Original paper

A plan-do-check-act (PDCA) structure for management of a long-rotation silviculture system: A case study of the Ise Jingu Memorial Forest[*1]

Tohru Nakajima[*2] ・ Satoshi Tatsuhara[*2] ・ Norihiko Shiraishi[*2]

Nakajima, T., Tatsuhara, S. and Shiraishi, N.: **A plan-do-check-act (PDCA) structure for management of a long-rotation silviculture system: A case study of the Ise Jingu Memorial Forest. Kyushu J. For. Res. 61: 18—20, 2008.** We developed a plan-do-check-act (PDCA) structure of long-term management system for the Memorial Forest of Ise Jingu. The structure includes the following: (1) plan: a management plan for self-supplying timber for the Shikinen Sengu (shrine rebuilding) Ceremony; (2) do: a silviculture system that maintains the environmental functions of the forest; (3) check: a system for monitoring forest resources, and (4) action: improvement of the management plan. The proposed forest management plan would achieve the objective of large timber production while also reducing costs and labor requirements.

Keywords: Ise Jingu, PDCA cycle, timber production

Ⅰ. Introduction

The Grand Shrine of Ise (Ise Jingu) has traditionally been rebuilt every 20 years since A.D. 690, with forests near the shrine providing the building material (Nagumo and Yamamoto, 1988). The main objectives of the managers of the shrine's forests are production of large timber and maintenance of the environmental functions of the forests. In this context, a long-term management system would be important.

In this study, our objective was to introduce a systematic program of long-rotation silviculture system into Ise Jingu's Memorial Forest. The management system is structured on the following plan-do-check-act (PDCA) cycle: (*1*) plan: a management plan for self-supplying timber for the Shikinen Sengu (shrine rebuilding) Ceremony; (*2*) do: a silviculture system focused on the environmental functions of forests; (*3*) check: a monitoring system for forest resources; and (*4*) action: improvement of the management plan.

Ⅱ. Methods

1. Study site

The study area was the Memorial Forest of Ise Jingu. Located in Kumamoto and Miyazaki Prefectures, this forest covers a total area of ca. 1000 ha. Plantation of *Chamaecyparis obtusa* make up approximately half of the forest. As shown in Fig. 1, *C. obtusa* and *Cryptomeria japonica* plantation forests vary in age from approximately 1 to 50 years old.

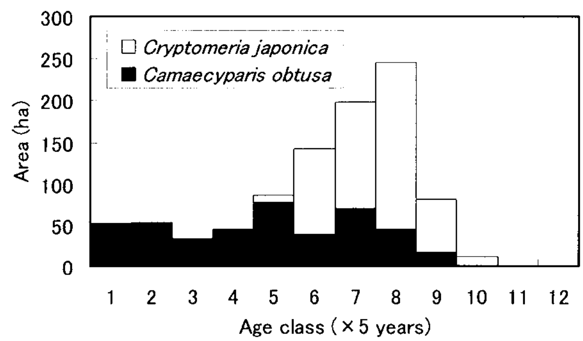


Fig. 1. Age class distribution of *Chamaecyparis obtusa* and *Cryptomeria japonica* in the Ise Jingu Memorial Forest

2. Structure of the PDCA cycle

Following a PDCA structure, we introduced the following systematic program into the Memorial Forest. First, the "plan" focused on self-supply of timber for the Shikinen Sengu Ceremony. A basic forest management plan for Ise Jingu's Memorial Forest was developed in 1976. This plan designates the final cutting age as 200 years and keeps stand density relatively low by thinning. By focusing on low stand density and long-rotation practices, this management plan is aimed at producing timbers with more than 60 cm diameter at breast height to use in the Shikinen Sengu Ceremony.

Based on this management plan, we predicted DBH growth in the study forest by inputting the standard thinning plan data into the Local Yield Table Construction System (LYCS: Nakajima *et al*., 2007).

Second, the "do" part involved a silviculture system aimed at

[*1] 中島　徹・龍原　哲・白石則彦：長伐期型人工林施業における PDCA サイクルの構築－伊勢神宮明治百年記念林を事例として－

[*2] Grad. Sch. Agric and Life Sci. the Univ. Tokyo, Tokyo 113-8657　東京大学大学院農学生命科学研究科

maintaining the environmental functions of the forest. To examine the performance of the current thinning system, we compared the thinning area based on the management plan to the actual thinned area implemented in the forest.

Third, to "check" forest resources, we established circular sample plots to monitor the effects of the silviculture system. Each plot was 0.04 ha. Table 1 provides information on the sample plots, for which the DBH were recorded. We analyzed the results of the management plan by comparing observed data to the LYCS-predicted data.

Fourth, as the "action" part of the plan, we recommend an improved forest management plan for the Memorial Forest. This plan would provide larger timber and reduce management costs.

Table 1. The sample plots in the Memorial Forest

Plot No.	Stand age	Mean DBH (cm)	Stand density (stems/ha)
1	41	21.5	1150
2	41	23.6	1000
3	19	17.0	1850
7	24	18.1	1375
9	23	15.9	1625
10	38	23.2	800
11	32	17.1	1200
12	43	24.9	650
14	55	30.6	575

Ⅲ. Results and discussion

(1) plan: Management plan for self-supplied timber for the Shikinen Sengu Ceremony. Fig. 2 shows the standard thinning plan for the Memorial Forest and the DBH growth predicted under the low stand density control. The average DBH at 200 years of age is approximately 60 cm, which is an appropriate size for rebuilding the shrine. This figure suggests that the management plan will produce appropriately sized timber for the Shikinen Sengu Ceremony.

