PERMANENT SAMPLE PLOTS

More than just forest data

Proceedings of International Workshop on Promoting Permanent Sample Plots in Asia and the Pacific Region
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Editors: Hari Priyadi, Petrus Gunarso and Markku Kanninen

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Foreword

Assalamualaikum wr. Wb.

Good morning and may peace and prosperity be with all of us.

Distinguished Director General of CIFOR, Dr. David Kaimowitz, Director of Environmental Services and Sustainable Use of Forests Program, Dr. Markku Kaninnen, Workshop participants.

Ladies and Gentlemen,
First of all, I would like to thank CIFOR for inviting me to officiate this workshop. It is a special honor to me to have a chance to be part of this event, which is of a high scientific eminence, and deals with an actual problem of natural forest management, namely the scarcity of growth and yield information. I also want to express my sincere appreciation to CIFOR for organizing this particular workshop.

Ladies and Gentlemen,
I am not a forester by training, however I am a forester by nature and process which has given me sufficient knowledge to grasp the main logic of managing forests. First of all, I understand that the forest is a growing thing. It grows, not only the trees composing the forest, but the other components as well, grow dynamically. I further understand that the forest interacts with the site where it grows, with the local climate, and affected by external factors such as management regimes applied upon the forest. This growth aspect and the inter-relationship with many factors make the forest a very complex ecosystem. And since it is complex, it is by nature also quite fragile. Furthermore, because of this fragility, forests must be managed in a carefull manner, taking into account its inherent characteristics, including its growth behavior. To this point, I understand that sustainable utilization of forests is simply taking no more than the complex and growing entity can provide, which is determined by its growing ability.

Ladies and Gentlemen,
I am not intending to teach you about forest growth, nor to brag of my limited knowledge of the subject. What I intended is merely to indicate that even a laymen like me can see the importance of this workshop in relation to attaining sustainable forest management.

Our predecessors actually have long adopted the same perception. I was informed that growth and yield research is old in Indonesia, dating back to the 19th century. A notable basic formula of relative-spacing for forest plantation management, which is still referred in today's forest management handbook, was invented and first published in the late 19th century by Mr Hart, a researcher at the Boschbouw Proefstation, Buitenzorg or Bogor. The tradition of establishing and measuring permanent sample plots (PSP) for monitoring forest growth continues in the period following the independence. From the accumulated data, we have developed stand tables for a number of forest plantation species in the century.

The tradition, however, began to discontinue in the mid seventies. That was the time when we started the exploitation of our natural forests in the outer islands. I discerned there might be a number of reasons for this.

Research, particularly on the subject of forest growth, is an undertaking that needs time in the scale of decades. The benefits are also not immediately recognizable. On the other hand, project-based planning approach, which was adopted in Indonesia in the several demands project output on as annual basis. In no way could forest growth research be able to give an output in such a short time. This fact alone may have led decision makers not to give adequate attention and allocate sufficient budget on growth data collection. On a fundamental level, it is apparent that our lack of understanding on the laymen-logic of sustainable forest management is what led us to disregard the importance of forest growth data collection. Indeed, "mining" natural forests does not require any knowledge of growth and yield.

Ladies and Gentlemen,
In the nineties we actually realized the mistake we have made. In 1994 the Minister of Forestry issued a decree requiring forest companies to establish and measure PSPs for monitoring the growth of the logged-over forest they managed. The growth data is to be submitted to FORDA of the Ministry of Forestry and, among others, will be used for calculating second cycle annual allowable cut. The data is to complement FORDA's PSP data which is very limited in scope due to limited funding. For sometime this policy was implemented, and regardless of the quality of the data, at least there was a recognition that forest growth data is necessary and must be collected before it is too late. Unfortunately, the huge recession hit the country, forest companies collapsed, and most PSPs were never re-measured again.

In the same period, there was cooperations with other countries, such as with France (CIRAD), UK (DFID) and The Netherlands (Tropenbosch) that included monitoring forest growth and yield as part of the subject of cooperation. I was told that these cooperation have resulted in substantial outputs, which turned out to be highly valuable. Among others, the Silvicultural Techniques for the Regeneration of Logged Over forest in East Kalimantan (STREK) PSP Series is now considered one of, if not the only, relatively good PSPs of Dipterocarp forests on earth.

Ladies and Gentlemen,
You may have been informed about the soft landing policy issued in 2002. It was a good policy, which was aimed at saving the remaining natural forests by reducing the national annual allowable cut. When it comes to implementation, however, the policy could not be implemented as it was really intended. The constraint, as you may guest, was the scarcity of growth data which is needed for determining the right annual allowable cut. With the absence of the critical data, the policy was implemented in a modified fashion. Ideally, the annual allowable cut of each single management unit must be calculated to come up with the aggregate national allowable cut. However, since it was not possible, the approach was the other way around, the national allowable cut was somehow determined, which was further disaggregated by province, and finally management unit. Of course that was not the right way of implementation.

With those illustrations, I want to indicate how I really welcome the workshop today. I have a high expectation that this workshop will be able to come up with a concrete and doable framework on how we together could be able to overcome the problem of forest growth data scarcity. The government of Indonesia will provide support and contribute to the effort. At this moment I understand that for some years FORDA has been putting more attention on this matter. And I know within its limitation FORDA also has something to contribute. I request FORDA to actively take part in this endeavor.

With that, Ladies and Gentlemen, I would like to conclude my words. Have a good and productive workshop. Thank you very much.

Wassalamualaikum Warachmatulahi Wabbarakatuh

Bogor, August 1, 2005

H.M.S. Kaban
Minister of Forestry
Republic of Indonesia

Opening remarks

His Excellency Minister of Forestry, today is represented by the Honorable Dr. Hadi Pasaribu, the Director General of Forestry Research and Development Agency (FORDA), Honorable Dr. Markku Kanninen, the Director of Environmental Services and Sustainable Forest Management Program of CIFOR, Distinguished Guests, Ladies and Gentlemen.

Good morning and welcome to CIFOR

First of all, I would like to thank all of you for coming to this workshop. I am pleased with the interest and response to this workshop. I have been informed that more than 75 participants applied for this workshop, and from those we have now 50 participants present here this morning and hopefully will be here until tomorrow. I have received some regrets and particularly I would like to convey the regret of my Director General, Dr. Kaimowitz, who is currently on his way from his duty travel to Brisbane for IUFRO Conference, so he cannot attend this workshop.

To those who have to travelled a long distance, I hope you had a sufficient rest, and now you are fresh and well.

Let me start with introducing myself. My name is Petrus Gunarso and my current position here at CIFOR is coordinator for Malinau Research Forest. Malinau Research Forest is located in North East part of Kalimantan or Indonesian Borneo. The MRF is designated and provided by the government of Indonesia as a long term research site to CIFOR in Indonesia.

I take the floor here to representing the organizing committee of the workshop and the Malinau Research Forest. It would be interesting if we could organize this workshop in Malinau, right in the middle of the forest in East Kalimantan, but due to limited resources and logistical problems we can not do so.

I would like to share with you now the background of this workshop.

First, the recent discussion on Annual Allowable Cut, particularly in Indonesia, and its rationale in setting it up has triggered this workshop. The workshop is also a response to a call from the Minister of Forestry for research results derived from many long established PSP initiatives across Indonesia.

Second, from my communication with several colleagues from Asia and the Pacific region, we came up with a similar concern and similar feeling that we need to talk to each other on the data and results of PSP initiatives that has been established in the region ranging from eight to almost 20 years ago.

Third, the PSP as a long term observation of forest growth and yield is often neglected as a result of ignorance from those who are supposed to look after the sustainability of the forest. This is mainly due to imbalanced competition between a long term sustainability vision and a short term economic gain vision.

And lastly is the emerging possibility to utilize the data from PSP to measure Carbon Annual Increment, particularly important for Climate Change Monitoring.

The overall objectives of our two day workshop are:
1. To share and compare data and analysis/results from different sites and different methods for better understanding growth and yield, forest health, silviculture techniques and carbon stock.
2. To explore possibilities to develop a regional network of permanent sample plots.
3. To come up with possible silvicultural recommendations toward sustainable forest management.

Dr. Pasaribu and Dr. Kanninen, Ladies and Gentlemen, I would like to report to you the diversity and representativeness of participants that are present here today. It is truly international and represents Asia and the Pacific Regions. We have participants from:

Lao PDR	2 participants
Malaysia	1 participant
Papua New Guinea	1 participant
Thailand	1 participant

The largest number is obviously from Indonesia with here 48 participants (representing FORDA 5, LIPI 7, Universities 13, MOF 4, International and National NGO 17 participants, private sector/concessionaries 1 and professional organization 1 participant).

I would like also to report that with us today are our colleagues from other networks, outside the region, from:

The Netherlands, representing sub tropical network: 1 participant France, representative of CIRAD Foret, bringing experience from network of tropical belt from Africa, Asia, and Latin America: 1 participant.

In total we have 50 participants.

In this occasion, I would like to thank the PERSAKI (The Indonesian Foresters Association) and INRR (Institute of Natural and Regional Resources) as our co-host of this workshop. This workshop is possible through funding of ITTO Project PD 39/00 Rev.3 (F) under the Forest and Livelihood Programme of CIFOR and Co Financed by Environmental Services and Forest Management Programme of CIFOR. I would like also express my sincere thanks to FORDA for actively participating since the initial stage in this workshop. I would like also to thank my colleagues and staff who have been working hard to make this workshop happen, to Hari Priyadi, Nani Djoko, Indah, Ketty, Kresno, Haris and Happy. These people will continue to serve you all during our two day workshop. If you have any problems, don't hesitate to contact them.

I hope that we will have a good working experience together here in our campus and hope you all enjoy Bogor, the city of rain. Thank you.

Bogor, August 2005

Petrus Gunarso
Malinau Research Forest Coordinator

Welcoming address

Good morning and welcome to you all,

First of all I would like to extend my warm thanks to the Minister of Forestry Mr. H.M.S. Kaban, represented here by Dr. Hadi Pasaribu, Director General of Forestry Research and Development Agency, for his kind welcoming words.

Issues and topics related to monitoring of forest ecosystems are gaining growing importance. We will be using permanent sample plots for monitoring of several of these topics. These include looking at forest health, forest productivity, and services other than wood such as water and climate regulation through carbon sequestration.

My home country, Finland was the first country in the world to complete a national forest inventory in 1921. Since then, Finland has been doing that as a continuous exercise and will soon complete the 10^{th} national inventory cycle. In addition, and as a response to concerns in the 1980s about forest ecosystem health, my countrymen established a network of 3500 permanent sample plots that have been monitored and measured ever since.

