Vegetational Landscape of Sai-no-kawara, a Lava Plateau, Zaô Volcanoes, Miyagi Prefecture

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Sai-no-kawara is a lava plateau at the altitude from 1200 to 1400 m on the east slope of the Zaô Volcanoes which rise over the backbone range of Northeast Japan (Fig. 1). This plateau gently inclines to the east and has a smooth relief except for small dissecting gullies (Sanzu-no-kawa and Shintaki-zawa) and an intersecting scarplet from north to south. Its surface is thinly covered with volcanic ejecta but partly, especially in the northwestern part, the lava base is exposed.

Bare lands or low and sparse vegetations obviously of volcanic origin extend eastward from Mt. Kumano-dake (1840 m) containing this plateau (Fig. 4). The paucity of vegetation is thought to be resulted from a series of eruptions which took place in late 19th Century at the crater "Okama" with some ejecta (Yoshioka 1935, Miyagi Pref. 1955), but it is not clear how far and how much the individual eruption destroyed the vegetation, and the vegetational conditions before the explosions are not to be known, too. It is, however, evident that the volcanic activities were strong enough to destroy the vegetation wholly on large area, because wide bare lands without any vegetation are found today. The northern part of this plateau belongs to such areas as the vegetation is sparse and bare ground extends broadly. The southern half, on the other hand, is covered with a forest vegetation looking close to the climax.

The contrast of such vegetational conditions brings remarkable gradient in vegetational landscape from south to north. The gradient can be recognized in the occupancy rate of bare area, the height of plant communities, the species composition, the degree of development of community stratification and so on.

The vegetation of this area was analysed quantitatively in the previous work (Makita 1969). In the present report the main discussion is concerning the species composition and vegetational landscape, in addition the meaning of vegetational succession to the geography is mentioned.

1 Methods

At the field surveys in 1968 and partly in 1973, species as components of communities and their coverage, coverage and height of each community layer, occupancy rate of bare area and so on were observed in 10×10 m quadrates around

