Continuing Project

Assessing and mapping regional variation in potential site carrying capacity

CAFS 19.76

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Justification

- ❑ Understocked stands underutilize site resources and will not reach maximum potential productivity
- ❑ Overstocked stands are slow to develop and susceptible to wildfire, drought and insect outbreaks due to competition for limited resources.
- ❑ To date, forest carrying capacity research is regionalized, utilizes multiple modeling approaches, and not universally available spatially across the US …...

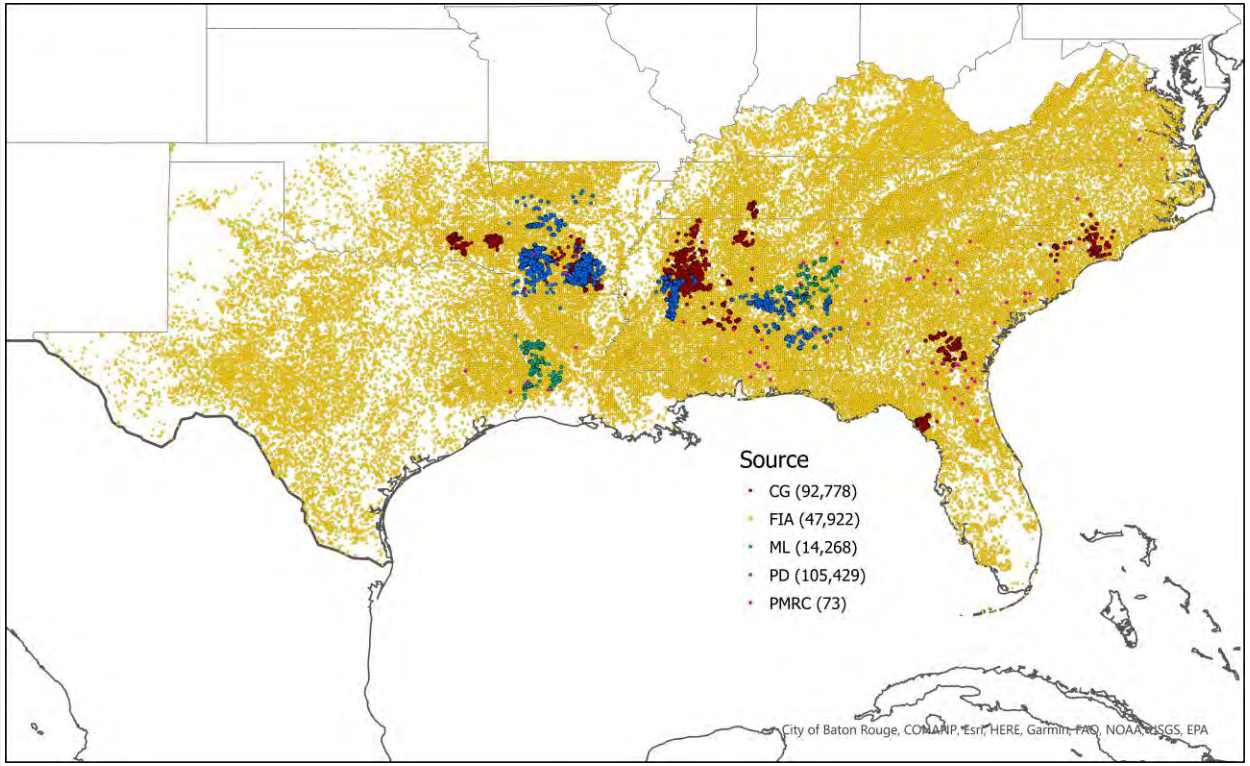
Objectives

1) Synthesize a nationwide forest inventory database from publicly available data and from CAFS members,
2) Standardize maximum carrying capacity modeling, and
3) Create efficiencies for multi-regional forest management organizations by providing consistent, species-site-silviculturally sensitive, wall-to-wall spatial models of SDImax for commercial species of the United States.

Data

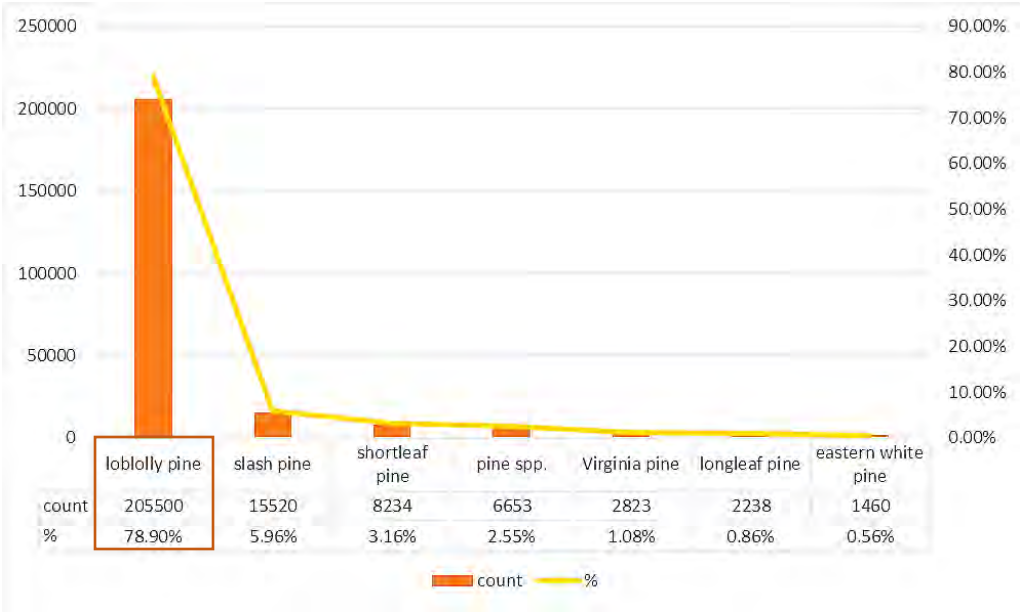
- QMD , TPA , Species BA proportions and Silvicultural info of each record
- Topography extraction from 30m DEM – 10 Variables (e.g., Slope, Aspect, Topographic wetness index, Solar radiation)
- ClimateNA – 128 Variables (Annual, Month, Season)
- Geology and Soil layer - 56 Variables (SGMC & gSSURGO geodatabase) –
- Enhanced soil parent material database by FPC

  (e.g., Depth to increase in clay content, Drainage class, Nature of surface soil modifier, Nature of subsoil (mineralogy) modifier)

