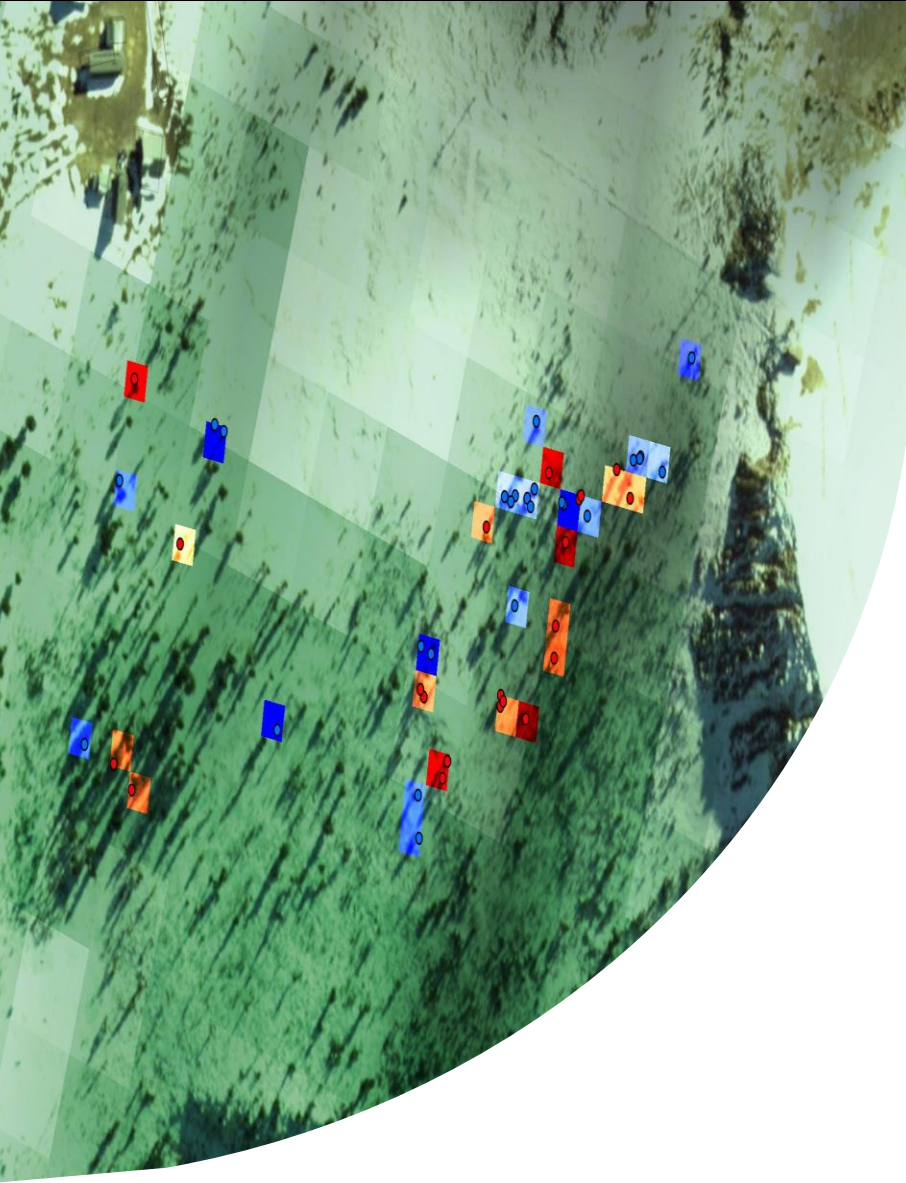




National Aeronautics and  
Space Administration



## Northern Rockies Ecological Conservation II

Determining the Distribution of Whitebark Pine in the Intermountain West Through Spectral Signature Classification to Assess Forest Health Within the Region

Dustin Corbridge, Nicholas Cramer,  
Genevieve Harman, Benjamin Shostak, Anna  
Thario (Analytical Mechanics Associates)

Idaho – Pocatello | Spring 2025



# Whitebark Pine



Image credit: Genevieve Harman

A **keystone species** in montane and subalpine ecosystems



Image credit: Dustin Corbridge

**Uniquely adapted** to thrive in harsh environments



Image credit: U.S. Forest Service, Flathead NF

Listed as **Federally Threatened** in 2023



# Concerns

## Mountain pine beetle outbreaks



Image credit: U.S. Forest Service

## White pine blister rust



Image credit: Genevieve Harman

## Wildland fire



Image credit: Rand Snyder





Image credit: Nelson Mills, Sawtooth NRA. WBP planting project.

