**Project Title:** Using Small Area Estimation and 3D-NAIP/Sentinel-derived Variables for Multivariate Prediction of Stand Attributes

**Project Personnel:**

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**Period for Report:**

Jan 1, 2025 - June 30, 2025

**Progress:**

During this period, we finalized the Material Transfer Agreement (MTA) and secured unfuzzed FIA plot coordinates for Oregon, Washington, Georgia, and Alabama. Access to these precise locations is essential for linking ground measurements with remote sensing data in our upcoming modeling efforts. We also completed the acquisition of the 3D-NAIP dataset for Washington and Oregon. Through continued collaboration with Green Diamond (Dale Hogg), we received a full set of cruise data for their Washington ownership.

Since the unfuzzed FIA coordinates were obtained in July 2025, the current reporting period relied exclusively on Green Diamond's cruise dataset. We clipped and masked 3D-NAIP height rasters and Sentinel-2 indices to the 219 Green Diamond management stands (5,736 plots) in Washington. These spatially aligned inputs now form the working database for initial modeling.

We began drafting the methodological framework for a multivariate unit-level small area estimation (SAE) model without incorporating FIA coordinates at this stage.

We first fit univariate Battese-Harter-Fuller unit-level mixed models for each response variable. Predictor variables were chosen based on the adjusted $R^2$ and followed by refitting with a variance inflation factor (VIF) threshold of 5 while testing several random effect structures. Using the Green Diamond dataset, these preliminary models for trees per acre (TPA), basal area (BA), and merchantable cubic foot volume (CFV) produced stand-level coefficients of variation (CV) of 7 to 9%. Building on the univariate results, we reformatted the data into a long format and specified a multivariate mixed model with a shared stand-level random effect across the three responses and an unstructured covariance matrix to capture their correlations. This joint specification aims to leverage strength across correlated attributes and enhance precision. Candidate predictors were selected from each univariate model and then rescreened using the same VIF $\leq 5$ criterion to control multicollinearity. After accounting for the covariance among TPA, BA, and CFV, the stand-level CV in the multivariate model declined by roughly one percentage point for each attribute except for TPA.

**Presentations:**

We presented preliminary findings from this project at the CIPS (Center for Intensive Planted-forest Silviculture) and CAFS (Center for Advanced Forestry Systems) meetings. We also shared early modeling results at the PSAE (Partnership for Small Area Estimation) meeting in June 2025. We are currently incorporating feedback from these meetings to refine our methodological framework for future use.

**Next Period Plans:**

We will integrate the newly obtained unfuzzed FIA plot coordinates with the existing 3D-NAIP metrics and Sentinel-2 indices, then refit both the univariate and multivariate unit-level models using this expanded spatial dataset. We will continue acquiring ground and remote sensing inventory data for Alabama and Georgia.

**Problems or Delays:**

None.