

National Aeronautics and
Space Administration



Monitoring Bighorn Sheep Habitat by Assessing Vegetation, Topography, and Soil Moisture

Manda Au

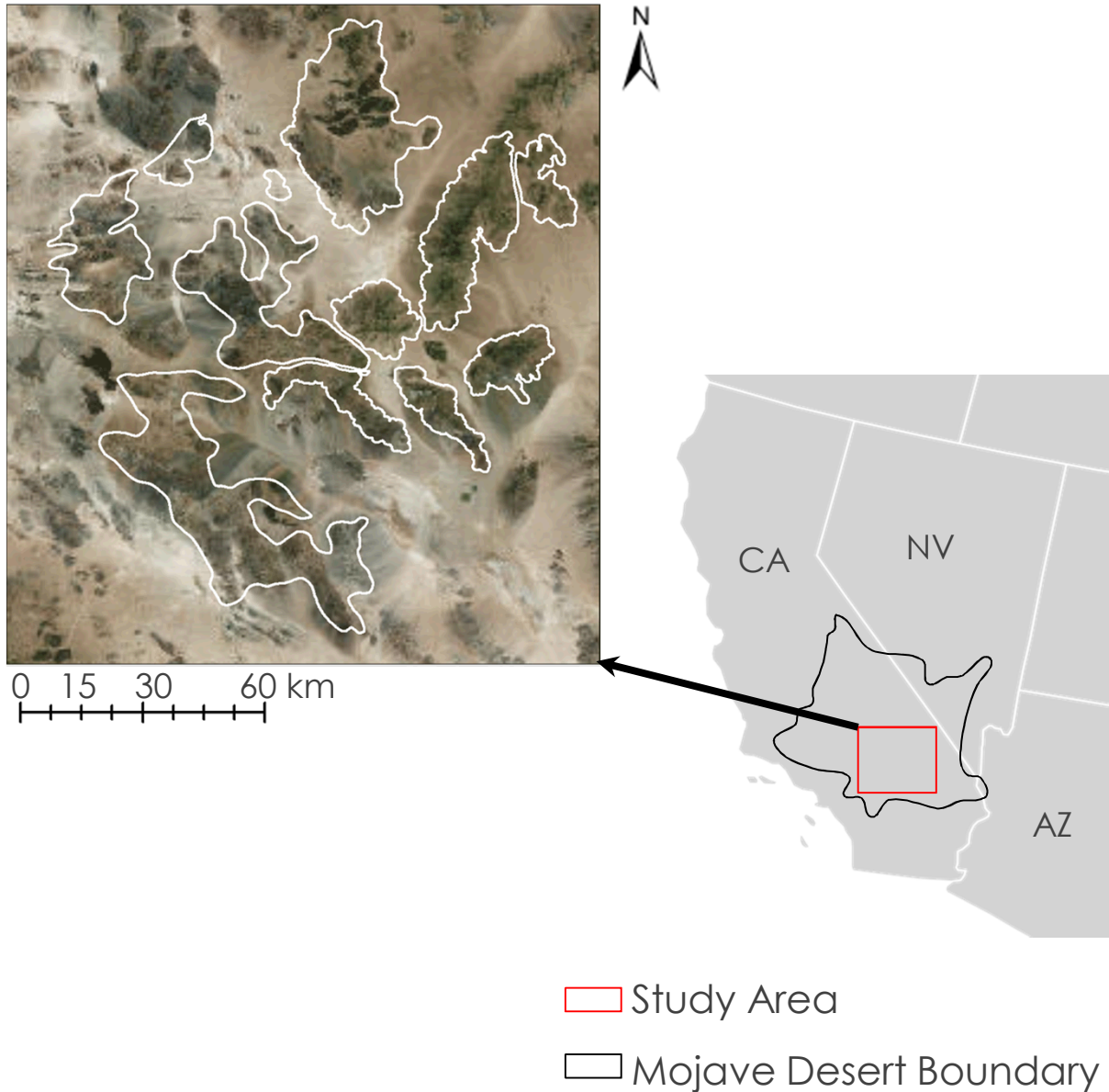
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Study Area



Bighorn Sheep (*Ovis canadensis*)

- ▶ Thrive exceptionally well in the desert environment
- ▶ Specially-adapted hooves and ruminant digestive system
- ▶ Forage for grass and sedge in the summer and woody shrubs in the winter



Community Concerns



Increased habitat fragmentation from anthropological disturbances

Valued by tourists, game hunters, and native communities



Habitat variation challenges to monitoring & management of existing BHS herds



Extremely selective preferred habitat range



Project Partners

National Park Service
Mojave National Preserve

National Park Service
Biological Resources Division, Wildlife Health Branch

California Department of Fish and Wildlife
Wildlife Branch, Game Management

Oregon State University
Department of Fisheries and Wildlife

Sierra Nevada Bighorn Sheep Foundation



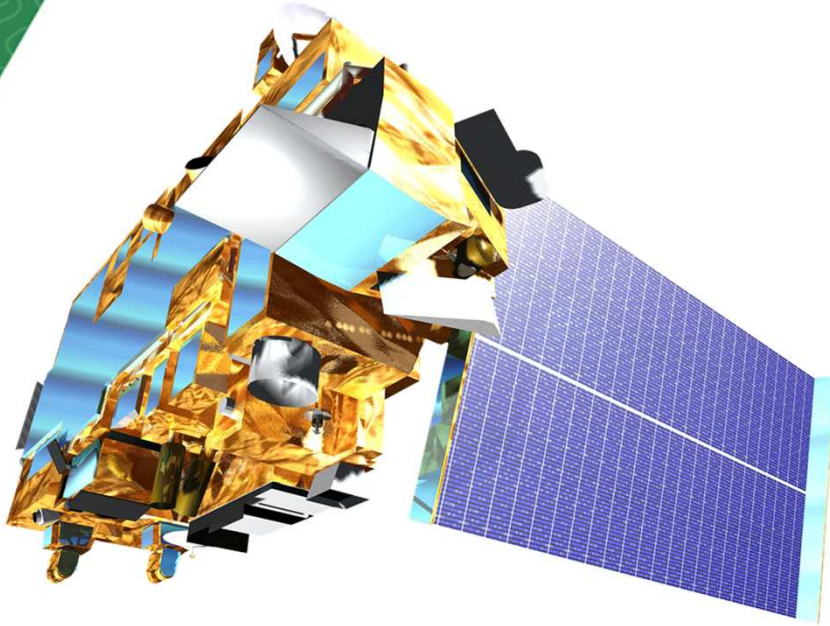


Image Credit: Manda Au

Objectives

- ▶ **Investigate** the relationship between desert vegetation and bighorn sheep preferred habitat
- ▶ **Identify** focal bighorn sheep forage area for priority management and monitoring
- ▶ **Provide** project partners with tools and methods to assist them in continuing the use of NASA Earth observations to aid their management plans

Earth Observations



Terra

**Moderate Resolution Imaging Spectroradiometer
(MODIS)
&
Advanced Spaceborne Thermal Emission and
Reflection Radiometer (ASTER)**



