New Project

A Neural Network Approach to Generating Leaf Area Index Estimates Using the Sentinel-2 Satellite Record

Co-PIs: Rachel L. Cook, NCSU (lead), Aaron Weiskittel, UMaine, Mark Kimsey, U Idaho, Cristian Montes & Alicia Peduzzi, UGA
Project Code CAFS.21.87

Andrew Trlica presenting

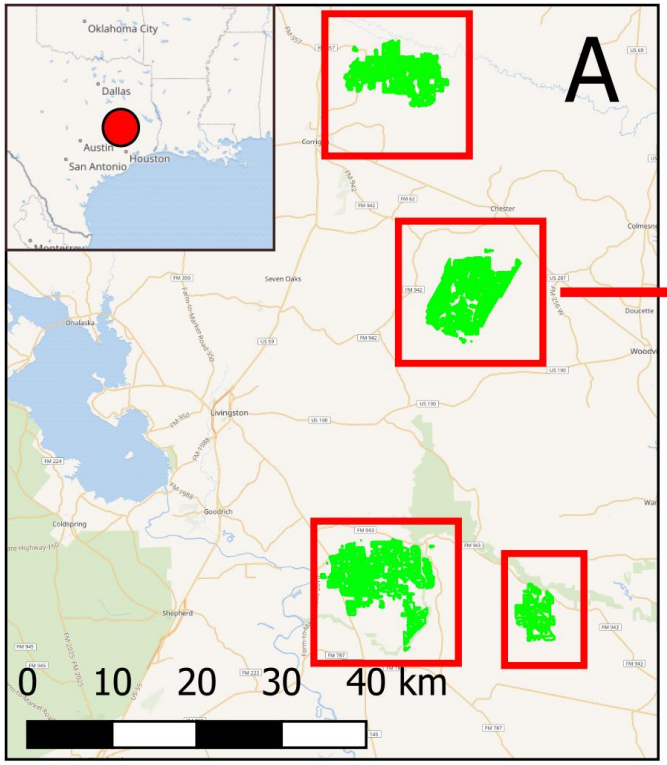
LAI Can Inform Forestry Decisions

- Need for an **Accurate, Flexible, Accessible** tool for LAI estimation
  - Current approaches pose barriers to forest practitioners
- Canopy LAI is critical for stand and sub-stand level management
- Understory LAI is critical for vegetation control decisions

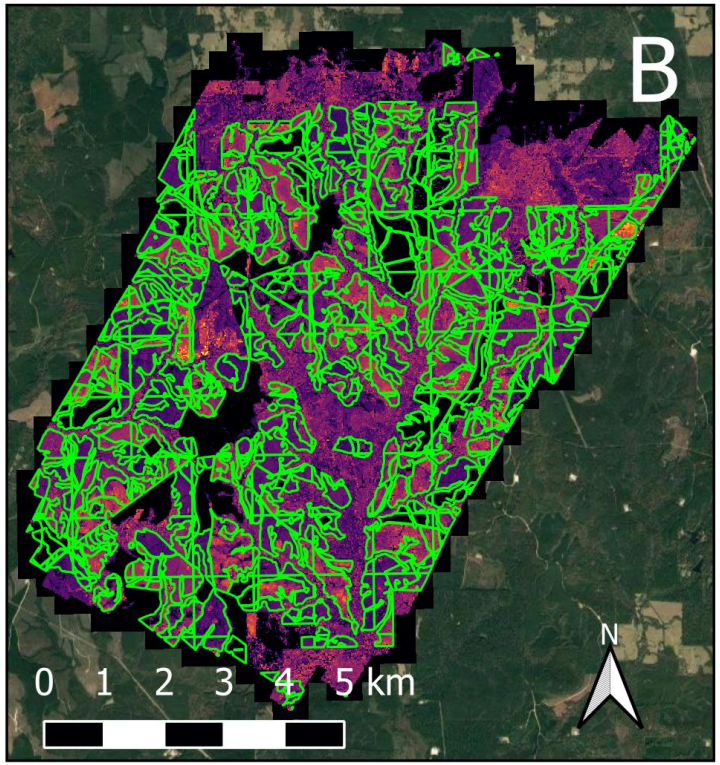
Objectives

- Operationalize web interface with loblolly pine canopy “machine-learning” LAI model (MLAI)
- Expand to other regions and species for a national level LAI model for production forests
- Develop understory model to run in parallel with overstory model
- Use LAI model to develop potential productivity and response maps in conjunction with soils and climate data

