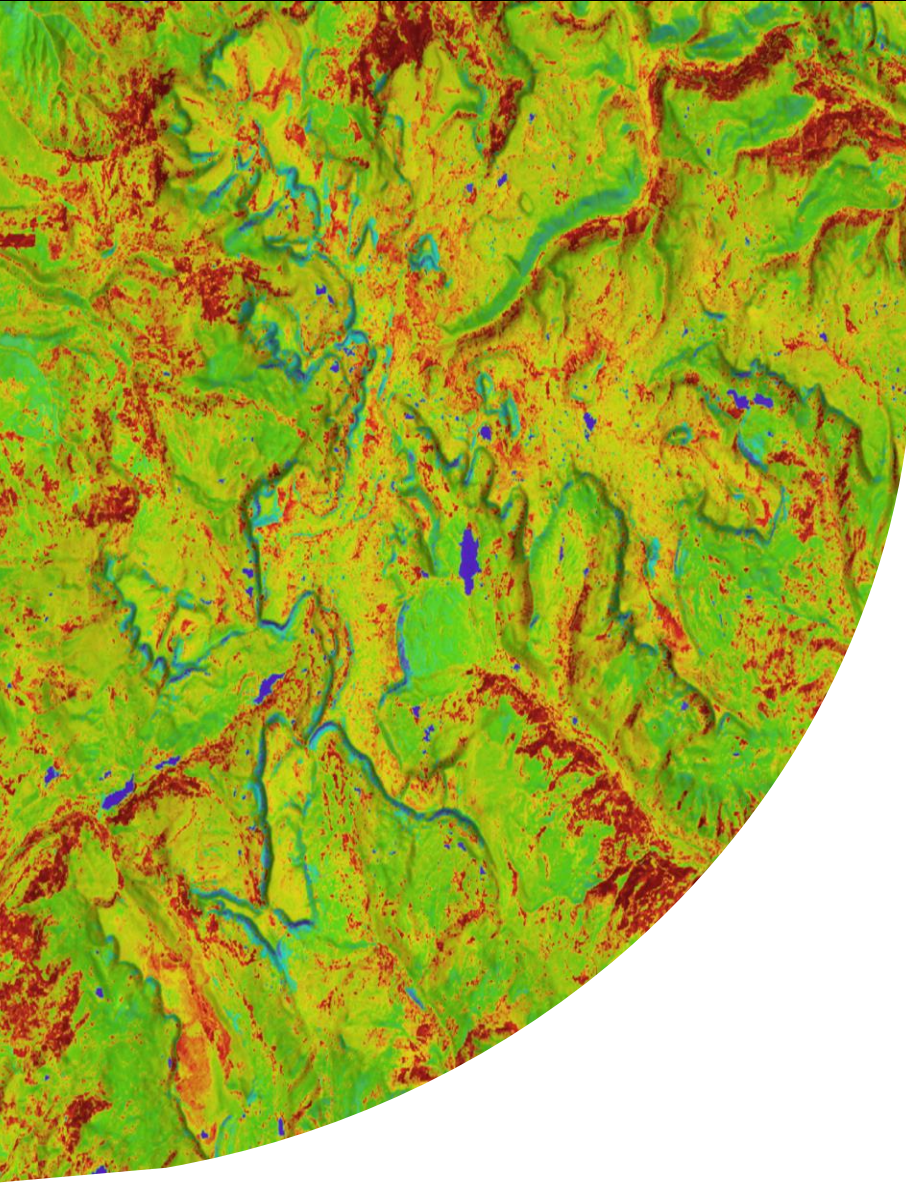




National Aeronautics and
Space Administration



Flat Tops Ecological Conservation

Mapping Yellow Toadflax to Inform Invasive
Species Management within the Flat Tops
Wilderness

Ambra Jacobson, Madison Hutchinson, Aryssa
Camenisch, Scott Mohan (Analytical
Mechanics Associates)

Colorado – Fort Collins | Spring 2025



Meet The Team



Ambra Jacobson



Aryssa Camenisch



Madison Hutchinson



Scott Mohan

Image Credit: USFS/DEVELOP Field Team

Background

Yellow Toadflax (*Linaria vulgaris*)



Image Credit: US Forest Service



Image Credit: Utah State University

History

- Native to Eurasia
- High prevalence in the Mountain West

Biological Characteristics

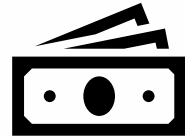
- Yellow and white flowers
- Prefers subalpine elevations

Management

- Repetitive herbicidal and biological treatments

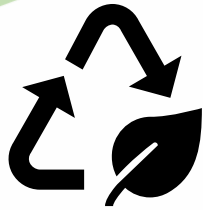
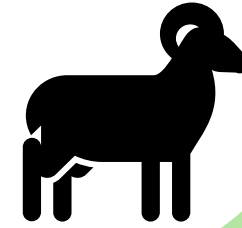


