# カラマツの間伐試験（Ⅲ）

# カラマツ植栽林における間伐に関する研究

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## 摘　要

著者は周知のドイツ，オーストリアに実行されていた間伐法，あるいは日本，特に吉野地方のスギ植栽林に対して慣用されていた方法等を文献によつて考察していたが，1903年に初めて実際に間伐種の型式を決めるために，浅間山麓の南面のカラマツ単純幼齢林分を観察する機会を得た。

いずれにしても，間伐というものは生存競争を調節し，林冠を構成する各個樹の樹冠の拡がりを発展せしめることにほかならぬとの考えに到達した。

これまで著者は樹冠のかたちによつて幹級を区分した。しかしながら，個々の樹木の樹冠がどんな成長をするのかがわからなかつたので，間伐のくり返し期間といつたようなもつとも困難な問題が残されていた。それで，まず最初10年間は第Ⅰ号の試験地について，林冠のうつぺいのうつり具合によつて次の間伐のくり返し時期をきめるというように，経験的に間伐のくり返し時期をみつけ出そうと試みた。

所与の間伐種によつて間伐されたカラマツの毎木の胸高円盤の年輪の成長解析に，KENDALL氏の連続相関および自己回帰として知られている時系列の方法を適用した。

この方法で林冠層別に計算されたそれぞれの自己回帰系列のすべての算術平均を計算した。その結果，

（a）　平均位相は後掲の表に示すように，4.5～4.9 年のようである。

（b）　間伐後の peak の出現に対する間伐種の影響は図表から明らかなように，C種間伐では上層下層に関係なく間伐の翌年に多く現われ，2年目，3年目は大変少ない。B種間伐では上層木については間伐の翌年に大変少なく，原則的には2年目，3年目に現われるのが多い。

これらの実験によつて，著者は間伐のくり返し年は次のように普通に推定し得られるのではないかと考えた。

| | |
|---|---|
| A 種 間 伐 | 約 3 年 |
| B 種 間 伐 | 約 5 年 |
| C 種 間 伐 | 約 8 年 |

しかしながら，C種間伐によるコレログラムの解析から，間伐実行後翌年に peak が現われるのが多く，2年目，3年目には少ないという事実がわかつたが，これは普通に考えられなかつた現象であつた。しかし，1932 年に著者の撮影した写真を参考にされれば，これらの事実を明らかに示しているのである。

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（注）　寺崎渡氏の遺稿“カラマツ林の間伐試験”を印刷する。本稿は寺崎氏が明治 36 年長野県浅間山麓の国有林に設定した“カラマツ間伐試験地”の 50 年にわたる調査成果を緯とし，多年の林木の成長に関する知見を経として，単木成長論の立場から間伐について検討を加えたものである。

計算ならびに図表の作製には林敬太技官の労によるところが多く感謝の意をささげる。編集は林および加藤が行なつた。　（昭和 37 年 12 月　造林部長　加藤善忠）

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# Note on the Study of Thinning Pure Japanese Larch Plantation.

Dr. Wataru TERAZAKI

**Contents**



Acknowledgments

These notes could not have been compiled without the assistance of numerous seniors, especially the late Dr. H. SHIRASAWA, and of others, especially Dr. Y. SAITO, present director of the Government Forest Experiment Station. For assistance in many problems and computation of statistical data the writer is indebted to Mr. K. HAYASHI.

Dr. Wataru TERAZAKI

## Part I. 1958

### Studies on the operation of systematic thinning in pure larch plantation.

The writer was born in 1876 in Tokyo and is one of the Tokyo-bred old boys, just 82 years old as of 1958. After studying the regular 3-year course (1891～1901) at the Forestry Faculty of Tokyo University, he studied, as a post graduate of Tokyo University during 1901～1903, the scientific methods of Forest Mensuration, particularly the regularities in growth curves, including rhythms and allometry with respect to Forestry Treatment and Management. During these courses, the writer experienced two significant revelations, namely:

(i) In 1899, the writer read the book "Yoshino Forestry" by Shoichiro MORI, published in 1898, which was presented by the then Prime Minister Count KATSURA to his father, and learned the reality of the Yoshino Forestry thinning system which has been practiced for the past 200 years.

(ii) Soon after his father's death, he toured the larch plantation region on the south-western foot of Mt. Asama as an official reseacher, and was the only post-graduate to attend the field survey on thinning practice of larch plantation (1903), where Dr. Homi SHIRASAWA, Senior forester in silvicultural section of Forestry Agency, Prof. Dr. Seiroku HONDA, Dr. HEFELE of Munich University from Forestry Faculty of Tokyo University attended as advisers. The leading members of the survey team were the chief of Nagano Regional Forestry Office, chiefs of silviculture, management, and other sections of the same office. Then the writer in 1903 toured the area for two weeks to inspect the management and treatment of the larch forests, and found only one pure self-generating natural stand and one pure plantation stand, in which two stands having typical density of spacing of stand canopy covers was represented.

Of these stands, the writer collected samples corresponding to the mean trees to use for stem-analysis. The samples were from a self-generating natural stand (a Government stand), situated near the river Saikawa near Taisho lake in Shimashima village of Nagano prefecture, and of a pure plantation (a private stand) planted very wide, 7 'shaku' to 9 'shaku', near Nozawa village of the same Nagano prefecture. Notes on these samples were destroyed by fire durning an air-raid on Tokyo during World War II.

But the writer remembered the characteristic difference of the annual rings; that is, the annual ring widths of b. h. d. section were very narrow in the self-generating natural stand, while those of the pure plantation were considerably wide.

These two examples of the growth of single trees were of course, not only eccentric as models, but they complicated the work. However, it may be said that the example of the growth of single trees of the pure plantation in the private forest of Nozawa village, enabled the writer to give some hints for the model of thinning operation.

On that occasion it was proposed that the overall problems on thinning be examined. He was ordered to stay at the plantation region to set the experimental sample plots by his own design which approached the idea and technique of the Yoshino Forestry. The thinning technique of the Yoshino Forestry was founded on the complicated struggle for existence of the crown spacing with respect to the environment and topographical and soil formations which are the general characteristics of our forest stands.

In this sense, it is incorrect to distinguish European thinning as 'high thinning' (Hochdurchforstung: eclaircie par le haut) and 'low thinning' (Niederdurch-forstung: eclaircie par le bar).

(i) Yoshino foresters divided the stand canopy into two storeys and classified them as follows:

A: The upper storey consisting of so-called elite ('Tate-ki') class trees as essential components.

B: The lower storey consisting of neutral[1] class trees as essential components.

(1) Neutral trees……Those not subjected to lateral competition from the nearest trees in the same storey.

C : And in each storey, there are some of the distorted[2] class trees and those distorting the development of the essential class trees.

(ii) When the same parts of stand canopy are densely closed in the upper storey, the canopy should be opened, as it satisfies the special categories of Yoshino forest products.

(iii) Yoshino foresters when marking, at first look for the elite class trees, then for neutral class trees, next, for distorting trees and lastly for the distorted trees.

(iv) Yoshino foresters understand by their long years of experience the crown spacial density of stand before and after the thinning by the harmonious distribution of standing and residual individuals.

(v) Yoshino foresters satisfy the yield of the forest products with the product of the thinning only, working to the so-called 'Dauerwaldbetriebs' system for over 200 years.

As to these conceptions, it is very difficult for the beginner to decide the neutral tree class and the so-called crown spacial density with the harmonious distribution of standing and residual individuals, and with this in mind, the writer established the following tree classification in 1903.

## Tree Classification

### I. The dominated individuals

1. The first-class tree (1) :

Crown takes a spindlical form and is well developed equally every direction ; trunks are healthy and straight ; predominating in the stand canopy.

2. The second-class tree (2) :

Somewhat shorter than the first-class tree ; certain defects in the form of trunk ; 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. Subordinate individuals

3. The third-class tree (3) :

Distinctly shorter than any of the dominated individuals but one of them suppressed ; some of them take the form similar to the first-class tree, or take the form similar to the above-mentioned second-class tree.

4. The fourth-class tree (4) :

Suppressed by the neighbouring trees ;

5. The fifth-class tree (5) :

Overtopped, dying and dead, falling and fallen :

Again, the writer has distinguished the grade of thinning as follows :

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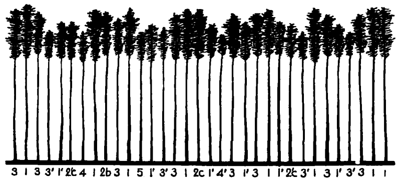
(2) Distorted trees……Suppressed :
a. Vertically.　b. Laterally.
Distorted :
by physical cause.
by competition with neighboring trees.

# 寺崎式間伐の仕方模型図
# DIAGRAM SHOWING METHODS OF THINNING BY TREE CLASSIFICATIONS
## BY DR. W. TERAZAKI

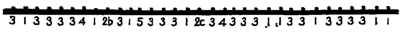
単純植栽の複層林の間伐実行直前の容姿　（模型図）
Diagram, showing the stand canopy profile of the 2 stories in a planted pure stand before thinning.

A Fig.




A列の数値は複層林の林冠層別の樹型級別を示したもの（数値の右肩にダッシを附したるは下層の樹型級別を示したもの）
A Figure, showing the two-story tree-classification and stratification of the stratum of the stand canopy.
(Figures with dash(')designate the tree classification of lower story those without dash designate of the upper story.)

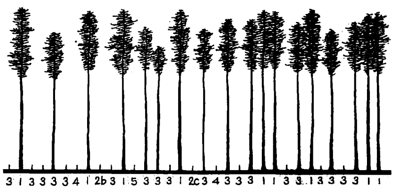
B Fig.



