Distribution Chart of *Cryptomeria japonica* Forest through Data Analysis of Landsat-TM

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(Received August 10, 1992)

An examination of the possibility of making a distribution chart of *Cryptomeria japonica* forests by using Landsat Thematic Mapper (TM) data for Yamagata Prefecture has been the object of this study. Based on a field survey and aerial photo interpretations, distribution charts for two areas (Tachikawa-machi and Atsumi-machi) of approximately 2 ㎢ each were prepared for comparison and evaluation purposes. The analysis of Landsat TM data was conducted with MicroImage™ software.

First, a clustering of TM data for Tachikawa-machi was applied. Second, through interactive examination of respective classes on the display screen, the class (es) and corresponding statistical values for *Cryptomeria japonica* were determined. Finally, through the use of selected statistical values, a maximum likelihood classification method was applied over a broad area, approximately two thirds of Yamagata Prefecture (Yamagata is not covered by a single Landsat scene). The classification results overlapped well with distribution charts prepared by field-survey/aerial-photo interpretations and corresponded well with the Atsumi-machi distribution chart. Mixed- planted areas of pines and *Cryptomeria japonica* and areas of immature *Cryptomeria japonica*, determined as such by aerial photo interpretation, were excluded from the classification results.

Some merits in using Landsat TM data for a distribution chart of *Cryptomeria japonica*:

1) The latest information can be obtained for a broad area, that is, the entire prefecture.
2) The method is economical and efficient, labor-saving and time-saving.
3) Digital data processing allows flexible data handling. Through registration and transformation techniques, it can overlay with any other kinds of sets of data.

Key Words: *Cryptomeria japonica,* Distribution chart, Forest, Landsat-TM.

Introduction

Cryptomeria japonica (Japanese cedar) pollinosis patients in Japan are rapidly increasing and have become a leading public health problem. To prevent exposure to the pollen, information (or forecasts) about airborne *Cryptomeria japonica* pollen is available from several institutes. Kawashima[1] developed a visual simulation method that detects concentrations and movement of airborne *Cryptomeria japonica* pollen on relevant maps. He also developed a method of forecasting the flowering periods of *Cryptomeria japonica* at each location [2][3]. These simulation methods require precise distribution charts of *Cryptomeria japonica* forests, where most pollen grains are produced. Charts entitled "Actual Vegetation Maps of the National Survey on the Natural Environment" describe distribution of the *Cryptomeria japonica* forests and are available from the Environment Agency[4]. However, because they are infrequently updated, they do not reveal recent afforestation and deforestation activities. They contain no information on tree ages, although *Cryptomeria japonica* pollen grains are produced mostly by trees more than 30 years old[5], and some vegetation maps categorize *Cryptomeria japonica* forests only as "needle leaf tree forests".

To compensate for these insufficiencies, the possibility of making a distribution chart of *Cryptomeria japonica* forest using Landsat TM data was therefore examined.

Materials and Methods

1. Objective areas

Forests of Tachikawa-machi and Atsumi-machi in Yamagata Prefecture were chosen as objective areas because large areas there contain *Cryptomeria japonica*. Tachikawa-machi was mainly used in the analysis and map-making procedures; Atsumi-machi was used for verification of the results.

2. Data

The following remote sensing data from Landsat-5 TM covering Tachikawa-machi and Atsumi-machi were used; May 21, 1987 (Path/Row 107/33); July 28, 1986 (P/R 108/33); May 10, 1989 (P/R 107/33); and August 21, 1989 (P/R 108/33). Panchromatic aeial photographs taken in 1986 by Otori Kosoku Co. were used for photographic interpretation of *Cryptomeria japonica* distribution areas, and "Actual Vegetation Maps" used were based on The Third National Survey on the Natural Environment (Vegetation) in 1986 and 1983, published by the Environment Agency in 1988 and 1986, respectively. A ground survey was performed at Tachikawa-machi in autumn 1990.

3. Software and Hardware

Data processing and analysis were performed with the MicroImage・TM software package of Terra-Mar, running on MS/DOS. CPU (Intel 80, 486/33mHz),imaging frame buffer memory (1,024×1,024×32 bits) for image display and overlay, and hard disk storage (2 giga bytes) were used. The equipment further consisted of a 1/2-inch magnetic tape drive, color image scanner, and color printer for images and classification results.

