Estimation of Material Budget in Okutama Forest Area from Satellite Images

Hisao Ito, Susumu Ogawa
Faculty of Geo-environment Science, Rissho University
1700 Magechi, Kumagaya, Saitama, 360-0194 Japan
001w00077@ris.ac.jp, ogawa@ris.ac.jp

Abstract: Capability of material fixation in forest was noticed since COP3, but now it was difficult to understand material fixation in wide area. In this study, we attempted to estimate and test the amount of carbon, nitrogen, and phosphorus fixed by forest from satellite images. First, we classified into tree species and estimated the number of trees in the forest by species, area, and digital numbers. We inspected to apply it in wide area. Next, we compared the amount of carbon, nitrogen, and phosphorus with NDVI and each band of satellite images.
Keywords: remote sensing, timber volume, haze redaction, topological normalization

1. Introduction

Since the amount of material fixation in a forest attracted people's attention on COP3, many expectations have focused on the remote sensing measurable in a wide area. However, many existing studies have used NDVI, which does not be almost independent of the topography and haze effects, for the amount of material fixation on forest. In this study, we reduced topography and haze effects as much as possible. We compared the timber volumes to NDVI and Tasseled Cap. Finally, we tried to develop better index to estimate the volumes

2. Method

1) Study Area

Okutama forest area is located in the western part of Tokyo. It is municipal drinking-water source for Tokyo and also the source for river recharge, sediment run-off prevention, and water purification. Most Okutama forest areas exist in mountainous area and are intensely uneven: the highest area is 2000m while the lowest area is 200m heights.

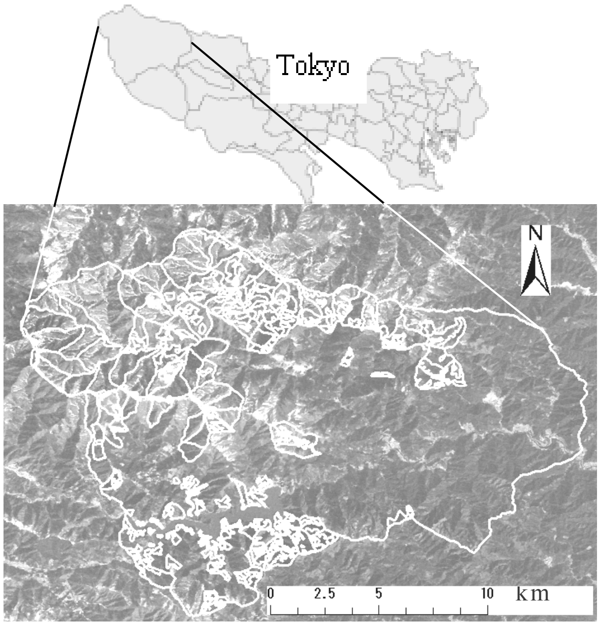

Fig. 1. Study area and a forest plot map

2) Data

We chose each seasonal data from Landsat-TM with path 107, row 35 and path 108, row 35 involving Okutama forest area on 21 July 1992, 5 June 1996, 5 October 1999, 23 December, and 13 April 2000. We also used a digital elevation map with 50-m Grid (Nippon-II) made by Japan Geographical Survey Institute and a forest plot map and timber volume data (1999) estimated by forest ages, tree species, and the number of trees in Okutama forest area offered by the Bureau of Waterworks of Tokyo Metropolitan Government.

3) Image Processing

First, we carried out orthorectification using DEM, because it was the intensely rugged.

Next, we reduced haze. We adopted a method to reduce the effect as the next step: topological notarization by trial and tribulation. An Eq. (1) liner combination show the intensity the haze of Tasseled Cap.

$$
\begin{aligned}
\text{Haze} = {} & 0.846\,B1 - 0.073\,B2 - 0.46\,B3 \\
& - 0.0032\,B4 - 0.049\,B5 \\
& + 0.0119\,B7 + 0.7879.
\end{aligned} \tag{1}
$$

where B1, B2, B3, B4, B5, B6, and B7 indicate each band of Landsat-TM. Furthermore, we executed noise elimination from the haze. That digital number, less than zero were transformed to zero. We subtract these digital number multiplied each 1.880, 0.890, 1.020, 0.850, 1.400, and 0.710 from the original image each band except the band 6.

