A New Method for Thinning Forest by Reserved Tree Marking System

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Summary

Overcrowded forests are frequently seen in various regions of Nagano Prefecture due to the decreased of forest workers. Accordingly, to prevail reasonable forest management such as reduction of labors became an important problem which calls for an urgent answer fitting present social situation on the forestry in Japan.

In the present study, the author proposed a new method for thinning by the reserved tree marking system in order to obtain thicker and more excellent trees within the relatively short period. In the initial step, superiority or inferiority in tree growth was estimated in a given forest using the site index curve, in addition reasonable tree density taking into consideration of height of the upper trees in 60-year stand age was estimated, and thereafter suitable trees selected as final cutting trees were marked. The distribution of the reserved trees should be considered when the trees are selected.

At the first time of thinning, the trees which are expected to prevent the growth of the reserved trees should be removed regardless of their growth or quality conditions. In addition, short diameter trees which ara not expected to yield in the future should be removed. Other trees remin up to next thinning time. The new method provided conspicuous effectiveness for thinning.

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Introduction

In Japan, methods and techniques for thinning forest have been highly-developed[5]. However such methods have not been used effectively due to the following reasons; (a) forest workers decreased remarkably with increase of population outflow to urban areas, (b) demand for slender timbers decreased extremely due to the change in wood utilization system, (c) large amount of timbers became to be imported frequently from various foreign countries to

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Japan at low cost, so that the timber produced in Japan became lower in market price, in addition severe fluctuation of the U. S. dollar rate accelerated such low price. Recently, overcrowded forests are freqently observed in various mountainous areas in Japan. Respecting such recent status of the forests, the author has been investigating to find out more effective methods for thinning since 1971[6].

In the present paper, the author proposed a new method for thinning forest by reserved tree marking system and discussed its properties for application to various types of forests.

Ⅰ. Conception of the method for thinning by the reserved tree marking system

Up to the present, in Japan, the TERAZAKI's method for thinning which was proposed in 1928[8] has been applied mainly to artificial forests. Forest management by this method is summarized as follows. Forest owner or forest worker, first of all, is needed to decide a schedule extending over his generation for management in a given forest. The thinning is carried out 3-5 times at a certain interval for the period of cultivation. Tree density becomes lower and lower with repeating of thinning. In a forest carried out thinning, therfore, only well-grown and higher quality trees are remained. Much attention should be paid for application of this method how wide extent may be able to cover and how many times should be repeated for thinning.

As mentioned in the section of introduction, overcrowded forests are frequently seen in today's Japan, because it became difficult to cope with recent social situation of forestry by using the traditional method for thinning. Therefore, it became urgent to find out a new method. Furthermore, it is needed for forest management in the future to obtain more advance-aged and thicker trees with change in wood utilization system.

In this regard, new method characterized by reduction of labor and efficiency of forest management to fit for various purposes should be devised. A new method presented here seems to be impotant to improve present status faced as mentioned above.

Ⅱ. Requisites prior to applying the new method and the application procedures

1. Requisites prior to applying the new method

It is important to learn at least following three articles prior to applying the new method for carrying out more effective thinning.

i) Evaluation of tree height in a given forest

There are various elements involving tree growth in a given forest, such

as tree height and tree volume. Among them, tree height and diameter of breast height are easy to be measured. Total basal area and stand volume par unit space can also be calculated from the data which are measured in the forest. In addition, we may evaluate either superiority or inferiority of the site class of the forest and the condition of growth of the forest up to the present, furthermore, to evaluate growth of the forest in the future by combinning the calculated values with the stand age. Evaluation of growth of the forest is one of the most impotant factors for forest management. The value of tree height does not vary with tree density or method for forest management[1] comparing with that of diameter of breast height, total basal area and stand volume. In addition, tree height is little affected by density competition among trees. It is conceivable, therefore, that height of upper trees can be a possible index to know superiority or inferiority in the site class of a given forest. In this regard, the tree height growth curve at each tree species in various types of the forests has been presented. Mean height of upper trees in the forest with 40-year stand age is generally called the site index. The tree height growth curve is called the site index curve as the figures of tree height (ordinate scale) shown on the "tree height growth curve" were corrected to integrate figure at an interval of 1-2m. For an instance, the tree height growth curves and the site index curves ovtained in the 3 forests of the Japanese larch (*Larix leptolepis*) in eastern part of Nagano Prefecture by the Nagano Regional Forest Office, Forest Division of Nagano Prefecture and Shinshu University (Faculty of Agriculture) were shown in Fig. 1.[3)4)7)]