**Soil Moisture Active Passive
(SMAP)**

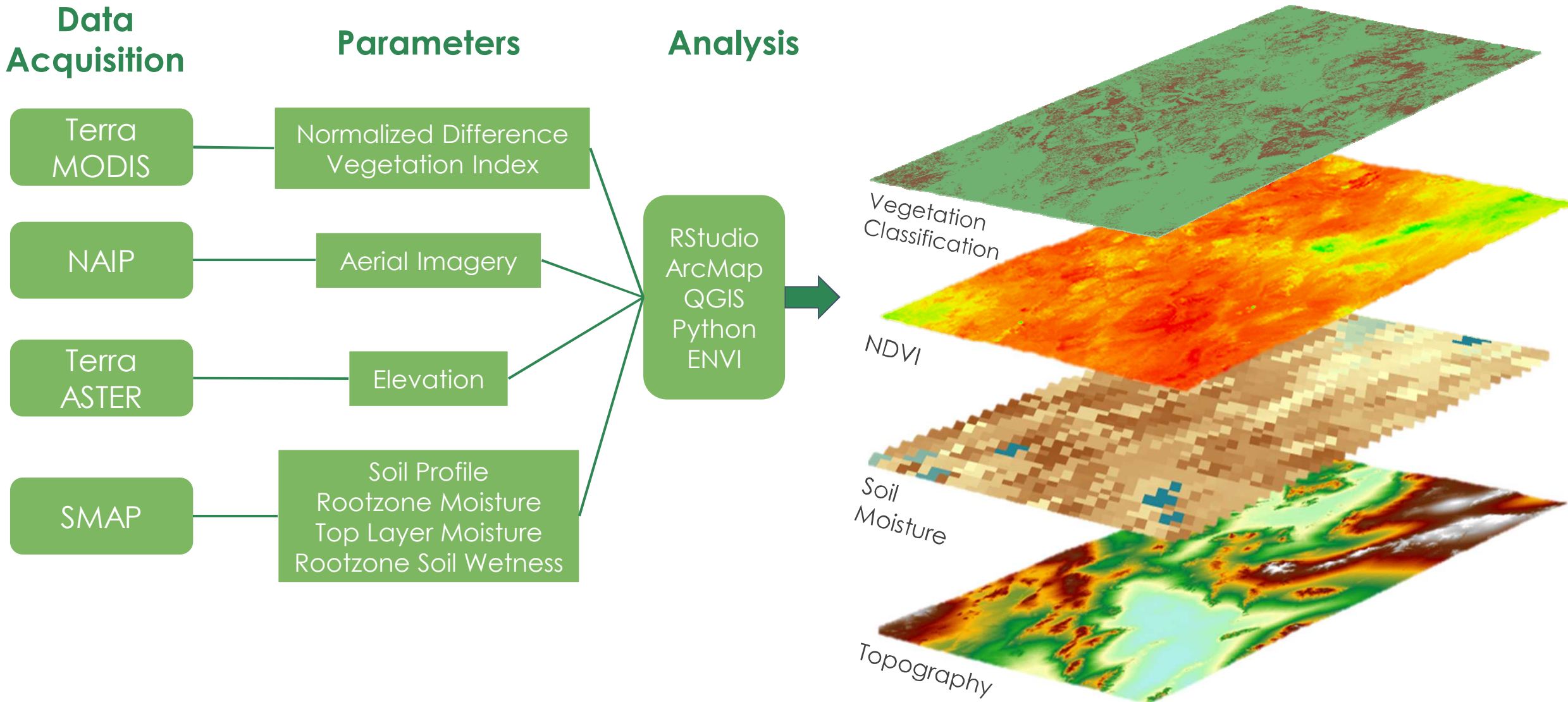
Methodology

Data Acquisition

Parameters

Analysis

End Products

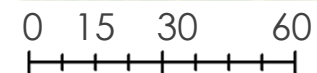
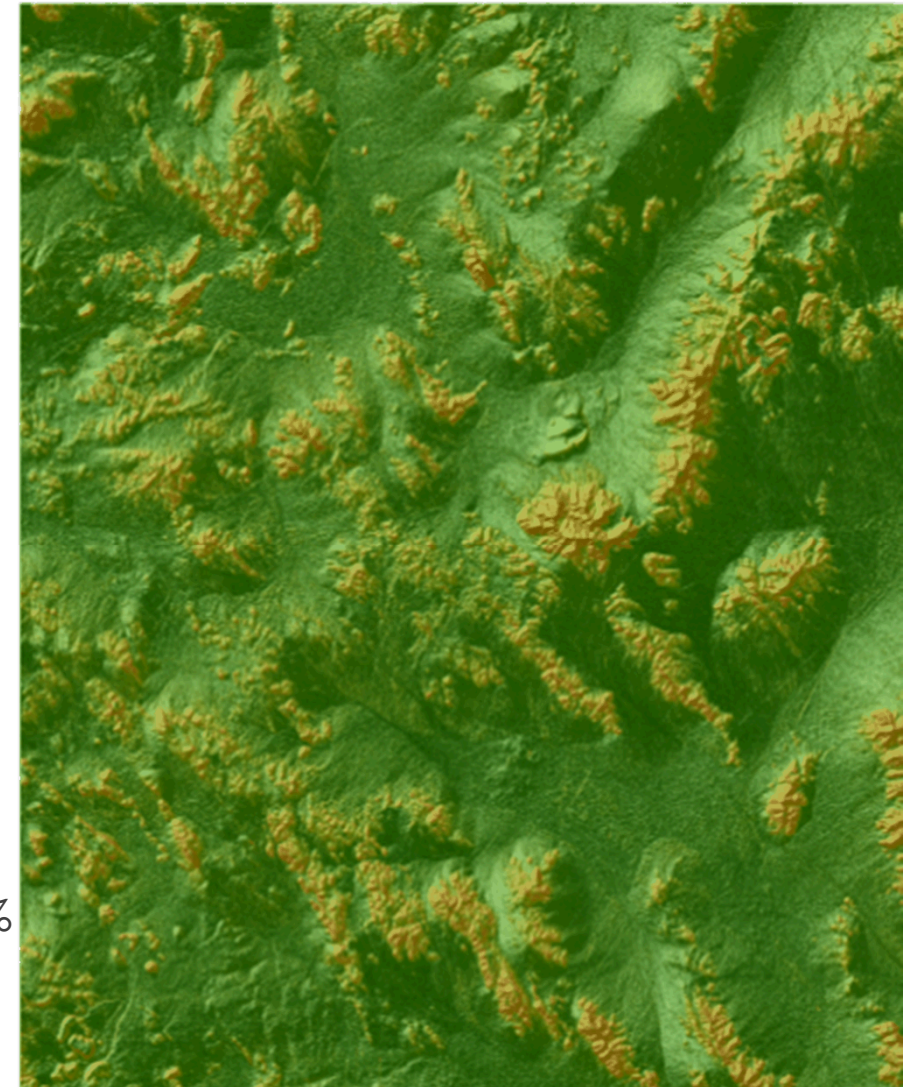
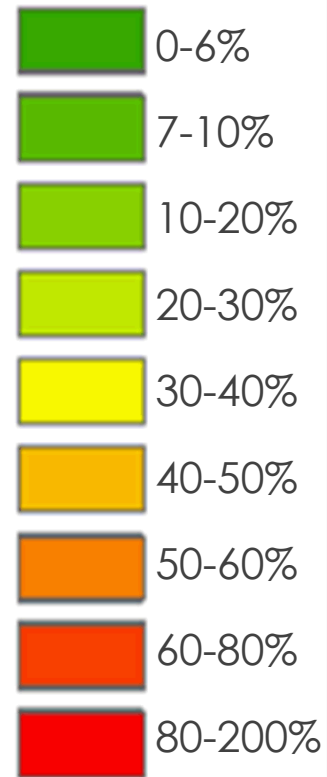




Topography

- Important bighorn sheep habitat predictor:

Topographic Position Index
Terrain Ruggedness Index
Terrain Roughness
Elevation
Slope
Aspect
Escape Terrain (>30% slope)