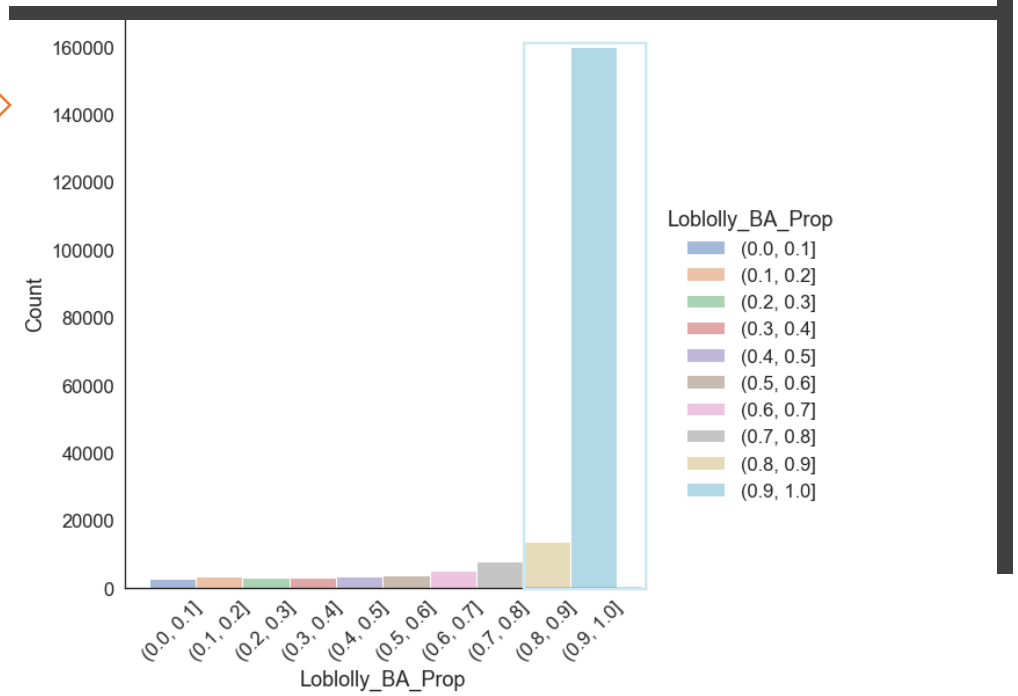


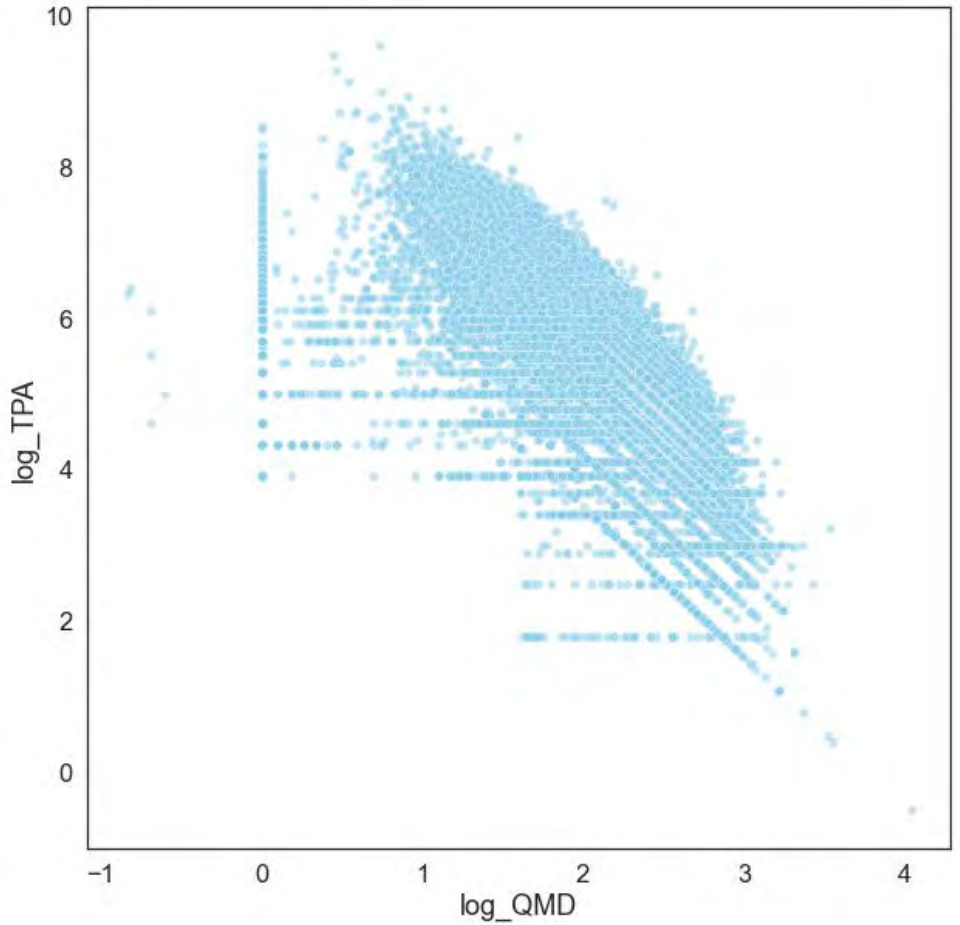
260,470 initial records from the forest land in the southern region.

Methods



174,370(84.8%) records with 0.8-1.0 BA proportion of Loblolly Pine





Loblolly Pine
Modeling Approach

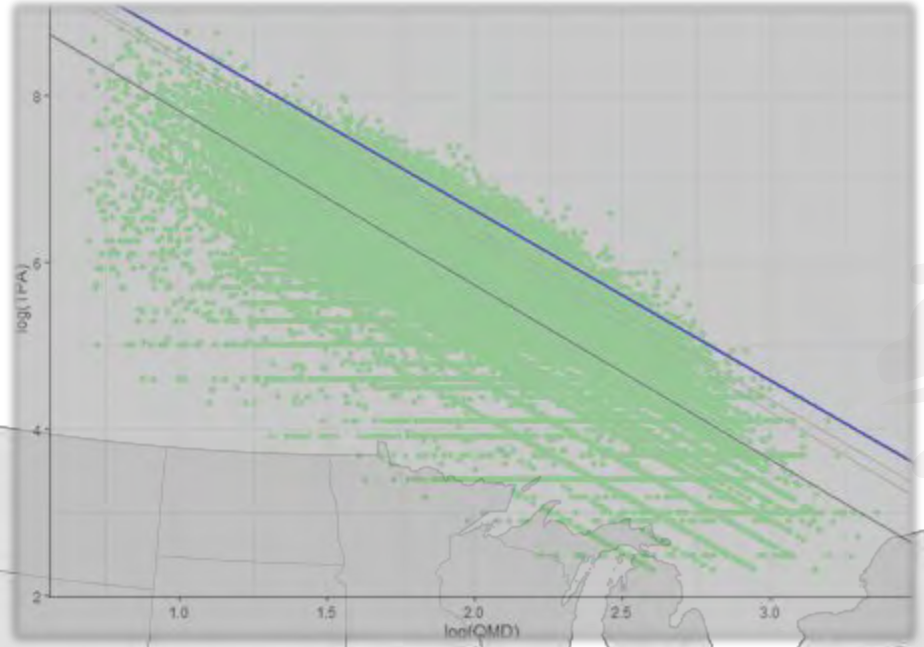
❑ 165,313 plots with BA of 0.8 to 1.0

Data Cleaning:

Missing expansion factors, at least 10 TPA, QMD at least 2-inch, questionable & missing data

Quantile Regression:

Linear Quantile Mixed Models to determine the quantile line of log(TPA)~log(QMD)



Variable Selection:

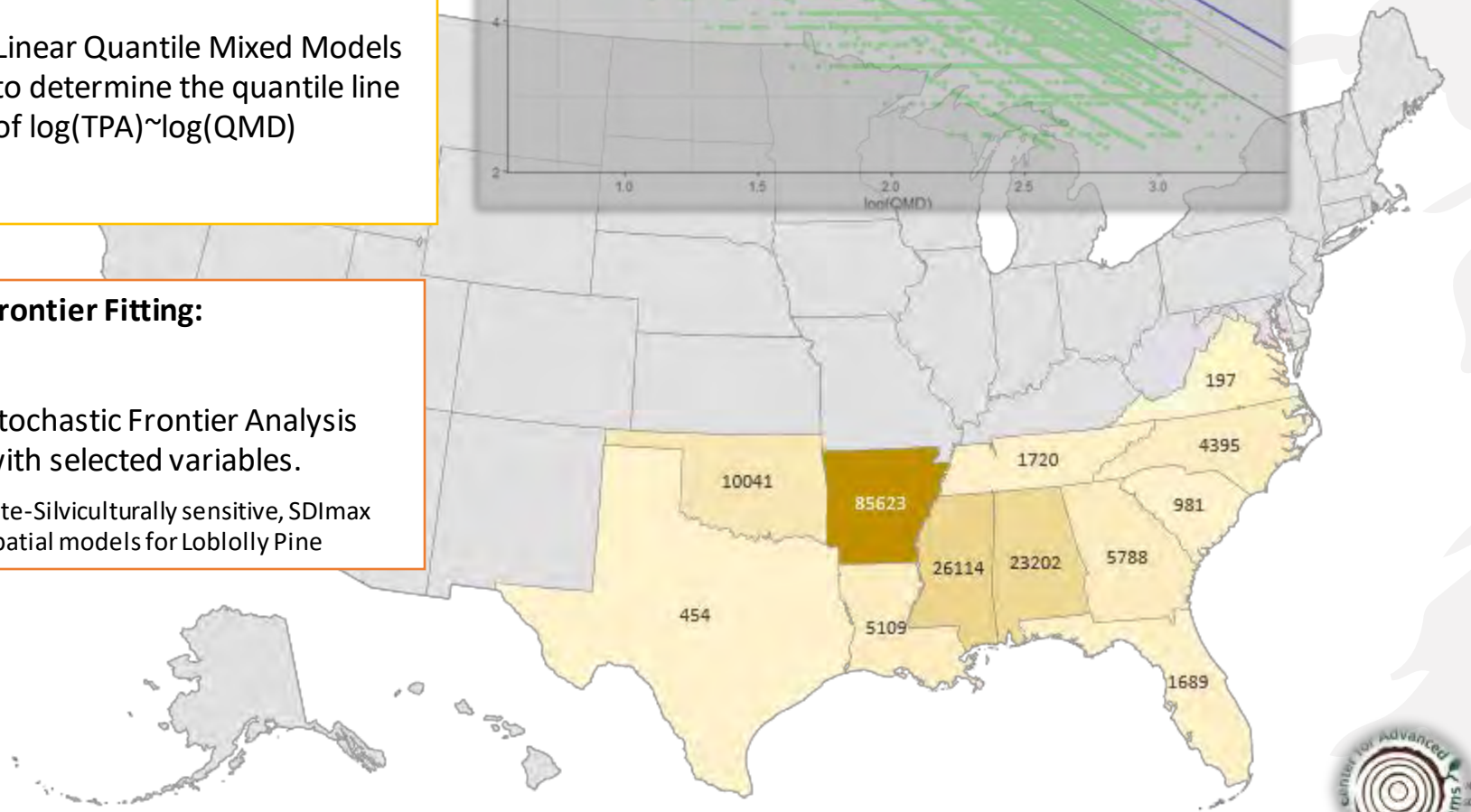
Featurewiz for feature selection and extraction

Based on Minimum Redundancy Maximum Relevance (MRMR) algorithms

Frontier Fitting:

Stochastic Frontier Analysis with selected variables.

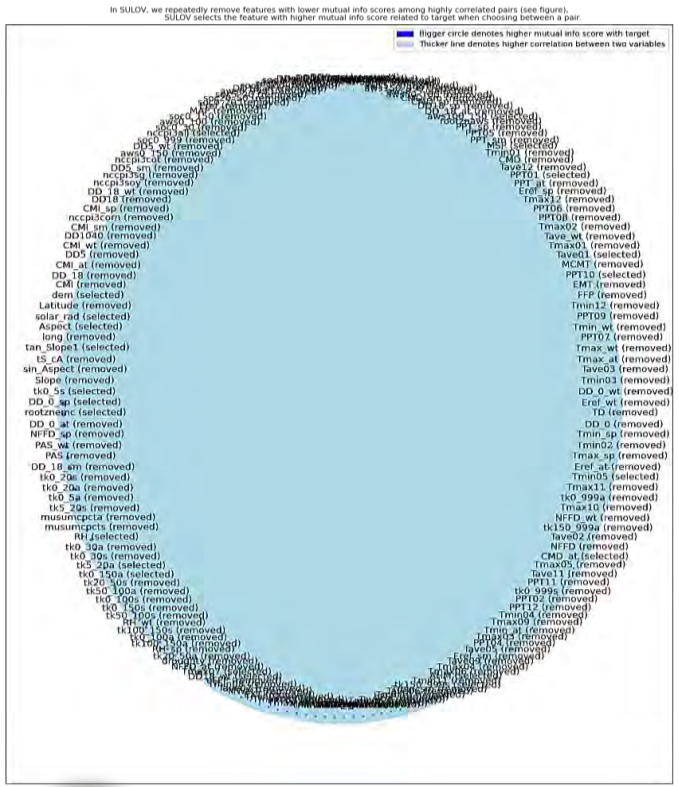
Site-Silviculturally sensitive, SDImax spatial models for Loblolly Pine



