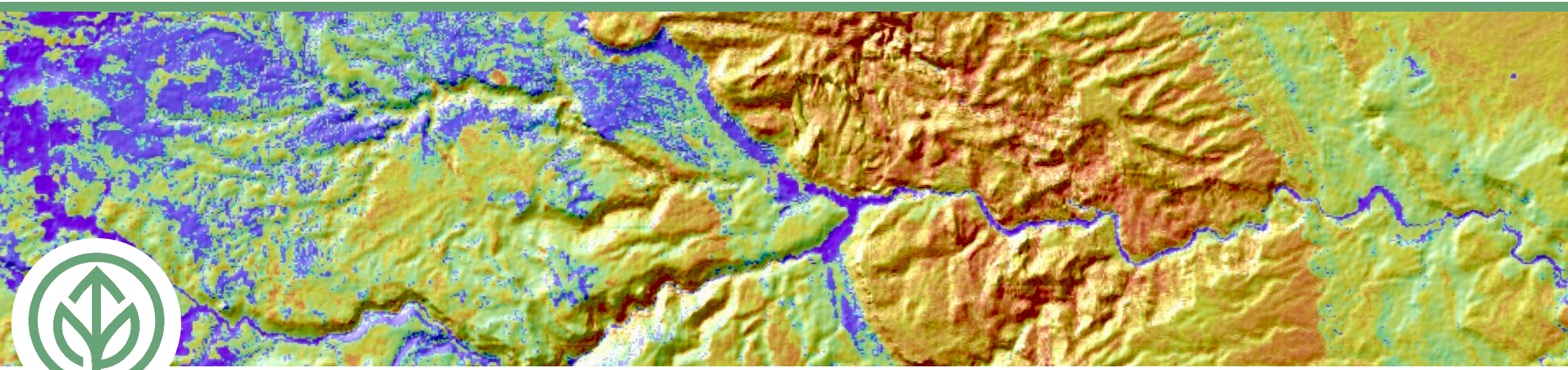
National Aeronautics and Space Administration



Capitol Reef Ecological Conservation

Mapping Vegetation Functional Groups to Inform Invasive Vegetation Management, Ecological Conservation, and Restoration in Capitol Reef National Park

Drew Comin • Kyleigh Kowalski • Vanchy Li • Zhenya Mazko

25TH EVELOP ANNIVERSARY

Study Area & Period

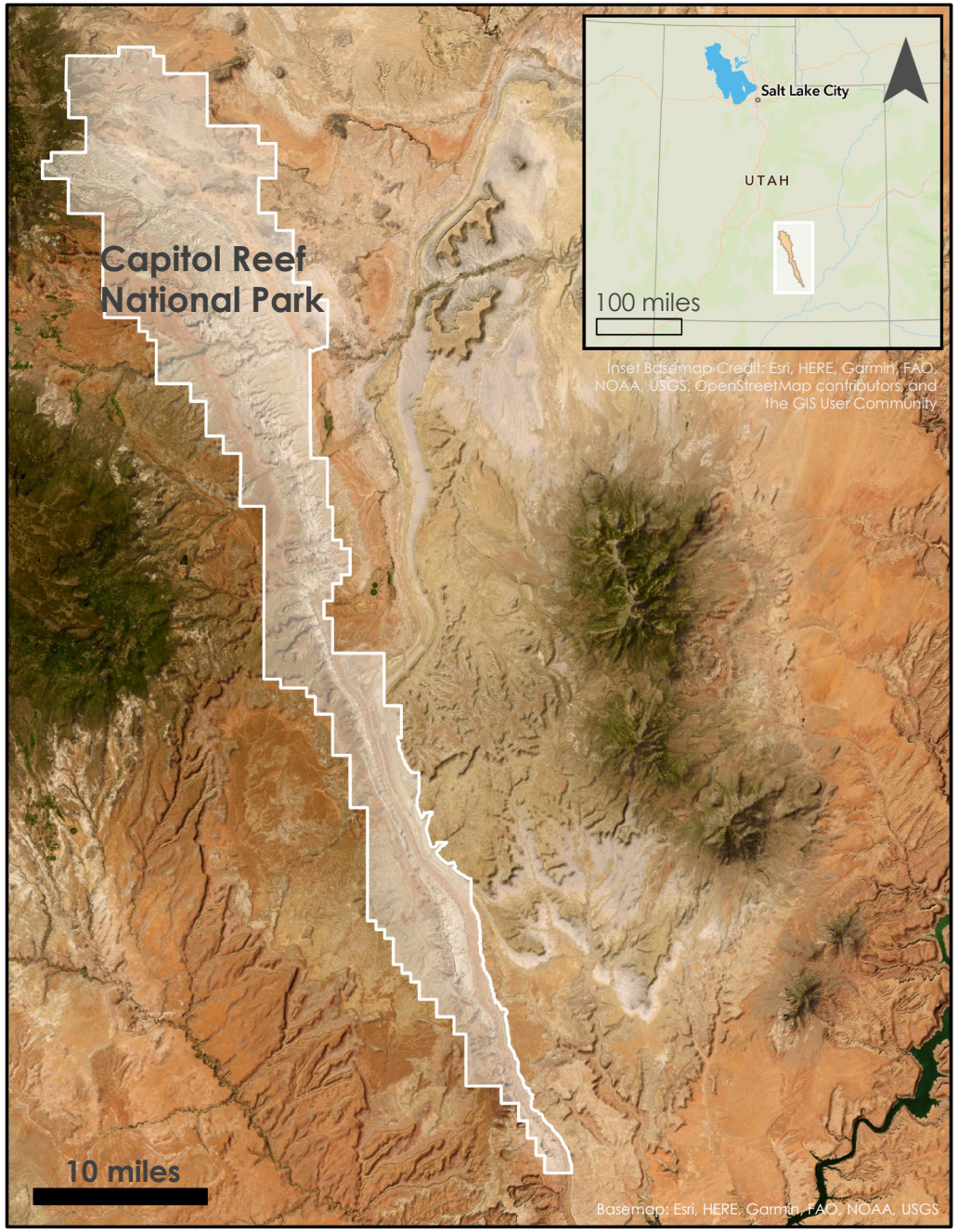
Capitol Reef (CARE) National Park

2013–2023:

Historical Annual Landcover Classification Maps

2023–2033:

Forecasted Annual Landcover Classification Maps



Invasive vs Native Plants

Tracking and managing vegetation

- Invasive vegetation can change the fire regime
- Native vegetation helps sustain healthy ecosystems


Cheatgrass (*Bromus tectorum*)


Russian thistle (*Salso tragus*)

Invasive species are part of the **annual grasses** and **forbs** group


Blue grama (*Bouteloua gracilis*)


Indian Ricegrass (*Achnatherum hymenoides*)

