A Note on Subalpine Coniferous Forests in North Honshu, Japan

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Introduction

The subalpine vegetation in north Honshu, Japan, is markedly affected by two distinct climatic types, the Pacific and the Japan Sea, and shows a sharp contrast in physiognomy. The Japan Sea climate is characterized by strong westerlies and heavy snowfall in winter, whereas the Pacific climate is rather moderate. Subalpine coniferous forests of *Abies mariesii* are well established on the Kitakami massif on the Pacific side and on the inland Ou range, but seldom on the Japan Sea side, where subalpine scrubs of *Acer tschonoskii*, *Sorbus commixta*, *Alnus maximowiczii*, *Quercus mongolica* var. *undulatifolia*, etc. prevail. Dense forests of *Abies mariesii*, often admixed with *Tsuga diversifolia*, are encountered in the Kitakami massif and also in the southern part of the Ou range, whereas we see sparse forests, luxuriantly undergrown with subalpine shrubs, in the northern part of the Ou range and even in the Japan Sea area.

This geographic variation, although generally recognized, has been scarcely examined in detail, apart from some local monographs viewed from phytosociological point (Yoshioka 1938, Ohba 1974, Miyawaki et al. 1978). The author previously described the subalpine coniferous forests in northeast Japan in terms of physiognomy and floristic composition, explaining the sociologic variation by an interpretation of the environmental controls, especially of climate (Saitō 1977, 1978). The aims of the present paper are to revise it and add some supplements.

I. Study Areas

The study areas were so selected as to cover the different types of forests as well as of climate. They are Mt. Hayachine, Mt. Azuma, Mt. Hachimantai, Mt. Zao, Mt. Hakkoda, Mt. Moriyoshi and Mt. Gassan (See Fig. 1)*.

Their climatic data are limited. The warmth index (Kira 1948, Yim and Kira 1975) at each mountain top was estimated from the monthly mean temperatures obtained at its nearest meteorological observatory by employing the diminishing rate of 0.55 C per 100 m in altitude increase. The mean temperatures at Fukushima, Yamagata, Morioka and Aomori were used for Mt. Azuma, Mts. Zao and Gassan, Mts. Hayachine, Hachimantai and Moriyoshi, and Mt.

* Apart from these, Mt. Hiuchi and Mt. Iwate are also vastly covered by the well-established forests of *Abies*. Mt. Adatara and Mt. Bandai are mostly occupied by various types of volcanic, seral vegetation. The rest are predominated by the subalpine deciduous broad-leaved scrubs, although a minor stand of *Abies* is encountered on Mt. Kurikoma.

