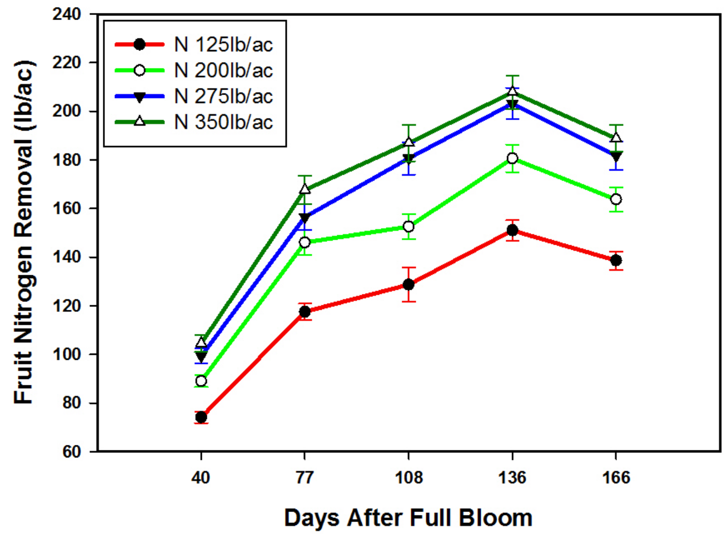
- Rate Trials
- Model/Methods Development
- Validation at 6 sites in 2012.

(8,500 x 11 = 93,500 data points)

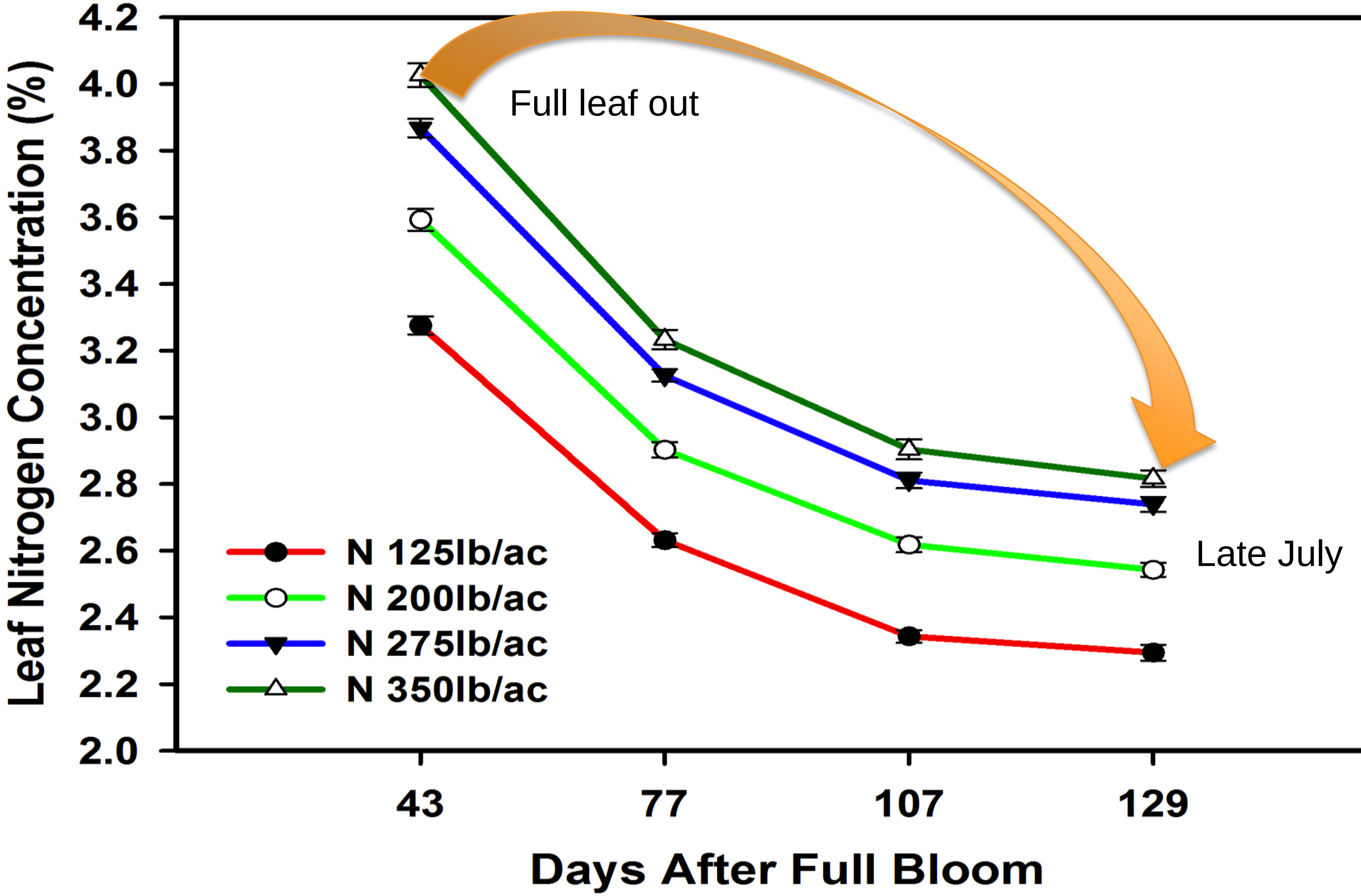
Experimental Trials



Rate Trials



Problem 1: Can we sample leaves in April and predict July leaf nutrients?



YES: Spring samples can effectively predict summer tissue values:

growing ADVANTAGE
The Almond Conference

Method based upon 5 years experimental data across California.