Procedures of Analysis

Figure 1 is a false color composite image of Tachikawa-machi, which was chosen as an objective area of the study. First, based on a field survey and aerial photo interpretation, a distribution chart (2 ㎢) of *Cryptomeria japonica* was prepared for the area. A *Cryptomeria japonica* forest was marked black on a map with a scale of 1:50,000 (Chart 1, Fig. 2).

Data processing and analysis were then applied to Landsat TM data over a white framed area (Fig. 1),which included the area of the aerial photo. Clustering without training sets using MicroImage™ was performed to classify the objective area into 128 classes (128 is the maximum number of classes the MicroImage™ software allows, Fig. 3). Through interactive examination of classification results with Chart 1, a couple of clusters that seemed to correspond to *Cryptomeria japonica* forest were selected. A distribution chart combining the selected clusters was established (Chart 2, Fig. 4), and the statistical values for these classes were saved in a file to be used as training sets in a forthcoming Maximum Likelihood Classification.

A comparison was made between the two distribution charts, Chart 1 and Chart 2, by using registration techniques. First, Chart 1 was digitized in raster format by a CCD scanner. By means of a display and comparison of two charts at the same time on the screen, 10 Ground Control Points (GCPs) were taken interactively for further calculation of coefficients for transformation (geometric correction). Chart 2 was then interpolated and resampled by using the above coefficients to be superimposed on Chart 1. Two Charts overlapped well, as shown in Fig. 5.

Some areas determimed to be *Cryptomeria japonica* in Chart 1 were not classified as such in Chart 2. After a second ground truth survey, these areas were identified to be (1) mixed-planted areas of pine trees and *Cryptomeria japonica*, or (2) immature *Cryptomeria japonica* forest less than 5 meters in height (younger than 10 years).

To verify the usefulness of this method, Maximum Likelihood Classification was applied to the Atsumi-machi region (Fig. 6) by using the same Landsat-TM data and the same training sets (statistical values) obtained in the Tachikawa-machi region. The results of classification corresponded well with the distribution chart of Atsumi-machi made by aerial photo interpretations (Fig. 6). Finally, the classification was applied for broad area (22km×17km), and the result was compared with the data of the "Actual Vegetation Maps". In this case, the result also corresponded well with the Vegetation Maps of Atsumi-machi region (Fig. 7).

Discussions

It has been clarified that the distribution chart obtained from Landsat TM data analysis is nearly equal to that of the aerial photo interpretations. That is, appropriate ground truth surveys make it possible to classify a wide area, for example, an entire Landsat scene or an entire area of a prefecture) while maintaining the same accuracy.

The use of Landsat TM data offers these advantages: (1) Up-to-date data: Information on current afforestation and deforestation and ages of trees. This information is not available in the "Actual Vegetation Maps".

(2) Economics: A broad area, such as an entire Landsat scene (185km×170km), or an entire area of a prefecture can be treated simultaneously. The ground spatial resolution is oftain much better with the Landsat TM (28.5㎡) than with the "Actual Vegetation Maps" or some kind of

mesh maps (1km²). This means that more-detailed data can be obtained at inexpensive cost.

(3) Efficiency: Data processing takes little time. One trial of Maximum Likelihood Classification, for example, took less than 1 minute for a 30 km² area (1,024 pixel ×1,024 pixel ×6 bands, 3 classes of Maximum Likelihood Classification) and less than 30 minutes for two thirds of Yamagata Prefecture. Moreover, the person doing the data processing and analysis need not be a computer specialist.

(4) Flexibility of data: Digital data processing contains various types of data conversion. transformation, and registration techniques. They include i) raster digitizing (rasterization) of aerial photos and maps through the use of scanners, ii) extracting GCPs between two raster data sets (or raster and vector data sets) for further calculation of coefficients for transformation, iii) interpolation and resampling of pixels (mesh data), iv) raster-to-vector conversion, v) vector-to-raster conversion. These techniques enable data comparison or data overlay to be easily and rapidly made.

