An Ecohydrology Study of Vernal Pools at Three Military Bases in California

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Vernal pool wetlands

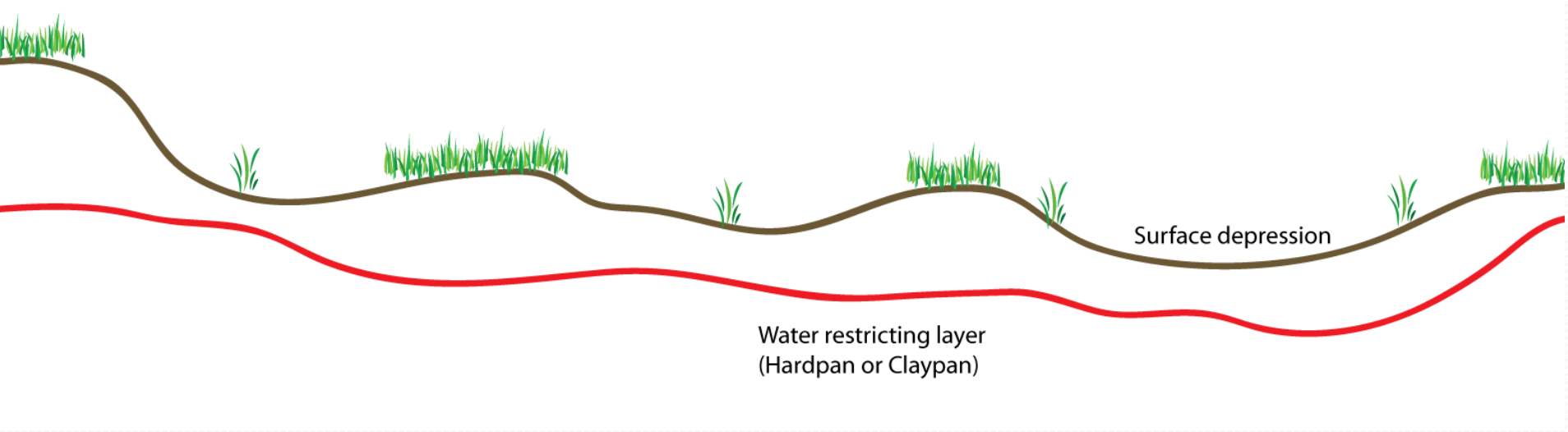
Seasonal wetlands

Habitat for a diverse set of plant, invertebrate, and vertebrate species, some of which are threatened or endangered.

Occur as a result of a combination of geology, soils, and regional climate

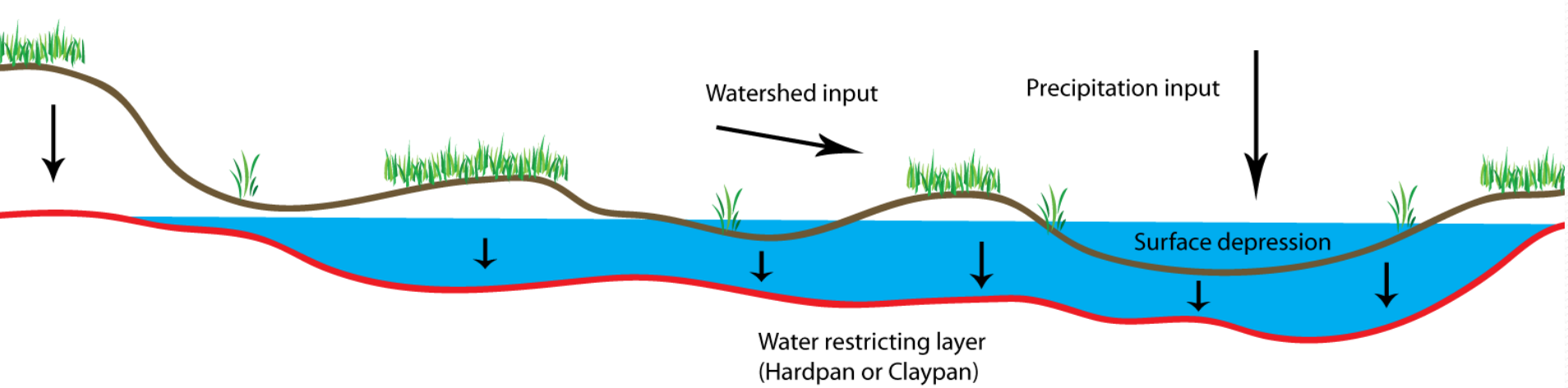
Vernal pool wetlands

A water restricting layer or high clay content in the soil prevents water from infiltrating downward and allows water to collect in the pools



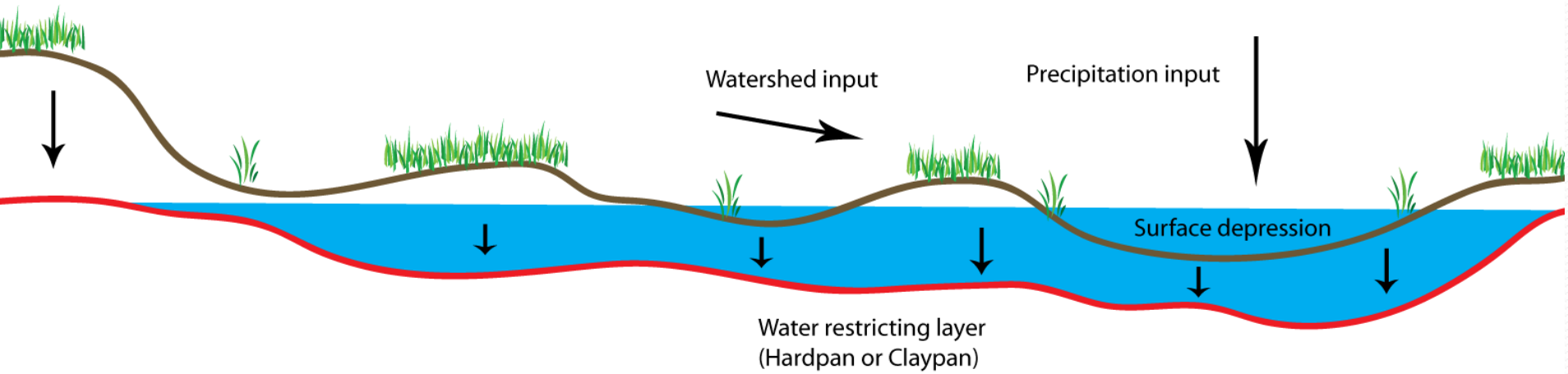
Vernal pool wetlands

During the rainy season, the soil becomes saturated and then water begins to collect in the surface depressions, forming vernal pools



Impacts to vernal pools

Changes to the landscape beyond direct changes to a vernal pool basin can cause hydrological impacts resulting in altered ecological functioning.



