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February 2-7 | San Diego Convention Center

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Managing Turfgrass Soil and Irrigation Salinity

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TYPES OF SALTS

- Cations:
  - Na^{+}, Ca^{++}, Mg^{++}, K^{+}, NH_4^{+}
- Anions:
  - Cl^{-}, NO_3^{-}, SO_4^{--}, BO_3^{3-}, CO_3^{--}, HCO_3^{-}

Low angle sprinkler

- normal soil has an EC < 4 dS/m and ESP < 15 or SAR < 13
- saline soil has an EC > 4 dS/m and ESP < 15 or SAR < 13
- sodic soil has an EC < 4 dS/m and ESP > 15 or SAR > 13
- saline-sodic soils has an EC > 4 dS/m and ESP > 15 or SAR > 13
- 4 dS/m approximates an ionic strength of 58 mol/m^3 or .058 mol/l (only about 10% of that in seawater); salt sensitive plants are effected at 1 dS/m or .014 mol/l



pH

- EC and ESP are diagnostic, not pH, but pH may be an indicator; soils with a pH above 8.5 usually have a Na problem; soils with a pH above 7.5 almost always have carbonates ($CaCO_3$, $MgCO_3$) present
- the equilibrium of $CaCO_3$ in water has a pH of about 8.3, but calcareous soils (with low SAR) have pH's 7.8 - 8.0 because of equilibration with CO_2 and other soil factors

- $CO_2 + H_2O$ <----> $H^+ + HCO_3^-$

Measuring electrical conductivity in soils:

- Saturated paste extract
  Distilled water is added to (soil-)media to saturation, yet no free water present
- 2:1 Method / 1:1 Method
  2 parts (1 part) distilled water mixed with 1 part air dried media

Measurements

- measurement of total dissolved solids (TDS) by evaporation and weighing
- measurement of individual cations (Na, K, Ca, Mg) and cation exchange capacity for sodicity (exchangeable sodium percentage- ESP or sodium adsorption ratio (SAR)

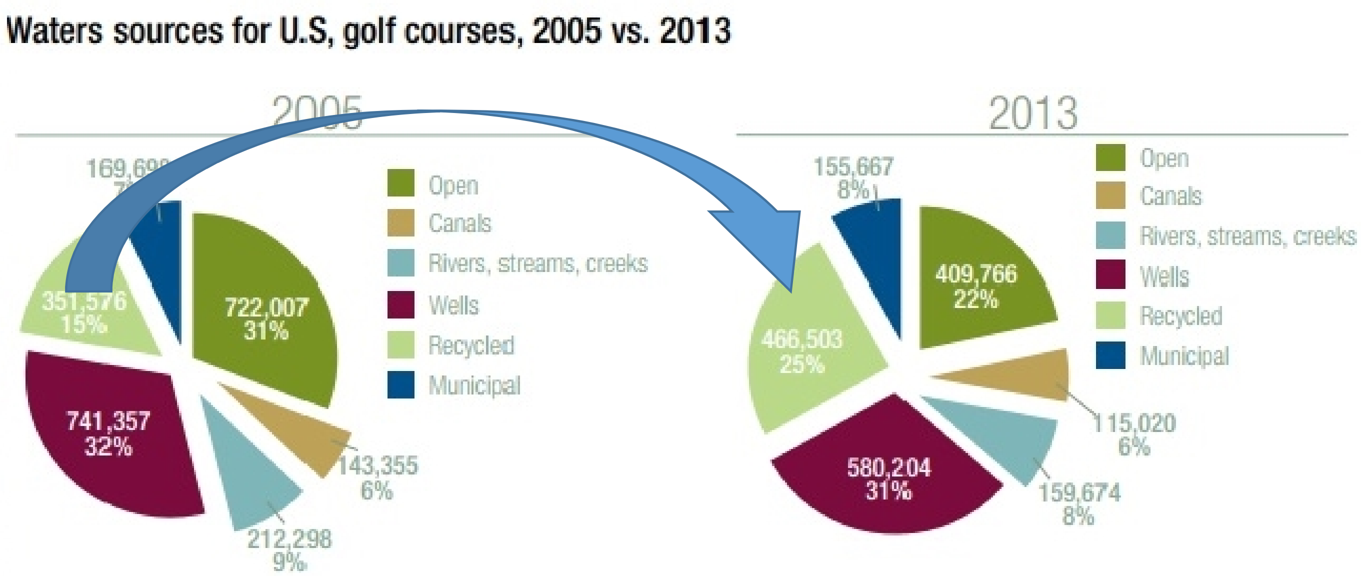
$$ESP = \frac{\text{Exchangeable Na}^{+}\ \text{(meq/100g soil)}}{\text{Cation exchange capacity (meq/100g soil)}} \quad [\%]$$

$$SAR = \frac{[Na^{+}]}{\sqrt{\frac{Ca^{2+} + Mg^{2+}}{2}}}$$

- where concentration ([ ]) is expressed as mmol/l or meq/l

$$\frac{[Na^{+}]}{([(Ca^{2+}) + (Mg^{2+})])1/2}$$

- the determination of SAR is less problematic than are measurements of CEC and exchangeable cations



2014 Water use and conservation practices on U.S. Golf Courses; Adapted from Gelernter et al., 2014

% facilities using water conservation practices

Water conservation practices	U.S.		North Central		Northeast		Pacific		Southeast		Southwest		Transition		Upper Mountain/ West	
	2005	2013	2005	2013	2005	2013	2005	2013	2005	2013	2005	2013	2005	2013	2005	2013
Wetting agents	88	94	90	96	84	87	86	94	91	95	76	91	91	94	90	98
Hand watering	72	77	65	71	70	74	80	86	69	74	72	79	85	86	74	81
Keep turf drier than in past	62	74	61	70	62	76	57	79	63	76	59	74	64	70	63	79
Mulch landscape beds	43	48	38	47	42	50	36	50	59	64	27	34	48	49	40	37
Use irrigation scheduling†		50	33	47	41	49	45	51	49	51	58	57	39	43	51	58
Adjust fertilizer practices	42	52	40	49	37	51	45	47	47	53	47	59	38	52	43	52
Soil amendments	29	40	22	34	35	48	25	33	34	44	33	37	27	44	34	39
Drip irrigation for landscape plants	13	16	4	6	6	7	18	27	15	18	38	47	9	9	32	30
Hand-held moisture sensors†		33		26		41		23		38		29		43		29
Increase no-mow acreage†		46		48		51		52		38		28		56		42

†Question not asked in initial survey.

