Estimation of stand attributes in *Cryptomeria japonica* and *Chamaecyparis obtusa* stands using QuickBird panchromatic data

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SUMMARY
This study aims to estimate stand density and stand volume from high-resolution satellite data in Cryptomeria japonica and Chamaecyparis obtusa stands and confirm the ability and uncertainty of them. Fifty-four circular sample plots of 0.04 ha were established.Stand density and stand volume were calculated from field data. QuickBird panchromatic data was prepared for the study. A local maximum filter was used to extract stand density and watershed method was used to estimate crown area of individual trees in sample plots. DBH was estimated from the crown area and DBH-height relationship was adopted to estimate tree height. The estimation of stand density was adequate in mature stands, while it was underestimated in young stands. The filter processing to detect stand density worked well in stands of less than 1,000 trees/ha. Percentages of estimated stand volumes against those derived from field survey were quit large in comparison with those of stand density.

KEYWORDS: *High-resolution satellite data, stand density, stand volume, Cryptomeria japonica, Chamaecyparis obtusa*

INTRODUCTION
The increase in timber demand for reconstruction after World War II caused natural forests to be converted into sugi (*Cryptomeria japonica*) and hinoki cypress (*Chamaecyparis obtusa*) plantations in Japan. As a result, 44% of forest area or 29% of the land is coved with artificial forests and 69% of them is occupied by these two species. Dull domestic timber price against imported one, however, has discouraged forest managers from sustainable forest management. The percentage of forested area against the land has slightly changed for 50 years; nevertheless, it is our conern that the condition of forests degrades gradually. It becomes a matter of great urgency to make the most of information on present condition of stands for sustainable forest management.

The new generation of commercial high-resolution (up to one-meter ground resolution) satellite data such as IKONOS and QuickBird opened a new era for digital mapping (Li, 1998). Using these data, a target of observation from space diverts from forest stands, cluster of trees or mixture of some land-cover into individual trees. We expect to acquire accurate data on stand papameters required for suitable silvicultural operations (Hirata *et al.*, 2005).

Privious studies applied effective methods to extract stand attributes from high resolution satellite data, such as local maxima filtering for treetop extraction (Pitkänen, 2001; Wang *et al*., 2004), object-oriented classification and segmentation using shadow properties to identify crown area (Song and Woodcock, 2003; Al-Khudhairy *et al*., 2005). These methods are very useful to understand stand conditions, but we should recognize that the result derived from high resolution satellite data involve the uncertainty in real stands because it observes only dominant trees and supressed trees are hidden by canopy layer. In addition, we can only observe crown diameter and tree number namely stand density directly using high-resolution satellite. Therefore, we have to estimate DBH and tree height using allometric relationships between crown diameter and DBH or between DBH and tree height.

Here, we estimate stand density and stand volume from high resolution satellite data in *Cryptomeria japonica* and *Chamaecyparis obtusa* stands and confirm the ability and uncertainty of them.

MATERIALS AND METHODS

STUDY AREA AND FIELD DATA

The study areas is located in the Shimanto river basin managed by the Shimanto District Forest Office, Shikoku Island, Japan. These areas are characterized by steep slopes and complicated patch structures that are formed by plantations and broad-leaved forests.

Fifty-four circular sample plots of 0.04 ha were established in *Cryptomeria japonica* and *Chamaecyparis obtusa* strands sited within two watershed, Nakatsugawa and Yoshikawa in the Shimanto river basin. The ceter coodinates of all sample plots were positioned with DGPS.

DBH of all standing trees in sample plots were measured and species were recorded. Stand density was calculated in each sample plot based on the number of standing trees per 0.04ha. Mean DBH of sample plots ranged from11.6 cm to 39.9 cm and stand density from 375 individual trees/ha to 2,175 individual trees/ha. Tree heights of more than 40% of standing trees were measured in each sample plot and others were estimated using the Näslund fomula, which is one of hight-diameter curves. Individual volume was calculated using a form factor method with DBH and height. Stand volume of each sample plot was calculated as the total sum of individual volumes.

SATELLITE DATA

QuickBird panchromatic data, which was acquired on 29 march 2005, was prepared for the study. Ground resolution of the data is 60cm and the data were geo-registered to the Japan 19 plane orthogonal coordinate system using nearest neighbor method for resampling to maintain original reflectance properties. The data for sample plots were extracted with 10m buffer zone from original data.

DATA ANALYSIS

We are anticipating that the digital analysis of high-resolution satellite data will supplant the interpretation of aerial photographs. In the present study, we applied a local maximum filter for high-resolution panchromatic data to estimate stand density. We tested two sizes of fiter, i.e., 3*3 and 5*5 to extract treetops of standing trees in each sample plot and the stand density derived from high-relolution satellite data was compared with that derived from field survey.

To segment the satelitte image to crown area, many methods have been developed, and watershed method is one of famous method to extract crown area. To apply the method, first, we create a reversal image from the panchromatic data. After segmenting it to crown, we calculate the area of each crown and we estimate crown diameter of individuals from them. We assumed that the order of crown diameter size was equivalent to the order of DBH size and we investigate the relationship between crown diameter and DBH in each plot. Tree height was estimated from the Näslund fomula and parameters of the fomula were selected by diameter distribution. Individual volumes of trees derived from high-resolution satellite data were calculated and stand volumes as the total sum of them in sample plots were compared with those calculated from the field survey.

RESULTS

Filter size of 5*5 was more suitable than that of 3*3 to extract treetops in *Cryptomeria japonica* and *Chamaecyparis obtusa* strands from QuickBird data.

Treetops were detected using the local maximum filter in sample plots. The estimation of stand density was adequate in mature stands, while it was underestimated in young stands. In the mature stands, the crowns of individual trees have enough area and their forms are sharp, therefore the difference of brightness at the top of a crown and in its edge is quite large. On the other hand, some treetops do not appear to have a canopy surface or they cannot be distinguished from each other in young stands. The filter processing to detect stand density worked well in stands of approximately less than 1,000 individual trees/ha.

Stand volumes estimated from high-resolution satellite data were, of course, underestimated, however, percentages of estimated stand volumes against those derived from field survey were quit large in comparison with those of stand density.

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