Vegetation of Tokyo and its Conservation and Management

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Introduction

Vegetation of the Tokyo Metropolis consists of three zones of warm temperate, cool temperate and subalpine vegetation on the mainland except for a number of islands scattered on the southern sea. It is presumed that the greater part of prewar Tokyo had been covered by various natural and secondary forests of these vegetation types though it has been the capital of Japan for about 400 years. However, most of these forests of the area, especially of lowland, have been damaged by a rapid urbanization in the post World War II period. Nevertheless, it is a fact that vegetation, even natural forest, still covers some areas of Tokyo, especially on the hills and mountains. It is also true that the natural vegetation is in danger of complete destruction by various exploitations in all parts of Tokyo.

In this situation we are making an effort for nature conservation in Tokyo in cooperation with the Tokyo Metropolitan Government and the regional inhabitants.

In this paper the author would like to discuss the characteristics of the natural vegetation of the mainland of Tokyo and its conservation and ecological management.

I. Geographic Setting of Tokyo

1. Location

The Tokyo Metropolis is composed of a mainland area and several small islands (Izu Islands and Ogasawara (Bonin) Islands). The mainland part is located in the Kanto region near the center of the Japanese Archipelago, and it covers an area of 1238 sq. km. Administratively, the area is divided into the ward area and the Tama district. The ward area is former Tokyo City, which is subdivided into 23 special wards. The Tama district is composed of 26 cities and 3 counties.

2. Topography

The eastern half of Tokyo lies in the flat Kanto Plain and the western half is situated in a part of the Kanto Mountains. Although small in size, the area of Tokyo ranges vertically from the coast of Tokyo Bay to Mt. Kumotori with an altitude of 2018 m which is located at the junction of the boundaries of three prefectures of Tokyo, Yamanashi and Saitama. Consequently the Tokyo area is remarkably rich in topographic variation, comprising four topographic zones of

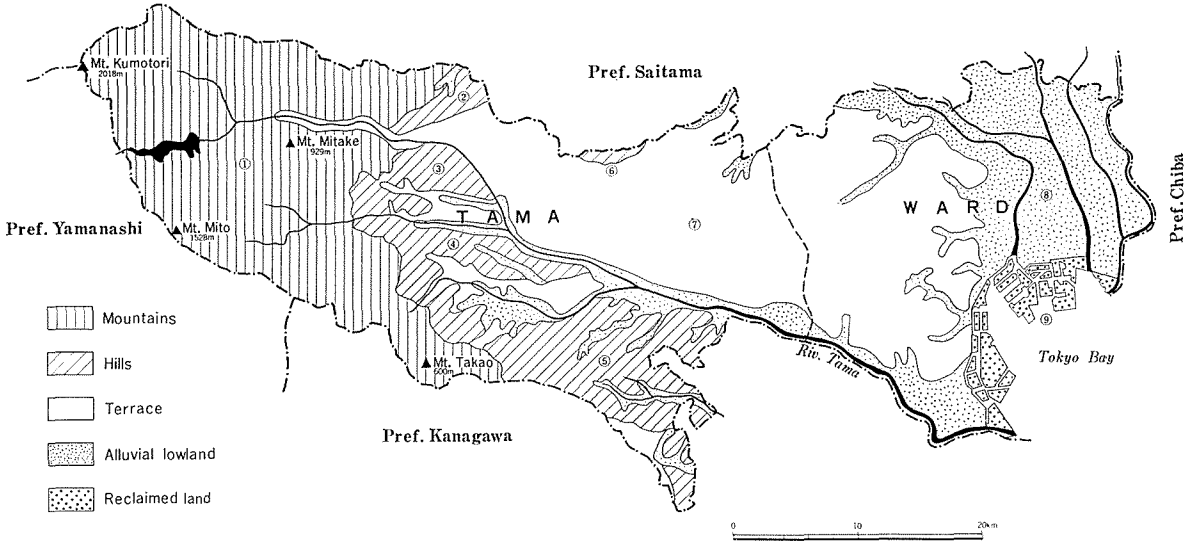

Fig. 1. General map of topography of Tokyo Metropolis (modefied from Tokyo Chiri Kyokai 1963)
① Kanto Mountains ② Kaji Hills ③ Kusabana Hills ④ Kasumi Hills
⑤ Tama Hills ⑥ Sayama Hills ⑦ Musashino Terrace ⑧ Tokyo Lowland
⑨ Tokyo Bay reclaimed land

alluvial lowland (Tokyo Lowland), terrace (Musashino Terrace), hills (Tama Hills, Kasumi Hills, Kusabana Hills, Sayama Hills and Kaji Hills) and mountains (Kanto Mountains) (Fig. 1). In addition to these natural topographic divisions there are artificially reclaimed plains as a special topographic unit along Tokyo Bay.

3. Geology and Soils

The Musashino Terrace and Tama and Kasumi Hills are composed of loam (Kanto loam) of the quarternary volcanic ash, while the Sayama and Kusabana Hills are constructed by sandstone, mudstone, conglomerate etc. of the Neogene period. Geology of the mountains is different on the left side and the right side of the Tama River basin. In the former, rocks of the Chichibu Paleozoic formations are dominant, while in the latter the area is covered by rocks of the Mesozoic.

