博 士（環境科学） エディ ミルマント

学 位 論 文 題 名

Spatial distribution, dynamics and recovery of wetland forest in Central Kalimantan

（中部カリマンタン湿地林の空間分布、動態と再生）

学位論文内容の要旨

Abstract

Tropical rain forest is rich in plant species. These species are distributed over a variety of forest types, where differences in species composition are markedly large. Peat swamp forest is one of tropical rain forest components that so far has been recognized to have low plant diversity. In addition the peat swamp forest has been expected to be a fragile system in terms of slow tree growth rate and high sensitivity to disturbance including human activities. To examine these premises, the ecological studies were carried out in peat swamp forests in the three selected sites, Lahei, Tanjung Puting and Sebangau, in Central Kalimantan, Indonesia. Studies are comprised of these aspects: spatial distribution of forest community, forest dynamics and response of forest to disturbance.

The species diversity in studied sites of peat swamp forests was relatively higher compared to other studies of peat swamp forests in Kalimantan, but it was still lower than that in lowland mixed-dipterocarp forests at Barito Ulu. Almost all of the dominant species were specific to peat swamp forest, except for some very uncommon species such as *Glochidion littorale* and *Macaranga* sp. Those species commonly occur on an open disturbed area in riparian habitats. Thus these selected sites are likely to represent the composition of intact peat swamp forest.

Fourteen permanent plots of 0.25 ha have been set up in the three study sites. Woody plant enumeration were made in all of plots in order to understand the forest structure and floristic composition. Spatial variation in plant community was evaluated with the effect of distance from river stream and peat-depth, based on the parameter recorded in 14 plots. In total 294 taxa of woody species were recorded. *Palaquium leiocarpum, Neoscortechinia philippinensis* and *Combretocarpus rotundatus* were the most common species in the study area. *Palaquium leiocarpum* was the most abundant species in density and basal area, which was followed by *Eugenia densinervium* and *Eugenia castaneum*, whereas the *Neoscortechinia philippinensis*, *Acronichya porteri* and *Stemonurus scorpioides* were only leading in density. On the other hand

Combretocarpus rotundatus was the most abandant species in basal area, which covered about 10% of total basal area. Other species such as *Gymnacranthera eugeniifolia*, *Horsfieldia crassifolia*, and *Stemonurus scorpioides* had wide distribution range which occurred at least in 13 of plots out of 14. The stem (girth ≥ 15 cm) density and cumulative basal area were ranged from 1612-3088 ha^{-1} and 18.5-44.6 m^2/ha, respectively, in these 14 plots. Species richness *S* was ranged from 41 to 87. Indices of species diversity *H'* and evenness *J'* were varied from 1.29 to 1.68 and 0.771 to 0.910, respectively.

Stem density was positively related to distance from river but not to peat depth, indicating that forest size became smaller in riversides. Geographical differences were also related to stem density. *H'* was related to distance to river, but *S* and *J'* were not explained by any environment factor examined. Plot distribution pattern examined by detrended canonical correspondence analysis (DCCA), indicated that the distance to river was surrogate to the intensity and/or frequency of flooding, and explained more on the plant community distribution than peat depth. Geographical difference also significantly affected the distribution patterns. Therefore, the distance to river is suggested to be a suitable parameter to estimate plant community distribution in the wetland forest even though peat thickness varies greatly across sites. Multiple regression analysis for selected species and species-habitat preference demonstrated that there were significant effects of peat-depth. However, the effect of other variables such as micro-topography were not too small to be ignored. Further studies are required to confirm local-scale relationship between species diversity and environmental factors, and species habitat preference as well.

Forest dynamics were studied for individuals > 15 cm in girth of 24 most common species in eight of 0.25-ha plots in the Sebangau site. The peat swamp forest in that site might be able to categorize as moderately dynamic stands in terms of the rate of tree growth, mortality and recruitment. Annual relative growth rate and mortality were comparable to the previous studies but recruitment rate was relatively high. There was a significant effect of diameter class on annual growth rate, but not to mortality. Two environment factors (peat depth and distance to river) were significantly correlated with tree mortality and recruitment rate. During one-year period study there was no significant change in vegetation structure.

The response of forest to disturbance characterizes vegetation recovery after forest fire. The vegetation recovery was studied in Sebangau, Lahei and Tanjung Harapan burnt forest. Five sample plots were selected based on the age of post fire. The study examined regeneration biomass, nutrient content in biomass and soil, and environmental factors. The results showed that vegetation recovery after fire in peat swamp forests was much slower than other kinds of forests, and there was a variety in quickness of recovery according to conditions of peat swamps. In addition there were unusual cases that the contents of P and K per dry weight of biomass were lower in young vegetation, despite that those contained in soils did not increase with age after fire.

