Progress report: **Applications of Small Area Estimation over the Contiguous United States: Testing and Development of Alternative Methods**
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Technical Accomplishments

Three broad project objectives outlined in the study work plan include: 1) Developing and testing F-H estimators for CONUS-wide county-level forest aboveground biomass; 2) extending point-in-time F-H estimators to change-over-time attributes for CONUS at county scales; and 3) Evaluating a quasi unit-level nested error model framework as an alternative to conventional unit-level SAE. Progress reported here aligns primarily with objective #1 with ongoing work for objectives #2 and #3 in early stages thus far.

1. Develop area-level F-H estimation algorithms for counties as CONUS-wide AOIs that include automated code scripts for model fitting, variable selection, and reporting estimates with efficiency and effective sample size gains for a suite of attributes including forest land area, volume, and biomass. Canopy height models (CHM) from available whole-state NAIP 3d acquisitions and spaceborne global canopy height models (GCHM; Potapov et al., 2021a) and GEDI L4B biomass ancillary data will be compared, with results evaluating the effectiveness of NAIP CHMs compared with spaceborne GCHMs and GEDI biomass density predictions, which our preliminary analyses indicate will support the wider application of NAIP 3d CHMs as ancillary data for SAE applications in FIA.
    a. Two-area and nested sub-area domain groupings.
        i. Preliminary work shows appreciable gains in precision for a small number of states where major differences in physiographic and/or ecological regions can be used to divide states into two major groups with distinct random-effects variances. Examples include Florida and Colorado. Gains beyond the base “whole-state” model (one random-effects variance) increase precision by 10% to 20% in these cases.
        ii. Hierarchical random effects with counties nested in survey units showed limited utility, with only results from one state, Georgia indicating that counties nested within survey units was a suitable structure for quantifying model random effects.
    b. Bivariate Fay-Herriot estimation that simultaneously estimate volume and biomass showed efficacy of results strongly dependent on the magnitudes of random effects. In states where regression synthetic models explained the bulk of variance in either volume or biomass in counties, correlations between the attributes’ random effects were too weak to increase precision beyond that of univariate models.

Publications and Presentations

Cao Q, Radtke PJ, Coulston JW, Thomas VA, Wynne RH, Gaines GC, Prisley SP, 2024a. County-level biomass estimates for the contiguous United States using Fay-Herriott small area estimators. *in preparation*.

Cao Q, Radtke PJ, Coulston JW, Thomas VA, Wynne RH, Prisley SP, 2024b. Comparing canopy height models from regional-scale aerial photogrammetry with global spaceborne lidar-derived data for estimating forest volume and biomass. Forest Science *(revised)*.

Cao Q, Radtke P, Coulston JW. 2024. Testing Fay-Herriot inferences from U.S. nationwide forest inventory county-level estimates of live tree aboveground biomass. SAE 2024 Conference, Lima Peru, June 4-6.

Cao Q, Radtke P, Coulston JW. 2024. Small area estimation of county-level biomass in forty-eight contiguous states in United States. FIA National User Group Meeting, Tucson, AZ, March 4-5.