DEVELOPMENT OF "JAPAN VEGETATION DATA BASE"

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ABSTRACT

Raster-type digital geographic data containing edaphic factors and climatic factors of national land is maintained in Japan. A large amount of data concerning plant distribution has already been accumulated as vegetation investigation sheets (relevé, Aufnahme). However, these sheets have not yet been digitized. Therefore, being attempted is the digitization of the vegetation investigation sheets and the linking of this data to other digital geographic data based on the information of "position." The "Japan Vegetation Data Base" consists of the following data files.

1) Relevé Data File
In this file, all description matters on the vegetation investigation sheets are included.
2) Grid-Cell Code Data File
This file contains names of topographical maps of 1/50,000, the position on each map (upper or lower, right or left), and the second grid-cell codes.
3) Natural Environment Data File
This file contains data on mean annual temperature, mean monthly temperature of the warmest month, mean monthly temperature of the coldest month, Kira's warmth index, Kira's coldness index, annual precipitation, summer precipitation, winter precipitation, altitude, relief, landform, surface geology, and soils.

The following analyses are possible under this data base system.
1) Gathering of relevés in which plant species of interest occur.
2) Mapping of plant species distribution and vegetation distribution.
3) Analysis of environmental factors which affect plant distribution.

Key Words:
Vegetation Distribution, Plant Species Distribution, Plant Sociology, Relevé (Aufnahme), Geographic Information System, Climatic Factor, Edaphic Factor, Japan

1. INTRODUCTION

An original geographic data base is being developed to analyze the vegetation distribution of Japan. This data base is called the "Japan Vegetation Data Base." This Japan Vegetation Data Base and the hardware used to process data is a system which analyzes geographic information by using a computer with position coordinates. Therefore, this system is a Geographic Information System (GIS).

Until now, there had been "Country-Wide Vegetation Data" and "Specific Plant Community Data," which the Environment Agency of the Japanese Government created, as digital geographic information related to the vegetation of Japan. However, because these two data files made "plant community" a unit, the files were insufficient in the analysis of the level of "plant species," such as the analysis of the northern limit of a Japanese beech tree or the range of the tree's distribution by mean annual temperature, etc.

In Japan, in accordance with the National Grid Code System (explained below), the Digital National Land Information and the Grid Climatic Value are maintained. By using these data files, we can analyze edaphic conditions such as relief, landform, surface geology etc., and climatic conditions such as monthly temperature, monthly precipitation and snowfall depth, with every approximate 1-km x 1-km grid-cell. A large amount of data concerning plant distribution has already been accumulated as vegetation investigation sheets (relevé, Aufnahme), which have not yet been digitized. It is possible to analyze the detailed distribution of "plant species" levels by using the data sheets. The Japan Vegetation Data Base links these data files mutually based on the information of "position" and uses them as a relational data base.

2. FRAMEWORK OF THE DATA BASE

2.1 Outline of the hardware (Figure 1)

Three computer systems are being used individually for the purpose of data entry, image processing, and the data analyses. A personal computer (NEC PC-9801 FA/CPU Intel i486SX) is being used for data entry with a general Japanese word processor, for simple calculation of statistics, and for the display of maps. "Terra-Mar" is being used for image processing. This system is chiefly for the analysis of remote sensing data. Image processing such as three-dimensional display, classification, zoom, etc., can be efficiently achieved. Moreover, a mainframe computer (HITAC M682) is being used for large-scale calculations and modeling. These three systems are connected by a Local Area Network (LAN) in the Institute.

2.2 Outline of the data files

The Japan Vegetation Data Base consists of following data files.

(1) Relevé Data File

This is the core of the Japan Vegetation Data Base and is made by digitizing the currently published releve sheets by word processor. At present, work is being conducted on the digitalization of the relevés gathered from the Basic Survey on Natural Environment Conservation carried out by the Environment Agency.

The Basic Survey on Natural Environment Conservation is based on the Nature Conservation Law and is executed approximately every five years to investigate the situation of the natural environment of Japan broadly and scientifically. In general, this survey is called the "Greenery Census." The first survey was executed in 1973, the second survey 1978-79, the third survey 1983-87, and the fourth survey has been in execution since 1988.

