Project Background/Need

- **MSCP Habitat Conservation Plan:**
  - Native vegetation.
  - Conservation measures → surface water or moist soils for riparian obligates (e.g. SWFL).

- **Water Use:**
  - Maximize irrigation efficiency → minimize volume of irrigation diversion.
Unknowns

- Soil moisture requirements for native species?
- Irrigation distribution?
- Soil moisture abundance/distribution?
- Can monitoring and adaptive management:
  - Enhance habitat quality?
  - Reduce water diversion?
Monitoring—Vegetation
Assessing Habitat—Wildlife

Walters Camp ca. 1986

Pea Island NWR, NC, USA, 2000
Irrigation Monitoring
Infiltration Curves

- Irrigation Sensors

![Infiltration Curve Graph](image)

- 81% Sand

Infiltrated Water, cm vs. Infiltration Time, hours
Monitoring—Soil Moisture?

Cibola NWR, 2007
Soil Moisture Point Sampling Methods

Manual Sampling/Lab Testing

Handheld TDR Probe
Soil Moisture Sensors

**Water Content**

**Soil Water Potential**

Internal Design of the Advanced Tensiometer

- Electric lead
- Air line
- Inner guide pipe
- Pressure transducer
- Connector
- Gasket

- Outer guide pipe (1" PVC)
- Adapter
- Gasket throat
- Water reservoir
- Porous ceramic cup

- Surface cap
- Data logger
- Water level
- Gasket seated in gasket throat
Palo Verde Ecological Reserve Phase 2 Pilot Project—*the 15-minute version*...
Monitoring Layout

- Irrigation and Soil Moisture
- Irrigation Only
Irrigation Monitoring Goals

1. Determine irrigation distribution.
   - When, how much (depth of water applied, total water volume), evenness (irrigation efficiency).

2. Quantify the presence of surface water.
   - When is irrigation present?

- Example: June 30-July 2, 2013 Irrigation Event
Irrigation Duration: 6/30-7/2/13
Applied Water: 6/30-7/2/13
Irrigation Summary Statistics: 6/30-7/2/13

<table>
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<th>Check</th>
<th>Surface Soil Sand Fraction, %</th>
<th>Irrigation Flow Rate, cfs</th>
<th>Average Applied Water, cm</th>
<th>Average Applied Water, in</th>
<th>Applied Water, acre-feet</th>
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</table>

-More water required in 5 than 2, despite higher flow rate!
-More water required in 4 than 2, because of higher flow rate.
Soil Moisture Monitoring Objectives

1. Quantify surface soil moisture.
   - A key habitat quality characteristic for riparian obligate birds.

2. Determine amount and distribution of plant-available water.
   - And how related to soil characteristics and irrigation distribution.
Surface Soil Moisture Following July 2012 Irrigation

![Graph showing soil moisture content over days since irrigation for different sand percentages (48%, 64%, 77%).]
Mean Surface Water Content—2013 Nesting Season

Volumetric Water Content
- 0.04 - 0.08
- 0.08 - 0.12
- 0.12 - 0.16
- 0.16 - 0.20
- 0.20 - 0.24
Soil Moisture Monitoring Conclusions

- Rapid drainage of sandy soils.
- Finer soils retain more moisture, even with less applied water.

Management options:
- Restoration designs according to soil distribution.
- Partition more water to finer soils to enhance surface soil moisture.
Applications

- **Irrigation Monitoring**
  - Determine irrigation distribution to obtain baseline data.
  - Use results to inform management decisions.
    - Alter site layouts, increase/decrease flow rates, longer/shorter irrigation duration.
  - Monitor success of alternate management actions.

- **Soil Moisture Monitoring**
  - Quantify soil moisture in known habitat.
  - Manage to maintain target soil moisture and vegetation.
Monitoring—Soil Moisture!

Where’s the peanut butter?
Large-Scale Monitoring Options

- Low-density/dispersed monitoring at all sites?
- Targeted monitoring in representative areas?
- Remote sensing with ground-truthing?
- Monitoring at vegetation locations, nest sites, etc., to facilitate habitat analysis.
Clear water, and a roost with a view.

Not by Accident

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Courtesy Jarrod Swackhammer
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matt@gsanalysis.com