

Natural Regeneration of the Pine Forest in Japan,

By

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In Japan there are numerous numbers of indigenous species belong to *Pinus*, but among them *Pinus densiflora* Sieb. et Zucc. and *Pinus Thunbergii* Parl. are the most important species for the forestry. *P. densiflora*, which is one of the most common inland species of conifer distributing from northern Honshiu to southern Kiushiu, is absolutely necessary as the timbers or materials for building, engineering works, and stakes for mine. *P. Thunbergii*, which is the very popular strand species of conifer, is useful not only as the timber of materials of engineering works, but as the best trees for establishment of reserved forest for defence of sea-wind, wind-blown sand, and invasion of sand dunes. The general classifications and those distributions of strand pine forests are described in the other paper titled "The general feature of coniferous forest in Japan."

Due to the very high adaptable habit for environment of these two species, the natural regeneration of the pine forest can be done very easily, and this fact makes a very remarkable contrast for the silviculture of *Pinus sylvestris*, for which the natural regeneration is rather more difficult in Europe. Caused by the strongly sun-loving habit, the selection cutting for *P. densiflora*, except the case of extra-ordinary strong grade, are generally not suitable for this species, and normally the wide strip system of clear cutting or uniform shelter-wood system are applied. The strand forest of *P. Thunbergii* is often treated under strong selection cutting or very narrow strip cutting, because, the habit for light of *P. Thunbergii* is slightly more tolerant than *P. densiflora*, and it is necessary to avoid clear cutting system caused from such forests must be reserved as defence for sea-wind etc. as above mentioned.

Although, broadly, it can be thought that the climate of cold dry winter is favourable for the forest of *P. densiflora*, due to the various environments, the physiognomies of the forests of *P. densiflora* are considerably unequal one another, and there are very marked two kinds of pine forest, that is, the one is the warm plain type and the other is the cold high type. The former type mainly occurs in the low plain district of central Honshiu and the mountain region, where has very low altitude of western Honshiu, and the latter mainly occurs in foot-mountain region of volcanoes in northern and central Honshiu and Kiushiu, and the hill region or strand of northern Honshiu. Generally, there is some tendency that the timber produced from the forest of warm plain type is heavier and more resinous than that from the cold high type. Consequently, for timber of building, the product from cold high type is accepted as better one.

While the strand pine forests distributing from southern Kiushiu to northern Honshiu, are mainly dominated by *P. Thunbergii*, some parts of coast of Japan sea side of central Honshiu, and Pacific ocean side of northern Honshiu are dominated by *P. densiflora* standing directly faced to sea-wind. This fact remains as a question for forest-ecology, because, broadly, the *P. densiflora* is recognized as very weak species for sea-wind.

These forests are selected as examples, A belongs to warm plain type of *P. densiflora*, B belongs to cold high type of *P. densiflora*, and C belongs to strand pine forest of *P. Thunbergii*, and the number of trees, mean diameters, mean heights, and mean volumes of each forest for a hectare are shown in following table.

		Number of trees.		
Forest	Age	A	B	C
	15	4.500	3.600	11.000
	30	1.100	1.080	2.100
	45	400	400	1.100

(Continued)

Forest Age	A	B	C
60	300	310	700
75	250	290	420
90	210	260	350
105	180	240	300
120	170	210	280

Mean diameters (cm.)

Forest Age	A	B	C
15	6.5	4.8	5.5
30	17.8	17.4	13.3
45	27.2	26.2	19.2
60	32.0	31.4	23.7
75	35.6	35.5	28.7
90	39.8	38.8	33.6
105	42.6	41.9	38.5
120	45.0	44.7	42.6

Mean heights (m.)

Forest Age	A	B	C
15	5.5	5.3	5.7
30	11.8	13.8	10.4
45	17.0	21.4	13.8
60	20.0	23.3	17.2
75	22.5	26.5	19.7
90	27.8	27.0	21.0
105	30.6	27.1	22.2
120	32.7	27.5	23.2

Mean volume (m³.)

Forest Age	A	B	C
15	72.0	41.0	83.0
30	144.0	170.0	135.0
45	195.0	300.0	195.0
60	247.0	364.0	250.0
75	298.0	393.0	305.0
90	335.0	411.0	370.0
105	385.0	425.0	435.0
120	415.0	438.0	450.0

**Some Notes on the Natural Regeneration of the Conifers
in the Mixed Self-regenerating Stands in Japan, especially
of *Cryptomeria japonica* and of *Abies firma***

By

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References.

- (1) W. Terazaki—Plant Succession in Self-regenerating Forest in Various Regions of Japan. Proceedings of the Third Pan-Pacific Congress Tokyo, 1926. p. 1887—1889.
- (2) W. Terazaki—Forestry of the "Sugi", (*Cryptomeria japonica*, Don.) and the "Karamatsu" (*Larix leptolepis*, Gord.). 1926. Department of Forestry, Ministerium of Agriculture and Forestry.

1. Introductory Remarks.

Since I have carried on the experiments for the thinnings and the selection cutting methods in the year of 1923 for our self-regenerating (1) state forests under the administration of the District Forest Office in Japan Proper, the recent investigations on the records and the field notes of the foresters in the Daimyo Era, especially those of Mr. Naoto Iwasaki for the self-regenerating forest of the "Sugi" in the Province Akita, are going to be proved that the theory of the treatment and the management for our self-regenerating forests, based on the natural selection in the vegetation with reference to the light and soil moisture on a partial forest floor is a reasonable one for our self-regenerating forest.

Here I am going to write an abstract of my studies, by the aids of the colleagues of the Forestry Department, Ministry of Agriculture and Forestry, the Forestry Experimental Station, Meguro and the six District Forest Offices, on the experimental data of the observations from the sample plots, summed up to 62, where I practised "the thinning for the stand of the polymorphically crowded groups of trees with stratified canopy," especially of the "Sugi" (*Cryptomeria japonica*) and the other conifers, and of the broad-leaved tree species.

Furthermore, I would like to write on some of the facts in the natural establishments in the self-regenerating stands and, in the artificially regenerated ones, which I have observed in the State Forests and in the systematically treated private owned stands, for the purpose to draw the attention not only of scientists but of all interested people to the forest communities.

Besides the natural regeneration of the "Sugi", here I would like to abstract of the experimental results of the "Momi" (*Abies firma*). The wood of the latter species is not so important and familiar one for us as that of the "Sugi", but this species occurs naturally almost all of the region of the south-western Japan, and about the south-western half of region of the north-eastern Japan, except the alpine regions of the both parts. We used the wood, produced from the self-regenerating stand, only,

but not from the planted stands, because we have very few of them.

While, the *Cryptomeria*, "Sugi", is the most usefull, in general way, popular and noblest of all the Japanese conifers. There is no self-regenerating stand of the other species so interesting and complicated formation of the natural regeneration to the investigators of the present day as the "Sugi" stand is.

Thus, all of our foresters are now going to study the natural regeneration from three points of view, first of all is to observe how the young growth are going to survive and to grow vigorously and healthy as for the successors to the elders and olders, secondly is to study the silvicultural systems of the "Sugi" stands, of which now is in practise by the private owned foresters who follow the methods from the former era and thirdly is to study comparatively the systems, based on the present conditions of the self-regenerating "Sugi" stands with the records and field notes which have been succeeded from the Daimyo to the Imperial government. The systems, of which the foresters of the Daimyo era have had practised for the mixed self-regenerating forests of the "Sugi" of the District Forest Office of Akita, are suggested as the most instructive one for us; and the forests are at present magnificently and vigorously remaining to us and we are now going to utilizing them as the abundant resources for the state finances.

The following table shows rough notes for the resources of the "Sugi" from the mixed self-regenerating forests in the six District Forest Offices in Japan Proper :

District Forest Office	Self-regenerating state forests of						Remarks
	the "Sugi" and broad-leaved tree species		the "Sugi", the "Hiba", the "Nezuko" and broad-leaved tree species		the "Sugi", the "Hinoki" the "Momi", the "Tsuga" and broad-leaved tree species		
	area	volume of the "Sugi"	area	volume of the "Sugi"	area	volume of the "Sugi"	
ha.	m ³ .	ha.	m ³ .	ha.	m ³ .		
Aomori	—	—	8,000	800,000	—	—	Furthermore, there occurs the mixed stands of the "Sugi" and the "Akamatsu", and of the "Sugi" and the "Momi" but the areas of these two are very narrow under 1,000ha., so I have here omitted; in addition, there occurs the areas where the "Sugi" are scattered.
Akita	50,000	20,000,000	45,000	4,000,000	—	—	
Tokyo	1,000	200,000	—	—	—	—	
Osaka	5,000	500,000	—	—	4,000	300,000	
Kochi	20,000	2,600,000	—	—	17,000	1,800,000	
Kumamoto	—	—	—	—	20,000	1,500,000	
Total	76,000	23,300,000	53,000	4,800,000	41,000	3,600,000	

As may be seen from the table, in the self-regenerating stands of the "Sugi", there mixed commonly with the broad-leaved tree species throughout Japan Proper, while in the north-eastern part, there occurs the mixed stands with the "Hiba" (*Thujaopsis dorabata*) and the "Nezuko" (*Thuja japonica*) and in the south-western part, there occurs the mixed stands with the "Hinoki" (*Chamaecyparis obtusa*), the "Momi" (*Abies firma*) and the "Tsuga" (*Tsuga sieboldii*).

