

Using classification trees to predict forest structure types from LiDAR data

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Torresan C., Corona P., Scrinzi G., Marsal J.V., 2016. Using classification trees to predict forest structure types from LiDAR data. Ann. For. Res. 59(1): 281-298.

Abstract. This study assesses whether metrics extracted from airborne LiDAR (Light Detection and Ranging) raw point cloud can be exploited to predict different forest structure types by means of classification trees. Preliminarily, a bivariate analysis by means of Pearson statistical test was developed to find associations between LiDAR metrics and the proportion of basal area into three stem diameter classes (understory, mid-story, and over-story trees) of 243 random distributed plots surveyed from 2007 to 2012 in Trento Province (Northern Italy). An unsupervised clustering approach was adopted to determine forest structural patterns on the basis of basal area proportion in the three stem diameter classes, using a k-means procedure combined with a previous hierarchical classification algorithm. A comparison among the identified clusters centroids was performed by the Kruskal-Wallis test. A classification tree model to predict forest structural patterns originating from the cluster analysis was developed and validated. Between 18 potential LiDAR metrics, 11 were significantly correlated with the proportion of basal area of understory, mid-story, and overstory trees. The results coming from the agglomerative hierarchical clustering allowed identification of 5 clusters of forest structure: pole-stage (70% of the considered cases), young (15%), adult (24.3%), mature (24.3%), and old forests (30%). Five LiDAR metrics were selected by the classification tree to predict the forest structural types: standard deviation and mode of canopy heights, height at which 95% and 99% of canopy heights fall below, difference between height at which 90% and 10% of canopy heights fall below. The validation tree model process showed a misclassification error of 45.9% and a level of user's accuracy ranging between 100% and 33.3% in the validation data set. The highest level of user's accuracy was reached in the classification of pole-stage forests (100%), in which more than 82% of basal area is due to the understory-trees, follow by the classification of old forests types (63.5% of basal area due to the overstory-trees) achieved 76.5% of user's accuracy. The model has provided moderately satisfactory results in term of classification performance: substantial room for improvement might be established by multi- or hyperspectral imaging that allow detailed characterization of the spectral behaviour of the forest structure types.

Keywords airborne laser scanning, discrete return laser scanner data, stem diameter classes, basal area, bivariate analysis, unsupervised clustering, classification tree model, forest inventory, forest management