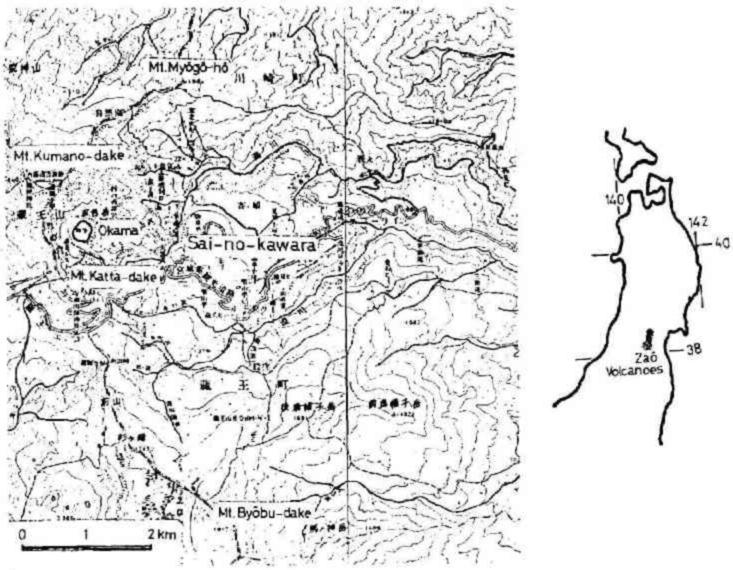


Fig. 1 Location of Zaô Volcanoes and Sai-no-kawara

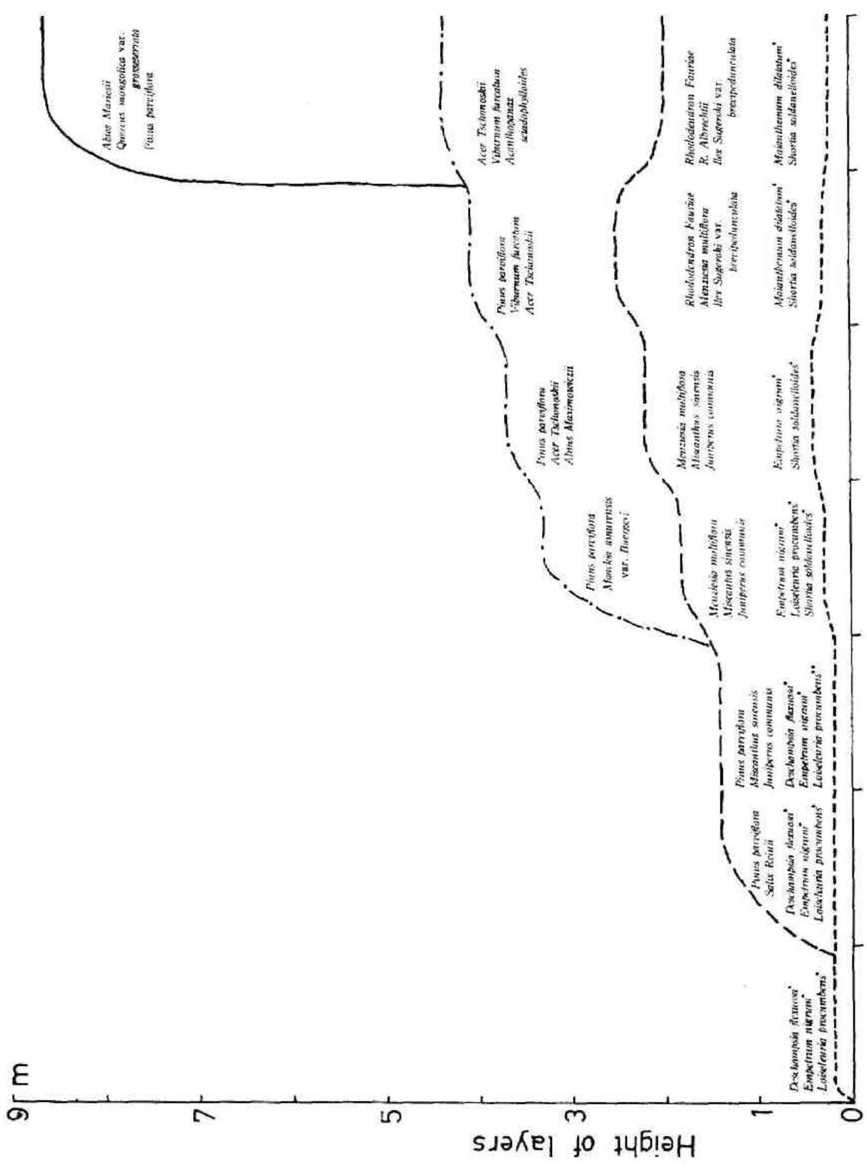
the survey points laid at random at intervals of about 200 m and at intervals of 50 m along the line a-b (Fig. 3).

The survey points were classified from the view point of vegetation, appropriating the plant sociological technique, *i.e.* in accordance with species composition (Table). As the survey points were set systematically and whole species in every quadrate were described, the types classified here, only concerning the survey points, are essentially different from those of communities in a sense of plant sociology, although they resemble each other.

2 Types of survey points and their distribution

Thus, seven types (A to G) are distinguished. Therein, species composition is transitional from type to type as shown in the table. It is caused by the systematic survey method as mentioned above. Since the survey points are arranged mechanically over the survey area, in which many community types are intermingled, showing general gradient of south to north, and species are listed without omission from each quadrate, species of different communities are notable at once in each survey point but as a result clear difference of species composition is unexpectable among survey points.

Fig. 2 **(opposite page)** Community stratification of each type and height and main components of each layer. Asterisks indicate the components of herb layer.


Height of layers
9 m
7
5
3
1
0
A
B
C
D
E
F
G
H
S
T2
T1

Floristic composition of each type

Roman numerals indicate constancy, *i.e.* r: less than 5%, +: less than 10%, I: less than 20%, II: less than 40%, III: less than 60%, IV: less than 80%, V: more than 80%. Species of low constancy are omitted.