It is interesting to see how the focus of forest monitoring and measurement has changed over time in Europe. It started more than a hundred years ago by purely looking at the sustainability of timber supply. Then in the 1980's the issue of forest health in relation to acid rain gained importance in Europe's forestry agenda. This was reflected in new monitoring schemes and now they are looking at biodiversity, carbon sequestration, and other aspects. My feeling is that we are heading in the same direction here in the Tropics, particularly if the second commitment period of the Kyoto Protocols includes all forests.

Since its inception in 1993, CIFOR's work on permanent sample plots has been very important. As mentioned by Petrus Gunarso in his presentation, we have been working with the kind support of the Indonesian Government in Malinau Research Forest in Kalimantan since the beginning of CIFOR's existence. During that time we have also established a network of permanent sample plots in the area looking at the aspects of sustainable forest management, reduced impact logging and other important elements. So working on permanent sample plots has been important for us.

During this workshop we will present ideas of how, in the future, we can move towards the direction I mentioned earlier, and how we can add value to the data already collected from permanent sample plots. For instance, to support studies and work on carbon sequestration, CIFOR is launching a web service (CarboFor) for those interested in carbon sequestration. This web service will make available information, literature, and data collected from permanent sample plots into wider audience.

I also think we should start a closer collaboration between the institutions that are already measuring or working with permanent sample plots. For that purpose, CIFOR aims to initiate a network of permanent sample plots in South-East Asia. We are also discussing this idea with other institutions such as CIRAD. These discussions also include building a global network of research sites related to long-term monitoring and measuring of forest status or the impact of forest management interventions.

I am truly confident that in future years this workshop will be recognized internationally as having played a key role in establishing both an international network and international cooperation on permanent sample plots. Certainly we at CIFOR have committed ourselves to this goal.

For those who are heading to the IUFRO World Congress in Brisbane next week I would like to mention one historical anecdote. The founding of IUFRO - the International Union of Forestry Research Organizations – was very much about permanent sample plots. In the 1880s, there was a need to coordinate forestry research work based on permanent sample plots in Central Europe. This led to the establishment of IUFRO in 1892. Now IUFRO is one of the oldest and well-known scientific organizations in the world. So we have a good historical background, a good legacy and many good reasons to continue.

So with these words, I welcome you. I hope we all have an interesting, challenging and productive meeting. And finally, let me repeat, CIFOR truly is committed to the long-term success of the aims of this workshop.

Thank you

Dr. Markku Kanninen
Director Environment and Sustainable Use of Forests, CIFOR

Preface

Determining Annual Allowable Cut (AAC) in Indonesia was becoming a very interesting issue and creating a hot debate among policy makers, forest practitioners, academia and research institutes. In the past 3 years, the AAC followed a soft landing policy issued by the Minister of Forestry showing declining a pattern from 6.892 million m^3 (2003) to 5.743 million m^3 (2004) and 5.456 million m^3 (2005). In contrast, demand for industry amounts to more than 46 million m^3, and is creating a huge gap between supply and demand.

In line with the above issue, the 35 year cutting cycle under TPTI regulation (Indonesian Selective Cutting and Replanting System) is now also in question. Is a 35 year cutting cycle appropriate enough towards sustainable forest management? More than three decades ago, silviculturists assumed that generalized tree growth for all species and all types of forests was 1 cm per year with the diameter limit for cutting at 50 cm and 60 cm (diameter at breast height or dbh), depending on forests type.

Tree growth data from permanent sample plots (PSPs) of tropical managed forest which were measured regularly proved less than that. Data figures from PSPs in dipterocarps forest of Malinau Research Forest of CIFOR, East Kalimantan show that the growth rate for non-dipterocarps family range from 0.24 – 0.39 cm per year, and for diptrocarps between 0.35 - 0.62 cm per year (CIFOR, 2004). Meanwhile in Berau, South of Malinau (under STREK and FORDA project) it is shown that the growth rate for all species is 0.22 cm per year, and 0.3 cm per year for dipterocarps (Nguyen-The *et al.* 1998). This is similar to the rates found by Manokaran, Khocummen (1987), Yong Teng Koon (1990) in mixed dipterocarp lowland forest of Peninsular Malaysia, although Nicholson (1965) mentioned an overall growth rate of 0.48 cm $year^{-1}$ in the Sepilok Forest Reserve in Sabah. The studies suggest that the simplification and generalization of growth is jeopardizing the sustainability of tropical forest management.

In order to have better forest stand data from the field in various types of forests and from several countries, an initiative to develop a network of PSPs in Asia and the Pacific is being established. The data would be useful for supporting tree growth and research on carbon sequestration. Laos, Malaysia, Indonesia, Papua New Guinea are among other countries that are experiencing long term measurement of PSPs which were being regularly measured. This initiative will be giving an invaluable input to determine appropriate natural forest sivicultural systems and provide baseline data for carbon sequestration study.

Current Annual Increment (CAI) data from PSPs is very useful information. CAI data is needed when calculating annual carbon stocks in the biomass compartment by using a carbon bookkeeping model such as CO2Fix which is a user friendly program.

An intensive discussion which was facilitated by The Association of Indonesian Foresters earlier this year has come up with recommendations from the Minister of Forestry, the Republic of Indonesia, H.E MS Kaban to look closer into the issue. He further encouraged national and international research organizations to publish their study results to address the issue (Media Persaki 2005).

This report presents the proceedings of the "International Workshop on Promoting Permanent Sample Plots in Asia and the Pacific Region: The role of Field Data to Support Silvicultural System and Carbon Sequestration Study in Naturally Managed Forests in Asia and the Pacific Region towards Sustainable Forest Management" which was held at CIFOR Headquaters, Bogor, Indonesia from 3-5 August 2005.

15 presentations have been delivered in different issues, namely: Overview Sustainable Forest Management, Permanent Sample plots and the Study on Growth and yield, The Importance of Permanent Sample Plots and Carbon Sequestration and Climate Change. At the end of the workshop, three working groups (WG) have been made to discuss different issues. WG 1 was about Data sharing from different sites, WG 2 was about Developing a Network of PSPs and the third WG was discussing Recommendation of Silvicultural Changes. In these proceedings, there are nine full papers, three abstracts and three slide presentations. We decided to publish abstracts and slides as well, because those are also important information.

Post workshop was arranged by visiting Bogor Botanical Garden in third day (5^{th} August 2005). The garden was established by Prof. Dr. C.G.C Reinwart, a German botanist who lived in Indonesia in the early 19^{th} century. Eventually on 18^{th} May 1817 the Land Plantentuin or Hortus Botanicus Bogorienses was founded covering an initial area of 47 hectares (now 87 ha). Later the garden become a beneficial education center for agricultural instructors and botanist to promote public awareness in plant uses and nature conservation. The collection consists of 20,827 specimens belong to 3.174 genera and 218 families.

Bogor, February 2006

Hari Priyadi
Petrus Gunarso
Markku Kanninen

Workshop summary

The workshop brings together practitioners, policy makers, researchers and academia working in the area of silvicultur of natural managed forests and plantation forests in the region and elsewhere. At the same time, it is expected to support development of the networking on PSPs and carbon sequestration. The overall objectives are to:

1. Share data and analysis from different sites
2. Develop a regional network of Permanent Sample Plots
3. Recommend silvicultural changes toward Sustainable Forest Management

Specific objectives are to:

1. Further use shared data for wider purposes such as Environmental Services (e.g. carbon trading) and link with networks of PSP for wildlife and PSP on Plantation Forests
2. Provide silvicultural approach that will help correcting unsustainable practices toward ITTO Objective 2000
3. Share efforts to make sure that the network is maintained and securely funded

The workshop was held in CIFOR campus, Bogor from 3-4 August 2005 followed by a post workshop in the Bogor Botanical Garden in 5 August 2005. 50 participants attended the workshop. They were from Malaysia, Papua New Guinea, Lao PDR, Japan, Indonesia, France and The Netherlands. In terms of background, they were working in multi fields such as universities, research institutions, NGOs, international projects, private companies and governmental agencies.

In the opening remarks Dr. Petrus Gunarso as a Coordinator of CIFOR's Malinau Research Forest (MRF) pointed out that the PSP as a long term observation of forest growth and yield is often neglected as a result of ignorance from those who are supposed to look after the sustainability of the forest. This is mainly due to imbalanced competition between long term sustainability vision and short term economic gain vision.

Dr. Markku Kanninen, who gave the welcoming address has highlighted that in the future other aspects related to permanent sample plots and looking at forest health, will be more important, such as looking at the services other than wood, and that forests can provide for humankind. He thinks that they are becoming more and more important and it is timely that we discuss in this workshop all the aspects related to permanent sample plots; not only growth and yield aspect, but all the aspects related to data, information that we are gathering from the permanent sample plots. It is timely also that we have this workshop to start collaborating with institutions that are already measuring or working with permanent sample plots. CIFOR is keen to build a network in the region of South East Asia and also to discuss with other institutions.

In the officiating speech, His Excellency Minister of Forestry M.S. Kaban (represented by Honorable Dr. Hadi Pasaribu, DG FORDA) stressed softlanding as a good policy, which was aimed at saving the remaining natural forests by reducing the national annual allowable cut (AAC). When it comes to implementation, however, the policy could not be implemented as it was really intended. The constraint was the scarcity of growth data which is needed for determining the right AAC. With the absence of the critical data, the policy was implemented in a modified fashion. Ideally, the AAC of each single management unit must be calculated to come up with the aggregate national allowable cut. However, since it was not possible, the approach was the other way around. The national allowable cut was somehow determined, which was further disaggregated by province, and finally management unit. Of course that was not the right way of implementation.

Followings are some conclusions and recommendations noted during the workshop:

1. PSP is an important field data to regulate forest yield. Basically, there are three things resulted from PSP, namely: diameter increment, volume increment and stand structure dynamics.
2. There is no single yield regulation that can be implemented across area and dynamic complex interaction between forests and people.
3. Any yield regulation practices have to be considered as a hypothesis
4. PT Sari Bumi Kusuma (Indonesia) has significant experiences with TPTJ (*Tebang Pilih Tanam Jalur* or Modified Indonesia Selective Cutting System). The company is part of a pilot project site for silviculture intensive implementation, which is being encouraged by Ministry of Forestry.

