PROCESS OF PHYTOSOCIOLOGICAL STUDIES AND VEGETATION MAPPING*

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Synopsis

Systematic phytosociological studies have delineated many of the Japanese vegetation types. However, the procedures in mapping the actual vegetation types and especially mapping the potential natural vegetation types have received limited attention. Most vegetation mapping has been based upon species dominance or physiognomy. The purpose of the present paper is to describe the various procedural steps involved in systematic vegetation mapping according to the Braun-Blanquet's system of vegetation classification. The significance of vegetation mapping is illustrated for land use planning and resource management.

INTRODUCTION

In recent years numerous intensive phytosociological studies have been published in Japan. Considerable attention has been given to describe, identify and classify plant communities into vegetation units according to the Braun-Blanquet School of Phytosociology. Several detailed vegetation mapping projects have been undertaken to map the existing or actual vegetation types. Almost nothing is known about the creation of a vegetation map of potential natural vegetation. This type of vegetation map better illustrates the potential productivity of the land and its natural vegetation on no condition of man's disturbances and alterations.

The process of creating such a potential natural vegetation map in described. Several sequential steps are to be undertaken in such a mapping project. The following discussions will deal with these steps, namely 1) Analysis of the plant community, 2) Synthesis and classification of the plant communities by synthesis tables, 3) Actual vegetation mapping procedures, and 4) Preparation of the potential natural vegetation map.

1. ANALYSIS OF THE PLANT COMMUNITY

The first and most significant step in vegetation studies is to collect reliable and quantitative field data. This is done in the field by adopting the Releve technique of

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Braun-Blanquet. The releve (Vegetationsaufnahme ; Aufnahme) is equivalent to a sample plot in vegetation analysis. All the existing plant species have to be properly identified regardless of their vegetative state being a seedling or a mature plant individual. It is very significant to record all the species occurring within the sampled area and to identify the plant taxon properly. The choice of the sample area is not arbitrary. Specific and significant requirements have been imposed on the releve size. The releve must first be of sufficient size to encompass the most characteristic species composition. This has been identified as the minimal area, i. e. an area sufficiently large to be representative of the most characteristic species assemblage. The definition of the minimal area is done empirically and it may differ from plant community to plant community. Our experience with Japanese vegetation has indicated the following empirical values:

Forest communities	200–500m²
Shrub communities	50–200m²
Miscanthus grasslands	25–100m²
(Dry or xeric grasslands)	
Hay meadows	10–25m²
Agricultural weed communities	25–100m²
Moss communities	1–4m²
Lichen communities	0.1–1m²

Secondly, the releve shape or form is not always quadratic or rectangular. The extent of the releve sample area must at least exceed the minimal area. It also must include only homogeneous vegetation and homogeneous site conditions. This requirement for floristic as well as environmental homogeneity is a very important one. The main philosophical thought behind this foremost requirement is to define the most typical or characteristic plant communities and to avoid as much as possible transitions, intergradations and mixtures of plant communities. This is because the releves are to be used as the foundation for a synthesis and a classification of plant communities. The researcher does recognize the various transitions in the vegetation pattern but his principal objective is to sample the purest and most homogeneous plant communities first and foremost to arrive at a practical definition and classification of vegetation units.

The traditionally accepted methodology of making a releve is to stratify the vegetation into height layers or strata. In Japan for forest communities the following height strata have been generally adopted:

1. $T_1(B_1)$ ………… Tree 1 layer (Overstory trees)
2. $T_2(B_2)$ ………… Tree 2 layer (Understory trees)
3. S ……………… Shrub layer
4. H(K) ………… Herb layer
5. M ……………… Moss and lichen layer

The individual species or taxa are listed by these height layers. Taxa or species can be repeated in the various height strata as they occur in that stratum. Many different scales have been proposed for estimation of the cover degree-abundance. The oldest and most accepted cover degree-abundance scale is the following one, originally proposed by Szafer-Pavlowksi in 1926 and Braun-Blanquet in 1932:

r = very rare and with the smallest cover degree
+ = sparsely or very sparsely present, cover very small or insignificant
1 = plentiful but of small cover value
2 = very numerous in abundance of individuals or covering at least 1/20 of the area
3 = any number of individuals but cover 1/4 to 1/2 of the area
4 = any number of individuals but cover 1/2 to 3/4 of the area
5 = any number of individuals but cover more than 3/4 of the area

Each individual taxon or species must be estimated for its appropriate cover degree. All the individuals of the same plant species or taxon are considered jointly to represent that cumulative cover degree, and the appropriate symbol must be chosen from the above cover degree-abundance scale. Tradition and practice has proven that the chosen cover degree intervals and designations are the most consistent and practical ones and that experienced field workers rate consistently the same vegetation with the same symbols, thereby developing great consistency among field workers. Practical experience in Japan has substantiated this and the above scale has been uniformly adopted for vegetation studies.

Another quantitative estimate per taxon is its sociability rating. Under sociability is meant the grouping or touching of individuals of the same species or taxon, the clumping or clustering of that one species within the confines of the sampled area. Braun-Blanquet (1932, 1951, 1964) has proposed the following sociability scale:

1 = growing singly or the plant individuals are not touching each other by foliage
2 = growing in small groups or tufts or clumps
3 = growing in small patches, troops, cushions
4 = growing in larger groups or colonies, forming patchy carpets, fairly extensive
5 = growing in very extensive patches or covering the sample area in one large population.

The above sociability scale has been almost universally adopted worldwide. It is also the standard sociability scale for our Japanese vegetation studies.

Another more pualitative, yet very significant attribute is the assessment of the vitality of the plant species. No standard vitality scale has been adopted or proposed by Braun-Blanquet and other phytosociologists. However, the following vitality scale has been informally adopted, tested and used in our Japenese vegetation studies.

°° = very feeble, weak, never fruiting (i. e. +°° or 2•2°°)
° = feeble or weak, unhealthy (i. e. 1•1°)
no indication = normal health of condition of the taxon
• = exceptionally vigorous (i. e. +•)

In the releve it has been the tradition to insert the symbols of cover degree-abundance, sociability and vitality in front of each taxon. An example of such a releve is included.

The releve is investigated with other data such as a description of the environment, slope position, slope aspect, slope angle, elevation, soil and geological information, and a detailed description of the releve location on maps with coordinates, etc. Additional information as to plant or crop productivity, crop biomass, human disturbance, etc. can be added, if available, to provide the cross-correlations of species combinations and/or the plant community with this kind of information.

Table 1. An example of a releve

No. of releve K-223, Date Sept. 30, 1978, Location (Pref.); Temple Saiho-ji (Kanagawa-Pref.)
By A. Miyawaki, K. Suzuki & H. Tohma

Height & cover of tree-1 layer	20 m	60 %
Height & cover of tree-2 layer	8 m	30 %
Height & cover of shrub layer	3 m	40 %
Height & cover of herb layer	0.8 m	30 %

Area 25×25 qm, No of species 54 spp.

Tree-1 layer			
4·4	*Quercus myrsianefolia*	1·1	*Chamaecyparis obtusa*
2·2	*Carpinus japonica*	1·1	*Meliosma myriantha*
1·1	*Carpinus tschonoskii*		
Tree-2 layer			
1·2	*Quercus myrsinaefolia*	+	*Zelkova serrata*
+·2	*Quercus glauca*	+	*Carpinus tschnoskii*
Shurb layer			
1·2	*Neolitsea sericea*	+	*Carpinus tschonoskii*
1·2	*Aucuba japonica*	+	*Kalopanax pictus*
1·2	*Akebia trifoliata*	+	*Lindera glauca*
1·2	*Zanthoxylum piperitum*	+	*Cephalotaxus harringtonia*
1·1	*Eurya japonica*	+	*Trachycarpus fortunei*
+	*Quercus glauca*		
Herb layer			
2·3	*Ophiopogon japonicus*	+	*Lilium auratum*
2·2	*Dryopteris erythrosora*	+	*Gynosemma pentaphyllum*
1·2	*Disporum sessile*	+	*Ardisia japonica*
1·2	*Trachycarpus fortunei*	+	*Zanthoxylum piperitum*
+·2	*Chlorantus japonicus*	+	*Neolitsea sericea*
+·2	*Lespedeza bicolor* f. *acutifolia*	+	*Hedera rhombea*
+·2	*Tricyrtis macropoda*	+	*Akebia trifoliata*
+·2	*Polygonatum falcatum*	+	*Aucuba japonica*
+	*Quercus myrsinaefolia*	+	*Quercus serrata*
+	*Liriope platophölla*	+	*Smilax china*
+	*Aphananthe aspera*	+	*Dioscorea tokoro*
+	*Styrax japonica*	+	*Ligustrum obtusifolium*
+	*Lonicera gracilipes* var. *glabra*	+	*Callicarpa japonica*
+	*Euscaphis japonica*	+	*Osmunda japonica*
+	*Hewingia japonica*	+	*Parthenocissus tricuspidata*
+	*Dryopteris bissetiana*	+	*Calanthe discolor*
+	*Ampelopsis brevipedunculata*	+	*Pourthiaea villosa* var. *laevis*
+	*Smilax japonica*	+	*Athyrium japonicum*
+	*Angelica decursiva*	+	*Aster scabra*
+	*Cymbidium goeringii*	+	*Stegnogramma pozoi* ssp. *mollissima*
+	*Euonymus fortunei* var. *radicans*	+	*Atractylodes japonica*
+	*Caphalanthera erecta*	+	*Rhus trichocarpa*

It is of further importance to sample as many local plant communities as possible to facilitate later the distinction of vegetation units like association, alliances, etc. Of great significance to the classification of plant communities is to recognize the relationship and patterns of plant communities with microrelief, landform, climate and other environmental factors. Special attention should be focused upon the dynamics of the plant communities under study, their successional trends and especially their so-called contact communities.

Fig. 1. Field investigation at Shimokita-area in N-Honshu.

These interrelationships can provide valuable insights into the dynamic changes in plant community evolvement. Certain species combinations present in the plant community may indicate future dominance or change in floristic composition. Traditionally, such successional trends can be classified as related associations belonging to the same alliance and class but this is not necessarily so. More often, certain shrub associations may evolve into forest associations belonging to an entirely different alliance and/or class. The significance of the above observations is that such dynamic patterns must be recognized and sampled in the field. Sufficient successional communities as well the end phase of floristic evolvement or succession be sampled by a sufficiently large number of releves to ascertain such postulated trends later in the tabular synthesis table work.

2. SYNTHESIS AND CLASSIFICATION OF PLANT COMMUNITIES BY SYNTHESIS TABLES

A synthesis table is a tabular arrangement and compilation of raw field data in a more appropriate format for synthesis. Generally, the traditional format of synthesis tables is to arrange the individual releves in vertical columns and to group or tentatively classify the species or taxa in horizontal rows. Thus, field data are copied into this format and relevant environmental data and locations are included into this tabulation. It is customary to include releves of similar floristic composition into one synthesis table. This constitutes the so-called raw synthesis table or raw table. Often, the listing of species is overwhelming. Usually, some 35–50 releves are grouped into one large synthesis table and the analysis techniques are applied to these limited raw tables. Raw tables are prepared in addition for other related communities.

The next step is to limit the species composition and the number of releves. It has been customary to exclude from this analysis species that are present in all the releves listed within one synthesis table since such species contribute little in segregating the various releves into more select groupings. Also excluded are species that occur only singly or very infrequently. There are no strict rules but customarily, Tüxen, Braun-Blanquet and other phytosociologists have used or limited their analyses to species that occur within the 15% to 85% frequency or constancy brackets, others for species within the 20% and 70% bracket. A new resorting of species into more homogeneous groupings as well as a reordering of releves is undertaken to determine a better segregation of the releve material. Sometimes even certain releves which are very dissimilar, are dropped from the synthesis table at this point. The synthesis table is now rewritten including only the species within the above frequency or constancy brackets and the resulting table is called the constancy table. This process can be repeated further to eliminate even more species and the result is a more condensed partial table.

With a good constancy table or partial table one is generally in a good position to discern distinct species groupings and releve groupings. A new table is rewritten this is called the differential table. This differential table is so arranged in such a way that the various plant species which best differentiate or segregate the various plant communities are listed first or in the top part of the synthesis table. Species or taxa that occur in several of the newly created groupings are listed towards the bottom of the synthesis table. Sometimes, a summary table is prepared extracting from the differential table only the most obvious and significant species groupings for the resulting segregation of the plant communities. This often has been called the summary table.

Upon satisfactory segregation of the releves into separate vegetation entities the most representative releves of the newly recognized vegetation entities are selected. These selected releves are properly grouped and their entire floristic composition is transcribed from the

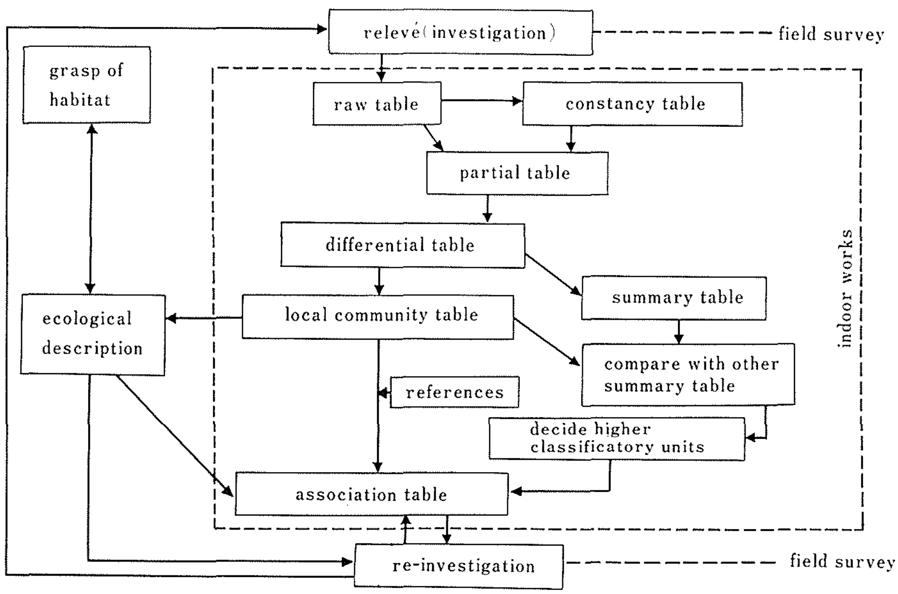

Fig. 2. Flow chart of the systematic procedures in applying the Br.-Bl. synthesis table technique.

original raw table. Additional species my be added to the various species groupings, if necessary, by including all the species present irrespective of the above constancy brackets of 15% to 85%. This table is called the local community table. Completing this table with the necessary ecological or environmental description of significant parameters and upon checking the literature references of formerly published plant communities, one can arrive upon a regrouping of species into more diagnostic groupings for classificatory purposes. At the same time, the summary table should be compared with other similar summary tables of other vegetation units to decide upon these diagnostic species groupings with the same classificatory purpose in mind. Through this intuitive process and appreciation of diagnostic species values one can arrive upon the so-called character value or fidelity of a given species or group of species in terms of the classificatory description of the vegetation unit. One can then provide a scientific name and nomenclature to the identified vegetation units. Certain species groupings are then identified for the purposes of the description as association character species, others as alliance charater species, or even as class character species. For a satisfactory nomenclature a sufficient number of releves must be published illustrating these various species groupings and their presumed diagnostic values. This will enable other researchers to check the original releves. It has been customary to classify associations only upon publication of as least 3–5 published releves although associations have been named upon the publication of even only 2 releves.

It would be better, upon creating the final association to reinvestigate the validity of the association with additional field surveys and additional releves. If upon such additional field work the distinctions among such associations remain valid, the association nomenclature is then published. Validity of the association nomenclature is based upon priority of publication date and the vegetation nomenclature follows the same general nomenclature rules of plant taxonomy.

The following flow chart (Fig. 2) illustrates diagrammetrically the above procedures.

3. ACTUAL VEGETATION MAPPING PROCEDURES

The field work or mapping process is aimed at delineating the areal extent of the classified plant communities. There are many types and kinds of vegetation maps, depending upon their purposes, scale and delineation of vegetation units. The various vegetation units are represented by colors and/or symbols and are superimposed upon a suitable map base. The current mapping in Japan has distinguished current or existing vegetation which has substituted the natural vegetation and has been strongly influenced by man. Natural or semi-natural vegetation remains only patchy in remote areas like high mountain tops or in very unstable and unsuitable habitats which have escaped the human impact so far.

The mapping objective is primarily to transmit environmental or ecological information in graphical format. The mapping process can be divided into the following steps:

1) The creation of a suitable classification of plant communities through phytosociological research and the distinction of diagnostic species groupings.

2) The precise location of representative stands of the classified vegetation units on the map and the areal extent of the recognized vegetation units. Often, important releves are indicated on such maps.

3) To aid other professional fields in disseminating the scientific phytosociological information and to indicate or relate this with the land use patterns on maps.
4) To illustrate the spatial arrangements of related vegetation units and to depict graphically the distribution pattern or mosaic of vegetation units.
5) To delineate the geographic limits of distribution of vegetation types.
6) To indicate areas of succesional patterns among vegetation units
7) To help distinguish causal relationships in the environment governing plant and/or crop distribution
8) To help identify practical applications of phytosociology like delineation of soil types, geological formations, areas of high crop productivity, poorly drained areas, etc. These practical applications interpret the distinguished plant communities as to their agricultural, silvicultural valus and can help in the decision-making process for proper land use.

One must proceed with the field work systematically. Use of suitable aerial photography facilitates greatly the interpretation of vegetation types. Sufficient ground reconnaissance must be undertaken to verify this photo-interpretation process. The degree of accuracy depends largely upon the mapping scale. In Japan, the most commonly used scales for vegetation mapping has been 1 : 25,000 or for very detailed mapping 1 : 5,000. Each map must be accompanied by a legend in which the recognized vegetation units are described for the indication of their environment. These phytosociological findings are often translated into practical applications in such map legends. Japanese experience has indicated that the existence of a good vegetation map can help in resolving conflicting land use options and also indicate the need for protection of the most proper land uses within a region or locale. The mapping process is costly and mapping is done in the field by experienced phytosociologists. It requires a field assessment of the characteristic species combination and a classification into the formalized association nomenclature. Transitions, if they are extensive, can be recognized by combining the color codes of the two adjoining associations. In case of the use of aerial photography numerous field checks are needed to verify the map distinctions and a systematic process of field checking must be initiated which is often time-consuming.

One of the values of such phytosociological maps is the distinction of plant communities and their environments even in the winter or dormant season. So land use planning

Table 2. Process of the actual vegetation mapping

releves
↓
classification based on floristic criteria
↓
establishing the mapping key for the actual vegetation map (legend)
↓
field mapping of the actual vegetation map
↓ ↑
mapping correct with the aid of aerial photographs & topographic maps
↓
the final map preparation of the actual vegetation

processes are not limited by the growing seasons.

Table 2. illustrates schematically the various steps described above.

In the mapping the actual vegetation attempts are made to assess the degree of human disturbance or human impact. Upon human impact certain sensitive floristic elements of the natural association have been replaced by other, often weedy species. Such foreign elements introduced into the natural species composition are called substitute species. Often, the total natural species composition has been eliminated as in the case of drastic conversion from natural forest to farmland. By mapping the potential natural vegetation on a map base one can make inferences as to the substitute vegetation types. Further degradation of the vegetation can occur by conversions of the farmland into residential areas, industrial parks, etc. The following scale of degradation has proven to be practical for the natural grade mapping (Fig. 5):

Symbol	Vegetation distinction
V ·········	Natural pristine vegetation, undistrubed by man (Ardisio-Castaneopsietum sieboldii)
IV ·········	Semi-natural vegetation, secondary forest, partly disturbed by man (Quercetum acutissimo-serratae)
III ·········	Miscanthus grassland communities (Arundinario chino-Miscanthetum sinensis)
II ·········	Rice fields, farmland communities (Pinellia ternata-Euphorbia pseudochamaesyce-association)
I ·········	Residential district and bare lands

The adoption of the above degradation scale permits the evaluation of environmental conditions within cities, urbanized areas, etc. even in the absence of the vegetation.

4. PREPARATION OF THE POTENTIAL NATURAL VEGETATION MAP

It is very important to prepare an additional map from the above phytosociological map which delineates pristine or primeval vegetation types, not influenced by man. The philosophy behind such a map is that the pristine natural vegetation would be most indicative of its environment or habitat and illustrate best the land productivity on a long term basis. It is very valuable to investigate and describe the floristic composition of these last remaining undisturbed areas and to study their dynamic processes, and soil formation processes and their evolution. Most of such pristine vegetation has been preserved in national monuments, religious shrines and national parks. These protected areas are the only remaining raeas indicating the original vegetation types and are therefore, of the greatest scientific signifance.

