A Study on the Automatic Extraction of Ground Cover Changes in the Forest Area using Remote Sensing and Existing GIS

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Abstract

The movement to construct GIS data base for forest management seems to have become active. Using such system, forest management regarding to entering, storing, and updating various kind of map informantion will be performed effectively. The problem, however, of time and cost to update the data should be solved, and appropriate ways are needed.

This study aimed to extract ground cover changes properly using Landsat data and existing GIS. Unsupervised classification method was utilized to detect deforested area, and the most proper number of clusters for ground cover classification was discussed. Finally, it was suggested that this method could be applied for maintenance of data base in forest management system.

Introduction

The computerization of social and/or statistical information linked with maps is becomming popular in various fields, such as land use, traffics, tax, drainage, forest, agriculture, and so on. GIS is now recognized as one of the best tools for such purposes, and it's also a matter of course in the forest management that is strictly required to reduce management cost. Information which relate to forest managemnt comprised of two types as natural environment (e.g. wood species, landforms, soils, etc.) and managemnt (e.g. planning unit, ownership, regulations, etc.). Utilizing those information in data base, the system generally performs many functions like entering and storing data, outputing maps or tabulations, or sometimes with more complex functions as overlay analysis, yield prospect, and other simulations. But even such an advanced system still depends on traditional ways for data acquisition or updating, so that appropriate methods should be developed.

On the other hand, many studies can be found trying to capture forest information by remote sensing. Though they still contain some problem of accuracy in acrage or classification, remote sensing can be applicable as a data resource for GIS. This study aimed to detect any changes in forest condition like a deforestation using remote sensing and existing GIS. For this purpose, characteristics of LANDSAT data were analyzed for each ground cover item in the forest managemnt data base. And then, by comparing existing maps with classified LANDSAT data, it was attempted to update the data base.

Kanagawa Forest Management System

In this study, a forest managemnt system, which is working in Kanagwa prefecture now, is used as an example of GIS. This system was developed based on ARC/INFO, and it comprises four sub-systems; data acquisition, data storing, analysis and management, and presentation. Over 20 kinds of data, such as wood species, height, planted year, ownership, canopy density, elevation, soil type, regulations, and so forth, are stored in this system as polygon format or grid format with relation to basic maps (1:5000) for forest management. This data base is updated every 5 years.

Methodology

To clarify applicability of remote sensing for this system, spectral patterns of LANDSAT TM (Aug. 26, 1985) data were analyzed for each ground cover type and slope aspect. Training areas for this analysis were selected after areal boundaries of each ground cover type were drawn over the LANDSAT image on the screen. These boundaries were transferred from data base of the forest information system. 27 training areas were finally selected for 5 ground cover types as table 1. Minamiashigara city, which locates 80 km westward from Tokyo, was selected as a study area (13.5 km x 9 km).

On the next stage, the image was classified by unsupervised classification method. Factors of forest stands condition which may affect clustering could be pointed out as slope aspects, wood species, canopy density, and so forth. In order to specify the most appropriate number of clusters to extract deforested areas by this method, classification was performed in 5 cases by limiting the maximum number of clusters was limited to 4, 5, 6, 7, and 8. The results were compared with aerial photos.

Caracteristics of ground covers in LANDSAT data

Fig. 1 shows spectral patterns of each ground cover type which all locate on south east slope. It is hard to find adequate differences between Japanese Ceder (hereinafter referred to as 'J. Ceder') and Japanese Cypress (hereinafter referred to as ' J. Cypress') in each band, hence it seems to be difficult to distinguish them using this season's data only. Broad-leaf tree was heigher in CCT value of bands 4 and 5 than coniferous trees (i.e. J. Ceder and J. Cypress). In case of deforested area, band 4 was almost as low as that of flood plain. Comparing flood plain to other types of ground cover, it could be mentioned that CCT value of flood plain was heigher in visible band, but lower in near-infrared band.

Comparison of spectral patterns between north-west slope and south-east slope was illustrated in Fig 2, taking an example of J. Ceder. It could be seen that CCT value of north-west slope fell down, especially in band 4 and 5. Though there are many studies to adjust such differences caused by varieties of slope, they are essentially diffemt matter, which should be analysed separately.

Extraction of deforested area by unsupervised classification

Spectral patterns of each cluster, which were classified under limitation of 7 clusters, were shown in Fig. 3. CCT values of almost all clusters are closed together in bands 1, 2, and 3, except for cluster 4. Cluster 4 indicates heigher values than other clusters for these bands, and it was recognized by aerial photo that this cluster contained artificially modified area or bare land.