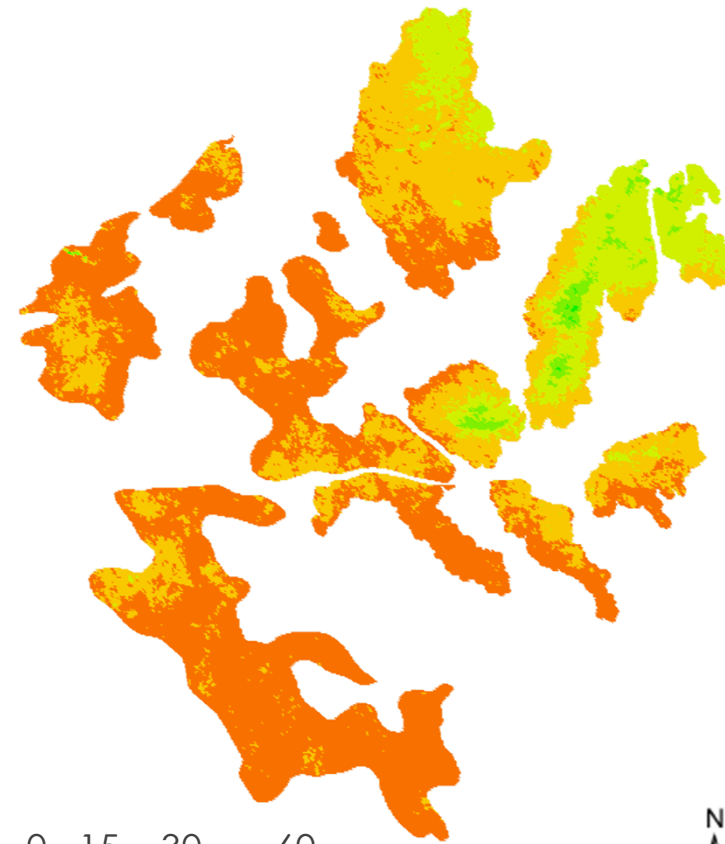
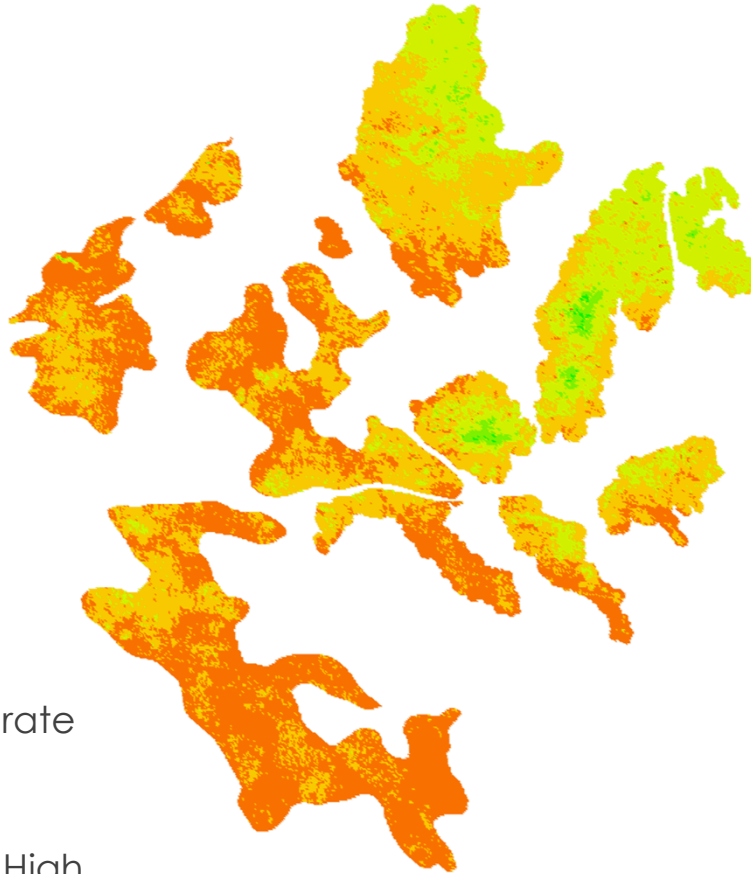


NDVI: Normalized Difference Vegetation Index

December 2016 NDVI

June 2016 NDVI

$$\frac{(NIR - R)}{(NIR + R)}$$



0 15 30 60



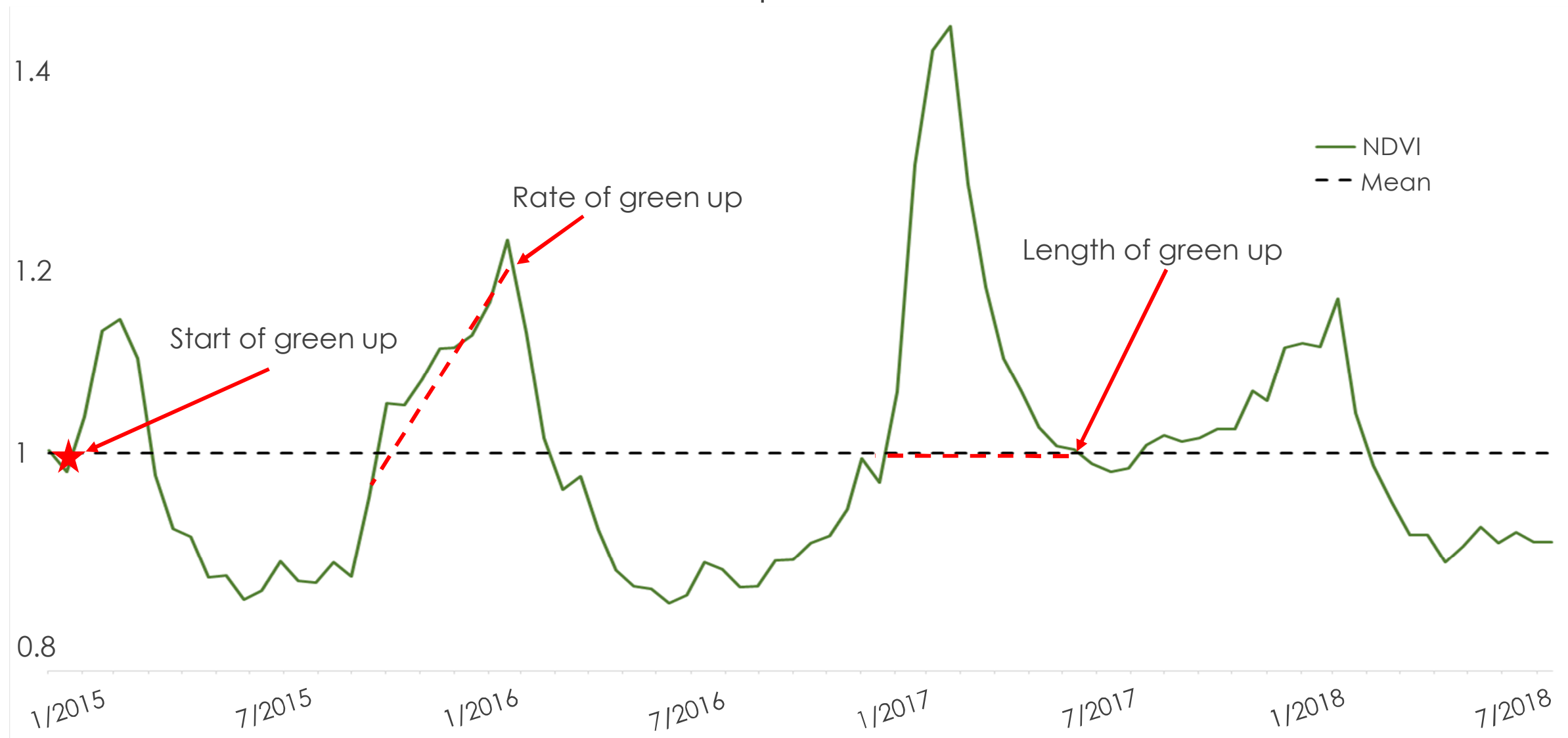
- ▶ Measures health of vegetation based on 'greenness'
- ▶ Shows influence of topography on vegetation



