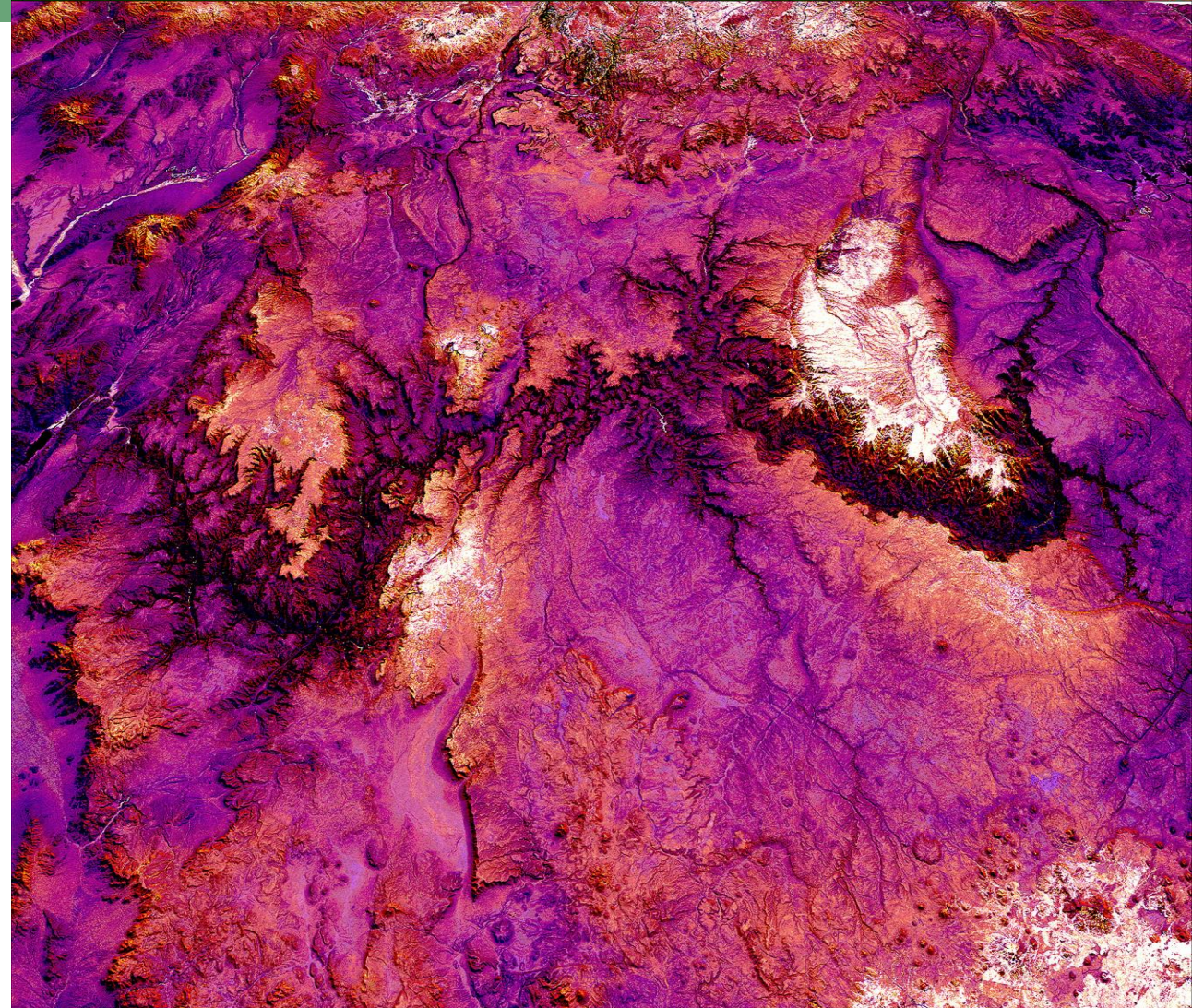




Using NASA Earth Observations to Monitor and Model Juniper Woodland Mortality in Grand Canyon National Park

Michael Hitchner*, Scarlet Jackson,
Miriam Ritchie, & Joe Miotke



JUNIPER BACKGROUND



Image credit: Mike Hitchner

- Junipers are coniferous trees and shrubs
- Mainly occur on the rims of the canyon from elevations between 3,000 to 8,000 ft
- Drought resistant species
- Recording of mass die-off began in 2018
- Native to the area



Terrain

- Terrain can vary from gentle valleys and plains to rugged and steep rocky terrain

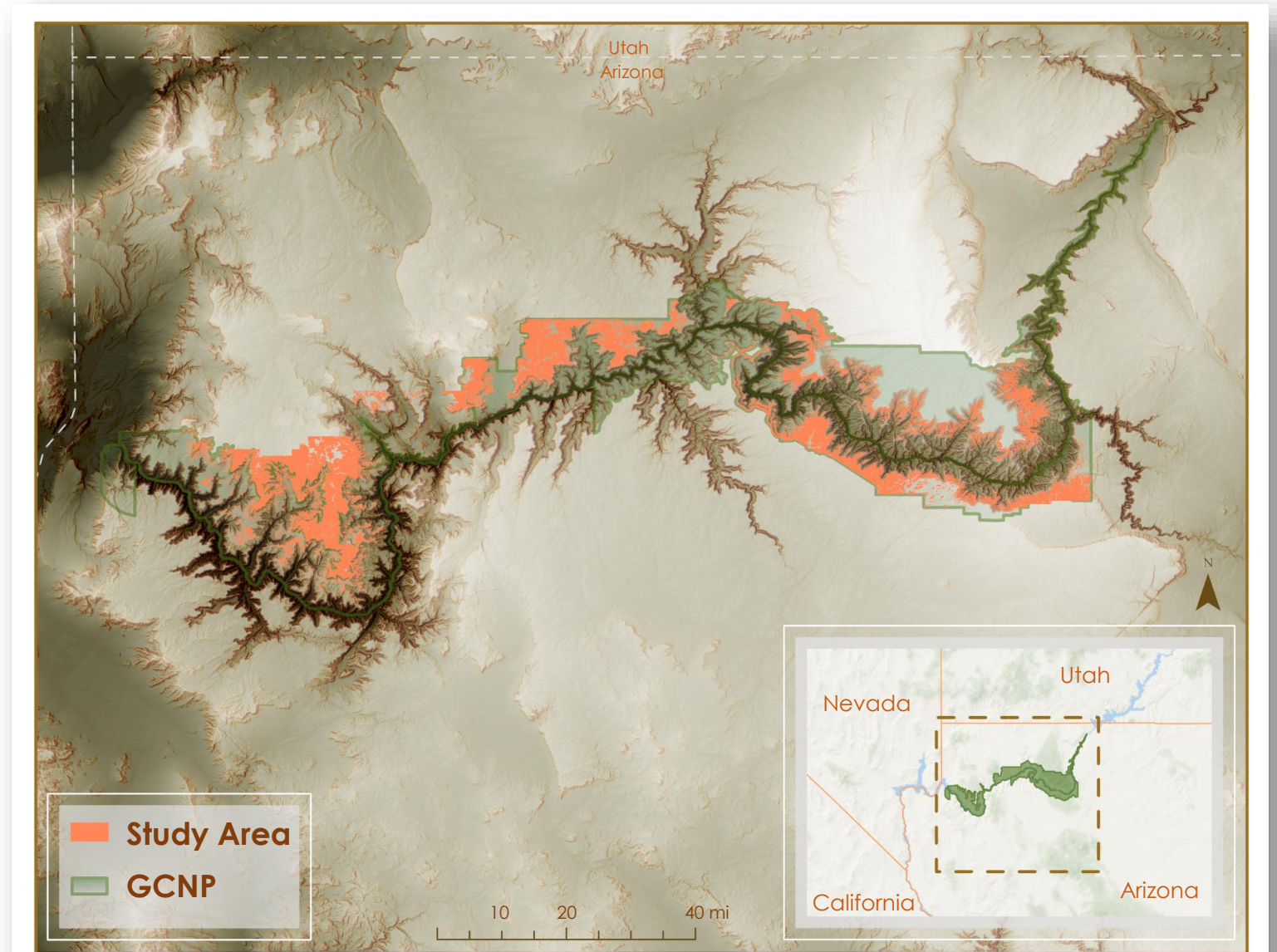


Soils

- Soils can range from deep, fine-textures to shallow and rocky soils

STUDY AREA & PERIOD

- Grand Canyon National Park
- Falls within areas that have substantial juniper presence
- Study period: 2015-2021



DROUGHT

The North American Southwest has been experiencing a "megadrought" for the **last 20 years**

Notice of juniper woodland mortality within and around Grand Canyon National park

