Forest Vegetation on Rocky Sites in Hiroshima Prefecture Southwestern Honshu, Japan*

by

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Introduction

Three erosion surfaces with moderate slopes have been recognized in the Chugoku mountains, which are named respectively Dogoyama surface (about 1000–1300 m above sea-level), Kibi-plateau surface (about 500–600 m) and Seto-uchi surface (lower than about 300 m). Areas between these surfaces form steep slopes including many gorges, where rocky ridges, rocky outcrops and cliffs are often found. On such rocky sites, natural forests have been preserved because the habitat is too steep to manage the logging or plantation.

The natural forests developing on the rocky sites are usually dominated by coniferous trees such as *Tsuga sieboldii*, *Chamaecyparis obtusa*, *Pinus densiflora*, *Pinus parviflora* and *Sciadopitys verticillata*, and are considered to be edaphic climax communities. It is well known that many ericaceous plants are apt to appear in these forests.

Until now, several phytosociological studies have been made on such conifer forests in Hiroshima Prefecture. Horikawa & Sasaki (1959) described the Iliceto-Tsugetum sieboldii from Sandankyo Gorge. Sasaki & Ando (1963) reported *Sciadopitys verticillata-Shortia sordanelloides* var. *magna* community from Rakankeikoku Gorge. Suzuki *et al.* (1975) studied the *Sciadopitys verticillata* community of Miyajima Island and identified it with the Pierideto-Tsugetum Yamanaka 1961. Suzuki (1974) reported *Chamaecyparis obtusa* forests associated with *Rhododendron metternichii* from both Nabara Gorge and Mt. Fukuojiyama, and Watanabe (1976) recognized similar forests from Mt. Kamakurajiyama.

As to the rocky-site forests in other districts, Yamanaka (1957) described the Rhodoreto-Chamaecyparidetum from Shikoku. Later, Yamanaka (1961) reconsidered that association and divided it into two associations: Rhodoreto-Chamaecyparidetum and Pierideto-Tsugetum.

The present study deals with a phytosociological classification of the natural forests developing on rocky sites in Hiroshima Prefecture, exclusive of those on coastal cliffs and rocky sites of limestone areas.

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I. Area studied and methods

Hiroshima Prefecture is situated in southwestern Honshu of Japan. The highest elevation in this section is 1346 m above sea-level. Geologically, it mainly consists of granite and rhyolite, and Palaeozoic formations are scattered locally. Climatically, it is warm-temperate in lowlands and cool-temperate in areas at higher elevations. The natural forest vegetation of Hiroshima Prefecture includes the evergreen broad-leaved forest, the intermediate conifer forest and the deciduous broad-leaved forest formations (Horikawa 1968). Ranges of the vertical distribution of these forest formations are known as follows: the first is developed at lower elevations than about 400 m, the second at elevations of about 400 m to 960 m, and the third is distributed at higher elevations above nearly 960 m (Suzuki *et al.* 1975, Toyohara 1977). In the present time, however, the greater part of these climax forest formations are replaced by secondary forests or plantations.

In the present study, phytosociological treatment was made by the method of ZM school. Sixty-four phytosociological records, whose stand size was usually about 15 × 15 m, were obtained for this study, and records previously reported