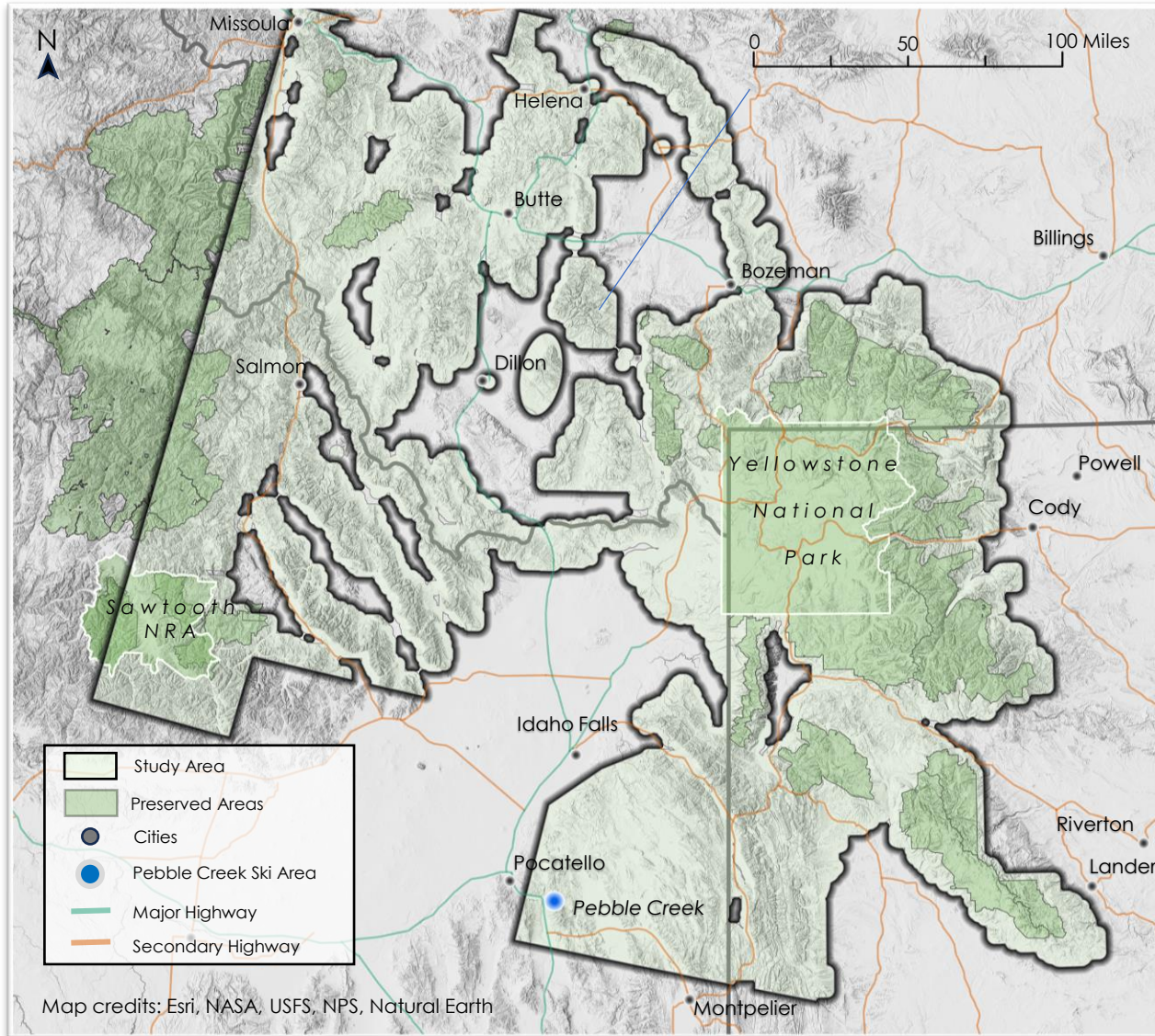
# Partners



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



# Study Area: Northern Rockies

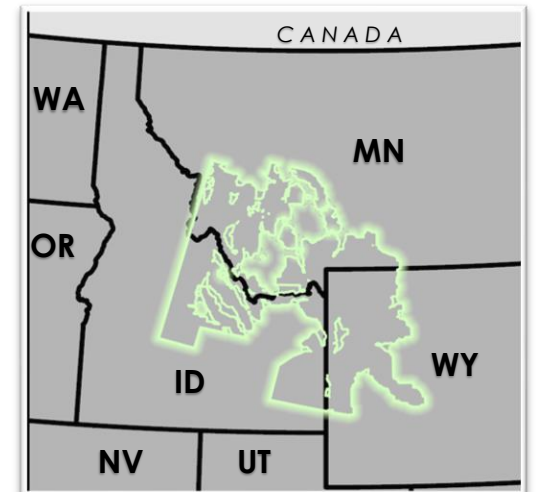


## Study Area

- 123,328 km<sup>2</sup> of montane and subalpine ecosystems
- Idaho, Montana, and Wyoming
- WBP points collected at:
  - Yellowstone National Park (NP)
  - Sawtooth National Recreation Area (NRA)
  - Pebble Creek Ski Area

## Study Period

April – September 2024





# Objectives

## Analyze WBP's Spectral Signature

Model WBP using satellite imagery and spectral signature analysis

## Develop Distribution Modeling Framework

Standardize methods for landscape management

## Create Field Maps Template

Template for accurate WBP population reporting

Term 1 DEVELOP participants collecting WBP data for later model construction.  
Image credit: Dustin Corbridge