The lack of true pioneer species may partly explain the slow vegetation recovery after fire, but it is indicated that the vegetation recovery was quicker on thin peat. Interesting point was that K content in soil was relatively high in shallow peat when there were a lot of remaining tall trees. This suggests that remaining trees on shallow peat play an important role in nutrient uptake and vegetation recovery.

The present results provide essential information for the planning of management and reforestation of endangered tropical wetland forests.

学位論文審査の要旨

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学位論文題名

Spatial distribution, dynamics and recovery of wetland forest in Central Kalimantan

（中部カリマンタン湿地林の空間分布、動態と再生）

Peat swamp forests in tropical South-east Asia have been recognized to have low plant diversity, slow turnover rate and high sensitivity to disturbance. To examine these premises, this paper examined ecological properties of peat swamp forests in Central Kalimantan, Indonesia, where this forest type is most widely distributed among South-east Asia.

The species diversity in three studied sites was relatively higher compared to other sites of peat swamp forests so far reported, but it was still lower than that in lowland mixed-dipterocarp forests. Almost all of the dominant species were specific to peat swamp forest. Fourteen permanent plots of 0.25 ha were established in the three study sites. Woody plant enumeration were made in all of plots in order to understand the forest structure and floristic composition. Spatial variation in plant community was evaluated with habitat properties such as the distance from river and peat depth. In total 294 woody species were recorded. *Palaquium leiocarpum*, *Neoscortechinia philippinensis* and *Combretocarpus rotundatus* were the most common species in the study area. *Palaquium leiocarpum* was the most abundant species in density and basal area, which was followed by *Eugenia densinervium* and *Eugenia castaneum*, whereas, *Neoscortechinia philippinensis*, *Acronichya porteri* and *Stemonurus scorpioides* were only abundant in density. On the other hand *Combretocarpus rotundatus* and *Gonystylus bancanus* were only abundant in basal area. Other species such as

Gymnacranthera eugeniifolia, *Horsfieldia crassifolia*, and *Stemonurus scorpioides* showed wide distribution ranges. Tree communities were differentiated among three sites with less than 10% similarity in species abundance in basal area. Within-site differentiation among ten plots set along the transect across a developed peat-dome showed gradual change along the transect. Stem density was positively related to distance from river but not to peat depth. The plot distribution pattern examined by the detrended canonical correspondence analysis (DCCA) indicated that the distance to river was surrogate to the intensity and/or frequency of flooding, and explained more the plant community distribution than peat depth. Multiple regression analysis of the species preference of habitats detected the significant effect of peat depth. However, the effect of other variables such as micro-topography were not too small to be ignored.

Forest dynamics were studied for individuals > 15 cm in girth of 24 most common species in eight plots along the peat doom. The peat swamp forest was categorized as moderately dynamic in terms of the rate of tree growth, mortality and recruitment. The recorded demographic turnover rates of these plots were comparable to those in lowland tropical rain forests on dry land. Two environment factors (peat depth and distance to river) were significantly correlated with tree mortality and recruitment rate.

The early-phase recovery of vegetation after forest fire was recorded to quantify the regeneration properties of peat swamp forests. The vegetation recovery was studied in three sites with five plots with different post fire age and the degree of fire disturbance. The study examined plant species composition, biomass, and nutrient content in biomass and soil. The results show that the post-fire vegetation was dominated by light-demanding ferns, and recovery after fire was much slower than other tropical forest types (2 t/ha biomass after 4 years at most), and there was a large variation in the speed of recovery according to the degree of disturbance and peat depth. Contents of P and K per dry biomass were lower in young regeneration, despite that those contained in soils did not increase with age after fire. The lack of variation in pioneer tree species partly explains the slow vegetation recovery after fire. Interestingly, K content in soil was relatively high in shallow peat when there were a lot of remaining tall trees. This suggests that remaining trees on shallow peat play an important role of nutrient uptake which contribute to quick vegetation recovery.

The examination committee of this paper recognized that these results provide essential information for the planning of management and reforestation of endangered tropical wetland forests. The committee also evaluated the great effort of the applicant in intensive field work

and skillful laboratory work in vegetation science, thereby concluded that the applicant is eligible for the degree of Doctor of Philosophy (Environmental Science).