Irrigation Water Quality for Walnut Production

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Goals

- Guidelines to evaluate irrigation water and soil quality for walnut production
- Trends in irrigation water quality in Tehama County
- Management options

Water and Soil Sampling

Basic Format of an Irrigation Water Quality or Soil Salinity Report

Lab No.
Sampled
Submitted
Submitted By
Reported
Ranch
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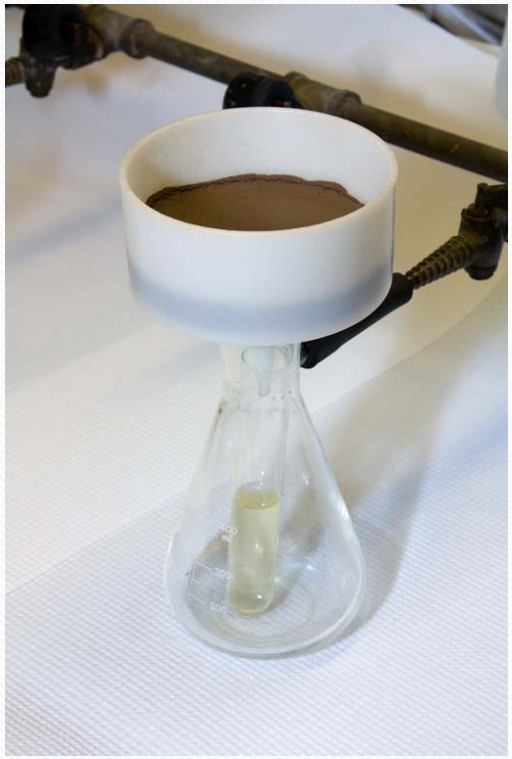
Identification

No.	Description	EC x10³	Ca (meq/l)	Mg (meq/l)	Na (meq/l)	SAR	SAR adj	Cl (meq/l)	CO_3+ HCO_3 (meq/l)	SO_4 (meq/l)	B (ppm)	NO_3-N (ppm)	Fe (ppm)	Mn (ppm)	pH
		0.91	3.3	2.7	4.0	2.3	5.2	2.7	5.1		1.8	12.0			7.6

EXAMPLE

Water Soluble Salts



Electrical Conductivity (EC)

Definition:

- Indicator of the total salinity in the irrigation water supply or soil
- Does not indicate salt composition

Electrical Conductivity (EC_w or EC_e)

- $EC = \frac{1}{\text{Resistance (ohms)}}$

- A common reporting unit is mmhos/cm *(millimhos per centimeter)*
  - dS/m *(deciseimen per meter, no conversion needed)*
  - *µmhos/cm (divide by 1000 to convert to mmhos/cm)*

- Electrical current passes more easily through water with higher salt content and results in a higher EC_w reading
- 0.1 mmhos/cm ~ 175 lbs of salt per ac-ft of irrigation water

Osmotic Effect

- Normally, a concentration gradient allows water to move freely from the soil into roots.
- If salinity from irrigation water increases in the soil, this gradient declines and less water is available to the tree.
- In response, the root cells adjust **osmotically**
- They synthesize more sugars and organic acids inside the root to re-establish a gradient. This adjustment requires energy that could otherwise be used for tree growth and crop development.

The Result Is -

Symptoms similar to under-irrigation

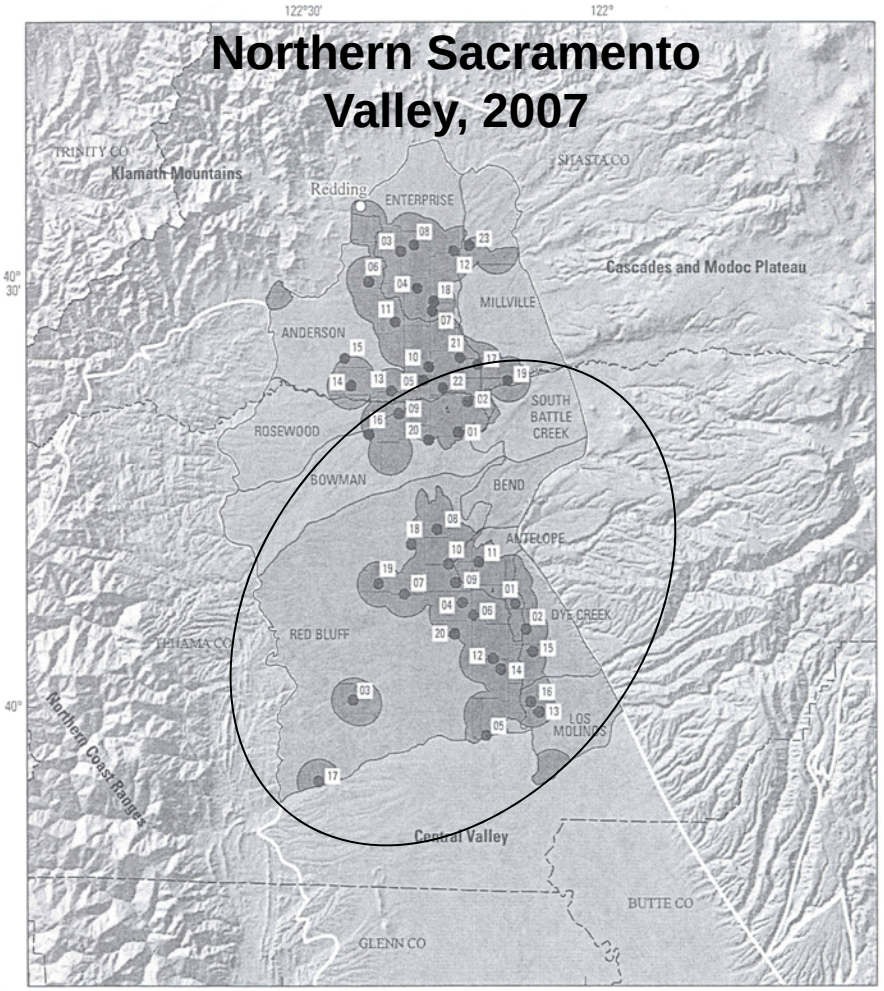
- Reduced tree vigor
- Less yield potential
- Problems with nut quality
- Foliar symptoms not always visible when osmotic effect is mild to moderate