Concerning Japanese vegetation, the "Vegetation Survey" was executed for the common plant communities for each prefecture and the "Specific Plant Community Survey" for the characteristic or scarce plant communities. Both surveys covered the entire area of Japan during the 1978-79 survey and the 1983-87 survey. More than 10,000 relevé sheets were collected, and approximately 1,000 of those releve sheets have already been digitized.

The same data sheet (relevé) is used across Japan in the Basic Survey. Table 1 shows a sample of a relévc. The core of a relevé (Aufnahme) is a list of plant species (taxa) with an index of cover, abundance, etc., per species. This investigation method is widely used for plant sociological vegetation investigations in Japan.

Particularly, the data sheet used during the Greenery Census includes information of the name of the topographical map of 1/50,000 and the position (right or left, upper or lower) on the map where each investigation was conducted. Therefore, the position can be mechanically specified by the accuracy of the second grid-cell (approximately 10 km x 10 km) of the National Grid Code System explained below.

(2) Grid-Cell Code Data File

This data file includes the name of the topographical map of 1/50,000, the position on the map, and the second grid-cell code.

(3) Natural Environment Data File

This data file contains various kinds of environmental information arranged according to the National Grid Code System by the accuracy of the third grid-cell (approximately 1 km x 1 km), such as climatic conditions including mean annual temperature, mean monthly temperature of the warmest month, mean monthly temperature of the coldest month, Kira's warmth index, Kira's coldness index, annual precipitation, summer precipitation, winter precipitation, etc., and edaphic conditions including altitude, relief, landform, surface geology, soils, etc.

The position coordinates of this data file conform to the National Grid Code

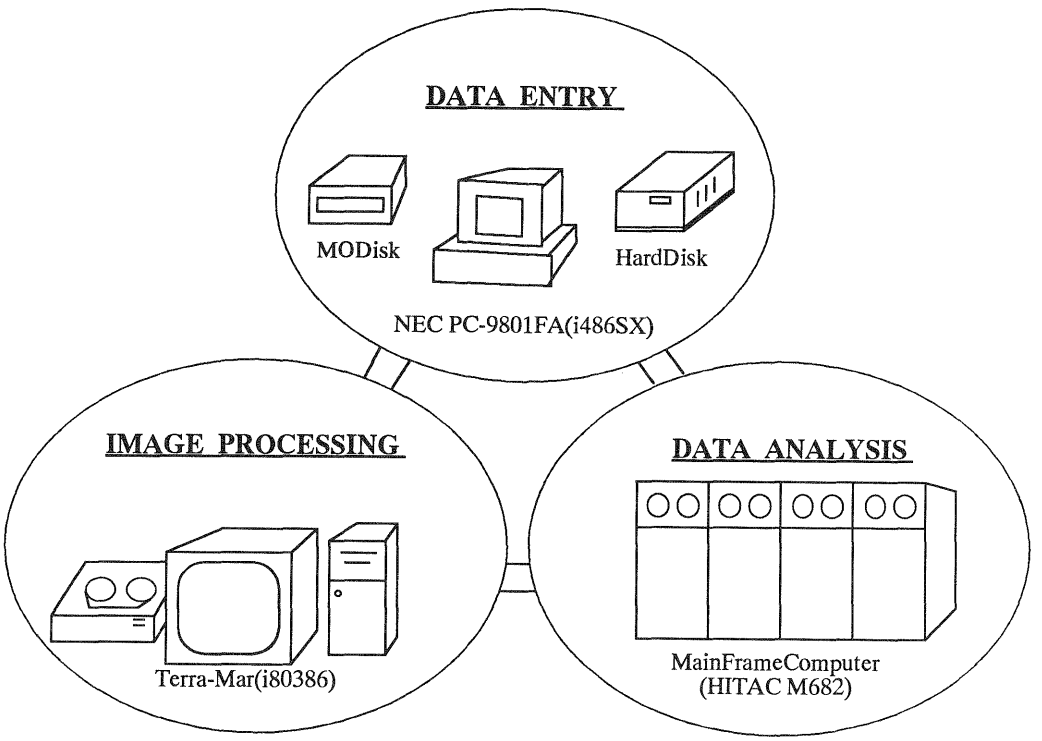

Figure 1 Composition of hardware

Table 1 Example of relevé

No.7
Plant community : *Quercetum myrsinaefoliae*
Map(1:50,000) : Tokyo-Seinan, Position : Upper-Left
Place: Higashi-One, Takatsu-Ward, Kawasaki-City, Kanagawa-Pref.
Landform: Slope(medium), Soil : Ando, Wind : medium, Sun: med.dark
Soil Moisture: Good, Altitude : 55m, Exposure : N, Slope : 30 degrees,
Site Sample 25 x 20 m^2, Total Taxa : 35 species, 1971.5.5 Observer : Toma

Strata	Dominant Species	Height(m)	Cover(%)	Basal Diameter(cm)	No. of Species
Trees 1	*Qurcus myrsinaefolia*	12-20	70	32	4
Trees 2	*Qurcus myrsinaefolia*	5-10	70		7
Shrubs	*Aucuba japonica*	1- 2	40		12
Herbs	*Dryopteris erythrosora*	1-0.8	20		22

S	L	D•S	V	SPP.	S	L	D•S	V	SPP.	S	L	D.S	V	SPP.
1		3.3		*Quercus myrsinaefolia*	**3**		2.2		*Aucuba japonica*	**4**		+2		*Dryopteris erythrosora*
		2.2		*Zelkova serrata*			2.2		*Neolitsea sericea*			+2		*Dryopteris bissetiana*
		2.2		*Cornus controversa*			1.1		*Cinnamomum japonicum*			+2		*Pleioblastus chino*
		1.1		*Cinnamomum japonicum*			+2		*Eurya japonica*			+2		*Carex morrowii*
							+		*Fatsia japonica*			+		*Quercus myrsinaefolia*
2		2.2		*Qurcus myrsinaefolia*			+		*Cephalotaxus harringtonia*			+		*Zelkova serrata*
		1.1		*Magnolia obovata*			+		*Viburnum dilatatum*			+		*Cornus controversa*
		+		*Cryptomeria japonica*			+		*Kalopanax pictus*			+		*Neolitsea sericea*
		+		*Callicarpa mollis*			+		*Helwingia japonica*			+		*Ardisia japonica*
		+		*Chamaecyparis obtusa*			+		*Akebia trifoliata*			+		*Ilex integra*
		+		*Stachyurus praecox*			+		*Wisteria floribunda*			+		*Thea sinensis*
		+		*Kalopanax pictus*			+		*Stachyurus praecox*			+		*Viburnum dilatatum*
												+		*Helwingia japonica*
												+		*Gynostemma pentaphyllum*
												+		*Hosta montana*
												+		*Trycyrtis macropoda*
												+		*Astilbe thunbergii*
												+		*Dioscorea tokoro*
												+		*Parthenocissus tricuspidata*
												+		*Chloranthus serratus*
												+		*Viola bissetii*
												+		*Dryopteris lacera*

* In this table, S : Strata, D : Dominance, S : Sociability, V : Vitality, L : Life Form.
** Original sheet is written in Japanese, and species' names are expressed using Japanese names..

System of Japan (JIS-C6304-1976) (Figure 2), which has three spatial levels: i) a first grid that is equivalent to the size of a 1/200,000 topographical map, ii) a second grid that is equivalent to the size of a 1/25,000 map, and iii) a third grid that divides the second grid into 10 grids equally in length and width. Near the center of Japan, the size of the second grid is approximately 10 km x 10 km and the third grid is approximately 1 km x 1 km. Because this coding system is based on latitude and longitude, the grid-cell is not an accurate square and the size is different for Hokkaido (north) and Kyushu (south).

The data of climatic conditions, which includes mean annual temperature, annual precipitation, etc., was merged into the data base from the data file offered by the Meteorological Agency of Japan.

The data of edaphic conditions, which includes altitude, relief, landform, surface geology, soils, etc., was merged into the data base by reordering data selected from the Digital National Land Information mainly offered by the Geographical Survey Institute and the National Land Agency.

The data of plant communities, which includes the plant community code for each third grid-cell, was merged into the data base from "Country-Wide Vegetation Data" offered by the Environment Agency.

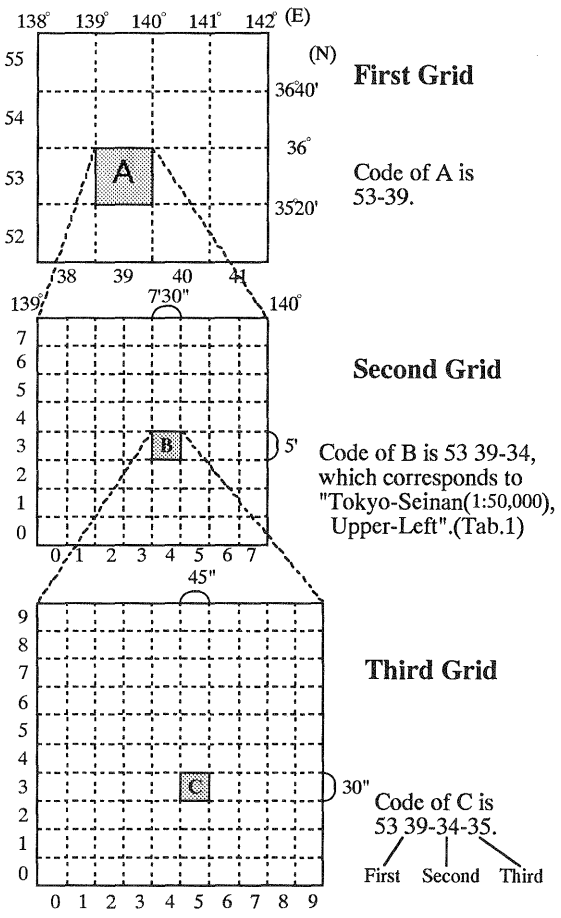

Figure 2 Explanation of National Grid Code System

2.3 Outline of the software (Figure 3)

Software includes the originally developed program (by C or FORTRAN), the program package (SAS) on the mainframe computer, and the application software (Ichitaro, Lotus, etc.) on the personal computer.

2.4 Outline of the function

The following analyses are possible using the Japan Vegetation Data Base system.

(1) Gathering of vegetation investigation sheets in which plant species of interest occurs.

(2) Mapping of the plant distribution, analysis of the northern or southern limit of distribution, and analysis of habitat segregation.

(3) Analysis of environmental factors which affect the plant distribution. That is, the system can analyze whether plant distribution is affected by the temperature factor or the precipitation factor, or in what range in Kira's warmth index the plant is distributed.

2.5 Problems

The following two problems could be pointed out for the Japan Vegetation Data Base.

(1) Because the information of "Position" extracted from the relevés corresponds with the second grid (approximately 10 km x 10 km), there is a possibility of a problem in accuracy. Especially in mountainous regions, there is certain possibility that correspondence with the environmental conditions will not succeed.

(2) It is considerably hard work to check the species' name filled in relevé sheets. Cases where errors have occurred include, for instance, the misspelling of relevé sheet, the misreading in data entry, or the use of different species names in the naming of one species. These mistakes are being checked as much as possible, however, ambiguous mistakes in a relevé sheet cannot be checked.

3. EXAMPLE OF ANALYSIS

At present, approximately 1,000 relevés had been digitized, however, this is not sufficient for a strict analysis. Here, some simple analyses were attempted to verify the effectiveness of this data base.

The Japanese islands are covered with various types of vegetation, from the subarctic conifer forest in the northern part to a mangrove forest in the southern part. From the viewpoint of the area, a summergreen broad-leaved forest in the northern half of Japan and an evergreen broad-leaved forest in the southern half of Japan occupy the majority of the natural vegetation on the Japanese islands. The two major forms of vegetation correspond to *Fagetea crenatae* (Japanese beech class) and *Camellietea japonicae* (Japanese camellia class), respectively, from the viewpoint of plant sociology.

Fagus crenata (Japanese beech) and *Quercus mongolica* (an oak) were analyzed

as character species of *Fagetea crenatae*, and *Camellia japonica* (Japanese camellia) and *Castanopsis cuspidata var. Sieboldii* (Japanese chinquapin) were analyzed as character species of *Camellietea japonicae*.

Firstly, relevés where each species occurs were extracted, which consist of relevés of beech (46 second grids), oak (62 grids), chinquapin (34 grids), and camellia (66 grids).

Then, the map names and positions on the map were extracted from the relevé sheets mentioned above, and they were converted into the second grid code by means of the Grid-Cell Code Data File. The distribution of the plant species was mapped by using the second grid-cell code. Figure 4 shows the points where beech or oak are distributed. They are distributed mainly in the northern part of the Japanese archipelago; however, they are also distributed in the mountainous region of Shikoku and Kyushu. Figure 5 shows the points where chinquapin or camellia is distributed. They are distributed mainly in the southern part of the Japanese archipelago; however, they also reach northern Honshu near the coastal zone.

Next, the climatic data, which corresponds to the second grid-cell codes, were extracted from the Natural Environment Data File. Since this Natural Environment Data File uses the third grid as a unit, each second grid code has 100 observations. Here, the mean values were calculated from 100 observations. Figure 6 takes the mean annual temperature as the horizontal axis, and the percentage of the occurrence of each plant species as the vertical axis. From Figure 6, the habitat segregation between beech-oak and chinquapin-camellia by the temperature factor can be found, and the boundary is approximately 12 - 14 degrees Centigrade. Similarly, Figure 7 takes the annual precipitation as the horizontal axis. The annual precipitation does not appear to affect the distribution.

The above-mentioned analysis results are not contradictory to the ecological findings. However, because other habitats are reported than the places shown in Figure 4 and Figure 5, it is necessary to increase amount of data further and to improve the accuracy of the analysis.

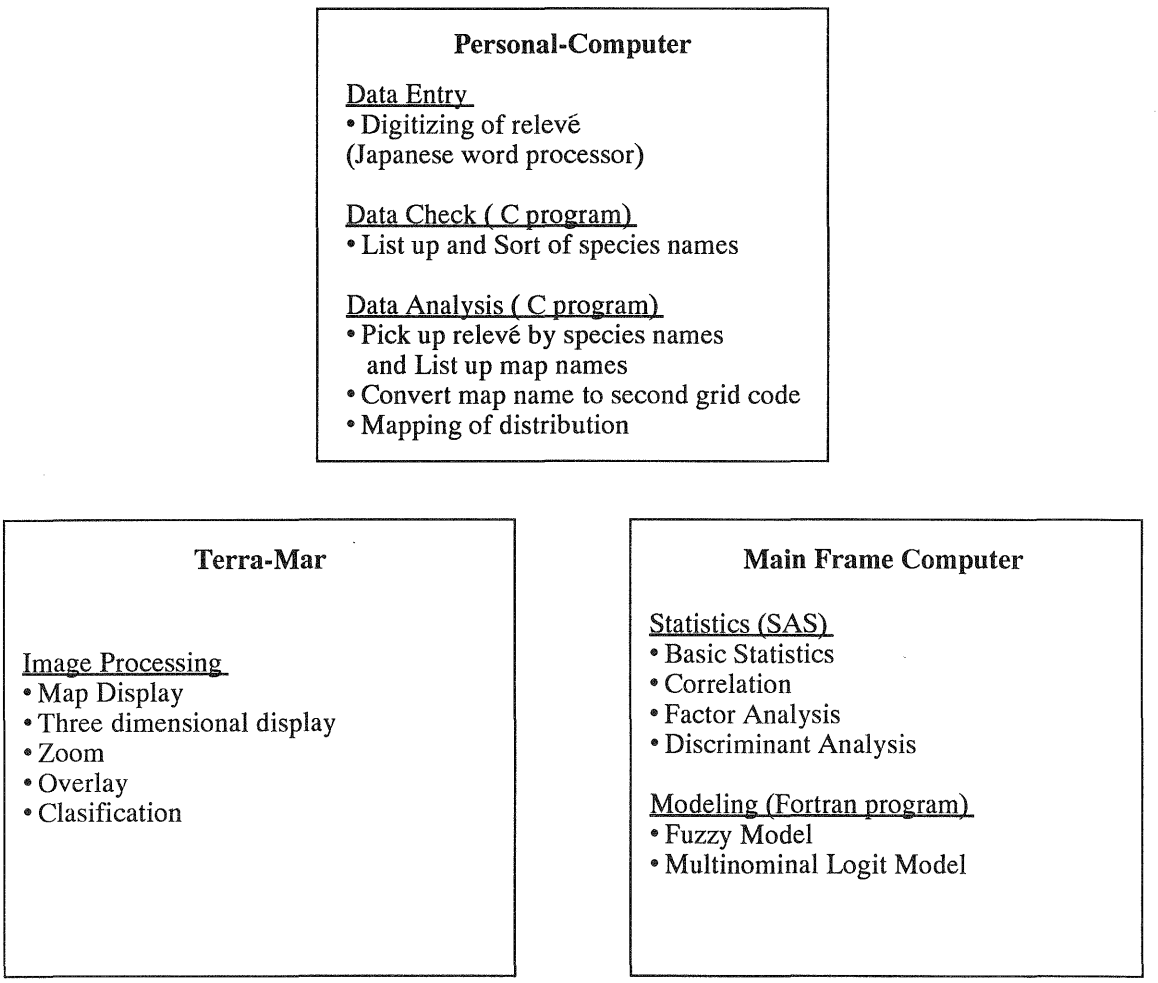

Figure 3 Composition of Software

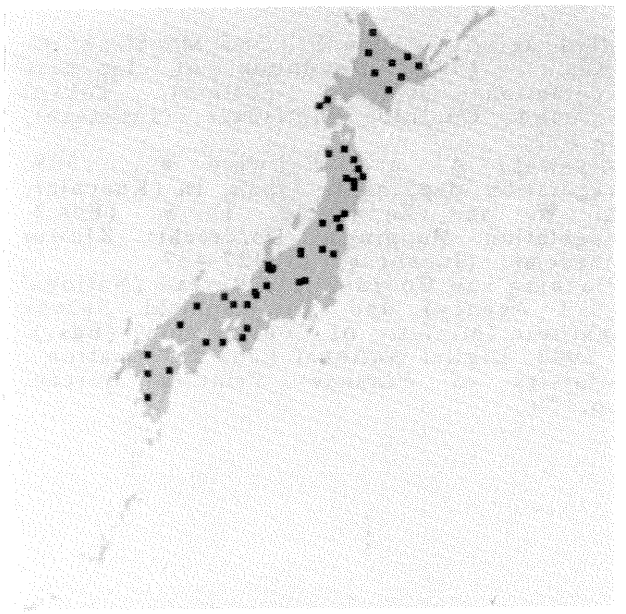

Figure 4 Distribution of *Fagus crenata* and *Qurcus mongolica*

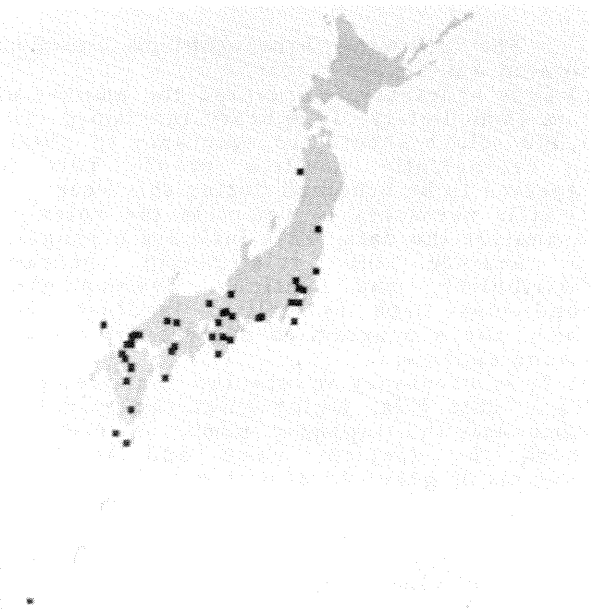

Figure 5 Distribution of *Camellia japonica* and *Castanopsis cuspidata var. Sieboldii*

