Bioindicators of Forest Sustainability: Using Remote Sensing to Monitor Forest Condition

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The *Bioindicators of Forest Sustainability Project* has applied a physiological, remote sensing approach to develop practical and objective measures of forest condition,. This project was designed to address ecosystem condition and productivity (C&I, Criteria Number 2), by producing an indicator for disturbance and stress. While stress indicators like chlorophyll fluorescence and pigment content exist at the leaf level, developing reliable indicators at the canopy level is a challenge. In this study, an inverse modelling approach has demonstrated the capability of hyperspectral sensor (compact airborne spectrographic imager (CASI)) reflectance images to map chlorophyll content in 12 stands of a tolerant hardwood sugar maple (*Acer saccharum*) forest in the Algoma region of Ontario, Canada that vary in condition from healthy to chronically stressed. The practical significance of developing spectral features related to chlorophyll concentration is in identifying whether forests are healthy or stressed. Temporal variations in chlorophyll concentrations could provide an objective, early-warning indicator of stress. The Bioindicators Project has expanded to include the boreal forest species jack pine (*Pinus banksiana*), black spruce (*Picea mariana*), trembling aspen (*Populus tremuloides*), and white birch (*Betula papyrifera*). Preliminary results suggest that chlorophyll concentrations of jack pine, aspen, and white birch canopies can be estimated from CASI images. Current efforts are focussing on scaling this technique up from the high spatial resolution of CASI images to lower spatial resolution, but larger image size, of satellite images of the hyperion sensor of NASA's Earth Observing-1 satellite. Once developed, this technique could be used as an efficient means to operationally assess both acute and chronic forest physiological stress and classify forest condition based on chlorophyll content. Forest condition maps developed using this technology could be used for state of the resource reporting, assessing the effects of silvicultural operations, and as indicators of incipient insect and disease outbreaks.

Keywords: remote sensing, forest condition, forest health, ecosystem condition, stress indicator