5. Using computer model SYMFOR, cutting cycle can be predicted. In the Jambi case, a 35 year cutting cycle is recommended.
6. CIRAD Foret suggested a good scenario to recommend would be the regular felling of 8 trees/ha every 40 years, which could yield 67 m3/ha at each harvesting.
7. According to field data monitoring from PSP the tree growth (≥20 cm dbh) is less than assumed by the Indonesian Silvicultural system (TPTI) which is 1 cm per year. Field data from MRF shows per species mean increment of dipterocarps range from 0.42 – 0.62 cm per year. If we assume that this pattern continues, a longer cutting cycle is needed for sustainable forest management.
8. Papua New Guinea is using a database management system called PERSYST to analyze and produce a model called PINFORM for predicting the growth and yield of selectively cut natural forests in PNG
9. Malaysia suggests efforts and commitment by various sectors are required to ensure the successful implementation of sustainable forest management for the benefits of future generation.
10. Example PSP in Indonesia are located in Malinau/MRF, Berau/STREK (East Kalimantan), Jambi (Sumatera), Krui/ICRAF-SEA (West Lampung), Muara Bungo/ICRAF-SEA (Jambi).
11. In Lao PDR, PSP is being used to estimate tree growth and to predict the yield for future sustainable forest management and planning system (SFMS).
12. 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 additional scenarios presented in the project development design. The use of long-term measurements provided by PSP would increase the project is profile and credibility.
13. CIFOR is very keen to facilitate data and information exchanges by providing a web-based platform, by which potential users may be directed to the originating institutions. **CarboFor©** will appear at CIFOR main page to serve both forestry and climate change communities.
14. Another role of PSP is to provide important means for up-scaling, both in time and space as well as to provide critical data for evaluation of ecological models.

Information regarding with CarboFor can be found in the website: *www.cifor.cgiar.org/carbofor*. CarboFor is web-based developed under CIFOR main webpage to serve the communities working on land-use, land-use change and forestry (LULUCF) activities and associated climate change. It features projects carried our by CIFOR and its partners: current publications of carbon/climate change related issues around LULUCF sector; Permanent Sample Plot (PSP) run by various agencies as part of their operational as well as research activities – mainly for forest management purposes. Highlights of current issues, detailed events and links to useful sites may be found.

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An overview on sustainable forest management in Peninsular Malaysia

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Abstract

Sustainable forest management has been a topical issue of today. It is not only limited to the removal of timber from the forest, but also the entire operation of planning and implementation of harvesting along established guidelines. The paper presents a brief overview of the development of sustainable forest management in Malaysia with special reference to Peninsular Malaysia. Among the topics discussed are the forest policy and legislation, forest management practices in different production forest types, forest management certification and the importance of research support to evaluate and review the current management prescription. As interest about the need to manage forests in a sustainable manner continues, efforts and commitment by various sectors are required to ensure the successful implementation of sustainable forest management for the benefits of future generations.

Keywords: Sustainable forest management, forest certification, dipterocarp forest, peat swamp forest, mangrove forest

Introduction

Sustainable forest management (SFM) has been a topical issue today not just by natural resource managers, but people from all walks of life. Not surprising though, because forests not only provide economic returns but also important social and cultural benefits and environmental services (Thang 2002). Forestry issues have gained greater attention in the international discussion, today than they had before. Through research, field implementation and review, forest management in Malaysia is evolving towards its goal of sustainable forest management. The scope of activities is not only limited to the actual process of harvesting, but also includes the entire operation of planning and implementation of harvesting along established guidelines (Anon. 2004).

One of the major issues regarding forest management is the sustainability of the resources that are to satisfy the needs of current and future generations. Sustainability of resources implies that the invaluable forest resource has to be managed to ensure a continuous flow of goods and services in perpetuity for the benefit of human kind, and which is compatible with the need to preserve the forest ecosystem and the environment (Thang 2002). To promote the implementation of sustainable forest management, International Tropical Timber Organization has published the "Guidelines for the Sustainable Management of Natural Tropical Forest" (1991 and updated in 1994) and "Criteria for Measurement of Sustainable Tropical Forest Management" (1992 and revised in 1998). The guidelines form the basis for the producer countries to develop their Criteria and Indicators for sustainable forest management. The development of sustainable forest management is still evolving with new findings being considered to improve the management prescription. The paper presents an overview of development of sustainable forest management as experienced in Malaysia with special reference to Peninsular Malaysia.

Forest policy and legislation

The National Forest Policy 1978 is the main guiding document for sustainable forest management in Malaysia. Some modification was made to the forest policy in 1992 due to concern by the world community on the importance of biological diversity conservation and sustainable utilization of forest genetic resources, as well as the role of local communities in forest development. The revised policy reflects these important aspects of forestry. Malaysia has also ratified several internationally-agreed conventions which include the Convention on Biological Diversity (CBD), Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and the Ramsar Convention on Wetlands (Anon. 2004).

Forest areas

The forested area in Peninsular Malaysia is divided into four major forest types, namely the Inland Dipterocarp Forest, Mangrove Swamp Forest, Peat Swamp Forest and plantation forest (Table 1). The management guidelines for the respective forest types depend on the standing stock, size structures, and species composition. Malaysia has a total of 17.13 million ha of forested land.

The forested areas covered 19.54 million ha in 2002, covering 60 % of the total land area. Production forest management based on sustainability covers 10.96 million ha, or 33 % of the total land area. In Peninsular Malaysia the production forest, mainly found in the inland and classified as inland mixed dipterocarp forest, covers approximately 8.5 % of the total land area (Table 2).

Table 1: Distribution and Extent of Major forest types in Malaysia (million ha) (Source: Anon. 2004)

Region	Mixed Dipterocarp forest	Swamp Forest	Mangrove Forest	Plantation Forest	Total Forested Land	Total Land Area	Percentage of Land Area under Forest
Peninsular Malaysia	5.40	0.30	0.11	0.08	5.89	13.16	44.8
Sabah	3.81	0.12	0.34	0.14	4.41	7.37	59.8
Sarawak	7.92	1.12	0.15	0.05	9.24	12.30	75.1
Malaysia	17.13	1.54	0.60	0.27	19.54	32.83	59.5

Figure is based on 2002 statistics for Peninsular Malaysia, Sabah and Sarawak

Table 2: Distribution and Extent of Protected and Production Forest in Malaysia (million ha) (Source: Modified from Anon. 2004)

Region	Production Forest	Total *protected areas	Total Land Area	Percentage of Land Area as Production Forest
Peninsular Malaysia	2.80	5.36	13.16	21.3
Sabah	3.00	3.87	7.37	40.7
Sarawak	5.16	7.16	12.30	42.0
Malaysia	10.96	16.39	32.83	33.4

*Total protected areas include the protection forest under permanent forest reserve, Wildlife sanctuary, National park and State park. Figure is based on 2002 statistics Peninsular Malaysia, Sabah and Sarawak

Managing forest resources

Forestry resource are categorized into timber and non-timber resources. As the timber resources look into single forest produce, the non-timber resources include goods and services provided by the forest ecosystem other than timber resources.

Mixed dipterocarp forest

Forest management practices began in the early 1900's. Several silvicultural practices have been introduced to manage the inland dipterocarp forest (Table 3). Harvests were initially very selective in the early days of forestry in Malaysia, and focused on felling of gutta percha (*Palaquium gutta*), as well as durable hardwoods like Chengal (*Neobalanocarpus heimii*). By 1948, the Malayan Uniform System was employed. The system converted primary tropical lowland forest to an even-aged and reduced species mixed stand containing greater proportion of the commercial light red meranti timbers. Currently inland dipterocarp forest is managed under two management systems, namely modified Malayan Uniform System (MMUS) and the Selective Management System (SMS). The MMUS is a modification of the classical Malayan uniform system. The SMS, a polycyclic system, was introduced in 1978 as most of the forest operation had shifted to the hill dipterocarp forest. The MMUS entails removing all crop trees greater than 45 cm dbh in one single felling, while the SMS provides an option for selecting optimum management regimes based on pre-felling forest inventory data (Thang 2002).

Under the SMS, a minimum cutting limit of 50 and 45 cm dbh are set for dipterocarps and non-dipterocarp trees, except for *Neobalanocarpus heimii*, with minimum cutting limits at 60 cm dbh. A difference of at least 5 cm dbh was set for dipterocarps and non-dipterocarps to conserve a higher proportion of dipterocarps for the next cut. For example, a 60 cm dbh cutting limit for dipterocarps and 50 cm for non-dipterocarps species. A prerequisite of the system is the 10 % systematic line plot sampling before felling to determine the stocking as a basis to decide the cutting regime. Marking of all trees earmarked for felling is carried out. The system requires that residual trees to be felled should be 32 trees per hectare of trees between 30-45 cm or its equivalent, and proportion of residual dipterocarps 30 cm dbh and above must be equal or higher than before felling (Thang 1997; Shaharudin 1997). The management prescription has been reviewed and some modifications recommended in light of new findings from growth and yield studies from permanent sample plots. Efforts are being made to look into the cutting regime for special forests such as Kapur (*Dryobalanops aromatica*) and Seraya-Ridge Forest (*Shorea curtisii*). The forest is rich in valuable timber stocking and in many cases dominated by single species in the larger size classes. Application of the selective cutting in these forests needs to be evaluated, as potentially extensive damage to the residual stand is unavoidable even when reduced impact logging is implemented. Simulation studies on these forest types indicated a need to control the amount of harvest to reduce the impact on residual stands (Abd. Rahman *et al.* 2002). Forestry Department has recently imposed another management prescription on the maximum allowable harvest both for primary forest and regulated forest. This move will reduce the potential impact of harvesting on the residual stands particularly for timber rich forest such as Kapur Forest and Seraya Ridge-Forest, and thus support the sustainable supply of timber for future cuts. The challenge will be to determine which trees to be cut among the harvestable size trees.

Peat swamp forest

The harvesting regime for the peat swamp forest is managed under the "modified" SMS, where higher cutting limits are prescribed due to a lower stocking of natural regeneration stand. Currently researche is being undertaken by UNDP/GEF project on Conservation and Sustainable Use of Tropical Peat Swamp Forest and Associated Wetland Ecosystems which is expected to be completed by 2006 (Thang 2002). The peat swamp forest is a delicate and complex forest ecosystem. Any disturbance due to removal of vegetation cover during harvesting has to consider the effects on water regime. When a sufficient quantity of water remains, plant material will continue to remain as peat, otherwise it will decay when water loss increases (Pahang Forestry Department 2005). The Forest Research Institute of Malaysia (FRIM) in collaboration with the Forestry Department of Peninsular Malaysia is conducting research on an appropriate harvesting regime for mixed peat swamp forest. Preliminary findings indicated that some modifications on the species grouping, damage factor and revised growth and yield figures are required to determine the sustainable level of harvest for peat swamp forest (Abd. Rahman, unpublished).