In the present research, we used Landsat TM data obtained in early summer or midsummer. Four different data sets with the same methodology were analyzed, and similar results were obtained. The question of any suitable period or season to make distribution charts of a *Cryptomeria japonica* forest was not discussed. Themes on a technique to ascertain the accuracy of the classification and a criteria of allowable error should be treated in our further research. This research should provide basic information about airborne *Cryptomeria japonica* pollen and also contribute to the investigation of physiological stress of forest caused by air pollution.

Acknowledgements

We are thankful to Mr. K. Saito of Yamagata Prefectural Office for kindly providing aerial photographs.

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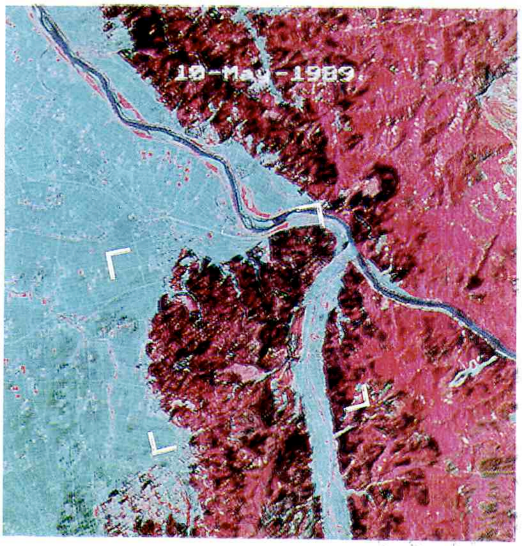

Fig. 1. False color composite image of an objective area (Tachikawa-machi). White frame corresponds to the area of Chart 1.

Fig. 2. Chart 1 Distribution chart of *Cryptomeria japonica* forest determined by aerial photo interpretation and ground truth survey. Black area represents a *Cryptomeria japonica* forest.

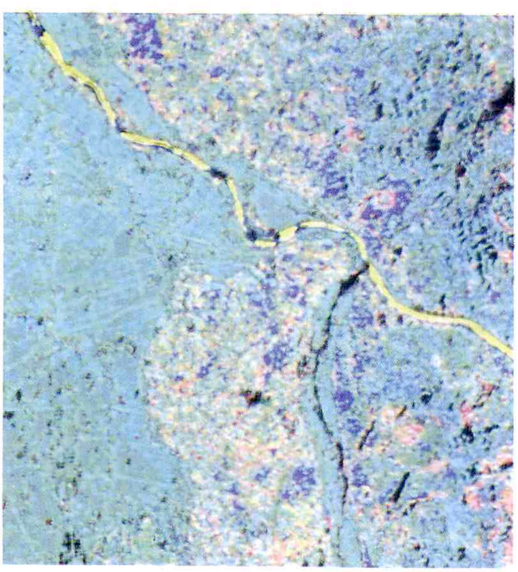

Fig. 3. Classification (clustering) results. Each class is painted with the same color. This photograph contains 128 different colored areas, the maximum number of the classification.

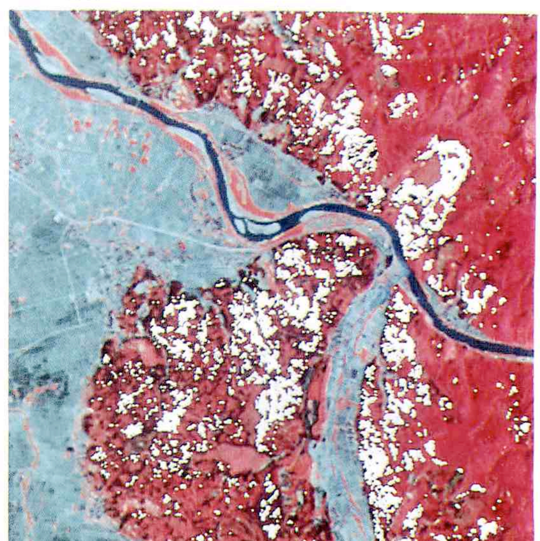

Fig. 4. Chart 2 Distribution chart of *Cryptomeria japonica* forest obtained from an analysis of Landsat TM data. The *Cryptomeria japonica* forest is represented as a white area on a false color composite image.

