Paper presented at the 22nd Asian Conference on Remote Sensing, 5 - 9 November 2001, Singapore.

ESTIMATES OF LAI FOR FOREST MANAGEMENT IN OKUTAMA

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KEY WORDS: LAI, NDVI, Landsat-TM, Forest Management

ABSTRACT: The seasonal variation of NDVI was obtained in Okutama with satellite data. LAI was estimated by the images that were taken with a fisheye-lens camera on ground. The regression equation between NDVI and LAI was derived from these data. Using this equation, LAI for forest was estimated directly fromsatellite data.

1. INTRODUCTION

Vegetation monitoring by satellite data has become important from a viewpoint of the management and maintenance of geo-environment recently. Since NDVI (Normalized Difference Vegetation Index) and LAI (Leaf Area Index) are obtained from satellite data (Gardner *et al*., 1988; Baret *et al*., 1991), the distinction of vegetation, quantitative assessment for its growth stage, and the estimates of its carbon absorption and evapotranspiration (Nemani *et al*., 1989; Ebisu, 2000) become possible (Ogawa *et al*., 2000). The Okutama forest area selected as an objective place in this study is municipal drinking-water source for Tokyo and also the source for a river recharge function, a sediment run-off prevention function, and water purification. In recent years, owing to the decline of forestry and aging of forest owners, the management has not beensufficient; therefore, the new methodology of forest habits management is required. However, at present, little study for the change of forest constitution in particular was carried out. The change of forest in Okutama for a seasonal period or an annual period were grasped through the field investigation and satellite image analysis, which suggested a method to manage vegetation in future. This paper reports a first finding of NDVI and LAI of the forest in Okutama.

2. MATERIALS AND METHOD

In this study, the investigation ground was considered to be the Okutama forest level, and the monitor of vegetation with satellite data was tried by the next procedures.
(i) Seasonal variation of NDVI was derived by satellite data of Okutama.
(ii) LAI was calculated by an image filmed using a fisheye-lens camera in ground.
(iii) Regression equation of NDVI and LAI was derived from these data.

2.1 Seasonal variation of NDVI

2.1.1 Materials: The Landsat-TM images (the date: 15/02/85, 04/03/91, 04/11/93, 13/01/96, 30/12/96, 18/05/95 and 13/04/00) covered the Okutama forest areas were used. They were corrected geometrically, and only the target areas were cut out. From them, the unsupervised land-cover classification and the calculation of NDVI were carried out. The geometry correction was done with the nearest neighbor method. In this method, bridges and the Ogochi dam which could grasp the shape definitely in the satellite data were selected as GCP (Ground Control Points). Unsupervised land-cover classification referred to topographical maps and figures of forest patches, and examined each class. Finally, land covers were classified into five categories: evergreen conifer forest, deciduous broadleaf forest, water body, urban areas, and bare soils.

2.1.2 Calculation of NDVI: NDVI in the forest area was calculated from satellite data by the following equation.

$$NDVI = \frac{NIR - VIS}{NIR + VIS} \tag{1}$$

where NIR is the near-infrared digit number and VIR is the red digit number.

2.2 LAI estimate

Eight observation points near the bridges easy to be taken a coordinate in a map were selected for distributing over Okutama forest area equally as a research point (Figure 1 and Table 1). The whole sky images were taken with digital camera mounted with a fisheye lens at the observation points (Figure 3). The photographs with the coordinates of observation points were taken by a GPS camera (Figure 2). However, each position was required a little far from forest because a GPS camera could not catch a satellite in the forest and where the GPS camera could not confirm a coordinate. For future study development, illumination in the forest, surface temperature of leaves were measured as well as local air temperature, the humidity and the wind velocity. In addition, the whole sky images were analyzed with 'LAI 2000' method using 'LIA for Windows 95', which gave the values of LAI.

2.3 Seasonal variations of NDVI and LAI

The correlation of values of NDVI and LAI was derived from satellite data and monthly field observation for the regression curve. Least squared method was applied for this regression.

3. RESULTS

3.1 Seasonal variation of NDVI

The seasonal variation of NDVI for each point is shown in Figure 5. NDVI decreased at all observation points from November, became the minimum in January or February, and increased in spring. Points 1 and 6, evergreen conifer forest, showed high values, while Point 4, deciduous broadleaf forest, indicated low values. In addition, at Points 5, 7 and 8, which are mixed forest far from a village, the seasonal changes of NDVI were similar each other. Points 7 and 8, which are the deepest place in forest, recorded a value more than 0.6 in May.

