WALNUT NUTRITION
How to Develop a Balanced Program

Bob Beede, UC Farm Advisor

Kings County

http://cekings.ucdavis.edu/

WALNUT

PRODUCTION MANUAL

UNIVERSITY OF CALIFORNIA
DIVISION OF AGRICULTURE AND NATURAL RESOURCES

PUBLICATION 3373

Nutrition Management Involves

Knowledge of:

- Site/Soil characteristics and chemistry
- Plant requirements
- Cropping history
- Fertilizer inputs
- Cultural practices (Irrigation, vegetation management, pruning)
- Tissue analysis
- Observation and judgement

MOST PLANTS REQUIRE 14 ESSENTIAL ELEMENTS FOR NORMAL GROWTH AND REPRODUCTION

THESE ELEMENTS ARE GROUP INTO TWO CATEGORIES, BASED ON THE QUANTITY REQUIRED (MACRO=LARGE, MICRO=SMALL)

MACRONUTRIENTS:

- NITROGEN (N)
- PHOSPHORUS (P)
- POTASSIUM (K)
- CALCIUM (Ca)
- MAGNESIUM (Mg)
- SULFUR (S)

MICRONUTRIENTS:

- IRON (Fe)
- MANGANESE (Mg)
- BORON (B)
- COPPER (Cu)
- ZINC (Zn)
- CHLORINE (Cl)
- MOLYBDENUM (Mo)
- NICKEL (Ni)

How are nutrients obtained?

Soil Science and Plant Nutrient Uptake

- Nutrients are taken up in water only by active roots.
  - Active root growth is required.
  - Water, oxygen, suitable temperatures are required for uptake
  - Leaves are required for nutrient uptake by roots
- N, S, Mg, Ca, B are mobile in most soils
  - Water movement delivers these nutrients to roots
- Mn, Zn, Cu, Ni, Fe have restricted solubility and movement in soils, hence:
  - Active root growth and soil exploration are critical
  - Nutrients and roots must be in the same place
  - Soils that limit root growth can cause Zn, Fe, Cu deficiencies
- K is mobile in some soils but not others
  - Soil tests to determine K-fixation are essential to K management.

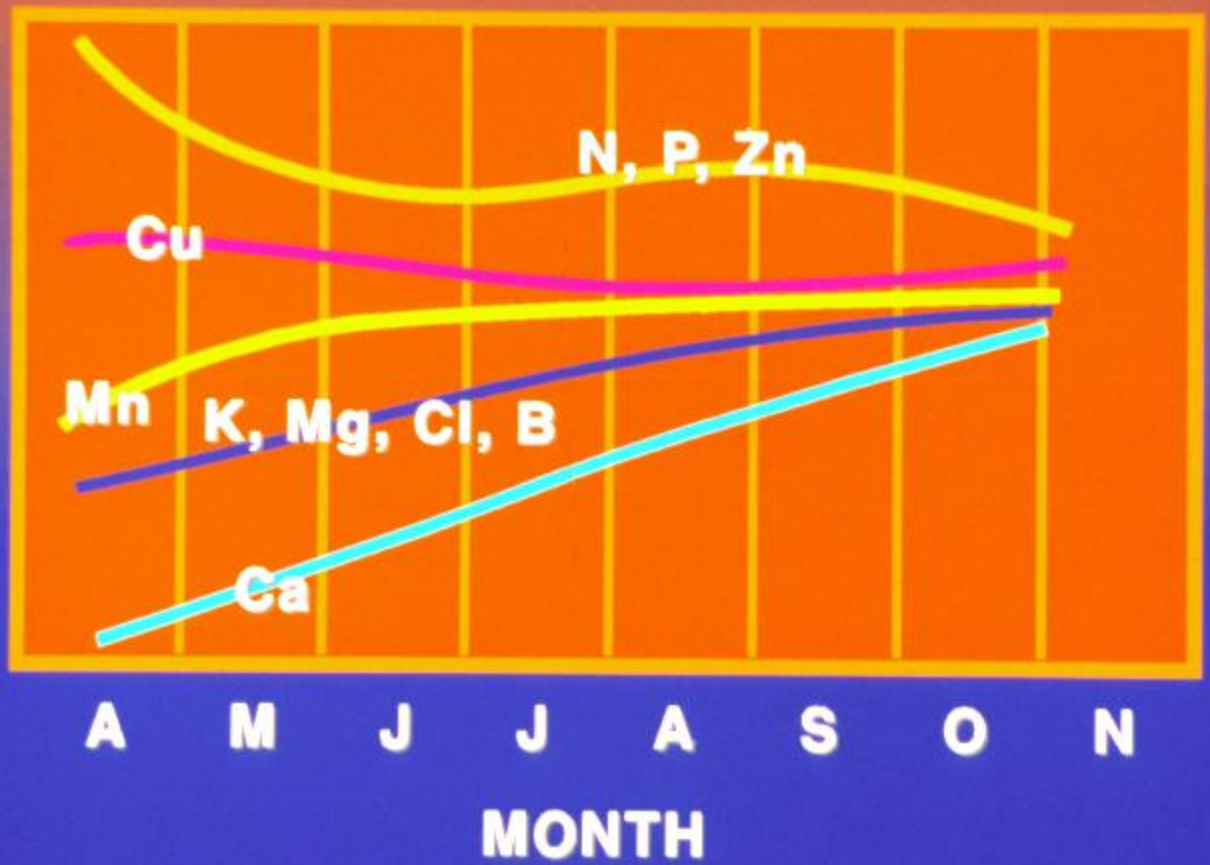
Annual Leaf Tissue Sampling:

- A plant-based measurement which integrates all the factors associated with nutrient extraction from the soil that it inhabits.

- Provides cause for further evaluation of soil and water quality, and fertilization practices.

- Best performed in July. Sample good and bad trees separately. Sample trees suspected of deficiency any time. Compare to good trees.

Nutrient Curves through Season



What approaches do we have to manage and optimize nutrition?

Leaf Samples and Critical Values for Walnut

	Deficient	Adequate	Toxic
Nitrogen	<2.1	2.2 - 3.2	
Potassium	0.9	>1.2	
Zinc	18		
Boron	20	36-300	>300

Concerns:

- Validated for mid-summer samples only.
- Limited guidance provided on how to sample effectively or respond appropriately.

Soil type and texture, pH and irrigation water all affect nutrient availability

Effect of Soil pH:

pH >7.5 < Zn, Cu, Mn, Fe

pH < 6.0 < P, Ca, B

- Old river beds, sandy soils, cuts or fills, old corrals, alkali patches, etc.)

- Soil series: Mg, K availability (dolomite, gypsum, lime)

- Irrigation waters differ in nutrient content

Value of Soil Testing (How and Why)

How:

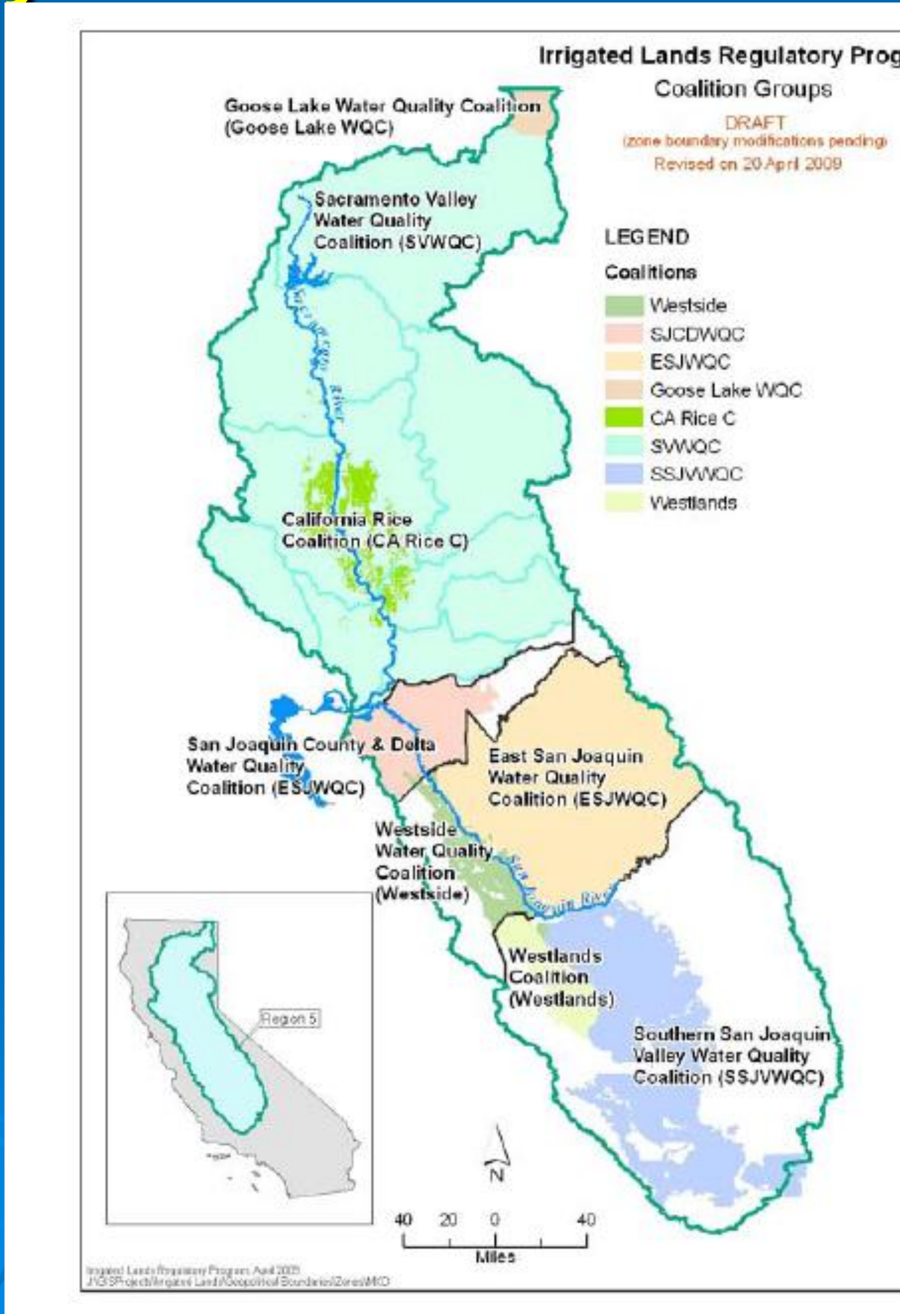
- Collect soil samples that reflect where roots will be growing
- Collect samples from all parts of the orchard and build a ‘map’ of the whole property. Do it and do it right, most soil characteristics don’t change with time.