# Earth Observations



**Landsat 8  
Operational Land  
Imager (OLI)**  
30 meter



**Landsat 9 OLI-2**  
30 meter

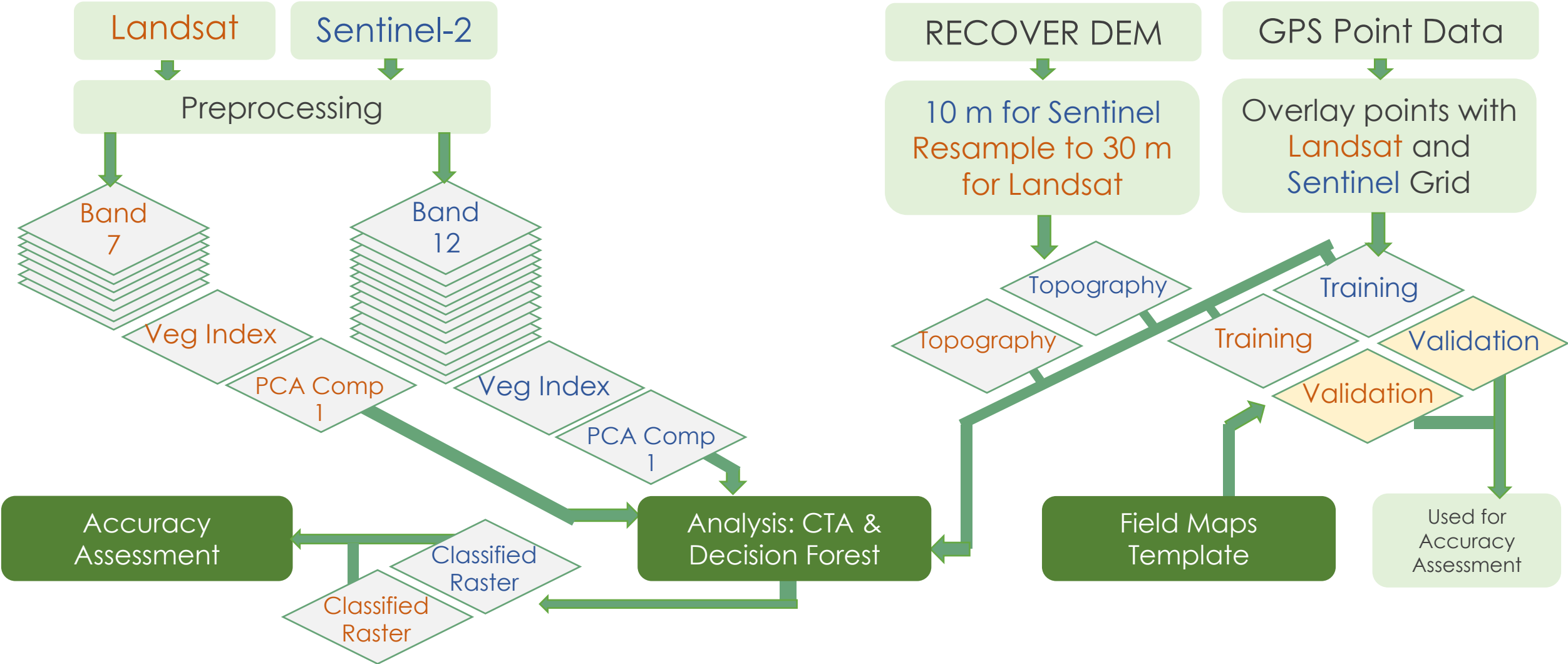


**Sentinel-2  
Multispectral  
Instrument (MSI)**  
10 meter

Image credits: NASA, Rama



# Methodology Overview



# Data Acquisition and Preprocessing

Landsat 8 OLI & Landsat 9 OLI-2



78 scenes cover the study area



Sentinel-2 MSI



140+ scenes cover the study area



All scenes were clipped, cloud masked, and composited using median pixel value.



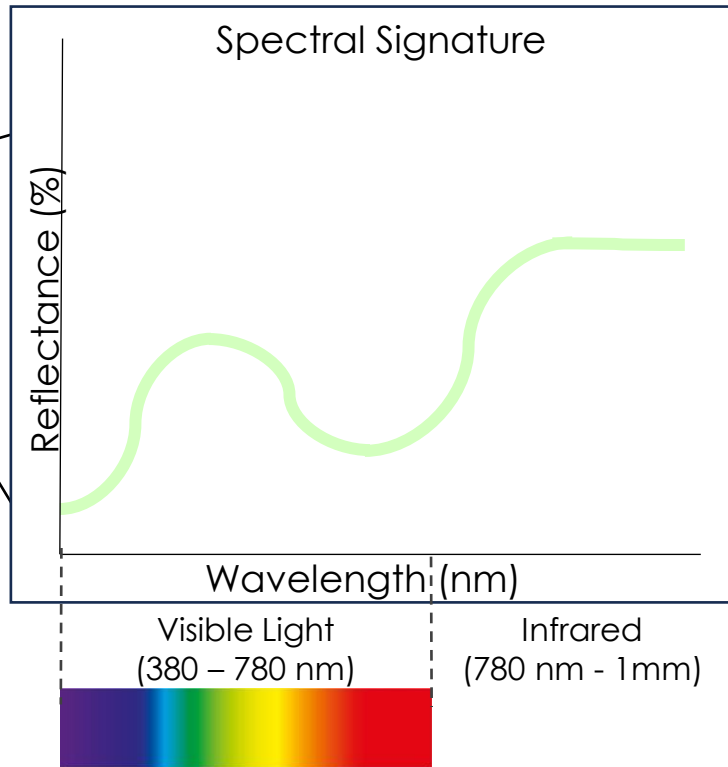
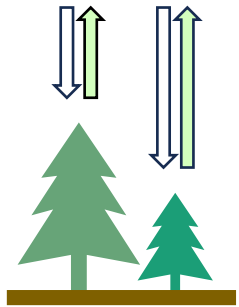
Vegetation indices from multiband composites (NDVI, EVI, NDMI).

Image credits: NASA, Rama



# Using Spectral Signatures from Satellite Data

Spectral signatures are the patterns of how light reflects off objects.



Can provide information on:

Vegetation Health



Vegetation Density



Also shows a:

Unique Identity

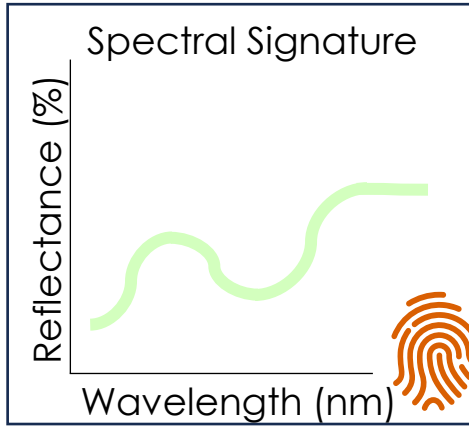


Can be used to identify objects!