It is estimated that >90% of vernal pools in California been destroyed.

Mitigation for loss of vernal pool habitat

Requires identifying sites and designing pool shapes, sizes, locations, etc.

Requires monitoring of the pool hydrology and biology for many years after pools are constructed

Mitigation pools do not always function hydrologically as well as natural pools

Project Objectives

1. Provide scientifically sound and detailed hydrological data

2. Provide a cost-effective method of collecting higher quality hydrological data for monitoring and management

3. Provide new methods to evaluate sites as potential compensatory mitigation vernal pool creation locations, and for specific hydrological functioning

4. Provide a better understanding of plant and macroinvertebrate species' hydrological requirements

Vernal Pool Ecosystems

Beale AFB, Mather Field

Hardpan Vernal Pools

- Hardpan = water restricting layer
- Water table formation from annual rainfall directly into pools plus subsurface water from the uplands

Beale AFB

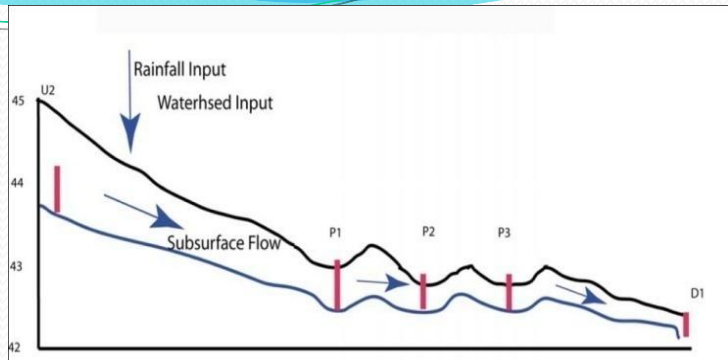
Claypan Vernal Pools

- More pervious water restricting layer but otherwise like hardpan vernal pools

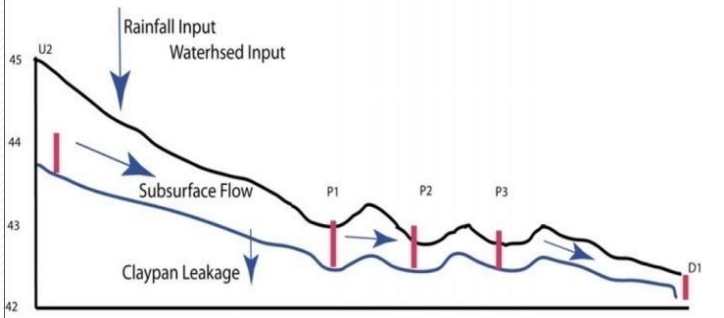
Travis AFB

Clay- Saline Soil Vernal Pools

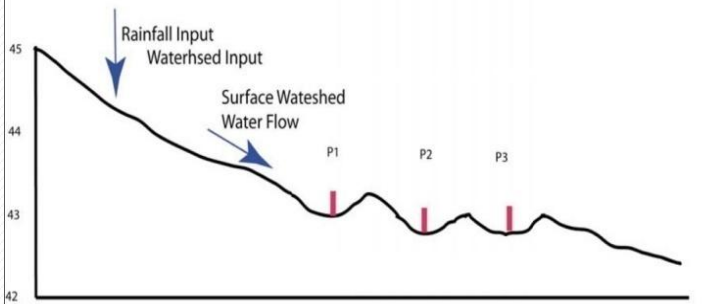
- High clay content and flocculation from salts reducing water infiltration.
- Once soil is saturated the basins fill with water from direct rainfall and surface runoff



Hardpan Vernal Pool- Surface and Subsurface Water Flow- No Leakage Through Hardpan, Water Loss From Subsurface Discharge, and Loss Due to Evapotranspiration



Claypan Vernal Pool- Surface and Subsurface Water Flow- Water Leakage Through Claypan, Water Loss From Subsurface Discharge, and Loss Due to Evapotranspiration



High Clay Content Surface DepressionVernal Pool- Surface Water Flow- Limited Water Loss Into Soil-Most Water Loss Due to Evapotranspiration

P1, P2, P3 Vernal Pool Basins Piezometer

U2 Upland Piezometer

D2 Discharge Drainage Piezometer

Levelogger

Technology/Methodology

1. **Ground Penetrating Radar (GPR)**
   - measure depth to water restricting layer throughout a watershed and identify potential mitigation sites,

2. **Global Positioning System (GPS)**
   - RTK for centimeter level measurement of watershed surface, equipment positions, and vegetation positions in wetlands,

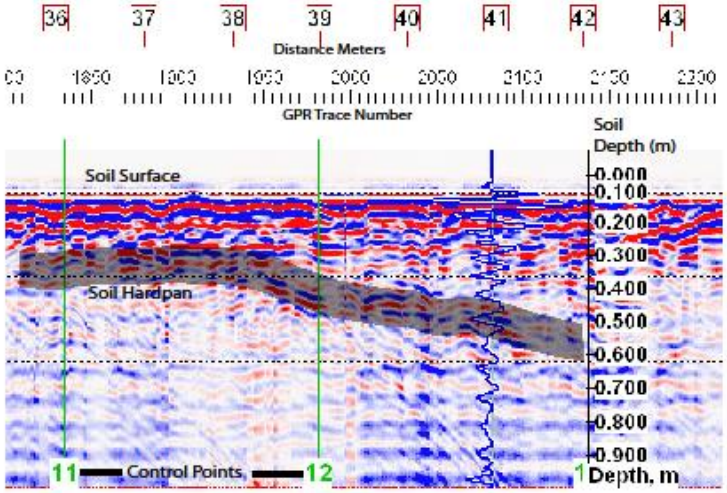
3. **Soil moisture measurements (hourly)**
   - can be correlated with elevation of plant species in wetland basin after the pools no longer have water,

4. **Levelogger water level measurements (hourly)**
   - obtain hydrographs for the entire watershed that can be correlated with presence and abundance of invertebrates and elevation of plant species in wetland basin; and used to identify hydrological functioning of individual vernal pools.

