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論文（Original Article）

# Height Growth Relationships in Secondary Plant Communities in Kalimantan for Forestry Projects under the Clean Development Mechanism of COP 7

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**Abstract**

We classified the secondary vegetation of degraded ecosystems in the humid tropics of Indonesian Borneo (Kalimantan) into 5 plant communities and analyzed their overstory height growth. Each community had a different growth curve, although the status of the soils was considered to be less variable. Overstory height was similar among plant communities during the initial stages of their establishment, but 2 or 3 y later, communities of trees (including species of small trees up to about 10 m high) were obviously taller than communities of shrub and short grass. The mean annual increment in overstory height, which is considered to be an index of the increase in biomass, varied with community type and age. Forest establishment in areas where shrubs and short-grass communities have become established may greatly increase overall carbon-fixation rates by vegetation. For forestry projects under the clean development mechanism (CDM), sites where are shrub and short-grass communities are considered to be most suitable, provided that fire prevention is done properly, because shrubs and short grasses are burned easily.

**Key words** : baseline scenario, height growth, biomass, afforestation, reforestation, Kyoto Protocol, CDM

## Introduction

The "clean development mechanism" (CDM) is a part of the Kyoto Protocol designed to help developed countries meet their legal commitments for reducing the emission of greenhouse gases and contribute to sustainable development in developing countries. At COP 7, afforestation and reforestation were included as activities under CDM. This inclusion can act as a stimulus to investment in plantation forestry.

"Additionality" is one of the important conditions for certification of a CDM project. Even if the project has not been implemented, the original vegetation already contains some carbon. This is called the "baseline scenario" and the amount of carbon in new plantations must be greater than ("additional to") that in the baseline scenario for the project to obtain carbon credits (certified emissions reductions, or CERs).

To estimate baselines we must quantify carbon stock in various types of vegetation. In the humid tropical regions of Indonesia, vegetation types differ according to the degree of disturbance by human intervention, wild-fires, and other factors. Differences in vegetation type can affect growth trends, depending on the dominant plant species.

Overstory height can be a useful parameter for estimating the biomass and carbon stock in vegetation. The overstory height of a closed community is considered to be a approximate index of biomass levels, because it is in direct proportion to the aboveground biomass in various forest stands, other than those populated primarily by dwarf plants (Kira et al., 1967). The biomass density of fully closed forest stands is mostly between 1.0 and 1.5 kg/m$^3$ (Kira et al., 1967), and that of *Imperata* grass communities in East Kalimantan is 1.8 ± 0.7kg/m$^3$ (Kiyono and Hastaniah, unpublished data). Although biomass density of *Imperata cylindrica* is a little larger than that of forest stands, overstory height is regarded as a parameter of carbon stock in the biomass for both forests and grass communities.

This report classifies lowland vegetation in East Kalimantan, one of the humid tropical regions of Indonesia, and provides information on the patterns of

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overstory height growth of each type of vegetation. This study was conducted as a part of Demonstration Study on Carbon Fixing Forest Management Project in Indonesia (Japan International Cooperation Agency (JICA)), and the methodology for converting overstory height to community biomass is being studied by JICA and others.

## Materials and methods

East Kalimantan is one of 4 provinces in Indonesian Borneo. It includes the southeastern parts of the central mountain ranges of the island and lies between approximately 4 ° north and 2 ° south latitude. Old igneous and volcanic rocks are found in the central mountain area, and most of the lowlands and hills of the province are composed of sedimentary deposits (TAD, 1982). The major soils are Dystropepts in the mountains and Tropudults (acid soils) on the plains. The climate of East Kalimantan is typical of the equatorial tropics, and air temperatures are relatively constant at around 28 ± 1℃ throughout the year (Fatawi et al., 2000). Mean annual precipitation is high - over 3000 mm - in the central mountains and northern parts of the province and below 2000 mm in the coastal lowlands in the central parts of the province, which are the driest parts (TAD, 1982). About 76% of the total forest in East Kalimantan is non-convertible according to the present land utilization plan (Fatawi et al., 2000).

In this region, slash-and-burn agriculture and forest fires are major agents in the degeneration of forests (succession to non-forest ecosystems) and regeneration of pyrophytic forest species (Kiyono et al., 2000). After commercial selective logging for a *Shorea* species group since the late 1960s in primary dipterocarp forests,farmers migrated into the logged-over forest and started slash-and-burn farming. Frequent wildfires resulted from the increased farming activity. Drought and fires in 1982-83, 1987, 1991, 1994, 1997-98, and other years had a large influence on the structure of plant communities in the region. The base nutrient status of soils under degraded ecosystems (secondary forests) was improved, rather than worsened compared with primary ecosystems in lowland East Kalimantan, although available nitrogen levels were lower in the *Imperata* grassland than in the other areas, and the stock level of available phosphorus in the surface soil layer decreased in the order of primary forests > secondary forests > grassland (Ohta et al., 2000).

