アカマツ林の中林作業法に関する研究

井上, 由扶

https://doi.org/10.15017/14986

出版情報：九州大学農学部演習林報告. 32, pp.1-265, 1960-08-31. 九州大学農学部附属演習林
バージョン：
権利関係：

STUDIES ON THE CLEARCUTTING MIDDLE FOREST SYSTEM OF AKAMATSU

(*Pinus densiflora* Sieb. et Zucc.)

By

Yoshisuke INOUE

Résumé

A survey of the forests of AKAMATSU (Japanese red pine; *Pinus densiflora* Sieb. et Zucc.) that are widely distributed in Japan reveals that generally in high class stands on fertile soil the lower story is overgrown with broad-leaved trees, while the stands growing on poor soil that suffered repeated destructive lumbering present an aspect of nearly pure stand AKAMATSU and have poorer increment. Even on one mountain, the high up-hill, the poorer the productive power, and at lower half of the mountain the lower story of AKAMATSU is overgrown with broad-leaved trees, but the up-hill side in many cases forms pure stands of AKAMATSU. Judging from these observations, the treatment aiming at preservation of productive power of soil and improvement of productivity of AKAMATSU forests should not be the formation of pure stands but should be the formation of middle forest type AKAMATSU forests with the lower story overgrown with broad-leaved trees. However, the treatment of AKAMATSU forests studied and put into practice in the past was mostly formation of pure stands by clearcutting system. Through his studies of actual conditions of middle forest type AKAMATSU forests, and tests and studies of appropriate methods of forestation continued over twenty-five years, the author established a treatment which he named "clearcutting middle forest system" and made it clear that the system had many long points as compared with the clearcutting system which has been practised in the past.

The present paper in ten chapters summarizes the results of the author's studies, clarifies the productive organization of the clearcutting middle forest system applied to AKAMATSU forests, and shows the basis for the treatment of AKAMATSU forests.

CHAPTER 1

This chapter treats the characteristics of AKAMATSU forests, object of study, outline of test areas, method of treatment of the results of study, etc.

CHAPTER 2

The bases of classification of silvicultural systems were analysed and systematic study was made in the middle forest system suitable for AKAMATSU forests. The silvicultural systems are in general classified into three; the high forest, the coppice and the middle forest systems, the middle forest system being a combination of the high forest and the coppice systems. Since the high forest system or the coppice system is classified into many working systems by the cutting method and other factors, the middle forest system that is a combination of the high forest and the coppice systems can also have a variety of working systems.

Based on the representative high forest and coppice systems employed actually in the Japanese forestry, the middle forest system is classified theoretically into the following six possible types.

Type (1) Upper story selection cutting; lower story clearcutting
Type (2) Upper story selection cutting; lower story selection cutting
Type (3) Upper story advance cutting; lower story clearcutting
Type (4) Upper story advance cutting; lower story selection cutting
Type (5) Upper story clearcutting; lower story selection cutting
Type (6) Upper story clearcutting; lower story clearcutting

With these types, the relation among characteristics of tree species, final age, circulation period, regeneration period, etc. was studied and the study of their practicability as technical organizations reveals that Types (1), (2), (5) and (6) are conceivable as practicable middle forest systems. However, Type (1) is the only middle forest system employed so far. The author finds that Type (6) is the simplest technically and most suited as the working system for AKAMATSU forests. The normal conditions of Type (6) are summarized as follows, and Fig. 6 shows its relationship with Type (1).

Normal Age Class: Upper stands: $a = \frac{F}{U}$ Lower stands: $na = \frac{F}{U}$

Normal Stand Arrangement: Same as clearcutting system

Normal Growing Stock: $V_{NS} = m_1 + m_2 + \ldots\ldots$

$$+ m_{U-1} + \frac{mU}{2} + n\left(m_1' + m_2' + \ldots\ldots + m'_{u-1} + \frac{mu}{2}\right)$$

Normal Growth: $Z_N = m_U + nm_u'$

where,

F = Forest area

U = Cutting age for upper stands

u = Cutting age for lower stands

$n = \frac{U}{u}$

m_1, m_2 ...... = Growing stock of upper stands in each age class.

m_1', m_2'...... = Growing stock of lower stands in each age class.

As in the case of Type (1), this working system can be divided further into middle forests of broken crown density, of medium crown density and of dense crown density, and it is also applicable to the uniform middle forest, the group middle forest and the strip middle forest.