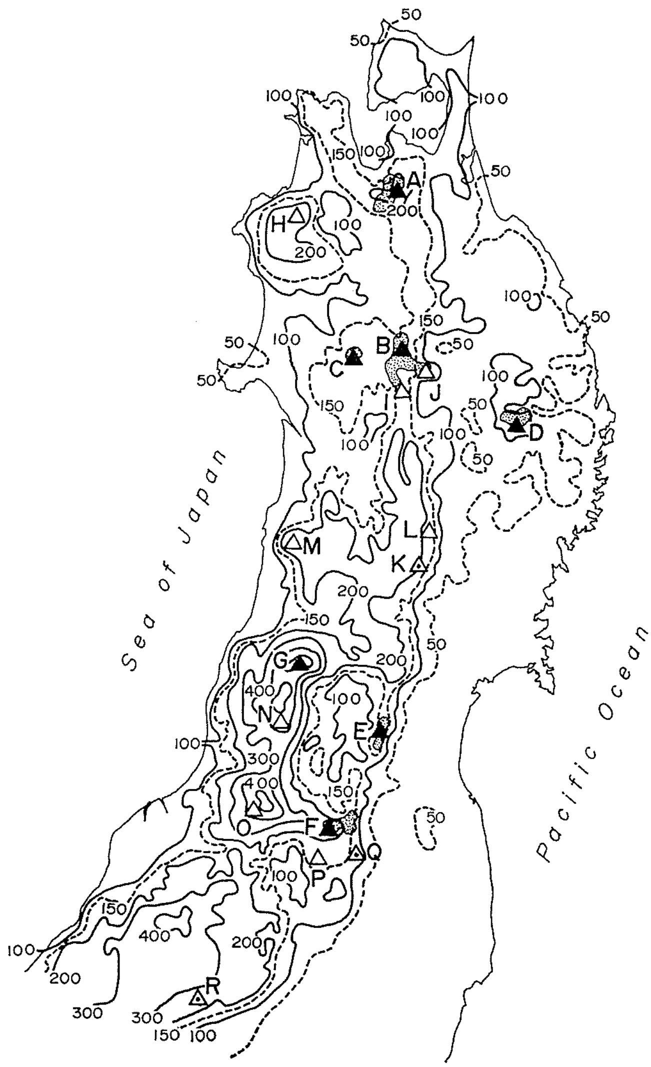

Fig. 1. Map showing the location of high mountains in north Honshu and the isopleths (cm) of mean maximum snow depth (cited from Society of Forest Environment 1972). A: Mt. Hakkoda, B: Mt. Hachimantai, C: Mt. Moriyoshi, D: Mt. Hayachine, E: Mt. Zao, F: Mt. Azuma, G: Mt. Gassan, H: Mt. Iwaki, I: Mt. Akita-koma, J: Mt. Iwate, K: Mt. Kurikoma, L: Mt. Yakeishi, M: Mt. Chokai, N: Mt. Asahi, O: Mt. Iide, P: Mt. Bandai, Q: Mt: Adatara, R: Mt. Hiuchi. The study areas are given as A-G.

Hakkoda, respectively. The results are given in Table 2. The values are all over 15 m. d. (month degree) of the theoretical border between the alpine and subalpine zones.

A great difference is found in their maximum snow depth. Information is available from the map of the annual mean maximum snow depth, which is cited in Fig. 1 from the Forest Environment Map of Japan (Society of Forest Environment 1972). Mt. Gassan has a thick snow cover of over 500 cm in late winter, while Mt. Hayachine shows below 100 cm. The are range in between. In addition, it is to be noted that Mt. Azuma and Mt. Zao are solidly screened from westerlies in winter by such high mountains on the Japan Sea side as Mt. Iide and Mt. Asahi, while Mt. Moriyoshi lies exposed.

In the Hayachine area, the uppermost geological horizon is made of serpentinite or granite originated in Palaeozoic era. Its alpine flora has been noted for many rare and endemic species characteristic of serpentinite. Two distinct zones of vegetation, montane and subalpine, primarily adequate to "deciduous broad-leaved" and "evergreen coniferous" respecitvely, are found mostly on granite and partly on the southwest slope of serpentinite, where the *Fagus crenata* forest shifts into the *Abies mariesii* and/or *Tsuga diversifolia* forest at an elevation of 1100 m or so. The vegetation on the north and east sides of the mountain is admixed with *Thujopsis dolabrata* var. *hondai*, a relic of the Tertiary flora (Miki 1958, Suzuki 1977), providing a physiognomy of a coniferous forest from the montane zone up to the forest limit on the main ridge of 1800 m or so in altitude. For another distinction, the southernmost relict of *Picea glehnii*, a subarctic conifer of Hokkaido, is also found on a rocky site on the northern slope.

The remnants of the study areas fall within a category of the Quaternary volcanoes. Their seral vegetation was excluded from the present study. The subalpine zone of stable coniferous forests ranges from 1400 m in elevation up to the mountain top of 2024 m on Mt. Azuma, from 1350 m upto 1750 m on Mt. Zao, from 1000 m up to the top of 1613 m on Mt. Hachimantai, from 950 m up to 1450 m on Mt. Hakkoda, and from 1000 m up to 1450 on Mt. Moriyoshi.

Mt. Moriyoshi has a unique pattern of forest distribution. The northern slope of the main peak, which is screened from westerlies by the somma, has sparse growth of *Abies* over a thick cover of shrubs and dwarf bamboo, while the southern slope is predominated by deciduous trees and shrubs.

On Mt. Gassan, *Abies mariesii* is restricted to a lava plateau situated on the leeward side of the mountain, ranging from 1450 m to 1580 m in altitude. A mixed thicket of *Abies* and deciduous shrubs covers the wet podzol on the ill-drained flat (Yamanaka et al. 1973).