Predicting LiDAR LAI from Sentinel-2

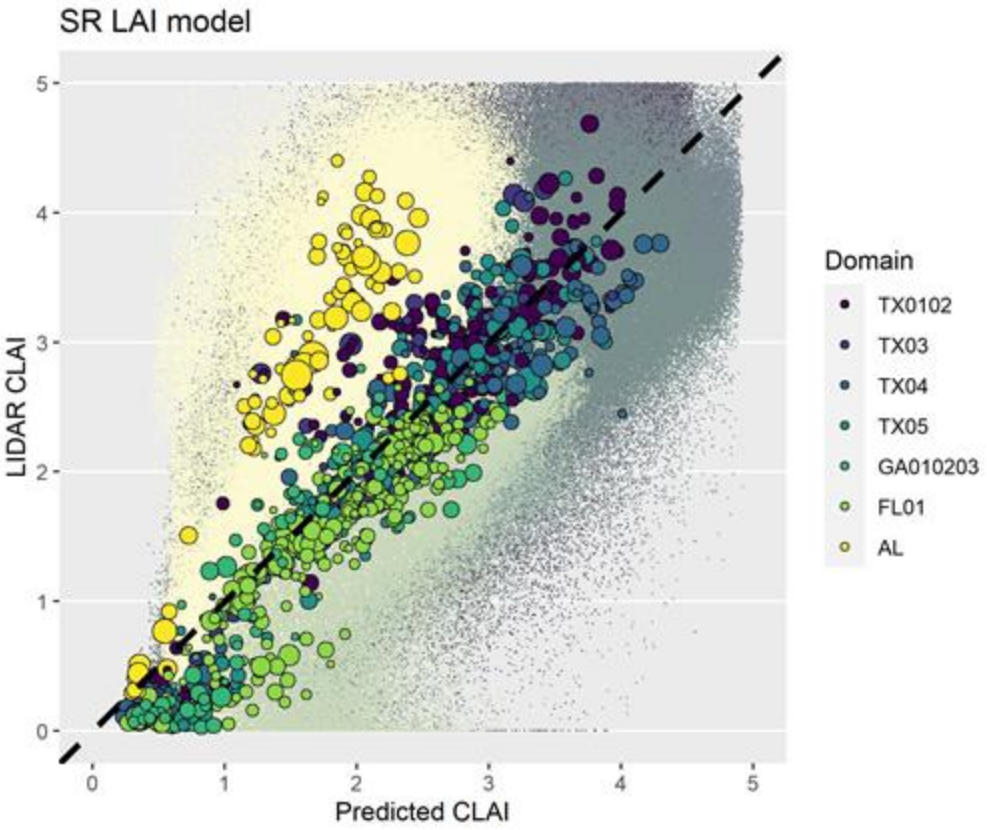


A: Example Loblolly pine plantation boundaries provided by coop member



B: Corresponding LIDAR Canopy LAI, January 2018

Current Standard LAI Estimation



Sentinel-2 Simple Ratio, Loblolly pine, 10 m

- Sentinel-2 (10-20 m) or Landsat (30 m)
- Linear model of Simple Ratio (SR)
- Accuracy (RMSE):
  - 0.78 (pixel)
  - 0.58 (whole stand)
- Requires manual data fetching+processing

