National Aeronautics and Space Administration

Monitoring Vegetation Health and Water Availability in Bryce Canyon National Park for Drought Stress Mitigation Planning

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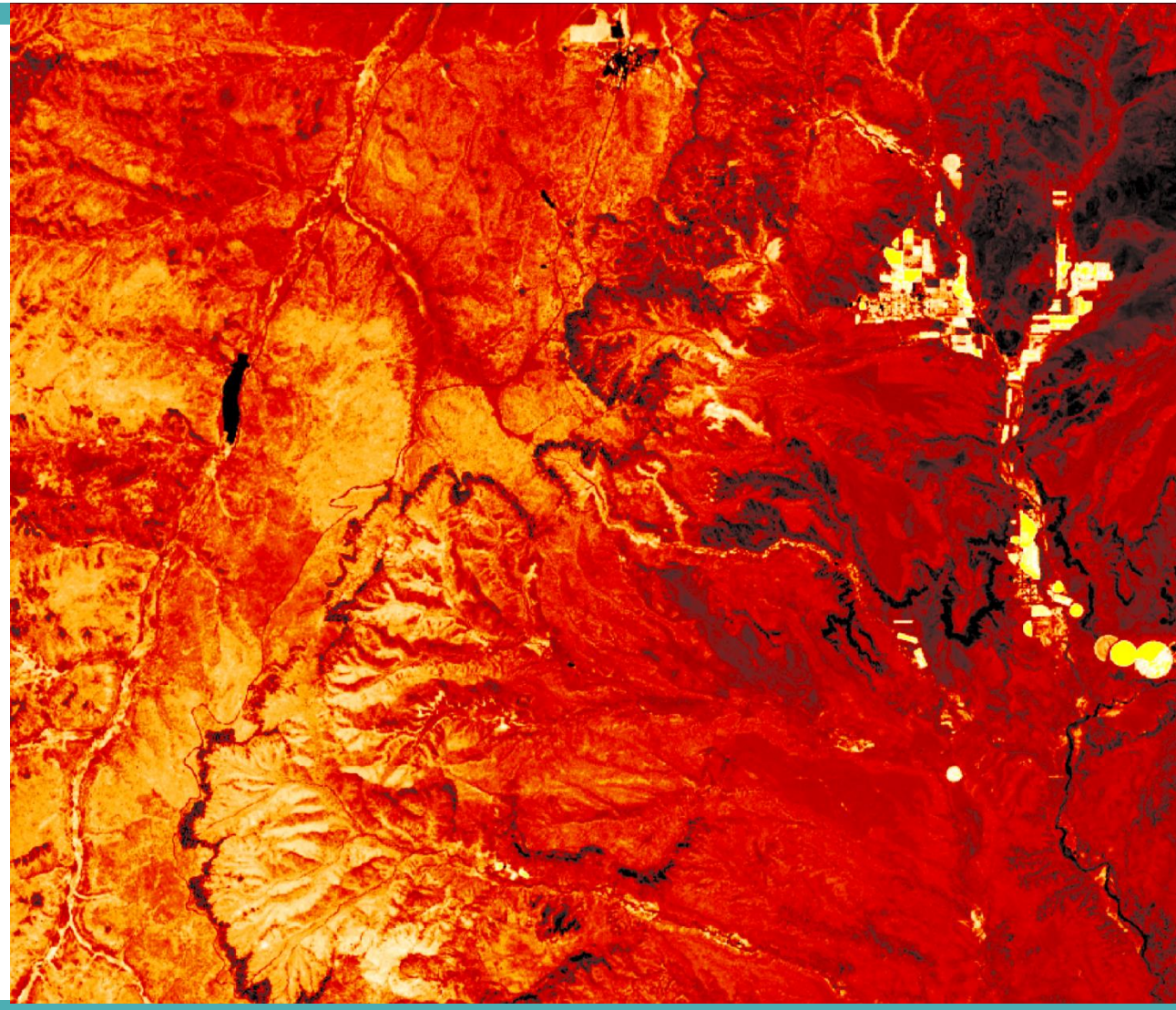


DEVELOP

Partners & Objectives

Partner: National Park Service, Bryce Canyon

- Tyra Olstad, Physical Scientist

Objectives:

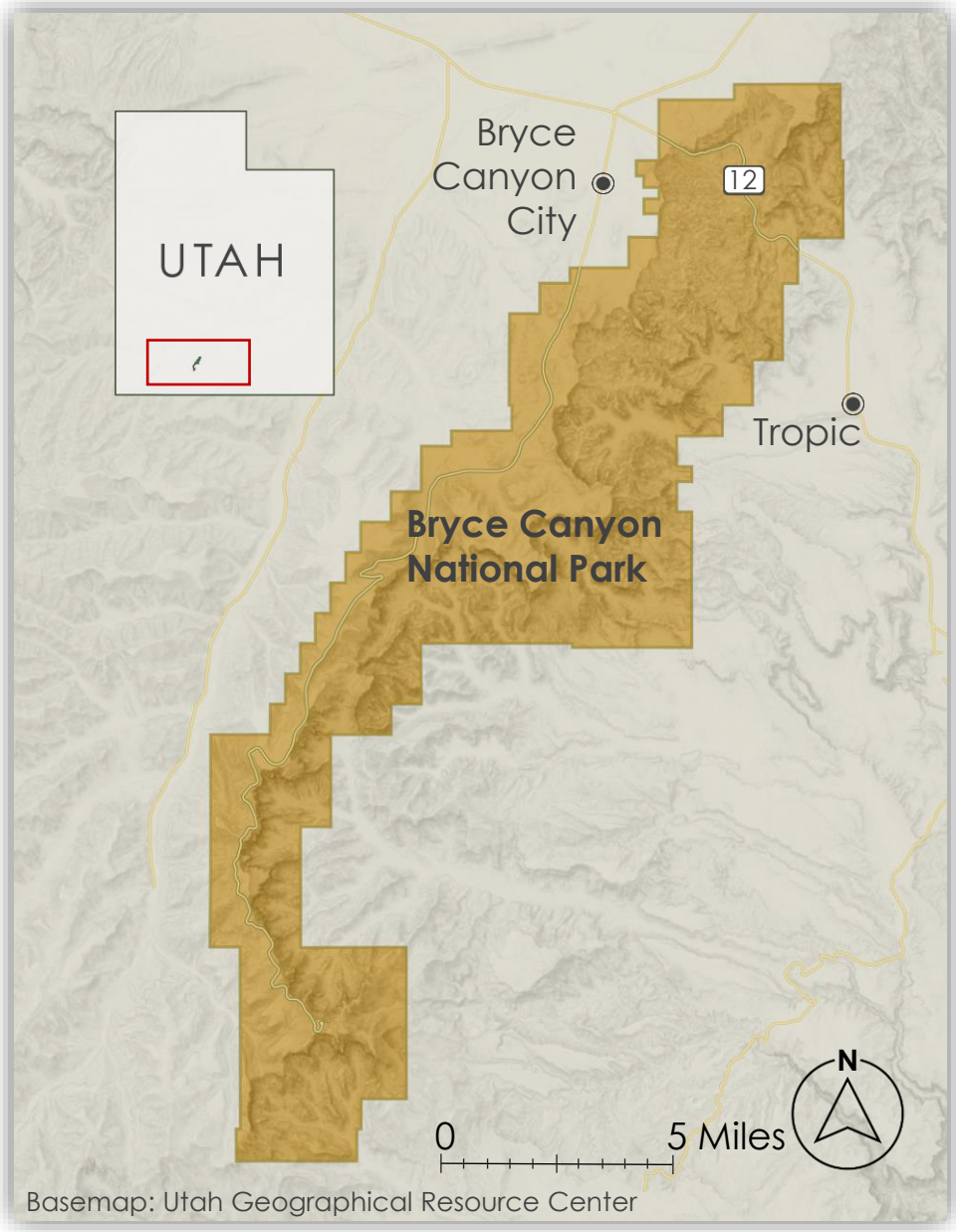
- **Apply** sophisticated remote sensing techniques to:
  - **Detect** springs, seeps, and groundwater-dependent ecosystems
  - **Examine** changes in surface water presence and vegetation health
  - **Report** changes in climate
- **Create** a framework for future applications