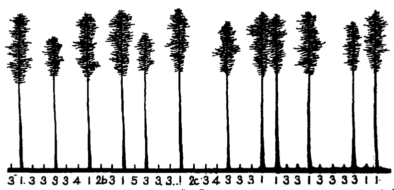

B列の数値は林冠を層別せず単層林としての樹型級別を示したもの
B Figures show the tree-classification of the single story of the stand canopy.

## I SINGLE STORY THINNINGS

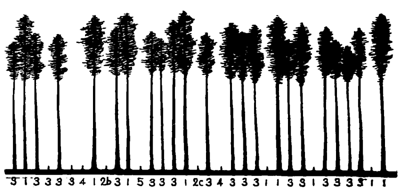
Single story thinnings were practiced on National and private forests from 1903 to 1921 on recommendation and instructions by Dr. W. Terazaki



第2図は複層林を単層林と鑑識して"B"種間伐をした直後の林冠疎開の容姿
Diagram 2. Showing the remainning stand of the "B" type thinning after the tree-classification of single story without any stratification of the stand canopy.



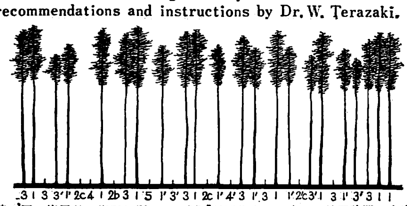
第3図は複層林を単層林と鑑識して"C"種間伐をした直後の林冠疎開の容姿
Diagram 3. Showing the remainning stand of the "C" type thinning after the tree-classification of single story without any stratification of the stand canopy.



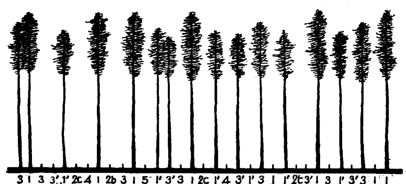
第4図は複層林を単層林と鑑識して"D"種間伐をした直後の林冠疎開の容姿
Diagram 4. Showing the remainning stand of the "D" type thinning after the tree-classification of single story without any stratification of the stand canopy.

## II. TWO-STORY THINNINGS (Pure planted conifers)

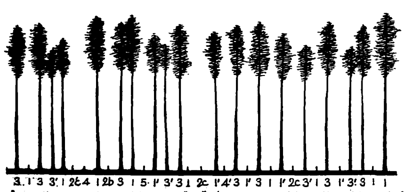
Two-story thinnings have been practiced on National and private forests in the sea coast region of the Japan Sea and those of the older age of 20 years old since 1921 on recommendations and instructions by Dr. W. Terazaki.



第2'図　複層林の樹型級別により"B"種間伐をした直後の林冠疎開の容姿
Diagram 2'. Showing the remainning stand of the "B" type thinning after the two-story tree-classification and stratification of the stratum of the stand canopy.



第3'図　複層林の樹型級別により"C"種間伐をした直後の林冠疎開の容姿
Diagram 3'. Showing the remainning stand of the "C" type thinning after the two-story tree-classification and stratification of the stratum of the stand canopy.



第4'図　複層林の樹型級別により"D"種間伐をした直後の林冠疎開の容姿
Diagram 4'. Showing the remainning stand of the "D" type thinning after the tree-classification and stratification of the stratum of the stand canopy.

A. The first kind of thinning, say, A-formation of stand canopy, in short, A-thinning :
Trees chosen for cutting :
All of the 4 and 5, and all of the 2b and 2e.

B. The second kind of thinning, say, B-formation of stand canopy, in short, B-thinning :
Trees chosen for cutting :
All of the 4 and 5, and all of the 2b and 2e ; majority of the 2c and 2d ; some of the 3.

C. The third kind of thinning, 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.

Note

1. Thinning must be done as early as possible if the crowns yet crowded and stem classes become distinguishable ;

2. The thinning is to be repeated as soon as crowns close up the openings ; the interval between thinnings is 5 years for the B thinning and 7 years for the C-thinning when trees are young.

3. During the young stage of trees such as those found in the sample plots, thinning should begin early, the C-thinning being the more favorable.

4. In practice, we must cut off the second-class trees whenever possible, and we must regulate the openings located there by arranging the crowns of the third-class trees. The arrangement of the crowns of the latter should be made by distributing the third-class trees in good order.

Later, observations and criticisms were made by a member of the Government management planning office about the writer's thinning operations, and helpful advice was given to the effect that the wood of larch, used for a number of years only for piles and poles, does not produce wood such as the woods of Sugi and Hinoki, and is not grown for the same purpose or uses as are those two woods. So the larch plantation must be comparatively widely planted and somewhat widely thinned, and rotation must be 40 years old.

Thus he planned the managements of self-generating natural government forests in the area of Mt. "Yatsugatake" and on the mountain pass of Jyumonji, notwithstanding the managements of pure larch plantation with wide density. Afterwards the writer observing the larch in the self-generating natural government forests of the above given localities where they mixed with the *Abies homolepis, Picea jezoensis* var. *hondoensis, Abies Mariesii, Abies Veichii, Tsuga Sieboldii, Pinus densiflora* (about which the writer published a report in Japanese from Tokyo Forestry Agency: The out line of the management and treatment of the forests in the Alpine regions of Mt. 'Yatsugatake' and upper course of the River 'Kinugawa' 1937) were revised somewhat.

1. Methods used since 1921 for the thinning test.

1.1 Differentiate the stand canopy into storeys :
Single storey……Youngest stand, about 15 years old plantation.
Compound storeys……2 storeys, very common in planted stand, sometimes 3 storeys, especially in old stand.

1.2 While in naturally regenerated stand :
Single stage……Stand structure corresponding to young stages of stand type $\mathrm{I}_{\beta}$.
Compound storey……Stand structure corresponding to types $\mathrm{I}_{\alpha}$, $\mathrm{II}_{\gamma}$, and $\mathrm{II}_{\delta}$ with 2 or more

storeys.

Discontinuous stage. Such as 2-storeys or 3-storeys stand. These forms are found also in the plantation.

1.3 New tree classification :

"A" class tree……So-called elite ("Tateki") class tree and trees with similar form.

"$A_1$" class tree……Neutral class tree ;

"B" class tree……Distorted class tree ;

Distorted

by physical cause, by competition with neighbouring trees

Suppressed

a. Vertically, b. Laterally

In the upper storey, A and $A_1$ class trees with B class trees.

In the lower storey, $A_1$ class trees with B class trees.

1.4 Thinning system

A formation……remove only some of the very much distorted trees and set free by removing one or more of the very near standing A class tree group or $A_1$ class group.

B formation……remove some of the distorted trees in both of the upper storey and lower storey, and all of the distorting trees for the development of both of A and $A_1$ class groups.

C formation……remove all of the distorted trees and the distorting trees in both the upper storey and lower storey, and some of the A class trees and $A_1$ class trees.

(3) Here, the writer used the word "formation" as applying to both forms of the crown. The stem bole of the individuals of the residual stand after the 3rd of 4th replication of the thinning represents the specialities according to the differentiation of the sort of thinning.

Analysis of stand structure.

A. By measuring the projection areas of crown of individual trees in the stand canopy with respect to each storey.

B. By measuring the widths of annual rings of the breast height section of the removed trees by the thinning.

C. By measuring the frequencies of the size classes of the individual trees in the stand canopy with respect to each storey.

A.

1. Calculations show that

$$\frac{K'}{K}=\frac{G'}{G} \text{ approximately}$$

where $K$ and $K'$ are the sums of the projection areas of crown of individual trees of the stand canopy before the thinning and of the removed trees, respectively ; and $G$ and $G'$ are the sums of the basal area at breast height of individual trees of the stand canopy before the thinning and of the removed trees, respectively.

2. From the local tables of "Karamatsu", "Akamatsu", "Sugi", and "Hinoki", we calculated

$$\log\frac{N'}{N}=0.7014\log\frac{G'}{G}-0.0771$$

where $N$ and $N'$ are the sums of the number of trees of stand canopy before the thinning and of the removed trees, respectively.

3. Thus we might deduce as follows :

The intensity of the openning of stand canopy.

for A formation $\frac{G'}{G}=0.15$, $\frac{N'}{N}=0.22\pm0.06$

for B formation $\frac{G'}{G}=0.15\sim0.25$, $\frac{N'}{N}=0.22\pm0.06\sim0.31\pm0.06$

for C formation $\frac{G'}{G}=0.25\sim0.40$, $\frac{N'}{N}=0.31\pm0.06\sim0.44\pm0.06$

B.

1. The graphs of the correlograms and the autoregression equations of "Karamatsu", "Hinoki", and "Sugi" give us the following :

The mean phases from the peaks and troughs,

approximately for "Karamatsu"……4.0～4.9 years,

and 〃 "Hinoki"…………5 or 6 〃

and 〃 "Sugi"…………… 〃 〃

2. Thus we may conclude as follows :

for A formation……about 3 years,

for B formation……about 3～7 yeras,

for C formation……about 8～10 years.

C. The graphs of the frequency curves of the size of individuals before the thinning is statistically heterogenous, but expressed as a mixed population composed of two or more groups which correspond to the individuals of two or more storeys in the stand canopy, and realized to approach them as a group of frequency curves of statistical normality.

## Part II. 1960

### Notes on the general view of the growth and yield of pure Japanese larch plantation from permanent sample plots where the writer operated his own thinning system.

1. General view on permanent sample plot when thinning experiment was operated.

Table 1 showing the general trend of the growth and yield of pure Japanese larch plantation obtained from the two permanent sample plots where one of them is situated about 800 meters above sea level at the foot of Mt. Asama, and the other situated about 200 meters higher above sea level on the similar slope and similar direction.

