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【論文の内容の要旨】

Tropical forests come under increasing pressures from direct anthropogenic influences such as deforestation and defaunation, as well as indirect influences such as global warming. A large proportion of human populations in the tropics are urban, and this proportion is expected to rise. These developments imply that more land has to give way to urban expansion, often at the expense of forests. The remaining forests found in urban areas are often small, fragmented, and isolated. Despite their small size, urban forests still provide the same ecosystem services as pristine forests, and are even more valuable due to their proximity to humans.

Among tropical countries, Singapore has lost more than 99% of its original forest, one of the highest rates of forest loss. The whole island used to be covered with forest, but deforestation began after Singapore's founding by the British. The city was built from the southern port, and agricultural activities crept deeper inland. After WWII, rapid urban development of the city necessitated large-scale forest clearance. The largest patch of remaining old forests can be found in the central part of Singapore, where the first water reservoirs are also located. However, even these forests are mostly secondary forests, and only <0.2% of the original primary forests remained. Despite these huge losses of forest cover, the remaining forests still hosted diverse suites of wildlife. Compared to nearby Malaysian primary forests, Singapore has, predictably, lower levels of biodiversity of most lifeforms. However, the number of species that have survived were disproportionately more than the area of forest lost. For example, only about a quarter of vascular plant species had gone extinct from Singapore, even though more than 99% of original forest had been lost. Of the forests remaining in Singapore, the 164-ha Bukit Timah Nature Reserve contains the largest patch of primary forest and has the greatest diversity of many taxa compared to other forests. Bukit Timah, a fully protected forest reserve, is also a popular weekend destination and exercise spot among residents, and is one of the nature attractions featured by the local tourism agency.

Bukit Timah has Singapore's highest natural peak at 164 m a.s.l., and its steep terrain may be one of the reasons it was spared from deforestation. The core 48-ha of primary forest is surrounded by secondary forests of mixed ages on the north and east, and by two disused granite quarries to the west. The entire reserve is surrounded by residential areas to the west and south, and an expressway separates Bukit Timah from the larger forest in the Central Catchment Nature Reserve. Therefore, Bukit Timah has been exposed to intense human disturbances for many decades, and this thesis examines the ecology of the forest and assesses its integrity for continued use as a leisure and tourism destination.

Chapters 1 and 2 provide the background and introduction of this thesis and a general outline of methodology respectively. In Chapter 3, I used a 19-year dataset from a 2-ha permanent plot within the primary forest of Bukit Timah and examined the dynamics of the forest, in particular looking for possible fragmentation and isolation effects that might have impacted the primary forest. In Chapter 4, I investigated the recovery dynamics of a secondary forest in Bukit Timah using another 2-ha permanent plot that was monitored over an 8-year period. In Chapter 5, a subset of trees from both the primary and secondary forest plots were measured at short time intervals in order to examine tree growth rates and their responses to environmental stress, such as droughts. Tree growth rates are closely linked to ecosystem net primary productivity and carbon sequestration rates, which influence future carbon cycling and climate. Chapter 6 is a discussion of the three preceding chapters and concludes the thesis.

The primary forest of Bukit Timah did not seem to be suffering from the typical effects of fragmentation that was observed in Amazonian fragments. The most common species were primary forest species, while pioneer species made up a very small proportion of both species and tree counts throughout the 19-year period. Tree abundance, basal area, and recruitment rates decreased after the two drought events in 1997 and 2009, while both mortality and recruitment rates were considerably higher than other forests in the region. The abundance of 86 out of 158 species with $\geq$10 trees changed more than expected under a neutral model of demographic change. Overall, the results show that the primary forest retained its integrity through time, but was sensitive to decadal-scale climatic events.

The secondary forest of Bukit Timah grew naturally for more than 60 years after land abandonment from agricultural activities. Although it was still structurally and floristically distinct from the adjacent primary forest, the 8-year monitoring showed that changes in species composition was occurring rapidly in the understorey, while the canopy layer continued to be dominated by the most abundant species. However, three out of four of these dominant species declined in abundance by 20% with the decreases occurring in the smaller size trees. Recruitment of primary forest species increased within the survey period but were concentrated near the primary forest without spreading deeper into secondary forest. Generalist species also increased in abundance at all distances from the primary forest, while secondary forest species decreased in abundance. Overall, the results indicate that the secondary forest is headed for changes that will reduce the contrast between primary and secondary forest.

Short-term growth rates of primary and secondary forest trees had significant fluctuations between measurement intervals that were higher than the long-term fluctuations. This showed that long measurement intervals mask tree responses to short-term environmental cues. Growth rates were not correlated with total within-interval rainfall, implying that other environmental factors influenced growth rates more strongly, even though tree turnover was influenced by acute dry periods like the two droughts in 1997 and 2009. Trees that died during the survey period had significantly lower growth rates than trees that survived, suggesting that slow growth rates could be an indicator of stressed trees.

In conclusion, the forests in Bukit Timah Nature Reserve have been resilient against intense human disturbances through time, with the original primary forest slowly expanding into the secondary forest. Overall results indicate that with careful management of visitors and public trails, Bukit Timah can continue to be a valuable resource for biodiversity conservation and nature-based tourist attraction.