Data such as the community age, overstory height, and botanical names of the dominant overstory species were collected from 165 secondary plant communities in lowland East Kalimantan (Appendix). Overstory height (Appendix) represents the mean height of at least several plants composing the uppermost surface of the community. Height was measured with a measuring rod or estimated geometrically by holding a stick at arm's length. In the field survey, information on land-use history, past fire events, and other disturbances was also collected. Community age (Appendix) was determined by monitoring research plots or by tree ring analyses for the stand of *Peronema canescens*, which is deciduous and forms clear annual rings in Kalimantan (Oobayashi et al., 1992), or by interviewing local people with regard to past fire events and farmland owners for their land-use histories.

## Results and discussion

### Plant communities

The 165 communities were classified into 5 distinct types on the basis of past land use and the ecological characteristics of the dominant overstory species. The 5 community types were as follows:

- A: primary forests and logged and burned forests that had not yet undergone slash-and-burn farming and that were often dominated by *Macaranga gigantea.* Dipterocarps were occasionally found. They are relatively long-lived, grow to over 30 m tall, and are usually highly vulnerable to felling and burning (Kiyono et al., 2000). The oldest among the surveyed communities was 17 y (Appendix).
- B: pyrophytic forests in swidden (slashed and burned) land and other disturbed land. If slash-and-burn farming had been carried out at least once, the stands contained many pyrophytic trees such as *Schima wallichii.* These trees are usually long-lived and grow to over 30 m. The oldest community among the surveyed communities was 95 y (Appendix). They are little vulnerable to felling and burning (Kiyono et al., 2000). Unlike canopies of the other community types (usually fully closed), the canopy of type B community was sometimes not closed (84 ± 19% coverage on average), and thick lianas were occasionally found. These communities were usually located in areas under slash-and-burn farming near villages. The ages of the communities depended on the cycle of slash-and-burn. If the area was abandoned and fire does not enter it, pyrophytic trees can grow tall. Since the canopy of this type of community is not fully closed, the aboveground biomass of this community can be overestimated when only the parameter of overstory height is used.
- C: forests of small tree species. In the study stands after the first cycle of slash-and-burn agriculture, *Macaranga gigantea* became sparse and *Macaranga trichocarpa*, *Mallotus paniculatus*, *Omalanthus populneus*, *Trema* spp., and other species formed small-tree forests. These are composed of small tree species that reach heights of up to about 10m. The

mean stand height was 5.4 m at 4.3 y (Kiyono et al., 1997), whereas type A communities reach about 10 m after 5 y (Matius et al., 1993). Small tree species are relatively short lived and less vulnerable to felling and burning. The oldest among the communities surveyed was 6 y (Appendix).

- D: shrub communities. After the second slash-and-burn cycle, shrub species such as *Austroeupatorium inulifolium* and *Piper aduncum* became dominant in the fallowed stands, and the small tree species found in type C communities became sparse. The stand heights usually reached about 2 or 3 m. Both *Austroeupatorium inulifolium* and *Piper aduncum* are exotic plants from the Americas.
- E: grassland or savanna established after human disturbance in which *Imperata cylindrica* is the dominant species.

Type D and E communities are always disturbed by fire. In this survey, D and E communities more than 4 y old could not be found (Appendix).

The main successional sequences among the 5 communities studied in East Kalimantan are presented in Fig. 1 (modified from Kiyono et al., 1997).

**Height growth**

We approximated the relationships between community age (Y, in years) and overstory height (H, in m) for each community assuming that the relation could indicate approximately the pattern of overstory height growth in each community. The results were shown in Table1 and Fig. 2.

Each community had a different growth curve. Overstory heights were similar in the first year of community establishment, but by the third or fourth year, types A, B, and C communities were obviously taller than types D and E communities (Fig.2). The mean annual increment of overstory height, which is considered to be an approximate index of biomass increment, varied with community type and age.

**Factors responsible for height growth**

The patterns of overstory height growth are influenced by environmental factors including soil conditions as well as ecological characteristics of plant species such as the lifespans and maximum heights of the dominant species in the community, and others. Among them, soil conditions cannot greatly affect the pattern of overstory height growth in the research sites, since the status of the soil seemed not to be much variable among the research