Machine Learning for Forest Remote Sensing

- Cloud data and distributed computing allows for new approaches

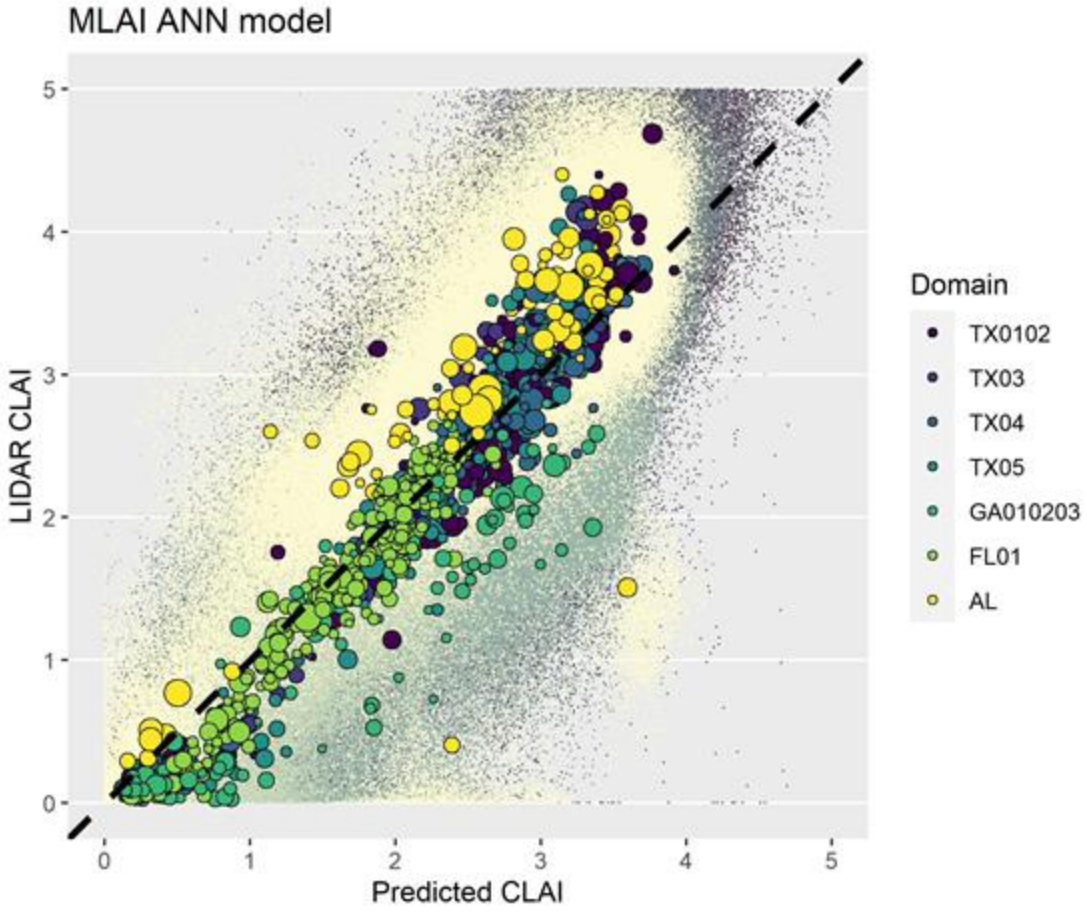
Current work:

1. Custom built Artificial Neural Net in TensorFlow
2. LiDAR from members & S2 data via Earth Engine for training
3. Google AI Platform hosts trained model to make predictions for any place/time with S2 coverage

Deep Learning Approach

- Introducing MLAI: Artificial Neural Network for LAI estimation in plantation forests
- Uses information from all 9 bands + pixel neighbors → greater match to LiDAR
- S2 needs no upfront processing, just specify date(s) and place(s)
- 10 predictions + confidence estimate for each pixel