Ground Penetrating Radar (GPR)

Identifies the **presence, continuity and depth** of a hardpan or other water restricting layer

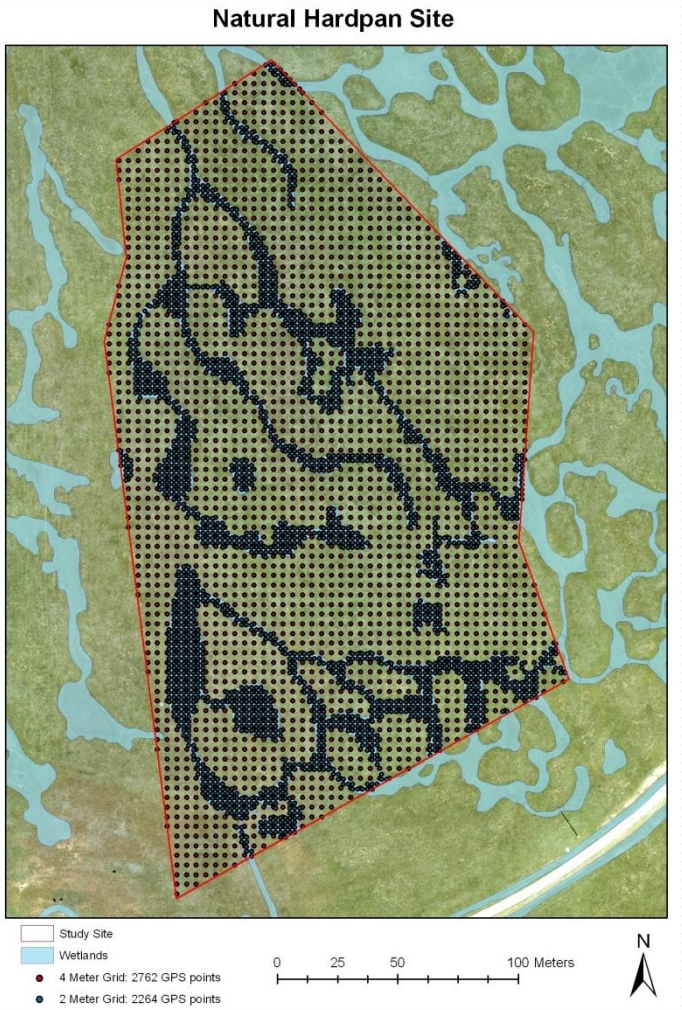
Measures soil density variation

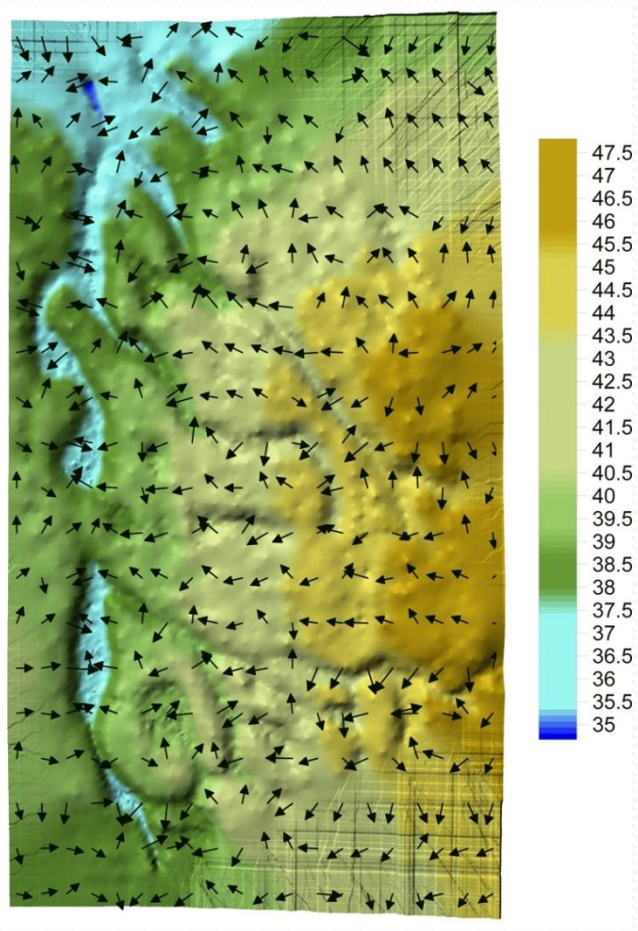


Real Time Kinematic GPS (RTK GPS)