3.2 Seasonal variation of LAI

The seasonal variation of NDVI for each point is shown in Figure 6. LAI decreased in the same manner as NDVI at all observation points from November, became the minimum in January or February, and increased in spring. During winter, the range of fluctuation for LAI was small compared with NDVI, though the evergreen conifer forest (Point 1: 1.6 to 1.8) where most leaves had fallen showed about 2 times as much as LAI values for deciduous broadleaf forest (Point 4: 0.7 to 0.9). In May, a value of deciduous broadleaf forest (Point 4: 1.6) increased and got closer to a value of evergreen conifer forest (Point 1: 1.7). Four pieces of photographs in figure 4 show different variations.

3.3 Correlation of LAI and NDVI

There was positive correlation between LAI and NDVI, and this regression was calculated as the next equation. The correlation is shown in Figure 7.

$$LAI=0.57exp(2.33NDVI) \qquad (R^2=0.46) \qquad (2)$$

4. DISCUSSION

As above, the regression equation of NDVI and LAI, and the seasonal change for each were derived from the analysis of satellite data and the ground truth research in Okutama forest area. In addition, difference between evergreen conifer forest and deciduous broadleaf forest, and the spots where vegetation resembled were distinguished. Positive correlation between NDVI derived from satellite data and LAI obtained from the ground truth was shown and this coefficient of correlation was 0.68. The next cause was nominated for these facts. An exact value of NDVI was not calculated by shadows of satellite images and mixels. A condition to measure LAI occasionally was not satisfied. Sometimes a few observationpoints were not available for LAI data by traffic construction and snow, too. In addition, this research will be necessary to be considered for the difference kinds of trees.

5. CONCLUSION

Each seasonal variation of NDVI and LAI, and the regression equation of both were derived in this study. The estimates of LAI in the whole Okutama forest area from satellite data became possible using this result. This study elucidates a change of forest area by collecting and analyzing temporarily continuous data. The examination of estimation method for LAI with higher precision is a future problem. In particular, revision for the dispersion of observation values in different observation conditions is needed. Furthermore, other physical characteristics, such as biomass quantity and evapotranspiration, will be intended for study in addition to NDVI and LAI relationship. Finally, general forest area management systems by remote sensing will be constructed.

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Table 1. Monthly observation locations for landcovers

No.	Location	Land cover
1	Komuro bus-stop	Evergreen conifer forest
2	Shimizu bridge	Mixed forest
3	Fujio district	Mixed forest
4	Ochiai bridge	Deciduous broadleaf forest
5	Garbage place	Mixed forest
6	Yakyu shrine	Evergreen conifer forest
7	Shiraito waterfall	Mixed forest
8	Entrance to Daibosatsu	Mixed forest

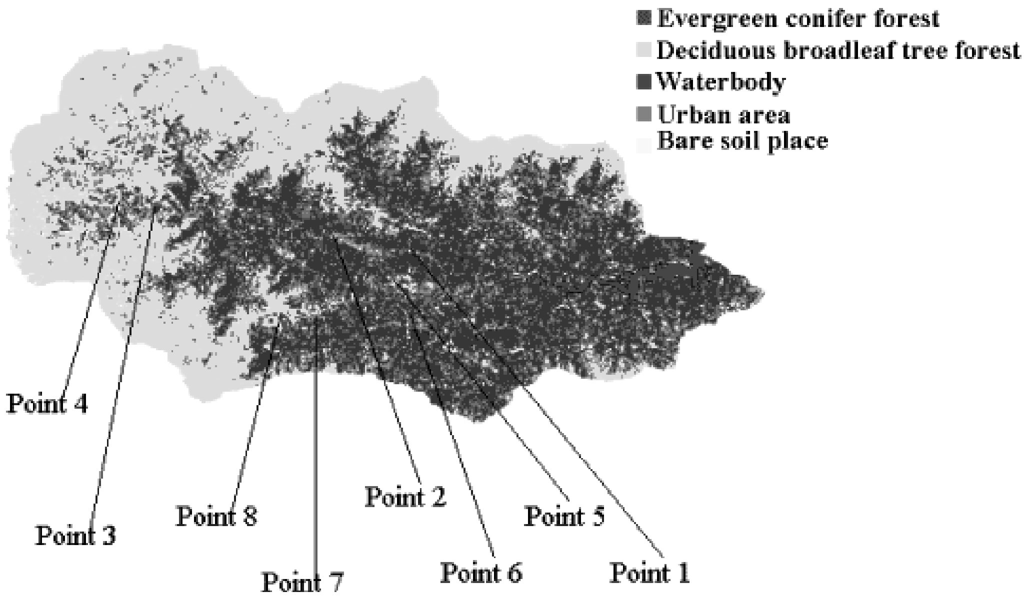
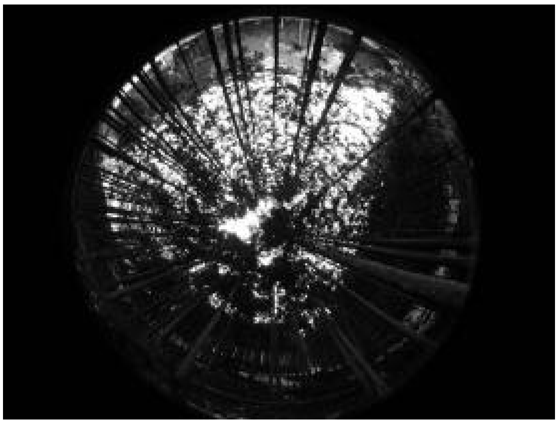