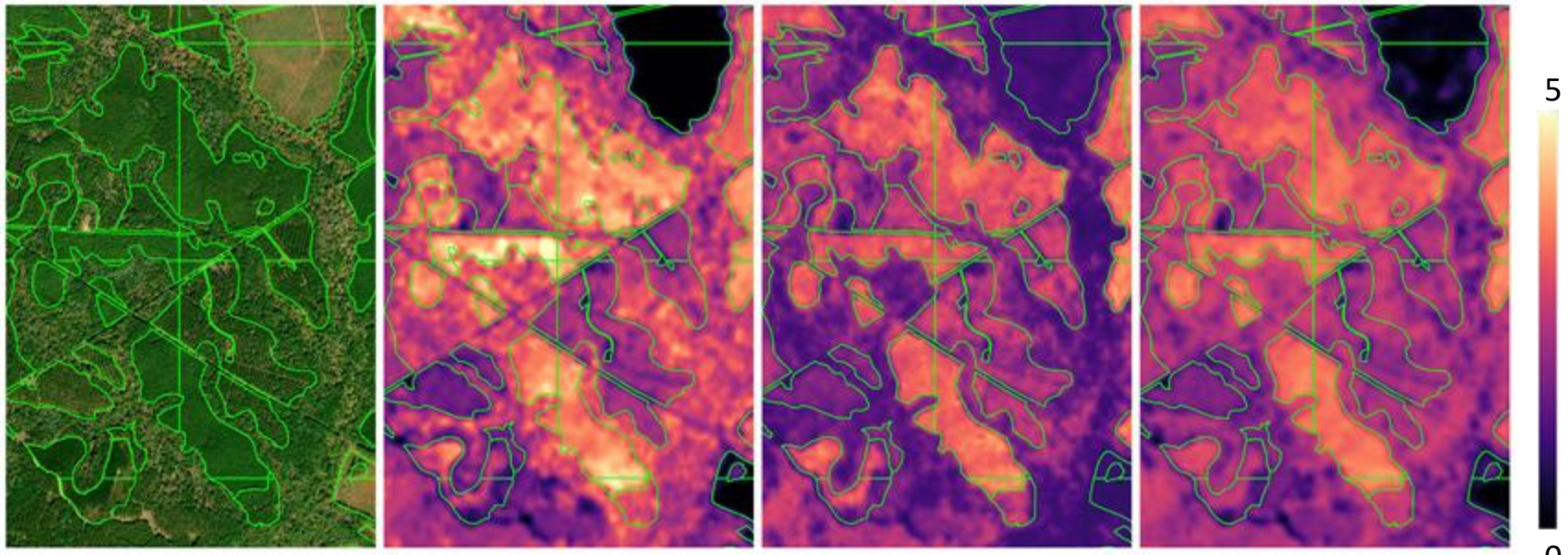
The “MLAI” Model



Sentinel-2 MLAI, Loblolly pine, 10 m

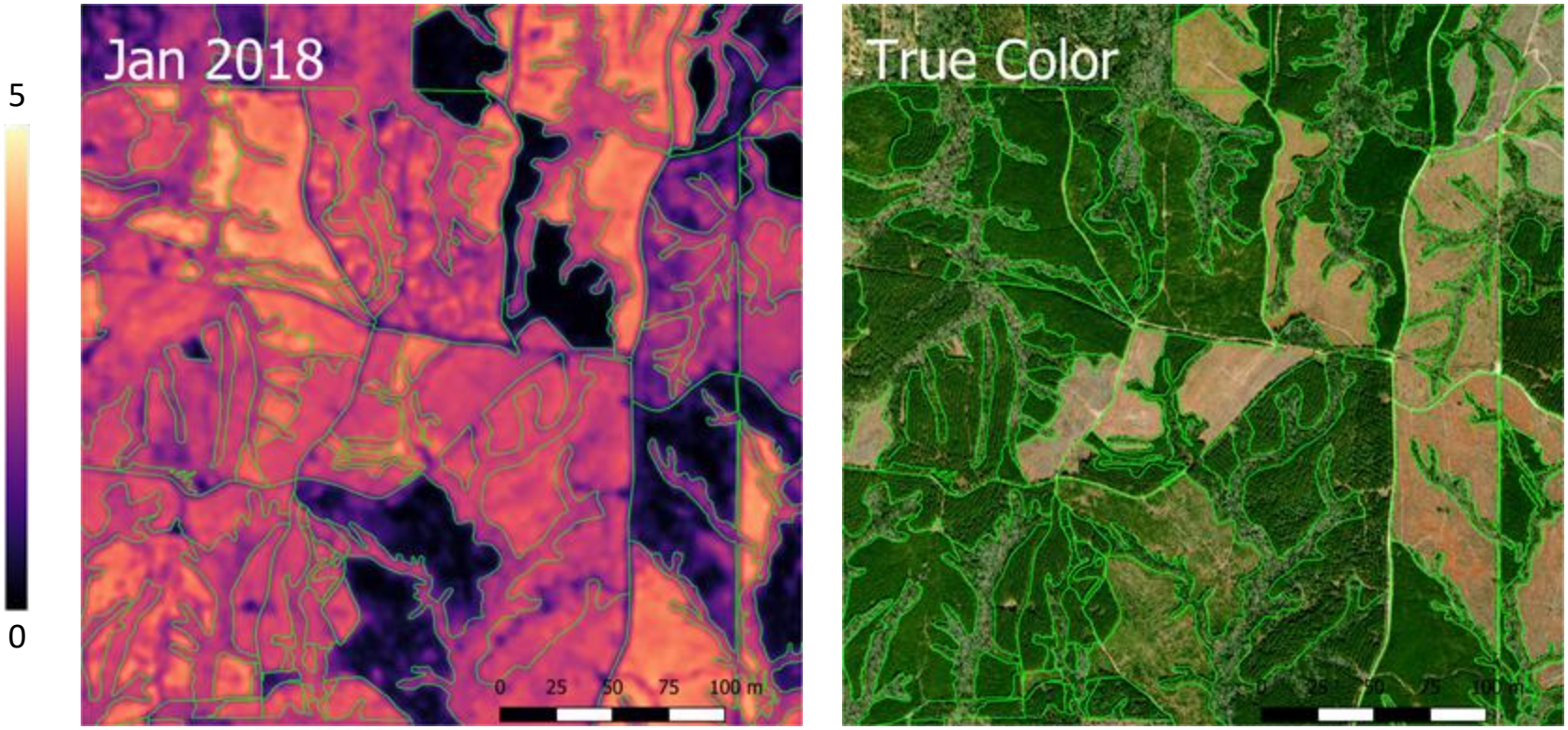
- Best-so-far accuracy
  - Pixel RMSE: 0.56
  - Stand RMSE: 0.38
- Applicable for Loblolly LAI anywhere on the globe, mid-2017 to present

