Managing Orchard Salinity

December 7, 2016

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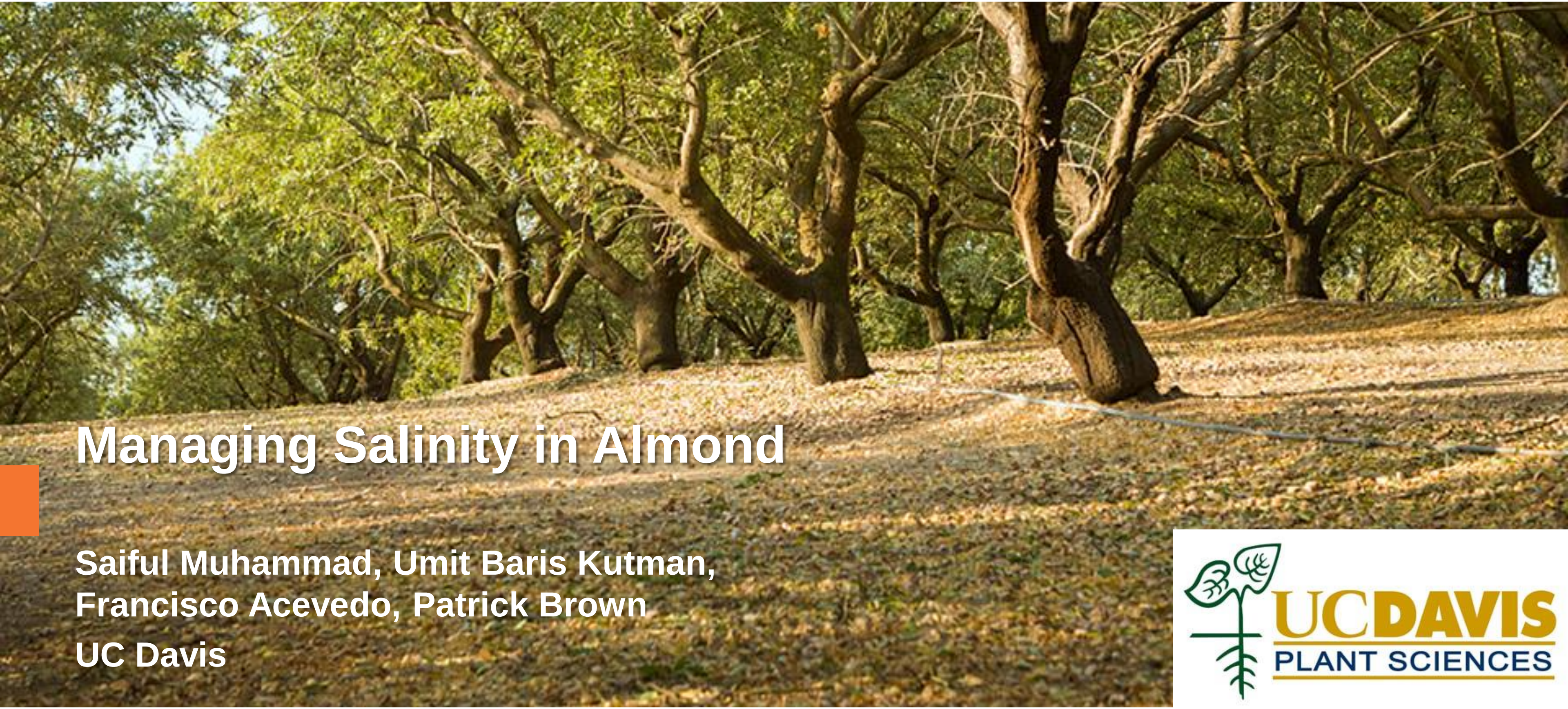

Managing Salinity in Almond

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UC Davis

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Salinity in California

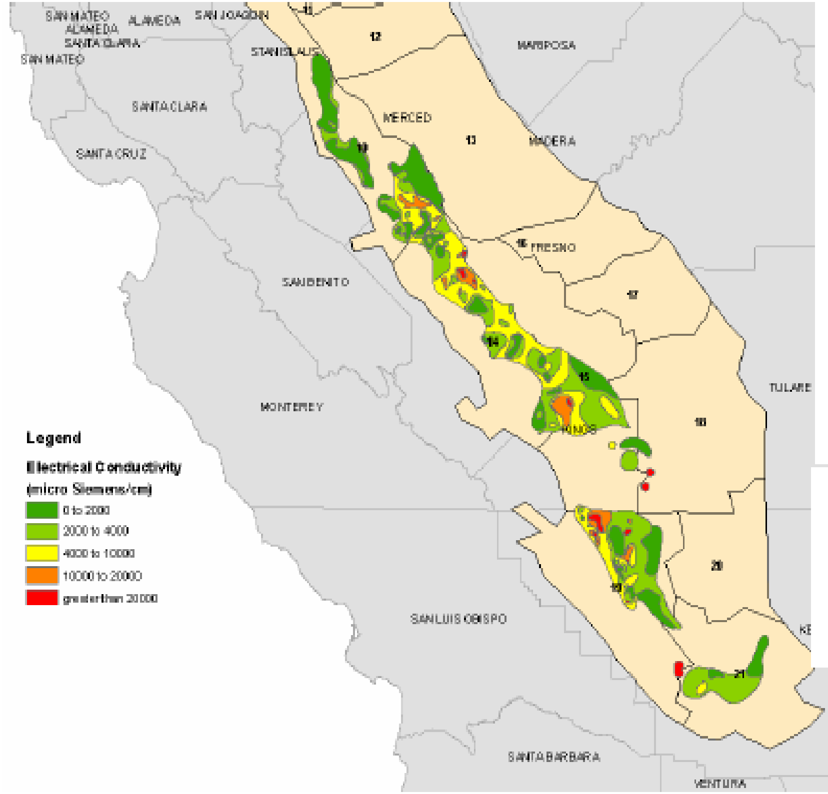


Table 3.34 Conversion of Non-saline Area to Saline Zones as a Result of Salt Accumulation by 2030