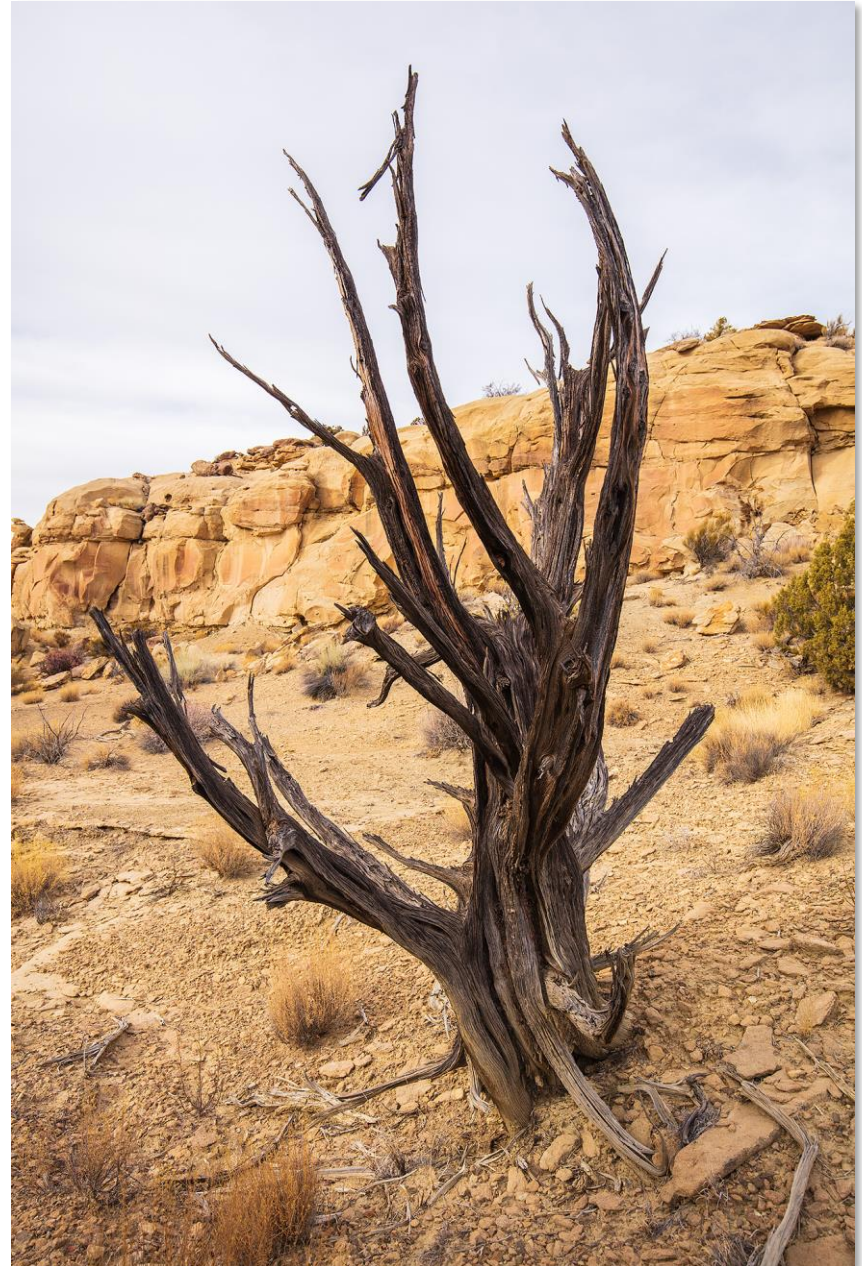


Image credit: Mike Hitchner



CONCERNS

Ecological Concerns

- Food and shelter source to area wildlife
- Helps to prevent erosion

Cultural Concerns

- Medicinal properties
- Wood quality

Community Concerns

- Fire regime shifts
- Decreases in water availability
- Forest composition + species shifts
- Carbon feedback to atmospheric and climatic systems