# Combining Spectral Signatures and Ground Data

## Unique Identity



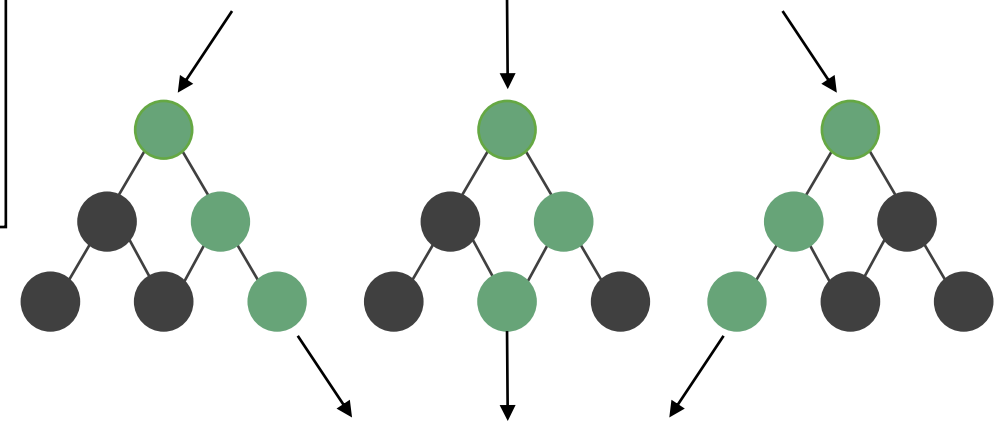
## Ground Data

- Tree Species
- Stand Homogeneity
- GPS Location

Classified Spectral Signatures

Random Forest Model\*  
\*named after using multiple *decision trees*

Training Dataset



Majority Voting

Validation Dataset

Result

compare



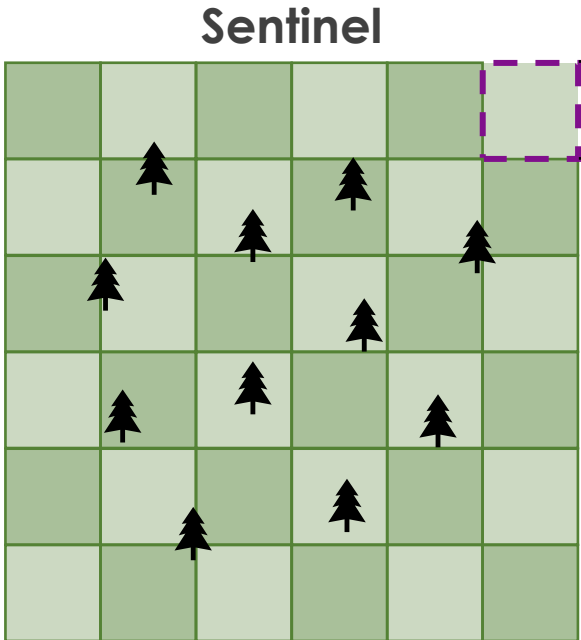
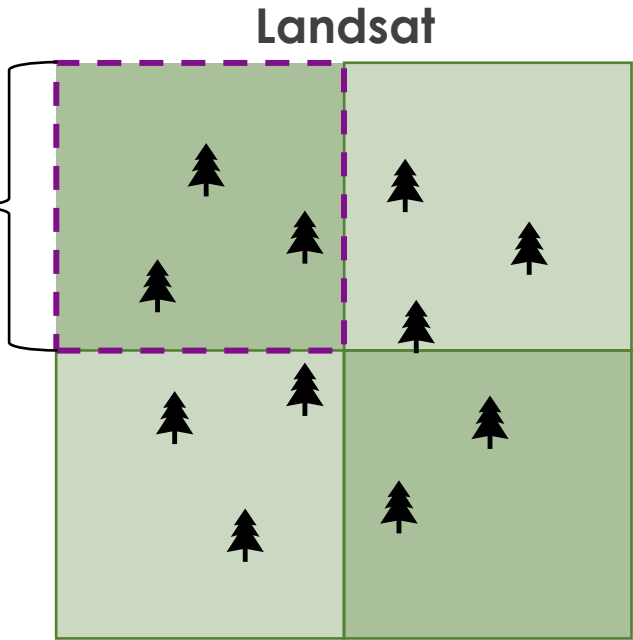
# Landsat vs Sentinel Observations