Generates precise and accurate (1 cm) digital elevation models of the catchment

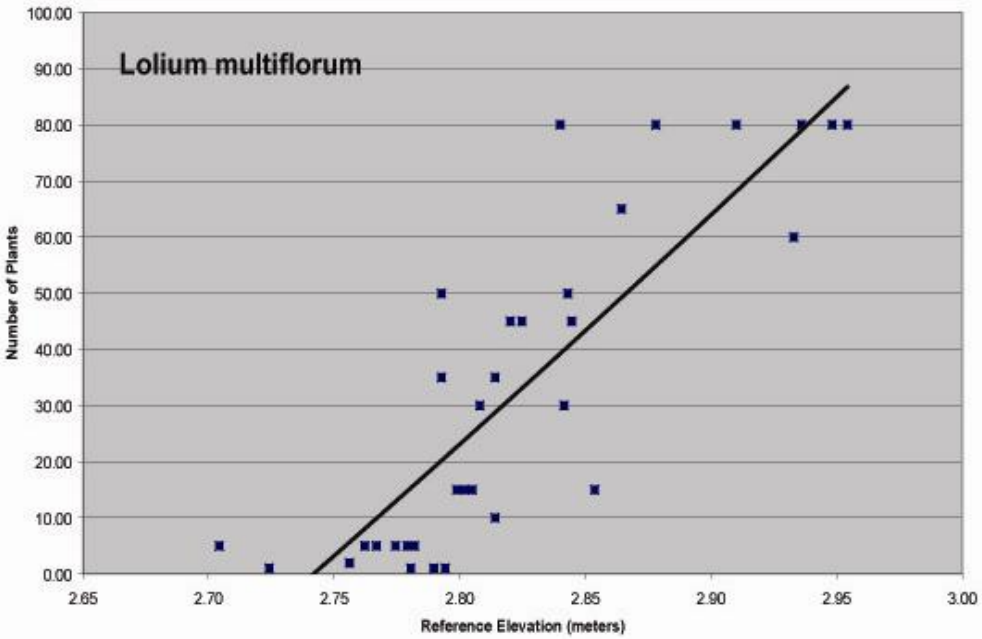
Digital elevation models



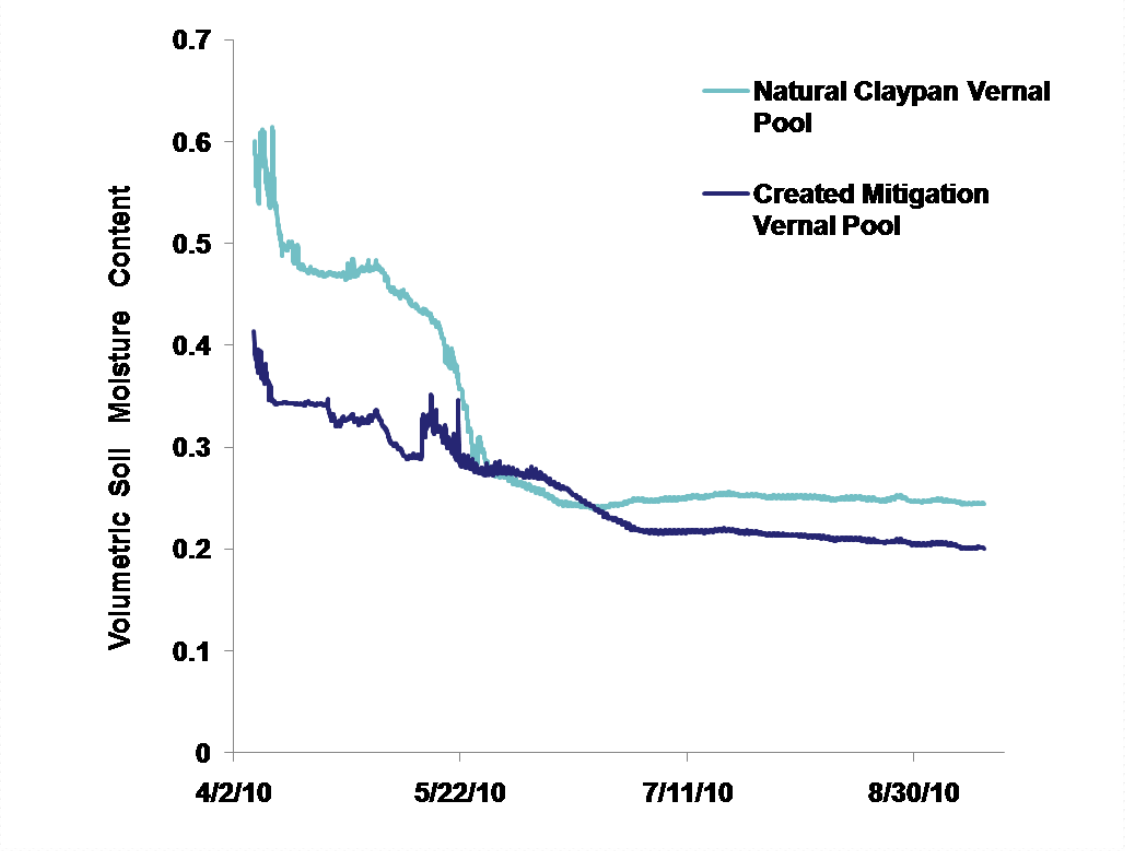


Vegetation Sampling

Combining GPS technology with vegetation surveys allows us to identify relationships between elevation, plant species percent cover and soil variables.