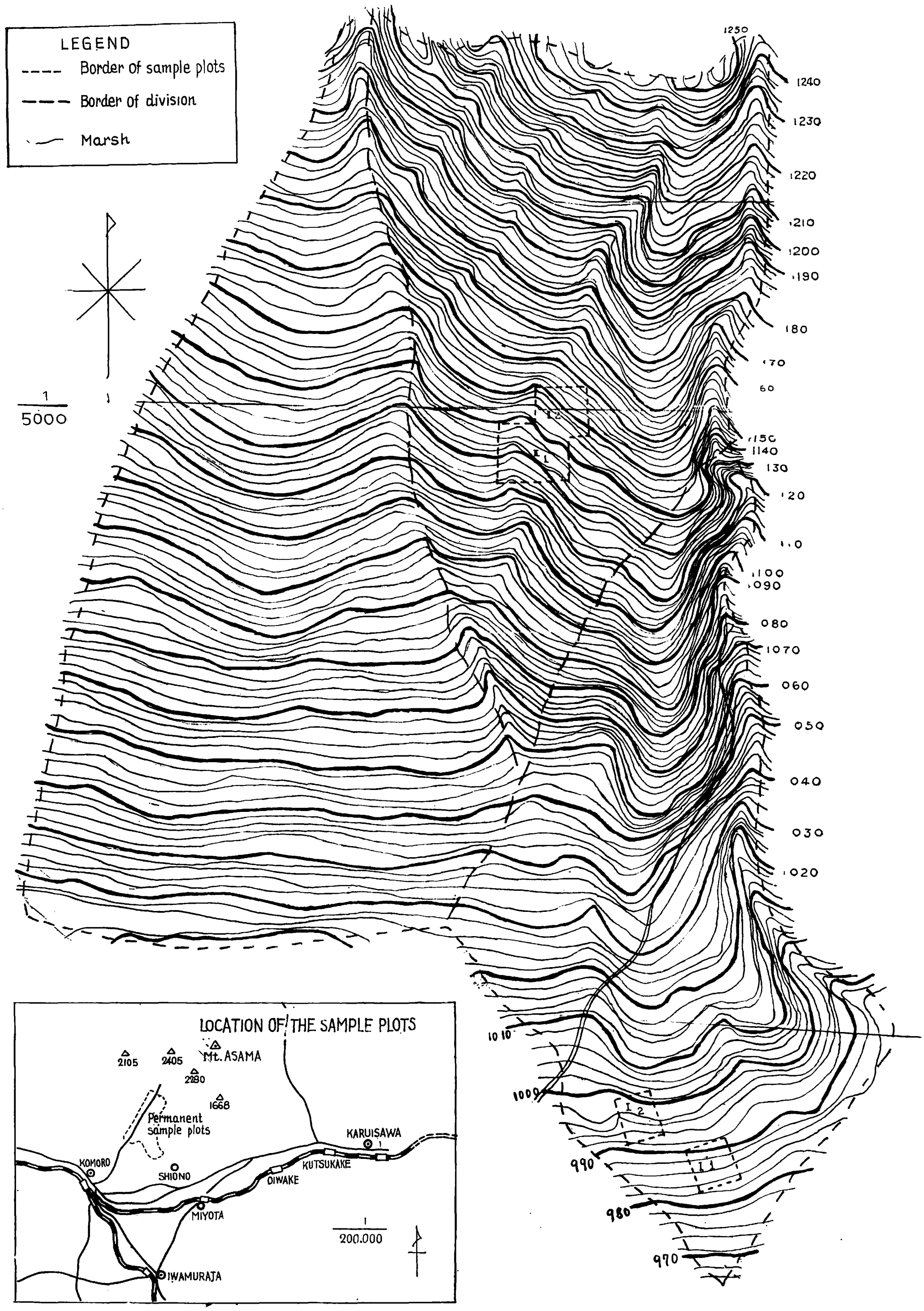
On the former, two subplots were laid out in 1903 when its stand age was 14 years old, in one of which the B thinning formation was conducted and in the other, the C thinning formation. On the latter, in 1904 when the stand age was 10 years old, the writer laid out two subplots and here operated only the B thinning formation in order to find out the long-term differentiality on the similar stand soil to the former,

Topographical features of the experimental plots.

The writer himself and those who visited the plots, especially in the 1st subplot of I plot, found big volcanic blocks, and at 2nd subplot something like expored head of the same rock

Table 1. Table of growth and yield of experimental plot. Japanese pure larch plantation

| Order of sample plot | | Operated thinning formation | Numerical order of thinning operated | Operated age | Years | Just before thinning operated per 0.1 *ha* | | | | | Thinned trees per 0.1 *ha* | | Residual trees per 0.1 *ha* | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Number of trees | Mean diameter | Mean height | Basal areas | Trunk volumes | Number of trees | Trunk volumes | Number of trees | Mean diameter | Mean height | Basal areas | Trunk volumes |
| | | | | | | | *cm* | *m* | $m^2$ | $m^3$ | | $m^3$ | | *cm* | *m* | $m^2$ | $m^3$ |
| I sample plot | 1st subplot | B formation | 1 | 1903.5 | 14 | 440 | 6.9 | 8.6 | 1.66 | 7.02 | 174 | 1.78 | 266 | 7.2 | 8.6 | 1.16 | 5.24 |
| | | | 2 | 1912.7 | 23 | 260 | 10.0 | 10.8 | 2.17 | 12.61 | 123 | 3.79 | 137 | 11.5 | 11.5 | 1.47 | 8.82 |
| | | | 3 | 1918.9 | 29 | 134 | 13.8 | 13.8 | 2.08 | 14.94 | 57 | 4.65 | 77 | 15.0 | 14.2 | 1.40 | 10.29 |
| | | | 4 | 1924.4 | 35 | 77 | 17.2 | 16.8 | 1.88 | 16.37 | 29 | 4.62 | 48 | 18.5 | 17.3 | 1.33 | 11.75 |
| | | | 5 | 1928.10 | 39 | 48 | 22.2 | 20.0 | 1.92 | 19.85 | 18 | 5.65 | 30 | 23.8 | 20.6 | 1.35 | 14.20 |
| | | | 6 | 1948 | 59 | 30 | 32.4 | 27.0 | 2.50 | 33.48 | 8 | 6.69 | 22 | 33.9 | 27.3 | 2.00 | 26.79 |
| | | | 7 | 1959.9 | 70 | 18 | 37.6 | 29.7 | 1.99 | 28.48 | | | | | | | |
| | 2nd subplot | C formation | 1 | 1903.5 | 14 | 433 | 7.2 | 8.6 | 1.83 | 8.54 | 250 | 3.84 | 183 | 8.1 | 9.1 | 0.97 | 4.70 |
| | | | 2 | 1912.7 | 23 | 179 | 12.3 | 12.1 | 2.25 | 14.15 | 80 | 4.15 | 99 | 14.0 | 12.6 | 1.56 | 10.00 |
| | | | 3 | 1920.10 | 31 | 95 | 18.1 | 17.6 | 2.49 | 22.70 | 53 | 10.28 | 42 | 19.8 | 18.5 | 1.32 | 12.42 |
| | | | 4 | 1930.7 | 41 | 41 | 26.5 | 22.6 | 2.32 | 26.47 | 16 | 9.03 | 25 | 27.5 | 22.9 | 1.51 | 17.44 |
| | | | 5 | 1952 | 63 | 25 | 36.5 | 28.1 | 2.62 | 35.49 | 7 | 8.52 | 18 | 37.5 | 28.0 | 2.01 | 26.97 |
| | | | 6 | 1959.9 | 70 | 18 | 39.4 | 30.0 | 2.16 | 31.79 | | | | | | | |
| II sample plot | 1st subplot early operated | B formation | 1 | 1904 | 12 | 500 | 5.4 | 6.9 | 1.13 | 4.71 | 211 | 1.37 | 289 | 6.0 | 7.1 | 0.84 | 3.34 |
| | | | 2 | 1912.7 | 20 | 283 | 10.7 | 11.7 | 2.70 | 16.42 | 111 | 3.90 | 172 | 12.0 | 12.1 | 2.02 | 12.52 |
| | | | 3 | 1918.9 | 26 | 156 | 13.8 | 14.0 | 2.44 | 17.59 | 72 | 5.66 | 84 | 15.4 | 14.6 | 1.61 | 11.93 |
| | | | 4 | 1924.4 | 32 | 84 | 17.9 | 16.7 | 2.16 | 18.41 | 32 | 5.75 | 52 | 18.8 | 16.8 | 1.47 | 12.66 |
| | | | 5 | 1928.10 | 36 | 52 | 22.3 | 19.4 | 2.07 | 20.51 | 19 | 6.37 | 33 | 23.3 | 19.5 | 1.43 | 14.14 |
| | | | 6 | 1948 | 56 | 33 | 31.5 | 24.9 | 2.61 | 31.95 | 7 | 5.18 | 26 | 32.3 | 24.8 | 2.20 | 26.77 |
| | | | 7 | 1959.9 | 67 | 26 | 35.5 | 27.3 | 2.11 | 35.24 | | | | | | | |
| | 2nd subplot lately operated | B formation | 1 | 1908 | 16 | 570 | 7.2 | 9.1 | 2.38 | 11.74 | 257 | 3.04 | 313 | 8.4 | 9.5 | 1.77 | 8.70 |
| | | | 2 | 1918.9 | 26 | 299 | 10.8 | 12.3 | 2.98 | 19.78 | 196 | 8.55 | 103 | 13.9 | 13.9 | 1.60 | 11.23 |
| | | | 3 | 1924.4 | 32 | 103 | 16.4 | 15.9 | 2.26 | 18.41 | 40 | 5.53 | 63 | 17.6 | 16.1 | 1.57 | 12.88 |
| | | | 4 | 1930.7 | 38 | 62 | 21.6 | 19.9 | 2.31 | 23.57 | 29 | 9.24 | 33 | 22.8 | 20.3 | 1.39 | 14.34 |
| | | | 5 | 1952 | 60 | 33 | 31.2 | 25.7 | 2.54 | 32.29 | 9 | 6.99 | 24 | 32.6 | 25.6 | 2.02 | 25.30 |
| | | | 6 | 1959.9 | 67 | 23 | 33.4 | 27.8 | 2.07 | 29.25 | | | | | | | |




Topographical map of the sample plots.

while investigating on the II plot. Such interesting topographic phenomenon was most surprising.

