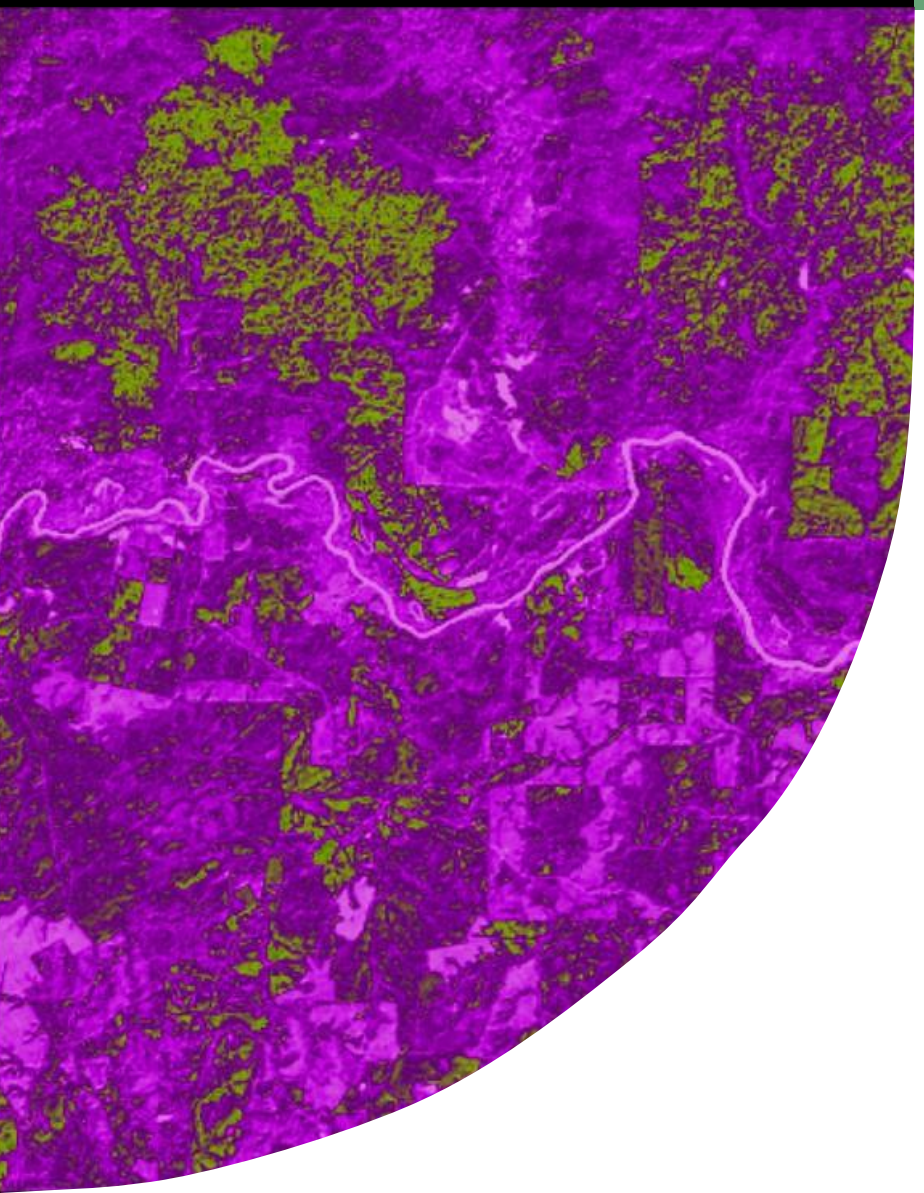
National Aeronautics and Space Administration



Eastern Texas Ecological Conservation

Mapping Change in Longleaf Pine Distribution Across Eastern Texas to Inform Conservation and Restoration Efforts

Seth Christiansen, Caiden Hartrich, Olivia Hockley-Rodes, Jennings Leavell

(Analytical Mechanics Associates)

Idaho – Pocatello | Fall 2025

The Longleaf Pine (*Pinus palustris*) Ecosystem

Fire-dependent ecosystem

Image credit: Parker Schuerman

Highly valued timber & sap

Image credit: Texas Longleaf Team

Image credit: Brady Beck

Image credit: US Forest Service

Image credit: Evan Grimes

Image credit: Texas A&M Forest Service

A keystone species sheltering endangered and endemic wildlife

Image credit: Texas Longleaf Team

Human Impacts Drive Longleaf Decline

Industrial Logging

Hardwood Encroachment

- Listed as endangered on the IUCN Red List
- Endemic and threatened species in decline
- Degradation of ecosystem services

Project Partners

Texas Longleaf Team

Non-profit

Texan By Nature

Non-profit

Texas A&M Forest Service

State Government

Community and Partner Concerns

- No comprehensive map of current longleaf stands in eastern Texas
- Challenging to measure success of restoration efforts over time and space
- Historical longleaf maps would help prioritization of future restoration projects

Image credit: Texas Longleaf Team

Image credit: Texas A&M Forest Service

Objectives

Determine the feasibility of remote pine species identification

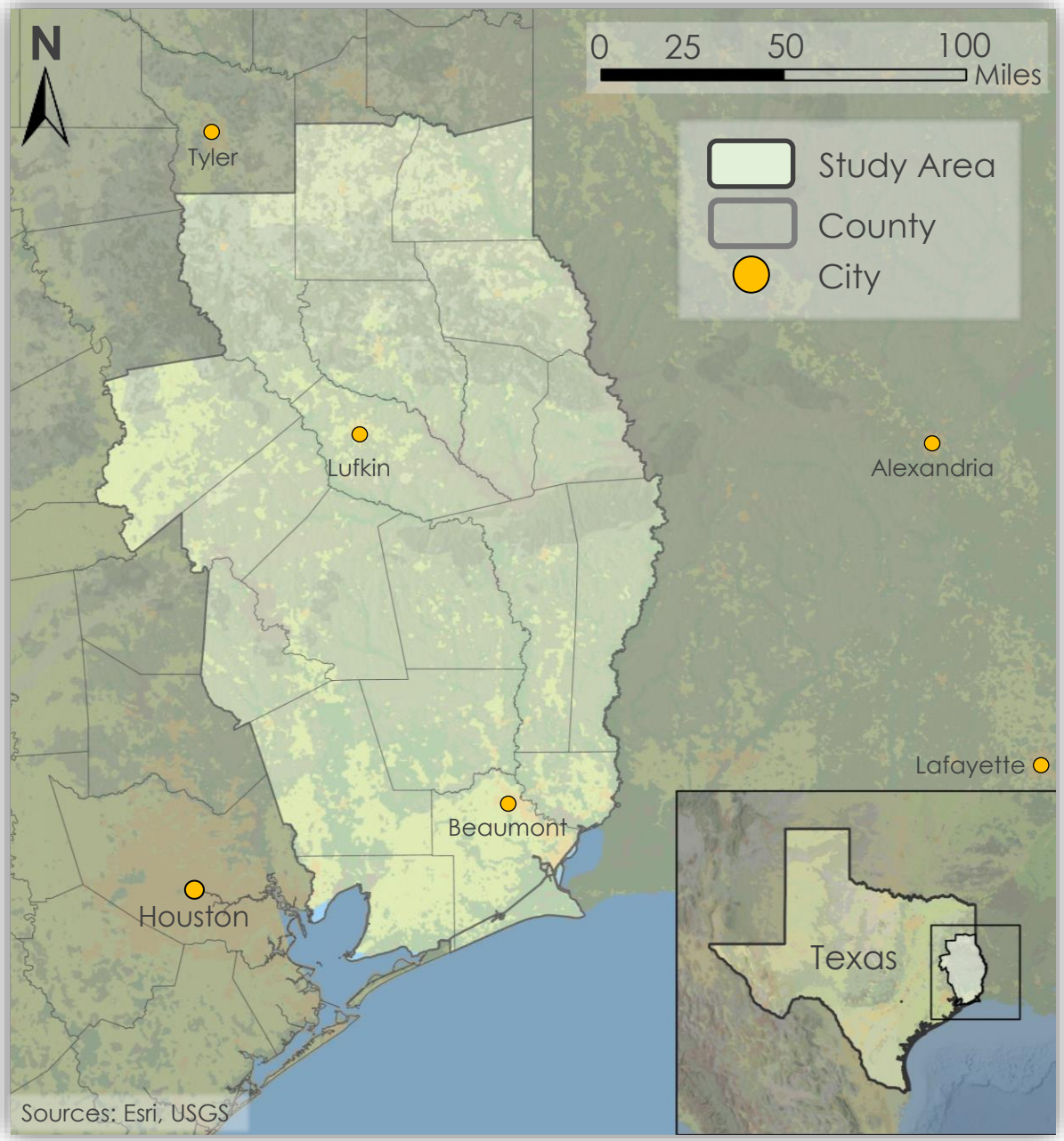
Use satellite data to differentiate longleaf and loblolly pine

Create a current map of longleaf distribution

Train a model to detect longleaf pine based on imagery and ground-truth points

Produce historical maps of longleaf distribution

Apply our model on historical imagery from each decade going back to 1985



Scope of Study

Study area
20 eastern Texas counties spanning
11.29 million acres

Study period

January 1985 – December 2024

Ground truth data

- 765 polygons containing longleaf pine
- 182 polygons containing loblolly pine
- Sampled and refined to 185 points for each species