The 3 curves showed similar tendency irrespective of locations in eastern Nagano. The average curve was obtained from the 3 curves and modified by

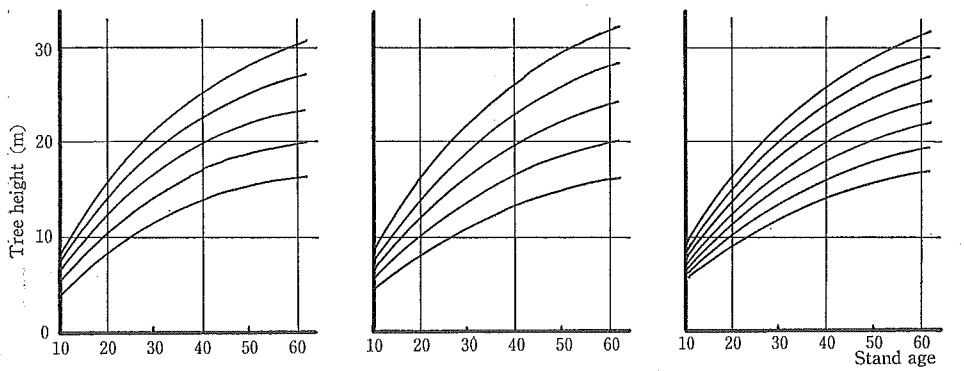

Fig. 1 The 3 "tree height growth curves" in the Japanese larch forests of eastern part of Nagano prefecture.

the following exponential equation;

$$h = e^{\frac{T}{a+bT}}$$

where, the symbol h indicates mean height of upper trees, T stand age, a and b coefficients and e base of logarithmic series.

Such curve could apply to the Japanese larch forests located on various regions in Nagano Prefecture. Therefore, it can be used as a common index