Image Credits: NPS & Tyra Olstad

Study Area & Period

- Study Period: 2013–2022
- Study Area: 35,835 acres

Yellow Creek spring in front of hoodoos
Image Credit: Tyra Olstad



Background Information

Image Credit: Barton Davis Smith

Park Tourism

- Visitors increased from 890,676 in 2006 to 2,679,478 in 2018
- Highest concentration of Hoodoos in the world
- Designated Dark Sky Park in 2019

Groundwater Dependent Ecosystems

- Unique species
- Sensitive to changing climate

Image Credit: Tyra Olstad

Methodology: NDVI & NDWI Analysis

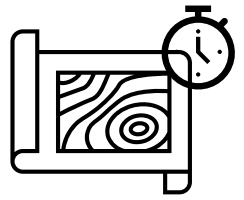
PlanetScope DOVEs (PlanetExplorer)
- 2017 – 2022

Landsat 8 OLI (USGS)
- 2013 – 2022

NAIP Imagery (USDA)
- 2018

Google Earth Engine

Change Maps
- How has vegetation and water changed in space?



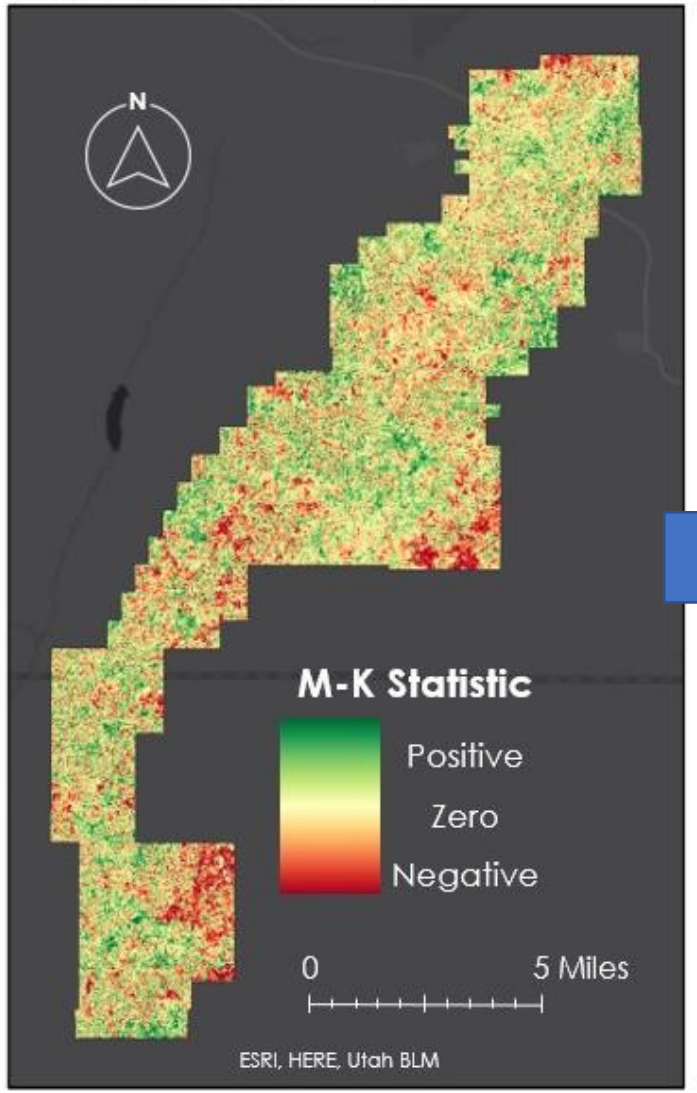
Time Series
- How have they changed over time?

Direct Detection
- Are spring and seep NDVI/NDWI values statistically unique?

NDVI as Measure of Vegetation Health, Landsat 8 OLI (30m)

Mann-Kendall NDVI Trend Test

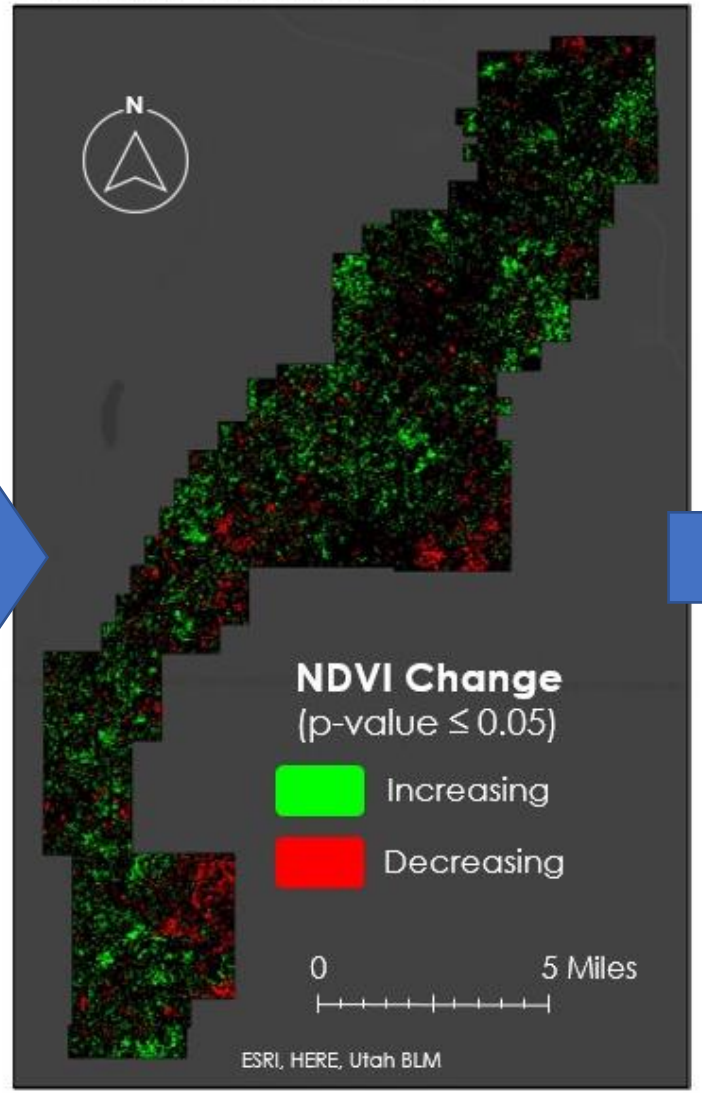
Landsat 8 OLI, 2013-2022



Where is there positive, negative, and zero trend in vegetation health?

