Ecological Restoration of A Logged-over Area in the South Bolaang Mongondow Rainforest

Restorasi Ekologis Pasca Penebangan di Hutan Hujan Bolaang Mongondow Selatan

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ABSTRACT

This research has been conducted over the past 12 years and was aimed to gain understanding on the complex interactions involved in the maintaining and restoring biodiversity that might influence the flow of ecosystem services. The method used in this study is annual measurement and observation conducted through surveys into similar sites conducted in every November to December since 2004. Stand structures consist of indicators of tree density, tree structure, crown coverage, and species composition. Function and sustainability are describes through biodiversity (Shannon index), natural colonization (abundance), wildlife density and status (species richness), nutrient retention (litter fall and decomposition), soil and water quality (erosion and sedimentation, soil physics, water debit and clarity). This study is still going on addressing an important question, that is "How long does it take for degraded forest land to achieve certain biodiversity or functional outcomes?" In relation to that, some indicators have begun to show certain patterns and tendencies.

Key words: forest restoration, rainforest, biodiversity, Sulawesi

ABSTRAK

Penelitian ini dilakukan selama 12 tahun terakhir dan bertujuan untuk mendapatkan pemahaman tentang interaksi kompleks yang terlibat dalam pemeliharaan serta pemulihan keanekaragaman hayati yang pada giliorannya mempengaruhi aliran jasa ekosistem. Metode yang digunakan dalam penelitian ini adalah pengukuran dan pengamatan tahunan yang dilakukan melalui survei ke plot-plot tetap pada setiap bulan November hingga Desember sejak tahun 2004. Struktur tegakan diindikasikan oleh kerapatan pohon, struktur pohon, tutupan tajuk, dan komposisi spesies. Fungsi dan keberlanjutan diindikasikan oleh keanekaragaman hayati (indeks Shannon), kolonisasi alami (kelimpahan), kepadatan dan status satwa liar (kekayaan spesies), retensi nutrisi (serasah dan dekomposisi), kualitas tanah dan air (erosi dan sedimentasi, fisika tanah, debit air, dan kejernihan). Studi ini masih terus membahas pertanyaan penting, yaitu "Berapa lama waktu yang dibutuhkan oleh lahan hutan terdegradasi guna mencapai hasil keanekaragaman hayati atau fungsi tertentu dari ekosistem? Untuk itu beberapa indikator telah mulai menunjukkan pola dan tendensi tertentu.

Kata kunci: restorasi hutan, hutan hujan, biodiversitas, Sulawesi

INTRODUCTION

Forest structure and function indicate the health and stability of this ever altered ecosystem particularly in the wet tropics. Silvicultural treatments, forest dynamics, and disturbance processes are among the factors behind the present state of a forest ecosystem let alone forest plantation in the wet tropic. Such indication has compromised forest ecosystem structure and functioning, despite their high-diversity of native tree and shrub species

Forest rehabilitation involves complex combinations of biological, physical, social and economic aspects. It usually takes many years as successional processes are involved. Such process as widely known can be unpredictable in nature; added to that is the role as well as impact to the communities. Several ecological indicators have been used to monitor the positive direction of rehabilitation or restoration (Lamb & Gilmour 2003). One of them is landscape stability indicated by forest structure, composition, and functions.

This long-term study had focused in secondary rainforest following logging activity in the past 12 years. Some intensively logged area had been planted with mixed industrial trees; however, there are still mosaics of natural rainforest maintained for wildlife corridors and natural regeneration. Data measured since 2004 include quantities of stand structure and composition; also ecological functions in stabilizing the soils, quality of water in streams, and the role of catchment area. The research question is that how long it takes for degraded forestland in order to achieve certain biodiversity or functional outcomes. Based on that, the purpose of this research stage is to gain understanding on the complex interactions involved in the maintaining and restoring biodiversity that might influence the flow of ecosystem services.

SITE AND METHODS

The study had been conducted in the managed forest of South Bolaang Mongondow, the province of North Sulawesi within the coordinates of 124^0 07' 05" to 1240 12' 29" East and 0^0 24' 57" to 0^0 29' 42" North (Figure 1). The whole area is 4,808.50 ha and presently well-managed by a private company (PT. *Kawanua Kahuripan Pantera*). The altitude ranges from 100 to 980 m above sea level; the average rainfall is 2,385 $mm.yr^{-1}$ and the area has been categorized as type A Schmidt & Fergusson.

Fig.1. Location of study area within the province of North Sulawesi

Gbr. 1. Lokasi penelitian di provinsi Sulawesi Utara.

The method used in this study was annual measurement and observation conducted through surveys into similar sites conducted in every November to December since 2004. Established plots within logged-over and rainforest areas were surveyed for stand structures and measures of function and sustainability. Stand structures consist of indicators of tree density, tree structure, crown coverage, and species composition. Function and sustainability were described through biodiversity (Shannon index), natural colonization (abundance), species richness, nutrient retention (litter fall and decomposition), soil and water quality (erosion and sedimentation, soil physics, water debit and clarity). All data once collected were then analyzed and compared to previous measurements and observations presented in tables and graphs.

RESULTS

Some of the results presented in this publication stage can be summarized here. As the research is still being conducted to date, final findings and conclusion will be reported with time.

A. Stand Structure

Tree density/ Kerapatan Pohon

The average tree density (trees 10 cm or above in diameter) in the rainforest is 1232 trees per ha. Woody lianas are common, and bamboos are sometimes present (Figure 1). The density of tropical ferns, aroids, orchids, mosses, and lichens varies with moisture regime.

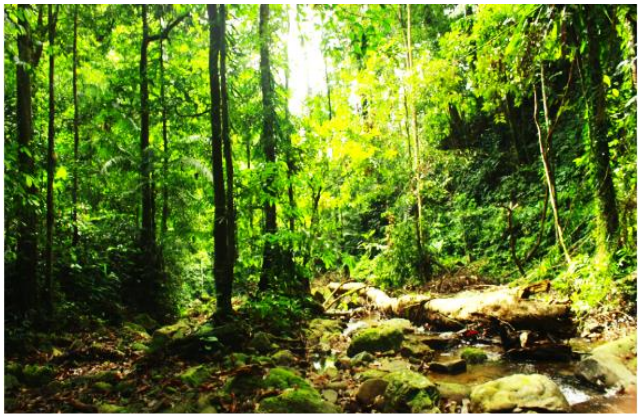

Fig. 1. Rainforest with small river of permanent flow

Gbr. 1. Hutan hujan dengan sungai permanen kecil.

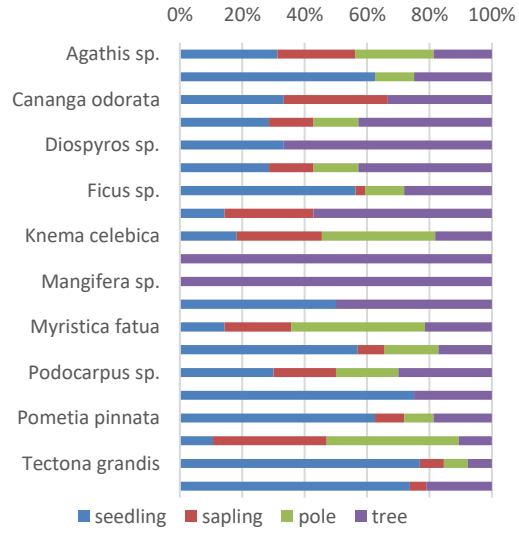

Fig. 2. Distribution (%) of tree growth phase

Gbr. 2. Distribusi (%) fase pertumbuhan pohon.

The dominant, middle layer, are between 15 and 35 m aboveground. The top layer is formed by *Palaquium* sp., *Pterospermum*, *Ficus* sp., and *Pometia* sp. as dominant species whose crowns reach up to 40–45 m. These trees are generally cylindrical boles and possess an umbrella-shaped top crown. The bottom layer consists of shade-tolerant trees, less than 15 m in height.

Tree structure/ Struktur Pohon.

Tree growth basic phases (seedling, sapling, pole, and mature trees) were monitored to see the regenerative prospect of the rainforest. Figure 2 showed one of the 5 sites observed and measured. *Koordersiodendron pinnatum* and *Mangifera* sp. need replanting as no longer younger trees were observed. Positive natural regeneration were shown by almost the rest of the tree species.

Crown coverage.

This is the proportion of the forest floor covered by the vertical projection of the tree crowns and hence determine the amount of light able to penetrate to the forest floor. Each tree's measurements are used to calculate the area projected by the crown onto the ground. This measure was obtained by summing the crown areas for all trees measured on a fixed plot area and then dividing it by the ground area. Exact cover measurements were made in vertical direction; and crown coverage is the proportion of a stand covered by the crowns of live trees. To date, crown structure of the forest can be differentiated into 4 layers resulting a range between 74 to 90% or categorized as dense to very dense (Brack 1999).

Tree species composition. Species composition provides the essential description of forest character at a site and time; thus can function as an attribute in forest inventory and monitoring. It is therefore an important indicator of ecological and management processes at a site. The relative contribution of a species also signifies its dominance in the vegetation and its ability to capture resources. Figure 4 shows the dominance of *Pometia pinnata*, *Palaquium* sp., *Pterospermum celebicum*, and *Ficus* sp. indicating late successional stage of the forest. Most of the species composed in the forest & Saprovide sources of shelter and food for wildlife including *Ailurops ursinus* (kuskus), *Anoa depressicornis*, *Tarsius spectrum, Macaca nigra, Sus celebensis, Viverra tangalunga, Prosciurillus leucomus, Paruromys dominator, Lenomys meyeri,* and *Maxomys hellwandii* reportedly found in the area. Such composition can determine their range condition as well as trend, which are valuable tools to judge the impact of previous management and guide future decisions. In the whole, species composition within the area consisting of secondary [S], primary [P], and wildlife [W] species gives a proportion of 20:68:12 for S:P:W.

Fig. 3. Typical dense crown coverage in the location

Gbr. 3. Gambaran tutupan tajuk rapat di lokasi penelitian.

This shows a significant portion of primary plant species in the area. *Pometia pinnata* (local name: *matoa*) are common along riverbanks, forest edges, and even open forest area; so it can be indicator to primary as well as secondary forest. The seeds are abundant on the forest floor, and once they become seedlings, the growth onward are usually fast. The other dominant tree species (*Palaquium* sp. with a local name: nantu) grows up to 30 m tall with distinctive bark (reddish brown). They are found abundant particularly in moist habitat.

Function and Sustainability

Biodiversity between forest plantation and the remaining intact forest was compared using Shannon Index indicating closer variation with time (Figure 5). Natural colonization (measured from abundance index) also shows closed values, in fact, compatible between the two. This is shared also by the wildlife.

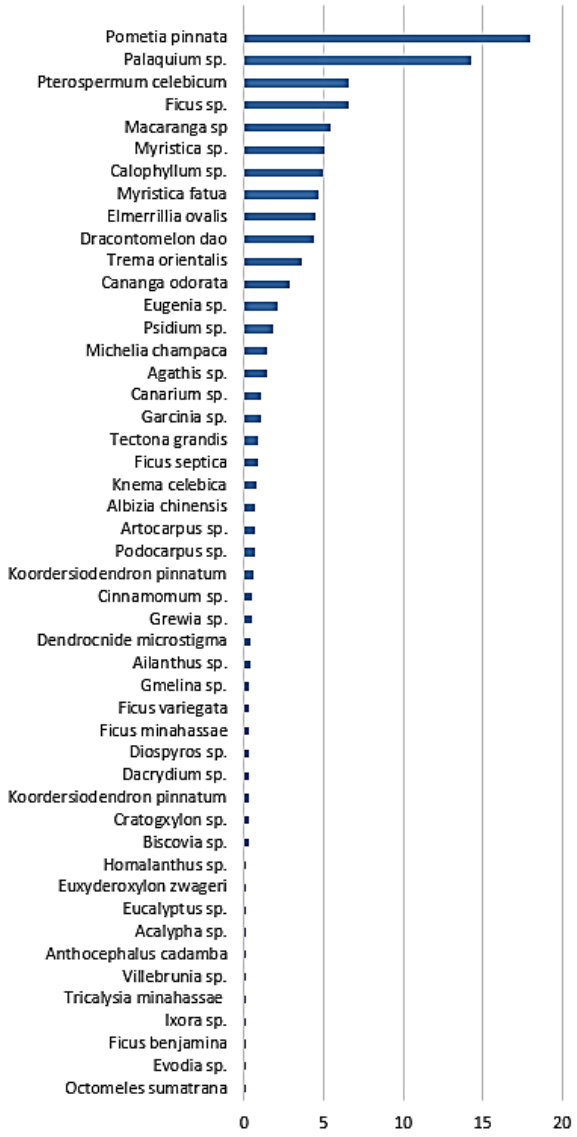

Fig. 4. Percentage composition of rainforest

Gbr. 4. Persentase komposisi hutan hujan.

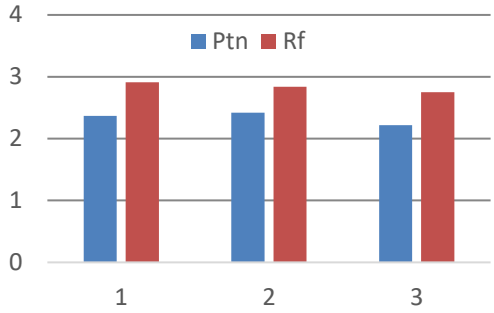

Fig. 5. Biodiversity index comparing forest plantation (secondary) and primary forest

Gbr. 5. Indeks keanekaragaman hayati membandingkan hutan tanaman (sekunder) dan hutan primer.

Nutrient retention (through the magnitude of litter deposition & decomposition) was still generally higher in remaining rainforest compared to the plantation. When the forest is harvested, nutrients will be lost from the ecosystem, but the outputs cannot exceed inputs for very long because the stock of nutrient capital in the system will be depleted. The nutrients that were in the tree biomass are simply removed from the system. Because there was only a small stock of nutrients in the soil and most of the nutrients were in the biomass, there is little nutrient stock remaining to support regrowth.

Root biomass is highest where soil quality is poorest, and vice-versa. When soil nutrients are high, the tree does not need to spend as much energy in building roots to forage in the soil for new nutrient sources. Litter decomposition was relatively lower at the less fertile sites. This might be because leaves are held longer under poor growth conditions; hence their turnover time is longer. Moreover, since they are exposed to herbivores longer they must be protected better or become less palatable. This causes slow decomposition of the leaves once they are dropped to the forest floor. In this light, forest productivity can be detained.

This study is still going on addressing an important question, that is “How long does it take for degraded forest land to achieve certain biodiversity or functional outcomes?” The challenge would be that how to bring restoration from a site-based activity up to a landscape activity so that biodiversity & production (and hence poverty alleviation) might be better addressed.

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