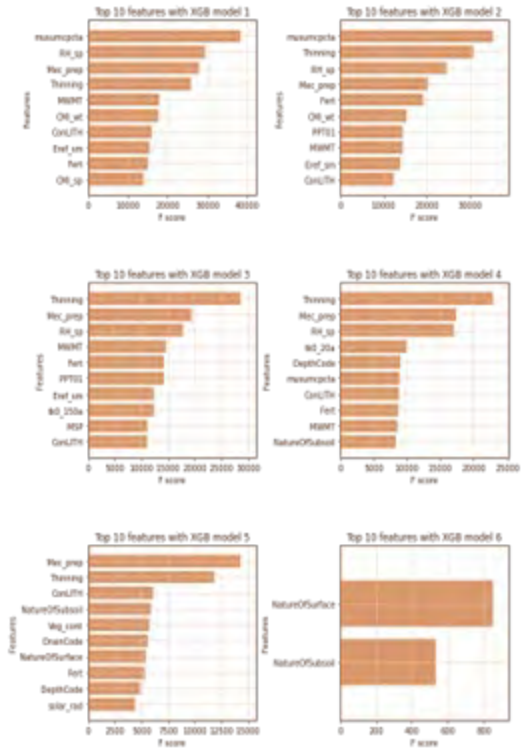
Variable Selection

featurewiz *performs feature selection in 2 steps.*

1. SULOV algorithm



2. Recursive XGBoost



Stochastic Frontier Regression

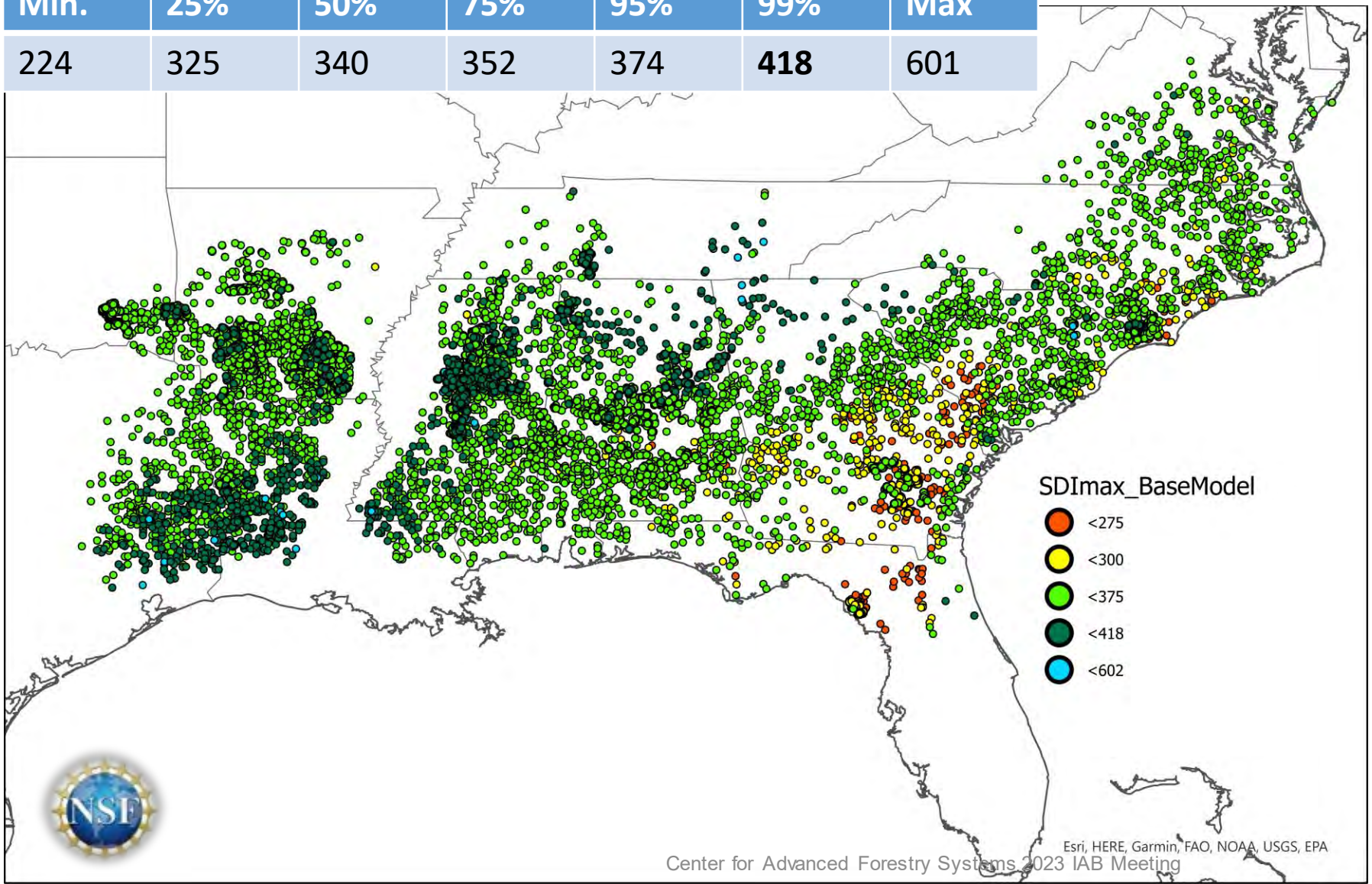
An initial model of predicting ln(TPA) with the single variable ln(QMD) served as the base model.

Then, through an iterative process, variables were introduced to the model and kept or removed based on variable significance and AIC score

- ❑ Topographic –Topographic wetness index, Cosine of Aspect, Tan of Slope
- ❑ Climatic - Autumn Hargreaves climatic moisture deficit, winter degree-days above 18°C, winter & april precipitation , May to September precipitation (mm),
- ❑ Geology and Soil – Consolidated lithology , Available water storage estimate in standard zone 1 & 6, FPC_ DrainCode, FPC_DepthCode, FPC_Nature of Surface, FPC_Nature of Subsoil,
- ❑ Silvicultural info: Interaction variable of Fertilization and Thinning

SDImax for loblolly pine: No silviculture treatments implied or stated in given inventory records or shown in map – base model

