Irrigation and Soil Moisture Analysis for Floodplain Riparian Restoration

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Lower Colorado River Multi-Species Conservation Program

Introduction

Re-vegetation of disconnected floodplains is a common component of riparian restoration projects due to extensive management of river systems. For example, through implementation of the Lower Colorado River Multi-species Conservation Program (MSCP), the Bureau of Reclamation will create over 7,200 acres of riparian vegetation communities in the historic floodplain, which lies outside of flood control levees. As a result, irrigation must be provided to ensure vegetation success—irrigation provides water for transpiration and leaches salts from the root zone. Additionally, irrigation enhances habitat quality for several target avian species by providing moist soils and surface water at restoration sites.

Irrigation and soil moisture distribution monitoring has been identified as a need for restoration site management. We implemented a pilot project at an MSCP restoration site to determine irrigation and soil moisture distribution and plant-available water. Through this effort, the capabilities and applications of equipment are being analyzed, and results will be used to provide program-wide recommendations for monitoring techniques.

Background and Project Objectives

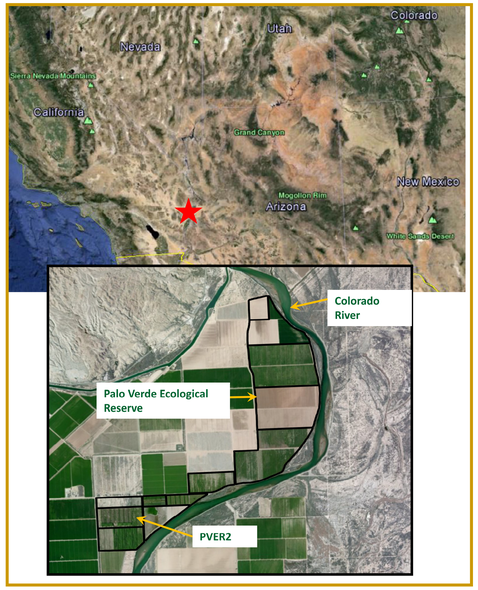
Lower Colorado River (LCR) Multi-Species Conservation Program (MSCP):

- Habitat-based, 50-year program to conserve and supplement remaining riparian, backwater, and marsh habitats to assist in the recovery of listed species and prevent additional listings while accommodating water diversions and power production.
- Three main components:
  1. Fish Augmentation
  2. Monitoring and Research
  3. Conservation Area Development and Management
- Conservation Areas:
  - Constructed primarily on disconnected floodplains (converted agricultural lands or cleared non-native vegetation).
  - Irrigation required to support vegetation, provide moist soils, and maintain acceptable soil salinity.
- Monitoring desired to:
  - Determine irrigation volume and distribution.
  - Quantify soil moisture.

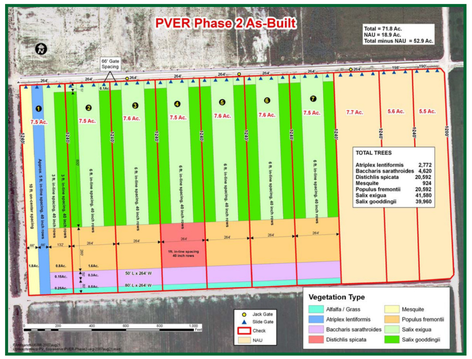
Pilot Project Objectives:

- Determine soil texture variability at Palo Verde Ecological Reserve (PVER) Phase 2 (PVER2) up to 6' below ground surface.
- Monitor irrigation application: frequency, duration, distribution.
- Analyze abundance and distribution of soil moisture.
- Evaluate sensor applications and data collection methods.
- Develop long-term, large-scale monitoring recommendations for the MSCP.

Study Location



Vegetation As-Built: 72 Acres

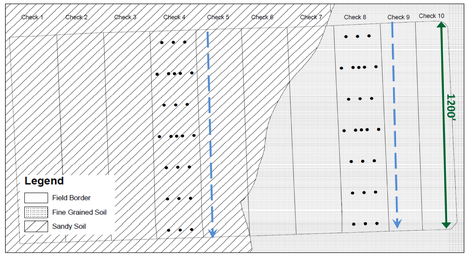


Characterization and Monitoring Schematics

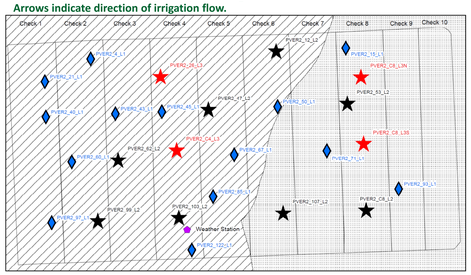
Four Levels:

- Irrigation Monitoring Location: Irrigation Only
  - Custom irrigation presence/absence sensor wired to single-channel data logger.
- Level 1: Irrigation, Surface Soil Moisture
  - Two irrigation sensors and two soil moisture (capacitance) probes installed in surface soil, wired to five-channel data logger.
- Level 2: Irrigation, Surface and Subsurface Soil Moisture
  - One irrigation sensor, one soil moisture sensor at surface, 1', 3', and 6' below ground surface wired to five-channel data logger.
- Level 3: Irrigation, Soil Moisture, Soil Plant-Water Dynamics
  - Five irrigation sensors distributed across irrigation check, one soil moisture sensor at surface, 1', 3', and 6' below ground surface, one tensiometer at 3' and 6' below ground surface, one heat dissipation sensor at 1' and 3' below ground surface. Wired to advanced data logger.