Native species are part of **perennial grasses** and **forbs** group

Image Credits: National Park Service

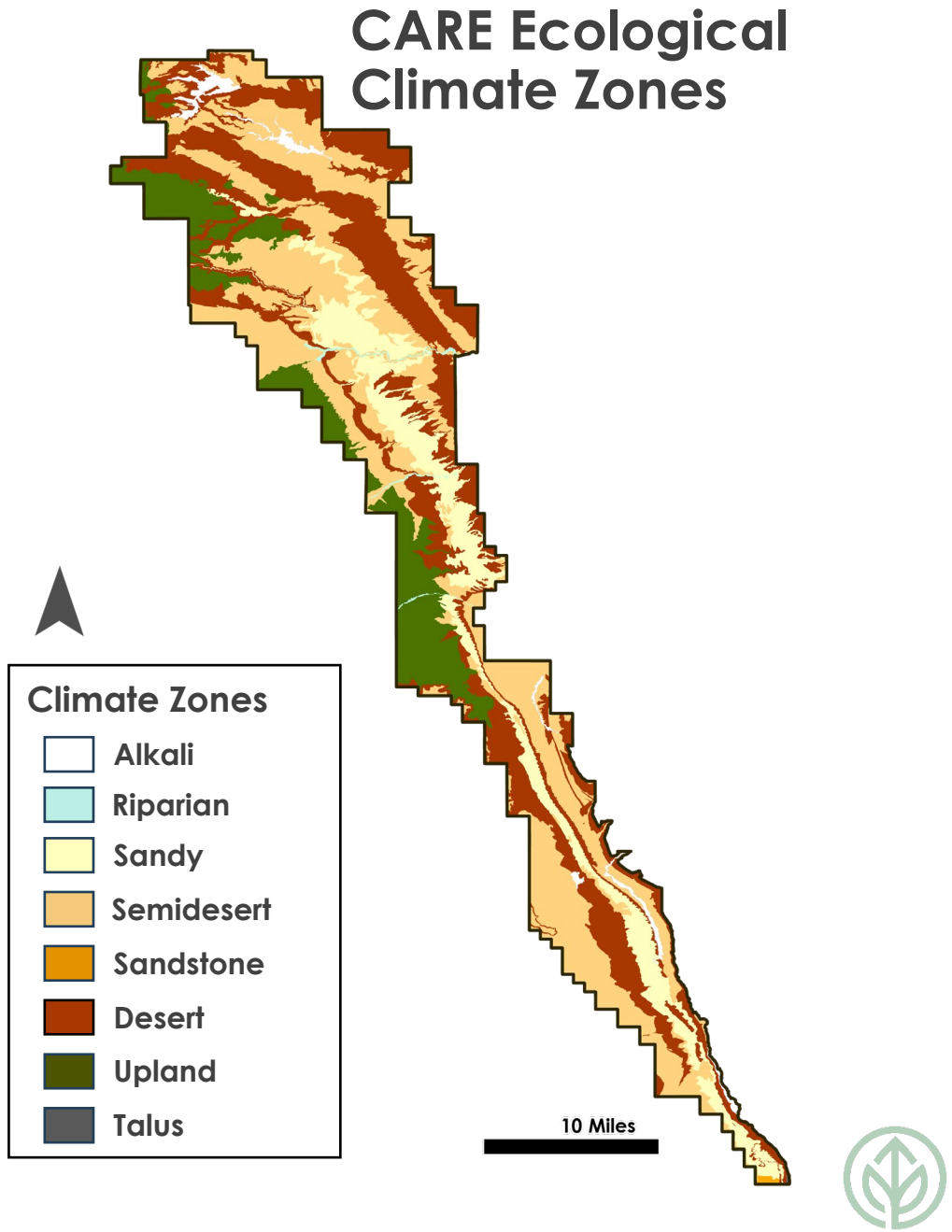
Project Objectives

Prioritize — Identify the most influential predictors for invasive species of interest

Classify — Map functional groups to improve efficiency of management protocols

Validate — Compare the accuracy of the new model to the current model (RAP)

Forecast — Utilize the classification model to predict future ecological change



Partner

National Park Service
Capitol Reef National Park

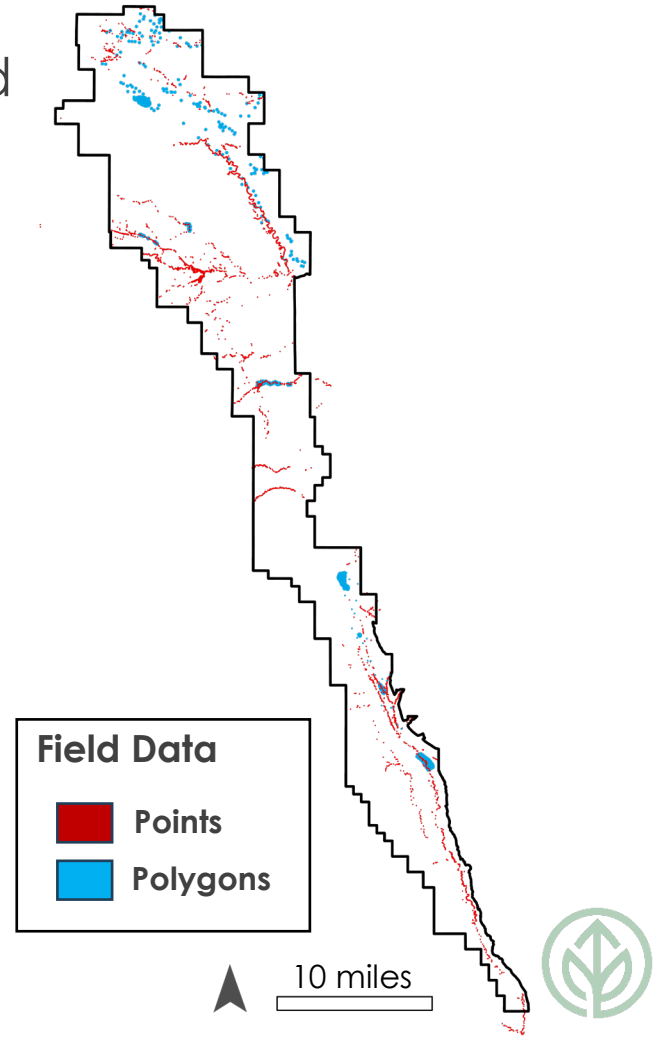
- Joseph Ceradini, Ecologist
- Morgan Wehtje, Wildlife Biologist
- Alex Stoneburner, Rangeland Ecologist and GIS Specialist

Partner Interest

- Improve efficiency and cost-effectiveness of exotic invasive species monitoring and control
- Establish remote-sensing based methods to target different types of vegetation

Provided Data

- In-situ polygons and points with land cover
- Phenological data for targeted plants
- Geological, ecological, soil maps and datasets
- Additional infrastructure and water resources layers



Community Concerns

Invasive Species Treatment / Removal

Native Species Conservation

Natural Resource Management

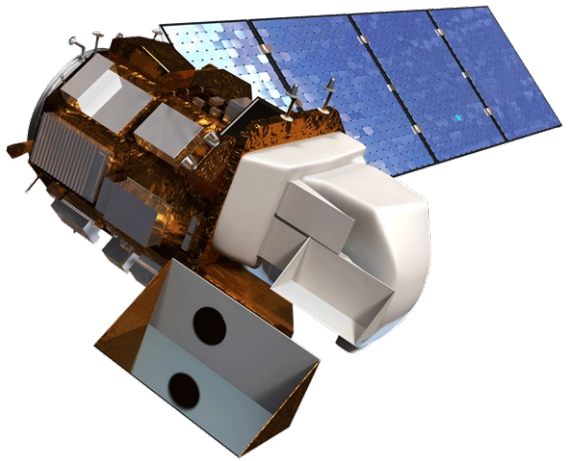
Capitol Reef National Park

The Capitol Dome and Fremont River

Image Credits: National Park Service

Earth Observations

Landsat 8 Operational Land Imager (OLI)



2013–2023

Spatial Resolution:
30 meters
Temporal Resolution:
16-day cycle

Sentinel-2 MultiSpectral Instrument (MSI)

2019–2023

Spatial Resolution:
10 meters
Temporal Resolution:
5-day cycle

PlanetScope SuperDove

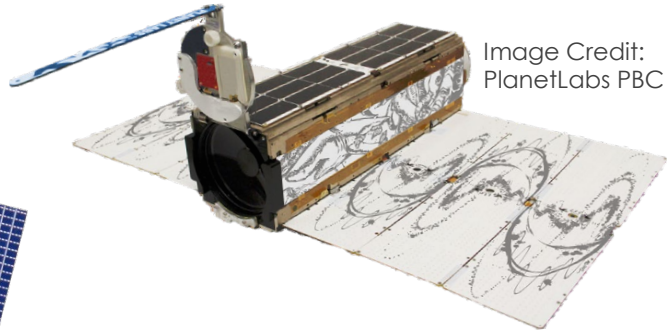
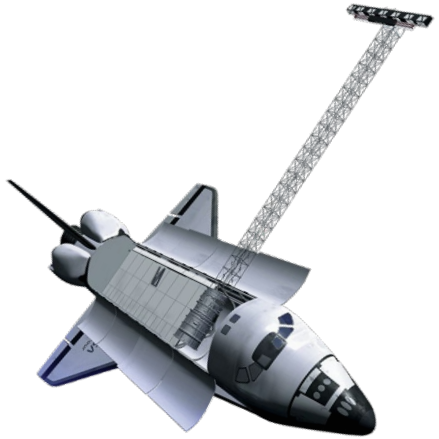


Image Credit:
PlanetLabs PBC

2022

Spatial Resolution:
3 meters
Temporal Resolution:
1–2-day cycle

Shuttle Radar Topography Mission (SRTM)