What:

- Soil tests that provide background information on general soil physical and chemical characteristics are essential for all orchards.
  - pH, Lime/Bicarbonate - as an index of potential solubility of natural and applied nutrients
  - CEC, OM as a measure of buffering capacity
  - Salinity, Toxic Elements, nutrient imbalances.
- Determine K fixation characteristics.
- For most nutrients (with the exception of K, B), soil analyses of nutrient availability are of limited value.

Central Valley Coalitions

- **Sacramento Valley Water Quality Coalition**
  - Bruce Houdesheldt
- **California Rice Commission**
  - Tim Johnson
- **Goose Lake Water Quality Coalition**
- **San Joaquin County & Delta Water Quality Coalition**
  - Michael Wackman
- **Westside San Joaquin River Watershed Coalition**
  - Joseph C. McGahan
  - David Cory
- **East San Joaquin Water Quality Coalition**
  - Parry Klassen
  - Wayne Zipser
- **Southern San Joaquin Valley Water Quality Coalition**
  - David Orth
- **Westlands Coalition**
  - Sue Ramos



What Will Be Required

Grower Responsibilities

- Complete Farm Evaluation *(everyone)*
- Complete Nitrogen Management Plan
  (In high vulnerability groundwater area)
  - Certified by 3rd party or grower trained
  - Low vulnerability keep on site; no certification required
- Sediment and Erosion Control Plan
  (In areas identified as high vulnerability for erosion and sediment discharge)
- More time provided for farming operations < 60 acres total

Farm Management Plans

- Template to be developed by coalitions, reviewed by Water Board
- Report practices "protective of surface and groundwater quality"
- Periodic Updates
  - More frequently in high vulnerability areas
- Deadline for reports
  - High vulnerability: 2014
  - Low Vulnerability: 2017 (keep on farm)

Nitrogen Management Plans

Key mechanism to minimize nitrogen discharge to surface and groundwater

- High Vulnerability Areas
  - CCA certifies nitrogen budgets for members
    - CDFA certification program in development
  - Member self-certification with training
  - Plans kept on site, summary info reported to Coalition
- Low Vulnerability Areas
  - Required but keep on farm

Nitrogen Management Plan Components

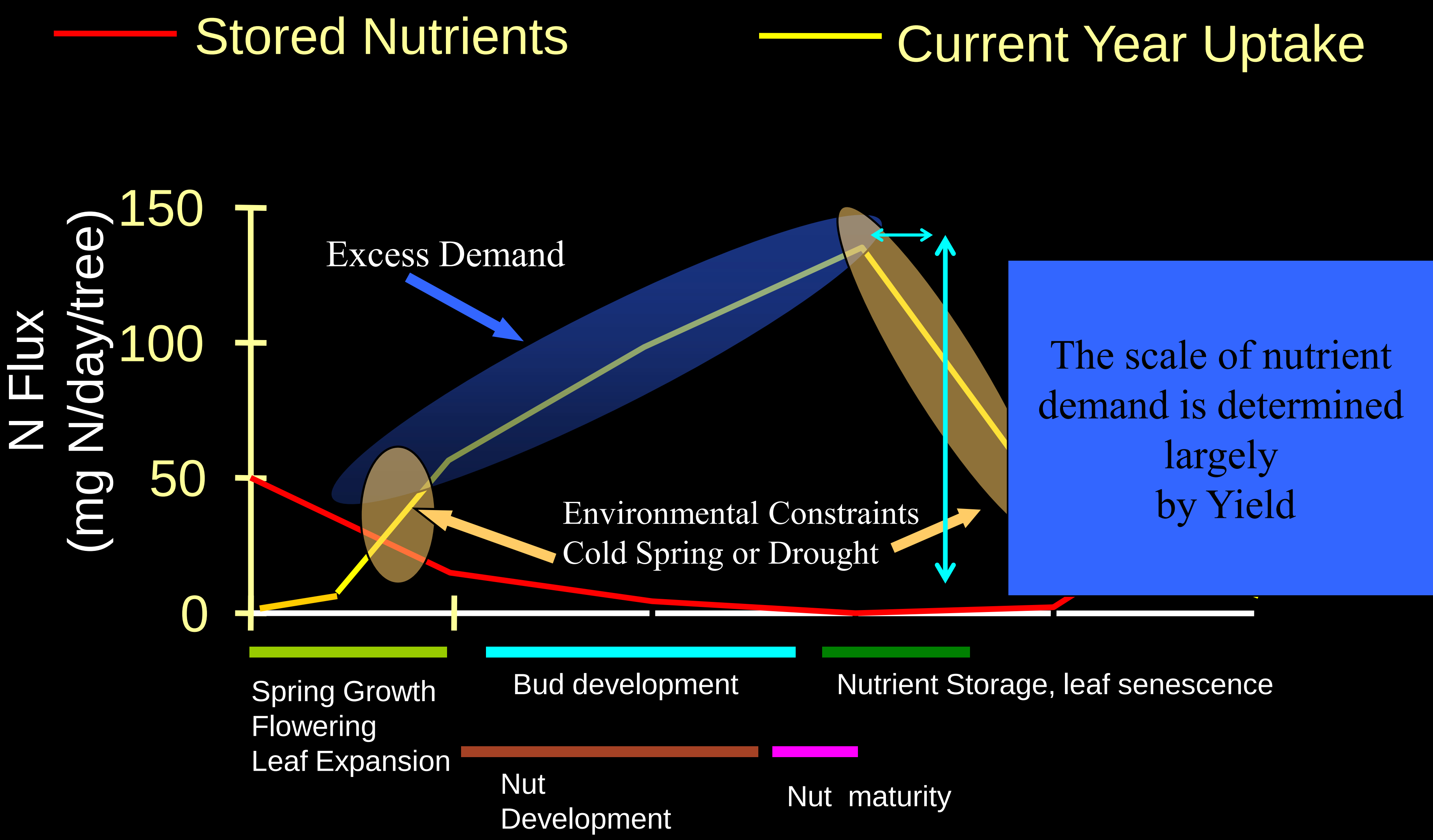
- Apply N at crop removal rates
  - Dairies regulated to 140% of crop use (N applications)
- Test well water for nitrogen levels (then adjust N applications accordingly)
- Leaf / tissue testing
- Soil testing

- Deadline for reports
  - High vulnerability: 2015 for crop year 2014
  - Low Vulnerability: 2017 (keep on farm)

Annual Nitrogen Budget

CROP NITROGEN DEMAND Crop Nitrogen Needs/Uptake	NITROGEN SUPPLY Credits and Applications	
Crop: **WALNUT**	Nutrients: **Total N applied to field** Nitrogen fertilizers (conventional and organic)	
Expected yield (Lbs of Production/acre): **6000**	Spring	75
Nitrogen Crop Needs to meet Excepted yield (lbs of Nitrogen per acre): **200**	Summer	125
	Fall	0
	Folair fertilizers	0
	Other fertilizers	
	Manure	0
	Compost	0
	Bacterial extracts/Compost teas	0
	Other nutritional product	0
	TOTAL N Applied	200
	Soil Nitrogen Credits Soil N ppm[3] Lbs N/acre	
	Nitrogen from previous legume crop	0
	Residual from long-term manure applications	10
	Soil organic matter mineralization	5
	Current soil test levels[4]	10
	Irrigation water nitrogen credits (annualized) (10PPM NITRATE N= 27 LBS N PER ACRE FOOT)	55
	TOTAL N CREDITS	80
	Totals N Credit and Applications:	280
	Crop N needs:	200
	Balance:	90
	Ratio:	1.40