Min.	25%	50%	75%	95%	99%	Max
224	325	340	352	374	**418**	601

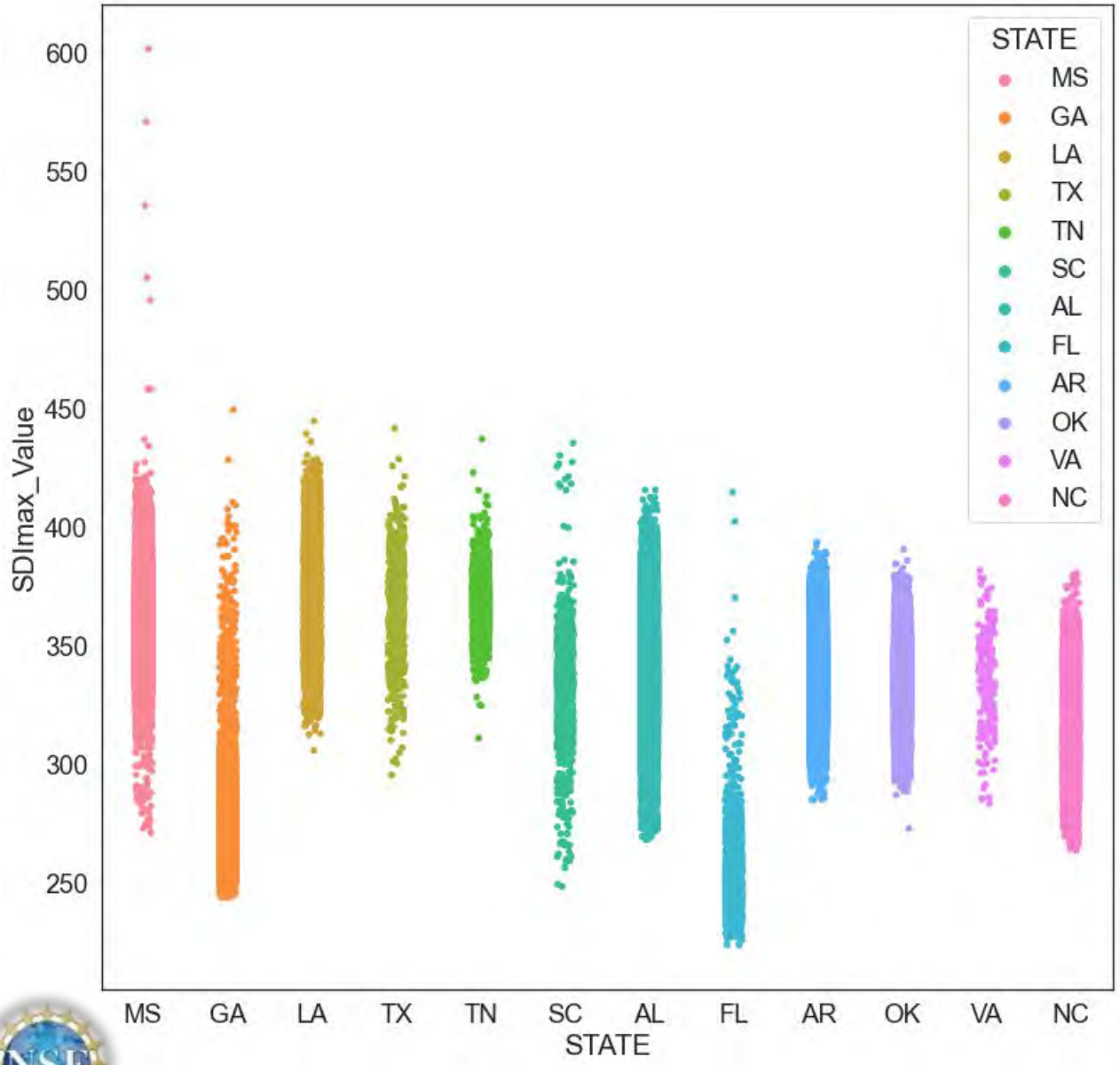


Major Findings

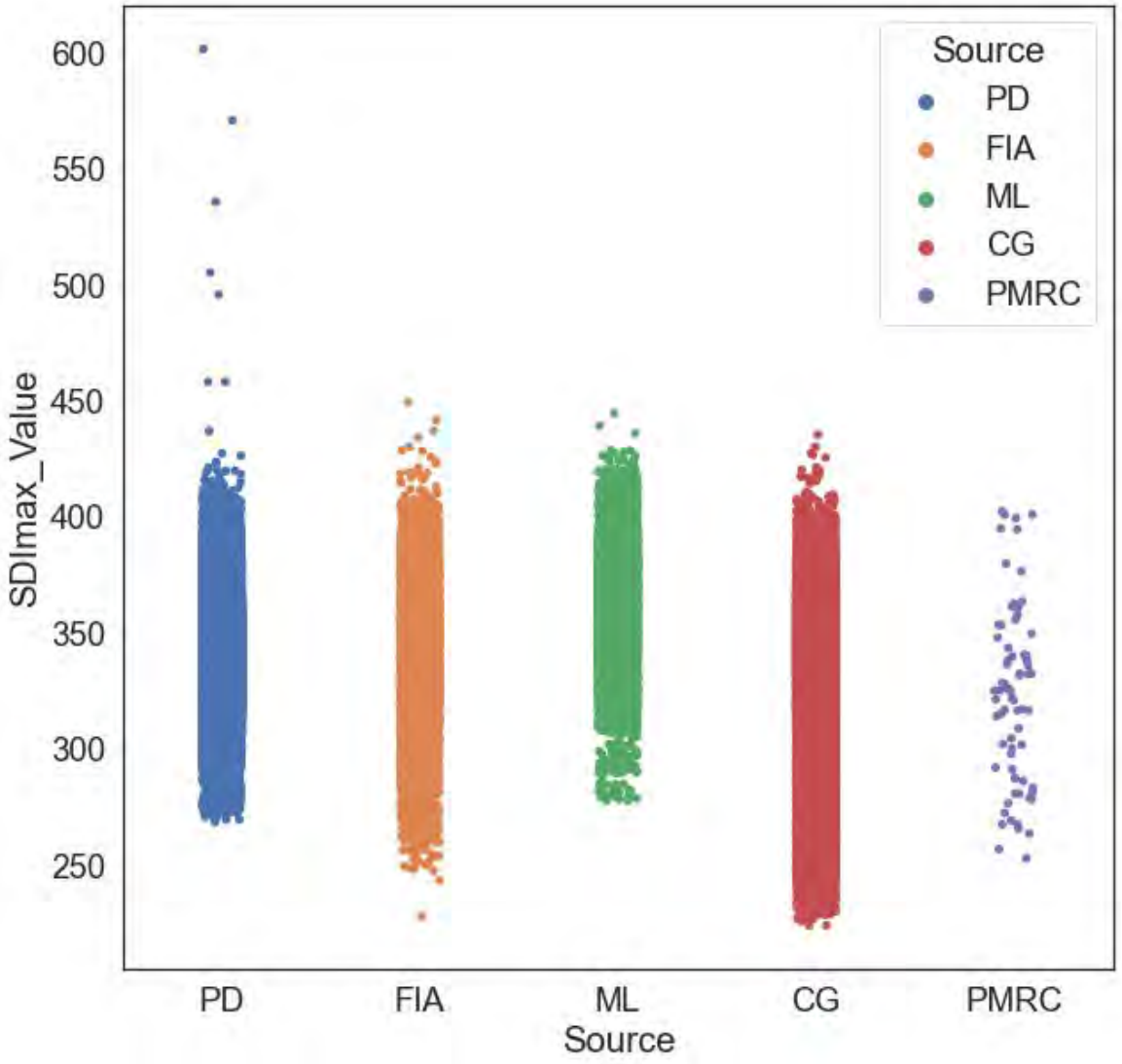
Comparative regional loblolly pine SDImax citations

