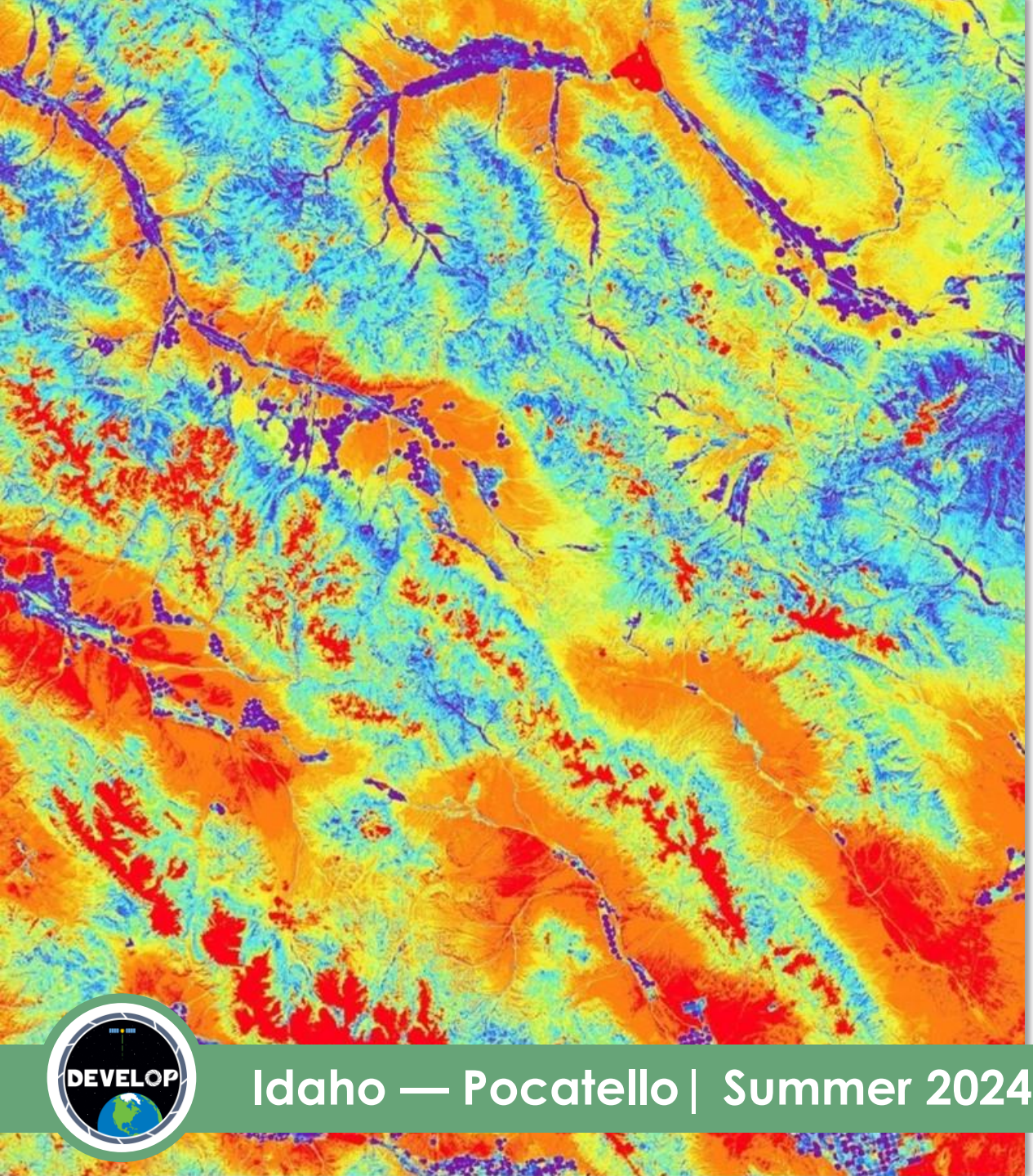

National Aeronautics and Space Administration

NORTHERN ROCKIES ECOLOGICAL CONSERVATION

Leveraging Earth Observations to Monitor and Predict Populations of Federally Threatened Whitebark Pine (*Pinus albicaulis*) Across the Intermountain West

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A H M Mainul Islam

Dustin Corbridge

Josh Carrell

Idaho — Pocatello | Summer 2024

Meet The Team

Background

Whitebark pine is a Keystone and Foundational Species

Image Credits: (left to right) Stephen Pavlov; Gregory "Slobirdr" Smith; Diane Renkin/Yellowstone National Park; Cephas

Partners

- USDA US Forest Service, Region 1
- National Park Service, Yellowstone Inventory and Monitoring Network
- Whitebark Pine Ecosystem Foundation
- US Fish & Wildlife Service, Montana Ecological Services Field Office
- Bureau of Land Management, Salmon Idaho Field Office
- US Fish & Wildlife Service, Wyoming Ecological Services Field Office