2014 Water use and conservation practices on U.S. Golf Courses; Adapted from Gelernter et al., 2014

Type of moisture sensors: Buried

Permanently installed:

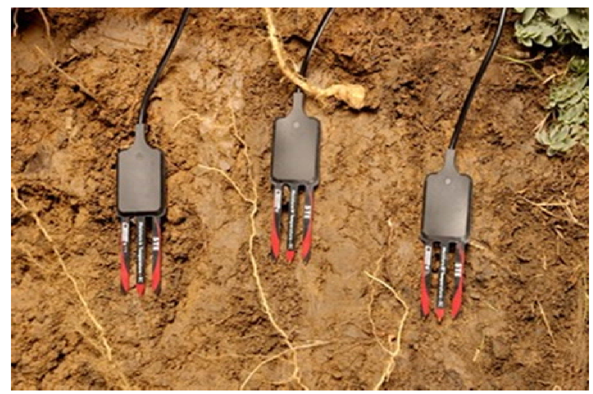
Turfguard (The Toro Company)

TDT (Acclima)

5TE (Decagon Devices)

TDR 100 (Campbell Scientific)

…Just to name few



Type of moisture sensors: Handheld

Currently most popular:

TDR 100/150 300/350 (Spectrum Technology Inc.)

POGO (Stevens Waters)

Dynamax TH2O

How does salinity affects moisture sensors readings?

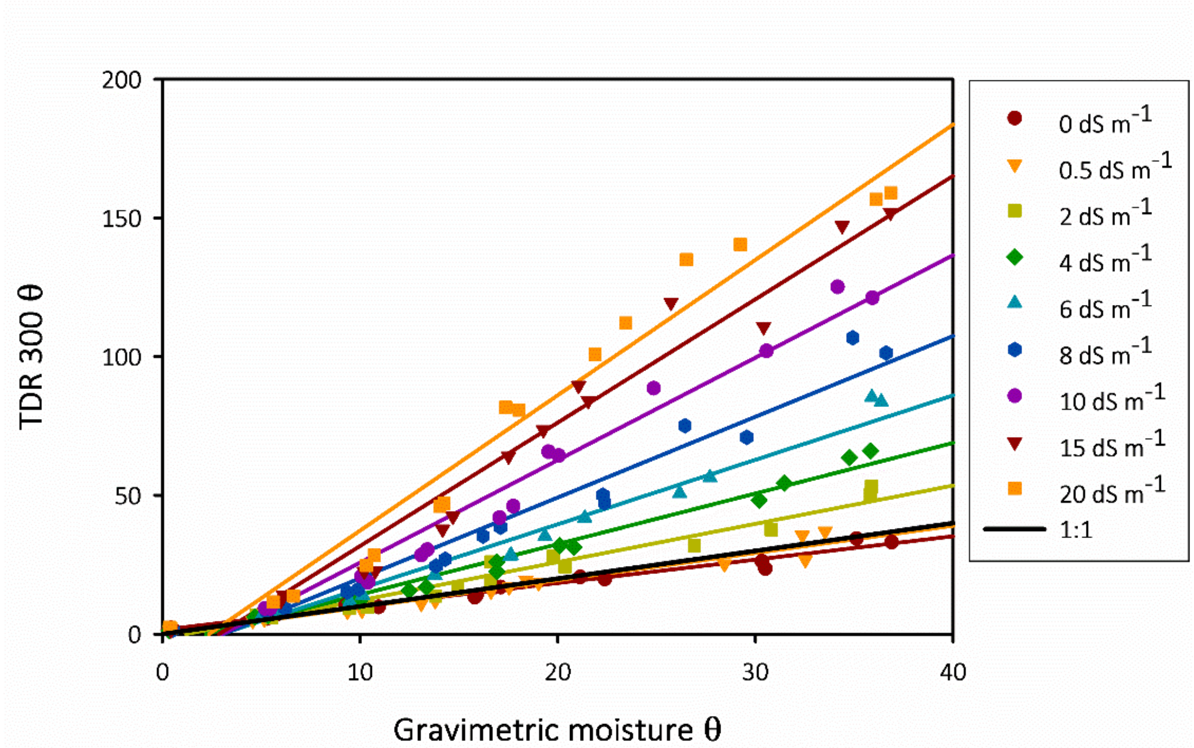
Material and Methods

- 5 Sensors:
  - Field Scout TDR 300/350
  - POGO
  - TH2O
  - Turf Guard
- Soil: USGA sand
- 9 solutions with different salt contents (NaCl): 0; 0.5; 2; 4; 6; 8; 10; 15; 20 dSm^{-1}
- Different amounts of solution were added to PVC containers filled with sand to produce a gradient of θ ranging from approximately 0 to 35%
- The sand and solution was mixed and compacted inside the PVC container to assure uniform moisture distribution (Rhoades et al., 1989)

Material and Methods

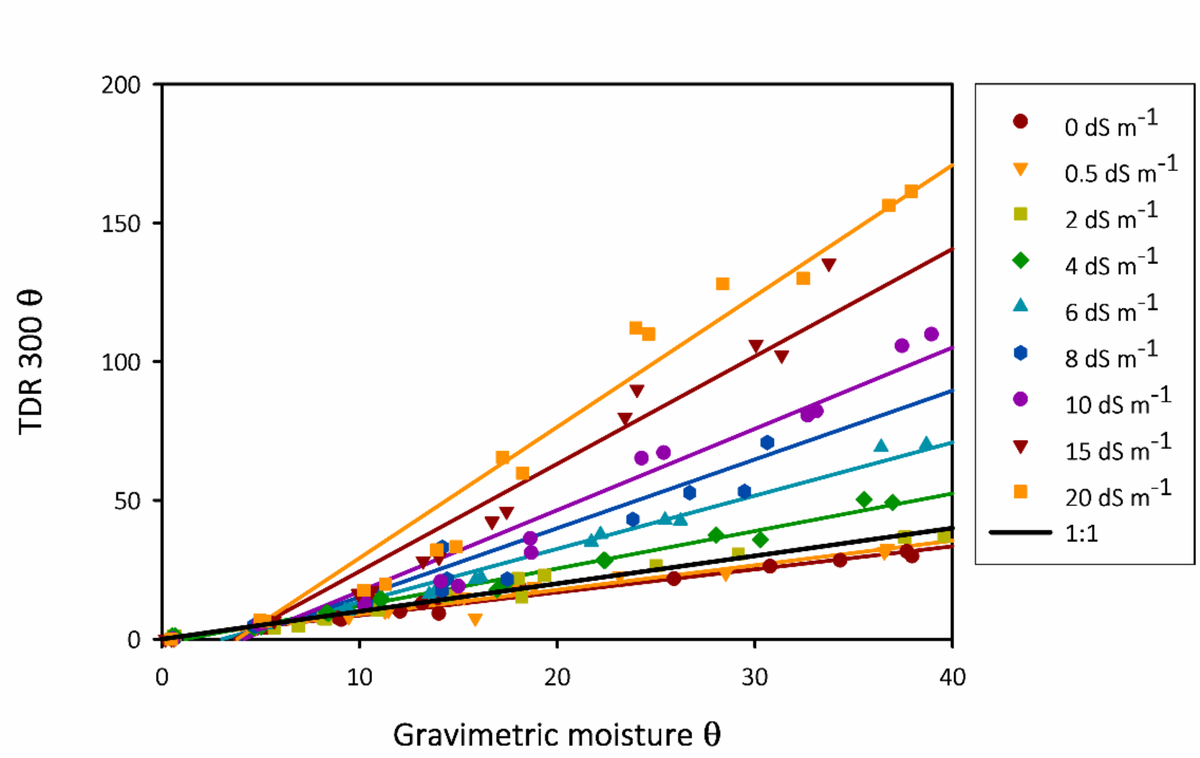
- Soil moisture for each container determined gravimetrically
- Sensor moisture readings were recorded and compared to the gravimetric water content
- At the end, saturated paste soil salinity (EC= dSm^{-1}) was determined for each container
- Treatments were replicated 4 times

