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Original paper

The vegetation on the granite rock area at Ashimori, Okayama City, S.W. Honshu, Japan

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岡山市足守における花崗岩地域の植生

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Abstract: The vegetation developed on the granite rock area was studied phytosociologically at Ashimori, Okayama City, S.W. Honshu, Japan. We recognized 12 communities of forest vegetation and three communities of moor vegetation. The typical *Pinus densiflora* community, covering 70% of the study area, was developed mainly on the ridges and slopes. We described the floristic composition of each communities, and drew a detailed vegetation map based on the recognized floristic communities in accord with the microtopographic data obtained through the field survey.

I. Introduction

To reveal the influence of geological and topographical feature on the vegetation, we investigated the vegetation of the granite rock area of Ashimori, Okayama City, S.W. Honshu, Japan. Study of the vegetation developed on granite rock area in Okayama Pref. were carried by Ishibashi (1980), and Nishimoto and Hada (1994). But these report has no vegetation map. To elucidate the relation between vegetation and geological and topographical feature, we needs an accurate vegetation map. We aim to draw the precise vegetation map considering the microtopography.

II. Study area

The study area (Fig. 1) of 3.99 km^2 is located at Ashimori, Okayama City, S.W. Honshu, Japan (34°42′ N, 133° 56′ E). The altitude ranges from 10 to 202 m above sea level. The climate of the area is characterized by a relatively small amount of rainfall and a warm temperature. Mean annual temperature is 16.1 °C and annual precipitation is 1,118 mm at the nearest meteorological station of Okayama (Website of the Japan Meteorological Agency). Geologically, the area is covered only by granite rocks (Mitsuno 1977).

III. Methods

Field surveys were carried out in 2005-2007. Cover-abundance and sociability (Braun-Blanquet 1964) of all vascular plants were recorded in 73 quadrats (size 100-225 m^2) in the forests. The names of species followed Satake et al. (1981, 1982a, 1982b, 1989a, 1989b) for flowering plants, and Iwatsuki (1992) for ferns.

Vegetation types were classified on the basis of species composition by phytosociological methods (Braun-Blanquet 1964). These data were analyzed by the computer program, Veget of Hada & Toyohara (1990).

A vegetation map, 2.1 km×1.9 km, were made in 2007 using field surveys based on floristic criteria, establishing whether diagnostic species of each vegetation type were present or absent in the field.

IV. Results

From the phytosociological research, following 15 communities including three communities of moor vegetation were recognized. Table 1 shows the species composition of forest and moor communities. Some explanations on those are as follows:

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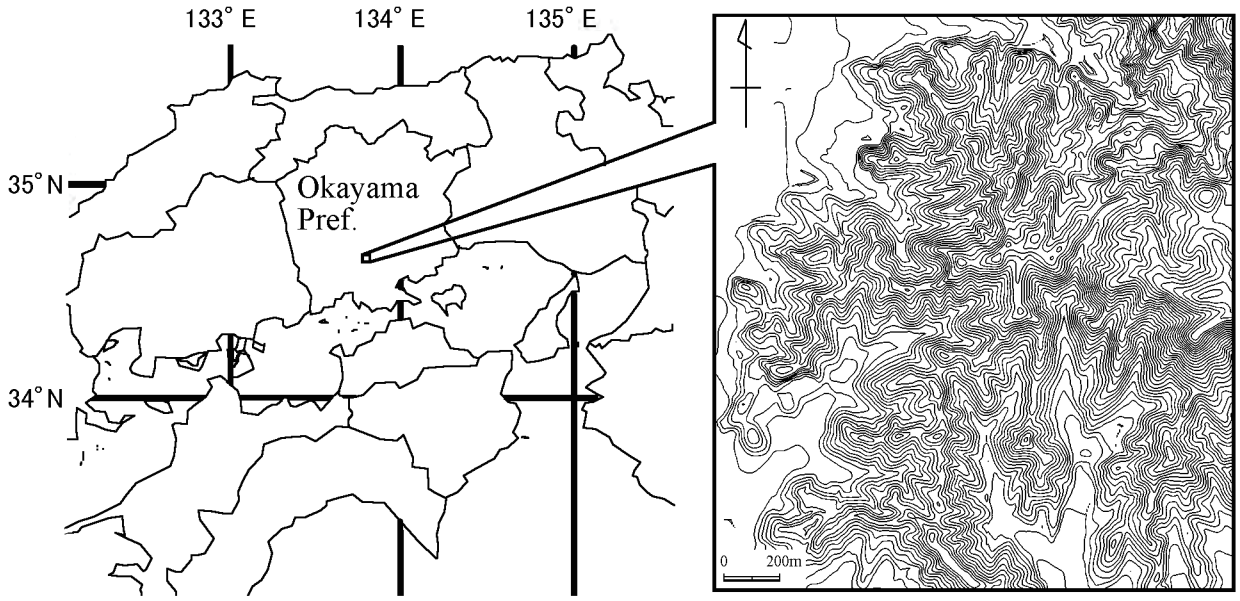