On this topographical phenomenon, the writer's junior Dr. S. YAMADA, now professor of Niigata University, when he was chief of Iwamurata District Forest office in 1940, demonstrated for the writer that the I plot situated on the plane was formed by the volcanic mud flow into the lower part, while the II plot was situated at the original higher part.

The above idea was proved in a topographical survey by students of the Forestry Department of Tokyo University in 1947 under the instruction of the chief of Iwamurata Office, Dr. S. YAMADA. The topographical survey map is as follows:

By the studies of Mr. T. KUROTORI, a specialist in the Soil Survey Division of the Government Forest Experiment Station, Meguro, the writer summarized the stand soil of permanent experiment sample plots for the thinning experiment as follows:

a) Generally, the stand soil corresponds to the Ando soil Brown-Ando soil Black in Mt. Asama volcanic ash soil and changes into the brown soil, so-called OHMASA's $B_D$ soil (moderate) and $B_F$ soil (Wetty) ; the stand soil of 1st subplot of II sample plot changes corresponding to the driest and 1st subplot of I sample plot to rather wetty, while 2nd subplot of II sample plot and 2nd subplot of I sample plot changes to the moderate.

b) As a special case it was found at the lower part of both subplots of I sample plot, when these are comparatively the small part of concaved planes, the soils are wetty. However, at 2nd subplot such a part extended, and is less concaved and less wetty than 1st subplot.

c) The thinning formation was operated, suited to the characteristics of the soil of every subplot, and the writer distinguished between the growth and yield curves of the stands with respect to the thinning-formation operated.

d) Thus far, by the characteristics of the above-described stand soils, the writer arrived at his findings for the pure Japanese larch plantation on volcanic ash soil, paying attention to the dryness and wetness especially in the case the small part of concaved plane ; for instance, for the dryness on 2nd subplot of II sample plot, and for the wetness on lower part of 1st subplot of I sample plot.

N. B. There occurred, however, three great misfortunes.

(1) World War II.

(2) The works of the normalising experiments and their demonstrations for the self-regenerating stands reserved in the mountain and hilly region during the previous era in the Daimiyô terrtiory under Tokugawa Shogunate Government.

(3) No. 7 Typhoon in 1959, as a result of which the greater part of the stemclass trees expected to be of elite class fell down like nine-pine or were otherwise blown down. Such being the case, the writer stopped the operation of thinning from 1930 to 1950.

2. Analytical studies of growth and yield curve from the table given in 1.

On the growth and yield of both coniferous and broad leaved pure plantations of our forests in this country, seniors have been endeavouring to construct reliable tables since 1890 either for local use or for giving a general standard.

Whatever they may be, there are some fundamental defects, in that they are not based on any experiments actually carried out in permanent sample plots and on any biostatistical data of unified thinning, even on the local bases.

Thus the writer has been intending even since 1903, to construct empirical tables from the permanent sample plots operated by the writer's systematic thinning, i. e. B thinning formation and C thinning formation.

He published from the Forest Experiment Station, Meguro, Tokyo in 1915, "Note on the Analytical Interpretation of Growth Curve of single tree and stands, and an Application for construction of Yield Table for "Sugi".

In the above pamphlet, the writer deduced by figures on common section paper the following empirical equations:

For the mean height and mean b. h. d. with basal areas, and stem volumes per unit area (0.1 *ha*)

$$\log_{10} Y = -\frac{\alpha}{t} + \beta t$$

where $\alpha$ and $\beta$ are denoted constants with regard to mean height and mean b. h. d. with basal areas and stem volumes, while the number of trees per 0.1 *ha* is as follows:

$$\log_{10} Y = \frac{\alpha'}{t} + \beta' t$$

Later the writer read "The Method of Empirical Equations" by Dr. S. DAVIS, 1943, McGraw-Hill Book Company, Inc., New York and London, and with the benefit of information derived there from deduced empirical equations as follows:

The writer constructed the growth and yield curves according to the empirical equations method of DAVIS, using the data given in the preceding table from about the 13-years-old to so far as about the 40-years-old in the sample plots that have continued existence for about 70 years, featured by several accidents as mentioned above in "N. B.".

General view of empirical equations.

| | Just before thinning operates | | Just after thinning has operated |
|---|---|---|---|
| B formation | $\log N = -\frac{a}{t} + b - ct$ | | $\log N = \frac{c - 10^{a-bt}}{t}$ |
| C formation | $\log N = \frac{a}{t} + b - ct$ | | |
| | $D = 10^{a+bt} - c$ | | $D = 10^{a+bt} - c$ |
| | $H = 10^{a+bt} - c$ | | $H = 10^{a+bt} - c$ |
| | $\log G = -\frac{a}{t} + b - ct$ | | $G = 10^{-\frac{a}{t}+d}$ |
| | $\log V = -\frac{a}{t} + b$ | B formation | $\log V = \frac{c - 10^{a-bt}}{t}$ |
| | | C formation | $\log V = \frac{10^{a+bt} - c}{t}$ |

where *a*, *b*, *c*, are denoted constants.

Logarithm to the base 10.

i. e. Just before thinning operates

Number of trees per 0.1 *ha*

B formation　$\log N = -12.8323/t + 4.4912 - 0.0640t$

C formation　$\log N = 3.8878/t + 2.7872 - 0.0306t$

Mean diameter *cm.*

B formation　$D = 10^{0.9100+0.0140t} - 6.2$

C formation　$D = 10^{1.3297+0.0085t} - 21.0$

Mean height $m$.

B formation $H=10^{1.2170+0.0077t}-13.0$

C formation $H=10^{1.3500+0.0069t}-19.8$

Basal areas per 0.1 $ha$ $m^2$.

B formation $\log G=-15.7118/t+1.6992-0.0265t$

C formation $\log G=-3.9368/t+0.5744-0.0022t$

Trunk volumes per 0.1 $ha$ $m^3$.

B formation $\log V=-9.5975/t+1.5710$

C formation $\log V=-12.3434/t+1.7350$

Just after thinning has operated

Number of trees per 0.1 $ha$.

B formation $\log N=\dfrac{61.8914-10^{1.9208-0.0355t}}{t}$

C formation $\log N=\dfrac{67.9872-10^{1.7851-0.0180t}}{t}$

Mean diameter $cm$.

B formation $D=10^{1.4252+0.0069t}-26.1$

C formation $D=10^{1.7826+0.0040t}-60.9$

Mean height $m$.

B formation $H=10^{0.8234+0.0139t}-2.0$

C formation $H=10^{1.6951+0.0039t}-47.6$

Basal areas per 0.1 $ha$ $m^2$.

B formation $G=10^{-0.4063/t+0.1719}$

C formation $G=10^{-1.4772/t+0.1949}$

Trunk volumes per 0.1 $ha$ $m^3$.

B formation $\log V=\dfrac{153.5943-10^{2.2203-0.0046t}}{t}$

C formation $\log V=\dfrac{10^{2.1718+0.0095t}-156.3753}{t}$

Total production $m^3$.

B formation $V=618.23-10^{2.7982-0.0009t}$

C formation $V=10^{1.8272+0.0061t}-74.0611$

3. Analytical studies of the spacing between the annual rings of the breast height section of trunks of the sample trees by the constructed autoregressive diagrams or correlograms computed from as many observations as possible with regard to the thinning formation and to the stand storeys of the stand canopy.

Though many methods were considered, the writer used the graphs known as correlograms, which may take one of three forms, and it may be proposed that they may oscillate, become damped as early as 20-years-old as the younger stage as can be seen by the following.

The writer used Prof. KENDALL's method on the time series in U. YULE and KENDALL's "An Introduction to the Theory of Statistics" (1953), in the paper of D. A. SHOLL (1954) on "Regularities in Growth Curves including Rhythms and Allometry in Dynamics of Growth Process" (pp. 224~241) edited by Edgar J. BOVELL, Princeton University Press, and G. TINTER's "Econometrics" (1952), stochastic difference equations (pp. 255~272).

Applying these literatures to our study, the writer prepared the records of several variables since the thinning was first operated on the changes of stemclass with regard to their positions under the stand canopy. And then measured the width of mean annual rings of sectional plate at b. h. d. of the sample tree, then computed the correlograms and the mean distance of peaks and lastly drew the graphs.

Studies of the growth of each single tree with respect to its b. h. d, and total height of sample tree in every sample plot with the different stories about the different thinning formation.