The resolution of Earth imagery influences the classifications used

30m Resolution

**Coarser** Grain =  
More  
Generalization

*Finer* Grain =  
More Specificity



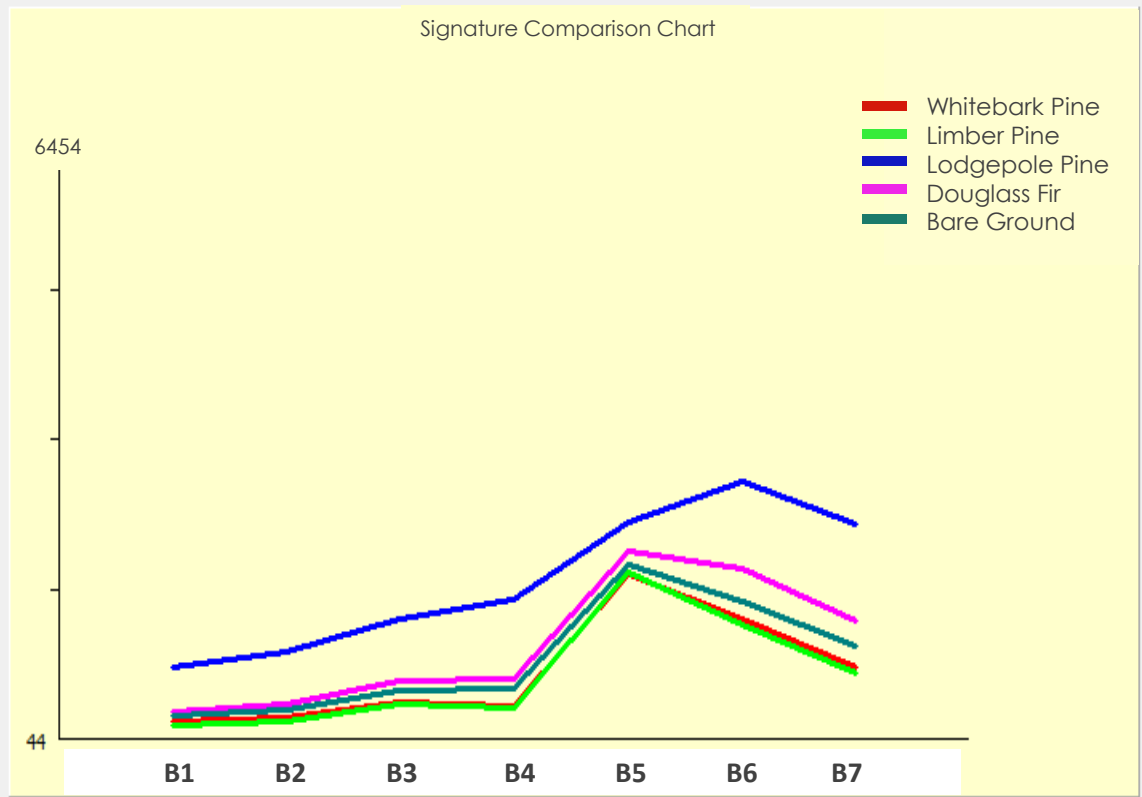
10m Resolution

- 1. Whitebark Pine**
- 2. Limber Pine
- 3. Lodgepole Pine
- 4. Douglas-Fir
- 5. Bare Ground