Normalized NDVI as a Green Up Indicator

$$\frac{(\text{NDVI})}{(\mu\text{NDVI})}$$

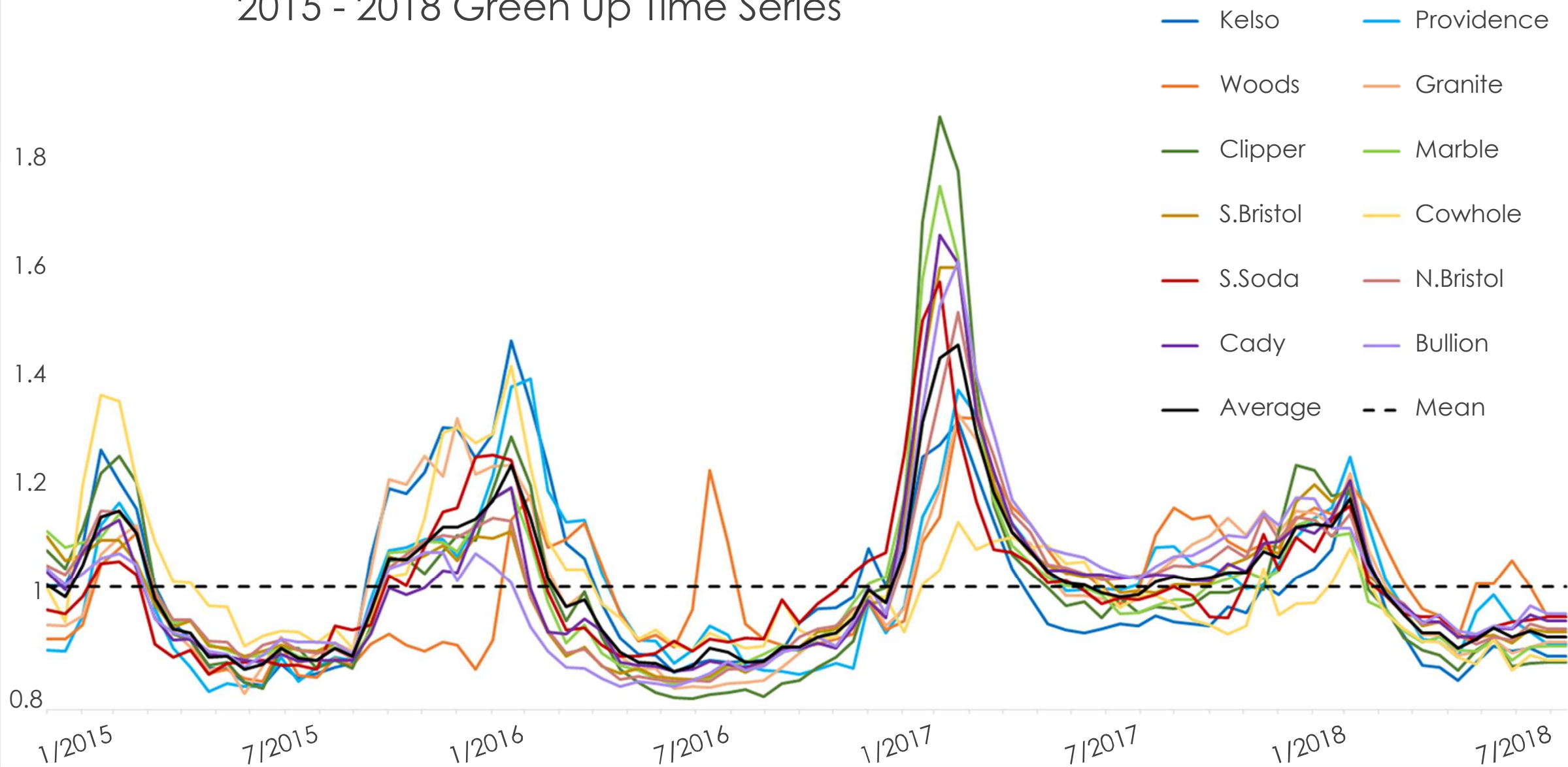
2015 - 2018 Green Up Time Series





NDVI as a Green Up Indicator

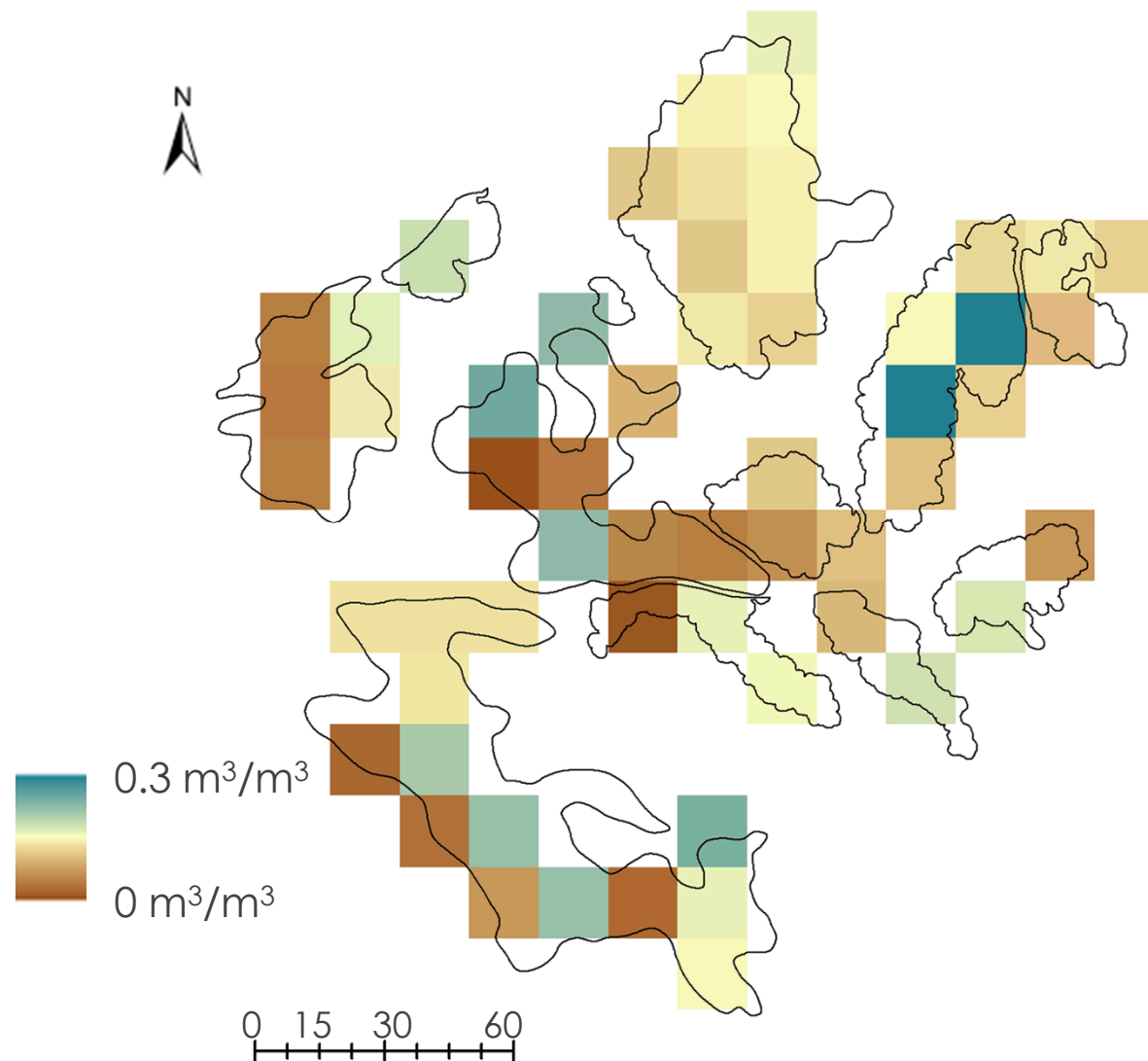
2015 - 2018 Green Up Time Series



Soil Moisture

- ▶ Several different products
 - Top layer vs Root zone
 - Total Profile
- ▶ Extremely coarse 9 km resolution limits utility