A. On the residual and measurable sample trees in the 1st subplot of I sample plot operated by the B formations blown down by typhoon in 1959.

a) The individuals stand upper storey showing vitality of growth.

| Numerical order of stem | | Order of remeasurement at thinning operated | | | | | | | Mean distance of peaks |
|---|---|---|---|---|---|---|---|---|---|
| | | 1st | 2nd | 3rd | 4th | 5th | 6th | 7th | |
| XIV 18 | stem class | 1 | 1 | 1 | 1 | 1 | $A_1$ | B | |
| | B. H. D. *cm* | 8.7 | 13.8 | 17.4 | 20.7 | 25.2 | 32.7 | 35.5 | |
| | Height *m* | 8.7 | 11.8 | 14.9 | 18.4 | 22.2 | 27.1 | 28.5 | 4.1 |
| XVI 12 | stem class | 1 | 1 | 1 | 1 | 1 | $A_1$ | A | |
| | B. H. D. *cm* | 8.1 | 12.6 | 15.9 | 19.5 | 23.7 | 33.9 | 36.2 | |
| | Height *m* | 9.3 | 12.4 | 15.5 | 17.8 | 22.4 | 26.2 | 30.6 | 4.3 |
| XIX 8 | stem class | 1 | 1 | 1 | 1 | 1 | $A_1$ | A | |
| | B. H. D. *cm* | 8.4 | 13.2 | 16.5 | 21.0 | 25.2 | 37.2 | 41.2 | |
| | Height *m* | 8.6 | 11.8 | 14.5 | 18.6 | 20.2 | 27.1 | 30.0 | 4.6 |
| XXI 2 | stem class | 1 | 1 | 1 | 1 | 1 | A | A | |
| | B. H. D. *cm* | 11.1 | 17.7 | 21.9 | 24.9 | 31.8 | 44.4 | 47.8 | |
| | Height *m* | 10.2 | 14.2 | 16.6 | 19.3 | 23.7 | 30.4 | 33.1 | 4.5 |
| XXI 18 | stem class | 1 | 1 | 1 | 1 | 1 | $A_1$ | $A_1$ | |
| | B. H. D. *cm* | 10.2 | 15.0 | 18.6 | 21.3 | 25.2 | 31.2 | 35.6 | |
| | Height *m* | 10.2 | 12.7 | 14.5 | 17.8 | 20.9 | 26.2 | 27.0 | 4.3 |
| XXIV 24 | stem class | 1 | 1 | 1 | 1 | 1 | $A_1$ | $A_1$ | |
| | B. H. D. *cm* | 9.3 | 14.1 | 17.1 | 20.4 | 24.3 | 33.0 | 37.1 | |
| | Height *m* | 9.1 | 13.8 | 15.6 | 19.1 | 21.8 | 27.1 | 28.8 | 4.4 |
| XXXI 8 | stem class | 1 | 1 | 1 | 1 | 1 | A | A | |
| | B. H. D. *cm* | 9.6 | 15.0 | 19.5 | 24.0 | 28.8 | 39.9 | 42.8 | |
| | Height *m* | 10.4 | 14.7 | 16.6 | 19.6 | 22.2 | 28.6 | 30.2 | 4.3 |
| XXXVII 1 | stem class | 1 | 1 | 1 | 1 | 1 | A | A | |
| | B. H. D. *cm* | 12.3 | 15.6 | 17.1 | 23.7 | 27.9 | 36.0 | 40.8 | |
| | Height *m* | 10.4 | 13.8 | 15.8 | 19.3 | 23.1 | 28.6 | 30.9 | 4.8 |
| XXXVIII 3 | stem class | 1 | 1 | 1 | 1 | 1 | $A_1$ | A | |
| | B. H. D. *cm* | 7.8 | 15.3 | 18.6 | 22.2 | 27.9 | 37.8 | 42.3 | |
| | Height *m* | 9.0 | 12.7 | 15.6 | 18.7 | 21.6 | 28.2 | 30.9 | 4.4 |
| XXXXV 6 | stem class | 1 | 1 | 1 | 1 | 1 | $A_1$ | B | |
| | B. H. D. *cm* | 10.8 | 14.7 | 18.0 | 21.0 | 24.9 | 34.2 | 38.6 | |
| | Height *m* | 10.0 | 13.6 | 16.0 | 19.1 | 23.1 | 27.8 | 29.5 | 4.0 |
| XXXXVII 7 | stem class | 1 | 1 | 1 | 1 | 1 | $A_1$ | B | |
| | B. H. D. *cm* | 8.7 | 13.5 | 18.3 | 21.3 | 26.1 | 34.8 | 39.5 | |
| | Height *m* | 9.5 | 13.1 | 15.6 | 19.3 | 23.7 | 29.1 | 31.4 | 4.6 |

b) The individuals stand under storey showing the dynamic tendency of the gorwth.

| Numerical order of stem | | Order of remeasurement at thinning operated | | | | | | | Mean distance of peaks |
|---|---|---|---|---|---|---|---|---|---|
| | | 1st | 2nd | 3rd | 4th | 5th | 6th | 7th | |
| I 19 | stem class | 1 | 1 | 1 | 3 | 3 | B | B | |
| | B. H. D. *cm* | 9.6 | 14.1 | 16.5 | 19.5 | 23.1 | 31.5 | 35.9 | |
| | Height *m* | 8.7 | 11.6 | 14.7 | 18.2 | 19.3 | 25.5 | 27.7 | 4.8 |
| Ⅳ 11 | stem class | 1 | 1 | 1 | 3 | 1 | $A_1$ | A | |
| | B. H. D. *cm* | 9.9 | 14.7 | 18.0 | 21.9 | 25.8 | 34.8 | 38.3 | |
| | Height *m* | 10.2 | 12.6 | 14.9 | 18.7 | 21.5 | 28.4 | 32.2 | 4.0 |
| Ⅶ 16 | stem class | 2C | 2C | 3 | 3 | 3 | B | B | |
| | B. H. D. *cm* | 6.6 | 10.5 | 13.5 | 15.6 | 20.1 | 30.0 | 34.9 | |
| | Height *m* | 8.4 | 10.9 | 13.3 | 16.9 | 19.1 | 25.1 | 27.5 | 4.6 |
| Ⅻ 11 | stem class | 1 | 1 | 3 | 3 | 3 | $A_1$ | $A_1$ | |
| | B. H. D. *cm* | 7.8 | 12.3 | 16.5 | 19.8 | 24.3 | 35.1 | 38.4 | |
| | Height *m* | 8.6 | 11.5 | 14.5 | 17.8 | 20.0 | 26.6 | 30.4 | 4.6 |
| XVII 17 | stem class | 1 | 1 | 3 | 3 | 3 | $A_1$ | $A_1$ | |
| | B. H. D. *cm* | 7.8 | 11.1 | 13.5 | 15.9 | 18.9 | 25.8 | 29.7 | |
| | Height *m* | 8.2 | 10.6 | 12.8 | 14.6 | 18.6 | 24.6 | 27.5 | 4.2 |
| XXVI 13 | stem class | 1 | 1 | 1 | 3 | 3 | B | A | |
| | B. H. D. *cm* | 5.4 | 13.5 | 16.8 | 19.5 | 24.0 | 33.9 | 38.4 | |
| | Height *m* | 6.0 | 12.6 | 15.1 | 17.8 | 20.7 | 27.8 | 30.4 | 4.0 |
| XXⅧ 10 | stem class | 1 | 1 | 3 | 3 | 3 | B | B | |
| | B. H. D. *cm* | 11.4 | 15.3 | 18.3 | 20.4 | 23.7 | 33.6 | 37.1 | |
| | Height *m* | 10.2 | 13.3 | 15.6 | 18.7 | 21.1 | 27.8 | 29.7 | 4.7 |
| XXⅨ 12 | stem class | 1 | 1 | 1 | 3 | 3 | $A_1$ | $A_1$ | |
| | B. H. D. *cm* | 8.7 | 13.2 | 16.5 | 18.0 | 21.9 | 29.1 | 32.6 | |
| | Height *m* | 9.3 | 12.4 | 15.3 | 17.3 | 18.7 | 25.3 | 27.5 | 4.8 |
| XXXXⅢ 18 | stem class | 1 | 1 | 1 | 3 | 1 | $A_1$ | $A_1$ | |
| | B. H. D. *cm* | 9.0 | 14.1 | 17.1 | 19.8 | 24.9 | 34.8 | 38.2 | |
| | Height *m* | 9.6 | 12.7 | 15.6 | 16.9 | 21.3 | 26.9 | 28.9 | 4.8 |
| XXXXⅣ 22 | stem class | 1 | 1 | 1 | 3 | 3 | $A_1$ | $A_1$ | |
| | B. H. D. *cm* | 8.4 | 12.6 | 15.9 | 18.9 | 23.7 | 33.0 | 36.9 | |
| | Height *m* | 9.3 | 12.7 | 15.6 | 17.8 | 20.9 | 27.3 | 29.1 | 4.6 |

Order of remeasurement at thinning operated, i. e. 1st 1903, 2nd 1912, 3rd 1918, 4th 1924, 5th 1928, 6th 1948, 7th 1959.

B. On the removed trees of 2nd subplot of I sample plot operated by C formations in the year 1952 (before typhoon).

a) The individuals stand upper storey showing the vitality of growth.

| Numerical order of stem | | Order of remeasurement at the thinning operated | | | | | Mean distance of peaks |
|---|---|---|---|---|---|---|---|
| | | 1st 1903 | 2nd 1912 | 3rd 1920 | 4th 1930 | 5th 1952 | |
| VIII 5 | stem class | 1 | 1 | 1 | $A_1$ | $A_1$ | |
| | B. H. D. *cm* | 8.4 | 13.8 | 19.2 | 26.5 | 34.5 | |
| | Height *m* | 9.9 | 13.3 | 20.0 | 23.7 | 30.0 | 4.2 |
| IX 20 | stem class | 1 | 1 | 1 | $A_1$ | $A_1$ | |
| | B. H. D. *cm* | 9.6 | 15.3 | 20.4 | 26.4 | 35.1 | |
| | Height *m* | 9.1 | 12.6 | 18.2 | 22.4 | 28.9 | 4.0 |
| XII 15 | stem class | 1 | 1 | 1 | $A_1$ | $A_1$ | |
| | B. H. D. *cm* | 8.4 | 13.8 | 17.7 | 25.5 | 34.2 | |
| | Height *m* | 8.9 | 14.0 | 19.1 | 22.4 | 28.8 | 4.4 |
| XXXI 20 | stem class | 1 | 1 | 1 | $A_1$ | A | |
| | B. H. D. *cm* | 10.2 | 17.4 | 23.7 | 31.5 | 42.4 | |
| | Height *m* | 9.0 | 13.6 | 20.0 | 23.5 | 30.4 | 4.5 |
| XXXII 4 | stem class | 1 | 1 | 1 | $A_1$ | A | |
| | B. H. D. *cm* | 9.3 | 16.2 | 21.3 | 28.1 | 37.2 | |
| | Height *m* | 10.2 | 13.4 | 20.0 | 22.2 | 28.6 | 4.4 |

b) The individuals stand under storey showing dynamic tendency of growth.