Left to Right: Custom irrigation sensor; Level 1 station; Level 3 station.



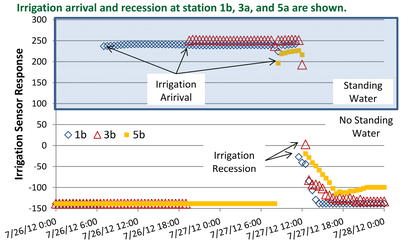
Dense irrigation monitoring grid to provide high-resolution in two different soil classes. Arrows indicate direction of irrigation flow.

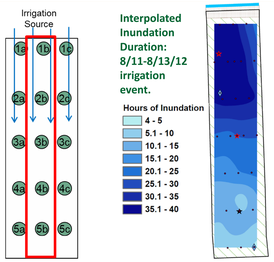


Level 1 (blue), Level 2 (black), and Level 3 (red) grid to monitor across the site in variable vegetation species and density and the range of observed soil classes.

Irrigation Monitoring Results

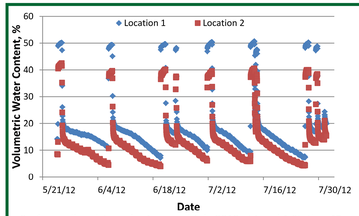
Example Irrigation Monitoring Data: Check 4, July 26, 2012 irrigation event. Irrigation arrival and recession at station 1b, 3a, and 5a are shown.



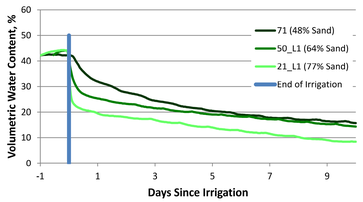


Interpolated Inundation Duration: 8/11-8/13/12 irrigation event.

Surface Soil Moisture Results

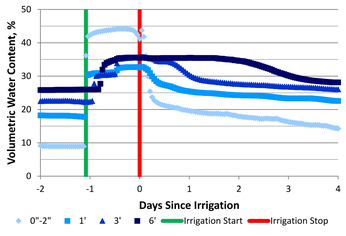


Surface soil moisture for June and July 2012 at Level 1 Station 45, with a 0-6' composite sand fraction of 78%. Peaks indicate irrigation events followed by soil drainage.

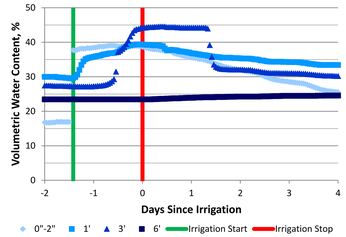


Comparative surface soil moisture depletion following an irrigation event in July, 2012. Sandy soils drain quickly after irrigation. Thereafter, soil moisture reduction is driven by evapotranspiration.

Soil Moisture Movement through Soil Profile



Surface (0"-2" below ground surface) and subsurface soil moisture following a July 2012 irrigation event at Level 2 Station 47, with a 0-6' composite sand fraction of 80%. Following irrigation onset, water quickly percolates through the soil profile. Drainage occurs rapidly after irrigation ceases.



Surface (0"-2" below ground surface) and subsurface soil moisture following a July 2012 irrigation event at Level 2 Station 53, with a 0-6' composite sand fraction of 54%. Little percolation is observed.

Applications:

Irrigation Management and Monitoring:

Scheduling:

1. Intelligent irrigation to satisfy vegetation demand or meet target soil moisture goals and/or inundation goals.
2. Ensure that contractors are meeting irrigation schedules.

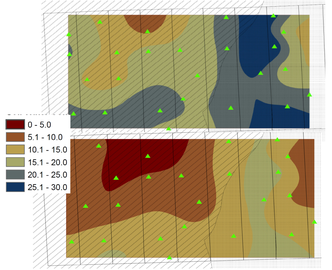
Distribution:

1. Ensure that entire site is being irrigated.
2. Determine irrigation efficiency.
3. Provide reference data for irrigation model applications, optimize flow rates and field dimensions.

Soil Moisture Quantification:

Spatial Analysis:

1. Monitor and quantify soil moisture at restoration sites for a desired time horizon. Example: Average July 2012 volumetric water content (top), and minimum July 2012 volumetric water content (bottom).



Obtain Reference Data:

1. Determine soil moisture and surface water abundance in known high-quality avian habitats.

Remaining Project Activities

Assess Irrigation Management:

1. What is the current irrigation efficiency and surface roughness?
2. How would alternate field length or flow rate affect efficiency?

Analyze Monitoring Station Density:

What monitoring density is required to achieve goal MSCP resolution?

Summarize Soil Moisture Results:

1. What were soil moisture conditions during the 2013 yellow-billed cuckoo nesting season?
2. What was soil matric potential during the growing season (what level of vegetation stress was experienced)?

Evaluate evapotranspirative demand and soil moisture trends.

1. Can soil moisture be predicted by reference ET and days since irrigation?
2. What are the effects of vegetation composition and density?

Acknowledgements

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