Collect leaf samples as early as 40 days after bloom from non fruiting spurs.

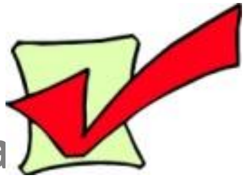
Analyze leaf P, S, B, Mn, Cu, N, K, Ca, Mg

Apply UCD-ESP model (available on-line and provided to all tissue testing labs)

Site	Year	Predicted N based on April Sample	Measured Leaf N in July
Arbuckle	8	2.4	2.3
Belridge	8	2.4	2.4
Madera	8	2.5	2.4
Modesto	8	2.4	2.4
Arbuckle	9	2.4	2.6
Belridge	9	2.4	2.4
Madera	9	2.6	2.4
Modesto	9	2.6	2.7
Arbuckle	10	2.4	2.5
Belridge	10	2.3	2.7
Madera	10	2.3	2.3
Modesto	10	2.4	2.5

Objectives:

- Develop methods to sample in spring and relate that number to late summer critical va



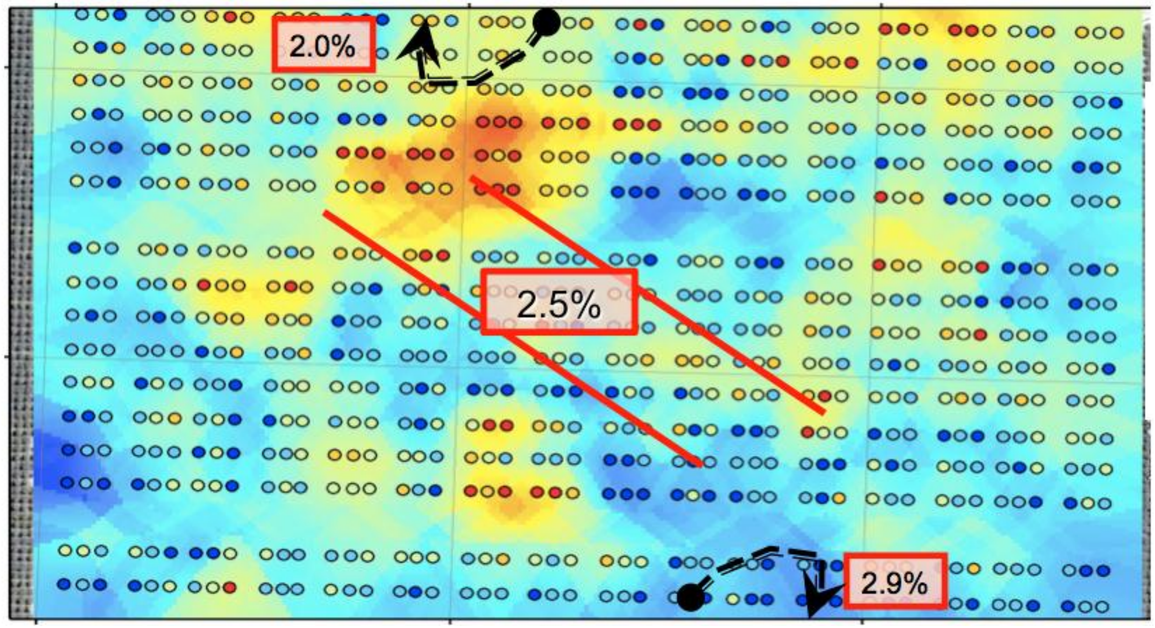
- **Develop a protocol for growers to sample their fields properly (recognizing that only 1 sample per field is generally collected).**

Field Variability:

How many trees should be sampled?

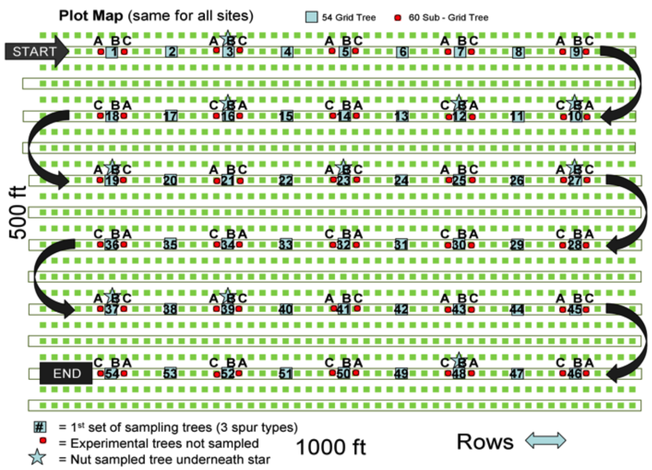
How far apart?

Which leaf type?



Experimental Design:

California Wide Sampling



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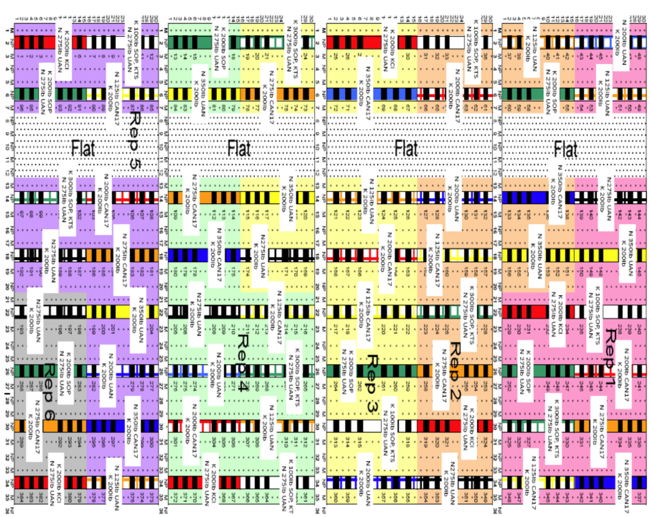
Experimental Trials