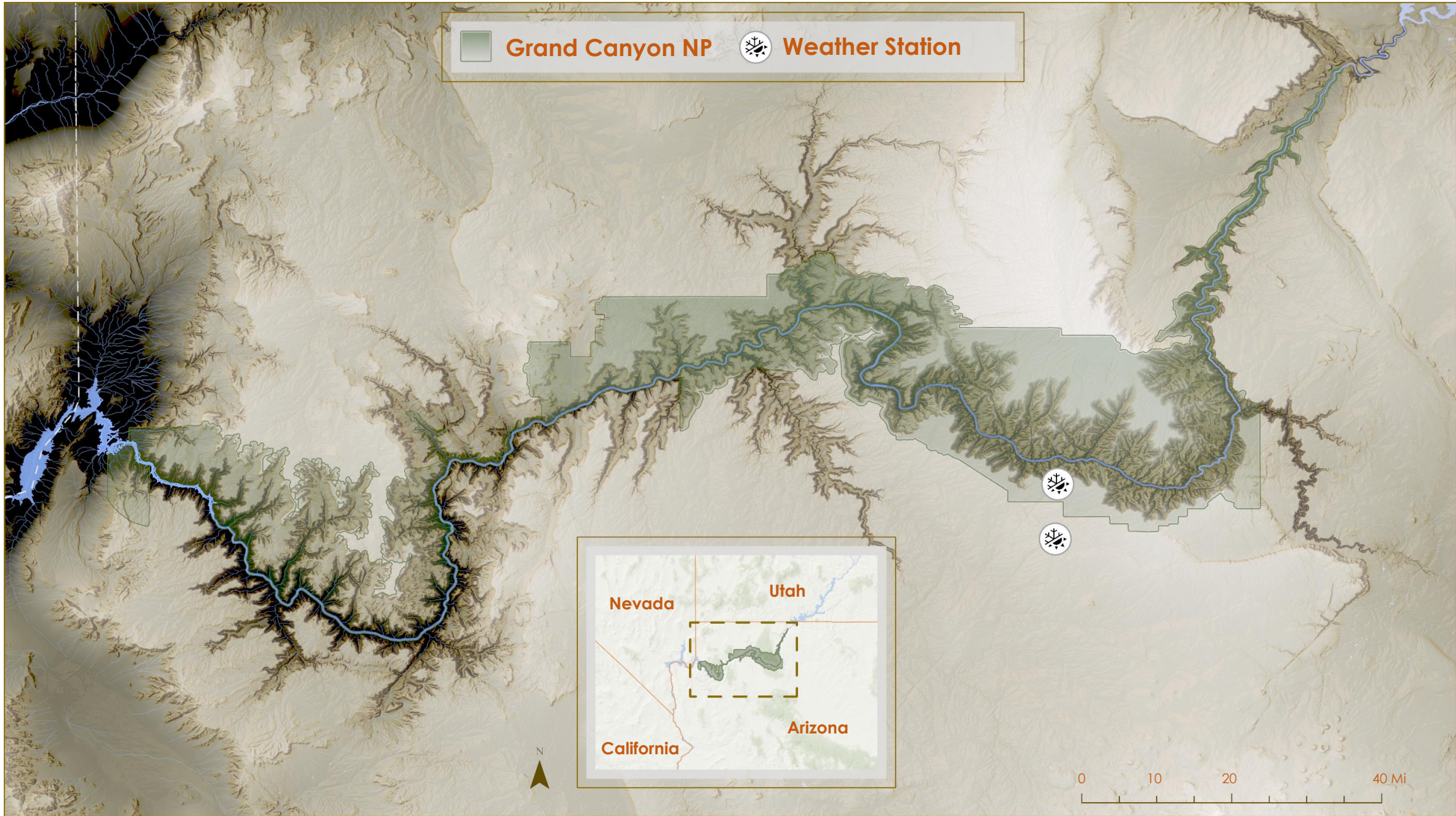
Image credit: Amy Washuta

PARTNERS

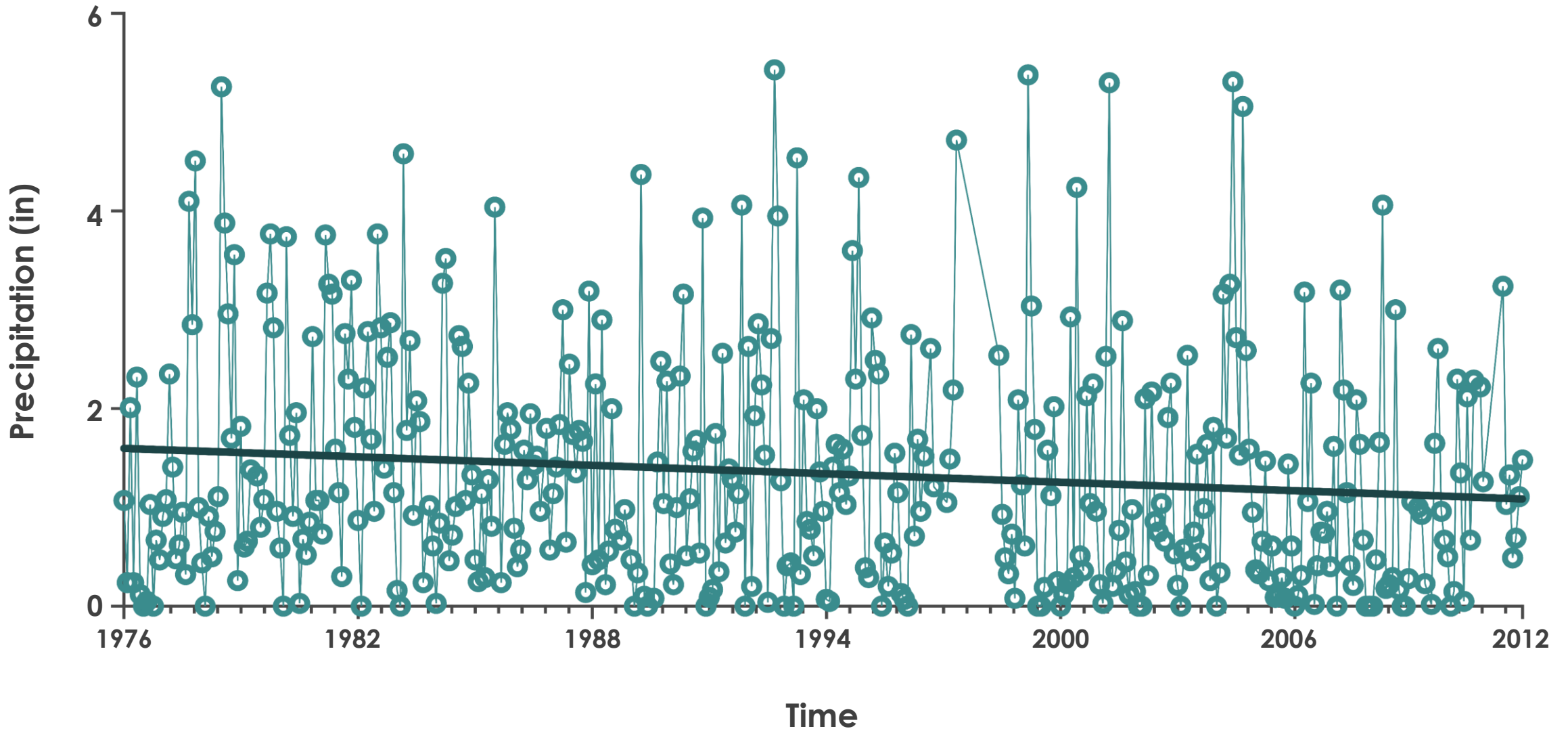


**Grand Canyon
National Park**
*Science & Resource
Management Division*

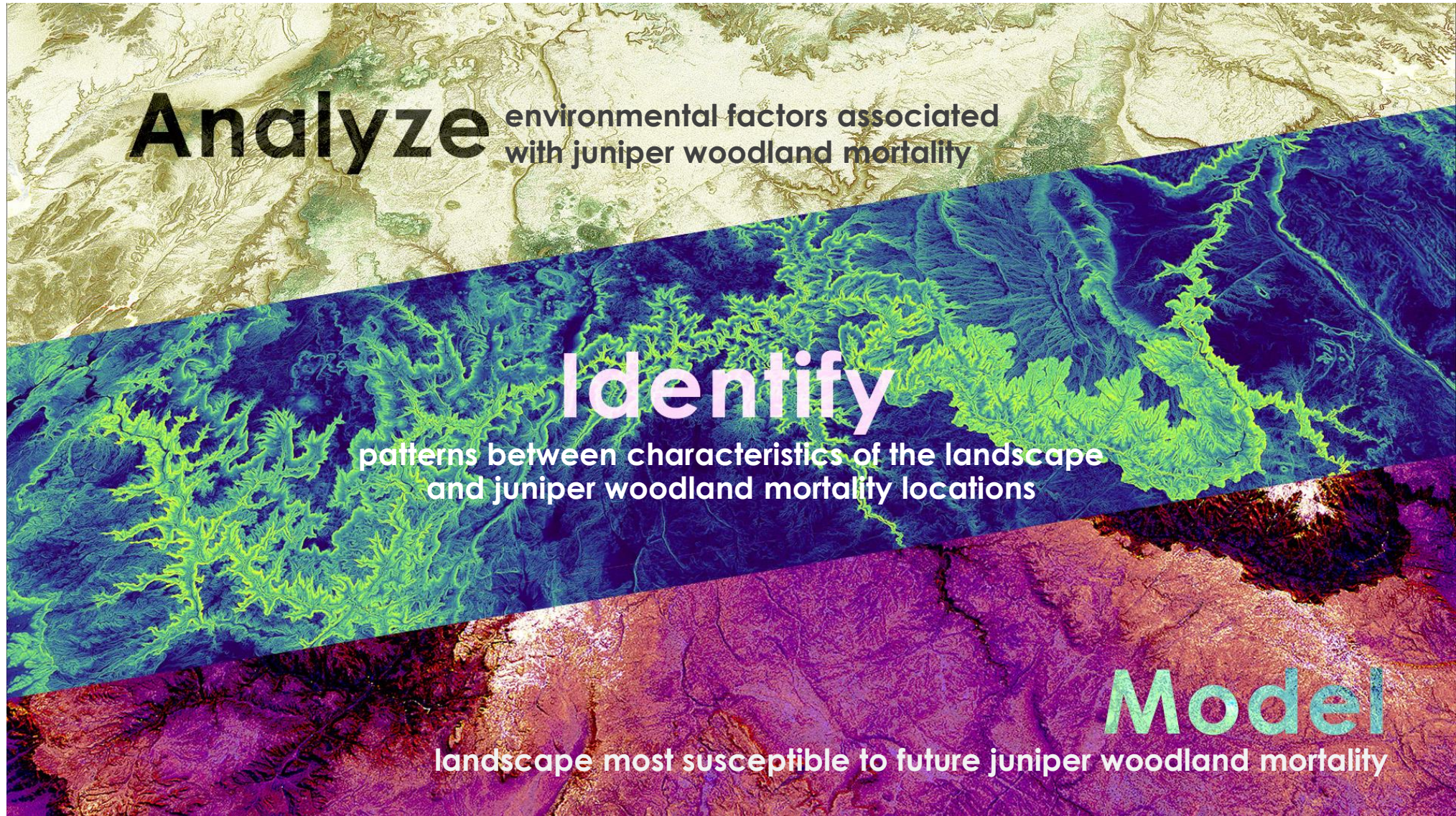




