Salinity Management – Soil and Cropping Systems Strategies

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Introduction to Salinity

Salt problems occur on approximately one-third of all irrigated land in the world.

Why do salts exist in soil?

- Parent material weathers to form salts
- Salts are carried in irrigation water
- Soil amendments may contain salts
- Presence of shallow, saline groundwater

Introduction to Salinity

- Salinity is typically evaluated as electrical conductivity (EC_e, EC_w) and/or sodium adsorption ratio (SAR)
- **Saline soil**: has sufficient soluble salts to impair productivity.
  - EC_e > 4 dS/m (Non-alkaline soil with pH < 8.5)
- **Sodic soil**: has sufficient Na^+ to impair productivity
  - SAR > 13 (An alkaline soil with pH > 8.5)

Effects of Salinity on Plant Growth

- **Osmotic stress:**

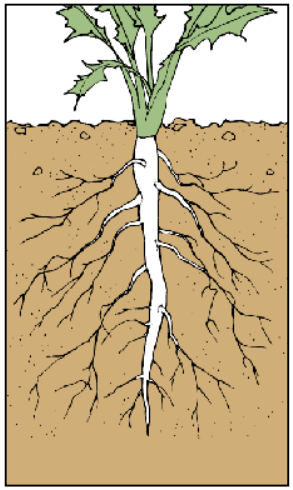
  Most common means by which salt impairs plant growth

- **Specific ion toxicities:**

  Na^+, Cl^-, B

- **Degraded soil conditions:**

  Limit plant water availability



Strategies for Salinity Management

- Irrigation water carries salts, and when irrigation water is applied to fields, salts are added to the soil.
- Salts accumulate in the soil at higher concentrations than they existed in the applied water, and salts may accumulate unevenly in the soil.
- It is important to test water and soil salinity regularly to understand baseline conditions and changes over time.

Site Selection/Pre-planting

Test soil and water.

- Typical soil sampling for nutrient status is 1-2 ft, but get a sample that will be representative of the salinity condition.

Consider site characteristics and seasonal or field patterns.

- **Texture:** A recent study from North Dakota found that corn and soybean yield declines occurred in sandy loams but not silty clays.
- **Specific ions:** Same study found that crops had higher salt tolerance when salts were composed of Ca^{2+}, Mg^{2+}, and SO_4^{2-} ions, compared to Na^{+} and Cl^{-}.
- **Patterns:** Leach salts before planting and consider irrigation modifications (e.g. increase on-flow rate of irrigation, shorten field length, narrow border width).

Site Selection/Pre-planting

Consider crop tolerances and when the crop is most sensitive to salinity (often the seedling stage).

- Establish stand with best quality water or blend sources (if different sources are available).

Relative salt tolerance ratings exist for many crops grown in California, as do threshold tolerances where we would expect to see yield decline.*

- Absolute tolerance will vary based on climate, soil, cultural practices, crop development, and variety.

**See Water Quality for Agriculture, FAO 29. http://www.fao.org/docrep/003/T0234E/T0234E00.HTM*

Variety Selection

Research by Cornacchione and Suarez (USDA, Riverside), Putnam (UC Davis) and Benes (CSU Fresno) describes salt tolerance of commercial alfalfa varieties.

- Some varieties may tolerate higher salinity based on the plant's ability to limit Na^+ and Cl^- accumulation.

Nevertheless, plant breeding should not be considered a substitute for soil salinity management.

Soil Amendments

Most effective in sodic soils:

- Calcium amendments can replace sodium on the soil and improve soil structure so that sodium can be leached.
- Gypsum ($CaSO_4$) is the most common amendment and may be used in acidic or alkaline soils.
- If soil contains “free lime”, (calcium carbonate, $CaCO_3$), then adding an acid, like sulfuric acid (H_2SO_4) will liberate the Ca in the soil.
  - Free lime may be present in alkaline soils.