Results: TDR 300



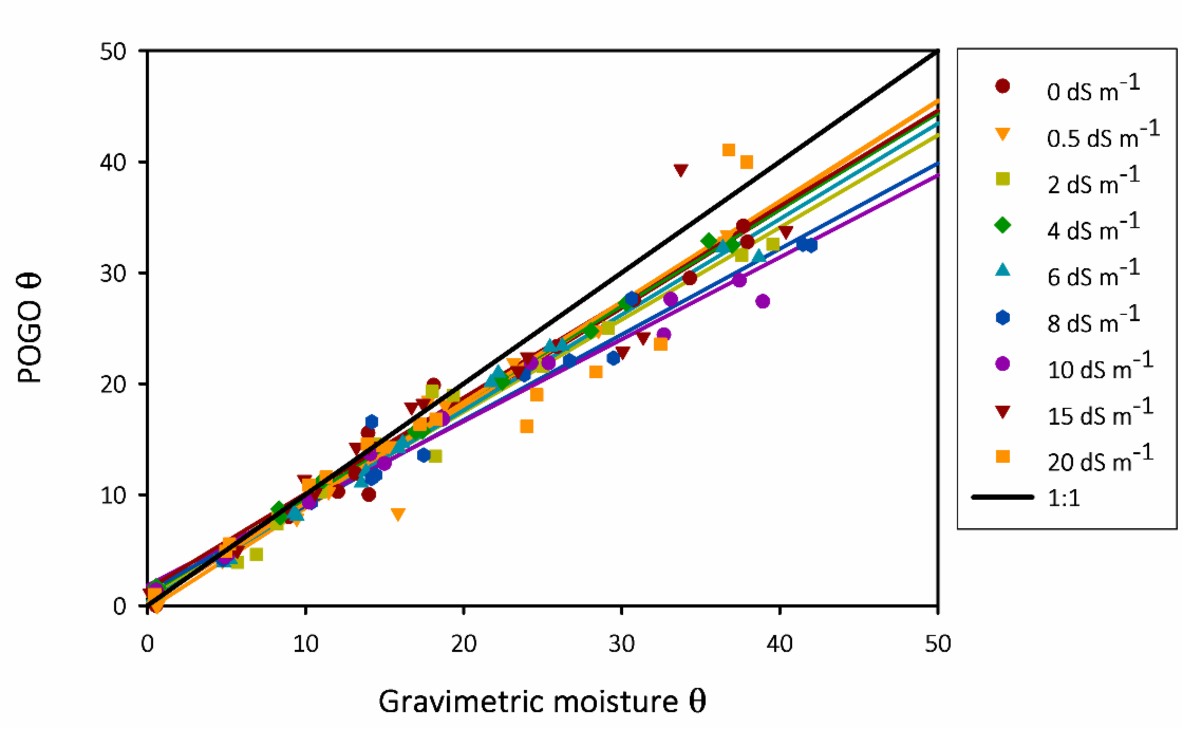
R^2 for 0 to 20 dS m^{-1} between 0.96 to 0.99

Results: TDR 350



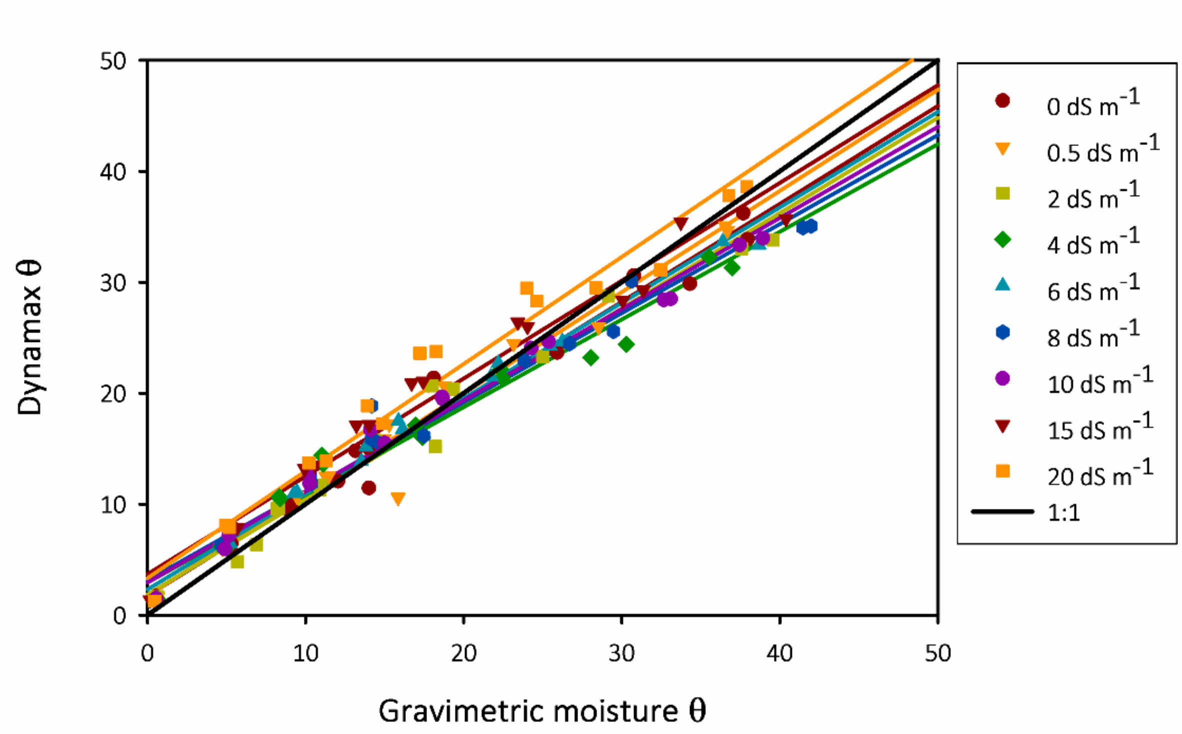
R^2 for 0 to 20 dS m^{-1} between 0.95 to 0.98