Grand Canyon Precipitation – Station 1 (1976-2012)



OBJECTIVES

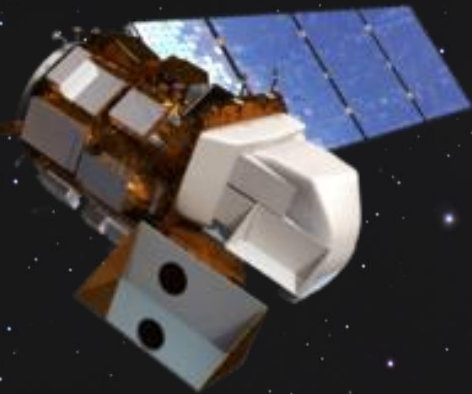


METHODS: SATELLITES AND SENSORS

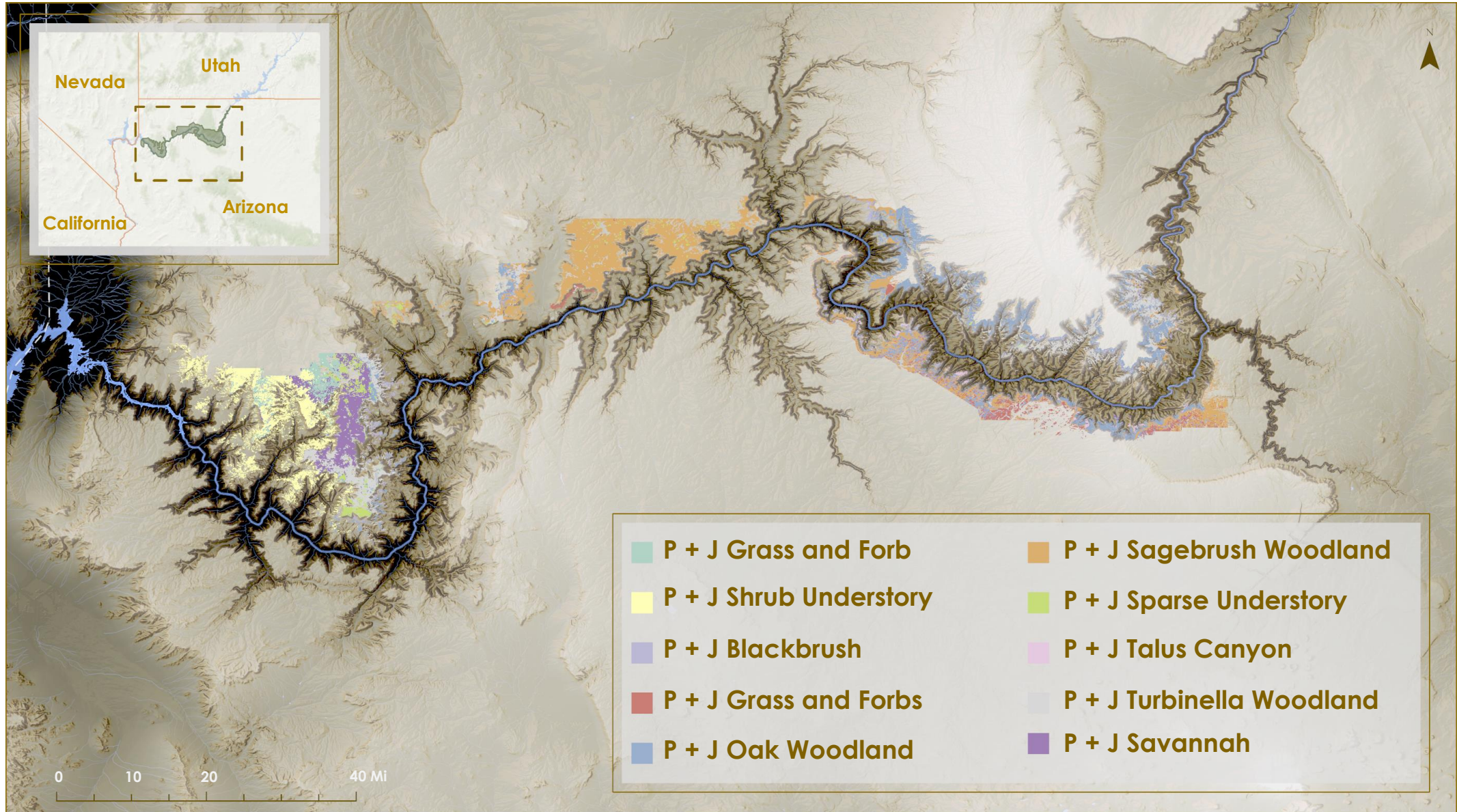
Landsat 8
Operational Land Imager
(OLI)