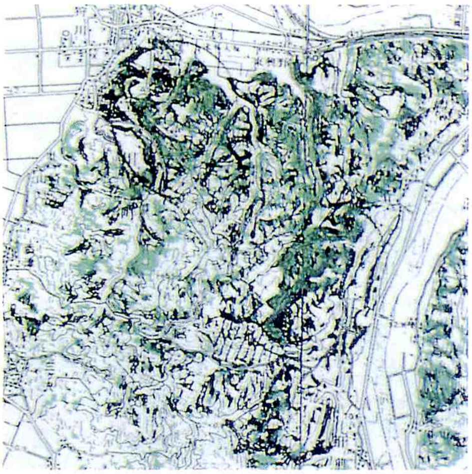

Fig. 5. Chart 2 overlaid onto Chart 1.

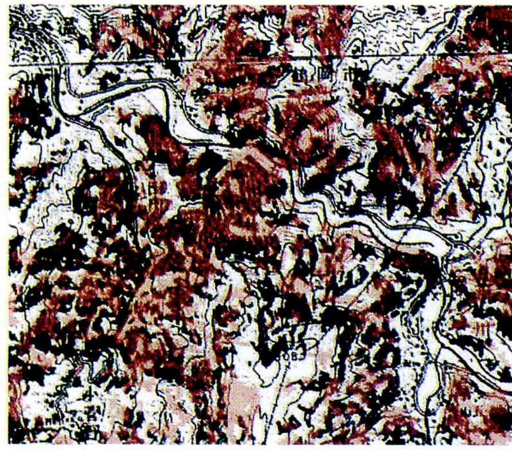

Fig. 6. Distribution chart of *Cryptomeria japonica* forest obtained from an analysis of Landsat TM data (orange areas) overlaid onto the chart determined by aerial photo interpretation and ground truth survey (black area).
Brown area represents *Cryptomeria japonica* forest obtained from both analysis.

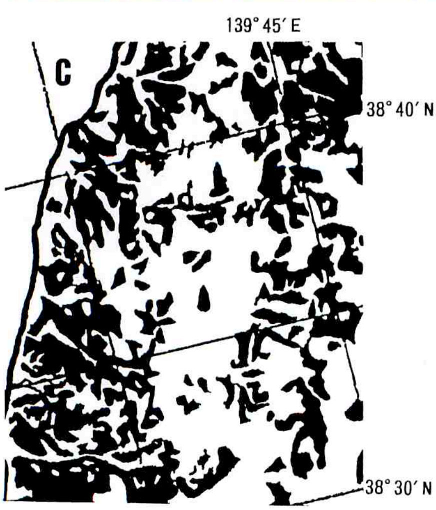

Fig. 7. Verification of the usefulness of the Maximum Likelihood Classification method applied to the Atsumi-machi region.
The following remote sensing data were used, A, July 28, 1986; B, August 21, 1989 (the area shaded by cloud in Fig. 7A); C, Distribution chart from the "Actual Vegetation Maps". The *Cryptomeria japonica* forest is represented as a red area on a true color image. Obviously good results could have been obtained if the area had not been shaded by clouds.

ランドサット衛星TM画像によるスギ森林分布図作成

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空中スギ花粉の拡散過程を検討している過程で，スギ花粉を大量に放出するスギ森林の分布図が必要となった．当初は，環境庁が作成した植生図を用いていたが，更新回数が少なく成熟スギ林を区別できないという不都合が生じた．そこで，現実に即したスギ森林分布図を作成できないか検討した．スギ植林面積の大きな山形県立川町と温海町を対象とし，現地調査と航空写真から作成したスギ森林分布図を教師とし，Terra-Mar 社の MicroImage ソフトを用いて128のクラスターに分類し，その中からスギ森林と思われるクラスターを選別した．さらに最尤法を用いて，立川町，温海町のスギ森林分布図を作成し，現地調査と航空写真で得られた分布図と比較したところ，両者は良く一致した．以上の結果から衛星画像を用いてスギ森林分布図を作成することが可能であると考えられた．