Areas, which aren't covered by forest, were classified into 4 clusters (2, 3, 5 and 6), and further more, these clusters could be classified into 2 groups. In areas of cluster 2 or 5, a few vegetation could be found and CCT values of band 4 were heigher than that of band 5. On the other hand, cluster 3 and 6 corresponded newly deforested area and CCT values of band 5 were heigher than that of band 4. Fig. 4 shows a relationship between clustering level and classified ground cover type. Artificially modified area was separated clearly and any changes of CCT value, which was caused by number of clusters, couldn't be found. Clusters corresponding to deforested area were re-classified partially into other clusters when number of clusters was increased from 7 to 8.

Updating of existing data base

Deforested areas, which were extracted using the method mentioned above, should be transferred to existing GIS data base. But, a problem is that the data type of detected deforestation is grid format while ground cover type in the data base has been initially entered as polygon. If such polygon format data is converted into grid format, it can be updated by LANDSAT data without any problem. In case of polygon format data, newly detected ground cover change should be only displayed over the maps in data base to avoid irregular errors caused by resolution of LANDSAT data.

Conclusion

The way to apply LANSAT data for computerized forest management system was examined. In this study, it was suggested that unsupervised classification method would be applicable to extract deforested area for GIS data base.

Table 1 Ground cover types for training area

Japanese Ceder
Japanese Cypress
Broadleaf trees
Deforested area
Flood plain

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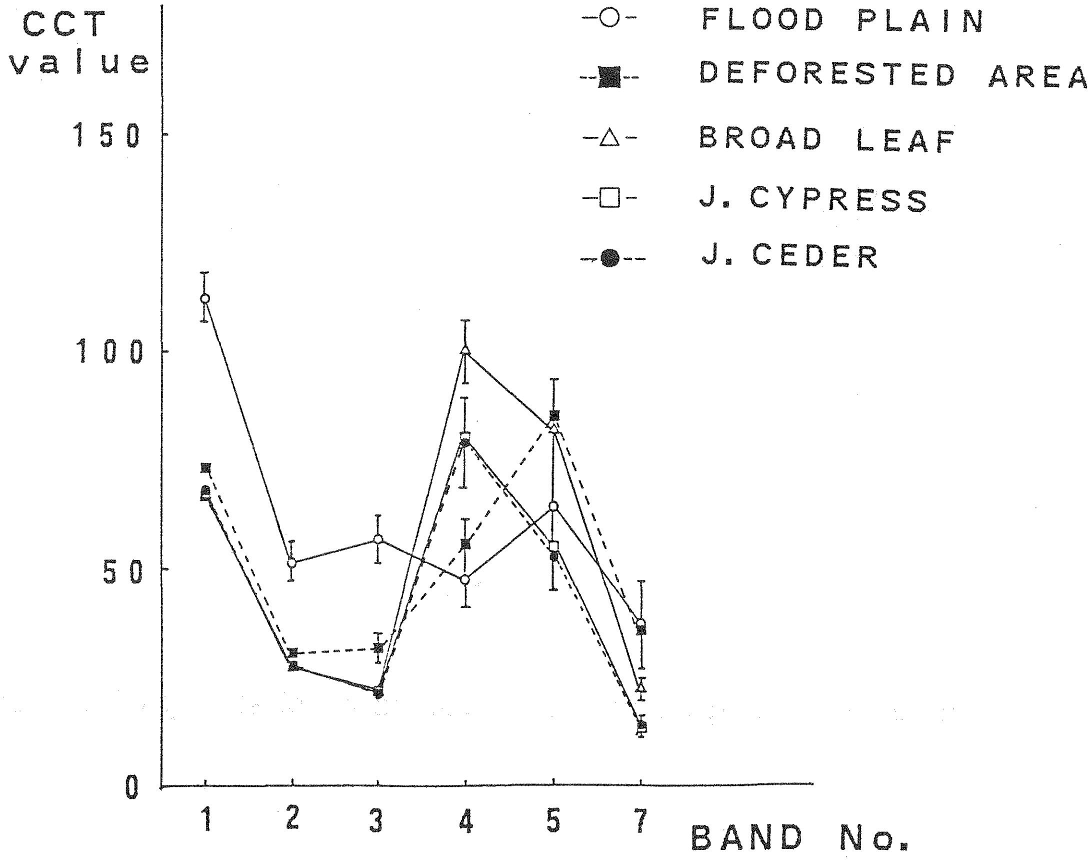

