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**YEAR:**  **4** of  **5**

**PROJECT TITLE:** Assessing and mapping regional variation in potential site carrying capacity

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| **PROJECT DESCRIPTION:**  Maximum site carrying capacity determines the number of individuals of a certain size per unit of area that a defined stand can support and maintain. The attribute is a complex function of species composition, genetics, environmental conditions, stand structure, and silvicultural treatments. Prior research has indicated that maximum site carrying capacity is primarily determined by stand purity (% dominance by primary species), stand origin (natural vs. planted), site index, skewness of the diameter distribution, and an array of site growth limiting factors (climate, soil, relief). To date, forest carrying capacity research is regionalized and utilize multiple modeling approaches, which in turn leads to spatial and species modeling gaps across the US. |
| **HYPOTHESES or OBJECTIVES:**  The objective of this research project is to 1) synthesize a nationwide forest measurements database from publicly available data and from CAFS members, 2) standardize maximum carrying capacity modeling, and 3) provide regionally relevant, national forest carrying capacity models as a function of species, site and silvicultural treatments. |
| **METHODS:**  Forest Plot Datasets from the USFS FIA program, PMRC, Manulife, Campbell group, and PotlatchDeltic were used to build the SDImax model for commercial species in the south US. These datasets were harmonized and linked to site growth characteristics such topography, climate, geology, and soil. Loblolly pines occupy 80% of the total plots gathered, and their basal area proportion is greater than 80% in most of the plots. Thus, it was decided to start with developing SDImax models for Loblolly pine.  The modeling approach began with data cleaning, in which we deleted missing expansion factors, at least 10 TPA, QMD of at least 2-inch, and doubtful and missing data before fitting the Linear Quantile Mixed Models to establish the 99% quantile line of log(TPH)log(QMD).Using a mixed model in which each record has a random intercept, giving each record a unique 99% max SDI value, we applied a variable selection approach called Featurewiz, which is based on Minimum Redundancy Maximum Relevance (MRMR) algorithms. The base model was an initial model predicting ln (TPA) with a single variable ln (QMD). The variables were then added to the model iteratively and retained or eliminated based on variable significance and AIC score. The model was evaluated in relation to the 90th and 50th percentiles of the growing circumstances at the location. The validation data set, i.e. the PMRC data set, was used to conduct a more rigorous study of the maximum stand density frontier for loblolly pine.  The emphasis was on comprehending and developing silviculturally sensitive models. Fertilization, thinning, vegetative, and mechanical control information has also been acquired, and we are currently looking for ways to account for the effect in order to establish the self-thinning line. |
| **MAJOR FINDINGS:**  The initial Loblolly pine site specific model has been built using the data from southern US states forests plots (Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, and Virginia). The developed frontier model includes highly significant topographical, climatic, geological, and soil variables. Based on possible evaluations, the model seems to be appropriate. The first takeaway point is that the interaction of the southern silvicultural operations is crucial in defining SDImax. We evaluated the influence of fertilizer applications on SDImax. The models may be enhanced with more in-depth data examination and professional help, which is the next step.  A northwest Douglas-fir SDImax model is available based on species purity, geology, climate and topography. Pacific or Inland Northwest SDImax models are available for western hemlock, grand fir, ponderosa pine, western larch, and lodgepole pine. The web-based SDImax APP has been updated with a stand density management diagram functionality. |
| **DELIVERABLES:**  The primary deliverables will include 1) a harmonized dataset that estimates the maximum stand density index (SDImax) for a range of study locations throughout US commercial forestlands; 2) an  equation that relates the observed site-specific SDImax to various species functional traits, stand attributes (e.g., structure, diameter distribution, site index), and environmental factors (e.g., soils, topography, climate); 3) and a high-resolution (10-30 m) raster map of predicted SDImax based on the factors identified in the developed equation. Annual progress reports and presentations will be provided at annual IAB meetings as well as a final report and presentation. At least three peer-review publications and conference presentations will be expected from this project. |
| **MEMBER COMPANY BENEFITS:**  Determination of optimal planting or thinning residual densities are an important management decision that influences stand development and final value. Currently, most regions use a single value of SDImax for each species that guide stand density management decisions and growth and yield projections. However, there is growing evidence that SDImax is highly dynamic and variable across the landscape, which can make optimizing management decision or growth projections difficult. An improved understanding of SDImax variation and the ability to predict it at rather high spatial resolutions will help refine future stand management. In addition, this will allow for the use of a nationally consistent variable for defining management, while currently a wide variety of variables are used. |