Mangrove forest

The mangrove forest is managed on a clear cutting system at varying cutting cycles of 20-50 years. Mature trees are felled with retention of several mother trees, and a three meters wide river bank and coastal strip to ensure adequate regeneration and protection of the environment. The Matang mangrove forest is a strong example of long-term sustainable forest management. Matang mangrove is the single largest mangrove forest in Peninsular Malaysia covering more than 40,000 hectares of a continuous belt of trees within 19 forest reserves. Matang mangrove has been sustainably managed for almost 100 years, and still provides forest resources, such as poles and charcoal, for local consumption as well as export. It also provides a healthy ecosystem that preserves important fishery breeding grounds. Efforts are being made to improve the appropriate time of thinning as many dead standing trees has been observed before the first thinning indicating occurrence of competition induced mortality among the trees (Abd. Rahman *et al.* 2004).

Managing non-timber resources

The forest ecosystem is an important source of non-timber resources. The forests provide food sources, medicinal plants, sandalwood, potential areas for eco-tourism areas and recreation, and support a favorable condition for safeguarding the environment.

The management of non-timber resources is an important activity under sustainable forest management to ensure a sustainable utilization of the resources to meet current and future generation's benefits. A study by Mohd. Azmi *et al.* (2002) estimated that the average economic value of non-timber resources is RM1.011.61 per hectare. Bamboo contributes the highest stocking value of RM 471 per hectare. The estimated realized economic value of non-timber resources by the local communities was RM210,717 per year. Among the non-timber resources, gaharu and sandalwood remain the most sought after products from the forest. Bamboo showed the lowest realized economic value although it supports the highest stock value, primarily due to low marketability.

The management of non-timber resources under sustainable forest management is crucial. Besides timber production, the forest is an important source of goods and services, particularly for the local communities. The integration of the non-timber resources into the sustainable forest management at forest management units requires comprehensive resource planning. In the 4th National Forest Inventory, non-timber resources are also recorded in the inventory. This will allow the estimate of the resources at national level.

Forest management certification

Malaysian forest management is evolving towards its goals of sustainable forest management through research, field implementation and review. A national committee on Sustainable Forest Management in Malaysia was established in 1994 to coordinate the implementation of all activities required to ensure that the forest resources in Malaysia are sustainably managed (Thang 2004). A set of Malaysian Criteria and Indicators (MC&I) for Sustainable Forest Management (MC&I) at the national level and forest management unit level was developed to assess and monitor its progress towards achieving sustainable forest management. The MC&I is based on the International Tropical Timber Organization (ITTO)'s *Criteria for Measurement of Sustainable Tropical Forest Management* (1992 and revised in 1998). An independent non-profit organization, Malaysian Timber Certification Council (MTCC), was established to plan and operate a voluntary national timber certification scheme to provide means of verifying that timber products have been sourced from sustainably managed forests. The MTCC scheme began in 2001, and is implemented using a phase approach.

The standard currently used for assessing Forest Management Units (FMUs) for the purpose of certification is the Malaysian Criteria, Indicators Activities and Standard of Performance for Forest Management (known as the MC&I(2001) in short) which is based on the 1998 ITTO Criteria and Indicators for Sustainable Management of Natural Tropical Forests. It contains the key elements for sustainable forest management covering economic, social, environmental and conservational aspects. So far, eight timber producing States FMUs in Peninsular Malaysia have been independently assessed using this standard. In addition, a FMU in Sarawak has undergone a pre-assessment against the requirements of this standard.

As part of the MTCC-FSC (Forest Stewardship Council) cooperation, a multi-stakeholder National Steering Committee (NSC) that was formed in April 2001 has developed the Malaysian Criteria and Indicators for Forest Management [known as the MC&I(2002) in short] using the FSC Principles and Criteria as the template. The development of the MC&I (2002) involved broad-based consultation and consensus between social, environmental and economic stakeholder groups through several meetings of the NSC and regional consultations held in Peninsular Malaysia, Sabah and Sarawak where appropriate regional verifiers were identified. The MC&I (2002) is being implemented at the beginning of 2005. The MC&I (2002) will be reviewed and updated periodically, based on feedback and experience gained through its application in the field (MTCC, 2005).

Research support

In support of the sustainable forest management, research into the growth and yield of the forest after harvesting is crucial. Wan Razali (1996) highlighted that growth and yield information can be used to:

i. update and project inventories
ii. determine harvesting levels/allowable cut
iii. schedule the harvesting units
iv. analyze the potential alternative stand treatments
v. develop regional resources availability studies, and
vi. determine site productivity.

In Peninsular Malaysia a number of permanent sample plots have been established. These include the growth plots, Growth and Yield Plots, Silviculture Research Plots and Continuous Forest Inventory Plots (Shamsudin *et al.* 2003). The growth plots were established with the objectives of studying the regeneration capacity and growth potential of logged forests in Permanent Forest Reserve. The Growth and Yield Plots examine the effects of different cutting regimes on the growth response of trees and stand. Ismail *et al.* (2005) reported the results of analysis for the nine growth and yield study sites (out of 12 sites managed by Forestry Department) and two study sites managed by FRIM. The following are the summary of the results based on diameter increment, mortality and ingrowth of all trees greater than 30 cm dbh. The growth figures used under Selective Management System (SMS) are also included in the table for comparison (Table 3).

Table 3: Summary of growth dynamics of forest from growth and yield plots

Parameter	Species group	Estimates under SMS	Estimates of Growth & Yield Plots	
			Mean	Range
Diameter increment	All marketable species	0.80	0.61	0.44-0.73
	Dark/Light Red Meranti	1.05	0.74	0.55-1.03
	Medium heavy marketable species	0.75	0.59	0.46-0.76
	Light non-meranti marketable species	0.80	0.53	0.32-0.69
	Non-marketable species	0.75	0.50	0.33-0.76
Gross volume growth	All species	2.75	1.11*	NA
	All marketable	2.20	1.63*	NA
Mortality rate	All species	0.9%	0.78%*	NA
Ingrowth rate	All species	0.6%	5.47%*	NA

*Based on 8-15 years after harvesting
Note that direct comparison between SMS and the figure above may not be appropriate due to data structure that include extreme cutting regime not applied under the SMS

The results from the growth and yield studies are being used to re-evaluate the assumptions used in the SMS to support sustainable forest management of the production forest. The results, although representing a variety of forest sites, reflect the need to look into the calculation of cutting cycles due to lower average volume estimates and higher mortality rates. Ismail *et al.* (2005) reiterates that variations among the data between study sites posed difficulties to recommend growth figures for specific sites, and suggested the need to establish permanent sample plots in all forest reserves for a localized growth data.

Conclusions

Sustainable forest management will remain an important agenda in the international discussion that requires commitment from various sectors to achieve it. Sustainable forest management is not without cost. Continuous support and commitment from various sectors at national, regional and international levels including government institutions, private sectors and NGOs is needed to ensure that the forest will be managed in a sustainable manner for the benefits of future generations.

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Making sustainability work for complex forests: towards adaptive forest yield regulation

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Abstract

Criteria and indicators (C&I) have been worldwide accepted as a way to conceptualize and measure sustainability of forest management. Various C&I sets or standards were formulated by different organizations and processes such as ITTO, CIFOR, FSC, ATO and Montréal Process. These standards, particularly in the production aspect, underline the sustained forest yield principle and the importance of using permanent sample plot data to regulate forest yield. This principle can only be achieved when the forest yield is regulated according to its dynamics and growth which is unique for each site and unlikely to be completely known. As a result, no single yield regulation can be implemented across areas and dynamic complex interaction between forest and people. Any yield regulation practice has to be considered as a hypothesis. This hypothesis then is to be tested in the real world and to be learned for better practice in the future. This is what we call adaptive yield regulation'. Some simulation studies proved that this adaptive yield regulation concept meet up with the need for yield regulation schemes for small-scale forest management. In the broader sense the concept and practice of adaptive yield regulation is enfolded in adaptive management, which considers continuous and conscious learning as the only way to manage the complex forests.

Keywords: Complex forest, sustainability, criteria and indicators, growth, yield regulation, adaptive management

Introduction

The concept of sustainable forest management

According to Webster's Dictionary (1988), the etymological root of sustainability is derived from the Latin verb *sustenere* (= to hold). This etymology is also reflected in the debate among Spanish-speaking scientists about whether *sostenibilidad* (from *sostener*) or *sustentabilidad* (from *sustentar*) is the more accurate translation. The first term is closer to "being upheld" while the latter term is closer to "to uphold" (Becker 1997). The latter terminology indicates a strong normative component in the concept of sustainable development.

Sustainable development has an essentially normative character, which makes it difficult to put into practice. It implies a close relationship between environmental considerations and economic growth. Within sustainable development, economic and social objectives must be balanced against natural constraints. A spirit of solidarity with future generations is included in the concept. Sustainable development is based on the common principles of self-reliance, fulfillment of basic needs and quality of life (Schtivelman and Russel 1989). Bruntland's Commission defined sustainable development as "a process in which the exploitation of resources, direction of investments, orientation of technology development and institutional changes are all in harmony, enhancing both current and future abilities to meet human needs and aspirations" (WCED 1987 in Haeruman 1995). To present the interdisciplinary nature of sustainability assessment, a conceptual framework or basic structure for sustainability assessment (Figure 1) was proposed (Becker 1997).

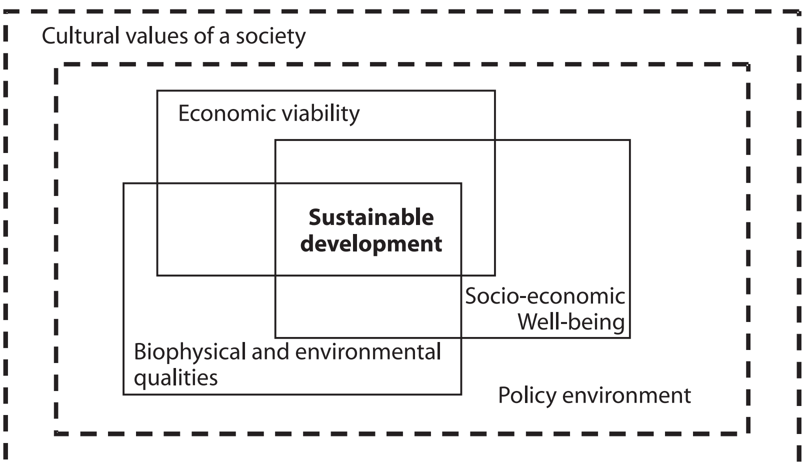


Figure 1. Conceptual framework for sustainability assessment (After Becker 1997)

The framework shows very clearly that an assessment of sustainable development must involve consideration of society's ethical or cultural values. Thus, any discussion about sustainable development should involve an understanding of local values. To assess or measure the degree of SFM a set of criteria and indicators (C&I) are needed. Indeed, C&I have been recognized as a way to conceptualize SFM as well as a practical guide towards SFM.

