

National Aeronautics and Space Administration



Utilizing Aerial Imagery and NASA Earth Observations to Assess Pinyon-Juniper Tree Mortality near Flagstaff, AZ

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### **PROJECT PARTNERS**

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National Park Service

Wupatki National Monument

NATIONAL PARK SERVICE

# **COMMUNITY CONCERNS**



loss of habitat and food sources



ecological & hydrological **shifts**altering the local fire regime



tree **vulnerability** to insect attacks & risk of wildfires



**threat** to Southwestern culture -Hopi, Navajo, and Zuni Indigenous peoples



Pinyon-juniper trees experiencing partial dieback Image Credit: Mark Szydlo & Julie Long

# **STUDY AREA**

- 1.9-million-acre study area near Flagstaff, AZ
- Federal land: Wupatki
  National Monument &
  Grand Canyon National Park
- Forest Service's Coconino
  National Forests
- Native American
  Reservations
- Study period: 2015 2021



Basemap Credit: NAIP Imagery, World Hillshade

### Term I Overview (Arizona Water Resources) PJW mortality estimates from NAIP aerial imagery

#### • 43% mortality

in high probability areas\*

#### 47% mortality

- in Wupatki National Monument
- Trees mapped for 2015 & 2021
- \*Areas excluding burn areas and mixed pinyon-juniper ponderosa forests



### **PROJECT OBJECTIVES**

**Measure** the extent of Pinyon – Juniper Woodland mortality

**Provide** partners with a standard operating procedure

Assess study area environmental relationships to tree mortality

Image Credit: Mark Szydlo & Julie Long

### **EARTH OBSERVATIONS**



### ENVIRONMENTAL VARIABLES





### **METHODOLOGY: Tree Mortality**



### **METHODOLOGY: Correlation**

#### Join Mortality Aggregate Correlation Add Timeframes **Environmental Data** Data ESoil\_tavg Qair f tavg Og tavg SoilMoist tavg TWS\_tavg WaterTableD\_ta Wind\_f\_tavg mortality percentar

#### 10 Environmental Variables

### % Mortality

Relationships between Mortality & Environmental Variables 2015–2021 2015–2017 2017–2019 2019–2021

### **RESULTS: Tree Mortality**

Across the **whole** study area:

- ▶ 6.45% mortality between 2015 & 2017
- 9.88% mortality between 2015 & 2019
- 21.63% mortality between 2015 & 2021

PJW Mortality in Wupatki National Monument

19.8% avg mortality in 2021



### **RESULTS: Mortality Correlations for 2019-2021**



Rainfall 0.14

20 km



### **RESULTS: Mortality Correlations for 2019 - 2021**

→ High

LOW

 $Low \rightarrow High$ 

Wind Speed

Mortality



### **CONCLUSIONS: Main Takeaways**

Large die back of PJW in Wupatki NM corresponds to NPS ground observations

NAIP imagery classification accurately identifies tree mortality

Weak correlations between environmental variables and mortality

Image Credit: Mark Szydlo & Julie Long

### **LIMITATIONS & FUTURE WORK**









#### Classification Method

 Errors in detecting tree type & mortality

#### Mortality Drivers

 Limitations in assessing long droughts

#### Spatial Resolution

 Limitations from 1km x 1km pixel size

#### Computational Constraints

 Limitations of hardware & software configurations

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- Past contributors:
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## **EXTRA SLIDES FOR PARTNERS**

### Term I Overview (Arizona Water Resources) PJW mortality estimates from NAIP aerial imagery

- **43% mortality** in high probability areas\*
- 47% mortality in Wupatki National Monument
- Trees mapped for 2015 & 2021

Environmental variables

Precipitation & soil moisture:

downward trend from 2015 to 2021

- Correlation between tree mortality in Wupatki National Monument and:
  - Elevation = -0.37
  - Soil moisture =  $0.39^*$
  - Land surface  $T = 0.38^*$



Image Credit: AZWRI DEVELOP Team

### **CLASSIFICATION ACCURACY**

#### Accuracy Assessment for live crown classification

Assessment	# of Random Points	Method	Accuracy	Карра	Error
2015 Vegetation Classification					
2017 Vegetation Classification					
2019 Vegetation Classification					
2021 Vegetation Classification					



### **RESULTS: Environmental Variable Correlations**



### **RESULTS: Correlations with Term I Mortality**

May 1,2, 2015 - May 1,2, 2021

- \* Bare Soil Evaporation (0.25)
- \* Wind Speed (0.24)
- \* Specific Humidity (0.23)

Soil Moisture (0.18)

\* Groundwater Storage (0.17)



May 2015 - May 2021

Evapotranspiration (0.21)

- \* Bare Soil Evaporation (0.16)
- \* Rainfall (0.15)
- \* Groundwater Storage (0.12)
- \* Specific Humidity (0.09)



### **RESULTS: Correlations with Term II Mortality**

2015-2017

Groundwater Storage (0.15)

Specific Humidity (0.11)

Bare Soil Evaporation (0.11)

Rainfall (0.09)

Wind Speed (0.09)

2019-2021

Rainfall (0.20)

Air temperature (0.19)

Soil temperature (0.19)

Wind speed (0.18)

Bare Soil Evaporation (0.18)

2017-2019

Wind Speed (0.09)

Air Temperature (0.11)

Groundwater Storage (0.10)

Rainfall (0.08)

Snowfall (0.08)

\*2015-2021\*

Rainfall (0.19)

Bare Soil Evaporation (0.16)

Air Temperature (0.15)

Soil Temperature (0.14)

Groundwater Storage (0.13)

O Annual Macro Level

### **RESULTS: Mortality Correlations**

### Highest correlated variables:

Environmental Variable	Avg Correlation		
1. Bare Soil Evaporation	0.15		
2. Rainfall	0.14		
3. Groundwater Storage	0.13		
4. Wind Speed <del></del>	0.12		

#### Least correlated variables:

Soil Moisture, Evapotranspiration, Snowfall, Soil Temperature

## **CLIMATE TRENDS** 1991 - 2021









# **CLIMATE TRENDS 1991 - 2021**