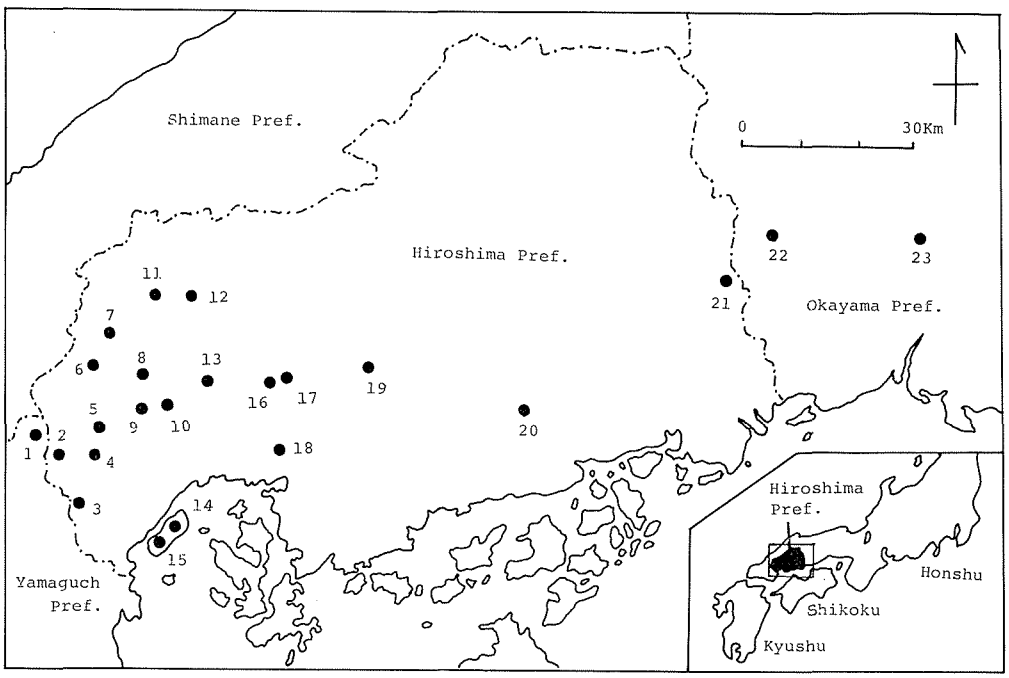

Fig. 1. A map showing the localities of the stands studied. Yamaguchi Prefecture: 1. Jakuchikyo Gorge. Hiroshima Prefecture: 2. Rakankeikoku Gorge, 3. Mt. Mikuradake, 4. Bankokei Gorge, 5. Iwaidani Gorge, 6. Sakane Gorge, 7. Sandankyo Gorge, 8. Ryuzukyo Gorge, 9. Ishigayakyo Gorge, 10. Egedani Gorge, 11. Takiyamakyo Gorge, 12. Miyama kyo Gorge, 13. Ugakyo Gorge, 14. Mt. Misen (including Mt. Komagabayashi), 15. Mt. Iwafunedake. 16. Mt. Fukuojiyama, 17. Nabarakyo Gorge, 18. Mt. Takaoyama, 19. Mt. Kamakurajiyama, 20. Hongo Gorge, 21. Enmeikyo Gorge. Okayama Prefec ture: 22. Iwayakei Gorge, 23. Gokei Gorge.

were additionally used. The stands studied are shown in Fig. 1; they range vertically from 210 to 960 m.

Nomenclature of species follows Ohwi (1975), Tagawa (1959), Iwatsuki & Mizutani (1972) and Yoshimura (1974) for seed plants, ferns, mosses, and lichens respectively.

II. Classification of the forest communities studied

The forest communities studied on rocky sites of Hiroshima Prefecture can be divided into six vegetation units which correspond to the association, and they are further subdivided into several subordinate units (Table 1). They are assumed to be edaphic climax communities characterized by many sun plants such as ericaceous plants. Ericaceous plants are also common in *Pinus densiflora* secondary forests, which, however, lack the species groups 1, 2, 3, 4, 5, 6, 8 and 9 shown in Table 1. These species groups are considered to indicate somewhat rocky sites. A description of the associations and their subordinate units is made as follows.

1. Iliceto-Tsugetum sieboldii Horikawa et Sasaki 1959 (Table 1: I–1)

This is recognized by having *Ilex sugerokii* var. *longipedunculata* as character species of the association, and *Tsuga sieboldii*, *Chamaecyparis obtusa*, etc. as character species of the alliance or order. The Iliceto-Tsugetum sieboldii was originally described by Horikawa & Sasaki (1959) from Sandankyo Gorge. As character species of the association, they selected *Ilex sugerokii* var. *longipedunculata*, *Chamaecyparis obtusa*, *Shortia soldanelloides* var. *magna*, *Tsuga sieboldii* and *Ilex pedunculosa*. However, these species, except the first one, abundantly occur also in other associations. Thus, in this study, it has been concluded that the character species of the association is to be restricted to *Ilex sugerokii* var. *longipedunculata*.