Fig. 1. Map showing the location of the study area. The interval of contour lines is 5 m.

1. Vegetation

A. *Pinus densiflora* sub-tree forest

Only the *Pinus densiflora* sub-tree forest, occurring on the rocky sites, was recognized in this forest type. In the sub-tree layer, *Pinus densiflora* was dominant, and *Miscanthus sinensis* was also appeared in the herb layer. Height of the communities is rather low, 6-8 m, and floristic composition was poor.

B. *Pinus densiflora* forest

In this forest, following heliophytes occurred, such as *Juniperus rigida*, *Diplomorpha sikokiana*, *Vaccinium oldhamii* and *Pinus densiflora*. This forest was divided into the following four communities. Among the communities, the *Pinus densiflora* typical community covered 70 % of the investigated area, of which height was 7-15 m.

a. *Pinus densiflora* - *Miscanthus sinensis* community

This community is characterized by the presence of species group 2, 4 and 5 (Table 1). Coverage of the tree layer and average number of species was rather small.

b. *Pinus densiflora*-*Dicranopteris linearis* community

Characteristic feature of this community was the dominant of *Dicranopteris linearis*. After the damage of the *Pine* disease, *D. linearis* has grown densely there. Thick coverage of *D. linearis* inhibits the growth of various herb species or wood seedling.

c. *Pinus densiflora* typical community

This community has no character species, but the most predominant vegetation unit in the study area.

d. *Pinus densiflora*-*Quercus serrata* community

This community is characterized by the presence of species group 4 and 7 (Table 1). Height of tree layer was 9 to 16 m, heigher than former vegetation unit. It seems to be intermediate stage to *Quercus serrata* community.

C. *Quercus serrata* forest

Quercus serrata forest is characterized by evergreen broad-leaved tree such as *Quercus glauca* and *Ilex chinensis*. It developes on the valley and gentle slopes of the mountain foot. Average number of the species is highest among the forests investigated.