Significant NDVI Change

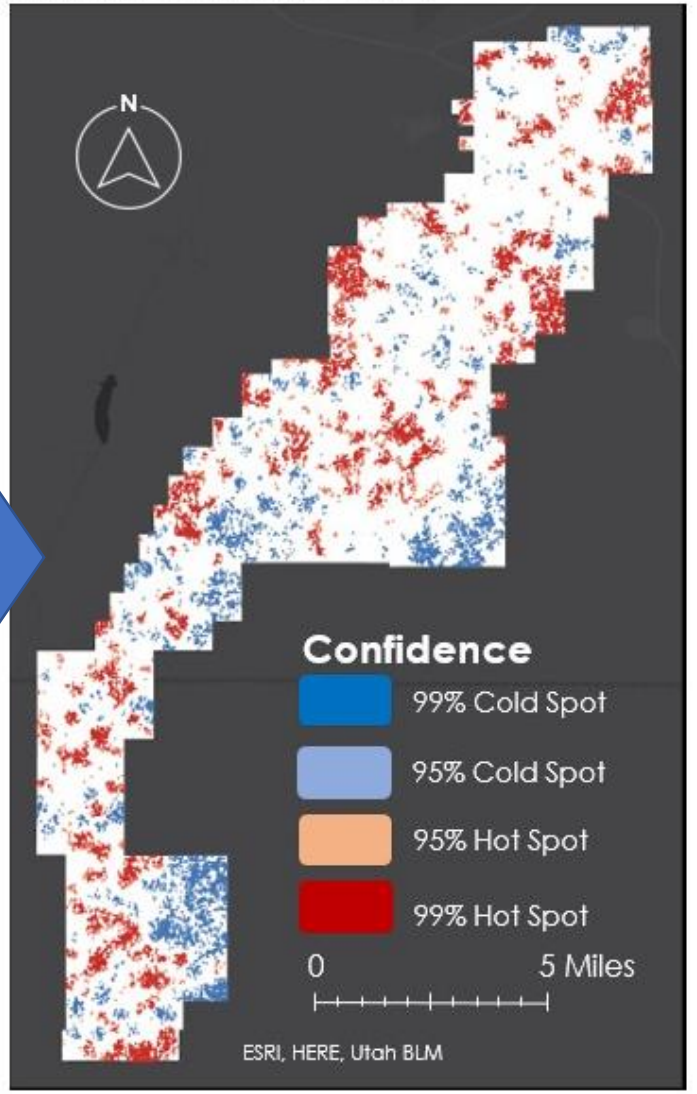
Landsat 8 OLI, 2013-2022



Where is there significant positive and negative trend?

NDVI Change Hot Spot Analysis

Landsat 8 OLI, 2013-2022



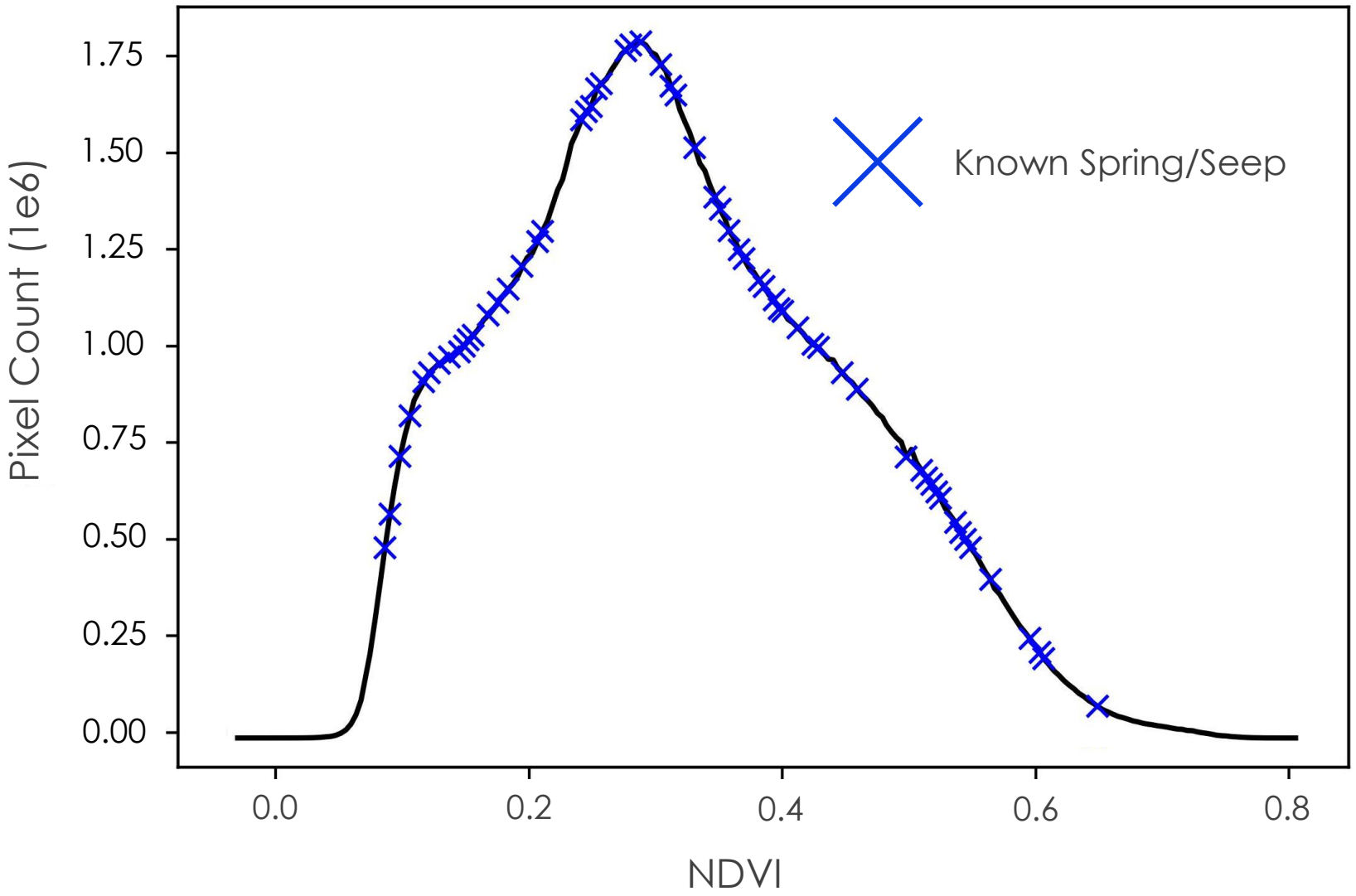
Where does significant positive and negative trend cluster?