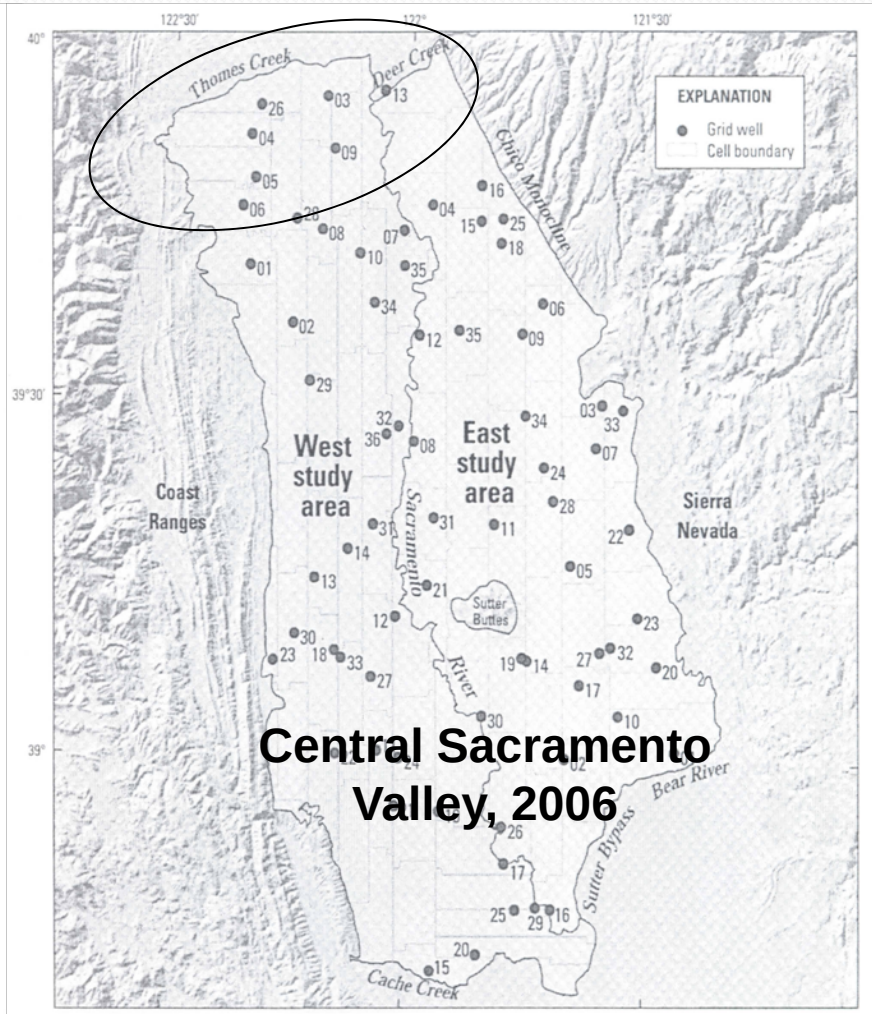
Water and Soil Quality Suitable for Walnut

Salinity Measurement	Unit	Degree of Osmotic Effect in Walnut		
		None	Increasing	Severe
Irrigation Water	mmhos/cm	< 1.1	1.1 – 3.2	> 3.2
Average root zone	mmhos/cm	< 1.5	1.5 -4.8	> 4.8

Adapted From: UC Publications 3373 and UC 3375

Recent Groundwater Quality Sampling Grid, Source: U.S. Geological Survey





Salinity Levels of Groundwater in Tehama County

- 38 wells sampled across the valley floor of Tehama County
- Range in well depth 80 to 980 feet
- Average well depth 351 feet
- 67 percent of the wells between 120 and 580 feet deep

Salinity Levels of Groundwater in Tehama County

- Average EC_w 0.35 mmhos/cm
- In terms of salinity and osmotic effects, none of the well water supplies exceeded **1.1** mmhos/cm or pose significant risk to walnut
    - 4 wells had EC_w ranging from 0.7 to 0.9 mmhos/cm

Specific Toxicities - Too Much of a Good Thing?

Boron Toxicity

Severe Boron Toxicity

Chloride Foliar Symptoms

Sodium Foliar Symptoms

Critical Levels of Specific Ions in Walnut Leaf Tissue (July Samples)

Salinity Measurement	Unit	Degree of toxicity		
		None	Increasing	Severe
Boron	ppm	< 36	36-200	> 200
Chloride	ppm	< 0.3	0.3 - 0.5	> 0.5
Sodium	%	<0.1	0.1 - 0.3	>0.3

Adapted From: UC Publications 3373 and UC 3375

Critical Levels of Specific Ions in irrigation water and Soil-Water Extracts

Salinity Measurement	Unit	Degree of toxicity		
		None	Increasing	Severe
Boron	mg/l	< 0.5	0.5 - 3	> 3
Chloride	meq/l	< 4	4 - 10	> 10
Sodium	SAR (meq/l)	<3	3 - 9	>9

Adapted From: UC Publications 3373 and UC 3375

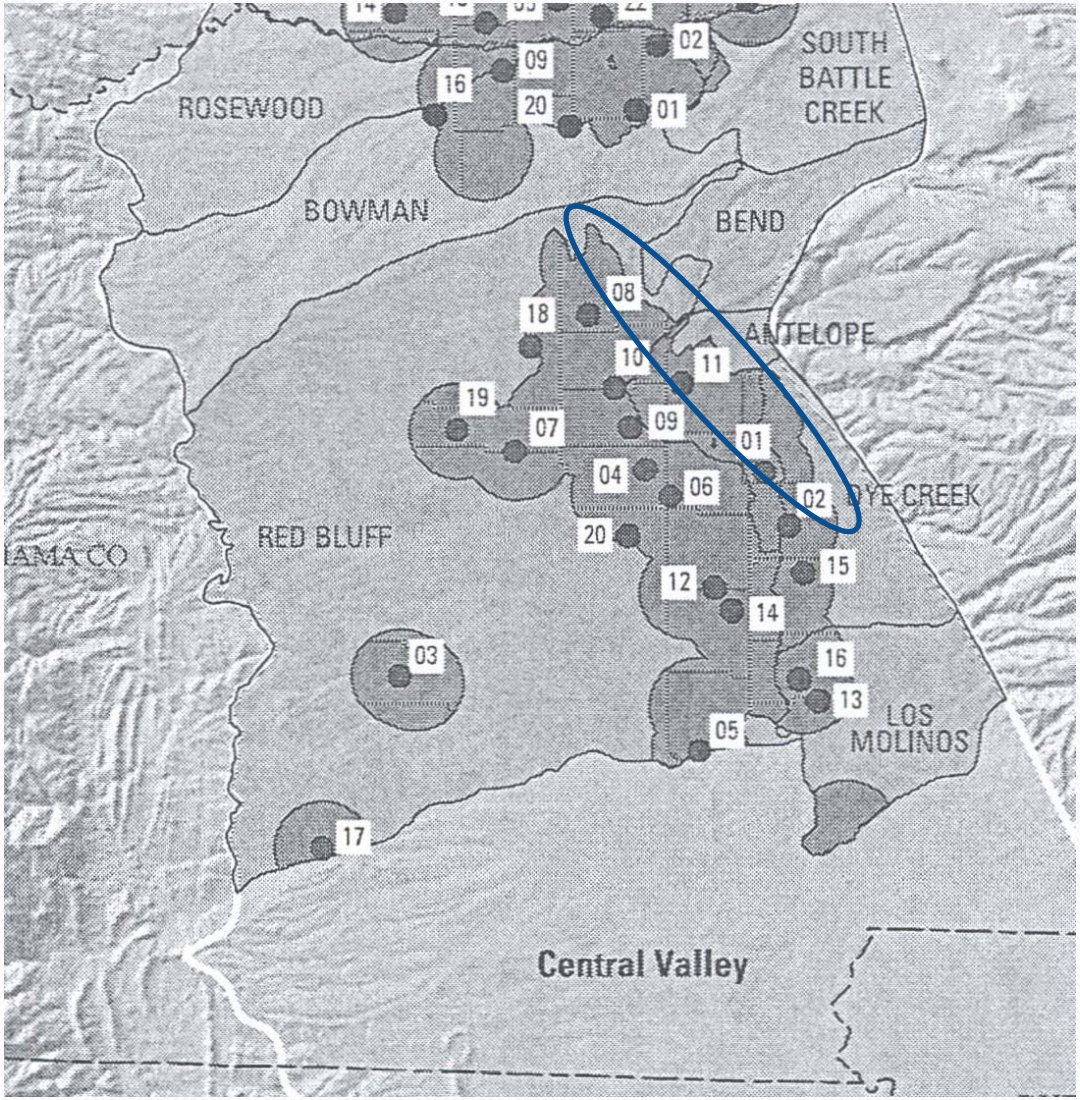
Why is the SAR Used to Assess Sodium in Water and Soil?

- High sodium levels in the presence of high calcium and magnesium levels are not as likely to lead to sodium toxicity.
- High sodium levels when calcium and magnesium levels are low are more likely to lead to sodium toxicity.
- The Sodium Adsorption Ration (SAR) accounts for this interaction.

Boron Levels in Groundwater of Tehama County

- Average Boron concentration 0.10 ppm
- 90 % of wells sampled had less than 0.5 ppm boron
- Exceptions were found along the east side of Tehama County
  - Levels of 0.9 to 1.0 ppm Boron were identified along the east side of Tehama County

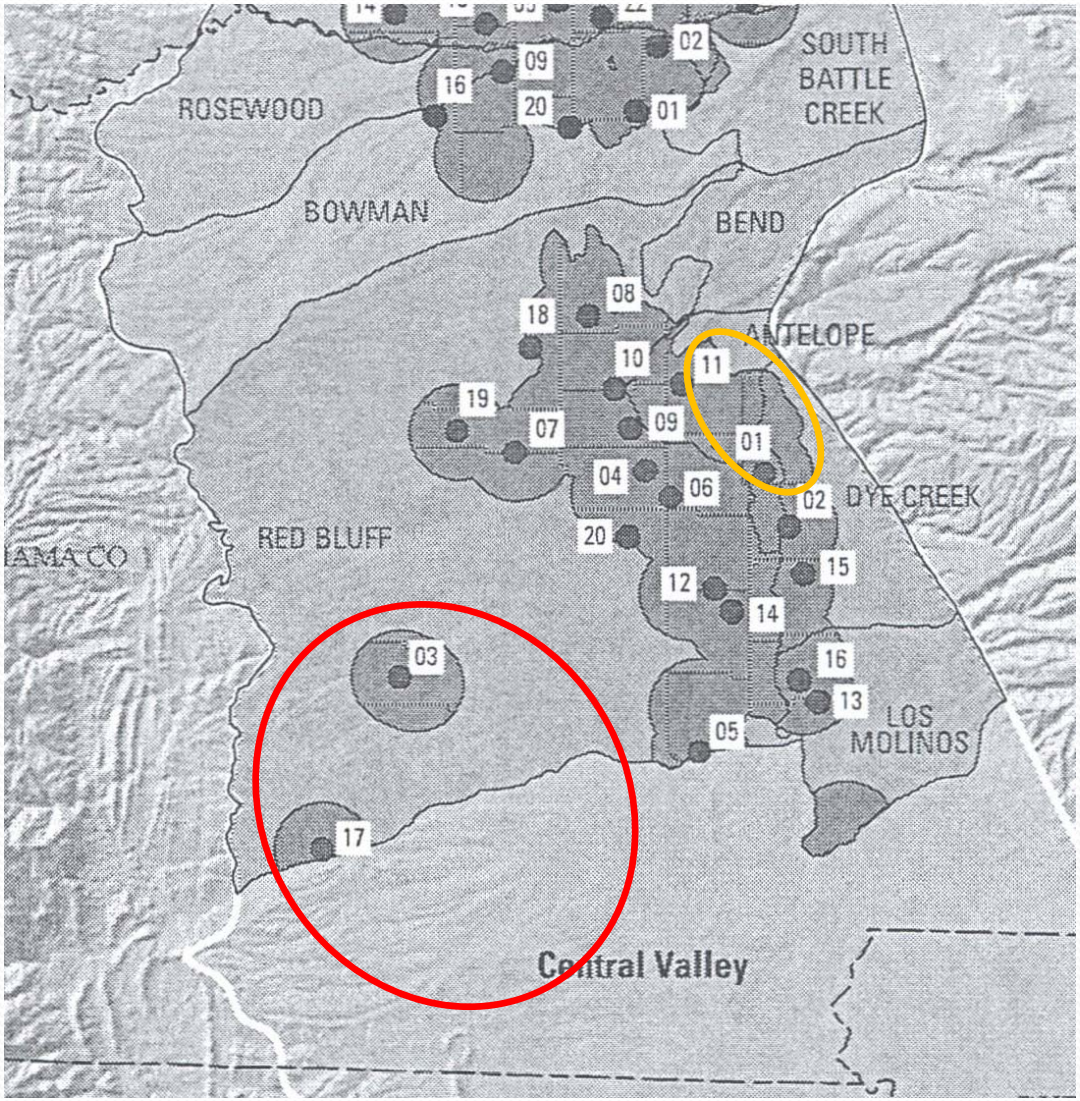
Areas of Tehama County where Boron in Irrigation Water may Pose Risk to Walnut



Chloride Levels in Groundwater in Tehama County

- Average chloride levels 0.5 meq/l
- 90 % of wells sampled had less than 4.0 meq/l Chloride
- Exceptions were found along the west side of Tehama County
  - 1 wells exceeded 4.0 meq Cl/l
  - 3 wells approached critical level

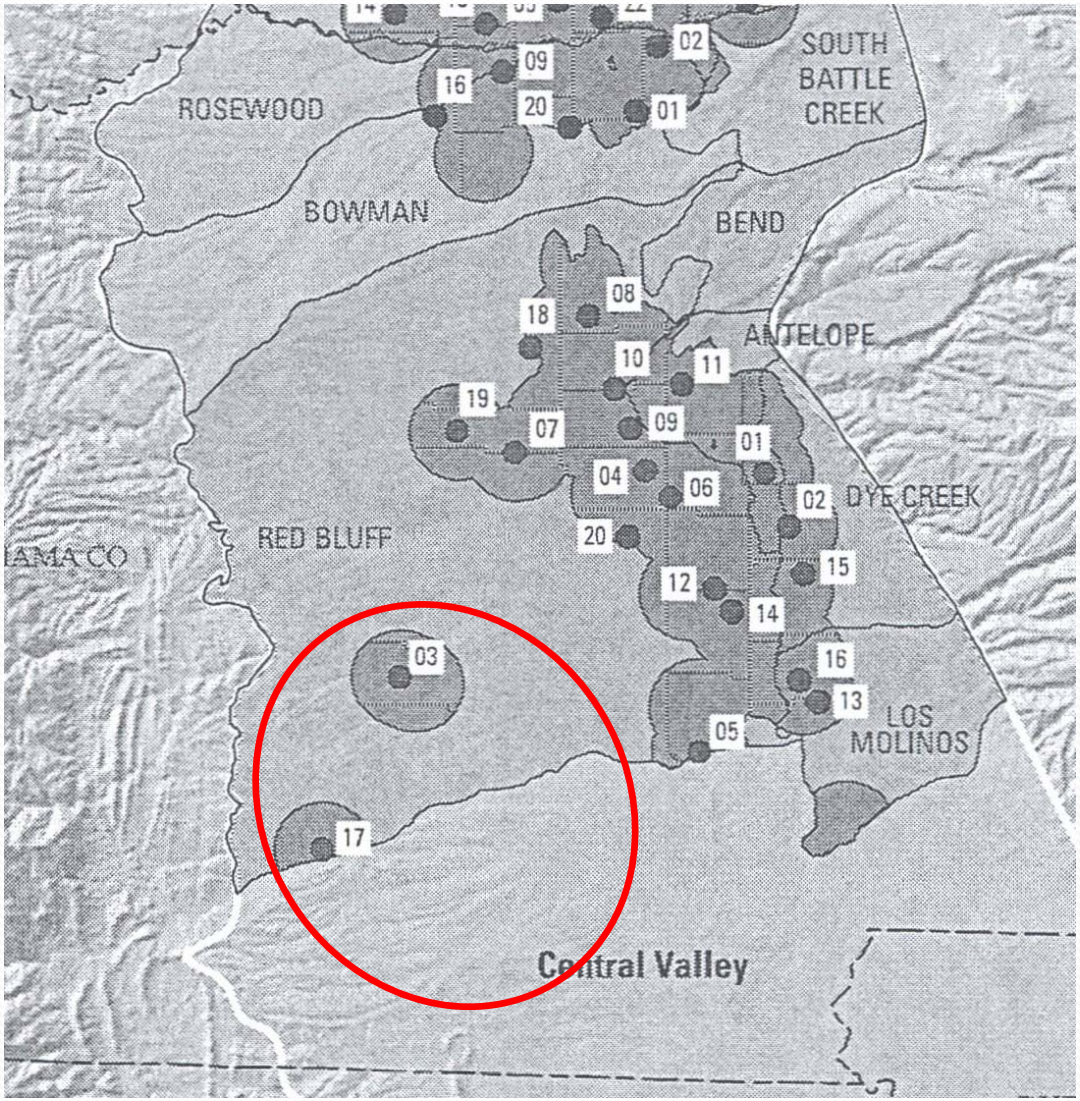
Areas of Tehama County where Chloride Levels may Exceed or Approach Critical Levels for Walnut