Image Credit: Famartin

Community Concerns

Whitebark pine is a Threatened *Keystone Species* in the Rocky Mountain West

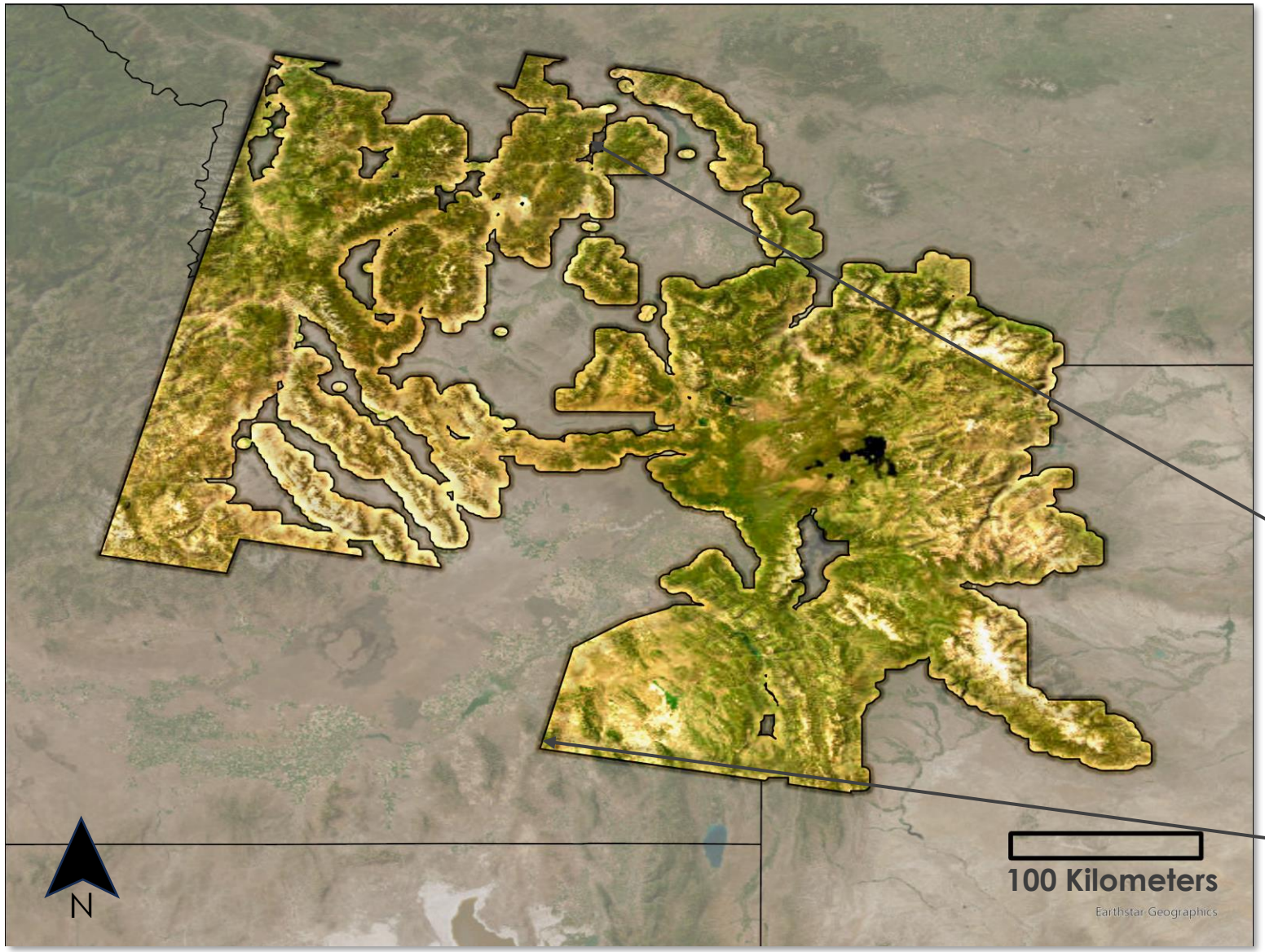
Image Credits: (left to right) USDA Forest Service; National Park Service/Shanahan; Glacier National Park Service

Objectives

1. **Investigate** Spectral Signatures
2. **Create** Distribution Models
3. **Generate** Habitat Suitability Model
4. **Develop** Accessibility Model

Image Credit: Jim Morefield

Study Area & Period



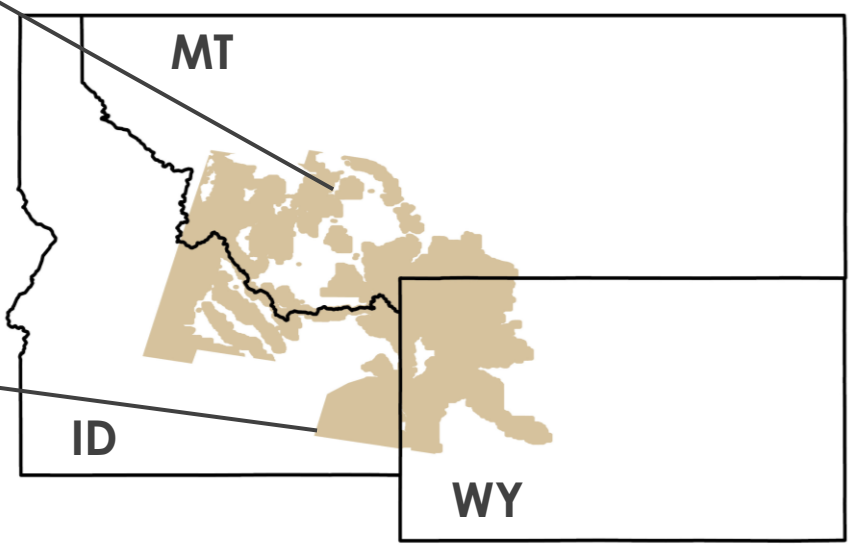
Basemap Credit: ESRI ArcGIS Pro MAXAR, Earthstar Geographics, and the GIS User Community

Study Area:

3 States (WY, ID, MT)
2 National Parks
10 National Forests

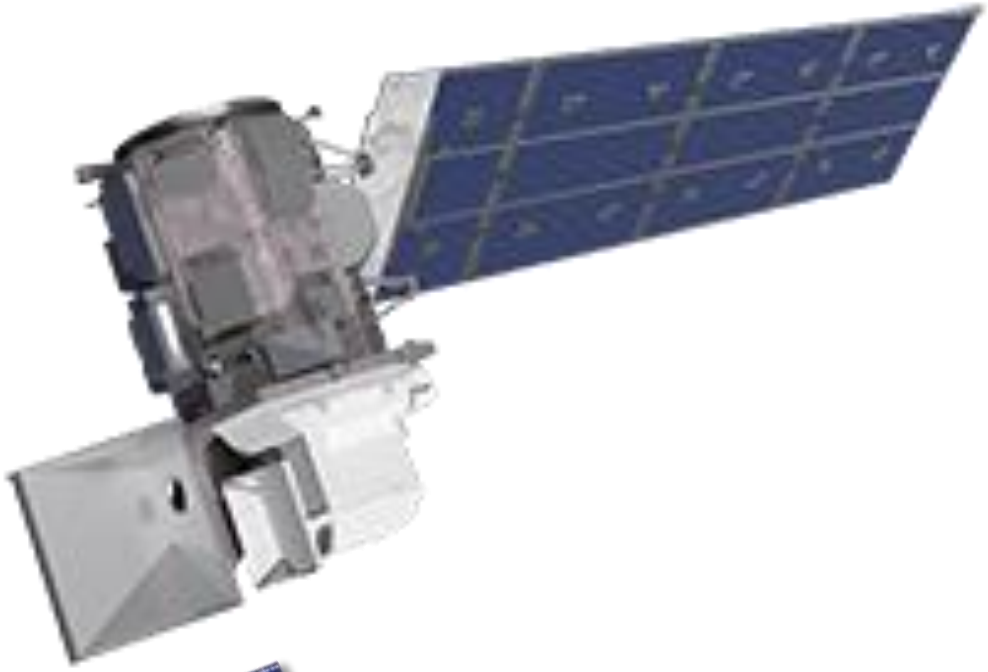
Study Period:

January 2023 - May 2024



Earth Observations

Landsat 9
Operational Land
Imager
(OLI - 2)



Sentinel- 2
Multispectral Imagery
Instrument
(MSI)