Nutrient Fluxes (N, K, S, P) in Walnut



Composition of walnut

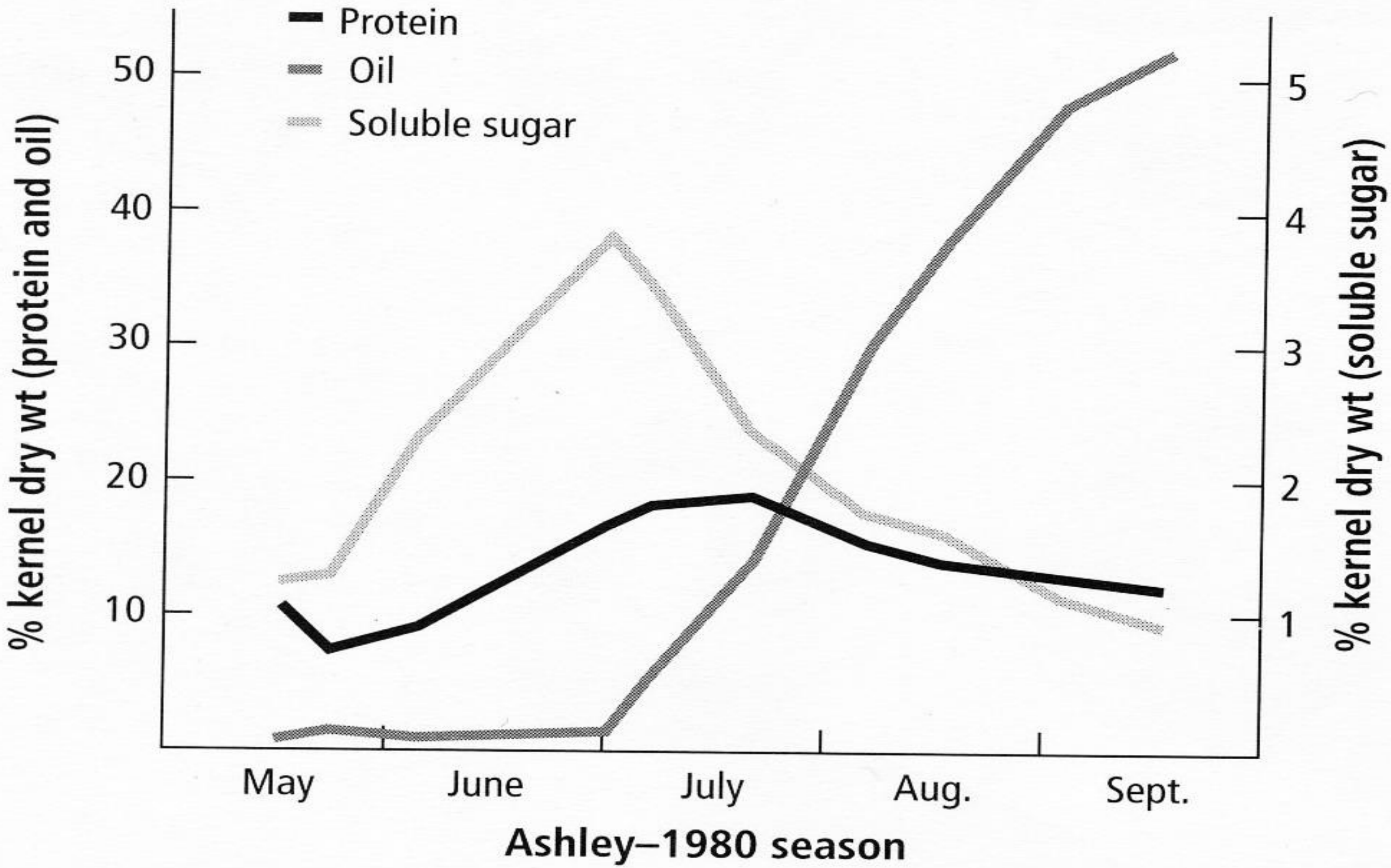


Figure 18.5 This graph shows development-related changes in the proportions of fats (oils), proteins, and alcohol-soluble sugars in the walnut kernel.

Weinbaum N Experiment
1984-1990

Studied N utilization, efficiency of N recovery using isotopic labeled NH_4SO_4

Yield reduction in Serr and Hartley corresponded to midsummer leaf N concentrations below 2.3% dry weight.

Yield recovery requires a minimum of 2 years after N re-application, even though tissue N levels recover in one year.

Weinbaum N Experiment
1984-1990

Approximately 110 lbs/ac of N was removed annually from the orchard in the form of fruit, prunings, and leaves. 80% of the consumed N was in the fruit.

65% of leaf N was transported back into the fruitwood before leaf fall!

Depending upon fertilizer application method, time of application, and irrigation uniformity, about 150-200 lbs actual N should be applied annually as a maintenance program.

Weinbaum N Experiment
1984-1990

The rate of uptake is function of demand and availability.

Approximately 50% of the N within the walnut tree is replaced annually by soil N.

PHOSPHOROUS DEFICIENCY: VOLCANIC PARENT MATERIAL, MT. KONOCTI, LAKE COUNTY

PHOSPHORUS DEFICIENCY: LEAF BROWNING AND DROP, BEGINNING AT THE BASE OF THE SHOOT

POTASSIUM DEFICIENCY IN WALNUT

24.6

Role of Potassium

1. Taken up in ionic form (K^+)

2. Unlike nitrogen, K^+ is not synthesized into compounds, but remains largely in ionic from within cells and tissues

3. K^+ essential for transport of sugars and formation of starch (complex sugar)

4. Regulates stomata through the guard cells

5. Promotes root growth

6. Reduces potential for disease infection

7. Increases fruit size and quality

8. Increases winter hardiness

Properties of Potassium (K) Salts

	Potassium Chloride KCL	Potassium Sulfate K_2SO_4	Potassium Nitrate KNO_3	Potassium Thiosulfate $K_2S_2O_3$
% K_2O	62	50	46	25
Solubility 20^oC H_2O	34gr/100	11gr/100	31.6gr/100	155gr/100
Cost per Ton	$695.00	$770.00	$0.85/lb	$700.00
Cost per Ton K_2O	$1,121.00	$1,540.00	$2,353.00	$2,800.00
250 lb of K_20	$140.00	$192.50	$294.00	$350.00

Note: K_2O X .83 = K

Annual walnut K requirement estimated at 61 lbs K_2O per year for 2 ton crop

Bill Olson K Experiment
(UC Farm Advisor, Emeritus, Butte County)
1984-1990

A. Two trials in K deficient walnut orchards
   1. Orchard 1 (1984): Clay loam

B. Treatments (all KCL):

1. 1000 lbs/ac drilled one time
2. 400 lbs/ac banded both sides 6ft from trunk annually in Nov.
3. 400 lbs/ac fertigated in sprinklers 4X annually (100 lbs each)
4. 1500 lbs/ac banded in 1986
5. 1500 lbs/ac banded in 1986-88, and 400 lbs banded in 1989
6. Untreated check

Olson K Experiment
1984-1990

Orchard 1 results (clay loam)

1. Five years required before annual 400lbs. KCL treatment corrected deficiency

2. Banded applications better than sprinkler

3. Single 1000 lbs. treatment only slightly effective

4. Single and multiple 1500 lbs. treatments both showed Immediate and continued tissue K improvement

Bill Olson K Experiment
1984-1990

Orchard 2 (1987): Sandy loam

Treatments (all KCL applied with Ranchero spreader):

1. 400 lbs/ac banded annually in Nov.
   on both sides 6 ft from trunk

2. 400 lbs/ac banded annually in Nov.
   in center of row

3. 1600 lbs/ac banded once in 1987

4. Untreated Check

Bill Olson K Experiment
1984-1990

Results

Orchard 2 (Sandy loam):

All Treatments provided correction

MICRONUTRIENT DEFICIENCIES IN NUT CROPS:

HOW COMMON ARE THEY?