Max SDI	Source
243-571	Zhao et al,2020
400	Williams,1996
450	Dean et al,1993

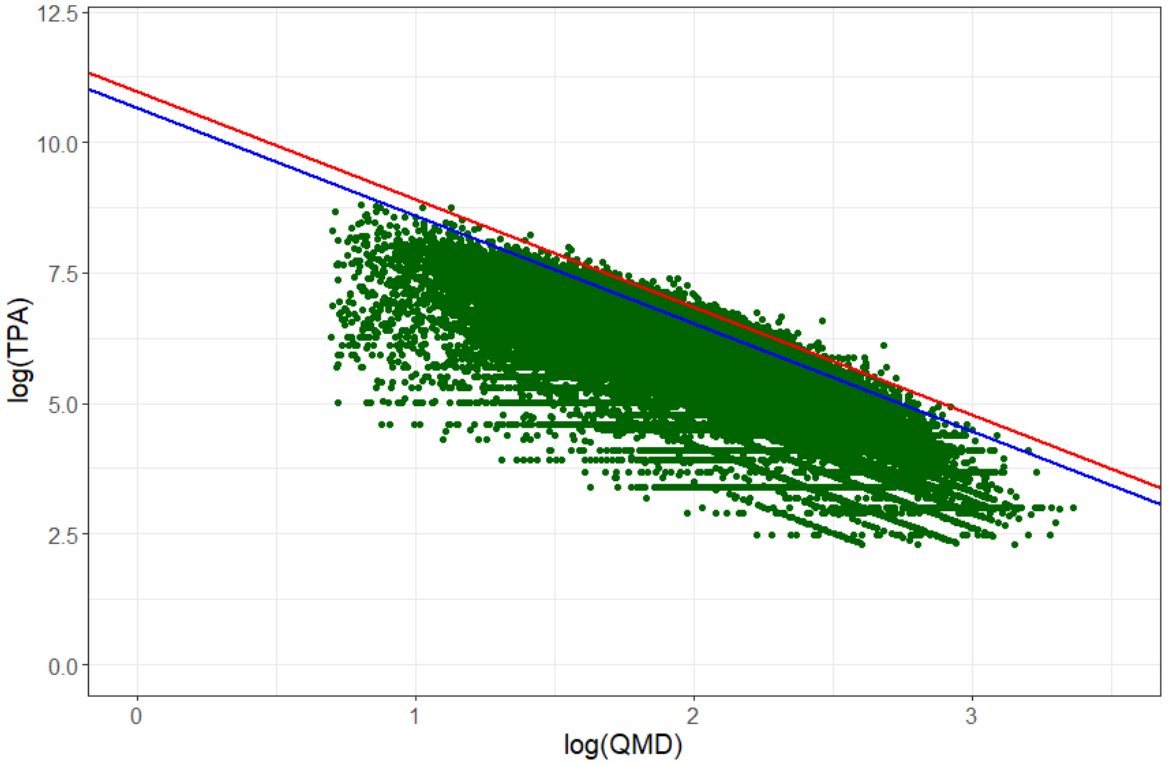
Strip plot: SDImax values of Southeast States



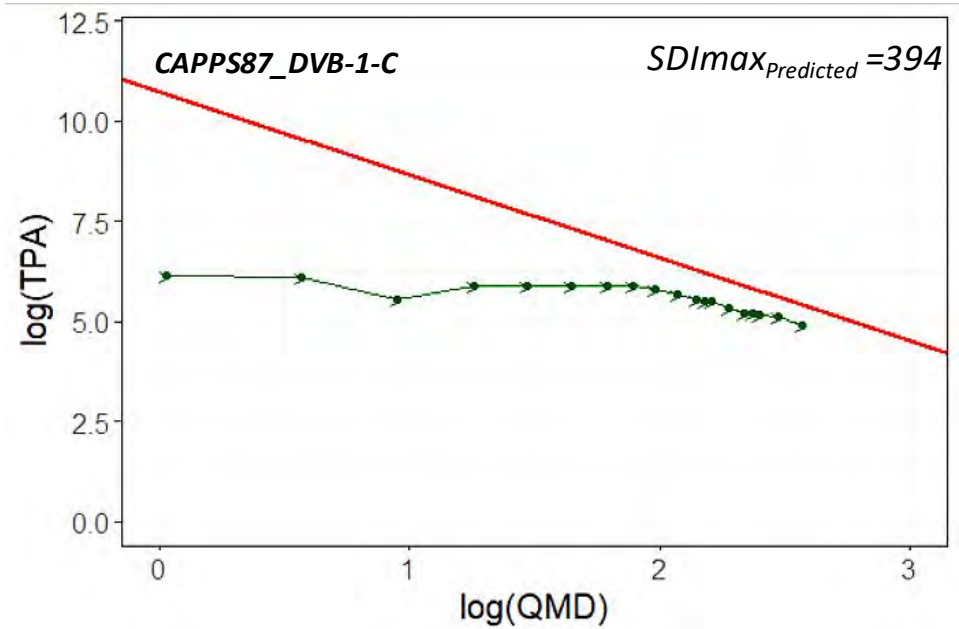
Strip plot: SDImax values of Data Sources

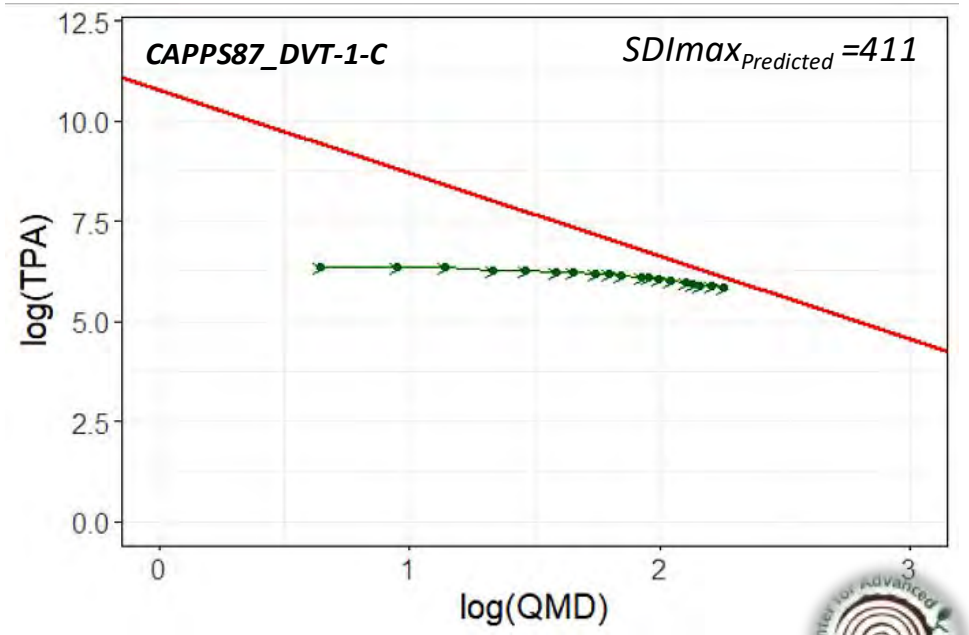


Evaluation of base model performance (i.e., no known silviculture influence on SDImax)