Map-to-map comparisons



Several ways to measure LAI — which one is “correct”?

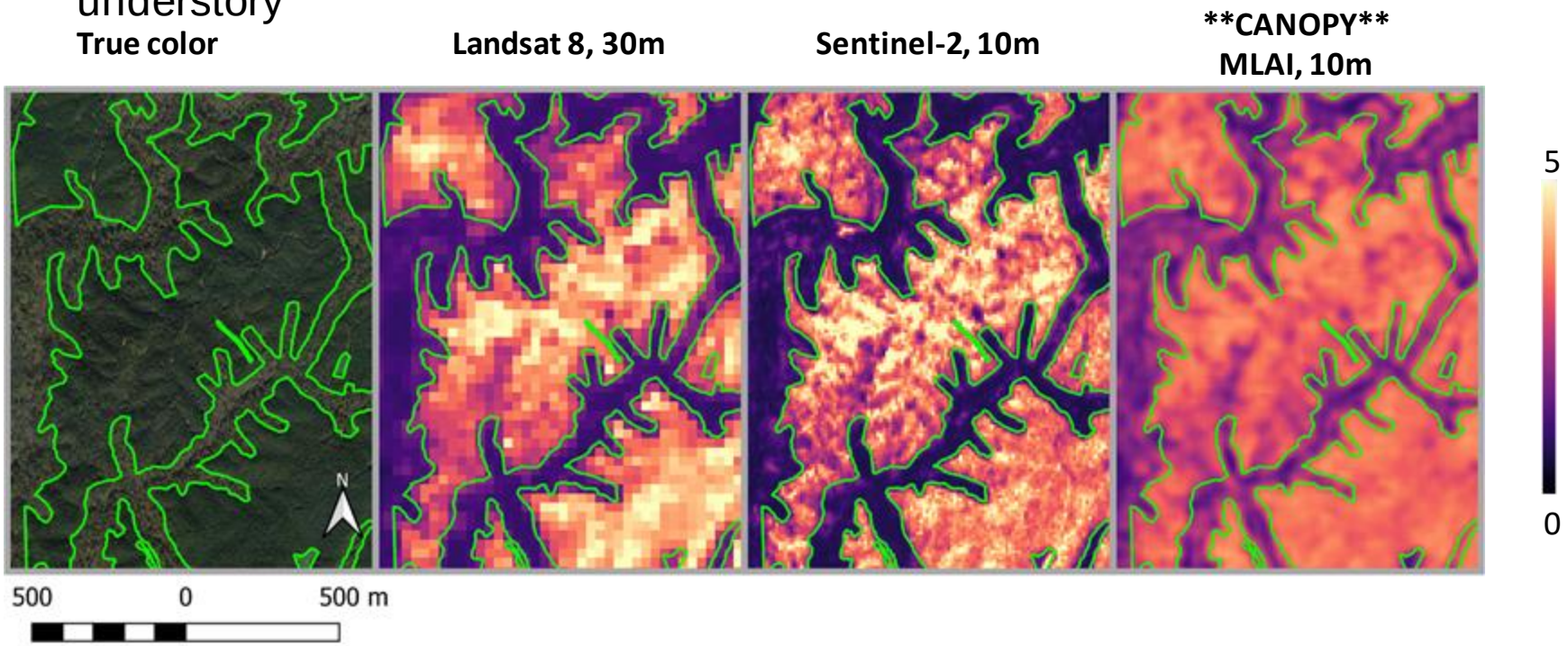
Continuous monitoring



Loblolly plots in Jan 2018 LIDAR track, East Texas