Soil moisture content



Provide information about unsaturated conditions in the pools

Not currently measured in pools

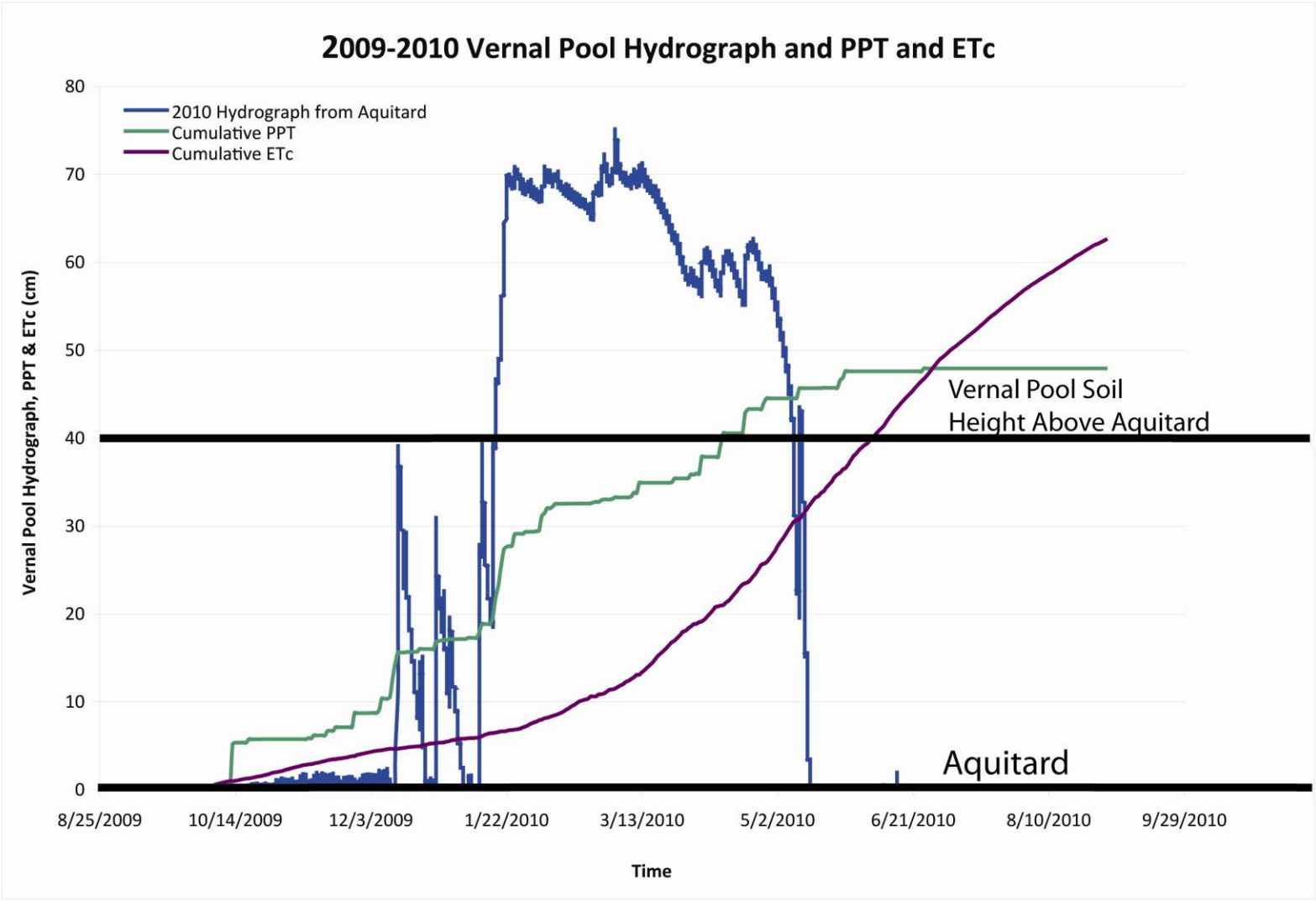
Soil moisture probe

Leveloggers

Measure water table level (mm accuracy)

Placed into pools, swales, and uplands

Left unattended until collection at the end of the season


2009-2010 Vernal Pool Hydrograph and PPT and ETc
2010 Hydrograph from Aquitard
Cumulative PPT
Cumulative ETc
Vernal Pool Soil Height Above Aquitard
Aquitard
Vernal Pool Hydrograph, PPT & ETc (cm)
Time
0
10
20
30
40
50
60
70
80
8/25/2009
10/14/2009
12/3/2009
1/22/2010
3/13/2010
5/2/2010
6/21/2010
8/10/2010
9/29/2010

Invertebrate Sampling

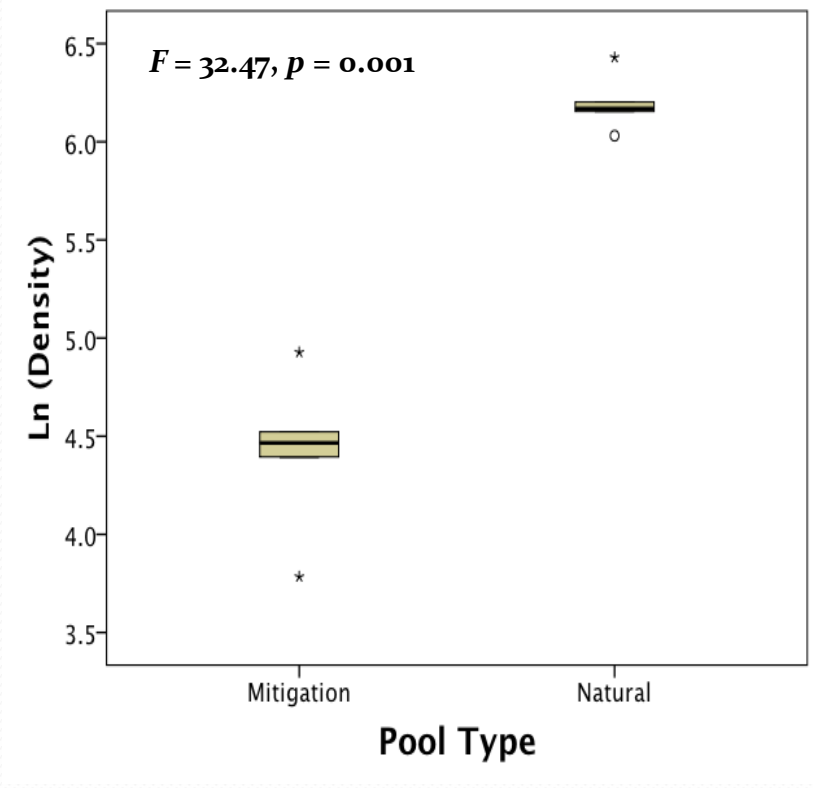
Collaborator Jamie Kneitel (CSUS)

Linderiella occidentalis (common)

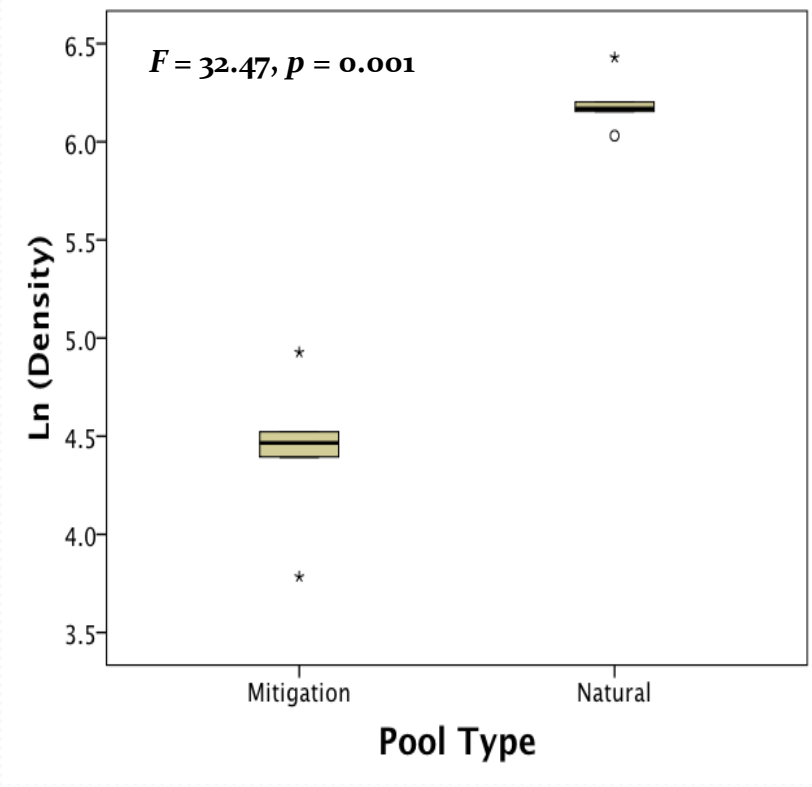
Branchinecta lynchi (threatened)