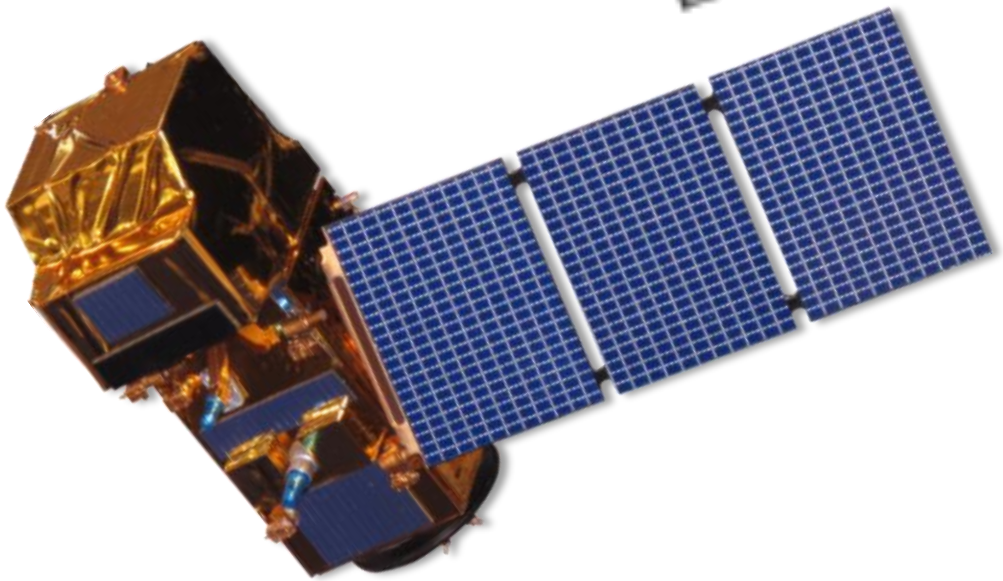


Image credits: NASA

Data Acquisition

Satellite/Sensor	Resolution
Landsat 9 Operational Land Imager (OLI – 2)	Temporal resolution: **16 days** Spatial resolution: **30m**
Sentinel-2 Multispectral Instrument (MSI)	Temporal resolution: **5 days** Spatial resolution: **10m, 20m, 60m**

Image Credit: Diana Renkin

Methods: Habitat Suitability

Predictor Variables

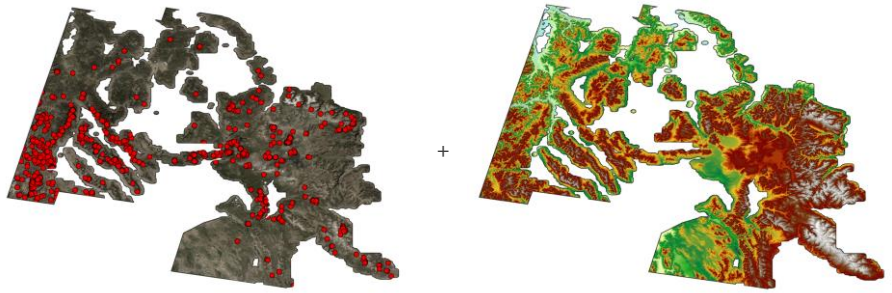
- Elevation
- Slope
- Aspect
- Percent Canopy Cover
- Landcover
- Landsat NDVI

Image Credit: Kait Lemon

Methods: Habitat Suitability Modeling

Occurrences

30m Predictors



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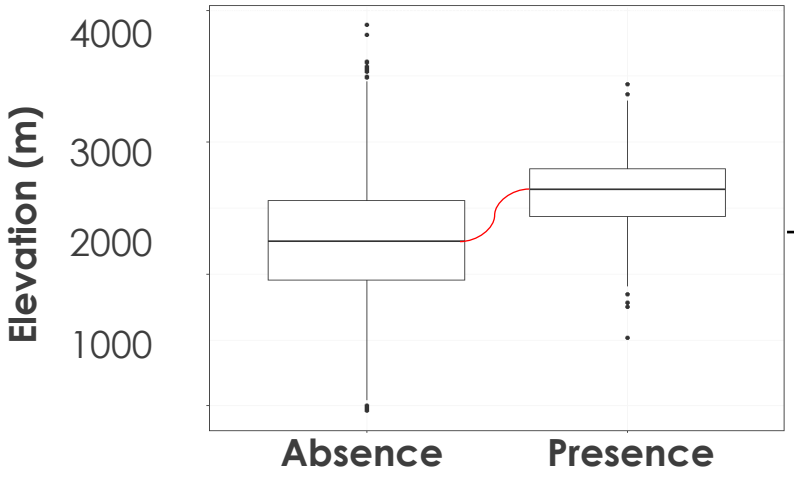
Pseudo-absence Creation