Measuring sustainable forest management

Forests, in general, possess ecological, economic and social functions. Consideration of these functions of forests was used to derive principles, criteria and indicators (P, C and I) for sustainable forest management, which are structured hierarchically (Figure 2). *A principle is a fundamental truth or law as the basis of reasoning* (Concise Oxford Dictionary 1995). A principle refers to a function of a forest ecosystem or to a relevant aspect of the social system(s) that interact with the ecosystem.

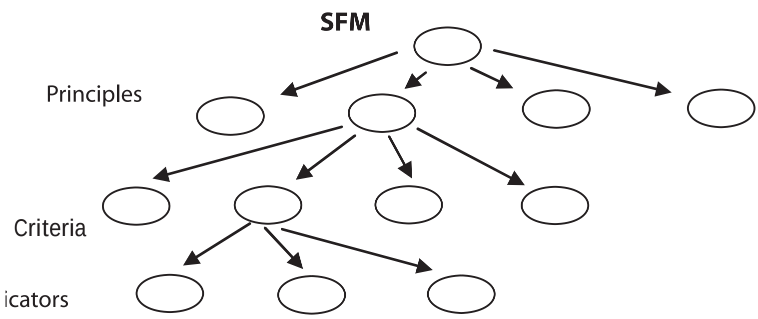


Figure 2. Hierarchy structure of SFM

Criterion is *a standard, rule or test by which something can be judged* (Concise Oxford Dictionary 1995). The function of the criteria is to show the level of compliance with principles related to the forest ecosystem or its related social system. Compliance with the principles is translated into descriptions of resulting specific and concrete states or dynamics of the forest ecosystem, or the resulting states of the interacting social system. As the function of criteria is to show the level of compliance with a principle for the forest ecosystem or related social systems, criteria should be formulated in terms of outcome. This means that a criterion describes which state is most desired in the forest or social system. Formulations of criteria must not express that a desired state should be achieved nor how this state is to be achieved. Formulations in the form of prescriptions do not comply with the requirements for criteria in the hierarchical framework. Prescriptions should be reserved for the formulation of guidelines and actions. The formulation of a criterion must allow a verdict to be given on the degree of compliance within an actual situation. (Bueren and Blom 1997).

An indicator was defined by the ITTO (1998) as a quantitative, qualitative or descriptive attribute that, when periodically measured or monitored, indicates the direction of change. To "indicate" is defined in the Concise Oxford Dictionary (1995) as *point out*, *make shown*, *show*, or *be a sign or symptom of*, *express the presence of*. FSC defined indicators as *any variable, which can be measured in relation to specific criteria*. An indicator is an assessable parameter describing features of the ecosystem or social system (outcome parameters), or policy and management conditions and processes (input or process indicators). An indicator as an outcome parameter often describes the actual condition of an element in the forest ecosystem or related social system in quantitative or relative terms. Indicators may also refer to a human process or intervention which is to be executed - or to an input (e.g. the existence or characteristics of a management plan; or a law). These types of indicators are respectively known as process and input indicators. They are in fact indirect indicators that reflect elements of the management and policy system (Bueren and Blom 1997).

A fourth hierarchical level, below the level of these indicators, may be needed to describe the way the indicators are measured in the field. The parameters at this level are called verifiers. Verifiers are not shown in the hierarchy because they are optional. They refer to the source of information for the indicator and relate to the measurable element of the indicator. The verification procedure clarifies the way the indicator is measured in the field and the way reference values are established. Choosing a reference value is always difficult when formulating target values or thresholds because it is often an arbitrary procedure (Bueren and Blom 1997).

SFM criteria and indicators and permanent sample plots

SFM may apply to the forest management unit (FMU) or national scale. This paper concerns SFM at FMU scale. To understand the term that refers to FMU or unit of forest management needs firstly understanding forest organization. A primary territorial unit of forest is shown in Figure 3. Osmaton (1968), and defines woods, blocks and enclosures as synonymous terms used to refer to wooded areas bounded by natural features, which have well-known local names. They may have been the result of legal separation by the closing off from surrounding land for the purposes of preservation or distinction of ownership. Osmaton also defined 'compartment' as the smallest permanent sub-division of a forest. B.C.F.T (1953) in Osmaton (1968) defined compartment as a territorial unit of a forest permanently defined for the purposes of administration and records. Being a permanent unit, the compartment should be clearly demarcated on the ground and its boundaries should follow natural features or definite artificial features. A sub-compartment was defined as a unit of treatment.

International Tropical Timber Organization or ITTO (1998 p. 5) defined an FMU as a clearly defined forest area, managed in accordance with a set of explicit

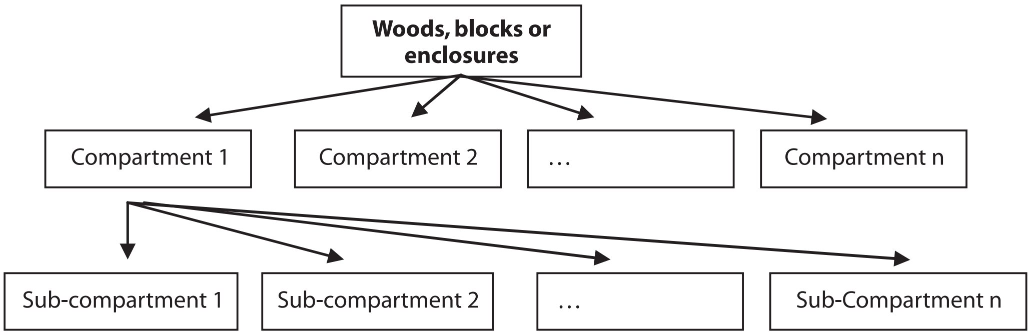


Figure 3. Organization of a forest

Box 1. ATO Standard concerning the FMU

P.3 AREAS DEVOTED TO FORESTRY ACTIVITIES OR THE PERMANENT FOREST ESTATE ARE NOT DECLINING.
C.3.1 Areas devoted to forestry activities or permanent forest estate are clearly delimited and their boundaries have been well established.
I.3.1.1 There exists a map showing the boundaries of the permanent forest estate.
I.3.1.2 The boundaries of the permanent forest estate are well marked in the field.

objectives and long-term management plan. Prabhu *et al.* (1996) defined an FMU as a clearly demarcated area of land predominantly covered by forests, managed in accordance with a set of explicit objectives and long-term management plan. Therefore an FMU is more or less similar to: wood, block and enclosure. However, FMU has a clearer definition than this.

SFM encompasses ecology, social and production principles. In the production principle, a sustained yield principle is spoken. This is true for various C&I produced by internationally recognized organizations and processes, including the (ITTO), Forest Stewardship Council (FSC), Montréal Process, African Timber Organization (ATO), CIFOR and Finnish Process. In addition, we can mention LEI standard for Indonesian process. We often use the word ‘standard’ for C&I, since not all processes result C&I. For instance, FSC produces principles and criteria, meanwhile ITTO produce criteria and indicators. Box 1 provides an example of the importance of FMU in the SFM standard to delineate the permanent forest estate.

“Sustained forest yield principle” is the central idea of the production aspect of SFM standard. Forest yields may refer to timber and non-timber forest products. In terms of timber products, regulating forest yield needs the precise and accurate forest stand growth. This growth can only be known through the continued measurement of permanent sample plots (PSPs). Box 2 provides standards that PSP directly matters.

Box 2. Examples where we can find standard that PSP directly matters

FSC Standard

P.9 MONITORING AND ASSESSMENT

C.9.2 Forest management should include the research and data collection needed to monitor, at a minimum, the following indicators:

1. Yield of all forest products harvested;
2. Growth rates, regeneration and condition of the forest;
3…

P.8 MANAGEMENT PLAN

C.8.1 The management plan and supporting documents shall provide:

…

4. Rationale for rate of annual harvest and species selection;
5. Provisions for monitoring of forest growth and dynamics

…

ITTO Standard

P.4 SUSTAINABLE FOREST MANAGEMENT RELATED TO PRODUCTION OF GOODS AND SERVICES ASPECT

C.4.1 Flow of Forest Produce

I.4.1.2 Estimate of level of sustainable harvest for each main wood and non-wood forest product for each forest type

I.4.1.8 Availability and implementation of management guidelines for each of the main wood and non-wood forest products to be harvested, to cover: (a) the assessment of natural regeneration, and (b) measures to supplement natural regeneration where necessary

Montréal Process Standard

Criterion 2: Maintenance of productive capacity of forest ecosystems

Indicators:

b. Total growing stock of both merchantable and non-merchantable tree species on forest land available for timber production.

ATO Standard

P.4 FORESTS ARE ADEQUATELY MANAGED AND DEVELOPED IRRESPECTIVE OF THEIR ROLE.

C.4.4 Planning and implementation of logging are carried out in conformity with guidelines of the management plan and the contract agreement based on technical and social standards as well as financial specifications.

I.4.4.3 Calculations of allowable cut and rotation period are clearly detailed in the management plan and are consistent with silviculture standards, increment data, prior inventory and harvestable areas, and are established at levels considered compatible with sustainable production of the forest.

Forest stand dynamic and cutting systems

Forest stand dynamics

Diameter class projection methods (DCPM) represent the oldest class of mathematical models developed for growth projection in tropical forests. The basic concept of DCPM is that the forest is represented as a stand table of tree numbers classified by diameter classes. The change in the stand table is calculated over an interval of perhaps 5-10 years using periodic increment data. The revised table is then used as a starting point from which to repeat the calculations. In this way, increment, mortality and in-growth observations made from permanent sample plots over relatively short periods may be used to estimate growth over a complete felling cycle or rotation (Alder 1995).

Vanclay (1994) categorized forest stand growth models into three categories: whole stand models; size class models; and single tree models. He stated that size class models provide information on the structure of the stand. This approach is a compromise between whole stand models and single tree models. Stand growth models, logging and logging damage constitute stand dynamic.

On the basis of information generated from the permanent growth plots, upgrowth (i.e. number of trees moving up to higher diameter class), mortality and ingrowth (i.e. number of trees growing into the smallest diameter class) are calculated. The projection method involves estimates of recruitment (R) representing ingrowth, outgrowth (O) or upgrowth and mortality (M). The projected number of trees at any diameter class 'j' and after a growth period 't+1' ($N_{j,t+1}$) is defined as

$$N_{j,t+1} = N_{j,t} + R_j + O_j - M_j \text{ ....(1)}$$

where $N_{j,t}$ is the initial number of trees in diameter class j at time t (Purnomo *et al*. 2004).

Logging damage varies in its form and extent. The method and intensity of logging will influence the degree and type of damage. Logging (L) and its damage (LD) changes model Eq. (1) into

$$N_{j,t+1} = N_{j,t} + R_j + O_j - M_j – Lj – LDj \text{ .... (2)}$$

Forest biometrics Laboratory, Faculty of Forestry, Bogor Agricultural University (IPB) has developed software called MNH-IPB, which stands for *Manajemen Hutan dengan Intensitas Penebangan Berimbang* or managing forest with proportional cutting intensity. This software implements stand DCPM and features various forest management scenarios and concerns.

Review and critics to the Indonesian yield regulation system

The natural production forests in Indonesia, which are mixed-species and uneven-aged forests, are managed based on the Indonesian selective cutting and replanting system (called TPTI). In the TPTI system, harvesting is only allowed for all commercial trees species having a certain limit of diameter, i.e. 50 cm for `full production forests` and 60 cm for `limited production forests`. In addition, the length of cutting cycle is 35 years which was based on the assumption that the diameter increment of commercial tree species is 1 cm per year and the volume increment is at least 1 m^3 ha^{-1} per year (van Gardingen *et al.* 2003, Suhendang 2002).

The TPTI system has been criticized by many parties particularly due to its simplified assumptions of the yield regulation as mentioned above. Suhendang (2002) pointed out some drawbacks of the TPTI system as follows:

- The assumption that diameter increment is 1 cm per year applicable to all forests is not valid. In fact, the diameter increment varies according to tree species and site condition. Sumarna *et al.* (2002) reported that the average diameter increment of commercial species was 0.59 cm yr^{-1} and that of non-commercial species was 0.53 cm yr^{-1}.
- The fixed length of cutting cycle (i.e. 35 years) which is applicable to all forests is unreasonable. Indeed, the length of cutting cycle should be determined based on the diameter increment and dynamic of stand structure.
- The method to calculate an annual allowable cut (AAC), which is only based upon standing stock volume and without considering current stand increment, is only suitable for virgin forests. It tends to be overestimated if it is applied to logged-over forests.

A study conducted by van Gardingen *et al.* (2003) in Labanan concession has also demonstrated that yield regulation based on the TPTI system would lead to a rapid deterioration of the forest structure. However, such conditions could be minimized by increasing the length of cutting cycle, controlling the yield strictly, and implementing reduced impact logging. For the Labanan concession, their simulations showed that the best options of yield regulation were limiting the yield to 50 m^3 ha^{-1} with a 35-years cutting cycle or 60 m^3 ha^{-1} for a 45-year cutting cycle.

Adaptive Yield Regulation

Principle of adaptive yield regulation

Forest grow the varies from one place to another place and from one time to another time. Most of them are not known very well. The interaction among biophysical forest components e.g. insects, mammals, viruses, light and nutrients may effect the forest growth. People surrounding forests as the important actors of forest management in people-forest interactions may vary from one site to another. Therefore, no single silviculture system (e.g. TPTI) can be applied across different complex forests and people living systems. Fortunately, some standards have guided the continuous viewing of any silviculture systems (Box 3).

Box 3. Adaptive Yield Regulation

ATO Standard
C.4.4 Planning and implementation of logging are carried out in conformity with guidelines of the management plan and the contract agreement based on technical and social standards as well as financial specifications.
I.4.4.5 Felling programmes are adjusted rapidly if the change in data collected on the field is significantly different from that on which the manager's initial estimate is based. The management plan is amended to be consistent with the true data.

ITTO Standard
C.4.1 Flow of Forest Produce
I.4.1.9 Availability and implementation of procedures to monitor and review the management guidelines
I.4.1.11 Availability and implementation of: (a) procedures for comprehensive evaluation of the implementation of management guidelines, (b) procedures to assess damage to the residual stand, and (c) post-harvest surveys to assess the effectiveness of regeneration

However, what is Adaptive Yield Regulation (AYR)? AYR is a term derived from the concept of adaptive management of forest. Purnomo (in press) defines adaptive management as "a management system which works consciously and actively in the complexity and uncertainty, which treats every action as a hypothesis to be tested in the real world, so that it will develop a continued learning process which reduces uncertainty in the system towards better management performance". AYR is a term of yield regulation to include the complexity and uncertainty of forest stand growth and yield, which effect and is affected by its ecosystems and people surrounding it. The principles of AYR include:

1. No single formula can be applied across the different complex forests. Forest yield must be regulated based on a spatially and temporarily representative PSP. Otherwise, it is untrue.
2. Every forest yield figure and formula is a hypothesis to be tested in the real world. Learning from the past and future to make continued improvement is the only strategy for regulating forest yield.

3. Maintaining the minimum number of trees entering diameter classes is the primary key in designing the forest management scenarios.
4. Rotation among cutting areas can be carried out in a flexible manner according to their area stand outgrowth.
5. It can be implemented in the big and small-scale FMUs through various scenario planning.

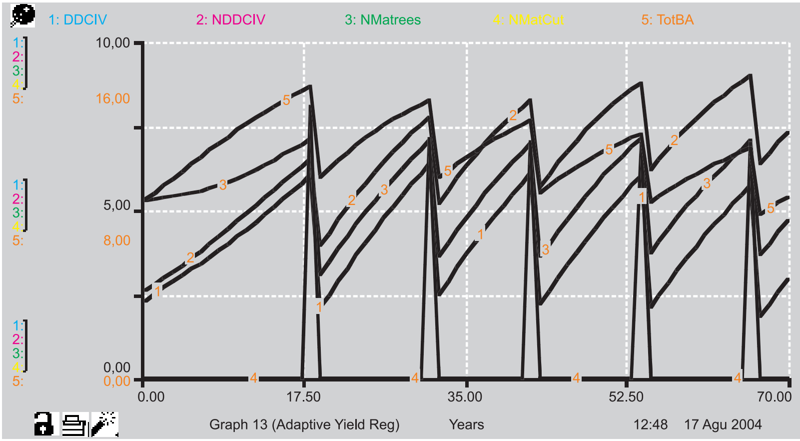
Adaptive yield regulation at small-scale forest management unit

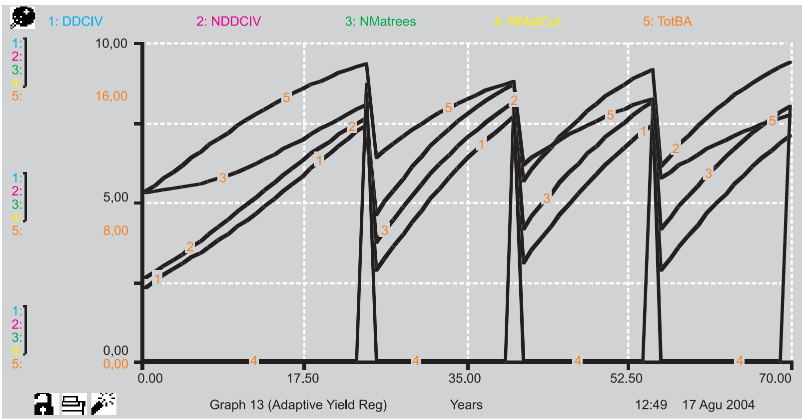
This session describes the example of using simulation method to implement AYR. The study was carried out by Aswandi (2005) in a community forest reserve that amounts to 3,500 ha in Tanjung Village, Kampar District, Riau Province in 2004. The stand volume is 107,90 m^3/ha, while the basal area is 8,51 m^2/ha. The average annual growth is 0,83 cm/year. Dipterocarps species found in the area are kapur (*Dryobalanops* sp.), meranti (*Shorea* spp.) and keruing (*Dipterocarpus* sp.). The non dipterocarps species are medang (*Litsea* spp.), kelat (*Xylopia* spp.) and rengas (*Gluta renghas*).

The primary question was how to manage timber in such small-scale FMU. TPTI is definitely not the answer to this problem. He then modeled the forest stand dynamic in the area using the closest available PSP. He searched what kind of cutting systems can increase the benefit to the communities. He then simulated different numbers of trees which can be cut and different cutting cycles. He then found seven trees with 14 years cutting cycles and eight trees and 22 years are the good choices. So that the AYR in his context was defined as cutting seven trees per hectare with 14 year-cutting-cycle. Using this kind of rule, the area was projected to have more than two times the benefit compared to the 35 year rotation. Figure 4 simulates the AYR system in this context.

Conclusion and policy implication

This paper describes the concept of adaptive yield regulation as a way to manage complex forests. This is not a new concept. Some standards have indicated the important role of permanent sample plots measurement to prescribe forest yield regulation. However, the rigid yield regulations have been dominating forest management systems in several countries. Many of them have failed to sustain forests. Forests are not as simple as they perceived. They are dynamic and most of them are not well known. Managing forests is managing the unknown. Continuous and conscious learning of complex and adaptive forest ecosystems is the only way to manage the complex forests. This is the basic concept towards adaptive management, where adaptive yield regulation is part of it.





1. DDIV: number of dipterocarps trees (>50 cm)
2. NDDIV: number of dipterocarps trees (>50 cm)
3. NMatrees: Number of matured tress
4. NMatcut: Number of matured trees to cut
5. TotBA: Basal area

Figure 4. Example of adaptive yield regulation (Aswandi 2005)

This paper suggests a freedom or flexibility of a forest concession manager to manage its FMU. The flexibility here means that the manager does not have to track the national prescription of yield regulation. The manager can regulate their forest yield according to its PSP data. However, not all concessions can be awarded this flexibility. Some necessary conditions must be fulfilled by the concession in order to get this flexibility i.e. (a) good performance in managing its forest indicated by a third party independent; (b) the completeness and sufficiency of PSP data; and (c) representation and reliability of PSP data.