Community Concerns



Costs for treatments
and tracking

Decreasing
palatable vegetation
for grazing
megafauna

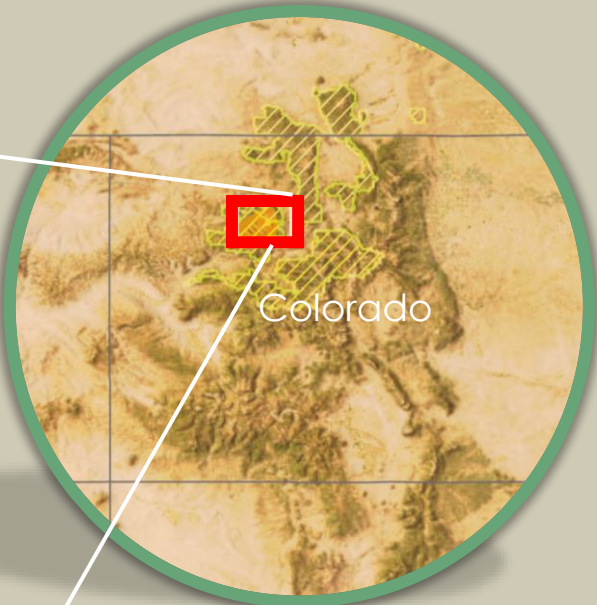
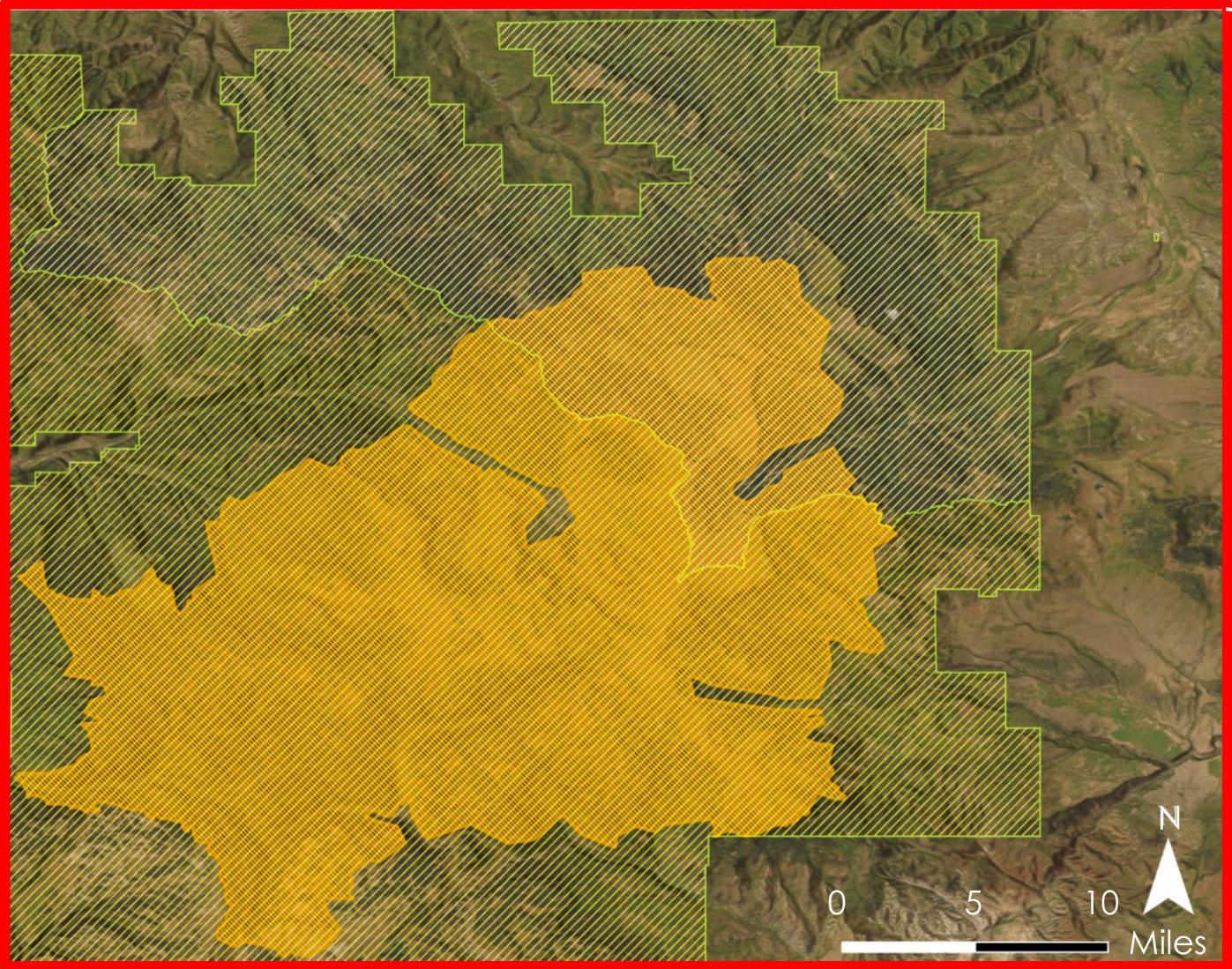



Decreasing biodiversity by
outcompeting native
species

Resilient to
treatments; must be
treated repeatedly



Study Area



-  DEVELOP Study Area
~814,000 acres
-  Flat Tops Wilderness Area
~235,000 acres
-  Medicine Bow-Routt
and White River
National Forests

Study Area



- Popular recreational area
- Grazed by elk, deer, sheep, and cattle
- Diverse terrain



Project Partners

USDA Forest Service (USFS), Yampa Ranger District

- **Partner background:**
 - Wilderness Act aims to maintain natural conditions and species, responsibility relies on the USFS
 - USFS has chemically treated yellow toadflax in the area for 18 years
 - Biological treatments have low efficacy due to freezing climate

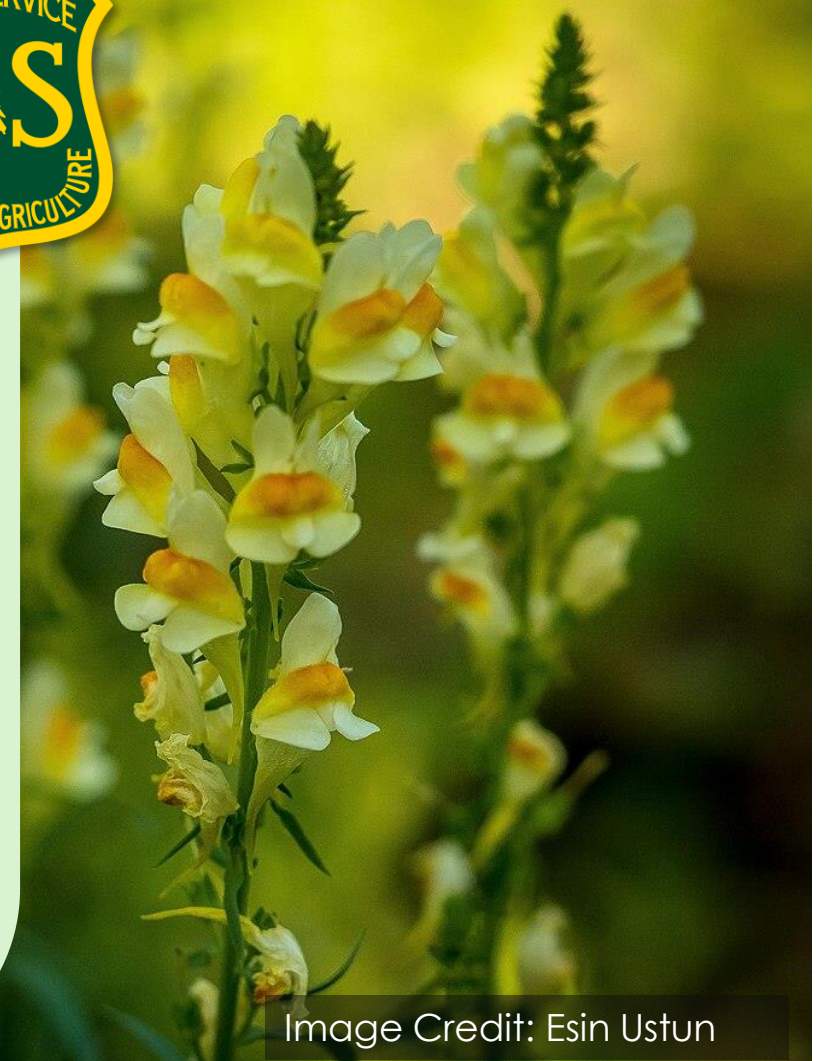
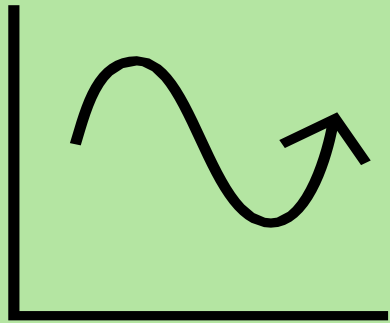