Most of the terrace and Tama Hills are covered by Andosols. The other hills and mountains are occupied by Brown forest soils.

4. Climate

In Tokyo, lowland, hills and the lower portion of mountains lie in the warm temperate zone. Annual mean temperature in those areas are about 12°C. to 15°C. The higher part of mountains has a climate of the cool temperate zone, and in the highest part it is a subalpine climate.

Annual precipitation of most areas of Tokyo is in the range of 1400 mm to 1600 mm.

II. Vegetation

1. Plant Communities

There are many phytosociological studies on the vegetation of Tokyo (Maeda and Shimazaki 1951, Maeda and Yoshioka 1952, Miyawaki 1969, Okuda 1969, 1970, 1975, Okutomi *et al.* 1971, 1973, 1975a, 1975b, 1976, 1977, Okutomi and Handa 1972, Okutomi and Tsuji 1974, 1975a, 1975b, 1978, Okutomi 1975a, Miyawaki and Tohma 1975, Fuji and Sone 1976, Nagano *et al.* 1976a, 1976b). Based on these studies a general view of the vegetation of Tokyo is given in the following summary.

(1) Natural forest communities

Figure 2A indicates the distribution of main natural forest communities of Tokyo with reference to two important habitat conditions, i. e., elevation and soil moisture. As seen in the figure, Ardisio-Castanopsietum sieboldii and Polysticho-Machiletum thunbergii which are typical evergreen broad-leaved forests in Japan are distributed in areas no higher than about 30 m above sea level. Quercetum myrsinaefoliae, the most important evergreen broad-leaved forest of the Kanto region including Tokyo, occurs on terrace, hills and the lower parts of mountains (30 m to 350 m). Illicio-Abietum firmae, a mixed forest composing of evergreen conifers and evergreen broad-leaved trees, occurs in the mountains from about 350 m to 750 m. All of these forest communities are of the class Camellietea japonicae.

The zone between about 750 m and 1700 m belongs to the region of Abelio-Fagetum crenatae, which is a beech forest on the Pacific Ocean side of Japan.

Abietum veitchii-mariesii, a widespread subalpine forest community in Japan, occurs in the mountains above about 1700 m.

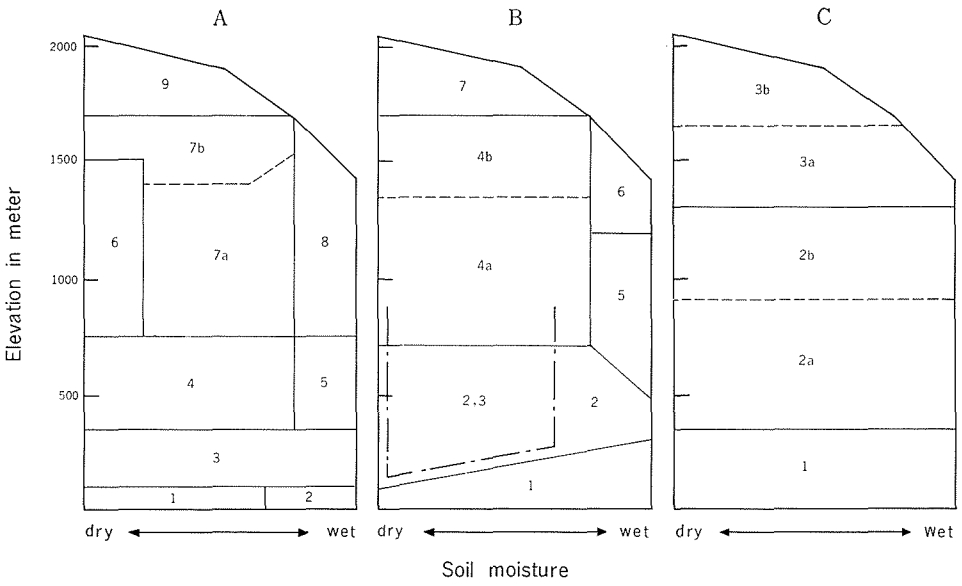

Fig. 2. Schema of the distribution of main forest communities in Tokyo Metropolis, referring to habitat conditions (collected from Okutomi and Tsuji 1975, Okutomi *et al.* 1976, 1977).

A. Natural forests

1. Ardisio-Castanopsietum sieboldii 2. Polysticho-Machiletum thunbergii
3. Quercetum myrsinaefoliae 4. Illicio-Abietum firmae 5. Acero-Zelkoetum
6. Carici-Tsugetum sieboldii 7a. Abelio-Fagetum crenatae, typical subass.
7b. Abelio-Fagetum crenatae, facies of *Abies homolepis* 8. Dryopteri-Fraxinetum commemoralis 9. Abietum veitchii-mariesii

B. Secondary forests

1. Quercetum acutissimo-serratae 2. Castaneo-Quercetum serratae
3. Rhododendro-Pinetum azumanum 4a. Castaneto-Quercetum crispulae, subass. of *Castanea crenata* 4b. Castaneto-Quercetum crispulae, typical subass.
5. Hydrangeo-Eupteletum polyandrae 6. *Pterocarya rhoifolia* forest
7. *Betula ermanii* community

C. Plantation

1. *Cryptomeria japonica, Chamaecyparis obtusa-Ardisia japonica* plantation
2a. *Cryptomeria japonica, Chamaecyparis obtusa-Kerria japonica* plantation, typical under-unit 2b. *Cryptomeria japonica, Chamaecyparis obtusa-Kerria japonica* plantation, under-unit of *Schisandra repanda* 3a. *Larix leptolepis, Chamaecyparis obtusa-Weigela decora* plantation, under-unit of *Prunus incisa* 3b. *Larix leptolepis, Chamaecyparis obtusa-Weigela decora* plantation, under-unit of *Sasa nipponica*

The habitats of the main natural forest communites mentioned above are all mesic. On the other hand, the other natural forest communities which are distributed in Tokyo are restricted to sites with particular habitat conditions. For example, Carici-Tsugetum sieboldii is restricted to dry sites, while Dryopteri-Fraxinetum commemoralis, Acero-Zelkoetum serratae and *Alnus japonica* communities are restricted to relatively wet and very wet sites.

The natural forest communities have potentially the distribution areas as mentioned above, but they have been almost completely destroyed by man in lower lands. They have survived in fragments in the nature protection areas such as national parks and nature reserves. On the other hand, some natural forest

communities such as Abietum veitchii-mariesii and Abelio-Fagetum crenatae still survive over considerable areas in the higher parts of mountains (cf. Fig. 3).

(2) Secondary forest communities

In Tokyo, some secondary forest communities have been predominant for a long time. As seen in Fig. 2B which shows the distribution of secondary forest communities, Quercetum acutissimo-serratae and Castaneo-Quercetum serratae dominated evenly by *Quercus serrata* and Rhododendro-Pinetum azumanum are widely distributed on terrace, hills and the lower part of mountains no higher than about 700 m above sea level. Predominace of these secondary forest communities was caused by the fact that the communities had been very useful economically, as they have excellent characteristics as a source of soil humus supply to farm lands and wood for domestic fuel supply. However, the forests are also rapidly decreasing due to the decline of agriculture, the change of fuel and the progress of urbanization.

In the mountain area of about 700 m to 1700 m Castaneto-Quercetum crispulae, one of the typical secondary forest communities in the Fagetea crenatae region in Japan, is widely distributed. But the community is quantitatively predominant only in the upper part of the region, while it is poor in the lower part of the region.

The *Betula ermanii* community is also a secondary forest community in the mountains of Tokyo. However, it is not predominant, because the highest part of the mountains, which coincides with the habitat of the community, is covered by natural forest of Abietum veitchii-mariesii.

(3) Planted forest

Okutama, the western part of Tokyo, have been one of the famous forestry areas in Japan. Therefore, the area is almost completely covered by planted forests of *Cryptomeria japonica*, *Chamaecyparis obtusa* and *Larix leptolepis*. Figure 2C shows the distribution of such planted forests, which are differentiated using phytosociological procedures, referring to elevation and soil moisture. As seen in the figure, the planted forests of *Cryptomeria* and *Chamaecyparis* are distributed in the area no higher than about 1300 m and the forests of *Larix* are found together with *Chamaecyparis* forests in the area above 1300 m.

(4) Grassland communities

In Tokyo, natural grassland communities are seldom found on the sites with normal habitat conditions, but a few of the communities can be seen on the sites with particular conditions. Communities of wind-exposed grassland (*Sasa nipponica-Spiraea japonica* association in subalpine zone) and submerged riverside grassland (Phragmitetum japonicae, Miscanthetum sacchariflori etc. in riverside of the Tama River) are the representatives of the natural grassland communities in Tokyo. Secondary grassland community is not abundant in Tokyo, either Arundinario chino-Miscanthetum sinensis is relatively dominant of the communities on river banks and clear cutting forest areas.

(5) Weed communities

Major weed communities of Tokyo are those on cultivated land and abandoned cultivated land, such as field weed communities (*Pinellia ternata-Euphorbia pseudochamaesyce* ass.), abandoned field weed communities (*Erigeron canadensis-Erigeron sumatrensis* ass.), paddy field weed communities (Sagittario-Monochorietum) and abandoned paddy field weed communities (*Polygonum thunbergii-*

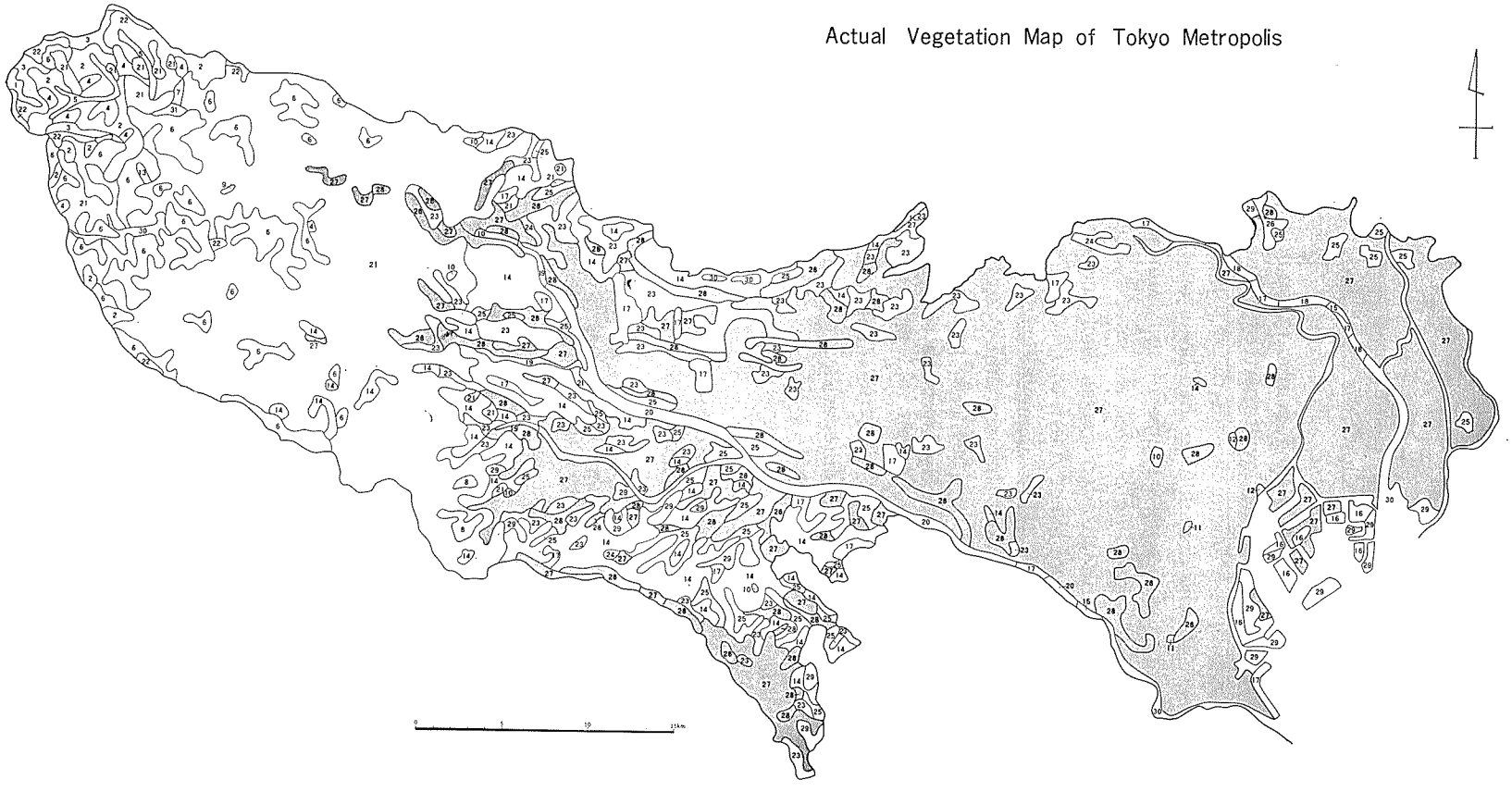

Fig. 3. Actual vegetation map of Tokyo Metropolis (simplified by S. Tsuji from Okutomi (ed.) 1975b). Parts of half-tone show urban, residential and industrial area.

Legend

Natural vegetation in Vaccinio-Piceetea region

1. Abietum veitchii-mariesii

Natural vegetation in Fagetea crenatae region

2. Abelio-Fagetum crenatae
3. Abelio-Fagetum crenatae, facies of *Abies homolepis*
4. Carici-Tsugetum sieboldii
5. Dryopteri-Fraxinetum commemoralis

Substitutional communities in Fagetea crenatae region

6. Castaneto-Quercetum crispulae
7. Plant communities in clear-cut area

Natural vegetation in Camellietea japonicae region

8. Illicio-Abietum firmae
9. Acero-Zelkoetum
10. Quercetum myrsinaefoliae
11. Ardisio-Castanopsietum sieboldii
12. Polysticho-Machiletum sieboldii
13. Hydrangeo-Eupteletum polyandrae

Substitutional communities in Camellietea japonicae region

14. Quercetum-acutissimo-serratae,Castaneo-Quercetum serratae and Rhododendro-Pinetum azumanum
15. Tread communities (*Plantago asiatica* community)
16. Weed communities of the coastal reclaimed land
17. Zoysion japonicae

Riverside vegetation

18. Phragmitetea (excep. 19, 20)
19. Phragmites japonica community
20. Miscanthetum sacchariflori

Plantation and cultivated land

21. *Cryptomeria japonica, Chamaecyparis obtusa* plantation
22. *Larix leptolepis* plantation
23. Field
24. Uncultivated field
25. Paddy field
26. Uncultivated paddy field

Others

27. Urban distict with a few trees (includ. industrial area)
28. City parks and urban district with many trees
29. Land constructed for residence and factory
30. Open water
31. Artificial bare land

Microstegium vimineum var. *polystachyum* comm.).

On the other hand, *Panicum dichotomiflorum-Aster subulatus* community is a characteristic weed community on the reclaimed plains along Tokyo Bay.

2. Vegetation Cover of Tokyo

Vegetation maps of Tokyo, showing in detail the vegetation cover of the earth surface, were drawn by several authors (Okutomi (ed.) 1974, 1975b, Okuda *et al.* 1977). Figure 3 is a map of a general view of the vegetation cover of Tokyo, which is based on the actual vegetation map of the Tokyo Metropolis with scale 1:200,000 by Okutomi (ed.) (1975b). Using this map a general view of vegetation cover of Tokyo is presented here.

(1) Vegetation cover of the terrace

Most of the terrace of Tokyo is occupied by urban, residential and industrial districts. A few surviving plant communities are mostly substitutional communities whose principal parts are secondary forests such as Quercetum acutissimo-serratae and field weed communities. Natural vegetation is very poor on the terrace, where Ardisio-Castanopsietum sieboldii and *Zelkova serrata* subassociation of Quercetum myrsinaefoliae are natural forest surviving over small areas on terrace cliffs.

(2) Vegetation cover of alluvial lowland

The alluvial lowlands of Tokyo also have been urbanized in the most part. Paddy field weed communities and abandoned paddy field weed communities are the main types of the vegetations survived in alluvial lowlands. On the other hand, some submerged grasslands cover the riverbeds of upper- and mid-stream of the Tama River and its tributary streams.

(3) Vegetation cover of hills

The hills of Tokyo are an area dominated by deciduous secondary forests such as Quercetum acutissimo-serratae, Castaneo-Quercetum serratae and Rhododendro-Pinetum azumanum. However, these forests are receiving strong impacts of rapid urbanization in the hills, especially in the Tama Hills.

Few natural vegetation units are found in the hills, but *Abies-Quercus* forest (*Abies firma* subass. of Quecetum myrsinaefoliae) survives on the ridges and *Zelkova-Quercus* forest (*Zelkova serrata* subass. of Quercetum myrsinaefoliae) occurs in fragments in the foot-hills.

(4) Vegetation cover of mountains

The lower part of the mountains, the Camellietea japonicae region, is occupied by planted forests of *Cryptomeria japonica* and *Chamaecyparis obtusa*, but some deciduous secondary forest are found in ill-suited sites for plantation on ridges and steep slopes. Locally, there are natural forests, especially *Abies* forest (Illicio-Abietum firmae) on some mountains such as Mt. Takao.

In middle and higher parts of Okutama, natural beech forest, deciduous secondary forests and planted conifer forests show a mosaic distribution.

The highest part of the mountains of Okutama is the only virgin forest area in the mainland of Tokyo. It is a natural forest dominated by *Tsuga diversifolia* (*Tsuga diversifolia* subass. of Abietum veitchii-mariesii).

III. Conservation and Management of Vegetation in Tokyo Metropolis

1. A Plan for Nature Conservation in Tokyo

Comparing maps or aerial photographs made or taken in past years, it is found that the urbanization of Tokyo has greatly expanded in the years since about 1960 and the vegetation cover of Tokyo has strikingly decreased during this time. Now, vegetation cover occupies only several percent of the whole ward area.

In the light of this situation with the vegetation in Tokyo, various kinds of planning for nature conservation in the Tokyo Metropolis have been attempted by the Metropolitan Government with the help of some ecologists and conservationists.

The planning should be based on some readily identifiable features of nature. Therefore, the whole area of Tokyo was classified into 9 area-types based on the topography and the vegetation. As a working base, a topographic map and an actual vegetation map were used.

The area-types classified are as follows :

Area-type 1 : Virgin forest area in mountains
Area-type 2 : Secondary forest area in mountains
Area-type 3 : Planted forest area in mountains
Area-type 4 : Secondary forest area in hills
Area-type 5 : Area dominated by farm land on terrace
Area-type 6 : Urban area with vegetation surviving in part on terrace
Area-type 7 : Urban-area with little vegetation
Area-type 8 : Urban area with paddy field and riverside vegetation in alluvial lowlands
Area-type 9 : Urban area without vegetation in alluvial lowlands

Figure 4 is a map showing the extent of every area-type in the mainland of Tokyo.

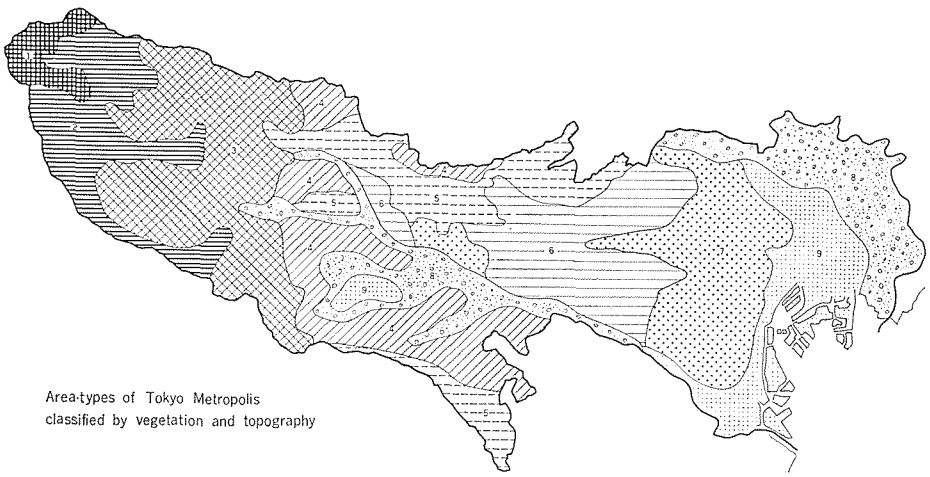

Fig. 4. Map of the extent of area-types in Tokyo Metropolis (Tokyo Metropolitan Government 1975). Explanation in text.

It is a matter of course that nature conservation in an area must be advanced according to the features of nature of the area. In the case of Tokyo a zoning for nature conservarion (in a broad sense) was attempted based on the extent of each area-type classifiied above by the topography and the vegetation. Eight zones were set as follows (Fig. 5) :

Zone 1 : Primeval nature conservation zone

This is a zone whose primeval nature should be preserved in status quo.

Zone 2 : Nature conservation (in a narrow sense) zone

In this zone, nature conservation should be thought of first as respecting the natural features, though some utlizations of nature, for example, uses as recreation areas, would be permitted.

Zone 3 : Planted forest conservation zone

This is a zone where forest management should be harmonized with nature conservation. This zone serves as a buffer zone of the primeval nature consevation zone and the nature conservation zone mentioned above.

Zone 4 : Hills conservation zone

This is a zone where typical forest and landscape of hills should be protected.

Zone 5 : The Tama River conservation zone

This is a zone where submerged grasslands in the riverbed of the Tama River should be protected together with the vegetation of the adjacent areas.

Zone 6 : Garden city zone

This is a zone where garden cities with plentiful greens are desired. Remaining forests and farm lands become the core of the green areas in this zone.

Zone 7 : Green urban zone

This is an urban zone where recovery of lost nature should be attempted by afforestation.

Zone 8 : Seabord conservetion zone

This is a zone where the natural features of the seasides of Tokyo Bay should be protected.

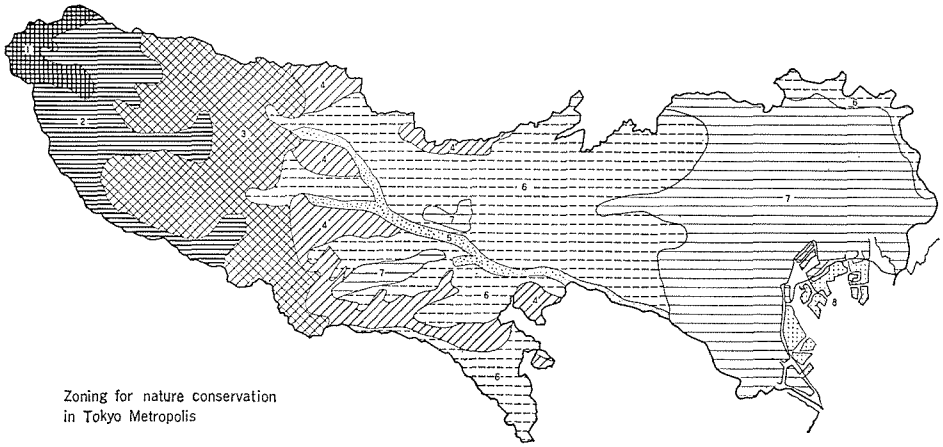

Fig. 5. Map of the zoning for nature conservation in Tokyo Metropolis (Tokyo Metropolitan Government 1975). Explanation in text.

This zoning is a master plan for conservation of nature, mainly of vegetation, in Tokyo. In this plan, the future appearance of natural features, procedures of conservation including preservation, protection, restoration and controls on various kinds of exploitations, are defined for every zone.

2. Ecological Management of Vegetation in the Conservation Area

In Tokyo a number of nature conservation areas have been designated by the Tokyo Metropolitan Government beside a national park (Chichibu-Tama National Park) and a quasi-national park (Meiji no Mori, Takao Quasi-National Park). Every conservation area of Tokyo is small in size, but has diverse vegetation types containing natural forests, secondary forests, grasslands and vegetations of cultivated and abandoned cultivated lands etc. Consequently, it is necessary to manage the vegetations ecologically and intensively.

(1) Fundamental idea for the planning of vegetation management

Figure 6 is a flow chart of the planning of vegetation management (in a broad sense) by the author (Okutomi 1977).

At the first step of the planning (I in Fig. 6), a list of plant communities occurring in the area concerned, an actual vegetation map and a potential natural vegetation map of the area should be made through phytosociological surveys. At the same time, community-ring (Gesellschaftsring, Schwickerath 1954) should be made clear in every habitat type through the investigation of community dynamics.

At the next step (II in Fig. 6) the vegetation units (communities) must be evaluated from the point of view of vegetation science, for example, for qualities of naturalness, scarcity and typicalness, and also from the view of particular purposes given to the area, for example, protection of man's environment, wildlife protection, conservation of natural resources, nature education and so on.

Then, conservation measures, or conservation forms are designated to every community according to the results of vegetation evaluation in the former step (III in Fig. 6). That is, it must be decided which community should be preserved, which should be conserved, and which should be restored.

The fourth step is a decision of the procedures of vegetation management (in a narrow sense). This step consists of three substeps (1 to 3 of III in Fig. 6).

The first substep is a zoning of the area concerned according to the conservation forms of every community. In the zoning the extent of every community which should be preserved, conserved or restored are concretely decided and shown on a map (this map is called an "object vegetation map" by the Tokyo Metropolitan Government). In this process the actual vegetation map and the potential natural vegetation map of the area concerned are very usefull.

In the next substep, fundamental procedures are decided as to how the communities should be preserved, conserved or restored. The fundamental procedures are chosen on the basis of the following five principles: to adjust to the rule of nature, to control succession, to accelerate succession, to create semi-natural communities similar to wild communities and to use as natural resources.

On the other hand, decisions are also made in this substep on fundamental procedures for protection against biological disturbances by man, wild animals and fungi and physical disturbances by strong wind, air pollution, degradation of habitat and so on.

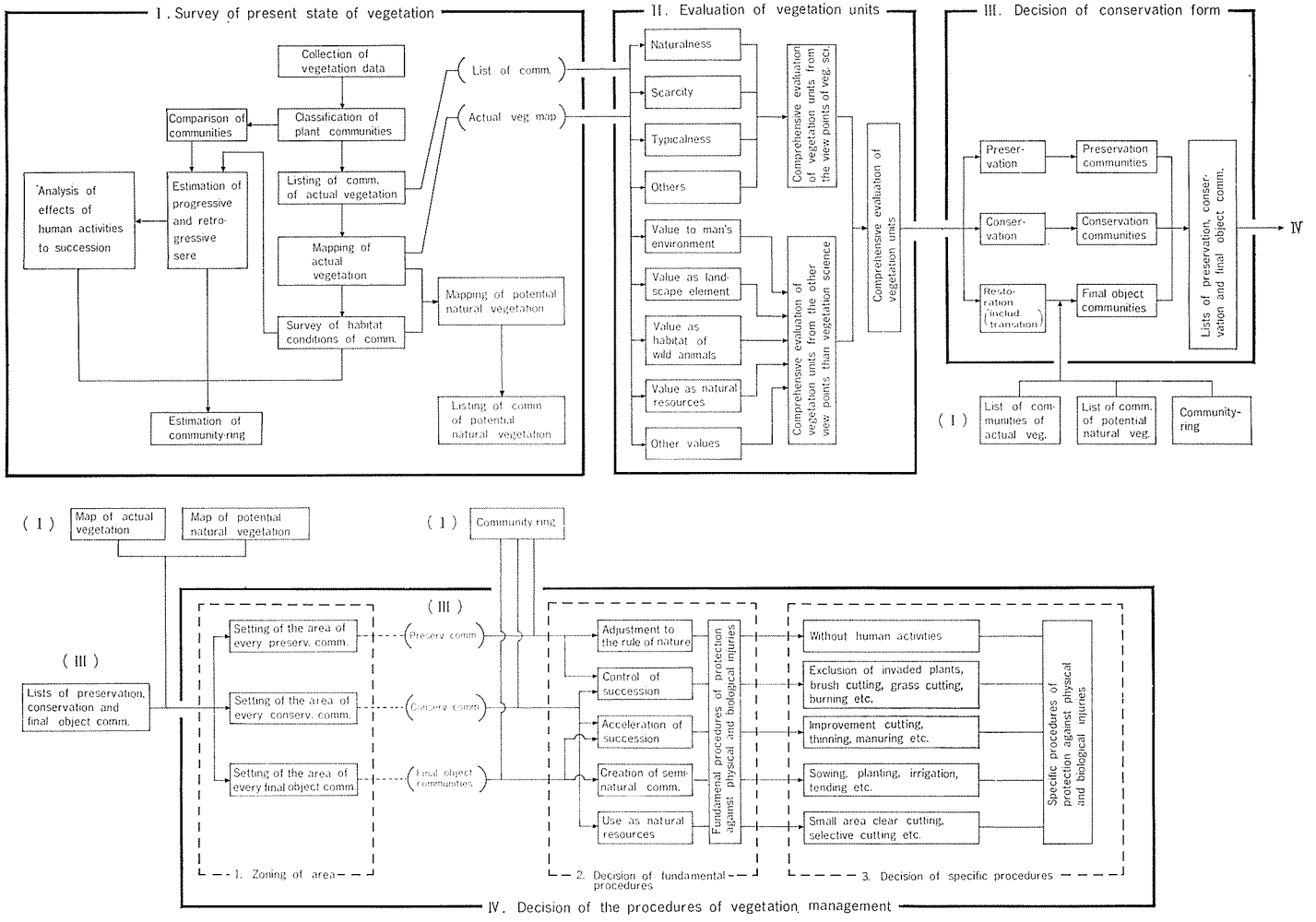

Fig. 6. A flow chart of the planning of vegetation management (Okutomi 1977)

In the third substep, the specific procedures of vegetation management must be defined to accomplish the purposes of the fundamental procedures taken in the second substep. Some examples of the specific procedures of vegetation management are given in Fig. 6.

(2) An example of vegetation management in the nature conservation area in Tokyo

Finally, an example will be presented of the vegetation management plan in one of several nature conservation areas of Tokyo, which was prepared by the Tokyo Metropolitan Government's Bureau of Environmental Protection in 1975.

Figure 7 indicates the extent of actual vegetation in the Nanakuniyama Nature Conservation Area in southern Tokyo. As seen in the actual vegetation map most

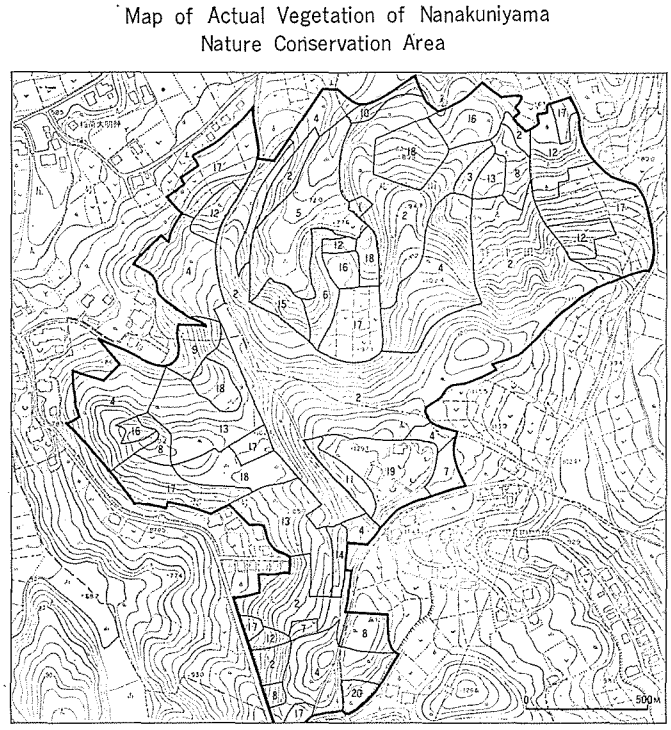

Fig. 7. Map of actual vegetation of Nanakuniyama Nature Conservation Area (Tokyo Metropolitan Government 1975).

1. Quercetum myrsinaefoliae 2. Quercetum acutissimo-serratae
3. Quercetum acutissimo-serratae with many evergreen broad-leaved shrubs
4. Quercetum acutissimo-serratae accepting brush cutting
5. *Phyllostachys nigra* var. *henonis-Aralia elata* community
6. Culled forest 7. *Pinus densiflora* plantation 8. *Cryptomeria japonica, Chamaecyparis obtusa* plantation 9. *Phyllostachys heterocycla* var. *pubescens* stand (culled stand) 10. *Phyllostachys heterocycla* var. *pubescens, P. bambusoides* stand (good stand) 11. *Pinus densiflora-Eurya japonica* plantation 12. Deciduous orchard 13. *Pleioblastus chino* community 14. *Miscanthus sinensis* community 15. Mantle community
16. Plant communities in clear cut area 17. Field 18. Uncultivated field
19. Planted trees in garden 20. Residential area with many planted trees

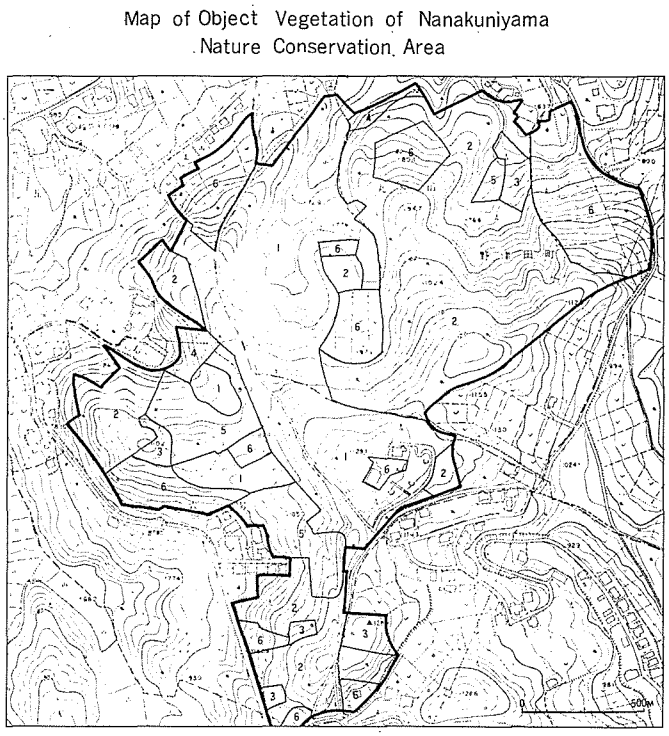

Fig. 8. Map of object vegetation of Nanakuniyama Nature Conservation Area (Tokyo Metoropolitan Government 1975)

1. Evergreen broad-leaved natural forest 2. Deciduous broad-leaved secondary forest 3. Plantation 4. Bamboo stand 5. Secondary grassland 6. Others (field, residence etc.)

of the area is covered by substitutional communities such as secondary forests, planted forests and secondary grasslands. Figure 8 shows an object vegetation map of the area, which was drawn on the basis of the concept of the planning of vegetation management explained above.

Some specific procedures in vegetation management were also developed from this concept and are now being put into practice, though the description is omitted in the present paper.

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