The average growing stock of the self-regenerating "Sugi" stand summed up about $\frac{100-900}{350}$ m³. per ha., while there occurs frequently the amount of the growing-stock of stand, which counted as about 900-2000 m³. per ha. The latter will be counted as to the stand, corresponding to the type of the formation of stand, I₂, of which there mixed with the growing-stock of the broad-leaved tree species of under about 10%, while the amount of the growing-stock of the stand, corresponding to the types, II₇ and II₈, will be counted as about 300-1800 m³. per ha. of which the percentage of the growing-stock summed up about 40-60% of the "Sugi", about 40-20% of the other conifers and about 20% of the broad-leaved tree species; lastly the amount of the growing-stock of the stand,

corresponding to the types, I_{β} , will be counted as about 100-450 m³. per ha. of which percentage of the young "Sugi" summed up to about 70%.

According to my estimations from the field-notes of our state foresters in the six District Forest Offices, it will be summarized the present states of the growing-stocks of the self-regenerating stands in Japan Proper as follows:

Type of the formation of the stand (I)	The growing-stocks per ha.
I_{β}	100-450 m ³ .
II_{δ}	250-800 m ³ .
II_{τ}	550-1800 m ³ .
I_{α}	850-2000 m ³ .

The ranges of the growing-stocks of the above given table correlated largely by the mixed tree species, especially the species of conifers, and partly either by the qualities of sites, or by the stages of the formation of each type. It is, however, unfortunately, not yet fairly determined the indicators for the estimation of the quality of site.

Throughout the self-regenerating stands of all of the six District Forest Offices, the percentage of the number of stands, corresponding to the type II_{τ} summed up as about 50%, the other one, about 20% of the stands correspond to those of the type I_{α} and the remaining about 30% correspond to those of the type II_{δ} and I_{β} .

Among these stands, the ones correspond to the types II_{τ} and I_{α} are comparatively difficult for the natural regeneration, while the others correspond to the types II_{δ} and I_{β} are rather easy and are very interesting for comparative studies with French and Swiss selection cutting methods. But the studies on the natural regeneration for the stands, corresponding to those of type II_{τ} and I_{α} are very important objects for us.

2. Distribution of the Self-regenerating Stands of the "Sugi".

A. General view

Since I wrote in the year 1926 on this subject in the pamphlet (2) from the Department of Forestry, Ministry of Agriculture and Forestry, I am attempting to study on the distribution of the self-regenerating stands of the "Sugi" and on the establishment with regard to the different forms of the reproductions and to the different growth-forms in the pure and mixed stands which distributed in the various parts in Japan. So I would like to write on a little more interesting facts from those above-mentioned observations.

Though the "Sugi" is planted, extensively, and has been planted from time immemorial in many parts of Japan, the occurrence of the self-regenerating "Sugi" is very limited in the present day. Being so important and familiar to the Japanese life, the self-regenerating "Sugi" stands might have been destructively treated. Such a valuable production among any timbers of ours, might have, at length, been caused to treat so intensively and systematically by our foresters in the Daimyo Era and by the private owners who follow of the silvicultural policies of the former Era as the "Sugi" stands treated and managed. On the other hand, it will be suggested that there is no other species so difficult as the natural regeneration in the self-regenerating "Sugi" stand according to my own observations of the past twenty years as the "Sugi". Thus far, such a destructive cutting in the past and a difficulty of the natural regeneration might have easily been conducted the alternation of species in the self-regenerating mixed "Sugi" stand and remained as the remnant individuals, groups and stands in the sporadic occurrences. It is however, very doubtful to protest that when the suitable cuttings and favourable methods for the natural regeneration might have been practised on, then we could have, probably, been extended the area of the mixed stand of the "Sugi". According to my own suggestion from the observations on the self-regeneration of these similar stand, we can only hold the areas so far as I can observed in the stands in the Island, Kyushu, at least in the state forests in the District Forest Office of Akita and Kochi. We can only extend the areas of the "Sugi" stands by the plantation or any other artificial regeneration with laborious and expensive works against the

natural vegetation.

Notwithstanding to this, I have many examples for the self-regeneration of the "Sugi" in the "Akamatsu" (*Pinus densiflora*) stand on the plains and hilly lands where there occurs, at present time, no self-regenerating "Sugi" stand, but not the mother tree of the "Sugi" either planted or naturally migrated in the vicinity of the "Akamatsu" stand. The similar fact of the self-regeneration of the "Sugi" in the planted "Hinoki" (*Chamaecyparis obtusa*) stand or in the "Hinoki" and the "Akamatsu" stand on the plains and hilly lands has been observed. Furthermore, I am going now in such as above mentioned planted "Sugi" stand, to observe the development of the individuals and the groups of the young growth of the "Sugi" which have been grown up from the survived seedlings on the floor where the thinnings carried on repeatedly.

These facts are in opposition to the above given suggestion still I dare say, these facts will prove that there is a special habitat for the invasion, the migration and the establishment of the "Sugi", but it is very difficult to point out the characteristics of the habitat, and that we can only deduce such a habitat where the seedlings, individuals and groups of the young growth develop, by means of the repetition of the thinnings, which are in conformity with the transformation of the structure of the stand, according to my theory and practice on the thinning, where thereon it will be suggested as if in former era the self-regenerated "Sugi" stand would have been existed on.

At any rate, the self-regenerating forests of the "Sugi" distributed from the Island Yakushima (about 90 sea miles apart, south from the city, Kagoshima, about 30°N. Lat.) to the state forest, Yanokurayama (about 41°N. Lat., about 80 Km. off, west of the city Aomori) in the Aomori District Forest Office.

But the self-regenerating "Sugi" stand is of somewhat sporadical occurrence, being usually found mixed with the other conifers and broad-leaved trees or with the broad-leaved trees only. Sometimes there occurs in a gregarious character, as it occurs on the state forest in the Island Yakushima, on the state forests in the Kochi District Forest Office in the region of the eastern end of the central mountain range in the Island Shikoku and on the state forests in the Akita District Forest Office in the region of the northern end of the Dewa mountain range and of the Nasu volcanic chain of the central mountain range. The first two forests mixed, principally, with the "Momi" (*Abies firma*), the "Hinoki", the "Tsuga" and a few broad-leaved trees, while the last one mixed principally, with the deciduous broad-leaved trees and with the "Nezuko" or with the "Hiba" or with "Nezuko" and the "Hiba". In the latter forests, the "Sugi" is frequently found in the pure formation. It is of my opinion and of the conclusion, from the historical studies by Mr. Naoto Iwasaki, that such a pure formation may probably represent only a certain stage in the course of the transformation of the structure of the stand during the practise of the treatment.

As may be seen from the chart, showing the distribution of the self-regenerating "Sugi" stands, they occur on the mountain range along the coast regions of the Sea of Nippon, the inner arc, and of the Pacific Ocean, the outer arc. In addition, it will be noticed that the tectonic divisional region between the north-eastern part and the south-western part of the Japan Proper appear as the buffer zone of the mixed species of the conifers, i.e. in the region of the north-eastern part there occurs no the "Hinoki" and the "Tsuga" mixed in the "Sugi" stand, and furthermore, there occurs, in the northern end of the region of the inner arc of the same part, the "Nezuko" mixed in the "Sugi" stand.

On the other hand, it will be observed that in the south-western adjoining district of the tectonic divisional region in the inner arc, there occurs, many of conifers, as the "Hinoki", the "Akamatsu", the "Hiba" and the "Nezuko" mixed together in the "Sugi" stand, and in the north-eastern adjoining district of the same part, there occurs, only the "Akamatsu", sometimes the "Goyomatsu" (*Pinus pentaphila*) mixed in the "Sugi" stand.

While in the tectonic divisional region of the outer arc, there occur the scattered individuals and the groups of the "Sugi" in the mixed stand of the "Momi", the "Tsuga" and the broad-leaved trees.

Broadly speaking, the self-regenerated "Sugi" stands are distributed over the mountain ranges where cloudy sky and damp weathers prevail and also where abundant precipitation is recorded during autumn and winter days. At any rate, under the self-regenerated and planted pure stand of the "Akamatsu" on the plains and hilly lands, the "Sugi" migrated and established naturally in the space

among and under the foliage covers of the individuals and the mixed groups of the "Konara" (*Quercus grandiflora*), the "Kuri" (*Castanea pubinervis*), the "Murasaki-shikibu" (*Callicarpa japonica*), the "Yabumurasaki" (*C. mollis*), the "Yamatsu-tsuji" (*Rhododendron indicum* var. *Kaempferi*), the "Taranoki" (*Aralia chinensis*), the "Nurude" (*Rhus japonica*), the "Yamaurushi" (*R. triocarpa*), the "Kiichigo" (*Rubus palmatus*), the "Fuyuchigo" (*R. Buergeri*), when the mother tree stands in the neighbourhood.