Image Credit: Esin Ustun



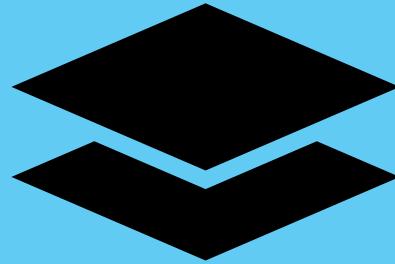
Project Objectives

Time Series Plot



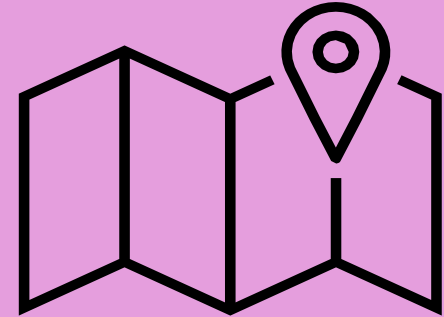
Compare spectral signatures of yellow toadflax with other vegetation over a growing season

Habitat Suitability Model



Locate yellow toadflax habitat using several topographic and remote sensing variables

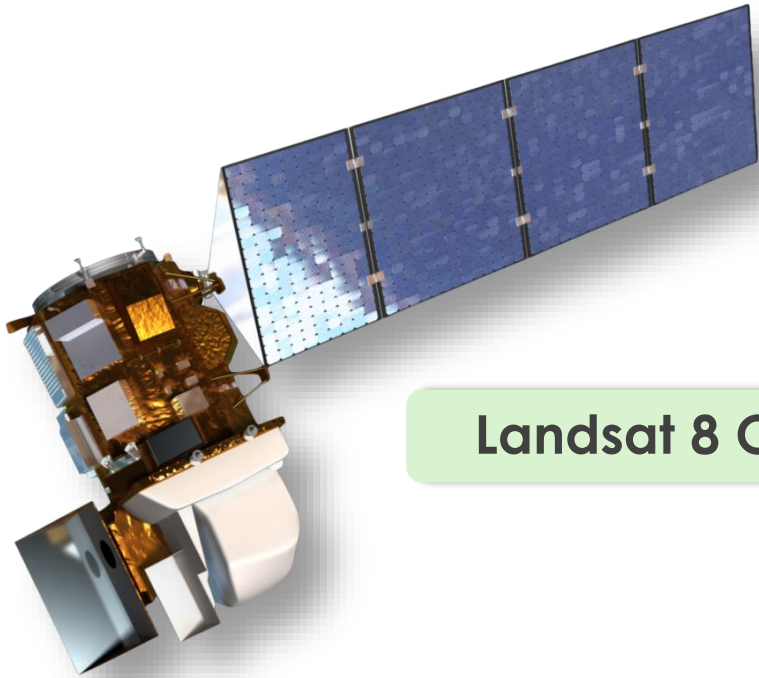
Species Detection Map



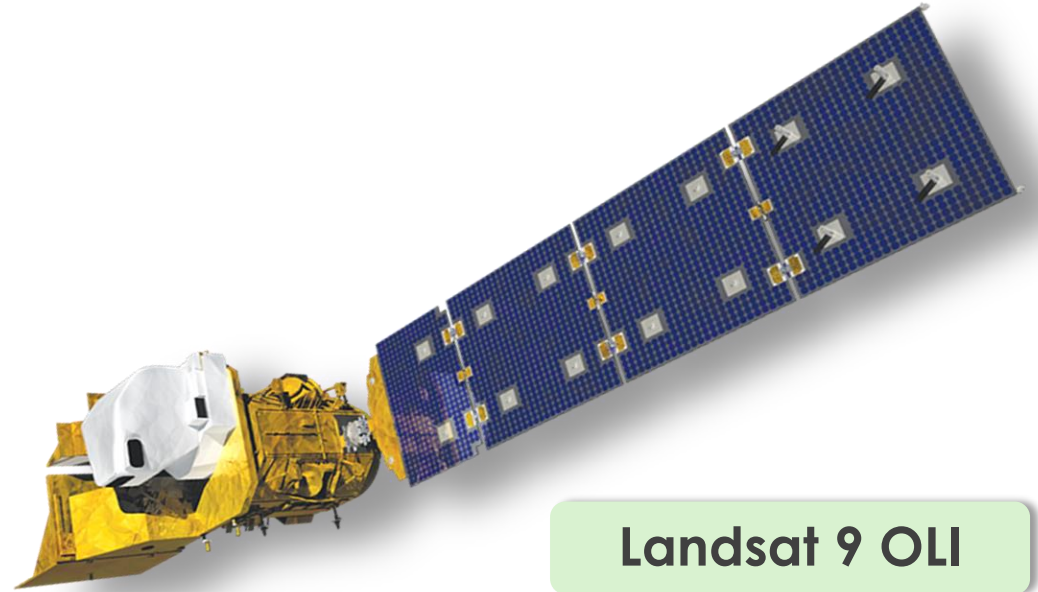
Identify current areas of yellow toadflax occurrence