Shuttle Radar
Topography Mission
(SRTM)

National Agriculture
Imagery Program
(NAIP)



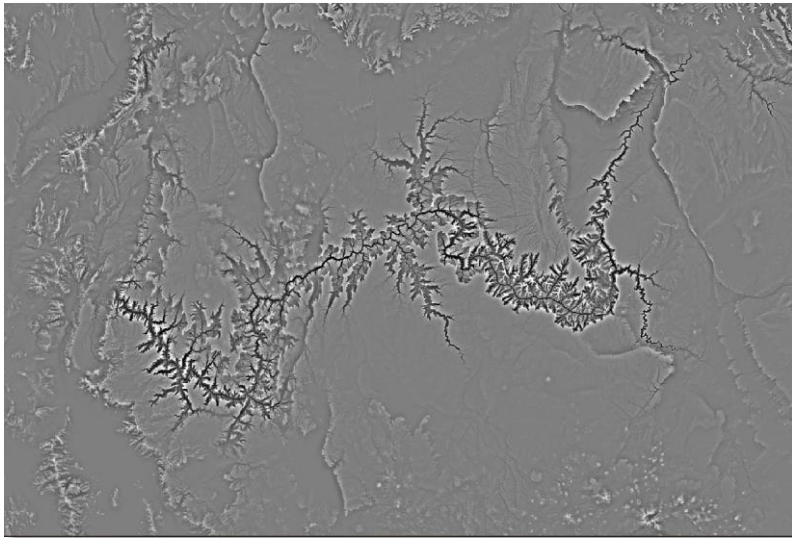
METHODS: ANCILLARY DATASETS



METHODS: ENVIRONMENTAL VARIABLES

mTPI

Multi-scale Topographic
Position Index



Measures topography while including hillslope position to be quantified

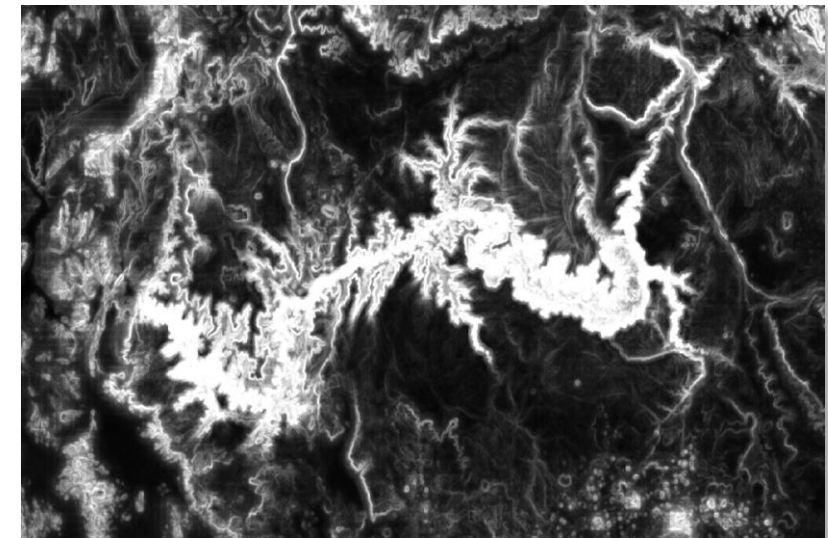
CHILI

Continuous Heat Insolation
Load Index



Assumes temperatures based on topographic position

Topographic Diversity



Measures the combinations of temperatures and moisture conditions that are occurring

METHODS: DERIVED INDICES

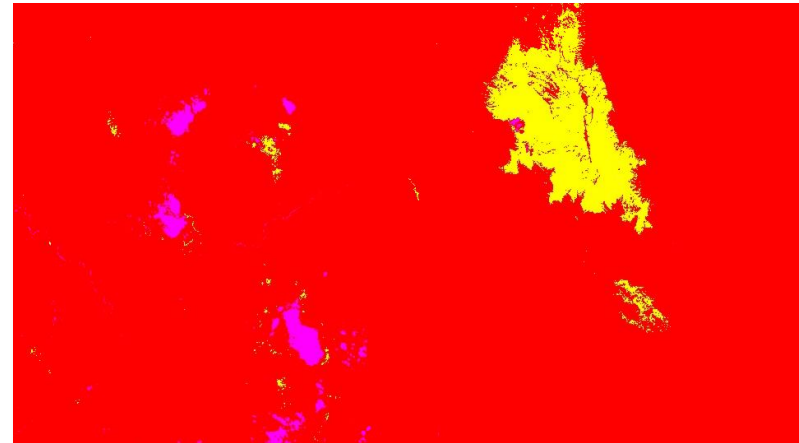
NDMI

Normalized Difference
Moisture Index



Indicates the water content in
vegetation

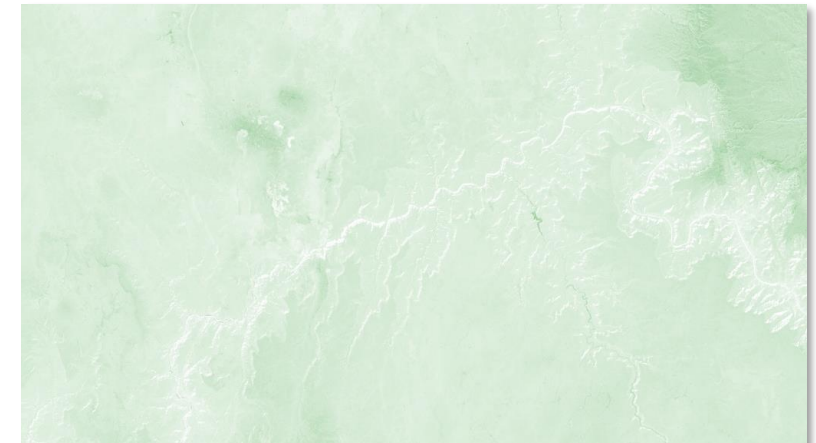
Tasseled Cap



Index made up of three band
images representing **brightness**,
greenness, **wetness** for the area
of interest

NDVI

Normalized Difference
Vegetation Index



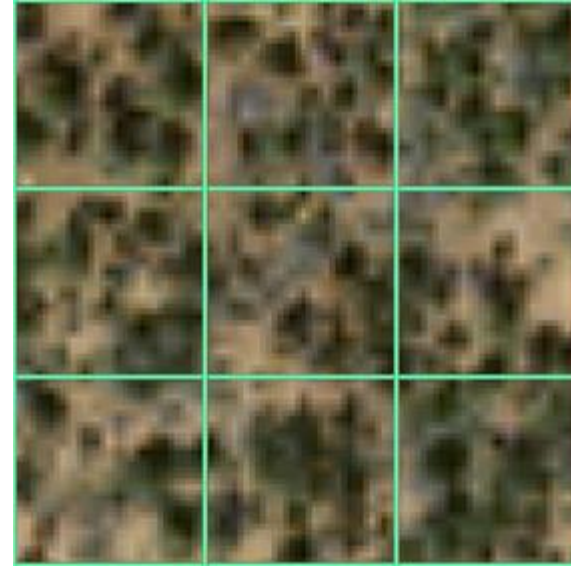
Quantify vegetation greenness
and is useful in understanding
vegetation density
and assessing changes in plant
health

