Regionally Specific Drivers of Land-Use Transitions and Future Scenarios

A SYNTHESIS CONSIDERING THE LAND MANAGEMENT INFLUENCE IN THE SOUTHEASTERN US

Co-Investigators and Students

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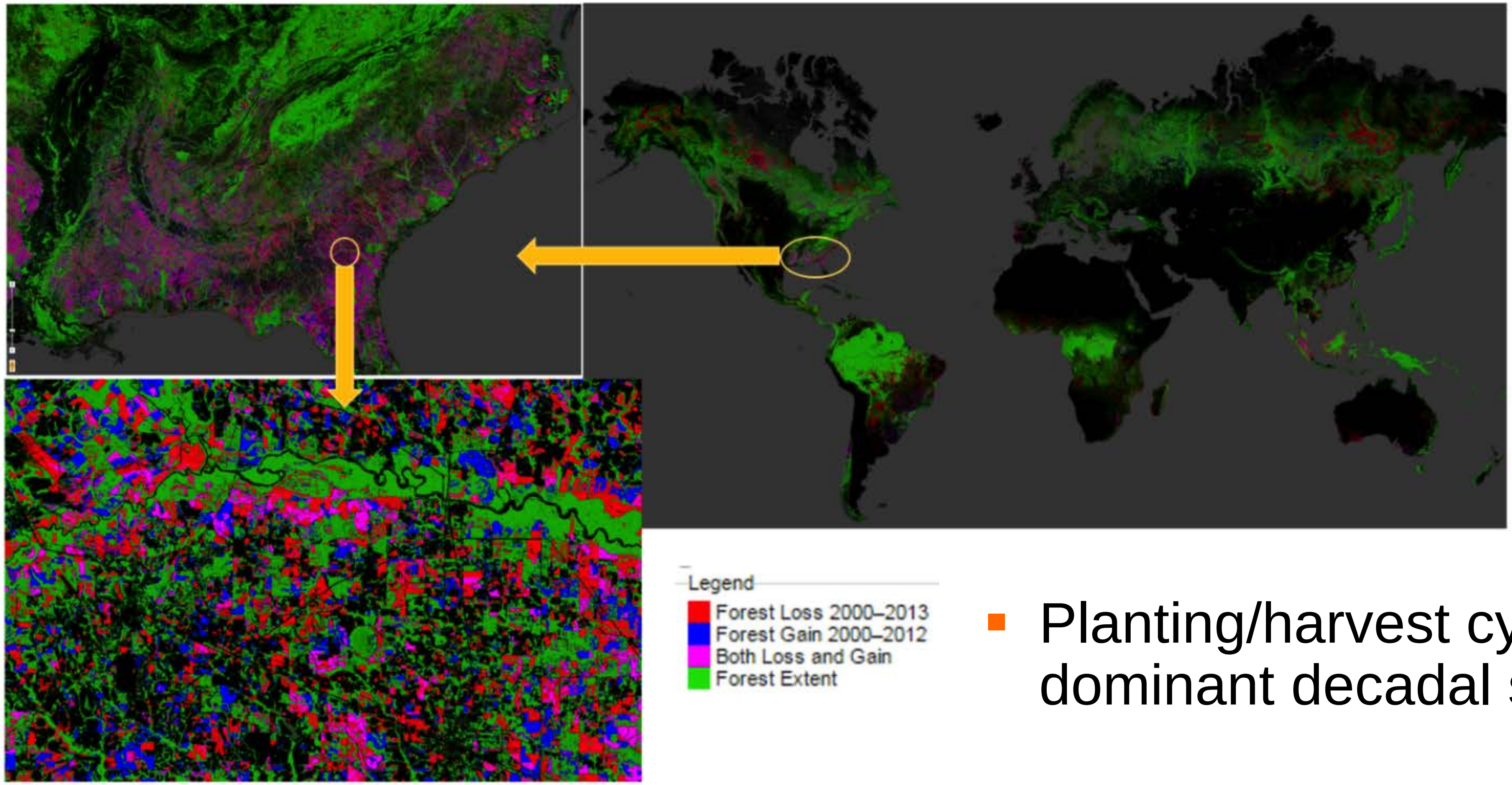
In the southeastern US, forests are dynamic

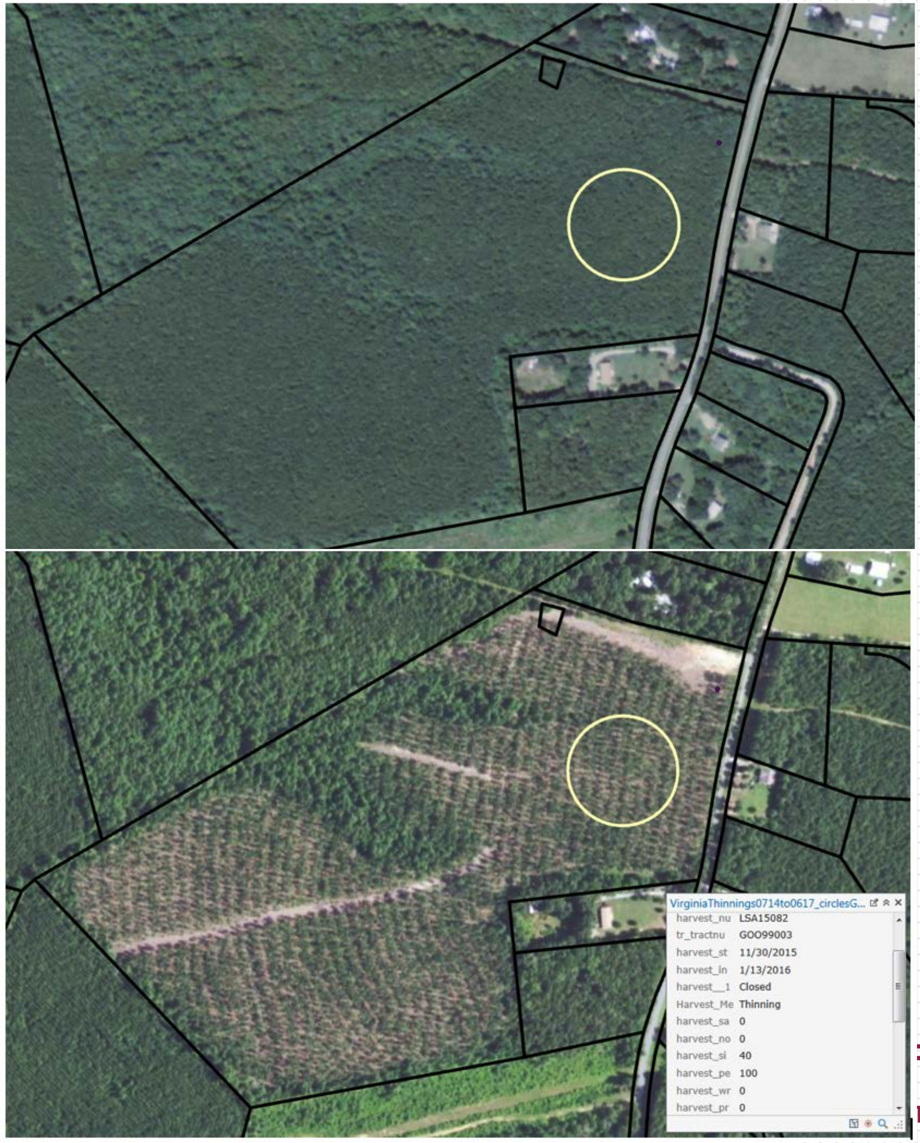


Derived from Hansen et al (2013)

- Planting/harvest cycle dominant decadal signal

Two major land change patterns in the region

- Land-use changes
  - Forest ←→ Agriculture
  - Forest → Developed (urban)
  - Agriculture → Developed (urban)
- Periodic land cover changes reflecting forest management
  - Harvest, regeneration
  - Changes in density/composition
    - Naturally regenerating hardwoods → planted pine