# Spectral Signature Differentiability

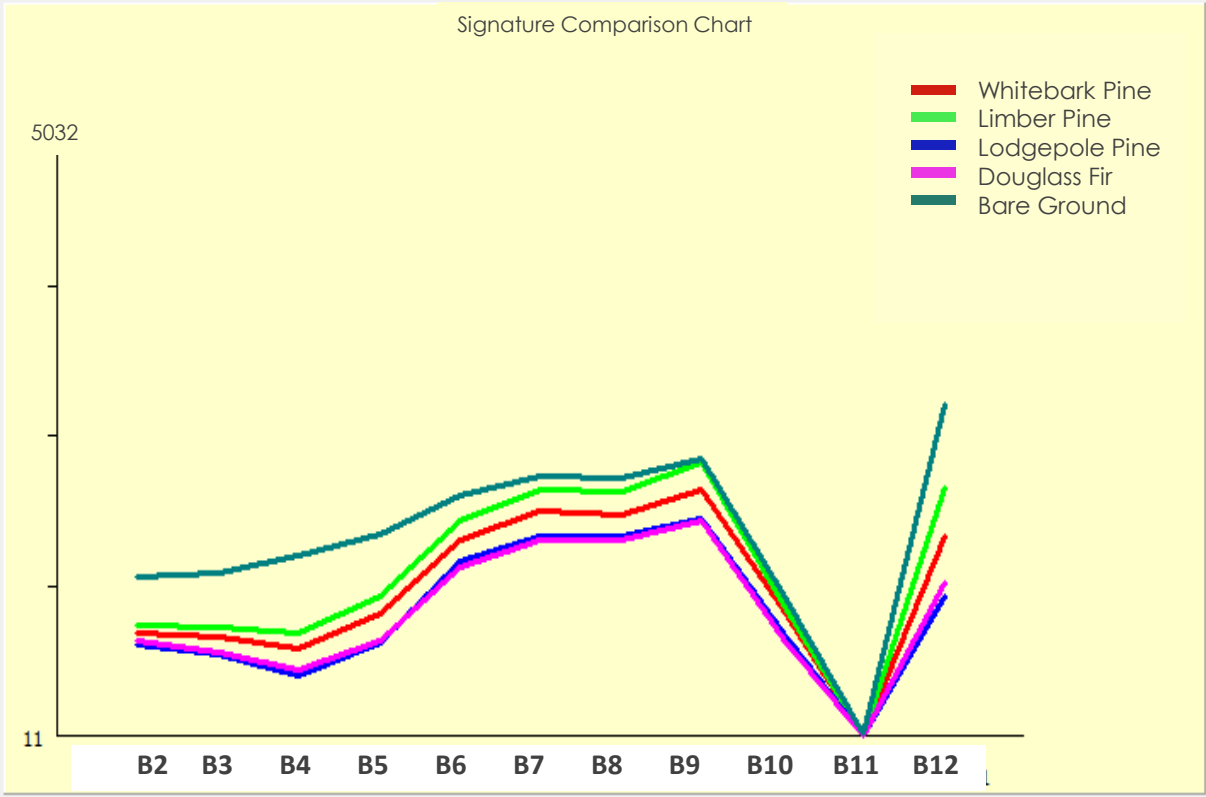
Landsat



Landsat 8/9 Bands

Image credits: TerrSet

Sentinel



Sentinel-2A Bands

**There is some separability, but it needs to be put to the test!**




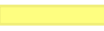
# Results: Sentinel-2 Whitebark Pine

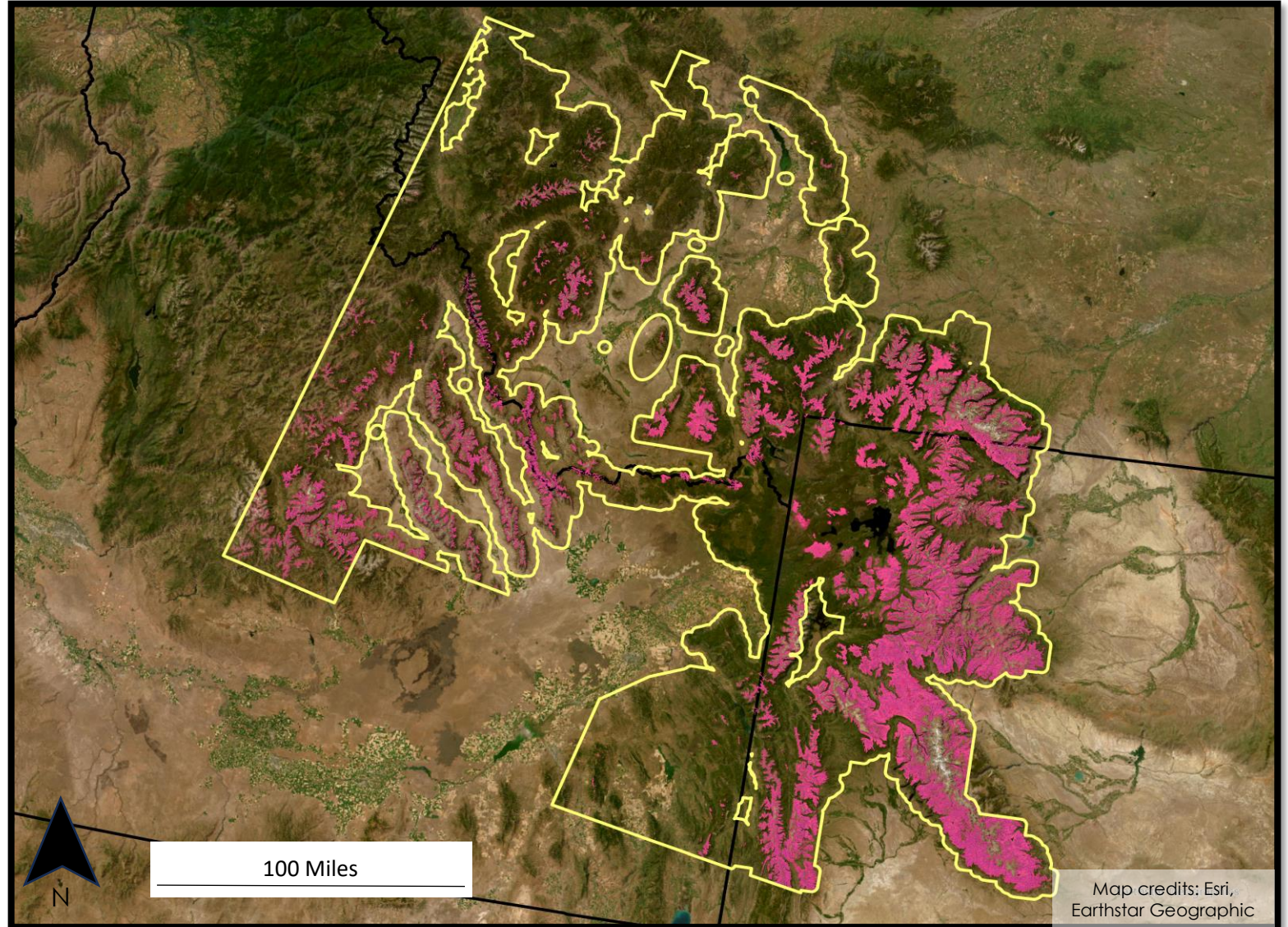
**KAPPA**  
0.93

Error of  
Omission  
3.9%

Error of  
Commission  
4.6%

*Limited samples to  
train and test  
model - potentially  
overclassifying WBP*

