

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

**Project Personnel:**

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**Bryce Frank**, Co-Principal Investigator, Research Mathematical Statistician, US Forest Service FIA, Pacific Northwest Research Station, Olympia, WA.

**Jacob Strunk**, Collaborator for US Forest Service FIA Support, Pacific Northwest Research Station, Olympia, WA.

**Dale Hogg**, Collaborator for Private Industry Support, Green Diamond Resource Company, Bogart, GA.

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**Ethan Hughes**, Collaborator for State Forestry Support, Washington State Department of Natural Resources, Olympia, WA.

**Period for Report:**

October 1, 2024 - December 31, 2024

**Progress:**

The project team has made progress in data acquisition and preparation. Through collaboration with Ethan Hughes at the Washington State Department of Natural Resources (DNR), we have arranged to receive field-based inventory data, Digital Aerial Photogrammetry (DAP) point clouds from 2021-2022, and forest management polygons delineating specific stand boundaries. The DNR team is currently transferring these datasets onto external hard drives for our use.

We have coordinated with project collaborators to secure 3D-NAIP datasets for multiple regions. We have been working with Jacob Strunk (USFS FIA) in Washington and Oregon to obtain statewide 3D-NAIP data. We are following the University of Idaho team's lead for the southern states to obtain corresponding 3D-NAIP imagery for Alabama and Georgia. Also, Bryce Frank

(Co-PI, USFS FIA) has submitted a spatial request to access the confidential FIA plot locations, which is essential for linking ground measurements with remote sensing data at the plot level. The initial spatial data services requests for Oregon and Washington were approved. Drafting of a material transfer agreement for Oregon and Washington is underway. Coordinates for Alabama and Georgia are undergoing a spatial data service request at the Southern Research Station.

We have begun outlining a methodological framework for a multivariate unit-level small area estimation (SAE) model that does not incorporate FIA coordinates at this stage. The core idea is to extend a typical unit-level linear mixed model to simultaneously predict correlated forest attributes (e.g., basal area, volume, and stand density). By modeling these attributes together rather than independently, we expect to leverage any existing correlations and potentially increase estimation precision. In practice, this involves specifying a multivariate normal distribution for the small-area random effects and incorporating relevant auxiliary data for each response variable.

#### **Next Period Plans:**

We will continue acquiring ground and remote sensing inventory data from Washington DNR, 3D-NAIP imagery for the Pacific Northwest (Oregon and Washington) and the southern states (Alabama and Georgia), and stand exam or cruise data from our private industry partners. Additionally, we will download and preprocess Sentinel data corresponding to the years in which 3D-NAIP and ground data were collected.

Once we have the appropriate data-sharing agreements in place and access to the FIA coordinates, we will apply our outlined multivariate approach and validate its performance using the fully spatially referenced dataset.

#### **Problems or Delays:**

Our search for a Ph.D. student to support this project remains ongoing.