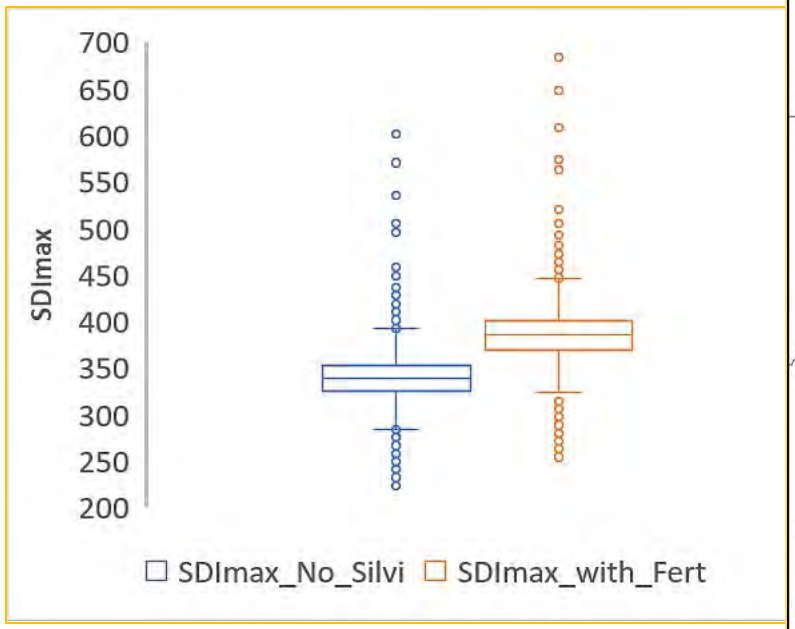
Models perform relative to the 90th (red line) and 50th percentile (blue line) of site growing conditions