Results: POGO



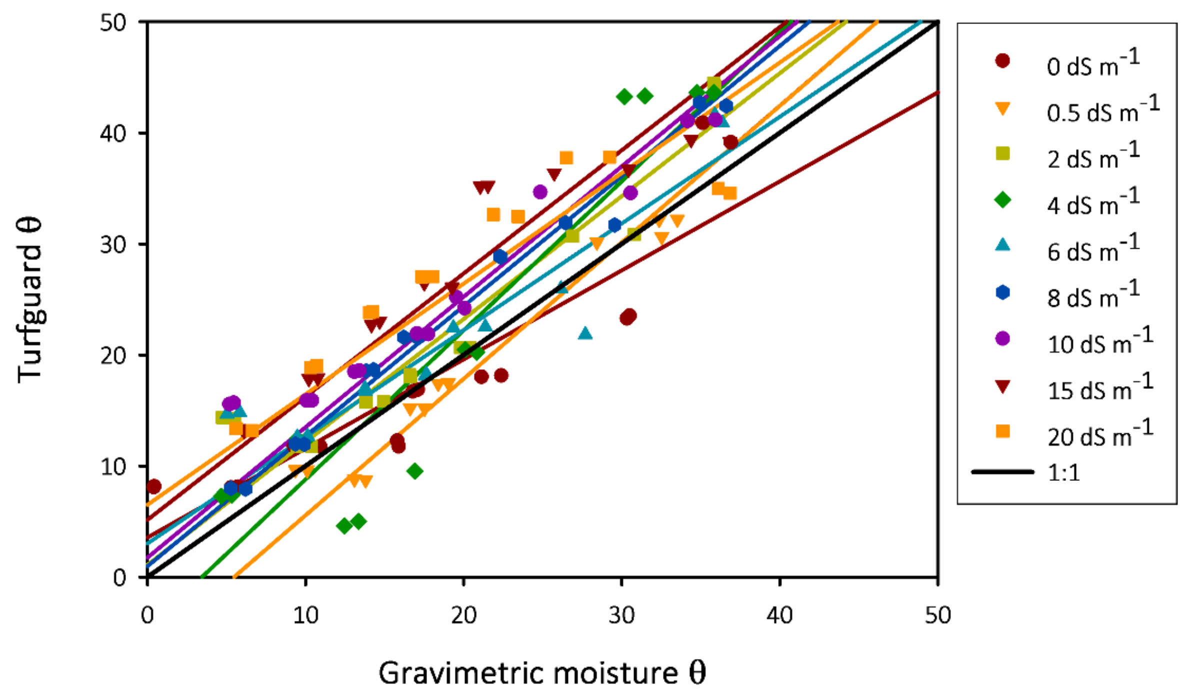
R^2 for 0 to 20 dS m^{-1} between 0.94 to 0.99

Results: TH20



R^2 for 0 to 20 dS m^{-1} between 0.97 to 0.99

Results: Turf Guard



R^2 for 0 to 20 dS m^{-1} between 0.81 to 0.99

Summary:

- The FieldScout TDR300 measured accurately soil moisture at the lowest water salinity levels (≤0.5 dS m^{-1})
- The new FieldScout TDR350 can handle accurately low level of salinity (≤4 dS m^{-1}), and adjust readings accordingly
- As salinity increased moisture readings were higher than measured values but deviated linearly.
- The POGO, TH2O and Turf Guard sensors performed well to water salinity levels as high as 20 dS m^{-1}

Acknowledgements

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USGA
TORO
Spectrum Technologies, Inc.
"To Measure Is To Know"
STEVENS
MEASUREMENTS TO MIND
Dynamax

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Salinity Management

- Site assessment: soil, irrigation water, distribution uniformity (DU)
- Selection of salt-tolerant species
- Leaching of salts: applying excess amounts of water above plant evapotranspiration (ET)
- Selection and proper use of amendments
  - Increase Ca and Mg

Turfgrass species tolerance to soil salinity (EC_e)

Sensitive (< 3 dS m^{-1})	Moderately sensitive (3-6 dS m^{-1})	Moderately tolerant (6-10 dS m^{-1})	Tolerant (> 10 dS m^{-1})
Annual bluegrass	Annual ryegrass	Perennial ryegrass	Saltgrass
Colonial bentgrass	Creeping bentgrass	Tall fescue	Alkaligrass
Kentucky bluegrass	Fine-leaf fescues	Zoysiagrass	Bermudagrass
Rough bluegrass	Buffalograss		Seashore Paspalum
			St. Augustine