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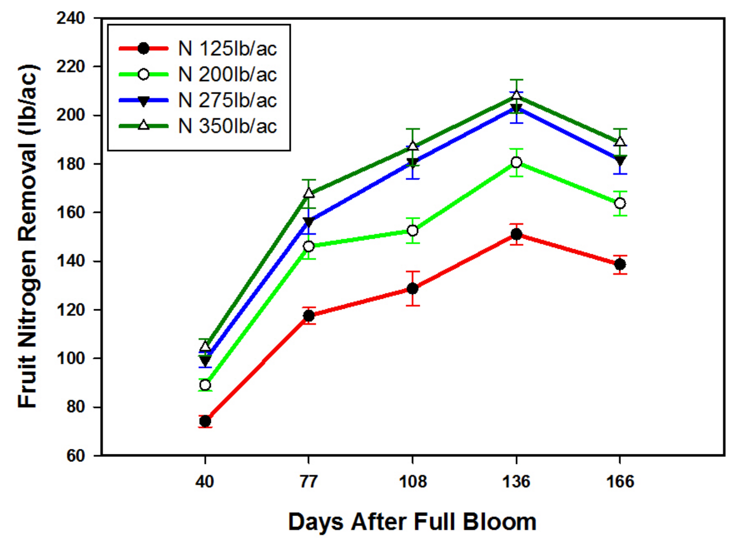


Recommended Sampling Criteria: Almond

<u>Average Orchard (10-200 acre block. Spring or Summer Sampling)</u>

Collect leaves from 18 trees in one bag.

Each tree sampled at least 30 yards apart.

In each tree collect leaves around the canopy from at least 8 well exposed spurs located between 5-7 feet from the ground.

In spring, collect samples soon after full leaf expansion (approx. 30-50 days after full bloom (DAFB). In summer, collect at traditional sampling date.

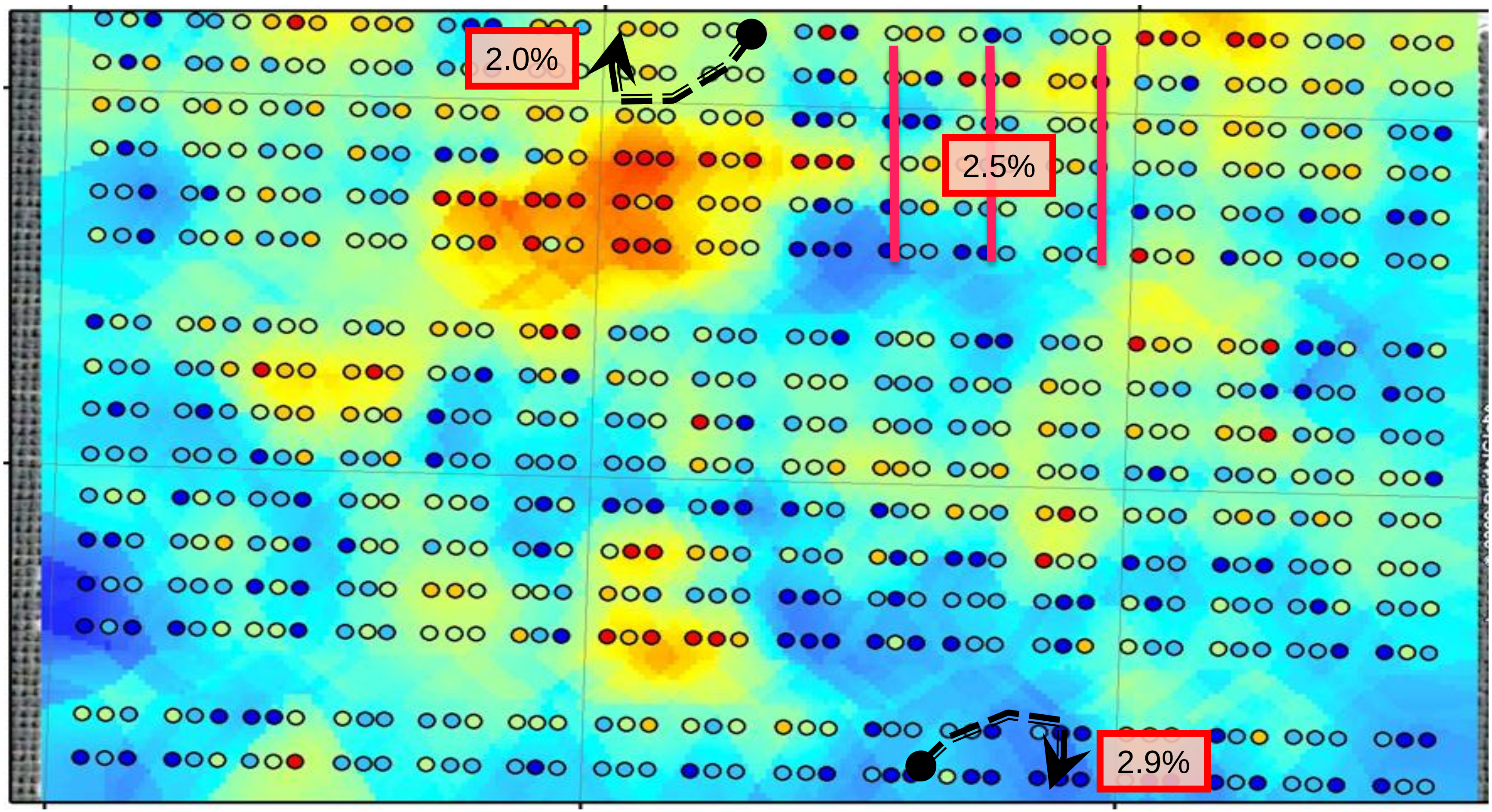
Have lab analyze for P, S, B, Mn, Cu, N, K, Ca, Mg and apply UCD-ESP model to predict July nutrient status.