However, such an occurrence of the self-regenerating "Sugi" is very limited. They occur on the hills and plains of the tertiary and the quaternary formations in the coast region of the Sea of Japan of the north-eastern part of Japan Proper, while in the tectonic divisional region of the inner arc, the self-regenerating "Sugi" occurs in the self-regenerating "Akamatsu" stand mixed with the "Hinoki".

Furthermore the "Sugi" migrated and established in the planted pure stand of the "Hinoki" or in the mixed planted stand of the "Hinoki" and the "Sawara" (*Chamaecyparis pisifera*) or in the mixed planted stand of the "Hinoki", the "Sawara" and the "Akamatsu" on the hills and plains in the region of the south-western part of the inner arc and in the region of the outer arc.

In these stands, the seedlings of the "Sugi" invade on the ground floor where the "Shippogoke" species (*Dicranum* sp.), the "Sugigoke" species (*Pogonatum* sp. and *Polytricum* sp.), and the "Shishigashira" (*Blechnum niponicum*), the "Yabusotetsu" (*Polystichum falcatum* v. *Fortunei*) and the "Tachibusumire" (*Viola gaypocerus* v. *japonica*), the "Tsubosumire" (*V. vercunda*) are scattered, but not the consociates of these plants; the individuals and groups of the younger growth of the "Sugi" migrate and develop where the groups of the "Hisakaki" (*Eurya japonica*) the "Kuroumemodoki" (*Phaninus japonica*), and the "Nezumimochi" (*Legstrum japonica*) are scattered, while in the north-eastern part, there scattered the various mixed groups of the "Konara", the "Kuri", the "Sakura", the "Ukogi" (*Acanthopanax spinosum*), the "Uwamizuzakura" (*Prunus Grayana*), the "Noruitsugi" (*Hydrangea paniculata*), the "Tsuitsugi" (*Diervilla japonica*), the "Aokiba" (*Aucuba japonica*), the "Yuzuriha" (*Daphniphyllum macropodium*), the "Momiji" (*Acer palmatum*), the "Itayakaede" (*A. pictum*), the "Kuromoji" (*Lindera umbellata*), the "Okamenoki".

Again, in the self-regenerating "Sugi" stand of the south-western part of Japan there are mixed with very large number of species of conifers, such as the "Momi", the "Tsuga", the "Hinoki", the "Akamatsu", the "Koyamaki" (*Sciadopitys verticillata*), the "Togawara" (*Pseudotsuga Shirasawa*), the "Nezuko" and the "Hiba". But there are the characteristics in the mixed conifers according to the different parts of the region. In the forest of the Island, Yakushima, the extreme southern end of the self-regenerating "Sugi" stand, in the region of the outer arc there are only three conifers, as the "Momi", the "Tsuga" and "Hinoki", where the "Hinoki" occurs very little in the number.

In the forest in the region of the northern end of the outer arc, there are the "Sugi" mixed with the "Momi", the "Akamatsu" and the "Kuri", the "Mizunara", the "Sakura", the "Egonoki" the "Toneriko", the "Honoki", the "Kaede" species, the "Kuromoji" and so on.

B. Distribution in locality.

On our mountain regions and hilly lands in the south-western part of Japan Proper the coniferous tree species flourish largely on the shade slopes, while on the sunny slopes, there occur the broad-leaved tree-species with sporadically scattered conifers, but it appears in the reverse on the slopes in of the mountain regions of the south-western part of Japan Proper, there occurs in the self-regenerating forests of the mixed coniferous tree-species with the ever-green and the deciduous broad-leaved species, the groups of the "Sugi" near the dales and ravines, while on the shade slopes, they distributed over and mixed with the other conifers. In such a stand, the groups of the "Akamatsu" distributed over the crests, some of them extended down on the side of the slope of the sunny part, where they mixed with the groups of broad-leaved tree species and those of the "Tsuga" and of the "Momi", while on the shade part, the groups of the "Akamatsu" replaced by the groups of the "Sugi" and of broad-leaved tree species where they are mixed with the groups of the "Hinoki" and of the "Tsuga" or of the "Hinoki" or of the "Tsuga", and with the groups of the "Momi". On this side, there exist the higher correlation on the frequencies of the groups of the "Sugi" and of the "Momi" with respect to the ages of the trees, and to the diameter classes. Again, there are the similar correlation on the frequencies of the groups of the "Hinoki" and of the "Tsuga",

while there exist the lower correlation with the mixture of the groups of the "Sugi" or of the "Momi" and of the "Hinoki" or of the "Tsuga", respectively.

Such as the above given differences will be explained by the following facts:

1) The requirement for the soil moisture of the groups of the survivals of the seedlings of "Sugi" and of the "Momi" appear as the similar one and at the same time differ with that for the survivals of the seedlings of the "Hinoki" and of the "Tsuga".

2) The requirement for the quantity and quality of the light under the canopy for the growth of the individuals and groups of the "Sugi" and of the "Momi" throughout the growth-stages differ with those of the "Hinoki" and of the "Tsuga".

3) The situation of the occurrences of the groups of the survived seedlings of the "Hinoki" and of the "Tsuga" differs and tends to alternate with those of the "Sugi" and of the "Momi". Again it will be observed that on the sunny slopes of the mountain regions of the northern half of the north-eastern Japan, the groups of the "Sugi" occurs gregariously with the broad-leaved tree species, while on the shade slopes, the groups of the "Sugi" occurs sporadically on the crest with the "Hiba", the "Nezuko" and the "Goyomatsu" or with the "Hiba", or with the "Nezuko" or with the "Goyomatsu", while the broad-leaved tree species occur near the ravines and the dales.

These above given differences of the distribution of the groups of the "Sugi" on the mountain regions of the south-western parts of Japan and of the north-eastern part would have been caused from the facts:

a) The groups of the "Sugi" on the north-eastern part and on the region of the inner arc stand on the clayey ground while on the south-western part and on the region of southern half of the north-eastern part of Japan Proper, they stand on the sandy ground.

b) On the latter part the sunny slopes show the xerophytic habitat for the groups of the "Sugi", while on the former part, the shade slope show the hydrophytic habitat for the groups of the "Sugi".

All of the differences of the habitat tends by and by to interchange with each other according to the stages of the growth of the trees of the groups.

These above given tendencies would have been caused the order of the alternation of the establishment of the tree species, and at the same time, such an order of alternation of the establishment of the tree species controls on the natural regeneration of a stand.

Thus far, I would like to venture to propose that the natural regeneration of the conifers and of the broad-leaved tree species controlled by the alternation of the establishment of the tree species and by the partial habitat with reference to the quantity and the quality of the light which reflected by and changed by the canopy of the group of trees on the slope-side of the locality, in spite of the consequence that we can try to practised on the skillful and controlled silvicultural and yielding system.

3. Characteristics of the Thinning and the Selection-cutting, Practised on the Sample Plots for the Studies on the Natural Regeneration and the Growth of the Planted and Self-Regenerating Stands.

It has been observed for a long time since I have inaugurated on the investigation of the thinning on the planted pure stand of the "Karamatsu" (*Larix leptorepis*) in the year of 1903 that the formation of the single story of the canopy of stand has to tendency to be transformed into that of the polymorphically crowded stories through that of the simply crowded stories or of the mixed stories, and then the planted pure even-aged stand moves naturally into the self-regenerating uneven-aged one. Such a tendency and some of its phases have been observed, inductively and experimentally, from the great deal of the stands of the pure planted "Akamatsu", "Hinoki" and "Sugi", especially on the plain and hilly lands, whereon the thinning have been repeatedly carried on.

Some of our private owners used to construct the many storied, pure or mixed stands, repeating the thinnings and utilizing the phases of the natural tendency of the transformation of the canopy of the stand by means of the plantation or of the natural regeneration. For examples forestries of the "Sugi" with the "Akamatsu" in the districts of the village Nire, near the city Nagano in the province Nagano and of the village Kurokawa, near the city Shibata, in the province Niigata, the former one of the these forestries establishes the successors of the "Sugi" by the artificial layers of the under

branches of the stems and of the very weak stem, itself, of the "Sugi" and the latter one establishes the successors by the elective branches from the foot of the stem of the "Sugi", sometimes from the upper parts of the stem; forestry of the "Sugi" in the villages Nakagawa and Onogo, near the city Kyoto where establishes the successors by the branchlets of the under branches near the foot of stem; the forestry of the "Sugi", "Hinoki" and "Akamatsu" in the district of Yamaguni and Kuroda, near the city Kyoto; the forestry of the "Kuromatsu" (*Pinus Thunbergii*) in the district of Yashima, near the city Takamatsu, and in the districts of the vicinities of the villages of Yunotsu and Taisen along the coastal region of the provinces Shimane and Tottori, respectively; and the forestry of the underplanting of the "Sugi", and "Hinoki", the "Sawara" in the "Kuromatsu" stands in the district of Mitsuoka, Minamoto and Okayama in the province Chiba.

