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Introduction

Fine-resolution natural resource maps effectively represent spatial patterns and can be flexibly aggregated to arbitrary map subregions by computing spatial averages or totals of pixel-level predictions. However, generalized model-based uncertainty estimation for spatial aggregates requires computationally expensive processes like iterative bootstrapping and computing spatial covariances between residuals (McRoberts et al. 2022; Wadoux and Heuvelink 2023). Here we propose that simple models relating subregion characteristics to subregion uncertainty can expedite the entire process.

Methods

Following McRoberts et al. (2022), we produced estimates of standard error (SE) associated with spatial averages of aboveground biomass (AGB) predictions developed in Johnson et al. (2023) for a stratified random sample of ownership parcels in New York State (n = 2224). We incorporated reference data uncertainty and model uncertainty through a 1000-iteration bootstrap procedure. We accounted for residual variability and spatial correlation of residuals by mapping residual variance and fitting a semivariogram to a random sample of spatial residuals.

After estimating SEs for all parcels, we randomly partioned them into training (80%) and testing (20%) sets. We fit a log-log regression model relating parcel characteristics (area, perimeter, forest cover, AGB) to parcel SE with the training set and assessed the model's accuracy against the testing set.

Results

Parcel-level standard error (SE) decreased as a function of parcel size (Figure 1). This high-level relationship serves as the basis for efficiently communicating uncertainty results to map users who are interested in arbitrary subregions of the map. We can infer that the trend in Figure 1 is largely driven by the decreasing contribution of residual spatial autocorrelation with increased parcel size (Figure 2).

Uncertainty estimation for arbitrary subregions of natural resource maps **is expensive. Simple models** relating subregion characteristics to standard error estimates can help **expedite the process.**

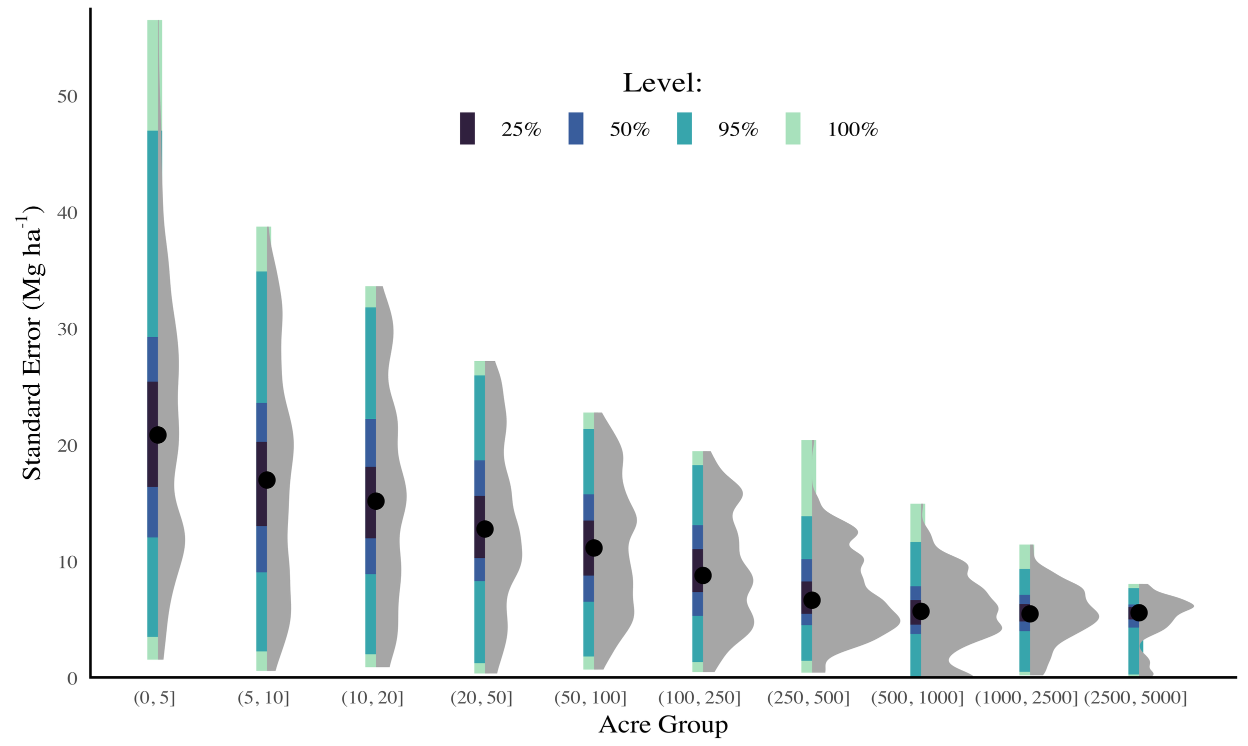

Figure 1: Parcel-level standard error distributions by acre group for the 80% training partition of the statewide parcel sample. Gray shaded areas represent smoothed kernel density estimates of standard errors. Black dot identifies median value, and colored bars show 25%, 50% 95% and 100% intervals.