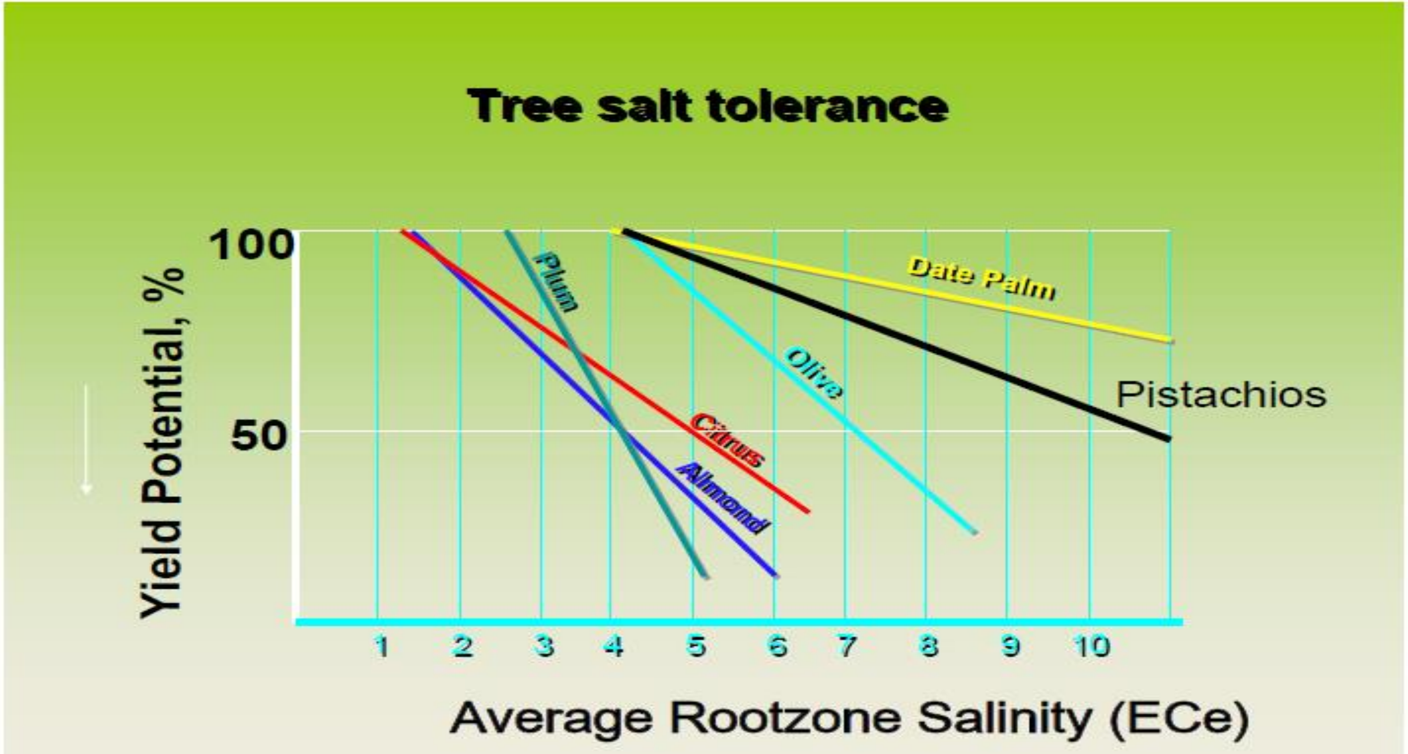
Zone	Salinity Level (EC in shallow groundwater (µS/cm))	Share of Non-saline Acres Transferred to the Saline Zone (%)
A	0-2,000	50
B	2,000-4,000	30
C	4,000-10,000	10
D	10,000-20,000	10
E	above 20,000	0

Source: Adapted from Howitt et al, 2008

~4 million acres of irrigated cropland in California, corresponding to more than half of the total, are affected by salt stress to varying degrees (Letey 2000; Schoups et al. 2005).

Salinity (as electrical conductivity) in Shallow Groundwater (Source: DWR)

Crop Sensitivity to Salinity



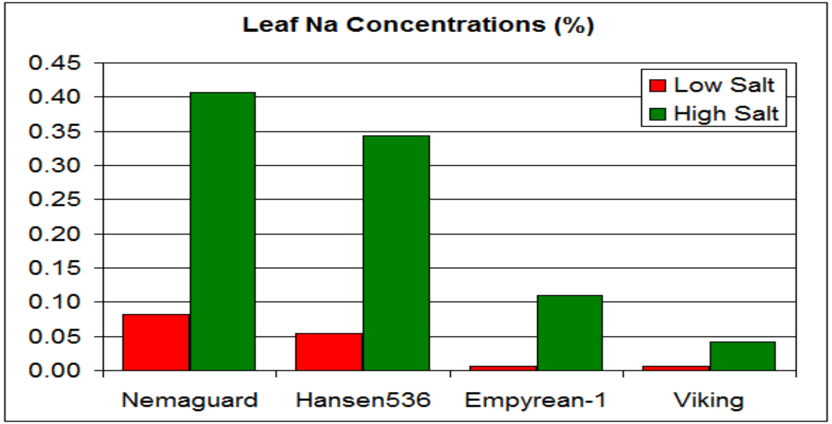
Objectives

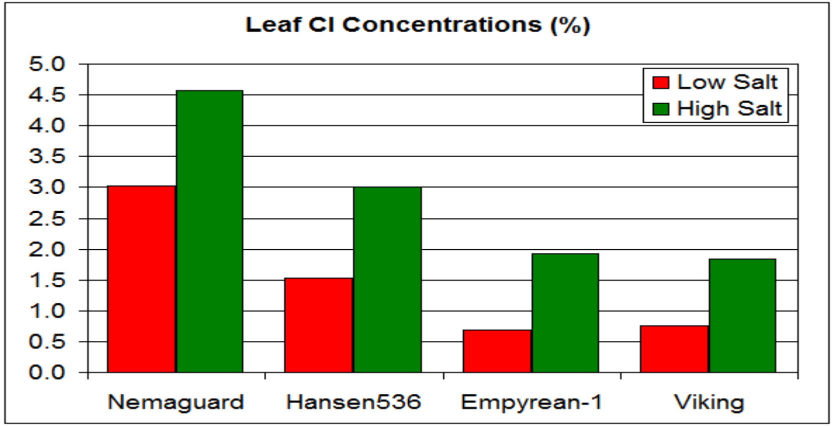
- How different rootstocks and cultivars affect the salinity tolerance of grafted almond trees and the tissue accumulation of Na and Cl
- How different salt types affect salinity tolerance of almond rootstocks
- How almond rootstocks respond to non-uniform salinity conditions

Experimental Design and Procedure

- Young grafted almond trees planted in 7-gal pots in Calcined clay (Turface)
- Rootstocks: Nemaguard, Hansen 536, Empyrean 1, Viking
- Cultivars: Nonpareil, Mission, Monterey, Fritz
- 3 salinity levels:
  - No salts added other than the essential minerals (~1 dS/m)
  - 20 mM NaCl (+2 dS/m)
  - 40 mM NaCl (+4 dS/m)
- Alternative salts tested: KCl and Na_2SO_4
- More rootstocks were screened under modified salinity condition to represent sodium dominant salinity
  - 45 mM 2:1 NaCl and Na_2SO_4 (+4.5 ds/m)
  - Bright 106, Bright Hybrid, Nemaguard, Emyprean 1, Krymsk 86, Corner Stone, RootPac-R