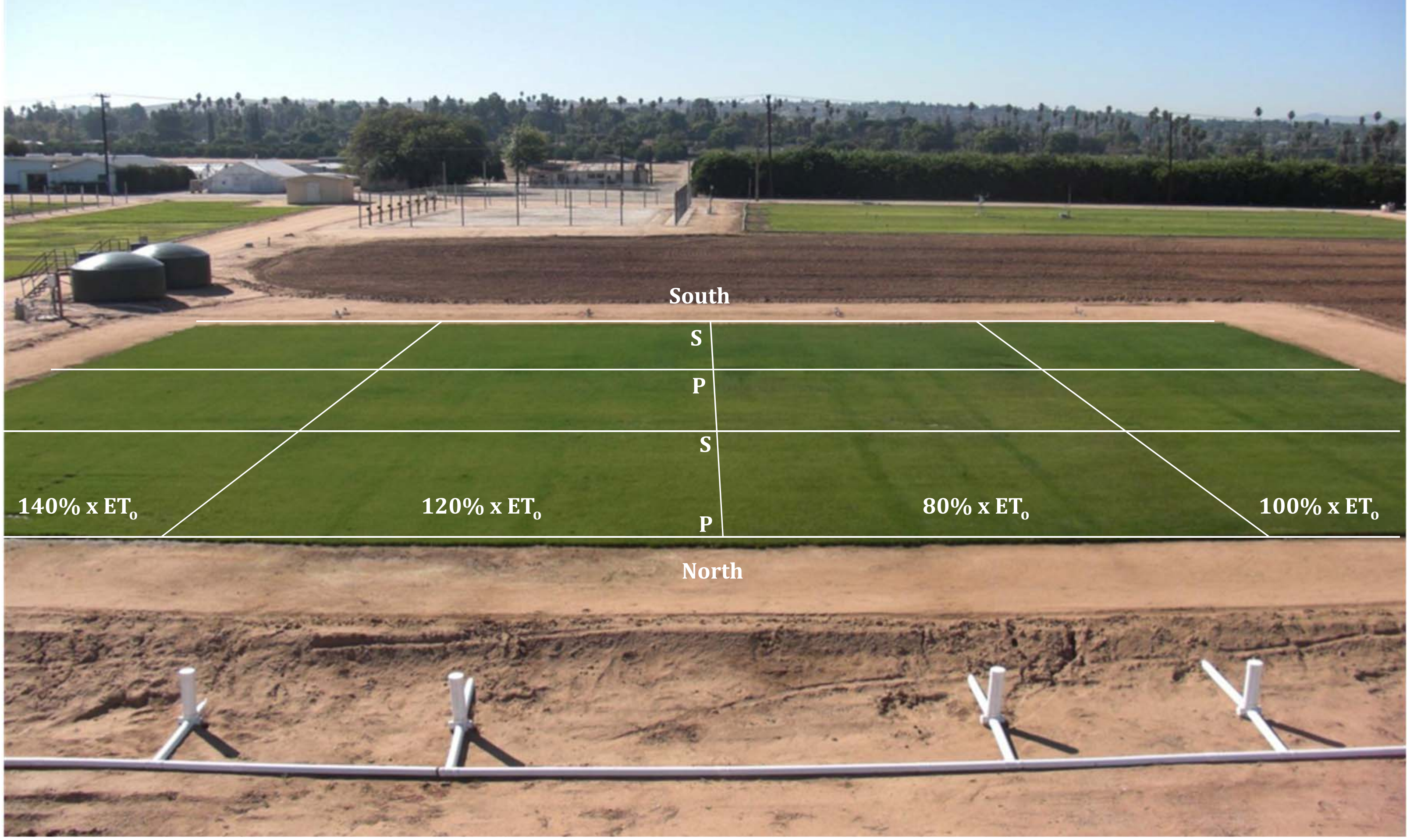
M. A. Harivandi, J. D. Butler, and L. Wu. 1992. Salinity and turfgrass culture. In D. V. Waddington, R. N. Carrow, and R. C. Shearman (eds.) Turfgrass, pp.207–229. Series No. 32. Madison: American Society of Agronomy.

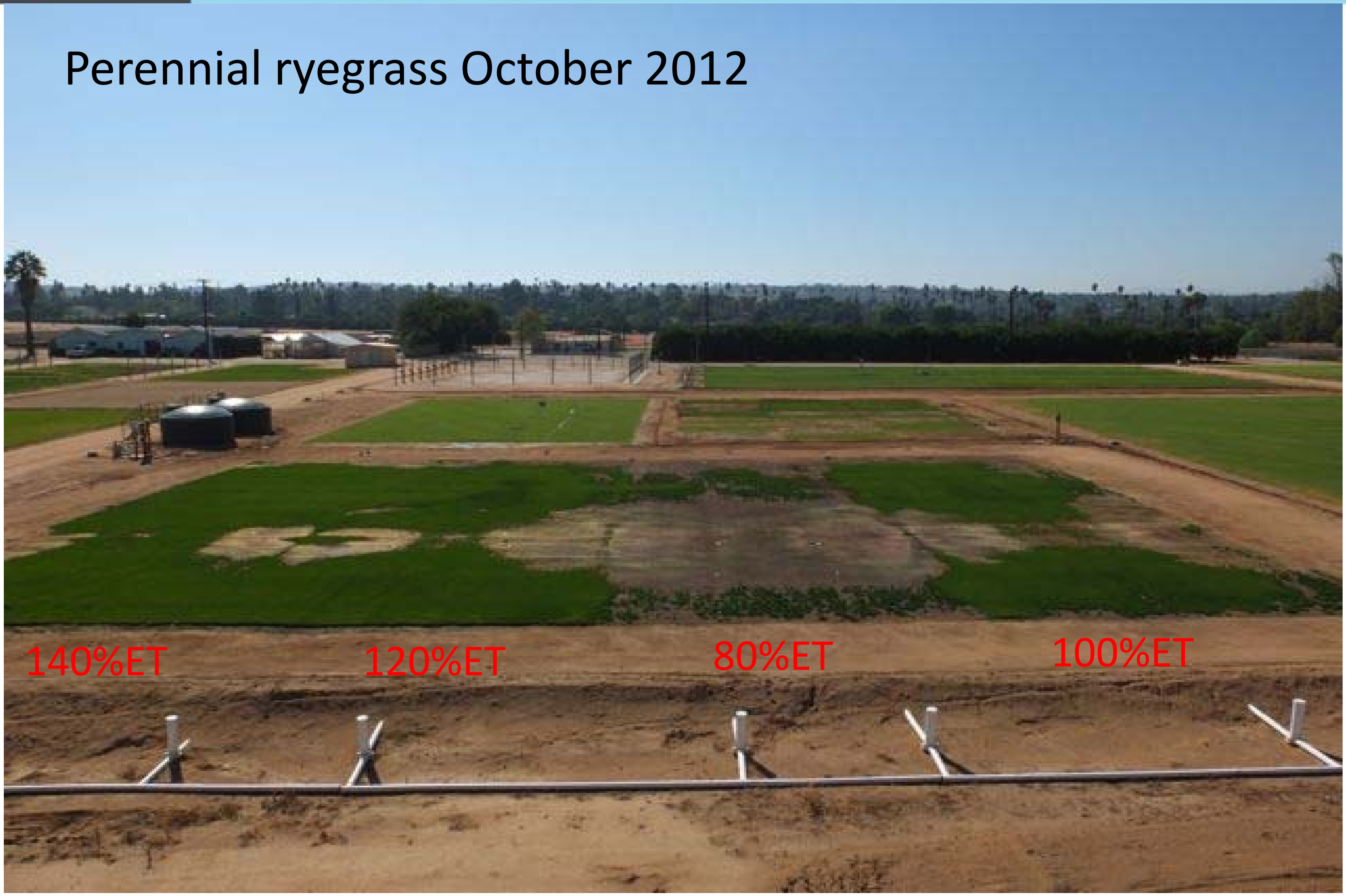
Leaching Requirements

- $LR = EC_w / (5EC_e – EC_w)$
  - EC_w = electrical conductivity of irrigation water
  - EC_e = soil salinity threshold
  - Developed by Rhoades (1974), presented by Ayers and Wescot (1985)
  - Assuming EC_e threshold of 6 for perennial ryegrass, leaching fraction calculated when EC_w of 4.2 dS m^{-1} would be 16%.
- Assumes steady-state approach: ET is constant over the growing season

Perennial ryegrass April 2011

S: Saline line source
P: Potable line source




Perennial ryegrass October 2012
140%ET
120%ET
80%ET
100%ET

Conclusions

- Perennial ryegrass requires irrigation above 140% Kc x ET_o, irrigation water quality below ~1.7 dS m^{-1} and soil salinity below 3.8 dS m^{-1} to maintain quality and cover in Riverside, CA.
- Our results show that this formula may underestimate the requirements for leaching in arid climates.