(Note: Hot Spots (red) are increasing NDVI)

Results: Detection with NDVI

Bryce Canyon NDVI Histogram

Planet, 05/14/2022



Bryce Canyon NDVI Table

6 Annual April/May Images, 2017–2022

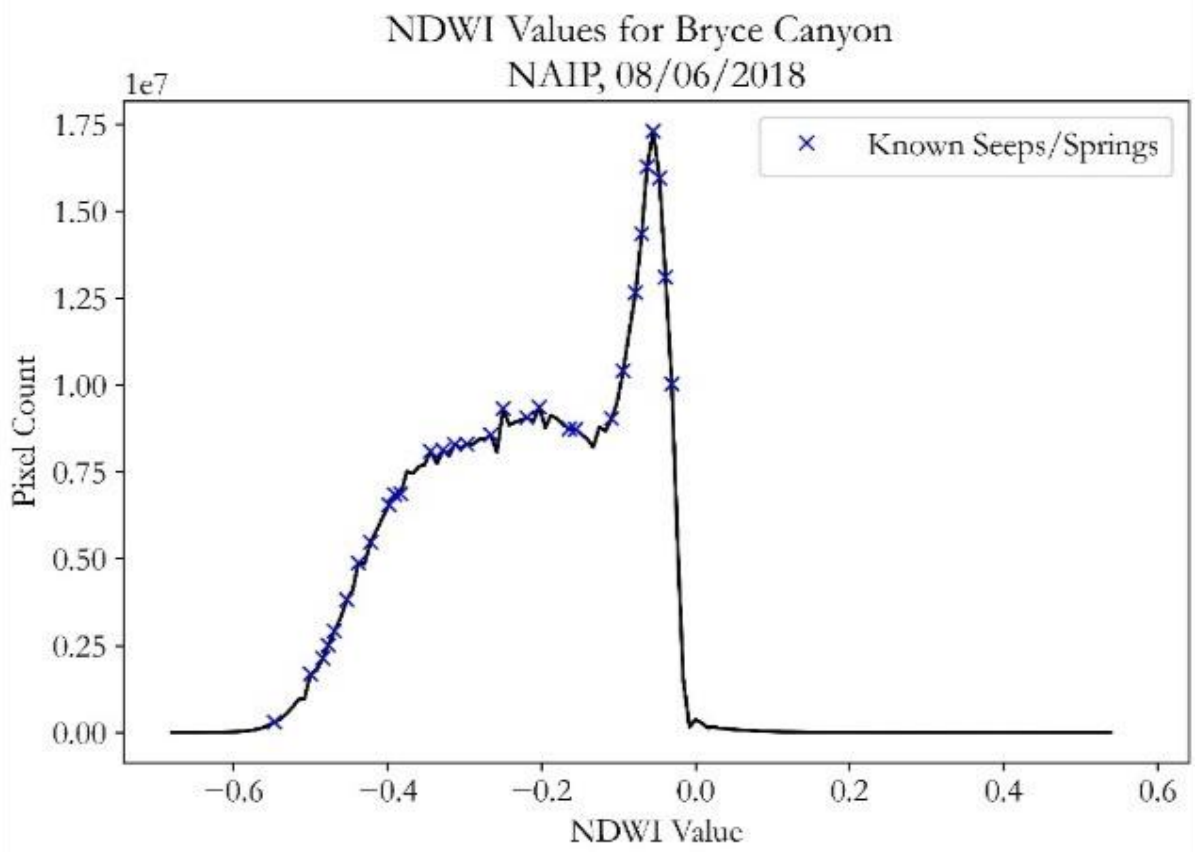
Overall Mean	Springs & Seeps Mean	Z-Score	P-Value
0.322	0.287	-0.271	0.787