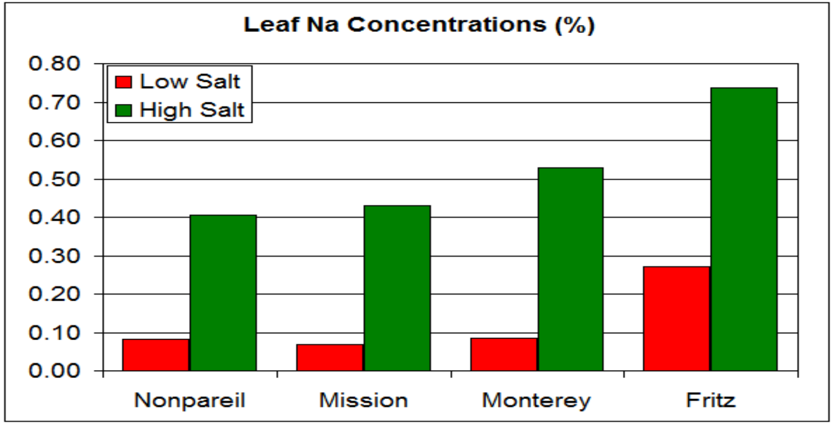
Leaf Na and Cl Accumulation
Rootstock Experiment, (cultivar-Nonpareil)

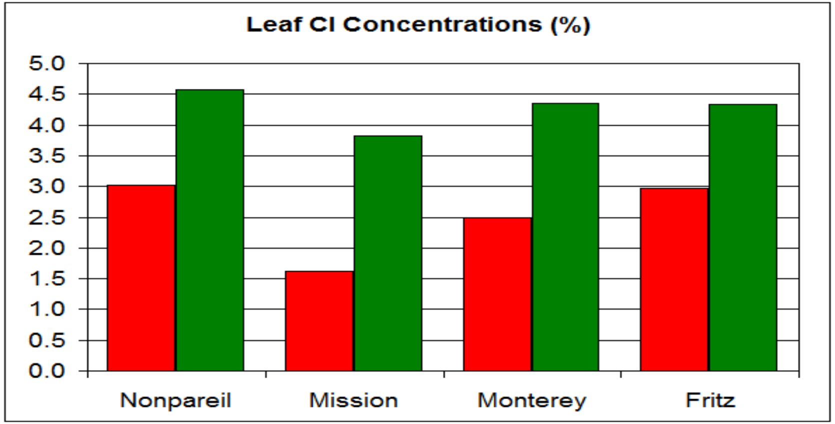




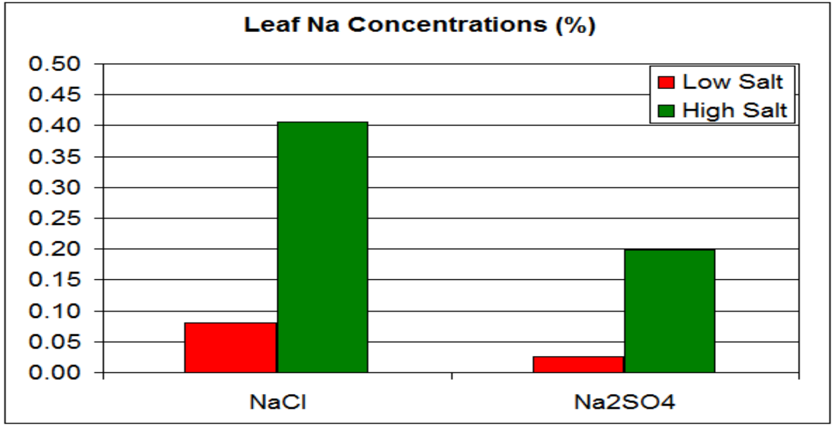
Leaf Na and Cl Accumulation

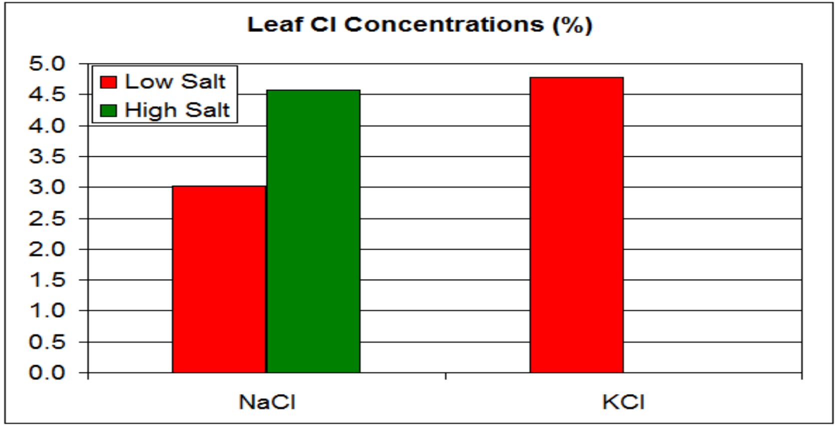
Cultivar Experiment (rootstock- Nemaguard)





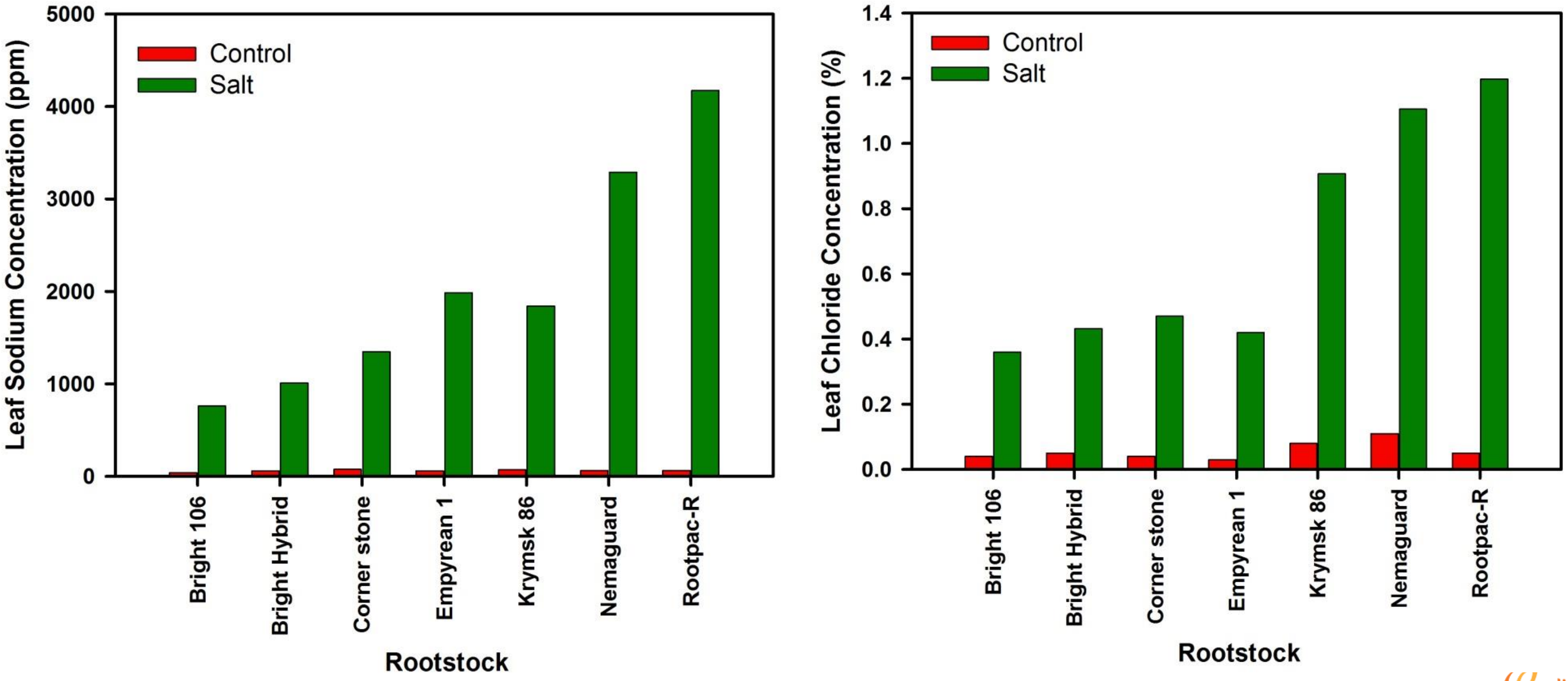
Leaf Na and Cl Accumulation
Salt Type Experiment