Other Solutions

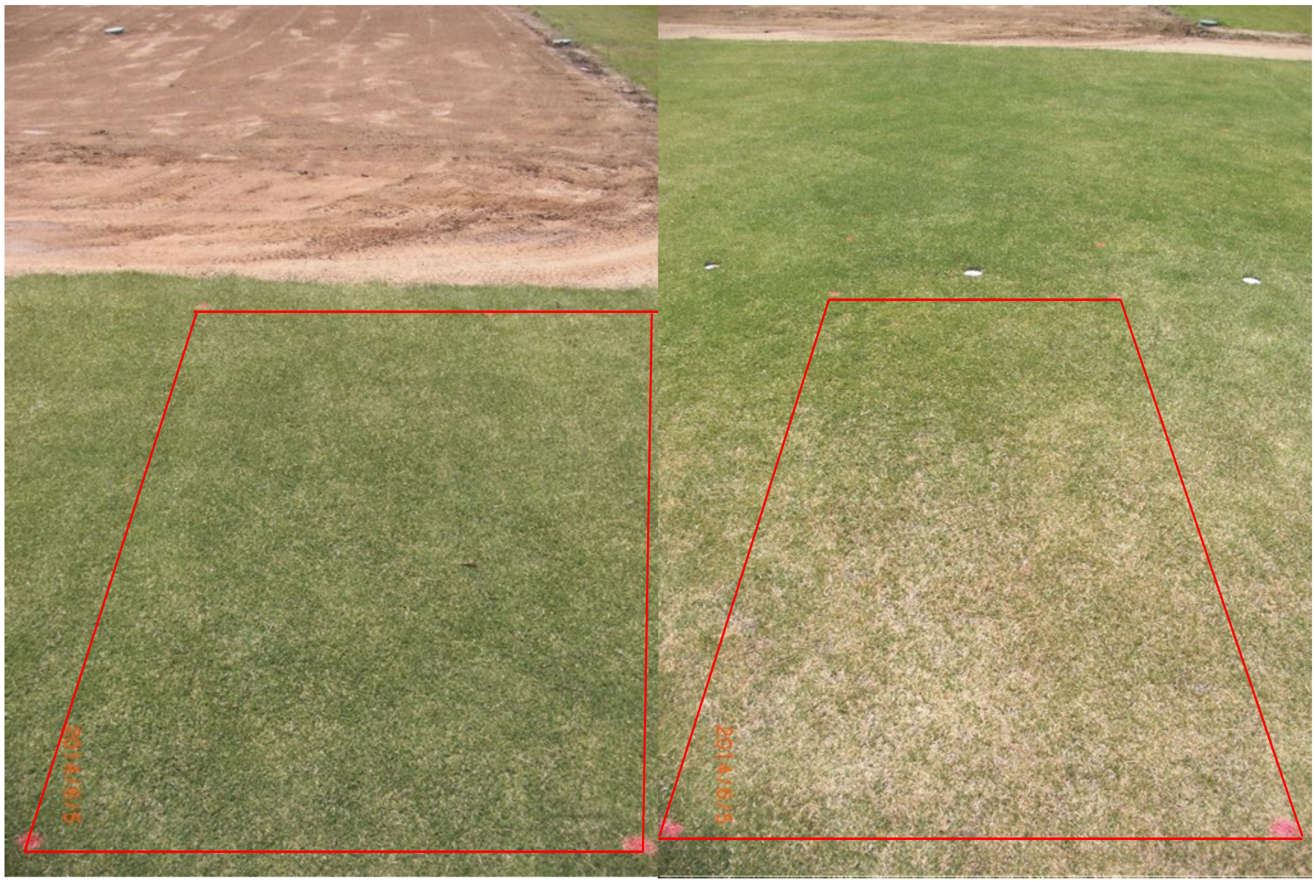
- Gypsum (Sodicity)
- Acidification (HCO_3^-)
- Aerification
- Soil Conditioners
- Plant Nutrients

Salinity Alleviation Study (2013-2015)