When this working system is applied to middle forest type AKAMATSU forests, it is very well suited for the treatment of actual forests, as evidenced in the following chapters. Therefore, the author proposes to establish it as an independent working system under the name of "Clearcutting Middle Forest System".

CHAPTER 3

The estimation of seed crops of single trees and stands of AKAMATSU was made on the basis of the annual survey of the number of cones, the average number of seeds in the cone and the germination percentage, with a view to studying the management of AKAMATSU forest by the middle forest system.

Forty plots of the middle forest of AKAMATSU of varied suit conditions and densities and ten plots of the uniform forest of AKAMATSU, of ages ranging from 35 to 70 years, were selected. And the measurement of seed crops was continued for six years with one sample tree from each plot as the test tree and at the same time the viability percentage was obtained with the working sample of the seeds of each test tree.

The result obtained by these investigations are summarized as follows.

i. Number of Cone Crops

1) The cone crops fluctuation depends not only on the individual tree and the seed year, but on the age, the density, the site conditions, etc., even in the same seed year. According to 299 data obtained in the 6-year period, the number of cones was 301 at the maximum and 1 at the minimum, the average being 124. They showed the normal distribution with the peak at 100–150 cones, and the samples yielding 50 cones and over were 85% of all.
2) There is a tendency that the cone crops of single trees fluctuate widely from year to year. The average of all the survey data by the seed year gives 182 cones in a good crop year, 113 cones in an average crop year and 32 cones in a poor crop year, and although the difference in the number of cones between the good crop year and the poor crop year was wide, there lower part of mountain was no year without any cone crop. Generally, AKAMATSU's growing at the side where the site conditions are favorable yield less number of cones than those at the upper part of mountain sides, but the relation is reverse in the poor crop year. Consequently, AKAMATSU forests at superior sites show less tendencies of fluctuation of cone crops

between the good crop year and the poor crop year, than those at inferior sites. The AKAMATSU's in the high age class give somewhat larger average cone crops than those in the middle age class, and the comparison by the forest type shows that the average cone crops of single trees in the sparse middle forest are larger than those in the dense pure forest.

3) A high degree of correlation is observed between the cone crops of a single tree and the components of the tree form. Especially, a high degree of correlation is observed between the number of cones and the age, the d.b.h., the stem volume, the crown volume, classified by the site conditions and the density. The coefficients of the correlation are 0.63–0.98.

ii. Average Number of Seeds in the Cone

4) The number of seeds in the cone growing on the single tree fluctuates between 0 and 70, and it shows the normal distribution with 30–40 seeds at the peak.

5) The average number of seeds in the cone of each single tree was 47 at the maximum, 19 at the minimum and 34 on the average. When these are classified by the age class, the density and the site class, practically no correlation was seen between the age class and the number of seeds, but the average number of seeds in the cone of the single tree is a little greater with the single tree in the broken forest than with the one in the dense forest, and so with the single tree at the superior site than with the one at the inferior site, and the cones in the good crop year have a little greater average number of seeds than those in the poor crop year.

iii. Germination Percentage of Seeds

6) If the viability percentage of the seeds excluding the empty seeds is regarded as the germination percentage, all the 299 working samples with which the measurement was taken had high germination percentages; 73% at the minimum, 97% at the maximum and 84% on the average. In other words, 80% of the working samples showed more than 80% of germination percentage.

7) The working samples were classified by the age class, the density and the site class of the stand from where the samples were taken and the tendencies similar to those observed in the aforementioned case of the average number of seed in the cone were observed.

iv. Seed Crops of Sample Tree and Stands

8) With each sample tree, the seed crop was computed by the average number of seeds in the cone multiplied by the number of cones, and the year-to-year variation of seed crops ranged from the minimum of 19 seeds to the maximum of 9,632, averaging 3,872. Ninety percent of the total sample trees

yielded more than 1,000 seed crops. These results were classified by the age class, the density, the site class, the good and poor crop years, of the stands where the sample trees grew, and it was observed that the seed crops of the single tree varied in direct proportion to the number of cones.