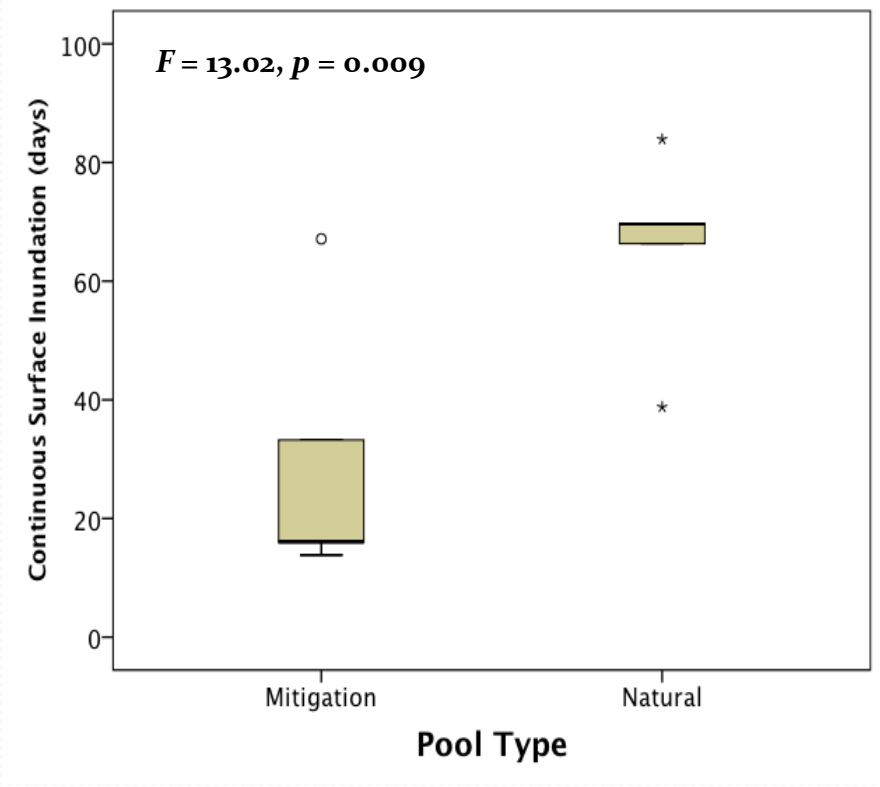
Lepidurus packardi (endangered)

Abundance of invertebrates differs among mitigation and natural vernal pools

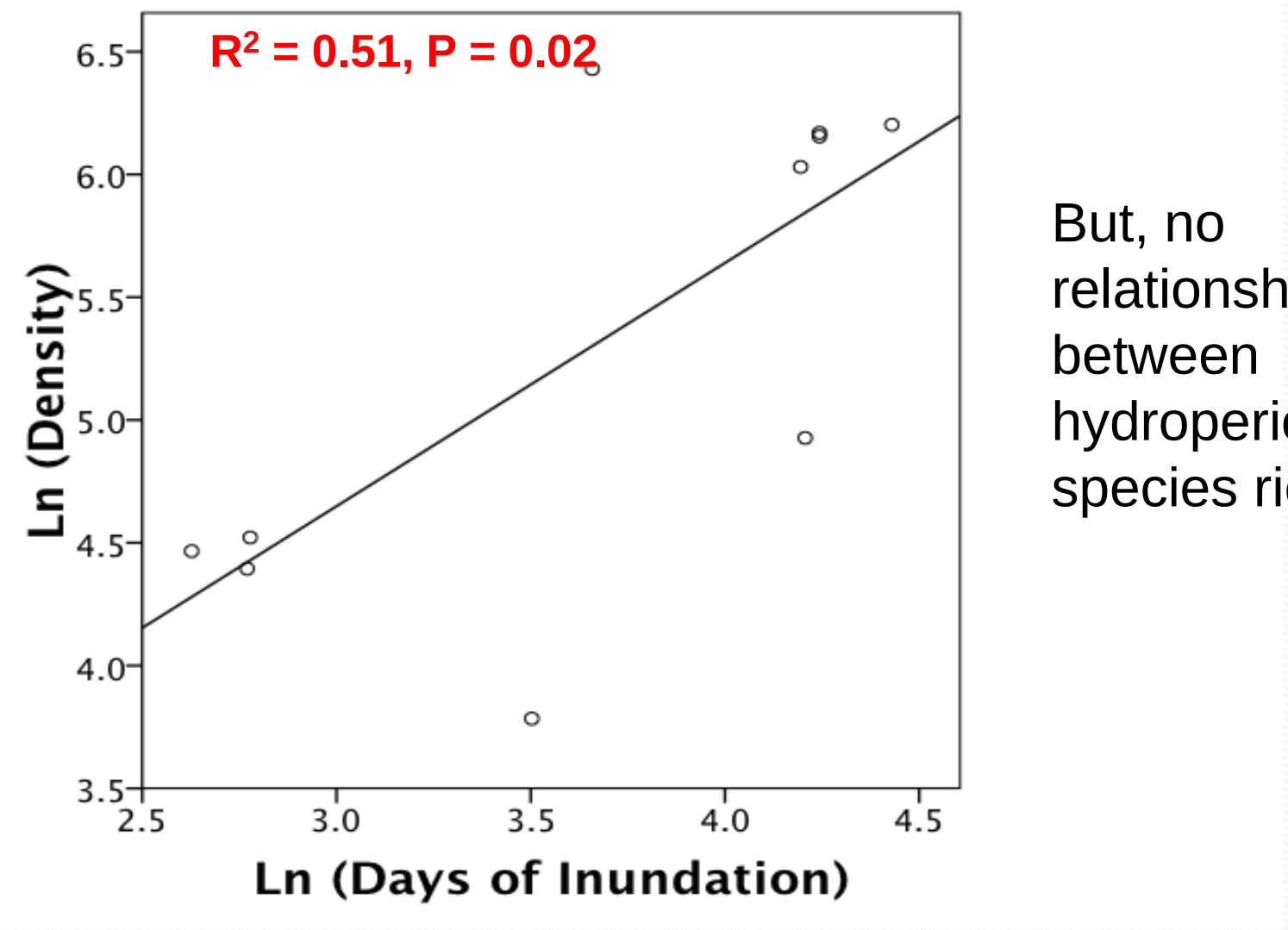


The number of days of continuous inundation is much lower in mitigation vernal pools



