Managing Turfgrass Soil and Irrigation Salinity

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Types of Salts

- Cations:
  - \( \text{Na}^+, \text{Ca}^{++}, \text{Mg}^{++}, \text{K}^+, \text{NH}_4^+ \)

- Anions:
  - \( \text{Cl}^-, \text{NO}_3^-, \text{SO}_4^{2-}, \text{BO}_3^{3-}, \text{CO}_3^{2-}, \text{HCO}_3^- \)
• 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/m³ 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$_2$O $\rightleftharpoons$ 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))

\[
ESP = \frac{\text{Exchangeable } Na^+ \text{ (meq/100g soil)}}{\text{Cation exchange capacity (meq/100g soil)}} \quad [%]
\]
\[
\text{SAR} = \frac{[\text{Na}^+]}{\sqrt{\frac{\text{Ca}^{2+} + \text{Mg}^{2+}}{2}}}
\]

- where concentration ([ ]) is expressed as mmol/l or meq/l
  
  \[
  \left[\text{Na}^+\right] \frac{1}{\sqrt{\left[\text{Ca}^{2+} + \text{Mg}^{2+}\right]}}
  \]
  
  \left[\left[\text{Ca}^{2+} + \text{Mg}^{2+}\right]\right]^{1/2}
  
- the determination of SAR is less problematic than are measurements of CEC and exchangeable cations
Waters sources for U.S, golf courses, 2005 vs. 2013

2014 Water use and conservation practices on U.S. Golf Courses; Adapted from Gelernter et al., 2014
### % facilities using water conservation practices

<table>
<thead>
<tr>
<th>Water conservation practices</th>
<th>U.S.</th>
<th>North Central</th>
<th>Northeast</th>
<th>Pacific</th>
<th>Southeast</th>
<th>Southwest</th>
<th>Transition</th>
<th>Upper Mountain/West</th>
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<td>Keep turf drier than in past</td>
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<td>70</td>
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<td>48</td>
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<td>47</td>
<td>42</td>
<td>50</td>
<td>36</td>
<td>50</td>
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<tr>
<td>Use irrigation scheduling¹</td>
<td></td>
<td>50</td>
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<td>47</td>
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<td>49</td>
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<td>Adj. fertilizer practices</td>
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<td>25</td>
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<td>Drip irrigation for landscape plants</td>
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<td>16</td>
<td>4</td>
<td>6</td>
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<td>7</td>
<td>18</td>
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<tr>
<td>Hand-held moisture sensors</td>
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<td>26</td>
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<td>23</td>
<td>38</td>
<td>29</td>
<td>43</td>
<td>29</td>
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<tr>
<td>Increase no-mow acreage¹</td>
<td>46</td>
<td>48</td>
<td>51</td>
<td>52</td>
<td>38</td>
<td>28</td>
<td>56</td>
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</tr>
</tbody>
</table>

¹Question 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 affect 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 \(\theta\) 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

R² for 0 to 20 dS m⁻¹ between 0.96 to 0.99
Results: TDR 350

R² for 0 to 20 dS m⁻¹ between 0.95 to 0.98
Results: POGO

R² for 0 to 20 dS m⁻¹ between 0.94 to 0.99
Results: TH20

R² for 0 to 20 dS m⁻¹ between 0.97 to 0.99
Results: Turf Guard

R² 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 ($\leq 0.5 \text{ dS m}^{-1}$)
- The new FieldScout TDR350 can handle accurately low level of salinity ($\leq 4 \text{ dS m}^{-1}$), 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

- Dr. Bernd Leinauer
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- Giuliano Sciusco
- Will Bosland

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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<sub>e</sub>)

<table>
<thead>
<tr>
<th>Sensitive (&lt; 3 dS m&lt;sup&gt;-1&lt;/sup&gt;)</th>
<th>Moderately sensitive (3-6 dS m&lt;sup&gt;-1&lt;/sup&gt;)</th>
<th>Moderately tolerant (6-10 dS m&lt;sup&gt;-1&lt;/sup&gt;)</th>
<th>Tolerant (&gt; 10 dS m&lt;sup&gt;-1&lt;/sup&gt;)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual bluegrass</td>
<td>Annual ryegrass</td>
<td>Perennial ryegrass</td>
<td>Saltgrass</td>
</tr>
<tr>
<td>Colonial bentgrass</td>
<td>Creeping bentgrass</td>
<td>Tall fescue</td>
<td>Alkaligrass</td>
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<tr>
<td>Kentucky bluegrass</td>
<td>Fine-leaf fescues</td>
<td>Zoysiagrass</td>
<td>Bermudagrass</td>
</tr>
<tr>
<td>Rough bluegrass</td>
<td>Buffalograss</td>
<td></td>
<td>Seashore Paspalum</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>St. Augustine</td>
</tr>
</tbody>
</table>