According to the system of the Japanese natural communities by T. Suzuki (1966), the Iliceto-Tsugetum sieboldii is classified in the alliance Tsugion sieboldii belonging to the order Tsugetalia sieboldii which seems equivalent to the intermediate conifer forest formation described by Horikawa (1968).

This association is developed on rocky sites with thin soil in somewhat humid conditions. The tree layer is dominated by *Tsuga sieboldii* and *Chamaecyparis obtusa*, and sometimes by *Pinus densiflora*. The subtree layer is usually occupied by evergreen broad-leaved trees such as *Quercus* (*Cyclobalanopsis*) *salicina* and *Cleyera japonica*. In the shrub layer, *Ilex sugerokii* var. *longipedunculata* characteristically appears and many species of Ericaceae are found.

This is further subdivided into three subassociations by a combination of the species groups 5, 8, 9, 10, 15, 17 and 21.

1–A. Shortietosum magnae

This subassociation coincides with the original concept of the Iliceto-Tsugetum sieboldii described by Horikawa & Sasaki (1959). It is found in Sandankyo Gorge (7 in Fig. 1), vertically ranging from 600 to 850 m.

1–B. Hymenophylletosum barbati

This is found in several localities, such as Rakankeikoku (2), Iwaidani (5), Sandankyo (7) and Egedani (10) Gorges, and the vertical range of its stands is 340–580 m.

1–C. Rhododendretosum metternichii

This is further subdivided into three groups by a combination of the species groups 11, 12, 13, 14 and 15.

1–C–a. *Rhododendron serphyllifolium* group

This is found in Nabarakyo Gorge (17), developing at altitudes of 340–500m.

1–C–b. *Vaccinium bracteatum* group

This is found on Mt. Fukuojiyama (16), where it vertically ranges from 410 to 600 m.

1–C–c. *Evodiopanax innovans* group

This is found on Mt. Kamakurajiyama (19), and the vertical range of its stands is about 400–600 m.

2. Pierideto-Tsugetum Yamanaka 1961 (Table 1: I–2)

This is distinguished from the Iliceto-Tsugetum sieboldii by the presence of the species groups 2 and 3. In the original description of the association from Shikoku District, Yamanaka (1961) mentioned the following character species, *Sciadopitys verticillata*, *Pseudotsuga japonica*, *Pieris japonica*, *Ilex pedunculosa*, *Enkianthus cernuus* f. *rubens*, *Vaccinium japonicum*, *Rhododendron keiskei* and *Mecodium polyanthus*. In the present study, however, *Pieris japonica*, *Ilex pedunculosa* and *Vaccinium japonicum* were known to appear abundantly also in other associations, and hence, they were excluded from the character species of the Pierideto-Tsugetum. Besides, *Tripetaleia paniculata*, *Sorbus gracilis* and *Trochodendron aralioides* were additionally assigned to the character or differential species of the association.

According to the system by T. Suzuki (1966), this association is, together with the Iliceto-Tsugetum sieboldii, referred to the alliance Tsugion sieboldii belonging to the order Tsugetalia sieboldii. On the other hand, Yamanaka (1961) suggested that such edaphic climax communities as Pierideto-Tsugetum and Iliceto-Tsugetum sieboldii should be excluded from the Tsugion sieboldii, and classified in another alliance, Chamacyparidion obtusae.

This association is developed on sites similar to those of the preceding Iliceto-Tsugetum sieboldii, but it occupies more steep and open places. The tree layer is dominated by *Scyadopitys verticillata*, *Chamaecyparis obtusa* and *Tsuga sieboldii*, the subtree and shrub layers by many ericaceous species, and the herb layer is usually dominated by *Shortia soldanelloides* var. *magna* and some small ferns of Hymenophyllaceae.