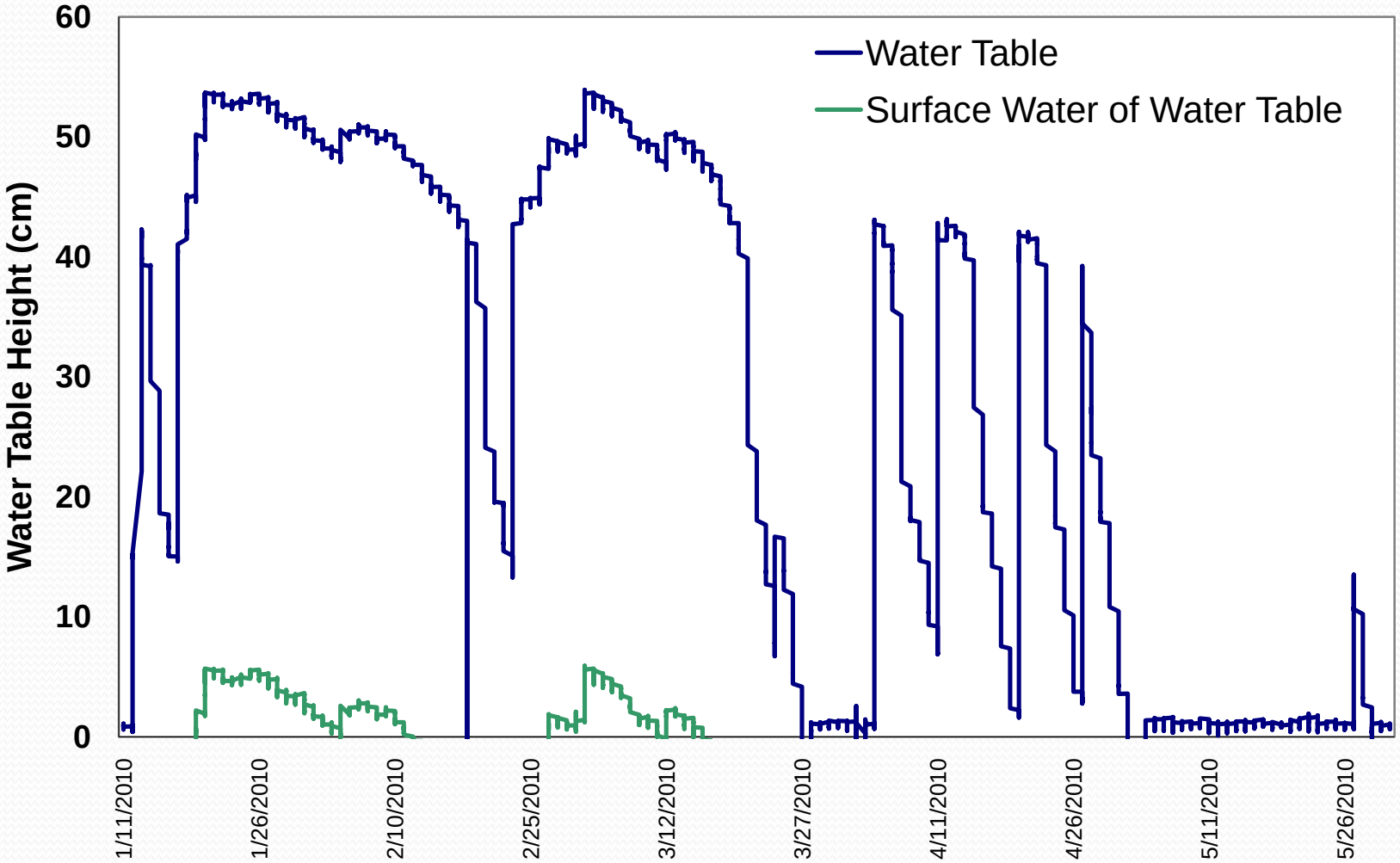


Hydroperiod-Invertebrate Density



But, no relationship between hydroperiod and species richness

Mitigation Vernal Pool 3



Conclusions

- These methods provide higher quality and more precise, detailed hydrological data about vernal pool systems