9) The annual yield of seed crops of a stand was computed by the seed crops of the single tree multiplied by the number of trees per ha, and then the yield of viable seeds was computed by the annual yield of seed crops thus obtained multiplied by the germination percentage. The annual yield of seed crops per ha. of the AKAMATSU stands ranged from the minimum of 20,000 seeds to the maximum of 6,130,000, the average being 3,020,000 in the good crop year, 1,840,000 in the average crop year and 490,000 in the poor crop year. Ninety percent of the 299 samples were found to be shedding more than 500,000 seeds on the forest floor year after year. If the results are classified by the stand, the yield of seed crops is greater in the dense forest than in the broken forest and so in the middle aged forest than in the high aged forest, and the tendency is opposite to that in the case of the seed crops of the single tree.

10) From the above observations, it has been made clear that the ordinary AKAMATSU stands are almost all scattering a number of seeds on the forest floor annually. Since the AKAMATSU forests under management in the final cutting period are considered to be a mass of high class timbers after the cutting of bad trees, if the whole seeds of the trees for the final cutting can be utilized for the formation of the secondary forest, a large quantity of seeds of superior quality could be shed uniformly, and the regeneration period would be shortened and the natural regeneration could be carried out readily and without fail.

CHAPTER 4

Studies of annual seed dispersal were carried out for the purpose of obtaining basic data for the study of the management of AKAMATSU forests. Over a six year period, measurements were made of the amount of seeds dispersed from the seed trees into the four directions, the distance of dispersal, the time of seedfall, the viability percentage of the fallen seeds, and at the same time studies were made regarding the amount of seeds dispersed from the stand, the distance of dispersal and the time of seedfall. The results of the analyses and considerations are summarized in the following.

i. Seed Dispersal from Seed Tree

1) The seeds dispersed from 17 seed trees into 1 m^2 of forest floor were measured by year, direction and distance, and the analysis of variance was made by

the three-factor experiment. It was observed that there was significance in each of the measuring year, the direction from the seed trees and the distance from the seed trees. A high significance was observed in the correlation between the distance from the seed trees and the measuring year, but no significance was observed in the correlation between the direction and the distance, nor in the correlation between the direction and the year.

2) The observation by direction of the amount of seeds dispersed at measuring points outside the area under the crown revealed that the amount of seeds dispersed was in the order of S, E, W and N each year, and significant difference was observed between S-direction on the leeward of the dominating wind and three other directions. The maximum of the distance of dispersal was 65 m in the N-direction and 85–95 m in three other directions each year. In other words, both the amount of seeds dispersed and the distance of dispersal are highly related with the frequency of the direction and the velocity of the wind in the season of seedfall and their daily variation.

3) The amount of seeds dispersed per unit area decreases as the distance from the seed trees becomes great, both by year and by direction, and the regression that can be represented by hyperbolas was observed. The mean value of the number of seeds dispersed (y) is obtained by

$$y = \frac{46.556 \times 1.000^{x^2}}{1.080^{x}}$$

where x = distance of dispersal

4) The total amount of seeds dispersed each year estimated from the area of forest floor by distance of dispersal and the amount of seeds dispersed per unit area agrees with the seed crops of the year estimated from the number of cones fairly well, the error being-0.5%—9%. Thus it is seen that almost all the ripe seeds fall in the October-February period of the year. The amount of seeds that fall under the crown is about 1/4 of the total amount of seeds dispersed from the seed trees on the forest floor, and the most part is presumed to be dispersed into the area not under the crown.

5) It was observed with the time of seedfall that the seedfall showed the normal distribution with the maximum in the middle to the latter part of November. About 2/3 of the total amount of monthly seedfall occurs in November. The observation of the amount of monthly seedfall by distance from the seed trees reveals that early fallen seeds fall nearer to the seed trees and the further from the seed trees, the more late fallen seeds. Also a tendency was observed that the rate of early seedfall is somewhat greater with isolated seed trees than with those in the stand, in years of better seed crops.

6) The viability was measured with the fallen seeds collected by month and by distance each year, and it was found that the early fallen seeds have

greater viability percentages than the late fallen seeds. And there is a marked tendency that the seeds falling near the seed trees has greater viability percentages than those dispersed far from the seed trees.

7) Based on the computation from the above experimental results, it is considered that at least 15—35 reserve seed trees per ha. are required in the scattered-seed-tree system and 4—5 reserve seed tree groups per ha. are required in the group-seed-tree system. However, since it is believed that the seeds dispersed far from the seed trees are inferior to the seeds falling under the crown both quality and in amount per unit area, it is not an easy task to secure full natural regeneration of AKAMATSU by the seed-tree system.

ii. Seed Dispersal from Stand

8) The seeds dispersed from the AKAMATSU stand were classified by measuring year, by distance from the wall of the stand and by measured place, and the analysis of variance was made by the three-factor experiment. High significance was observed in each of the year, the distance and the place, and further, significance was observed in the correlation between the year and the distance. However, no significance was observed in the correlation between the distance and the place.