NASA Earth Observations

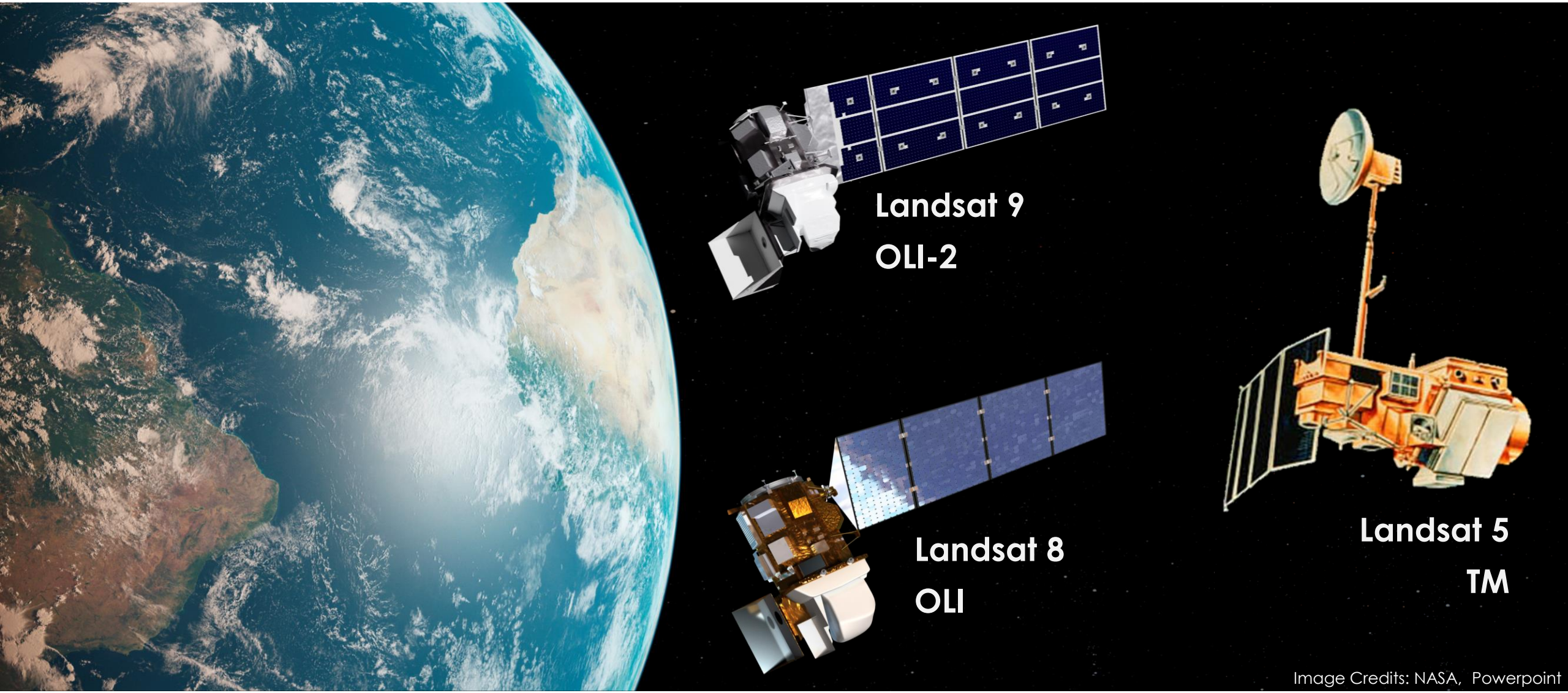
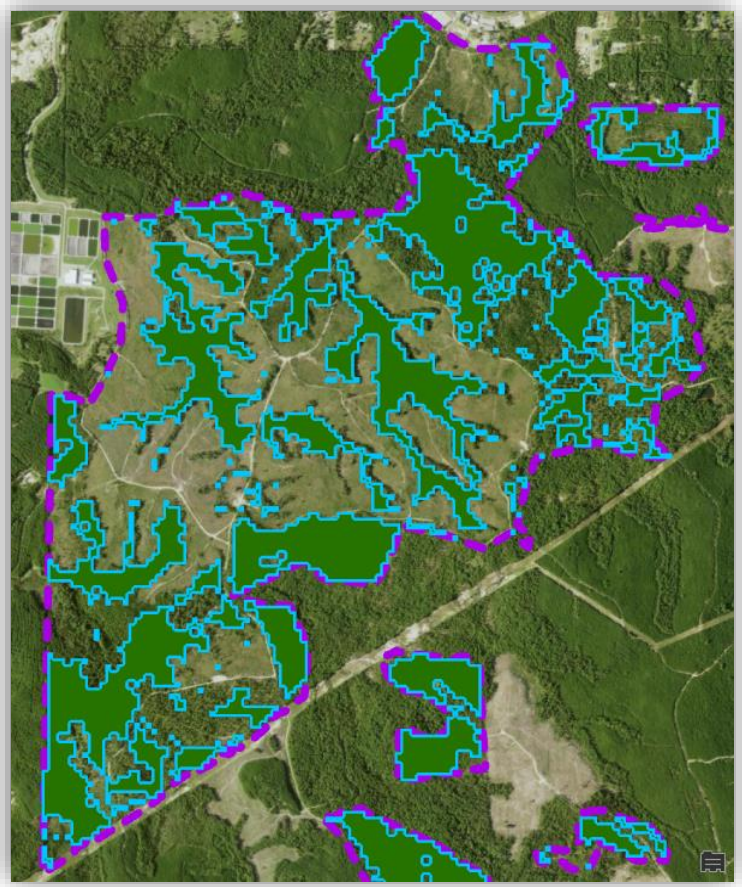