Group of types		←		I		→	← II	→
Types		A	B	C	D	E	F	G
Mean coverage of layers (%)	T_1	—	—	—	—	—	—	50
	T_2	—	—	—	20	20	60	60
	S	—	20	30	50	60	60	50
	H	20	30	50	50	70	50	40
Number of survey points		6	22	16	10	9	6	19
Mean species number		4	12	21	27	28	28	28
Species differential for groups								
Deschampsia flexuosa		V	IV	V	IV	III		
Empetrum nigrum		III	V	V	V	V		
Loiseleuria procumbens		III	V	V	V	V		
Viburnum furcatum						II	V	V
Abies Mariesii					+	I	II	IV
Acanthopanax sciadophylloides						I	III	IV
Taxus cuspidata							III	IV
Rhododendron Albrechtii							II	IV
Acer japonicum						I	II	IV
Species differential for types								
Aletris foliata			III	V	IV	IV	I	
Arcterica nana			IV	III	IV	II		
Anaphalis margaritacea			II	V	III	I		
Hypericum erectum			I	IV	III	III		
Miscanthus sinensis			II	V	V	V	V	
Juniperus communis			II	V	V	V	V	
Rhododendron Tschonoskii			IV	V	V	III	II	+
Sanguisorba albiflora			r	II	V	IV	IV	
Gaultheria Miqueliana			I	III	IV	IV	V	
Maackia amurensis var. *Buergeri*				III	IV	III	III	I
Menziesia multiflora				III	IV	V	V	II
Gentiana triflora			r	III	IV	IV	V	II
Hydrangea paniculata				III	II		II	III
Weigela hortensis				II	III	I	II	III
Ilex Sugeroki var. *brevipedunculata*				V	IV	V	V	V
Tripterygium Regelii			+	IV	IV	III	V	V
Platanthera ophrydioides			r	I	II	III	IV	IV
Trientalis europaea var. *europaea*					II	IV	V	V
Solidago japonica				+	III	IV	V	IV
Lycopodium clavatum var. *nipponicum*			r	I	IV	III	IV	II
Acer Tschonoskii			r	+	II	V	V	V
Maianthemum dilatatum					I	III	V	V
Vaccinium hirtum					II	II	IV	II
Listera nipponica					+	IV	IV	III
Tripterospermum japonicum					+	III	V	V
Prunus nipponica					+	III	V	III
Rhododendron Fauriae						III	V	V
Vaccinium axillare			r	I		III	V	III
Quercus mongolica var. *grosseserrata*					I	II	II	IV
Fraxinus Sieboldiana							I	III
Leucothoe Grayana var. *oblongifolia*				I	I	II	II	V
Sorbus commixta					I	II	II	V
Ilex leucoclada								IV
Betula Ermani					II	I	I	III
Cornus controversa								III
Carex breviculmis					I		I	III
Streptopus streptopoides var. *japonicus*								II
Other species occurring in this plateau								
Shortia soldanelloides		II	V	V	V	V	V	IV
Pinus parviflora			IV	V	V	V	V	V
Calamagrostis hakonensis		I	V	V	V	IV	V	I
Spiraea betulifolia		IV	V	V	IV	IV	III	
Salix Reinii		I	IV	V	V	V	IV	I
Alnus Maximowiczii			IV	IV	III	IV	II	III
Gaultheria adenothrix				+	III	III	II	+
Heloniopsis orientalis				+	II	II	IV	II
Tilingia ajanensis			r	I	II	III		
Aruncus sylvester			r	III	I		I	+
Ixeris dentata				+	II		II	II
Orchis aristata				I	II	II	II	+