Earth Observations



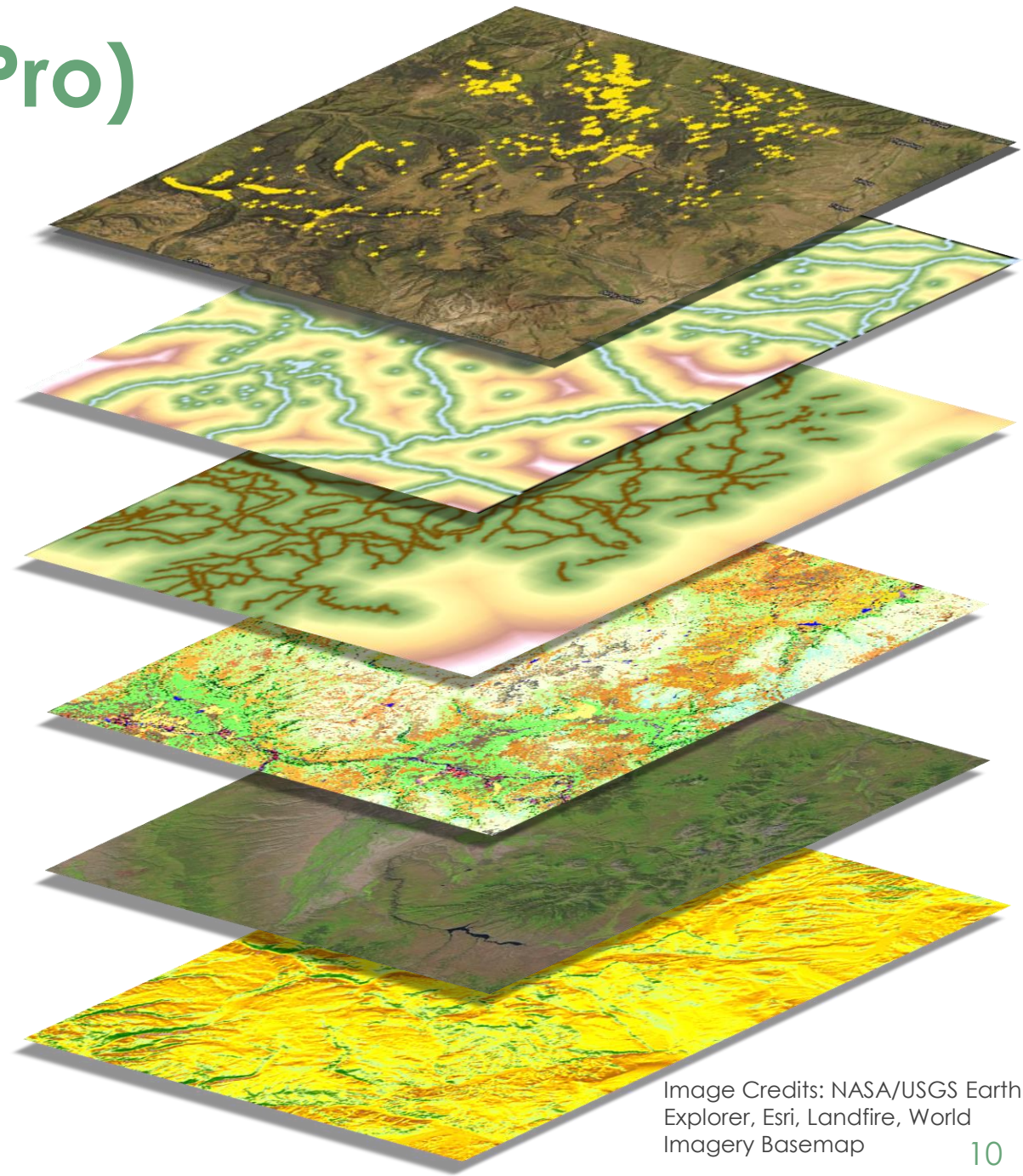
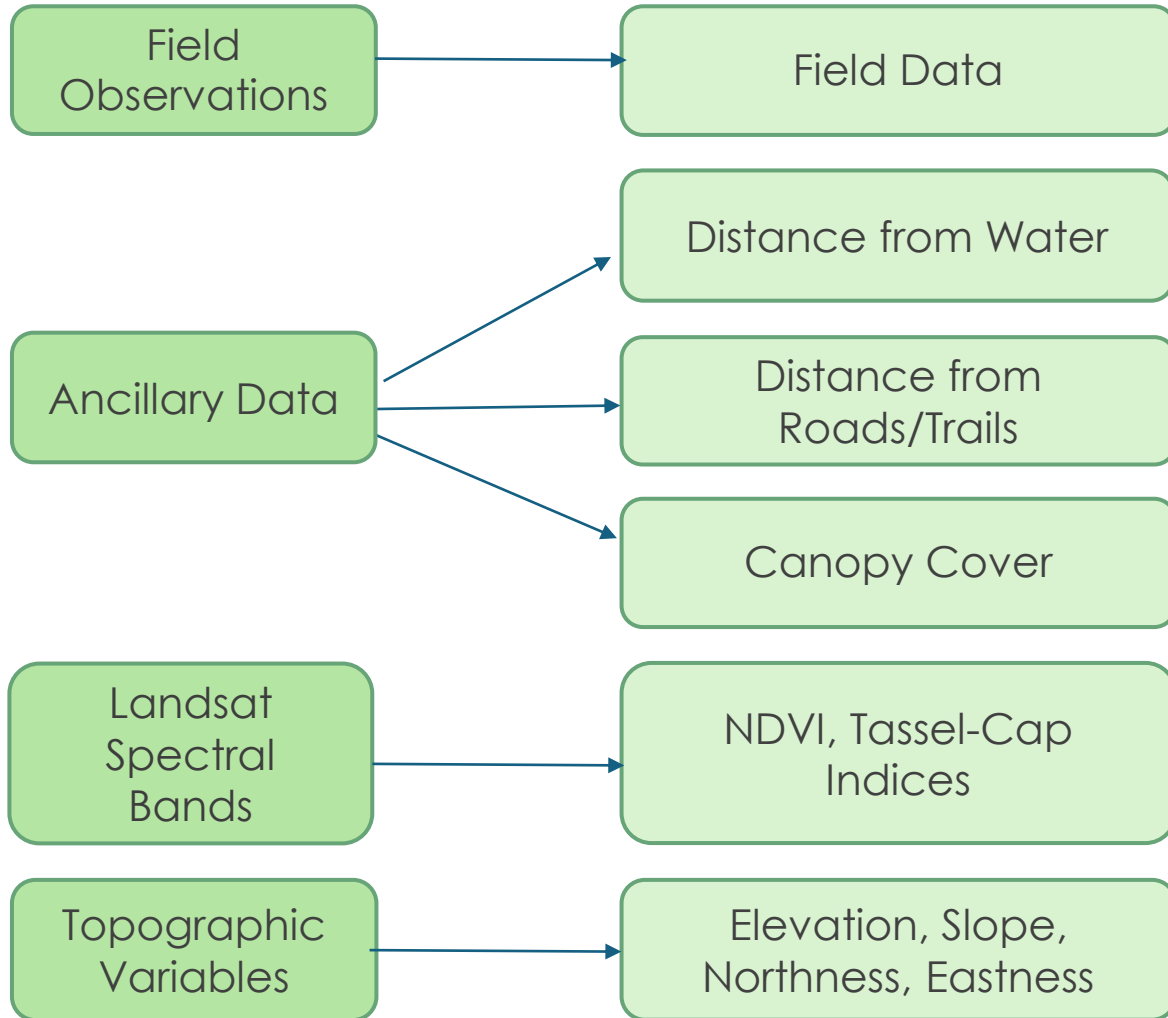
Landsat 8 OLI