Image Credits: NASA, Powerpoint

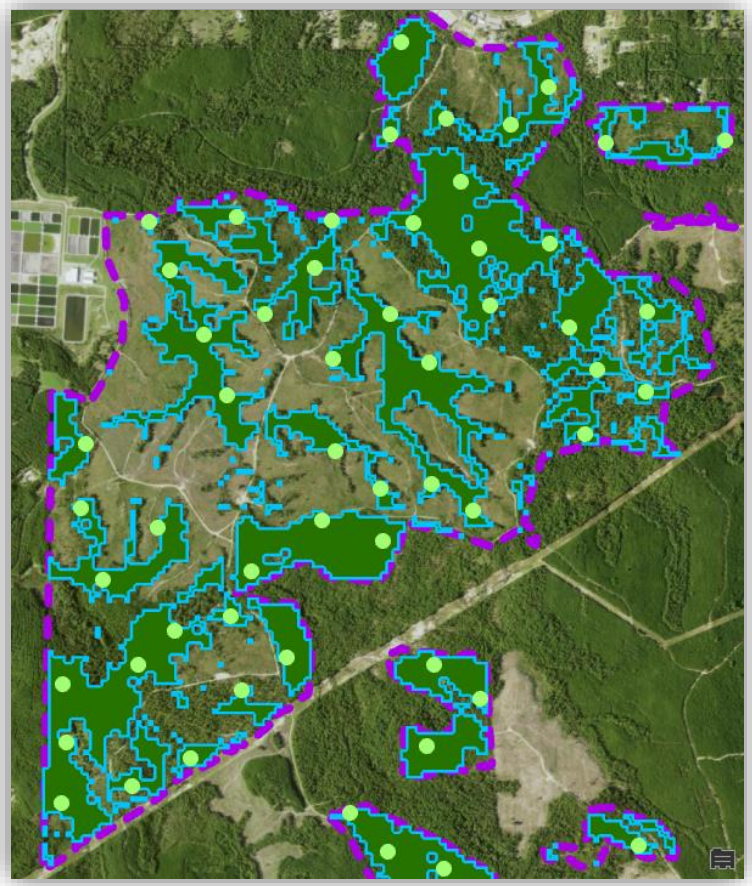
Ground Truth Data Refinement

Image credit: Esri, USDA FSA

Filter ground truth data



Mask and buffer evergreen areas



Randomly generate training points and purify

Comparison of Eastern Texas Pines

Longleaf pine

- Open, rounded crown of glossy foliage
- Long, dark green needles

Image credits: Texas A&M Forest Service

Loblolly pine

- Dense, rounded crown of dark foliage
- Shorter, blue-green needles

Image credits: Texas A&M Forest Service

Spectral Signatures

Different surfaces reflect different amounts of light back to the sensor

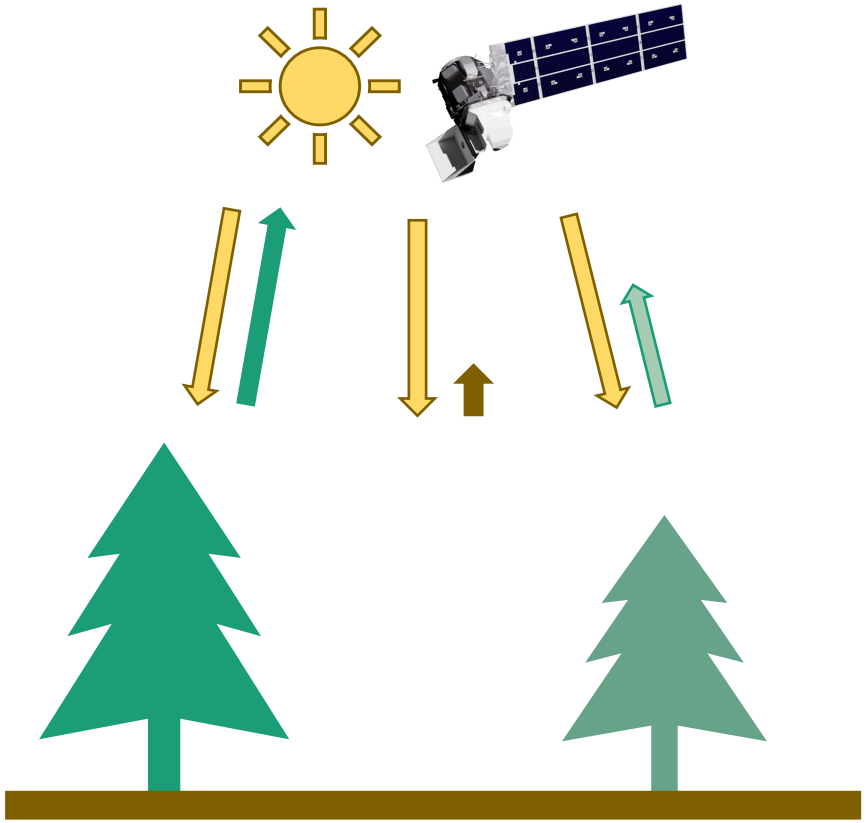
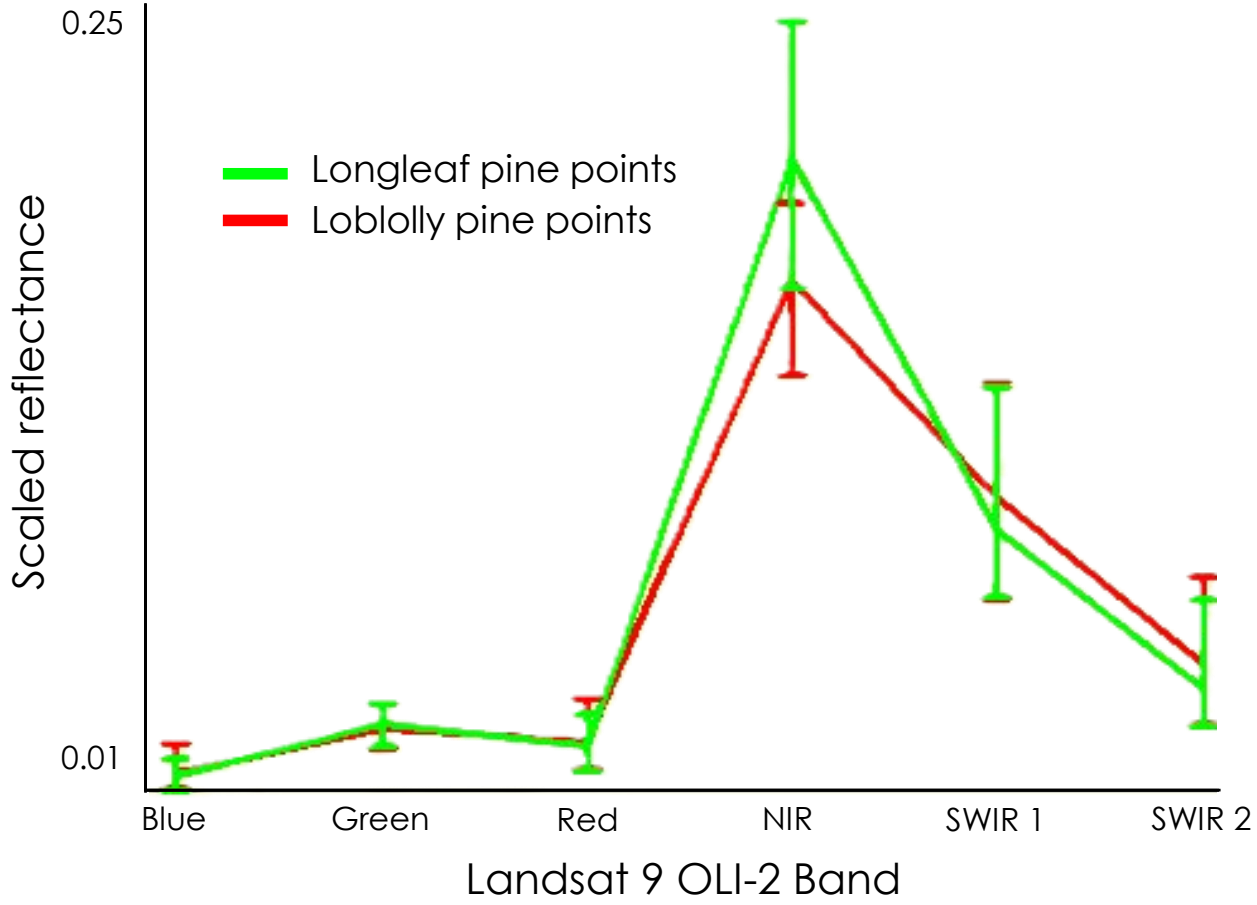


Image credit: NASA

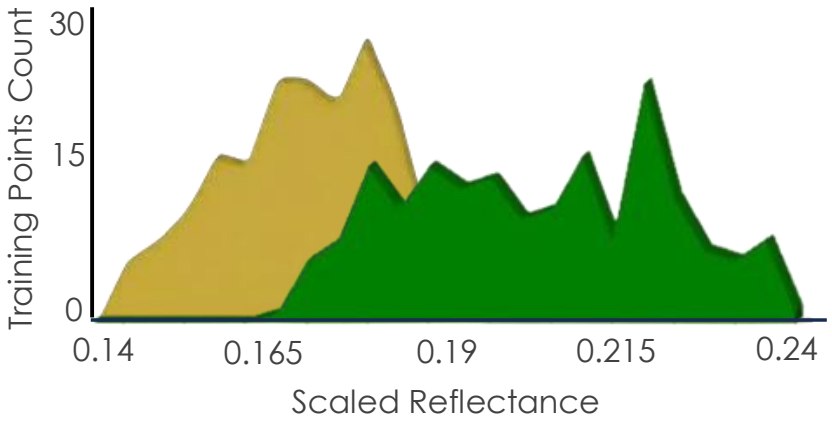
Mean spectral signatures of purified longleaf and loblolly points by band



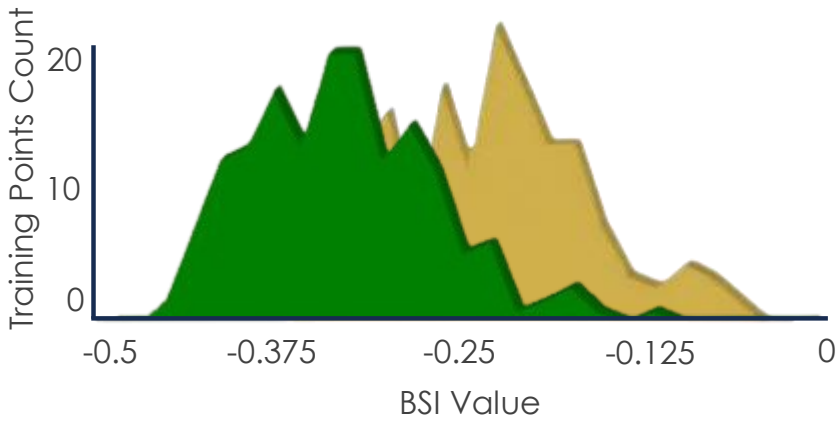
The purified longleaf and loblolly points may only be spectrally differentiable using the NIR band

Indices Improve Spectral Differentiability

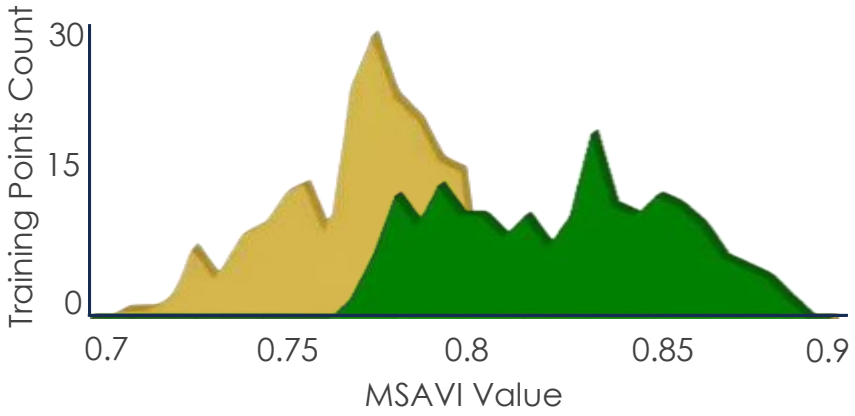
Near Infrared (NIR) Spectral Comparison



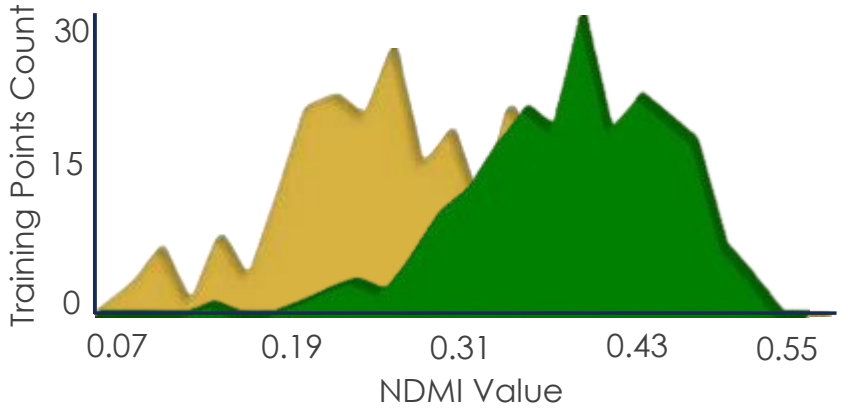
Bare Soil Index Spectral Comparison



Modified Soil-Adjusted Vegetation Index Spectral Comparison



Normalized Difference Moisture Index Spectral Comparison



Longleaf Points

Loblolly Points

Selected indices showed **more spectral differentiation** between longleaf and loblolly points