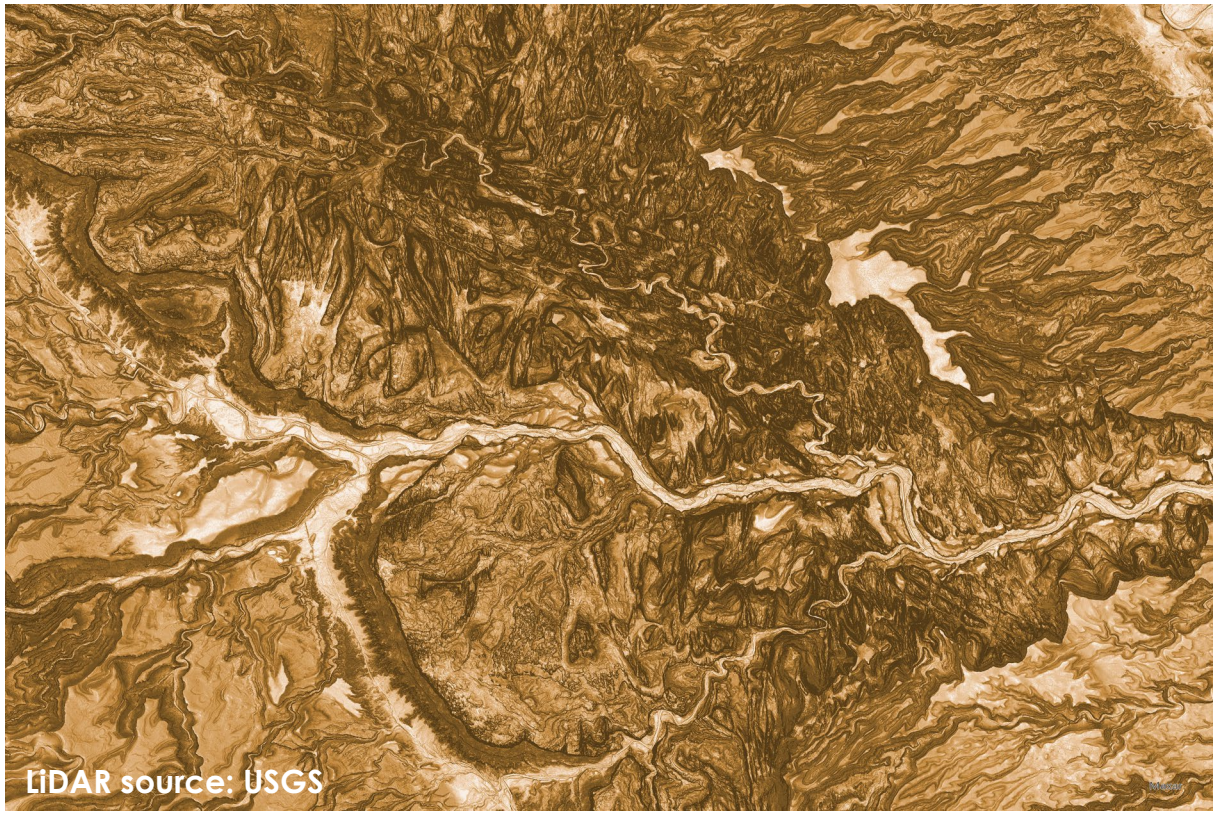
Usage:
Topographic variables
Spatial Resolution:
30 meters

Additional Datasets

National Agriculture Imagery Program (NAIP)

Usage:
Generating training sites | Visual validation
Spatial Resolution: 0.5 meters

LiDAR Elevation Data



Usage:
Generating training sites | Topographic variables
Spatial Resolution: 1 meter

Methodology Workflow

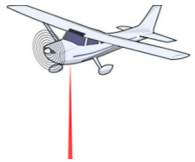
Selection and Collection of Data

Landsat 8 OLI-2

Sentinel-2 MSI

Planetscope SuperDove

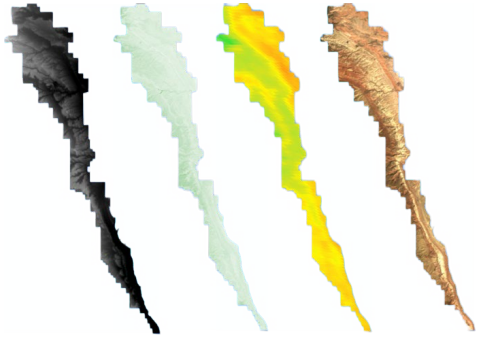
SRTM



LiDAR

NAIP

Generation of Indexes and other Variables

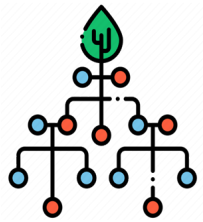


Input Predictors:

- Landsat 8 Imagery
- August NDVI – May NDVI
- August MSAVI2 – May MSAVI2
- May Indices: NDVI, MSAVI2, BSI, NDWI - McFeeters
- August Indices: NDVI, MSAVI2, BSI, NDWI
- LiDAR Height Above Ground
- SRTM Slope, Aspect, and Elevation

Training sites generation

Training Data

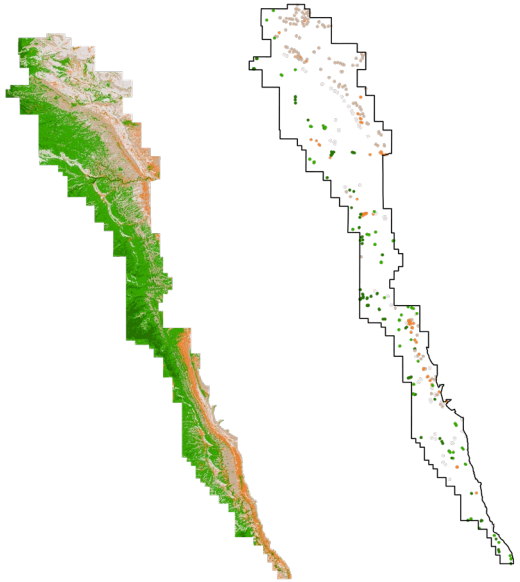


Random Forest Model

Modeling

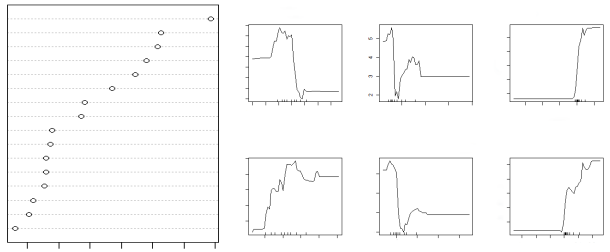
Maps Generation

Classification Maps & Probability maps



Methodology Workflow

Importance Plot & Partial Plots

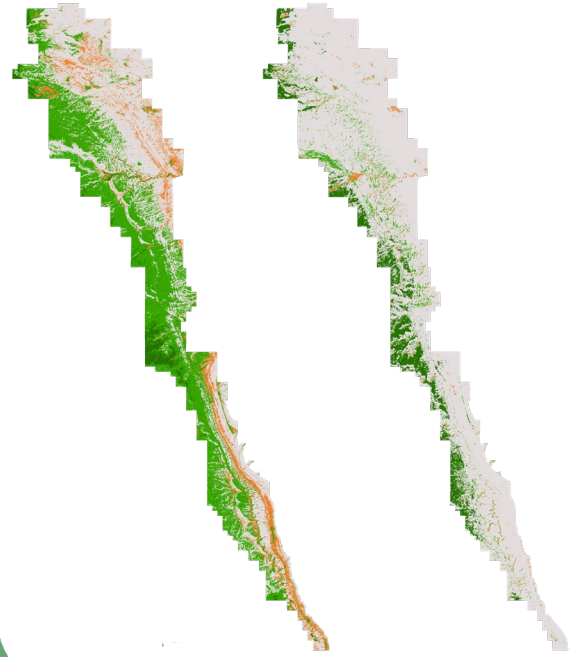


Validation (Confusion Matrix)

Ground Truth / Classified	Grass	Bare Soil	Rock	Shrub	Tree	Total	Accuracy
Grass	118	10	1	8	0	137	86.13%
Bare Soil	7	189	1	1	0	198	95.45%
Rock	5	3	184	0	0	192	95.83%
Shrub	2	0	5	117	14	138	84.78%
Tree	2	0	0	7	169	178	94.94%
Total	134	202	191	133	183	843	
Accuracy	88.06%	93.56%	96.34%	87.97%	92.35%		92.17%

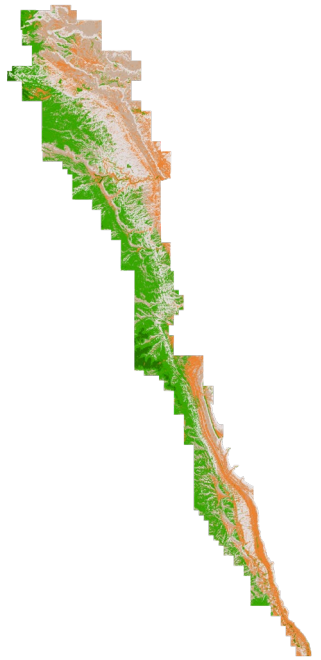
Display Important Predictors & Accuracy Assessment