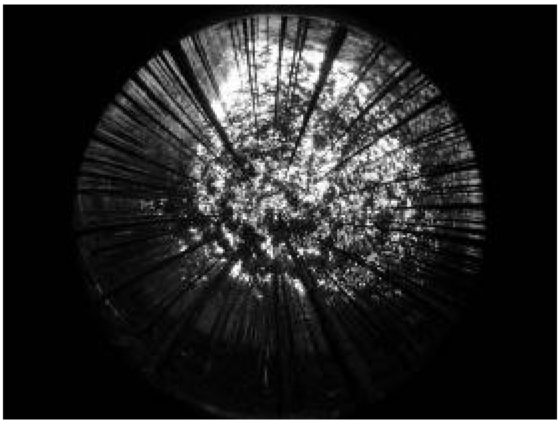
Figure 1. Land-cover classification in Okutama

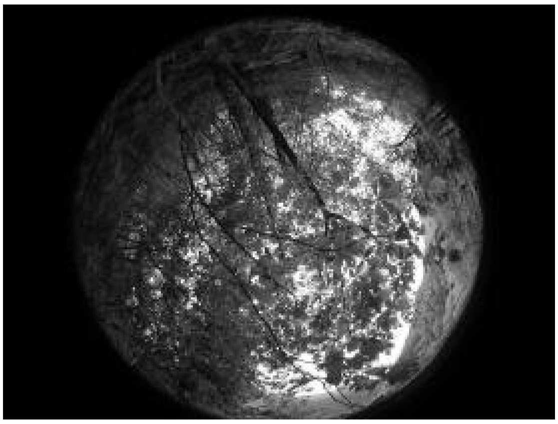
Figure 2. GPS-camera photograph of Point 6