D. *Quercus variabilis* forest

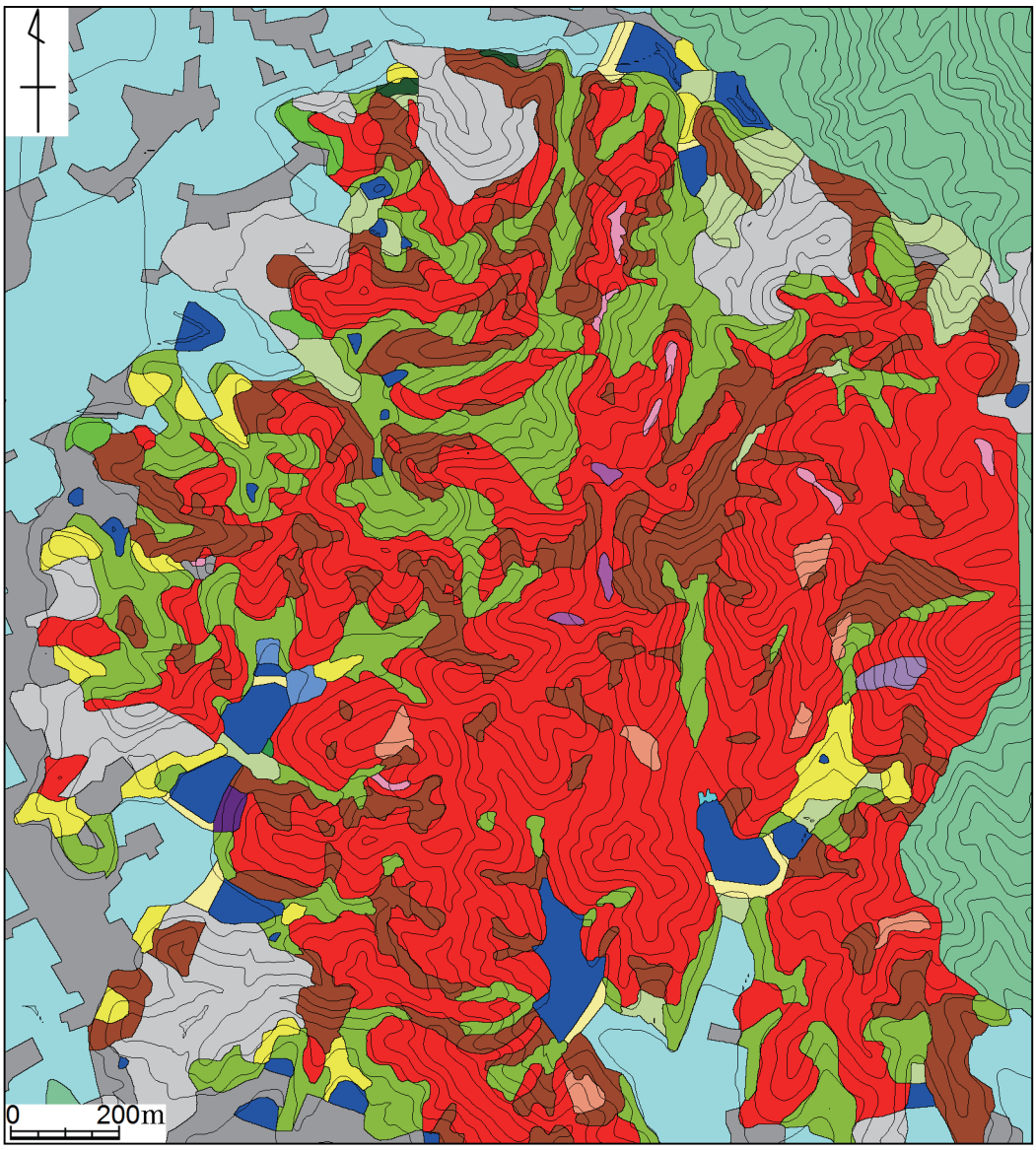
This forest was predominant by *Querus variabilis* in tree layer. *Q. variabilis* is deciduous broad-leaved tree grown up to more over 15 m. This forest was developed around village or cultivated land.

E. *Quercus glauca* forest

Quercus glauca is evergreen broad-leaved tree, one of the species occurring in late stage of succession. This forest was developed at shores of pond.

F. *Lithocarpus glabra* forest

Lithocarpus glabra (Fagaceae) is evergreen broad-leaved tree. Distribution of this species is rare in this area relatively, but constantly found in granite area in western part of Japan. Community of *L. glabra* was distributed around the cultivated land. *Lithocarpus glabra* in the community was grown up to 16 m in heignt, and to the bust height diameter of 25 cm.



Pinus densiflora sub - tree comm.
Pinus densiflora – *Miscanthus sinensis* comm.
Pinus densiflora – *Dicranopteris linearis* comm.
Pinus densiflora typical comm.
Pinus densiflora – *Quercus serrata* comm.
Quercus serrata typical comm.
Quercus variabilis forest
Quercus glauca forest
Lithocarpus glabra forest
Pinus taeda plantation
Bamboo forest
Alnus japonica forest
Moor vegetation
Cryptomeria japonica, Chamaecyparis obtusa plantation
Shrub community
Weed communities
Arable(field, paddy field)
City areas
Quarry
Open water
Other forest

Fig. 2. Actual vegetation map of the study area in 2007.