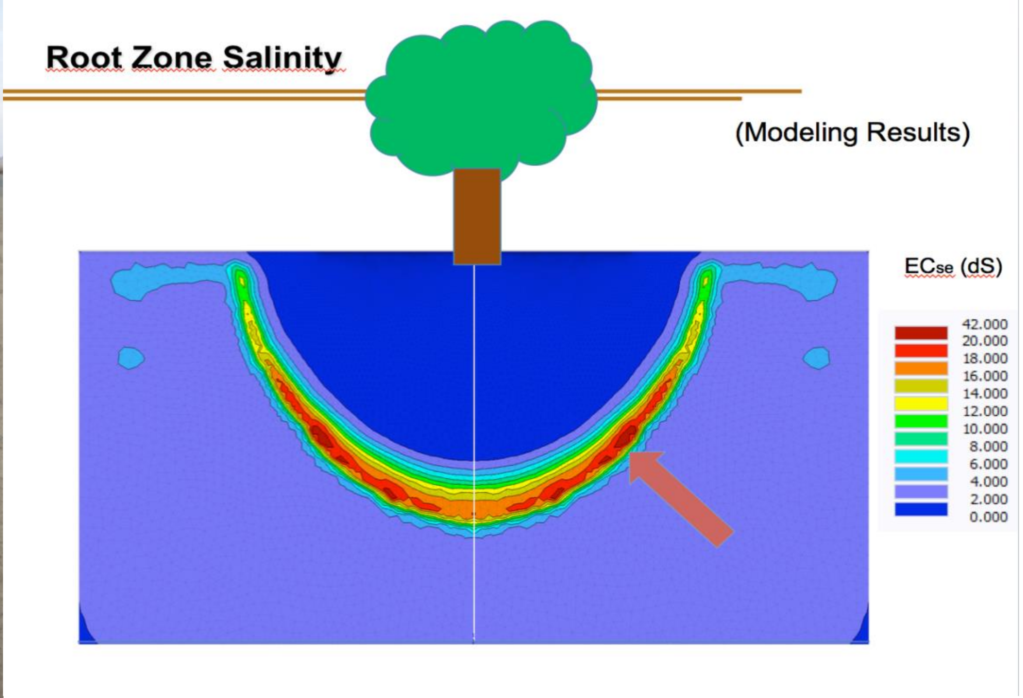


Leaf Na and Cl Accumulation

Rootstocks Experiment with Na dominant salinity



Non Uniform Soil Salinity is Normal in Microirrigated Almond



Effect of Non-uniform Salinity on growth and Salt uptake

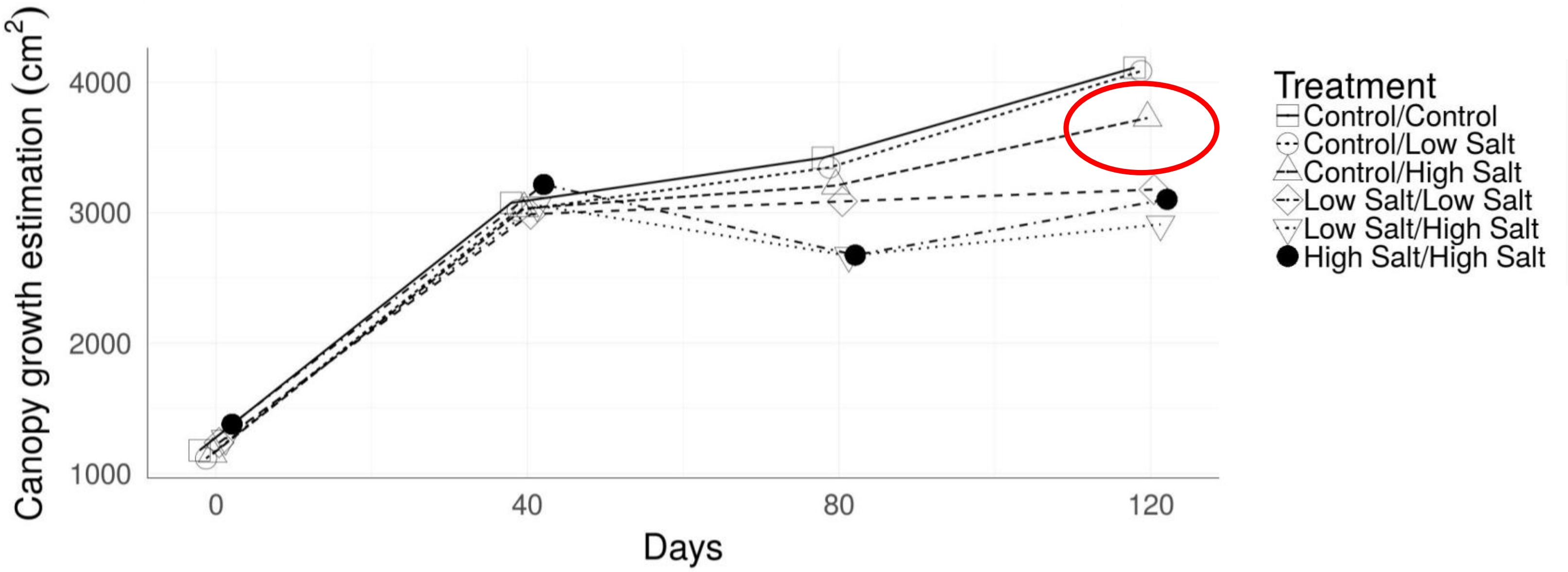
<u>Rootstocks</u>
Nemaguard, Empyrean 1 and Hansen 536