<u>Non-Uniform Orchard:</u>

Areas of clearly different production should be sampled (and managed) separately.

Correct Sampling Strategy

Collect all leaves from 8 non-fruiting well exposed spurs from 18 trees. Combine leaves in single bag. Each tree MUST be 30 yards apart.
Areas of clearly different production should be sampled (and managed) separately.

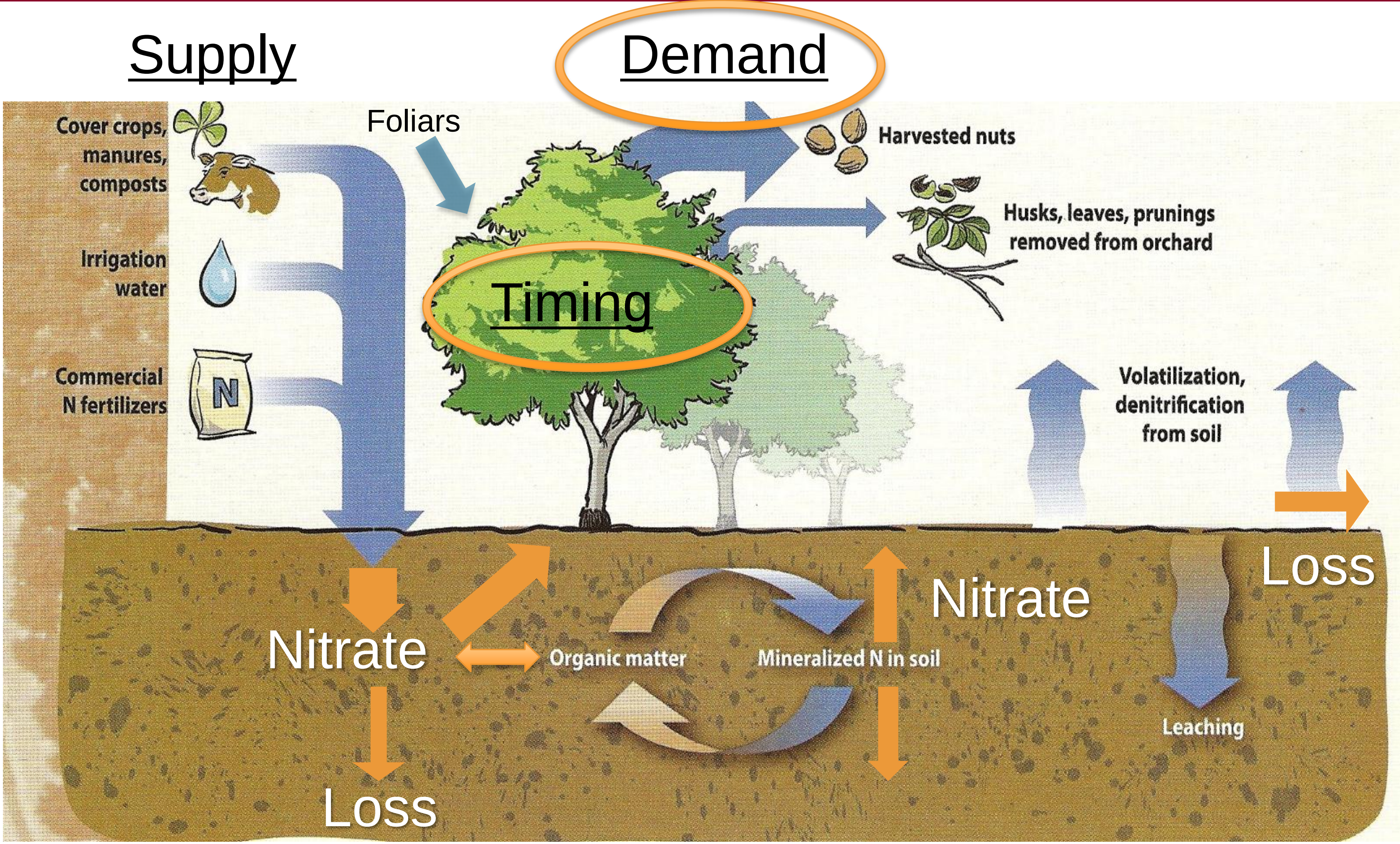


Objectives:

- Develop methods to sample in Spring and relate that number to Summer critical value.
- Develop method for grower to sample his field (recognizing that only 1 sample per field is generally collected).
- Leaf sampling (even perfectly done) is useful for detection and monitoring but provides no guideline on how to fertilize!
    - No guidance on Rate, Timing, or Placement (NO R’s)
    - Provides no estimate of efficiency of N use

AN ADDITIONAL APPROACH IS NEEDED

The Nitrogen Cycle: A balancing act.



Kathy Kelley-Anderson et al: ANR Pub # 21623

Efficient Nitrogen Management
-the 4 R's-

Apply the Right Rate

- Match supply with tree demand (all inputs- fertilizer, organic N, water, soil).

Apply at the Right Time

- Apply coincident with tree demand and root uptake.

Apply In the Right Place

- Ensure delivery to the active roots.
- Minimize movement below root zone

Use the Right Sampling and Monitoring Procedures

The 4 R's are specific to ever individual orchard and every year.