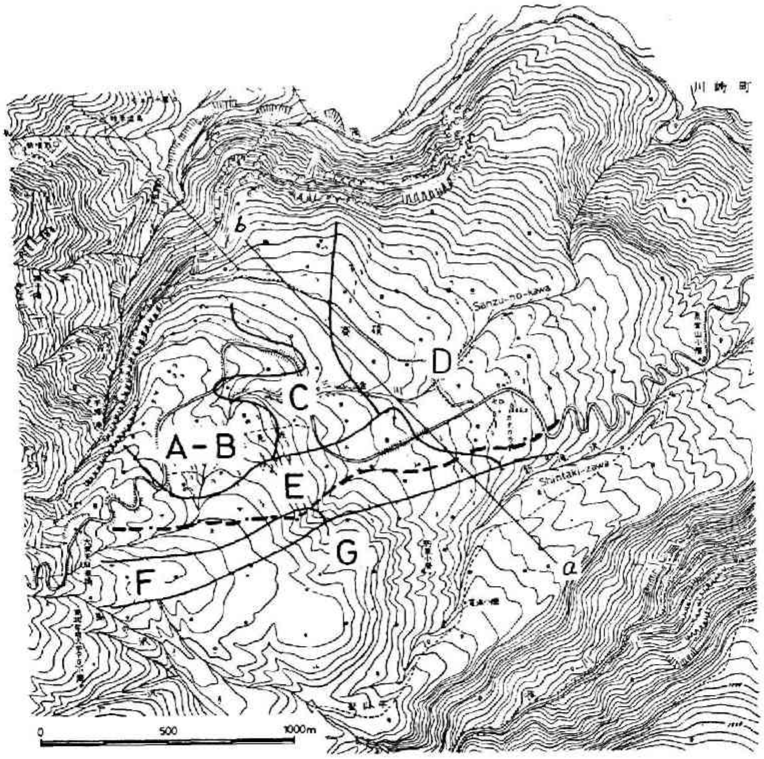


Fig. 3 Distribution areas of each type
dots: survey points a-b: line transect dick broken line: southern limit of bare grounds

The types are grouped into two; Group I (A to E) characterized by *Deschampsia flexuosa*, *Empetrum nigrum* and *Loiseleuria procumbens* and Group II (F and G) characterized by *Viburnum furcatum*, *Abies Mariesii*, *Acanthopanax sciadophylloides*, *Taxus cuspidata*, *Rhododendron Albrechtii* and *Acer japonicum*.

Three species characterizing the former group are all found on and around bare ground but not inside forest. Among them *D. flexuosa* often occurs on sandy or gravelly ground of high mountains (Ohba 1969), especially on new volcanic ejecta. In Northeast Japan it is found on newly-born surfaces of volcanoes of Mt. Bandai (Yoshii 1940, Makita 1974), Mt. Azuma and Mt. Adatara (Yoshii 1940), being typical of pioneer species of primary succession.

In other words, they cannot grow without some bare grounds, and from this point it is interesting that the southern limit of the area of Group I well agrees with that of the occurrence of the scattered island-like bare spots (Fig 3, Makita

1969).

The differential species of Group II are tree or sub-tree. Among them *Abies Mariesii* is characteristic to so called "sub-alpine" evergreen coniferous forest and *Acanhtopanax ciadophylloides*, *Rhododendron Albrechtii* and *Acer japonicum* are to montane *Fagus crenata* forest in Japan. This mixture of characteristic species of two altitudinal zones will be referred later.

Seven types are characterized as follows (Table, Figs. 2 and 3):

Type A This is the poorest type in vegetational cover, number of species and height and stratification of community. Greater part of the quadrates are remained without vegetation. Beside the differential species of Group A, *Spiraea betulifolia* which occurs widely on volcanic desert is found with high constancy.

Type B *Alteris foliata, Arcterica nana, Anaphalis margaritacea, Hypericum erectum, Miscanthus sinensis, Juniperus communis and Rhododendron Tschonoskii* join as component. These are the components of forest edge, herb and shrub communities. From this type, afterwards, *Pinus parviflora* and *Salix Reinii* occur in high constancy. In this type, shrub layer is found but with low coverage, and the vegetational cover as a whole is yet low. This type and Type A are distributed intermingled in northwestern part of the plateau (Fig. 3).

Type C Components of herb community and shrubs such as *Sanguisorba albiflora, Gentiana triflora, Gaultheria Miqueliana, Menziesia multiflora, Hydrangea paniculata, Weigela hortensis, Ilex Sugiroki* var. *brevipedunculata* and *Tripterigium Regelii* join anew and sub-tree species *Maackia amurensis* var. *Buergeri* is found at first. But yet only herb and shrub layer develop, although vegetational coverage is higher than former two.

Type D *Platanthera ophrydioides, Trientaris europaea* var. *europaea, Solidago japonica, Lycopodium clavatum* var. *nipponicum, Acer Tschonoskii, Maianthemum dilatatum* and *Vaccinium hirtum* join as components. Among them *A. Tschonoskii* as a sub-tree and *M. Dilatatum* as an undergrowth occur generally in forest of this region. From this type sub-tree layer is found, dominated by *Pinus parviflora*. Vegetational coverage becomes nearly 100%.

Type E Beside above species *Listera nipponica, Tripterospermum japonicum, Prunus nipponica, Rhododendron Fauriae, Vaccinium axillare* and *Quercus mongolica* var. *grosseserrata* are found as differential species for this type. The last one occurs in the forest of this plateau as a canopy tree and compose wide pure stand adjoining downward to the plateau (Fig. 4). Until the area of this type bare spots of different size are found.