Point 1: January

Point 5: January





Point 1: May

Point 5: May

Figure 3. Whole sky pictorial images

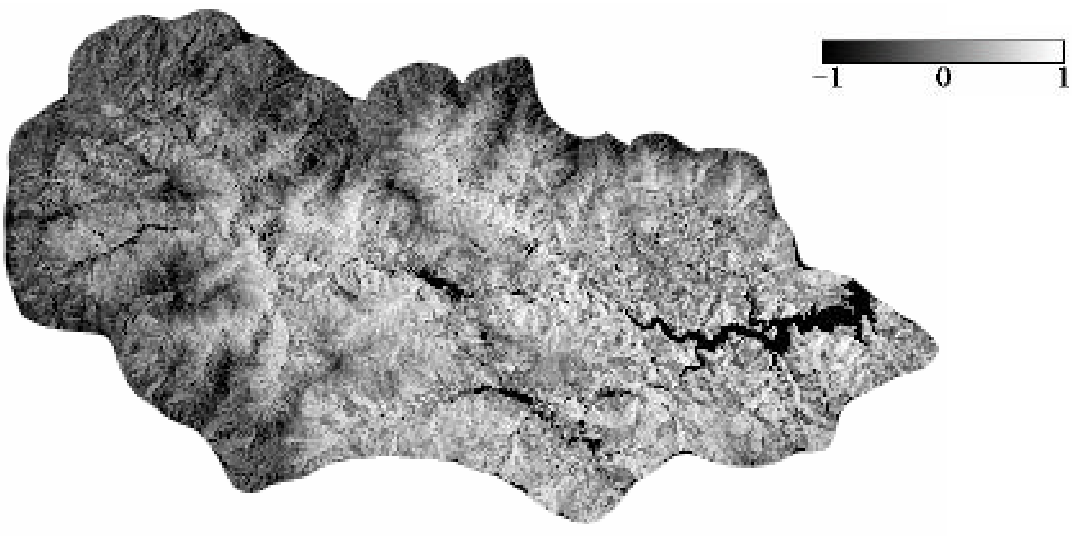


Figure 4. NDVI distribution in Okutama

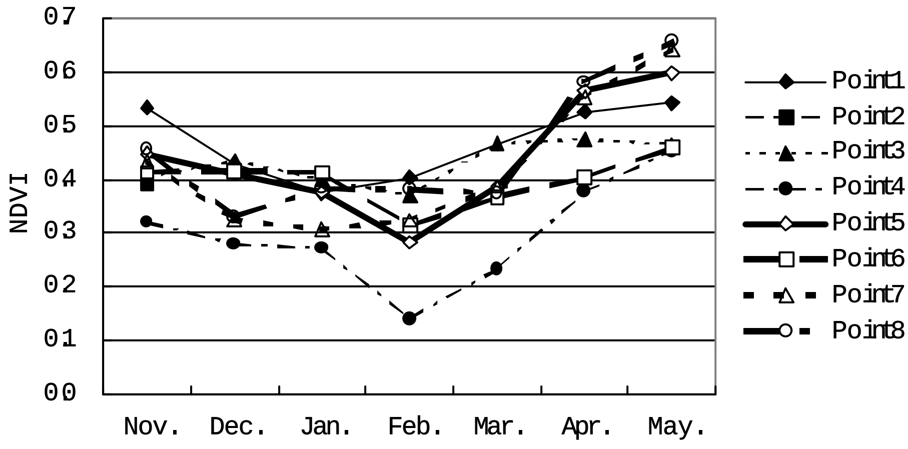


Figure 5. Seasonal variations of NDVI for forest in Okutama

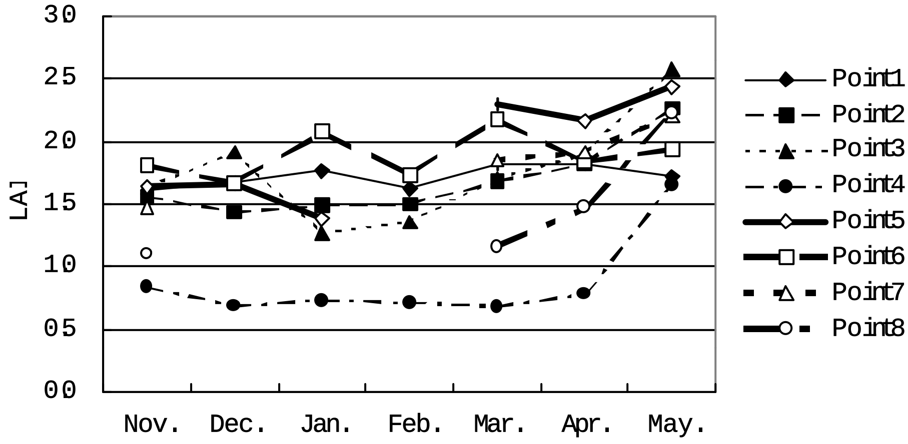


Figure 6. Seasonal variations of LAI for forest in Okutama

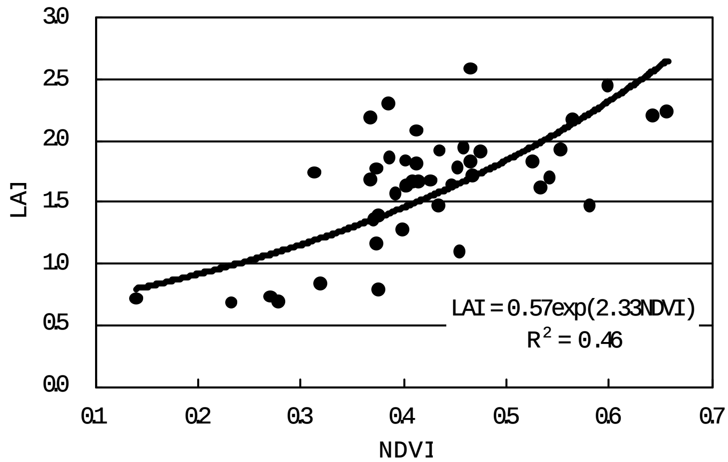


Figure 7. Correlation of NDVI and LAI for forest in Okutama