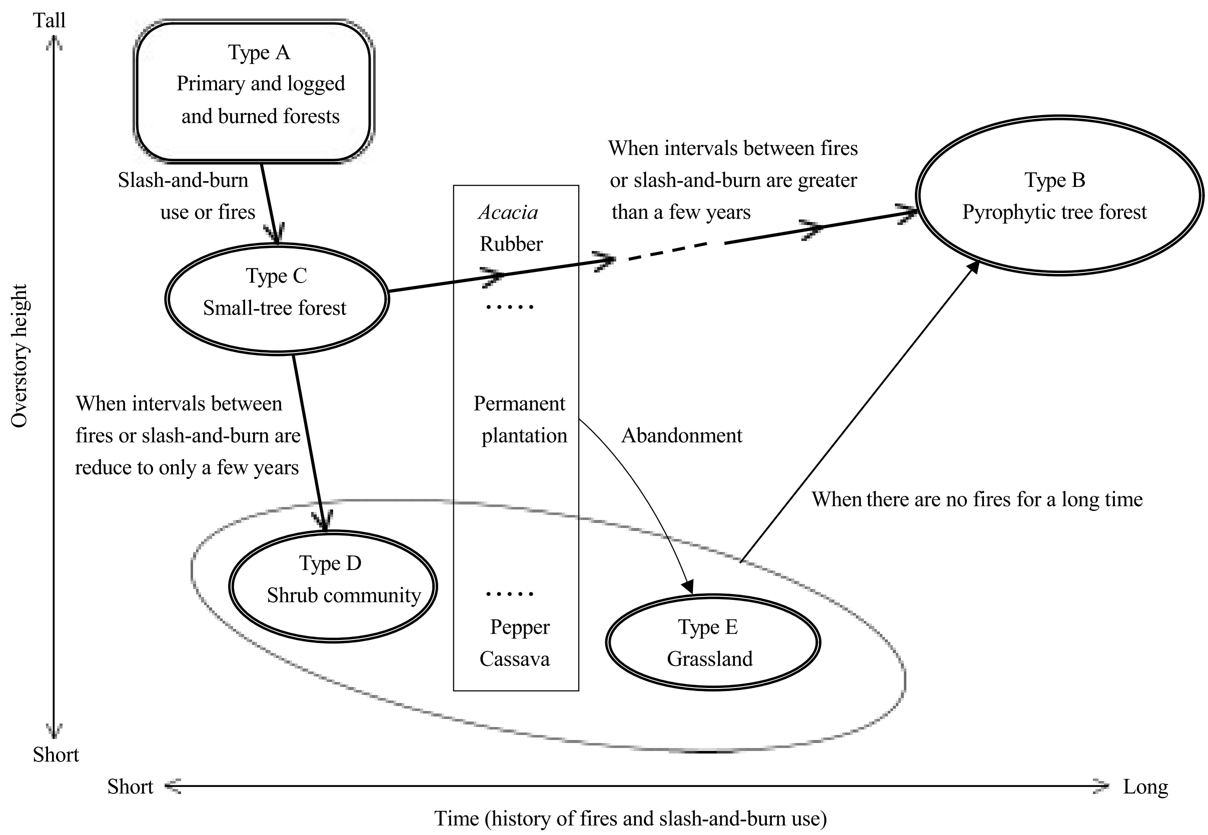


Fig. 1. Successional sequence of secondary plant communities in lowland East Kalimantan (modified from Kiyono and Hastaniah 1997). The arrows (→) represent crop production by slash-and-burn or fires. This figure shows the seral relations between the 5 types of plant community: primary and logged and burned forests, in which many dipterocarps and *Macaranga* trees are found (type A); pyrophytic forests in swidden and other disturbed land (type B); small-tree forests (type C); shrub communities (type D); and grassland or savanna in which *Imperata cylindrica* is the dominant species (type E).

Table 1. Regression equations for the 5 community types studied.

| Community type* | Regression equation** | $R^2$ | $P$ | Range of community ages (y) |
|---|---|---|---|---|
| A | $H = 17.6/(1+12.4e^{-0.803Y})$ | 0.866 | < 0.01 | 0.58-17 |
| B | $H = 15.1/(1+4.73e^{-0.428Y})$ | 0.691 | < 0.01 | 0.58-95 |
| C | $H = 4.90/(1+7.17e^{-3.91Y})$ | 0.637 | < 0.01 | 0.58-6 |
| D | $H = 2.61/(1+5688e^{-50.6Y})$ | 0.193 | 0.068 | 0.17-4 |
| E | $H = 1.19/(1+2.75e^{-6.61Y})$ | 0.419 | < 0.01 | 0.33-3.5 |

* A: primary and logged and burned forests. B: pyrophytic forests.
C: forests of small-tree species. D: shrub communities. E: grassland or savanna.
** H: overstory height (m), Y: community age (years)

sites (Ohta et al., 2000). In types A and B communities, the dominant species are relatively long-lived trees that reach heights of 30 m or more (Kiyono et al., 1997). *Macaranga gigantea* is a typical species in type A communities, and most of these trees are highly vulnerable to fire; in contrast, the dominant species of type B communities are usually pyrophytic trees (Kiyono et al., 1997, 2000). Type A communities grow faster than type B communities (Fig. 2) because of rapid initial growth of *Macaranga gigantea* and other pioneer trees.

The dominant species of type C communities are small-tree pioneer species that grow fast in their initial few years of development. However, they are relatively short-lived and reach at most to 10 m in height. Few such communities may last more than 10 y before regeneration or succession to another community occurs.

The dominant species of type D communities are shrubs up to about 2 or 3 m tall, whereas short grasses

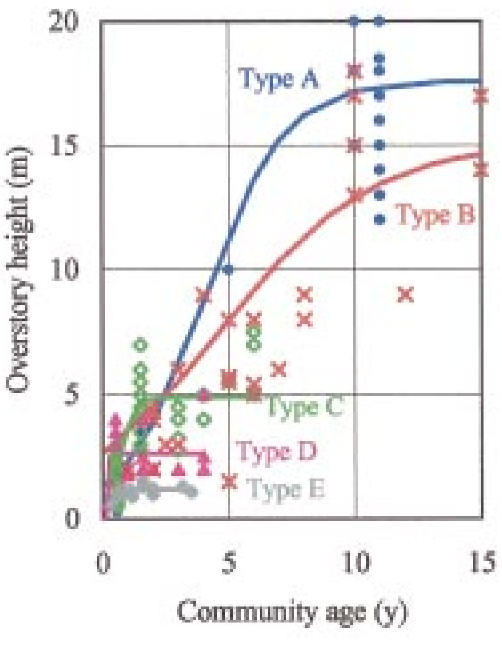


Fig. 2. Growth of mean overstory height in the secondary plant communities studied in lowland East Kalimantan. Regression equations for the 5 community types are given in Table 1.

