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# Remote sensing of forest condition — estimation of foliar chemical components by using hyperspectral reflectance data

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Hyperspectral remote sensing is one of the strong tools for the detection of chemical/structural characteristics of plant tissue. Although several researchers have reported the potential of multiband reflectance-based indices (*ex*. NDVI) for the monitoring of leaf phenology and productivity of forest, new monitoring method using hyperspectral reflectance data and spectroscopic analyze technique is recently spotlighted for the detection of more detail biological characteristics such as leaf thickness and leaf concentrations in photosynthetic pigments, carbohydrates and nutrients (they are generally called 'leaf traits') (Asner and Martin, 2008; Asner *et al*., 2011). In this presentation, we summarize the current studies on the remote estimation of leaf traits of forest tree species briefly, and introduce our field studies about hyperspectral remote sensing of tree leaf traits under warming environment.

In some deciduous forests in Hokkaido region, we have carried out warming experiments to study the potential effects of global warming on forests. For example, in the Tomakomai Experimental Forest of Hokkaido University, soil temperature in 5 x 5 m area around mature oak (*Quercus crispula*, approx. 20 m height) has been elevated to 5 degC above control soil temperature from 2007 by heating cables dug into the soil (Nakamura *et al*., 2010). Several parameters have been monitored such as photosynthesis, herbivory, leaf traits and phenology. We measured the reflectance of intact leaf at visible-shortwave infrared spectral region (350-2500 nm) using a portable spectrometer (FieldSpec FR, ASD) after the monitoring of herbivory in July and September of each year. Hyperspectral images at the visible-near infrared region (400-1000nm, 150bands) of the oak canopy were captured at daily interval using the spectral camera system (ImSpector V10, Specim).

In 2009, the ratio of herbivory in summer and autumn was lower in soil warmed trees than control trees significantly. The leaf concentrations of total N and lignin were reduced and the concentrations in total phenol and tannin were increased in canopy leaves by soil warming. This result suggests that the soil warmed oak tree increased chemical materials rather than structural materials to protect against herbivory. To estimate the chemical defensive materials from hyperspectral reflectance data, we tested the utility of (1) simple regression model using Normalized Difference Spectral Index (NDSI) and (2) Partial Least Square (PLS) regression model. Root mean square error of cross validation (RMSECV) was smaller in PLS model than NDSI simple regression model. When the spatial variation of phenol concentration in the canopy top leaves was predicted by calculating the PLS regression in each pixel of hyperspectral canopy images, higher phenol concentration in the warmed trees was visualized successfully. Although future studies on validity of this method are needed, our results indicate that the monitoring of hyperspectral reflectance is an useful method in estimating specific canopy leaf traits in a cool temperature forest. We believe that such methods are essential to help us understand how forest will respond to future climate conditions.

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Asner G P. *et al*.(2011) *Remote Sens. Environ*. 115, 3587-3598
Nakamura, M. *et al*. (2010) *Agr. For. Meteorol*. 150, 1026-1029.