Next, we performed topological normalization. We did not use the existing Lambertian Reflection Model and Minnaert method because we could not normalize them in this study area through the season, and used methods judging shades by spectral characteristics. We judged shades using an Eq. (2) liner combination as well as Tasseled Cap.

$$
\begin{aligned}
\text{Shade} = {} & 0.085\,B1 + 0.078\,B2 + 0.119\,B3 \\
& + 0.525\,B4 + 0.612\,B5 + 0.121\,B6 \\
& + 0.236\,B7 - 39.
\end{aligned} \tag{2}
$$

This equation was obtained by reducing effects of tree species and soil. By this equation, the stronger shade area was normalized more strongly.

3. Result

Each band, NDVI, and the vegetation volumes of Tasseled Cap were calculated from that processed data. We added each digital number in the digitized forest plot map. We once transformed digital numbers from 0 to 255 for NDVI and Tasseled Cap, because these original digital numbers involved negative numbers. Furthermore, we performed regression analysis between these added digital numbers and timber volume data. Fig. 2 shows the result of regression analysis in this study. Table1 shows these coefficients of determination each image. Moreover, we performed multiple liner regression analysis to the timber volume from each band. Multiple linear regression analysis was adjusted for the coefficients of determination to be the highest.

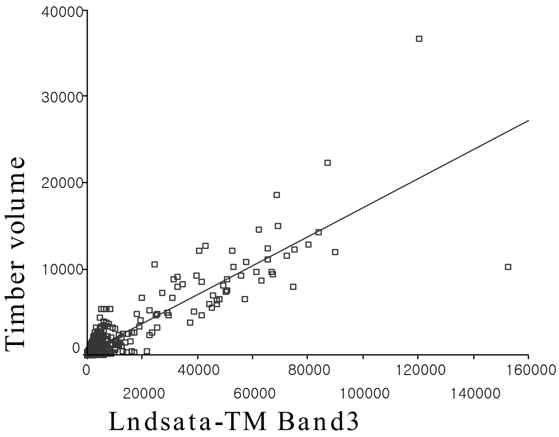

Fig. 2. Result of regression analysis

Image on 21 July 1992,

$$
\begin{aligned}
\text{Timber volume} = {} & -0.631\,B1 - 0.41\,B4 \\
& + 0.49\,B6 + 2.32\,B7 + 259.73 \qquad (R^2 = 0.828)
\end{aligned}
$$

Image on 5 June 1996

$$
\begin{aligned}
\text{Timber volume} = {} & 1.30\,B1 + 0.35\,B2 \\
& - 1.70\,B3 - 0.22\,B4 - 0.38\,B6 \\
& + 0.43\,B7 + 274.96 \qquad (R^2 = 0.87)
\end{aligned}
$$

Image on 5 October 1999

$$
\begin{aligned}
\text{Timber volume} = {} & 1.85\,B1 - 0.87\,B3 \\
& - 0.2\,B4 - 0.13\,B5 - 0.65\,B6 \\
& + 0.034\,B7 + 95.04 \qquad (R^2 = 0.864)
\end{aligned}
$$

Image on 23 December 1999

$$
\begin{aligned}
\text{Timber volume} = {} & 3.02\,B2 - 2.06\,B4 - 0.61\,B5 \\
& - 0.11\,B6 + 0.63\,B7 + 220.23 \qquad (R^2 = 0.863)
\end{aligned}
$$

Image on 13 April 2000

$$
\begin{aligned}
\text{Timber volume} = {} & 2.33\,B1 - 1.68\,B3 - 0.27\,B4 \\
& - 0.0872\,B6 + 0.56\,B7 + 234.50 \quad (R^2 = 0.859)
\end{aligned}
$$

4. Conclusion

The estimated volumes from each band reduced haze and shade effects also showed equal or more coefficient of determination than the ones from NDVI and Tasseled Cap. In the season of the data used this study, a June-image showed the highest coefficient of determination for the estimated volumes from each band. The analysis of small areas did not make good results for Lnadsat-TM. However, analysis of wide areas made good results. Furthermore, the multiple linear regression analysis differed greatly each image.