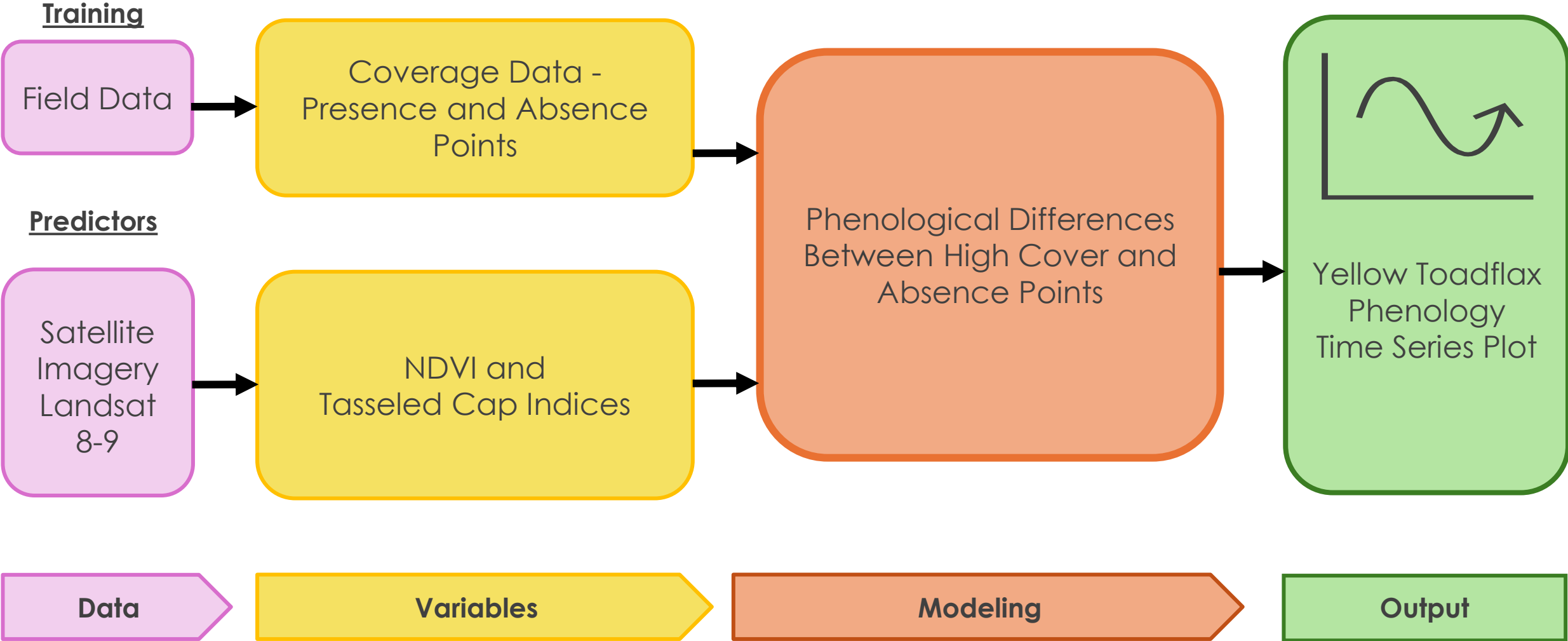
Landsat 9 OLI

Image Credits: NASA

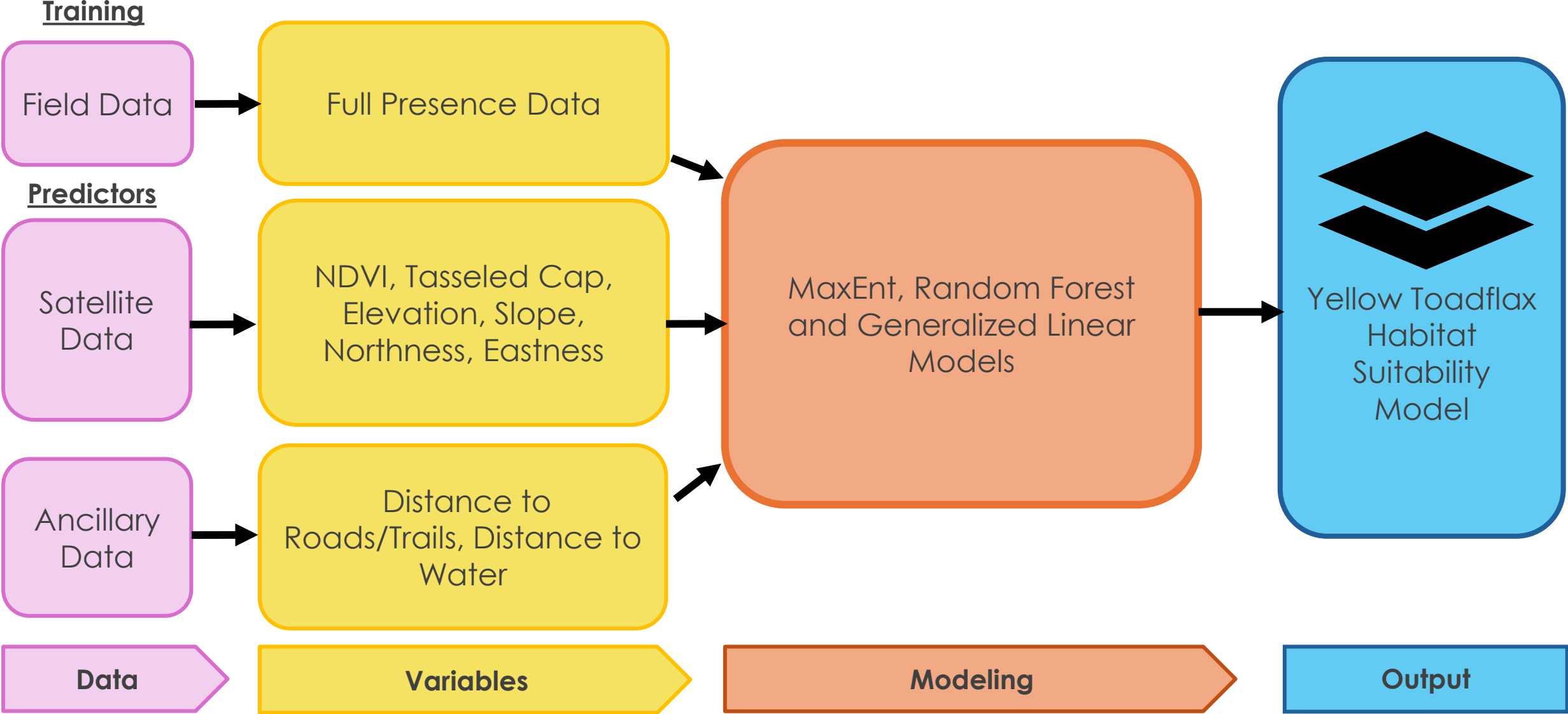
Data Processing (ArcGIS Pro)



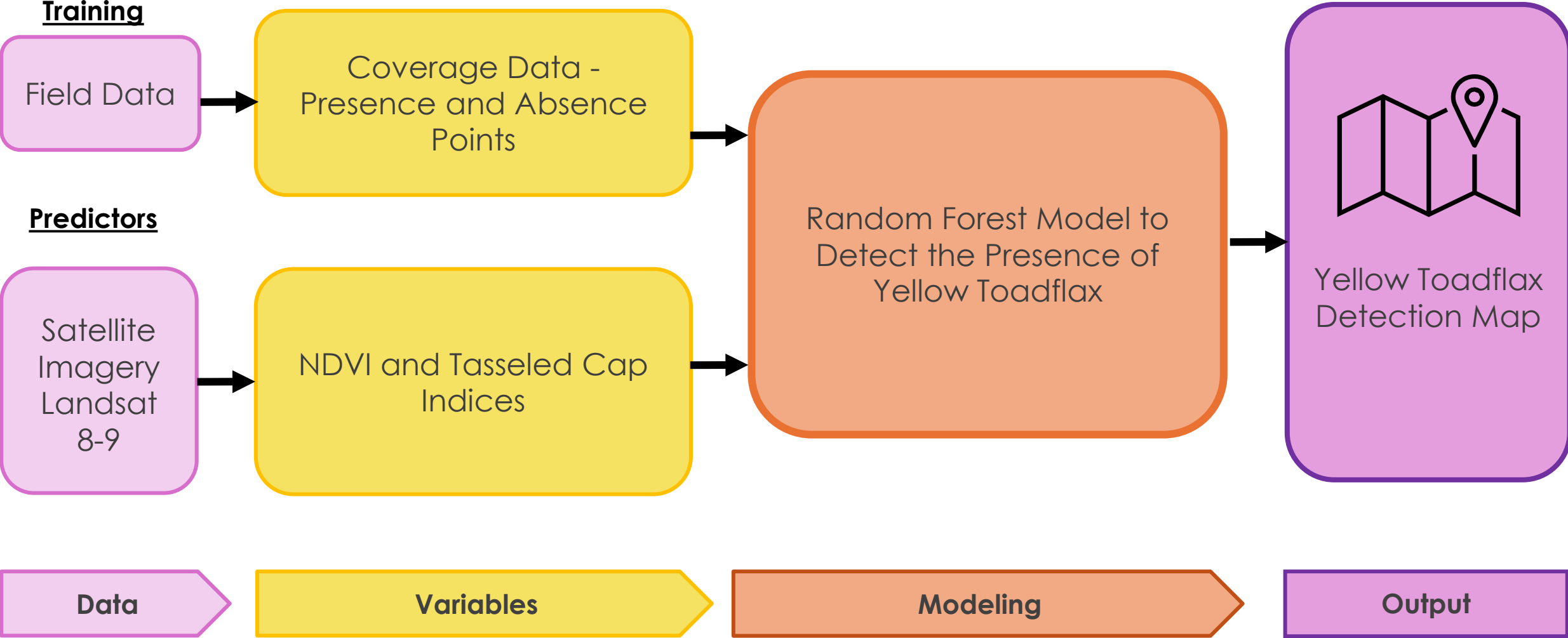
Project Workflow: Phenology Time Series Plot (R)