+

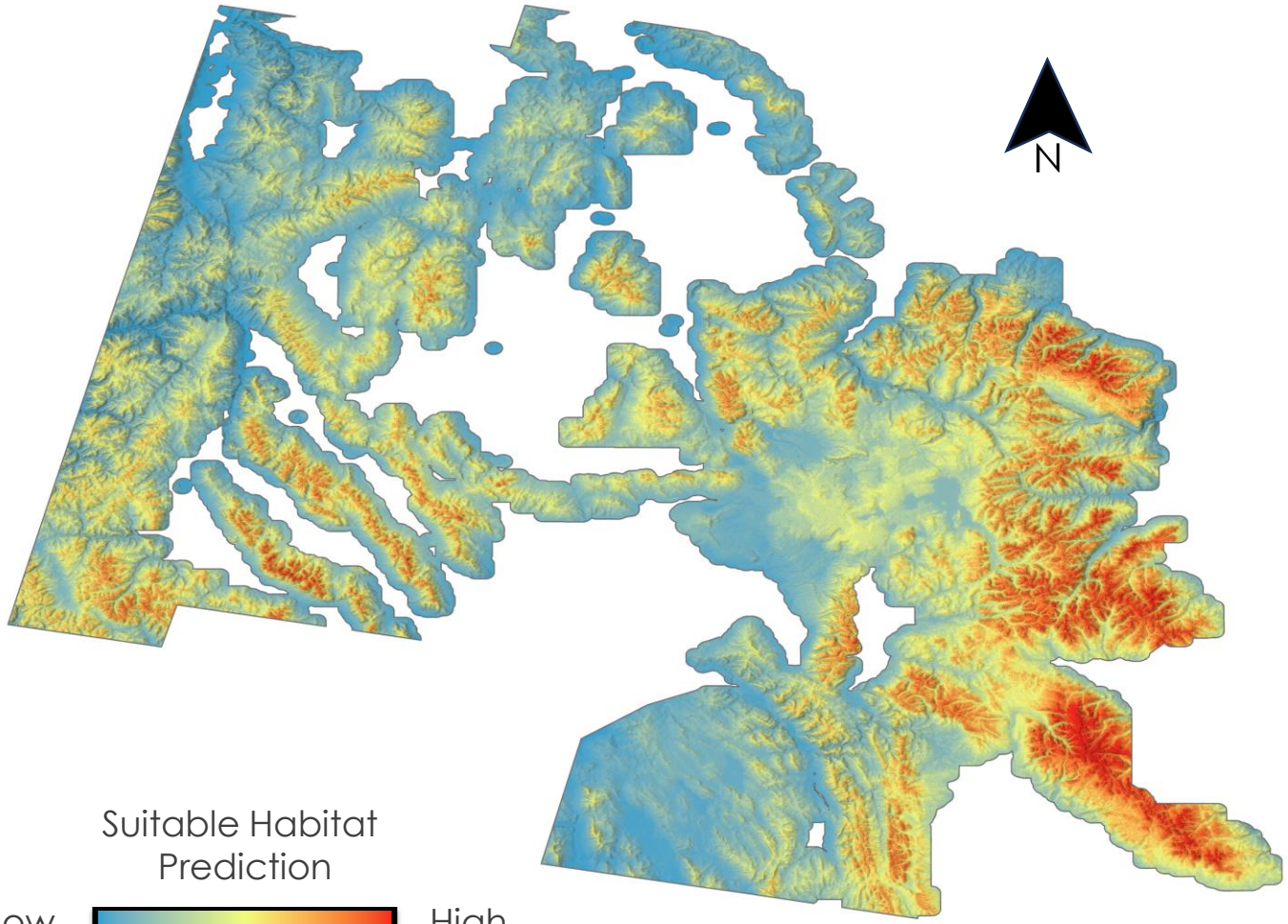
Model Training

+

Generalized Logistic Regression



Spatial Prediction

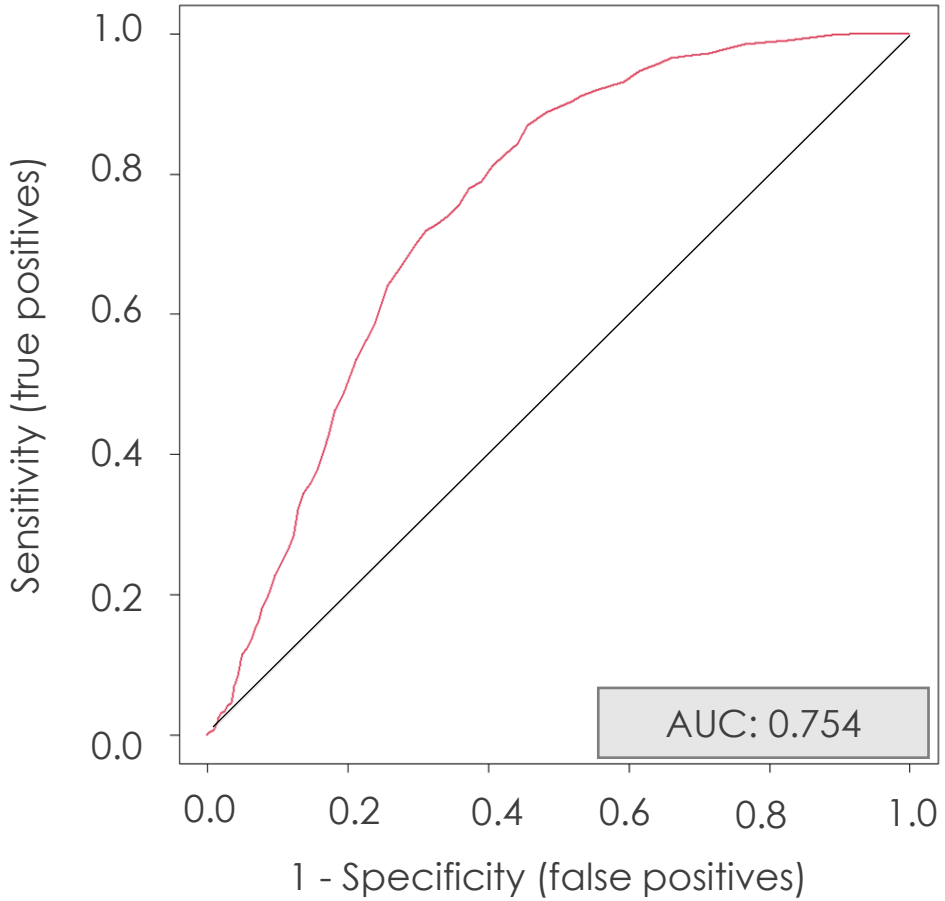


Results: Habitat Suitability Model

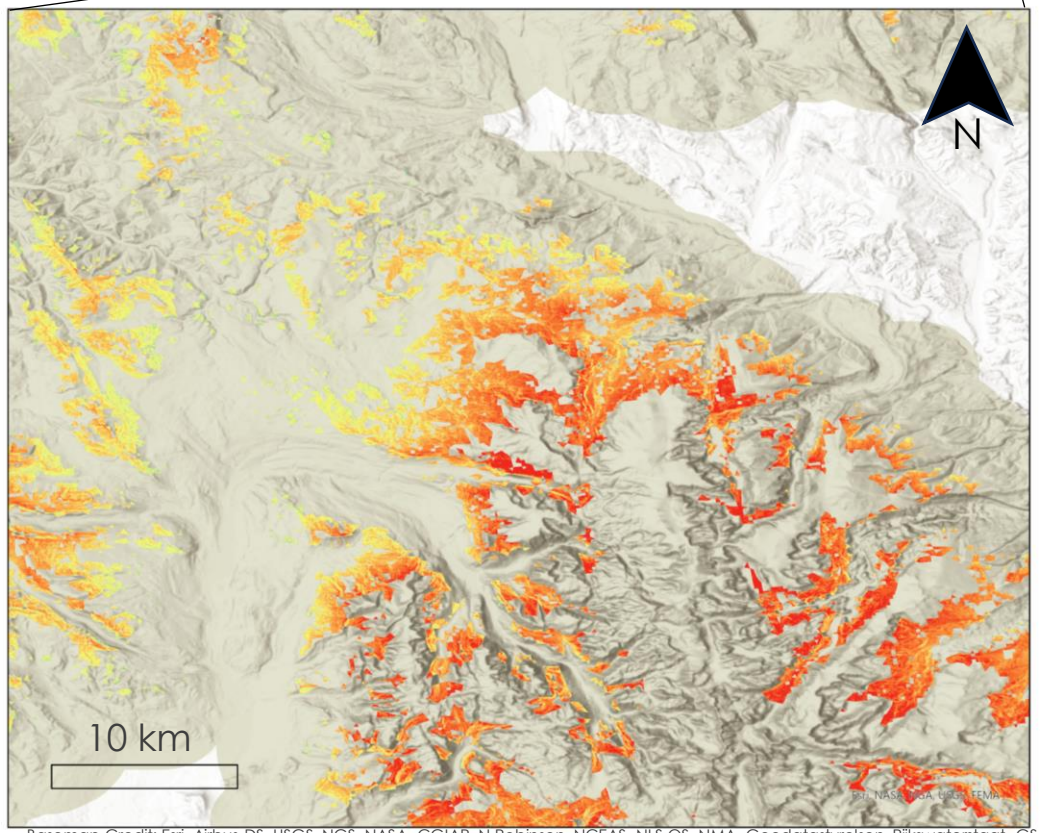
Performance Metrics

- Sensitivity: 0.719 (ability to model suitable locations)
- Specificity: 0.689 (ability to model non-suitable locations)
- Area Under the Curve (AUC): 0.754 (overall model performance – Good!)