II. Dominants and Commodal Undergrowths

Each community type is here distinguished by its dominants and remarkable groups of commodal undergrowths, and mentioned as a combination of them. The dominants or the main tree species primarily determine the physiognomy of plant communities. The commodal undergrowths play a role of the indicators for the habitat condition. Undergrowths similar in ecological amplitude can be combined into one group, whether they are in the same stratum or not. This system of grouping also leads to an orderly arrangement of vegetation samples with respect to species composition. The undergrowth commodium under question is not neccessarily equivalent to an ecological species group, since species in an ecological group must be closely similar in their life form (Mueller-Dombois and Ellenberg 1974). The commodal undergrowths are defined as undergrowths which show similar responses to the more important site factors.

The community type determined by the dominants and the commodal undergrowths, although similar to the forest site type of the Finnish school (Frey

1973), is not applicable to any hierarchy of phytosociological classification. It should rather be a segment of total vegetation continuum, since the individual components are naturally gradual along the environmental gradients.

A special advantage of describing the communities by the dominants and the undergrowths is that each sample of vegetation can be evaluated through the environmental relationship of both physiognomy and species composition.

In the derivation of the groups direct observation and tabular comparison were employed. Much information was also obtained from the previous works concerned with the montane and subalpine forests in northeast Japan (Saitō 1970 1977, 1978, Saitō et al. 1977, Ishizuka et al. 1975).

Nine dominant or main tree species and ten undergrowth groups were designated as follows.

Dominants or main tree species: *Abies mariesii*, *Tsuga diversifolia*, *Betula ermanii*, *B. corylifolia*, *Thuja standishii*, *Pinus parvifolia* var. *pentaphylla*, *Thujopsis dolabrata* var. *hondai*, *Picea glehnii*, and *Fagus crenata* are here assigned for the dominants or main tree species. In north Honshu, subalpine coniferous forests are mostly dominated by *Abies mariesii* and often associated with the others. Their distribution pattern is here further noted. *Tsuga diversifolia*, as generally recognized, shows a preference for dry soils and particularly predominates steep, boulder-much slopes or ridges both in the higher parts of the montane zone and in the entire subalpine zone, although it normally admixes in the *Abies* forests. *Pinus parvifolia* var. *pentaphylla* and *Thuja standishii* are more remarkable on rocky, impoverished soils on narrow ridges. *Thujopsis dolabrata* var. *hondai* forms an unique forest in Hayachine as mentioned above, where even *Picea glehnii* sporadically occurs on a rocky slope. Finally *Fagus crenata*, a normal dominant of a cool temperate montane forest, often admixes in the tree or subtree stratum in the montane-subalpine transitional zone.

Undergrowth group a: Species having a wide amplitude against altitudinal and physiographical conditions, except for slight declines at higher altitudes; *Sorbus commixta*, *Viburnum frucatum*, *Streptopus streptopoides*/var. *japonicus* (*St. streptopoides* is restricted to Hayachine although its variety prevails throughout the study areas), *Lycopodium serratum* var. *serratum*, *Polystrichopsis mutica*, *Maianthemum dilatatum*, *Skimmia japonica* var. *repens*, *Tripterospermum japonicum*, *Plagiogyria matsumureana*, *Acer tschonoskii*, *Sasa kurilensis*, etc.

Undergrowth group b: Species occurring from the montane to the lower subalpine; *Carex multiflora*, *Hydrangea petiolaris*, *H. paniculata*, *Schizophragma hydrangeoides*, etc.

Undergrowth group c: Species showing the maximum dominance or occurrence in the subalpine zone but without sharp preference for physiognomic condition; *Acer ukurunduense*, *Rhododendron albrechtii*, *Rh. brachycarpum*, *Menziesia pentandra*, *M. multiflora*, *Vaccinium smallii*, *V. hirtum*, *Ilex rugosa*, *Coptis trifolia*, *Heloniopsis orientalis*, etc.

Undergrowth group d: Montane elements in the proper sense; *Fraxinus lanuginosa* var. *serrata*, *Prunus grayana*, *Lindera umbellata* var. *membranacea*, *Magnolia salicifolia*, *Ilex leucoclada*, *Hamamelis japonica* var. *obtusata*, *Quercus mongolica* var. *undulatifolia*, etc. Most of them are important components in beech forests, with the exception of *Quercus*, which forms the deciduous broad-leaved scrubs observable at special sites, where tall forests fail to establish themselves under the Japan Sea climate.