Classifier Input Data

Winter Imagery

Landsat Bands 2-7

Principal Component Analysis

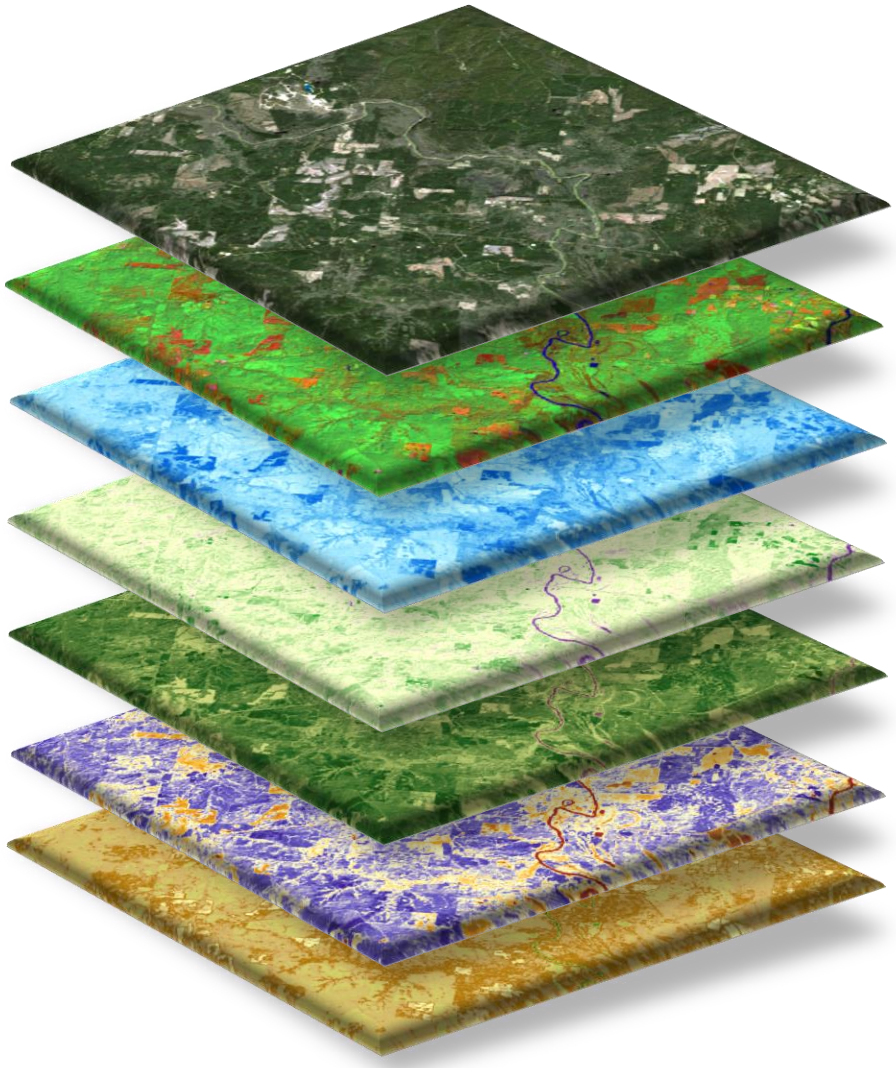
Normalized Difference Moisture Index

Modified Soil Adjusted Vegetation Index

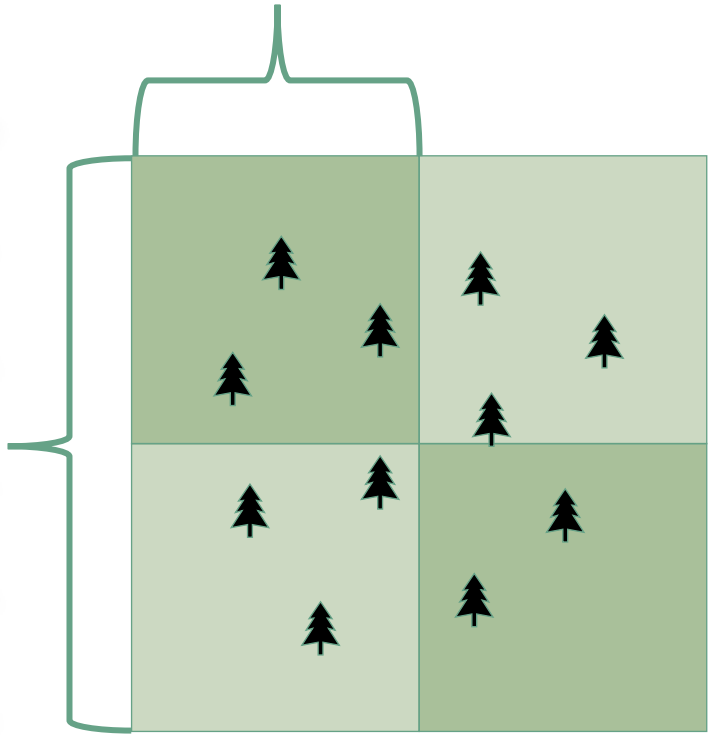
Normalized Difference Vegetation Index

Enhanced Vegetation Index