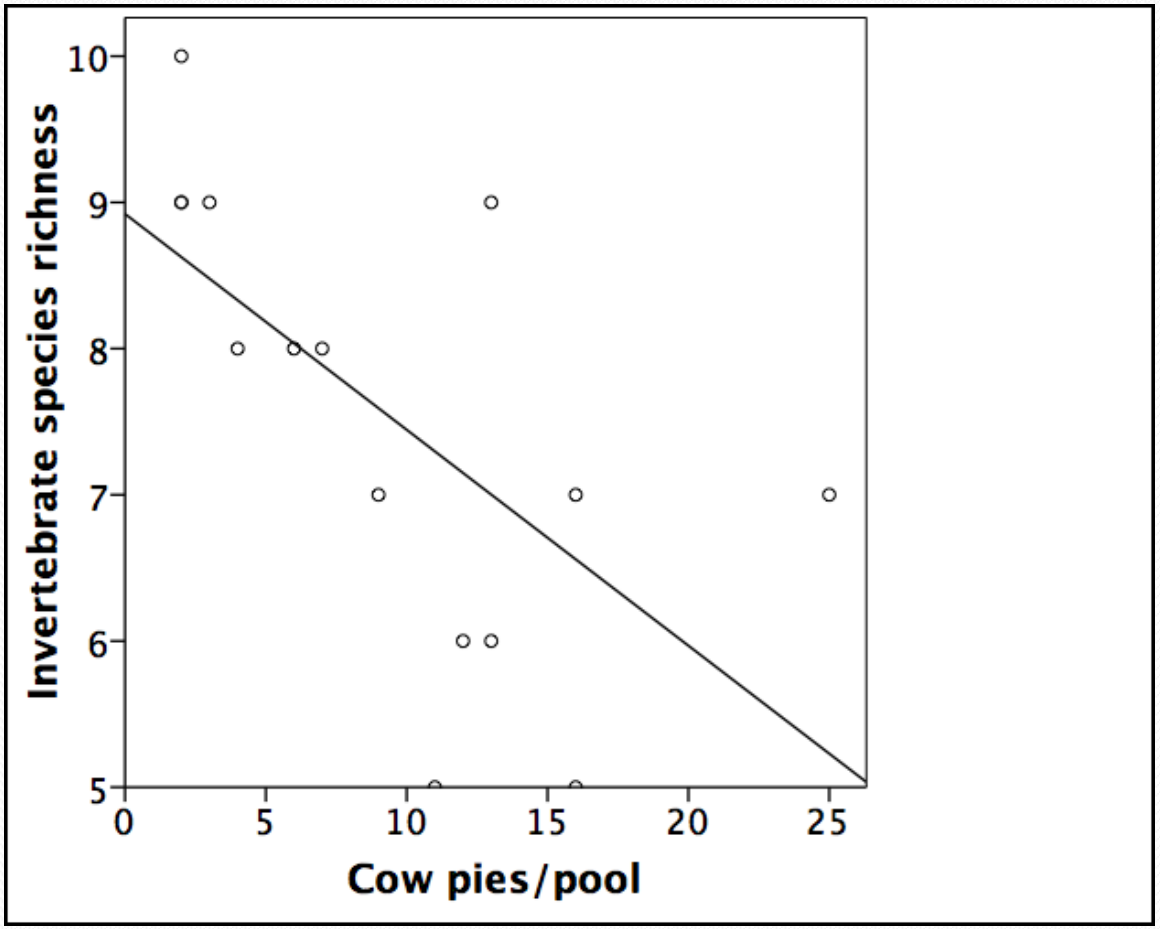
- The information will help us to better understand the ecological functioning of natural and created pools

- Sites can be assessed to a better extent as potential compensatory mitigation vernal pool creation locations

Acknowledgements

- Funding from the DoD ESTCP
- Beale AFB and Travis AFB

Related Research by Jamie Kneitel (CSUS) from the Beale AFB Study Determining the Influence of Cattle Grazing on Macroinvertebrates in Vernal Pools

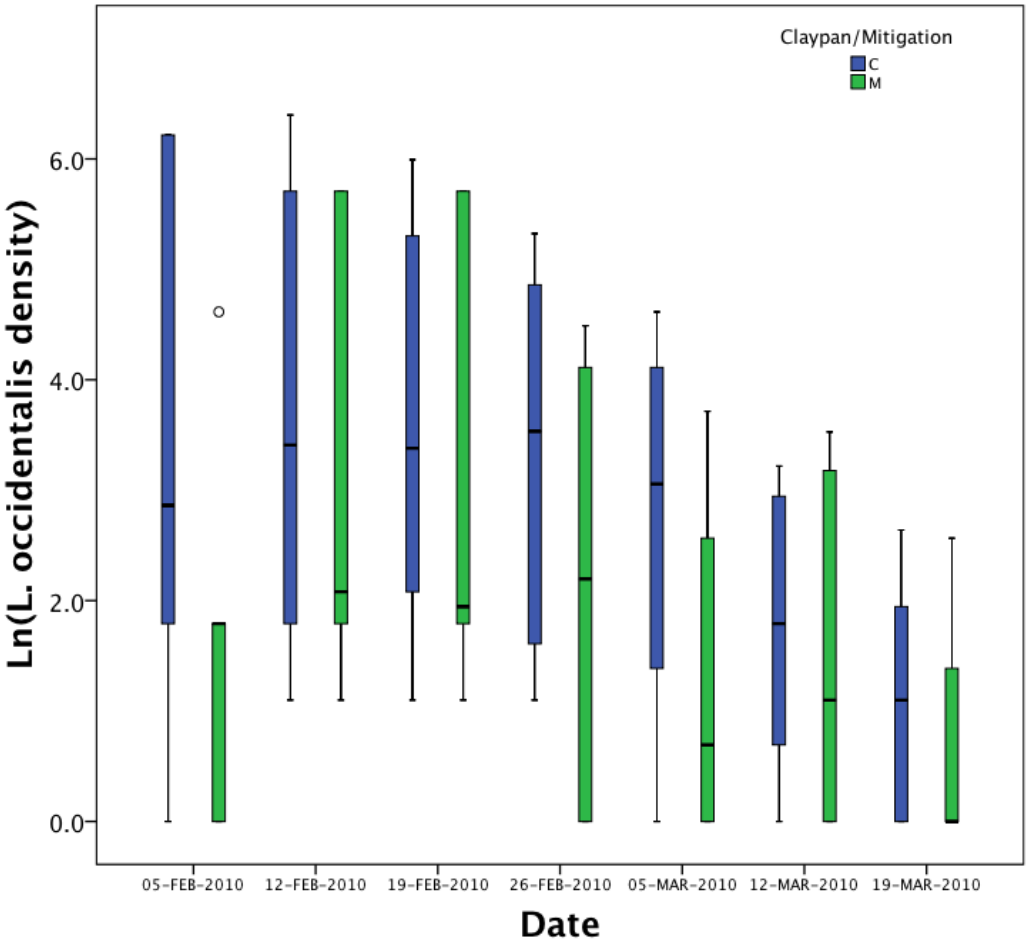


Water quality monitoring

Water quality measurements of

- temperature,
- pH,
- dissolved oxygen,
- redox potential, and
- conductivity.

Linderiella occidentalis



California fairy shrimp
(*Linderiella occidentalis*)

ANOVA:
Date: $F = 6.29$, $p < 0.001$
Pool Type: $F = 0.77$, $p = 0.39$

Water chemistry covariates:
Turbidity: $F = 13.46$, $p < 0.001$