Comparison with RAP



Cross Validation

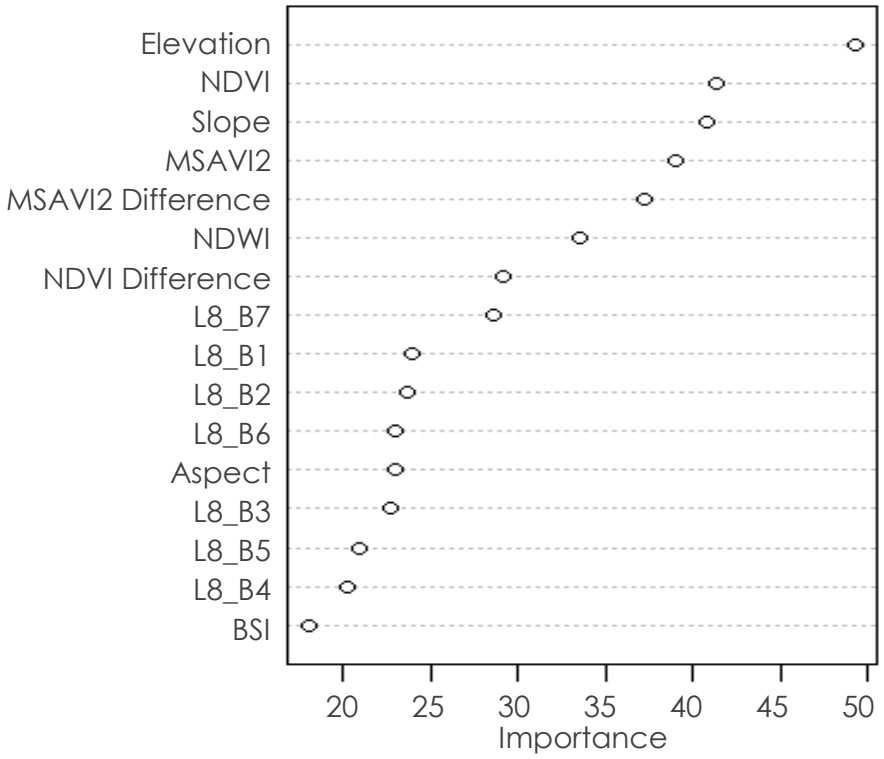
Future Prediction Map



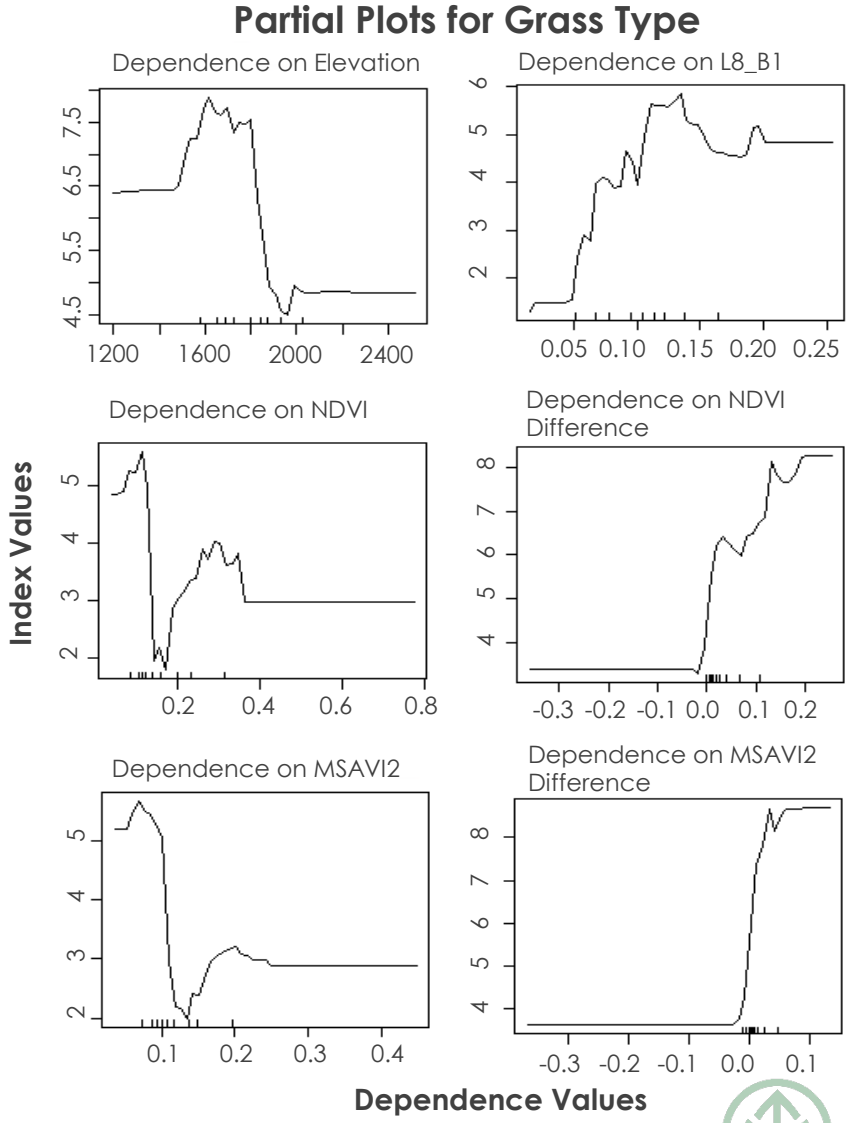
Land Change Modeler Prediction Map Generation

Methodology: Random Forest Classification

- **Elevation, NDVI, and Slope** were the most influential predictors in the Random Forest classification



- An **increasing curve** suggests a positive relationship
- A **decreasing curve** suggests a **negative** relationship



Results | Classification Map

- **Landsat 8** based
- **5 classes** based on functional groups comparable to RAP
- Date: **26th May 2022**
- **92.17%** overall agreement