Determining the Right Rate and Timing

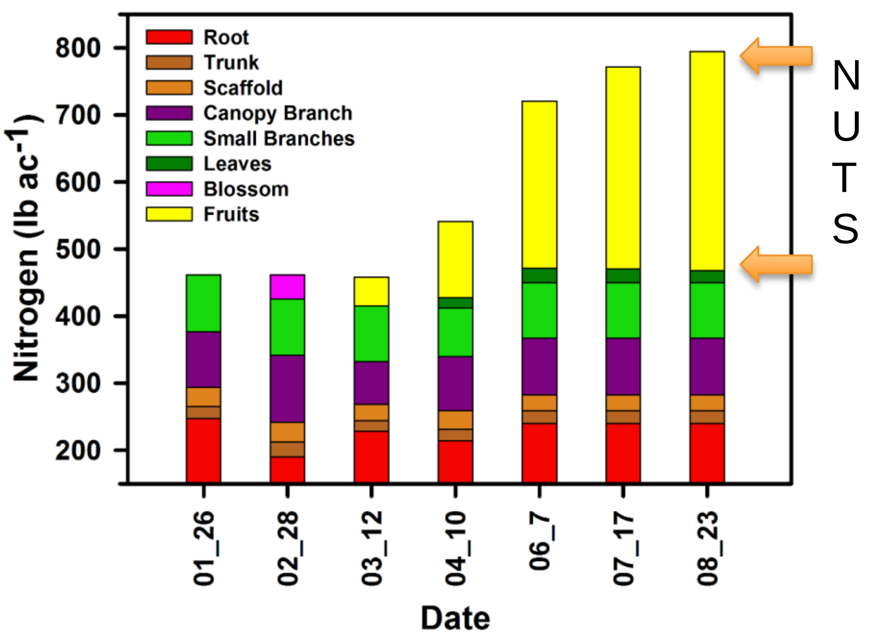
Nutrient Budget Approach

- **What is the total annual tree demand**
- **When during growth and development does uptake occur.**

Approach:

- **Whole tree excavation, trunk coring, sequential nut collection and analysis, yield modeling- 1000's of individual trees**

Nutrient Distribution in Tree Organs



Nutrient Demand is Determined by Yield

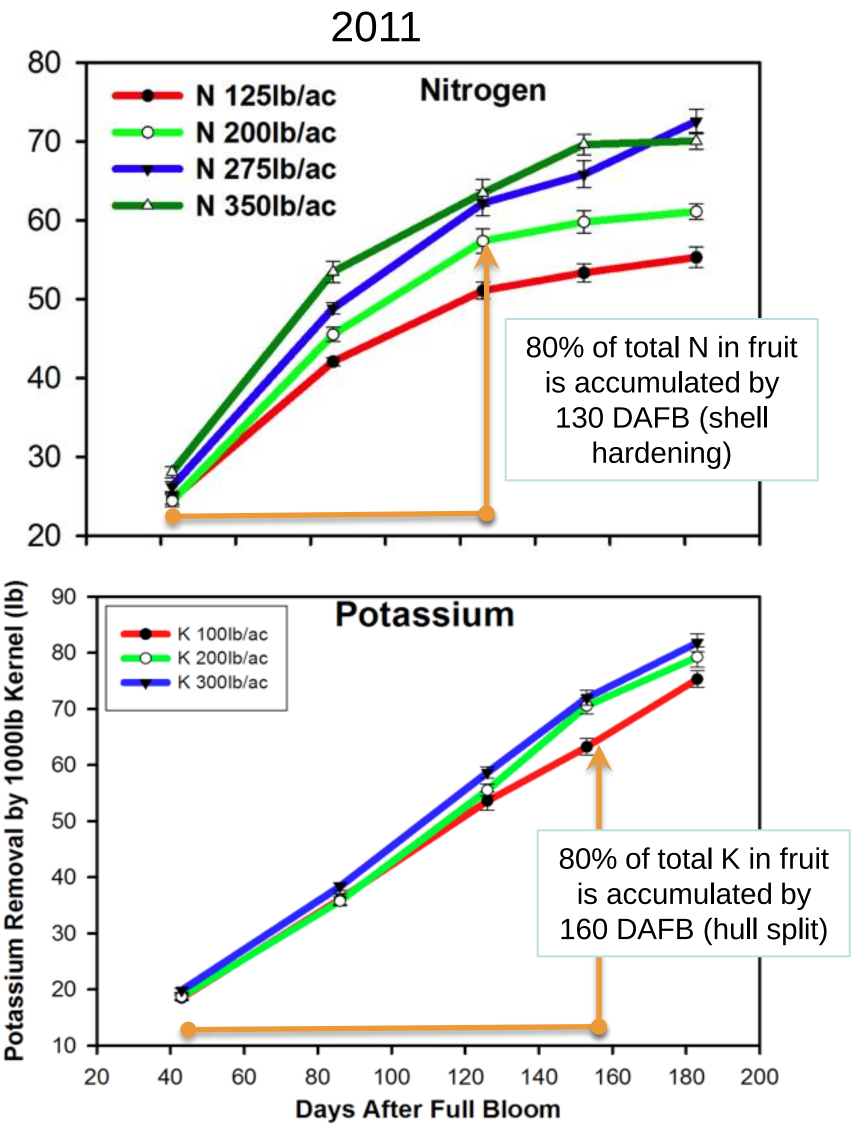
Nutrient removal Per 1000 lb
(Almond =Kernel equivalent)

