Bioindicators of forest sustainability: Validation of a physiological, remote sensing approach

Noland, Thomas L.[1], Pablo J. Zarco-Tejada[2], John R. Miller[3], Gina H. Mohammed[1], Paul H. Sampson[1], Denzil Irving[1], and Paul M. Treitz[4]

Objective measures of forest ecosystem condition are needed to gauge the effects of management activities and natural phenomena, like ice storms, on sustainability. The Bioindicators of Forest Sustainability Project seeks to develop a Forest Condition Rating system using a physiological, remote sensing approach. A series of experiments were performed at the leaf level, laboratory canopy level, and field canopy and stand levels to scale-up leaf-based physiological indicators. For the field campaign, a plot network in the Algoma region was used that represented a wide range in tree condition, and included twelve sugar maple sites from provincial growth and yield and hardwood decline plot networks. For three years, these plots were assessed by collecting leaves for physiological analysis and using a compact airborne spectrographic imager (CASI) to acquire hyperspectral data. Reflectance, transmittance, chlorophyll fluorescence, and chlorophyll *a* and *b* levels were measured from leaves of five trees per site. Stand estimates of chlorophyll and chlorophyll fluorescence calculated from a number of optical indices derived from CASI data were found to correlate well with leaf-measured stand averages of chlorophyll concentration and chlorophyll fluorescence. Ten ice storm maple plots and six hardwood decline plots in Eastern Ontario were chosen to validate the optical indices developed with the Algoma plot network. In mid-June 2000, leaves were collected and CASI images acquired for these sites. Chlorophyll concentration maps generated from the remote sensing data correlate well with measured levels of chlorophyll. Ice storm damage did not seem to affect the chlorophyll levels of maples. Chlorophyll content estimates from CASI data were relatively accurate despite ice storm damage-induced differences in stand structure. Soil pH was positively correlated with chlorophyll concentration in the ice storm plots. These results suggest that the methods developed in the Bioindicators project for estimating chlorophyll content of maple stands have broad applicability.

[1] Ontario Forest Research Institute, Ontario Ministry of Natural Resources, 1235 Queen St. E., Sault Ste. Marie, ON, P6A 2E5; tom.noland@mnr.gov.on.ca

[2] Centre for Research in Earth and Space Science, York University, Petrie Science Building, 4700 Keele St., Toronto, ON, M3J 1P3

[3] Department of Physics and Astronomy, York University, and Centre for Research in Earth and Space Technology, 4700 Keele St., Toronto, ON, M3J 1P3

[4] Department of Geography, Queen's University, Kingston, ON, K7L 3N6