9) The amount of seeds dispersed per unit area was the greatest inside the stand, and the farther from the wall of the stand, the less the amount. In other words, regression represented by a hyperbola is generally observed between the distance from the forest wall and the amount of seeds dispersed, and the mean value of the number of seeds dispersed (y) at a distance (x) can be obtained by

$$y = \frac{56.700}{1.044^x}$$

10) The amount of seeds dispersed differs by year and is closely related with the seed crops. The comparison between the amount of seeds dispersed within the stand per unit area of the forest floor and the estimated amount of seed crops obtained from the cone crops reveals that the former is 11–21% less than the latter, the percentage varying by year. This difference is believed to be mainly due to the fact that a portion of the seeds are dispersed outside the stand.

11) The amount of seeds dispersed outside the wall of the stand computed by distance on the assumption that the percentage by distance of the amount of seeds dispersed from the trees in a plot into the area outside the area under the crown, to the amount of seeds dispersed under the crown be the same as that in the case of the foregoing seed tree measurement, agrees with the mean value of the measurements fairly well. However, the mea-

surements are a little less than the computed values up to 20 m distance from the forest wall and vice versa beyond this distance, and this is believed to be due to the difference in the mode of dispersion between the seed trees in the stand from and the isolated seed trees.

12) The time of seedfall shows the left-learning normal distribution with the maximum in the middle to the latter part of November, as in the case of the foregoing seed tree measurement, and about 2/3 of the total amount of seeds fall in November, but a tendency is observed that the time of seedfall is somewhat delayed in the case of seed trees in the stand as compared with the case of isolated seed trees. The observation of the monthly seedfall by distance from the forest wall shows that the percentage of later seedfall increases as the distance from the forest wall becomes greater.

13) The width of the regeneration area for the regeneration by seeds from the adjoining wood to expect an amount of seeds dispersed exceeding a set amount in the cutting area (regeneration area) per unit area, differs by the width of the stand left on the periphery, as well as by the land features, the climatic conditions, the good or poor crops.

14) Since the amount of seeds dispersed in the unit area of the forest floor is exceedingly greater within the forest than outside the forest wall, if these fallen seeds can be utilized for natural regeneration in the cutting period. sufficient seeding could be expected even in the year of poor crops.

CHAPTER 5

Studies were made in the influence of shade on the regeneration of AKAMATSU and in the generation and growth of seedling in the stands with different degrees of shade.

1) The ratio of the intensity of illumination at the test area in a forest to that at the unshaded control area measured simultaneously with a luxmeter, multiplied by a fixed constant, is taken as the intensity ratio of illumination. Then the following relation is found between the degree of shade (x) and the intensity ratio of illumination (y).

   Degree of shade (x) of latticed shelter: $y = 1 - 1.0x$

   Density of AKAMATSU stand (x'): $y = 1 - 0.8x'$

   The intensity ratio of illumination was measured by this relation and corrected for the density by the method of crown projection. And the relation between the degree of shade and the growth and death of AKAMATSU seedling was clarified.

2) The grown seedling rate and the number of dead seedlings show no significant difference in the range of from 0 to 0.3, but over 0.4, the greater the degree of shade, the less the number of germination and the greater the

number of dead seeelings. The following relation was found between the degree of shade (x) and the dead seedling rate (y)

$$\log y = 0.8280 + 0.422x + 0.0070x^2$$

In July of the year of germination, the degree of shade of from 0 to 0.7 does not influence the average height of seedlings significantly, but with the seedlings in the second year and after, the height of seedlings becomes markedly smaller as the degree of shade increases.

3) Variation of natural regeneration was studied in the cut-over area and many areas in AKAMATSU forests with a variety of upper story densities after weeding and grading. The seedlings start to germinate in the latter part of April, the majority of seedlings germinating in May, and the germination is finished by the early part of July. The germination occurs earliest in the unshaded area, and late in the heavily shaded forest. The dead seedling rate during one year after germination is highest in August, irrespective of the degree of shade. Those seedlings that are late in germinating are more liable to die, and the rate of survival is higher with seedling that germinate earlier. The death and growth of seedlings during 5 years after germination are closely related with the growth of the terrestrial plants, but when weeds are removed, a tendency similar to 2) is observed. Consequently, forestation of AKAMATSU by natural regeneration cannot be expected under shade.