Nonpareil

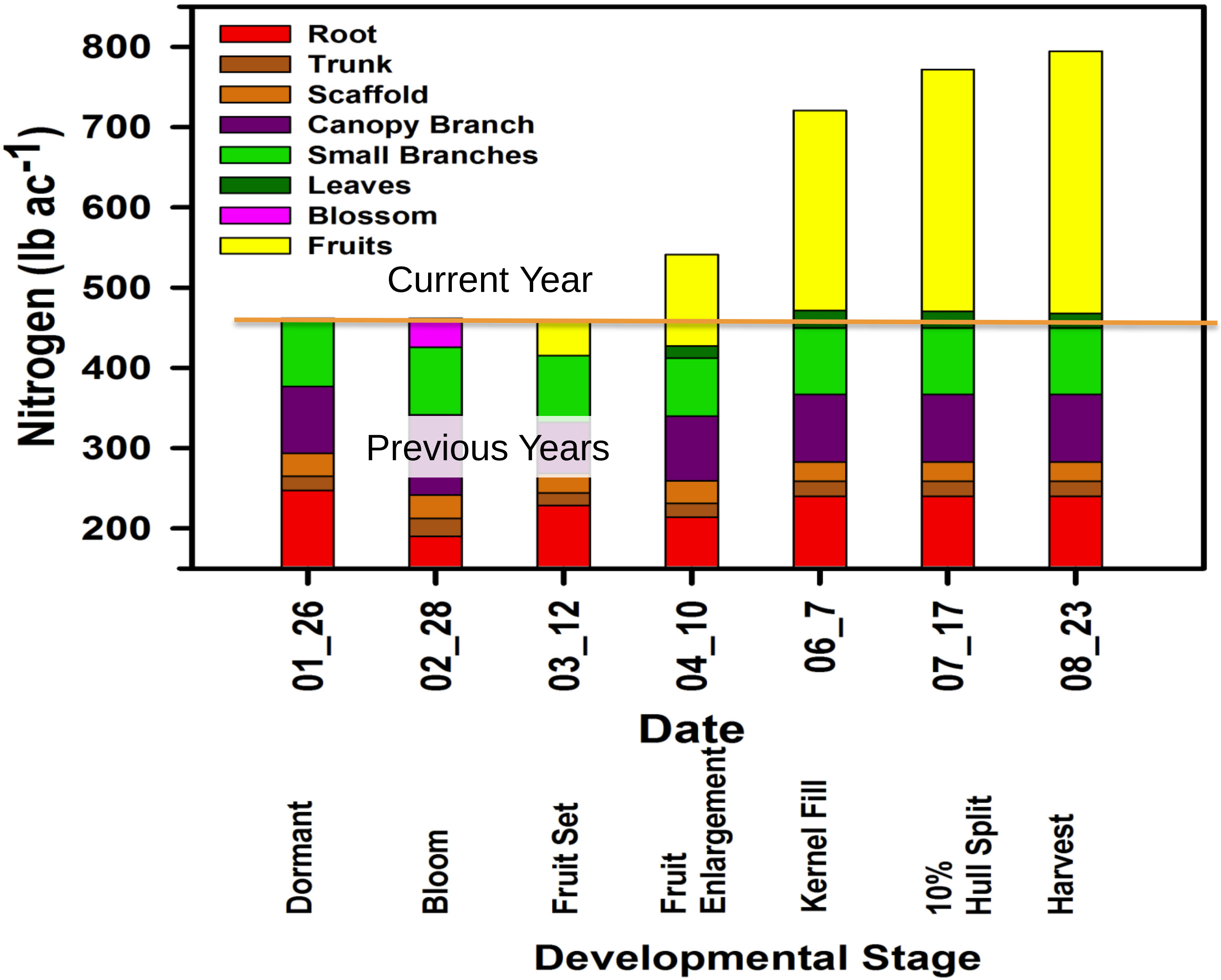
- N removal 68 lb per 1000
- K removal 80 lb per 1000
- P removal 8 lb per 1000