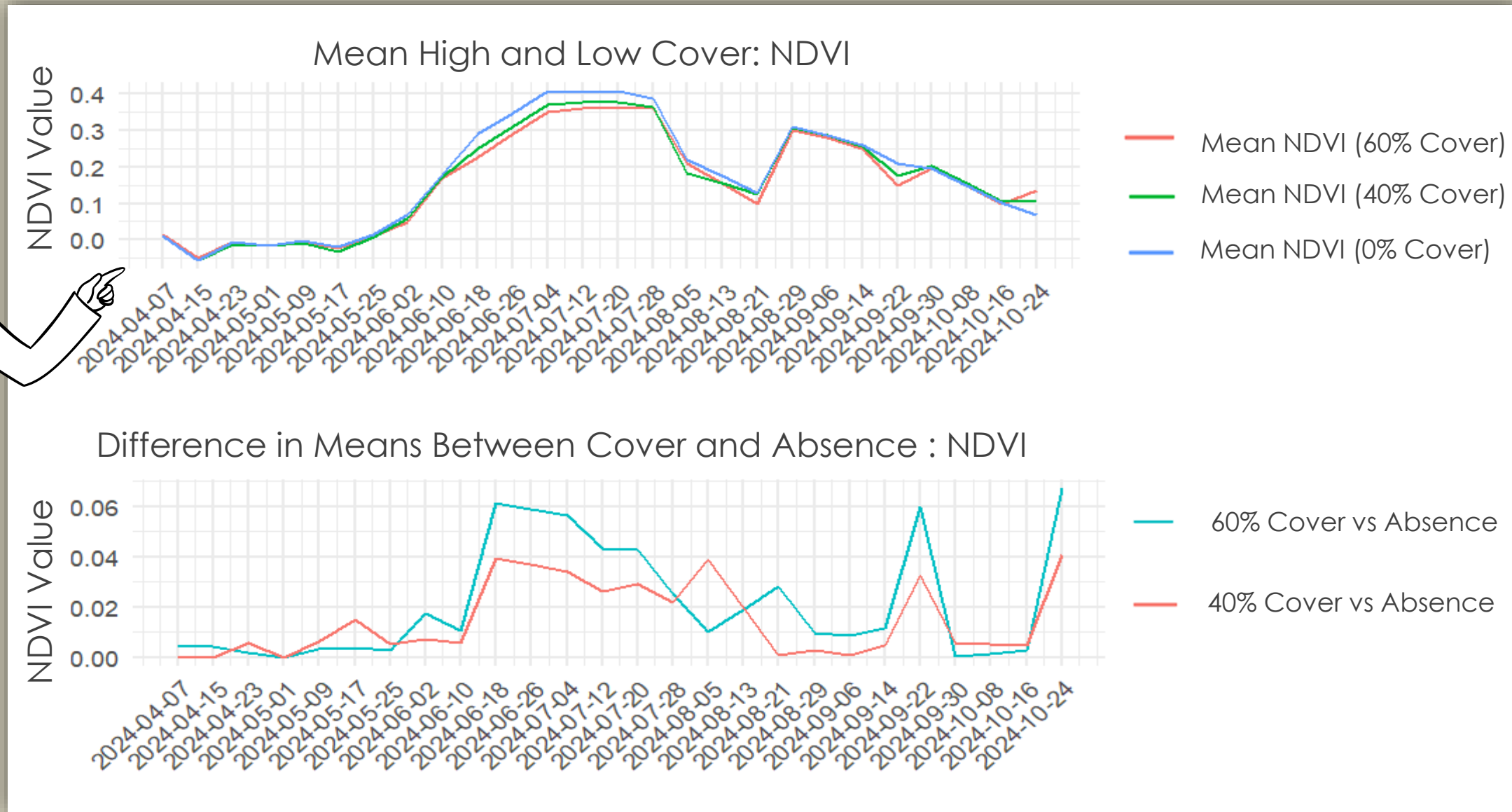
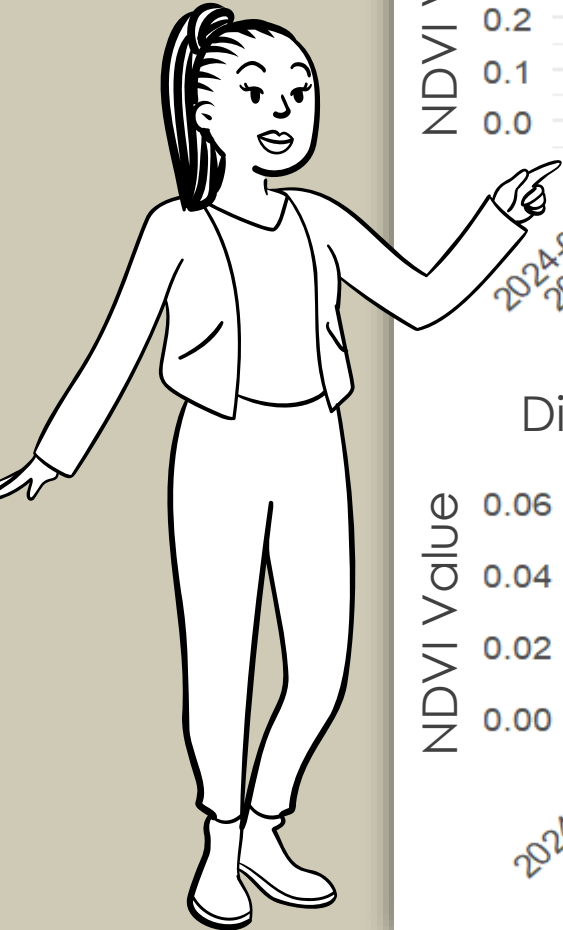
Project Workflow: Habitat Suitability Model (SAHM)



Project Workflow: Detection Map (R)