4) Thus, since regrowth of such intolerant trees as AKAMATSU cannot be expected under shade of the upper story, it is difficult to adopt the selection cutting system or advance cutting system for AKAMATSU forests. And the clearcutting system or the clearcutting middle forests system which eliminates shade in the young growth stage is suitable for AKAMATSU forests.

CHAPTER 6

To clarify the effect of shade on the regeneration of broad-leaved trees growing in the AKAMATSU forest, the author carried out experiments with seedlings and shoots of broad-leaved trees.

1) Ten species of broad-leaved trees commonly seen in the middle forest type AKAMATSU forests in the south-west part of Japan were sown under latticed shelter of degree of shade ranging from 0 to 0.9, and the heights of seedlings in two years were measured. It was found that the evergreen species, *Styrax japonica*, *Clethra barbinervis* and *Pieris elliptica* had fairly high tolerances of shade, and the maximum value of the average height of seedlings lay between 0.1 and 0.3 of the degree of shade, and no significant difference was observed between the shaded stand and the open stand, if the degree of shade was not greater than 0.7. However, ***Quercus acutissima***

and *Quercus serrata* had a little lower tolerance at the growth in height declined under 0.4 and higher degree of shade.

2) Next, in many AKAMATSU forests with different densities, the sprouting of of forty species of broad-leaved trees after they were clearcut in winter was surveyed. In general, species of higher tolerance had larger percentages of sprouting from stool than those of lower tolerance, and with the former species the rate of sprouting is not lowered by the increase of the upper story density, and rather the rate of sprouting tends to increase with the density up to 0.4 or 0.5, while with the latter the rate of sprouting decreases with the increase of upper story density. Generally, most of the evergreen species have greater tolerances of shade than deciduous species, and the species of higher grades of charcoal-wood have greater tolerances of shade than the species of lower grades, and this relation is clearly expressed in the average rate of sprouting of broad-leaved trees growing under shade. With the average number of shoots per stump, the same tendency as the foregoing rate of sprouting is observed, but the average number of shoots decreases as the degree of shade increases.

   The average height of shoots differs with the tree species, and site conditions, but with intolerant species it decreases markedly as the degree of shade increases, while with shade-bearing species the growth in height tends rather to increase as the upper story density increases up to 0.4 or 0.5. Therefore, generally speaking, the decrease of growth in height due to larger upper story density is greater with deciduous trees than with evergreen trees and with species of lower grade of charcoal-wood than with species of higher grade.

3) With the clearcutting middle forest of AKAMATSU, in the clearcutting period of the lower story of broad-leaved trees, the upper story of AKAMATSU also is thinned heavily and the crown cover is broken, but the density increases gradually as time elapses. On the other hand, the effect of shade is seen at first on the underwood of broad-leaved trees, but the effect of shade decreases as the trees advance in age, and especially the intolerant species come to decline and die.

   It is understandable from the above-mentioned relations between the degree of shade and the rate of sprouting, and between that and the length of shoots, etc. that shade-bearing broad-leaved trees grow well in the middle forest type AKAMATSU forest, and it follows that the clearcutting middle forest system is an appropriate system for production of the underwood of broad-leaved trees.

CHAPTER 7

Statistical studies of some components of the tree form of the broad-leaved trees growing under the canopy were carried out as a basis for the study of the middle forest system for AKAMATSU. The following is the results of the studies in the relationship among such factors as age, d.b.h., height, stem volume, breast-height form factor, branch percentage, etc. with 1,607 sample trees of ages ranging from 4 to 24 years, consisting of 14 species and growing in the following 4 stand types of sample plots.

A : 23 plots of uniform forest with a mixture of AKAMATSU and broad-leaved trees, regenerated in the areas where the upper and the lower stands had been cut clear in their own rotation.

B_{11}: 28 plots of middle forest of AKAMATSU of medium crown density (0.4 to 0.5), with the lower stands growing in the 2nd rotation.

C_{11}: 32 plots of middle forests of AKAMATSU of medium crown density, with the lower stand growing in the 3rd rotation.

E : 23 plots of coppice under the clearcutting system.

i. Branch Percentage

1) The experimental formula,

$$y = a + \frac{b}{c + x^2}$$

where y = branch percentage

x = d.b.h.

a, b, c = constants

is introduced to represent the branch percentage curve, and it is confirmed that this formula holds very well with various species of trees and also with their mean values.