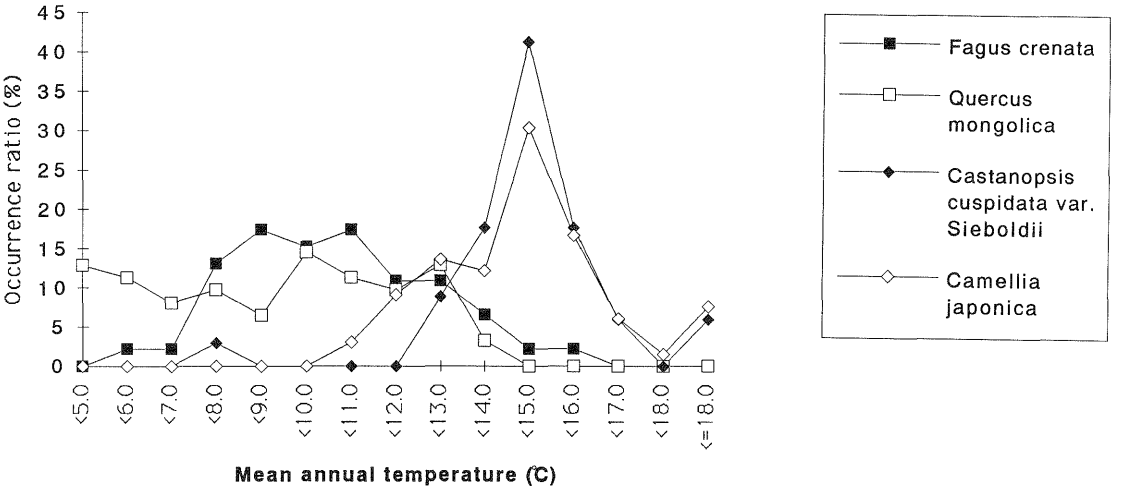

Figure 6 Mean annual temperature and occurrence ratio

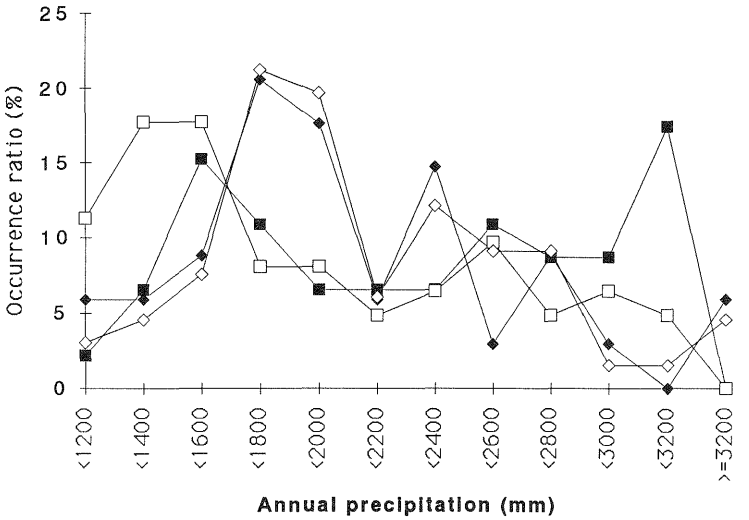

Figure 7 Annual precipitation and occurence ratio

4. FUTURE PROBLEMS

The following three problems could be pointed out for the future.

1) It is necessary to increase the amount of data immediately. It appears that more than 5,000 relevé sheets are necessary to obtain an ecologically positive proof. This is expected to be achieved during this year.

2) It is necessary to complete the software to analyze the data. This includes a program to analyze the relationship between distribution and various environmental conditions such as relief, landform and soils, and a program to analyze the linkage among species.

3) It is necessary to develop the Scientific Name Data File, which links the scientific name and the Japanese name, in order to check the species' name and to make analysis of genus level or family level.

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