2 parallel approaches to modeling past and future land use change

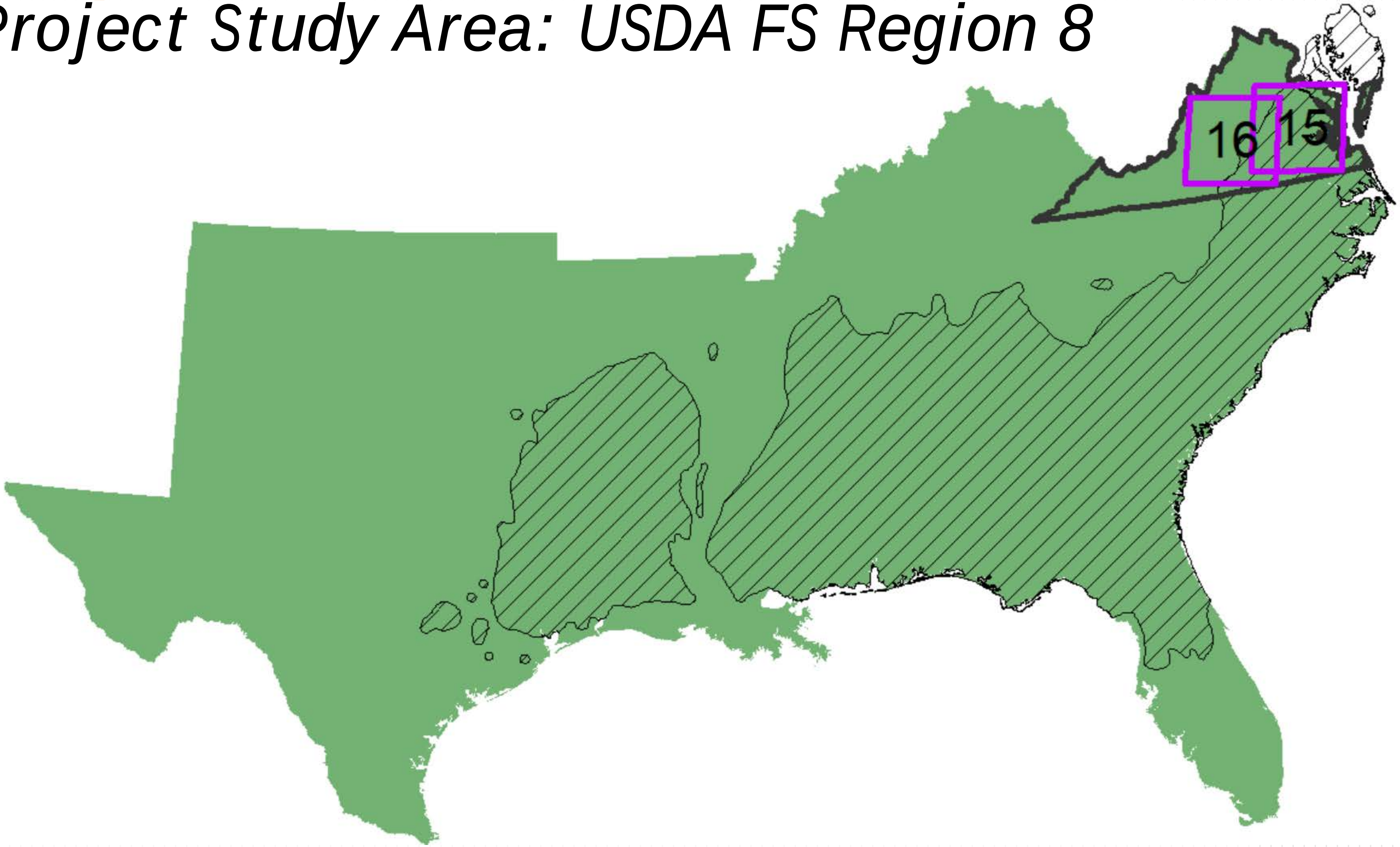
- Globally gridded land-use change products
- Regional, expert driven socioeconomic analysis

- a limiting feature of previous studies has been the treatment of secondary forests as a single land use
  - lumping passively managed or unmanaged forests with those that are intensively managed

Overall project goal

- To develop regionally refined land-use transition matrices that consider the economic structure of land management and land use decisions, incorporating forest management

Project Study Area: USDA FS Region 8



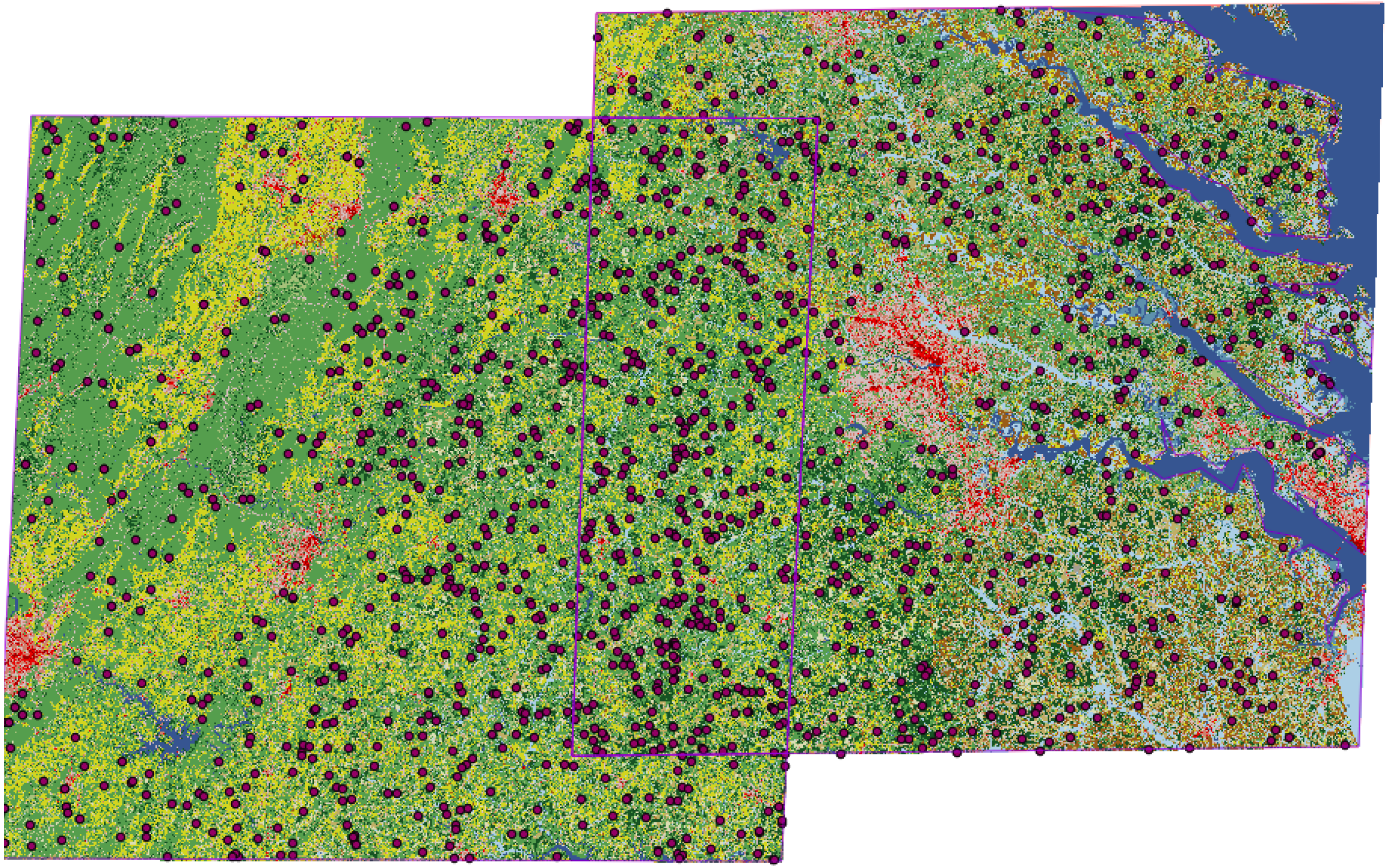
Mapping forest management and thins in Virginia

V.A. THOMAS, R.H. WYNNE, J. KAUFFMAN, E. BROOKS, R.Q. THOMAS, L. CHINI, R. BIN MEI, D. WEAR, J. RAKESTRAW

Developing a vetted subset of harvest records

Aug 2014-June 2017

- 1) Manual adjustment of coordinates from landing to stand
  - High resolution imagery in Google Earth
  - 1200 points
- 2) Development of a persistent pine class
  - Because only harvests are in the database
  - 300 points



