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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Idaho — Pocatello | Summer 2024

DEVELOP

Meet The Team

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Background

Whitebark pine is a Keystone and Foundational Species

Food Provision - Clark's Nutcrackers

Food Provision - Grizzly Bears

Food Provision - Red Squirrels

Ecological Facilitation

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

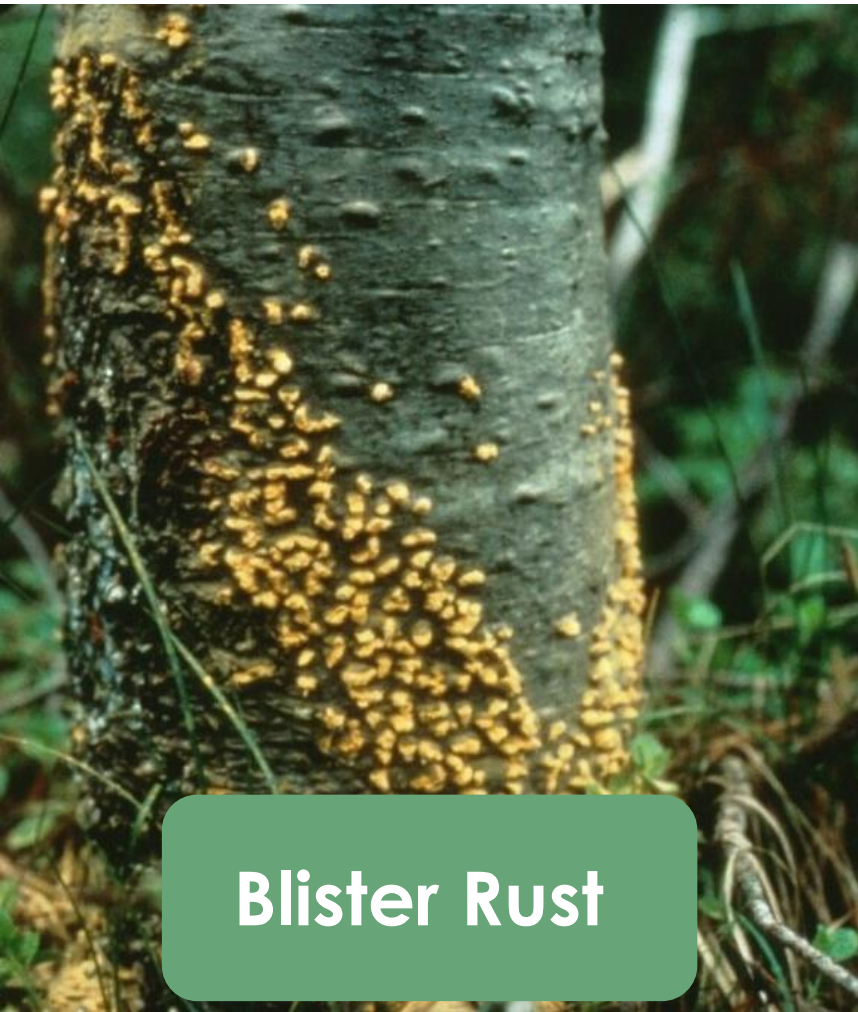**US Fish & Wildlife Service, Montana Ecological Services Field Office**

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

Blister Rust

Pine Beetle Outbreaks

Ecosystem Collapse

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
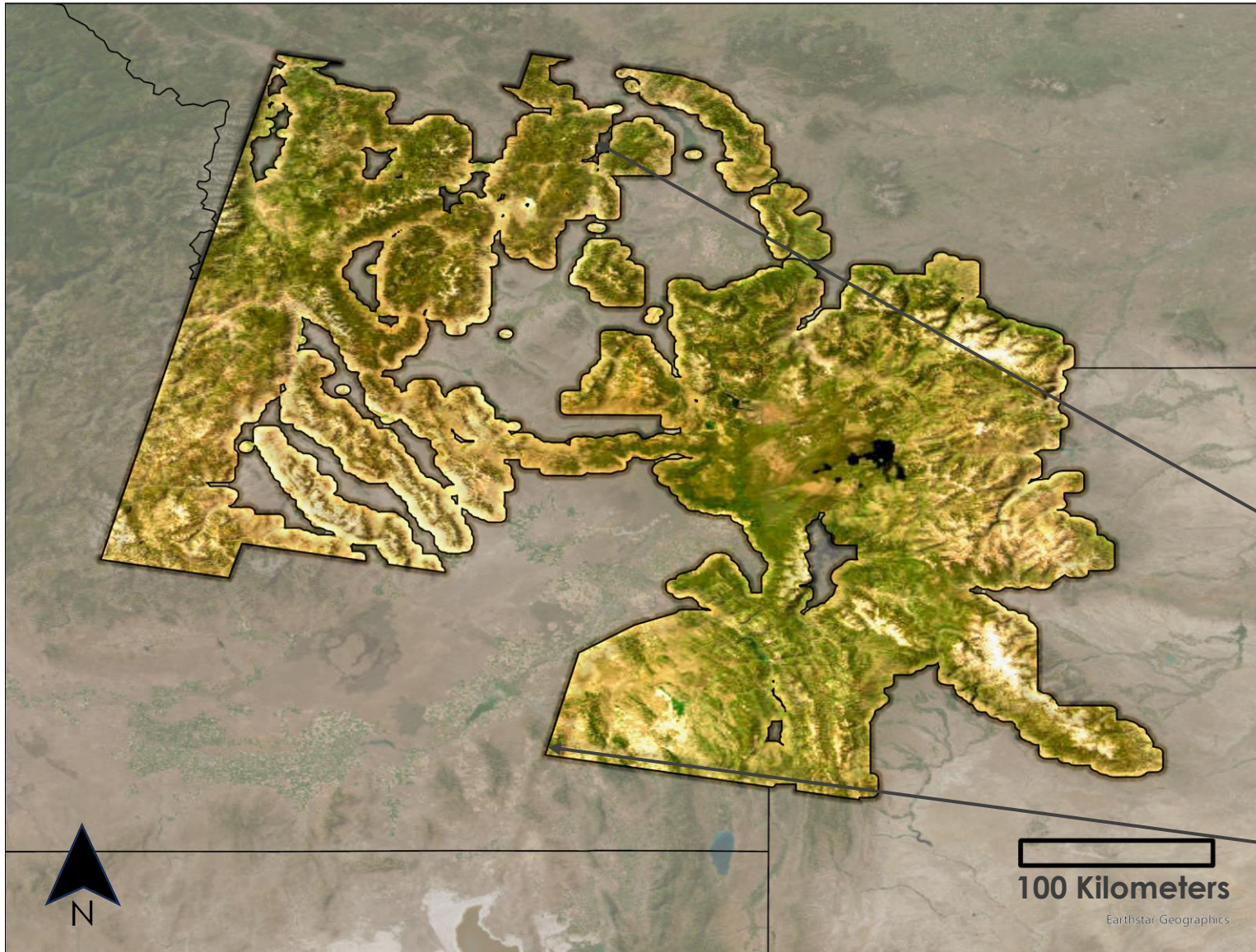
3 **Generate** Habitat Suitability Model

