Salinity Management for Floodplain Riparian Restoration

National Conference on Ecosystem Restoration
July 30, 2013

Matt Grabau, Michael Milczarek, Monisha Banerjee, Ashlee Rudolph
Soil and Groundwater Salinity along Regulated Rivers

- Most large rivers extensively regulated by dams, reservoirs, and levees.
- Hydraulically disconnected floodplain.
Traditional Salinity Management

- A: Drain
- B: Add Water
What About Riparian Vegetation?

- Riparian trees need low-salinity water, and lots of it.
  - Shallow groundwater and/or high irrigation rates:
    - Shallow groundwater ➔
      - No salt “sink” available in soils.
      - Capillary rise, evapotranspiration.
    - Irrigation ➔
      - Salt addition.
      - Increased groundwater elevation.
Project Objectives

1. Identify salinization causes and management options for riparian restoration areas.
2. Characterize three habitat creation sites on the lower Colorado River.
3. Develop a salinity model to assess irrigation and drainage management scenarios.
Lower Colorado River (LCR) Multi-species Conservation Program (MSCP)

Background

- MSCP tasked with creation and maintenance of riparian habitat on LCR (Lake Mead to Mexico).
- A regulated river system/disconnected floodplain prone to salinization.
- Irrigation and aquifer management to:
  - Provide water for transpiration.
  - Provide moist soils.
  - Maintain acceptable salinity: ~8 dS/m soil salinity.
Project Locations
Site Characterizations

- **Soils (May 2010, Feb 2012):**
  - Sampled to 6’.
  - Measured: Texture, salinity, nutrients.

- **Groundwater (2010-July 2013):**
  - Piezometer grid.
  - Measured: Groundwater depth, elevation/gradient, groundwater salinity.

- **Aquifer:**
  - Slug testing.
  - Measured: Hydraulic conductivity.
Beal Lake Conservation Area (BLCA)
107 acres, 30 independently-irrigated fields.
Palo Verde Ecological Reserve (PVER)
1,352 acres, 8 phases. Phase 2 and 3—150 acres.
Cibola NWR Unit 1 Conservation Area (CNU1) 900 acres, 5 Areas. 200 acres for this study.
Groundwater Salinity: January 2011-July 2013

- Higher groundwater EC at Cibola, lowest at PVER, BLCA intermediate.

Note:
1 dS/m = 1 mS/cm = 1,000 µS/cm
Representative Groundwater Depth: 2012

- Shallowest at BLCA, deepest at PVER, CNU1 intermediate.
- Frequent, extensive mounding at BLCA and PVER.
Relative Site Condition Summary

- **Good, Neutral, Bad** in terms of salinity management.

<table>
<thead>
<tr>
<th>Site</th>
<th>Soil texture</th>
<th>Groundwater depth</th>
<th>Groundwater salinity</th>
<th>Irrigation Frequency</th>
<th>Percolation</th>
</tr>
</thead>
<tbody>
<tr>
<td>BLCA</td>
<td>Coarse</td>
<td>Shallow</td>
<td>Intermediate</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>PVER</td>
<td>Intermediate</td>
<td>Deep</td>
<td>Low</td>
<td>Intermediate</td>
<td>High</td>
</tr>
<tr>
<td>CNU1</td>
<td>Fine</td>
<td>Intermediate</td>
<td>High</td>
<td>Low</td>
<td>Low</td>
</tr>
</tbody>
</table>
Soil Salinity Conditions

Soil Texture: Coarse

0-6" Composite Saturated Paste EC, dS/m

- May/June 2010
- February 2012

Approximate Riparian Tree Salinity Tolerance

- Note: 1 dS/m = 1 mS/cm = 1,000 µS/cm

Project Site (Irrigation Frequency)

- BLCA
- PVER2
- PVER3
- SFS
- CNT
- MT
- CR1
- CR2

Groundwater: Shallow

Deep

Intermediate
Dense Goodding’s willow growth at PVER—intermediate soil texture, low salinity, deep groundwater.

Salt crusts and marginal cottonwood success at CNU1 Crane Roost—fine soils, high salinity, intermediate groundwater depth.
Model Development and Calibration

- SaltMod: http://www.waterlog.info/saltmod.htm
  - 1-D salt balance model.
- Model Development:
  - Use available data to specify model parameters.
  - Calibrate to observed soil and groundwater salinity.
- Model Projections:
  - How much water is needed to achieve desired soil salinity?
Example Modeling Predictions: BLCA

Sandy soils, shallow, moderate-salinity groundwater.

Note: 1 dS/m = 1 mS/cm = 1,000 µS/cm
Modeling Predictions: PVER
Sandy and loamy soils, deep, low-salinity groundwater.

- Note: 1 dS/m = 1 mS/cm = 1,000 µS/cm
Example Modeling Predictions: CNU1

Silty loam soils, intermediate depth groundwater. High-salinity groundwater (CR-2) versus moderate-salinity groundwater (MT)

• Note:
  1 dS/m = 1 mS/cm = 1,000 µS/cm
Conclusions

- Soil and groundwater salinity determined by:

1. Soil texture: More sand $\rightarrow$ more efficient drainage and leaching.
2. Groundwater depth: Shallower water $\Rightarrow$ more capillary rise and evapoconcentration in root zone.
3. Incoming groundwater salinity: up-gradient groundwater EC dictates groundwater EC at each site.
4. Irrigation application: Greater irrigation depth $\rightarrow$ more leaching.
Recommendations

1. Soil texture: Select sites with intermediate soil textures.
2. Irrigation: Optimize irrigation depth.
4. Groundwater salinity: Avoid leaching high salt loads up-gradient.
Monitoring and Adaptive Management Framework

- **Sites with acceptable salinity:**
  1. Monitor for changes.

- **Sites with unacceptable salinity:**
  1. Identify site-specific remediation tools.
  2. Implement demonstration project.
  3. Monitor for favorable results, and revise remediation tools as needed.

- **Additional considerations:** vegetation maintenance, habitat quality.
Acknowledgements:

Havasu and Cibola NWR
US FWS
California Fish and Game

MSCP:
Gregg Garnett
Ashlee Rudolph
Terry Murphy

matt@gsanalysis.com