Undergrowth group e: Shrubs usually comprising the alpine scrubs; *Pinus pumila*, *Prunus nipponica*, *Alnus maximowiczii*, *Sorbus matsumurana*, etc.

Undergrowth group f: Species closely related to the moist soil with much humus, especially under the thick canopy of subalpine conifers: *Oplopanax japonicus*, *Oxalis acetosella*, *Cacalia adenostyloides*, *Clintonia udensis*, *Diphylleia grayi*, *Dryopteris austriaca*, *Lastrea quelpaertensis*, *Trautvetteria japonica*, etc.

Undegrowth group g: Alpine and subalpine mosses; *Pleurozium schreberi*, *Hyloconium splendens*, *Dicranum japonicum*, *Paraleucobryum enerue*, *Rhytidiadephus triquertrus*, etc. They form thick mats under a thick canopy in the fog zone at high altitudes.

Undergrowth group h: Species more or less related to the unfavourable conditions, both dry and wet, especially under open canopies; *Ilex sugerokii* var. *brevipedunculata*, *Leucothoe grayana* var. *oblongifolia*, *Vaccinium japonicum*, *Trientalis europaea*, *Shortia soldanelloides*, *Epigaea asiatica*, *Mitchella undulata*, *Solidago virga-aurea* var. *gigantea*, *Cornus canadensis*, etc.

Undergrowth group i: Species occurring mainly at wet sites of the subalpine zone; *Ilex crenata* var. *paludosa*, *Sphagnum fibriatum*, *Sph. girgensohnii*, *Carex blepharicarpa*, *Hosta rectifolia*, *Lysichiton camtschatcence*, *Veratrum stamineum*, *Osmundastrum cinnamomeum*, etc.

Undergrowth group j: Species comprising the alpine dwarf scrubs, grassland and snow-bed vegetation: *Calamagrostis sachalinensis*, *C. hakonensis*, *Empetrum nigra*, *Gaultheria adenothrix*, *G. miqueliana*, *Vaccinium vitis-idaea*, *Tripetaleia bracteata*, etc.

The above groups are often further divided into subgroups which correspond, although not so rigidly, to delicate variations in the habitat condition.

III. Community Types

The community types determined, together with the summarized species composition, are given in Table 1. As for the species arrangement in the table, the uppermost components are designated as the dominants or main tree species, and the subsequent as the representatives of each undergrowth group, except the components of Group b and j.

Geographic distribution of each community is shown in Table 2, where the subalpine coniferous forests are grouped into two major categories; climatogenic forests and topogenic forests. The climatogenic forests are here defined as the normal forests established on gentle slopes and primarily affected by geographic and climatic conditions. They are further categorized as the montane-subalpine ecotonal forests, the thick forests with densely closed canopy, the thin forests with sparse canopy, and the alpine-subalpine ecotonal forests.

On the other hand, the topogenic forests are those on such special topography as ridges, steep slopes, convex and concave grounds with much boulder, flat or ill-drained grounds, etc., where physiographic factors are more effectively operative.

Table 2. The thermal environments of the study areas and the distribution of the communities determined. The numerals indicate the altitudinal ranges of occurrence.