Monterrey

- N removal 65 lb per 1000
- K removal 76 lb per 1000
- P removal 7 lb per 1000



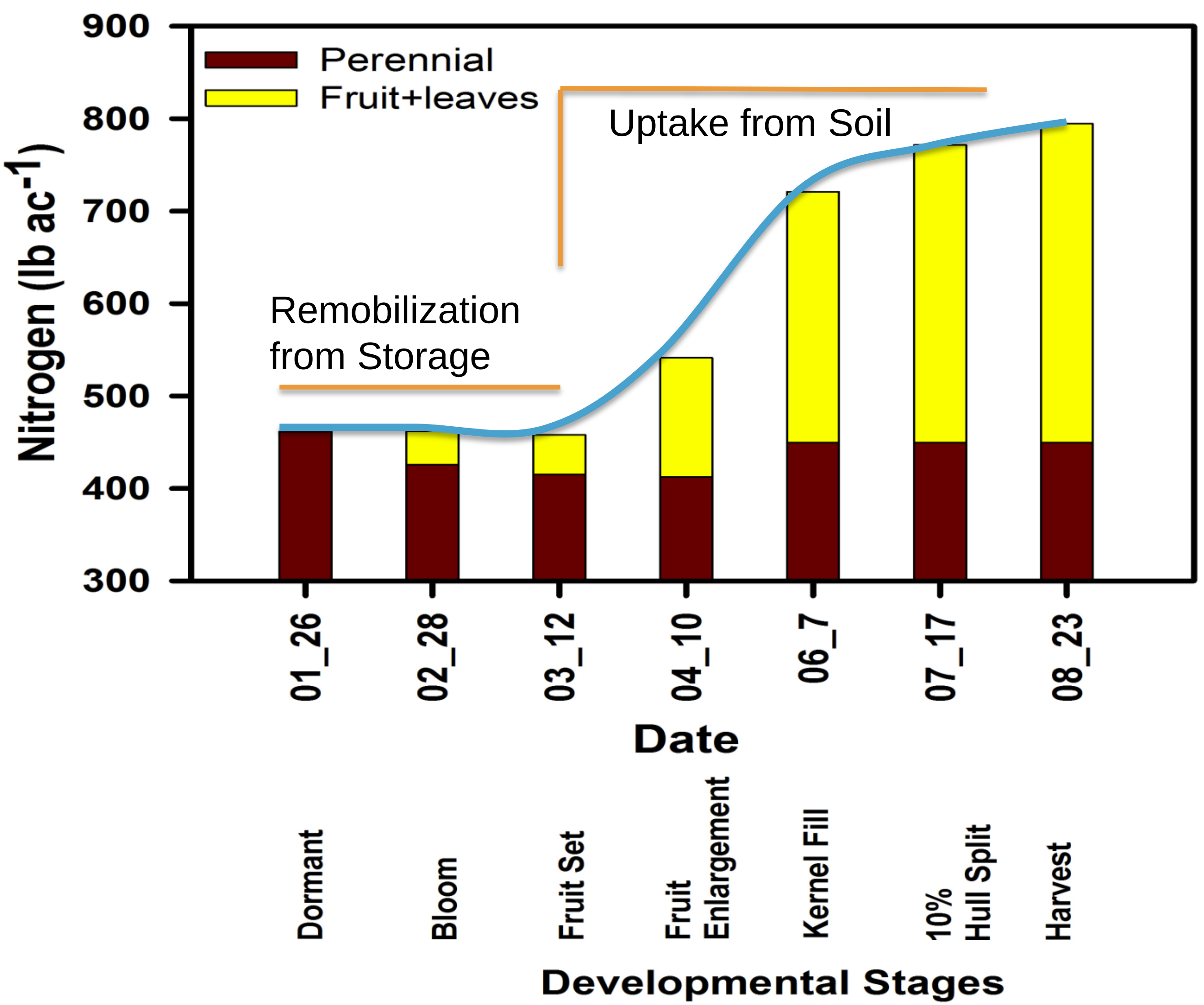
Total and Annual Dynamics of N in Mature Almond Tree (data from 12 year old trees)



Annual accumulation

Nuts = 90%
Leaves = 2%
Bloom = 4%
Perennial = 5%

Total and Annual Dynamics of N in Mature Almond (data from 12 year old trees)



From dormancy to mid-march there is very little N uptake. N for flowering, fruit set and leaf formation is supplied from storage in perennial tissues.

Uptake commences at mid-leaf out and is essentially complete by hull split.

Conclusions: Managing Nitrogen in Almond

growing ADVANTAGE The Almond Conference

Base your fertilization rate on realistic, orchard specific yield, account for all N inputs and adjust in response to spring nutrient and yield estimates.

- **Make a preseason fertilizer plan based on expected yield LESS the N in irrigation and other inputs.**
  - **1000lb kernel removes from 68lb N, 8lb P and 80lb K.**
  - **Apply 20% of seasonal demand after leaf out**
- **Conduct (properly!) a leaf analysis following full leaf out.**
- **In May, review your leaf analysis results and your updated yield estimate, then adjust fertilization for remainder of season.**
- **Time application to match demand in as many split applications as feasible**
  - **80% N uptake occurs from full leaf out to kernel fill.**
  - **Apply up to 20% hull split to immediately post harvest, corrected for actual yield - but only if trees are healthy. Use foliars if N loss is possible**

Conclusions: Managing Nitrogen

Leaf analysis is useful to monitor orchards but it is NOT adequate to make fertilizer decisions.

Follow the sampling rules!

- **18 trees/one bag/each 30 yards apart. You can sample in spring to estimate summer. (working with ABC to validate)**
- **Use leaf analysis in conjunction with yield estimate to adjust in-season fertilization.**
- **Keep good records and sample consistently and correctly over the years.**

How efficient can we be?

Experiment initiated in 2008 – 2013 utilizing best practices based on 4 R's and detailed monitoring:

Applying the Right Rate

- Match demand with supply (all inputs- fertilizer, organic N, water, soil).

At Right Time

- Fertigate coincident with demand.