Soil Amendments

Cautionary Considerations:

- The amount of amendment depends on the amount of exchangeable Na^+ in the soil and could be costly.
- The process can be slow – amendments must solubilize and react in the soil.
- If infiltration is already good, then applying a calcium amendment might not be economical.
- ***Soil amendments do NOT eliminate the need for leaching.***

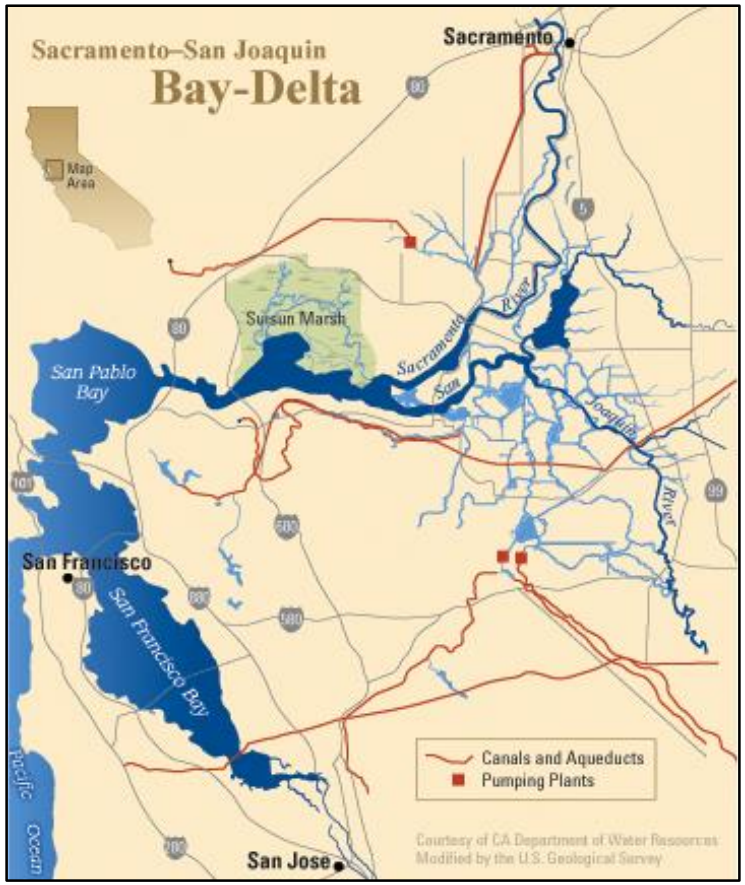
See https://extension.arizona.edu/sites/extension.arizona.edu/files/pubs/az1413.pdf "Using Gypsum and Other Calcium Amendments in Southwestern Soils"

Leaching

- Leaching must be practiced when soil salinity has the potential to impact yield.
- It occurs when water is applied in excess of soil moisture depletion due to evapotranspiration (ET).
- Leaching may occur during the rainy season or whenever an irrigation event occurs.
  - During the season, leaching may not be advised because of the potential for nutrients to be lost.

Delta Research Projects:

Salinity Management and Leaching



Salinity Management and Leaching

Background: Environmental conditions in the Delta (e.g. low permeability soils, shallow groundwater), coupled with water-saving management (e.g. conversion to drip irrigation), limit growers' ability to manage salts.

Furthermore, State Water Resources Control Board adopts water quality objectives for the protection of agriculture in the Delta. The salinity objectives are currently under reconsideration.

Objective: Understand soil salinity profiles in Delta tomato and alfalfa fields to help inform salinity management.

Salinity of Drip Irrigated Tomato Field

(Silty Clay Loam)

Electrical Conductivity, ECe (dS/m)

Depth (cm)	Spring 2013				Fall 2015							
	Bed Center			Furrow	Bed Center							Furrow
0 - 10	0.84	0.74	1.24		2.50	2.51	2.97	2.34	2.67	2.27	2.76	2.69
10 - 20	0.93	0.84	0.75	0.72	1.37	1.17	1.12	1.02	1.05	0.96	2.51	4.49
20 - 30	0.81	0.84	0.92	0.74	0.85	0.85	0.85	0.86	0.90	1.08	0.81	1.04
30 - 40	0.94	0.84	0.73	0.76	0.87	0.94	0.99	0.92	0.95	0.87	0.74	0.76
40 - 50	0.67	0.92	0.74	0.79	1.12	0.89	1.26	1.15	0.99	0.86	0.85	0.71
50 - 60	0.64	0.76	0.74	0.79	1.06	1.05	1.37	1.08	0.89	0.84	0.61	0.71
60 - 70	0.68	0.79	0.75	0.71	0.94	0.96	1.52	1.16	1.09	0.88	0.71	0.87
70 - 80	0.82	0.77	0.79	0.71	0.83	0.94	1.32	1.49	1.21	1.11	1.01	0.87
80 - 90	0.83	0.77	0.74	0.73	1.15	1.17	1.46	1.51	1.58	1.56	1.43	1.21
90 - 100	0.81	0.80	0.78	0.66	1.47	1.75	1.66	1.68	1.67	1.68	1.68	1.51