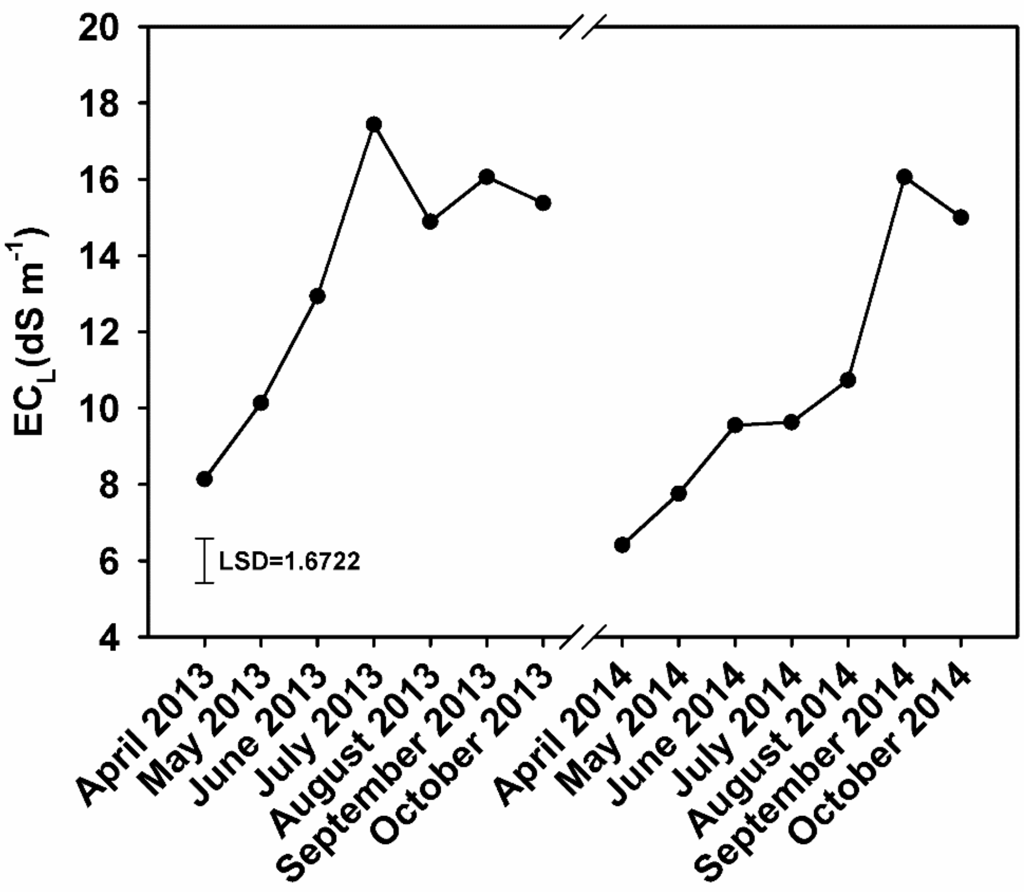
Treatment	Company	Year	Rate	Frequency (wks)
Control	--	2013; 2014	--	--
ACA 2786	Aquatrols	2013	4.5 oz/M	2
ACA 3086	Aquatrols	2013	8 oz/M	2
ACA 3217	Aquatrols	2014	6 oz/M	2
ACA 2994	Aquatrols	2013; 2014	8 oz/M	2
ACA 2994	Aquatrols	2014	4 oz/M	6
ACA 2994	Aquatrols	2014	8 oz/M	6
ACA 1849	Aquatrols	2013; 2014	3 oz/M	2
ACA 1849	Aquatrols	2013; 2014	3 oz/M	2
Gypsum		2013; 2014	5 lbs/M	2
Cal-Vantage	EarthWorks	2014	5 oz/M	Cal-Vantage and Kick rotated every
Kick	Earthworks	2014	10 oz/M	2 wks with Proactin and TriCure
Proactin	Mitchell Products	2014	1.5 oz/M	
TriCure AD	Mitchell Prod	2014	4 oz/M	
MC TP	Mitchell Products	2013; 2014	2 oz/M	2
MC TP3	Mitchell Products	2013; 2014	2 oz/M	2
Crossover	Numerator Tech.	2013; 2014	5 lb/M	4
Revert	Numerator Tech.	2013; 2014	6 oz/M	4
ST 8%CA	Numerator Tech.	2013; 2014	8 oz/M	2
pHAcid Sprayable	Numerator Tech.	2013	1.5 oz/M	2
pHAcid Sprayable	Numerator Tech.	2014	2 oz/M	2
Crossover	Numerator Tech.	2014	5 lb/M	4
Cal Plus 1	Westbridge Agric.	2013; 2014	0.75 oz/M	2
Cal Plus 2	Westbridge Agric.	2013; 2014	1.5 oz/M	2
DeSal	Ocean Organics	2013; 2014	0.75 oz/M	2
Stress Rx	Ocean Organics	2013; 2014	6 oz/M	2
XP 5-0-1	Ocean Organics	2013; 2014	6 oz/M	2
Displace	Grigg Brothers	2013	12 oz/M	2
Carboplex	Grigg Brothers	2013	6 oz/M	2
Elicitor	Grigg Brothers	2013	2 oz/M	2
Kelplex	Grigg Brothers	2013	2 oz/M	2
SumaGrow	Agribiotic Products	2013	5 oz/M	Initial
SumaGrow		2013	3 oz/M	2
Soil System 1	LH Organics	2013	50 g/18 gal	2 (alternate months)
UCR001	UC Riverside	2013		
Gypsum		2014	5 lb/M	2
Gypsum		2014	10 lb/M	2
MST-1410		2014	3 oz/M	2
MST-1410		2014*	5 oz/M	2
Turfcare NPN	Gantec	2013; 2014	0.1 oz/M	2 (Apr-May)
Turfcare NPN	Gantec	2013; 2014	0.1 oz/M	4 (Jun-Oct)
Turfcare 6-1-2	Gantec	2013; 2014	2.3 lb/M	Apr/May/Jul/Sep

- 11 Amendments
- 9 Ca based-products
- 4 combinations
- 2 biostimulants
- 2 bacteria-based products