SAR Levels of Groundwater in Tehama County

- Average SAR levels 1.2 meq/l
- 90 % of wells sampled SAR's below 3.0 meq/l
- Exceptions were found along the west side of Tehama County
  - 1 Well had an SAR approaching 9.0 meq/l
  - 1 Well had an SAR approaching 5.0 meq/l

General Areas of Tehama County where SAR Levels Exceed or Approach Critical Levels for Walnut



Managing Salinity (Osmotic Effects) and Toxicity in Walnut

- Irrigation Management (leaching)
- Alternative irrigation water supply
- Conventional soil and water amendments
- Water conditioning devices

Scenario: Too Little or No Leaching

Scenario: Sufficient Leaching

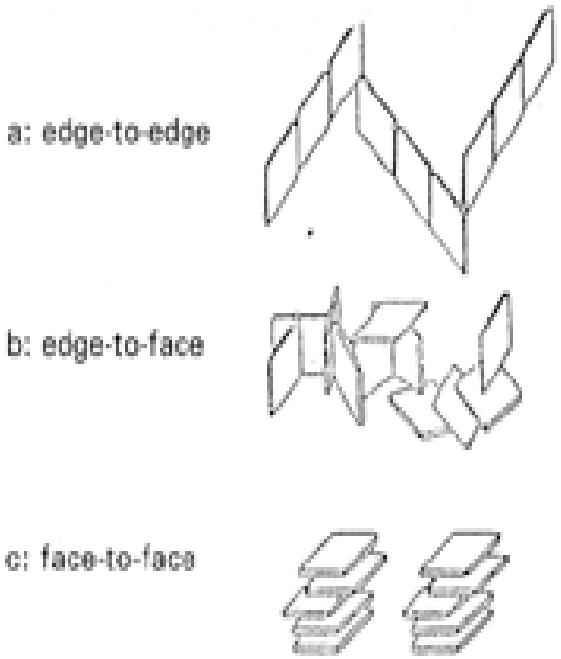
Basics of Leaching

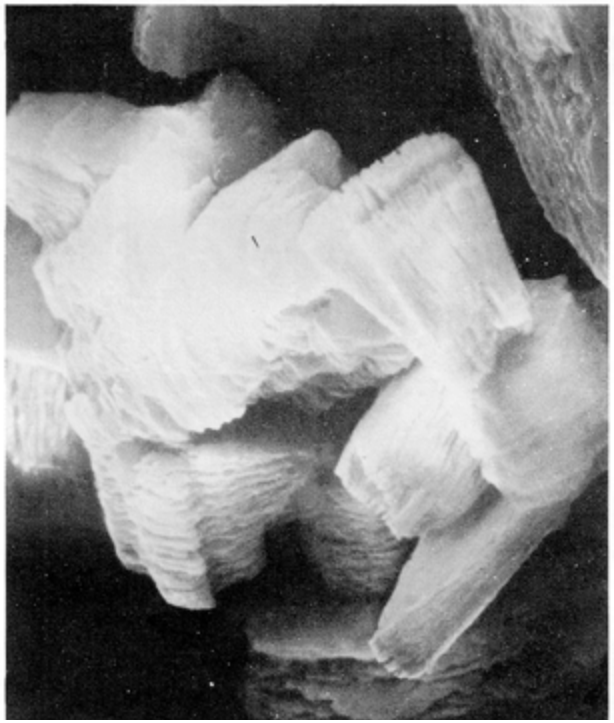
- Easier to accomplish on deep, well drained profiles
- Soil moisture in root zone must exceed field capacity for leaching to occur
- Smaller, intermittent applications of irrigation water or rainfall will result in more effective leaching
- Leaching is only needed when critical levels are approached, monitoring helps determine if that will occur
- Leaching is most efficient when trees are dormant and crop ET is minimal

Regroup and Change Focus

Irrigation Water Quality Affects on Infiltration Rates of Soils

Structural Soil Crusts





Source: J. Morin, The Institute of Earth Sciences

Using EC_w and SAR to Evaluate Effects of Water Quality on Infiltration Rates of Soils

Lab No.
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Ranch
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Identification