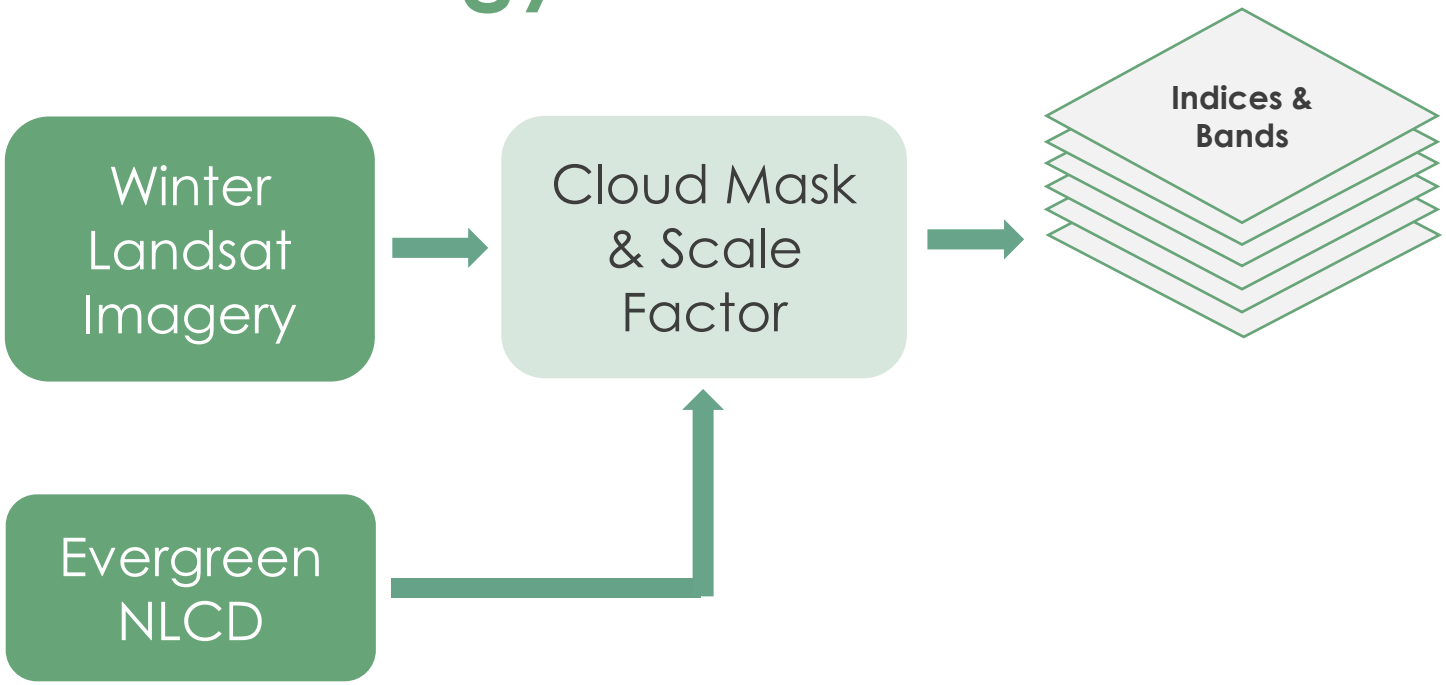
Bare Soil Index



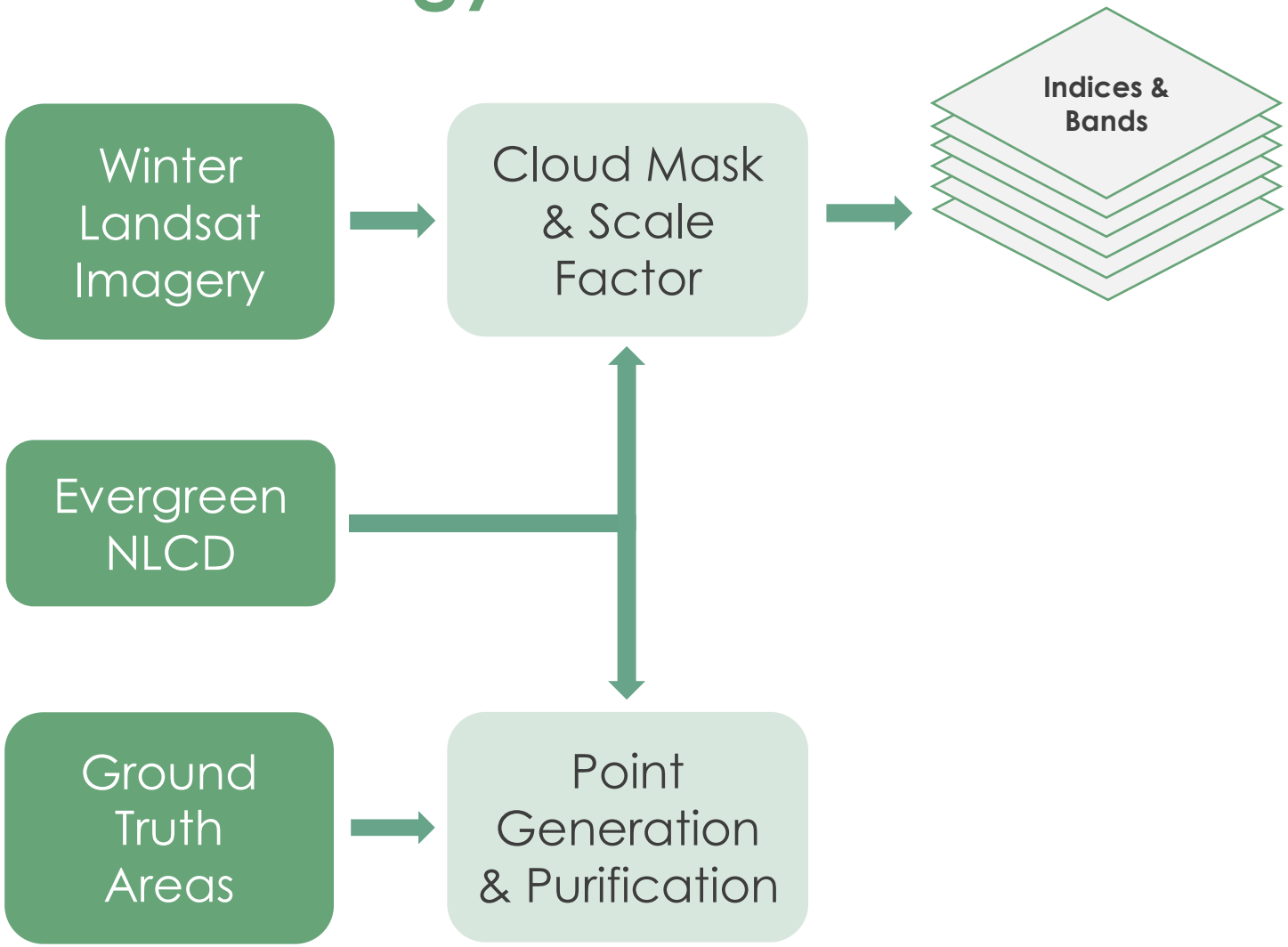
30 Meter Landsat Resolution



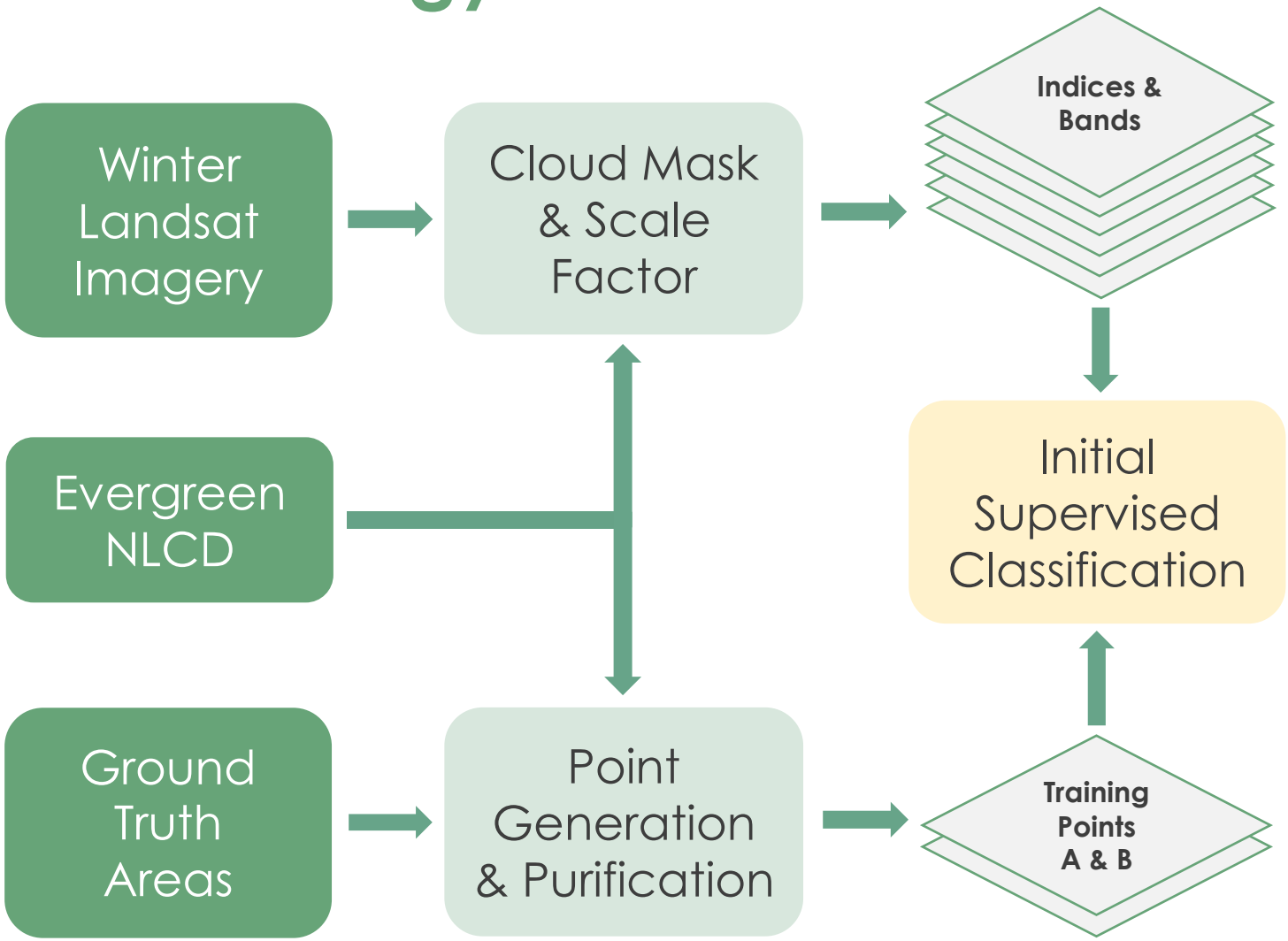
Methodology



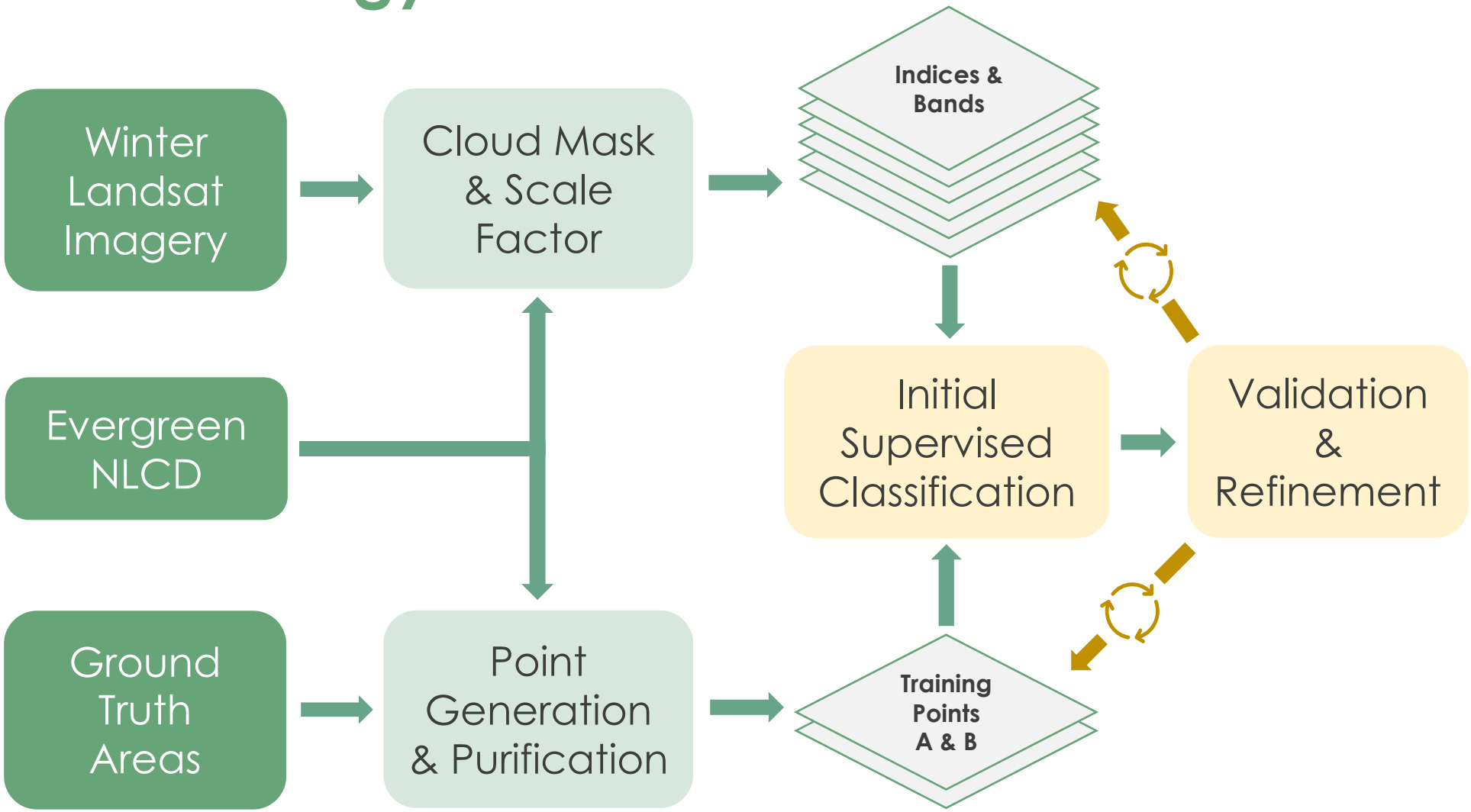
Methodology



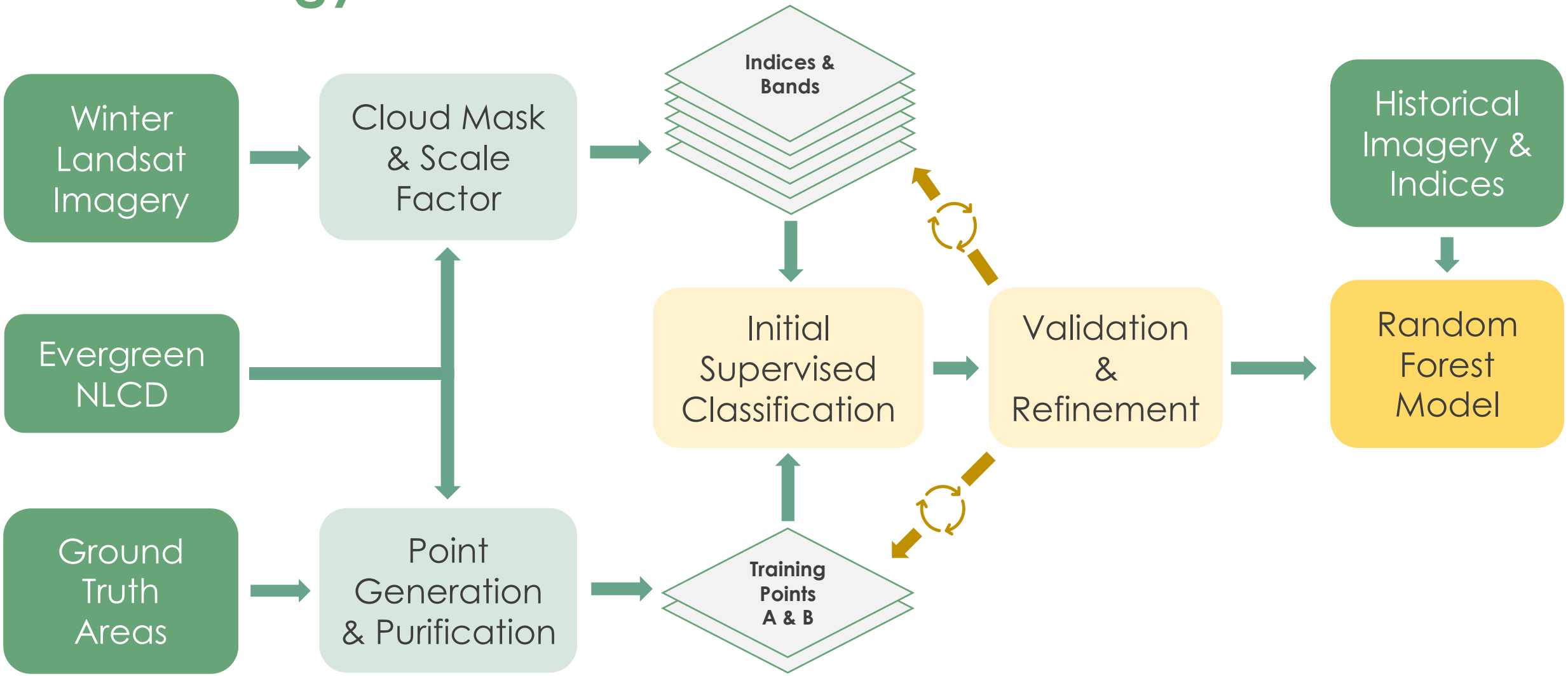
Methodology



Methodology