4 **Develop** Accessibility Model

Image Credit: Jim Morefield
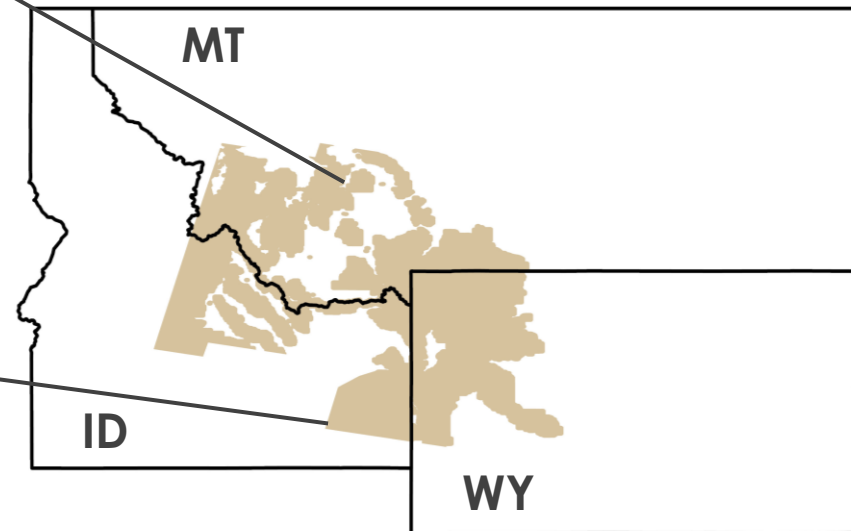
Study Area & Period

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

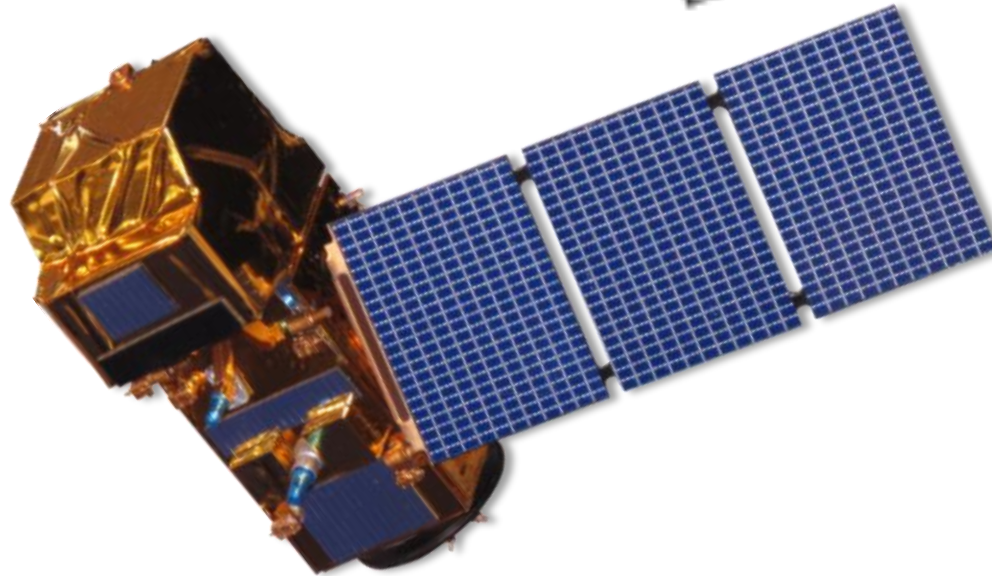**Study Period:**
  January 2023 - May 2024