Based upon the analysis of floristic components inferences and/or interpretations can be made as to their areal extent prior to the dominantion of man. Plotting such tracts of remnant pristine vegetation on a map base and classifying them into vegetation units can illustrate graphically their potential distribution in the landscape. Such maps may further reveal significant information as to the deterioration and damage done by the human impact upon the native resources of Japan. Thus, the distinction of such potential natural vegetation types can be of great value to land use planners in the allocation of land resources to the human benefit and to protect such inherent resources from further degradation and ultimate loss. It may further indicate the need for continued and renewed preservation efforts to protect the last remaining unspoiled areas of great significance as part of the national heritage of Japan.

The following schematic representation illustrates the various steps in the preparation of the potential natural vegetation map (Fig. 3).

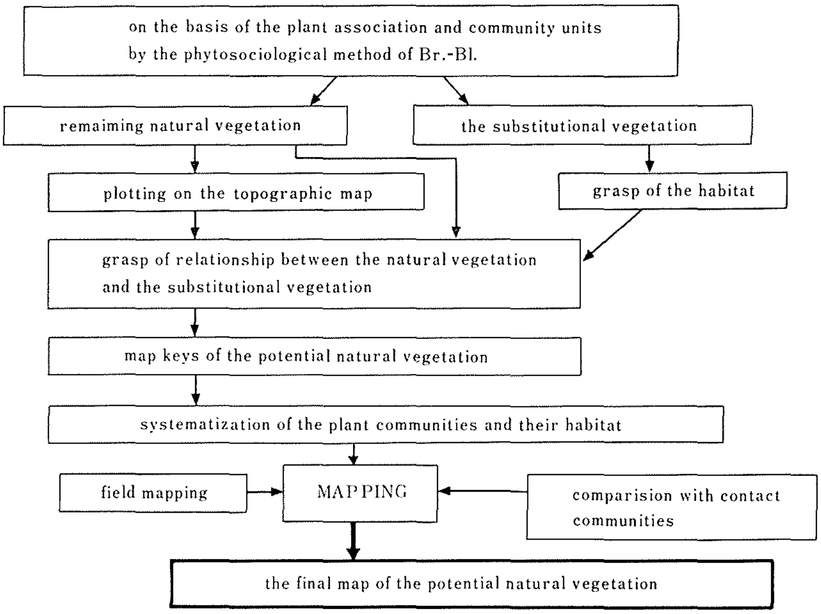

Fig. 3. Flow chart of the potential natural vegetation mapping.

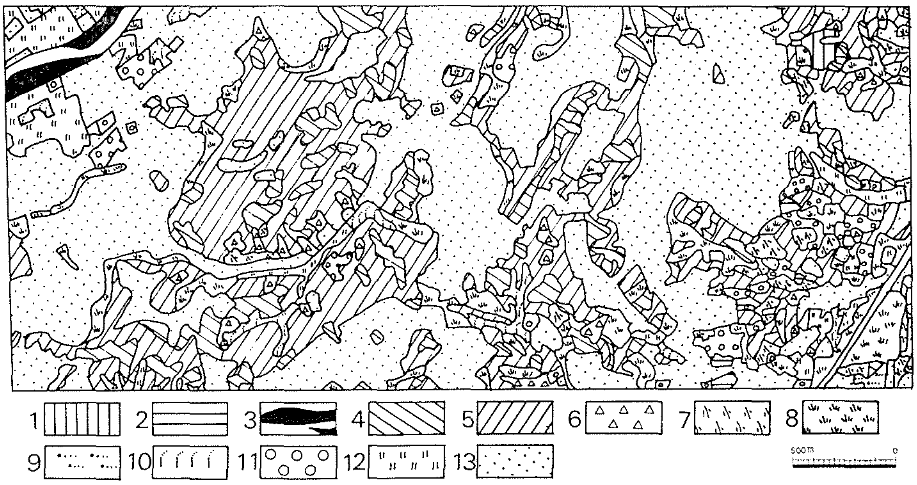

Fig. 4. Actual Vegetation Map of Musashi-fuchu-Area, Tokyo.

