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Geographical Distribution of Forest Types in the Tokyo University Forest in Chiba

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Introduction

Several forest information databases have been constructed at universities in Japan. For example, YOSHIDA and KOBAYASHI (1989) constructed a stand table database for the Takakuma Experimental Forest and applied it to forest planning system and FUKUSHIMA *et al.* (1989) constructed database containing terrain and vegetation information as raster data for the Ashu Experimental Forest. Moreover, ZHENG *et al.* (1990) entered forest map and stand table data into GIS (geographic information system) for the Terasawayama Experimental Forest and applied it to management planning. GIS makes it easier to associate spatial data and non-spatial data, overlay some layers, and convert vector data to raster data and vice versa.

TATSUHARA *et al.* (1993) constructed a database containing forest map, stand table, vegetation and terrain information for the Tokyo University's Chiba Forest, using GIS on a personal computer. Road data was added to the database and geographical distribution was analyzed for the forest types using GIS.

Study Area and Devices

The study area was the Tokyo University's Chiba Forest, which is located in the southern part of Boso Peninsula. Its area is 2,200 ha, including 47 compartments and about 700 subcompartments.

Geographic information system, TerraSoft and database management system, dBaseIV were used on a NEC personal computer PC-9801 for analyzing data. A Graphtec digitizer KD1250 were used for entering maps. These are utilized more easily in Japan.

Constructing Database

Compartments, subcompartments and forest type

The field is covered with twelve orthophotographs, whose scale is 1 : 5,000. The orthophotographs use the ninth projection system, one of the nineteen projection systems which are used for public measurements in Japan. Boundaries of compartment, subcompartment and forest type were digitized from the orthophotographs. Three "themes", that is, compartment theme, subcompartment theme, and forest type theme were made. For each theme, polygons that cover closed areas were associated with a set of attributes. Each subcompartment in the Chiba Forest consists of one or more forest type areas. The number of polygons in the forest type theme was about 2,000. Thus there are about 2,700 polygons in the three themes. Attribute data, which were written in a stand table, were stored in a database table corresponding to each theme. These were converted into dBASE files. Figs. 1 and 2 show the content of the database tables corresponding to the sub-

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Subcompartment ID	Compartment	Subcompartment	Areas				Forest conditions		Site conditions		
			Forest	River	Road	Total	Managemet type	Species	Aspect class	Slope class	Topography

Fig. 1. Summary of the database table corresponding to the subcompartment theme.

Stand ID	Compartment	Subcompartment	Stand	Area	Planting year	Age	Species	Height	Crown density	Site class	Basal area	Volume

Fig. 2. Summary of the database table corresponding to the forest type theme.

compartment theme and the forest type theme, respectively. The table for the subcompartment theme has area, forest conditions, and site conditions, which were recorded in the existing stand table. The table for the forest type theme has species, year at planting, height, crown density, and so on for each polygon. Moreover, they have area, perimeter, and X and Y coordinates of polygon centroid, which were calculated by TerraSoft for each polygon. Fig. 3 shows the boundaries of compartment and subcompartment in the Chiba Forest. The large central part in it represents private forests.

Terrain

Contours are basic data for terrain information in this database. Fig. 4 shows the contours on the compartment and subcompartment map. The difference between the contours is 20 m. The contours were also digitized from the orthophotographs. TerraSoft can create an elevation raster layer from contours and some other raster layers from the elevation layer. Users can specify a spatial resolution of the raster layers.

Roads

Roads were digitized from a map, whose scale was 1 : 10,000. Fig. 5 shows the roads on the compartment map. Each road was associated with its set of attributes in the corresponding database table. It has the road name and some spatial attributes created by TerraSoft, length of line and X and Y coordinates of line centroid.

Processing Data

The following raster layers were created by TerraSoft for analyzing data. Their resolution was specified as 10 m × 10 m because of smaller forest type areas. Areas of each forest type by site condition were calculated by overlaying the layers and totalizing their pixels.

Creating forest type layer

The raster layer of forest type was created from the above vector data. The forest type was classified into Sugi (*Cryptomeria japonica*) plantation, Hinoki (*Chamaecyparis obtusa*) plantation, Matsu (*Pinus densiflora* and *Pinus Thunbergii*) plantation, Momi (*Abies firma*) plantation, other coniferous plantation, coniferous natural forest where Momi and Tsuga (*Tsuga Sieboldii*) are dominant, broad-leaved natural forest, and bamboo forest. Furthermore, another class was nursery and camp. The classes were coded as Table 1. Fig. 6 shows

Table 1. Forest type classes

Class	Forest type
1	Sugi plantation
2	Hinoki plantation
3	Matsu plantation
4	Momi plantation
9	Other coniferous plantation
11	Coniferous natural forest
12	Broad-leaved natural forest
14	Bamboo forest
0	Nursery and Camp

Table 2. Slope classes

Class	Slope angle (degrees)
1	0–15
2	15–25
3	25–35
4	35

Table 3. Aspect classes

Class	Compass Direction	Azimuth (degrees)
1	North	337.5–360.0 and 0.0–22.5
2	Northeast	22.5–67.5
3	East	67.5–112.5
4	Southeast	112.5–157.5
5	South	157.5–202.5
6	Southwest	202.5–247.5
7	West	247.5–292.5
8	Northwest	292.5–337.5

the forest type layer.

Creating terrain layers

Three terrain layers, that is, elevation layer, slope layer, and aspect layer, were created based on the contours. Slope was classified into four classes as in Table 2, which was used in the Chiba Forest. Aspect was classified into eight classes as in Table 3. Figs. 7, 8, and 9 show the elevation layer, slope layer, and aspect layer, respectively.

Creating location layer

The road data were converted to a raster layer. The location layer, which shows the distance from road, was created from the road raster layer. Location was classified into six classes as in Table 4. Fig. 10 shows the location layer.

Results and Discussion

Table 4. Location classes

Class	Distance from road(m)
1	0–100
2	100–200
3	200–300
4	300–500
5	500–1,000
6	1,000–1,500

An area proportion of each forest type to the Chiba Forest is shown in Fig. 11. Natural forests occupied two thirds of the Chiba Forest and coniferous plantations one third. Broad-leaved natural forest occupied a half and coniferous natural forest 14%. The predominant coniferous plantation species is Sugi, 21%. Hinoki plantation occupied 11%, Matsu plantation 2.5%, Momi plantation 0.2%, and other coniferous plan-

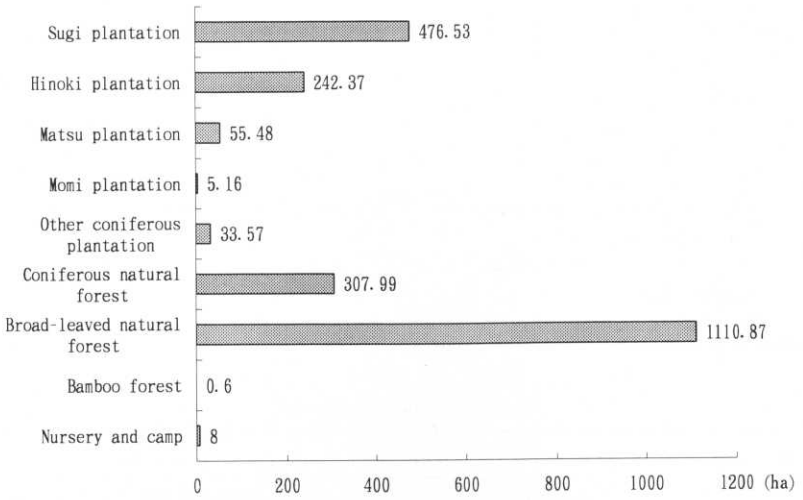

Fig. 11. Area by forest type.

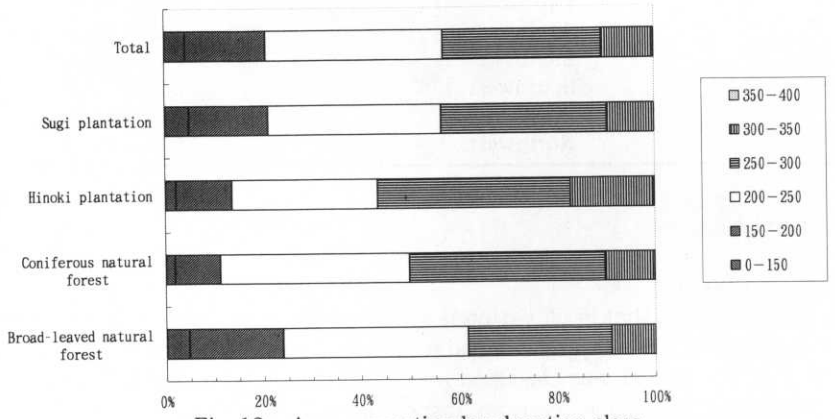

Fig. 12. Area proportion by elevation class.

tation 1.5%. Here we confine our discussion to four forest types; Sugi plantation, Hinoki plantation, coniferous natural forest and broad-leaved natural forest, because other forest types have little area.

An area proportion of each elevation class is shown in Fig. 12. 0 m–150 m occupied 4.3%, 150 m–200 m 16.5%, 200 m–250 m 36.0%, 250 m–300 m 32.5%, 300 m–350 m 10.5%, and 350 m–400 m 0.1%. That is to say, most of the Chiba Forest ranged from 150 m to 350 m. The figure indicated that all the plantations and all the natural forests had a similar tendency in an elevation distribution, however, each forest type had slight differences. Sugi plantations were distributed on lower land than Hinoki plantations. The reason for this may be that Sugi is planted on the lower part of slope and Hinoki on the higher part of slope when both Sugi and Hinoki are planted in a subcompartment. Coniferous natural forests were distributed in higher land than broad-leaved natural forests. This showed that Momi and Tsuga were dominant on higher land than broad-leaved trees in the Chiba Forest.

An area proportion of each slope class is shown in Fig. 13. The range of slope 0°–15° occupied 25.4%, 15°–25° 16.9%, 25°–35° 27.5%, and 35°–30.2%. This figure indicated that

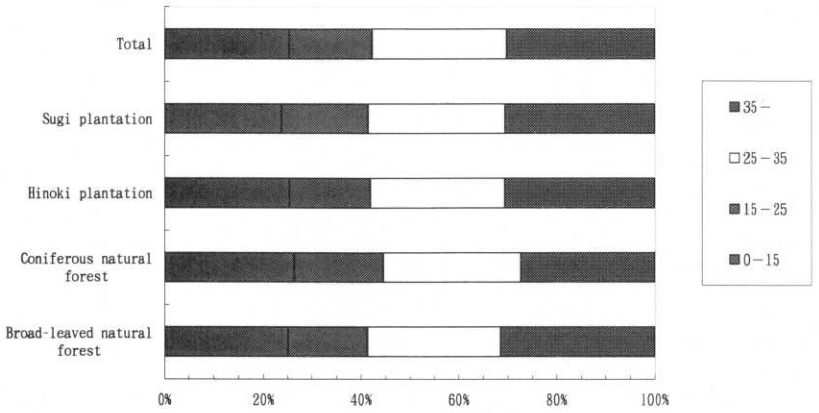

Fig. 13. Area proportion by slope class.

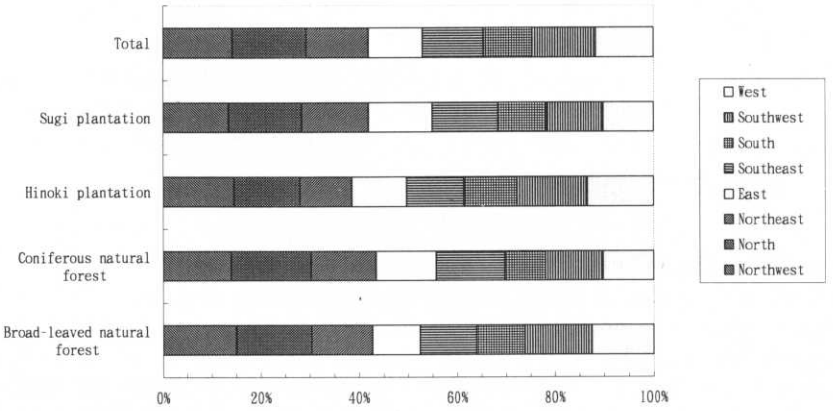

Fig. 14. Area proportion by aspect class.

plantations and natural forests were distributed in a similar pattern. This means that Sugi and Hinoki trees were planted independently of slope.

An area proportion of each aspect class is shown in Fig. 14. North occupied 15.0%, Northeast 12.6%, East 11.1%, Southeast 12.4%, South 9.8%, Southwest 13.0%, West 11.7%, and Northwest 14.3%. North had the most area in the eight classes and Northwest had the second most area. South had the least area and East had the second least area. Sugi plantation, coniferous natural forest, and broad-leaved natural forest were mostly distributed on land with north slope and Hinoki plantation was mostly distributed on land with northwest slope. These showed a similar tendency to that of the total distribution over forest types.

An area proportion of each location class is shown in Fig. 15. 0 m–100 m occupied 14.9%, 100 m–200 m 12.1%, 200 m–300 m 10.9%, 300 m–500 m 18.9%, 500 m–1000 m 32.1%, and 1000 m–1500 m 11.0%. This figure indicated that the coniferous plantations occupied more area close to roads than the natural forests. 60% of Sugi and Hinoki plantations were located within 300 m from a road and 90% of them were located within 500 m from a road. There must be two reasons for this: One is that coniferous trees have been planted near roads and the other is that roads have been made near coniferous plantations.

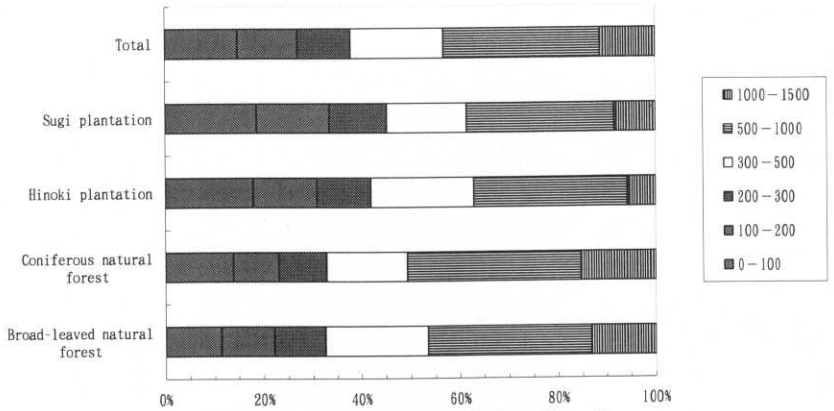

Fig. 15. Area proportion by location class.

Conclusion

The above analyses shows area proportion of each forest type by site condition. The proportions can be regarded as the result from forest management which has been carried out for a long period by the Chiba Forest Office. Constructing database with GIS allowed us to analyze forests numerically.

Summary

The relationship between forest type and site condition in the Tokyo University's Chiba Forest was analyzed using geographic information system. First, the database containing forest conditions and site conditions was constructed. Forest map, stand tables, terrain, roads were stored in this database. Next, the raster layers of forest type and site conditions were created and the areas of each forest type by site condition were calculated by overlaying the layers and totalizing their pixels. The analyses showed the relationship between forest management carried out by the Chiba Forest Office and site conditions in the Chiba Forest.