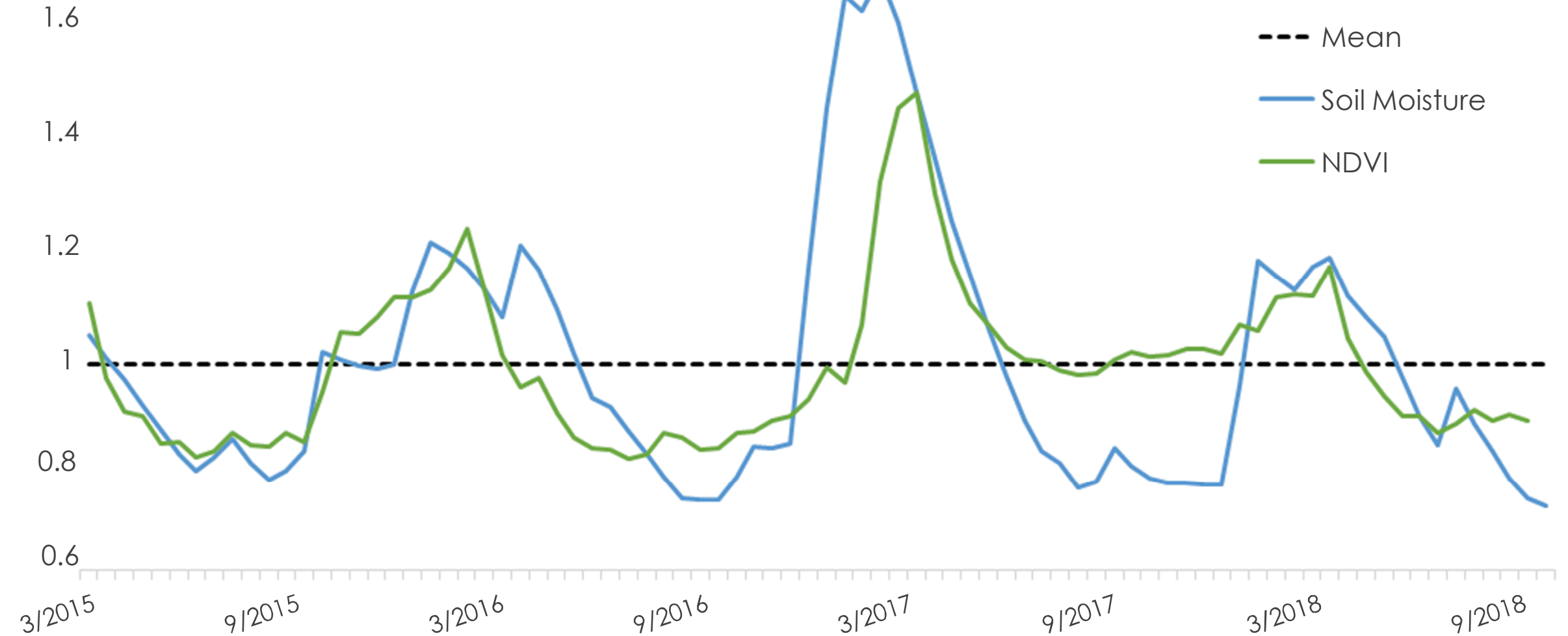
15'-18' Mean Soil Moisture Profile





Soil Moisture and NDVI

Normalized Soil Moisture and NDVI
March 2015 - September 2018



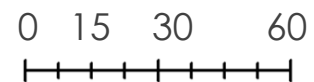
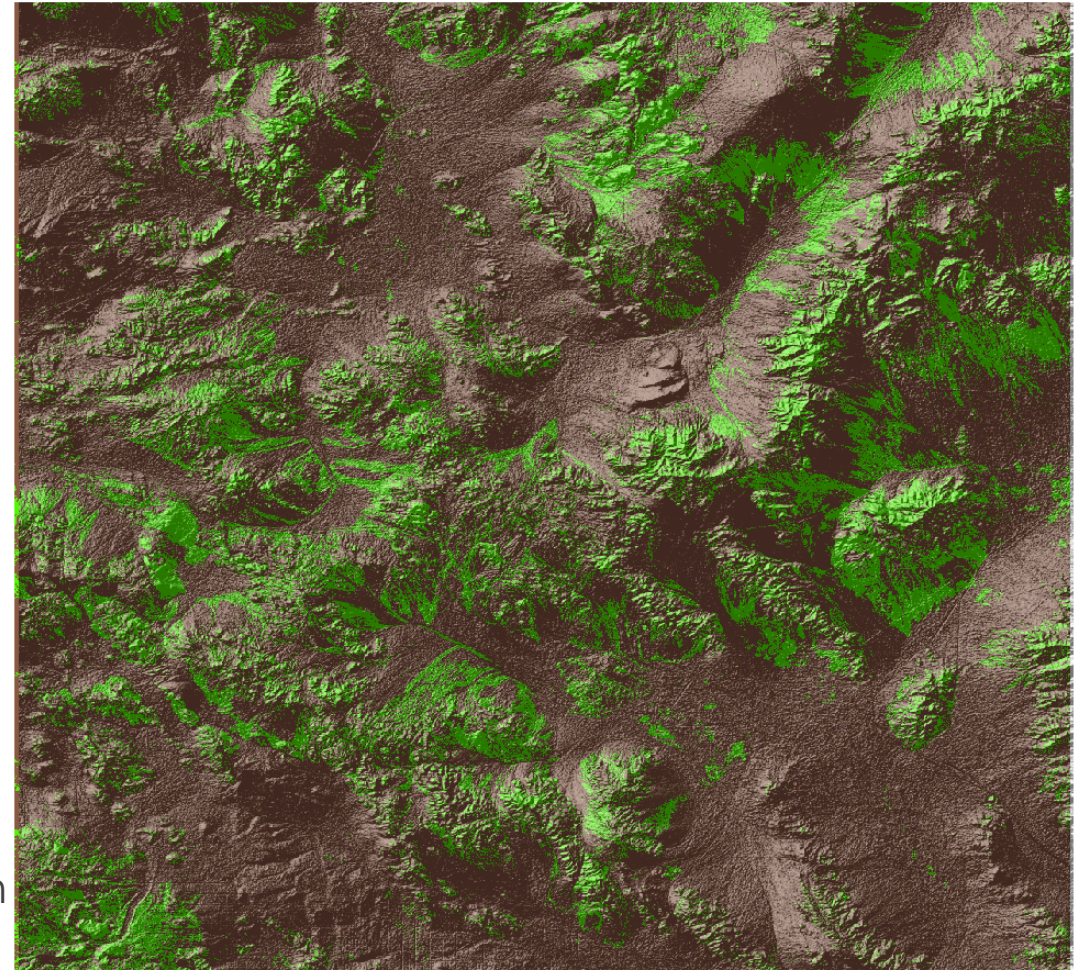


Vegetation Classification

- ▶ Unable to pick up specific vegetation due to variable terrain and similarity of species
- ▶ Random Forest Accuracy .79
- ▶ Lack of ground truth

