Poster #B12D-1108

Evaluating Rock Pool Hydroperiod Fluctuation using Climate Variables to Inform Habitat Monitoring and Protection in the Western Sonoran Desert

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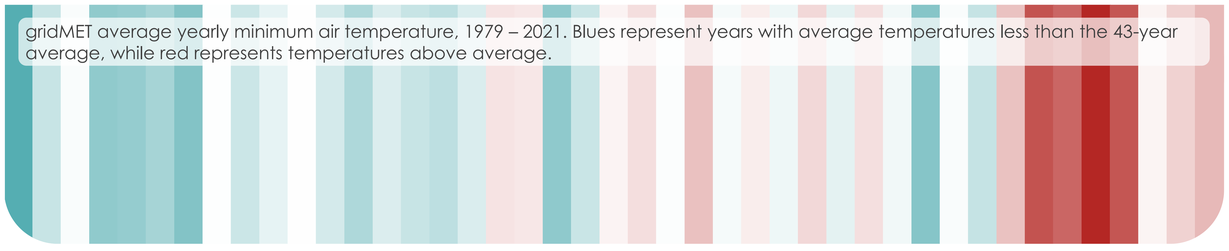
ABSTRACT

As warming and drying trends continue to impact the greater American Southwest, effective ecosystem management increasingly relies upon understanding the relationships between climate and water resources. Ephemeral freshwater rock pools, known as tinajas, have great ecological and cultural importance as some of the only sources of surface water in the western Sonoran Desert (WSD). Tinaja flooding and drying cycles, known as hydroperiods, vary based on meteorologic and climatologic conditions; however, a lack of extensive research relating climatic impacts to tinajas puts these critical ecosystems further at risk. Tinajas throughout the WSD are monitored by the National Park Service (NPS) using resource intensive strategies including in situ trail camera observation and direct measurement. To aid NPS monitoring efforts, this research used remotely sensed climate data to analyze spatiotemporal climate trends and relationships between climate variables and tinaja hydroperiods in the WSD between 1979–2022. Using Aqua and Terra Moderate Resolution Imaging Spectroradiometers (MODIS), University of Idaho Gridded Surface Meteorological Dataset (gridMET), and OpenET data, the project analyzed land surface temperature, evapotranspiration, precipitation, wind velocity, and solar radiation. The team generated climate anomaly time series and climate normal maps for the WSD, identifying statistically significant spatial and temporal trends. These data were then compared to daily, qualitative in situ hydroperiod observations taken between 2019–2022. This work will be used by the NPS to inform the monitoring and protection of tinajas in the WSD. Findings contribute to a limited body of research concerning climate and tinajas, which are often overlooked despite their disproportionate ecological importance.

KEY FINDING

Rates of **warming and drying** are increasing rapidly in the **western Sonoran Desert**. By integrating ***in situ* data** and **Earth observations**, research can inform rock pool conservation and management priorities.



OBJECTIVES

- Generate **climate time series** for Organ Pipe Cactus National Monument (OPCNM)
- Produce **climate maps** to analyze spatial climate patterns and identify rock pools most at risk
- Integrate Earth observations with *in situ* data to analyze **relationships between environmental variables and hydroperiods**

DATA & METHODS

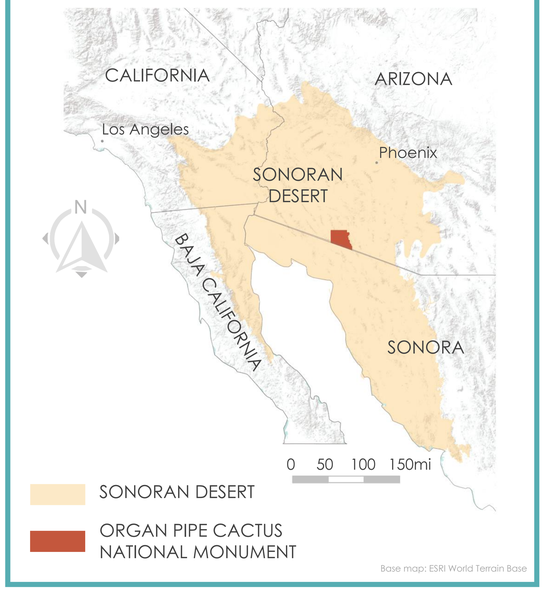
Data: Aqua & Terra MODIS, gridMET, OpenET, and *In Situ* Hydroperiod Camera Observations

- Utilized Google Earth Engine Python API for data processing and analysis
- Performed linear regressions on timeseries of environmental variables to investigate statistically significant climate trends - slopes for each linear regression indicated the average change per year for each environmental variable
- Produced climate normal, change, and variability maps for all variables in Python and ArcGIS Pro
- Performed Spearman's correlations to examine relationships between environmental variables and *in situ* hydroperiod data

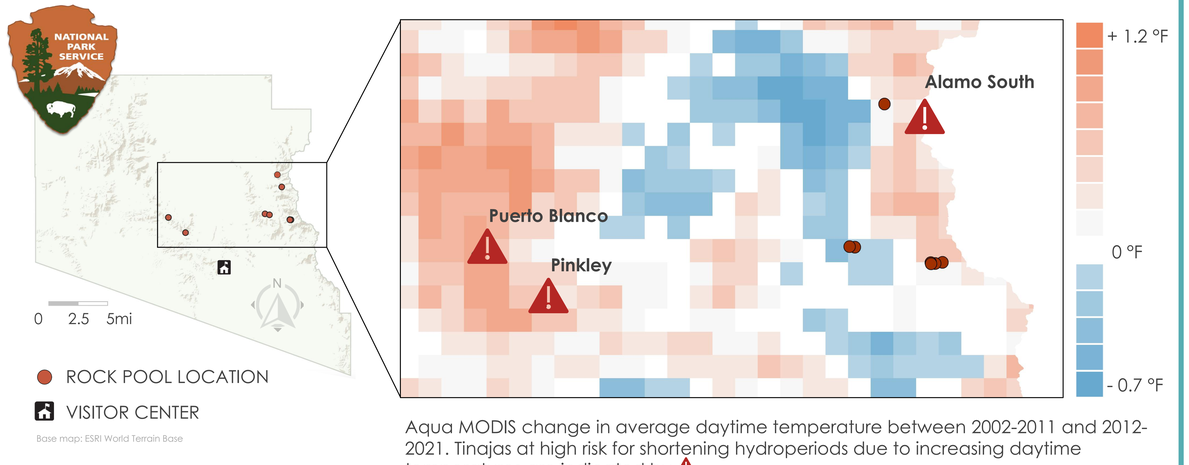
LIMITATIONS

- **Short temporal resolution** of *in situ* data and some environmental variables
- **Small geographic scope** within OPCNM
- Other **contributing variables** not considered

STUDY AREA



CONSERVATION OUTPUTS



Aqua MODIS change in average daytime temperature between 2002-2011 and 2012-2021. Tinajas at high risk for shortening hydroperiods due to increasing daytime temperatures are indicated by ⚠.

RESULTS

+3 °F rise in average **minimum air temperature** over the past 40 years ($p<0.05$)

+8 W/m² rise in average **solar radiation** over the past 40 years ($p<0.05$)

The number of rock pool wet days/month had the most significant correlation with **monthly averages** of **evapotranspiration** and **precipitation.**

WESTERN SONORAN DESERT Water Resources

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