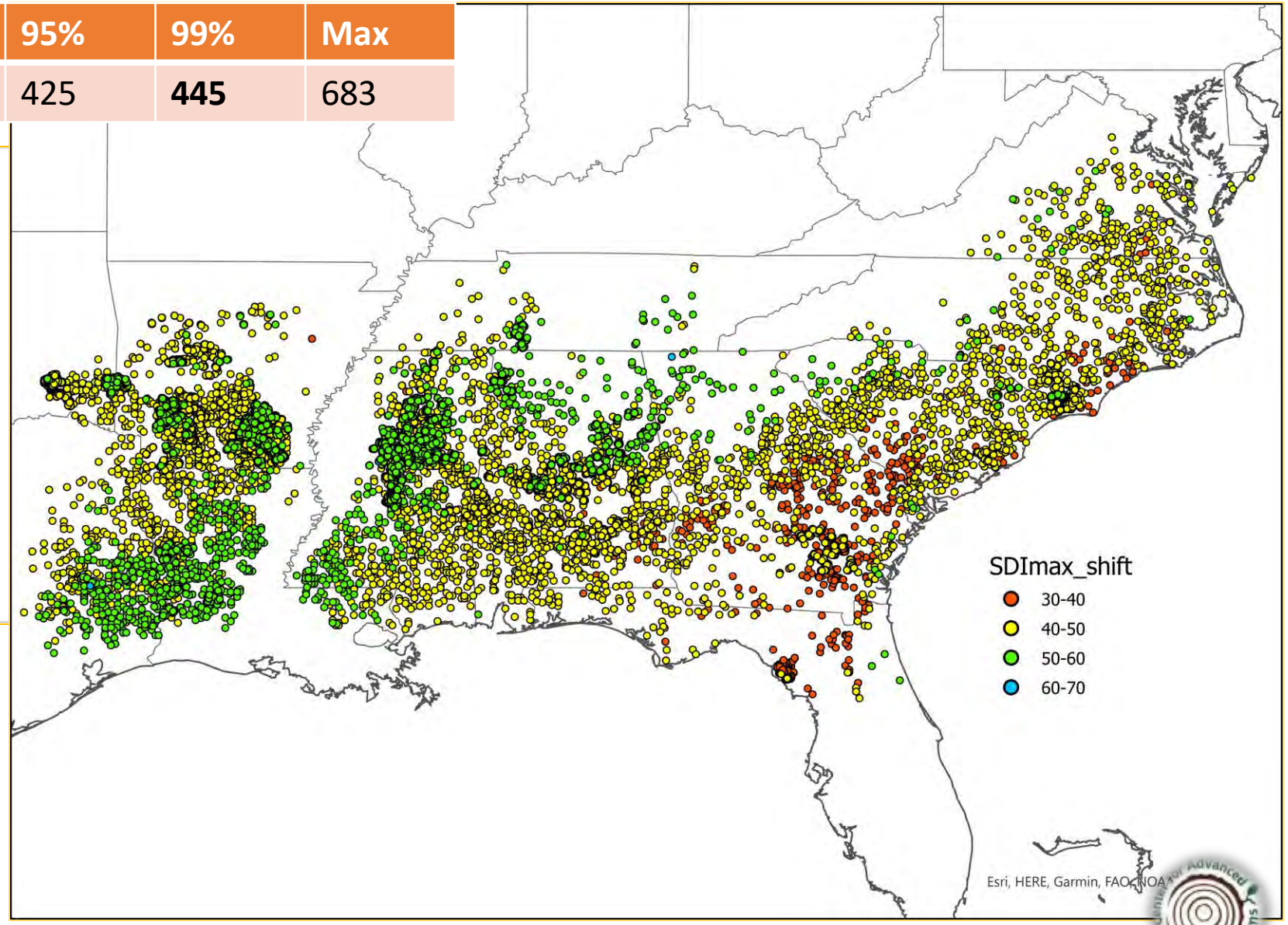




SDImax for loblolly pine using base model with fertilizer application

Min.	25%	50%	75%	95%	99%	Max
254	370	386	384	425	**445**	683





Deliverables

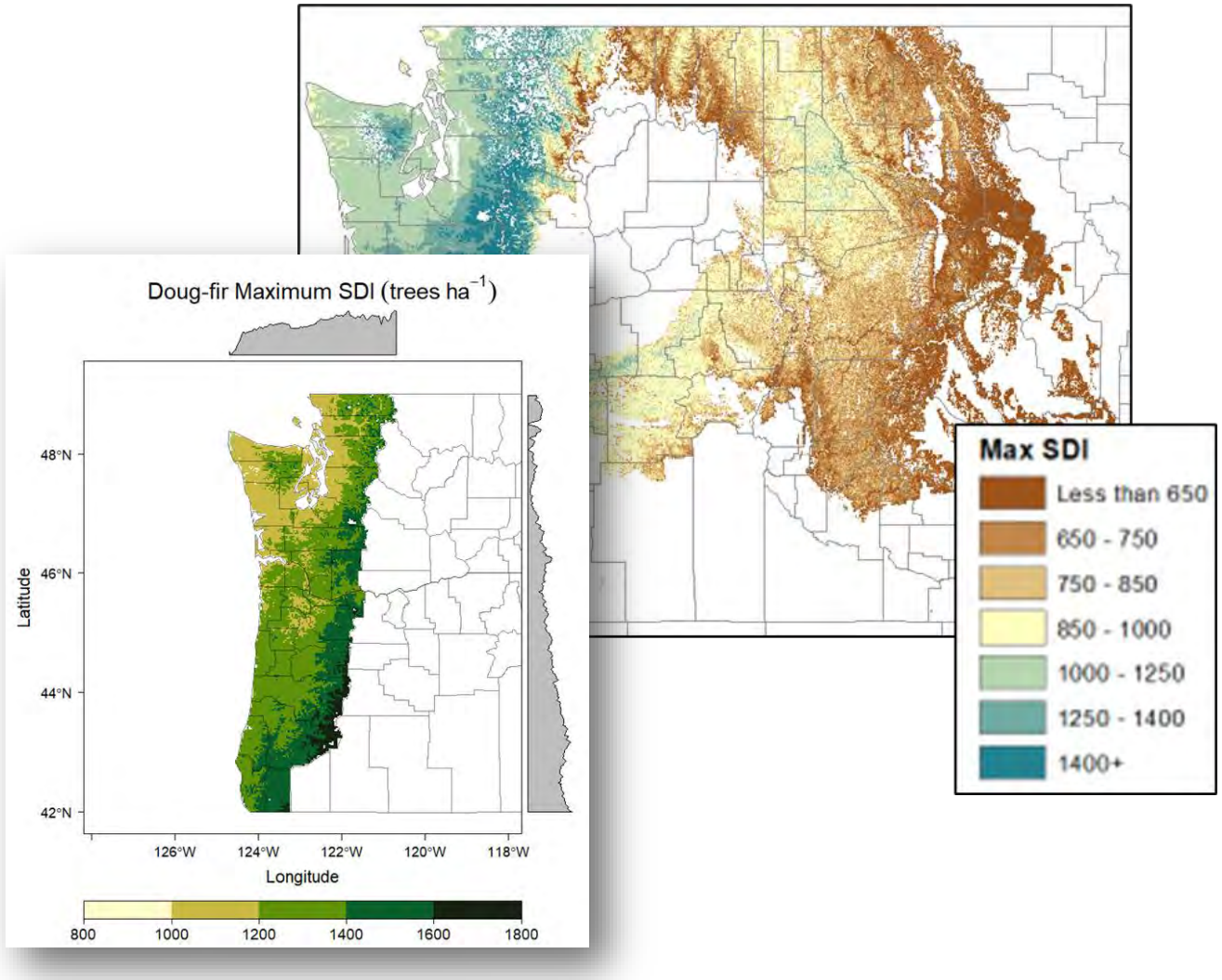
The primary deliverables will include:

1) Harmonized dataset for major commercial species throughout US forestlands;

2) Machine learning models relating SDImax to various species functional traits, stand attributes (e.g., structure, diameter distribution, site index), and environmental factors (e.g., soils, topography, climate);

3) High-resolution (10-30 m) raster maps of predicted SDImax for use in multiple digital platforms;

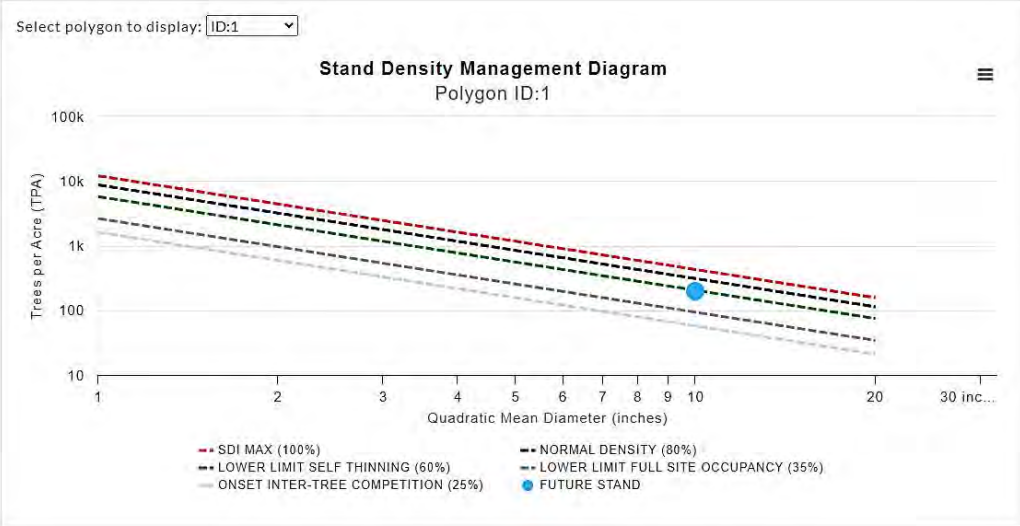
4) Annual progress reports and presentations and a final report and presentation + peer-review publications and conference presentations.

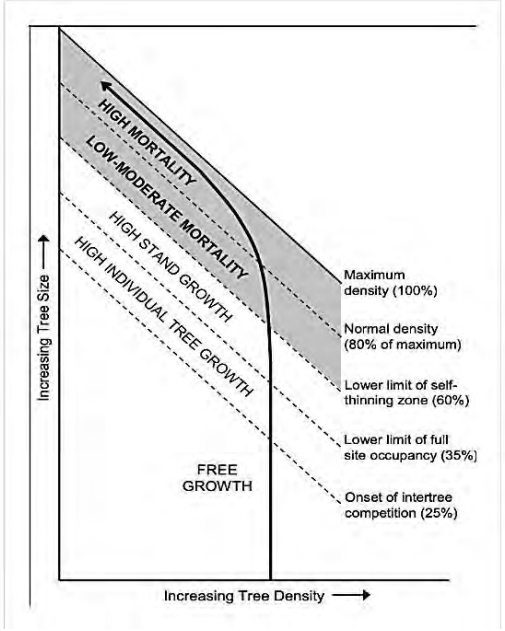


Company Benefits

- Identification of optimal planting or thinning residual densities as a function of:
  - Species composition
  - Site resources
  - Silvicultural treatments

- Consistent methodology/platform for identifying and managing forest density across multi-regional land holdings





Summary

Database acquisition & development completed

Fall 2022

Harmonized industry/FIA datasets and associating site characteristics to these stand inventory records

Winter 2022

Began SDImax model development, prioritizing Southern US, Pacific southwest, and Northeastern US

Spring 2023

Draft regional SDImax models review by IAB members

Winter 2023