The Spectral Data Collection of Specific Trees in Peat-Forest in Central Kalimantan, Indonesia

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Introduction

Remote sensing applications in precision identification of agriculture and forest vegetation have been steadily increasing in recent years due to improvements in spatial and spectral resolutions of remotely sensed imagery. There is a rapidly growing interest in methods for automatic plant identification, especially in agricultural and forestry researches. Innovations in sensors are permitting the connection of remote sensing with methods of laboratory spectroscopy (*3, 10*).

The Spectral library is "a set of class or end member spectrum to be referred during feature extraction process from hyperspectral data". It can be further explained as a collection of spectral plots which is being compiled so that it can be used as a reference in information extraction from hyperspectral data. The reflection of radiation from the forest under-storey and ground vegetation, in particular, plays a significant role in the forming of total forest reflectance (*4*).

Field campaign is the most common and easiest way to collect object spectra of different land cover types or vegetations, and this method produces results which can be easily compiled into spectral library (*2, 3*). Furthermore, to carry out a field campaign, a spectroradiometer is used to record the spectra received from the objects.

Materials and Methods

Study Area

The study area is located in a tropical peat swamp forest area around Palangka Raya, the capital city of Central Kalimantan Province, Indonesia (Fig. 1) and approximately 120 km from the Java sea with the elevation between 15-20 m above sea level (*12, 13*). Peat swamps cover extensive areas of lowland Kalimantan, with estimates varying between 8% and 11% (*7*). Area of Central Kalimantan is 153,564 km^2, comprising mostly jungle (ca. 126,200 km^2, 82.18%), swamps (11.80%), rivers and lakes (2.97%), and agricultural land (3.05%).

Central Kalimantan contains about three million hectares of peatland which is one of the largest unbroken peatland in the world and located between 0º 45' N and 3º 3' S, between 111º and 116º E. Ground surveys and field investigations were carried out in the study area in July 2011, July 2012 and August-September 2012.

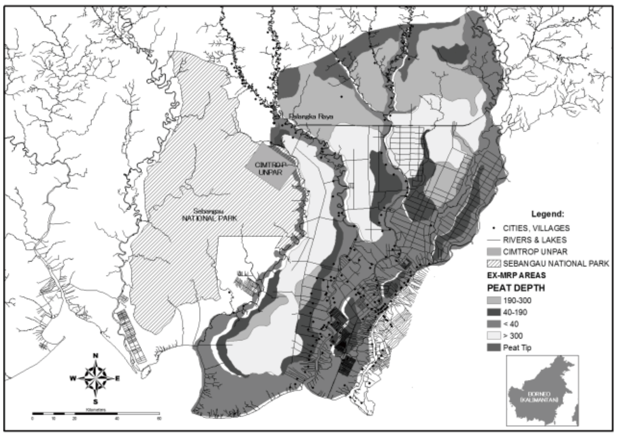

Figure 1. Map of study area in Central Kalimantan Province, Indonesia

Methods

The measurements of the reflectance spectra of ground vegetation were performed by an Analytical Spectral Devices (ASD) FieldSpec Pro-FR Spectroradiometer (FieldSpec 3 FR) with a spectral range of 350-2500 nm and a rapid data collection time of 0.1 second per spectrum. The main purpose of this study is to develop the spectral library of individual tree of peat-forest using a ground-based spectroradiometer. The instrument uses three detectors spanning the visible and near infrared (VNIR) and shortwave infrared (SWIR1 and SWIR2). The FieldSpec spectroradiometer is specifically designed for field environment remote sensing to acquire visible near-infrared (VNIR) and short-wave infrared (SWIR) spectra.

The sensor, with a field of view of 25°, was positioned 30-40 cm above the samples at nadir position. Prior to each three measurements, a white reference panel with approximately 100% reflectance was used as a reference standard. The measurements were conducted under clear and cloudless sky between 10:00 and 14:00 at local time (West Indonesian Time).

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A contact probe-fore optic was used to minimize BRDF effects from shiny surfaces. Measurements were made with a standard laboratory setup (*9*) using the high intensity contact probe at 30° of nadir. The ASD contact probe is equipped with an internal light source (a halogen bulb light source 6.5 W, with colour temperature 2901 ± 10% K). Spot size of the contact probe has the diameter of 22 mm as shown in Figure 2.

The contact probe is an alternative method for collection of laboratory spectra because SWIR spectra collected are found to exhibit improved signal to noise (S:N) ratios, lower standard deviation and less intrinsic uncertainty than spectra collected using more traditional laboratory techniques (*6*). The spectrometer and contact probe were warmed prior to use for 90 minutes and 30 minutes, respectively.

A white reference measurement was undertaken prior to each material (tree leaves) being sampled. Spectral measurements were made on each tree species using the average of 30 times measurements.

Figure 2. Spectral library data collection activities (field survey and sample measurements)

Results

The samples of the library spectra measurements from 10 dominant trees species in peat-forest in Central Kalimantan are shown in Figure 3 from the total of 33 species during field survey and measurements in full-range wavelength (350 – 2500 nm). The definition of dominant trees are trees (or shrubs) with crowns receiving full light from above and partly from the side; usually larger than the average trees or shrubs in the stand, with crowns that extend above the general level of the canopy and that are well developed but possibly somewhat crowded on the sides. A dominant tree is one which generally stands head and shoulders above all other trees in its vicinity. In some cases, a number of young trees and strong but not covered by the dominant tree nearby. This smaller tree may be considerably shorter than the dominant, but still be receiving full light from above and partly from the sides. In its own immediate environment, it is dominant and should be recorded as such. Only understory trees immediately adjacent to the overstory tree will be assigned subordinate crown classes (*5, 8*).