 WBP Distribution  
 Study Area

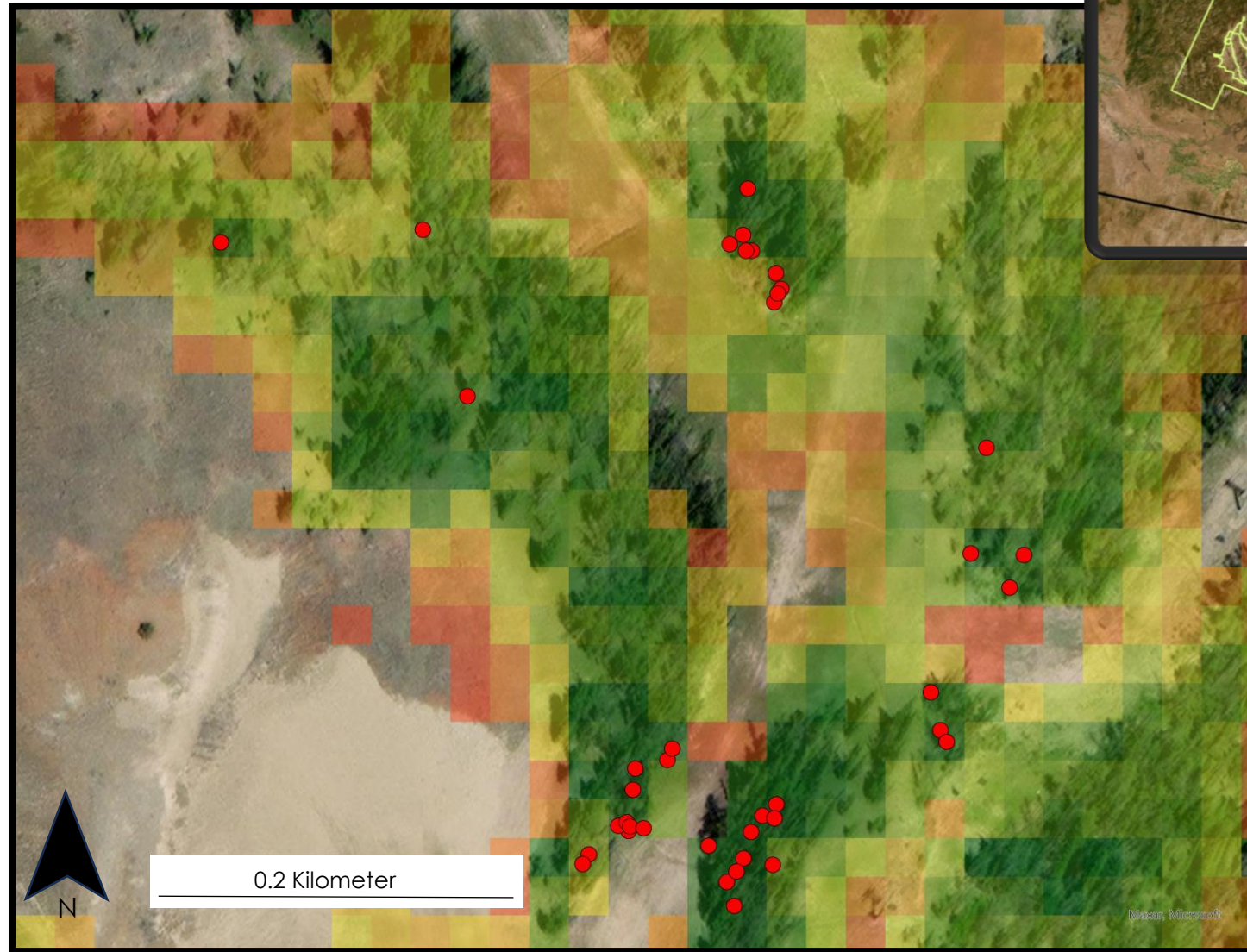
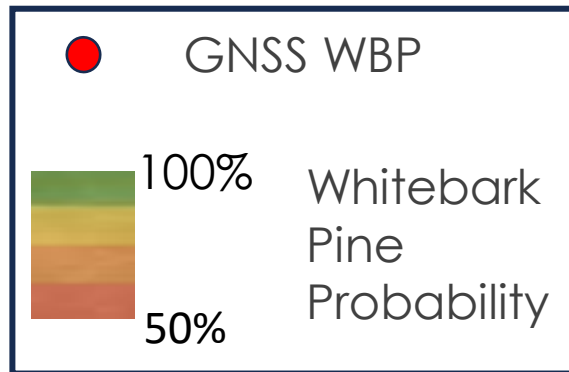