2) This formula is applicable to the branch percentage-age curve. In this case, however, the accuracy is not as good as in the case of branch percentage-d.b.h. curves, because the volume increment of the stem and that of branches differ by the site.

3) Since the branch percentage is affected greatly by the degree of crown density of the upper story, the following differences are observed among the stand types of the middle forest.

$A > B_{11}$ $A > C_{11}$ $B \fallingdotseq C_{11}$

And the branch percentage of the stand of E type is almost equal to that of A type stand, no significant difference is observed between the two types, with any species of trees; that is,

$A \fallingdotseq E$ $E > B_{11}$ $E > C_{11}$

4) The branch percentages of broad-leaved trees show characteristics of the species, but generally they are classified into two groups, the evergreen tree

group and the deciduous tree group, and the former has a larger branch percentage than the latter.

In the case of B_{11} or C_{11}, the species are arranged in order of value of the branch percentages as follows, and the order agrees with that of the tolerance of shade.

Kuroki	*Otherodendron japonicum* Makino.
> Arakashi	*Quercus glauca* Thunb.
≒ Shirakashi	*Quercus myrsinaefolia* Blume.
≒ Asebi	*Pieris japonica* D. Don
> Soyogo	*Ilex pedunculosa* Miq.
≒ Nezumimochi	*Ligustrum japonicum* Thunb.
≒ Hisakaki	*Eurya japonica* Thunb.
> Ryōbu	*Clethra barbinervis* Sieb. et Zucc.
≓ Nejiki	*Pieris elliptica* Nakai.
≓ Inushide	*Carpinus Tschonoskii* Maxim.
≒ Kunugi	*Quercus acutissma* Carruth.
≒ Konara	*Quercus serrata* Thunb.
≒ Egonoki	*Styrax japonica* Sieb. et Zucc.
≒ Kamatsuka	*Pourthiaea villosa* Decne.

ii. Breast-height Diameter

5) The formula,

$$y = ax^2 + bx + c$$

represents the d.b.h.-age curve, and exceptionally in some cases,

$$y = \frac{x^2}{ax^2 + bx + c}$$

holds.

6) Under the canopy, the diameter increment of broad-leaved trees is not as good as it is without shading, and the following relation holds with all the species alike.

$$A \fallingdotseq E > B_{11} \fallingdotseq C_{11}$$

The diameter increment is greatly influenced by shading with Kunugi and Konara, and not influenced very much with Kuroki, Hisakaki, Ryōbu, Inushide and Egonoki.

7) In one stand type, the diameter increments of broad-leaved trees agree with the quality of site represented by AKAMATSU growing together with those trees.

8) In the case of B_{11} or C_{11}, the species are arranged in order of growth in d.b.h. as follows.

Kuroki > Arakashi ≒ Egonoki ≒ Shirakashi > Konara ≒
Kunugi ≒ Ryōbu > Nezumimochi ≒ Asebi ≒ Inushide ≒

Nejiki ≑ Soyogo ≑ Hisakaki ≑ Kamatsuka

iii. Height

9) The formula

$$y = \frac{x^2}{ax^2 + bx + c}$$

holds for the height increment curve very well.

10) The height increment in Type B_{11} or Type C_{11} under the canopy is almost equal to that in Type A or Type E without shading.

11) The height increment of the broad-leaved trees agrees very well with the quality of site represented by AKAMATSU growing together with them.

12) In Type B_{11} and C_{11}, the species are arranged in order of height increment as follows.

Arakashi ≑ Shirakashi ≑ Egonoki ≑ Ryōbu > Kuroki ≑
Kunugi ≑ Konara ≑ Nejiki ≑ Nezumimochi ≑ Inushide >
Soyogo > Kamatsuka ≑ Asebi ≑ Hisakaki

13) There is a high degree of correlation between the breast-height diameter and the tree height, and both of the following formulas hold very well.

$$y = ax^2 + bx + c$$

$$y = \frac{x^2}{ax^2 + bx + c}$$

iv. Stem Volume

14) The relationship between the stem volume increment and the stand type is similar to the situation stand in (6).

15) The order of species according to the stem volume increment is similar to the order in (8).