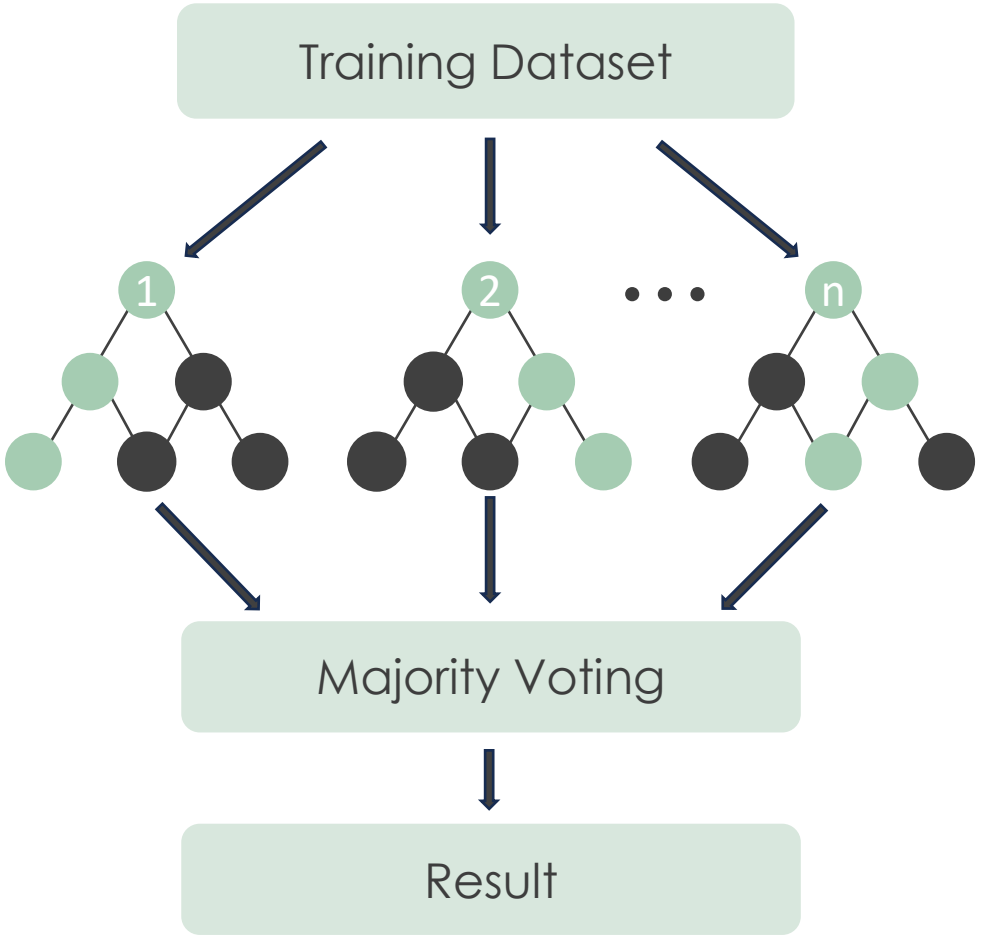


Methodology



Modeling and Validation

Random Forest Model



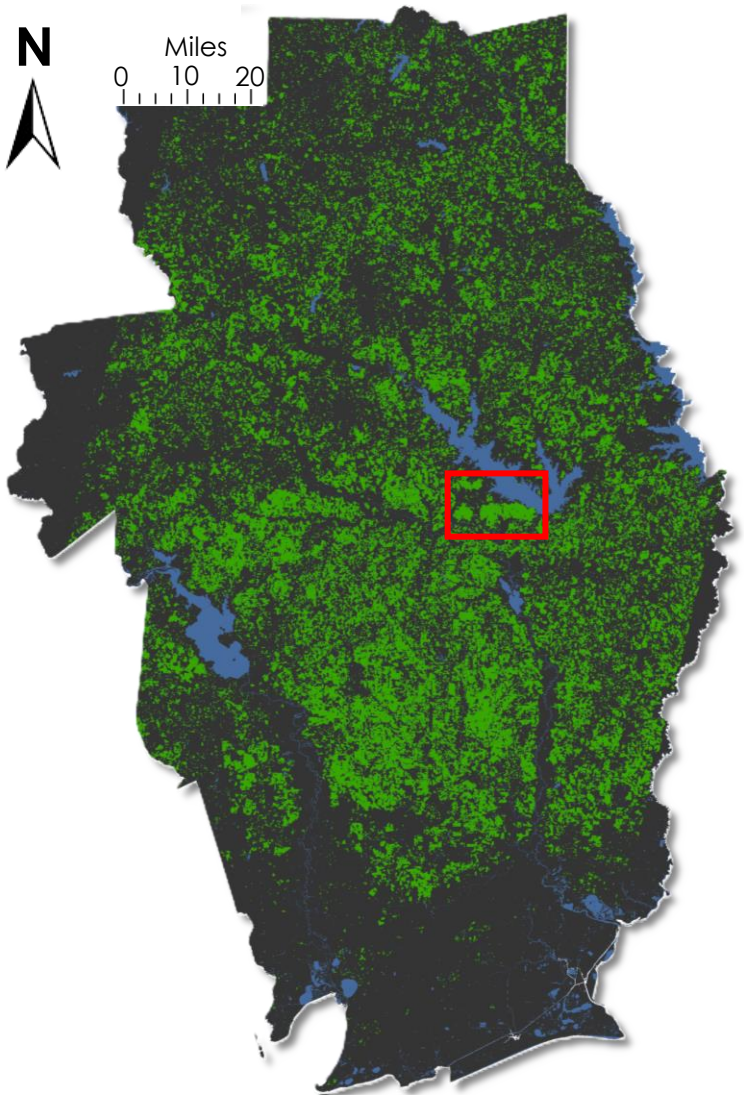
Ground truth

Predicted	Longleaf	Loblolly	Total	Error of Commission
Longleaf	76	5	81	0.06
Loblolly	12	90	102	0.12
Total	88	95	183	
Error of Omission	0.14	0.05		0.09