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A brief note on TPTJ (Tebang Pilih dan Tanam Jalur), a modified Indonesia selective cutting system, from experience of PT Sari Bumi Kusuma timber concessionaire

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Abstract

TPTJ is the selective cutting and strip planting system. This system is a modification of the Indonesia Selective Cutting and Planting System (TPTI), and was put in practice in PT SBK in 1998. The main purpose of TPTJ is to ensure sustainable harvests, and the conservation of rainforest ecosystems.

The practice was carried out in a logged-over forest (208 300 ha), consisting of 148,939 ha for logging, 10,972 ha for replanting and 48 389 Ha for conservation. In TPTJ, selected trees with diameter > 45 cm were harvested. The width of clearcut strip is 3 m. A 15-22 m block or intermediate block is established between the clearcut strips. Only selected trees are cut in these blocks. Selected Shorea species are planted along the clearcut strip, and parent trees (Ø > 20 cm) in intermediate blocks were carefully maintained.

This management practice shows that TPTJ is a lot better than the former Indonesia Selective Cutting System. The natural regeneration in intermediate blocks is high due to the opening gaps. Under this adjustable TPTJ system, trees with Ø > 45 cm are logged, while in the Indonesia Selective Cutting and Planting System (TPTI) the harvest is limited to trees with Ø > 60 cm. Since the robust growths of natural regeneration, the logging cycle is predicted to be shorter than the 35 years logging cycle of TPTI. However, TPTJ is only applied to logged-over forests. Other disadvantages that are associated with the practice of TPTJ are increases in production costs and potential environmental impacts, resulting from the establishment of clearcut strips.

Keywords: Modified Indonsian Selective Cutting, sustainable forest

Introduction

Indonesian Cutting Systems have experienced many modifications. The first cutting system is called TPI (Tebang Pilih Indonesia, Indonesian Selective Cutting), which was introduced in 1972. The presently practiced cutting method is known as Tabang Pilih dan Tanam Indonesia (Indonesia Selective Cutting and Planting System, TPTI), which was firstly implemented in 1989. Finally, the Government has introduced a modified TPTI, and this is called *Tebang Pilih dan Tanam Jalur* (Selective Cutting and Strip Planting System ,TPTJ).

PT Sari Bumi Kusuma (PT SBK), a forest concession company, was given a second lease for 70 years on 27 February 1998, with a total area of logged over forest of 208,300 ha. Under this new lease, the Government authorized PT SBK to apply TPTJ. The first concession area, 270,000 ha, was granted in 1978.

The harvest was initially commenced in 1978, with the TPTI system. Major species found in the area are Meranti (*Shorea* spp), Melapi (*Terictia* spp), Kapur (*Dryobalanops* spp), Bangkirai (*Shorea laevifolia*), Keruing (*Dipterocapus* spp) and Mersawa (*Anisoptera* spp). The comparison of forest conditions in uncut and cut areas at the end of the first concession cycle is presented in Tables 1 and 2.

This paper aims to introduce the preliminary results of TPTJ implementation in PT SBK.

Material

The system was applied in 1989. The logging area covers 148,939 ha for logging, 10,972 ha for replanting and 48,389 ha for conservation. The total concession area is 208,300 ha, which is divided into two blocks:

1. Katingan/Seruyan Block, with a total area of about 147,600 ha, located in the Katingan Hulu & Seruyan Hulu Sub District (Kecamatan), Katingan & Seruyan District (Kabupaten) of Central Kalimantan.
2. Delang Block, with a total area of about 60,700 ha, located in the Lamandau and Delang sub-districts, Lamandau District, Central Kalimantan.

The total effective forest area available under the new agreement is 148,939 ha and the annual area available for cutting is 4,255 ha of which 3,405 ha is in Block Katingan/Seruyan and 850 ha in Delang Block.

Study site and methods

The location of PT SBK is in Central Kalimantan (See Figure 1). The accessibility is easier from Melawi District, which is located in West Kalimantan Province. The concession area is located about 460 km from Pontianak, the capital of West Kalimantan Province. The concession area is divided into three categories (See Table 1). About 74.4% of the total area is considered effective for harvesting & Replanting (TPTJ), and 5.5% for reforestation. The remaining area is not available both for logging and replanting.

Table 1. The plan of PT SBK, following the effective area for logging

Details	Katingan/Seruyan Block	Delang Block	Total
Effective Forested Area			
Limited production Forest	107,011	28,126	135,137
Production Forest	12,168	1,634	13,802
Sub Total	119,179	29,760	148,939
Available for Reforestation ex. Grass land			
Limited production Forest	5,241	5,182	10,423
Production Forest	189	360	549
Sub Total	5,430	5,542	10,972
Non Available Area			
Limited production Forest	21,901	22,402	44,303
Production Forest	1,090	2,996	4,086
Sub Total	22,991	25,398	48,389
Grand Total	147,600	60,700	208,300

The logging activities follow the Annual Allowable Cut (AAC) that is officially approved by the Provincial Forestry Department (Dishut Propinsi). The annual logging block is 4,255 ha, and this block is divided into ± 100 ha compartments.

The TPTJ system is only applied in logged-over forests, while in uncut or virgin forests, the TPTI system is put into practice. Under the TPTI, the harvest is only aimed to trees with Ø > 60 cm, with the estimated yield of 55 m^3 per ha. In comparison, we cut trees with Ø > 45 cm under TPTJ system.

Under the TPTJ system, seedlings are planted in line, spaced 25 m apart. The strips are totally cleared, with 3 m width. Main species planted are *Shorea Leprosula*, other *Shorea*, *Diptrocarpus* spp., *Hopea* spp and *Peronema canescens*. A comparison of TPTJ system between the government policy and PT SBK practice is presented in Table 2.

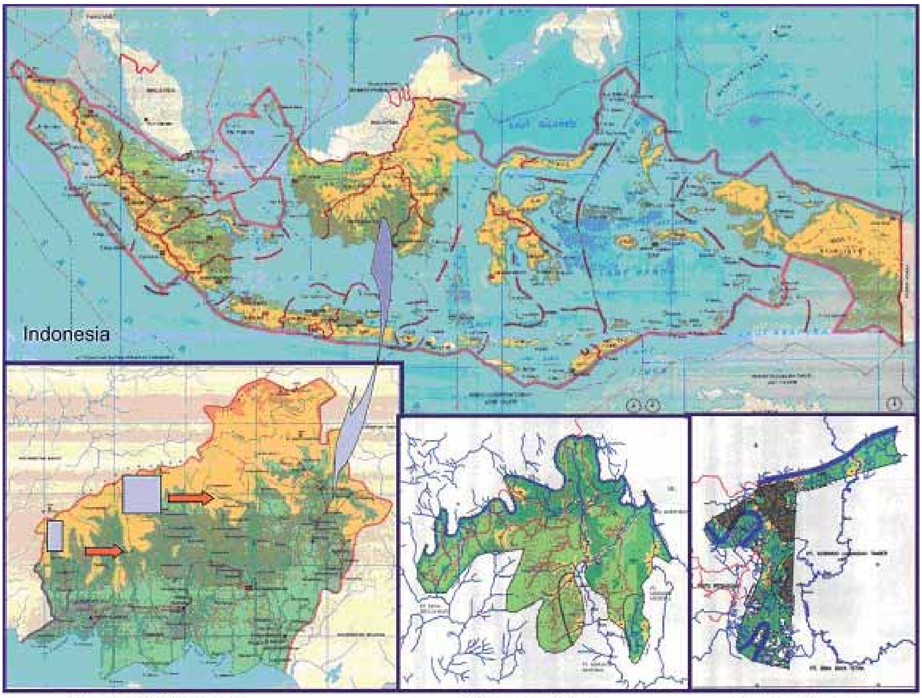

Figure 1. The location of PT SBK concession area

Table 2. A comparison of TPTJ practice by PT SBK and the government policy

Criteria	Govt. Prescriptions	SBK modified System
Distance between planting lines	25 m	25 m
Distance between trees on planting line	5 m	5 m
Witdh of clear-cut planting strip	3 m	3 m
Partially cleared strip on either side of clear-cut strip to reduce shading (all trees above 30 cm DBH are to be cut)	3.5 m wide on both sides of each clear-cut strips	None
Witdh of area in-between strips	15 m	22 m
Minimal DBH of trees to be harvested in the area in-between strips	40 cm Up	45 cm Up

Between two clearcut strips, a 22 m block is retained in order to enhance natural regeneration. A 35-year cutting cycle will be applied in this block.

Results

Before we present the results of TPTJ practice, we would like to present the conditions of uncut and logged areas from the concession.

Table 3. The mean number of trees and estimated timber volume in uncut (virgin) area at the end of first concession lease, with sampling intensity of 1%

Species	Diameter Class					
	20 – 49 cm		50 – 59 cm		60 cm up	
	N (trees)	V (m³)	N (trees)	V (m³)	N (trees)	V (m³)
I. Commercial						
Dipterocarpaceae	20.42	17.58	5.18	12.13	7.37	53.23
- Floater	9.16	6.50	2.57	5.93	1.58	11.33
- Sinker						
Sub Total	29.58	24.08	7.75	18.06	8.95	64.56
Non-Dipterocarpaceae						
- Floater	14.39	11.84	3.94	8.13	1.14	6.10
- Sinker	3.60	2.60	1.32	2.71	0.12	0.56
Sub Total	17.99	14.44	5.26	10.84	1.26	6.66
Total I	47.57	38.52	13.01	28.90	10.21	71.22
II. Non Commercial						
- Floater	7.78	6.06	2.06	4.33	0.97	5.13
- Sinker	5.18	3.56	1.37	2.89	0.83	3.90
Total II	12.96	9.62	3.43	7.22	1.80	9.03
Total I + II	60.53	48.14	16.44	36.12	12.01	80.25

Table 4. The number of trees and estimated timber volume in logged-over area at the end of first concession lease

Species	Diameter Class					
	20 – 49 cm		50 – 59 cm		60 cm up	
	N (trees)	V (m³)	N (trees)	V (m³)	N (trees)	V (m³)
A. Meranti Group	13.71	9.31	2.33	5.86	4.48	30.62
B. Mix Species	14.22	9.59	1.52	3.44	1.10	5.52
C. Fancy Woods	0.88	0.68	0.21	0.46	0.25	1.04
Total	28.81	19.58	4.06	9.76	5.83	37.18

Table 5 shows that average yields of TPTJ practice is higher that that of TPTI. An inventory one year after logging in virgin forest is presented in table 7. This table shows that natural regeneration is insufficient, about 2.1 %. Post-harvest inventory also indicated that one year after logging, the logged-over area has an average 32.85 trees of diameter 20 cm and above with a volume of 47.65 m^3 per ha, along with 102 poles (diameter 10 cm to 20 cm), 418 saplings (diameter less than 10 cm) and 2,650 seedlings.