No.	Description	EC x10³	Ca (meq/l)	Mg (meq/l)	Na (meq/l)	SAR	SAR adj	Cl (meq/l)	CO_3+ HCO_3 (meq/l)	SO_4 (meq/l)	B (ppm)	NO_3-N (ppm)	Fe (ppm)	Mn (ppm)	pH
		0.91	3.3	2.7	4.0	2.3	5.2	2.7	5.1		1.8	12.0			7.6

EXAMPLE

Irrigation Water Quality in Tehama County and Potential Effects of Infiltration Rates of Soils

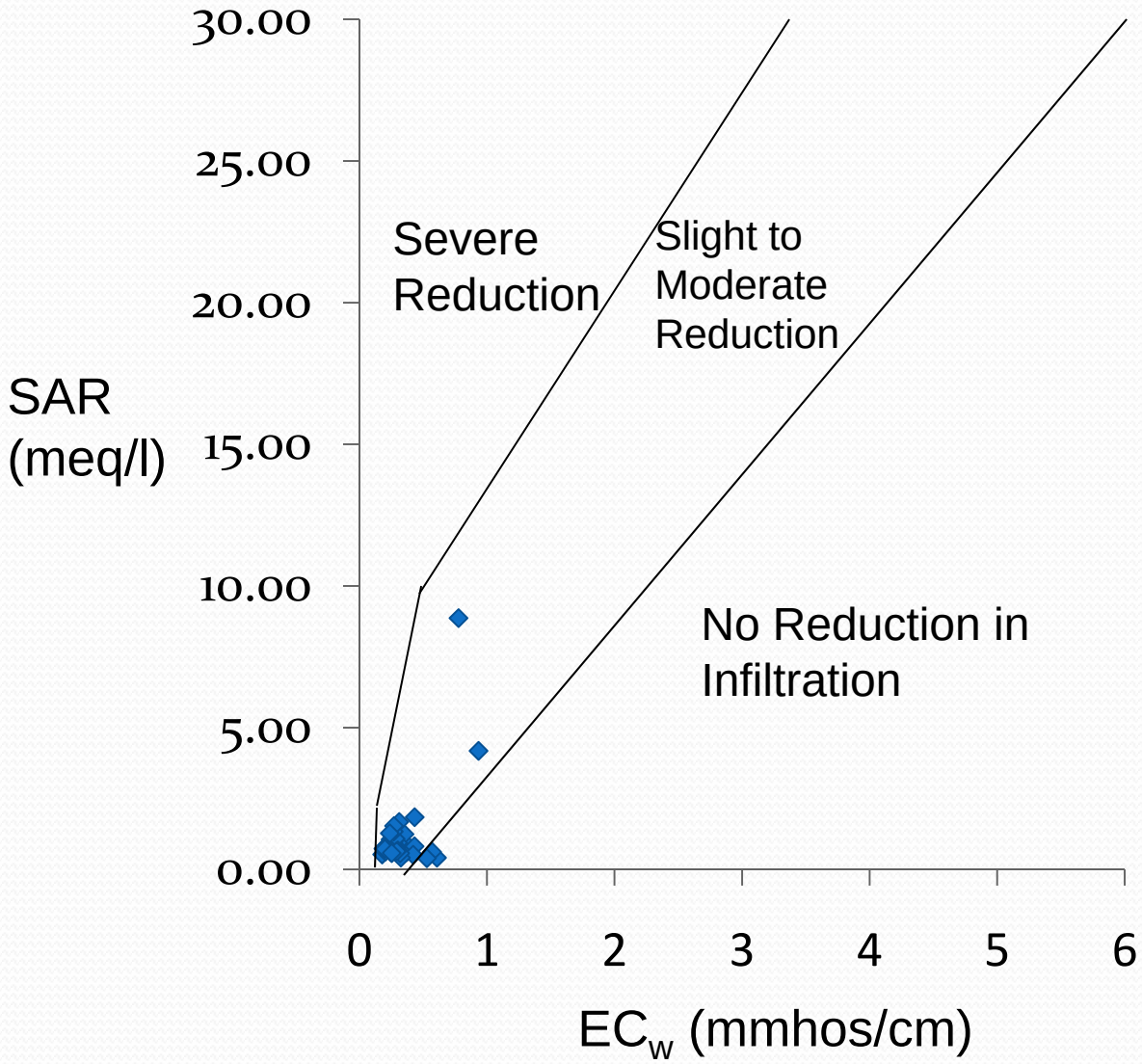
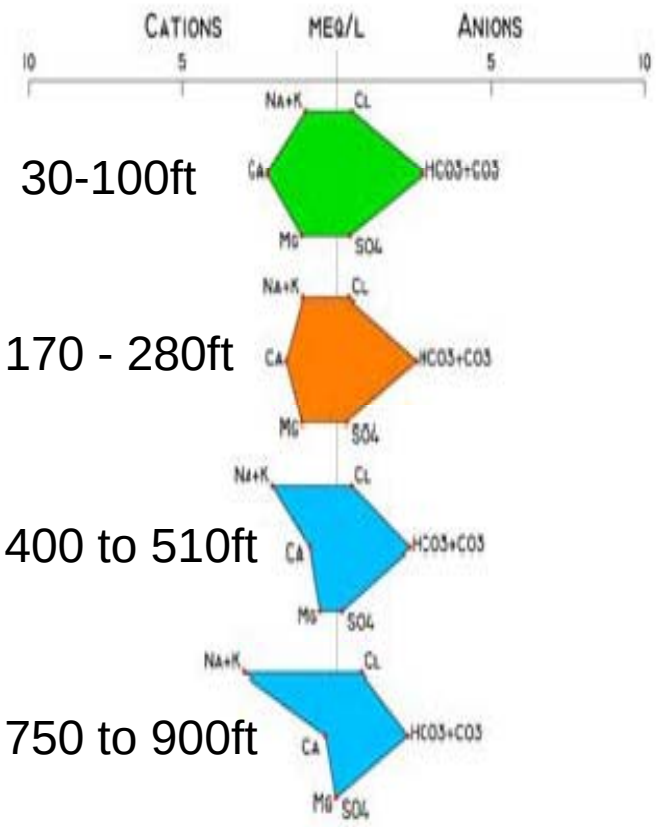
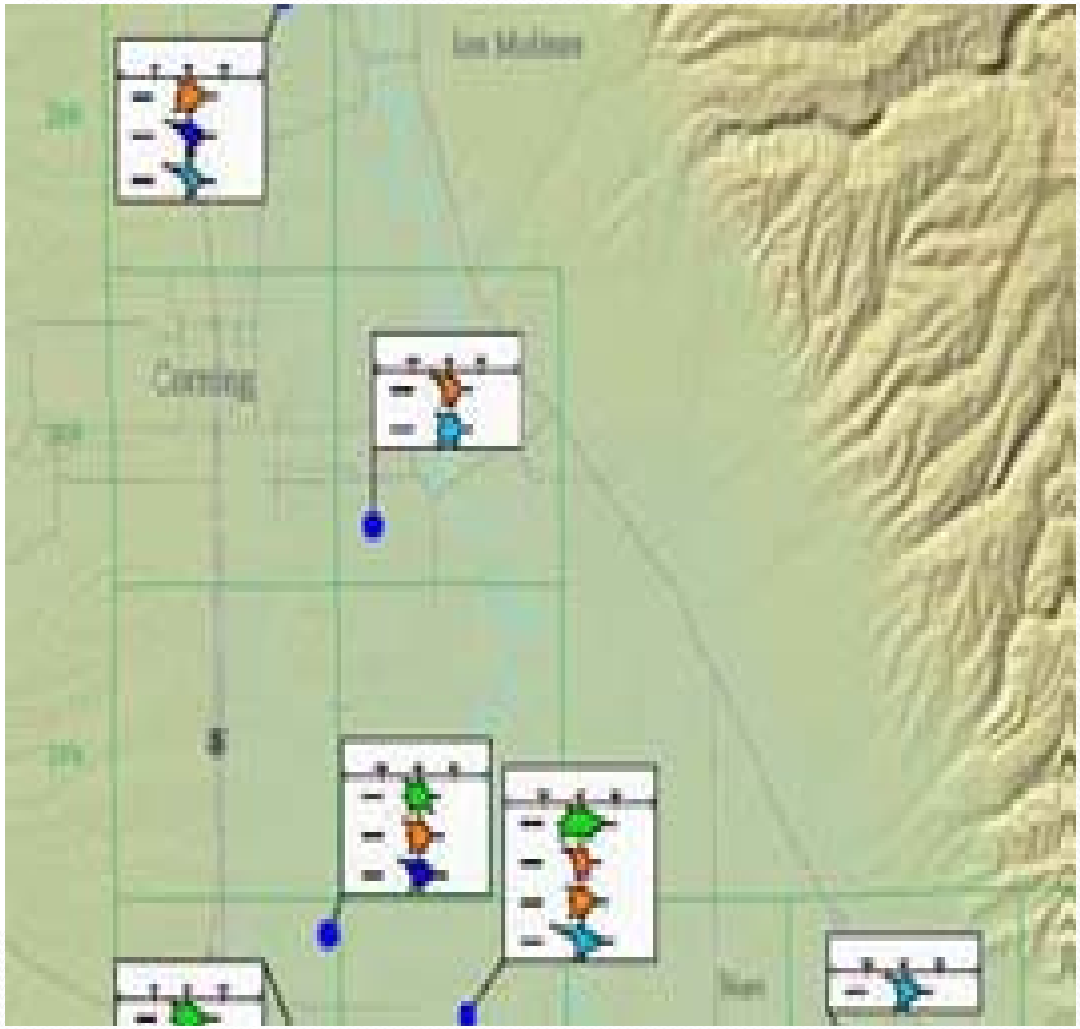


