Prediction of FRI attributes in different forest types in Ontario using a core set of ALS metrics

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Abstract

To date, many airborne laser scanning (ALS) metrics have been developed to predict key Forest Resource Inventory (FRI) attributes. With this multitude of ALS metrics, however, two major issues arise: i) strong inter-correlations exist between metrics causing problems for feature selection and model generalization; and ii) a large subset of these metrics can be linked to only a few forest stand characteristics, mainly related to the vertical stand structure [1]. The goal of our research is to identify a core set of ALS metrics that: (i) relate to all aspects of stand structure that ‘drive’ the FRI attributes; (ii) have stable correlations between metrics and with FRI attributes across different forest types; and (iii) have high predictive power for the estimation of FRI attributes within these types using a non-parametric modeling approach. Our study sites include two temperate mixedwood forests in central Ontario (i.e., Petawawa Research Forest (PRF) and Haliburton Forest) and one northeastern Ontario boreal mixedwood forest (i.e., Hearst Forest).

To identify a core set of ALS metrics for modeling specific FRI attributes (i.e., basal area (BA), quadratic mean diameter-at-breast height (QMDBH) and stem density (SD)), we analysed a number of commonly used ALS metrics, derived from the height and intensity of ALS returns, and other, less common, metrics derived from the leaf area density profile, and digital terrain and canopy model such as gap fraction and texture indices. We then tested several feature selection methods to determine the optimal combination of ALS metrics for each of the forest types that maximized the predictive model performance of the FRI attributes using the Random Forest algorithm. FRI predictive models, utilizing a full set, a forest specific or ‘local’ core set, and an across forests or ‘regional’ core set of ALS metric, were subsequently compared using Repeated Measure ANOVA and Equivalence tests [2].

Our initial Principal Component Analysis (PCA) results indicated that the three forest types consistently identify similar ALS metric groupings in ordination space, which could be characterized as a structural, intensity, and combined leaf area density, texture and terrain metrics group. Initial analyses of ALS metrics and FRI attributes also indicated consistent correlations between ALS metric groups and FRI attributes and the usefulness of some of the less common ALS metrics. For all three FRI attributes and across the forest types, our validation models that included ‘local’ subsets of ALS metrics performed best in terms of Root Mean Square Error (RMSE) and bias, except for the BA and SD estimations in the PRF, where the full set of ALS metrics yielded the best predictive results. However, no significant differences between predictive models with full, local core, and regional core sets of ALS metrics were observed. The regional core sets of ALS metrics for the three FRI attributes mainly included ALS metrics from the structural and intensity group but also one texture and LAD metric.

References: