# 学位論文の要旨

Abstract of Thesis

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| 研究科 School | Graduate School of Environmental and Life Science |
| 専　攻 Division | Environmental Science |
| 学生番号 Student No. | 77428202 |
| 氏　名 Name | DINH TIEN TAI |

**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）

Natural regeneration of *Quercus serrata* Thunb. and *Q. acutissima* Carruth. after cutting canopy trees in an abandoned coppice forest in western Japan

（西日本の放棄薪炭林における林冠木伐採後のコナラとクヌギの自然更新）

**学位論文の要旨** Abstract of Thesis

In Japan and many regions of Eurasia, oak dominated coppice forests were widespread because of their economic, cultural, and ecological values. However, due to the fuel revolution and changes in socio-economic factors, oak dominated coppices were largely abandoned or converted to more developed forests and other land uses since the middle of 20$^{th}$ century. Unmanaged coppice forests have faced with various threats of degradation such as biodiversity decline, changes in forest structure, and outbreak of oak wilt disease. Recently, the concern regarding the re-establishment of coppice forests has increased with respect to biodiversity conservation, bioenergy, and ecological services. The success of regenerating the oak dominated coppices, however, is being challenged owing to reduction in re-sprouting ability of large-sized and aged trees in several oaks concurrent with the negative effects of invasion and competition by other species. To successfully restore the oak dominated coppices, understanding the factors affecting both sprout and seedling regeneration is necessary because they are important sources of natural oak reproduction. The present study, therefore, aimed to evaluate the initial natural regeneration and its potential associated factors for the two widely distributed oak species in western Japan, *Quercus serrata* and *Q. acutissima*, after cutting canopy trees in abandoned coppice forest. Specifically, the study objectives were to (1) examine the sprouting capacity of two oak species in the first growing season after cutting; (2) investigate the stump sprout dynamics of two oak species over a 4-year period following cutting; and (3) determine seedling regeneration of *Q. serrata* in the first two growing seasons after cutting.

In 2013, we set a study plot of 0.36 ha (40 × 90 m) in an oak dominated coppice stand abandoned since the late

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1960s. In winter 2013, canopy trees within and outside the study plot were cut. The data of stump and sprout characteristics, and environmental factors were recorded in the first growing season from May to October 2014. In our study, the stump diameter ranged from 10.7 to 48.5 cm and from 14.0 to 41.4 cm in *Q. serrata* and *Q. acutissima*, respectively, and no significant difference was found between the species. The proportion of sprouted stumps was not significantly different between *Q. serrata* (70%, n = 98) and *Q. acutissim*a (74%, n = 61). In *Q. acutissima*, the sprouting probability increased with light availability and was higher in concave area. The number of living sprouts per stump was 28.9 (SD: 35.6) and 17.9 (20.6) in *Q. serrata* and *Q. acutissima* respectively, and no significant difference was found between the two oaks. Canopy closure showed a significantly negative effect on the number of living sprouts per stump in *Q. serrata*, while the sprout number in *Q. acutissima* increased with stump diameter. Sprouts emerged earlier and/or originated from the lower part of stump exhibited a higher survival probability. Additionally, earlier emerging sprouts appeared to have a greater sprout length than those later emerging ones. Our data suggest that within the observed range of stump diameter, the ability of sprouting and the number of living sprouts per stump in both species (ca. 60 years old) might not be reduced with increasing stump diameter, and the increasing of light availability could promote sprout regeneration. In addition, it is likely that sprout-level survival and growth pattern in the first growing season might be affected by stump size and sprout characteristics, rather than the examined environmental factors.

To investigate the stump sprout dynamics, we collected data of sprout survival and growth twice a year (spring and winter) from 2014 to 2017. Four years after cutting, the proportion of surviving stumps decreased to 37% (n = 98) and 56% (n = 61) in *Q. serrata* and *Q. acutissima*, respectively, and the significant difference was found between species. In both species, stump survival was not significantly affected by stump size and the examined environmental factors. The number of living sprouts per stump differed between *Q. serrata* (8.7 ± 6.7) and *Q. acutissima* (5.1 ± 4.6) after four years. The number of sprouts per stump in both species tended to increase with stump diameter and was greater in convex area, but only significant for *Q. acutissima*. Dominant sprouts of *Q. acutissima* exhibited greater diameter and length than those of *Q. serrata*, and the relative growth rate of sprouts in both species decreased with time after cutting. Dominant sprouts originating from a higher position on the stump grew better than those closer to the ground level. Sprout growth was negatively affected by sprout number per clump and positively affected by dead sprout number per stump, but only significant for *Q. serrata*. Light availability positively, although modestly, influenced sprout growth. Four-year data confirm

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the finding in the first growing season that stump diameter may not be a factor responsible for the regeneration failure in the two species. Our results indicate that stump sprouts for the restoration of abandoned coppice stands dominated by the two species is insufficient because stump survival rate decreased over time and was low four years after cutting, especially for *Q. serrata*. Due to the trade-off between sprout growth and sprout number, we suggest that artificially thinning small and suppressed sprouts may promote the growth of the remaining dominant sprouts.

In 2014, one growing season after cutting, seedlings of all species were identified and recorded in 36 sub-quadrats (each 1×1 m) in the study plot. Data of survival and height growth of seedlings were collected in 2014 and 2015. We recorded no seedlings of *Q. acutissima* and 29 seedlings of *Q. serata* in 36 sub-quadrats. Although having a few seedlings, *Q. serrata* was one of three species exhibited the greatest seedling survival rate after two years. Among examined species, on average, *Q. serrata* had the greatest seedling height in the first (19.9 cm) and second (47.8 cm) growing seasons. We observed that seedling survival and growth of *Q. serrata* and some other species tended to decrease with increasing canopy closure and vegetation cover on forest floor that mainly composed of dwarf bamboo, but not statistically significant. Additionally, earlier germinating seedlings appeared to show greater survival probability and height growth, although not significant, than those germinating later. Our results reveal that *Q. serrata* might have a few seedlings, but its seedlings can be competitive with those of other species.

The present study indicates that both sprout and seedling sources must be used to regenerate abandoned coppice forests dominated by the two species. Within the observed range of stump diameter, stump survival rate of both oak species may not be related to this factor. However, stump survival rate decreased over time and was low after four years. Although having low seedling density, *Q. serrata* exhibited high seedling survival rate and height growth. Therefore, we suggest that increasing seedling density by planting must be considered as additional sources contributing to regenerate the original stand. In addition, increasing light availability and thinning suppressed sprouts can be useful for promoting natural regeneration of these oak species.