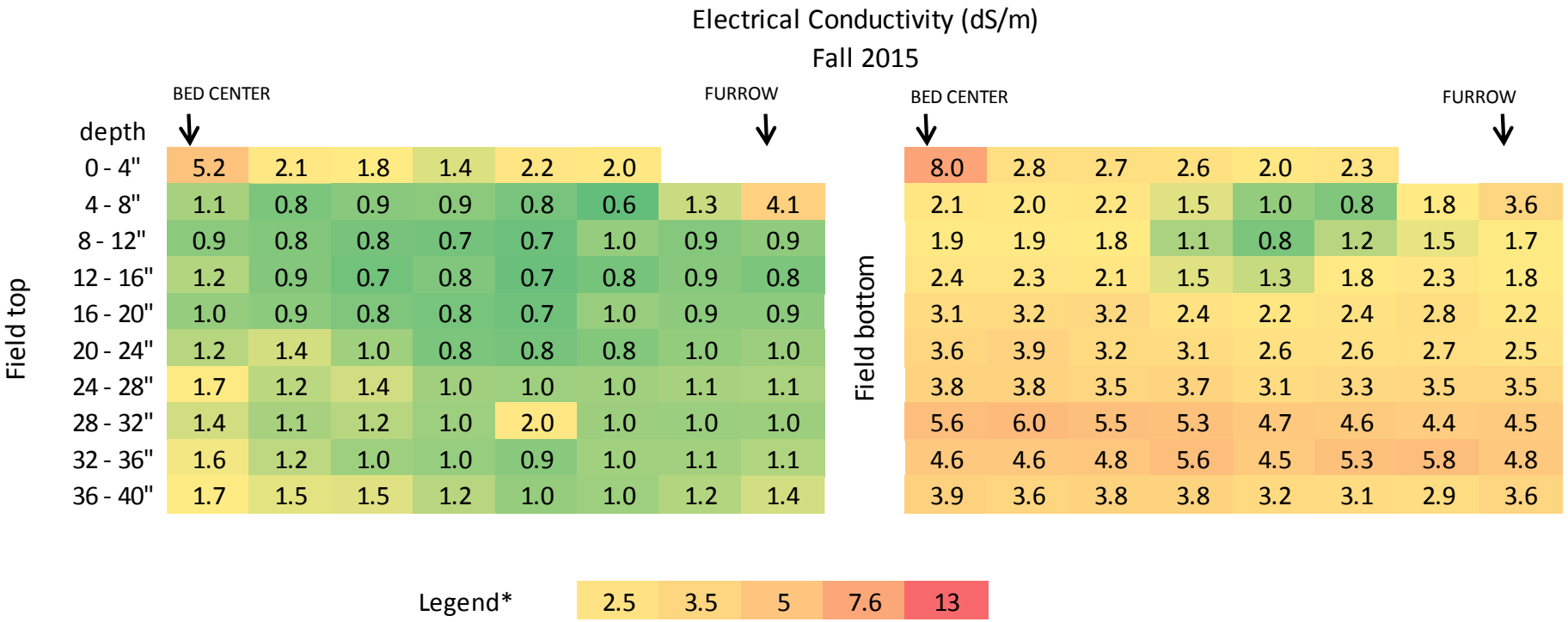
Legend* 2.5 3.5 5.0 7.6 13.0

*Ayers and Westcot, 1985

(Project Leaders: B. Aegerter and M. Leinfelder-Miles)

Salinity of Furrow Irrigated Tomato Field

(Silty Clay Loam)