Figure adapted from FAO Paper 29.Rev.1, Water Quality and Agriculture

Change in Irrigation Water Quality with Depth





Source: DWR, Northern District

Using Calcium and Magnesium Ratios to Evaluate Effects of Water Quality on Infiltration Rates of Soils

Lab No.
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Identification

No.	Description	EC x10³	Ca	Mg	Na	SAR	SAR adj	Cl	CO_3+ HCO_3	SO_4	B	NO_3-N	Fe	Mn	pH
			meq/l					meq/l			ppm				
		0.91	3.3	2.7	4.0	2.3	5.2	2.7	5.1		1.8	12.0			7.6

EXAMPLE

Guidelines for Ca:Mg Ratios

- Based primarily upon anecdotal evidence
- Research shows uncertainty about Ca:Mg ratios and infiltration rates
  - May be more important to plant nutrition than to water infiltration rates of soils
  - Not as important to infiltration as the SAR and EC relationship

Two Rules of Thumb

- Ca:Mg ratio > 1:1
- Calcium should account for at least 15 percent of the total salinity

Trends in Tehama County

- 56 percent of wells sampled had a Ca:Mg ratio < **1.0**
- In 97 percent of wells sampled, Ca accounted for more than 15 (23) percent of the total salinity

Managing Water Quality to Improve Infiltration

- Attention to irrigation management
- Modify irrigation water quality
  - Conventional soil and water amendments
  - Shallow tillage
  - Vegetation