Overall Agreement: 91%
Overall Kappa: 0.81

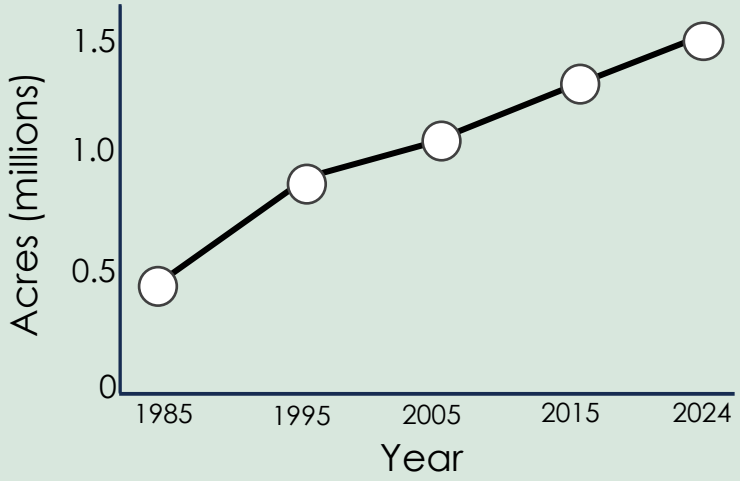
The high agreement and kappa suggest this model fit the ground truth data exceptionally well

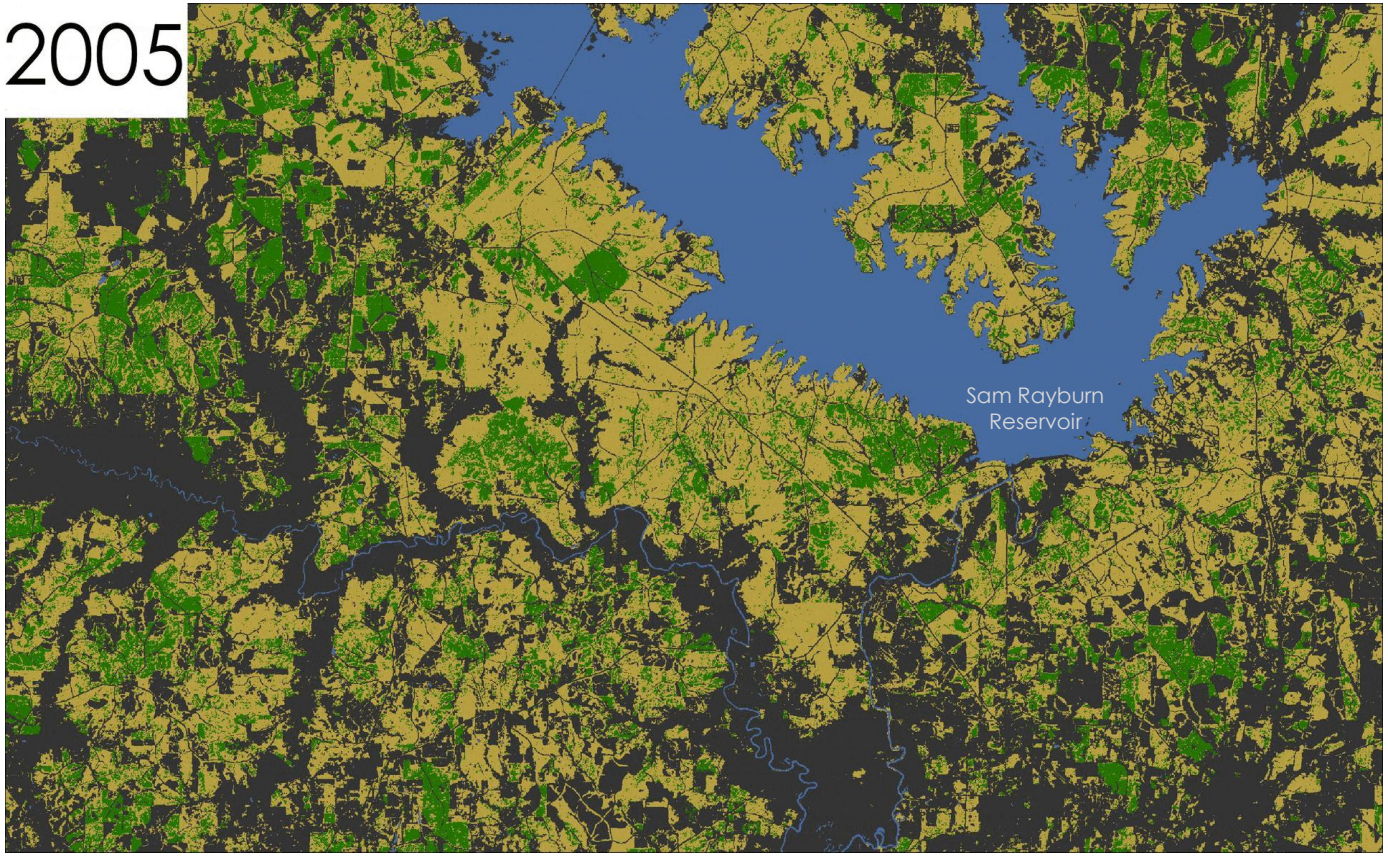
Current Longleaf Distribution Results



Historical Results: 1985, 1995, 2005, 2015

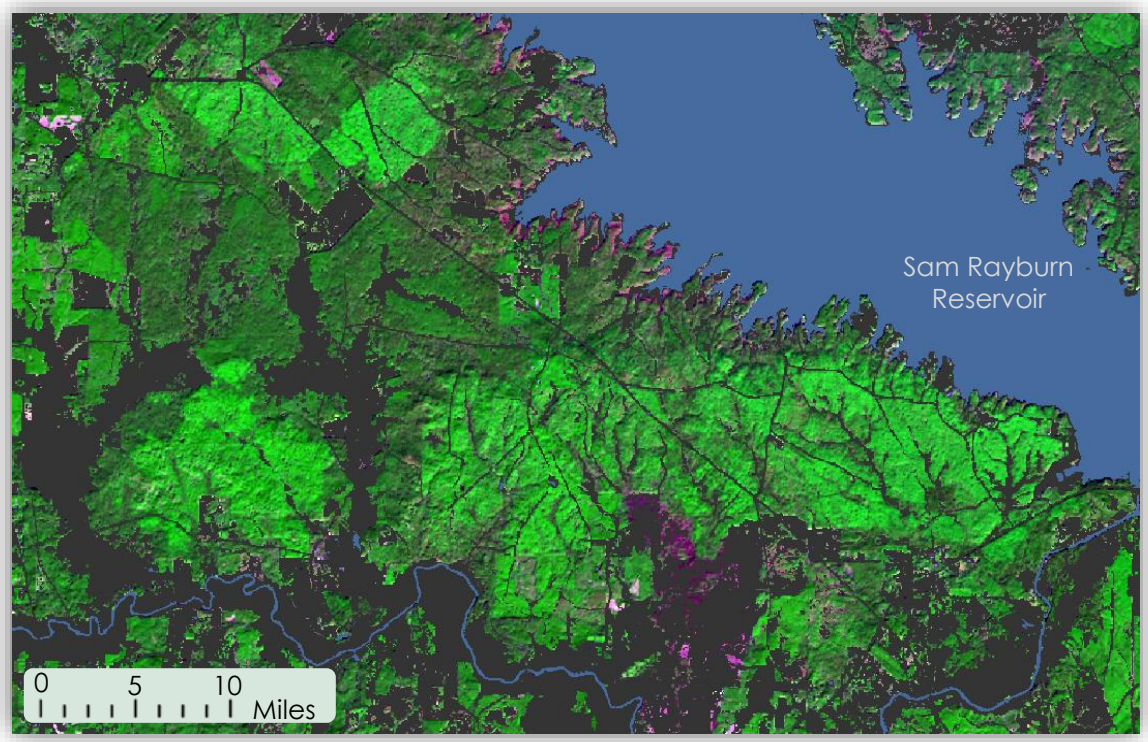
Area of longleaf pine stands by decade





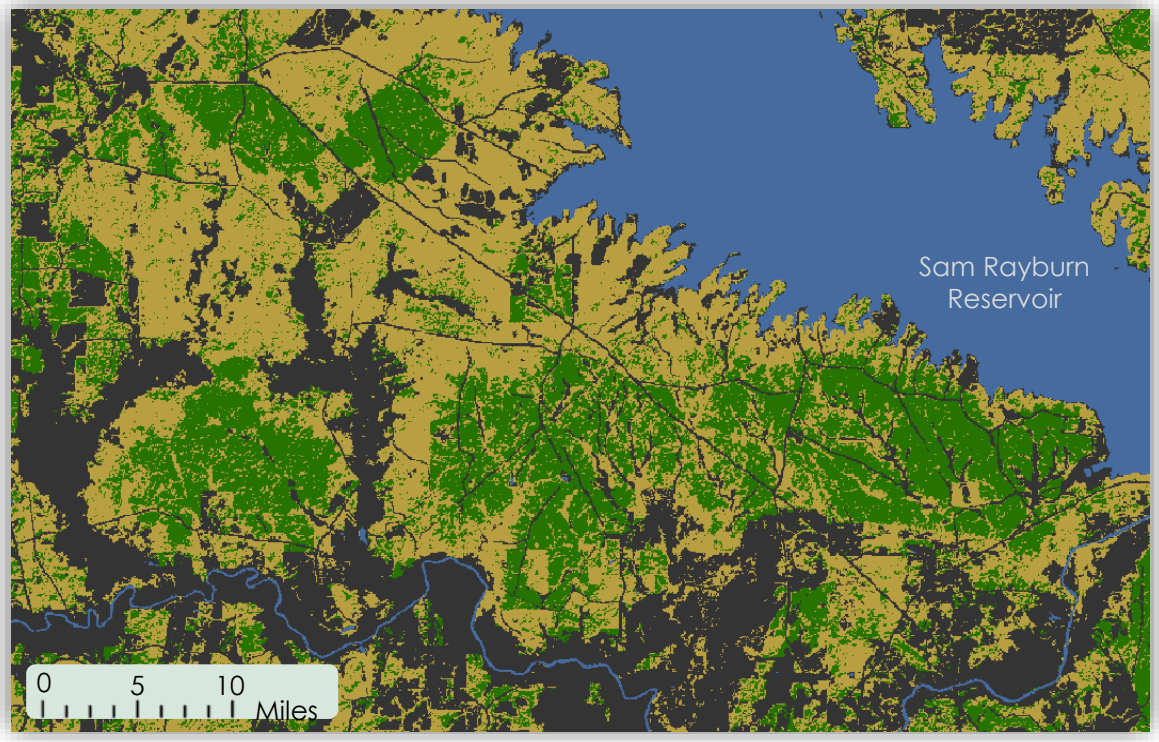
Discussion of Model Behavior

Enhanced Landsat RGB Imagery



Model keying in on "brightness"