16) A positive correlation is observed between the age and the stem volume, but it is difficult to express this relationship by a formula, because of the big differences in the quality of site. However, the formula,

$$y = ax^b$$

where y = stem volume
x = d.b.h.

holds between the d.b.h. and the stem volume, with all the species.

v. Breast-height form factor

17) There are big individual differences in the breast-height form factor among sample trees of the same diameter grade, even among trees of the same species, but the general tendency is that the greater the d.b.h., the smaller the breast-height form factor. The formula,

$$y = a + \frac{b}{c + x^2}$$

where $y =$ mean breast-height form factor

$x =$ mean d.b.h.

holds very well between the mean value of the breast-height form factor of trees of each species in a sample plot and the mean breast-height diameter.

18) The formula,

$$y = a + \frac{b}{c + x^2}$$

where $x =$ age of sample forest

holds well between the age of each sample forest and the mean breast-height form factor.

CHAPTER 8

The characteristics of stand composition were clarified with the pure stands of AKAMATSU and the middle forest type AKAMATSU stands at various localities in Japan, and standard yield tables were prepared for the middle forest type AKAMATSU forests of medium crown density in Hiroshima and Fukuoka Districts to show their yields and features.

1) The study of the stand age composition of the middle forest type AKAMATSU forests reveals that almost all the upper stories of AKAMATSU consist of even-aged stands growing in the same year. And the broad-leaved trees of the lower stories produces new shoots year after year, after they are regenerated uniformly, but the dominant portion of the broad-leaved trees are mostly those that grow initially. Therefore, they can be considered to be of the even-aged stand composition substantially. Consequently, the yield tables for the middle forest type AKAMATSU forests may be prepared separately for the upper stands and the lower stands in the similar way to the yield tables for even-aged stands. However, the mixed growth of lower stand species differ widely in different districts, and it seems advisable to prepare local yield tables rather than general yield tables.

2) In Hiroshima District, 137 plots were selected in the middle forest type AKAMATSU forests of medium crown density where the lower stands were cut three times during one rotation of the upper stands, and after their fitness was checked, the standard yield tables were prepared by the following regression formulas.

Upper Stands

Average height of dominant crops:

$$\log y = a + b \log x + c (\log x)^2$$

where y: height, x: age

Average d.b.h. of dominant crops:

$$\log y = a + b \log x + c (\log x)^2$$

where y: diameter, x: age

Volume of trunk of dominant crops:

$$\log y = a + b \log x + c (\log x)^2$$

where y: volume, x: age

Number of trees of dominat crops:

$$y = ax^b$$

where y=number of trees x: diameter

Average height of dominated crops:

$$y = a + bx$$

where y: average height of dominated crops

x: average height of dominant crops

Average d.b.h. of dominated crops:

$$y = a + bx$$

where y: average d.b.h. of dominated crops

x: average d.b.h. of dominant crops.

Lower Stands

Average height:

$$y = ax^b$$

where y: height, x: age

Average d.b.h.:

$$y = ax^b$$

where y: diameter, x: age

number of trees:

$$y = \frac{x^{1 \cdot 5} + r}{px^{1 \cdot 5} + q}$$

where y: number of trees, x: diameter

Volume of trunk:

(Average height) × (Average basal area) ×

(Average breast-height form-factor) × (Number of trees)

The comparison of the yield table for the middle forest type AKAMATSU forests thus prepared and the yield table for the pure forests of AKAMATSU in the same district reveales the following with the former.

1. Number of AKAMATSU trees is less.
2, Average d.b.h. is smaller in the younger period and larger in and after the prime-age period.
3. Volume of dominant crop is somewhat less.
4. The current annual growth and the mean annual growth have their maximum periods high, at around 60 years,
5. The total yields including the upper stands and the lower stands are larger than those of the pure stands.

The total yields of the lower stands in one rotation of the upper stands amount 40—50% of the yields of the upper stands.

3) In Fukuoka District, the middle forest working section was established, where the lower stands were cut twice in one rotation of the upper stands. And the yield table for the mean site-class was prepared by the use of the same regression formulas as in the foregoing. The average height of dominant crop in this yield table is almost equal to that in the middle site-class in Hiroshima District, and the former is compared with the latter as follows.
   1. Number of trees of dominant crop is less.
   2. Average d.b.h., volume of trunk and mean annual growth of the upper stands are larger.
   3. Mean annual growth of the upper stands has its maximum period somewhat lower than the former.
   4. Average tree height, d.b.h., number of trees, volume, and mean annual growth of the lower stands are smaller than those of the former. This seems to be due to the fact that the rate of mixture of evergreen broad-leaved trees is high.
   5. The total yields including the upper stands and the lower stands for both the districts are almost equal, and are greater than that obtained from the yield table for the pure stands of AKAMATSU.