Predictor layers

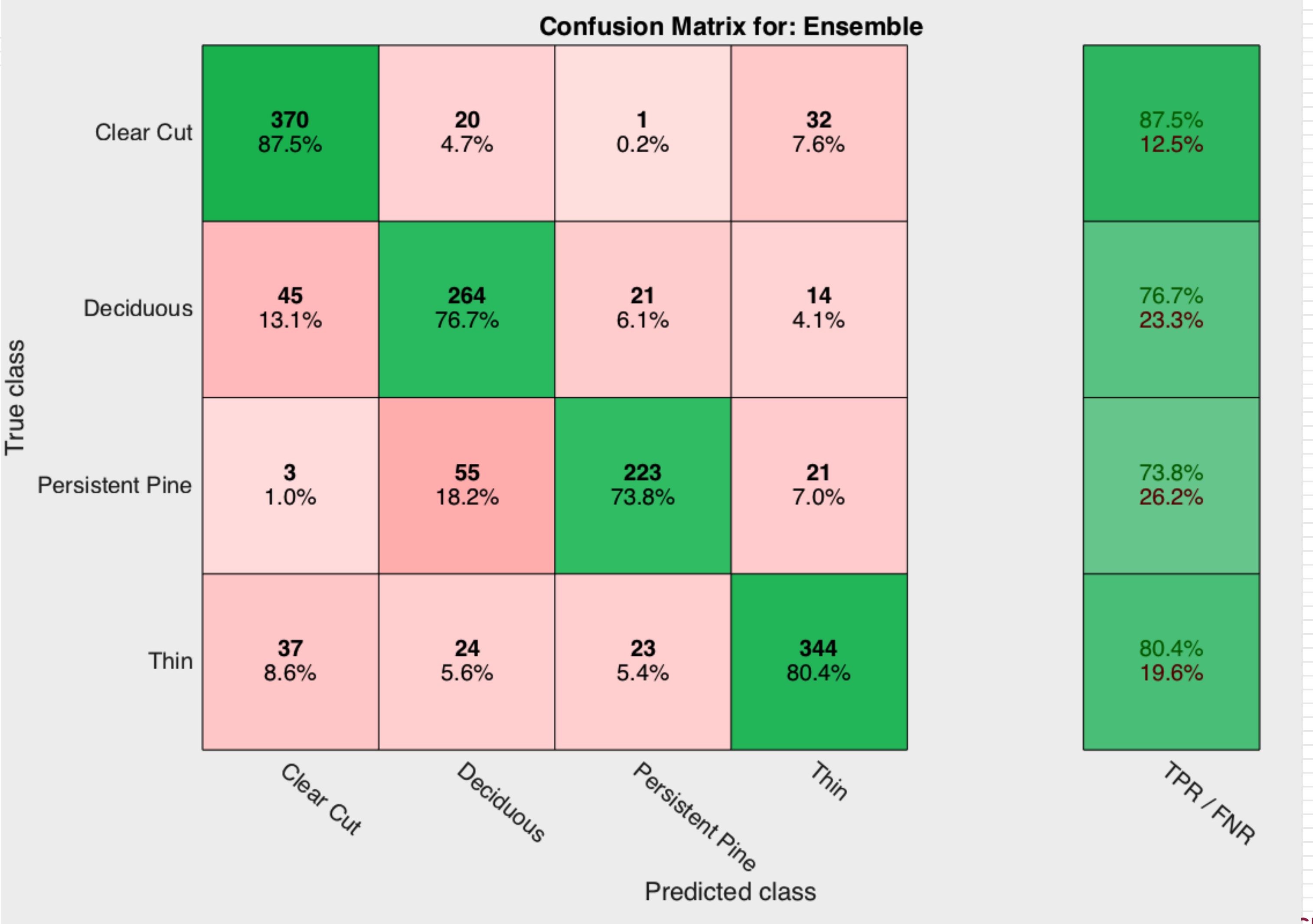
- HR constant, sine, cosine, RMSE, R2
  - 2009-11, 2014-16 [~156 acquisition dates]
  - L5 NDVI, L5 SWIR1, L5 SWIR2, L8 Pan (for 2014-16)
- 2011 NLCD, NLCD Change, CDL
- 2011 NLCD Tree Canopy Cover
- Hansen Global Forest Product
  - Loss year
  - Gain
  - Tree cover

GEE for cloud-masking and EWMACD algorithm

https://earthenginepartners.appspot.com/science-2013-global-forest/download_v1.5.html

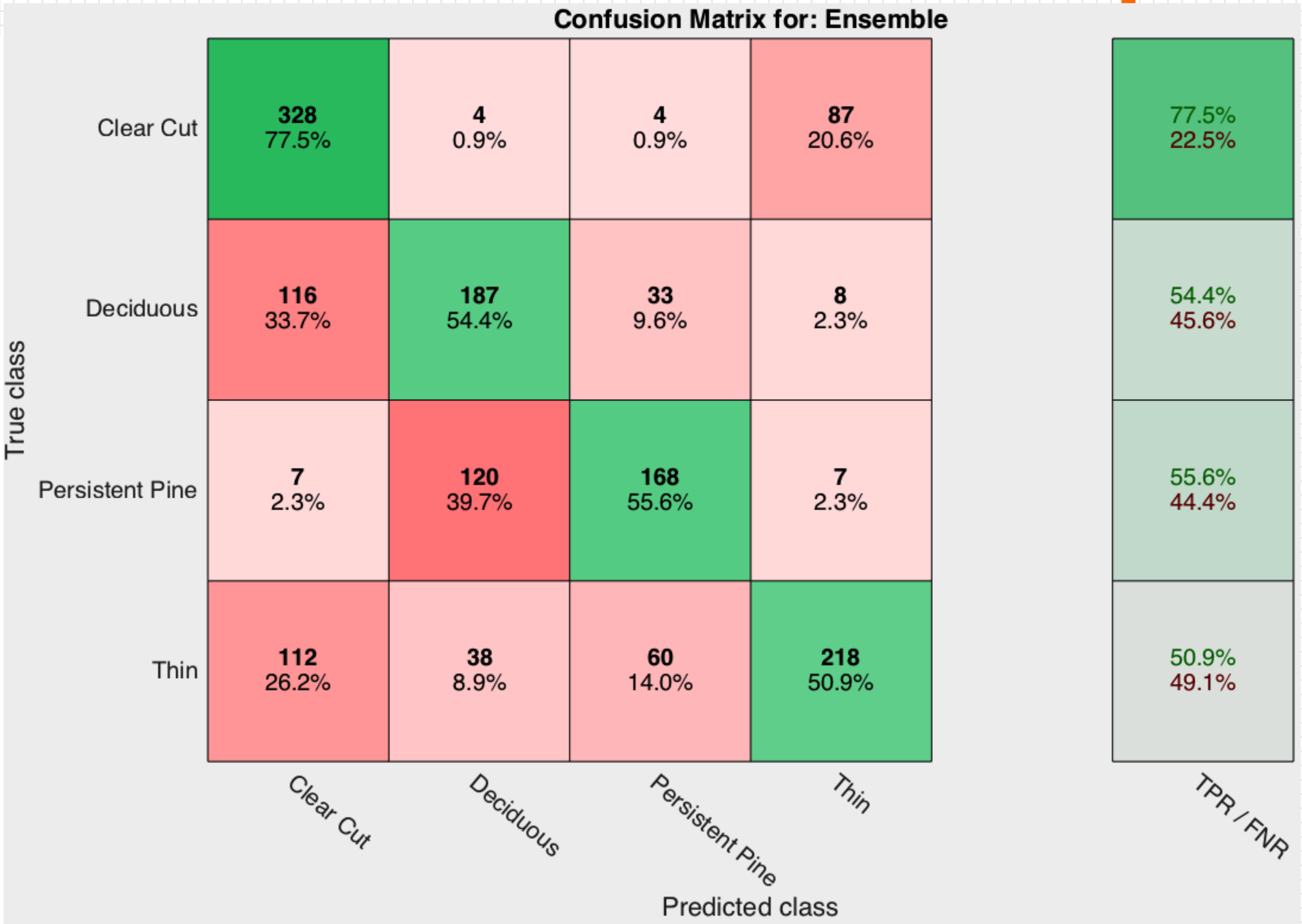
Classification within CDL forest classes
(deciduous, mixed, coniferous, and woody wetlands)
(n samples=1497)

- Overall accuracy 80.2%
- 20 predictors
  - 2014-16 HR constant, sine, and cosine, R^2 and RMSE for NDVI, SWIR1, Pan
  - R^2 & RMSE for SWIR2
  - Hansen et al. loss year, tree cover, and gain



