Original paper

The estimation of plantation forest resources focusing on the long rotation silvicultural practices in the management unit level: A case study in First Memorial Forest of Ise Jingu[*1]

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Nakajima, T., Matsumoto, M., Kanomata, H., Takezoe, K., Hiroshima, T., Tatsuhara, S., Shiraishi, N. and Lee, J. S. : **The estimation of plantation forest resources focusing on the long rotation silvicultural practices in the management unit level : A case study in First Memorial Forest of Ise Jingu. Kyushu J. For. Res. 60 : 6－8, 2007** In Ise Jingu, one of the grand shrines in Japan, the forest administration department is planning to use large timbers to rebuild the shrine. This study aims to estimate the forest resources in the management unit, the First Memorial Forest of Ise Jingu. We used the Geographic Information System (GIS) and the Local Yield table Construction System (LYCS) with parameters introduced from a yield table of *Chamaecyparis obtusa* in Kyushu district. Our results from linking GIS data to a simulation based on the LYCS showed that the average DBH of the timbers harvested with the present thinning plan will not completely meet the requirements for Ise Jingu. We suggest that the thinning plan in this site be shifted to a lower stand density control as a strategy for large timber production.

Key words ; thinning plan, GIS, growth model, Ise Jingu, LYCS

Ⅰ. Introduction

Ise Jingu is a grand shrine of Shinto, one of the Japanese religions. The "Shikinen Sengu Ceremony," the periodic rebuilding of the shrine, is carried out every 20 years. This traditional ceremony has been held since the 7th century.

The Shikinen Sengu Ceremony requires *Chamaecyparis obtusa* in a quantity more than about 10,000 m^3. These timbers have been supplied from some prefectures since ancient days. However, Ise Jingu decided to supply its own timbers for the next ceremony that is to be held in 2013. The "Shikinen Sengu Ceremony" needs giant trees whose DBH is more than 60 cm.

The purpose of this study is to apply the Local Yield table Construction System (LYCS) (Shiraishi, 1986; Nakajima and Shiraishi, in press) and the Geographic Information System (GIS) to the forest planning of the Ise Jingu forests. To be more precise, we simulated the tree growth based on a thinning plan in the Ise Jingu forests.

Ⅱ. Methods

1 . Study site

The targeted area is the First Memorial Forest of Ise Jingu in Kumamoto Prefecture, Japan. In this forest, ground survey data of sample plots and forest inventory data are linked to the GIS.

The forest area is 65 ha, of which *Cryptomeria japonica* occupies 33 ha, and *Chamaecyparis obtusa* 32 ha. We focused on the *Chamaecyparis obtusa* plantation forest as the study site. The age of around half of the *Chamaecyparis obtusa* stands are less than 40 years, which is an early stage in the silvicultural process. For this reason, it is important to consider the future stand density control in these forests.

2 . A tool for forest resource simulation

The LYCS is used for estimating forest resources. The original growth model of the LYCS was developed for the *Cryptomeria japonica* and *Chamaecyparis obtusa* stands in the University Forest in Chiba at the University of Tokyo.

For simulating forest resources with the LYCS, growth parameters are required. We used the yield table of *Chamaecyparis obtusa* in Kyushu District (Forestry Agency, 1961) for estimating these parameters. The yield table was constructed in 1961 for the national forests in Kyushu, including Kumamoto Prefecture. It includes the following data: (1) the harvesting age from 10 to 120, (2) the number of trees per ha, and (3) the average DBH and tree height.

3 . Procedures

Matsumoto's method (Matsumoto, 1997) enabled us to estimate the parameters of the LYCS from yield tables.

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The relational expression between LYCS and each parameter is as follows.

Height growth curve of yield table

$H = M\ (1 - L \exp(-kt))$ (1)

H: stand height (m), t: stand age (year)

M, L, k: parameters

Decreasing number of trees in yield table

$N = \exp(a\ (1 + b \exp(-ct)))$ (2)

N: number of trees per ha

a, b, c: parameters

The relationship between stand density and mean DBH

$\log N + d \log D = K$ (3)

D: mean DBH (cm)

d, K: parameters

Increment rate of mean DBH

$r = m \exp(-nt)$ (4)

r: increment rate (%)

m, n: parameters

The growth model for the diameter increment, using results from (2) to (4)

$r = m \exp(-nt) + p\ (K - \log N - d \log D)$ (5)

p: parameter

The parameters of formula (1) were estimated by applying Mitscherlich's equation to the tree height growth curve introduced from the yield table.

The DBH growth was calculated with parameters from formulas (2) − (4). The parameters of formula (2) were estimated with a curve fitting the Gompertz function to the number of trees per ha. According to precedent researches, the parameters M a, and b were shown as functions of the site class (Tanaka *et al.*, 2004).

Formula (3) is the standard density curve (Shiraishi,1986). This formula is expressed by a linear curve in a logarithmic graph. Formula (4) was estimated by applying the Gompertz function to the DBH growth ratio.

The parameter p in formula (5) showed the influence of the stand density, which affects DBH growth. The estimation of p required continuous examinations in the permanent plots. Unfortunately, it is difficult to collect these data in Kumamoto Prefecture. In this study, we used 4.6 as parameter p, which was estimated by Shiraishi for *Chamaecyparis obtusa* (Shiraishi, 1986).