Kappa: 0.9015

Ground Truth / Classified	Grass	Bare Soil	Rock	Shrub	Tree	Total	Accuracy
Grass	118	10	1	8	0	137	86.13%
Bare Soil	7	189	1	1	0	198	95.45%
Rock	5	3	184	0	0	192	95.83%
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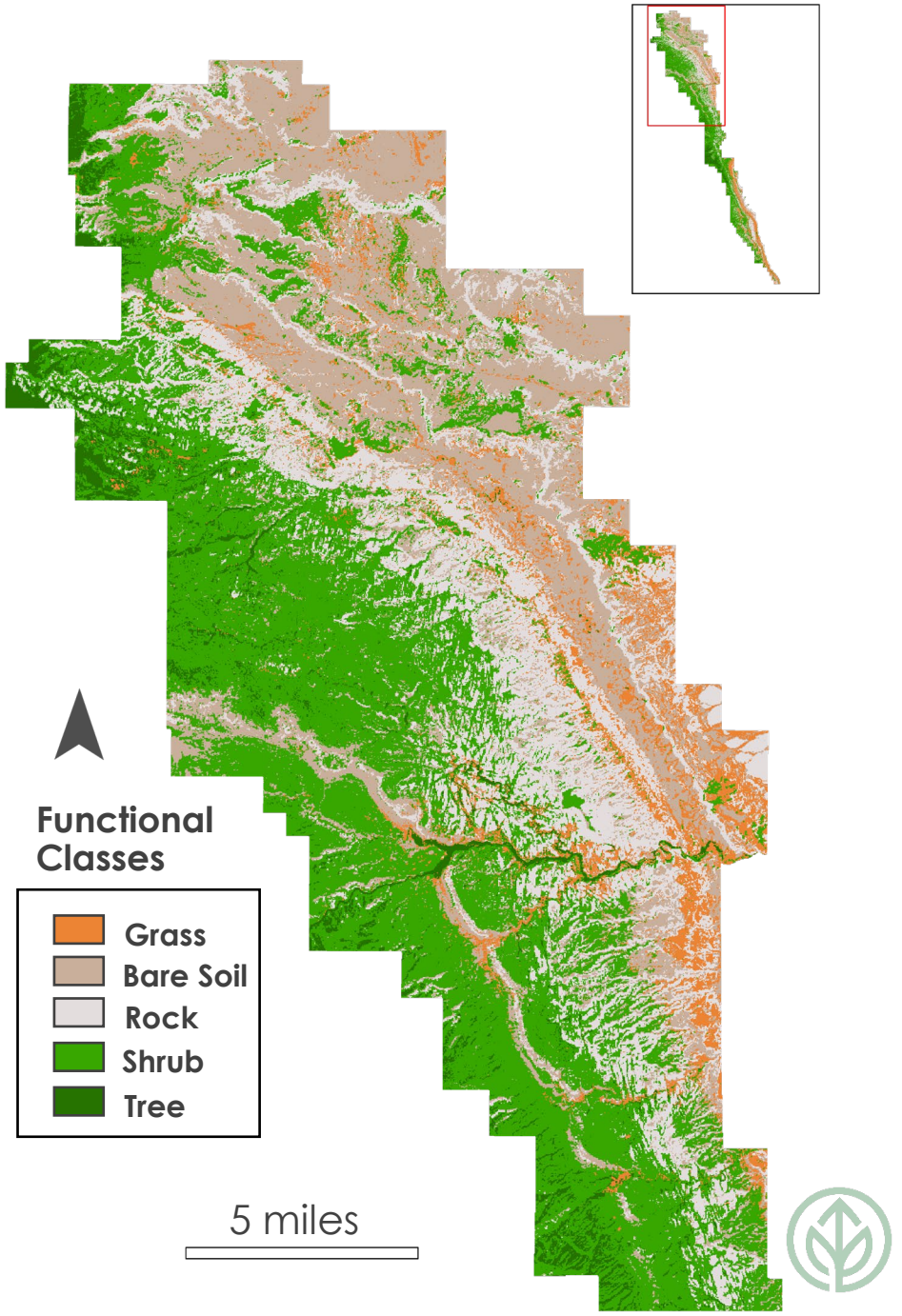
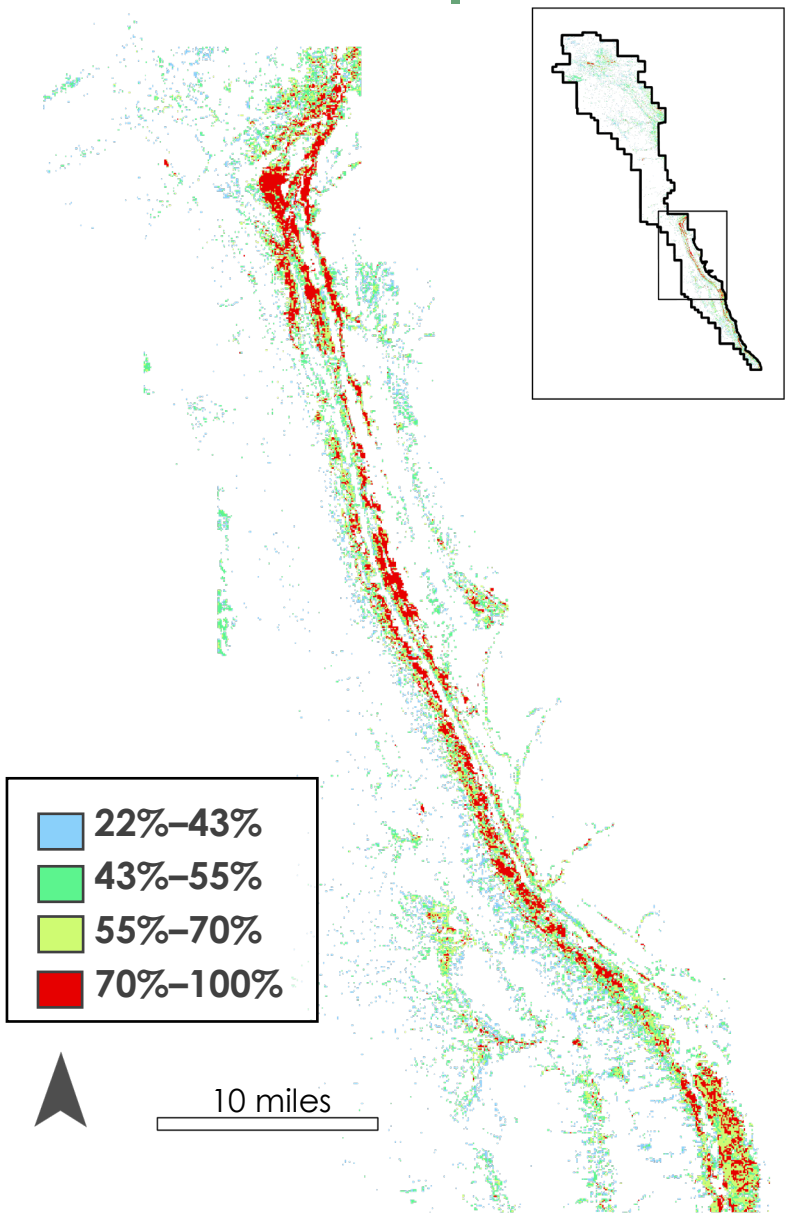


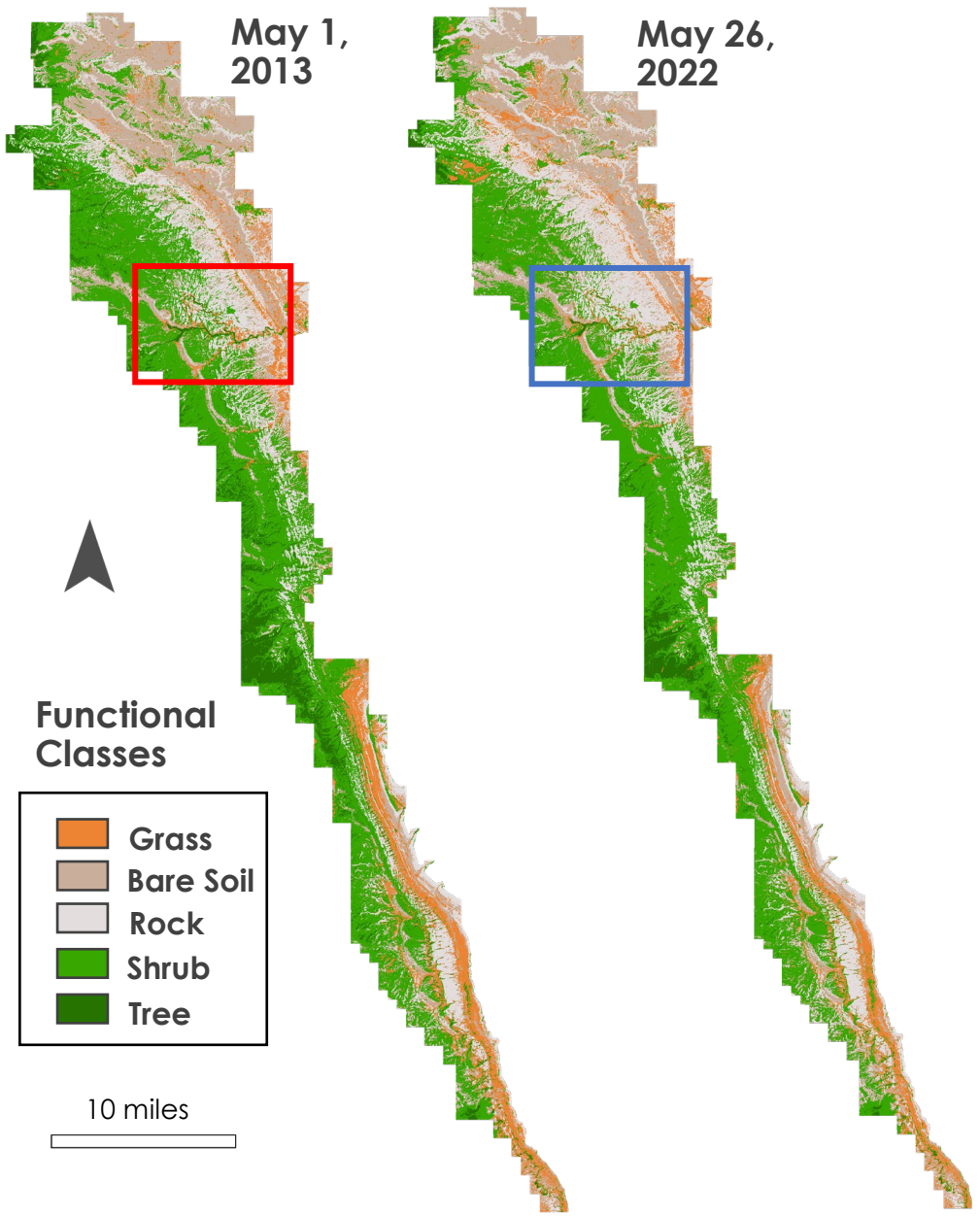
Results | Annual Grass Probability Mapping