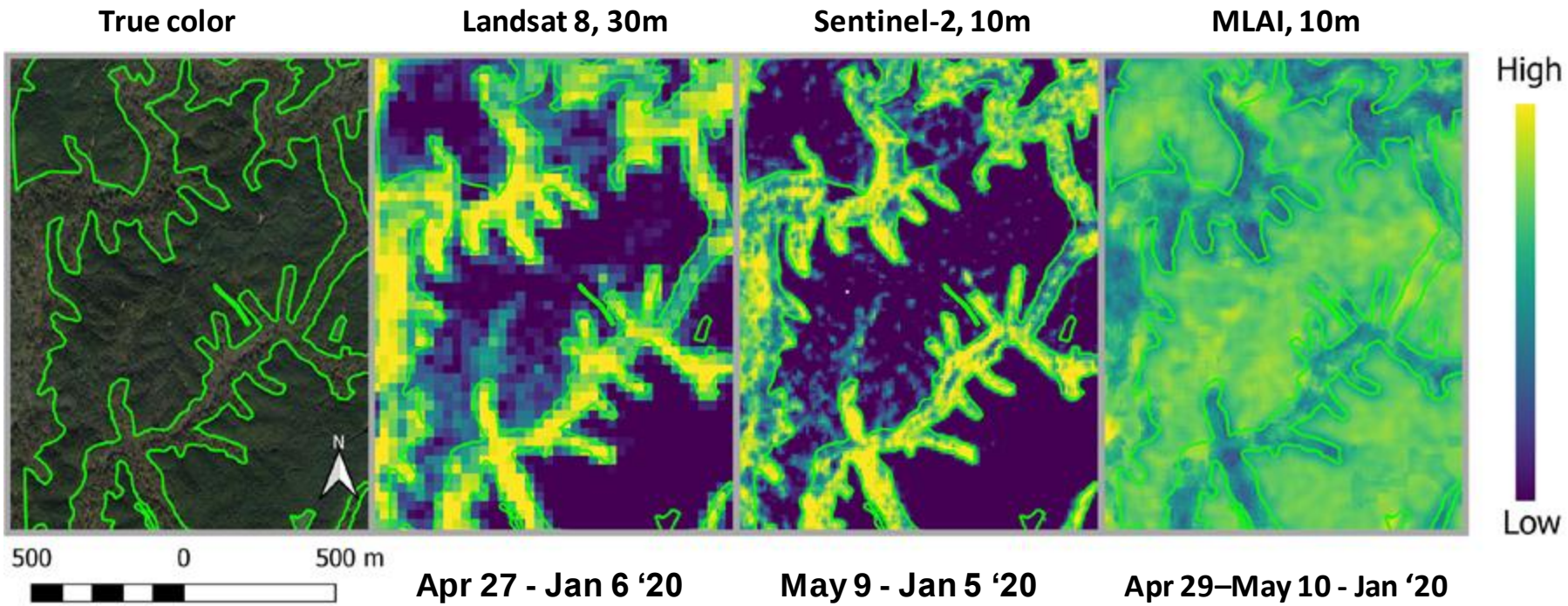
Understory identification

Difference in Winter vs Spring LAI deciduous understory



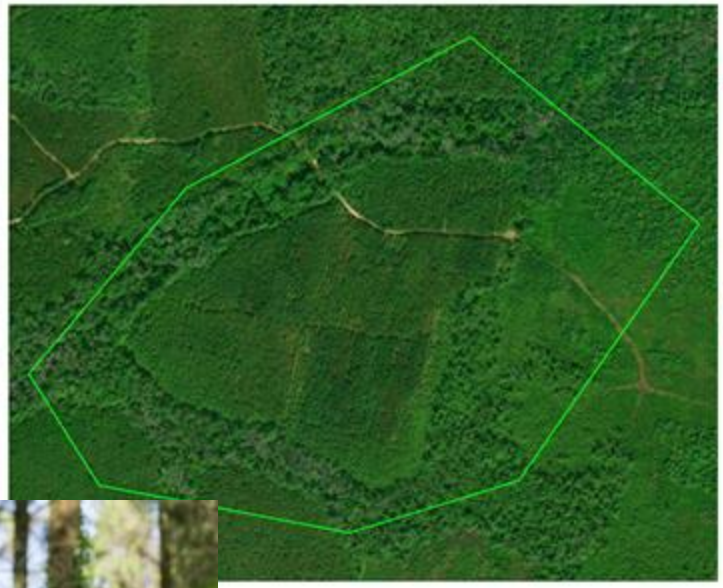
Loblolly LAI, Jan 2020, Alabama Coastal Plain