Table 1. Plant communities of the study area; granite rock area in southern Okayama, Japan.

A. *Pinus densiflora* sub - tree forest
B. *Pinus densiflora* forest
a. *Pinus densiflora* — *Miscanthus sinensis* community, b. *Pinus densiflora* — *Dicranopteris linearis* community
c. *Pinus densiflora* typical community, d. *Pinus densiflora* —*Quercus serrata* community
C. *Quercus serrata* forest
D. *Quercus variabilis* forest
E. *Quercus glauca* forest
F. *Lithocarpus glabra* forest.
G. *Pinus taeda* plantation
H. Bamboo forest.
I. *Alnus japonica* forest
J. Moor vegetation
a. *Eriocaulon sikokianum* — *Rhynchospora faberi* community, b. *Rhynchospora fujiiana* community, c. *Rhynchospora rugosa* community.

Community types		A	B				C	D	E	F	G	H	I	J		
			a	b	c	d								a	b	c
Record number		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Total number of records		3	5	6	16	6	15	2	1	1	1	1	2	4	5	5
Average number of species		22	19	29	26	26	28	26	15	26	16	19	32	6	9	10
Group1																
Juniperus rigida	S	31	Ⅳ1-2	Ⅴ+-3	Ⅳ1	Ⅱ1	·	·	·	·	·	·	·	·	·	·
Rhus trichocarpa	S	21	Ⅳ+-1	Ⅲ+-1	Ⅴ+-1	Ⅲ+-1	Ⅰ+-1	12	1+	·	·	·	1+	·	·	·
Juniperus rigida	T2	21	Ⅲ1-2	Ⅳ1-2	Ⅳ1-2	Ⅱ1	·	·	·	·	·	·	·	·	·	·
Lyonia ovalifolia var. *elliptica*	S	21-2	Ⅱ1-2	Ⅲ1	Ⅳ+-3	Ⅳ+-2	Ⅰ1	11	·	·	·	·	·	·	·	·
Juniperus rigida	H	3+-2	Ⅱ+-1	Ⅲ+-1	Ⅲ+-1	·	·	1+	·	·	·	·	·	·	Ⅰ+	·
Diplomorpha sikokiana	H	2+-1	Ⅰ+	Ⅱ+-1	Ⅲ+	Ⅰ+	Ⅰ+	·	·	·	·	·	·	·	·	·
Group2																
Pinus densiflora	T2	31-4	Ⅴ2-3	Ⅰ3	Ⅲ1-2	Ⅱ1	·	·	·	·	·	·	·	·	·	·
Miscanthus sinensis	H	2+	Ⅲ+	Ⅰ+	Ⅱ+	·	·	·	·	·	·	·	1+	·	Ⅰ+	·
Group3																
Pinus densiflora	S	21-2	Ⅱ1-2	Ⅰ+	Ⅰ+	·	·	·	·	·	·	·	·	·	Ⅱ1	·