This association is subdivided into three groups, whose sociological ranking, however, was retained in this study. Their status will be determined after a further study in comparison with similar communities in Shikoku and other districts.

2–A. *Shortia soldanelloides* var. *magna* group

This group, lacking *Sciadopitys verticillata*, is found in several localities, such as Rakankeikoku (2), Iwaidani (5), Sakane (6) and Sandankyo (7) Gorges, and the vertical range of its stands is 390–620 m.

2–B. *Sciadopitys-Shortia* group

This group, having *Sciadopitys verticillata*, *Shortia soldanelloides* var. *magna*, etc., is found in Rakankeikoku Gorge (2), ranging vertically from 480 to 680m.

2–C. *Sciadopitys verticillata* group

This group, having *Sciadopitys verticillata* but lacking many important species, is found on both Mt. Misen (14) and Mt. Iwafunedake (15) in Miyajima Island, where it ranges in 355–500 m above sea-level. This group coincides with the typical group of the Pierideto-Tsugetum recognized by Suzuki *et al.* (1975).

3. Davallio-Pinetum densiflorae, ass. nov. (Table 1: II–3, Table 2, Table 3)

This association is characterized by the species groups 4, 23, 24 and 25. As its character species were selected *Davallia mariesii*, *Rhododendron mucronulatum* var. *ciliatum*, *Repisorus thunbergii*, *Bulbophyllum drymoglossum* and *Dendrobium moniliforme*. The association resembles the preceding two in having the species groups 1, 2 and 3, but it is essentially different from them by having the species group 23, 24 and 25 which are main components of *Pinus densiflora* secondary forests.

In the system of Japanese pine forests by Toyohara (1973), this community was treated without definite rank under the Pinetalia densiflorae Suz.-Tok. 1966, the order composed of two alliances: Cyclobalanopsio-Pinion densiflorae and Querco-Pinion densiflorae, which correspond to the warm-temperate pine forests and the cool-temperate pine forests respectively. However, the new association is now considered to be excluded from either of the two alliances, and it may be classified in a new alliance, Cladonio-Pinion densiflorae characterized by the species group 23. The new alliance is composed of natural pine forests which are assumed to be edaphic climax communities.

This association is developed on the most steep and rocky sites. The tree layer is usually dominated by *Pinus densiflora*, or sometimes, by *Tsuga sieboldii* and *Chamaecyparis obtusa*. In both the subtree and the shrub layers, ericaceous plants occur characteristically. In the herb layer, *Shortia soldanelloides* var. *magna* is often found. In the moss layer, some species of Hymenophyllaceae and *Cladonia rangiferina* are characteristic. On exposed rocks, some epilithic vascular plants such as *Davallia mariesii* and *Dendrobium moniliforme* grow, but they are often destructed by collecting for the purpose of gardening.

This is subdivided into two subassociations by the species groups 10 and 17.

3–A. Quercetosum glaucae

This occupies areas at lower elevation near the coast. It is further subdivided into two variants by the species groups 18, 20 and 21.

3–A–a. *Juniperus rigida* variant

Table 3. Topographical and physiognomical explanations of the recorded stands shown in Table 2.