Model Prediction



Confounding variables of tree age and stand type

Error and Limitations

Temporal delay between NLCD and winter Landsat data

Image credit: Esri, USDA FSA

Longleaf data are biased toward young, planted stands

Image credit: Esri, USDA FSA

Loblolly data are biased toward natural, mature stands

Slash pine
(*Pinus elliottii*)

Shortleaf pine
(*Pinus echinata*)

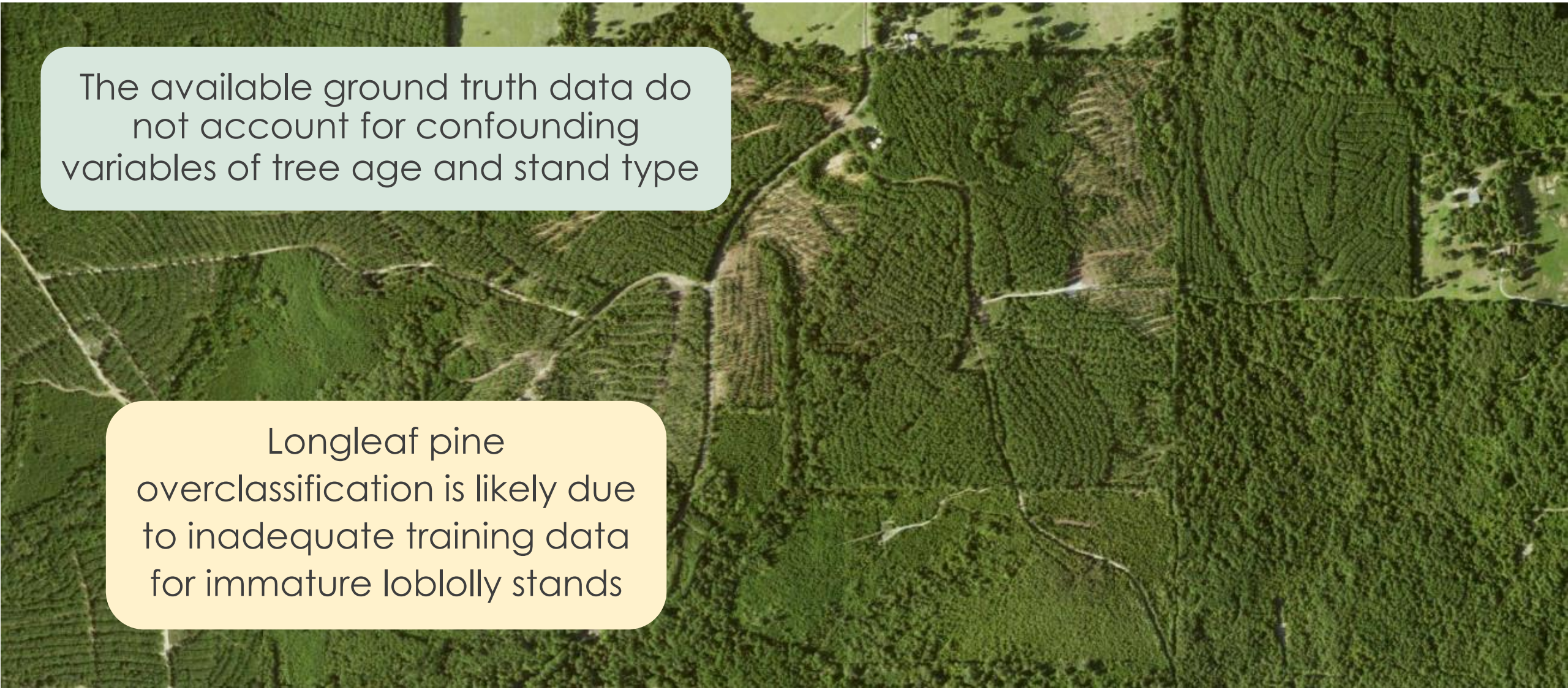
Image credit: Texas A&M Forest Service

Slash pine, shortleaf pine, & hybridized longleaf-loblolly

Feasibility

Image credit: Esri, USDA FSA

Feasibility

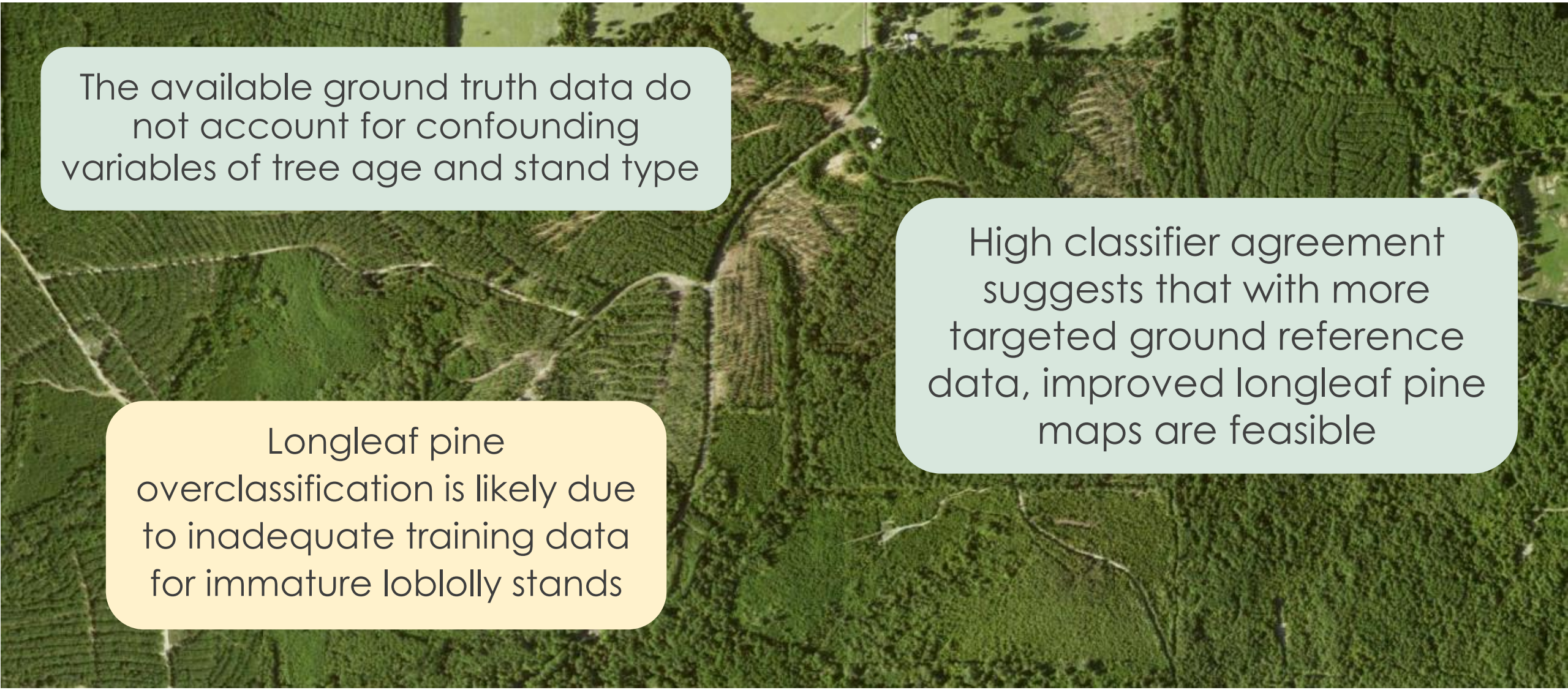


The available ground truth data do not account for confounding variables of tree age and stand type

Longleaf pine overclassification is likely due to inadequate training data for immature loblolly stands

Image credit: Esri, USDA FSA

Feasibility



The available ground truth data do not account for confounding variables of tree age and stand type

High classifier agreement suggests that with more targeted ground reference data, improved longleaf pine maps are feasible

Longleaf pine overclassification is likely due to inadequate training data for immature loblolly stands

Image credit: Esri, USDA FSA

Partner Implementation

Image credit: Sue Waters

Decrease scope, increase resolution

Use high resolution data for tree-level analysis within a priority area

Diversify ground truth data

Collect tree data across a variety of ages, species, and stand types

Increase number of classes

Classify across multiple variables such as stand age, type, and other species

Acknowledgements

Advisors:

Keith Weber - Idaho State University GIS Training and Research Center

Joseph Spruce - Analytical Mechanics Associates

Partners:

Jennifer Sanders – Texas Longleaf Team Coordinator

Taylor Keys – Texan by Nature Director of Programs

Caitlin Tran – Texan by Nature Program Manager

Hughes Simpson – Texas A&M Forest Service Assistant Director

Eric Wannlund – Texas A&M Forest Service Staff Forester

Lead:

Isaac Goldings – NASA DEVELOP Idaho Node Lead

This material is based upon work supported by NASA through contract 80LARC23FA024. Any mention of a commercial product, service, or activity in this material does not constitute NASA endorsement. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Aeronautics and Space Administration and partner organizations.