Group4																
Pinus densiflora	T1	15	·	V 1–3	V 2–5	V 1–5	·	·	·	·	·	·	·	·	·	·
Vaccinium oldhamii	H	1+	III+–1	I +	III+–1	II 1	·	1+	·	·	·	·	·	·	·	·
Group5																
Clethra barvinervis	S	12	IV 1–3	I 2	I +–1	I 1	I 1	·	·	·	·	·	·	·	·	·
Group6																
Dicranopteris linearis	H	·	I 1	V +–4	·	·	·	·	·	·	·	·	·	·	·	·
Ilex pedunculosa	S	2+–1	II 1	IV +–2	I 1	·	II +–1	·	·	·	·	·	·	·	·	·
Quercus serrata	S	13	II 1	IV +–1	I 1	II 1–2	·	11	·	·	·	·	·	·	·	·
Fraxinus sieboldiana	S	·	I +	III 1	·	·	·	·	·	·	·	·	·	·	I 1	·
Fraxinus sieboldiana	H	·	I +	III +	·	I +	I +	·	·	·	·	·	·	·	·	·
Solidago virgaurea var. *asiatica*	H	·	·	III +	I +	·	·	·	·	·	·	·	·	1+	I +	·
Group7																
Quercus serrata	T1	·	·	I 4	I 1	IV 2–4	V 3–5	11	·	·	·	·	·	·	·	·
Ardisia japonica	H	·	·	I +	I +	IV +	IV +	2+	·	·	·	1+	2+	·	·	·
Dendropanax trifidus	H	·	I +	I +	II +	IV +	II +	·	·	1+	·	1+	·	·	·	·
Quercus serrata	T2	·	I 3	I 2	II 1–3	III 1–2	III 1–2	·	·	·	11	·	·	·	·	·
Ophiopogon japonicus	H	·	·	I +	I +	III +	II +	2+	·	1+	·	1+	·	·	·	·
Group8																
Akebia trifoliata	H	·	I +	II +	I +	·	V +	1+	·	·	1+	1+	1+	·	·	·
Quercus glauca	T2	·	·	·	·	I 1	III 1–3	11	12	·	·	11	·	·	·	·
Quercus glauca	S	·	·	·	·	I 1	III +–3	12	11	11	11	11	·	·	·	·
Ilex chinensis	T1	·	·	·	·	·	II 1–2	·	·	·	·	·	·	·	·	·
Hydrangea luteovenosa	H	1+	·	·	·	·	II +–1	·	·	·	·	·	·	·	·	·
Wisteria floribunda	H	·	·	·	·	II +	II +–1	2+	1+	·	1+	·	·	·	·	·
Callicarpa mollis	H	·	·	·	·	·	II +–1	·	·	1+	·	·	·	·	·	·
Carex conica	H	·	·	II +	I +	·	II +	·	·	·	·	·	·	·	·	·
Elaeagnus pungens	H	·	·	·	I +	·	II +	·	·	1+	·	1+	1+	·	·	·
Blechnum niponicum	H	·	·	·	·	I +	II +	·	·	·	·	·	·	·	·	·
Group9																
Rhododendron reticulatum	H	32–3	V 1–2	V 1–3	V 1–3	V 1–3	III +–2	11	·	·	1+	·	·	·	·	·
Rhus trichocarpa	H	3+–1	III +–1	V +–1	V +–1	IV +–1	III +	1+	·	·	·	1+	1+	1+	·	·
Quercus serrata	H	3+	III +–2	III +–1	IV +–1	V +–1	III +	·	·	·	·	·	·	·	·	·
Ilex pedunculosa	H	2+	III +	III +	V +–1	III +–1	II +–1	·	·	·	·	·	·	·	·	·

Continued.

Table 1. (continued)

Community types		A	B				C	D	E	F	G	H	I	J		
			a	b	c	d								a	b	c
Group10																
Rhododendoron obtusm var. *kaempferi*	H	21	I +	IV+	IV+	V +	IV+−1	·	·	·	·	·	·	·	·	·
Viburnum erosum var. *punctatum*	H	·	I +	IV+	III+−1	IV+−1	IV+−2	1+	·	1+	·	·	·	·	·	·
Ilex crenata	H	1+	I +	III 1−2	IV+−1	III+	V +−1	2+	·	·	·	1+	12	·	·	·
Eurya japonica	S	1+	·	II 1−2	III 1−3	V 1−3	IV 1−3	·	·	11	13	·	·	·	·	·
Quercus glauca	H	1+	II +−1	II +	III +−1	III+	III +−1	2+	1+	11	·	11	·	·	·	·
Vaccinium bracteatum	H	·	·	IV+	III +−2	I 1	I +−1	1+	·	·	·	·	·	·	·	·
Rhododendron reticulatum	S	·	I 3	II 1−2	III 2−3	I 1	I +−1	·	·	·	·	·	·	·	·	·
Pourthiaea villosa var. *laevis*	H	·	·	II +−1	I +	II +−1	II +−1	·	·	·	·	·	·	·	·	·
Ilex pedunculosa	T1	·	·	II 1−2	II 1−2	I 1	I 1	·	·	·	·	·	·	·	·	·
Ilex pedunculosa	T2	21	·	II 1	II 1−3	·	II 1−2	·	·	·	·	·	·	·	·	·
Platanthera minor	H	·	·	II +	II +	·	I +	·	·	·	·	·	·	·	·	·
Group11																
Quercus variabilis	T1	·	·	·	·	I 5	I 2−5	25	·	·	·	12	·	·	·	·
Group12																
Quercus glauca	T1	·	·	·	·	·	I 3	·	15	·	·	·	·	·	·	·
Group13																
Lithocarpus glabra	T1	·	·	·	·	·	·	·	·	15	·	·	·	·	·	·
Group14																
Pinus taeda	T1	·	·	·	·	·	·	·	·	·	15	·	·	·	·	·
Group15																
Phyllostachys pubescens	T1	·	·	·	·	·	·	·	·	·	·	15	·	·	·	·
Group16																
Smilax china	H	3+	IV+	V +	IV+	V +	V +	2+	·	1+	1+	1+	1+	·	·	·
Eurya japonica	H	2+−1	III 1−2	V +−2	V +−2	IV 1−2	V +−1	11	1+	1+	11	1+	·	·	·	·
Pleioblastus fortunei f. *pubescens*	H	1+	V +−1	IV+−1	III +−1	IV+−1	III +−1	23	11	·	·	1+	1+	·	II +−1	·
Group17																
Alnus japonica	T1	·	·	·	·	·	·	·	·	·	·	·	25	·	·	·
Ilex crenata	S	·	·	II 1	I 1−2	·	I 1	·	·	·	·	·	21−3	·	·	·
Alnus japonica	T2	·	·	·	·	·	·	·	·	·	·	·	21	·	·	·