On the contrary, some of our private owners of the "Sugi" stand used, by means of the thinning, to transform into the simple few storied stand from the single story of canopy of stand at earlier period of the growth of stand, about 20 years old and to complete the formation until about 70 years old. Since then by the thinning, they forced to turn again into the single story of the canopy of stand. For example, the forestry of the "Sugi" in the district of Yoshino of the province Nara.

The method of the thinnings for the single story of the canopy of stand which I have been inaugurated since the year of 1903 (2), is as follows:

- A. The first kind of thinnings, say, A-formation of stand canopy, in short, A-thinning:
Trees chosen for cutting: all of the 4 and 5, and of the 2b and 2e.
- B. The second kind of thinnings, say, B-formation of stand canopy, in short, B-thinning:
Tree chosen for cutting: all of the 4 and 5, and all of the 2b and 2e; majority of 2b and 2d; some of the 3.
- C. The third kind of thinnings, say, C-formation of stand canopy, in short, C-thinning:
Trees chosen for cutting: all of the 4 and 5; and all of the 2; majority of the 3; a few of the 1.

And I have distinguished the tree-forms as follows:

I. The dominated individuals:

1. The first class trees (1);

crown takes a spindlically pyramidal form and is well developed equally into every direction; trunks are healthy and straight; predominating in the stand canopy.

2. The second class trees (2);

somewhat shorter than the first class trees, certain defects in the form of trunks and crowns; they are distinguished as follows:

- "a" Crown is exceedingly flattened and extended,
- "b" Crown is extraordinarily slender;
- "c" Crown takes a form compressed either from one side or from all sides;
- "d" Trunk forked into two or three;
- "e" Crown or trunk is damaged or injured.

II. The subordinate individuals:

3. The third class trees (3):

distinctly shorter than any of the dominates individuals, but one of them is suppressed; some of them take the form similar to the first class trees, or take the forms similar to the above-mentioned for the second class-trees.

4. The fourth class trees (4):

suppressed by the neighbouring trees;

5. The fifth class trees (5):

overtopped, and dying and dead, falling and fallen.

Experiments have been shown us that:

- 1) It must be thinned as early as possible if crowns of the single trees which compose the canopy of stand, get crowded, and the tree-classes become distinguishable;
- 2) The thinnings are to be repeated as soon as crowns close up the openings; the interval between thinnings is about 5 years for the B-thinning and about 7 years for C-thinning, when trees are young;
- 3) During the young stages of trees such as the canopy of stand forming the simple story, thinnings begin early, and the C-thinning quite better.

4) The formation of the canopy of stand begins to transform from the simple story into the single few stories at the period of the first distinguishable minimum phase of the growth, from about 30 years old to about 50 years old of the ages of the planted pure stand with respect to the tree species. Such a transformation begins to be observed when the groupings of the dominated trees and the subordinate ones are distinguishable. The group of the dominated trees takes place that of the upper story and the group of the subordinate trees takes place that of the under story.

5) Since then, we must change the thinnings for the simple story of the canopy of stand into those for the polymorphically crowded stories, corresponding to the Biolley's "eclaircie jardinage."

6) Repeating such thinnings for the polymorphically crowded stories, we have the seedlings, individuals and groups of the young growth both of the same species of the of the upper stories and of the others with great deals of the broad-leaved species either by the natural migration or by the artificial one.

The simplest form—the preliminarily method—of the thinning for the polymorphically crowded stories or the method of the selection cutting is the thinning for every groups of the canopy of the stand. For the latter, it will be practised the thinnings for the single story of the canopy of the stand on the each group as if it corresponds to the stand of a single story.

According to my own observations for a long time, since after the year of 1914, the polymorphically crowded stories of our self-regeenerating stand composed of great deals of the groups of tree-species either of the same species or of the different ones, of which we distinguish the two formations. The one is the fundamental group and the another is the collective ones of the former, while the the former happens to be occur either of single tree or of the group of the single trees. The last one, the group of the single trees, composed of the trees with different dimensions either of the same age or of the different ages, according to the tree species; and these two formations of groups come to take place depending to the vegetations of the undergrowth and of the ground floor.

Mr. K. Matsukawa, Forest Expert at the District Forest Office of Aomori, has investigated about the formation of the groups, as the above-mentioned, and introduced to us the descriptive formulæ of the groups, especially on the self-regenerating stands of *Thujopsis dolabrata*, the "Hiba".

The frequencies of the fundamental groups and of those of the collective groups with respect to the diameter classes of the composing single trees lead us to distinguish the types of formation of the stand.

The thinning for the polymorphically crowded stories or the method of the selection cutting is that for the fundamental groups and for the collective groups, that is to say, that for the openings of the canopies of the fundamental groups and of the collective groups in the horizontal and vertical directions in order to form the harmoniously balanced distribution of the canopies of the above mentioned groups, themselves, and of their combinations with respect to the canopy of stand, as a whole. Thus the technik of the thinnings is the only application of those of the single story of the canopy of the stand.

4. Brief Sketches of the Establishment of the Self-regenerating Stands of the "Sugi".

There is no other forest, as instructive and interesing as the three gregariously occurred self-regenerating forests of the "Sugi" forest in the Island, Yakushima, the forests in the Yanase State Forest and the forests in its vicinities in the Kochi District Forest Office and the forests along the river Yoneshiro and its surrounding mountains ranges with the peninsula Oga in the Akita District Forest Office with regard to the study of the establishment.

The economical forest of the Yakujima State Forest situated on the region of the granite rock, and on the elevation of about 400 m—1000 m. height above the sea level, and the island stand in the "Black Stream". The amount of mean annual precipitation is about 5000 mm, and it is said that throughout every month "the thirty five days are the rainy". While the economical forests of the State Forest of the Yanase and its vicinities situated on the region of the mesozic rocks of the sandstone, shale and clayslates, and on the elevation of about 200 m.—1000 m. above the sea level. The amount of the mean annual precipitation is about 2000—4000mm. and mean monthly cloudy and rainy days are summed up about half a month.

These above given two localities of the forests lay in and along the coast of Pacific Ocean, while the forests along the river Yoneshiro and its surrounding mountain ranges with the Oga peninsula

situated along the coast of the Sea of Japan. The economical forests of these parts situated largely on the tertiary rocks and partly on the volcanic rocks, and on the elevation of about 100m—700m., above the the sea level, and in some part, of about 700m.—800m. above the sea level. The amount of the mean annual precipitation is about 1500—3000 mm. and mean monthly cloudy and rainy days are summed up about twothird of a month.

Throughout these three gregariously distributed localities of the "Sugi", there will be found, as the characteristics of the meteorological phenomena, the amount of the precipitation in January and February summed up over about 100 mm.

The first of these mentioned forests, remained, since about 200 years ago, as practically unexpoliated in the greater part of the forest, but not the big "Sugi", so called the "Yakusugi", about twenty hundred years old, with the diameter about 2—4 m. and the height about 30—40 m. with the broken down top-bole. There are the mixed stands, composed of the individuals and groups of the "Sugi", of the "Momi", of the "Tsuga", of the "Hinoki" and of the broad-leaved trees such as the "Yamaguruma", the "Isunoki", the "Kashi" species, the "Tabu", the "Sakura-tsutsuji", the "Ryobu", the "Himechara", the "Tsubaki", the "Yabunikkei" and so on.

Here we have seen the "Sugi" of the various stages of the developments with their natural formation of the tree groups, with the natural alternations of their successors, with the self-regeneration of the seedlings, and individuals and groups of the young growth on the ground floor, and on the stumps, furthermore on the healthy stems of the conifers and of the broad-leaved trees, but I have hardly found any natural reproduction either with the natural layers or with the elective stems of the under-branches from the foots of the stems and of the branchlets from any part of stems.

While the last two forests have been from about 300 years ago, fully expoliated and successfully improved, sometimes strictly protected under the plans, constructed by the foresters of the Daimyo Era; and we can hardly assumed from the historical data and from my own theory, based on the theory of the natural selection that the areas of the "Sugi" stands extend their areas by the self-regeneration only, but not there will be found, in the stands, only the rythmic altereation of the naturally mixed tree-species, where not the serious desiructive actions and not the expensive plantat'on carried on.

Of course, the duration of rejuvenescence and senescence of the tree species differs with one another. Broadly speaking, it will be summed up as follows: almost of all broad-leaved tree species alternate with the duration of about 50—150 years, while almost of all the conifers alternate with the duration of about 100—300 years and the ranges of the duration are very wide as if it will be assumed as the immemorial. It seems that a scene of the rejuvenescence and senescence of tree-species differs and there are some of characteristics with respect to tree-species. For example: among the conifers, such as the group of the "Matsu" species, the "Karamatsu", the "Hinoki", the "Momi" species, the "Tsuga" species appears as the gregarious while the "Sugi", the "Nezuko", the "Hiba" as the sporadical one.