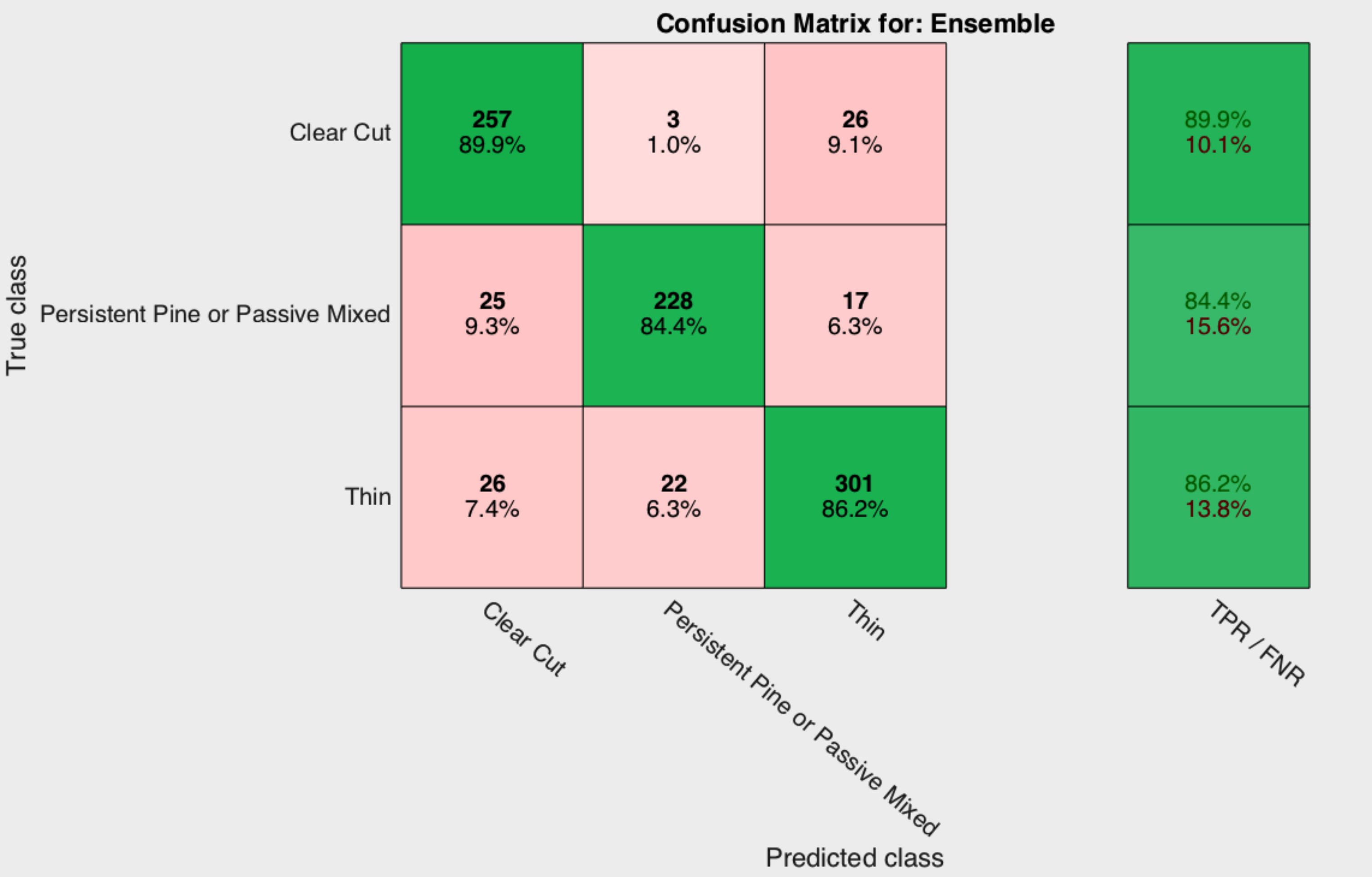
Hansen et al (2013) and updated products (Loss year, tree cover, gain) by themselves

- Very valuable as predictor variables.
- Alone, 60% accuracy
  - 51% for thins
  - Consistent with Breidenbach et al. (2018)



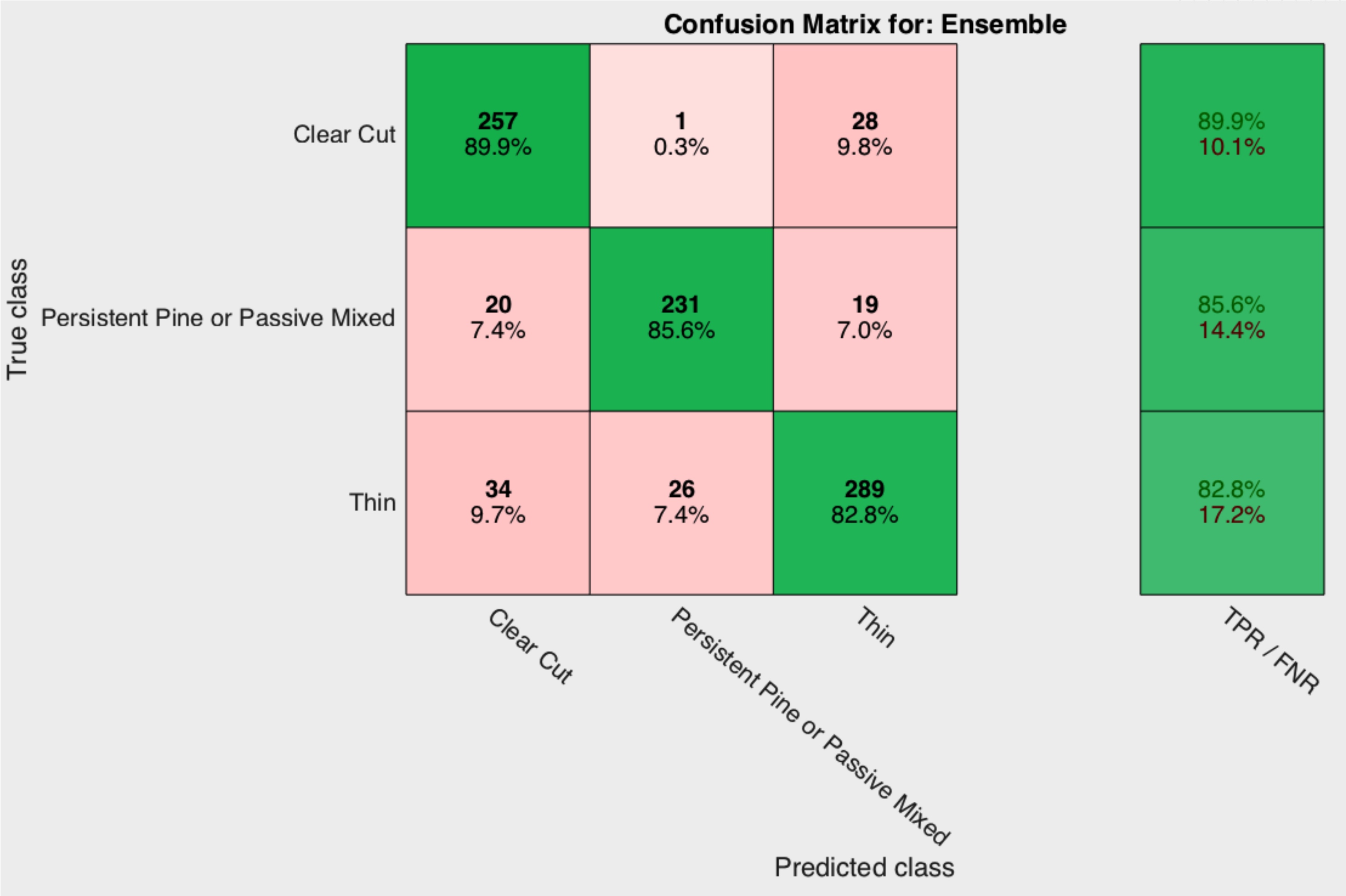
Exclude the deciduous

- Combine
  - Passive mixed
  - Persistent Pine
- Overall accuracy 87%
  - Same 20 predictors