Type F Lacking the differential species for Group I, this type has almost all differential species of above types and at the same time those of Group II. There is already no bare spot in the area of this type, but the occurrence of *Miscanthus sinensis*, *Sanguisorba albiflora*, *Juniperus communis* and other components of herb and shrub communities indicates that the forest canopy is not yet closed in this type.

This type and Type E have rather narrow distribution area than other types.

Tybe G Though the species composition of this type is similar to those of the last type, *Leucothoe Grayana* var. *oblongifolia* and *Sorbus commixta* occur in this type with high constancy and *Ilex leucoclada*, *Cornus controversa* and *Streptopus streptopoides* var. *japonicus* are peculiar in this type. Four layered forest begins with this type, however the absence of tree layer at several points of this type suggests that the vegetation represented by this type is not in full climax. The area of this type is located in the southernmost part of the plateau.

Pinus parviflora is a noticeable species, prevailing in every type without Type A. It is creeping in Types B and C, increases the height gradually, and is standing as sub-tree or tree from Type D afterward. At the same time, it occupies the uppermost layers of communities in the greater part of this plateau, and plays an important role to construct the gradient in vegetational landscape.

Types G, F, E and D are arranged from south to north, suggesting the plant invasion from the south. East to west arrangement of Types D, C, B and A may be attributed to the invasion from the *Quercus mongolica* var. *grossesserrata* forest to the east of this plateau (Fig. 4) superposing the above invasion from the south. More important is the difference in substratum or the landsurface condition. Overlying fine materials such as volcanic ash and sand are less in the area of Types A and B than in other areas, and lava base is exposed everywhere in the area. This landsurface condition is supposed to be the major factor for the arrangement of the areas of Types D, C, B and A, and also for the direct connection between the areas of Types A and B and that of Type E without any interruption by that of Type C or D. In other words, if fine materials were deposited more intensively on the areas of Types A and B, their vegetations would be as advanced as in the areas of Types C and D.

3 Plant succession and its significance to the vegetational geography

As hitherto mentioned, the states of vegetation are various on this plateau, low and sparse or high and closed. The former is obviously the early stage of succession and the latter is nearly to the climax. These states may seemingly belong to one successional sere, which is shown with its profile in Fig. 2. Yoshioka (1935) once estimated seres able to be in these volcanoes containing this plateau.

His method was just to arrange the communities from sparse and low to dense and high.

But this method does not clarify a sere in a strict sense. Plant succession is a change of vegetation which takes place with the proceeding of time at one fixed area. Therefore, strictly speaking, a sere of succession is identified only by the enduring investigation for a long period in a certain sample area. Approximately, some seral stages are possible to be estimated by careful comparison of communities located on grounds in different ages but in similar conditions.

In the present survey area, vegetational condition changes continuously and transitionally from north to south. From Type A to Type G, increase of components of forest or climax vegetation takes place gradually, as well as decrease of those of pioneer, without remarkable gaps. Many species occur simultaneously in several types. Accordingly, any age differences of habitat is not| able to be recognized by means of species composition. On the other hand, the narrower areas of Types E and F than of other types suggest possible age difference between the combined area of Types A, B, C and D and the area of Type G, and transitional or frontal character in plant invasion of the areas of Types E and F. Hence, there was scarcely age difference of the areas except for that of Type G. In this sense, difference in species composition between survey points is probably caused by the relative difficulty in plant invasion. For species of earlier successional stage which have stronger migrating ability, this relative difficulty should be owing to edaphic condition of the habitat. The distribution of Types A, B, C and D in the northern half is well explained from the above inference. Otherwise, for the plants peculiar in advanced stages of succession, the relative difficulty should be due to the distance from the seed source. In the southern half, the areas of Types G, F, E and D are arranged according to the distance from the climax forest to the south of the plateau. Anyway, the different states of vegetation seen in this plateau are not caused by age difference of land surface, except that between the area of Type G and others. So the sere is not to be estimated logically here.

But at least it can be said that the earliest pioneer is a herb and dwarfshrub community represented by *Deschampsia flexuosa* and that *Pinus parviflora* composes closed vegetation at first predominating the landscape, when a broad bare land is newly originated by volcanic activities.