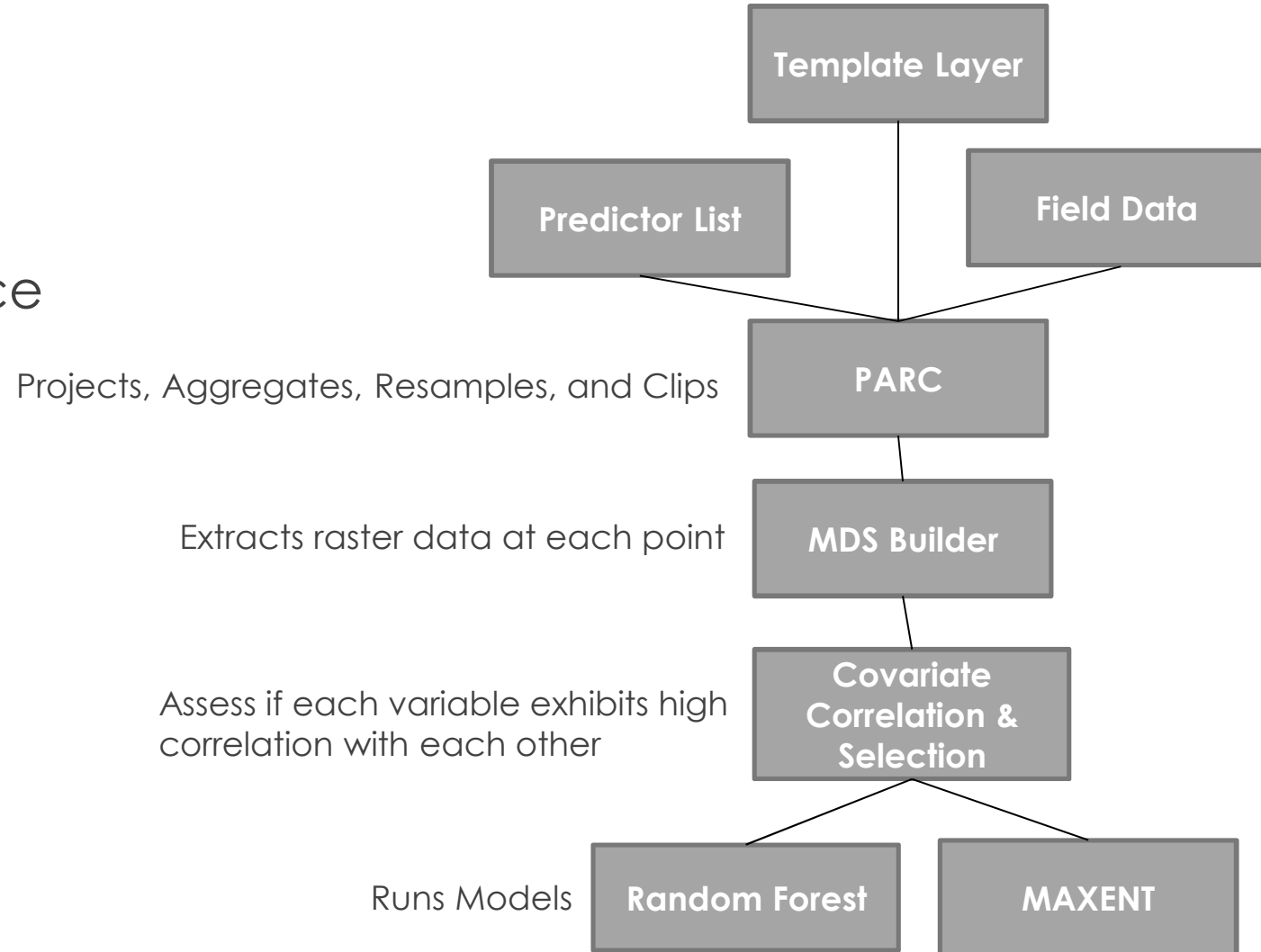
0, Sand/Bare

1, Vegetation



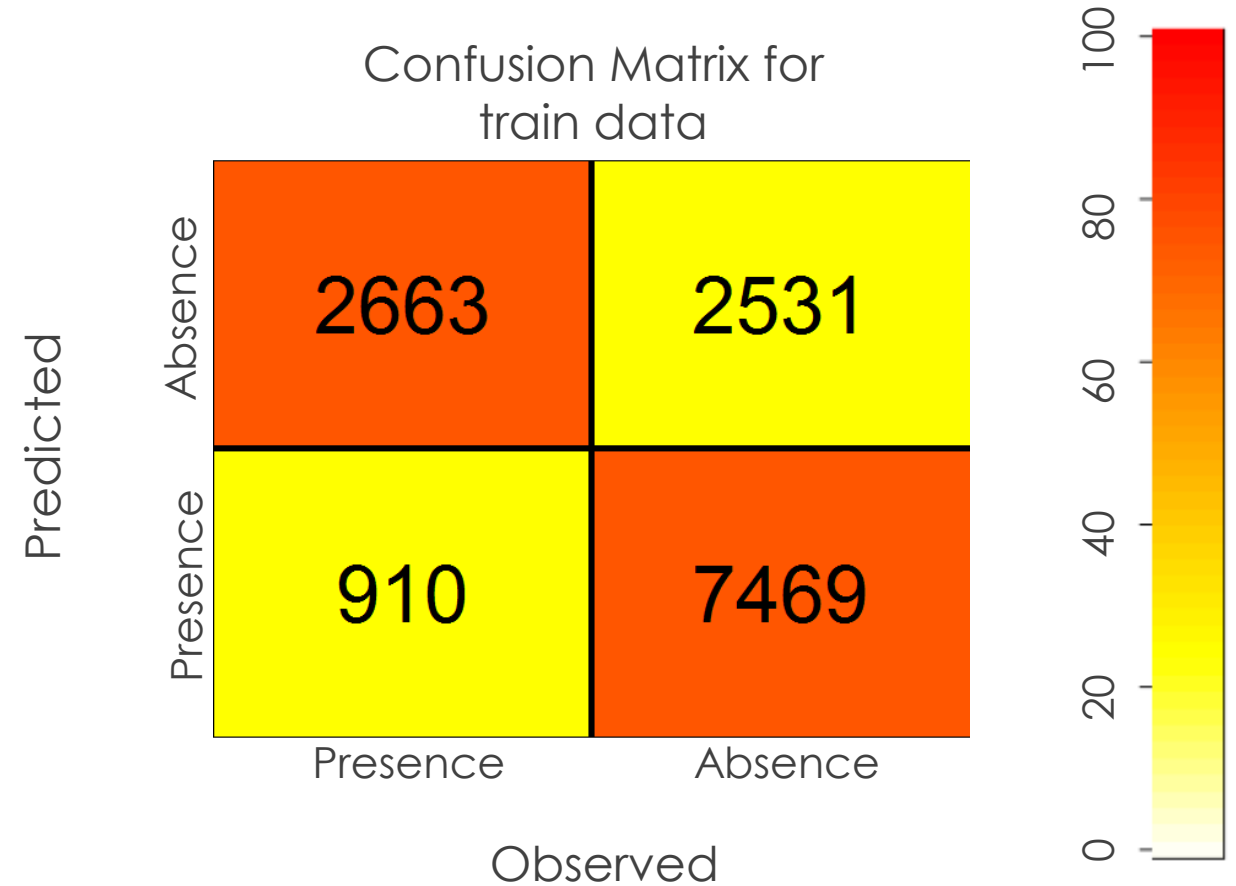
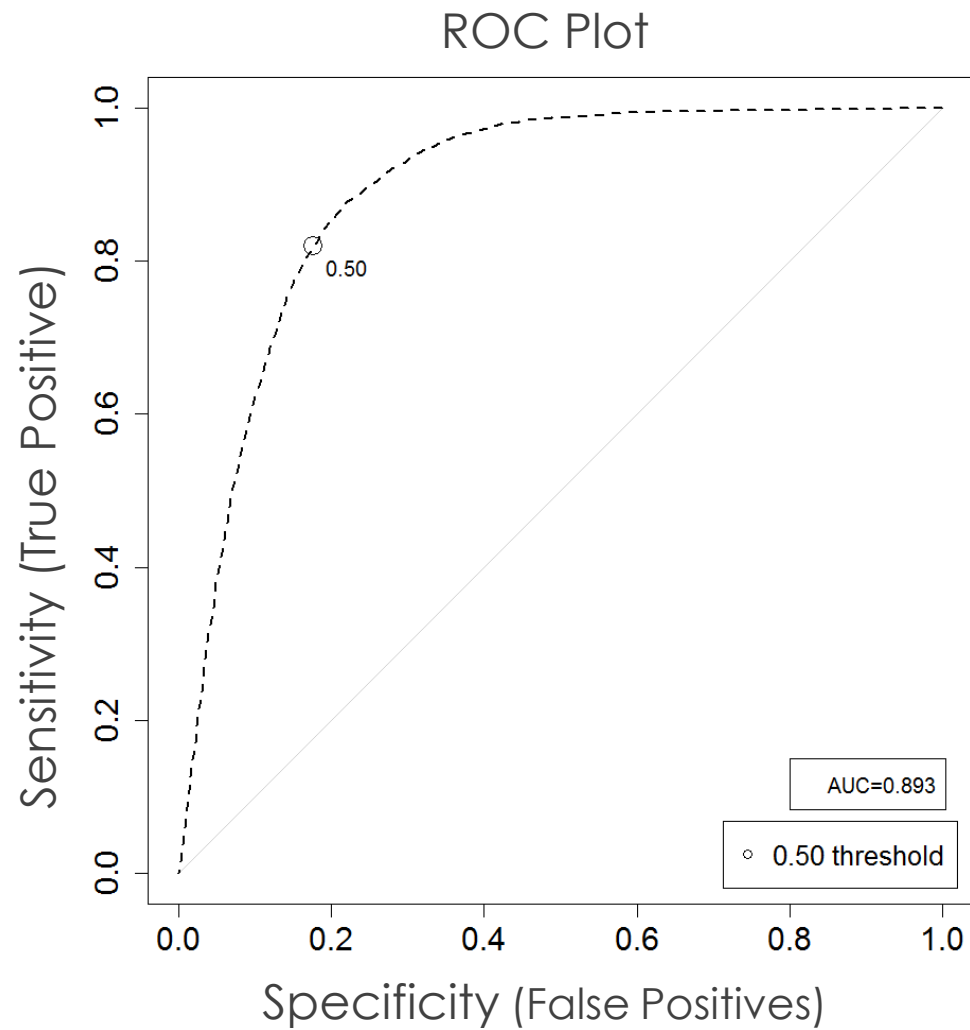
Software for Assisted Habitat Modeling