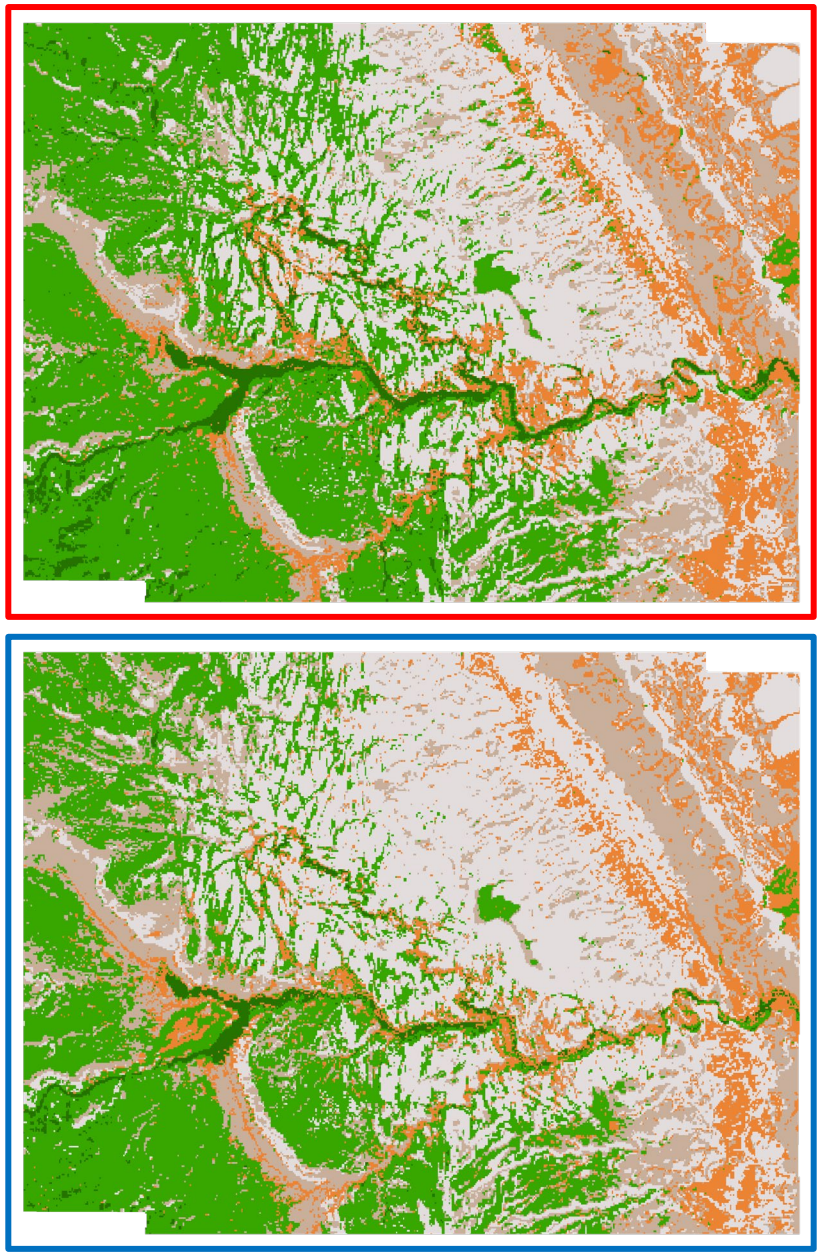


Probability mapping of specific invasive species in CARE was **not feasible** for our project timeline and data availability:

- **Higher values** in the probability map indicate the **pixel is more likely annual grass**
- Higher probability of annual grasses are clustered along the **southeastern part of the national park** (May 2022)

Results | Land Cover Change 2013–2022





From 2013 to 2022

Grass: + 0.11%

Bare Soil: + 1.99%

Rock: + 3.97%

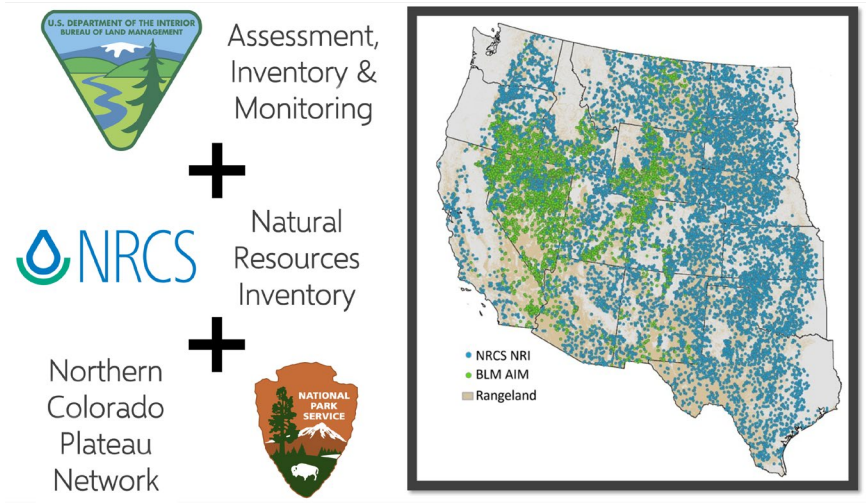
Shrub: - 2.4%

Tree: -3.67%

Rangeland Analysis Platform

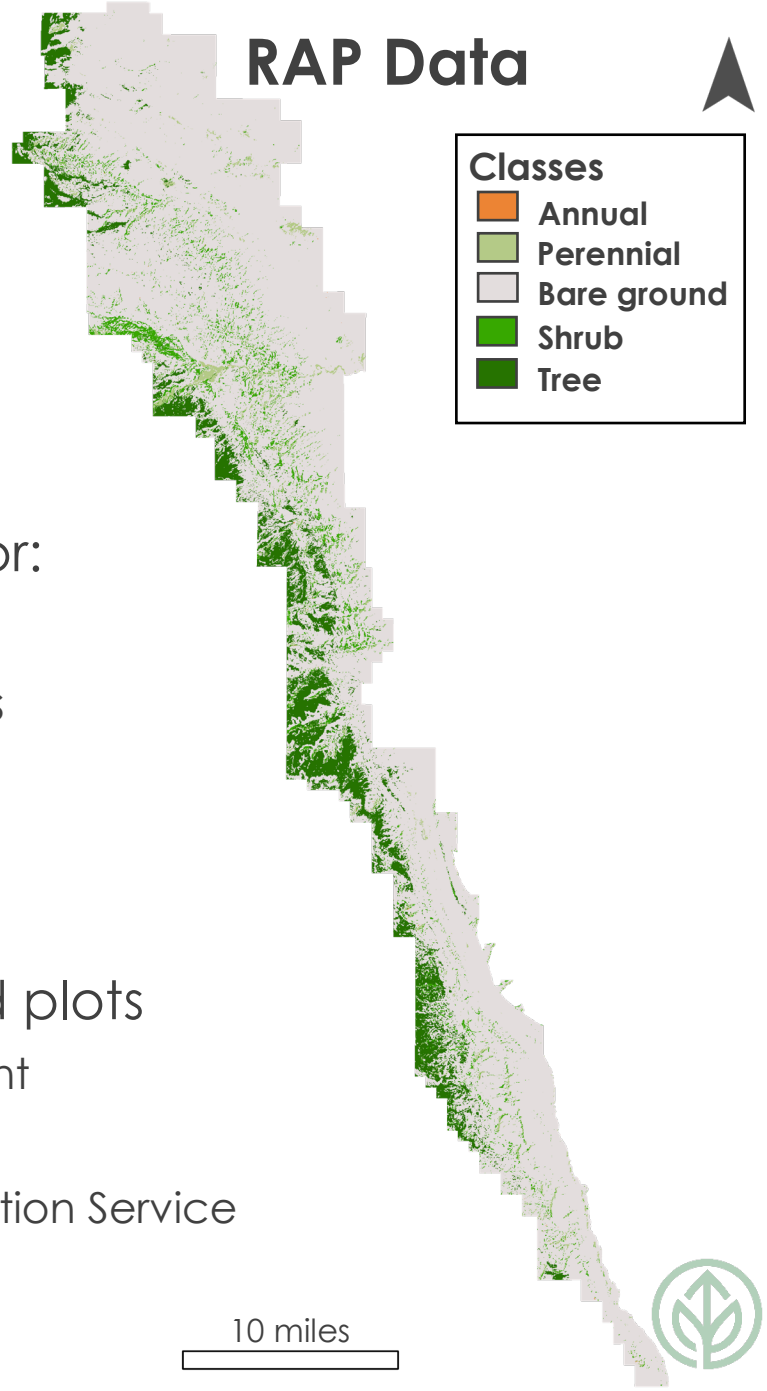
- The RAP is a classification model designed by the USDA to support rangeland conservation planning.