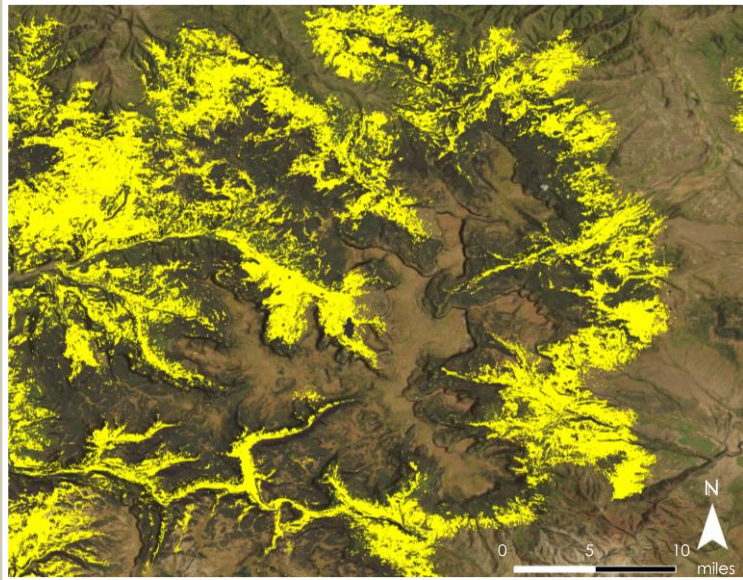


Results: Phenology Time Series Plot (R)

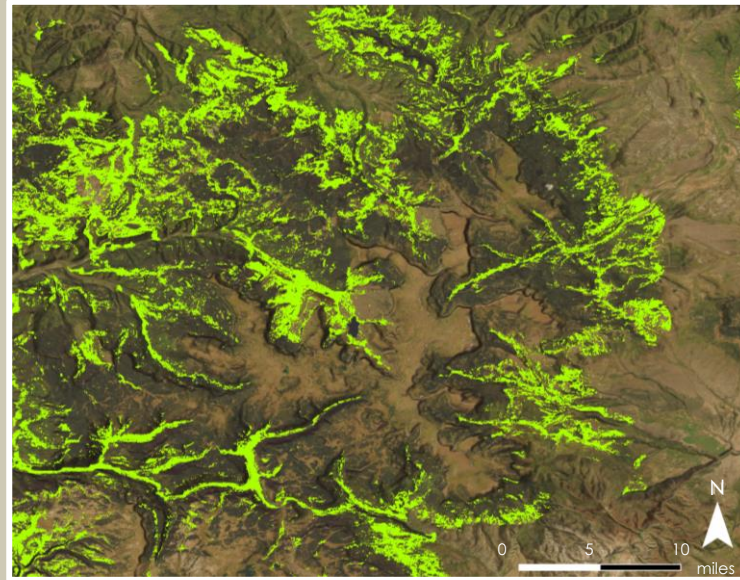


Results: Habitat Suitability Models

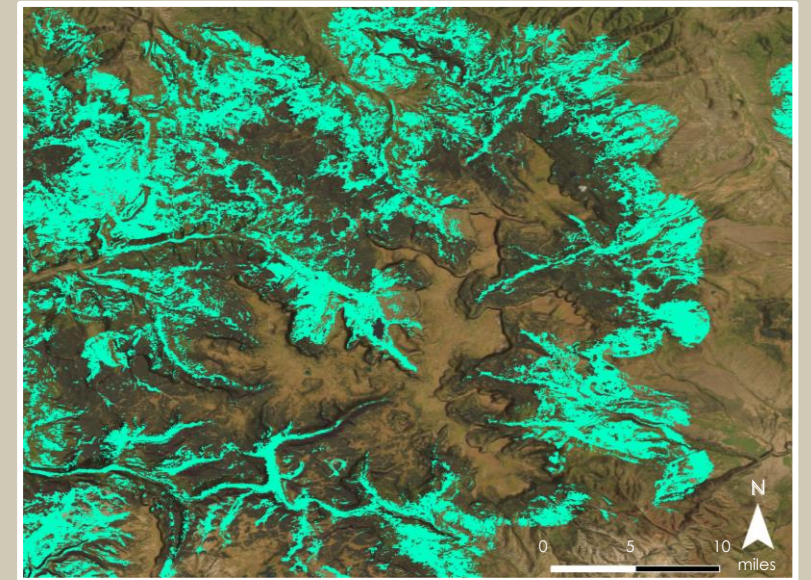
Colored areas show where the models predicted to be suitable habitat



Generalized Linear Model



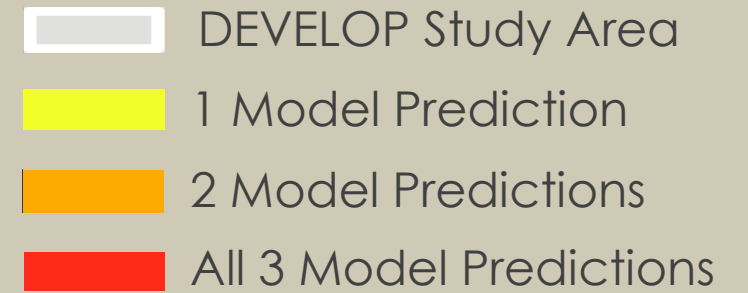
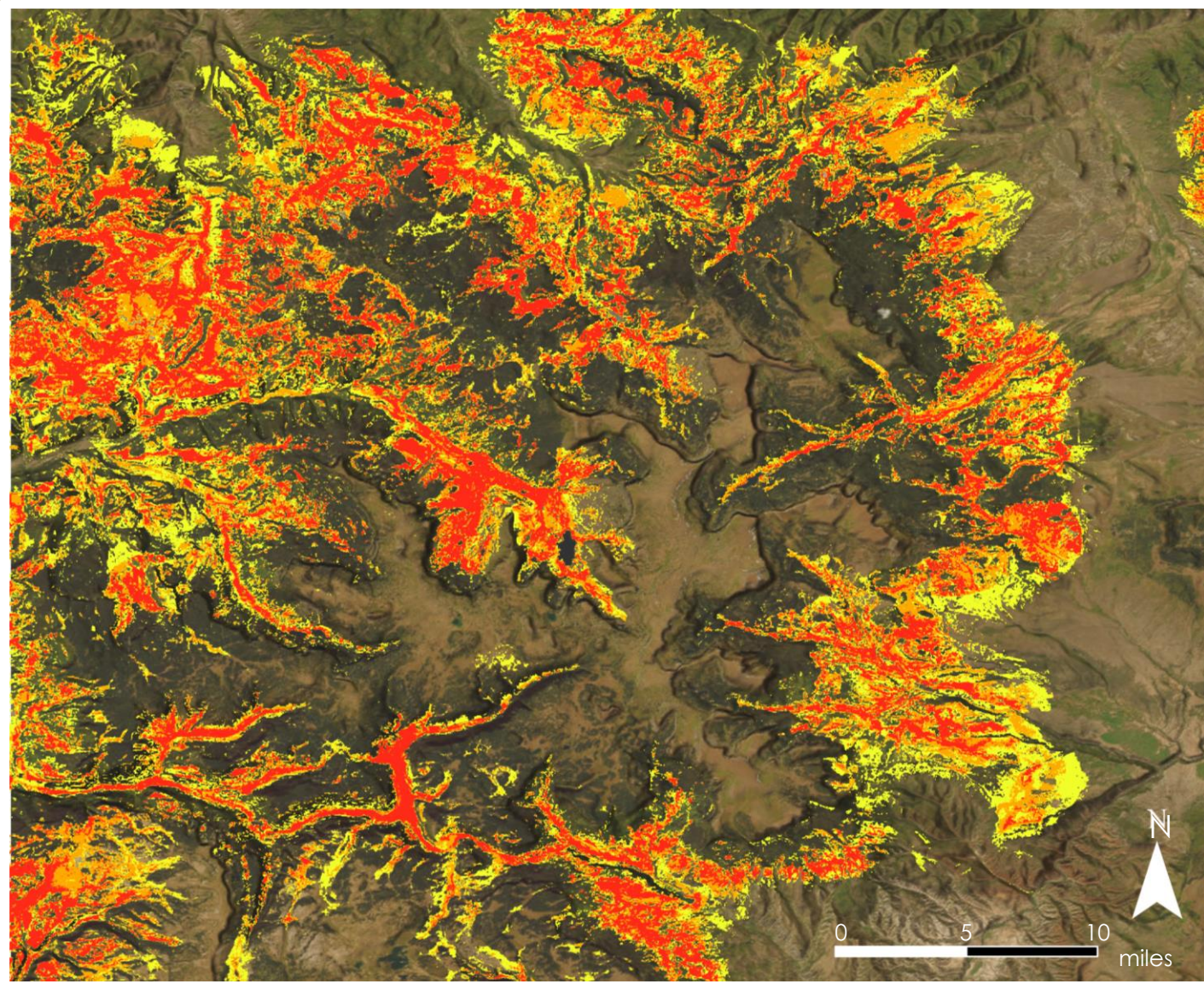
Random Forest