100 Kilometers

N

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

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

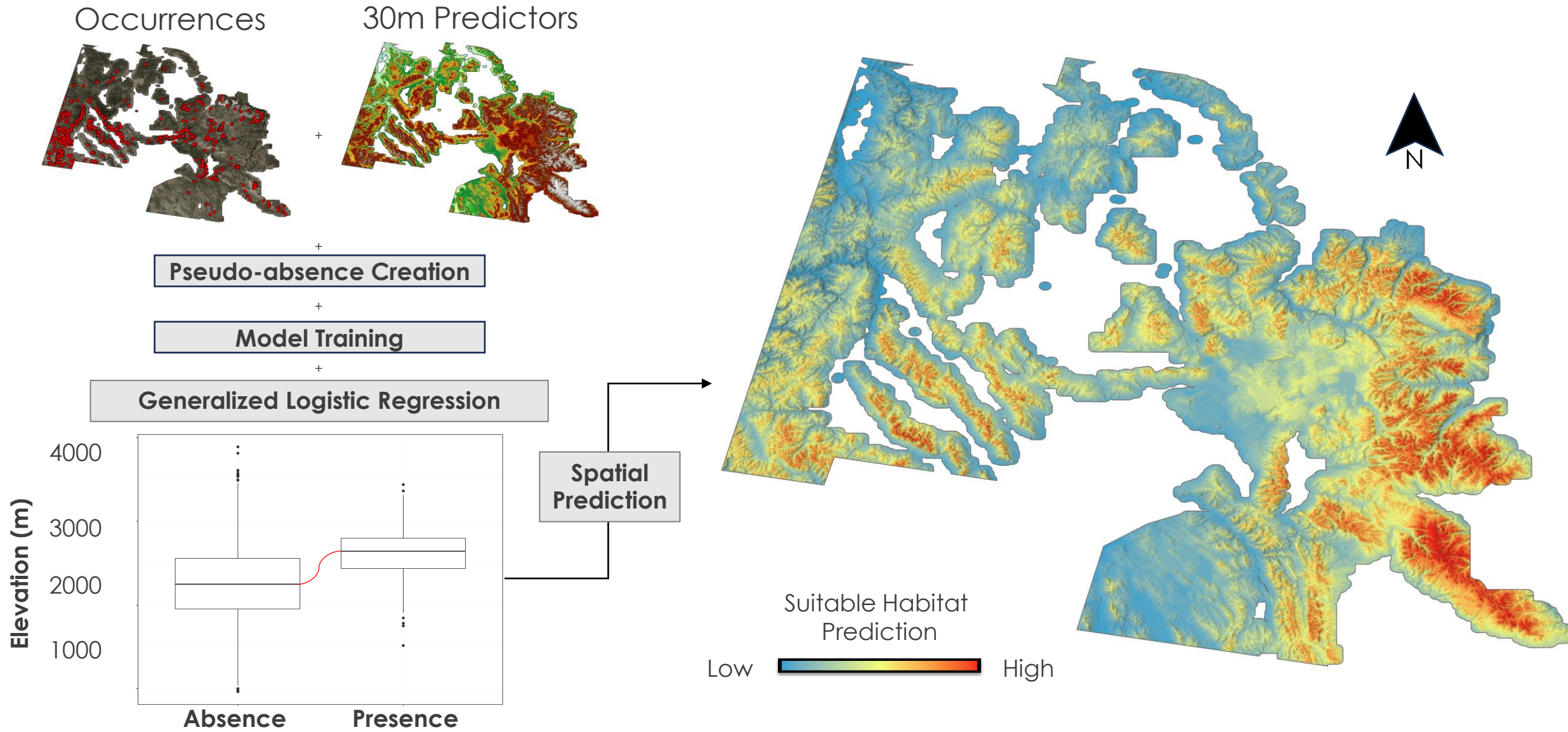## Predictor Variables

Elevation

Percent Canopy Cover

Slope

Landcover

Aspect
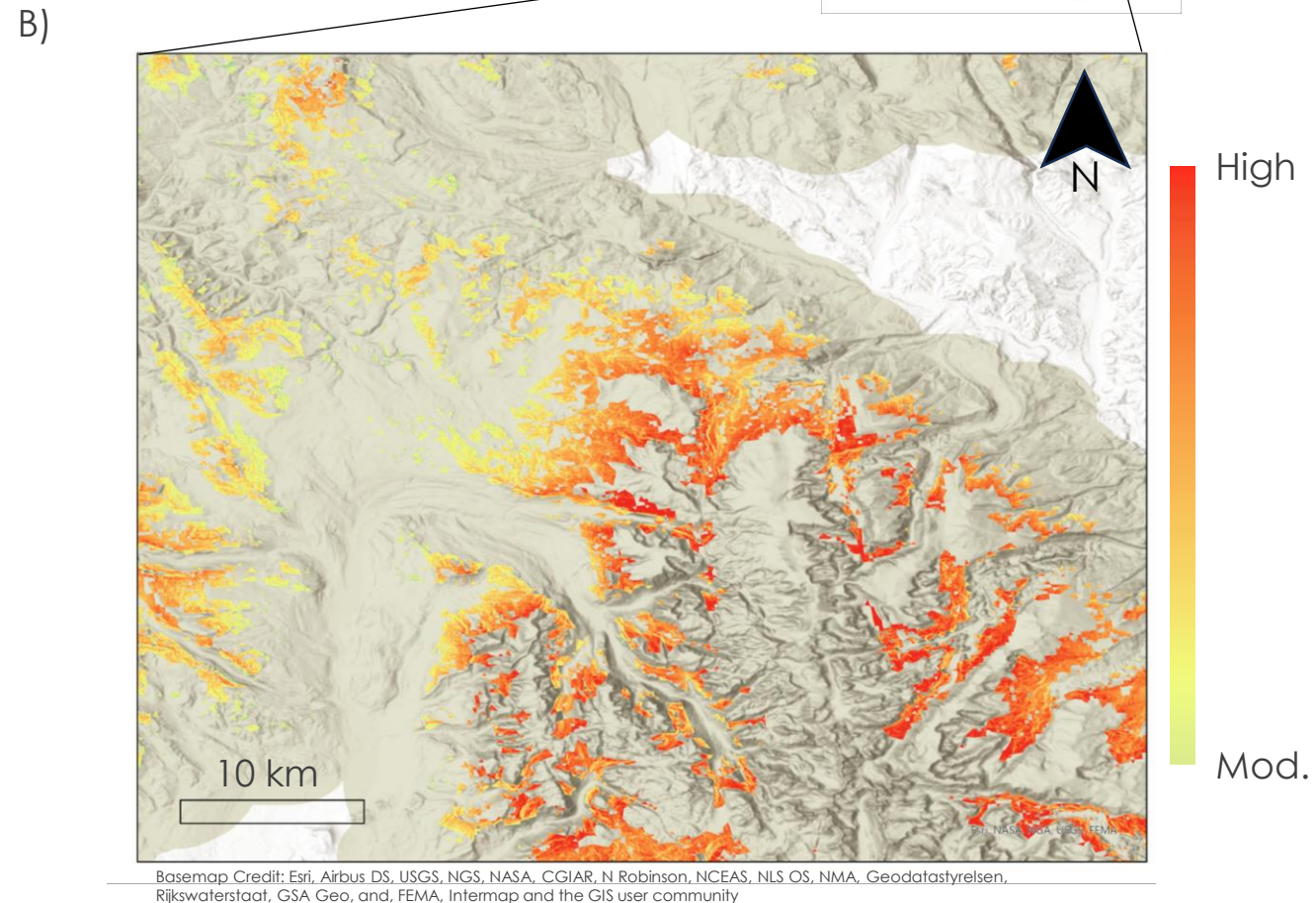
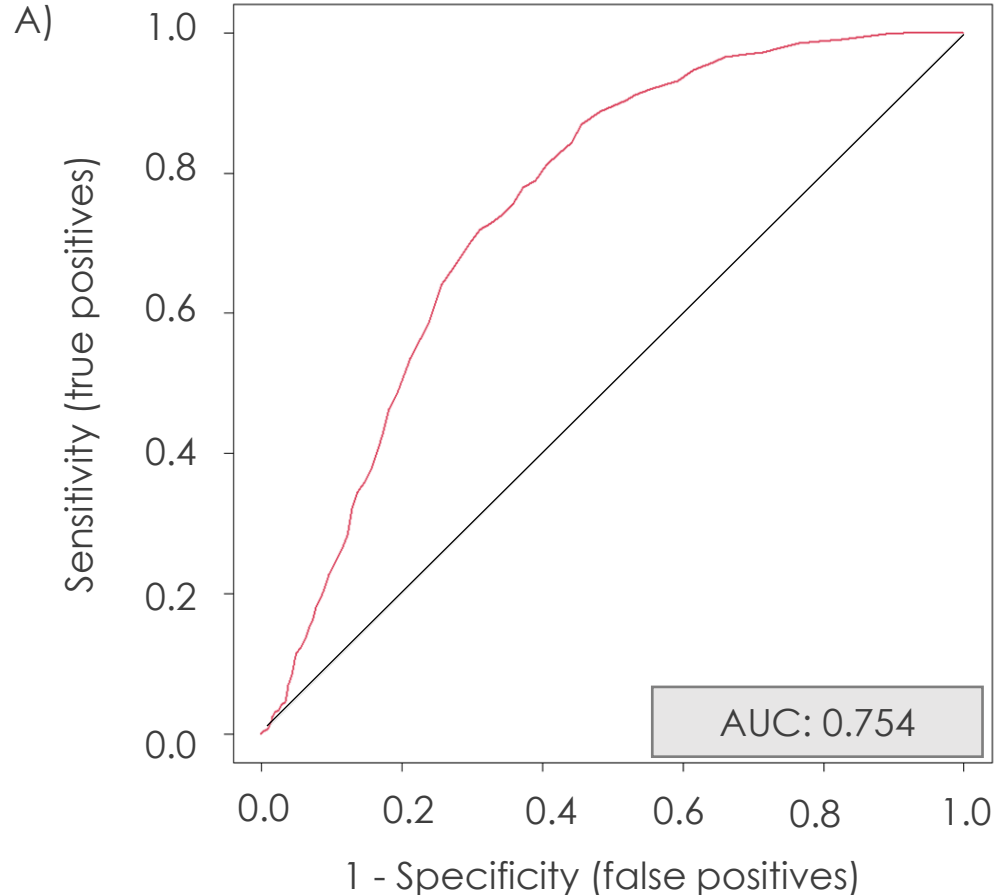Landsat NDVI