<u>6 Treatments</u>
Control/Control
Control/Low Salt
Control/High Salt
Low Salt/Low Salt
Low Salt/High Salt
High Salt/High Salt

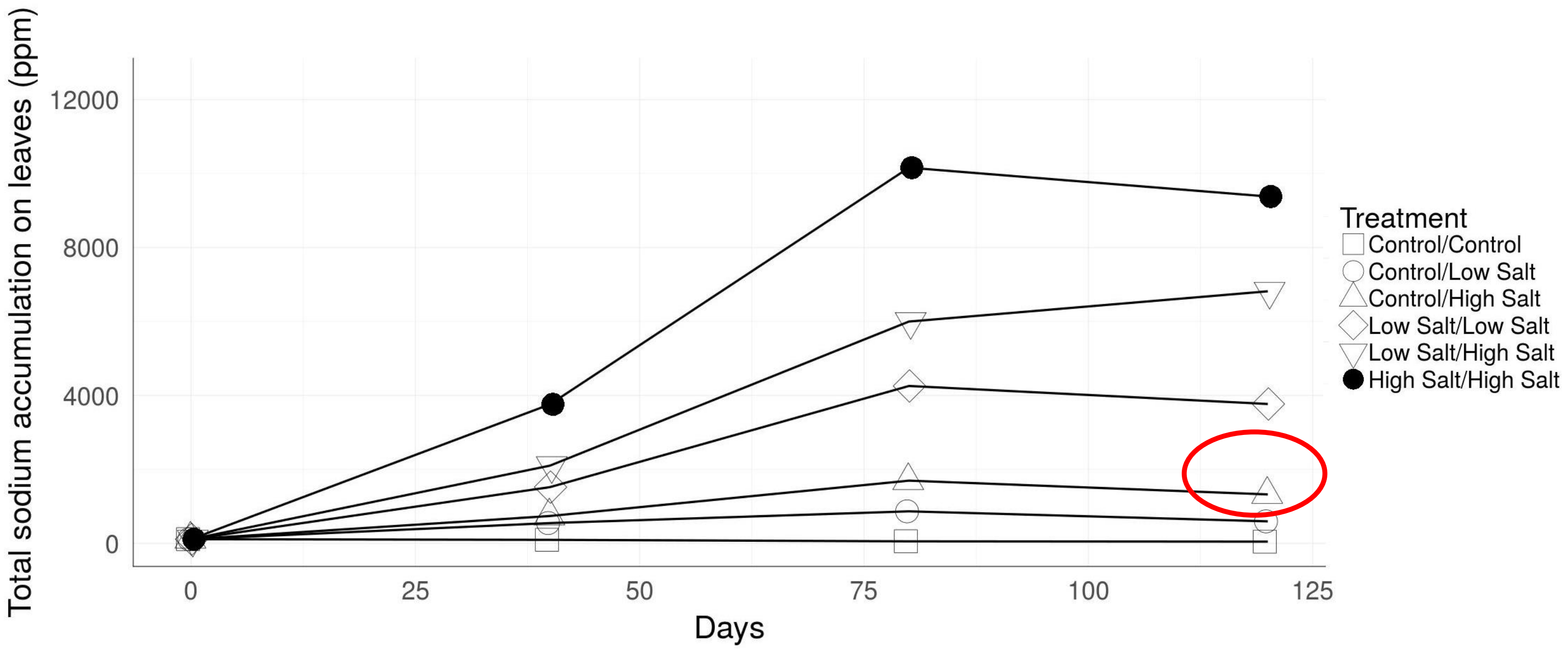
Split Root Experiment

Final Set Up

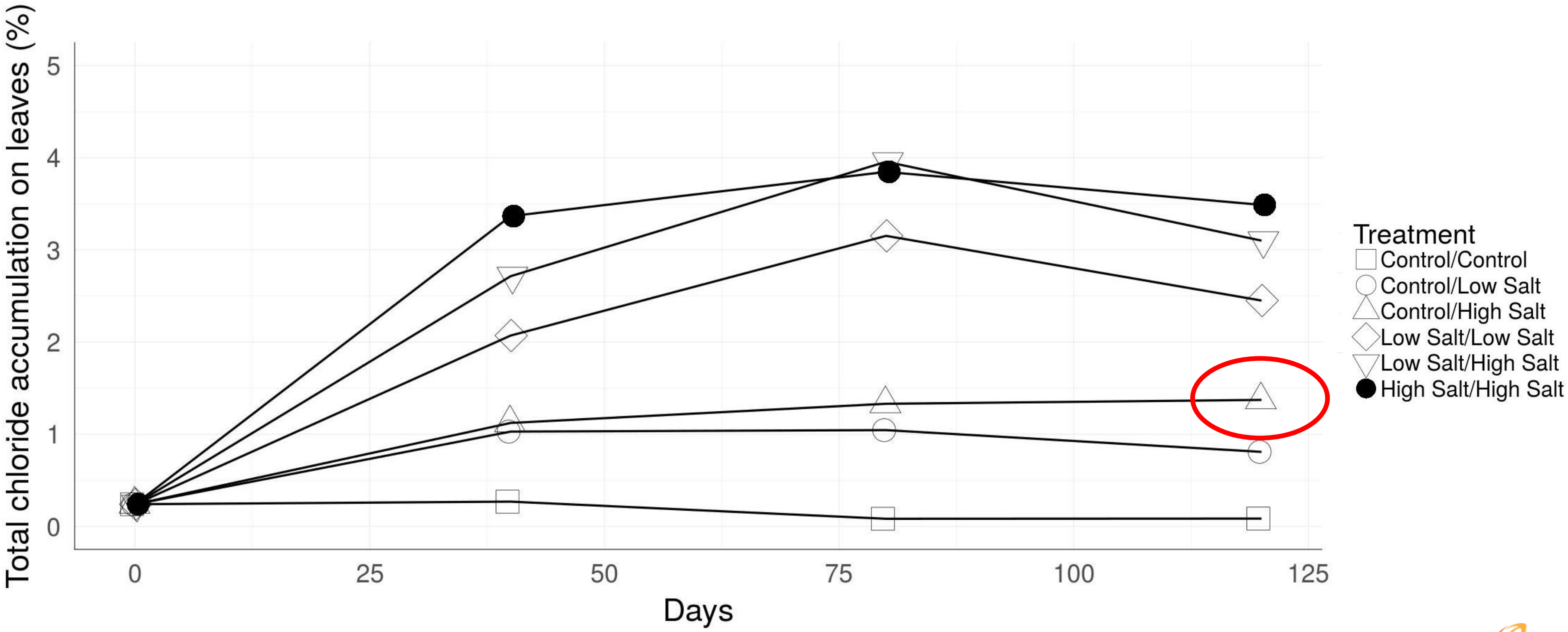
Canopy Growth
Nonpareil on Nemaguard



Leaf Sodium Accumulation
Nonpareil on Nemaguard



Leaf Chloride Accumulation
Nonpareil on Nemaguard



Conclusions

- Rootstock and cultivars vary in their tolerance to salinity. For rootstock: Nemaguard < Hansen536 < Empyrean-1 = Viking when NaCl was a salinity source
- For Cultivar: Fritz< Monterey < Mission =Nonpareil
- Under Na dominant salinity Rootstock sensitivity to Na:
  - RootPac-R < Nemaguard < Empyrean 1 = Krymsk 86 < Corner Stone < Bright Hybrid < Bright 106
- Under Na dominant salinity Rootstock sensitivity to Cl
  - RootPac-R < Nemaguard < Krymsk 86 < Empyrean 1 = Corner Stone = Bright Hybrid = Bright 106 for Cl
- Specific ion toxicity from Cl^- results in defoliation where as sodium accumulate in leaves to high concentration and may not cause severe defoliation
