

**MODEL-ASSISTED ESTIMATION OF FOREST RESOURCES WITH  
GENERALIZED ADDITIVE MODELS**

by

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**ABSTRACT**

Multi-phase surveys are often conducted in forest inventory, with the goal of estimating forested area and tree characteristics over large regions. This article describes how design-based estimation of such quantities, based on information gathered during ground visits of sampled plots, can be made more precise by incorporating auxiliary information available from remote sensing. The relationship between the ground visit measurements and the remote sensing variables is modelled using generalized additive models. Nonparametric estimators for these models are discussed and applied to forest data collected in the mountains of northern Utah in the United States. Model-assisted estimators that utilize the nonparametric regression fits are proposed for these data.

The design context of this study is two-phase systematic sampling from a spatial continuum, under which properties of model-assisted estimators are derived. Difficulties with the standard variance estimation approach, which assumes simple random sampling in each phase, are described. An alternative assessment of estimator performance based on simulation is implemented. The simulation provides strong evidence that using the model predictions in a model-assisted survey estimation procedure results in substantial efficiency improvements over current estimation approaches.