Key words: Forest type, Site conditions, Geographic information system

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東京大学千葉演習林における林型の地理的分布

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要　旨

地理情報システムを利用して，東京大学千葉演習林における林型と地況との関係を分析した。最初に，林況および地況に関するデータベースを構築した。このデータベースには森林基本図，森林現況簿，地形，林道を蓄積した。次に，林型や地況のラスタレイヤを生成した。そして，ラスタレイヤをオーバーレイし，各ピクセルを集計して，地況ごとに各林型の面積を求めた。その結果，当演習林が行った施業の結果と地況との関係が明らかとなった。

キーワード: 林型，地況，地理情報システム

Fig. 3

Fig. 4

Fig. 5

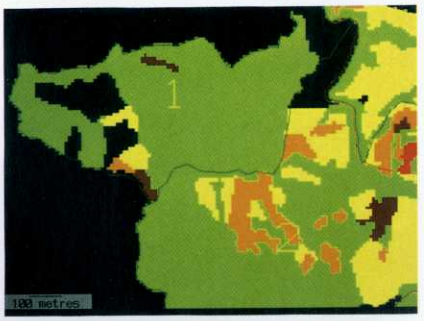

Fig. 6

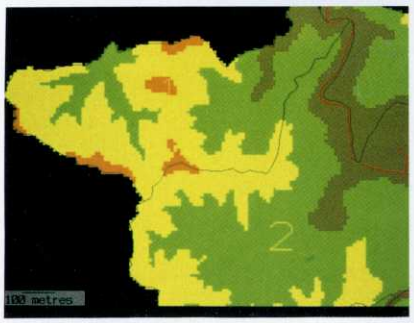

Fig. 7

Fig. 8

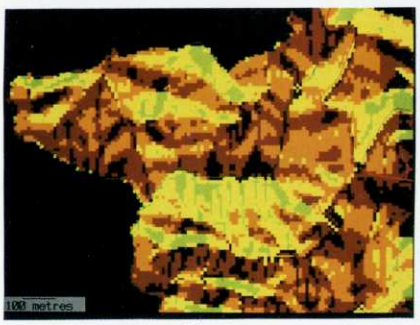

Fig. 9

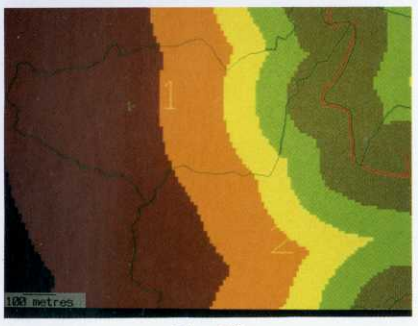

Fig. 10

Fig. 3. Boundaries of compartment and subcompartment.
Green lines and light green lines show the boundaries of compartment and subcompartment, respectively.

Fig. 4. Contours on the compartment and subcompartment map.
White lines show contours and green lines and light green lines show the boundaries of compartment and subcompartment, respectively.

Fig. 5. Roads on the compartment map.
Red lines show roads and green lines show the boundaries of compartment.

Fig. 6. Forest type layer.
Yellow, Sugi plantation; Orange, Hinoki plantation; Brown, Matsu, Momi, and other coniferous plantations; Dark green; Coniferous natural forest ; Light green, broad-leaved natural forest and bamboo forest; Red, Nursery and camp.

Fig. 7. Elevation layer.
Dark green, 0 m–100 m; Yellow green, 100 m–150 m; Light green, 150 m–200 m; Yellow, 200 m–250 m; Orange, 250 m–300 m; Brown, 300 m–350 m; Dark brown, 350 m–400 m.

Fig. 8. Slope layer.
Light green, 0°–15°; Yellow green, 15°–25°; Green, 25°–35°; Dark green, 35°.

Fig. 9. Aspect layer.
Dark brown, North; Brown, Northeast; Orange, East and West; Yellow, Southeast and Southwest; Light green, South.

Fig. 10. Location layer.
Yellow green, 0 m–100 m; Light green, 100 m–200 m; Yellow, 200 m–300 m; Orange, 300 m–500 m; Brown, 500 m–1,000 m; Dark brown, 1,000 m–1,500 m.