	Zn	B	Fe	Cu	Mn	Ni
ALMONDS	3	2	2	0	2	0
WALNUTS	3	1	0	0	2	0
PISTACHIOS	3	3	0	3	2	0
PECANS	3	0	0	0	2	0

VISUAL SCALE: 0= never seen, 1= rarely, 2= occasional, 3= often

The Role of Zinc in Plants

1. Required for Auxin (NAA) formulation
2. Auxin involved in cell elongation
3. Associated with chloroplast formulation
4. Essential for pollen development, flower bud differentiation and fruit set

Diagnosing Zinc Deficiency

1. Visual symptoms
2. Consider soil chemistry
3. Rootstock: Nemaguard > Lovell > Marianna
4. Variety: Plum > Peach, Nectarine
   - Friar, Blackamber

Diagnosing Zinc Defieiency
(continued)

5. Tree vigor
6. Nitrogen source:
   – High Phosphorous (manure) ties up Zinc
7. Weather/Spring irrigation source
8. Tissue analysis

Factors Affecting Soil-Zinc Availability

1. pH
   - Solubility decreases 100 fold for each unit increase in pH
     - pH 5 = 10^{-4} M (6.5 ppm)
     - pH 8 10^{-6} M (0.007 ppm)
2. Cut areas likely to be more deficient

Factors Affecting Soil-Zinc Availability

3. High Magnesium or Phosphorous reduces Zinc availability
4. Methyl Bromide fumigation causes temporary loss of mycorrhizal fungi
5. Calcareous materials (lime) reduce Zinc availability

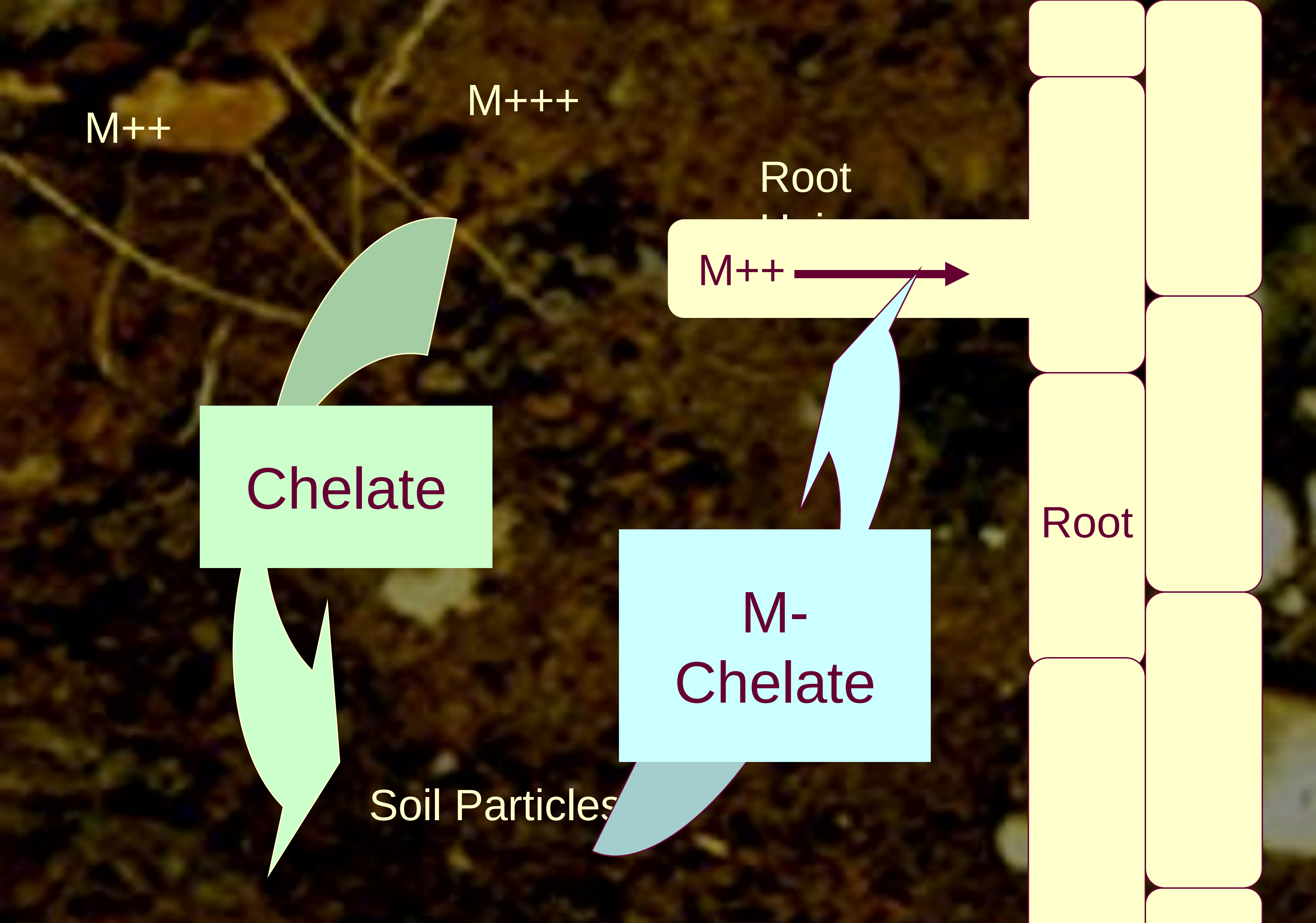
Tissue Sampling for Zinc Deficiency

1. Compare leaves of similar age from trees with and without symptoms
2. Sample leaves with symptoms
3. Do not sample leaves sprayed with zinc

Correcting Zinc Defieiency

Soil:

1. Expensive
2. Less effective due to fixation



Mobilization of soil metal ions by chelates (after Lindsay [1974])

Correcting Zinc Defieiency

Foliar

1. Effective
2. Safe with correct material for desired time
3. Concentrate (100 GPA) safer than dilute (300-400 GPA)

SPRING FOLIAR TREATMENT RECOMMENDATIONS FOR NUT CROPS:

ALMONDS:

A. CHLEATED ZINCS OR ZIRAM AT PETAL FALL WHEN ADEQUATE FOLIAGE EXISTS

B. WHEN RAIN UNLIKELY, 10 LBS/AC BASIC ZINC SULFATE IN 100 GALS. APPLIED ONCE OR TWICE, 3 WEEKS APART.

C. ADD ZN COMPATIBLE WITH COVER SPRAYS DURING SEASON

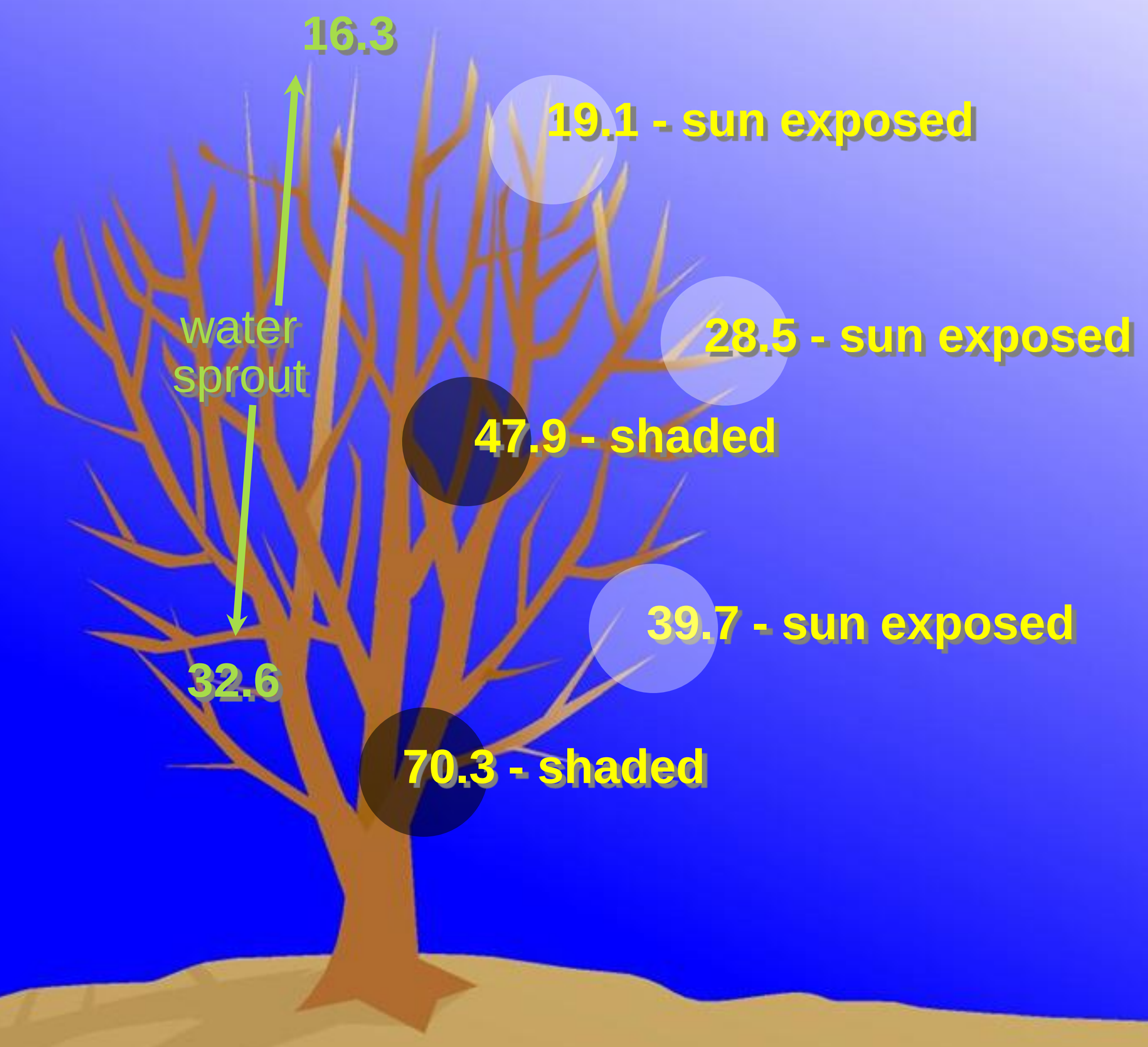
WALNUTS:

A. 3-4 LBS/AC 36% ZN IN 100GPA APPLIED POST-BLOOM AT 6-10” OF SHOOT GROWTH. REPEAT IF ZINC SYMPTOMS SEEN

B. FOR SEVERE DEFICIENCY, APPLY ONE LB. ZN EDTA 14% PER TREE, 4-5’ FROM TRUNK, IN A SMALL TRENCH. COVER.

C. SURVEY TREES> 40’ FOR ZINC IN UPPER CANOPY. TREAT BY AIR WITH 36% OR CHELATE

Shoot Zn Distribution Through A Dormant Peach Tree (ppm)



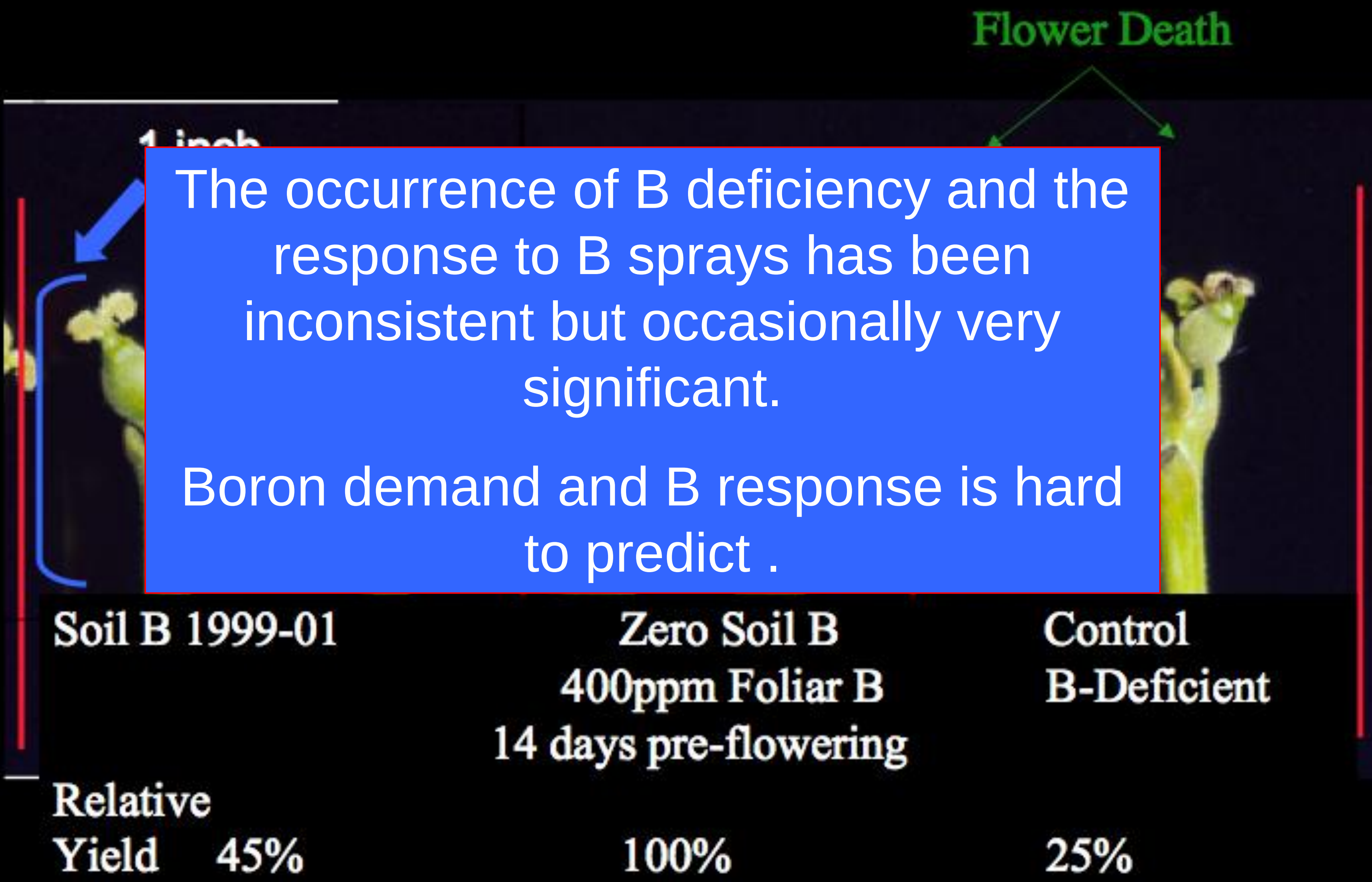
Boron

Boron is a Building Block for the cell wall and

hence all Growth, especially flowers and fruits.

- Nutrient Uptake and Assimilation
  - Uncharged element, not fixed in CA Walnut soils. Deficiency can occur in all soils supplied with low B irrigation water.
  - Stored in organic residue.
- Function
  - Cell Wall Construction
  - Pollen formation and fertilization
- Mobility
  - Highly immobile in Walnut
  - Lack of mobility and high demand for reproduction can result in critical short term deficiencies that are hard to detect or predict but are potentially very important.

B Deficiency: Flower Abortion in Walnut



The occurrence of B deficiency and the response to B sprays has been inconsistent but occasionally very significant.

Boron demand and B response is hard to predict .


24.11

Methyl Bromide Alternatives Trial-Kings County

Bob Beede, UC Kings Co. Farm Advisor

Mike McKenry, Extension Specialist Riverside

Dan Kluepfel, USDA-ARS Davis

Tony Garcia, Kings Co. Ag. Assist.

USDA-ARS and UC GIVE GREAT THANKS

To Tri-Cal, Inc. for their superior support!

Local Reps:

Bob Montgomery

Ramon Sanchez

Treatments

1 - White: Untreated Control

2 - Pink: Methyl Bromide broadcast at 400 lb/ac.

3 - Yellow: Telone II at 33.7 g/ac strip-treated (10' swath) and shanked at 20".

4 - Blue: Telone II at 33.7 g/ac broadcast and shanked at 20".

5 - Orange: Telone II at 33.7 g/ac broadcast and shanked at 20" plus Chloropicrin at 175 lb/ac shanked at 28".

6 - Green: Telone II at 33.7 g/ac broadcast and shanked at 20" plus Methyl Bromide at 125 lb/ac shanked at 28"

Kings County Fumigation Trial
Cooperator : Doug Verboon
Spacing: 25' Between Rows: 40' between Trees
Plots: 12 trees (6 Paradox Seedlings, 6 VX211) Tulare Cultivar
TOTAL ACREAGE: 13.14

12 Avenue

450'

	Buffer	Buffer	Buffer	Buffer	Buffer	Buffer
BLK 1	Paradox T-5 VX211	Paradox T-2 VX211	Paradox T-3 VX211	Paradox T-6 VX211	Paradox T-4 VX211	Paradox T-1 VX211
	Buffer	Buffer	Buffer	Buffer	Buffer	Buffer
BLK 2	T-2	T-5	T-4	T-1	T-3	T-6
1300'	Buffer	Buffer	Buffer	Buffer	Buffer	Buffer
BLK 3	T-3	T-6	T-1	T-2	T-5	T-4
	Buffer	Buffer	Buffer	Buffer	Buffer	Buffer
BLK 4	T-4	T-1	T-6	T-5	T-2	T-3
	Buffer	Buffer	Buffer	Buffer	Buffer	Buffer
BLK 5	T-1	T-3	T-2	T-4	T-6	T-5
	Buffer	Buffer	Buffer	Buffer	Buffer	Buffer
BLK 6	T-6	T-4	T-5	T-3	T-1	T-2
	Buffer	Buffer	Buffer	Buffer	Buffer	Buffer

200'