- Turf quality was acceptable only on plots treated with DeSal+StressRx+XP Micro



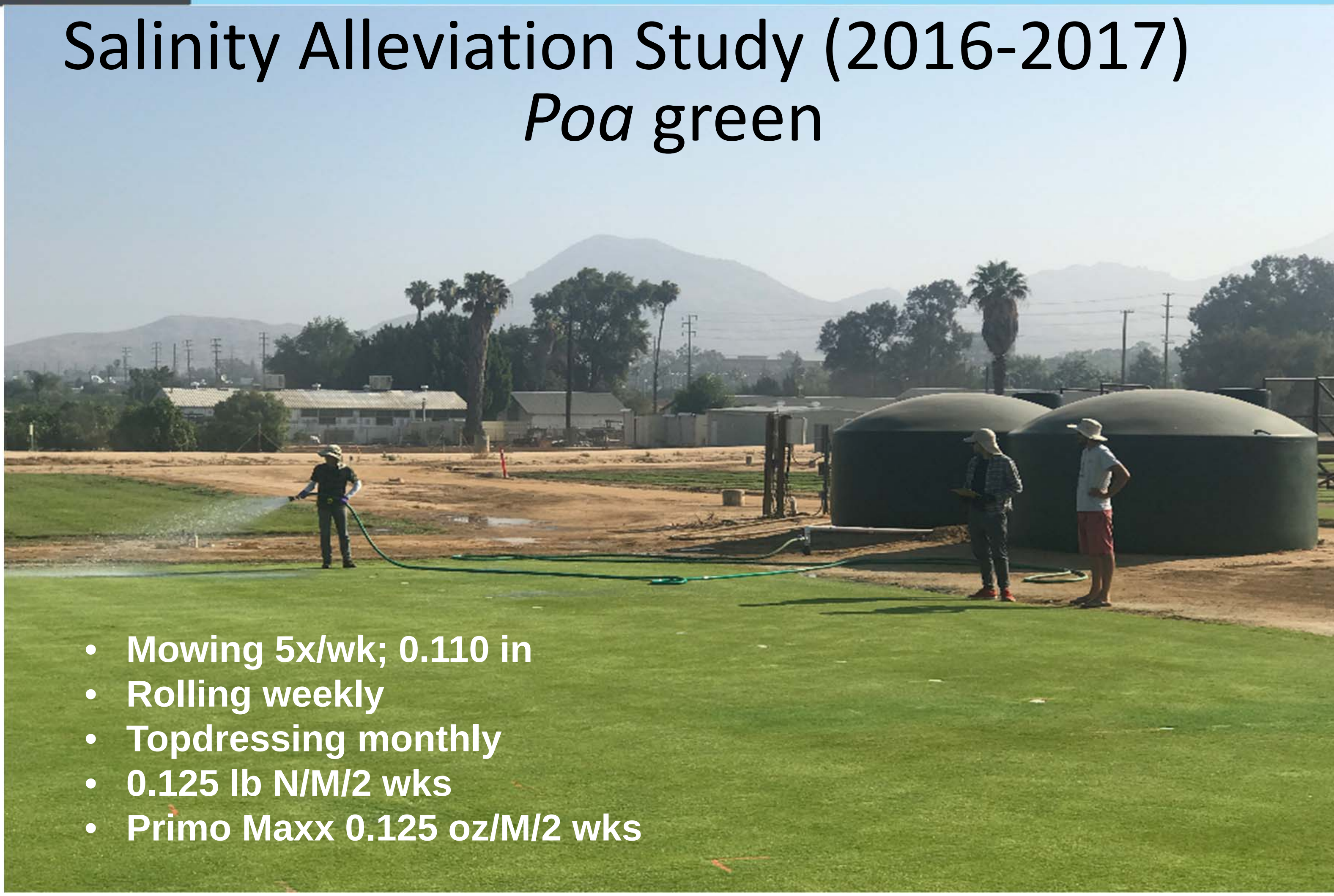
Soil Testing



Conclusions

- Treatments containing Ca helped decrease rootzone SAR and Na content but no visible effect was detected on turfgrass
- More research is needed to determine if application of N at higher than recommended rates for fertilization would be able to mask salinity stress

Salinity Alleviation Study (2016-2017)
Poa green



- **Mowing 5x/wk; 0.110 in**
- **Rolling weekly**
- **Topdressing monthly**
- **0.125 lb N/M/2 wks**
- **Primo Maxx 0.125 oz/M/2 wks**


Nutrimend+Komodo Pro
(every week)

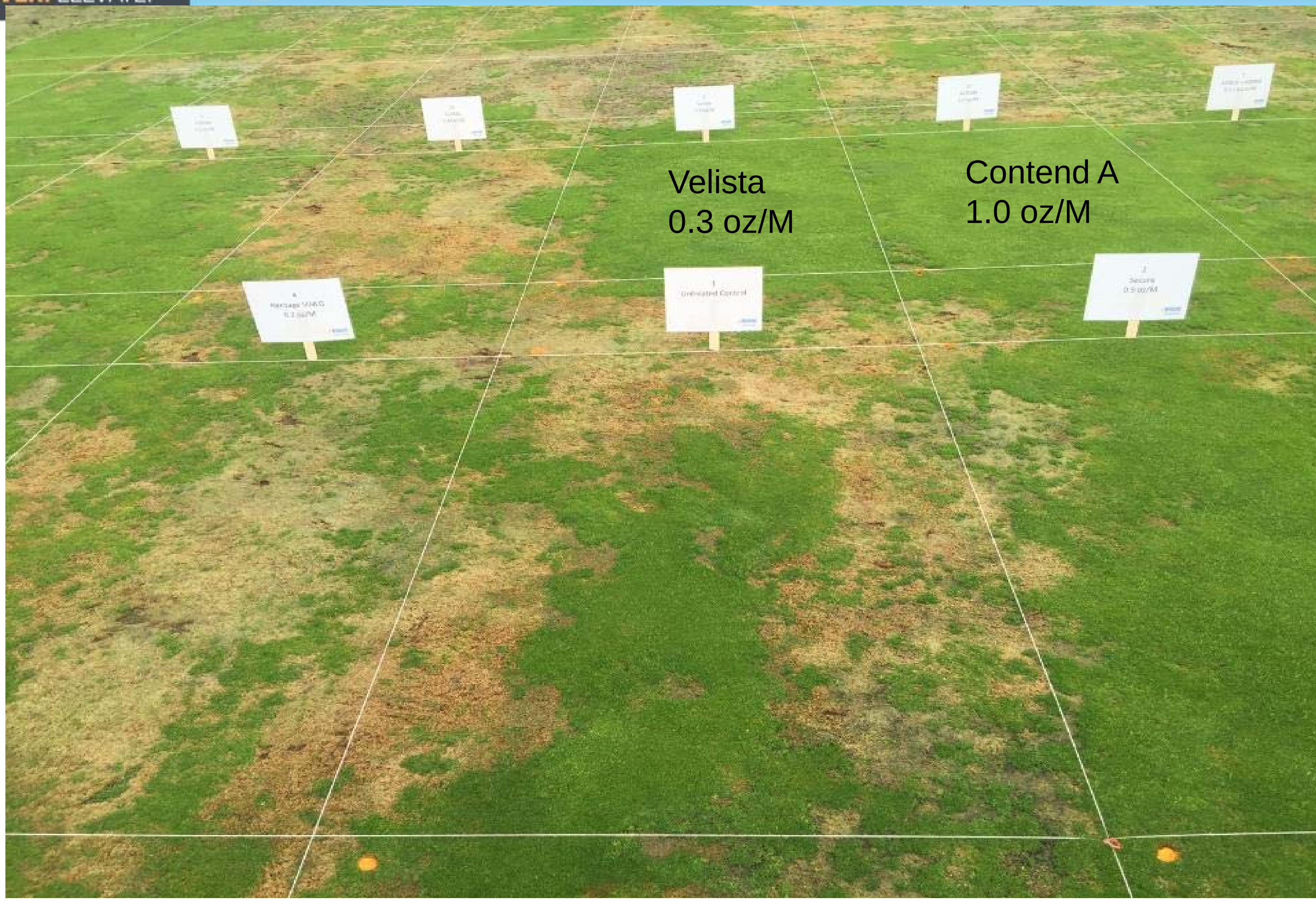
Conclusions

- Treatments containing Ca helped decrease rootzone SAR and Na content but no visible effect was detected on turfgrass
- More research is needed to determine if application of N at higher than recommended rates for fertilization would be able to mask salinity stress

Rapid Blight

- Caused by *Labyrinthula terrestris* discovered as a disease of turfgrass in the early part of this century
- *Poa trivialis, Poa annua, and Lolium perenne*
- Disease is usually associated with poor quality irrigation water with elevated sodium chloride
- Historically, few fungicides have provided effective control of rapid blight, but include pyraclostrobin (Insignia), trifloxystrobin (Compass), and mancozeb (Fore)

2015 Rapid Blight/Anthracnose Fungicide Trial
Hollister, CA


Velista
0.3 oz/M
Contend A
1.0 oz/M

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- Dr. Jim Baird
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- Toan Khuong
- Steve Reis
- Joe Espeleta

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CA TURFGRASS & LANDSCAPE FOUNDATION
"Keeping California Green and Growing"

UCR turfgrass science

USDA

THE METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA


Thank you!