A)



B)



Basemap Credit: Esri, Airbus DS, USGS, NGS, NASA, CGIAR, N Robinson, NCEAS, NLS OS, NMA, Geodatastyrelsen, Rijkswaterstaat, GSA Geo, and, FEMA, Intermap and the GIS user community

Methods: Accessibility Model

Habitat Suitability Model
<60% Occurrence Probability

Trail & Roads Data

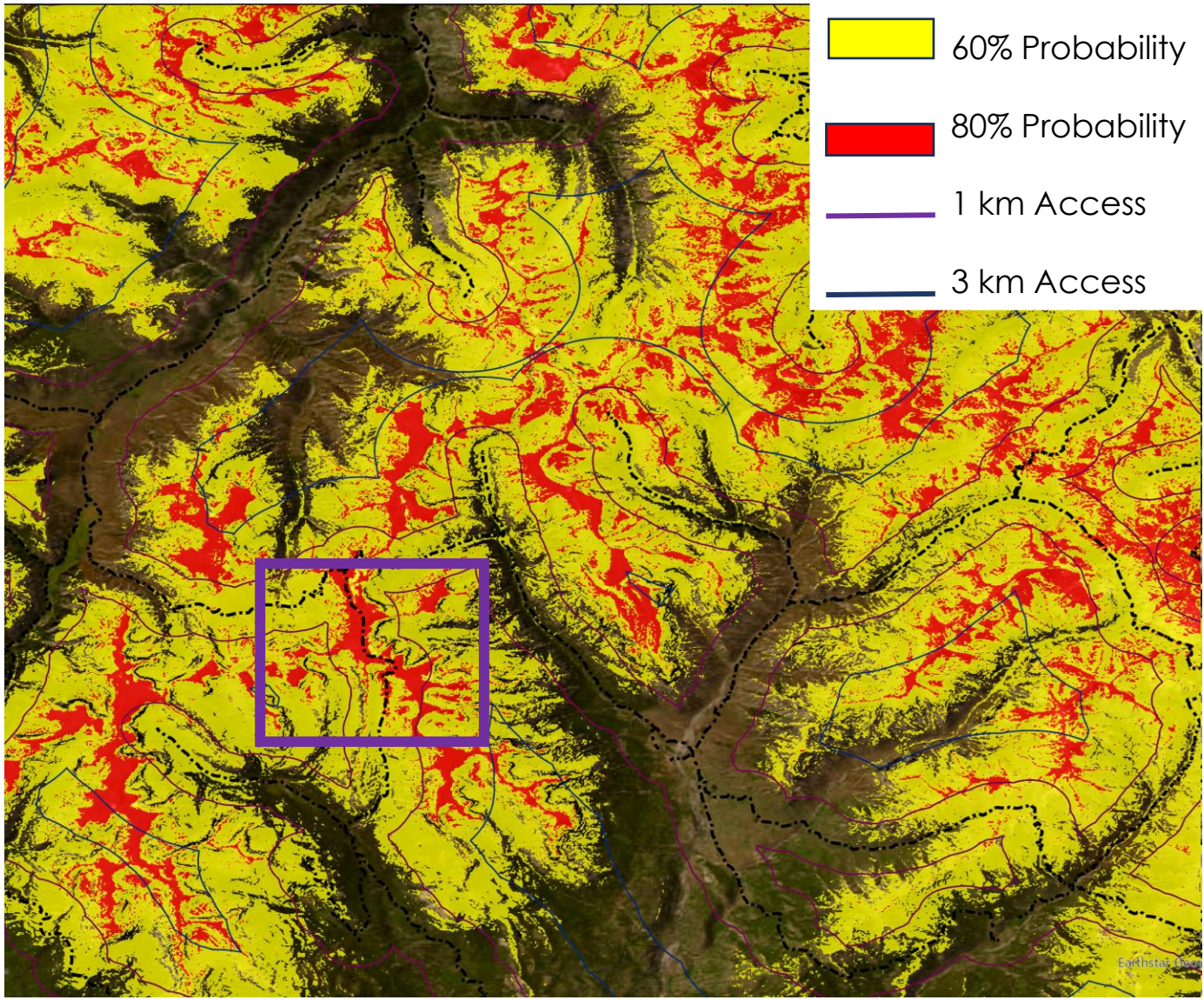
Clip Relevant Roads & Trails

Calculate 1km and 3km Buffer

Image Credit: Kait Lemon

Results: Accessibility Model

- **Whitebark pine is difficult to access** because of its remote high elevation habitat
- **To prioritize areas of conservation,** we used trail, road and land ownership, allowing land managers to prioritize areas based on accessibility
- **Shows high probability areas** for whitebark pine and their distance from trails and roads



Basemap Credit: Esri, TomTom, Gardmin, FAO, NOAA, USGS, OpenStreetMap contributors, and the GIS User Community