METHODS: OCULAR SAMPLING

- **270** randomly distributed sample points
- Ocularly sampled each point
- Estimating the percentage of:
 - Green
 - Mortality
 - Shadow
 - Other



Percent Green: 10%
Percent Mortality: 30%
Percent Shadow: 5%
Percent Other: 55%



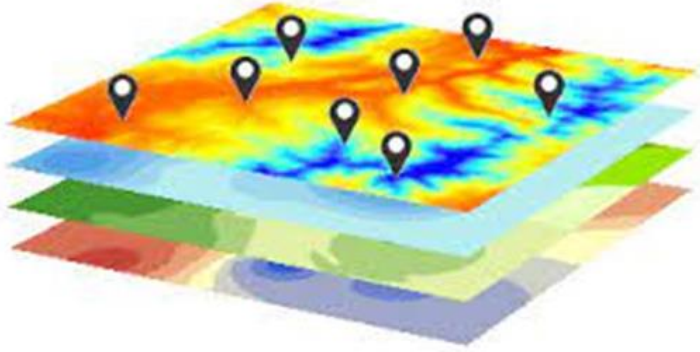
Percent Green: 35%
Percent Mortality: 20%
Percent Shadow: 15%
Percent Other: 30%



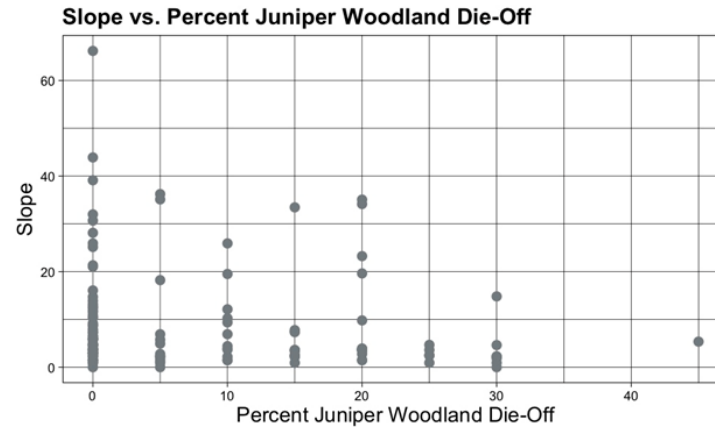
Percent Green: 20%
Percent Mortality: 20%
Percent Shadow: 10%
Percent Other: 50%



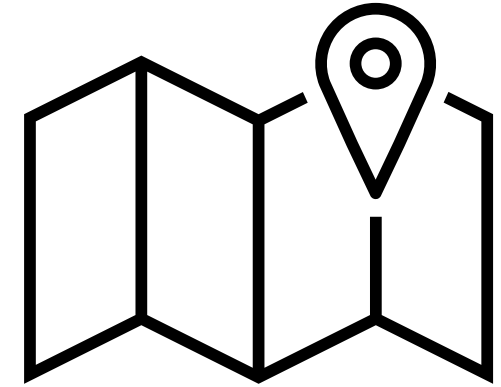
METHODS: DATA ANALYSIS



1. Extracting values at each sample point

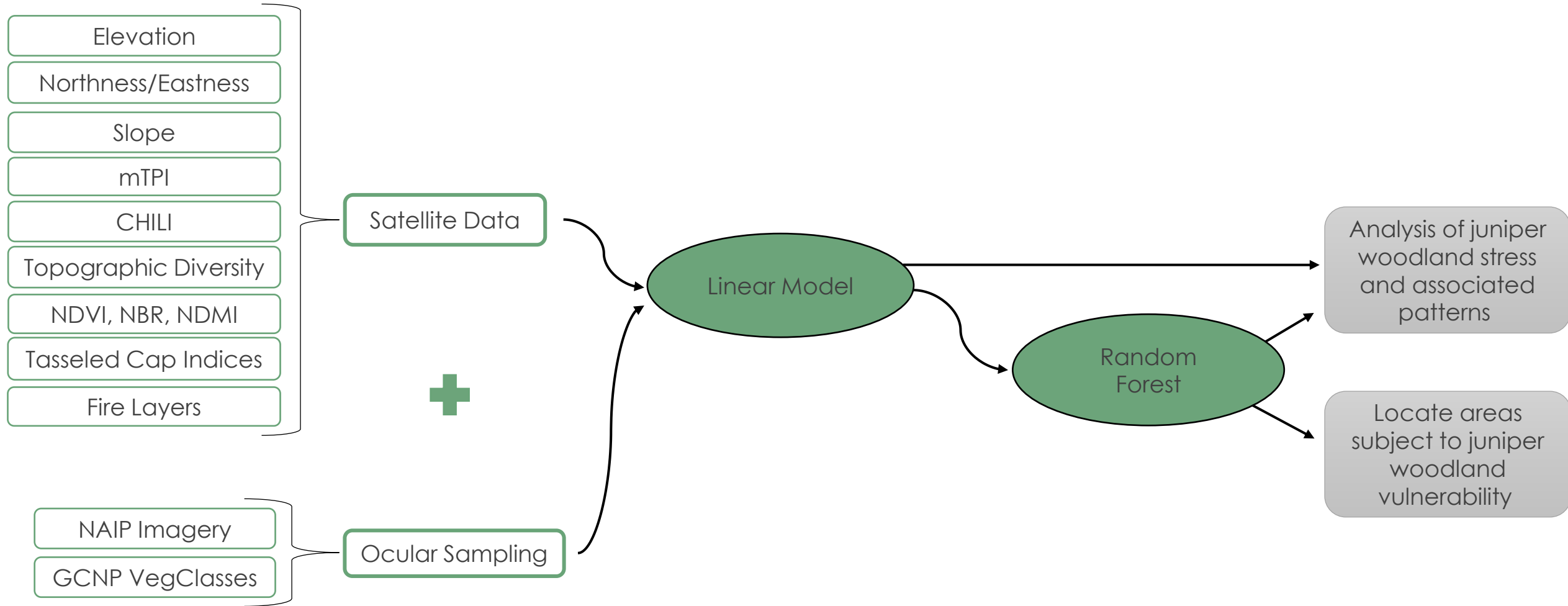


2. Plotting values of predictor variables against juniper woodland mortality



3. Running random forest models to assess the feasibility of predicting juniper mortality

METHODS: WORKFLOW



RESULTS

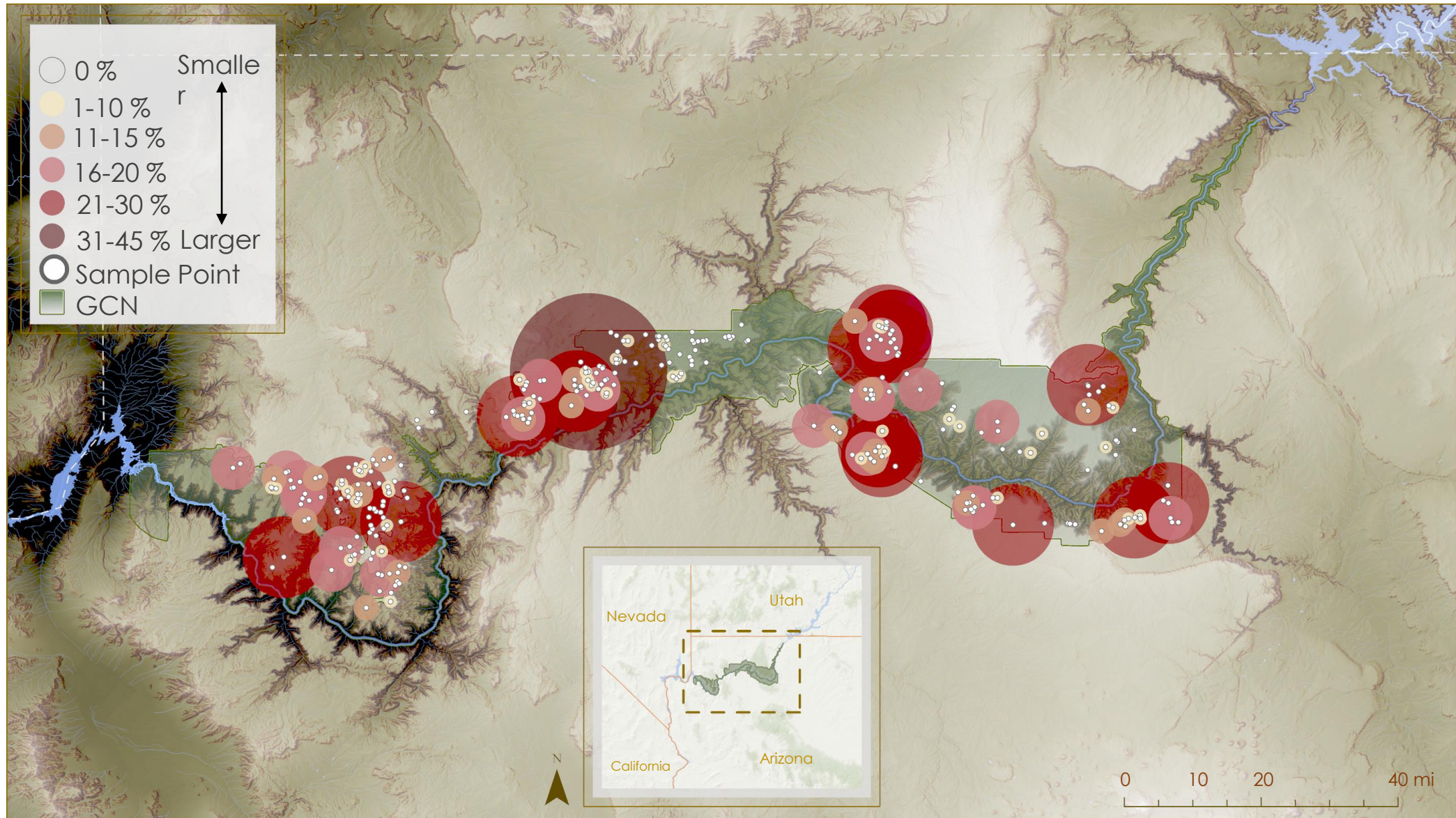
There was not a significant correlation between observed mortality and the environmental variables included in the analysis



