Distinguishing between live and dead tree biomass on North Rim of the Grand Canyon with lidar data

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Abstract

Accurate estimates of both live and dead biomass in forested ecosystem are important for carbon dynamics studies and forest management. Lidar remote sensing has been used successfully to estimate live biomass, but few studies estimated dead biomass. In this study, our primary goal was to distinguish between live and dead biomass in a mixed coniferous forest on North Rim of the Grand Canyon using small footprint discrete lidar. The study is a part of a project to develop forest structure monitoring protocols for the National Park. The park's goal is to understand present and future ecosystem states and dynamics, biodiversity, habitat, movements of organisms, and flow rates of energy and materials. We examined lidar intensity values for differentiating live vs dead trees using field measurement on 58 plots measured in 2007. We found that lidar intensity values hold great promise for separating dead from live trees. Applying regression techniques we modeled both live and dead biomass.

North Rim forests consist of mixed conifer, dominated by Spruce fir (*Picea spp*.) and Subalpine fir (*Abies lasiocarpa*) on the higher elevation, mixed conifer with various combinations of ponderosa pine (*Pinus ponderosa*), Douglas-fir (*Pseudotsuga menziesii*), Engelmann spruce (*Picea engelmannii*), blue spruce (*Picea pungens*), white fir (*Abies concolor*), and quaking aspen (*Populus tremuloides*) in the mid elevation, and pure ponderosa pine forest on the lower elevations. The park has been preserved by the federal government since late 19th century, at which time grazing and wildfire have been suppressed. This has resulted in development of structures associated with older forest, including a significant amount of standing dead trees.

In this study, lidar intensity was used to separate the first return pulses into live and dead trees. We hypothesized that dead trees have lower intensity values relative to live trees. Regression analysis, and associated cross validation demonstrated that live and dead tree biomass were separable. Total biomass estimation averaged 251.1 Mg ha-1 (R2 = 0.83, RMSE = 61.5 Mg ha-1, bias: 0.35 Mg ha-1), dead averaged 54.7 Mg ha-1(R2: 0.52, RMSE: 41.9 Mg ha-1, bias: -1.28 Mg ha-1). Live biomass was estimated as the difference of total and dead, averaging 195.4 Mg ha-1 (R2: 0.69, RMSE: 55 Mg ha-1, bias: 0.45 Mg ha-1).

Keywords: small footprint, lidar, forest, biomass, dead trees, North Rim USA