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Optically-based methods for measuring seasonal variation of leaf area index in boreal conifer stands

Jing M. Chen *

Canada Centre for Remote Sensing, #419-588 Booth Street, Ottawa, Ont. K1A 0Y7, Canada

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Abstract

The feasibility of detecting the seasonal variation in leaf area index (LAI) in boreal conifer forests is investigated using optical instruments. The LAI of six stands was measured. They include young and old jack pine (*Pinus banksiana*) and old black spruce (*Picea mariana*) located near the southern border (near Prince Albert, Saskatchewan) and near the northern border (near Thompson, Manitoba) of the Canadian boreal ecotone. LAI values of the stands are obtained by making several corrections to the effective LAI measured from the LI-COR LAI-2000 Plant Canopy Analyzer (PCA). The corrections include a foliage element (shoot) clumping index (for clumping at scales larger than the shoot) measured using the optical instrument TRAC (Tracing Radiation and Architecture of Canopies) developed by Chen and Cihlar (Chen, J.M. and Cihlar, J., 1995a, Plant canopy gap size analysis theory for improving optical measurements of leaf area index of plant canopies, Appl. Opt., 34: 6211–6222), a needle-to-shoot area ratio (for clumping within the shoot) obtained from shoot samples, and a woody-to-total area ratio obtained through destructive sampling of trees. It is found that the effective LAI varied about 5% to 10% in the growing season and the element clumping index remained almost unchanged. The needle-to-shoot area ratio varied the most, about 15% to 25%, which is of the same order of magnitude as the expected seasonal variability in LAI. This demonstrates that most of the seasonal variation information is contained in the needle-to-shoot area ratio, which can not be measured indirectly using in situ optical instruments and has to be obtained from a large quantity of shoot sample analysis which is laborious and error-prone. Based on our experience, an improved and convenient shoot sampling strategy is suggested for future studies. The optically-based LAI values were compared with destructive sampling results for three of the stands. Based on error analysis, we believe that optical measurements combined with shoot sample analysis can produce LAI values for conifer stands which are more accurate than destructive sampling results.

* Corresponding author.

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