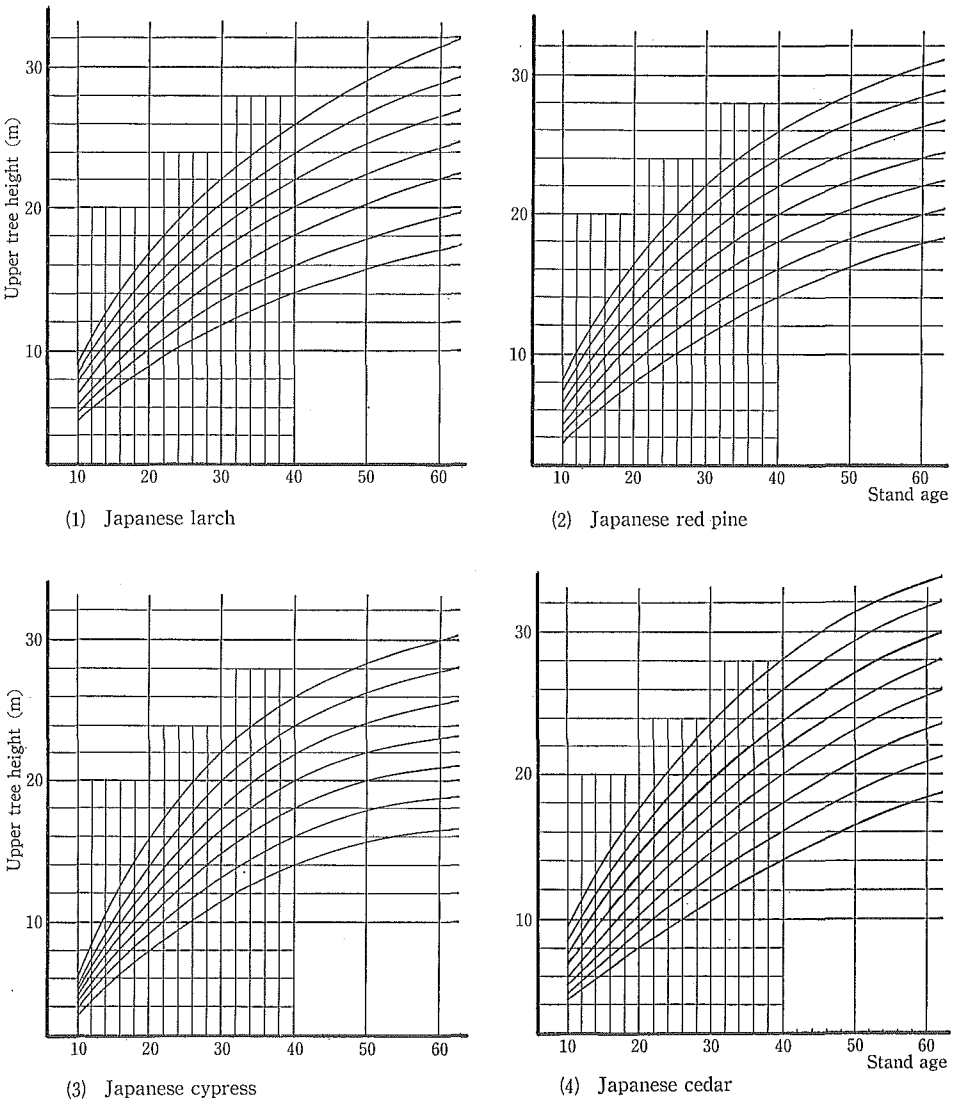

Fig. 2 "Site index curves" of each tree species.

to evaluate growth of a forest in Nagano Prefecture[3] (Fig. 2-(1)). If the stand age and mean height of upper tree were measured in the forest, tree height in the future could be estimated. The stand age and height of upper tree can easily by calculated by measuring the number of annual rings and the length of upper trees which were sampled in a given forest. In this connection, the site index curves available for the Japanese red pine (*Pinus densiflora*), Japanese cypress (*Chamaecyparis obtusa*) and Japanese cedar (*Cryptomeria japonica*) forests in Nagano Prefecture are drawn and represent in Fig. 2-(2)-(4), respectively.

ii) Making a plan for forest management

If the tree height were estimated, planning for forest management could easily be made. At present, it seems to be postulated, in general, that final cutting period is 60-year stand age in various tree species. Important factors upon deciding final cutting period are the size of diameter of breast height and volume of total growing stock which are often varied with tree density, i. e. the higher the density was, the shorter the tree diameter became. These values are estimated by the yield table which becomes a guide table for efficient thinning work and density control figure made up from the data in the past.

Correlation between the mean in diameter of breast height calculated by density control figure[3] and measured in a given forest is shown in Fig. 3. There observed higher correlation between the theoretical and observed values. Although the forest management depends on a forest owner's idea, he should try to manage producing thick trees within a short period.

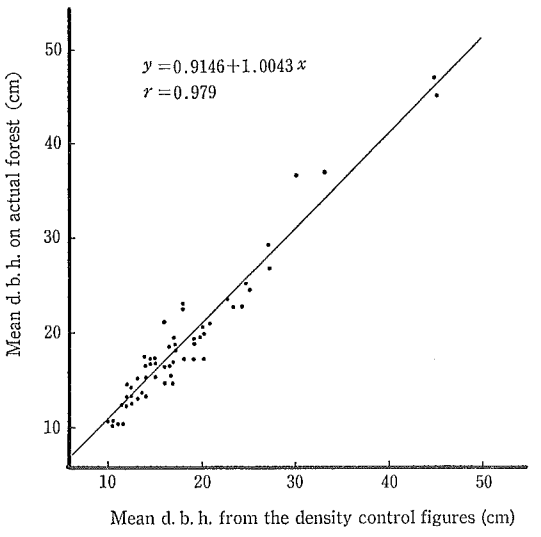

Fig. 3 Correlation of the mean diameters of breast height between the values of existing forest and those of calculated from the density control figures.

iii) Investigation of a technique for forest management to obtain thick trees in a given period.

As stated earlier, the thick trees are obtained by the forest of lower tree density. It is generally important to manage the forest in obtaining higher and thicker trees, i.e. longer diameter and more excellent qualities. With this view, the new method is available for forest management. However, frequency distribution of diameter of trees in a forest showed the normal distribution with an optimum size. Table 1 shows the frequency distribution of diameter in the Japanese cedar forest with 20-40-year stand age. It was found that the diviation of diameter around the mean spreaded at 10-20cm interval. Therefore, if we used the means to make thicker trees, ca. 300-500 per ha could be obtained easily. Standard of the thick tree is not defined clearly, however, we set conveniently the trees which is ca. 4m in length (butt log) with ca. 32-34cm in diameter of breast height as a standard. One rectangle wood with ca. 12×24cm can be made from a thick tree.

Table 1 Number of trees and diameter of breast height with the advance of stand age in the forest of the Japanese larch and Japanese cedar.