- ▶ Species Distribution Model developed by USGS Fort Collins Science Center
- ▶ Runs several models, using presence only or presence/absence data
- ▶ Software is free to download
- ▶ No software support, utilize google help desk and user manual





MAXENT Results: Granite Mountain



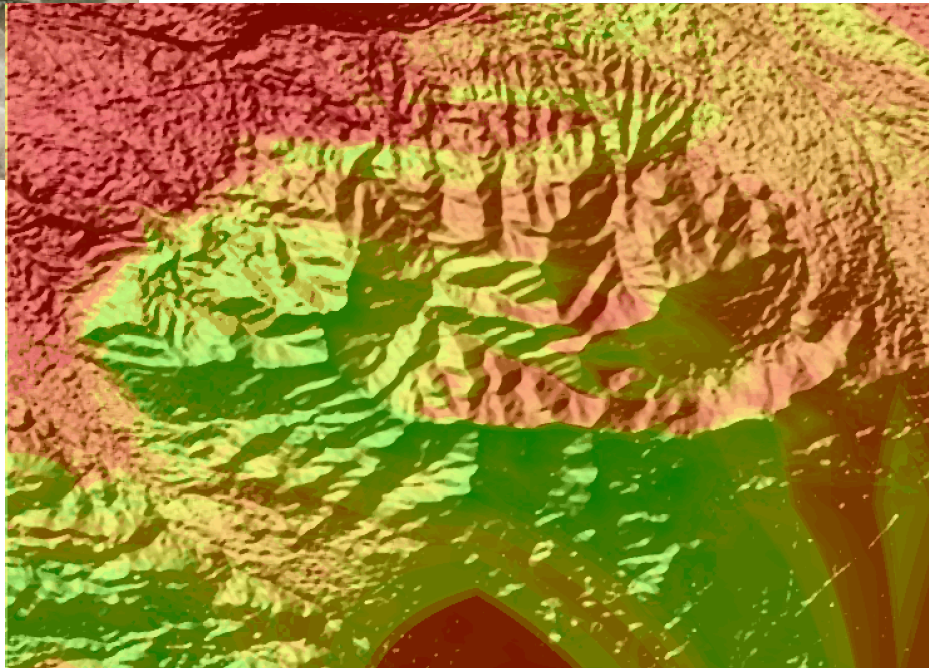
Sensitivity: 0.745
Specificity: 0.747
True Skills Stat: 0.492
Cohen's Kappa: 0.43
Percent Correctly Classified: 74.6%



