Automated Soil Moisture and Surface Water Monitoring to Enhance Restoration Monitoring and Adaptive Management

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Is Soil Moisture Important?

- If riparian ecosystems depend on shallow groundwater, why do we need to worry about soil moisture?
  - Soil moisture can seasonally support riparian vegetation.
  - Irrigation needed on restoration projects where groundwater is not shallow enough or does not provide sufficient water for plant establishment.
  - Known to affect habitat quality.
Automated Soil Moisture Monitoring

- Install sensors in the field, wire to data logger.
  - Essentially no limit to sampling frequency.
  - High temporal resolution with infrequent field downloads (can use telemetry, cell phone, satellite)
  - Potentially high accuracy
  - Variable costs
  - Installation requires training
  - Maybe soil chemistry limitations
  - Spatial representation
Sensor Types

- **Water Content Sensors**
  - Time Domain and Frequency Domain (Capacitance) Probes
  - Measure dielectric constant of soil
  - Affected by soil type, bulk density, clay content and salinity.
  - Various manufacturers
  - *Soil specific calibrations needed for accurate data, regardless of manufacturer recommendations!*

- **Soil Matric Potential Sensors:**
  - Heat Dissipation Sensor (HDS) – medium to dry conditions.
  - Tensiometers – saturated to near saturated conditions

- **Inundation Sensors:**
  - Resistance sensors to detect presence of surface water
Data Loggers

- Type and sophistication/cost depends on data needs and sensor types.
Some Applications

- **Short-term irrigation monitoring to establish plants:**
  - Buckman Bosque Restoration (Buckman Drainage District, NM)
  - Goose Creek Restoration Site (IERCD, CA)

- **Irrigation monitoring and efficiency:**
  - Cibola NWR Seeding Study (BOR, AZ)
  - Palo Verde Ecological Reserve Irrigation Monitoring (BOR, CA)
  - Soil Amendment Study Beal Lake Conservation Area (BOR, AZ)

- **Plant water use and habitat improvement**
  - Texas Canyon Hydrology Study (SIA, AZ)
  - Willow Wetland Restoration Research (ACOE, NM)
PROJECT EXAMPLE
Palo Verde Ecological Reserve Phase 2
Irrigation Monitoring
Palo Verde Ecological Reserve Phase 2
**Project Objectives**

- Depth to water at site > 15 feet
- Large irrigation checks
- Key objectives
  1. Determine plant available water in soils across site
  2. Determine uniformity of irrigation water
  3. Determine the presence of surface water and saturated soils.

- Focus on avian breeding season (roughly March through July)
Monitoring Station Types

- Different levels of monitoring intensity
  - Irrigation monitoring: presence and distribution of surface water
  - Level 1: The above, plus surface (0-2”) soil moisture
  - Level 2: The above, plus 1’, 3’, and 6’ soil moisture
  - Level 3: The above, plus soil matric potential
Irrigation Monitoring Stations

- Irrigation Sensors
Level 1 Stations

Decagon EM50 Datalogger

Irrigation sensor

EC5 soil moisture sensor
Level 2 Stations

EC5 Soil moisture sensor

Irrigation sensor

10HS Soil moisture sensor

Decagon EM50 Datalogger

~10’
Level 1 and 2 Stations
Level 3 Stations

- CSI CR1000 Datalogger
- 5TE soil moisture/Temp/EC sensors
- Irrigation sensors
- HDS soil water potential sensors
- 10HS soil moisture sensors
- Advanced tensiometers
Monitoring Station Layout

Legend:
- Field Border
- Fine Grained Soil
- Sandy Soil

- Irrigation Monitoring
- Level 1
- Level 2
- Level 3
Irrigation Distribution
Surface Soil Saturation: Probability of Exceedance

- 25%
- 50%
- 75%
- 95%
Plant-Water Availability: Soil Moisture Profile
Adaptive Management

Results indicate:

- Irrigation distribution could be improved with smaller or intermediate checks
- Soil saturation intervals could be improved with better check management for finer-grained soils
- Plant pallet in sandy soil area could be reconsidered
- Level 1 and 2 stations are adequate
- Groundwater system heavily influenced by irrigation (data not shown)
Monitoring Approach Strategies

- Application and site dependent. Examples:
  1) Irrigation monitoring for irrigation efficiency, soil saturation
  2) Soil moisture monitoring for plant water use, irrigation scheduling, efficiency
  3) Soil moisture monitoring in non-irrigated riparian areas to determine water availability for understory species

- Targeted monitoring in representative locations and soil types
Thank you!

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