- Under Non-uniform salinity condition, roots in the non-saline and low saline zone uptake water and nutrients thus reducing salt uptake from the high saline zones

Thank You

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David Doll, UC Davis

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Understanding and Managing Salinity for Almonds

David Doll, UCCE Merced

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Salinity Tolerance of Almond

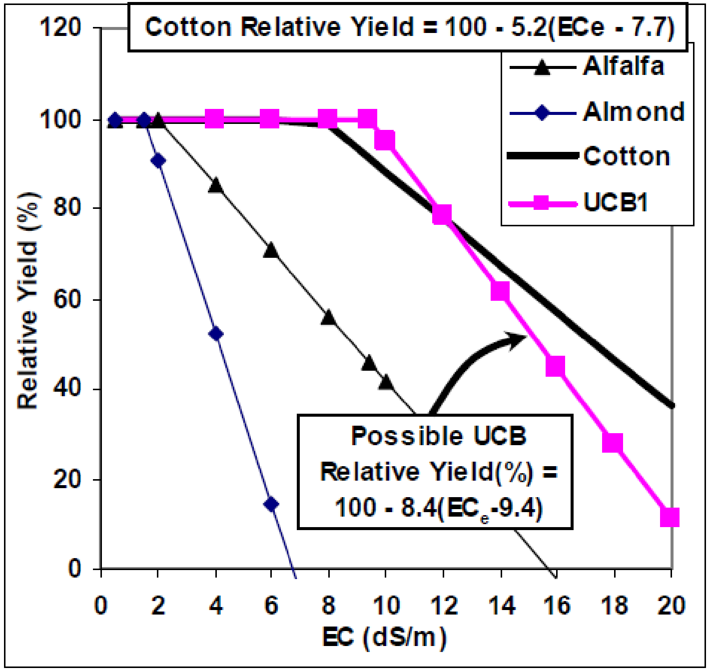

Fig. 2. Relative yield (RY) of various crops as a function of soil EC_e (Sanden, et al., 2004).

- How Tough are Almonds?
  - Sodium Sensitive
  - Every dS/m above 1.5 = 18-21 % growth rate decrease

	Degree of Growth/Yield Reduction			
Salinity of:	Unit	None	Increasing	Severe
Avg. root zone[1]	dS/m	< 1.5	1.5 – 4.8	> 4.8
Irrigation water[1]	dS/m	< 1.1	1.1 – 3.2	> 3.2

* Source: Adapted from E.V. Maas (1990), p. 280. Guidelines assume a 15 percent

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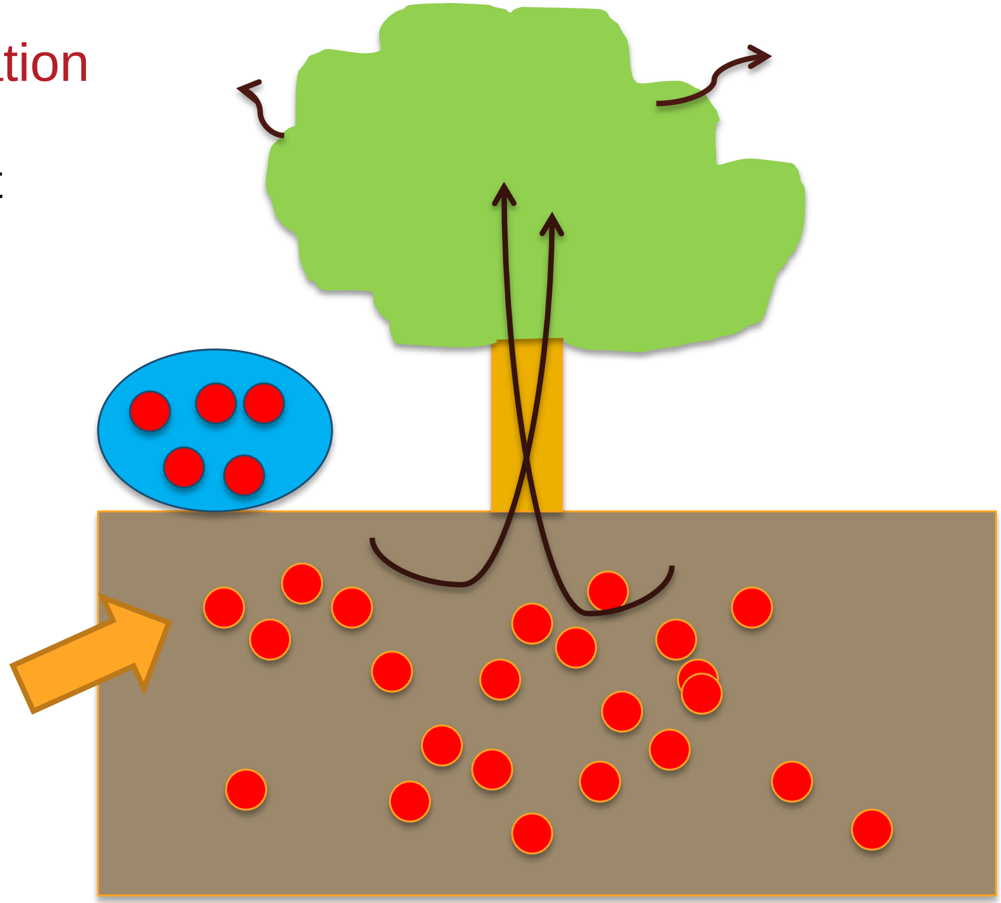
Salt Accumulation

- Why does salt accumulation occur?



Even good water can create salt issues!

Salt exclusion happens at the root.