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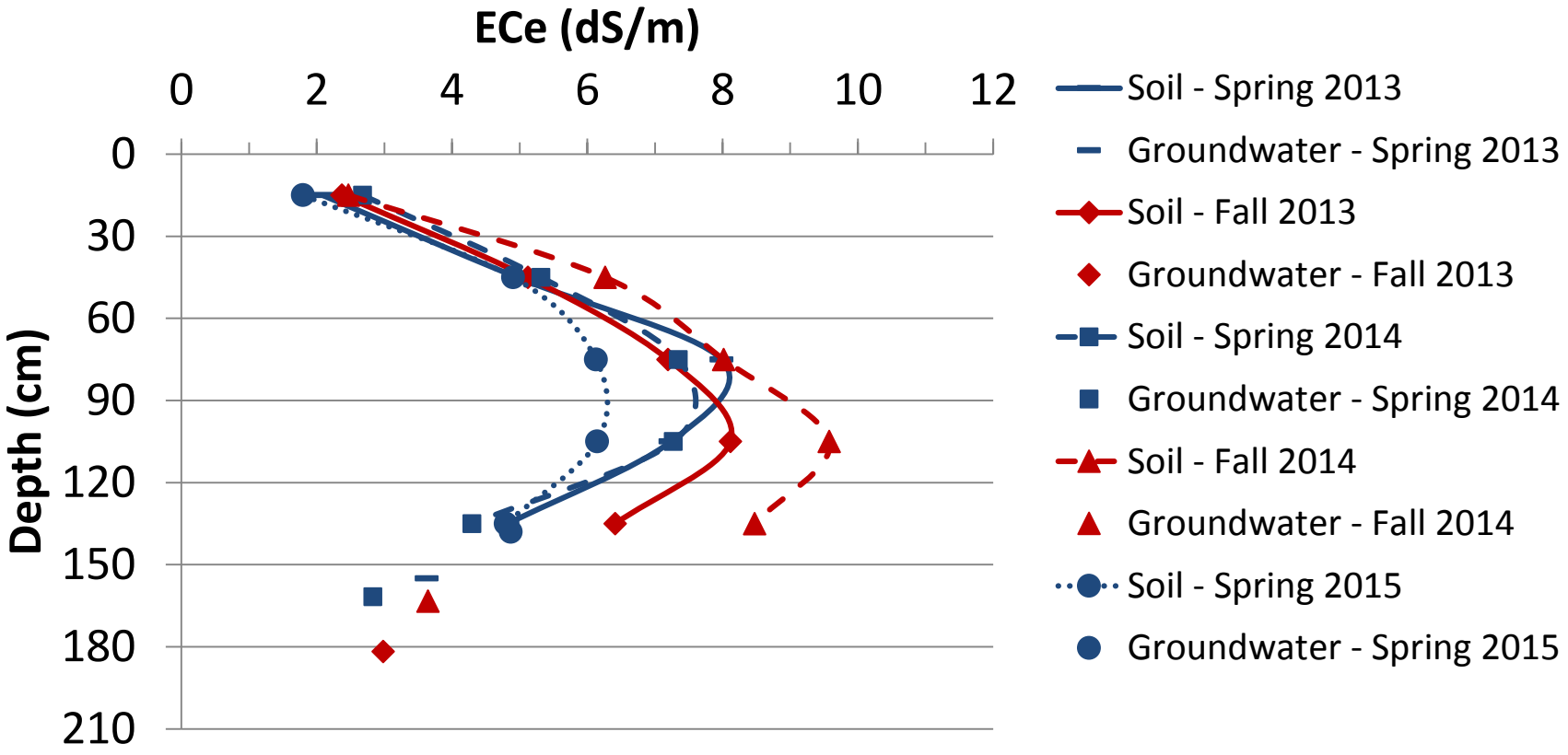
Salinity of Flood Irrigated Alfalfa Field

(Fine Sandy Loam)