Two-Tailed Z-Test

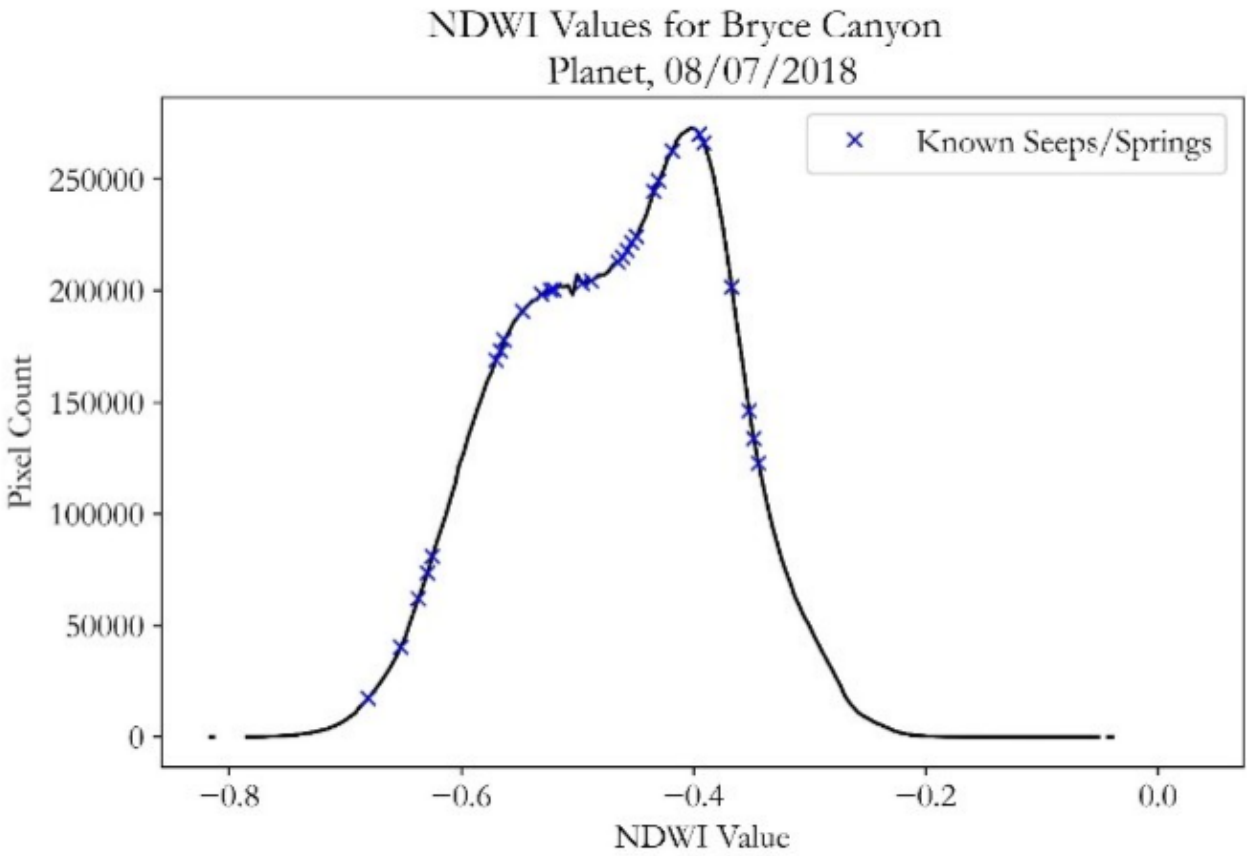
$H_o: \mu = \mu_o$

$H_1: \mu \neq \mu_o$

Results: NDWI Surface Water & Change



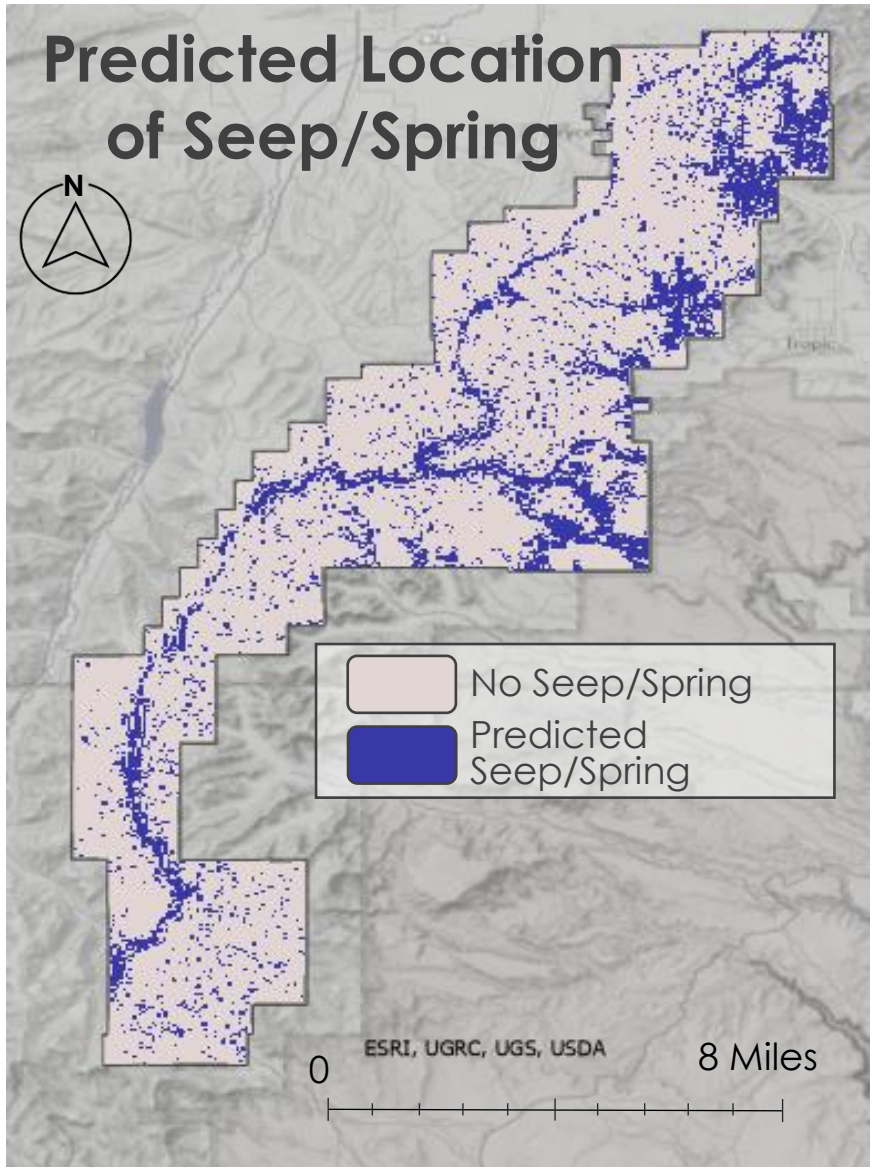
Overall Mean	Spring/Seep Mean	Z-Score	P-Value
-0.215	-0.239	-0.151	0.880