Image credit: Mike Hitchner

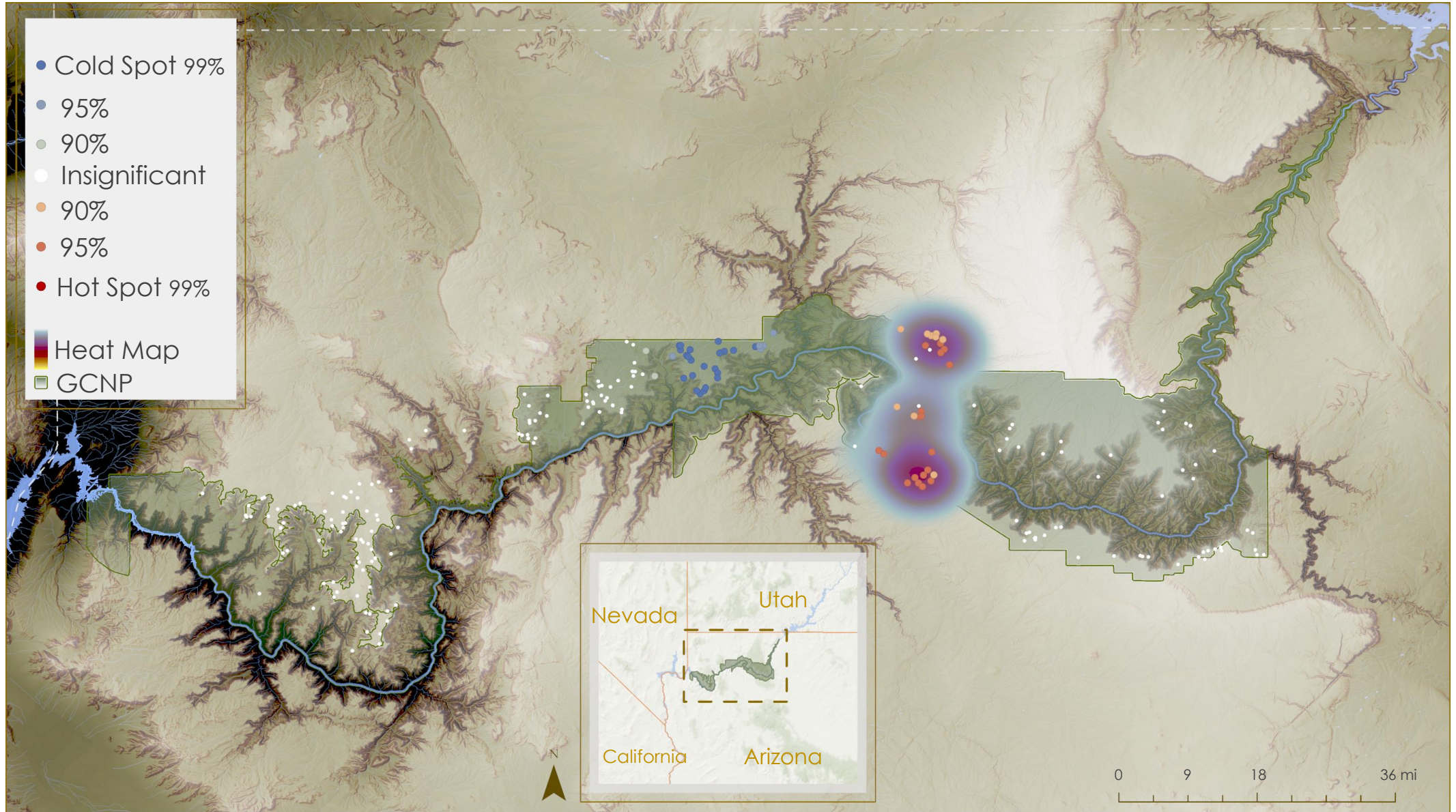
RESULTS

Graduated Symbolology – Percent Observed Mortality



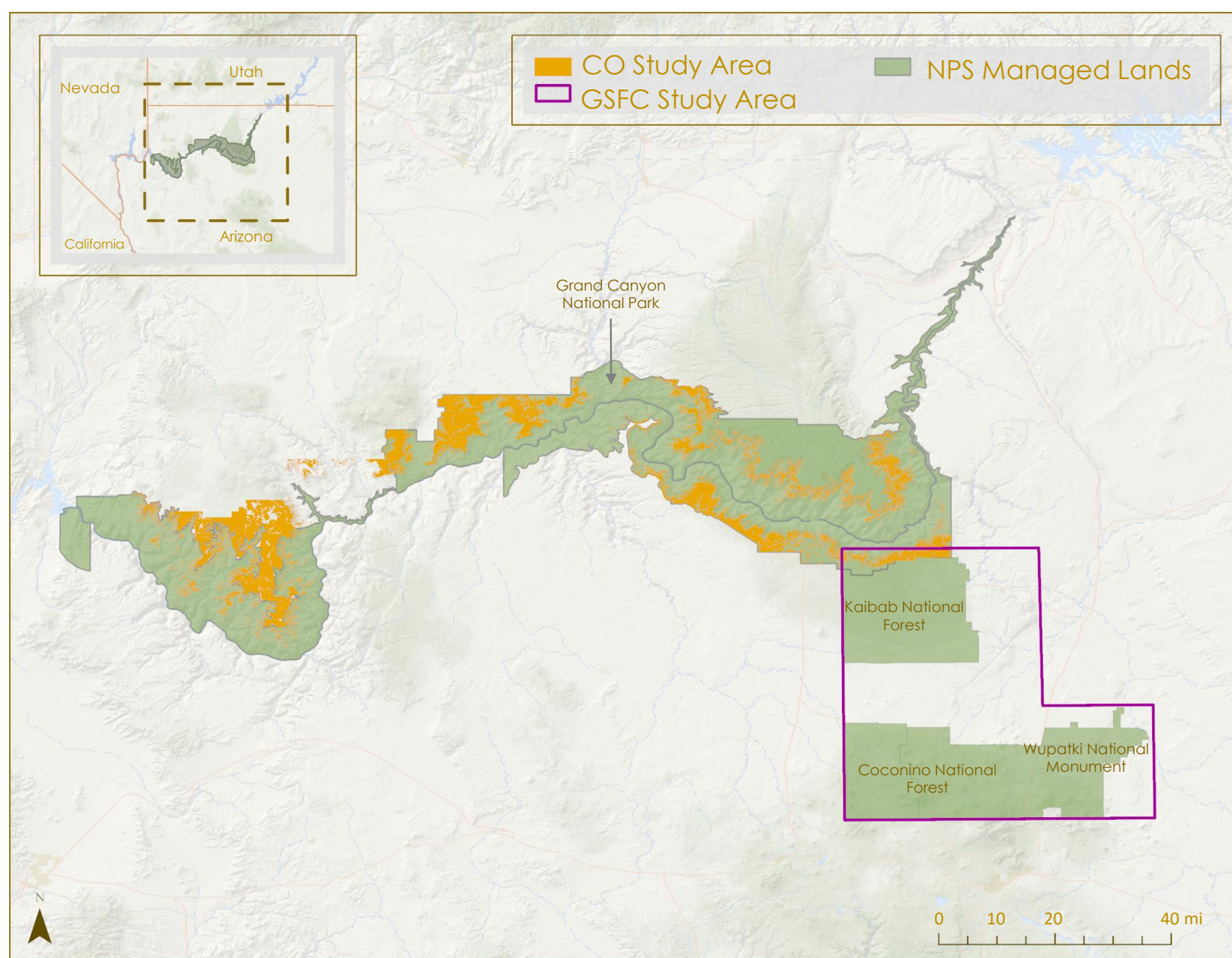
RESULTS

Percent Mortality Optimized Hotspot Analysis and Heat Map



RESULTS

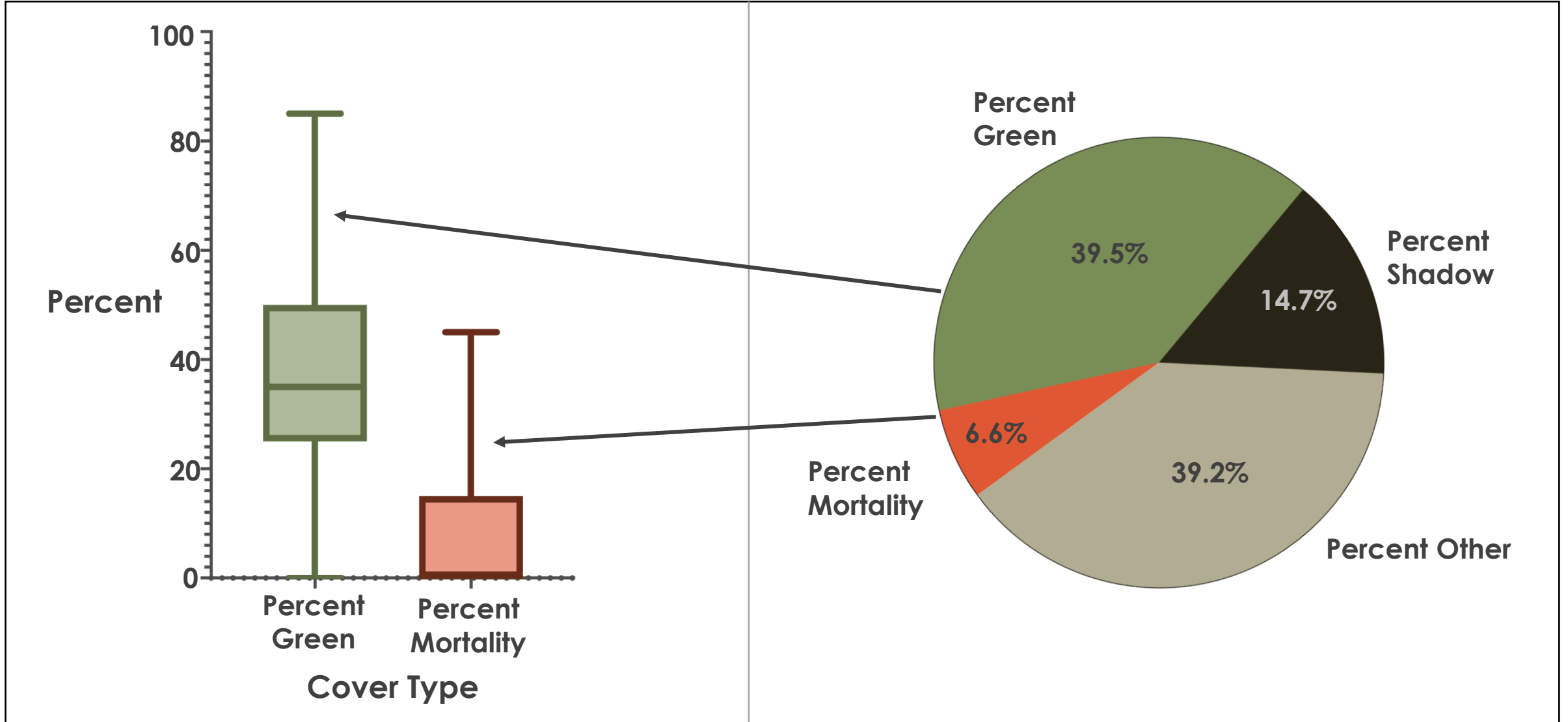
- Colorado DEVELOP Team
- Grand Canyon (Orange)
 - Approximate study area mortality: **6.60%**
- Goddard DEVELOP Team
- Arizona (Purple)
 - Approximate study area mortality: **42.57%**