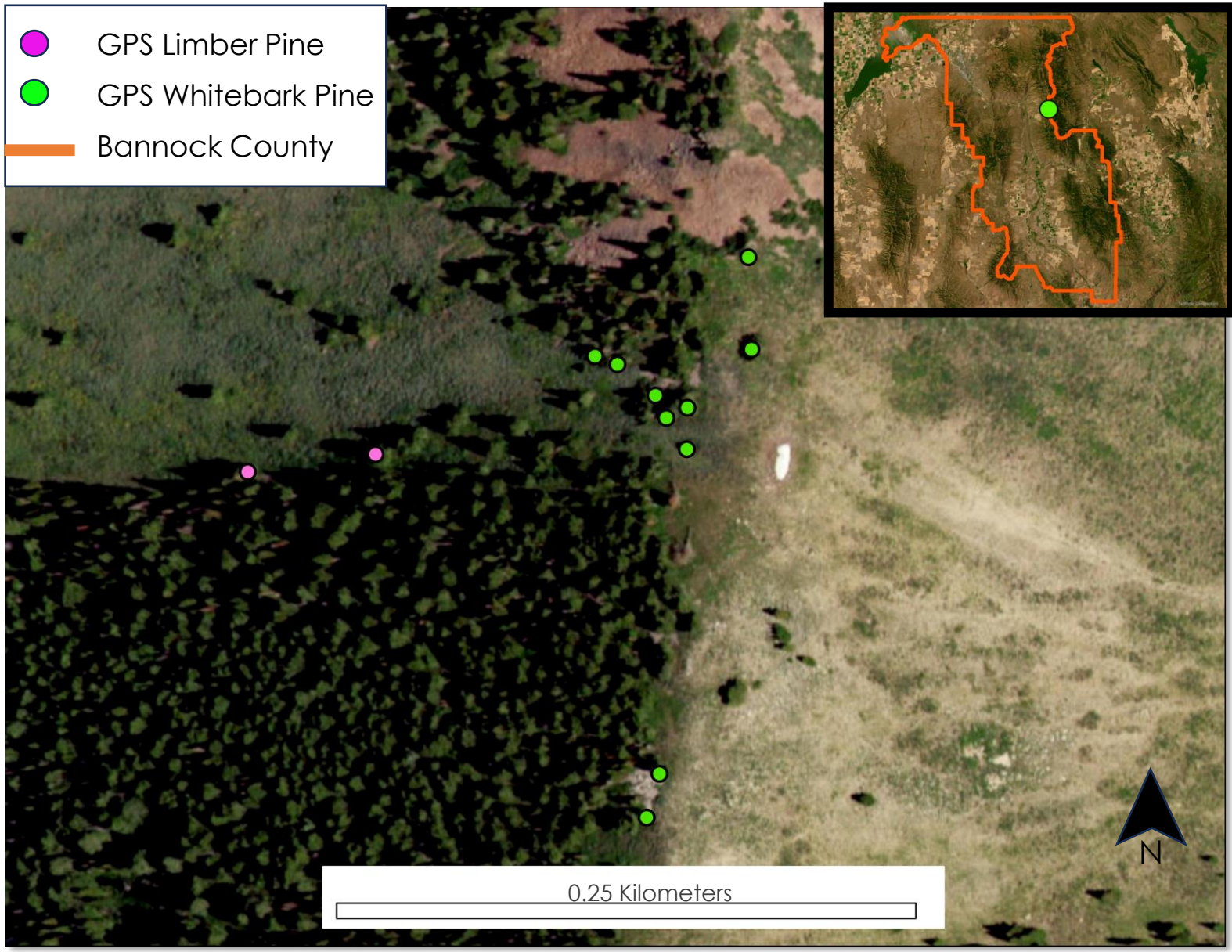
Ground Truth Data Collection

Study Area - Bonneville Peak

ArcGIS Field Maps

Trimble

Dichotomous Key



Basemap: Esri, USDA FSA, Source: Esri, MAXAR, Earthstar Geographics, and the GIS User Community, Esri Community Maps Contributors, OpenStreetMap, Microsoft, Esri, TomTom, Garmin, SafeGraph, Geotechnologies, Inc, METI/NASA, USGS, Bureau of Land Management, EPA, NPS, US Census, Bureau, USDA, USFWS.

Spectral Signature Image & Data Processing

Data Acquisition

Sentinel-2 Image → Google Earth Engine

Image Preprocessing

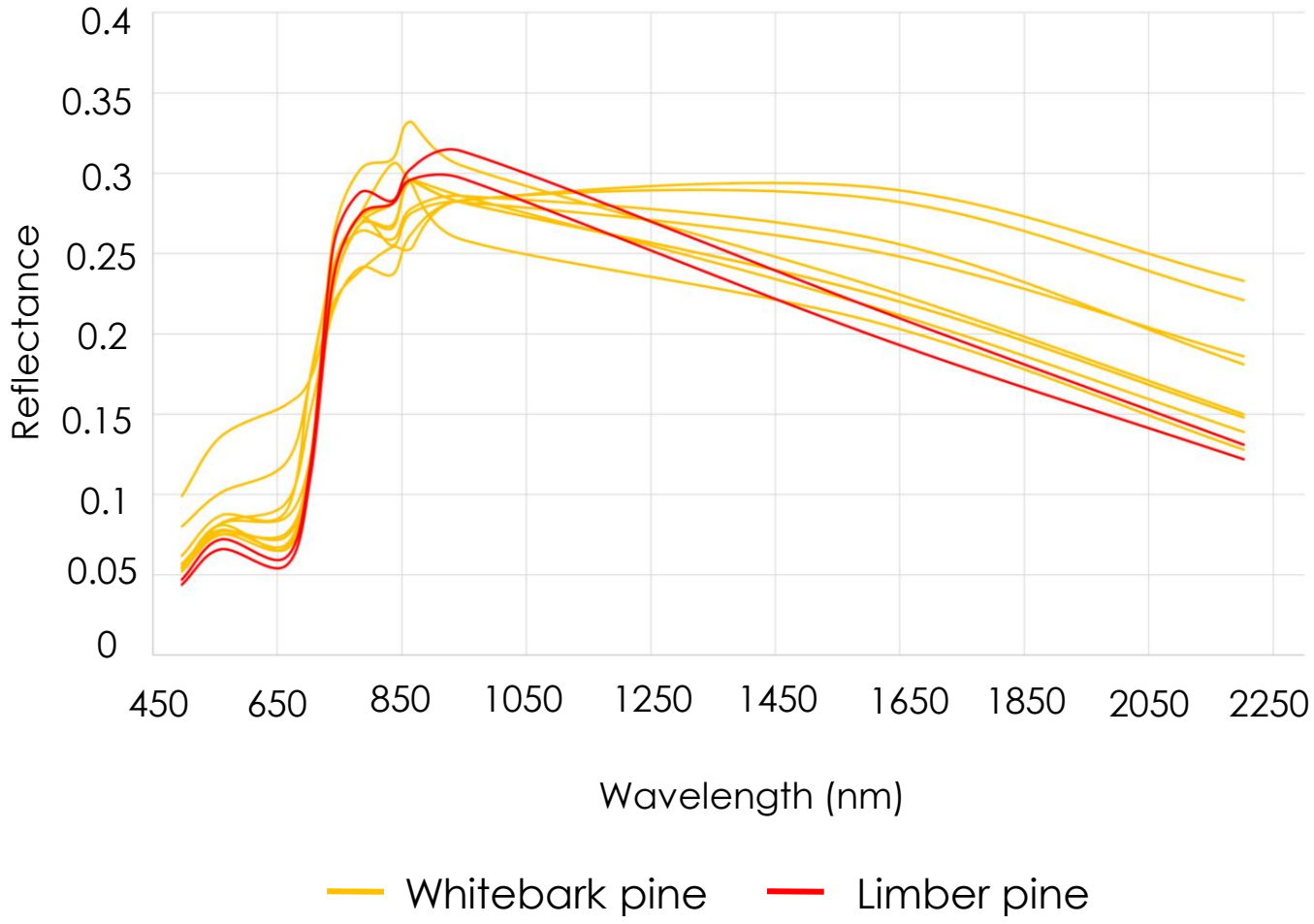
Temporal Filtering → Spatial Filtering → Cloud Masking

Median of Image Collection → Ground Truth GPS WBP → Extract Spectral Signature

Image Credit: Hannah Rogers

Spectral Signature Analysis

- The team collected whitebark pine and limber pine coordinates from the field
- Sentinel-2 MSI derived spectral signatures indicates that **average spectral reflectance of whitebark pine is higher than limber pine** in Visible (VIS) and Short-wave Infrared (SWIR) region.