				Localities	Hayachine	Azuma	Hachimantai	Hakkoda	Zao	Moriyoshi	Gassan
				Altitude of the top (m)	1913	2024	1613	1585	1840	1452	1979
				Warmth index at the top (m. d.)	22.2	22.0	28.2	23.4	29.9	33.3	26.1
				Altitude of the 45 m. d. isopleth (m)	1105	1415	1105	853	1337	1105	1337
Climatogenic forests	Lower ecotone		A	*Abies*•*Fagus* comm.	1100 ~1200		910 ~1260	920 ~1150	1300 ~1350	1140	—
Climatogenic forests	Gentle slopes	Thick forests	B	*Abies*• *Tsuga*• *Thujopsis*-*Oplopanax* comm.	1090 ~1550	—	—	—	—	—	—
Climatogenic forests	Gentle slopes	Thick forests	C	*Abies*• *Tsuga*-*Oplopanax* comm.	1150 ~1690	1560 ~1880	1150 ~1490	—	—	—	—
Climatogenic forests	Gentle slopes	Thick forests	D	*Abies*-*Oplopanax* comm.	1200 ~1690	1440 ~2000	1570 ~1600	1320 ~1450	—	—	—
Climatogenic forests	Gentle slopes	Thick forests	E	*Abies*-*Thujopsis*-*Oplopanax* comm.	1560 ~1680	—	—	—	—	—	—
Climatogenic forests	Gentle slopes	Thick forests	F	*Abies*-mosses comm.	—	1930 ~2024	—	—	—	—	—
Climatogenic forests	Gentle slopes	Thin forests	G	*Abies*•*Betula*-*Oplopanax* comm.	—	—	1300 ~1560	—	—	—	—
Climatogenic forests	Gentle slopes	Thin forests	H	*Abies*-*Ilex*-*Oplopanax* comm.	—	—	1460 ~1600	1110 ~1350	1380 ~1750	—	1350 ~1400
Climatogenic forests	Gentle slopes	Thin forests	I	*Abies*• *Tsuga*-*Ilex* comm.	—	1540 ~1880	—	—	—	—	—
Climatogenic forests	Gentle slopes	Thin forests	J	*Abies*-*Ilex* comm.	—	1680 ~2024	—	—	1470 ~1600	1250 ~1400	1350 ~1400
Climatogenic forests	Gentle slopes	Thin forests	K	Ibid. (*Quercus type*)	—	—	—	—	1420 ~1520	—	1350 ~1500
Climatogenic forests	Upper ecotone		L	*Abies*-*Pinus pumila* comm.	1500 ~1830	—	1580 ~1600	1320 ~1600	1540 ~1760	1400 ~1430	—
Topogenic forests	Flats and Wet sites	Tall forests	M	*Abies*-*Ilex*-*Sphagnum* comm.	1200 ~1660	—	—	—	—	—	—
Topogenic forests	Flats and Wet sites	Tall forests	N	*Pinus*•*Abies*-*Osmudastrum* comm.	—	—	910 ~990	—	—	—	—
Topogenic forests	Flats and Wet sites	Stunted forests	O	*Abies*-*Carex* comm. (*Thuja* type)	—	1500 ~1860	—	—	—	—	—
Topogenic forests	Flats and Wet sites	Stunted forests	P	Ibid. (*Quercus* type)	—	—	—	1020 ~1050	1450 ~1520	1280 ~1300	1400 ~1500
Topogenic forests	Flats and Wet sites	Stunted forests	Q	Ibid. (*Pinus* type)	—	1820 ~2000	1560 ~1600	1250 ~1330	—	—	—
Topogenic forests	Ridges and Steep slopes	Drier sites	R	*Thuja*•*Abies*-*Ilex* comm.	—	1580 ~1860	—	—	1250 ~1400	—	—
Topogenic forests	Ridges and Steep slopes	Drier sites	S	*Tsuga*•*Abies*•*Pinus* comm.	—	—	910 ~1160	—	—	—	—
Topogenic forests	Ridges and Steep slopes	Fog zone	T	*Tsuga*-mosses comm.	1020 ~1430	—	—	1220	—	—	—
Topogenic forests	Ridges and Steep slopes	Sloping sites	U	*Tsuga*• *Thujopsis*•*Abies*-(*Oplopanax*) comm.	980 ~1500	—	—	—	—	—	—
Topogenic forests	Ridges and Steep slopes	Sloping sites	V	*Tsuga*•*Abies*-(*Oplopanax*) comm.	1070 ~1520	—	1400 ~1550	1100 ~1200	—	—	—

1. Climatogenic forests

A. *Abies mariesii* · *Fagus crenata* community (Montane-subalpine ecotonal forests)

This type of community occurs throughout the study areas except Mt. Gassan on gentle slopes at lower altitudes close to the montane zone. The altitudinal ranges at which this community occurs closely correspond to the isopleth of 45 m. d. or so in the warmth index. The dominance of the community is shared by *Abies* and *Fagus*, although the latter declines with increasing altitude. Montane and subalpine floral elements are equally found among the undergrowths.