Dirt Road Between Young Walnuts and New Planting Site

OCTOBER 27, 2010

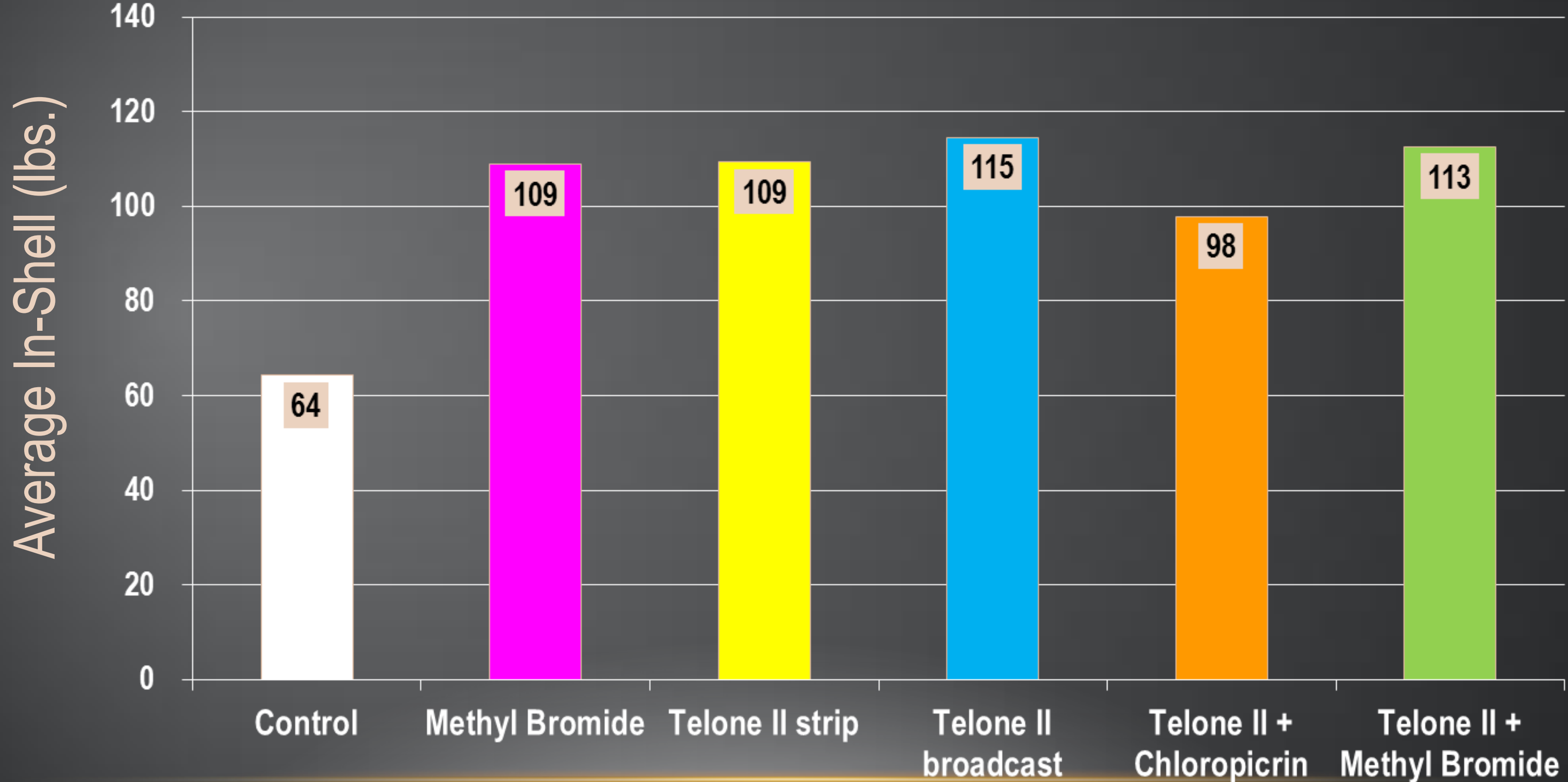
FUMIGATED

Two-year-old Tulare Scion


OCTOBER 27, 2010
NO FUMIGATION CONTROL
SAME TREE AGE


Walnut Replant Trial

Effect of pre-plant fumigation on first –year production of “Tulare” walnuts in a replant situation. Averages based on six .35 acre plots in a Latin Square Design. October 10, 2012



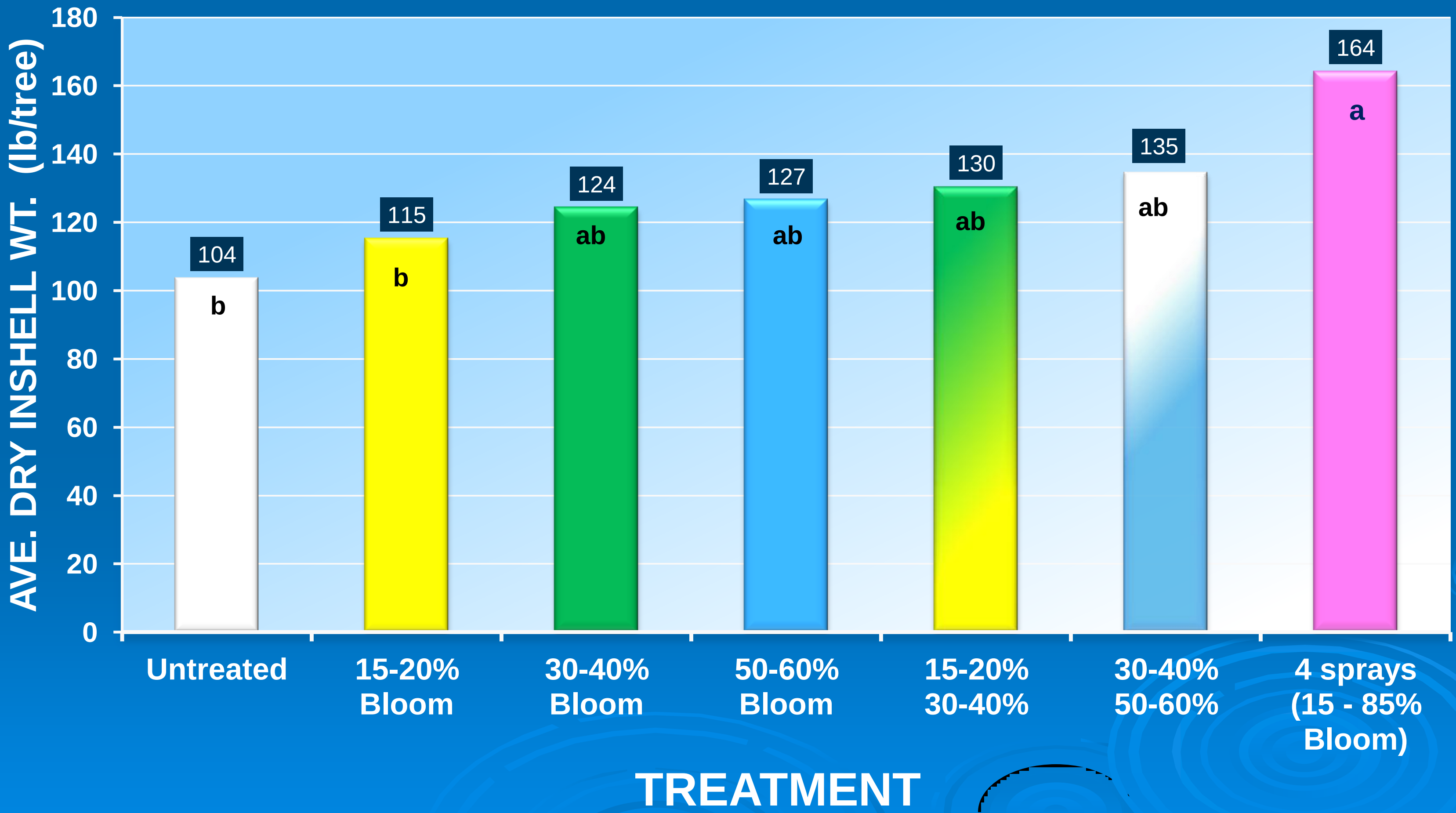
EFFECT OF RETAIN TIMING AND CONCENTRATION ON REDUCING SERR WALNUT PISTILLATE FLOWER ABORTION

