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学位論文の要旨

Abstract of Thesis

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学位論文題目 Title of Thesis（学位論文題目が英語の場合は和訳を付記）

Regeneration of *Fagus crenata* in an old-growth beech forest with codominant species in the canopy layer
（林冠層を複数樹種が混交するブナ原生林におけるブナの更新）

学位論文の要旨 Abstract of Thesis

Beech forests in the temperate zone are important and valuable for biodiversity and environmental conservation. The beech, *Fagus crenata*, is dominant species and one of the symbolic species for natural ecosystems in Japan. However, the beech forests have been diminished and isolated because of human's activities like expansion of artificial forests in Japan. Accordingly, conservation of remaining beech forests is important, and for the conservation, mechanisms of the dynamics and regeneration of beech forests should be researched and demonstrated. The dynamics and regeneration in beech forests have been well studied, and the previous researches have told us that advance regeneration, canopy gaps by fallen trees, and phenological gap by mixed structure in the canopy layer are key points for regeneration and maintenance mechanisms of beech forests. To precisely confirm the knowledge and obtain the new knowledge, long term ecological researches are more necessary. Therefore, this study aimed (1) to detect relations between dynamics of *Fagus crenata* understory trees and canopy tree species for a long term, (2) to determine relations between establishment of canopy trees and disturbance history, and then (3) to discussed regeneration of *F. crenata* in an old-growth beech forest. For the purpose, I conducted the researches in an old-growth beech forests with codominant species in canopy layer by long term ecological research and dendrochronological methods.

The present study was conducted in an old-growth beech forest in a forest reserve of Okayama Prefecture in western Japan (35º14' N, 134º23' E; 1050 m a.s.l.). This forest is located in the cool temperate zone, the annual average temperature is 8ºC, and annual precipitation is 2400 mm. Maximum snow depth 1.8 m. The canopy layer was mixed with *F. crenata* and other codominant species, and dominance of *F. crenata* and *Magnolia obovata* was prominent in the canopy layer. In the old-growth beech forest, a study plot of 50m x 240m was set in the north-facing slope.

Firstly, tree census was conducted in 1992 and in 2011. In the tree census, tree individuals with diameter at breast height (DBH) ≥ 4 cm were numbered, the species were identified, the DBHs were measured, and the

positions were recorded. This study defined understory trees as the measured trees growing under canopy layer. These understory trees were taller than dwarf bamboo community in the forest floor, and probably it is not necessary to consider effects of dwarf bamboo coverage on the understory trees. For estimating light conditions in the understory, leaf unfolding and shedding of canopy trees was observed with automatic phenology cameras, and light intensity in the understory were measured from the beginning of leaf unfolding till the end of leaf shedding with color acetate films degrading the color according to light intensity. From the data obtained in the field work, I analyzed relations between dynamics of *F. crenata* understory trees and the canopy tree species between 1992 and 2011.　In most of species including *F. crenata*, density of understory trees decreased from 1992 to 2011, and mortality of *F. crenata* understory trees was much higher than that of recruitment rate probably because of a little gap formation. In the spatial distribution correlations, *F. crenata* understory trees changed spatial correlation to *F. crenata* canopy trees from independent relation to dissociated relation. On the other hand, *F. crenata* understory trees constantly had associated relation to *M. obovata* canopy trees that are codominant species in the forest. Survival and diameter growth rates of *F. crenata* understory trees were significantly higher under *M. obovata* canopy trees than under *F. crenata* canopy tees. Accordingly, I intended to explain the reason from viewpoints of the light conditions in the understory. Leaf unfolding was later and leaf shedding was earlier in the canopy trees of *M. obovata* than *F. crenata*. In this season, light intensity was significantly higher under *M. obovata* canopy trees than under *F. crenata* canopy trees. The results demonstrated the existence of phenological gaps under *M. obovata* canopy trees. Moreover, the light intensity in the understory was higher under *M. obovata* canopy trees than canopy trees of *F. crenata* even in the growing season between the completion of leaf unfolding and the beginning of leaf shedding. Therefore, it is likely that the population size of *F. crenata* understory trees tends to be more maintained and stable under *M. obovata* than under *F. crenata* because of differences of light conditions.

Secondly, increment cores were taken for tree ring analysis from the trunk of all canopy trees in the area of 50 m x 130 m within the study plot. In the tree ring analysis, tree ring widths were measured at the unit of 0.01mm with a microscope, and then ages of trees were estimated, growing patterns were determined, and radial growth release criteria were developed to identify significant growth releases and estimate occurrence of disturbance. From those data, I analyzed dynamics of canopy trees by dendrochronological methods. Age structure of canopy trees indicated continuous establishment by *F. crenata* canopy trees and simultaneous establishment by *M. obovata* canopy trees. Next, canopy trees were classified into gap-origin and non-gap-origin trees by analysis of growth rates and patterns in the initial growing stage, and then spatial distributions of canopy trees were analyzed. *F. crenata canopy* trees had both gap-origin canopy trees and non-gap-origin canopy trees abundantly, and gap-origin canopy trees of *F. crenata* showed random distribution. On the other hand, Most of *M. obovata* canopy trees were gap-origin individuals, and those gap-origin canopy trees of *M. obovata* showed aggregated distribution patterns. Additionally, the aggregated *M. obovata* canopy trees occupied considerably large areas. From growth release analysis, a few and small growth releases were observed in the canopy trees for around 150 years after the estimated establishment period of *M. obovate* canopy trees, therefore, it was estimated that a few and low intensity disturbances occurred but prominently intensive disturbances did not occur for a long time. These results suggested that *F. crenata* canopy trees gradually and constantly regenerated before and after both large and small scale disturbances, whereas canopy trees of *M. obovata* simultaneously regenerated after large scale disturbances which are estimated to rarely occur.

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Finally, I discussed the regeneration of *F. crenata* from these results. Dynamics of *F. crenata* understory trees suggested that advance regeneration by these understory trees has been facilitated under the canopy trees of *M. obovata*. It is probably the reason that *M. obovata* canopy trees provided *F. crenata* understory trees with light conditions sufficient for maintaining the understory trees by phenological gap in spring and autumn and higher light intensity in the other growing season as well. The canopy trees of *M. obovata* originally regenerated after rare and large scale disturbances and then attained to canopy layer. Therefore, this study suggested that the large scale disturbances are important factor to facilitate regeneration of *F. crenata* through the coexistence of *M. obovata* in the canopy layer. It will be stated that large scale disturbances in old beech forests contribute to sustainably maintaining structure of forest as well as species diversity.