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Quantification of live aboveground forest biomass dynamics with Landsat time-series and field inventory data: A comparison of empirical modeling approaches

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Abstract

Spatially and temporally explicit knowledge of biomass dynamics at broad scales is critical to understanding how forest disturbance and regrowth processes influence carbon dynamics. We modeled live, aboveground tree biomass using Forest Inventory and Analysis (FIA) field data and applied the models to 20+ year time-series of Landsat satellite imagery to derive trajectories of aboveground forest biomass for study locations in Arizona and Minnesota. We compared three statistical techniques (Reduced Major Axis regression, Gradient Nearest Neighbor imputation, and Random Forests regression trees) for modeling biomass to better understand how the choice of model type affected predictions of biomass dynamics. Models from each technique were applied across the 20+ year Landsat time-series to derive biomass trajectories, to which a curve-fitting algorithm was applied to leverage the temporal information contained within the time-series itself and to minimize error associated with exogenous effects such as biomass measurements, phenology, sun angle, and other sources. The effect of curve-fitting was an improvement in predictions of biomass change when validated against observed biomass change from repeat FIA inventories. Maps of biomass dynamics were integrated with maps depicting the location and timing of forest disturbance and regrowth to assess the biomass consequences of these processes over large areas and long time frames. The application of these techniques to a large sample of Landsat scenes across North America will facilitate spatial and temporal estimation of biomass dynamics associated with forest disturbance and regrowth, and aid in national-level estimates of biomass change in support of the North American Carbon Program.

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Keywords

Biomass; Landsat; FIA; Disturbance; Curve-fitting; Random forests

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