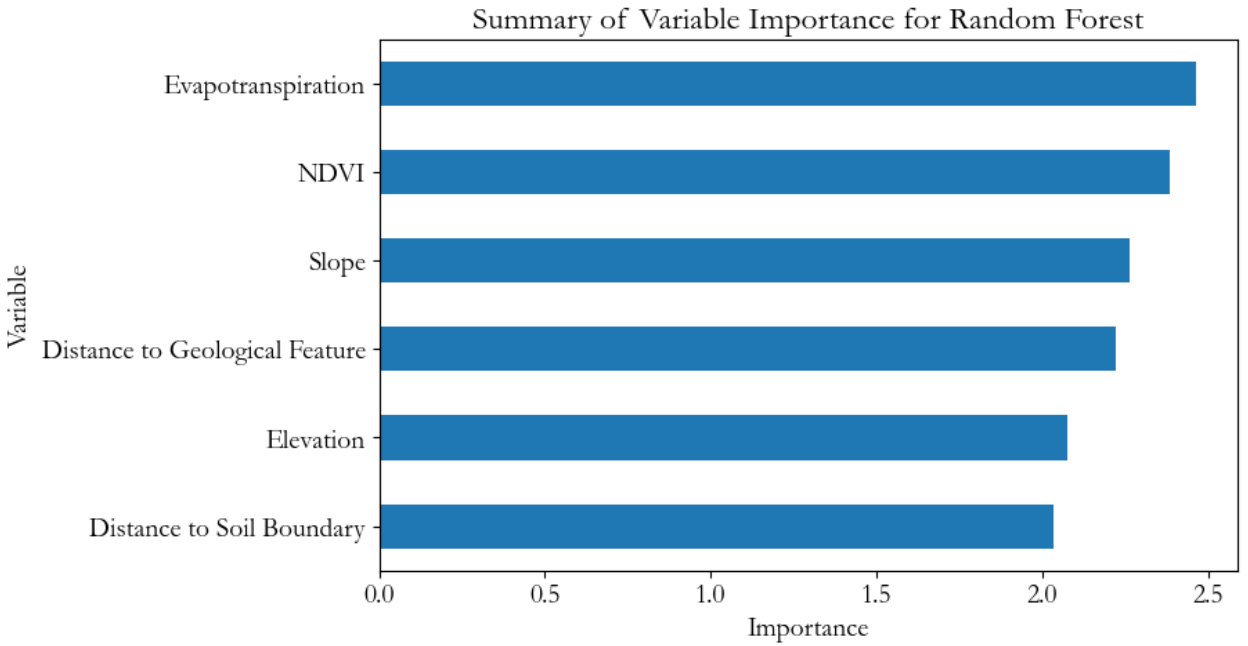


Overall Mean	Spring/Seep Mean	Z-Score	P-Value
-0.465	-0.504	-0.404	0.686

Methodology: Predictive Modeling

Results: Random Forest Model

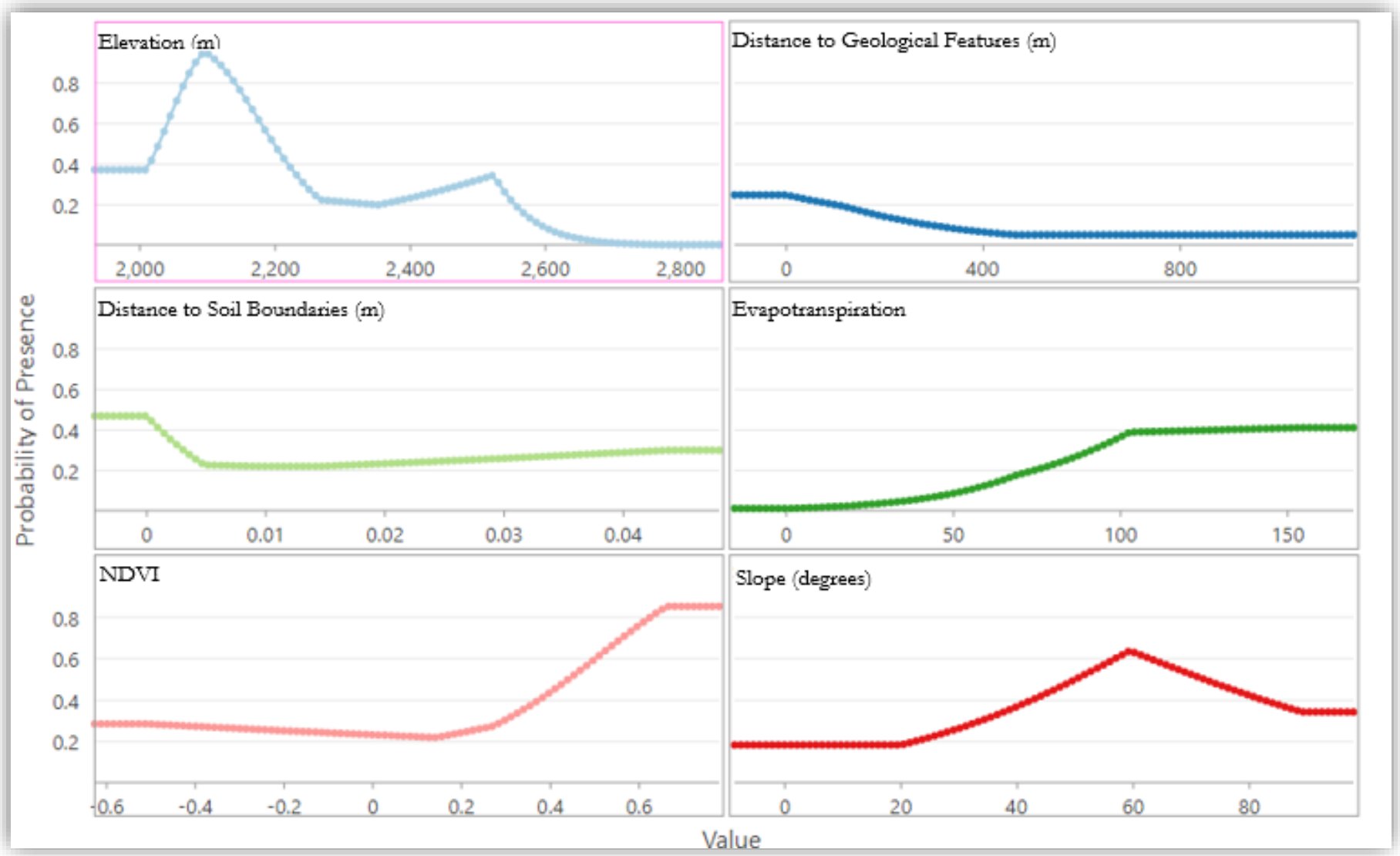




Validation Classification

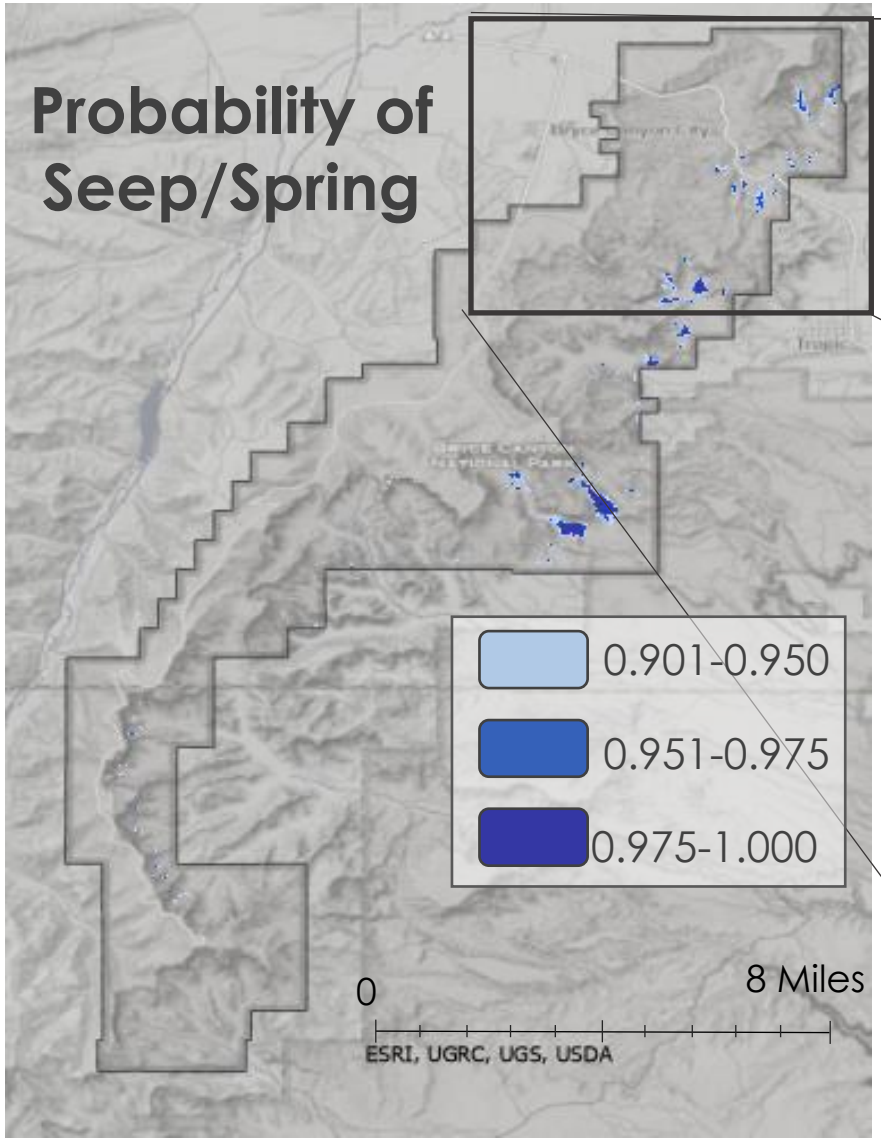
	Seep/Spring (observed)	Not Seep/Spring (observed)
Seep/Spring (predicted)	56%	92%
Not Seep/Spring (predicted)	44%	8%

