Estimation of growing stock of broadleaved forests by airborne laser scanning

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ABSTRACT

Airborne laser scanning (ALS) is increasingly being proposed for surveying forest attributes. The objective of this paper is to present a new approach for the estimation of growing stock based on ALS data. The approach is distinctively developed for broadleaved stands where conventional methods for growing stock estimation based on ALS measurements of single tree heights frequently provide poor results. Theoretical background and model-based statistical estimators are reported.

Keywords: *LiDAR, growing stock, model-based estimation*

INTRODUCTION

Growing stock and above-ground tree biomass are key parameters for forest ecosystem planning and management. Over the last decades the processes of acquisition of such attributes by forest inventory have greatly advanced (Corona & Marchetti 2007).With the advent of active laser (LiDAR - Light Detection and Ranging) sensors, the techniques for obtaining from remotely sensed data information on such forest structural attributes are also approaching operational feasibility for forest inventory (Mc Roberts & Tomppo 2007).

Airborne laser scanning (ALS) technology is increasingly being investigated in ecosystem studies (e.g. Lefsky *et al.* 2002), mainly due to the increased availability of ALS data. Actually, during the last years ALS has been established as the standard method for high precision topographic data acquisition on large areas: this fact contributes to decreased operation cost, making that ALS data are developing into cost-efficient covariates to support forest inventory.

Although most ALS systems have been designed for purposes other than forest inventory, they have proven to be potentially suitable for the estimation of relevant dendrometrical attributes (e.g. Holmgren 2004; Lim *et al.* 2003; Naesset 1997; Naesset & Gobakken 2005; Nelson *et al.* 1984). On the other hand, such estimation is still frequently characterized by not negligible uncertainty. The accuracy of LiDAR observations is highly dependent on both the extrinsic specifications of the ALS survey as well as the intrinsic effects by the underlying forest structure (e.g. Goodwin *et al.* 2006). This is particularly true in the case of temperate forests dominated by broadleaved species, where, for instance, the conventional methods for assessing growing stock by single-tree-based LiDAR measurements give generally poor results. In fact, in temperate broadleaved stands the delineation of single trees is generally difficult due to the frequent geometrically irregular crown shapes, high local variation of foliage and branch density and to the more pronounced tendency of tree crowns to interpenetrate each other than in coniferous stands.

To overcome such shortcoming, LiDAR measurements can be used according to the area-based methods (as called in the jargon of LiDAR mensurationists) to extract information about the spatial distribution of forest stand canopy and its height. Under this framework, this paper focuses on developing a new approach for the ALS-supported assessment of growing stock in temperate broadleaved forests.

From a dendrometrical point of view, the proposed approach takes into account that, as showed by Corona