Reduce Variables to 10 for mapping

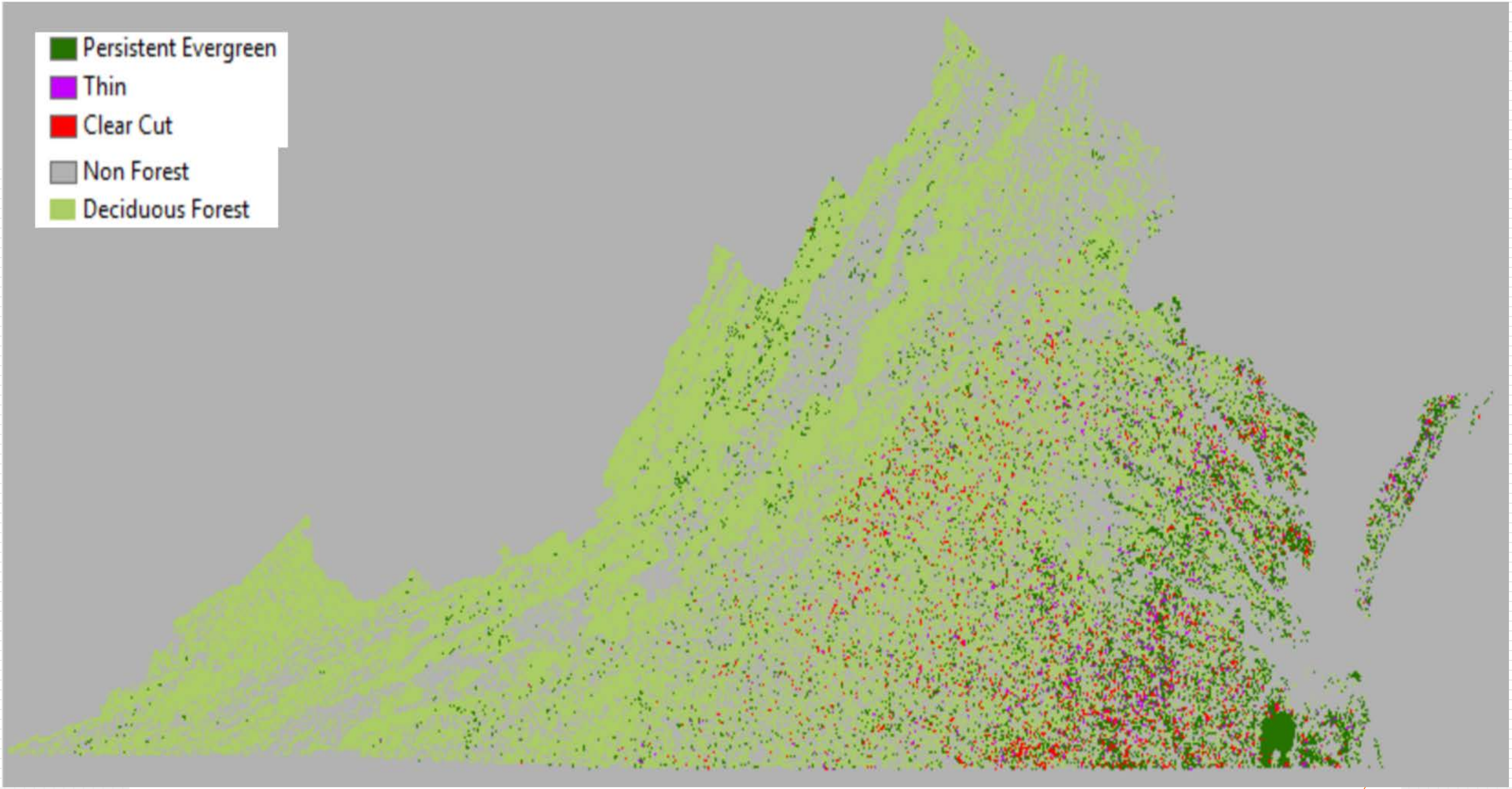
- Overall Accuracy 86%
  - HR Constant, Sine, Cosine, R^2, RMSE for Pan
  - R^2, RMSE for NDVI 2014-16
  - Hansen et al. Loss year, tree cover, gain



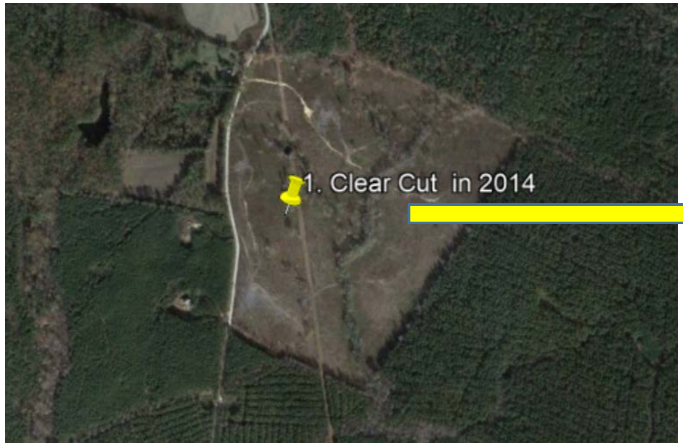
Development of a mask to apply to management classification

	Commercial Selection	Non-harvested Pine	Thin	Clear Cut	Total
NLCD	93.8	96.7	76.1	89.1	87.8
NLCD + change	95.7	96.7	79.6	91.6	90
CDL	97.7	99.7	94.1	98.4	97.2

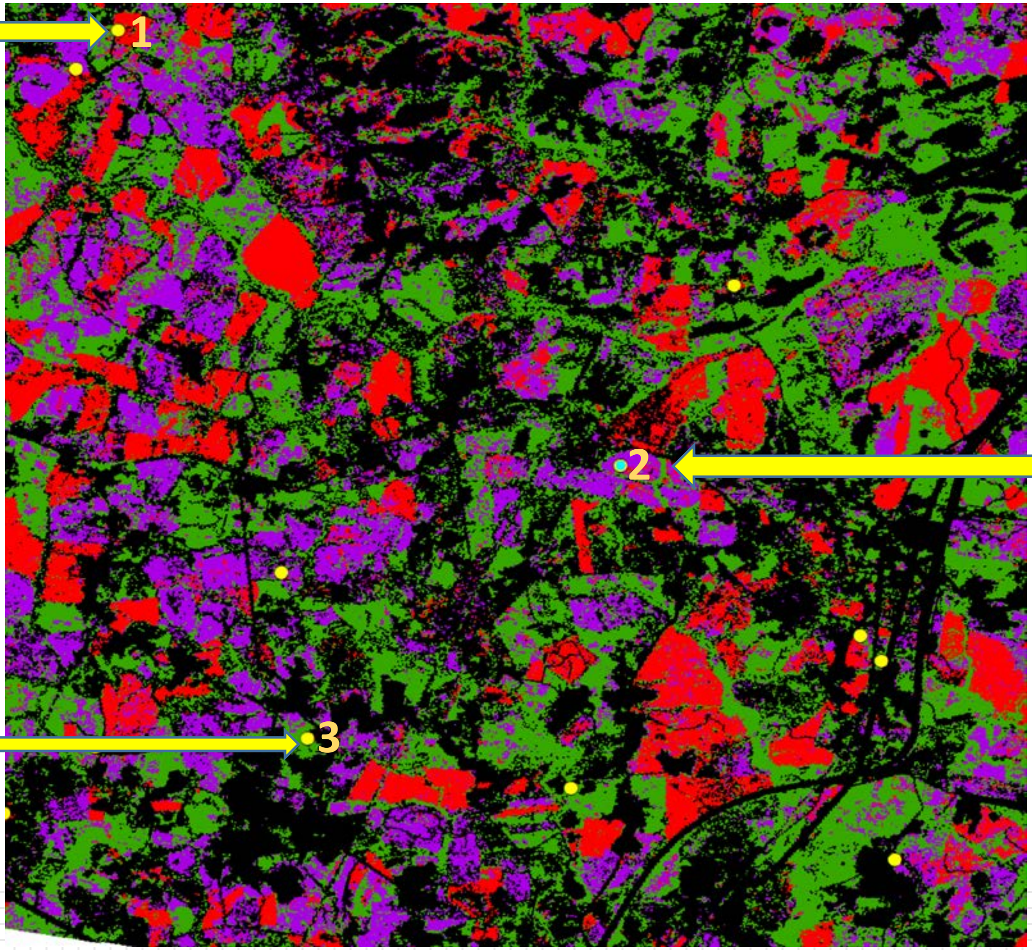
- NLCD classes: 41, 42, 43, 90
- CDL classes: 141, 142, 143, 190
- Maximize amount of thins captured by forest classes