Results: Maximum Entropy Model

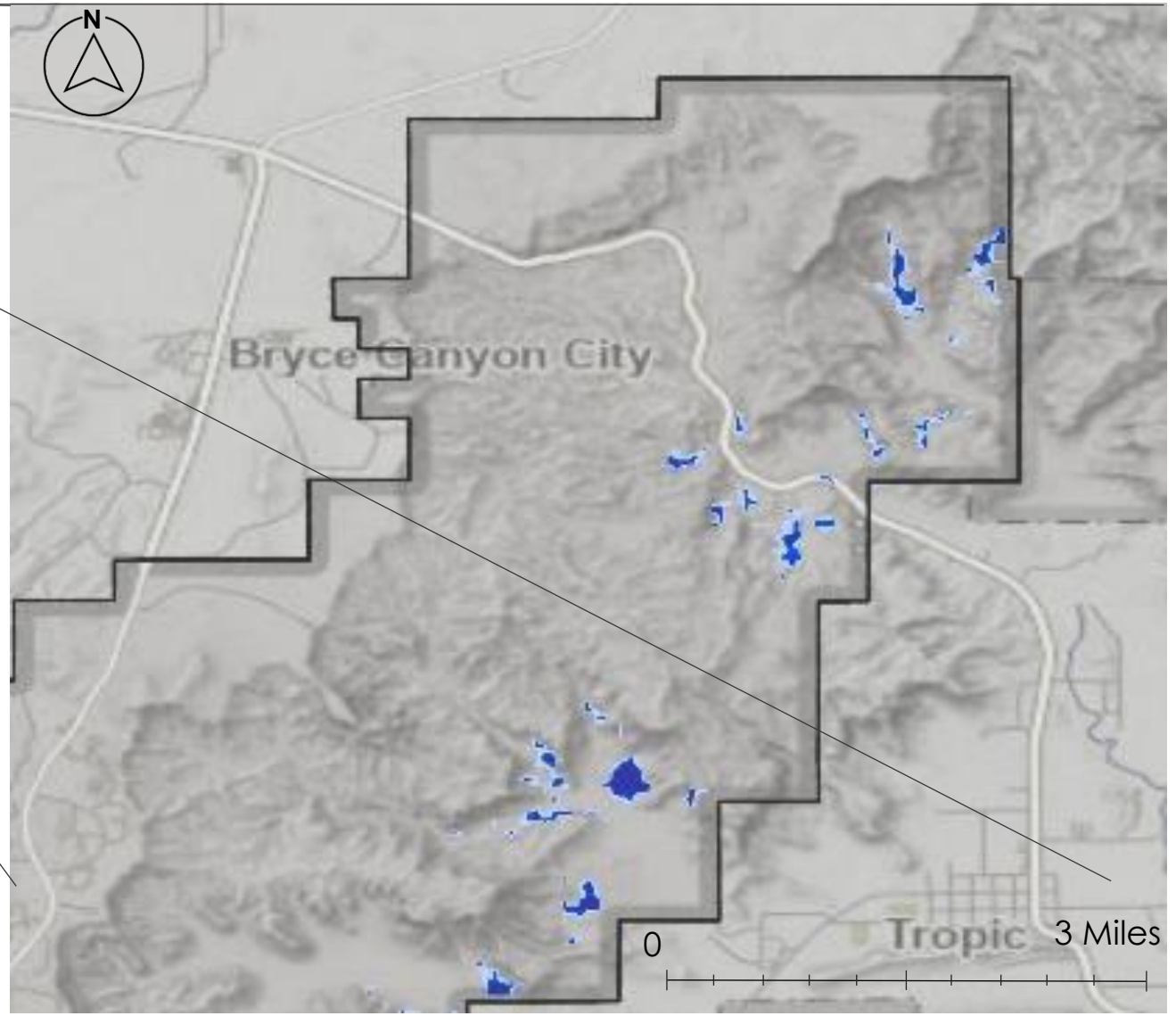


Partial Response of Continuous Variables

Results: Maximum Entropy Model

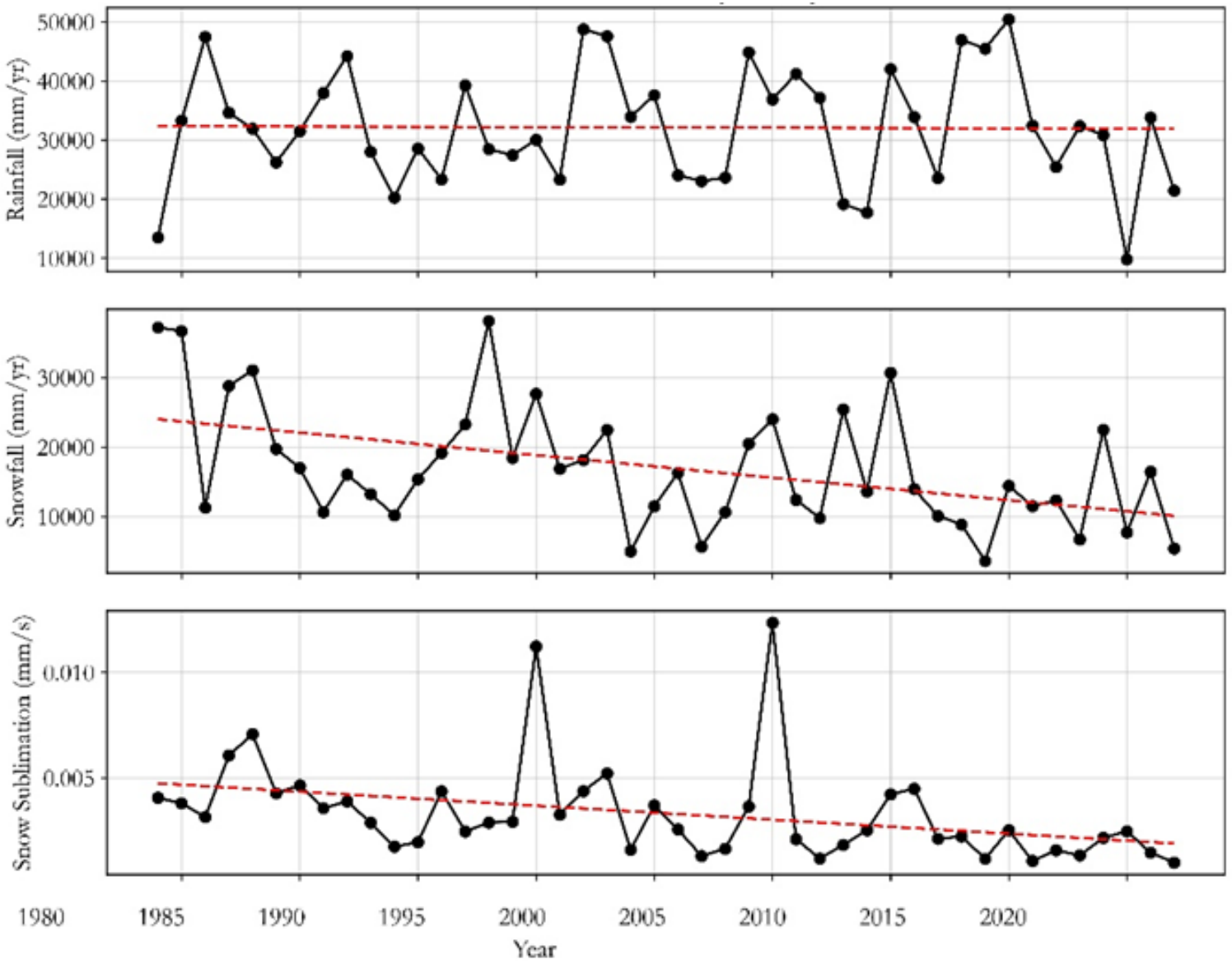


High Probability of Seep or Spring Location

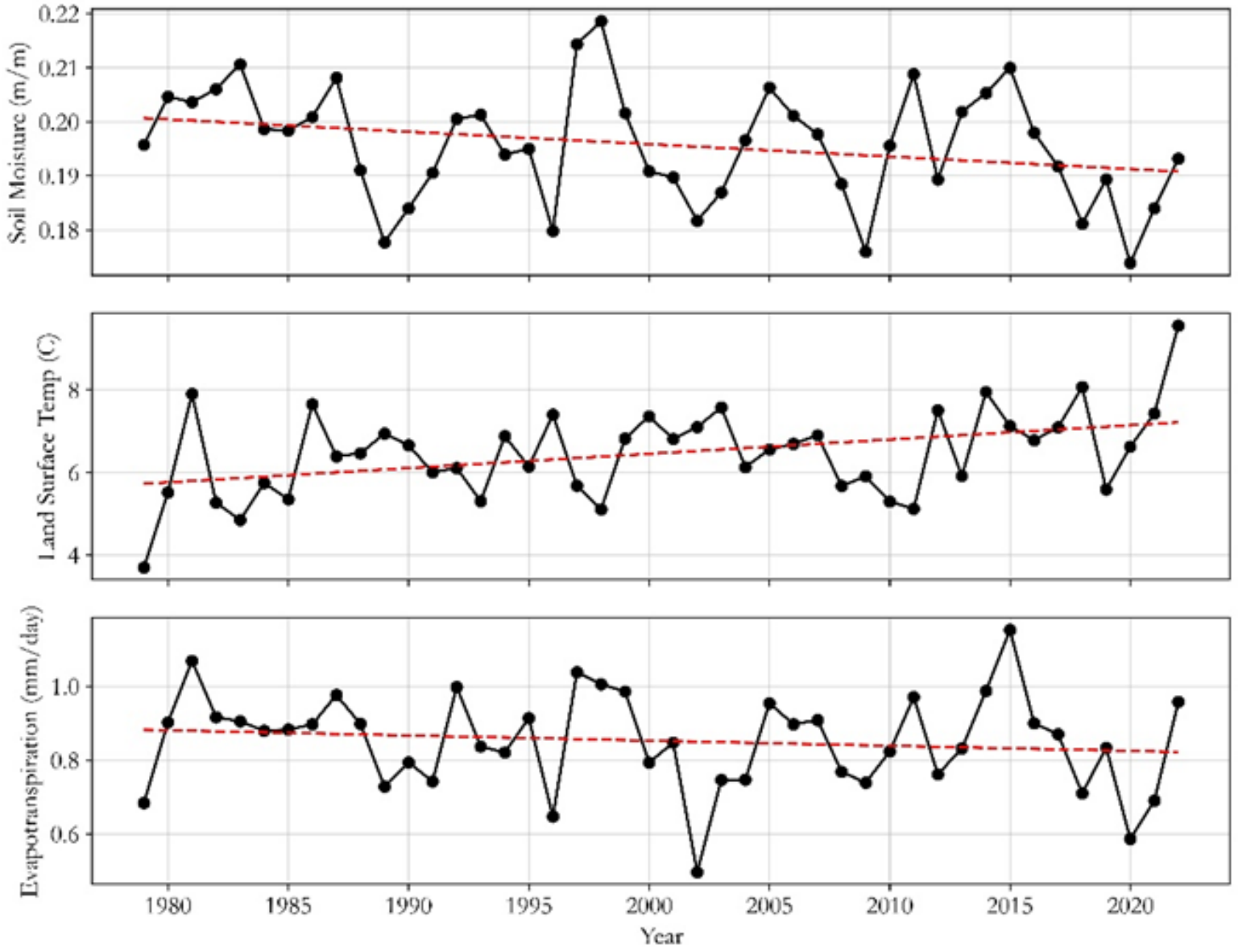


90%+ Seep or Spring Locations

Results: Precipitation Time Series



Results: Climatic Time Series



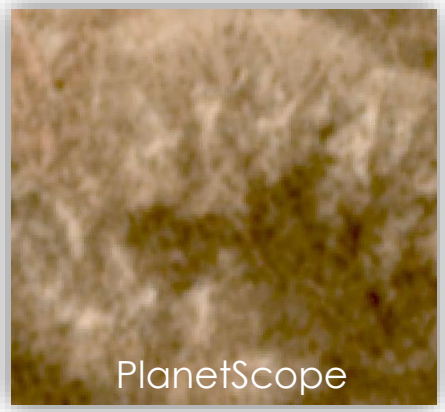
Conclusions

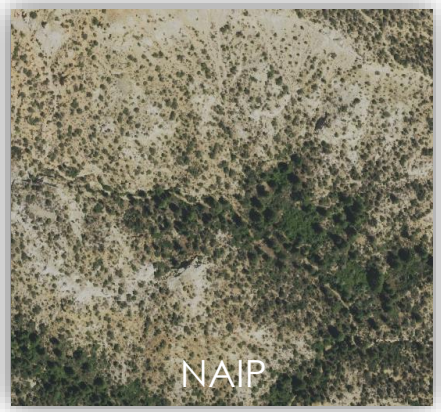
- NDVI and NDWI alone are not a reliable indicator of spring and seep presence
- Maximum Entropy model predicted the probability of where springs and seeps were located
- Snowfall and snow sublimation has decreased since 1979, but rainfall has remained relatively consistent

A slope in Bryce Canyon covered in autumn foliage.
Image Credit: Tyra Olstad

Future Work

- Request and collect aerial thermal imagery
  - Groundwater discharge may have a distinguishable temperature in thermal imagery
- Utilize park stratigraphy
  - Geologic factors may be a reliable indicator of spring and seep occurrence
- Use different machine learning/statistical approaches
- Utilize high evapotranspiration importance through OpenET





Acknowledgements

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