The formation of the stands in the forests of the first two districts have some similarities, i. e. they are mixed with about 80% of the conifers, the "Sugi", the "Momi", the "Tsuga", and the "Hinoki" and about 20% of the ever-green and of the deciduous broad-leaved tree species. While in the "Sugi" forest of the Island, Yakushima, there occurs no other conifers, as the "Koyamaki", the "Togasawara", the "Akamatsu". It seems that in the Yakushima, the percentage of the "Hinoki" and the "Tsuga" is comparatively lesser than that of the "Momi", while in the forests near the Yanase State Forest, the percentage of the "Hinoki" and the "Sugi" is exceedingly greater than that of the "Momi" and the "Tsuga". Furthermore, the percentage of the "Sugi" is the greater, the higher the elevation is; on the other hand, the percentage of the deciduous broad-leaved tree species is the greater, the higher the elevation is.

The following species are common: the "Akashide", the "Sakura", the "Egonoki", the "Shikimi", the "Sakaki", the "Yuzuriha", the "Taranoki", the "Tsubaki", the "Himeshara", the "Kagonoki", and so on. In the deciduous broad-leaved tree species there occurs in the Island Yakushima, the "Sakuratsutsuji", the "Shimaurikaede", but not the "Keyaki", the "Kiwada", the "Tochino", the "Horoiki", the "Yogusominebari", the "Taniutsugi", the "Midzuki", the "Kae-de" species and so on.

While in the self-regenerating "Sugi" stands in the Akita District Forest Office, there occurs no ever-green *Quercus* species, but only the deciduous one, such as the "Mizunara", the "Konara". Furthermore there occurs the deciduous broad-leaved tree species, such as the "Buna", the "Onigurumi", the "Sawagurumi", the "Kuri", the "Harigiri", the "Ohyonire", the "Katsura", the "Uwamizusakura", the "Yachidamo", the "Hakuunboku", the "Mansaku", the "Nanakamado", the "Azukinashi", the "Kuwa", the "Nnrude", the "Okamenoki", the "Noritsugi", and the followings are the common to those of the Yagushima and Kochi: the "Akashide", the "Sakura", the "Egonoki", the "Taranoki", the "Yuzuriha"; and to those of the Kochi, the "Kiwada", the "Tochinoki", the "Honoki", the "Taniutsugi", the "Koshiabura", the "Kaede" species, the "Mizuki" and so on.

In the first two forests, the seedlings, individuals and groups of the young growth of the "Sugi" regenerated naturally on the ground floor of the fairly well opened part of the polymorphically crowded stories of the canopy of stand, especially on the southern or the western slopes, where on the adjoining place, there occurs no group of the larger size of the broad-leaved tree species, forming such as the single story of the canopy.

While, on the higher elevation, there occurs sometimes not only the seedlings and the young growth stand on the fallen rotten woods or stumps of the "Sugi" but also the older and larger trees of the "Sugi" seems to be assumed as if they have had grown on the similar beds. On the other hand, in the stand of the "Sugi" of the Akita district which hold the areas on the higher elevation, about 800—900 m. above the sea level, the older and larger trees of the "Sugi" stand on the fallen rotten woods of the "Goyomatsu", not of the "Sugi". Notwithstanding this, there occurs, in the Akita district, some of the "Sugi" grow up on the fallen rotten woods and stumps of the "Sugi" and indicate on the part of the basis of stem such a form as if they would have been grown up in the same way in the stand on the normal elevation, about 100—700 m. above the sea level. We can observe the same phenomena in the stand of the "Hiba". While we can hardly observe the similar facts for the "Hinoki", the "Momi", and the "Akamatsu".

Thus far, it will be reduced that the seedlings, individuals and groups of the young growth of the "Sugi" need of tolerable humidity of the floors and enough of the intensity and the quality of the light on the canopy of the young growth. In the case when the humidity of the floors increase too much under the shade and shadow of the closed crowded canopies of the individuals and groups of the deciduous broad-leaved trees, such as the "Buna" and the "Mizunara" there will be found the natural layers of the branchlets of the under-branches near the foot of the "Sugi" stems.

Such layers would be elect as the individuals and groups when they found the stumps or stems of the deciduous broad-leaved trees to lean against. The above mentioned fact will be found, usually, in the stands on the mountain ranges of the coastal districts along the Sea of Japan, but not along the Pacific Ocean where the ever-green broad-leaved tree-species mixed with; while in this part, the more the deciduous broad-leaved tree species increase, the more the layers found.

From the sample plots and the various stands for the thinnings and the selection cuttings on the planted and self-regenerating stands, I have observed the following facts:

1) Stands composed of the tree-groups, of which each of them is taking the growth-form as similar as the individual stand.

2) Tree-groups in the self-regenerating pure stand are the results of the competition of the tree-groups of the mixed stand and the artificial results of such as the thinnings of the widest sense and of the selection cuttings of the several meanings of the utilization.

3) The most simplest one of all of the tree-groups occurs in the planted pure stand, of which composed of the groups corresponding to the trees of the dominate tree-form (2) (trees of the 1st and 2nd classes of tree-forms) and the other corresponding to the subordinate one (trees of the 3rd, 4th, and 5th, classes of tree-forms).

In any stand of the pure formation, these tree-groups occur in the two typical combinations: that is, the one appears as if the group of trees of the dominated tree-form wedged in between the group of trees of the dominated tree-form.

It occurs usually that such a distribution of the tree-groups of the dominated tree-form and of the subordinate one differs in every stand. At the younger stage of the pure stand, even in the case where the total number of trees, total sectional area of the diameters at breast-high and the mean

diameter, the mean height of two given stands on the equal area and of the same tree-species are very closely similar, we can distinguish the difference of the frequencies of the tree-groups of the dominated tree-form and of the subordinate tree-form. Furthermore, the stand becomes older and older, the differentiation between the development of the tree-groups of the dominated tree-form and of the subordinate ones becomes highly distinguishable and then we can discriminate the stories in the stand canopy.

4) In the self-regenerating stand, there occurs in various gradations of the complexities of the grouping of trees corresponding to the formations as follows:

- a) At the younger stages, there occurs various cases mentioned in 3, of which in the mixed stand, the dominated one represents the principal tree-species and the subordinate one the not-principal tree-species;
- b) At the mature stages, each group differentiate into many subgroups of the dominated and the subordinate tree-groups by the development of the growth of trees, and the succeeding migration and establishment lead, furthermore, such a group to integrate into complicate ones. Thus the stand forms the complicated, polymorphically crowded storied canopy.

Thus I have distinguished the tree-groups as follows: tree-groups will be considered in various ways of the combination of the fundamental groups and the latter is distinguished into two types, of which it composed of such as single tree and two or more trees. The fundamental group differentiates into subgroups of the dominated and subordinate trees.

5) It will easily be distinguished, in the self-regenerating stand, the types of the stand formation looking after the distribution of the tree-groups such as:

Frequency of tree-groups of which composed of the tree with			Types of stand formation (1)
Larger diameter	Middle diameter	Small diameter	
very abundant	frequent	very rare	I _α
very rare	frequent	very abundant	I _β
abundant	frequent	very rare	} ... II _γ
frequent	abundant	rare	
abundant	comparatively abundant	abundant	II _δ

6) In the self-regenerating stands in Japan, the seedlings, individuals and groups of young growth will be found on the spots where the conditions of the ground flora and the shrub layer are not stable under or near the open parts or the border parts of the canopy of the stand, and will be grown in the favourable conditions, whereon the frequency of the variation of sunflecks through the canopy and shades of crowds and stems throughout the whole day are great. It occurs probably that such conditions will be found under the canopy of polymorphically crowded stories—of which they are composed either of the mixed group of tree-species of the different many tree-group—of the types of stand formation, I_β and II_δ, while under the canopy of the stands of the other remaining two types, I_α and II_γ, the ground flora and the shrub layer are in stable condition; and the number and the growth of the young growth are very poor, where there occur the less variation of light and shade on the ground floor throughout the whole day.

7) Longevity of the servival of seedlings will be recognizized under near the opened space of the forest canopy of stand, corresponding to the type of stand formation, II_δ, while on the floor of the stand corresponding to the earlier stage of the type of stand formation, I_β is hardly seen. It will, however, easily seen that in the older stage of the type, I_β, the seedlings survive in healthy and grow as the young growth. And on the floor of the stands, corresponding to the type of stand formation, I_α, and II_δ, the germination takes place and we see the seedlings, but the competition between the ground flora, and the shrub layer and the seedlings, causes to loss the longevity of seedlings.

8) By the thinning, the growth of tree-groups composing of the forest canopy of various different stories, i.e. the types of stand formation corresponding to the type II_δ, appears as the vigorous and healthy one and the next is the stand corresponding to the type I_β, and succeeding to the type

II γ , the last is the stand corresponding to the type I α , while the volume of the whole stand are the greatest for that of corresponding to the type I α and next for that of corresponding to the type II γ , and succeeding to that corresponding to the type II δ , and the last is the stand corresponding to the type I β . However, such as above-mentioned descriptions are only the tendencies, because these differ with the tree-species composing the stand and with the habitat of the stand.