Almond Salinity Issues: Plant Effects

	Degree of Restriction		
	None	Increasing	Severe
Sodium (%)	<0.25	.25-0.40	>0.40
Chloride (%)	<3.0	3.0-0.5	>0.5
Boron ppm	<30	30-85	>85

Almond Salinity Issues: Plant Effects

By the time you see toxicity::

- Trees are already experiencing osmotic effects prior to showing symptoms
- Can occur rapidly (especially with chloride)
- Takes 2-3 years of effective leaching to reduce tissue levels, regain productivity

Salinity Tolerance of Almond

Sources of Salts in CA ag:

Present in soils

Fertilizer and composts

Irrigation water

- Surface – tends to be cleaner
- Well – variable quality

Water analysis needs to be conducted to know the quality of water!

Managing Salinity within Almond Orchards

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Almond Salinity Issues: Soil Sampling

Soil Sampling should occur in the fall after the completion of the irrigation season

- Samples should be taken within the wetting profile;
- A complete soil profile should be pulled at even increments down to a minimum depth of five feet (e.g. 0”-12”, 13”-24”, 25”-36”, 37”-48”, and 49”-60”);
- Multiple locations can be pooled within a block, but each block/irrigation set should have an analysis;
- If struggling with infiltration, consider pulling a 0-6” sample to look for chemical imbalances;
- If average root system salinity is over 1.5 dS/m, than a leaching program should be considered;
- Follow up the leaching program with another round of sampling to determine the effectiveness of the program.

4 Management Practices:

- Managing Salt Build-up → In-Season Leaching Fractions
- Displacement of Salts → Water Amendments
- Leaching of Salts → Dormant Leaching
- Rootstock Resistance → Pre-plant decision

Almond Salinity Management: In-Season Leaching

- Dependent upon the salinity of the soil and water applied.
- Requires salinity analysis of soil and water

ECe = Salinity of the Soil (dS/m)

ECiw = Salinity of Irrigation Water (dS/m)

Ea = irrigation system application efficiency

$$\text{Leaching Requirement (LR)} = \frac{ECiw}{(5 \times ECe) - ECiw}$$

$$\text{Gross Inches} = \frac{\text{Net Inches Required}}{(1 - LR)\,(Ea)}$$

Almond Salinity Management: In-Season Leaching

- Example: 2.33 net inches of water needed, Ea=80%

ECe = Salinity of the Soil (dS/m) = 4.0

ECiw = Salinity of Irrigation Water (dS/m) = 2

$$\text{Leaching Requirement (LR)} = \frac{ECiw}{(5 \times ECe) - ECiw} = \frac{2}{(5 \times 4.0) - 2} = 0.11$$

$$\text{Gross Inches} = \frac{\text{Net Inches Required}}{(1 - LR)(Ea)} = \frac{2.33}{(1 - 0.11)(0.8)} = 3.27$$

Almond Salinity Management: In-Season Leaching

Generalized LC:

- If want soil EC (ECe) = water EC (ECw)= 33%
- ECe = 2X ECw, LF = 10%
- ECe = 3X ECw, LF = 5%

Almond Salinity Management: In-Season Leaching

Risks of in-season leaching programs:

- Too wet of soils for proper root development
  - Encourages root disease
- May encourage vigor, increased timing of fruit development, risk of hull-rot;
- May leach nitrate;
- Dry down will pull salts back into the rootzone (e.g. hull-split RDI or harvest).

Is this the best strategy?

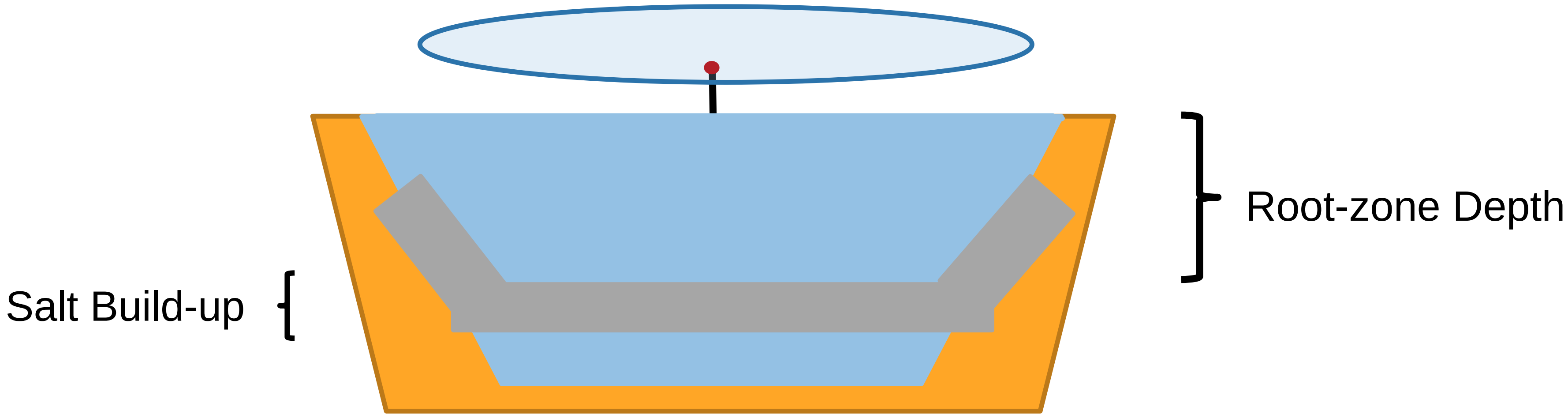
Almond Salinity Management: Dormant Leaching

Dormant leaching should be the primary step to manage salts in established orchards.

Almond Salinity Management: Dormant Leaching

- The soil water content must exceed field capacity in the root zone for leaching to occur;
- Intermittent periods of irrigation and rainfall will more efficiently leach salts and boron than continuous,
- During rain events, drip systems, or limited pattern microsprinklers should be ran to help keep salts out of rootzone
- Low CEC soils (sands, loamy sands) will require less water than higher CEC soils due to reduced salt concentration/cation “tie up”

Example of a Dormant Leaching Program



Almond Salinity Management: Dormant Leaching

	Proportion that rootzone salinity exceeds threshold					
	1.0X	1.3X	2X	2.6X	3.3X	4X
Peach (dS/m)	1.5	1.95	3	3.9	4.95	6
PxA Hybrid (dS/m)	2	2.6	4	5.2	6.6	8
Inches of water/Foot	0	0.6	1.8	3	4.2	5.4

Assumes that rootzone is at field capacity

Almond Salinity Management: Dormant Leaching

Dormant leaching programs for sodium will most likely reduce chloride and boron

- Managing chloride is easier due to being an anion, and less water will be needed;
- If managing boron (weak anion/neutral), more water will be needed than chloride (about twice the amount), acidification may be needed;
- Amounts will vary based on soil and chloride load, but would start with about ½ the amount required for sodium

Almond Salinity Management: Displacement

Increasing cation concentrations can help to displace sodium;

- Use of calcium or magnesium containing amendments;
  - Generally rely on calcium as it has other plant benefits;
  - Some sources may precipitate with water source.
- Acidifying the soil to decrease soil pH, increasing hydrogen ions;
- Not needed for chloride;
- May not be as useful for low CEC soils.