| Numerical order of stem | | Order of remeasurement at thinning operated | | | | | Mean distance of peaks |
|---|---|---|---|---|---|---|---|
| | | 1st 1903 | 2nd 1912 | 3rd 1920 | 4th 1930 | 5th 1952 | |
| X 4 | stem class | 1 | 1 | 1 | $A_1$ | $A_1$ | |
| | B. H. D. *cm* | 6.9 | 16.2 | 21.3 | 25.8 | 32.7 | |
| | Height *m* | 9.7 | 12.8 | 18.2 | 21.8 | 26.6 | 4.4 |
| XI 14 | stem class | 1 | 1 | 1 | $A_1$ | $A_1$ | |
| | B. H. D. *cm* | 9.3 | 15.9 | 20.3 | 26.4 | 35.1 | |
| | Height *m* | 10.2 | 12.6 | 17.3 | 22.6 | 28.9 | 4.3 |
| XII 8 | stem class | 1 | 1 | 1 | B | B | |
| | B. H. D. *cm* | 8.1 | 13.5 | 18.0 | 24.5 | 31.8 | |
| | Height *m* | 9.2 | 13.3 | 17.3 | 22.6 | 28.2 | 4.3 |
| XX 3 | stem class | 1 | 3 | 3 | $A_1$ | $A_1$ | |
| | B. H. D. *cm* | 9.7 | 15.0 | 19.2 | 24.9 | 33.9 | |
| | Height *m* | 9.3 | 12.8 | 18.2 | 22.4 | 27.8 | 4.1 |
| XXII 23 | stem class | 1 | 3 | 3 | $A_1$ | $A_1$ | |
| | B. H. D. *cm* | 12.2 | 17.0 | 20.0 | 24.2 | 29.4 | |
| | Height *m* | 9.0 | 12.2 | 16.4 | 20.0 | 25.3 | 4.2 |
| XXV 2 | stem class | 1 | 1 | 3 | $A_1$ | $A_1$ | |
| | B. H. D. *cm* | 8.4 | 15.3 | 20.0 | 26.7 | 35.6 | |
| | Height *m* | 8.8 | 14.0 | 18.2 | 22.4 | 26.4 | 4.4 |
| XXXIII 8 | stem class | 1 | 3 | 3 | $A_1$ | $A_1$ | |
| | B. H. D. *cm* | 8.1 | 12.9 | 17.1 | 21.9 | 28.5 | |
| | Height *m* | 9.3 | 12.0 | 18.2 | 21.3 | 27.5 | 4.4 |

C. On the residual sample trees in the 2nd subplot operated by the C formation blown down by typhoon in 1959.

The individuals stand upper storey showing the vitality of growth.

| Numerical order of stem | | Order of remeasurement at thinning operated | | | | | | Mean distance of peaks |
|---|---|---|---|---|---|---|---|---|
| | | 1st 1903 | 2nd 1912 | 3rd 1920 | 4th 1930 | 5th 1952 | 6th 1959 | |
| II 2 | stem class | 1 | 1 | 1 | A | A | $A_1$ | |
| | B. H. D. *cm* | 9.3 | 16.8 | 22.2 | 29.4 | 38.7 | 41.3 | |
| | Height *m* | 9.8 | 13.0 | 19.9 | 24.4 | 28.4 | 30.0 | 4.9 |
| VII 12 | stem class | 1 | 1 | 1 | A | A | A | |
| | B. H. D. *cm* | 10.6 | 16.8 | 22.8 | 31.8 | 41.7 | 42.7 | |
| | Height *m* | 10.1 | 14.5 | 19.1 | 25.8 | 29.1 | 31.8 | 4.0 |
| VII 21 | stem class | 1 | 1 | 1 | $A_1$ | $A_1$ | $A_1$ | |
| | B. H. D. *cm* | 9.6 | 14.7 | 19.2 | 26.4 | 38.1 | 41.3 | |
| | Height *m* | 9.8 | 13.1 | 18.1 | 22.1 | 27.8 | 30.5 | 4.0 |
| XIV 8 | stem class | 1 | 1 | 1 | A | A | A | |
| | B. H. D. *cm* | 10.4 | 16.1 | 22.2 | 29.0 | 39.0 | 43.9 | |
| | Height *m* | 9.6 | 12.6 | 19.1 | 24.8 | 29.1 | 31.0 | 4.2 |
| XV 4 | stem class | 1 | 1 | 1 | A | A | A | |
| | B. H. D. *cm* | 6.9 | 14.1 | 22.2 | 30.9 | 40.2 | 42.6 | |
| | Height *m* | 8.7 | 12.5 | 20.0 | 24.8 | 28.0 | 30.0 | 4.3 |
| XXIII 14 | stem class | 1 | 1 | 3 | $A_1$ | $A_1$ | B | |
| | B. H. D. *cm* | 8.2 | 15.0 | 21.6 | 31.2 | 40.8 | 43.8 | |
| | Height *m* | 8.8 | 12.4 | 19.9 | 22.6 | 28.8 | 31.0 | 4.3 |
| XXVI 13 | stem class | 1 | 1 | 1 | $A_1$ | $A_1$ | $A_1$ | |
| | B. H. D. *cm* | 10.3 | 17.4 | 22.1 | 29.1 | 34.8 | 36.2 | |
| | Height *m* | 9.7 | 13.4 | 18.2 | 21.3 | 26.6 | 27.5 | 4.9 |
| XXVI 18 | stem class | 1 | 1 | 1 | A | A | A | |
| | B. H. D. *cm* | 11.8 | 20.4 | 27.0 | 35.7 | 47.7 | 50.4 | |
| | Height *m* | 10.1 | 13.9 | 19.9 | 24.8 | 30.2 | 32.5 | 4.7 |
| XXVIII 11 | stem class | 1 | 1 | 3 | $A_1$ | $A_1$ | B | |
| | B. H. D. *cm* | 9.6 | 15.2 | 20.7 | 29.7 | 43.2 | 45.4 | |
| | Height *m* | 9.4 | 13.0 | 18.2 | 22.0 | 28.4 | 29.5 | 4.9 |
| XXIX 16 | stem class | 1 | 1 | 1 | $A_1$ | A | A | |
| | B. H. D. *cm* | 9.6 | 17.4 | 23.1 | 32.4 | 44.4 | 46.3 | |
| | Height *m* | 10.0 | 13.2 | 18.1 | 22 2 | 27.3 | 30.5 | 4.2 |
| XXX 3 | stem class | 1 | 1 | 3 | A | A | A | |
| | B. H. D. *cm* | 9.6 | 15.9 | 21.3 | 30.0 | 44.7 | 47.3 | |
| | Height *m* | 9.4 | 13.5 | 20.9 | 24.6 | 30.2 | 31.5 | 4.2 |
| XXXIV 22 | stem class | 1 | 1 | 1 | A | A | A | |
| | B. H. D. *cm* | 12.2 | 17.0 | 21.5 | 28.5 | 39.3 | 41.9 | |
| | Height *m* | 10.2 | 14.0 | 19.2 | 24.8 | 26.9 | 31.0 | 4.4 |
| XXXVI 4 | stem class | 1 | 1 | 3 | $A_1$ | $A_1$ | A | |
| | B. H. D. *cm* | 10.2 | 16.2 | 20.4 | 26.4 | 34.8 | 37.0 | |
| | Height *m* | 10.2 | 12.2 | 19.1 | 23.0 | 29.1 | 31.0 | 4.9 |

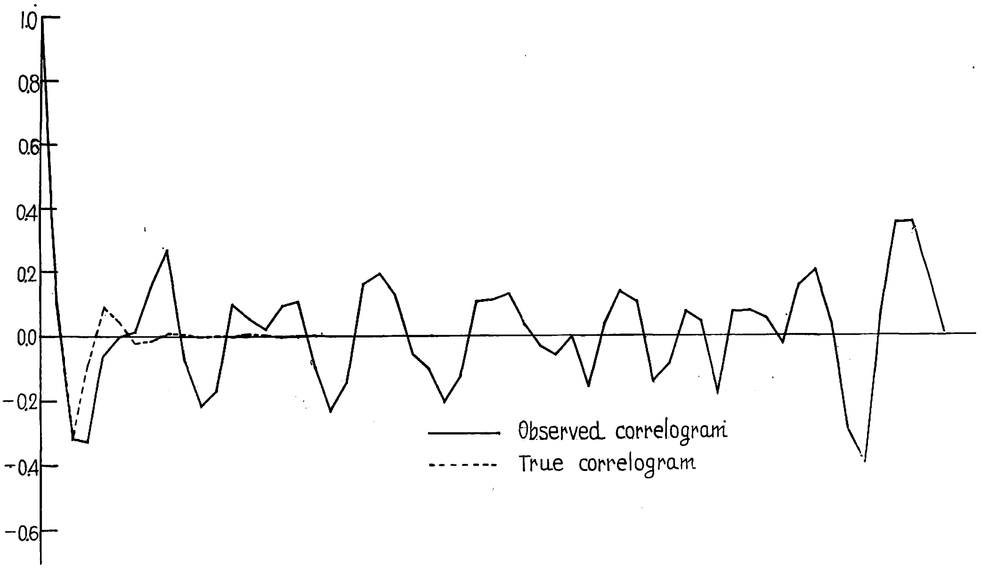



Fig. 1 Correlogram of constructed autoregressive series of examples in upper storey from B formation thinning 11 observations (fallen down by typhoon 1959), compared with true correlogram.