In the Right Place

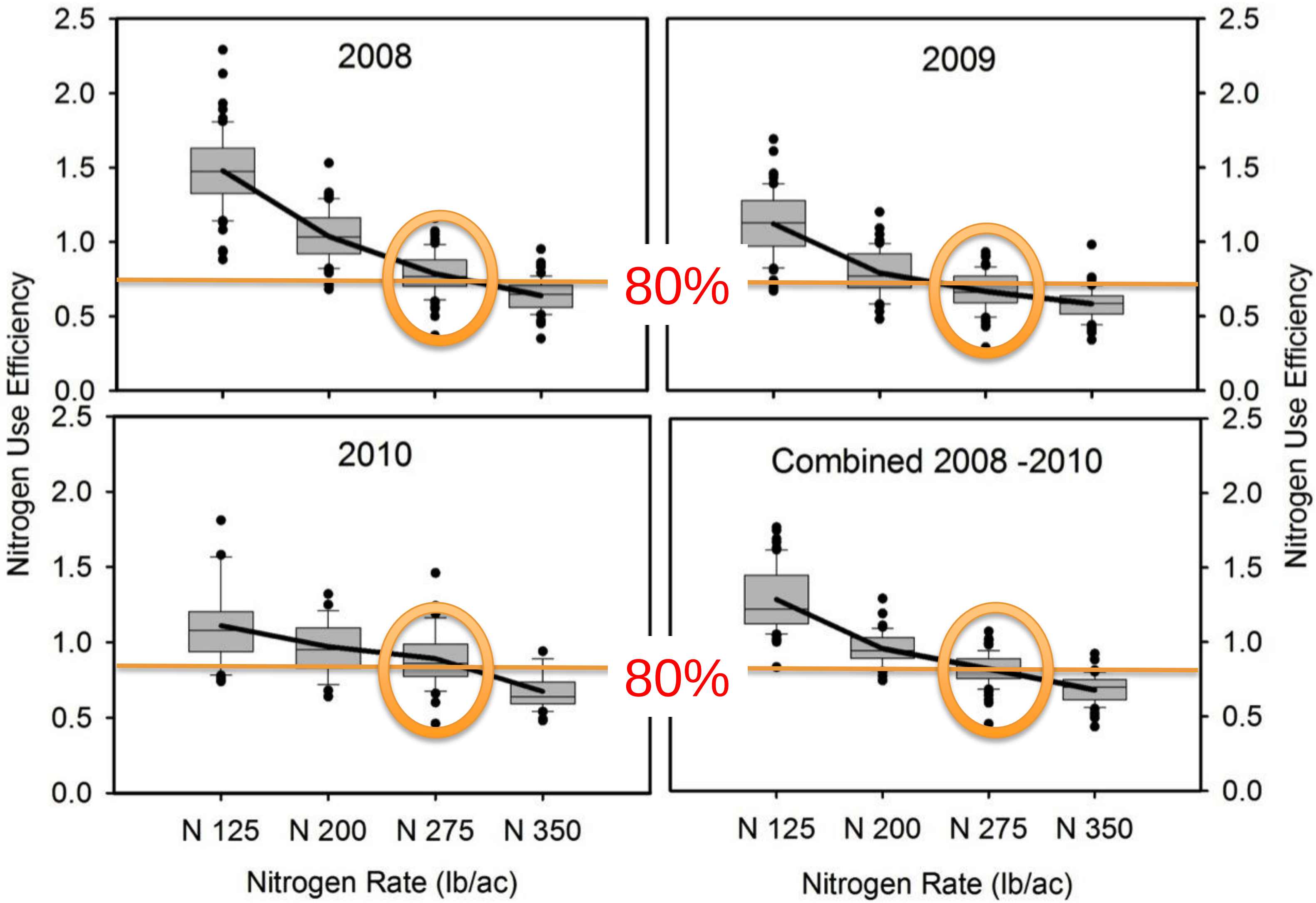
- Ensure delivery to the active roots.

Using the Right Source

- Soluble, compatible and balanced.

New Sampling Methods

Nitrogen Use efficiency 2008 – 2010 under optimum treatment (N 275) was >80%

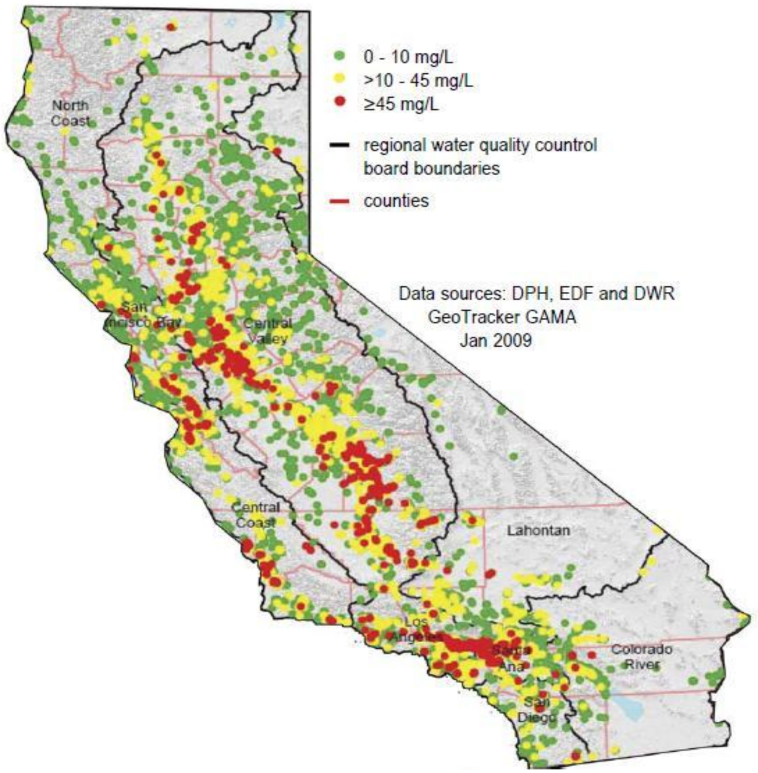


NUE = N Export in Fruit/N Applied

Improving the Efficiency of Nitrogen use will Reduce Production Costs and Reduce the Environmental Impact of Nitrogen

Approaches to improve N use efficiency in Almond:

- Improve orchard sampling and monitoring techniques
- Match orchard specific fertilizer rate and timing with orchard specific demand.
- Manage irrigation to minimize losses.
- Develop nitrate monitoring practices that allow growers to adapt and adjust (budgeting, soil and water soil sampling….)
- Watch the Almond Board website for worksheets, applications and online management tools.
- Contact me (phbrown@ucdavis.edu)



(Ekdahl and others, 2009; Harter Report, 2012)

Thank you!

- Weinbaum, Rosecrance, Uriu, Farm Advisors.

- Sebastian Saa
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- Paramount Farming
- Almond Board of California
- USDA, CDFA