Plot	Japanese larch				Japanese cedar			
	Stand	No. of	d. b. h. (cm)		Stand	No. of	d. b. h. (cm)	
No.	age	trees/ha	Min.	Max.	age	trees/ha	Min.	Max.
1	18	2,200	8	20	15	2,600	4	20
2	19	1,800	8	16	17	3,825	6	14
3	20	2,900	4	16	19	1,825	10	22
4	21	2,400	2	16	20	1,675	8	26
5	22	3,000	4	16	22	2,000	12	30
6	23	2,400	8	18	13	1,475	8	30
7	24	1,800	12	24	24	2,000	10	20
8	25	900	10	24	25	1,550	14	26
9	25	1,900	12	26	26	2,175	10	28
10	26	1,600	6	20	27	1,850	12	22
11	27	900	14	26	28	1,900	10	32
12	28	1,300	14	22	29	1,630	14	28
13	29	2,200	8	22	30	1,875	8	30
14	30	1,600	8	20	32	1,275	12	28
15	31	1,400	10	20	33	1,075	8	30
16	32	1,000	12	22	32	1,600	6	26
17	33	1,300	8	28	37	1,225	6	38
18	34	1,100	12	24	44	1,650	6	26
19	35	1,600	10	34	50	1,050	16	42
20	41	800	18	28	60	475	22	62

2. Application procedure of the new method

i) Estimation of the site index

Prior to operation of thinning, first of all, 2 or 3 trees are sampled at random. The number of annual rings and length of trees are measured, and the stand age and mean height of upper trees are also estimated. Even-aged artificial forests are generally seen, and 2 or 3 samples are enough to estimate the site index in such a forest. However, in a forest which had been filled up more trees after the first plantation, 1 or 2 more samples will be added to estimate the stand age. In this case, hypsometer may be available for measurement of tree height. Secondly, a site index figure corresponding to the tree species of the forest is selected from the Figs. 2-(1)-(4), and the values of stand age and mean height of upper tress are plotted on the figure selected. The values at an intersecting point between those values shows the site index of the forest. In addition, the tree height in the future can be estimated by the growing curve of tree height which is close to the intersecting point.

ii) Decision of the number of reserved trees required for reasonable forest management

In order to decide the number of reserved trees required for reasonable management, stand age at the final cutting period and tree density of reserved trees are discussed with regard to growth of trees in the future. However, such sort of discussion changes depending on purpose for tree utilization and forest owners thought itself.

The author recommends 60-year stand age for final cutting taking into consideration that the owner can yield the trees once in his lifetime. Tree density at the final cutting period should be estimated for each tree species comparing with a standard which is expected in sufficient growth in diameter referred to the yield tables and density control figures.

a) The ratio of yield (Ry) and ratio of relativity stem distance (Sr) are 0.7 and 17-18, respectively both for the Japanese cedar and Japanese cypress forest.

b) The value of Ry is 0.6 and that of Sr is 19-21 both for the Japanese red pine and Japanese larch forest.

Ratio of yield (Ry) can be calculated by the density control figure for each tree species. On the one hand, ratio of relativity stem distance can be calculated by the following equation:

$$Sr=\sqrt{\frac{10000}{n}}\Big/h\times 100 \qquad \therefore\ n=\frac{1}{(Sr\times h)^2}\times 10^8$$

where, the symbol Sr indicates ratio of relativity stem distance, n the number of trees per ha and h mean height of upper trees.

Table 2 shows the standard value calculated from the equation as an exa-

mple of the Japanese cedar with 60-year stand age. It was estimated from the result of Table 2 that the numbers of reserved trees expected was 500-600/ha and 350-400/ha in the forest with inferior site class and superior site class, respectively. There was no remarkable difference in the number of reserved trees between the forests of both classes. Moreover, it was also considered that mean stem distance required for reasonable forest management was ranging from 4 to 5.5m between the forests of both classes. Accordingly, it seems to be less difficult to select the reserved trees for reasonable management either in inferior site class or superior one.

Table 2 Tree density in the forest with 60-year stand age at each site index.