Using these parameters, we simulated the forest resources up to the clear-cutting age, 200 years old. In this simulation, the input data for the LYCS were the average DBH (cm), stand age (year), stand density (number of trees/ha) and the standard thinning plan presented by the Ise Jingu forest administration department. We linked this simulation to the GIS data.

Ⅲ. Results and discussion

Table 1. The estimated parameters for *Chamaecyparis obtusa* in Kyushu district

Height growth curve of yield table $H = M\ (1 - L \exp(-kt))$		
M	L	k
$46.54 - 7.92S$	1.02	0.02

Decreasing number of trees in yield table $N = \exp(a\ (1 + b \exp(-ct)))$		
a	b	c
$5.83 + 0.26S$	$0.55 - 0.05S$	0.03

The relationship between stand density and mean DBH $\log N + d \log D = K$	
d	K
1.27	4.71

Increment rate of mean DBH $r = m \exp(-nt)$		
stand age	m	n
under 40	9.07	0.05
above 40	4.12	0.03

S: site class (1 - 3)

Table 1 shows the estimated parameters.

The parameters of the LYCS for *Chamaecyparis obtusa* stands in Kyushu district could be estimated by Matsumoto's methodology. We simulated the harvested timbers with these parameters as follows.

Figure 1 shows the DBH growth as predicted in a sample

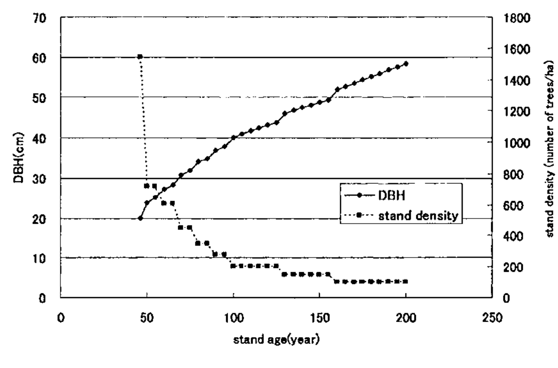

Fig. 1. The DBH growth predicted in one sample plot

plot of the First Memorial Forest.

In Ise Jingu, a 200-year-long-rotation is being planned in order to produce *Chamaecyparis obtusa* timbers with a DBH over 60 cm. The planting density was about 3000 trees per ha; the stands in Jingu forest are to be thinned 8 times before a final cutting.

The average DBH at the clear-cutting age was less than 60 cm, which suggests that the present thinning plan will not be suitable for the timber production strategy in Ise Jingu. Considering this, it is necessary either to manage stands with a lower density control or to delay the clear-cutting age in this subcompartment.

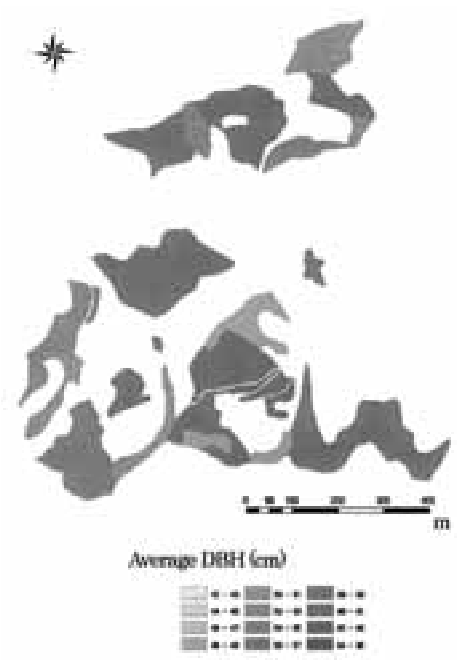

Fig. 2. The average DBH of harvested timbers in the management unit level.

Figure 2 shows the average DBH of the subcompartments in the First Memorial Forest at each clear-cutting age, 200.

It had been implied that the DBH of some harvested trees would not reach 60 cm. Therefore, it is necessary to shift these stands to a lower stand density control or to longer-rotation silvicultural practices. However, if rotation age is made longer, the risk of wind hazards would become higher. Therefore, it is more realistic to manage these forests with a lower stand density control. The next challenge will be to explore a more suitable thinning plan for improving the average DBH in the First Memorial Forest.

Ⅳ. Conclusion

In conclusion, the following points can be made. First, the growth parameters of *Chamaecyparis obtusa* in Kyushu district have been estimated by Matsumoto’s methodology. Second, the timbers required for the Shikinen Sengu Ceremony cannot completely be supplied by the current thinning plan in the First Memorial Forest. Third, we suggest that the forest management plan in this site be shifted to a lower stand density control to produce the timbers required for the Shikinen Sengu Ceremony.

References

Forestry Agency (1961) Yield table of *Chamaecyparis obtusa* in Kyushu district, 11pp, Forestry Agency, Tokyo (in Japanese).

Matsumoto, M. (1997) J. For. Plann. 3 : 55-62.

Nakajima, T. and Shiraishi, N. (in press) J. Jpn. For. Soc. (in Japanese with English summary).

Shiraishi, N. (1986) Bull. Tokyo Univ. For. 75 : 199-256 (in Japanese with English summary).

Tanaka, K. *et al.* (2004) Trans. Jpn. For. Soc. 115 : 607 (in Japanese).

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