Fig.1 Reflectance of Ground cover

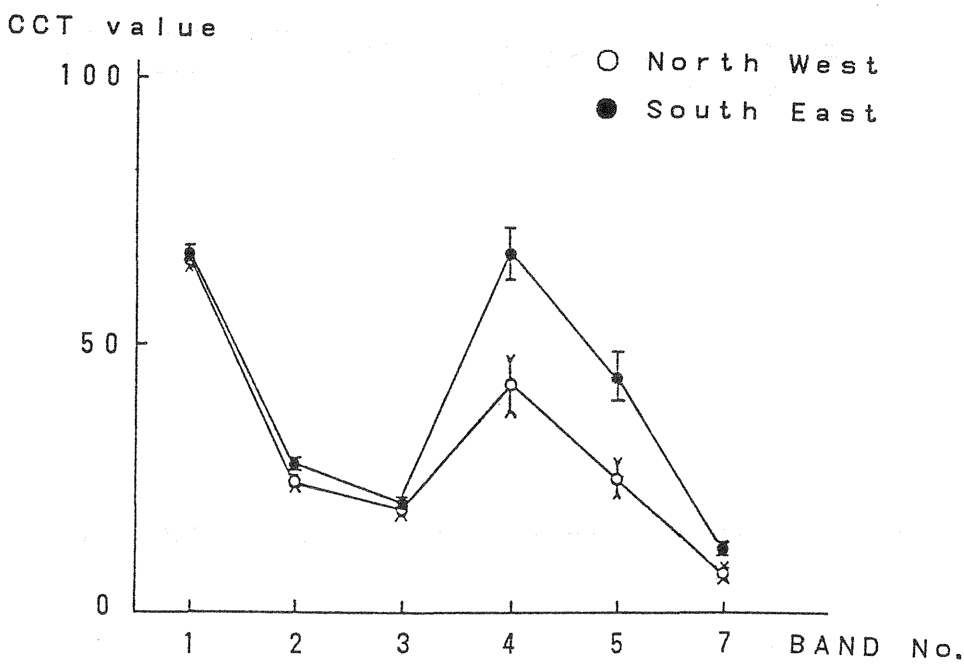

Fig.2 Reflectance of Ground cover by slope Aspects

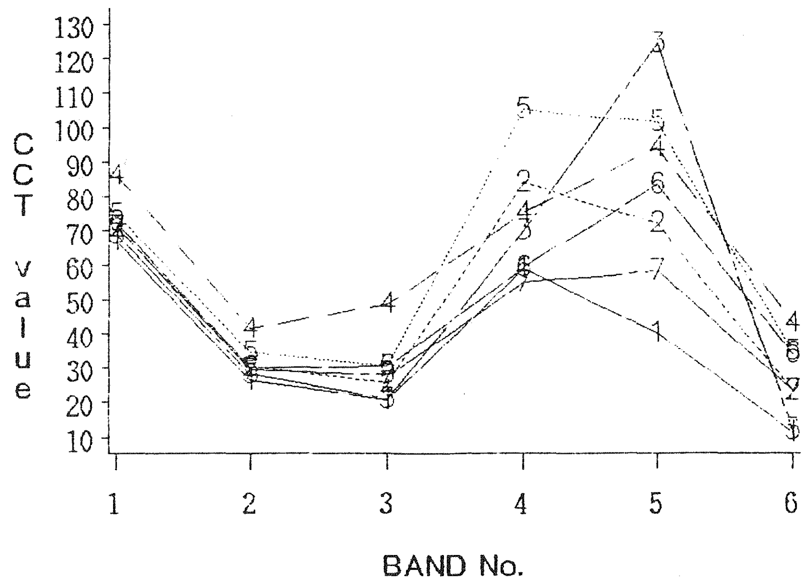

Fig.3 Reflectance of groundcover classified by clustering (7 clusters)

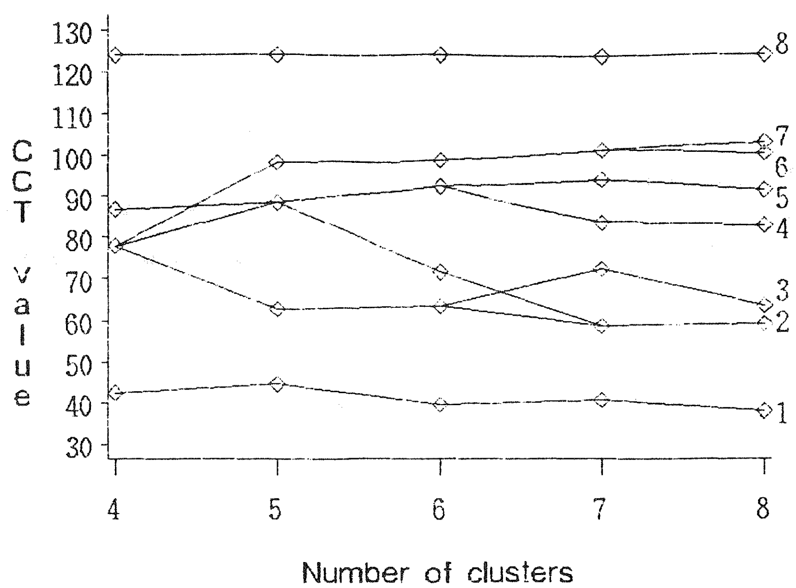

Fig.4 Classification tendancy compared with number of clusters