(2) do: Silviculture system for maintaining the environmental functions of the forest. Fig. 3 shows an example of a final cutting area in the Memorial Forest. As shown in this figure, clear cutting is not conducted; thus, this type of silviculture system could help maintain the environmental functions of the forest (Kawana *et al,* 1992). Furthermore, forest management records for the forest show that on average >96% of the planned thinning area has been thinned. In the Ise Jingu Memorial Forest, the rotation period of the plantation forests is 200 years, and thinning is planned about 15 times during that time by harvesting. Controlling plantation forests at low stand densities and in long-rotation silvicultural systems, this management plan aims to produce old forests with a component of broad-leaved species. Such low stand density control should help enhance environmental functions such as biodiversity (Nakajima *et al.*, in press).

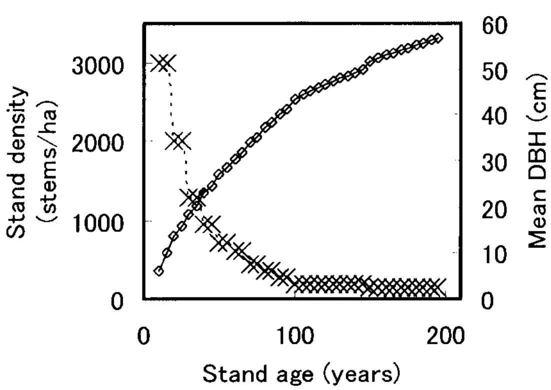
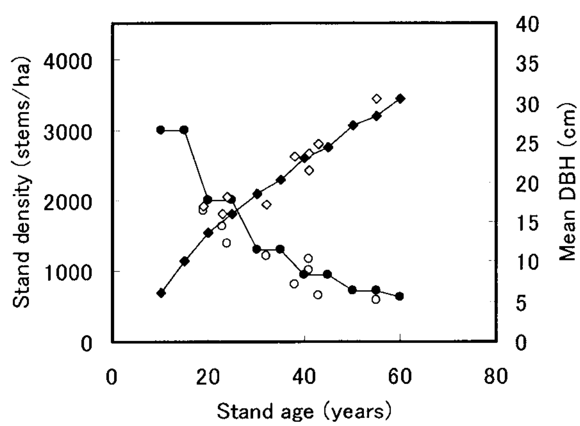


Fig. 2. The DBH growth (diamonds) predicted under the standard stand density (crosses) control plan for Memorial Forest

Fig. 3. A final cutting area in the Memorial Forest

(3) check: Monitoring forest resources. Fig. 4 shows the predicted DBH and observed DBH in the sample plots. Observed DBHs were generally larger than predicted ones. This figure also shows the observed and planned stand densities. Differences between these two values were less than 20%, except in two sample plots. It is possible that the objective



◇, Observed DBH; ◆, Predicted DBH;
○, Observed stand density; ●, Planned stand density

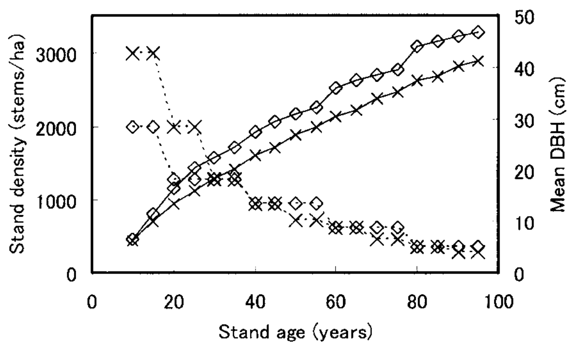
Fig. 4. Comparison of predicted DBH or stand density and observed DBH or stand density in the sample plots

large timber could be produced under the Memorial Forest management plan.

(4) action: Improvement of the management plan. Finally, we suggest an improved forest management plan for the Memorial Forest. As shown in the Fig. 1, *Cryptomeria japonica* plantation also covers nearly half of Memorial Forest. However, *Chamaecyparis obtusa* would be required for rebuilding the shrine. Therefore, *Cryptomeria japonica* plantation forests should be changed to *Chamaecyparis obtusa* plantation forests.

The standard final cutting age of *Cryptomeria japonica* is approximately 50 years old in the Memorial Forest. As shown in Fig. 1, many areas of *C. japonica* plantation forest are reaching this final cutting age. Final cutting, harvesting, and re-planting are both costly and labor intensive. Thus it is important to consider cost and labor reductions as part of the management plan.

Fig. 5 presents a new management plan for low-cost production of large timber. As implied in the figure, reducing the density of planting would allow for the production of larger timber than that in the original management plan and would require less frequent thinning. Therefore, we suggest the use of this improved management plan to produce large timber while reducing costs and labor requirements.



×, Original management plan; ◇, Improved management plan
The stand density and mean DBH are indicated by dotted and solid lines, respectively.

Fig. 5. Comparison of DBH growth and stand densities based on the original and improved management plans

Ⅳ. Conclusion

In this study, we structured the management of Ise Jingu's Memorial Forest as a PDCA cycle. While the objective large timber could be produced by the current management plan for the forest, reduction of the planting density could produce larger timber and reduce the costs, including labor requirements.

Acknowledgments

We thank the staff of Ise Jingu for assistance with the field measurements. This study was partly supported by research fellowships from the Japan Science Society.

References

Kawana, A. *et al.* (1992) Silviculture, 200pp, Asakura Publishing, Tokyo (in Japanese).

Nagumo, H. and Yamamoto, H. (1988) Bull. Tokyo Univ. For. 78: 259-303 (in Japanese with English summary).

Nakajima, T. *et al.* (2007) Kyushu J. For. Soc. 60：6-8.

Nakajima, T. *et al.* (in press) Chubu J. For. Soc. 56.

(2007年11月19日受付；2008年２月18日受理)