Image Credit: Kait Lemon

Methods: Habitat Suitability Modeling

Occurrences

30m Predictors

+

Pseudo-absence Creation

+

Model Training

+

Generalized Logistic Regression

Spatial Prediction

Elevation (m)

4000

3000

2000

1000

Absence   Presence

Suitable Habitat
Prediction

Low   High

N

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)

AUC: 0.754

Sensitivity (true positives)

1 - Specificity (false positives)

High

Mod.

10 km

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
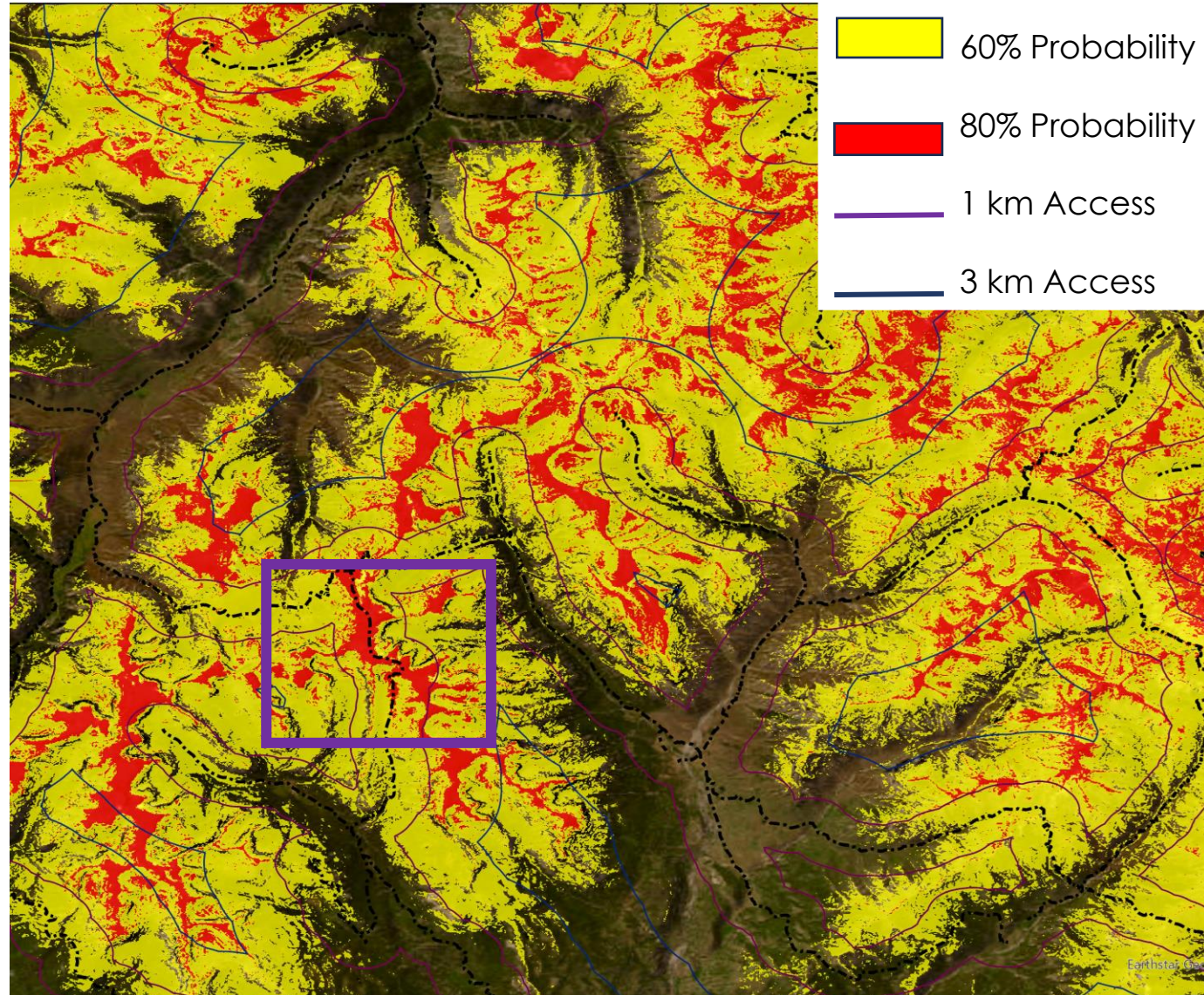
↓