Persistent Evergreen
Thin
Clear Cut
Non Forest
Deciduous Forest

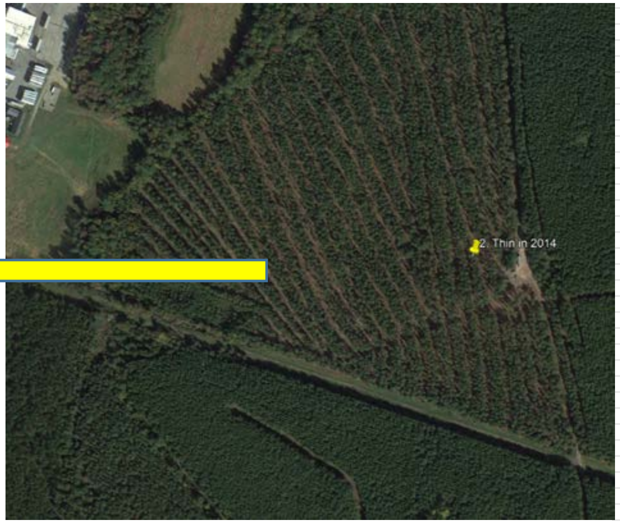
Clear Cut in 2014



Persistent Pine

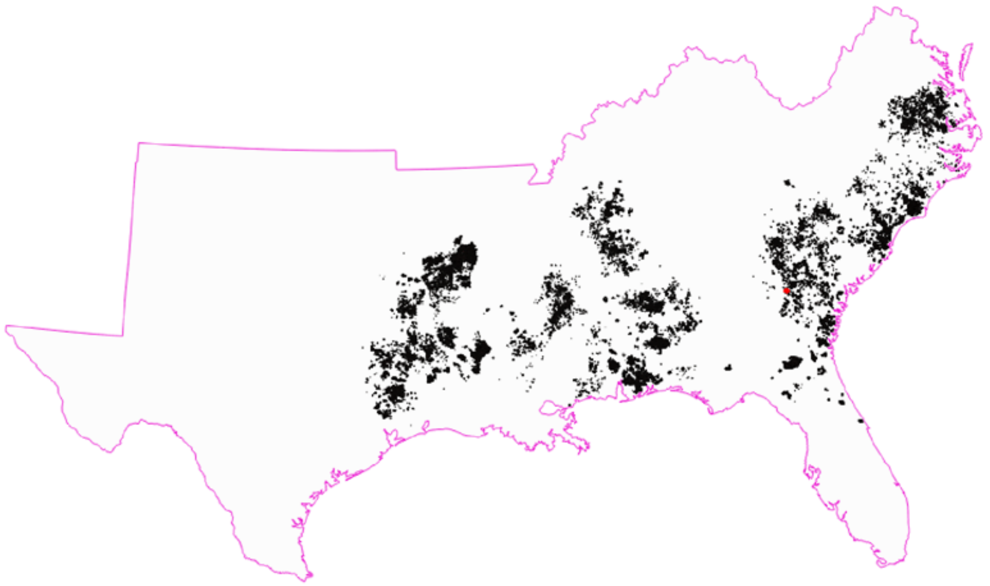


2014 Thin



Implications of forest management mapping progress to date

- Single-harmonic fourier regression valuable predictors for forest thins.
- The Hansen et al. (2013) global forest product layers were valuable predictors in our algorithm
  - Not sufficient for thins on there own
- High-resolution panchromatic band in Landsat 8 valuable
- High performance computing needed



Forest management and LAI

Blinn, C.E., M.N. House, R.H. Wynne, V.A. Thomas, T.R. Fox, and M. Sumnall. 2019. Landsat 8 based leaf area index estimation in loblolly pine plantations. *Forests*. 10(3): 222; https://doi.org/10.3390/f10030222

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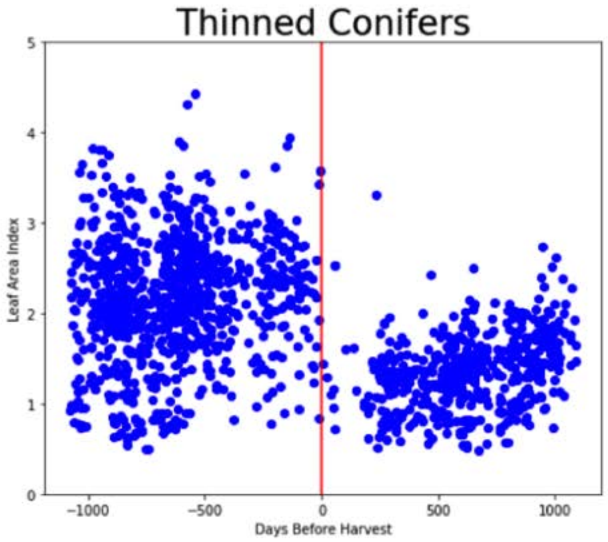
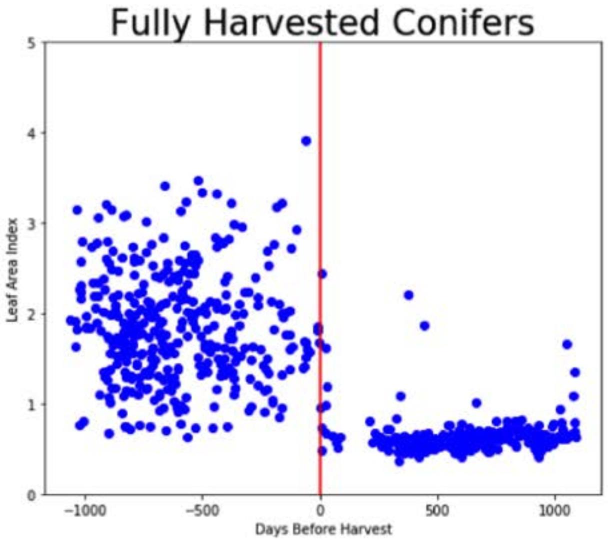
Management and LAI: Loss and Recovery

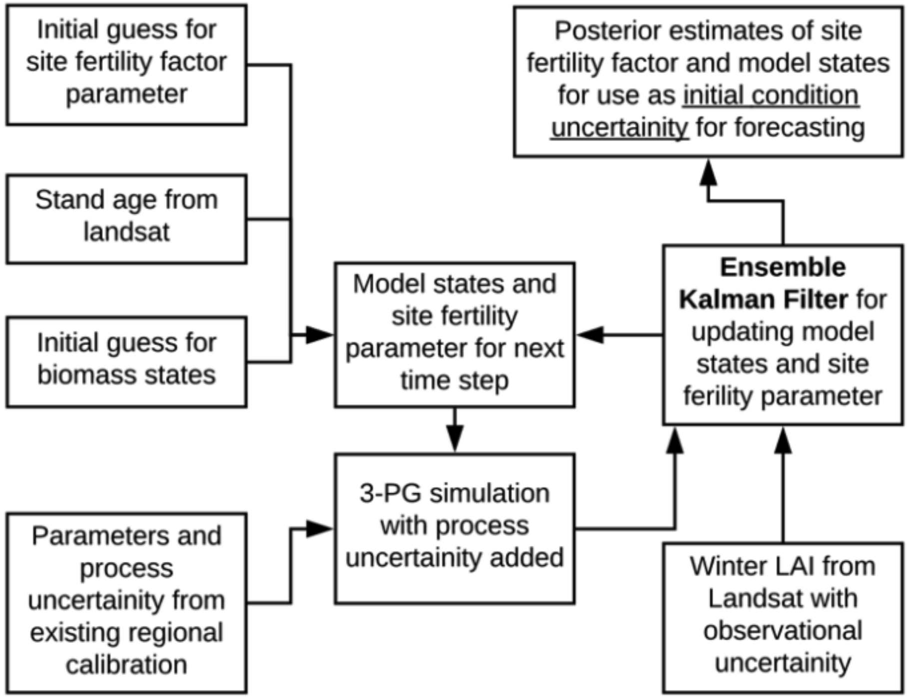
- Loss and recovery
- Fertilization
- Understory and competition