Rangeland Analysis Platform (RAP); Image Credit: USDA



RAP Support; Image Credit: USDA

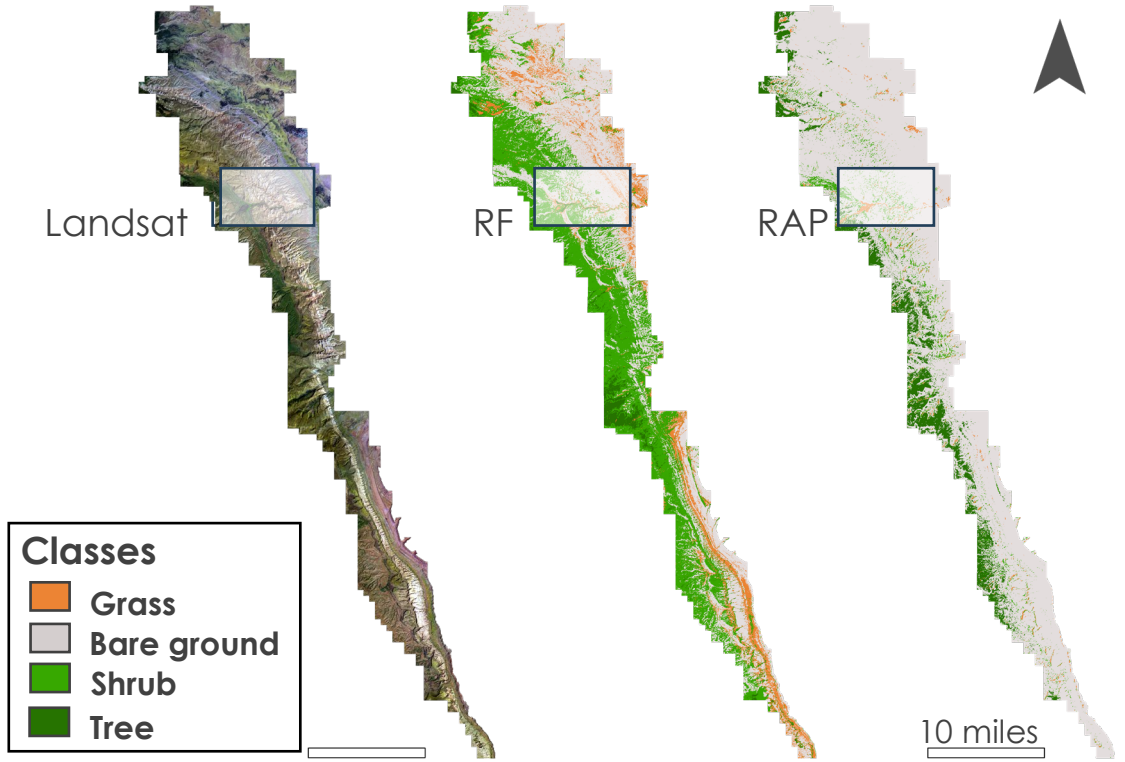
- Percent cover estimates for:
  - Annual Forbs & Grasses
  - Perennial Forbs & Grasses
  - Shrubs
  - Trees
  - Bare ground
- Estimated from 75,000 field plots
  - Bureau of Land Management
  - National Parks Service
  - Natural Resources Conservation Service
- Landsat satellite record



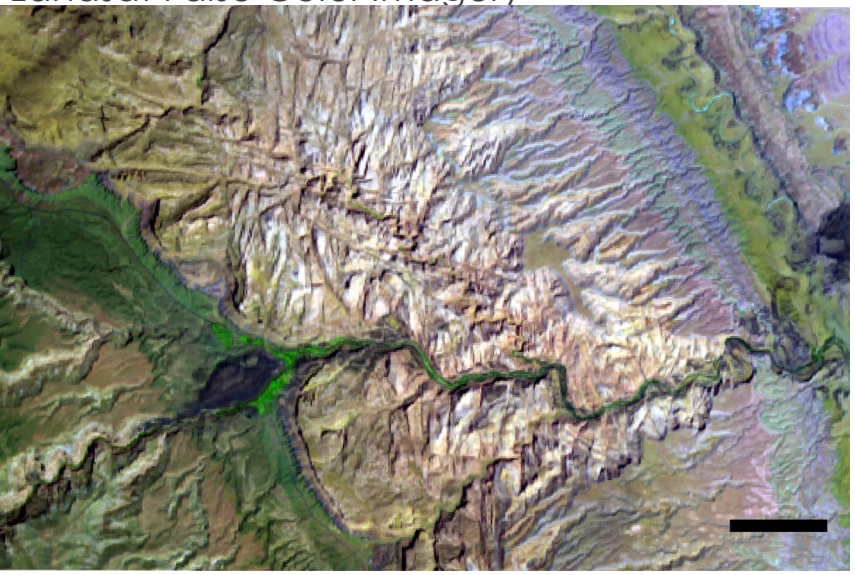
Results | Comparison between RAP and Random Forest

RAP Data Observations

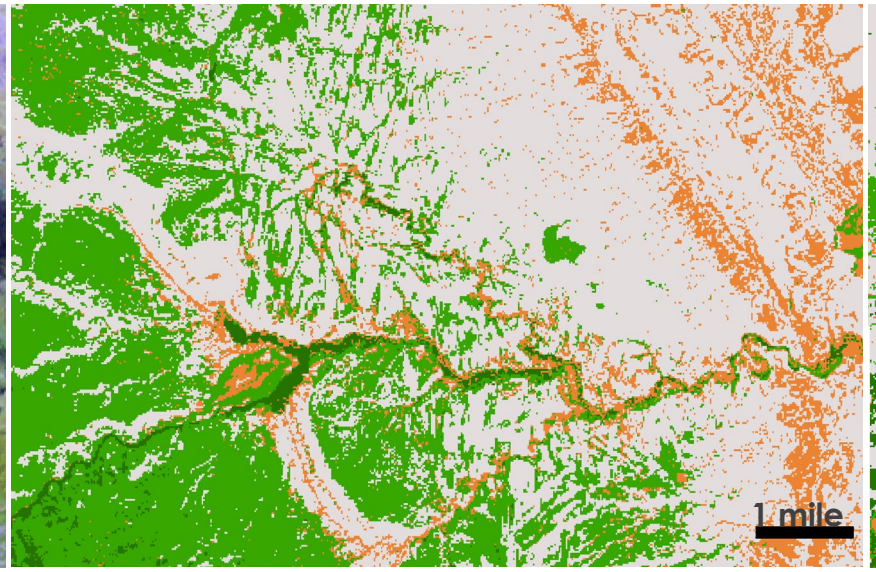
- Potential overclassification of bare ground & underclassification of grass
- The Random Forest classifier potentially returns a greater accuracy than is reported by the RAP, based on field validation data