These facts, above-mentioned, especially of 6) and 7) lead me to propose to studies the effects of the diffused light which reflected from the crown of the tree-species and the canopy of the tree-groups, and passed through the space of the crown and the space between the canopies of the tree-groups where the conditions of the moisture and properties of soil are not so poorer as the effect of light.

Recently it is ascertained from the records that the stands, corresponding to the type I β would be found in the areas where the clear cuttings and the irregular selection cuttings had been carried on about 30—60 years ago; and by the studies of the records, especially by the investigations from the records and the field notes in the era of the Akita Han by Mr. Naoto Iwasaki, it is concluded that the stands corresponding to the types II γ and II δ would be found in the area where the improvement cuttings and the utilization of the shrubby broad-leaved tree-species as for the materials of firewood had been practised about 100—200 years ago in the stage of the stands, corresponding to the type I β and leaved as it was, and lastly the stands, corresponding to the type I α will be found in the areas where the above given treatment had been carried on as early as about 200—300 years ago, passing through the type II γ and II δ from the stage of the type I β , and leaved as it had been.

A. Natural Regeneration of the "Sugi" in the Pure, Planted Stand.

From the observation of the sample plots of the thinnings and of some of the pure planted stands, it will be concluded that when the thinning has been repeatedly carried out on the stand and reached to about thirty to forty years old, the formation of the stand canopy will be transformed from the single story into the complicated stories, then it comes to carried out the thinnings for the polymorphically crowded stories. It occurs, about these phases of the transformation of the story of the canopy of the stand, that the seedlings of the "Sugi" come to survive on the shade and not dried floor under the canopy. The survived seedlings develop in a sporadic on the portions where no sheet of mosses, no bunches of fern and of herbaceous, no groups of shrubs and of tree-species does thickly consociated over. They grow up as the individuals and groups, vigorously and healthy on a part where the direct light and reflected diffused light will pass, sufficiently through the space between the leaves of the crowns and the space between the crowds of the canopy.

It will be proposed that the seedlings of the "Sugi" survive on the ground where the mesophytic vegetation of the ground flora as bunches of the "Suge" (*Carex*) species and of the "Sumire" (*Viola*) species (ones of the carex and viola species which grow under the shade and the not dried ground), sheets of the "Togeshiba" (*Lycopodium serratum*), of the "Shippogoke" (*Decrantom*) species and of the "Yabukoji" (*Ardisia japonica*) and the bunches of the "Shishigashira" (*Blechnum niponicum*) and the "Yabusotetsu" (*Polysticum falcatum* var. *Fortunei*) are scattered here and there. While the seedlings develop in the favourable state as the individuals and the groups of the young growth under the mixed xerophytic vegetation of the under growth as the "Hisakaki" (*Eurya japonica*), the "Nezumimochi" (*Ligstrum japonica*), (these are some of the characteristic indicator shrubby plants of the south-western part of Japan Proper), the "Taniutsugi" (*Diosvilla japonica*), the "Okamenoki" (*Viburnum furcatum*), the "Ukogi" (*Acanthopanax spinosum*), the "Kuromoji" (*Lindera umbellata*) (these are the characteristic indicator plants for the north-eastern part of Japan Proper), the "Taranoki" (*Arabis chinensis*), the "Nurude" (*Rhus japonica*), the "Yamaurushi" (*R. tricoarpa*), the "Kiichigo" (*Rubus palmates*), the "Fuyuchigo" (*R. Buergeri*), the "Miyamafuyuchigo" (*R. hakonensis*), the "Kumaichigo" (*R. morifolius*), the "Murasakishikibu" (*Carlicarpar japonica*), the "Yabumurasaki" (*C. mollis*), the "Tsutaurushi" (*Rhus toricodendron*, var. *vulgaris*, f. *radicans*), the "Inuzansho" (*Fagara shinifolia*), the "Karasuzansho" (*F. ailanthoides*).

In the south-western part of Japan proper, the young growth of the "Sugi" associated with the conifers, the "Hinoki" (*Chamaecyparis obtusa*), the "Sawara" (*C. pisifera*) and the "Akamatsu" and with the ever-green *Quercus*, as the "Arakashi" (*Quercus glauca*), the "Akagashi" (*Quercus acuta*), the "Kusunoki" (*Chinnamomum camphora*), and "Shirodamo" (*Tetradenia glauca*).

In the hill-land of the north-western part of Japan, as for the example, the pure planted stands of the "Sugi" in the State Forest, Tanikawayama, near the village Ohara in the peninsula Ojika, the southern end of the Kitagami plateau (on the region of triassic rock) we have favourable natural regeneration under the thinning for the polymorphically crowded stories of my own system of thinning where the only the "Murasakishikibu", the "Nurude", the "Taranoki", the "Ukogi", the "Kuromoji", the "Inuzansho", the "Kiichigo" are associated in mixed groups, and on the floor, there are the "Tsutaurushi", the "Miyamafuyuichigo", the "Tsubosumire", the "Okatoranoo", the "Toriashishoma" are scattered here and there, but not where each of the species of the "Kusagi", the "Niwatoko", the "Utsugi", the "Egonoki", the "Yagurumazo", the "Kibanamotsurifune" the "Yabusotetsu", the "Tsurarafuji", the "Chizimizusa", are gregariously consociated.

In the hill-lands of the south-western part of Japan, as for example, the pure planted stands of the "Sugi" in the State Forest, Kimpozan, near the city of Kumamoto, there are the stands which are going to explain my own method of the favourable natural regeneration on the better site (II class site), where under-growth of the "Hisakaki" associated with the "Nezumimochi", the "Yamahaze", the "Shashanpo", the "Murasakishikibu", the "Inuzansho" scattered here and there, a some of the groups of the "Yabukoji", of the "Suge" sp., of the "Tachitsubosumire, Tsubosumire" are scattered.

B. The Natural Regeneration of the Self-regenerating Stands of the Mixed Formation of the "Sugi" and the Other Conifers, with the Broad-leaved Tree-species and of the "Sugi" and the Broad-leaved Tree-species.

From the observations of the sample plots, it will be resumed that, broadly speaking, the seedlings, individuals and groups of the young growth of the "Sugi" and other conifers grow favourably on the plots of the ground floor where the sunflecks passing throw the branches of the crowns and the openings between each crown of the polymorphically crowded canopy and of the undergrowth, and the shades both of the crowns and stems of the canopy and of those of the under growth change frequently with each other from time to time.

Furthermore, from the sample plots in the Yanase and Shimano-kawa State Forests in the Kochi District Forest Office we have.

- a. Plots where the mosses thinly covers: many of the seedling of the "Sugi" and the "Hinoki" grow fairly well;
- b. Plots where the "Susuki" and the "Nagabanomomijiba-ichigo" cover thinly: the groups of the seedlings of the "Sugi", of the "Hinoki", of the "Momi" and of the "Tsuga" grow luxuriantly with the vigorously and healthy forms;
- c. Plots where the ferns cover scatteringly with the mosses: the groups of the seedlings of the "Momi", of the "Tsuga" and of the "Hinoki" grow scatteringly with moderate growth;
- d. Plots where the "Susudake" and the "Chijimizasa" grow up: the seedlings of the "Momi" and of the "Tsuga" grow scatteringly with the moderate growth;
- e. Plots where the fallen branchlets of the "Sugi" accumulate: no the seedlings of conifers found;
- f. Plots where the shrubs and the under growth cover: the seedlings of the "Momi" and of the "Tsuga" found very rarely with the weak form.
- g. Plots where the groups of the "Kusagi" cover: no the seedlings of conifers found.

At any rate, occurs in the State Forests of the above given region that the natural regeneration of the conifers take place luxuriantly on the plots from the north-eastern facing slopes to the north-western facing one.

Such a tendency will be found in the State Forests of the region of the Akita District Forest Office.

In addition, from the sample plots of the State Forests in the Akita District Forest Office, we have:

1. The great deal of the seedlings of the "Sugi" survived on the ground floor where the thickness of the accumulation of the fallen branchlets of the "Sugi" with the fallen leaves of the "Buna", the "Kaede" species, the "Midzumara" the "Hinoki", the "Tochinoki" and other species with the humus exceeds not more than about 0.5 cm; furthermore on such a ground floor, the sunflecks through

the widely openings of the polymorphically crowded canopy of the stand and the shades of the crowns of the border parts of the openings alternate with one another from time to time.

2. The great deal of the seedlings of the "Sugi" will be survived on the ground floor where the mixed flora of some of the "Iwagarami", the "Itayakaede", the "Buna", the "Mizunara", the "Suge" species, the "Susuki", the "Chigoyuri" the "Shishigashira", the "Inuwarabi" migrated on; of course in the case when any of them close up the floor and form the thick society, the seedlings of the "Sugi", in the long run, disappear.

3. The young growth of the "Sugi" grow up vigorously and healthy where they are mixed with the some of the above-mentioned species and with the migration of the "Hakuunboku", the "Kobushi", the "Koshiabura", the "Honoki", the "Okamenoki", the "Yamaurushi", the "Ryobu", the "Taranoki", the "Sasa" species, the "Aoki", the "Yezoyuzuriha", the "Himemochi", the "Miyamashikimi" and the "Kuromoji".