Preliminary Distribution Model

Area of Interest

Sentinel-2 Imagery

Calculate NDVI → Calculate EVI

Load DEM Raster Set → Classify regions of interest

Extract All Spectral Signatures → Random Forest Model

Calculate Confusion Matrix → Visual Validation

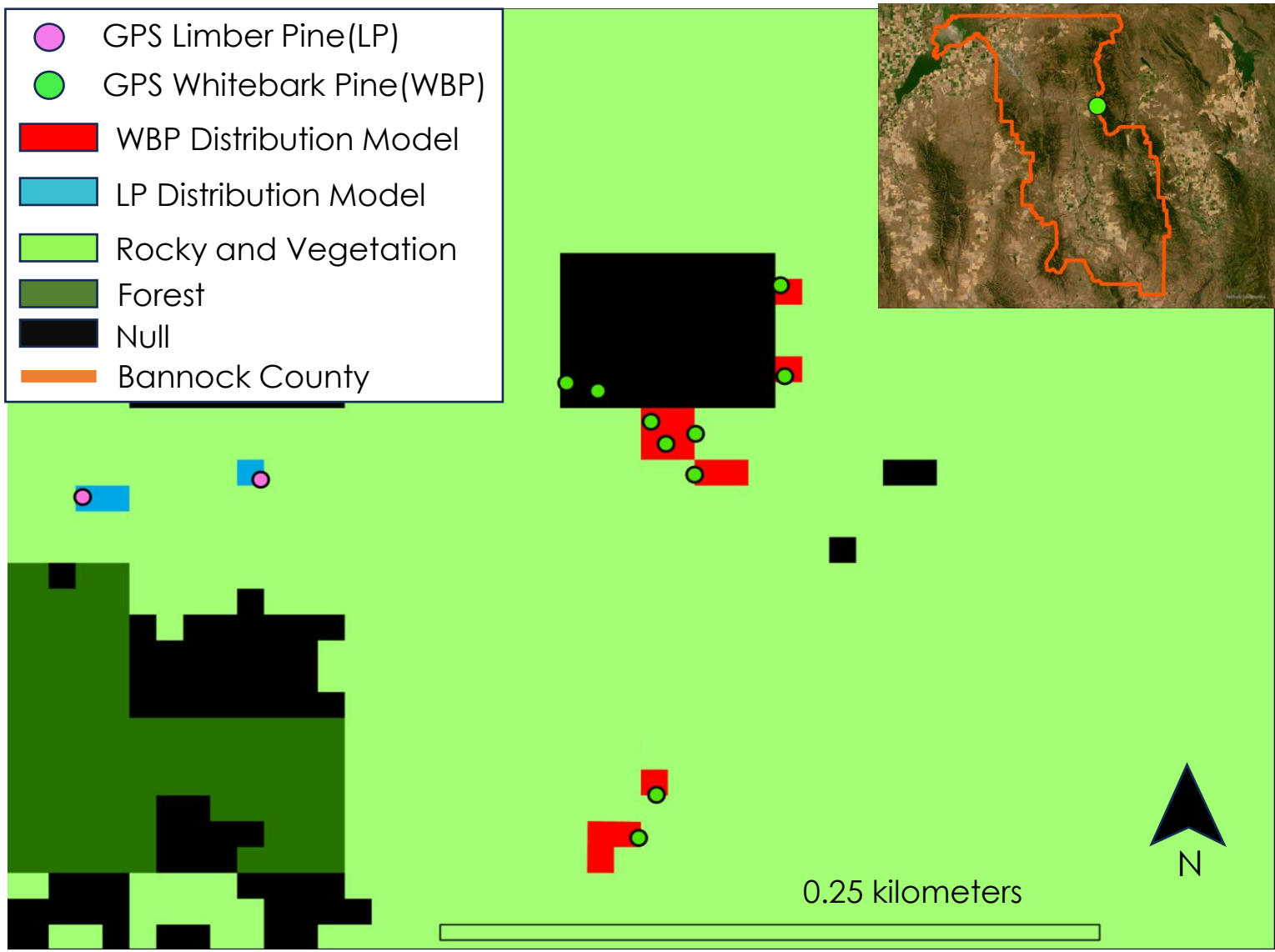
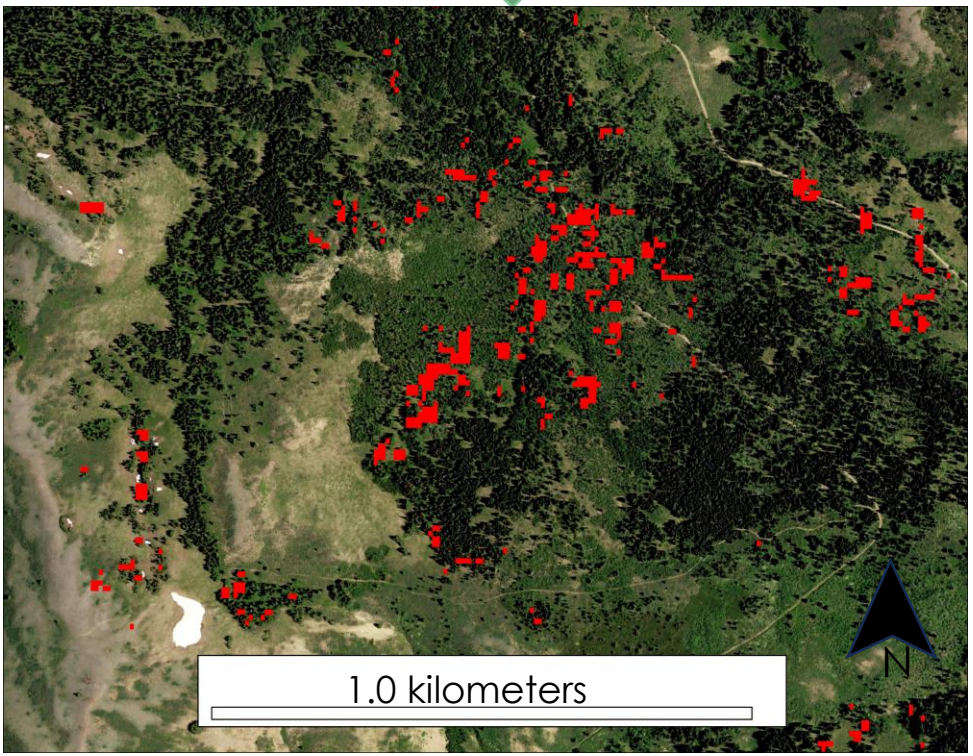