Choices in Methods of Application

Amend Water

Amend Soil

Choices in Types of Chemical Amendments

- Direct calcium suppliers (salts)
- Indirect calcium suppliers (sulfur and acids)
- Surfactants

Projected Effect of 750 lbs per Acre-Foot of Solution Grade Gypsum on Irrigation Water Quality in Tehama County

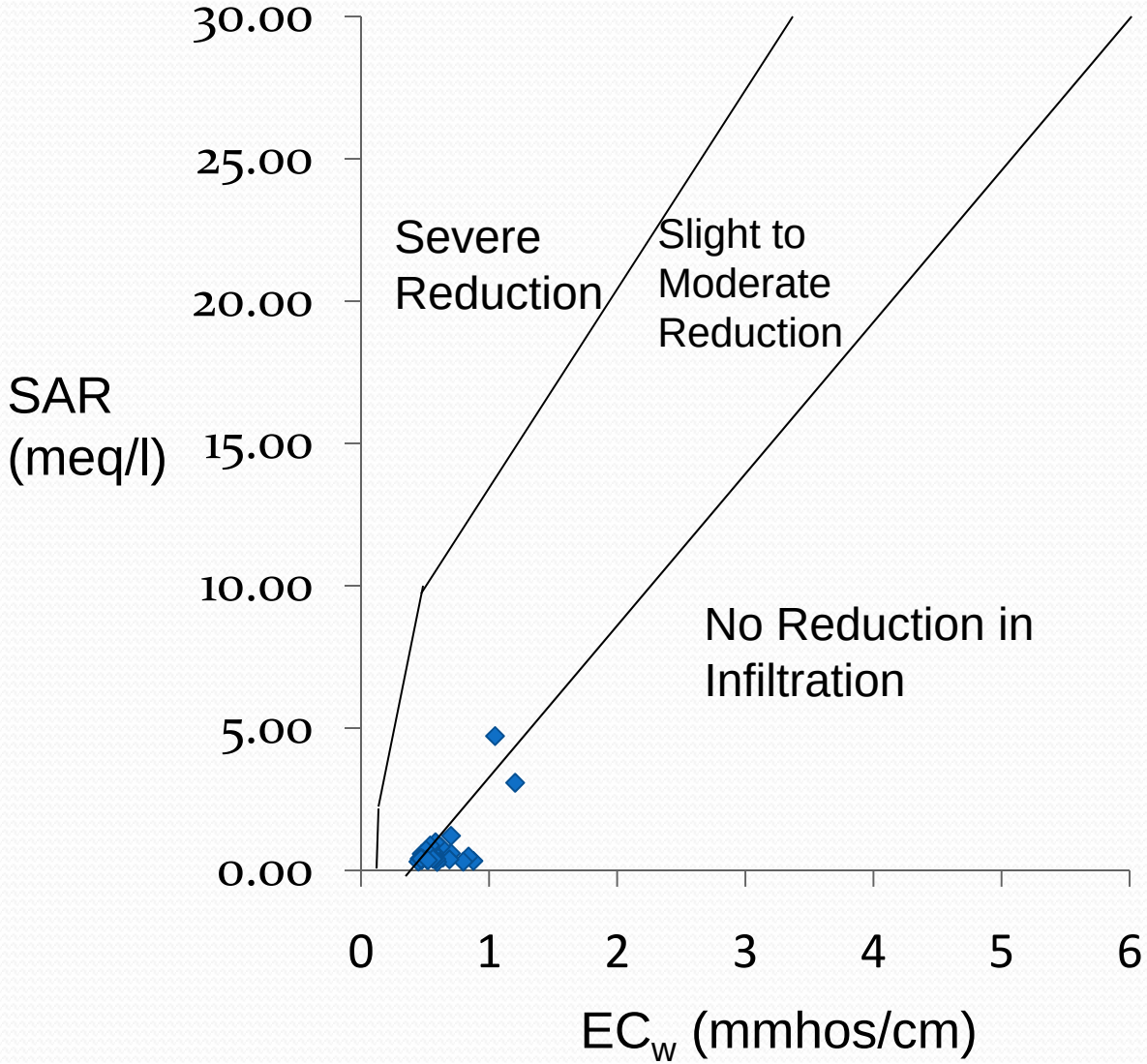

Figure adapted from FAO Paper 29.Rev.1, Water Quality and Agriculture

Chemical Plugging

Guideline

- Risk of chemical plugging increases when irrigation water contains more the **2.0** meq/l Bicarbonate/Carbonate
- Acidification or use of polymer surfactants becomes increasingly important

Bicarbonate levels in Tehama County

- Average bicarbonate 2.9 meq/l
- Carbonate species virtually absent, expected for pH range of 6.6 -8.7 and average of 7.6
- 75 percent of wells sampled had bicarbonate levels above 2.0 meq/l
- Highest 5.0 meq/l

Nitrate-nitrogen levels in Tehama County

- Average nitrate-nitrogen content was 1.6 mg/l, 4 lbs per ac-ft
- 95 percent of wells sampled averaged less than 4.0 mg/l, 11 lbs per acre-ft
- Highest 5.5 mg/l, 15 lbs per acre-ft

Summary: Water and Soil Quality for Walnut Production in Tehama County

- Osmotic effects – UNLIKELY
- Specific Ion Toxicity –
  - BORON POSSIBLE AND MORE LIKELY THAN CHLORIDE AND SODIUM
- Factor in slow water infiltration - POSSIBLE BUT QUESTIONABLE
- Plugging of emitters – LIKELY CONTRIBUTOR
- Nitrogen contribution - GENERALLY LOW

Don’t Let Water and Soil Quality Sneak Up on You!

Grant Puffers Tehama Walnut Day Jan 2010.ppt