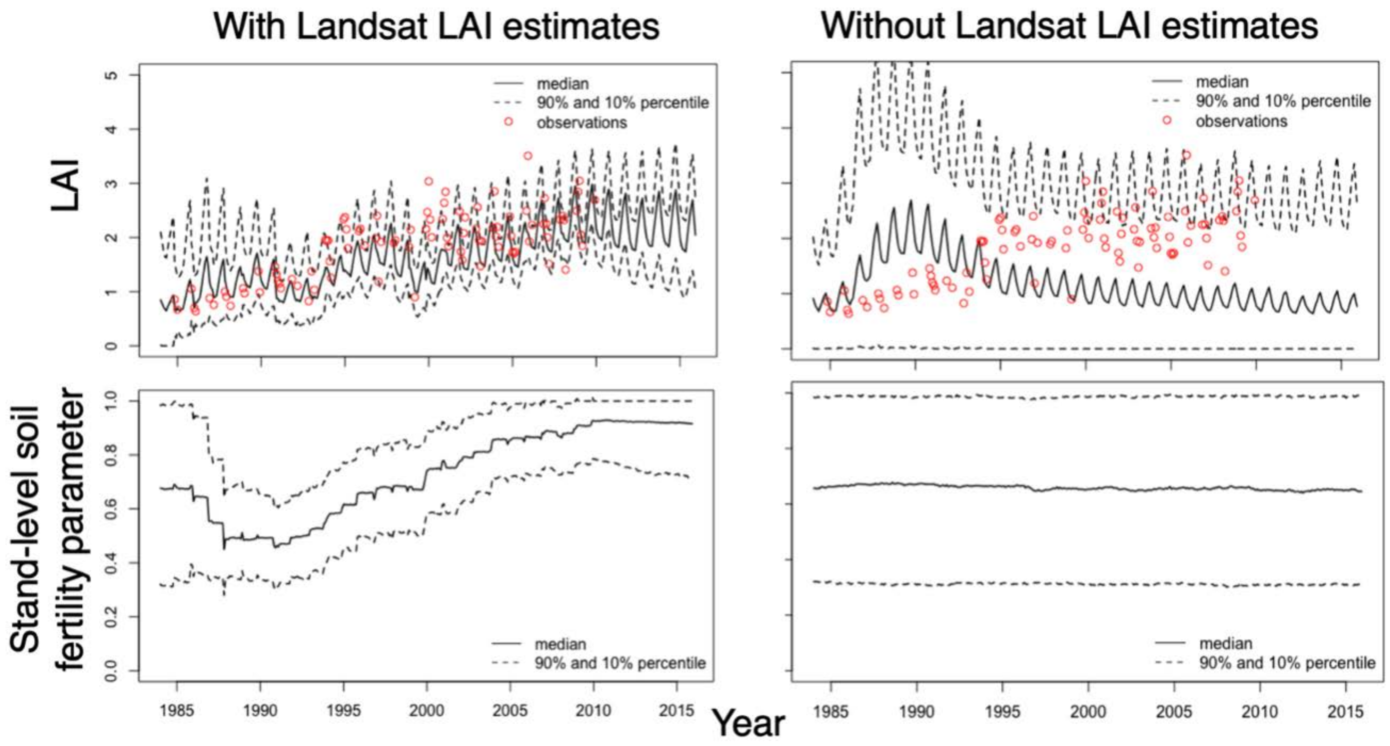




Landsat-LAI for regional projections of productivity and fertility

Ensemble Kalman Filter approach





Economic framework that incorporates biophysical and financial risk

Mei, B., D. Wear, and J. Henderson. 2019. Timberland investment under both financial and biophysical risk. *Land Economics*, 95(2): 279-291.

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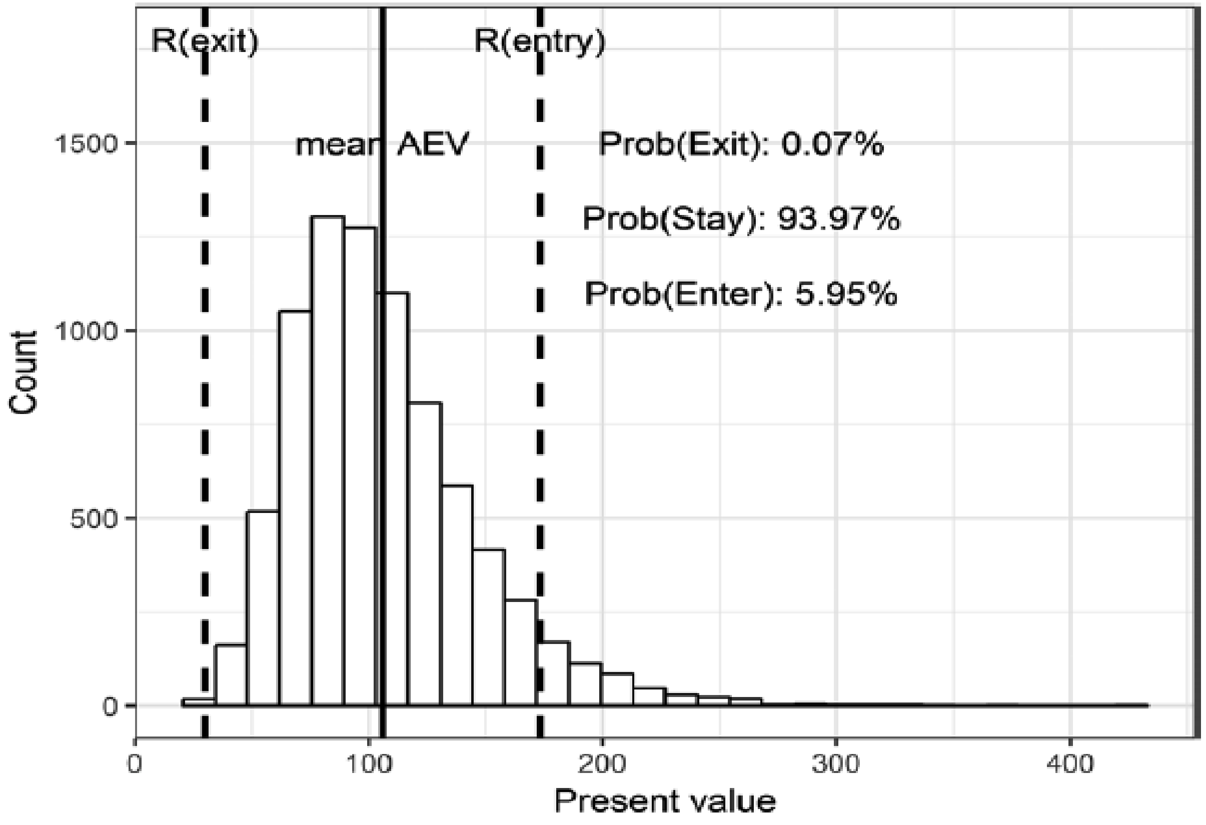
Economic framework for land use transitions that includes biophysical and financial risk

- blend stochastic processes for prices and net yields within a real options framework that accounts for the temporal structure of forest production
- Timber Mart-South (TMS) timber price data
- 3-PG models of growth and yield for 20 global circulation models (GCMs) based on the RCP 8.5 emissions scenario
- Monte Carlo simulations to incorporate both financial and biophysical risk
  - geometric Brownian motion (GBM) stochastic function
  - examined the optimal entry and exit opportunities of timberland investment in 10 southern states in the United States.
  - Mostly “hold”
  - Slight upward trend in investment



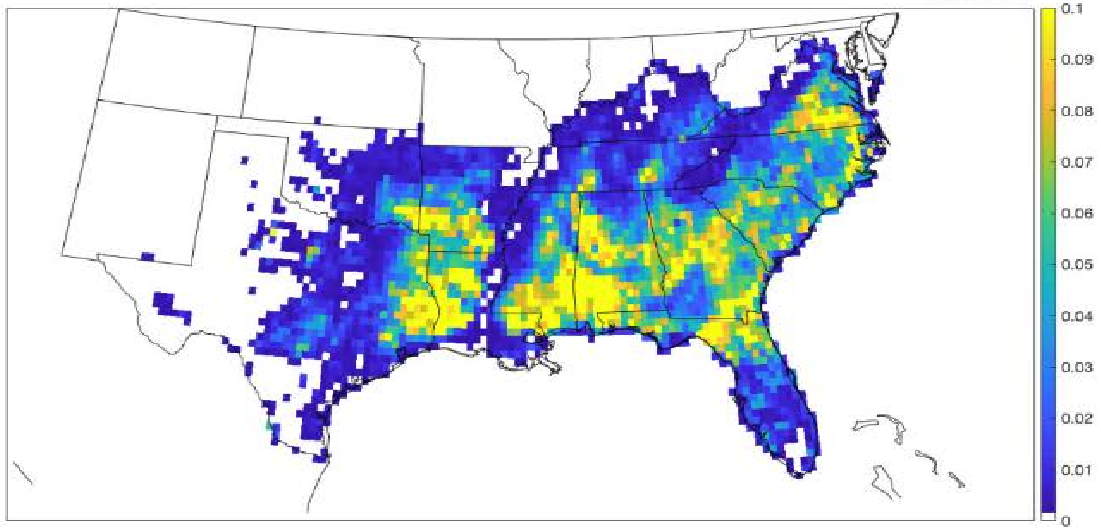
Synthesis and Intercomparisons

- Synthesis of
  - Landsat classifications
    - At GLM scale
  - Southern Forest Futures
    - At GLM scale
  - GLM Land Use transition matrices
- Establish a baseline to quantify the impact of regionally-specific land use transition matrix.