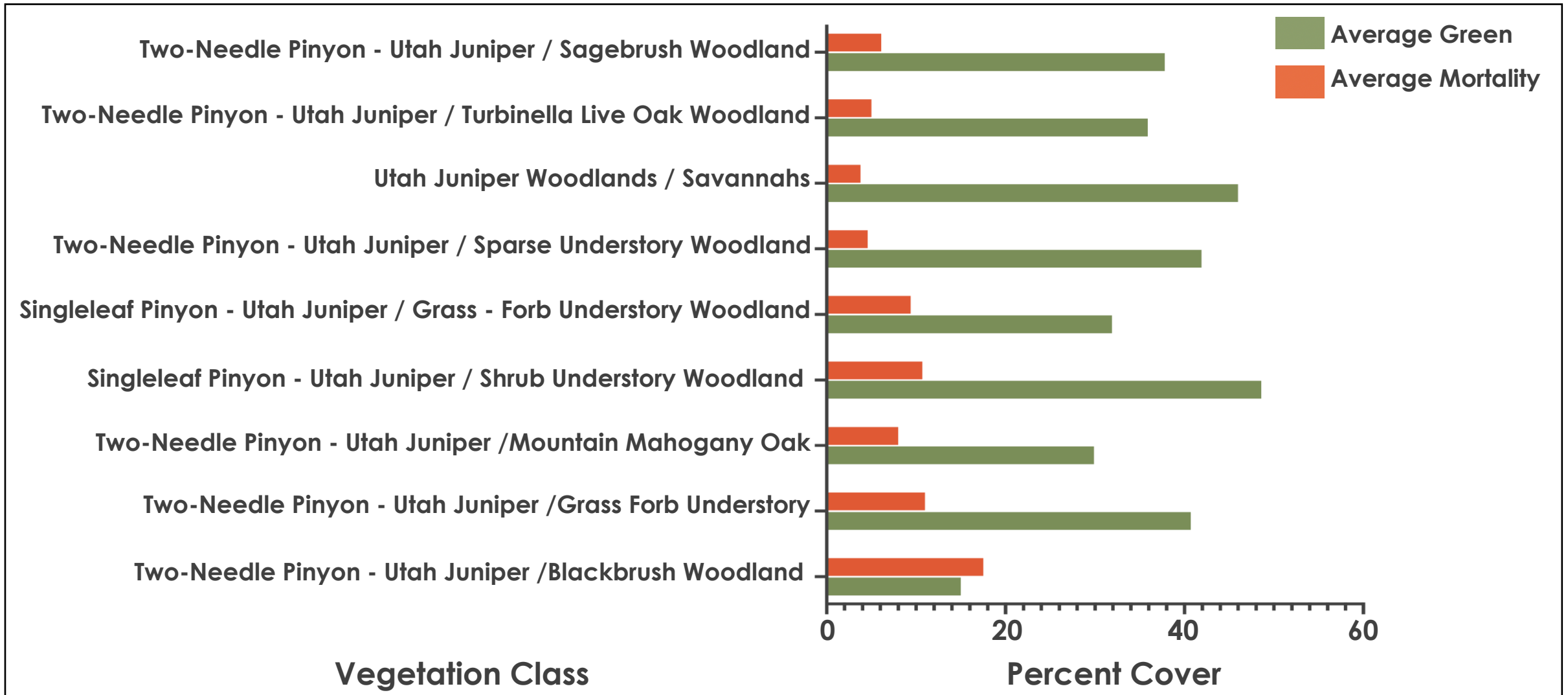
SUMMARY OF OCULAR SAMPLING RESULTS

Comparison of Percent Green and Percent Mortality

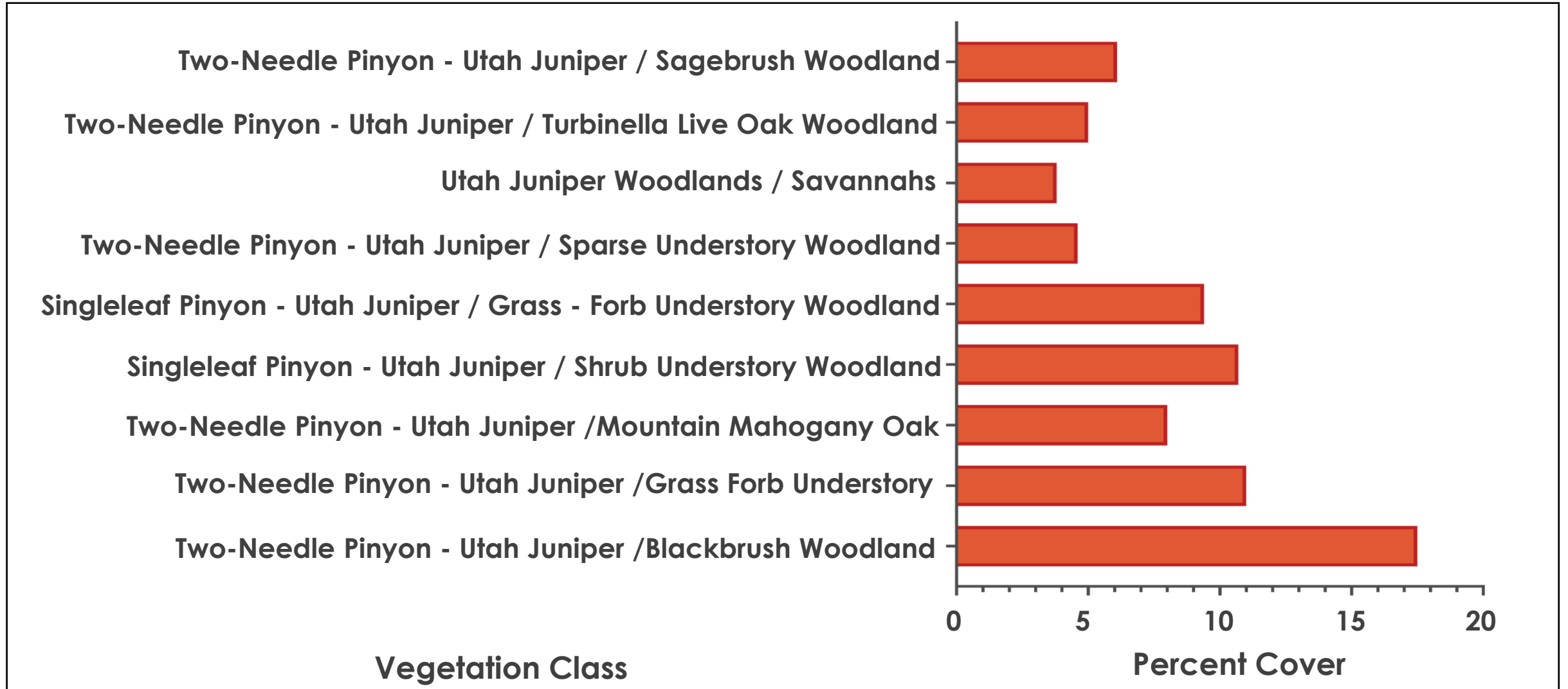
Cover Type Percent Breakdown

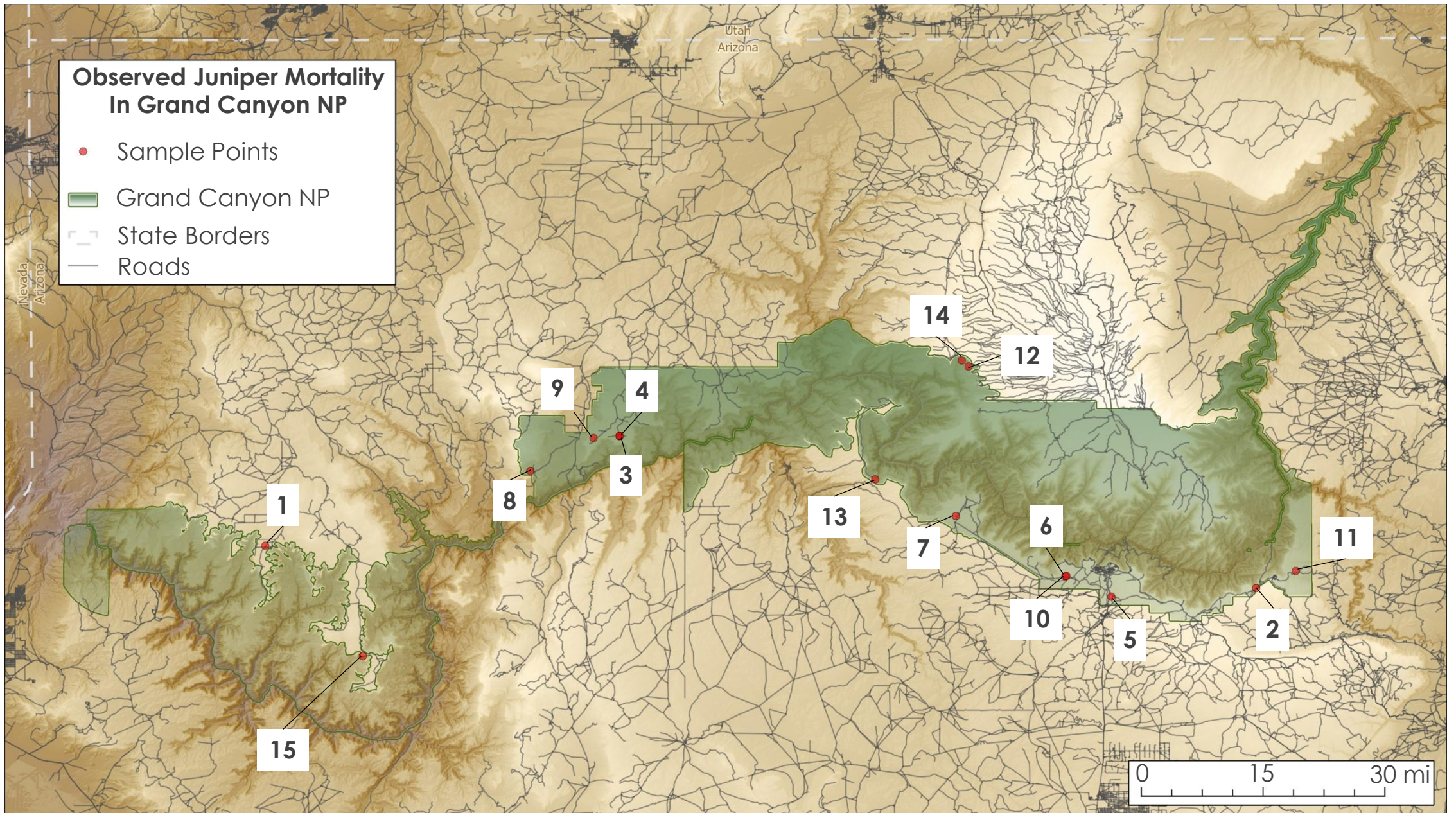


COMPARISON OF AVERAGE % GREEN & % MORTALITY ACROSS JUNIPER WOODLAND VEGETATION CLASSES



COMPARISON OF AVERAGE MORTALITY ACROSS JUNIPER WOODLAND VEGETATION CLASSES



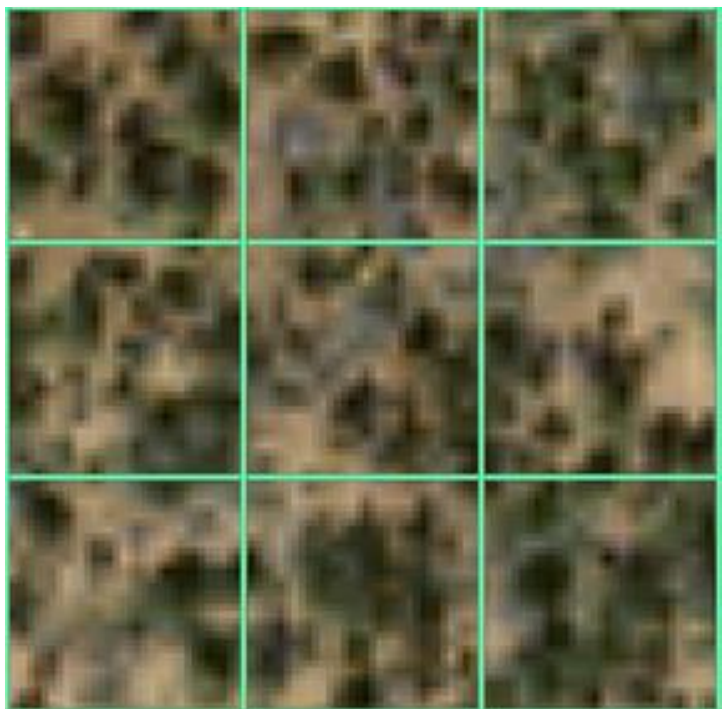


Basemap: Esri, GEBCO, DeLorme, NaturalVue



LIMITATIONS / CONCLUSIONS

Ocular sampling may need to be field validated, but it provides targeted direction



Juniper stress and mortality can be difficult to detect using remote sensing



Image credit: USDA

We hope this provides some initial steps in studying this phenomena within the park



Targeted locations and vegetation classes

FUTURE WORK



Field surveys and sampling
within park boundary



Introduce new
environmental variables
(such as soils, tree
characteristics, etc.)



Incorporate historic climate
models to study drought
effects in its entirety and
historic imagery into analysis
– predating satellite images



ACKNOWLEDGEMENTS

The Grand Canyon Ecological Forecasting team is thankful for our project partners and node advisors/mentors for making this project possible:

Partners:

Lonnie Pilkington (Science and Resource Management Division, Grand Canyon National Park
- Vegetation Program Manager)

Node advisors & mentors:

Dr. Paul Evangelista (Colorado State University, Natural Resource Ecology Laboratory)

Dr. Catherine Jarnevich (USGS, Fort Collins Science Center)

Peder Engelstad (Colorado State University, Natural Resource Ecology Laboratory)

Dr. Tony Vorster (Colorado State University, Natural Resource Ecology Laboratory)

Nicholas Young (Colorado State University, Natural Resource Ecology Laboratory)

Scott Cunningham (NASA DEVELOP, CO – Fort Collins Fellow)

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