such as *Imperata cylindrica* dominate type E communities. Few type D and E communities remain undisturbed for more than 3 or 4 y, because they usually lie close to villages and are easily burned during droughts. Our monitoring in East Kalimantan (20 localities for 34 months from December 1995, unpublished data) revealed that typical *Imperata* grassland containing scattered shrubs burned about once every 2 y, then recovered almost immediately. These repeated wildfires are an important factor in maintaining types D and E communities.

**Types of communities suitable as baselines for CDM projects**

From this research, it became clear that each community type has a different growth curve. If community height data are converted into biomass and carbon stock, it will therefore be possible to estimate baselines by determining the type of communities. Since overstory height is regarded as a parameter of carbon stock in the biomass for both forests and grass communities, growth curves in Fig. 2 are considered to show differences in the rate of carbon fixation in natural vegetation.

Of the 5 communities at the initial stages of their establishment, type A communities grow largest. This means that the carbon credit obtained by establishing plantation forests in such sites will be smaller. Type B communities grow slower than type A, but the potential for carbon accumulation by this type is high in the long term if fire does not affect the vegetation. In such cases, the total amount of carbon credit depends on the crediting period of the project. Type C communities are short-lived and have smaller potential for carbon accumulation than types A and B.

The ranges of net primary productivity (NPP) of shrub and short-grass communities were as follows: 12.8-17.0 Mg $ha^{-1}y^{-1}$ (aboveground) for an *Austroeupatorium inulifolium* community (type D, unpublished data); and 17.7-29.0 Mg $ha^{-1}y^{-1}$ for an *Imperata cylindrica* community (type E, Kiyono et al., 1997). The productivities of these communities are thus comparable to the values reported for forests in the tropics: 25.8 Mg $ha^{-1}y^{-1}$ for *Schima wallichii* secondary forest (type B, Kiyono et al., 1997); 26.9 Mg $ha^{-1}y^{-1}$ for mature dipterocarp forest (type A) (Kira, 1978); and 14.7-17.5 Mg $ha^{-1}y^{-1}$ (aboveground) for disturbed dipterocarp forest (type A) (Toma et al., 2000). However, the high NPP in types D and E communities does not result in biomass accumulation within the vegetation, because shrubs and short-grasses cannot grow tall, and more important, their communities are usually destroyed by fire or other disturbances and rarely succeeds to secondary forest. In these communities the overall rates of carbon fixation into biomass must therefore be low. Fire prevention in types D and E communities will accelerate biomass accumulation within the vegetation, and conversion of types D and E communities into plantations (man-made forests) may increase the net carbon-fixation rates far more than conversion of young communities of types A, B, and C into plantations.

In the Marrakesh Accords (codified in COP 7, 2001), one of the definitions of forest is "with potential to reach a minimum height of 2-5 meters at maturity in *situ*". Afforestation can be implemented on "land that has not been forested for a period of at least 50 y" and "reforestation activities will be limited to reforestation occurring on those lands that did not contain forest on 31 December 1989" for the first commitment period. According to the definitions, vegetation in types A, B, and C communities falls into "forest", because the overstory heights in these communities can reach about 5 m or more (Fig. 2). These definitions considerably limit the areas in which CDM projects can be implemented. A final decision regarding these definitions will be made in COP 9, which will take place in 2003.

In conclusion, for forestry projects under the CDM, sites containing types D and E communities are currently the most suitable. If plantation forests are established in areas of these types by CDM projects, fire control will be carried out carefully to protect the carbon sequestered in the biomass of the plantations, and their risk of being burned will be reduced. Carbon credits gained by the project will be greater if the forests are managed properly.

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Appendix Summary of dominant species, overstory height, and community age of the secondary plant communities studied in degraded ecosystems in lowland East Kalimantan.