Group18																
Eriocaulon sikokianum	H	·	·	·	·	·	·	·	·	·	·	·	·	41–3	II +–1	V +
Rhynchospora faberi	H	·	·	·	·	·	·	·	·	·	·	·	·	31–4	III +–2	·
Schoenus apogon	H	·	·	·	·	·	·	·	·	·	·	·	·	31–2	·	I 1
Haloragis micrantha	H	·	·	I +	·	·	·	·	·	·	·	·	·	2+–2	I +	I +
Drosera rotundifolia	H	·	·	·	·	·	·	·	·	·	·	·	·	2+	I +	·
Group19																
Rhynchospora fujiiana	H	·	·	·	·	·	·	·	·	·	·	·	·	·	V 1–4	II +–2
Group20																
Ischaemum aristatum var. *glaucum*	H	·	·	·	·	·	·	·	·	·	·	·	·	·	IV 3–4	V 1–3
Fimbristylis subbispicata	H	·	·	·	·	·	·	·	·	·	·	·	·	11	II 1	III +
Hololeion krameri	H	·	·	·	·	·	·	·	·	·	·	·	·	·	II +	III +–1
Group21																
Rhynchospora rugosa	H	·	·	·	·	·	·	·	·	·	·	·	·	·	I 1	V 3–5
Eupatorium lindleyanum	H	·	·	·	·	·	·	·	·	·	·	·	·	·	I +	III +–1
Persicaria thunbergii var. *thunbergii*	H	·	·	·	·	·	·	·	·	·	·	·	11	·	·	III +
Group22																
Isachne globosa	H	·	·	·	·	·	·	·	·	·	·	·	1+	3+–1	III 1	III +
Utricularia racemosa	H	·	·	·	·	·	·	·	·	·	·	·	·	1+	II +	I +
Utricularia bifida	H	·	·	·	·	·	·	·	·	·	·	·	·	1+	II +	I +
Juncus effusus var. *decipiens*	H	·	·	·	·	·	·	·	·	·	·	·	1+	·	I 1	I 1
Companions																
Rosa multiflora	H	·	·	I +	I +	·	I +	·	·	·	·	·	11	1+	II +	III +–1
Lyonia ovalifolia var. *elliptica*	H	1+	I +	I 1	II +–1	II +–1	I +	11	·	·	·	·	·	·	·	·
Smilax china	S	1+	I +	II +–1	I +	I +	I +	·	·	·	·	·	·	·	·	·
Quercus variabilis	H	1+	II +	·	I +	II +	I +	1+	·	·	1+	·	·	·	·	·
Carex lenta	H	·	I +	I +	II +–1	I +	I +	·	1+	·	·	·	·	·	·	·
Pinus densiflora	H	11	·	I +	II +	·	·	·	·	·	·	·	·	2+	I +	I +
Lyonia ovalifolia var. *elliptica*	T2	11	·	·	II 1–2	II 1–2	I 1	·	·	·	·	·	·	·	·	·
Vaccinium oldhamii	S	·	II 1	I 1	II 1	·	·	·	·	·	·	·	·	·	·	·
Ilex chinensis	H	·	I +	I +	I +	·	II +	1+	·	·	·	1+	·	·	·	·
Rhus trichocarpa	T2	·	·	I 1	I +	I 1	II 1	·	·	·	·	11	21	·	·	·
Calamagrostis arundinacea	H	·	·	I +	II +	I +	I +	·	1+	·	·	·	·	·	·	·
Ternstroemia gymnanthera	H	1+	·	I +	II +–1	·	I +–1	·	·	·	·	·	·	·	·	·