A: Natural Vegetation, 1: Ardisio-Castanopsietum sieboldii, 2: Quercetum myrsinaefoliae, 3: Miscanthetum sacchariflori, B: Substitutional Vegetation, 4: Rhododendro-Pinetum kaempferi, 5: Quercetum acutissimo-serratae, 6: *Crypto-*

meria japonica and *Chamaecyparis obtusa*-plantation, 7: *Phyllostachys heterocycla* f. *pubescens*-comm., 8: Arundinario chino-Miscanthetum sinensis, 9: *Zoysia japonica*-comm., 10: *Polygonum thunbergii-Microstegium vimineum* var. *polystachyum*-comm., 11: Pinellia ternata-Euphorbia pseudochamesyce-association, 12: Sagittaria pygmaea-Monochoria vaginalis-association, C: Other, 13: Residential district and bare lands.

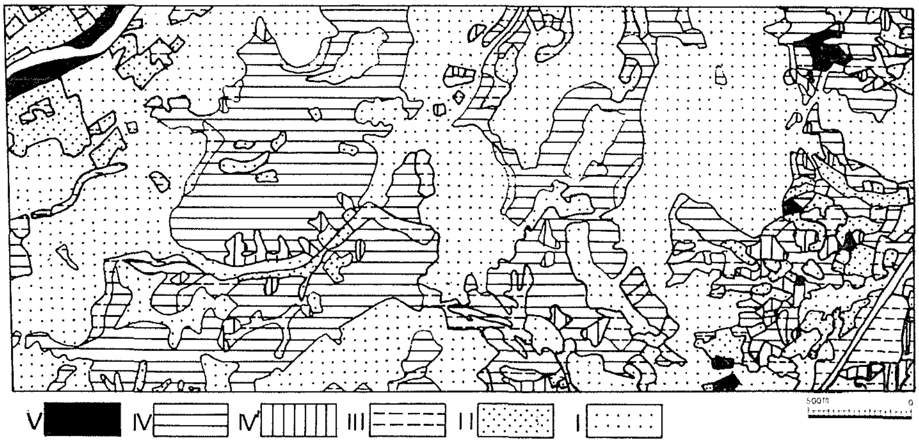

Fig. 5. Natural Grade Map of Vegetation on the Musashi-fuchu-Area, Tokyo.

Symbol V: Natural vegetation, IV: Semi-natural vegetation, IV′: Plantations, III: *Miscanthus sinensis* grasslands, II: Rice fields, farmland communities, I: Residential district and bare lands

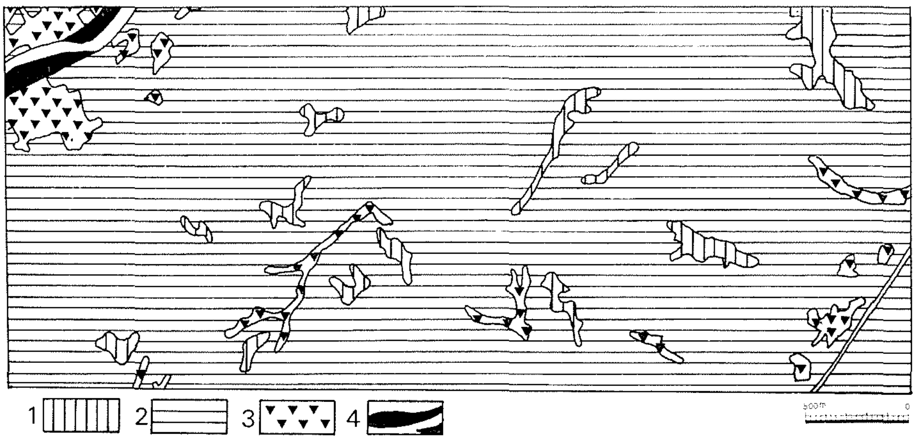

Fig. 6. Potential Natural Vegetation Map of Musashi-fuchu-Area, Tokyo.

1: Ardisio-Castanopsietum sieboldii, 2: Quercetum myrsinaefoliae, 3: *Quercus acutissima-Alnus japonica*-comm., 4: Miscanthetum sacchariflori.

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