| Plant community type [1] | The most dominant species in overstory | Overstory height m | Community age y | Plot size [10] m² | Locality (Kecamatan) | Source |
|---|---|---|---|---|---|---|
| A | *Anthocephalus cadamba* | 13 [2] | 11 [4] | 7500 | Muara Badak | |
| A | *Anthocephalus cadamba* | 13 [2] | 11 [4] | 7500 | Muara Badak | |
| A | dipterocarps | 18.5 [2] | 11 [4] | 20000 | Muara Badak | |
| A | *Macaranga gigantea*, *Vernonia arborea* | 3.5 [2] | 1.5 [6] | 4 | Samboja | |
| A | *Macaranga gigantea* | 1 [2] | 0.58 [6] | 4 | Samboja | |
| A | *Macaranga gigantea* | 0.5 [2] | 0.58 [6] | 4 | Samboja | |
| A | *Macaranga gigantea* | 0.5 [2] | 0.58 [6] | 4 | Samboja | |
| A | *Macaranga gigantea* | 0.48 [2] | 0.58 [6] | 4 | Samboja | |
| A | *Macaranga gigantea* | 0.32 [2] | 0.58 [6] | 4 | Samboja | |
| A | *Macaranga gigantea* | 0.3 [2] | 0.58 [6] | 4 | Samboja | |
| A | *Macaranga gigantea* | 1 [2] | 0.58 [6] | 4 | Samboja | |
| A | *Macaranga gigantea* | 10 [3] | 5 [4] | 3600 | Samboja | 11) |
| A | *Macaranga gigantea* | 20 [2] | 10 [4] | 314 | Samboja | 12) |
| A | *Macaranga gigantea* | 23 [2] | 10 [4] | 415 | Samboja | 12) |
| A | *Macaranga gigantea* | 24 [2] | 10 [4] | 452 | Samboja | 12) |
| A | *Macaranga gigantea* | 23 [2] | 10 [4] | 415 | Samboja | 12) |
| A | *Macaranga gigantea* | 15 [2] | 10 [4] | 177 | Muara Jawa | 12) |
| A | *Macaranga gigantea* | 21 [2] | 10 [4] | 346 | Muara Jawa | 12) |
| A | *Macaranga gigantea* | 18 [2] | 10 [4] | 254 | Muara Jawa | 12) |
| A | *Macaranga gigantea* | 15 [2] | 11 [4] | 2500 | Muara Badak | |
| A | *Macaranga gigantea* | 17 [2] | 11 [4] | 5000 | Muara Badak | |
| A | *Macaranga gigantea* | 12 [2] | 11 [4] | 70000 | Muara Badak | |
| A | *Macaranga gigantea* | 14 [2] | 11 [4] | 5000 | Muara Badak | |
| A | *Macaranga gigantea* | 18 [2] | 11 [4] | 10000 | Muara Badak | |
| A | *Macaranga gigantea* | 18 [2] | 11 [4] | 10000 | Muara Badak | |
| A | *Macaranga gigantea* | 20 [2] | 11 [4] | 10000 | Muara Badak | |
| A | *Macaranga gigantea* | 20 [2] | 11 [4] | 20000 | Muara Badak | |
| A | *Macaranga gigantea* | 24 [3] | 17 [4] | 3600 | Samboja | 13) |
| A | *Macaranga triloba* | 0.8 [2] | 0.58 [6] | 4 | Samboja | |
| A | *Macaranga triloba* | 0.75 [2] | 0.58 [6] | 4 | Samboja | |
| A | *Macaranga triloba* | 1.4 [2] | 0.58 [6] | 4 | Samboja | |
| A | *Macaranga triloba* | 14 [2] | 11 [4] | 2500 | Muara Badak | |
| A | *Macaranga triloba* | 14 [2] | 11 [4] | 1670 | Muara Badak | |
| A | *Macaranga triloba* | 14 [2] | 11 [4] | 830 | Muara Badak | |
| A | *Macaranga triloba* | 17 [2] | 11 [4] | 15000 | Muara Badak | |
| A | *Macaranga triloba* | 16 [2] | 11 [4] | 8330 | Muara Badak | |
| A | *Macaranga triloba* | 16 [2] | 11 [4] | 16670 | Muara Badak | |
| B | *Artocarpus* sp. | 4.3 [2] | 2 [5] | 15 | Samboja | 12) |
| B | *Artocarpus* sp. | 5.7 [2] | 5 [5] | 26 | Samboja | 12) |
| B | *Artocarpus* sp. | 5.4 [2] | 6 [5] | 23 | Muara Jawa | 12) |
| B | *Artocarpus* sp. | 17 [2] | 10 [5] | 227 | Samboja | 12) |
| B | *Artocarpus* sp. | 18 [2] | 10 [5] | 254 | Muara Jawa | 12) |
| B | *Artocarpus* sp. | 15 [2] | 10 [5] | 177 | Muara Jawa | 12) |
| B | *Artocarpus* sp. | 17 [2] | 10 [5] | 227 | Muara Jawa | 12) |
| B | *Elaeocarpus* sp. | 3 [2] | 2.5 [5] | no data | Barongtongkok | 12) |
| B | *Elaeocarpus* sp. | 5 [2] | 6 [5] | no data | Barongtongkok | 12) |
| B | *Peronema canescens* | 21.9 [3] | 95 [9] | 1100 | Kuaro | 12) |
| B | *Schima wallichii* | 2 [2] | 1 [5] | no data | Barongtongkok | 12) |
| B | *Schima wallichii* | 4 [2] | 2 [5] | no data | Barongtongkok | 12) |
| B | *Schima wallichii* | 2 [2] | 2 [5] | no data | Barongtongkok | 12) |
| B | *Schima wallichii* | 6 [2] | 3 [5] | no data | Barongtongkok | 12) |
| B | *Schima wallichii* | 3 [2] | 3 [5] | no data | Barongtongkok | 12) |
| B | *Schima wallichii* | 8 [2] | 6 [5] | no data | Barongtongkok | 12) |
| B | *Schima wallichii* | 5 [2] | 6 [5] | no data | Barongtongkok | 12) |
| B | *Schima wallichii* | 6 [2] | 7 [5] | no data | Barongtongkok | 12) |

| Plant community type [1] | The most dominant species in overstory | Overstory height m | Community age y | Plot size [10] m² | Locality (Kecamatan) | Source |
|---|---|---|---|---|---|---|
| B | *Schima wallichii* | 8 [2] | 8 [5] | no data | Barongtongkok | [12] |
| B | *Schima wallichii* | 9 [2] | 8 [5] | no data | Barongtongkok | [12] |
| B | *Schima wallichii* | 9 [2] | 12 [5] | no data | Barongtongkok | [12] |
| B | *Schima wallichii* | 14 [2] | 15 [5] | no data | Barongtongkok | [12] |
| B | *Schima wallichii* | 17 [2] | 15 [5] | no data | Barongtongkok | [12] |
| B | *Schima wallichii* | 10 [2] | 16 [5] | no data | Barongtongkok | [12] |
| B | *Schima wallichii* | 10 [2] | 20 [5] | no data | Barongtongkok | [12] |
| B | *Schima wallichii* | 8 [2] | 26 [5] | no data | Barongtongkok | [12] |
| B | *Schima wallichii* | 18 [2] | 31 [5] | no data | Barongtongkok | [12] |
| B | *Schima wallichii* | 18 [2] | 33 [5] | no data | Barongtongkok | [12] |
| B | *Vernonia arborea*, *Macaranga gigantea* | 1.25 [2] | 0.58 [6] | 4 | Samboja | |
| B | *Vitex pinnata*, *Vernonia arborea* | 5.5 [2] | 5 [5] | 28 | Samboja | [12] |
| B | *Vernonia arborea* | 15 [2] | 10 [5] | 177 | Samboja | [12] |
| B | *Vernonia arborea* | 13 [2] | 10 [5] | 133 | Samboja | [12] |
| B | *Vernonia arborea* | 15 [2] | 10 [5] | 177 | Samboja | [12] |
| B | *Vitex pinnata* | 4 [2] | 2 [5] | no data | Barongtongkok | [12] |
| B | *Vitex pinnata* | 9 [2] | 4 [5] | no data | Barongtongkok | [12] |
| B | *Vitex pinnata* | 1.5 [2] | 5 [5] | no data | Barongtongkok | [12] |
| B | *Vitex pinnata* | 8 [2] | 5 [5] | 50 | Samboja | [12] |
| B | *Vitex pinnata* | 13 [2] | 20 [5] | no data | Barongtongkok | [12] |
| C | *Mallotus paniculatus*, *Omalanthus populneus* | 4.5 [2] | 3 [5] | 20 | Muara Jawa | [12] |
| C | *Macaranga tanarius* | 2.5 [2] | 0.5 [7] | 25000 | Muara Badak | |
| C | *Macaranga tanarius* | 1.8 [2] | 0.5 [7] | 20000 | Muara Badak | |
| C | *Macaranga trichocarpa* | 0.64 [2] | 0.58 [6] | 4 | Samboja | |
| C | *Macaranga trichocarpa* | 0.5 [2] | 0.58 [6] | 4 | Samboja | |
| C | *Macaranga trichocarpa* | 0.76 [2] | 0.58 [6] | 4 | Samboja | |
| C | *Macaranga trichocarpa* | 5.0 [2] | 1.5 [6] | 4 | Samboja | |
| C | *Macaranga trichocarpa* | 3.0 [2] | 1.5 [6] | 4 | Samboja | |
| C | *Macaranga trichocarpa* | 4 [2] | 3 [5] | 13 | Muara Jawa | [12] |
| C | *Mallotus paniculatus* | 2.75 [2] | 3 [5] | 6 | Muara Jawa | [12] |
| C | *Mallotus paniculatus* | 3.25 [2] | 3 [5] | 8 | Muara Jawa | [12] |
| C | *Mallotus paniculatus* | 5 [2] | 4 [5] | 20 | Samboja | [12] |
| C | *Mallotus paniculatus* | 5.5 [2] | 5 [5] | 28 | Muara Jawa | [12] |
| C | *Mallotus paniculatus* | 7.5 [2] | 6 [5] | 51 | Samboja | [12] |
| C | *Mallotus paniculatus* | 7 [2] | 6 [5] | 50 | Samboja | [12] |
| C | *Mallotus paniculatus* | 5 [2] | 6 [5] | 28 | Muara Jawa | [12] |
| C | *Omalanthus populneus* | 1.7 [2] | 0.58 [6] | 4 | Samboja | |
| C | *Omalanthus populneus* | 0.7 [2] | 0.58 [6] | 4 | Samboja | |
| C | *Omalanthus populneus* | 2.8 [2] | 1.5 [6] | 4 | Samboja | |
| C | *Omalanthus populneus* | 4.0 [2] | 1.5 [6] | 4 | Samboja | |
| C | *Omalanthus populneus* | 5.5 [2] | 1.5 [6] | 4 | Samboja | |
| C | *Omalanthus populneus* | 7.0 [2] | 1.5 [6] | 4 | Samboja | |
| C | *Omalanthus populneus* | 4.5 [2] | 1.5 [6] | 4 | Samboja | |
| C | *Omalanthus populneus* | 3.5 [2] | 1.5 [6] | 4 | Samboja | |
| C | *Omalanthus populneus* | 3.0 [2] | 1.5 [6] | 4 | Samboja | |
| C | *Omalanthus populneus* | 3.5 [2] | 1.5 [6] | 4 | Samboja | |
| C | *Omalanthus populneus* | 4 [2] | 4 [7] | 10000 | Muara Badak | |
| C | *Trema cannabina*, *Omalanthus populneus* | 1 [2] | 0.58 [6] | 4 | Samboja | |
| C | *Trema cannabina* | 2 [2] | 0.58 [6] | 4 | Samboja | |
| C | *Trema cannabina* | 1.1 [2] | 0.58 [6] | 4 | Samboja | |
| C | *Trema cannabina* | 1.4 [2] | 0.58 [6] | 4 | Samboja | |
| C | *Trema cannabina* | 4.0 [2] | 1.5 [6] | 4 | Samboja | |
| C | *Trema cannabina* | 4.0 [2] | 1.5 [6] | 4 | Samboja | |
| C | *Trema cannabina* | 3.5 [2] | 1.5 [6] | 4 | Samboja | |

| Plant community type[1] | The most dominant species in overstory | Overstory height m | Community age y | Plot size[10] m² | Locality (Kecamatan) | Source |
|---|---|---|---|---|---|---|
| C | *Trema cannabina* | 4.5 [2] | 1.5 [6] | 4 | Samboja | |
| C | *Trema cannabina* | 6.0 [2] | 1.5 [6] | 4 | Samboja | |
| C | *Trema cannabina* | 5.5 [2] | 1.5 [6] | 4 | Samboja | |
| C | *Trema cannabina* | 4.0 [2] | 1.5 [6] | 4 | Samboja | |
| C | *Trema cannabina* | 4.5 [2] | 1.5 [6] | 4 | Samboja | |
| C | *Trema orientalis* | 4.0 [2] | 1.5 [6] | 4 | Samboja | |
| C | *Trema tomentosa* | 1.9 [2] | 0.58 [6] | 4 | Samboja | |
| C | *Trema tomentosa* | 2.6 [2] | 0.58 [6] | 4 | Samboja | |
| C | *Trema tomentosa* | 1.7 [2] | 0.58 [6] | 4 | Samboja | |
| C | *Trema tomentosa* | 3 [2] | 0.58 [6] | 4 | Samboja | |
| C | *Trema tomentosa* | 2.2 [2] | 0.58 [6] | 4 | Samboja | |
| C | *Trema tomentosa* | 1.5 [2] | 0.58 [6] | 4 | Samboja | |
| C | *Trema tomentosa* | 1.8 [2] | 0.58 [6] | 4 | Samboja | |
| C | *Trema tomentosa* | 1.7 [2] | 0.58 [6] | 4 | Samboja | |
| C | *Trema tomentosa* | 4.0 [2] | 1.5 [6] | 4 | Samboja | |
| C | *Trema tomentosa* | 6.0 [2] | 1.5 [6] | 4 | Samboja | |
| C | *Trema tomentosa* | 6.0 [2] | 1.5 [6] | 4 | Samboja | |
| C | *Trema tomentosa* | 6.0 [2] | 1.5 [6] | 4 | Samboja | |
| C | *Trema tomentosa* | 7.0 [2] | 1.5 [6] | 4 | Samboja | |
| C | *Trema tomentosa* | 6.0 [2] | 1.5 [6] | 4 | Samboja | |
| D | *Austroeupatorium inuliforium*, *Piper* | 2.5 [2] | 4 [7] | 5000 | Muara Badak | |
| D | *Austroeupatorium inuliforium* | 0.6 [2] | 0.17 [7] | 5000 | Muara Badak | |
| D | *Austroeupatorium inuliforium* | 3 [2] | 0.5 [7] | 70000 | Muara Badak | |
| D | *Austroeupatorium inuliforium* | 3.5 [2] | 0.5 [7] | 15000 | Muara Badak | |
| D | *Austroeupatorium inuliforium* | 1.1 [2] | 0.5 [7] | 2500 | Muara Badak | |
| D | *Austroeupatorium inuliforium* | 4 [2] | 0.5 [7] | 830 | Muara Badak | |
| D | *Austroeupatorium inuliforium* | 1.8 [2] | 1 [8] | 2 | Samboja | |
| D | *Austroeupatorium inuliforium* | 1.9 [2] | 1 [8] | 2 | Samboja | |
| D | *Austroeupatorium inuliforium* | 2 [2] | 1 [8] | 2 | Samboja | |
| D | *Austroeupatorium inuliforium* | 2.5 [2] | 1.58 [7] | 2500 | Muara Badak | |
| D | *Austroeupatorium inuliforium* | 2.5 [2] | 1.58 [7] | 5000 | Muara Badak | |
| D | *Austroeupatorium inuliforium* | 2 [2] | 1.58 [7] | 20000 | Muara Badak | |
| D | *Austroeupatorium inuliforium* | 4 [2] | 1.58 [7] | 1670 | Muara Badak | |
| D | *Austroeupatorium inuliforium* | 2 [2] | 2 [7] | 16670 | Muara Badak | |
| D | *Austroeupatorium inuliforium* | 2 [2] | 3 [7] | 7500 | Muara Badak | |
| D | *Austroeupatorium inuliforium* | 2.5 [2] | 4 [7] | 15000 | Muara Badak | |
| D | *Austroeupatorium inuliforium* | 5 [2] | 4 [7] | 8330 | Muara Badak | |
| D | *Austroeupatorium inuliforium* | 2 [2] | 4 [7] | 15000 | Muara Badak | |
| E | *Imperata cylindrica* | 0.6 [2] | 0.33 [8] | 2000 | Samboja | |
| E | *Imperata cylindrica* | 1.1 [2] | 0.5 [8] | 2000 | Samboja | |
| E | *Imperata cylindrica* | 0.9 [2] | 0.58 [8] | 2000 | Muara Jawa | |
| E | *Imperata cylindrica* | 1 [2] | 0.67 [8] | 2000 | Muara Jawa | |
| E | *Imperata cylindrica* | 1.1 [2] | 0.67 [8] | 2000 | Muara Jawa | |
| E | *Imperata cylindrica* | 1.2 [2] | 0.67 [8] | 2000 | Samboja | |

| Plant community type [1] | The most dominant species in overstory | Overstory height m | Community age y | Plot size [10] m² | Locality (Kecamatan) | Source |
|---|---|---|---|---|---|---|
| E | *Imperata cylindrica* | 1.2 [2] | 1.08 [8] | 2000 | Samboja | |
| E | *Imperata cylindrica* | 1 [2] | 1.08 [8] | 2000 | Samboja | |
| E | *Imperata cylindrica* | 0.9 [2] | 1.17 [8] | 2000 | Samboja | |
| E | *Imperata cylindrica* | 1.1 [2] | 1.17 [8] | 2000 | Samboja | |
| E | *Imperata cylindrica* | 1.3 [2] | 1.58 [7] | 20000 | Muara Badak | |
| E | *Imperata cylindrica* | 1.5 [2] | 1.58 [7] | 40000 | Muara Badak | |
| E | *Imperata cylindrica* | 1.5 [2] | 1.58 [7] | 25000 | Muara Badak | |
| E | *Imperata cylindrica* | 1 [2] | 2 [7] | 20000 | Muara Badak | |
| E | *Imperata cylindrica* | 1.25 [2] | 2 [7] | 40000 | Muara Badak | |
| E | *Imperata cylindrica* | 1.3 [2] | 3.17 [8] | 2000 | Muara Jawa | |
| E | *Imperata cylindrica* | 1.1 [2] | 3.5 [8] | 2000 | Muara Jawa | |
| E | *Imperata cylindrica* | 1.1 [2] | 3.5 [8] | 2000 | Muara Jawa | |

[1] A: primary and logged and burned forests. B: pyrophytic forests. C: forests of small-tree species. D: shrub communities. E: grassland or savanna.
[2] Mean height of plants that form the uppermost surface of the community.
[3] Mean height of trees with a dbh (diameter at breast high) > 10 cm.
[4] Years after the fire of 1983. Original vegetation caught fire in 1983, according to interviews with local people.
[5] Years after being fallowed. Original vegetation was slashed-and-burned, according to interviews with farm owners.
[6] Years after the fire of March 1998. Plant communities were monitored from 1993 in research plots.
[7] Years after the fire or years of being fallowed. Vegetation in slash-and-burn areas was monitored from 1994 in research plots.
[8] Years after the last fire. Grassland vegetation was monitored from 1995 in research plots.
[9] Number of annual rings for 8 overstory trees of *Peronema canescens* . *P. canescens* forms clear annual rings (Oobayashi et al. 1992).
[10] Areas were not measured and only overstory heights were measured for some fallow stands.
[11] Matius et al. (1993).
[12] Kiyono and Hastaniah (1997).
[13] Toma et al. (2000).

# カリマンタンにおける二次植物群落の高さの成長：植林によるCOP 7の吸収源CDM（クリーン開発メカニズム）事業の適地

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要　旨
インドネシア国カリマンタン島の湿潤熱帯地域で劣化生態系の二次植生を５つの植物群落に分類し、上層高の成長を解析した。土壌養分の状態に大きな違いはないが、成長曲線は群落によって異なった。上層高は群落の成立初期には群落間で大差ないが、２、３年後には、高木種（最大高10 m程度の小高木を含む）の群落は低木や草本群落よりも明らかに背が高かった。上層高の年平均増加量は群落バイオマスの増加の指標と考えられる値で、群落のタイプや齢によって変化した。低木や草本群落に森林を造成すると、植生が固定する炭素量は大きく増加するであろう。低木や草本は類焼しやすいが、適切に防火できるのであれば、低木や草本群落の成立する土地が植林による吸収源CDM事業に最も適していると考えられる。

キーワード：ベースラインシナリオ、樹高成長、バイオマス、新規植林、再植林、京都議定書、CDM

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