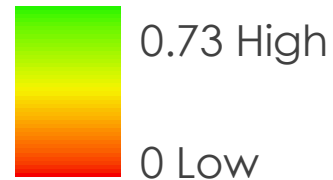
MAXENT Results: Granite Mountain



Probability of Bighorn
Sheep Distribution

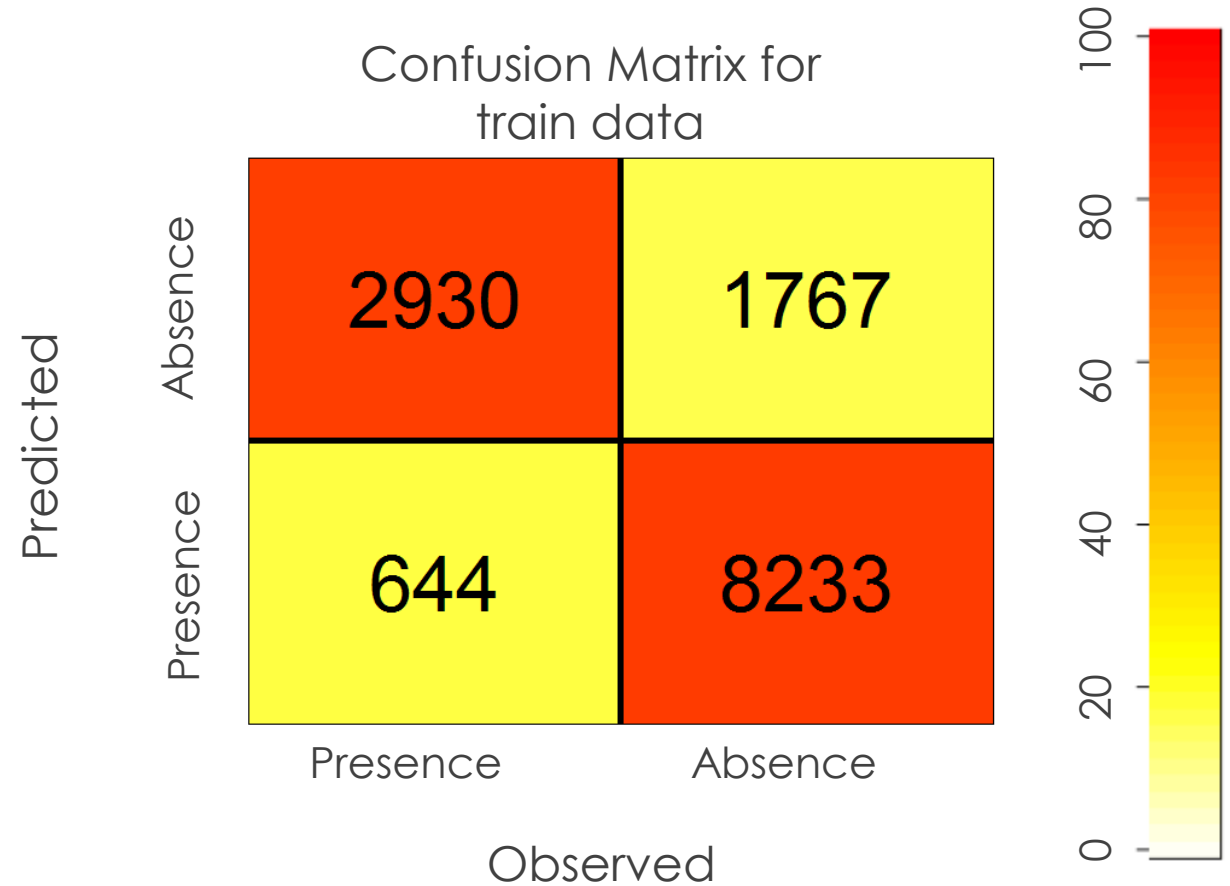
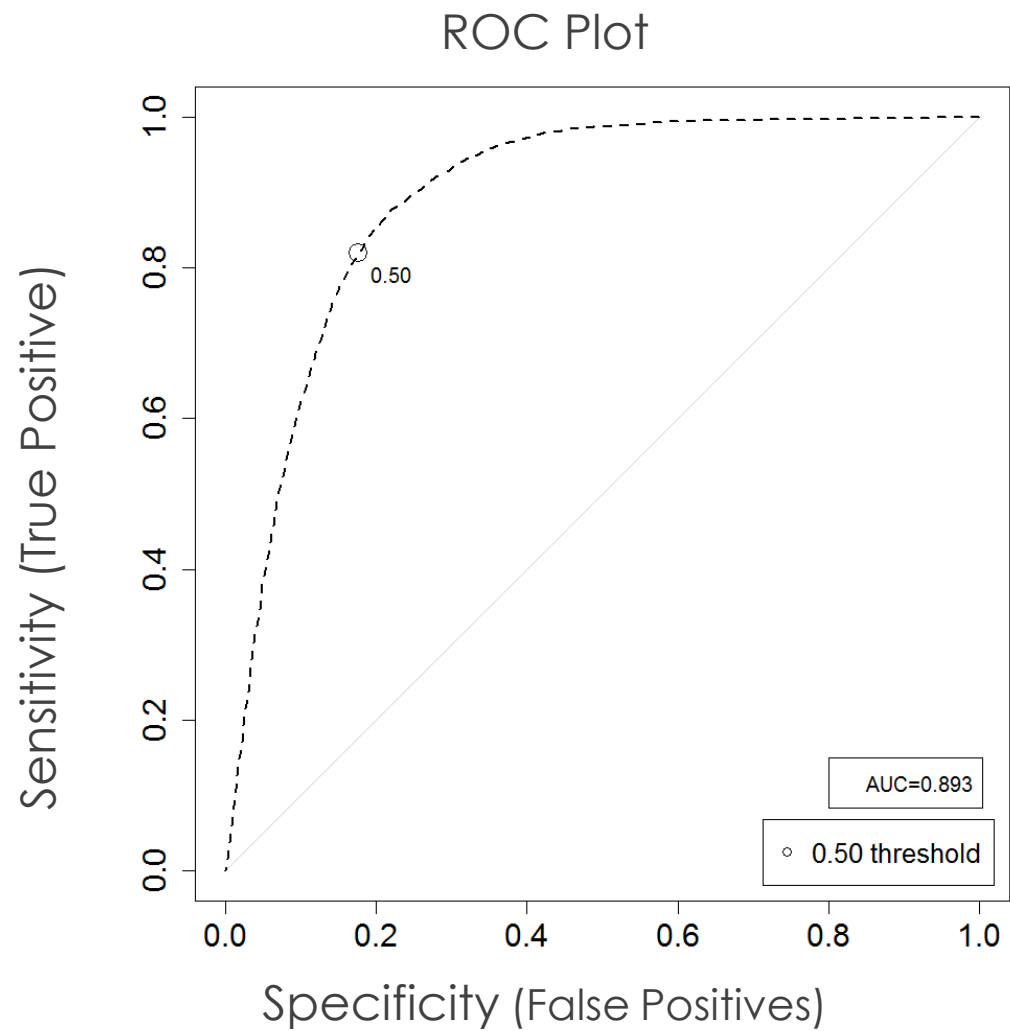


0 1.5 3 6 km



- Shows areas within the Granite Mountains with a high probability of sheep distribution
- Shows influence of topography and aspect

Random Forest Results: Granite Mountain

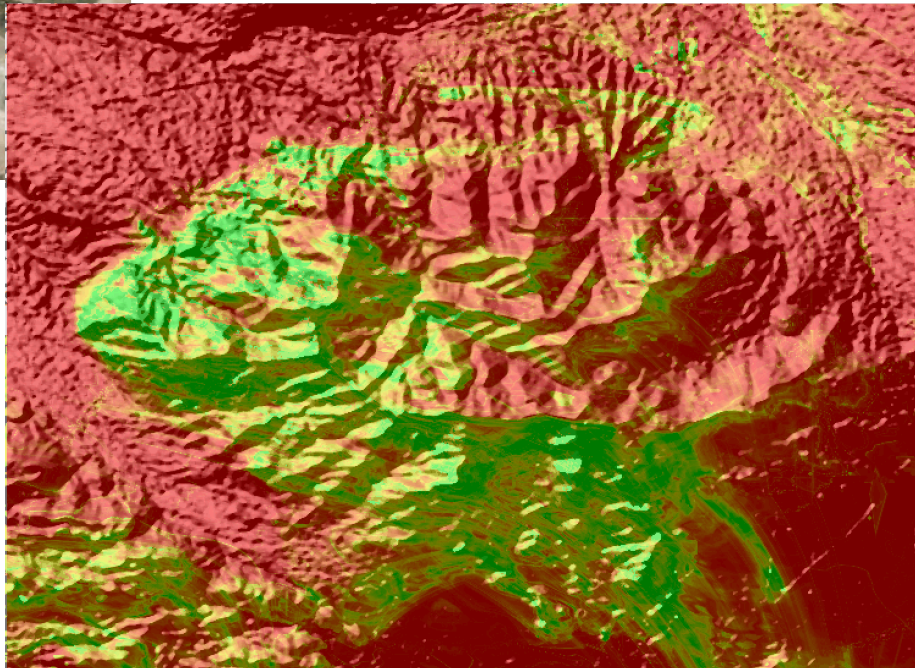


Sensitivity: 0.82
Specificity: 0.823
True Skills Stat: 0.643
Cohen's Kappa: 0.58
Percent Correctly Classified: 82.2%

Random Forest Results: Granite Mountain



Probability of Bighorn
Sheep Distribution



0 1.5 3 6 km



0.73 High

0 Low

- Shows areas within the Granite Mountains with a high probability of sheep distribution
- Shows influence of topography and aspect

Errors and Uncertainties

- ▶ Lacking adequate ground truth, both quality and quantity
- ▶ Variability of terrain and vegetation species
- ▶ SAHM user error can be difficult to correct





Image Credit: Brigitte Moneymaker

Future Work

- ▶ There is an ongoing effort to create a comprehensive geology map for the region, which could help in assessing topography/vegetation interactions.
- ▶ ECOSTRESS is a potential data source for aiding habitat mapping, plus vegetation and soil assessments.



Conclusions

- ▶ Green up events are immensely variable in the in the Mojave Desert. This could be accounted for highly variable precipitation having a higher affect on NDVI and soil moisture values, regardless of season.
- ▶ Soil moisture has a noticeable influence on green up. Higher levels resulted in higher NDVI values. Higher resolution soil moisture products will be able to better quantify this relationship on a better scale.
- ▶ Higher quality and quantity of ground truth data are necessary to achieve a supervised vegetation classification with a better selection of land cover types. This will better inform habitat selection models such as SAHM.
- ▶ Bighorn sheep habitat selection favors higher elevation, which was shown to have a higher NDVI and vegetation cover, but still varies significantly due to a variety of factors such as predation risk and lambing season.





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