Species of low frequencies are omitted.

G. *Pinus taeda* plantation

Pinus taeda is the native species of the south-eastern United States of America. After the prevalent of the *Pine* disease in Japan, *P. taeda* was often planted there aiming to resist the *Pine* disease.

H. Bamboo forest

Phyllostachys pubescens was useful plants before the wide use of petrochemical products. Bamboo was used for agriculture and construction materials. Therefore, the forest is usually distributed around the village.

I. *Alnus japonica* forest

Swamp forest dominated by *Alnus japonica* developed at the watery area around the pond. Height of *A. japonica* was 13-16 m, and the bust height diameter was about 20 cm.

J. Moor vegetation

The moor vegetation, developed on the granitic area, was developed on the sediment around pond, is characterized by occurrence of wetland plants, such as *Isachne globosa* and *Utricularia racemosa*. This vegetation was subdivided into following three communities.

a. *Eriocaulon sikokianum* - *Rhynchospora faberi* community

Coverage and height of herb layer is smallest in these three communities. Characteristic species of this community; *Eriocaulon sikokianum* is annual, sign of the unstable soil condition.

b. *Rhynchospora fujiiana* community

This community is characterized by the presence of the species group 19 and 20 (Table 1). It is main and typical moor vegetation of study area. Height of herb layer was 20 to 60 cm.

c. *Rhynchospora rugosa* community

This community is characterized by the presence of the species group 20 and 21 (Table 1). Its developed at marginal area of the moor and watery area around the pond.

2. Vegetation map

As the result of the studies, 21 units shown in the legend of the vegetation map were recognized (Fig. 2).

V. Discussion

1. *Pinus densiflora* forest

Toyohara (1984) studied phytosociologically the secondary pine forests of Hiroshima Pref., and he described vegetation types based on species composition. The *Pinus densiflora* forest, recognized in this study, seems to be similar to the Querco glaucae-Pinetum densiflorae (Toyohara 1984) by the presence of the character species, such as *Dicranopteris linearis* and *Vaccinium bracteatum*.

Forest vegetation of the granite rock area at the southern part of Okayama Pref. (Setouchi area), has previously been studied by Ishibashi (1980) at Kojima Peninsula, and by Nishimoto & Hada (1994) at Wake-Cho. The main components of vegetation of the investigated area of Ashimori area seem to be almost common with the formerly studied area, but the cover abundance of *Pinus densifolra* in the Ashimori is higher than those of other areas. Moreover, in the *Pinus densiflora* forest of the Ashimori area, the occurrence of *Rhododendoron obtusm* var. *kaempferi* and *Vaccinium bracteatum* is higher than other areas.

2. Moor vegetation

Plant communities recognized in this moor may be similar to the subassociation Rhynchosporetosum faberi (Hada 1984) by the presence of the character species, such as *Rhynchospora faberi*, *Utricularia racemosa*, *Utricularia bifida* and *Drosera rotundifolia*.

Among the known moor vegetation in the southern Okayama Pref., the pond of Akaiwa Oike (Hada 1972) has similar vegetational components with that of the Ashimori area.

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