The climax vegetation of this plateau realized far afterwards is estimated to be montane *Fagus crenata* forest or so called "sub-alpine" *Abies Mariesii* forest from the view point of altitudinal zonation as shown in Fig. 4. Type G has many species characteristic to the beech forest of Japan Sea side of Northeast Japan such as *Menziesia multiflora, Ilex Sugeroki* var. *brevipedunclata, Acer Tschonoskii,*

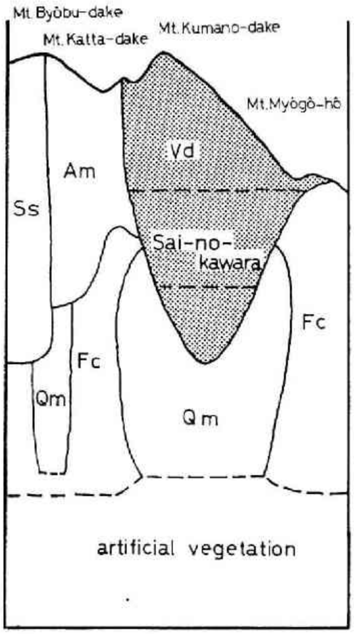


Fig. 4 Altitudinal zonation of the east slope of Zaô Volcanoes (modelized in accordance with the vegetation map published by the Agency for Cultural Affairs, Ministry of Education)
Vd: volcanic desert, Am: *Abies Mariesii* forest, Fc: *Fagus crenata* forest, Qm: *Quercus mongolica* var. *grosseserrata* forest, Ss: sub-alpine deciduous broadleafed communities

A. japonicum, Rhododendron Albrechtii and Leucothoe Grayana var. *oblongifolia*, and those to the whole Japanese beech forest such as *Quercus mongolica* var. *grosseserrata, Acanthopanax sciadophylloides* and *Hydrangea paniculata* (Sasaki 1970). Moreover, there are species characteristic to *Abies Mariesii* forest such as *A. Mariesii, Platanthera ophrydioides, Listera nipponica* and *Streptopus streptopoides* var. *japonicus* (Miyawaki ed. 1967). This mixture of characteristic species in two altitudinal zones may be caused by the fact that the vegetation is changing successively and yet instable on this plateau which lies on the bordering area of two atltitudinal zones. However, since the southern half of the plateau, at least above 1300 m, is occupied by the forest, in which dominance of *A. Mariesii* is high, most of the plateau will be covered with *A. Mariesii* forest or its altitudinal equivalents such as *Sphagnum*-moor in the future.

Recent vegetational geography is concerned mainly in the distribution of the visible communities, especially the climatic climax such as *A. Mariesii* forest and beech forest of this region. But it should deal with regional distribution of all phenomena seen in vegetation, whether they are visible or not.

Among such phenomena, regionality of succession is an intresting object of geography, although such precise elucidation of sere as carried out by ecologists is not necessary for the study at first. Precise comparison of sere after difference of edaphical conditions is also not suitable for the purpose. Such phenomena are too complicated for investigation of regionality in a large area. It will be efficient to elucidate the regional difference in successional sere on the ordinary landsurface, where climatic climax is expected. And in this case simplified sere in three stages is useful; the first characterized by the earliest pioneer, the second by the main species of earliest closed vegetation and the third by the climax species. In the study area, the first is characterized by *Deschampsia flexuosa*, *Empetrum nigrum* and *Loiseleuria procumbens*, the second by *Pinus parviflora* and the third by *Abies Mariesii*.

Summary

1) Vegetational landscape is studied on a lava plateau recently covered with volcanic ejecta, on which many kinds of plant communities occur with a gradient from south to north.

2) Land surface is classified into seven types in accordance with species composition of vegetation. From the view point of vegetational landscape, types range from low and sparse to high and dense. Types occupy the plateau with an order which should be caused by relative difficulty of arrival and establishment for species on the habitat.

3) In like other volcanoes in Northeast Japan pioneer community consists of *Deschampsia flexuosa*, *Empetrum nigrum* and *Loiseleuria procumbens*. *Spiraea betulifolia* and *Salix Reinii* are also frequent.

4) *Pinus parviflora* is an important species occurring in large area, occupying always the uppermost layer of vegetation from shrub to forest and representing the gradient in vegetational landscape.

5) Such a tree species as *P. parviflora* and above mentioned pioneer species play an important role deciding the character of primary succession on volcanoes in landscape. Regional difference in such species should be studied profoundly from a geographical point of view.

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