Record No.	Locality*	Altitude (m)	Micro-topography**	Slope aspect	Slope degree	Exposed rock (%)	DBH (cm)	Height and coverage of layers***								
								T1(m)	T1(%)	T2(m)	T2(%)	S(m)	S(%)	H(m)	H(%)	M(%)
1	20	200	T	.	.	30	30	.	.	6	40	2.0	40	0.5	40	40
2	14	510	T	N20E	10	-	20	.	.	7	55	2.5	40	0.5	30	-
3	18	430	U	N40W	50	40	25	10	60	6	50	2.0	85	0.5	50	5
4	23	210	U	S30W	60	40	25	9	60	4	40	2.0	40	0.4	20	5
5	21	380	R	N40E	40	-	30	12	75	4	40	1.5	40	0.5	35	10
6	22	310	R	S40E	40	30	40	10	60	4	40	2.0	40	0.4	30	30
7	21	320	R	S80E	35	60	15	6	60	3	35	1.0	30	0.3	15	10
8	4	450	R	S30W	45	80	25	13	60	5	50	2.0	30	0.5	10	20
9	13	320	R	S40E	50	75	20	.	.	7	55	2.5	40	0.2	30	30
10	13	290	R	S60E	50	40	30	18	80	6	40	2.0	20	0.2	30	10
11	4	470	R	S50W	70	70	20	.	.	5	60	2.0	40	0.5	10	40
12	2	430	R	N50W	70	90	20	6	30	3	40	2.0	50	0.5	30	65
13	4	470	R	S60W	75	80	20	.	.	7	40	2.5	40	0.5	30	20
14	9	350	R	S30W	40	40	25	10	40	4	30	2.0	60	0.5	30	30
15	9	370	R	N70E	55	50	20	10	35	5	60	2.0	40	0.3	30	20
16	9	370	R	E	80	90	-	10	10	5	10	2.0	15	0.2	10	10
17	9	430	R	N70E	60	70	20	10	50	6	15	2.0	40	0.3	40	35
18	9	390	R	N80E	40	.	50	15	75	9	40	2.5	40	0.5	60	5
19	8	520	R	N65E	65	40	40	12	90	7	60	2.0	40	0.2	55	30
20	7	440	R	N10E	45	80	30	8	50	5	15	1.5	35	0.3	30	40
21	7	400	R	S80W	50	80	20	10	60	3	15	1.5	40	0.4	40	40
22	11	510	R	N60W	15	.	30	15	90	8	40	2.0	70	0.5	70	30
23	6	670	R	S60E	55	30	40	12	20	7	75	2.5	60	0.5	20	30
24	1	690	R	S70E	70	85	15	.	.	7	50	1.5	30	0.3	10	7
25	1	690	U	S60W	45	.	30	15	90	5	55	2.0	35	0.3	15	5
26	4	470	R	S40E	70	70	30	.	.	8	40	3.0	40	0.5	30	20
27	7	430	R	S60E	60	60	40	15	50	8	40	2.5	30	0.3	40	60
28	5	610	R	N	30	30	30	15	70	5	45	1.5	55	0.4	45	35
29	6	630	R	E	50	30	40	12	20	7	50	2.0	50	0.5	30	70
30	3	710	R	N10E	40	-	-	.	.	4	80	1.0	75	0.5	100	20
31	5	580	R	N40E	35	.	50	20	90	7	50	3.0	40	0.5	40	10
32	11	510	R	S20W	45	70	40	15	85	6	35	2.5	45	0.5	20	10
33	11	610	R	N20E	45	5	25	10	70	4	75	2.0	80	0.5	75	15
34	11	650	R	N50E	40	20	40	10	60	5	40	2.0	60	0.5	60	40
35	11	590	R	N10E	45	5	30	10	40	5	70	2.0	80	0.5	60	10
36	12	460	R	S10W	50	50	25	10	55	6	15	3.0	60	0.3	40	30
37	12	500	R	S40E	10	20	25	13	70	5	65	2.0	60	0.5	85	5

* Figer show the Locality No. in Fig. 1.
** T : Top, R : Ridge, U : Upper part of slope.
*** T1 : Tree layer, T2 : Subtree layer, S : Shrub layer, H : Herb layer, M : Moss layer.

This is found in several localities, such as Mt. Misen (14), Mt. Takaoyama (18), Hongo Gorge (20), Enmeikyo Gorge (21), Iwayakei Gorge (22) and Gokei Gorge (23), occurring at elevations of 210–500 m.

3–A–b. *Tsuga sieboldii* variant

This is further subdivided into three subvariants by a combination of the species groups 1, 3, 5, 6, 8, 12, 13 and 19.

3–A–b–i. Typical subvariant

This is found in Rakankeikoku (2), Bankokei (4), Ishigayakyo (9) and Ugakyo (13) Gorges, and the vertical range of its stands is 290–470 m.

3–A–b–ii. *Symplocos prunifolia* subvariant

This is found on both Mt. Misen (14) and Mt. Iwafunedake (15) in Miyajima Island, ranging vertically between 400 and 510 m. It coincides with the *Davallia mariesii* group in Pierideto-Tsugetum by Suzuki *et al.* (1975).

3–A–b–iii. *Shortia soldanelloides* var. *magna* subvariant

This is found in Ishigayakyo Gorge (9) at elevations of 370–430 m.

3–B. Quercetosum grosseserratae

This is developed on sites at rather higher elevations. It is further subdivided into two variants by the species groups 20 and 22.

3–B–a. *Tsuga sieboldii* variant

This is further subdivided into two subvariants by the species groups 1, 5 and 6.

3–B–a–i. *Pinus parviflora* subvariant

This is found in several localities such as Jakuchikyo (1), Ryuzukyo (8), Sakane (6), Sandankyo (7) and Takiyamakyo (11) Gorges, and the vertical range of its stands is 400–680 m.

3–B–a–ii. Typical subvariant

This is found on Mt. Mikuradake (3), and in Bankokei (4), Iwaidani (5), Sakane (6) and Sandankyo (7) Gorges, ranging in 430–700 m above sea-level.

3–B–b. *Quercus mongolica* var. *grosseserrata* variant

This is further subdivided into two subvariants by the species group 6.

3–B–b–i. *Pinus parviflora* subvariant

This is found in Takiyamakyo Gorge (11), and the vertical range of its stands is 510–650 m.

3–B–b–ii. Typical subvariant

This is found in Miyamakyo Gorge (12) at elevations of 460 to 580 m.

4. *Rhododendron metternichii* community (Table 1: III–4)

This is distinguished from other communities by having the species groups 5 and 25. It resembles the Pierideto-Tsugetum, but is differentiated by lacking the species group 20 which includes main components of the order Tsugetalia sieboldii. Moreover, it contains also such character species of the order Pinetalia densiflorae as seen in the species group 25. It is thus concluded that this community is to be placed in the alliance Querco-Pinion densiflorae belonging to the order Pinetalia densiflorae.

The tree layer of the community is dominated by deciduous broad-leaved trees.

The shrub layer and sometimes the subtree layer are characterized by dom inant occurrence of *Rhododendron metternichii*.

This is found in Miyamakyo Gorge (12), and the vertical range of its stands is 560–650 m.

5. *Pinus parviflora* community (Table 1: III–5)

This is distinguished from other communities by having the species groups 6 and 25, but lacking the 4, 5, 7, 20, 21, 23 and 24. It resembles the preceding *Rhododendron metternichii* community in floristic composition, and is likewise classified in the alliance Querco-Pinion densiflorae.

The tree layer is dominated by *Pinus parviflora*. This is found in Takiyamakyo Gorge (11), and the vertical range of its stands is from 510 to 670m.

6. Lindello umbellatae-Fagetum crenatae (Sasaki 1964) Sasaki 1970 shortietosum magnae (Table 1: IV–6)

This subassociation is characterized by the species group 7. According to the system of Japanese beech forests by Sasaki (1970), it is classified in the alliance Saso-Fagion crenatae (Suz.-Tok. 1954) Miyawaki *et al.* 1964.

This is developed on rocky or windy sites in areas of the cool-temperate zone. It is observed in Sandankyo Gorge (7) at elevations of 820–900 m.

Summury

The forest communities developing on rocky sites in Hiroshima Prefecture were studied phytosociologically, and were divided into six associations belonging to the four alliances as follows. I. Tsugion sieboldii: 1. Iliceto-Tsugetum sieboldii, 2. Pierideto-Tsugetum. II. Cladonio-Pinion densiflorae, all. nov.: 3. Davallio-Pinetum densiflorae, ass. nov. III. Querco-Pinion densiflorae: 4. *Rhododendron metternichii* community, 5. *Pinus parviflora* community. IV. Saso-Fagion crenatae: 6. Lindello umbellatae-Fagetum crenatae shortietosum magnae.

One alliance and one association were newly described.

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