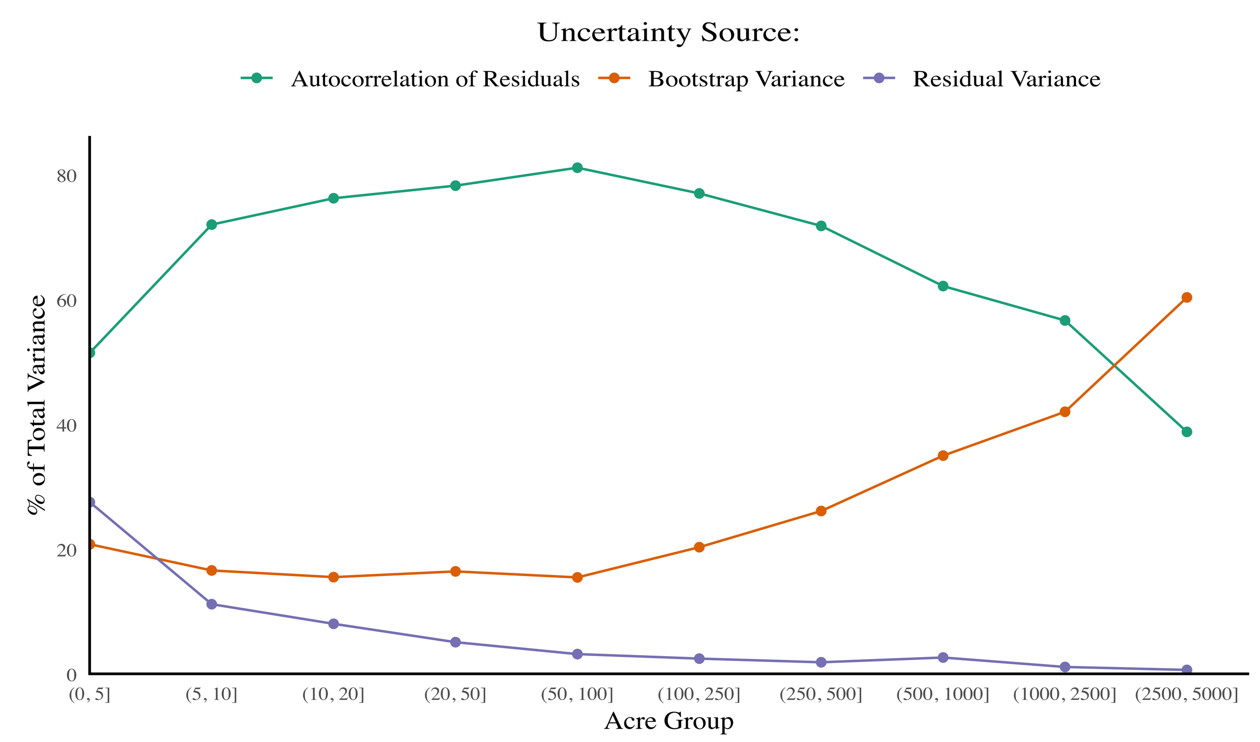

Figure 2: Parcel-level uncertainty contributions (% of total variance) as a function of parcel size (acre group) for the 80% training partition of the statewide parcel sample. For each acre group and source of uncertainty, the average proportion of the total uncertainty was summarized across all parcels within the acre group.

The log-log regression accurately predicted SEs for parcels in our 20% test set (Figure 3; RMSE 2.38, MAE 1.38, ME -0.05, R^2 0.92). These results suggest that we can estimate the SEs associated with spatial averages of aboveground biomass predictions for any arbitrary subregion of NYS with a small fraction of the computing resources and data required to do so from scratch.

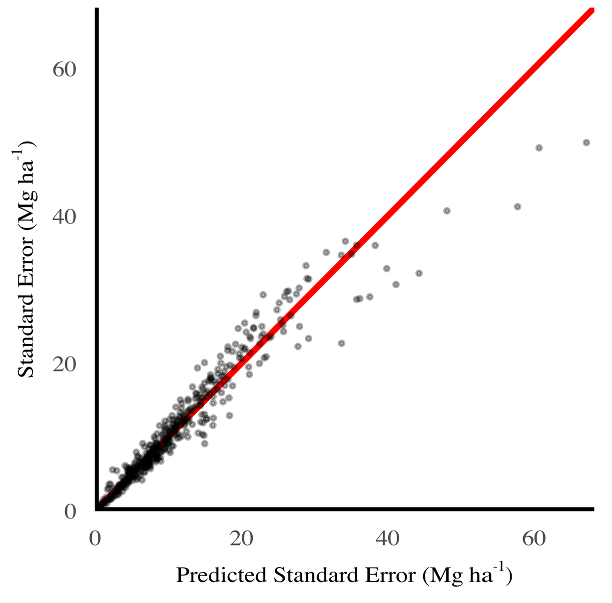

Figure 3: Computed standard error (SE) vs log-log regression predicted SE for the 20% testing portion of the parcel sample. 1:1 line in red.

References

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