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

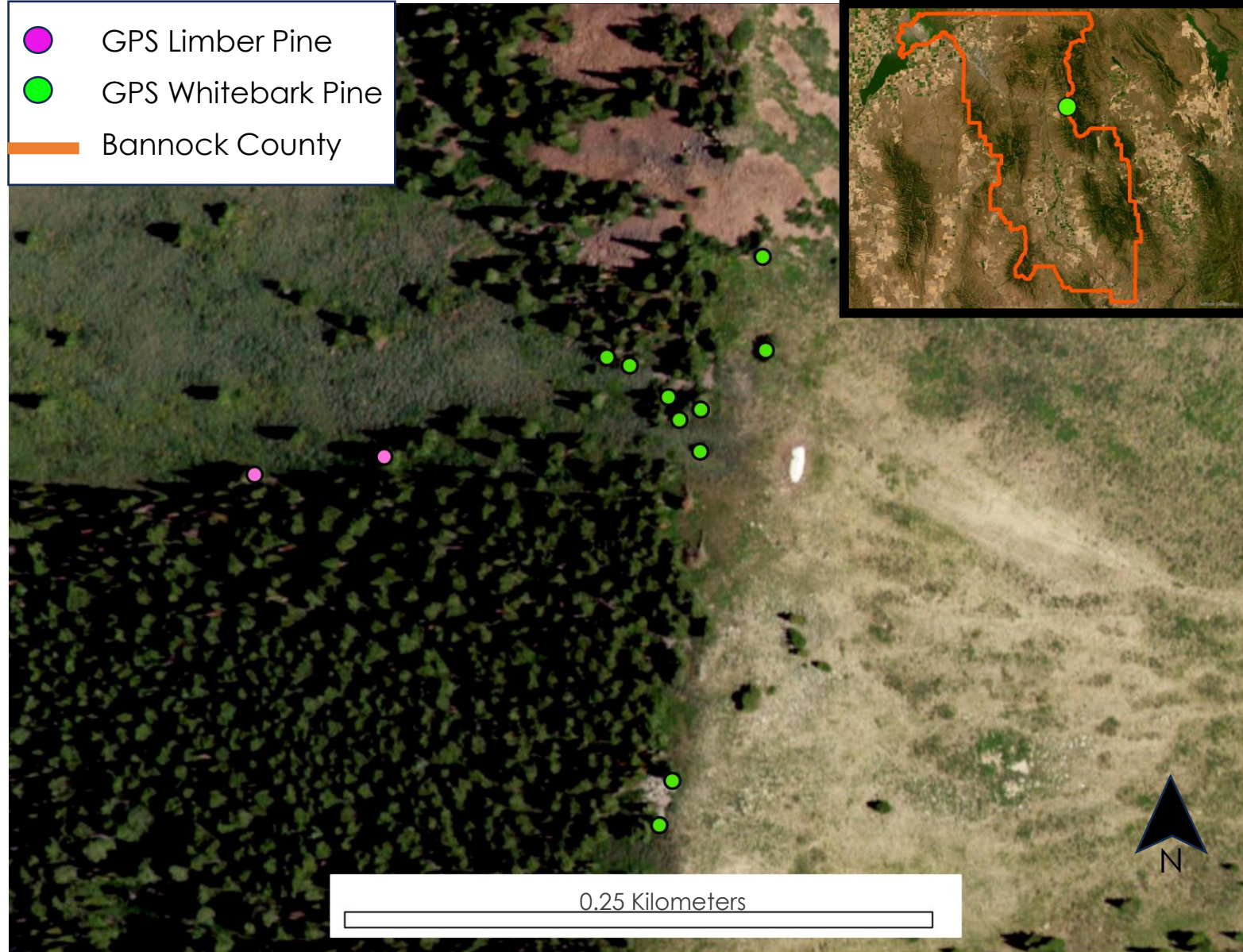- **Shows high probability areas** for whitebark pine and their distance from trails and roads