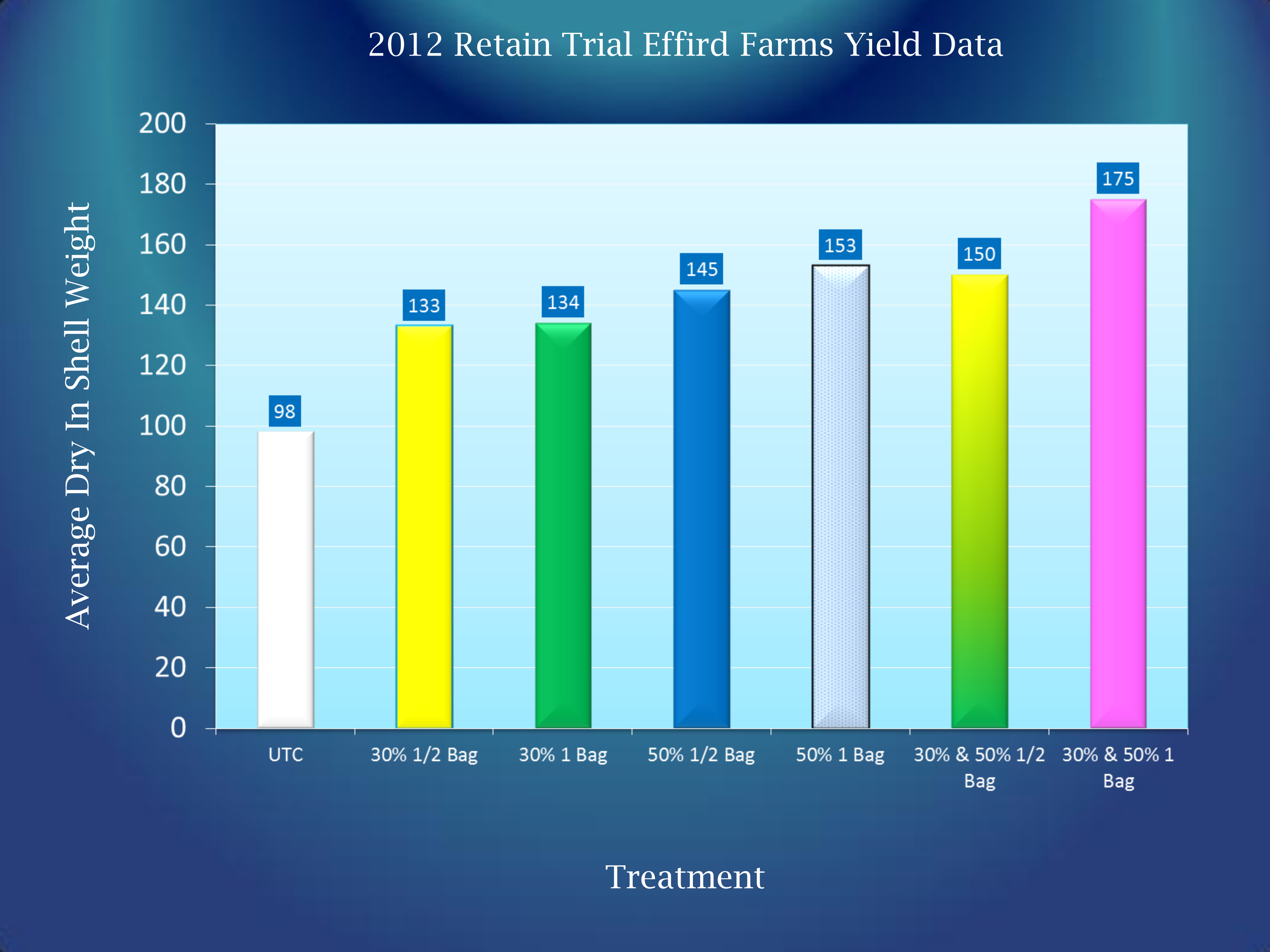
Efird Farms, 2012

2011 ReTain Timing Trial: Efird Farms

Data represents average dry wt yield of seven single trees

Rate per application: 1 bag/ac, 200 gpa (50 tree/ac)




2012 Retain Trial Effird Farms Yield Data
Average Dry In Shell Weight
200
180
160
140
120
100
80
60
40
20
0
98
133
134
145
153
150
175
UTC
30% 1/2 Bag
30% 1 Bag
50% 1/2 Bag
50% 1 Bag
30% & 50% 1/2 Bag
30% & 50% 1 Bag
Treatment

THANK YOU!

HAPPY FARMING!

THANKS TO ALL OUR SPONSORS!

Zinc

- Nutrient Uptake and Assimilation
  - Walnut (and Pecan) are very sensitive to low Zn.
  - Zn^{2+} is a charged ion easily immobilized ‘fixed’ in the soil
  - Deficient in alkaline (pH>7), bi-carbonate rich soils (co-precipitation of Fe-Oxides), leached acid soils and organic rich soils.
  - Soil fertilizers must overcome this fixation (Chelates, high local concentrations and bands) or foliars.
- Function
  - Key roles in gene regulation and protein synthesis (bud break and shoot extension)
  - Alters stress tolerance (high light, drought, disease?)
- Mobility
  - Phloem immobile or slightly mobile in walnut in the fall and spring.
  - Limited foliar uptake into mature leaves.

Nitrogen, Potassium, Sulfur, Phosphorus, Magnesium, Calcium

Essential for all stages of plant growth.

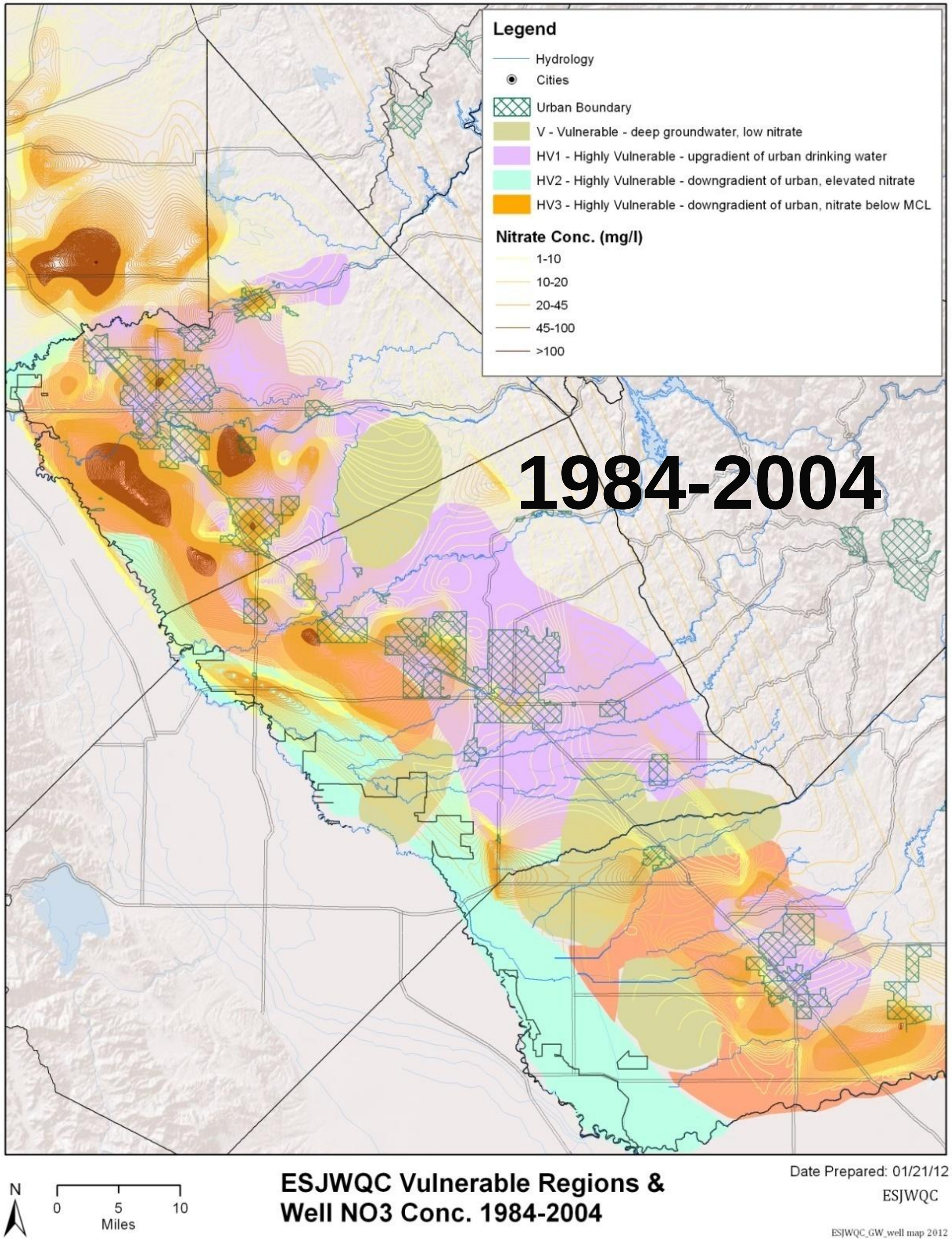
- N, K and P exported in the crop should be replaced to avoid soil depletion (yield drives fertilization)
- K, S, P, Mg are mobile in plants and can be effectively stored for later use (1 fertilization - prolonged effect)
- K response is highly soil specific
  - Conduct soil tests and follow soils consultant advice
- N is mobile in plant and soil and can be lost to the environment
  - apply only when the tree is growing actively.
- S, Mg, Ca and P are rarely deficient in CA soils
  - S is supplied in K, Ca and Mg sulfate fertilizers, if none of these are used S monitoring is recommended.
- Ca is important for growth and is immobile,
  - some responses to in-season foliar Ca at flowering have been reported.

When are nutrients required?