MaxEnt



Results: Habitat Suitability Modeling Heatmap



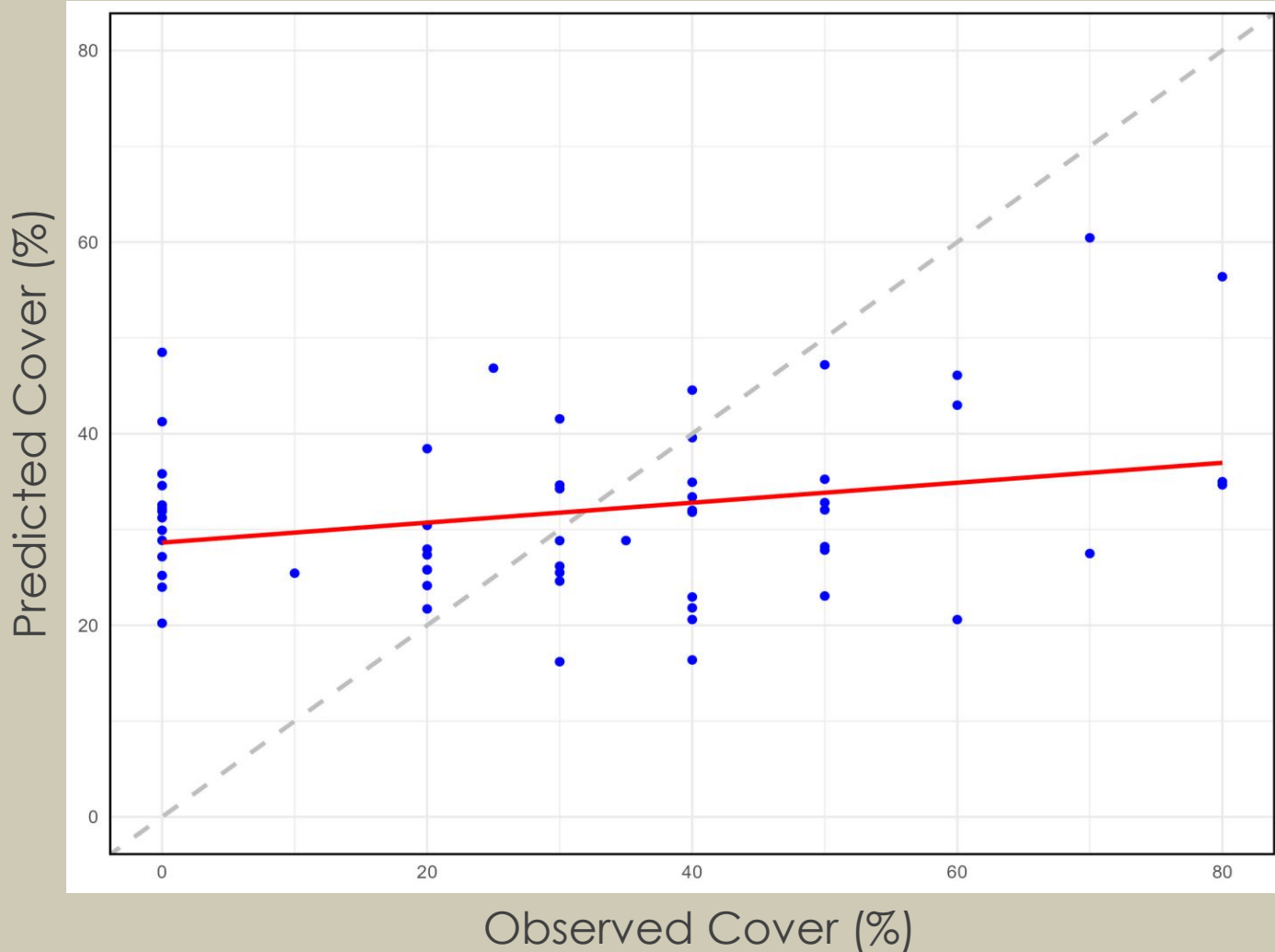
All 3 models predict suitable yellow toadflax habitat in **8.63%** of the total study area, or **86,296.6 acres**

- Top habitat predictors:**
- 1) Elevation
 - 2) Distance to roads/trails
 - 3) Tasseled-cap brightness



Results: Detection Model

Predicted vs. Actual: $R^2 = 0.052$, RMSE = 22.52



Confusion Matrix
OOB Error: 0.259

	TRUE	FALSE	Error
TRUE	4	12	75%
FALSE	3	39	7.1%



Uncertainties and Caveats

- Sampling Bias – roads, rivers, and elevation
- Time Series – differences between high cover and absence were small
- Detection Model – Landsat resolution may be too coarse



Feasibility and Partner Implementation

Overall: This feasibility study may be useful for addressing our partners' concerns. Future studies may benefit from using finer-resolution satellite imagery.

Time Series Plot: Useful to track annual patterns of phenological traits of yellow toadflax and inform Detection Models

Habitat Suitability Model: May be used to refine monitoring locations and to better understand yellow toadflax's environmental preferences

Detection Model: This method did **not** adequately predict yellow toadflax presence.



Image Credit:
US Forest
Service



Conclusions

There are limitations in using remote sensing imagery to detect invasive plants

Indices from Remote Sensing Imagery can provide complex insight into species phenology

Models using remotely sensed imagery, combined with topographic variables, can help save time and resources



Image Credit: USFS



Acknowledgements

- Advisors:
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- Lead:
 - Truman Anarella (CO – Fort Collins)
- Partners:
 - USDA Forest Service, Yampa Ranger District: John Anarella, Doug Myhre, and Jason Szyba



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