CHAPTER 9

Based on the characteristics of the middle forest type AKAMATSU forests and the organization of the clear-cutting middle forest system as described in the foregoing chapter, experiments of treatment for the formation of middle forest type AKAMATSU forests were carried out. The rational method of treatment of AKAMATSU forests, as derived from the results of the experiments, is summarized in the following.

1) For reliable natural regeneration of AKAMATSU, it is most effective to clear cut and remove the upper and the lower stands simultaneously in the period of seedfall of AKAMATSU (October—February) and carry out the strip weeding and grading in the early part of March.
2) For several years of growth of AKAMATSU, shrubs and weeds must be cleared so that the death of young trees under suppression may be prevented. It is most effective to cut clear in strips between the two adjacent strips prepared in the weeding and grading operation.
3) With the tending as described in 2) above, the forests grow into the middle forest type stands, but as there are dangers of suppression of AKAMATSU

by broad-leaved trees and climbing plants until the AKAMATSU trees reach the age of about 10 years, removal of climbing plants and improvement cutting must be carried out. It is advisable for better tree-form and quality of AKAMATSU not to remove all the broad-leaved trees but to remove only the broad-leaved trees suppressing the AKAMATSU.

4) When the age of wood reaches 15—25 years, AKAMATSU's occupy the upper story crown and assume closed conditions and the broad-leaved trees forming the lower story begin to decline in growth. Therefore, it makes the cutting age, when the broad-leaved trees are clear-cut and AKAMATSU's are thinned. In this case a heavy thinning is performed on AKAMATSU's, leaving predominant trees, so that the growth of the upper stands of AKAMATSU may be accelerated after thinning and reproduction of broad-leaved trees (mostly regeneration by sprouts) in the forest may be expedited.

5) In case the middle forest of medium crown density or the middle forest of broken crown density of AKAMATSU is established through heavy thinning, the shade-bearing species of broad-leaved trees regenerated in the forest continues good growth, and therefore, with such tending of removal of bad tree species, selection of shoots, removal of climbing plants, improvement cutting, etc. as given in the treatment of coppice forests, a nearly equal volume of yields of broad-leaved trees is obtainable at the second lower stand cutting period as that at the first cutting period.

6) In the clear cutting middle forest system of AKAMATSU forests, the cutting period of the lower stands is set at an integral multiple of the cutting period of the upper stands, and consequently, when AKAMATSU trees are subjected to final cutting in short term rotation, both the upper and the lower stands are clear cut at the second cutting period of the lower stand. However, since the formation of the middle forest type AKAMATSU forests aims at the production of large lumbers of AKAMATSU together with cordwood and at the same time at the preservation of the yield power, it is advisable to set the cutting age for the upper stands high and to produce the lower stands more than three times in one production period of the upper stands.

Based on the results of experiments of treatment as described over 1)—6) in the foregoing, the standard of treatment is shown for the case where the actual forest is a middle forest type AKAMATSU forest and at the same time discussions are made on the method of leading the pure stand of AKAMATSU and the coppice forest of broad-leaved trees into the middle forest type AKAMATSU stands.

CHAPTER 10

The results of studies described in the foregoing chapters are summarized, and the working characteristics of the clear cutting middle forest system for AKAMATSU are summarized as follows.

1) Broad-leaved trees always grow in the AKAMATSU forests, and it meets the principle of soil preservation.
2) Since the seeds falling from the trees for final cutting onto the forest ground are utilized for regeneration of AKAMATSU, it meets the principle of succession of excellent nature.
3) As both AKAMATSU and the broad-leaved trees very readily regenerate naturally, it requires very little cost of planting, and it is economically advantageous.
4) It meets the principle of fostering excellent form and quality to utilize in tending the similar characteristics of trees between AKAMATSU and the broad-leaved trees.
5) Besides the above, the system is more suitable to a smaller-scale management than to a large-scale management in view of the facts that timber and cordwood are produced simultaneously, the working technique is very simple and easy, the sustained working is possible even in a small forest, and other characteristics.

Based on the above characteristics, the applicative value of the present study was discussed and it is made the conclusion that this working system fits very well to the farm forests very commonly seen in the south-western part of this country.