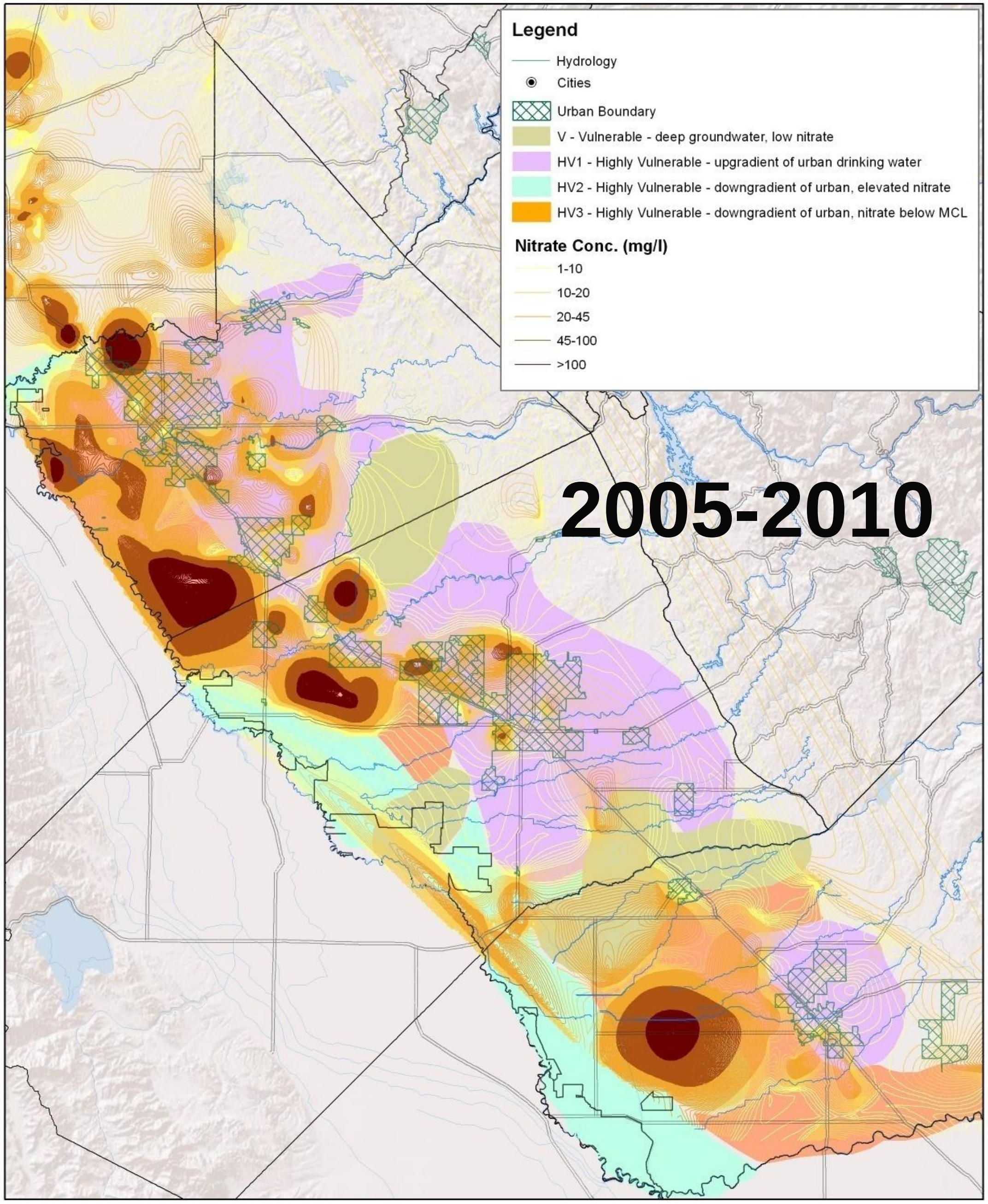
Nutrient Demand Is Not Uniform Through the Year.

- Uptake only occurs in actively growing plants
  - No uptake in fall, winter or before leaf out.
- For N and K yield determines demand
  - The size of the crop determines the demand for N and K
- Short Term Nutrient Deficiencies can be important (transient)
  - During times of High Nutrient Demand
    - Heavy crop, marginal supply.
  - When Environmental Conditions prevent uptake
    - Cold weather at flowering
    - Drought
  - For immobile elements with critical short term demand
    - Zinc during spring growth
    - Boron during flowering

1984-2004



ESJWQC Vulnerable Regions & Well NO3 Conc. 1984-2004



ESJWQC Vulnerable Regions & Well NO3 Conc. 2005-2010

Date Prepared: 01/21/12

ESJWQC

ESJWQC_GW_well map 2012

New Program Requirements

Grower Responsibilities

- Farm Management Practices performance standards *(everyone)*
  - *Minimize waste discharge offsite in surface water,*
  - *Minimize percolation of waste to groundwater,*
  - *Minimize excess nutrient application relative to crop need,*
  - *Implement effective sediment discharge and erosion prevention practices to minimize or eliminate the discharge of sediment above natural background levels*
  - *Prevent pollution and nuisance,*
  - *Achieve and maintain water quality objectives and beneficial uses*
  - *Protect wellheads from surface water intrusion.*

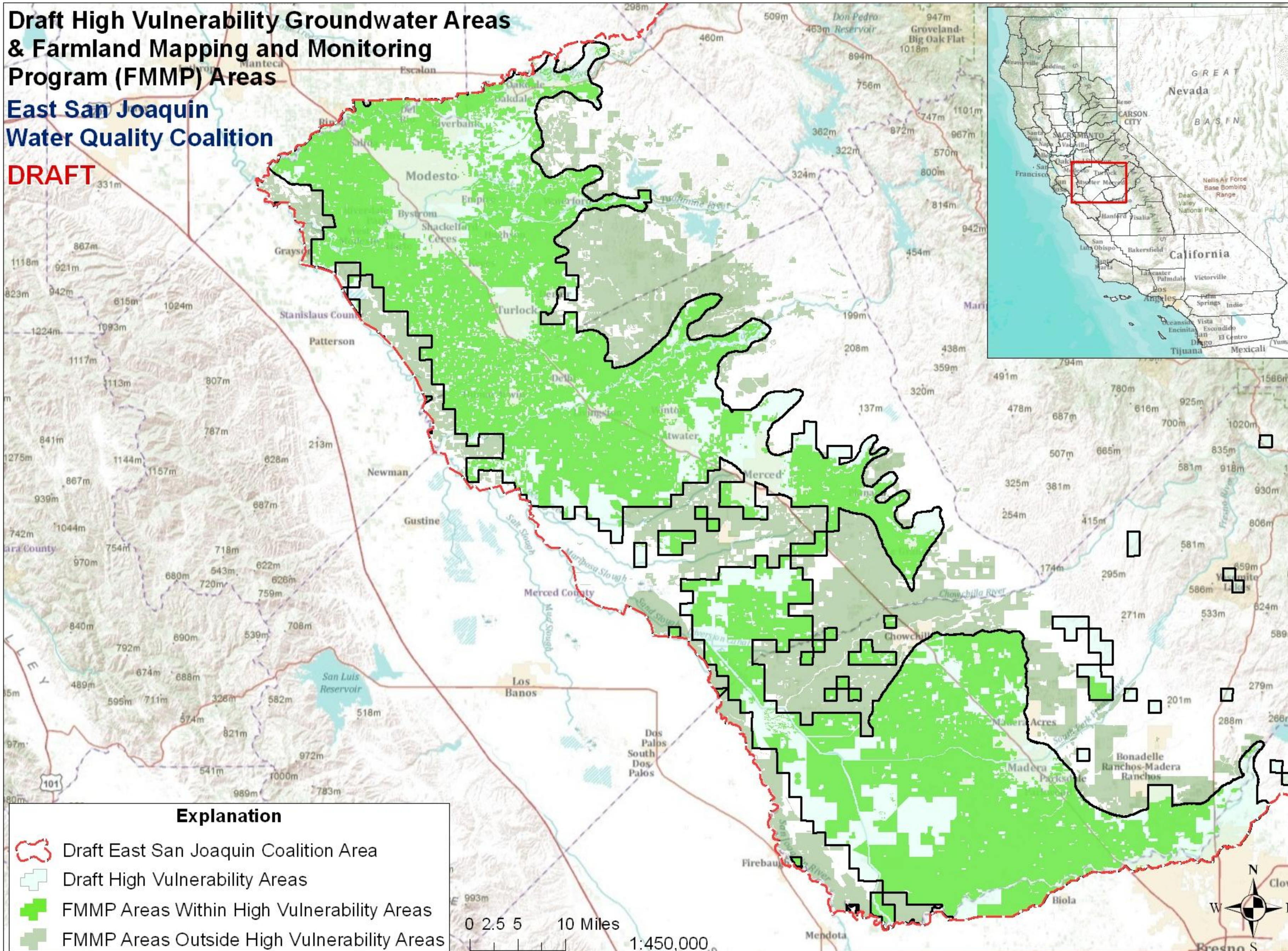
Waste Discharge Requirements
Irrigated Lands Regulatory Program

Groundwater Assessment Report

- Rank land vulnerability based on Assessment Report
  - **High Vulnerability**

    Areas ID'd using DPR pesticide groundwater protection areas, State Water Board vulnerable areas

  - **Low Vulnerability**
    - Keep farm assessment / nitrogen budgets on farm


Draft High Vulnerability Groundwater Areas
& Farmland Mapping and Monitoring
Program (FMMP) Areas
East San Joaquin
Water Quality Coalition
DRAFT
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
W
E
S
Modesto
Turlock
Merced
Madera
Newman
Gustine
Patterson
Los Banos
Chowchilla
Dos Palos
South Dos Palos
Firebaugh
Mendota
Biola
Fresno
Clovis
Oakdale
Riverbank
Escalon
Manteca
Atwater
Winton
Livingston
Delhi
Ceres
Hughson
Waterford
Bystrom
Shackelford
Empire
Madera Acres
Parksdale
Bonadelle Ranchos-Madera Ranchos
San Luis Reservoir
Don Pedro Reservoir
Groveland-Big Oak Flat
Stanislaus County
Merced County
Tuolumne River
Chowchilla River
Mariposa Slough
Salt Slough
Mud Slough
Sand Slough
San Joaquin River
Nevada
GREAT BASIN
California
CARSON CITY
SACRAMENTO
San Francisco
Reno
Redding
Weaverville
Turlock
Merced
Hanford
Visalia
Bakersfield
San Luis Obispo
Santa Maria
Lancaster
Palmdale
Victorville
Los Angeles
Palm Springs
Indio
Oceanside
Vista
Encinitas
Escondido
San Diego
El Centro
Tijuana
Mexicali
Yuma
Death Valley National Park
Nellis Air Force Base Bombing Range