Group of vitality of tree growth

Mean distance of peaks 4.4

$$r_k=\frac{0.5773^k \sin(k82°27'+85°94')}{0.9978}$$

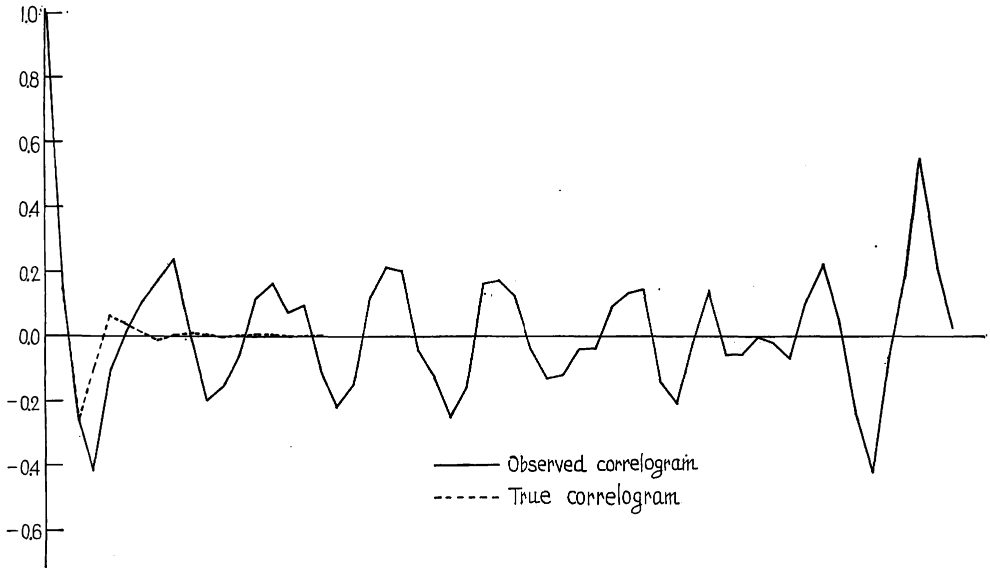



Fig. 2 Correlogram of constructed autoregressive series of examples in under storey from B formation thinning 10 observations (fallen down by typhoon 1959), compared with true correlogram.

Group of dynamic tendency of tree growth.

Mean distance of peaks 4.5

$$r_k=\frac{0.5367^k \sin(k79°39'+84°14')}{0.9950}$$

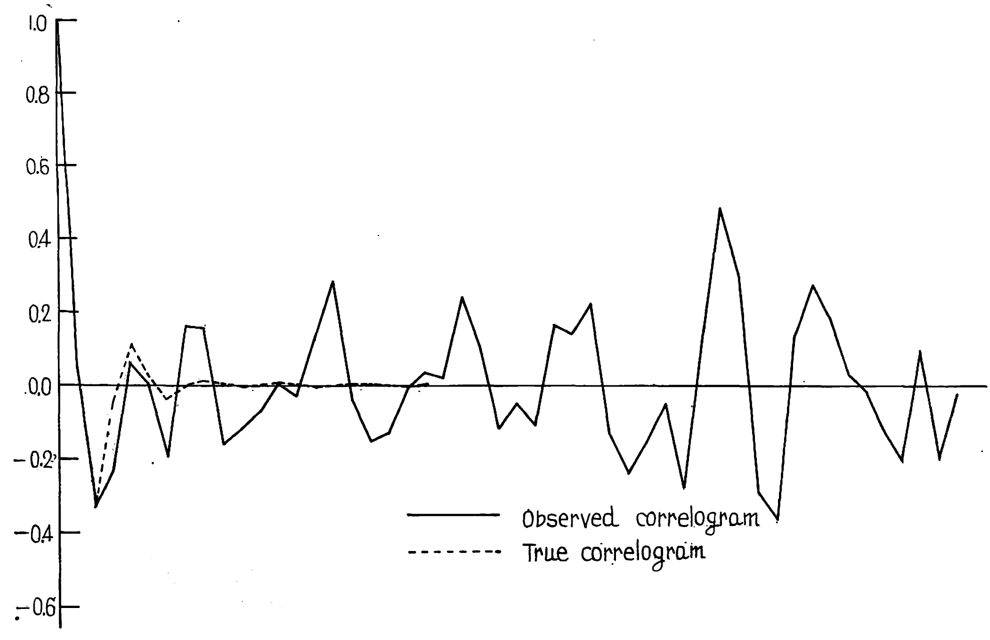



Fig. 3 Correlogram of constructed autoregressive series of examples in upper storey from C formation thinning 5 observations (removed trees at the year 1952), compared with true correlogram.
Group of vitality of tree growth.
Mean distance of peaks 4.2

$$r_k=\frac{0.5805^k \sin(k86°45'+88°23')}{0.9996}$$

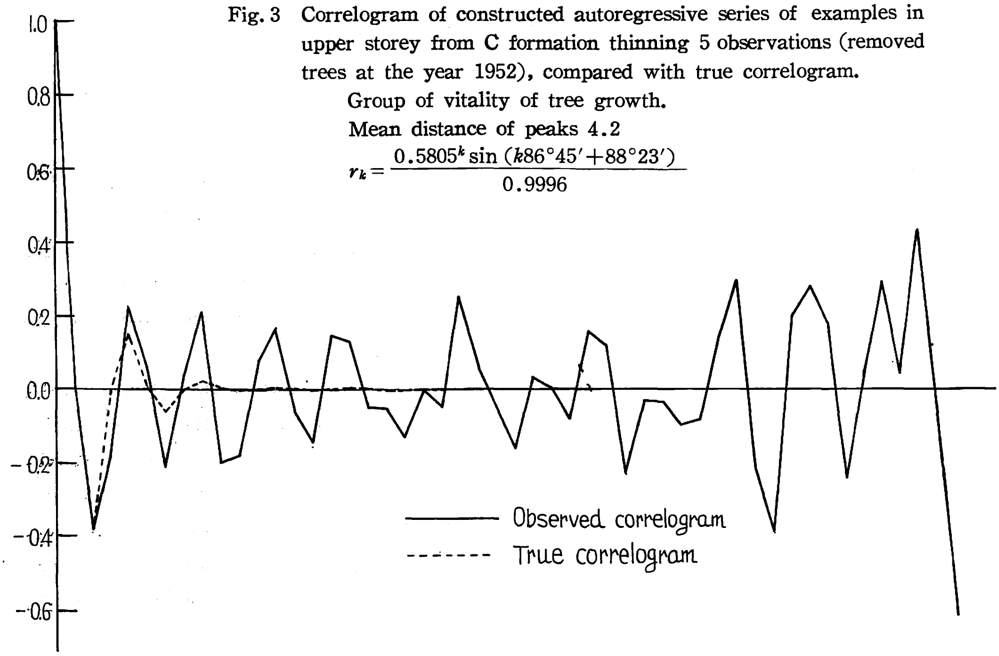



Fig. 4 Correlogram of constructed autoregressive series of examples in under storey from C formation thinning 7 observations (removed trees at the year 1952), compared with true correlogram.
Group of dynamic tendency of tree growth.
Mean distance of peaks 4.0

$$r_k=\frac{0.6255^k \sin(k89°40'+89°51')}{0.9999}$$

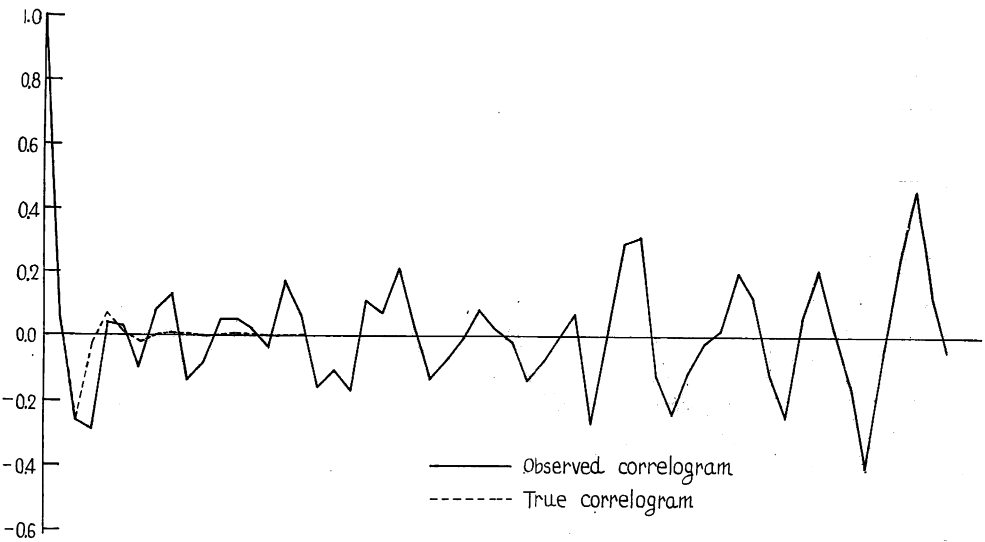



Fig. 5 Correlogram of constructed autoregressive series of examples in upper storey from C formation thinning 13 observations (fallen down by typhoon 1959), compared with true correlogram.
Group of vitality of tree growth.
Mean distance of peaks 4.2

$$r_k = \frac{0.5183^k \sin(k86°4' + 87°40')}{0.9992}$$

## Summary

In the year 1903, the writer at first observed the stand types of the pure larch plantation at the southern foot of Mt. Asama in order to determine the type of thinning-formation to be operated; that is, whether to apply the well-known German and Austrian ideas or the Japanese, especially Yoshino, "the Sugi" plantation customarily practised in theory by literature only.

At any rate, the writer saw the need to adjust the struggle for existence and evolution between cover of the aerial parts of individuals of stand canopy.

Thus far, the writer differentiated the stem classification by crown type. Even so, these remained the difficult question as to the time period; that is, when to repeat the thinning operation, having in mind the unknown growth of individual crowns of stand canopy. Consequently, the writer first, tried to find out empirically for both sample sub-plot of I sample plot during 10 years, the next repeating period by the changing of crown covering.

Analysing the growth of annual rings in the section of breast height of trunk of individual pure larch plantation which is operated by the given thinning formation, the writer applied the method of KENDALL's time series, the serial correlation and autoregression.

By these methods, the writer computed the arithmetical. mean of every autoregressive series from the observations with respect to the situation of stand storeys of crown canopy.

(a) Mean distance of peaks, as in preceding tables shows the constant 4.0～4.9 years.

(b) Influence of thinning-formation on the peaks, as in diagrams is clearly found in peaks regardless of upper storey and under storey of C formation with following year of thinning, while second and third year are very few.

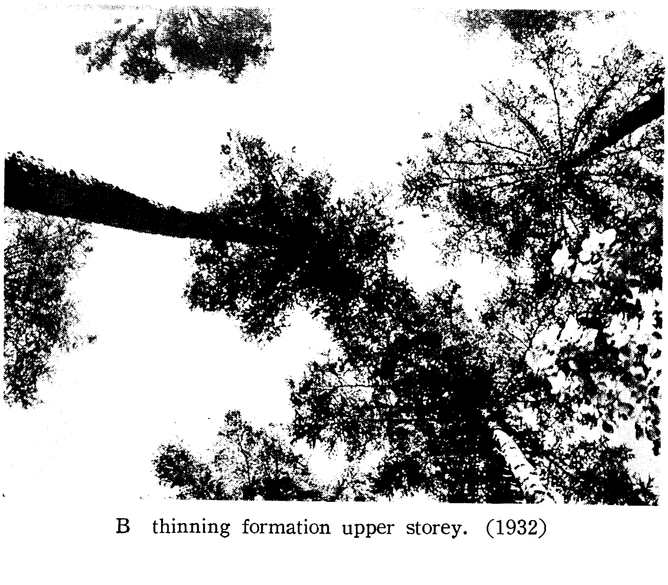
Nevertheless very few on B formation of upper storey with following year of thinning but principally second and third year. By these experiments, the writer deduced the repeating period to be commonly as follows :

for A formation……about 3 years,

for B formation……about 5 years,

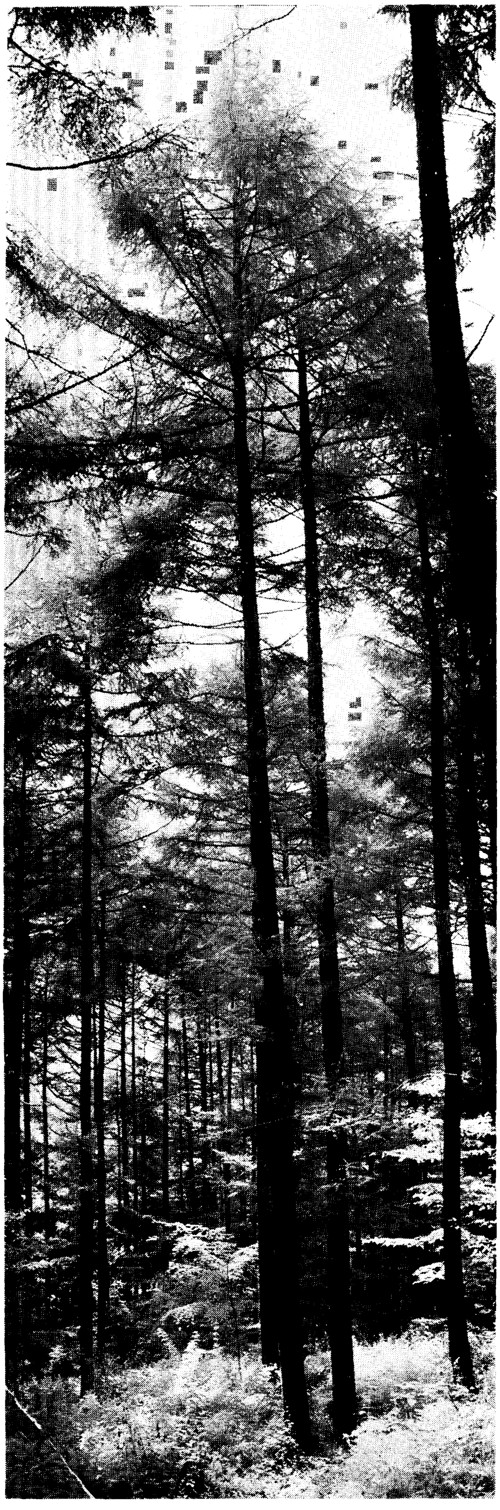
for C formation……about 8 years.

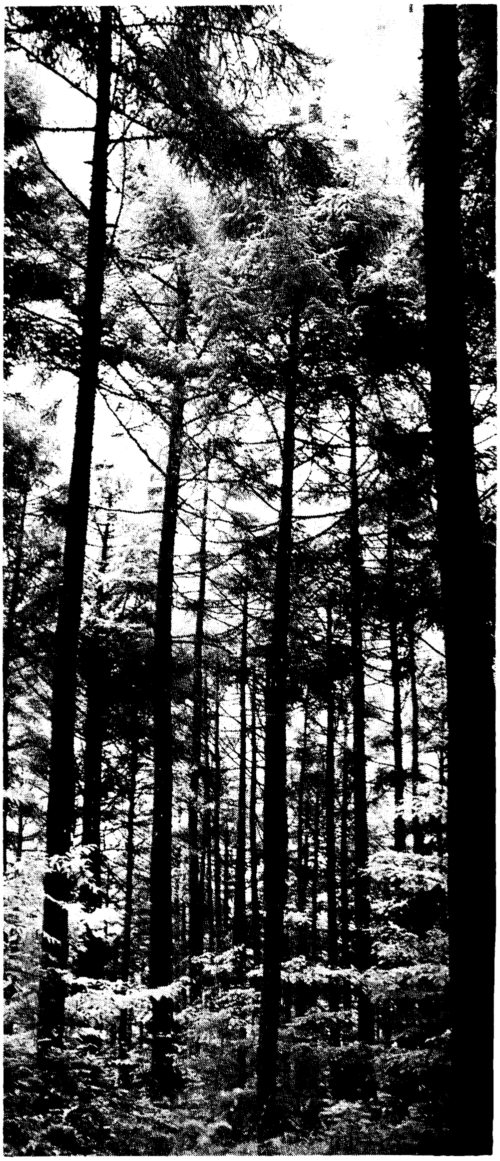
However the analysis of correlograms of C thinning formation clearly indicates for the writer the peak with following year of thinning operated, while second and third year show very few of peak. These might be dismissed as improbable and perhaps impossible phenomena, but please refer to the writer's photographs of 1932 which verify these facts clearly.



B thinning formation upper storey. (1932)

—Plate 2—





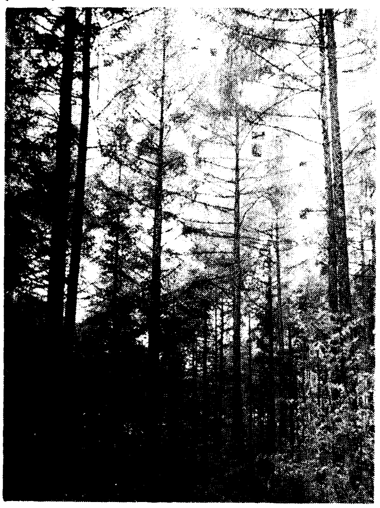
⇧

Under storey.

⇦ Upper storey.

C thinning formation. (1932)

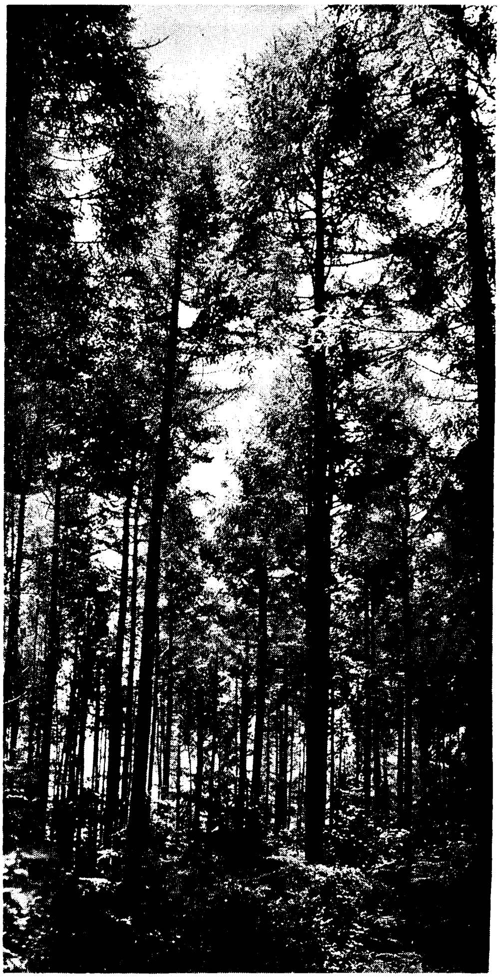

B thinning formation. (1933)

B thinning formation. (1933)


Protection zone. (1933)

—**Plate 4**—



(1934)

2nd subplot of I sample plot
C thinning formation.

2nd subplot of II sample plot
B thinning formation.

According to Mr. KUROTORI's soil survey, the soil characteristic are almost the same.