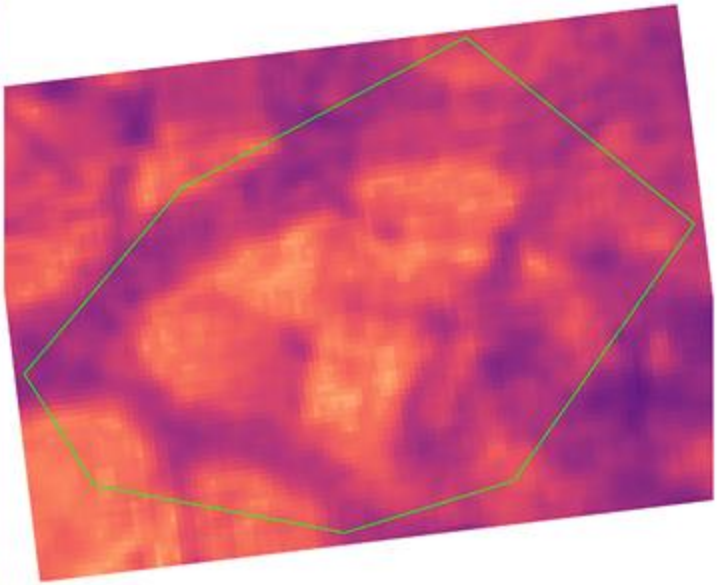
Understory identification



Little available springtime LiDAR at present to inform MLAI estimation

On-demand forest information

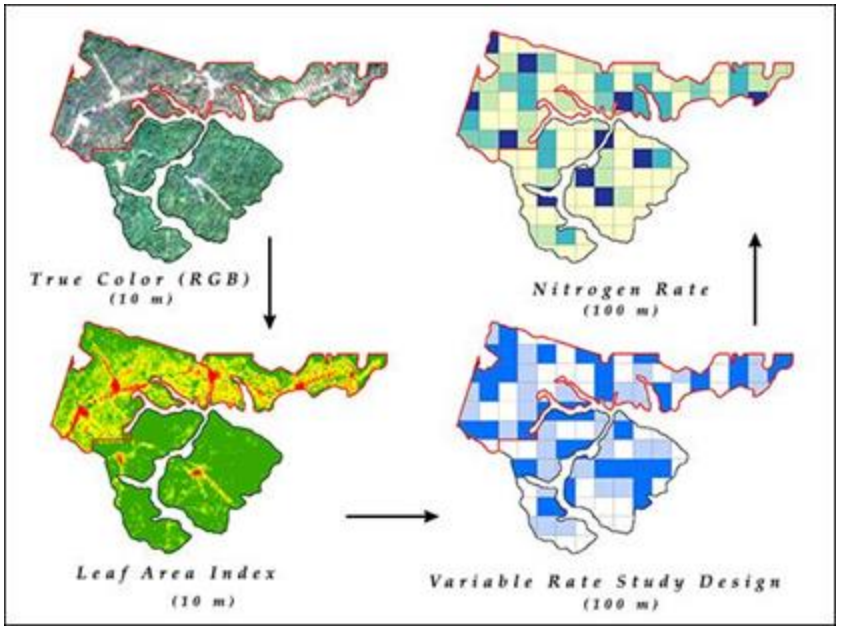




- In field, on site estimation (new windshield cruise)
- Identify stands + sub-stands to prioritize management

Optimize management across land base

- Prioritize stands more efficiently for fertilization or vegetation control
- Optimize return on investment of management
- Learn from operational “experiments” on a landscape scale



Deliverables:
Year 1

Develop User Interface

- Web-based app to interface MLAI model
- Input place + time → LAI map
- Develop underlying understory estimation process for parallel delivery

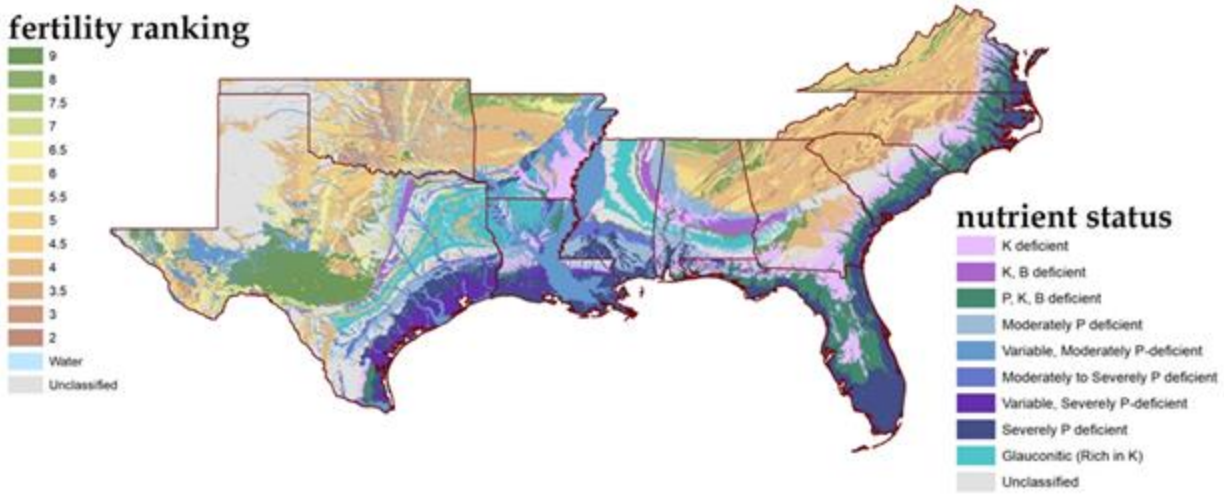
Deliverables:
Year 1-2

Species-specific LAI models

- Douglas fir
- Slash pine
- Western larch
- NE conifers
- Flexible intake + training + prediction → Anywhere with enough LiDAR can form the basis of a new specialized model

Create Site Specific Recommendations

- Overlay with soils map and operational responses over time to fine tune silvicultural prescriptions
- Model with soil and climate variables to make better predictions for future response and current conditions



Moving towards data-driven forestry

- **Accurate, Flexible, Accessible** tools are in the wings to better use the growing body of forest information
- Need industry and university accumulated LiDAR+stand data from multiple regions to further develop models
- Will require continued IT support for updates, development, and maintenance