5. Future Development

We will attempted to develop regression equations considered by seasonal characteristics to match any seasonal images. We will enhance the degree of accuracy about timber volume in close area to use unmixing. Although we used forest plot map, we think to use classification and enhance its degree of accuracy to estimate timber volume by only satellite images. Furthermore we will enhance degree of accuracy about reduction of haze and shade.

Acknowledgement

Thanks for borrowing of forest plot map and timber volume data by the bureau of waterworks of Tokyo metropolitan.

References

[1] S. Saito, S. Ogawa, M. Aihara, K. Otowa, 2001. Estimates of LAI for Forest Management in Okutama, ACRS'2001, Singapore, volume 1 pp. 600 – 605.

[2] H. Tanaka, H. Oguma, etc, 2003. Seasonal Change about vegetation indices, CO^2 Flax, and LAI *in Japanese*, Proc. of 2003 Spring Meeting of Japan Soc. of Photogrammetry and Remote Sensing, June 2003, pp. 229-230.

[3] Jensen, john R. J, 1996. Introductory Digital Image Processing, A Remote Sensing Perspective. Englewood Cliffs, New Jersey:Prentice-Hall.

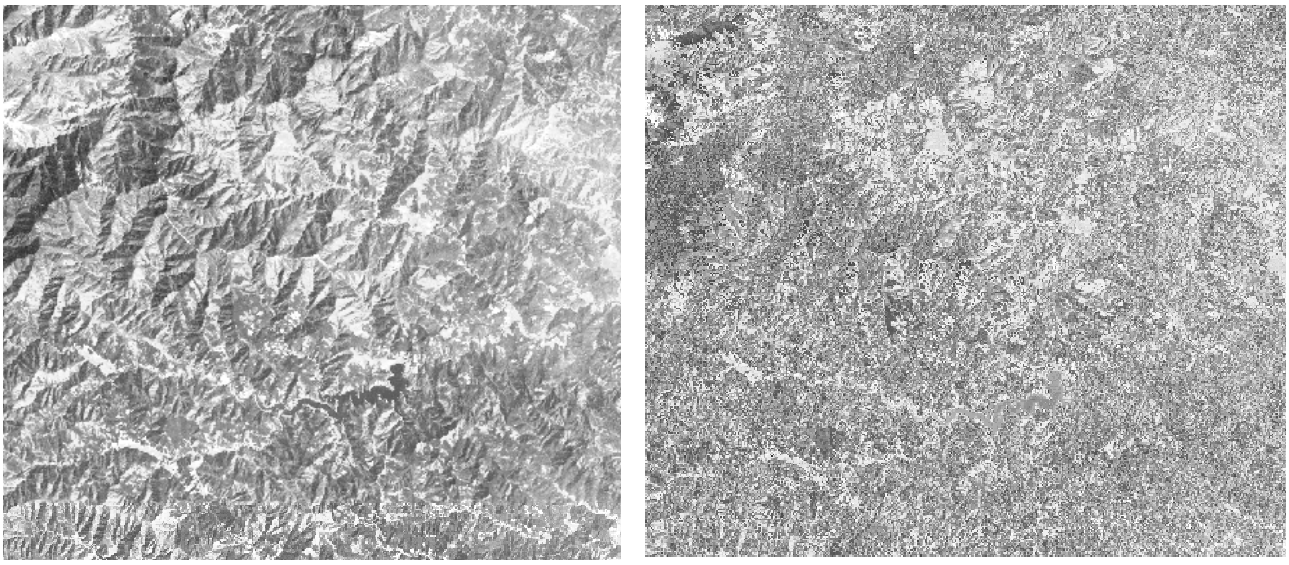

Fig. 3. Original image (left) and processed image (right)

Table1. Coefficients of determination about timber volume and satellite images

Date	Band1	Band2	Band3	Band4	Band5	Band6	Band7	NDVI	Tasseleed Cap
21 July 1992	0.781	0.778	0.778	0.759	0.766	0.783	0.771	0.781	0.771
5 June 1996	0.803	0.787	0.794	0.787	0.781	0.767	0.781	0.741	0.780
5 October 1999	0.785	0.780	0.774	0.766	0.755	0.780	0.759	0.781	0.778
23 December 1999	0.783	0.780	0.773	0.783	0.755	0.780	0.760	0.781	0.774
13 April 2000	0.781	0.778	0.774	0.757	0.776	0.781	0.780	0.766	0.769