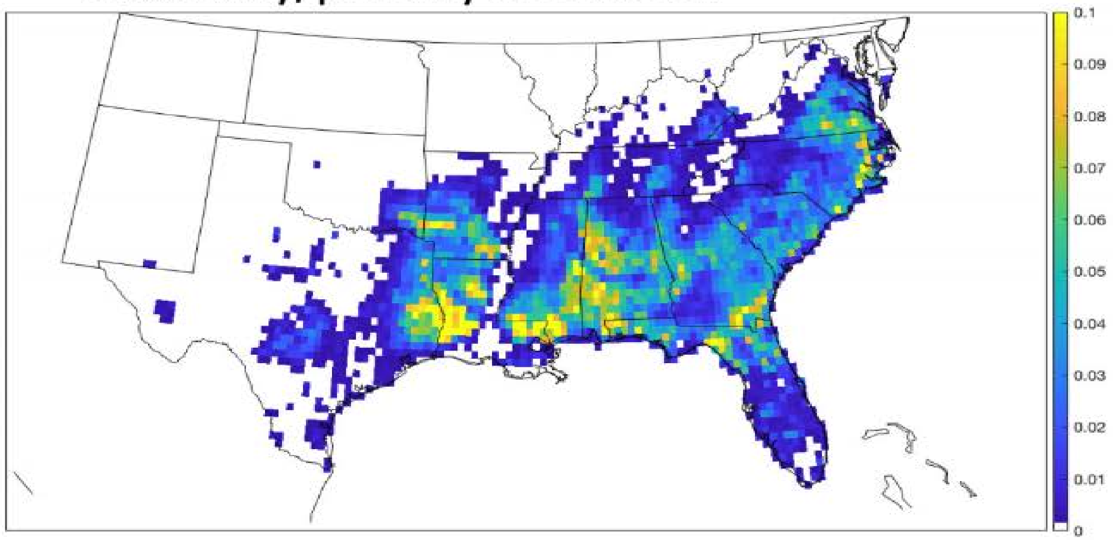
GLM Class	NLCD Class
Urban	21 Developed, Open Space 22 Developed, Low Intensity 23 Developed, Medium Intensity 24 Developed High Intensity
Crop Functional Types	82 Cultivated Crops
Managed Pasture	81 Pasture/Hay
Rangelands	71 Grassland/Herbaceous
Primary Non-Forest	31 Barren Land (Rock/Sand/Clay)
Secondary Non-Forest	11 Open Water 12 Perennial Ice/Snow 51 Dwarf Scrub 52 Shrub/Scrub 72 Sedge/Herbaceous 73 Lichens 74 Moss 95 Emergent Herbaceous Wetlands
Secondary Forest	41 Deciduous Forest 42 Evergreen Forest 43 Mixed Forest 90 Woody Wetlands

2001 to 2011

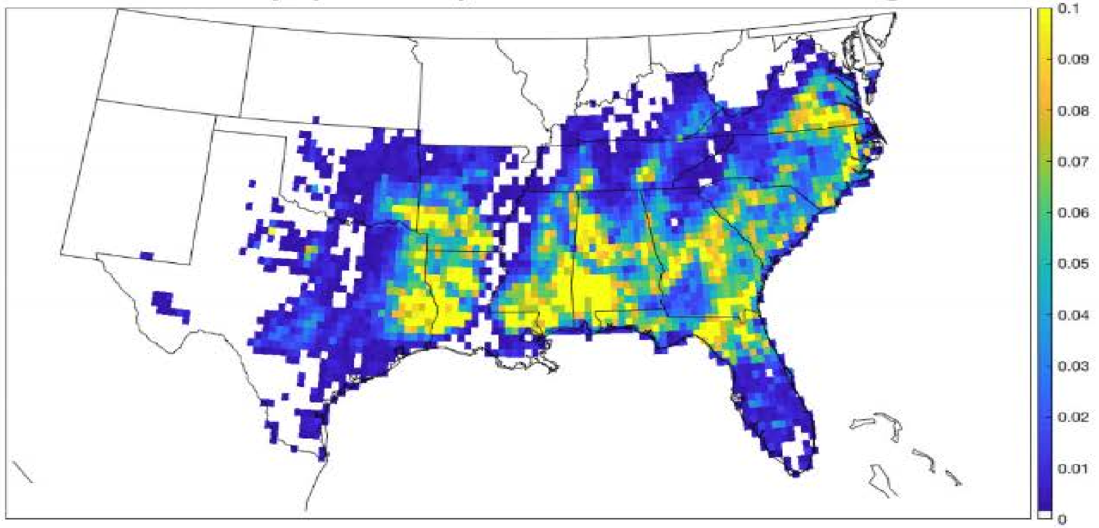
NLCD, all transitions away from secondary forest



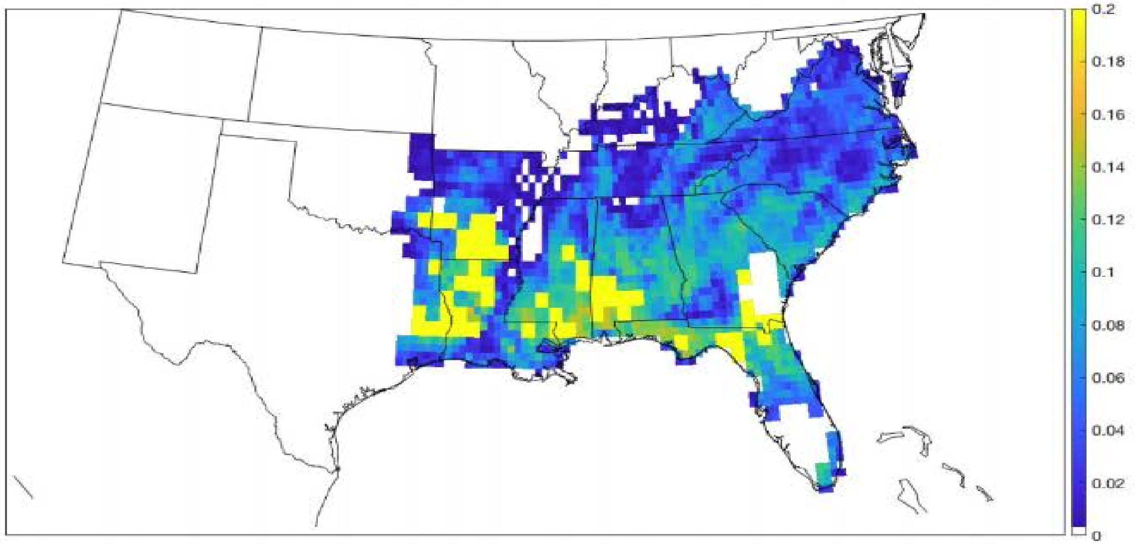
NLCD, transitions from secondary forest to secondary/primary non-forest



NLCD, transitions from secondary forest to secondary/primary non-forest and rangeland



LUH wood harvest (from forest) area



Next steps

- Complete the regional analysis of thins and management based on the management classification techniques described above.
- Incorporate Landsat-derived land use transitions from production forestry as a separate new class in the LUH/GLM.
- Upscaling the Southern Forest Futures projections to the GLM to finalize the baseline comparison between the GLM, NLCD, and Southern Forest Futures land use transition matrices.
- Conduct intercomparison of (three) with land use transitions described by Landsat-based models, economic projections that incorporate risk, and the GLM.
- Continue to disseminate results.

Questions?

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