B. *Abies mareisii* · *Tsuga diversifolia* · *Thujopsis dolabrata* var. *hondai*-*Oplopanax japonicus* community and E. *Abies mariesii* · *Thujopsis dolabrata* var. *hondai*-*Oplopanax japonicus* community

Thujopsis dolabrata var. *hondai*, in the peninsulas of Shimokita and Tsugaru at the northern extremity of Honshu, forms the mixed forests with such montane deciduous trees as *Fagus crenata*, *Magnolia obovata*, *Aesculus turbinata*, etc. (Yoshioka 1965, Suzuki 1977), while in the Kitakami massif it is often mixed with *Tsuga diversifolia* (Okuda 1968, Suzuki 1977, Saitō et al. 1977). In the case of Hayachine, it grows upto the subalpine zone along the northern slope of the mountain. The lower part of this zone is often predominated by *Tsuga* and *Thujopsis* of a height of 25 m or so. *Abies* much intermingles in the tree and subtree strata and characterizes the forest canopy. Among the undergrowths Groups c and f are common while the components of Groups h and i are seldom detected. The *Abies* · *Tsuga* · *Thujopsis*-*Oplopanax* community is named after both the main trees and the representative of the remarkable undergrowth group.

At altitudes over 1500 m, forest trees are rather stunted. *Thujopsis* especially is so stunted as to flourish merely in the shrub and herb layers. *Abies* consequently predominates the forest there. The undergrowths are similar to those of the above community. The *Abies*-*Thujopsis*-*Oplopanax* community is applicable to this type.

C. *Abies mariesii* · *Tsuga diversifolia*-*Oplopanax japonicus* community

Typical stands of this community are found on the granitic area of Hayachine. The forests are primarily four or three stratified and dominated by *Abies*, intermingled with *Tsuga* and *Betula* often attain a height of 27 m or so and form the uppermost canopy over the 18–23 m stratum of *Abies*. With increasing altitude, *Abies* increases dominance in the forest. Conspicuous undergrowths are those of Groups a, c, and f. In addition, it is also to be noted that *Pteridophyllum racemosum* predominates the forest floor under a thick canopy. Throughout northern Honshu, such a combination of the layered dominants as *Abies* · *Tsuga*-*Oplopanax*/*Cacalia*-*Pteridophyllum* cannot be found elsewhere. This type of community may be related to the subalpine forests of central Honshu, especially on the Pacific side. The same community type is also found extensively on Mt. Azuma and partly on Mt. Hayachine, although without *Pteridophyllum*.

D. *Abies mariesii*-*Oplopanax japonicus* community

Abies mariesii often forms a thick canopy at high altitudes either with conspicuous decrease of *Tsuga* on Mts. Hayachine and Azuma or with increasing density of the *Abies* stems on Hachimantai and Hakkoda, so that it becomes a pure forest. The undergrowth components are almost similar to those of the community mentioned just above, although with an increase of mosses.

F. *Abies mareisii*-mosses community

Typical stands of this community are found on the flat at the top of Nishi-Azuma, the highest peak of Mt. Azuma. This type is characterized by the densely closed canopy of *Abies* 4–5 m tall and the well-established moss layer. Even the undergrowths of Group f are scarcely found, except for *Oplopanax japonicus* and *Oxalis acetosella.* This type may be closely related to high air humidity during the growing season at this high altitude.

G. *Abies mariesii*·*Betula ermanii-Oplopanax japonicus* community

Most of the lower subalpine of Hachimantai (alt. 1300–1400 m) are covered by this communty. *Betula ermanii* commonly intermingles in the canopy layer dominated by *Abies* 15–20 m tall. The sparse type of canopy occurs on the windward side of the mountain. The components of Group f still dominante the forest floor.

H. *Abies mariesii-Ilex sugerokii* var. *brevipedunculata-Oplopanax japonicus* community

This occurs extensively on the windward sides of Hachimantai and Hakkoda, and locally on the leeward slopes at higher altitudes on Zao. In the former cases, the canopy is tall and thin, while in the latter case, it is more or less stunted and thick with an increasing density of *Abies* stems. The same also occurs on the edge of a lava plateau on Mt. Gassan. In all cases, the forest floor is luxuriantly grown with *Sasa kurilesis,* associated by the both of Groups f and h, although *Oplopanax* and *Ilex* are not necessarily frequent.