Site index	Tree height at 60-years(m)	No. of trees /ha	Mean stem distance(m)
18	23	640～570	4.1
20	26	520～470	4.5
22	28	450～400	4.8
24	30	390～350	5.2
26	32	340～310	5.5

iii) Selection of reserved trees in the forest

It is easy to select the candidacy trees in the forest followed by expectation of the number of reserved trees. As reserved trees may affect quality of a forest in the future, we should select the trees characterized by thicker, higher and straight trees from the base of the stem to ca. 10m upward. It is desirable that the reserved trees should be distributed uniformly in a given forest taking the mean stem distance into consideration from Table 2.

iv) Selection of thinning trees in the forest

The thinning trees are selected by the following procedures and cut down subsequently.

a) Trees which are close to the reserved tree and prevent growth of them should be selected and cut down. It is clear from an evidence of the experiment that the number of obstruct trees is ca. less than 1.5 times as many as that of the reserved trees. In addition, the thinning rate is, in general, 30%.

b) In a younger forest with ca. 20-year stand age, a thinning scheme can work only by removal of the obstruct trees, however it is desirable that the trees being inferior in growth and qualities are also removed other than the obstruct trees at the same time.

c) As the trees with excellent qualities having high market value, for example squared timbers, are often seen in a forest with ca. 30-year stand

age, other than the reserved trees, these trees should be cut down and yielded in order to fill up the expense for thinning work.

v) The remainders other than the thinning trees may allow to leave up to the next thinning period, as they neither prevent growth of the reserved trees nor have height market value.

Ⅲ. Properties of the new method

The new method by the reserved tree marking system is a modification of the upper story thinning method which has been revealed to be practicable in the past by the author. In the process of history of the upper story thinning, following two methods which stemmed from the similar conception to the author's one are proposed.

i) Growing method of cash woods (Taru-maru)

This was one of a popular methods applied in the period during 1848-1854 in Yoshino district, Nara Prefecture, Japan and also for the period from 1894 in the western Europe[9]. Final cutting trees for excellent cash woods were selected in the forest with younger stand age, and all of the remainders other than the reserved trees were removed in order to obtain cash woods efficiently.

ii) Growing method of excellent trees in qualities for various purposes

This method was proposed by JUNAK[2] (1921). Final cutting trees were selected in the forest prior to thinning work, and the trees which prevented growth of the crown of the final cutting trees were removed. On the other hand, since 1860 demand for slender and middle-sized timbers increased rapidly, and methods and techniques obtainning those timbers were developed. Therefore, TERAZAKI's lower thinning method, as shown in the earlier part of this paper, turned out to be applicable to such forests, instead of upper thinning method dealing in this section.

The method by the reserved tree marking system is a newly improved stemmed from the upper thinning method which had been used in the past year. This new method takes in modern scientific knowledge for growth and tree density and is characterized by the following items:

(1) purpose for tree growing becomes clear in each forest with a chance of thinning, (2) obstruct trees preventing growth of the reserved trees can be fully removed, (3) thinning trees can be selected easily, (4) thinning woods with higher market value can be obtained easily and (5) applicability to various forest irrespective of tree density or tree species is fully expected.

The new method is especially useful for the forest, for example, of the Japanese cedar or Japanese cypress. Remainders other than the reserved trees may be able to yield at any time whenever the trees grew fully, since demand

of middle-sized timbers is increasing.

Accordingly, application of the new method to the even-aged uniform forest, makes possible for effective forest mamagement to obtain thicker and more excellent timbers.

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保残木マーク方式による新しい間伐法

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最近林業活動の不振にともなって人工林の過密化が進み，間伐の実行が緊急な課題となっている。一方木材利用の仕方が変化して大径木の育成も強く求められるようになってきた。

限られた期間内に大径木を育成するためには，できるだけ樹高生長が優れていることが条件である。またいちじるしい労働力の不足を補うためには，できるだけ省力的な間伐法を適用することが求められている。

従来の間伐法だけではこれらの状況に対応しにくいため，1977年以来省力的な間伐法の検討をすすめ，新しい間伐法として“保残木マーク法”を提案し，実践的な方法論をほぼ確立し得た。

本法は，間伐に先だって対象林分の生長の優劣を地位指数曲線図によって判定し，また将来60年生頃の上層樹高に相当する適正密度を予定し，立木の配置を考慮しながら林分内で形質並びに生長が優れた林木を選んで，保残木としてマークする。

最初の間伐では，保残マークした林木の生育を妨たげている隣接木を生長・形質の良し悪しにかかわらず除去する。

これら以外の林木は保残木の生育を妨げるおそれが少ないので，次回以降の収穫対象に充当する。

本法は次のような特徴が挙げられる。

1)　林分の育成目標が間伐を契機に一層明確にできる。
2)　保残木の生育を妨げる隣接木が確実に除去される。
3)　間伐木の選定がきわめて容易である。
4)　市場性が高い間伐材も得られる。
5)　林分密度の高低や樹種を問わず適用できる。