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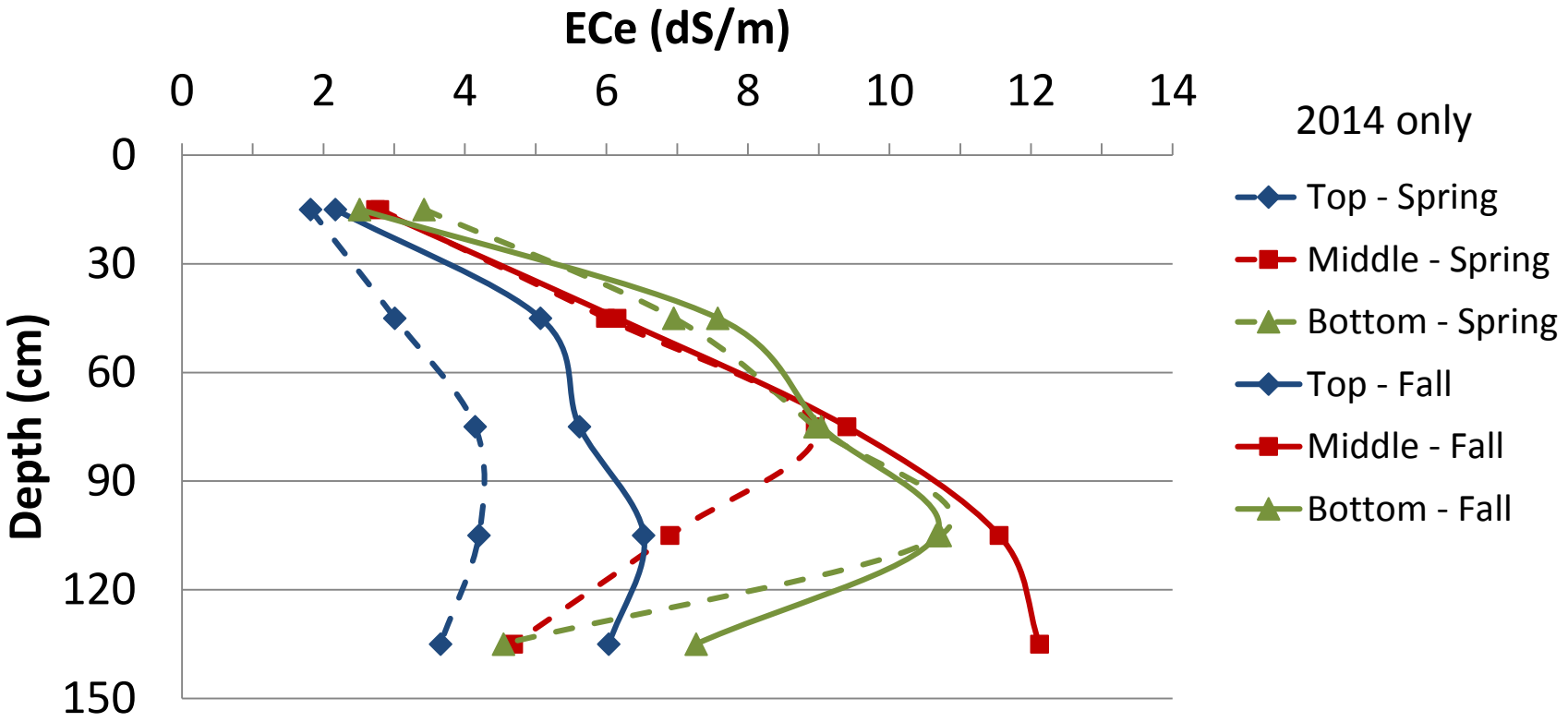

*Management may improve leaching at this site because the coarser-textured soil has better water infiltration.

Research Summary

- Project results illustrate the salinity conditions in the Delta and the unique growing conditions that constrain growers' ability to leach salts.
- ***Winter rain appears to provide our best leaching in normal rainfall years.***
- ***Enhance leaching during the off-season by leveraging rainfall with irrigation water to wet profile before a rain event. This could be particularly beneficial in drought years.***

Overall Conclusions on Salinity Management

- Understand the differences among saline and sodic soils because management may differ.
- Consider salinity condition at site selection by testing soil and water, leaching salts, and managing irrigation.
- Variety selection and soil amendments may help mitigate salinity, but these do not eliminate the need for leaching.
- Research results illustrate the challenges associated with leaching but suggest strategies for alleviating salty conditions.

Thank you!

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http://ucanr.edu/sites/deltacrops/

http://ucanr.edu/blogs/sjcfieldcrops/