I. *Abies mariesii*·*Tsuga divresifolia-Ilex sugeroki* var. *brevipedunculata* community

This is sporadically encountered on Mt. Azuma. The forest canopy becomes thinner or more sparse on the drier and shallower soils on the convex or steep slopes. The understoried vegetation usually contains the components of Groups a, c and h but scarcely of f.

J. *Abies mariesii-Ilex sugerokii* var. *brevipedunculata* community and K. Ibid (*Quercus* type).

The gentle slopes of Mt. Zao, Mt. Moriyoshi and Mt. Gassan are mostly occupied by this type of sparse forest which lacks *Tsuga* and Group f. This community also occurs on the convex slopes at the high altitudes of Mt. Azuma. Such sparse forests are grouped into two types: the typical *Abies-Ilex* community and the *Quercus* type of the same community. They are distinguished from each other by *Quercus mongolica* var. *undulatifolia* which increases dominance on gentler slopes under the Japan Sea climate.

L. *Abies mariesii-Pinus pumila* community

This is encountered along the upper limit of the subalpine coniferous forest, much invaded by such alpine shrubs as *Pinus pumila, Sorbus matsumureana, Prunus nipponica,* etc. The components of Group h are also conspicuous. Viewed physiognomically and floristically, this type shows a transition between the alpine and the subalpine vegetation. It is, however, to be noted that none of the study areas attains an elevation of 15 m. d. in the warmth index, the theoretical alpine-subalpine border, although even the top of Mt. Moriyoshi, where the index is over 30 m. d., is covered by this community. This type may primarily be caused by such summit phenomena as strong wind, heavy snowfall, etc. On the other hand, the *Abies* forests are often established on the tops of the older volcanoes of Mt. Azuma (2024 m, 22 m. d.) and Mt. Hachimantai (1613 m, 28.2 m. d.) but not on Mt. Zao (1840 m, 29.9 m. d.) which is younger. In the latter case, the forest limit descends to an elevation of 1650 m or so and above this such volcanic vegetation as scrubs, heathlands and deserts extends vastly. Thus, past volcanic activities may be at least partly responsible for the existent distribution of the *Abies-Pinus pumila* community.

A geographic gradient is, as mentioned above, found in the distribution pattern of the climatogenic forests. The thickness of forest canopy decreases in the following order: Hayachine, Azuma, Hachimantai, Hakkoda, Zao, Moriyoshi, Gassan. This nearly corresponds to the Pacific-Japan Sea gradient of climate. As for the community types, Hayachine and Azuma are extensively covered by the thick forests of the *Abies*・*Tsuga*・*Thujopsis-Oplopanax* community, the *Abies*・*Tsuga-Oplopanax* community and the *Abies-Oplopanax* community, while Zao Hachimantai, Hakkoda, Moriyoshi and Gassan are predominated by the thin forests of the *Abies*・*Betula-Oplopanax* community, the *Abies-Ilex-Oplopanax* community and the *Abies-Ilex* community.

2. Topogenic forests

M. *Abies mariesii-Ilex sugerokii* var. *brevipedunculata-Sphagnum fibriatum* community

The more or less wet sites on Mt. Hayachine are often occupied by this community. The canopy layer 5–7 m high is commonly dominated by *Abies* and the shrub layer by *Sasa kurilensis*. The herbs of Group f decrease or utterly disappear while the components of Group h and i sharply increase.

N. *Pinus parvifolia* var. *pentaphylla-Abies maresii-Osmunastrum cinnamomeum* community

This is encountered on the flats in the upper montane of Hachimantai. The uppermost canopy of 20 m or so in height is comprised of *Pinus*, *Abies* and *Betula ermanii*. Among the undergrowths Groups h, i and also b are remarkable.

O. *Abies mariesii-Carex blepharicarpa* community (*Thuja standishii* type), P. Ibid. (*Quercus mongolica* var. *undulatifolia* type) and Q. Ibid. (*Pinus pumila* type)

Throughout north Honshu, stunted forests of *Abies* often occur on flats or wet sites surrounding moors and snow-bed vegetation. They are commonly undergrown with the hygrophyllous plants of Group i, together with Group h, while the shrub layer is dominated by any one of *Thuja*, *Quercus* or *Pinus*, after which the subordinate types are determined. The types of *Thuja* and *Quercus* usually occur in the lower subalpine while the *Pinus* type does at higher altitudes. The *Thuja* type is characteristically restricted to Mt. Azuma. The *Quercus* type is more closely related to the Japan Sea climate and restricted to Hakkoda, Zao, Moriyoshi, and Gassan, although *Quercus mongolica* var. *undula-*

tifolia prevails in the potential floras of all the study areas. The *Pinus* type is commonly found in the study areas except Mt. Gassan.