Almond Salinity Management: Overview

Low CEC Soils (< 12 meq/100 g)		Higher CEC Soils (> 12 meq/100 g)
Sand, Loamy sands	**Texture**	Sandy loams, loams, silts, and clays
0.4”-1.5” per foot	**Water Holding Capacity**	>1.5” per foot
High	**Severity of Uptake Burn**	Increases with salinity
Low	**Difficulty to Leach**	High due to WHC, CEC
2-4 times the WHC, (8”- 15”)	**Leaching Amounts**	3”-15” plus profile fill (~10-22”)
Low rates	**Amendments**	High Rates (CEC)

Almond Salinity Management

- START EARLY (i.e. NOW)
- Work to improve distribution uniformity in orchard
- Be careful with too salty of water – may do more harm than good!
- Know your water, soil, and utilize a leaching program
- Monitor tissue levels consistently

Stephanie Tillman, Land IQ

CV-SALTS Overview

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Introduction and Outline

- 5 Ws of CV-SALTS
- Salt Management Strategies and Policies
- What next?

CV-SALTS: What is it?

Central Valley Salinity Alternatives for Long-term Sustainability – collaborative process

Goals

- Sustain the Valley's lifestyle
- Support regional economic growth
- Retain a world-class agricultural economy
- Maintain a reliable, high-quality water supply
- Protect and enhance the environment

Objectives

- Address salinity and nitrate issues in Central Valley
- Comply with Recycled Water Policy (2009)
- Use technical efforts to inform/update knowledge of Central Valley conditions
- Develop new strategies and tools
- Update Basin Plans

CV-SALTS: Who is involved?

Central Valley Salinity Coalition

(Permittees)

Municipal

Industrial

Agricultural

Stakeholders

(Environmental Justice)

Clean Water Action

Community Water Center

Regulatory Representatives

Regional Water Quality Control Board Region 5

State Water Control Board

CV-SALTS

CV-SALTS: Where and When

- Where
  - Central Valley
  - 1.5 million acres of irrigated land have been identified as salinity impaired
  - 0.25M acres have been taken out of production.
  - SV and SJV Basin Plan + Tulare Lake Basin Plan
- When
  - Began in 2006
  - Basin Plan adoption – June 2018

CV-SALTS: Why is this effort necessary?

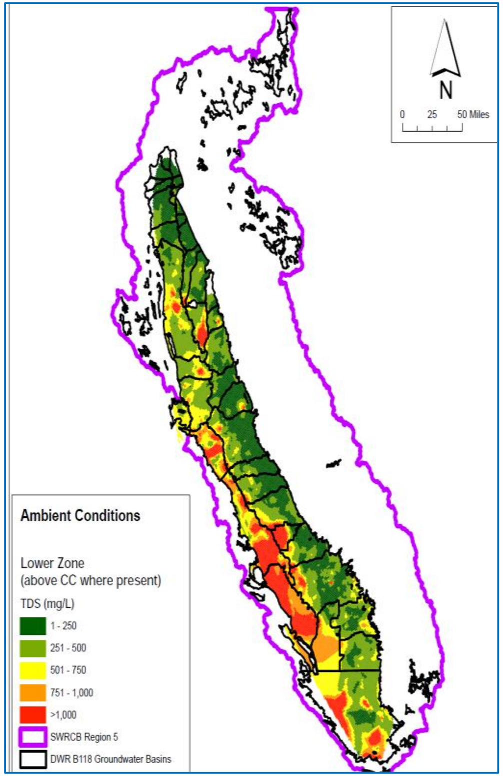
Problem 1: Worsening Conditions

- "*the slow and steady accumulation of salts in Central Valley groundwater basins threatens not only the long-term viability of agriculture and industry, but also the water supplies of more than 25 million people*."
- Conditions worsening since 1970s
- *"Unless steps are taken to address these issues, salts will affect an even greater portion of California's communities, economy, and environment"*.

Problem 2: Regulatory Framework

- Many city and regional wastewater facilities cannot meet current water quality objectives
- Industries struggle to comply with salinity limitations; places limitations on growth
- Agriculture is limited and faces increased costs to manage salinity
- Drinking water sources throughout the region are impacted by high levels of salts.

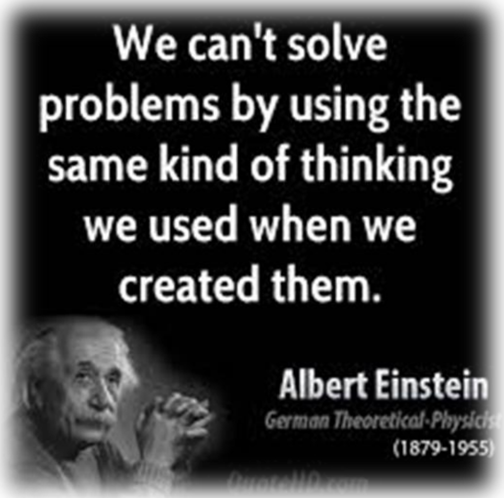
Salinity Management – Technical Foundation



- Models - maps of current groundwater conditions
  - Estimated **current salinity conditions** in DWR basins throughout Central Valley on 1-mile grid
  - Projected **future salinity conditions** out to 50 years
- Strategic Salt Accumulation Land and Transportation Study (SSALTS)
  - Identified and evaluated **potential salt management strategies**.
  - Current salinity management address **15%** of the annual salt load.
  - **Long-term solutions** (regional de-salters, regulated brine line) to address other 85%.

Salinity Management - Strategy

- **Long-term management strategies** require significant state and federal funding.
- **Short-term** adoption of WDRs/Conditional Waivers
- **Innovative salt management** strategies that move the region toward salt balance and restoration of impacted areas where feasible.
- **Additional regulatory flexibility** in WDRs/Conditional Waivers with salinity related requirements.



Salinity Management –Strategic Approach

Phase	Years from Basin Plan Adoption	Activities
1	1-10	Prioritization and Optimization Study • feasibility study • identifies appropriate regional and subregional projects • location, routing and implementation/ operation of specific salt management projects
2	10-20	Environmental permitting Engineering design Funding acquisition
3	20-30	Construction of salt mitigation projects

Salinity Management – Interim Permitting Approach

- Option 1
  - Continue current reasonable, feasible and practicable efforts to control levels of salinity in their discharges
  - Participate in (fund) efforts to conduct the Phase I Prioritization and Optimization Study
  - Receive interim resolution/waiver
- Option 2
  - Comply with current permit
  - Do not participate in (fund) study
- Years 1-15

What next?

- Key point: Basin Plan amendments are still 1.5 years away from adoption
- ILRP
  - In process
  - Some coordination
- SGMA
  - May have relevance/coordination with Drought and Water Conservation Policy

Questions?

growing
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