60% Probability

80% Probability

1 km Access

3 km Access

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

Legend:
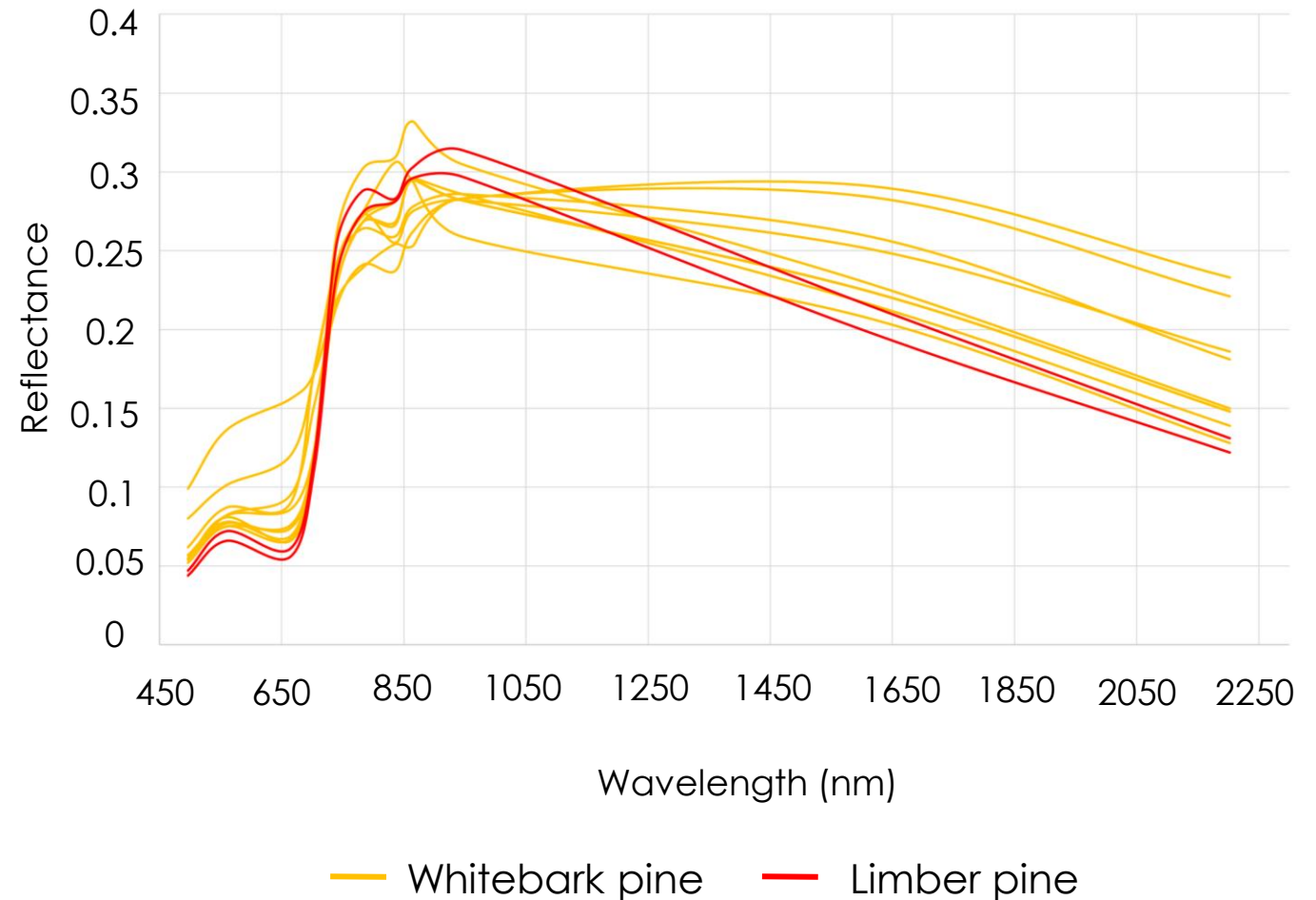- ● GPS Limber Pine
- ● GPS Whitebark Pine
- — Bannock County