R. *Thuja standishii*·*Abies mariesii*-*Ilex sugerokii* var. *brevipedunculata* community and S. *Tsuga diversifolia*·*Abies mariesii*·*Pinus parvifolia* var. *pentaphylla* community

Thuja standishii and *Tsuga diversifolia* often predominate the convex grounds with shallow soil and form the *Thuja*·*Abies*-*Ilex* community at the lower subalpine of Azuma and Zao and the *Tsuga*·*Abies*·*Pinus* community on Hachimantai. The geopraphic distribution of these two, sharply marked, is probably related to the subalpine flora of each mountain: *Thuja* is not encountered in the subalpine zone of Hachimantai, Hayachine, Hakkoda, Moriyoshi and Gassan, and *Tsuga* not in Zao and Gassan. The forests are dominated either by *Thuja* oɪ by *Tsuga*, but equally associated by *Abies* and often by *Pinus*. The remarkable undergrowths of both types fall within Group h.

T. *Tsuga diversifolia*-Mosses community

Even the rocky shallow soil is often moistened in the fog zone and on the north-facing slope at high altitudes, and covered by the thick canopy of *Tsuga diversifolia*. Usually the spermatophytic undergrowths are poor in quality except for some of Groups a and c, while the moss mats are well developed on the ground floor. Such forests are found on Hayachine and Hakkoda. The relic stand of *Picea glenii* on Hayachine falls in this type.

U. *Tsuga diversifolia*·*Thujopsis dolabrata* var. *hondai*·*Abies mariesii*-(*Oplopanax japonicus*) community and V. *Tsuga diversifolia*·*Abies mariesii*-(*Oplopanax japonicus*) community

The former type is found on Hayachine and the latter on Hachimantai, Hakkoda and Hayachine. Both types are transitional in their floristic composition: the former between the *Tsuga*-moss community and the climatogenic *Abies*·*Tsuga*-*Oplopanax* community, the latter between the *Tsuga*·*Abies*·*Pinus* community and the *Abies*·*Thujopsis*·*Tsuga*-*Oplopanax* community. Generally *Tsuga* and *Pinus* are constant in the canopy layer. Among the undergrowths *Ilex sugerokii* var. *brevipedunculata* is frequent although *Oplopanax japonicus* and *Oxalis acetosella* are still constant. Most of the well established forests of *Tsuga* fall in either of these types.

Summary

1. In the attempt to describe the geographic variation of the subalpine coniferous forests in north Honshu, Japan, the community types were mentioned as the combination of the dominants and remarkable undergrowths.
2. The undergrowths were grouped into ten commodia: a) species distributed widely in the montane and subalpine zones, b) species centered in the upper montane-lower subalpine, c) species in the subalpine, d) species in the montane, e) species in the alpine scrubs, f) species characteristic of the thick forests, g) alpine and subalpine mosses, h) species excluded from the thick forests, i) hygrophyllous species, and j) species centered in the alpine heathlands, windward grasslands and snow-bed vegetation.
3. As a consequence, 12 types of the climatogenic forests and 10 of the topo-

genic forests were determined.

4. A sharp geographic gradient was found in the distribution pattern of the climatogenic forests. The mountains under the Japan Sea climate are covered by the thin forests, while those under the Pacific climate by the thick forests.
5. The *Abies*·*Fagus* community, transitional between the subalpine and montane forests, occurs at an elevation of 45 m. d. or so in the warmth index. However, the *Abies-Pinus pumila* community, transitional between the alpine and subalpine vegetation, is encountered at elevations below the theoretical forest limits of 15 m. d. The primary cause for this may be attributed to the summit phenomena and, in some cases, also to the past volcanic activities.
6. The topogenic forests also show a geographic variation. Most conspicuously, the wet sites are covered by the *Abies-Carex* community and the subordinate type of *Quercus* prevails under the Japan Sea climate, while the *Thuja* type occurs on the southern part of the Ou range.

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