Of these above-mentioned species, the first nine species migrate usually in the part where the direct light frequently strikes, while the last five species in the part where shaded frequently by the crowns and stems. However, the more some of them grew up faster than the "Sugi" and form the thickly crowded societies, the more slender the young growth of the "Sugi" grow, and the more the stems of the "Sugi" elongate and the stems of the "Sugi" used to bent down to the floor by the annual massive accumulation of snow. The more the above given conditions continue, the more the elevated stems run to the direction, where the sunflecks frequently happen to appear. Thus, they take somethinglike the forms of runners and, in the long run, the forms of the natural layers. In addition, on the steep slopes, they run to the foot along the slopes and take the forms of the natural layers.

By any chance, when the crowded crown of the canopy of the stand happen widely to open and when they found to such as the stumps, the stems, and any other things to lean against, the layers elect their stems upright and then grew up vigorously and healthy.

The similar conditions of the natural regeneration of the "Sugi" will be seen in the state forests along the coastal region of the Sea of Japan. While in the State Forests in the plains and hilly lands in the region of the central Japan and in the coastal region along the Pacific Ocean in the Japan Proper, the natural regeneration by the seedlings of the "Sugi", the "Momi", the "Hinoki" and the "Akamatsu" will be happened in the shaded part, that is to say, the part where the direct sunlight does not strike, through the day, on the floor as I have given in the description of the sample plots in the Kochi Forest Office.

5. Some of the Abstract for the Experimental Data from the Sample Plots Since After the Year of 1924.

We have, at present time, 104 sample plots on the thinnings and on the selection-cuttings for the planted and self-regenerating stands; among those plots, the number summed up to 62 is of the latter. The oldest ones of the latter are inaugurated the experiments in the year of 1917 for the self-regenerating stands of *Thujaopsis dolabrata*, the "Hita". While for *Abies firma*, the "Momi" self-regenerating stands, I have carried on the experiments since after the year of 1924 and for the "Sugi" self-regenerating stands, since after the year before.

Before concluding this paper, I wish to give some results obtained in some of the sample plots for the treatment of the self-regenerating stands by the methods of the selection cutting and thinning.

For saving the pages and for simplifying the matter, the following tables would have been, probably, served as for the explanations of the progression of the growth and the natural regeneration.

One of the examples from the sample plots of the mixed self-regenerating stands for the "Momi".

Sample plots of the selection cutting in the Bateikei State Forest in Otawara Local Forestry Branch Office in the Tokyo District Forest Office.

The stand situated on the Nasu plain, near the city Utsunomiya. Sample plot I, the type of the formation of the stand, I β .

In this plot, there occurs:

32.9 % of the deciduous broad-leaved tree species and

67.1 % of the "Momi", in the number of trees.

Here I have practised the first selection cutting of about one half of the growth for the volume in the year of 1924, and also nearly the same amount of growth in the second selection cutting in the year of 1930.

Sample plot II, the type of the formation of the stand, I₃.

In this plot, there occurs:

40.0 % of the deciduous broad-leaved tree species and

60.0 % of the "Momi", in the number of trees.

Here I have practised the first selection cutting of about the same amount of the growth for the volume in the year of 1924, and also nearly the same amount in the second selection cutting in the year of 1930.

Sample plot I. Area 1.0 ha. The type of the formation of the stand, I_β.

Diameter classes, in "Sun"	Conifers												Broad-leaved tree species			
	"Momi"				"Akamatsu"				"Sugi"							
	number of trees															
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
3	292	187	164	125	1				1	1			153	40	89	71
4	184	136	138	99								1	119	36	38	24
5	122	90	104	79									79	27	25	16
6	82	68	71	58	2	1							42	15	23	18
7	73	62	66	53	1	1	1	1					17	6	15	15
8	41	27	53	44	1				3	2			12	3	9	9
9	44	32	26	23					1	1		1	8	4	6	6
10	29	26	27	23	1	1						2	2		4	4
11	19	14	22	21			1	1	1				8	4	2	2
12	9	7	15	13									7	2	2	2
13	6	6	13	13									3		2	2
14	3	3	10	8									2	1	2	2
14	2	2											1			
16	3	2	3	2												
17	2	1	3	3	3	3	1	1					1	1		
18			1	1			2	2					1		1	1
19	1	1	1		1								1			
20	1	1	1	1	3	2	1	1					2			
21									1	1						
22			1	1												
23												1	1			
30					1	1										
33							1	1								
Total	913	665	719	567	14	9	7	7	7	5	5	5	458	139	218	172

Percentage of the number of trees by the selection cuttings

Conifers in the cases for

(1) 27.3 % (3) 20.8 %

Broad-leaved species in the cases for

(1) 69.7 % (3) 12.1 %

Percentage of the volume by the selection cutting, in "Koku"

Conifers

(1) 21.8 % (3) 14.1 %

Broad-leaved species in the cases for

(1) 70.5 % (3) 10.9 %

Remarks:

(1) Denote the number of trees before the selection cutting in the year 1924

(2) " " " after " " " "

(3) " " " before " " " 1930

(4) " " " after " " " "

The species of broad-leaved trees are as follow:

The "Akashide", the "Kuri", the "Keyamasakura", the "Aohada", the "Yamamomiji", the "Kohauchiwakaede", the "Kobanotoneriko", the "Tsuribananomayumi", the "Konara", the "Hohoncki", the "Urajironoki" and so on.

Number of trees, summed up the conifers and broad-leaved tree-species				Volume of trees, summed up the conifers and broad-leaved tree-species in "Koku".			
(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
1392	818	949	751	1082.9	678.1	930.1	803.5
41.2 %		20.9 %		36.6 %		13.1 %	

Growth of the Volume during the first 6 years, in "Koku" 243.1

Average annual growth, in "Koku" per ha. 40.5

$$\frac{\text{Volume of Selection cutting}}{\text{Growth Volume during the 6 years}} = \frac{126.6}{243.1} = 0.52$$

1 "Saku" = 10 "Sun" = 30.3cm.

1 "Koku" = 0.278m³.

In this plot, the developments of the young growth of the "Momi" are not so vigorous and healthy as in the plot, II, but there occurs great deal of the survivals of the seedlings of the "Akamatsu", the "Sugi", and especially the "Momi"

Surveyer: Mr. M. Aso, Assistant Forester in the Forestry Experiment Station, Meguro.

Sample plot, II. Area 1.0 ha. The type of the formation of the stand, Iβ.

Diameter classes, in "Sun"	Conifers												Broad-leaved tree species			
	"Momi"				"Akamatsu"				"Sugi"							
	number of trees															
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
3	104	54	59	51									185		70	61
4	91	38	35	21									121	3	3	3
5	73	47	42	24	1	1							95		2	2
6	93	59	44	25									67	3	1	1
7	81	54	53	29			1	1					35	5	1	1
8	70	44	48	28									13	1	5	5
9	75	53	39	25									3		4	4
10	71	54	48	33					1	1			1	1		
11	45	39	42	36					1		1	1	2			
12	27	17	41	39									1		1	1
13	25	20	27	22												
14	9	6	14	12												
15	10	9	13	10									1			
16	2	2	6	6												
17	5	5	4	4												
18	3	3	5	5												
19			2	2												
20	3	2														
21			2	2												
22	1	1														
23			1	1												
24			1	1												
25					1	1										
26							1	1								
Total	788	507	526	376	2	2	2	2	2	1	1	1	527	13	87	78

Percentage of the number of the tree by the selection cuttings

Conifers in the cases for

(1) 35.6 % (3) 28.4 %

Broad-leaved tree-species in the cases for

(1) 97.5 % (3) 10.3 %

Percentage of the volume by the selection cutting, in Koku.

in the cases for

(1) 25.6 % (3) 19.5 %

in the cases for

(1) 94.7 % (3) 3.9 %

Remarks

- (1) Denote the number of trees before the selection cutting in the year 1924
 (2) " " " after " " " "
 (3) " " " before " " " 1930
 (4) " " " after " " " "

The species of broad-leaved trees are as follow :

Number of trees, summed up the conifers and broad-leaved trees				Volume of trees, summed up the conifers and broad-leaved trees, in "Koku"			
(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
1319	523	616	457	1433.0	891.0	1128.1	913.8
percentage 60.3 %		25.8 %		37.8 %		19.0 %	

Growth of the volume during the 6 years, in "Koku" 237.1
 Average annual growth, in "Koku" per ha. 39.5

$$\frac{\text{Volume of selection cutting}}{\text{Growth Volume during the 6 years}} = \frac{214.3}{237.1} = 0.90$$

- 1 "Saku" = 10 "Sun" = 30.3cm.
 1 "Koku" = 0.278m³.

In this plot, the developments of the young growth of the "Momi" are vigorous and healthy, while there are not so much of the survivals of the fresh seedlings of the "Momi" as in the plot I.
 Surveyer: Mr. M. Aso, Assistant Forester in the Forestry Experimental Station, Meguro.