The spectra demonstrate the basic varieties in the spectral shapes across the visible to shortwave infrared (350–2500 nm) wavelength ranges. These are examples from 33 species measured from various locations in study areas. *Figure 4* also presents examples of spectral reflectance from 10 dominant tree species of peat-forest in SWIR wavelength (1000-1800 nm) with special characteristic of Tumeh (*Combretocarpus rotundatus*) which was always in lowest reflectance values than other tree species such as Belangeran (*Shorea belangeran*), Gerunggang (*Cratoxylon* sp.), Jelutung (*Dyera costulata*), Kayu Hitam (*Dyospiros* sp.), Manggis Hutan (*Garcinia* sp.), Ramin (*Gonystilus bancanus*), Mahang (*Macaranga* sp.), Nyatoh (*Palaquium* sp.), and Kayu Pelawan (*Tristania maingayi*).

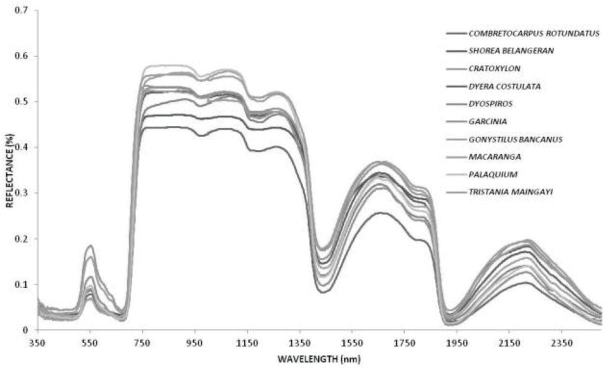

Figure 3. Spectral reflectance from 10 species of peat-forest in full-range wavelength (350 – 2500 nm)

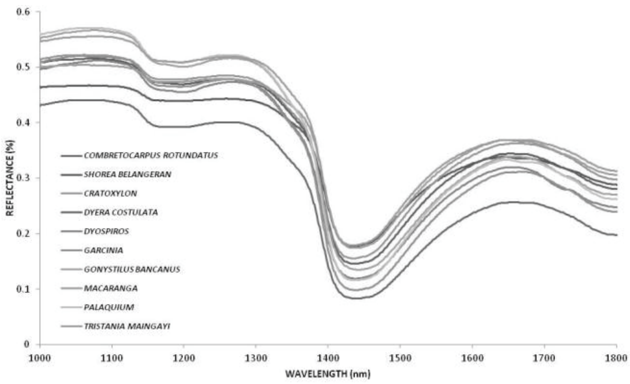

Figure 4. Spectral reflectance from 10 species of peat-forest in SWIR wavelength (1000 – 1800 nm)

As shown in Fig. 3 and Fig. 4, the variability are caused mainly by the spatial inhomogeneities of canopies and species. If we made a series of measurements without moving the spectrometer, the variability (caused by noise and possible changes in illumination) was several times less (*1, 3*). However, even though the spectral measurement is very important, leaf optical properties alone are not adequate to explicitly spectrally distinguish tree species such as in peat-forest ecosystem in Central Kalimantan. Also other canopy components such as bark branches, twigs and understory must to be considered.

Conclusion/Discussion

Spectral analysis and measurements were performed during the field campaign to 33 vegetation species spectra and found that the vegetation spectra are very sensitive to environmental parameters such as leaf condition, vigorous and other physiological and biochemical parameters. Spectral libraries are data archives that consist of spectral signatures measured on selected natural and/or man-made materials. These libraries should also include the corresponding meta-information on the records.

There are in principle two potential purposes: the use of the data in remote sensing as in-situ radiance/reflectance measurements for the calibration and/or end-members selection for further data processing (*11*).

The knowledge gained from laboratory and field studies of vegetation spectra and laboratory spectral analysis methods are directly applicable to remote sensing data. This analysis highlights the possible integration of in-situ hyperspectral measurements with airborne/space-borne hyperspectral remote sensing data for automatic identification and discrimination of various species/vegetation on the study areas.

The frequently updated of spectral library in peatland forest provides initial collections of spectra covering the wavelength range 350–2500 nm that allows for the modeling of basic vegetation and land-cover properties by statistical inference. This study has produced the first preliminary spectral library of the dominant forest tree species of the peat-forest in Central Kalimantan (Indonesia) taking into account the range of spectral variability expected for the species measured under natural illumination conditions.

Meanwhile, spectral libraries from ground measurements and hyperspectral sensors can collect continuous spectral reflectance data with narrowband measurements that enable classification of peat-forest types, discrimination of plant/tree species (through biophysical parameters), forest degradation, soil types and so on. This activity also could support the integrated measurement, reporting and verification (MRV) of Reducing Emissions from Deforestation and Forest Degradation (REDD) programs in Indonesia. Monitoring systems that allow for credible measurement, reporting and verification of REDD+ activities are among the most critical elements for the successful implementation of any REDD+ mechanism.

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