The importance of permanent sample plots for long term observation on growth and yield and carbon sequestration: a case study in a hill mixed dipterocarp forest of Kalimantan, Indonesia

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Abstract Permanent Sample Plots (PSP) play an important role as a tool to monitor forest dynamics and changes, long term growth and yield and to provide critical data for evaluation of ecological model. For silvicultural purposes, PSP supply data on diameter and volume increment as well as stand structure dynamics. In addition to that, there has been an increasing demand for data and information collected from PSP for the accounting purposes in carbon sequestration projects under climate change agreements. Such information would support the development of the so-called baseline and additionality scenarios presented in the project development design. The use of long-term measurements provided by PSP would increase the project's profile and credibility.

In the Malinau Research Forest, East Kalimantan, 24 PSPs of 1 ha each were established in 1998 prior to logging activity and re-assessed in 2000 and 2004. Two logging systems were implemented during that period, namely reduced-impact logging (RIL) and conventional logging (CNV). A total of 705 trees species ($\geq$ 20 cm dbh) were recorded from the permanent sample plots, of which 67 (9.5%) were dipterocarp species. Among the most common Dipterocarpaceae included *Dipterocarpus lowii, D. stellatus, Shorea beccariana, S. brunescens, S. exelliptica, S. macroptera, S.maxwelliana, S. multiflora, S. parvifolia, S. rubra* and *S. venulosa*. Carbon stock in dipterocarp forest has been modeled by using CO2 Fix. It is a simple carbon bookkeeping model that consists of six modules, focusing onbiomass, soil, product, bioenergy, financial, carbon accounting.

Periodic annual diameter increment and forest regeneration were observed. Based on inventory (2000) of the regeneration plots after logging (both types), sapling density calculated from the census of the 12 plots (5 x 100 m^2 each) was more than 4600 stem ha^{-1} on average. We found that the different species of dipterocarps varied from 0.35 to 0.52 cm $year^{-1}$ according to logging intensity in RIL plots ($\geq$ 20 cm dbh), while in CNV plots, increment of dipterocarps ranged from 0.42 to 0.62 cm $year^{-1}$. A group of non-dipterocarps was also assessed. The relationship between growth (cm $year^{-1}$) and felling intensity (F_I in total number trees ha^{-1}) in the plots was also measured for dipterocarps and non-dipterocarps groups. Linear regressions are positive: $Dipt_{RIL} = 0.242\ yr^{-1} + 0.0850\ F_I$ (R^2=70.4%) and $Non\text{-}Dipt_{RIL} = 0.190 + 0.0683\ F_I$ (R^2=54.3%). The growth is less than assumed by the Indonesian Selective Cutting and Replanting System or TPTI (Tebang Pilih Tanam Indonesia) which is 1 cm $year^{-1}$. If we assume that this pattern continues, a longer cutting cycle is needed for sustainable forest management.

Keywords permanent sample plots, East Kalimantan, hill mixed dipterocarp forest, periodic annual diameter increment, reduced-impact logging, TPTI, logging damage, forest regeneration, Carbon Sequestration