Some of the examples from the sample plots of the mixed self-regenerating stands for the "Sugi" in the Kochi District Forest Office.

1. Sample plot of the selection cutting in the Senbonyama State Forest in Yanase Local Forestry Branch Office, corresponds to the type of the formation of the stand, II δ .

The stand situated in a part of the Shikoku mountain range, where there occur the vast areas of the mixed formation of the "Sugi", the "Hinoki", the "Momi", the "Tsuga", the "Akamatsu" and the "Togasawara".

Here I have practised the first selection cutting in the year of 1926, and the progression of the experiment are as follows:

The Area of the sample plot.....1.20 ha.

Tree-species	Before the selection cutting in 1926		After the selection cutting in 1926		Percentage for the selection		Present stand in 1930		Growth of
	Number of tree	Volume m ³ .	Number of tree	Volume m ³ .	Number of trees%	Volume %	Number of trees	Volume m ³ .	
"Sugi"	245	250.908	214	188.837	13	25	214	236.179	47.342
"Hinoki"	38	12.416	34	9.141	11	26	34	12.463	3.322
"Momi"	51	215.356	25	91.993	51	57	25	102.669	10.676
"Tsuga"	43	61.625	15	16.947	65	72	15	20.629	3.682
"Akamatsu"	4	21.108	1	10.759	25	49	1	11.148	0.389
"Togasawarr"	1	4.916	1	4.916	—	—	1	6.381	1.465
Total	382	566.329	290	322.593	24	42	290	389.469	66.876

Surveyer: Mr. Horiuchi, Assistant Forester in the Kochi District Forestry Department.

From this table, it will be suggested that if the amount of the growth of the "Sugi" and the "Hinoki" increase with the same rate as it is, then the volume of the "Hinoki" will be approached as nearly as the amount of that in the year of 1926, and also the volume of the "Sugi" will be approached as nearly as the amount of that in the year of 1926 after one year.

The number of the survived seedlings in the quadrates (the area of 100 m.), which set in the sample plots, are as follows:

A. The quadrate set whereon there occurs no seedlings in the year of 1926.

The occurrence in the year	The number of seedlings of						Total
	"Sugi"	"Hinoki"	"Momi"	"Tsuga"	"Togasawara"	"Akamatsu"	
1927	4	—	11	1	2	1	19
1930	430	2	21	9	3	1	466

B. The quadrate set whereon there occurs some of seedlings before the year of 1926.

The occurrence in the year	The number of seedlings of						Total
	"Sugi"	"Hinoki"	"Momi"	"Tsuga"	"Togasawara"	"Akamatsu"	
1927	14	—	53	12	1	—	80
1930	348	2	78	451	2	2	883

2. Sample plot of the selection cutting in the Koyashikiyama State Forest in Yanase Local Forestry Branch Office, corresponds to the type of the formation of the stand, II γ.

Here I have practised the first selection cutting in the same year as the sample plot Nr. 1, and the progression of the experiment are as follows:

The Area of the sample plot.....3.93 ha.

Tree-species	Before the selection in 1926		After the selection in 1926		Percentage of selection		Present stand in 1930		Growth of
	Number of trees	Volume m ³ .	Number of trees	Volume m ³ .	Number of trees%	Volume %	Number of trees	Volume m ³ .	Volume m ³ .
"Sugi"	260	819.224	187	673.623	28	18	187	741.739	68.116
"Hinoki"	56	52.610	48	39.943	14	24	48	52.810	12.867
"Momi"	74	353.095	43	248.225	42	30	43	271.468	23.243
"Tsuga"	433	1122.104	177	432.995	59	61	177	478.861	45.866
"Yoyamaki"	2	0.547	2	0.547	—	—	2	0.547	0
"Kaya"	3	2.103	3	2.103	—	—	3	2.483	0.380
Total	828	2349.683	460	1397.436	44	41	460	1547.908	150.472

Surveyer: Mr. Horiuchi, Assistant Forester in the Kochi District Forest Office.

From this table, it will be suggested that if the amount of the growth of the "Sugi" and the "Hinoki" increase with the same rates as it is, then the volume of the "Hinoki" in the year of 1930 has already approached as nearly as the same amount of that in the year of 1926, while the volume of the "Sugi" will be approached as nearly as the amount of that in the year of 1926 after the five years.

The number of the survived seedlings in the quadrates (the area 100 m.), which set in the sample plots, are as follows:

A. The quadrat set, whereon there occurs no seedlings in the year of 1926.

The occurrence in the year	The number of seedlings of					Total
	"Sugi"	"Hinoki"	"Momi"	"Tsuga"	"Akamatsu"	
1927	8	—	10	—	—	18
1930	216	9	41	205	—	471

B. The quadrat set, whereon there occurs some of seedlings before the year of 1926.

The occurrence in the year	The number of seedlings of					Total
	"Sugi"	"Hinoki"	"Momi"	"Tsuga"	"Akamatsu"	
1927	98	2	22	—	1	132
1930	75	51	255	236	1	1218

As for an example of the sample plots for the selection cutting on the mixed self-regenerating stands of the "Sugi" and the deciduous broadleaved tree-species in the State Forests in the Akita District Forest Office, here I would like to give some notes on the sample plot in the Ozakuzure State Forest in the Fujikoto Local Forestry Branch Office.

The plot situated on the elevation of 300—420 m. over the sea level, and on one of branches of the mountain range which runs through the boundary line between the provinces Akita and Aomori. It faces to NW. 24—80° with inclination of 26°.

The stand corresponds to the type of the formation of the stand, II δ.

There occurs many broad-leaved trees such as the "Buna", the "Mizunara", the "Tochinoki", the "Yamazakura", the "Uwamizuzakura", the "Itayakaede", the "Hauchiwakaede", the "Kaminekaede", the "Honoki", the "Koshiabura", the "Hakuunboku", the "Yegonoki", the "Inushide", the "Aodamo", the "Mansaku", the "Azukinashi", the "Sawashiba", the "Mizuki", the "Udai-kanba", the "Awabuki", the "Katsura", the "Sawagurumi", the "Ohyonire".

I have carried on the selection cutting in the autumn in the year of 1925 and the progression of the growth of the sample plot is as follows:

The sample plot in the Ozakuzure State Forest.

The Area of the sample plot.....4.58 ha.

Diameter classes	Before the selection cutting in 1925					
	"Sugi"		Broad-leaved trees		Total	
	Number of trees	Volume in "Koku"	Number of trees	Volume in "Koku"	Number of trees	Volume in "Koku"
Small classes	493	951.86	2135	1514.34	2578	2466.20
Middle classes	205	2867.11	42	355.14	247	2202.25
Large classes	18	707.74	3	56.32	21	764.06
Total	716	4526.71	2180	1905.80	2846	6432.51
Diameter classes	After the selection cutting in 1925					
	"Sugi"		Broad-leaved trees		Total	
	Number of trees	Volume in "Koku"	Number of trees	Volume of "Koku"	Number of trees	Volume in "Koku"
Small classes	433	763.56	1745	920.73	2178	9684.39
Middle class	161	2265.67	12	99.47	173	2365.14
Large classes	18	569.07	1	20.57	19	589.64
Total	613	3598.30	1758	1040.77	2370	4639.07

Diameter classes	The present stand in 1929					
	"Sugi"		Broad-leaved trees		Total	
	Number of trees	Volume in "Koku"	Number of trees	Volume in "Koku"	Number of trees	Volume in "Koku"
Small classes	433	669.49	1731	1068.08	2164	1737.57
Middle classes	173	2354.37	27	238.81	200	2593.18
Large classes	17	894.87	3	63.28	20	958.15
Total	623	3918.73	1761	1370.17	2384	5288.90

Remarks.

Small classes (0.10 "Saku"—1.50 "Saku")

Middle classes (1.55 " " —2.50 " ")

Large classes (2.50 " " — " ")

The range of the ages of the "Sugi" is from about 80 years old to about 170 years old, and those of the broad-leaved trees from about 20 years old to about 140 years old.

The seedlings of the "Sugi" have been occurred in this plots as in the following way:

Divisions.

Year	Divisions.									Total
	I	II	III	IV	V	VI	VII	VIII	IX	
1918							1			1
19							1			1
20							—			—
21			3			1	3			7
22		1	—	1		6	3			11
23	5	5	2	2		6	1		2	23
24	14	4	7	21	11	8	2		—	67
25	25	15	6	6	2	20	7	1	2	84
26	21	12	8	21	12	41	3	7	1	126
27	7	5	2	6	4	12	3	—	2	41
28	8	13	5	20	6	37	—	23	1	113
29	3	9	16	2	5	8	—	17	3	63
30	9	54	19	—	9	1	1	7	9	109
Total	92	118	68	79	49	140	25	55	20	646

Remarks:

For the convenience of the surveying of the diameter and the height of each tree, we divided the plot into the nine parts according to the topographical differentiations.

In each one of the division, we select one belt in the width of 5 m. Here we have accounted the survived seedlings of the "Sugi".

Surveyers: Y. Saki and S. Ishikawa, Assistant Foresters in the Akita District Forest Office.