0.25 Kilometers

N
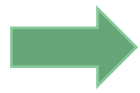
Image Credit: Hannah Rogers

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.
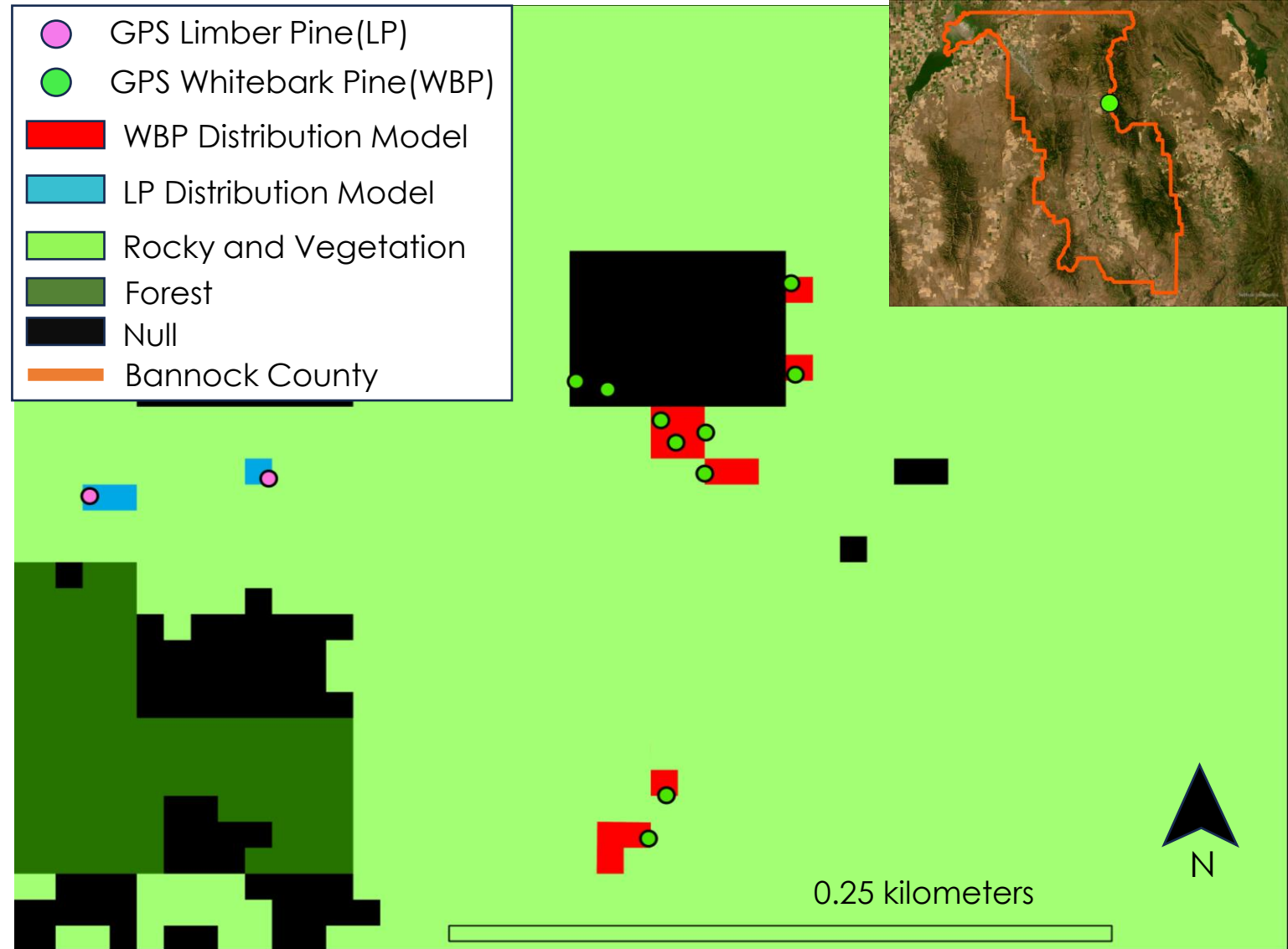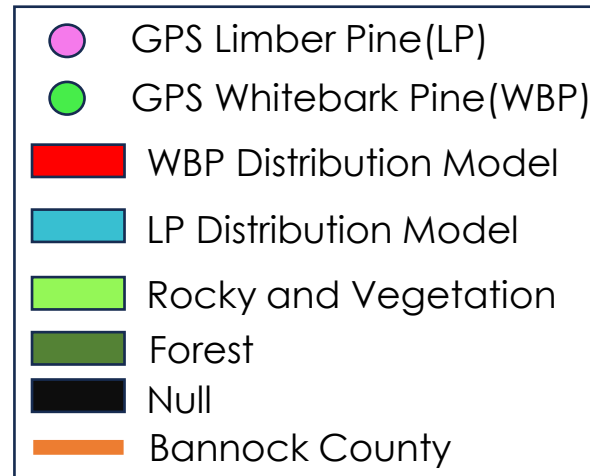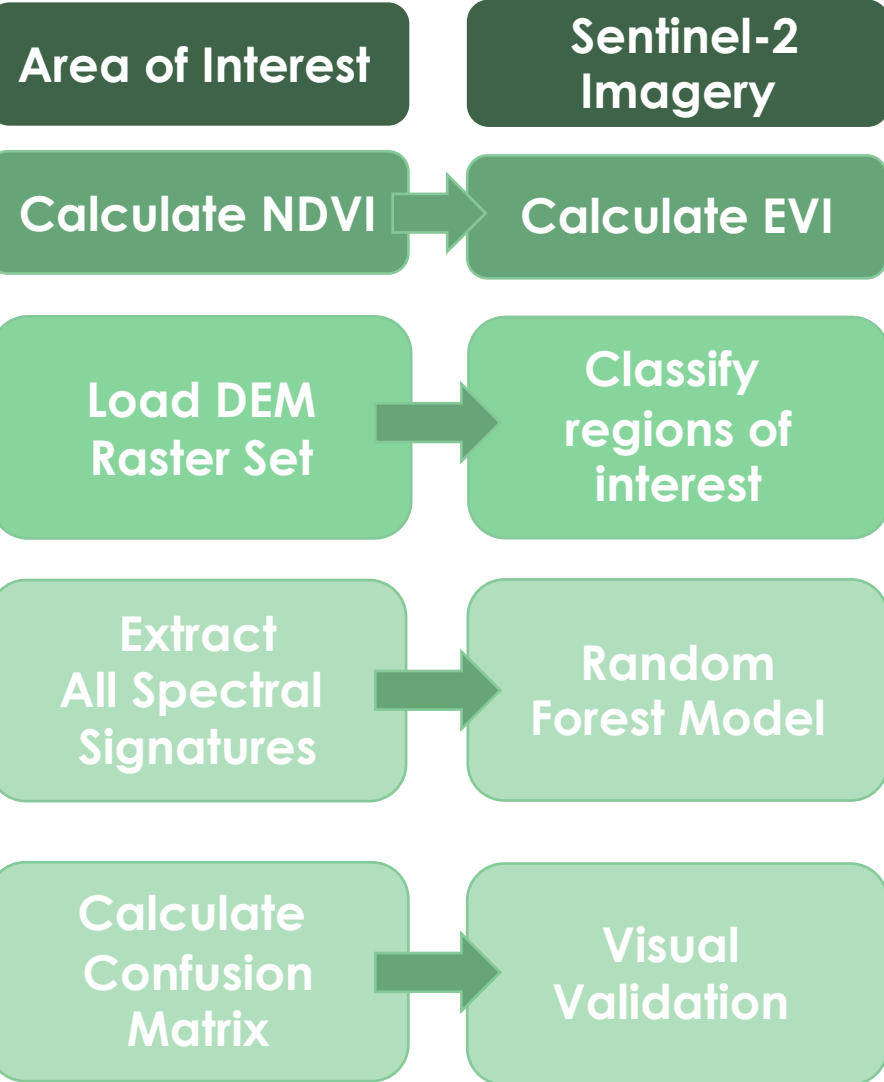

Whitebark pine   Limber pine

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

Legend:
- GPS Limber Pine(LP)
- GPS Whitebark Pine(WBP)
- WBP Distribution Model
- LP Distribution Model
- Rocky and Vegetation
- Forest
- Null
- Bannock County