# Results: Sentinel

**KAPPA**  
0.93

Error of  
Omission  
3.9%

Error of  
Commission  
4.6%



Map credits: Esri, Maxar, Microsoft



# Results: Sentinel Limber Pine

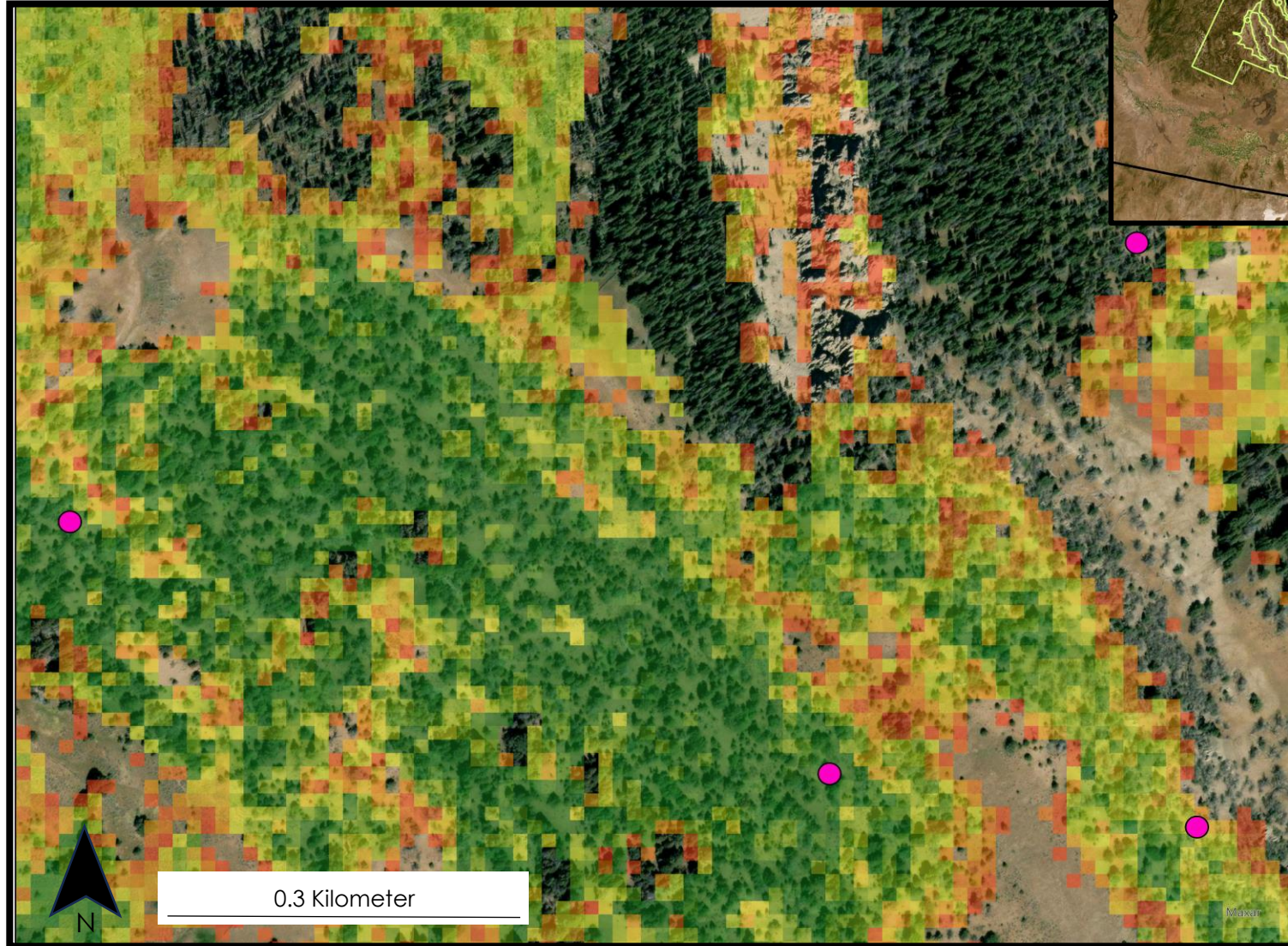
KAPPA  
0.73

Error of  
Omission  
24%

Error of  
Commission  
22%

● GNSS Limber Pine

100%  
Limber Pine  
Probability  
50%



Map credits:  
Esri, Maxar



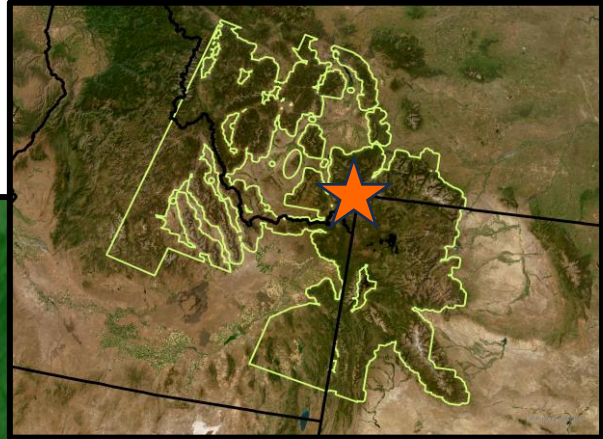
# Results: Landsat

KAPPA  
0.62

Error of  
Omission  
25%

Error of  
Commission  
25%

- GNSS WBP
- Whitebark Pine Distribution



Map credits: Esri, Maxar, Microsoft



# Results: Field Maps Template

## Esri Field Maps

- Versatile app for variety of mobile devices.
- Maps linked to mobile form.

## Template 1:

- Captures basic whitebark pine population information.
- Designed for accurate reporting no matter an individual's forestry skill.

## Template 2:

- Features similar to Template 1.
- Designed for revisiting designated monitoring trees.

Image credit: Genevieve Harman



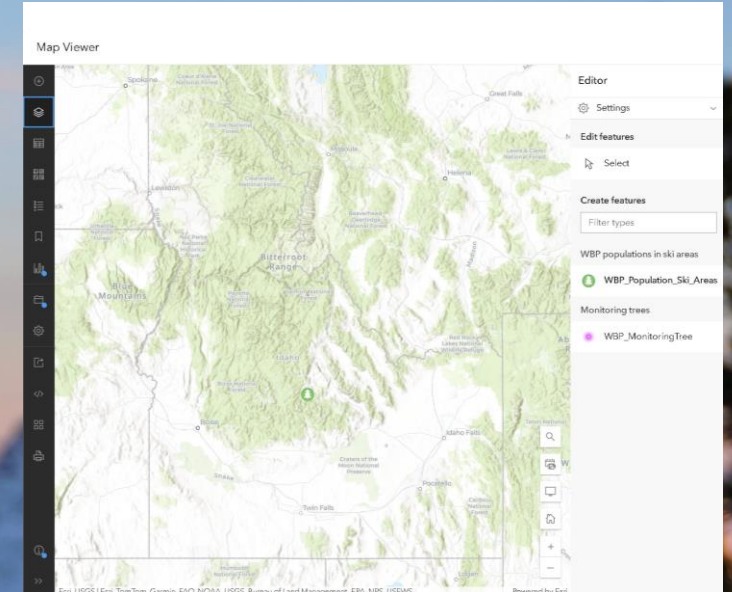
# Results: Field Maps Template



Publicly available layer, sharable from phone to phone or via **QR code**.



Surveys can be **mapped in the field** on phones or tablets.



Points from all surveyors **synced in one map** for land manager use.

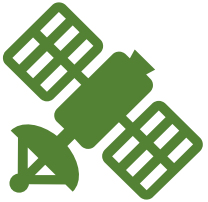
Image credits: Rand Snyder, DEVELOP Team, Genevieve Harman



# Errors & Limitations



Inconsistent terminology and data descriptions



Limitations of satellite data and ground-truth accuracy



Variability in data collection protocols



Time constraints and learning unfamiliar software



# Feasibility & Partner Implementation

## Improved WBP Monitoring

- More accurate distribution model

## Framework for Fieldwork

- Standardized survey templates (Field Maps)
- Efficient resource allocation

## Integration into Partner Workflows

- Supports conservation & restoration
- Monitoring from multiple user groups streamlined

## Recommendations for Partners

- Continue ground truth data collection
- Standardize monitoring with Field Maps
- Integrate fire history & pest outbreaks into models

Image credit: Dustin Corbridge



# Conclusions

- Partners will use our distribution model to identify WBP within their regions.
- Partners will utilize the distribution model to direct focused surveys using the completed Field Maps templates.
- Our end products will aid partners in combating the decline of WBP populations across the Intermountain West.



Image Credits: Dustin Corbridge



# Acknowledgements

**Advisors:** **Keith Weber** - Idaho State University GIS Training and Research Center | **Joe Spruce** - Analytical Mechanics Associates

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**Project Lead:** **Isaac Goldings** – NASA DEVELOP ID Lead | **Kait Lemon** – Previous Term Lead

**Previous DEVELOPERS:** **Hannah Rogers, Dustin Corbridge, A H M Mainul Islam, Joshua Daniel Carrell**

*This material contains modified Copernicus Sentinel data (2024), processed by ESA*



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