Leaching Requirements

- \( LR = \frac{EC_w}{5EC_e - EC_w} \)
  - \( EC_w \): 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

140% x $E_T_0$
120% x $E_T_0$
80% x $E_T_0$
100% x $E_T_0$

S: Saline line source
P: Potable line source
Perennial ryegrass October 2012
Conclusions

• Perennial ryegrass requires irrigation above 140% $Kc \times ET_o$, irrigation water quality below $\sim 1.7 \text{ dS m}^{-1}$ 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 ($\text{HCO}_3^-$)
- Aerification
- Soil Conditioners
- Plant Nutrients
Salinity Alleviation Study (2013-2015)
<table>
<thead>
<tr>
<th>Treatment</th>
<th>Company</th>
<th>Year</th>
<th>Rate</th>
<th>Frequency (wks)</th>
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<tr>
<td>Control</td>
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<td>2013; 2014</td>
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<tr>
<td>CA 2786</td>
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<tr>
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<td>6 oz/M 2</td>
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<tr>
<td>CA 2994</td>
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<td>CA 2994</td>
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<td>8 oz/M 6</td>
<td>2</td>
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<td>CA 1849</td>
<td>Aquatrols</td>
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<td>3 oz/M 2</td>
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<tr>
<td>CA 1849</td>
<td>Aquatrols</td>
<td>2013; 2014</td>
<td>5 lbs/M 2</td>
<td>2</td>
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<tr>
<td>Ypsum</td>
<td></td>
<td>2013; 2014</td>
<td>3 oz/M 2</td>
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<tr>
<td>Ypsum</td>
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<td>2013; 2014</td>
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<tr>
<td>Cal-Vantage</td>
<td>Kick</td>
<td>2014</td>
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<td>Cal-Vantage and Kick rotated every 2 wks with Proactin and TriCure</td>
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<tr>
<td>Cal-Vantage</td>
<td>TriCure</td>
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<td>10 oz/M 1.5</td>
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<td>Proactin</td>
<td>Mitchell Products</td>
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<td>TriCure</td>
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<tr>
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<td>2 oz/M 2</td>
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<td>MC TP3</td>
<td>Mitchell Products</td>
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<td>Crossover</td>
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<td>2013; 2014</td>
<td>5 lb/M 4</td>
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<tr>
<td>Tevert</td>
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<td>6 oz/M 4</td>
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<td>ST 8%CA</td>
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<tr>
<td>HAcid Sprayable</td>
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<td>Westbridge Agric.</td>
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<td>Cal Plus 2</td>
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<td>5-0-1</td>
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<tr>
<td>Carboplex</td>
<td>Grigg Brothers</td>
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<td>Elicitor</td>
<td>Grigg Brothers</td>
<td>2013</td>
<td>2 oz/M 2</td>
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<tr>
<td>Eplex</td>
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<td>2 oz/M 2</td>
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<td>SumaGrow</td>
<td>Agribiotic Products</td>
<td>2013</td>
<td>5 oz/M 3 oz/M</td>
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<td>SumaGrow</td>
<td>Agribiotic Products</td>
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<td>5 oz/M 3 oz/M</td>
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<td>Soil System 1</td>
<td>LH Organics</td>
<td>2013</td>
<td>50 g/18 gal</td>
<td>2 (alternate months)</td>
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<td>UCR001</td>
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<td>Surfacer NPN</td>
<td>Gantec</td>
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<td>0.1 oz/M 2</td>
<td>2 (Apr-May)</td>
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<td>Surfacer NPN</td>
<td>Gantec</td>
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<td>0.1 oz/M 2</td>
<td>2 (Apr-May)</td>
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<tr>
<td>Surfacer 6-1-2</td>
<td>Gantec</td>
<td>2013; 2014</td>
<td>2.3 lb/M 2</td>
<td>2 (Apr-May/Jul-Sep)</td>
</tr>
</tbody>
</table>

- 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

EC_L (dS m⁻¹) vs. Month

- April 2013
- May 2013
- June 2013
- July 2013
- August 2013
- September 2013
- October 2013
- April 2014
- May 2014
- June 2014
- July 2014
- August 2014
- September 2014
- October 2014

LSD = 1.6722
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
Acknowledgments

- Dr. Jim Baird
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- Steve Reis
- Joe Espeleta

@ucrsavingturf
Thank you!