0.25 kilometers

N

Preliminary Visual Validation

Spring Mountain Canyon - Idaho

Caribou-Targhee National Forest
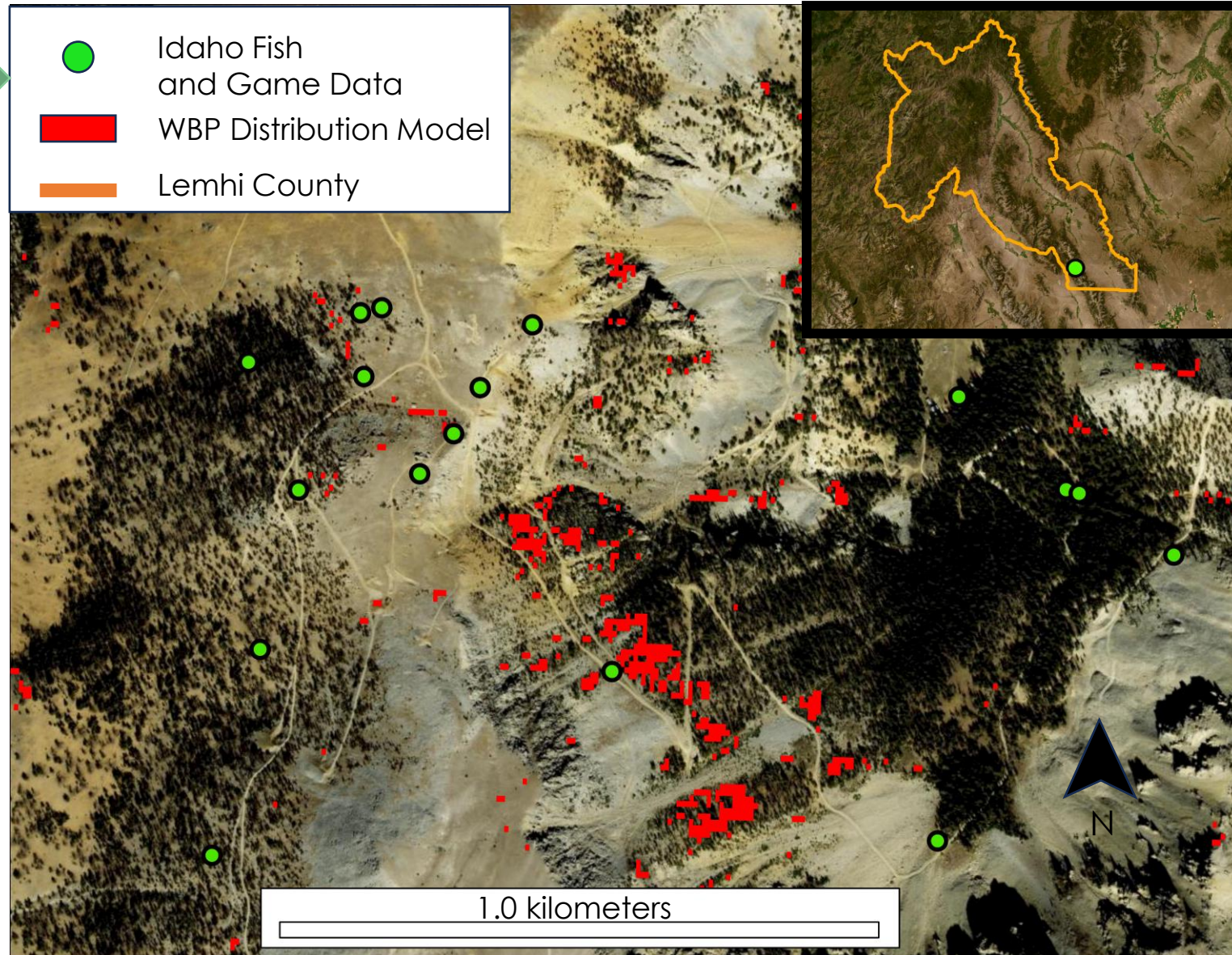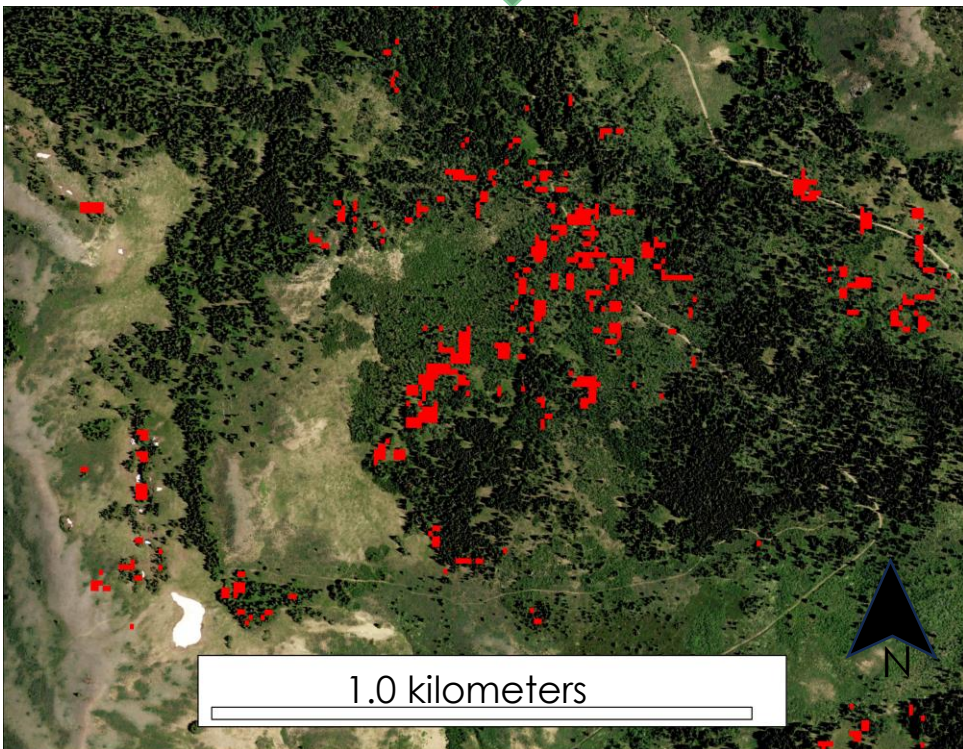
Legend:
- 🟢 Idaho Fish and Game Data
- 🟥 WBP Distribution Model
- ▬ Lemhi County

1.0 kilometers

1.0 kilometers

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
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- **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