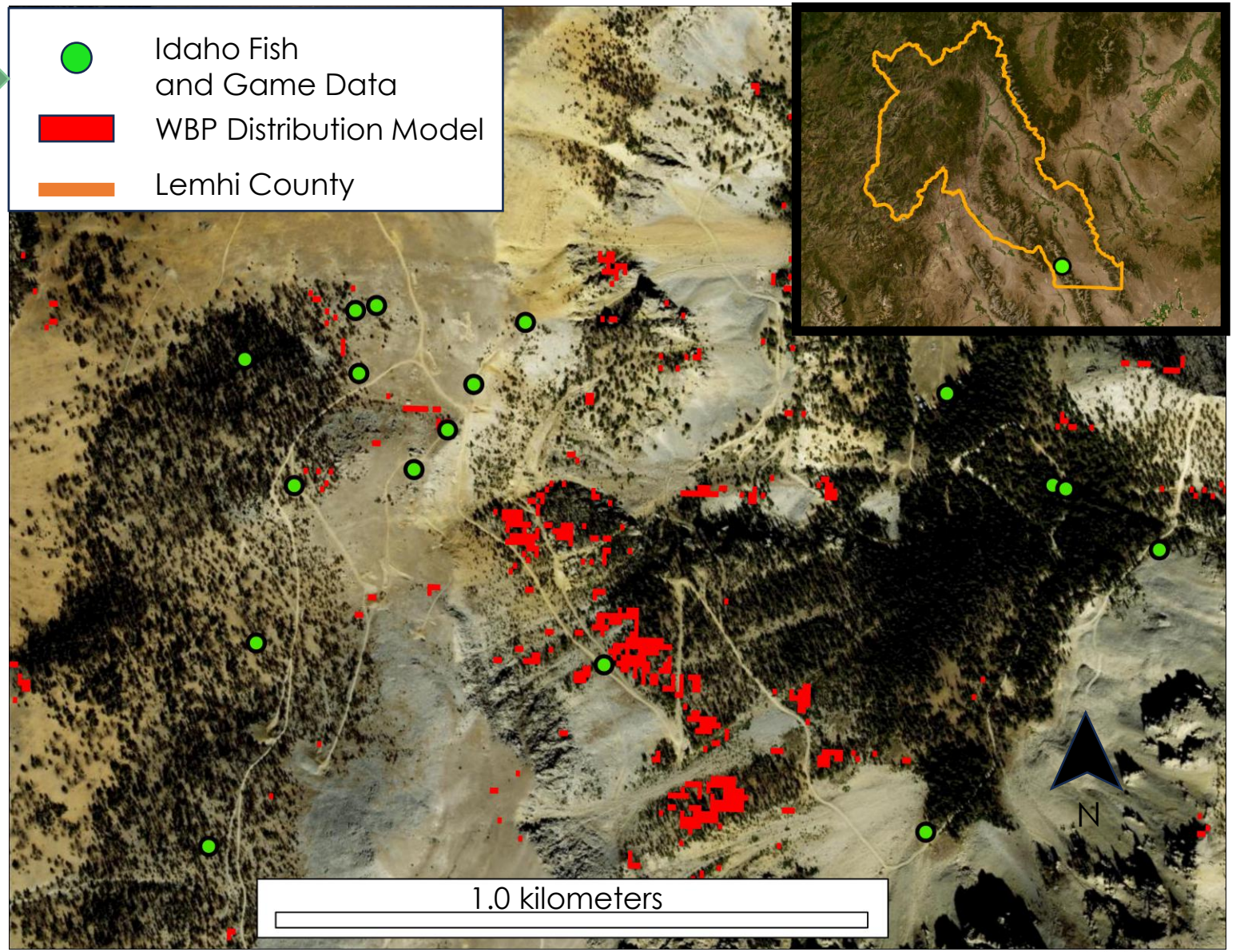
Image left and image rirght - Basemap: Esri, USDA FSA, Source: Esri, MAXAR, Earthstar Geographics, and the GIS User Community, Esri Community Maps Contributors, OpenStreetMap, Microsoft, Esri, TomTom, Garmin, SafeGraph, Geotechnologies, Inc, METI/NASA, USGS, Bureau of Land Management, EPA, NPS, US Census, Bureau, USDA, USFWS.

Preliminary Visual Validation

Spring Mountain Canyon - Idaho

Caribou-Targhee National Forest





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Errors and Uncertainty

- We did not have enough accurate whitebark pine coordinates to **validate** the model

- To ensure the distribution model's accuracy and achieve higher classification precision, we need a **substantial number of ground truth observations per species** for statistical validation

Image Credit: Hannah Rogers

Limitations & Future Work: Spectral Signature

- The differences between spectral signatures of whitebark pine and limber pine **shows the feasibility of classifying tree species**

- **Finer spatial and temporal resolution** of Maxar Worldview (~1m; 1.1 day) provide accurate species classification than Sentinel-2 MSI (10m - 60 m; 5 days) using spectral signatures. Hence, extensive use of Maxar worldview should be incorporated in validation approach

Image Credit: Hannah Rogers

Limitations: Habitat Suitability

- Models have **bias**
  - Additional models may provide insight into habitat suitability
- Habitat suitability models are meant to be **updated**
  - Additional occurrence records
  - Additional predictor variables
- Habitat suitability models are meant to be **expanded**
  - They can predict across landscapes including locations where whitebark pine occurrence is unknown

Image Credit: Hannah Rogers

Conclusions

- The differences between spectral signatures of whitebark pine and limber pine shows the feasibility of classifying tree species
- Additional models such as Random Forest, Gradient Boosting Machine, etc., working in conjunction with the generalized linear model may provide further insights into whitebark pine habitat suitability
- Future development of downscaled climate, soil, and topographic predictor variables and the addition of new occurrence records will improve habitat suitability model's predictive power

Image Credit: Kait Lemon

Acknowledgements

- **Dr. Keith Weber** - Idaho State University | GIS Director & NASA DEVELOP Science Advisor
- **Joe Spruce** - NASA DEVELOP | Science Advisor
- **Julee Shamhart** - Executive Director | Whitebark Pine Ecosystem Foundation
- **Kait Lemon** - NASA DEVELOP ID | Pocatello Fellow
- **Dr. Chris Earle** - Wildlife Biologist | The Gymnosperm Database
- **Dr. Dianna Tomback** - University of Colorado, Denver | Department of Integrative Biology
- **Jim Strickland** – Botany Director | Idaho Fish and Wildlife

Image Credit: Kait Lemon