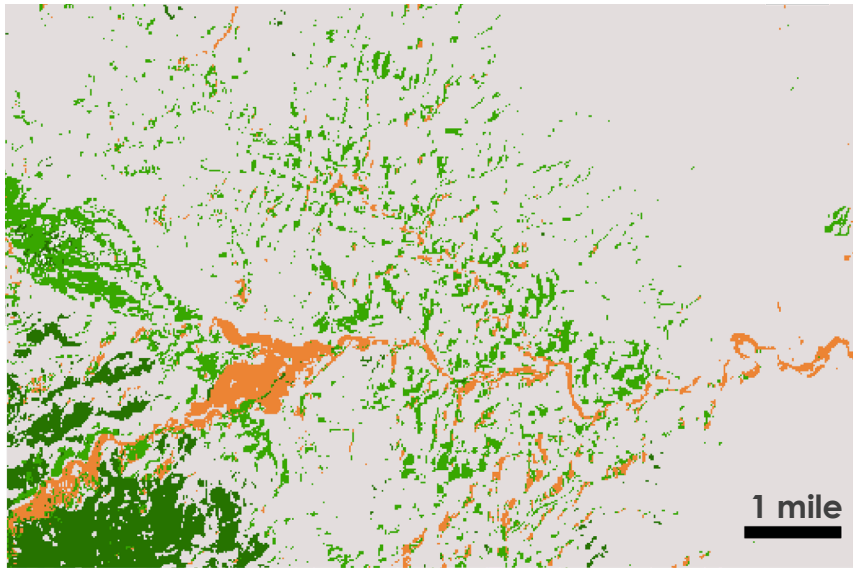
Landsat False Color Imagery



Random Forest Classification



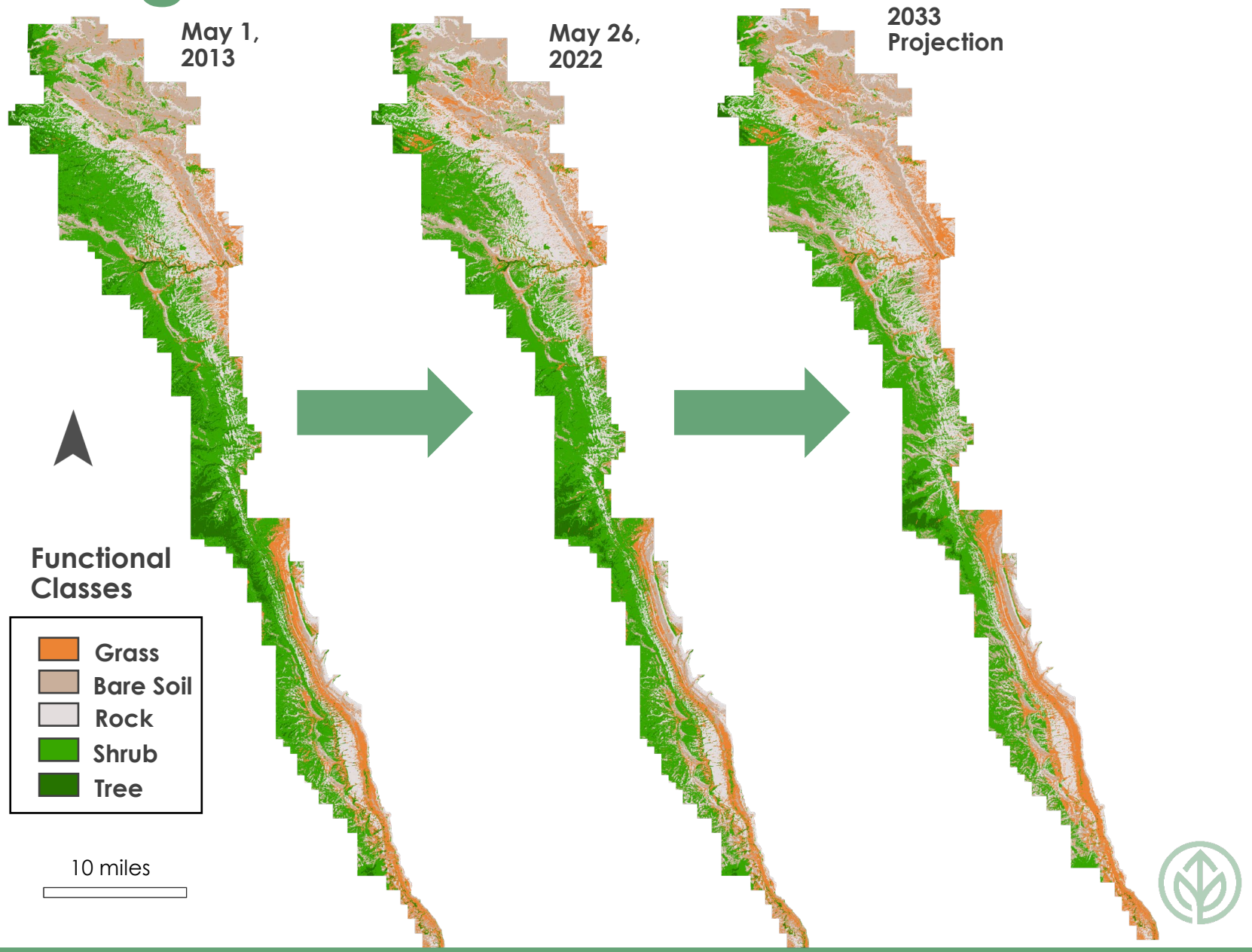
RAP Classification



Results | Forecasting to 2033

From 2022 to 2033

- Grass: + 5.64%
- Bare Soil: + 1.56%
- Rock: + 1.77%
- Shrub: - 6.76%
- Tree: - 2.02%



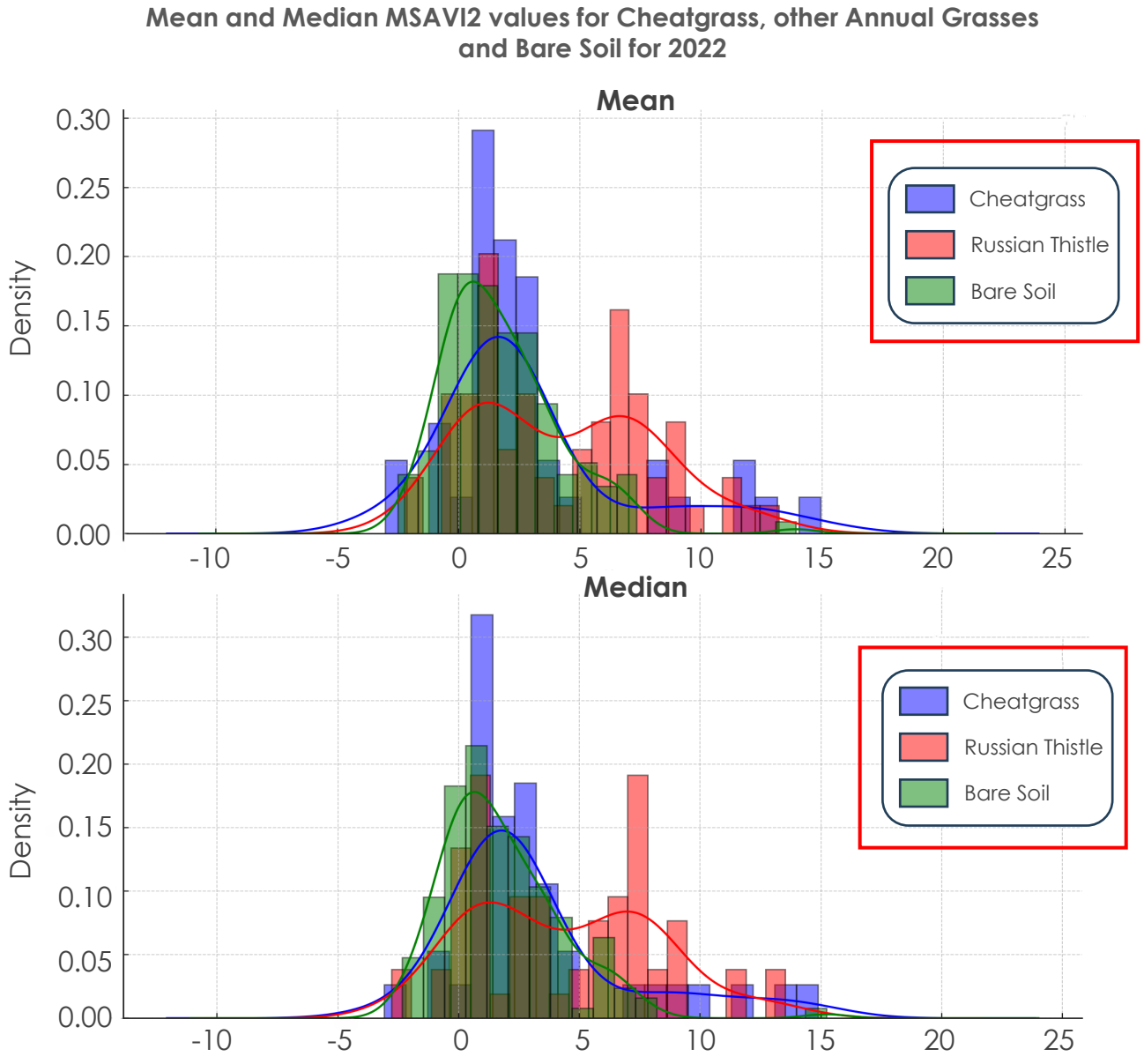
Conclusion

- **Random Forest classification** – showed **high overall agreement** with available reference data
- **Most significant predictors** are **elevation**, **NDVI**, **slope**, **MSAVI2**, **MSAVI2 difference**, **NDWI**, and **NDVI difference**
- **Unable** to differentiate **perennial** and **annual grasses** due to data constraints and limitations of the multispectral imagery and its spatial / temporal resolution
- **RAP data vs RF Classification** – **latter** provides a much **more detailed** land cover map and more options for analysis and predictive modeling
- **Land Cover Change** – between 2013 and 2022 overall **vegetation decreased** with trees decreasing by 3.7% and shrubs by 2.4%. Bare soil and rocks increased by a combined 5.9%

Cathedral Valley, Image Credit: National Park Service

Study Limitations And Uncertainties

- **Spatial** and **categorical** limitations of in-situ data
- Functional classes were not separatable for **Perennial** and **Annual** grasses and forbs
- Some classes showed a high percentage of **overlap** and variability over time



Future Work/Considerations

- Additional ground-truth data for training and validation samples to improve classification mapping
- Data with finer spatial and spectral resolution for use in differentiating perennial and annual grasses and other species that are too similar to be differentiated with the current multi-spectral satellite data
- HLS, harmonized Landsat/Sentinel-2 data could be used to increase the data collection frequency and improve the odds of getting cloud-free data during critical periods of phenological cycles

Cathedral Valley, Image Credit: National Park Service

Acknowledgments

Partners

- Joseph Ceradini, NPS
- Morgan Wehtje, NPS
- Alex Stoneburner, NPS

Fellow

- Ryan M Healey, ID

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- Keith Weber, ISU
- Joseph Spruce, SSAI

Others

- Ethan Ostraff, NPS

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Questions?

Image Credit: Ryan M Healey

Capitol Reef Ecological Conservation Team:

- Drew Comin
- Vanchy Li
- Kyleigh Kowalski
- Zhenya Mazko