This data shows that the annual growth of selected dipterocarps planted under TPTJ is substantially high. In contrast, the average annual growth for dipterocarp species is usually about 1 cm.

Table 5. The comparison of yields between TPTI and TPTJ practices

Time	Year	Cutting	
		Ha	Cum
Original Concession (TPTI)	1980 / 1981	195	14.528
	1981 / 1982	1.421	96.535
	1982 / 1983	1.035	87.967
	1983 / 1984	2.500	103.063
	1984 / 1985	4.250	168.667
	1985 / 1986	4.300	136.520
	1986 / 1987	4.200	109.361
	1987 / 1988	3.200	118.864
	1988 / 1989	2.800	136.874
	1989 / 1990	5.000	181.256
	1990 / 1991	4.300	198.820
	1991 / 1992	4.300	210.823
	1992 / 1993	3.500	228.897
	1993 / 1994	5.130	239.420
	1994 / 1995	5.250	308.398
	1995 / 1996	4.920	253.754
	1996 / 1997	5.361	253.673
	1997 / 1998	3.902	248.339
TOTAL		65.564	3.095.759
AVERAGE		3.642	171.987
Renewed Concession (TPTJ)	1998 / 1999	6.186	319.094
	1999 / 2000	7.502	349.812
	2000	6.070	260.568
	2001	6.438	289.785
	2002	7.781	313.132
	2003	7.062	275.073
	2004	7.212	274.198
TOTAL		48.251	2.081.661
AVERAGE		6.891	297.380

Discussion

The TPTJ system has some potential advantages and disadvantages. These include:

- An increase of productivity, particularly rapid growth in blocks between the clear cut strips.
- It is approved that the diameter of 45 cm is sufficient to enhance the natural regeneration. This size is lower than TPTI limit, which is 60 cm.
- It is estimated that the logging cycle would be less than 35 years.
- TPTJ is ideal for managing the logged-over forests where production and protection functions are ensured in blocks among the clear cut strips.

Table 6. The annual growth of selected dipterocarps planted in the TPTJ concession area

No	Species	Age Year	Mean		MAI		Remark
			Diameter Cm	Height M	Diameter Cm	Height M	
1	*Shorea leprosula*	4.50	9.06	7.62	2.01	1.69	MAI from 3 selected species = 1.94 Cm/ year
2	*Shorea johorensis*	4.50	8.69	7.54	1.93	1.68	
3	*Shorea parvifolia*	4.50	8.42	7.07	1.87	1.57	
4	*Shorea compresa*	4.50	7.61	6.29	1.69	1.40	
5	*Shorea seminis*	4.50	5.98	4.17	1.33	0.93	
6	*Shorea virescens*	3.30	4.38	3.67	1.33	1.11	
7	*Shorea fallax*	4.50	5.46	4.45	1.21	0.99	
8	*Shorea macroptera*	3.28	3.25	3.22	0.99	0.98	
9	*Hopea mangerawan*	3.23	2.25	2.98	0.70	0.92	
10	*Shorea leavis*	3.42	2.19	2.79	0.64	0.92	

Table 7. Inventory results one year after logging

Cutting	Trees of diam. 20 cm up			Opened area (ha)				Insufficient young trees (enrichment needed)	
Year	Area (ha)	Trees/ ha	m³/ha	Permanent (ha)	%	Temporary (planting needed) (ha)	%	ha	%
84/85	4,250	30.95	64.81	103.13	2.42	136.01	3.20	105.84	2.49
85/86	4,300	25.75	41.93	183.08	4.25	133.94	3.11	118.85	2.76
86/87	3,600	25.19	47.48	114.92	3.19	104.11	2.89	82.24	2.28
87/88	2,600	26.92	62.55	67.60	2.60	89.70	3.45	87.36	3.36
88/89	2,800	26.22	50.69	78.40	2.80	115.32	4.12	66.43	2.37
89/90	5,000	26.22	50.69	131.13	2.62	255.63	5.11	140.44	2.81
90/91	4,300	25.22	48.08	157.76	3.66	215.00	5.00	109.22	2.54
91/92	4,300	25.35	49.81	130.13	3.02	250.90	5.83	124.08	2.89
92/93	3,125	25.04	29.62	109.28	3.49	261.66	8.34	79.06	2.53
93/94	4,150	31.98	61.75	218.18	5.25	346.04	3.34	104.99	2.53
94/95	4,125	28.34	34.98	254.70	6.17	148.83	3.61	7.76	0.19
95/96	3,950	46.54	36.53	302.35	7.65	168.24	4.26	27.55	0.70
96/97	4,290	60.06	48.37	562.66	13.12	171.17	3.99	35.67	0.83
97/98	3,984	56.06	39.84	212.80	5.34	184.00	4.62	40.30	1.01
Total	54,774	459.84	667.13	2.626.12	65.58	2.580.60	60.87	1.129.79	29.29
Average	3,912	32.85	47.65	187.58	4.79	184.33	4.71	80.70	2.06

- From a socio-economic perspective, the TPTJ needs more workers than the TPTI system (almost twice in number). And forest managed under TPTJ is locally considered as a man-made forest, which would prohibit local people to conduct shifting cultivation, as the customary law doesn't allow cultivation in a man-made forest.
- TPTJ system is more costly than the other system.
- Environmental impact from the clearcut strips could be potentially high, and this needs a good environmental management plan.

In a 35-year-cycle, the estimated yield is about 267 m^3 per ha from the clearcut strips, and 72 m^3 from the blocks. Our calculation shows that the annual growth under TPTJ system is about 9.7 m^3. This is a lot higher than the TPTI system, which is about 1 m^3/ha/yr.

Conclusion

At this stage, we found that the TPTJ system is much better than the TPTI system. A major advantage of TPTJ is robust growth and rapid diameter increment of planted dipterocarps, both on the clearcut strips and intermediate blocks. This means that the logging cycle would be shorter than 35 years, and the company would enjoy sustainable harvest from planted dipterocarp forest. The TPTJ also employs more workers than the TPTI.

It is also important to note that environmental impact of clearcut strip establishment is potentially detrimental if no control measure is applied. With proper environmental management, the potential impacts could be reduced or managed. The establishment of planted forests also would reduce the rate of forest conversion into small scale food crop agriculture, particularly by shifting cultivators. According to customary laws, indigenous communities are not allowed to practice shifting cultivation in any planted forest without a permit from the owners.

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Indonesian natural tropical forests would not be sustainable under the current silvicultural guidelines – TPTI

A simulation study

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Abstract

A permanent sample plot (PSP) dataset was enumerated from primary forest in Jambi province, Indonesia. No logging treatment was applied to the plot during the period in which measurements were taken. The dataset including individual tree information, such as tree identity, diameter and position within the plot, was put into the Sustainable Yield Management for Tropical Forests (SYMFOR) computer framework. The model has been calibrated using the Berau PSP dataset (a region in East Kalimantan).

Prior to the simulation, the Jambi dataset was compared to the Berau dataset in terms of diameter class distribution, the dominant tree species and tree family distribution. It was concluded that both datasets are not significantly different. Moreover, both datasets are lowland tropical primary forest types. Therefore, the software recalibration process is not necessary.

Using the SYMFOR computer model several silvicultural methods were simulated. These were the conventional methods of TPTI, RIL (Reduced Impact Logging) and a set of silvicultural methods derived from the RIL namely RIL8, RIL50 and RIL60. The RIL8 indicates that 8 stems ha^{-1} *is the maximum number of trees for the allowable cut, while the RIL50 and RIL60 are the maximum volume of the allowable cut are 50 m*^{3} *ha*$^{-1}$ *and 60 m*^{3} *ha*$^{-1}$ *respectively.*

The simulation was run over a long time in order to cover multiple harvest cycles, and was repeated several times to capture the variability among runs. Some macro commands in a spreadsheet computer package were developed to obtain the evolution of timber extracted and the stand quantity follows logging as simulation time went on.

Under 35 years cutting cycle, both RIL50 and RIL60 performed better than other methods - the amount of timber extracted per hectare in the first harvest was successfully attained again.

The simulation was also conducted by altering the length of the cutting cycle within the TPTI, RIL and RIL8. The results showed that timber production increased with the cutting cycle. In particular, under the RIL8 on 45 years cycle, the quantity of timber extracted reached its first harvest level. This might be due to the fact that the maximum allowable cut assigned for the RIL8 was less severe compared to both methods.

The effect of logging on residual stands was also simulated. It was found that both the RIL50 and RIL60 were consistently better than the other silvicultural methods; the forest system could be revived almost to the condition of pre-first harvest level.

Upon the cutting cycle extension, it was found that under RIL50 and RIL60 methods, the level of residual stand beyond the 35 years cycle was successfully returned to its pre-first harvest level. In contrast, both the TPTI and the RIL methods failed to reach their respective pre-first harvest levels despite substantial extension of the cutting cycle applied. Notably, the RIL8 which is considered to be less severe logging compared to the RIL, still failed to reach the pre-first harvest level if the cutting cycle was less than 45 years. This might suggest that careful logging operations as assigned within the RIL methods should be in conjunction with the reduction on logging severity.

This study consistently suggested that the current silvicultural guidelines in Indonesia (the TPTI) would not use our natural tropical forests sustainably. Both RIL50 and RIL60 silvicultural methods on 35 year cycles could be good alternatives for the TPTI.

Keywords: Conventional TPTI, reduced-impact logging (RIL), initial level, maximum allowable cut, extracted timber, residual stand

Introduction

TPTI (Tebang Pilih dan Tanam Indonesia) is the current silvicultural guideline for the management of natural tropical forests in Indonesia. Among the rules assigned in this selective cutting method are: individual trees above 50 cm in dbh may be harvested and the forest company may re-harvest the same area in the next 35 years. It is expected that a similar amount of timber will be obtained given this length of time for regeneration. However, those figures (e.g., 35-year cycle) were calculated from an assumption that the dbh increment of individual trees was 1 cm yr^{-1} and the volume increment was at least 1 $m^3ha^{-1}yr^{-1}$. Kartawinata (pers. comm.) indicated that the figures were too optimistic as they were not obtained from PSP datasets established in Indonesian forests. This might cause some doubt whether our natural tropical forests would be sustainable or not under this silvicultural method. Here, sustainability was only defined as to the extent that the forest system could be restored back to the respective initial level of harvest and the pre-first harvest level of the residual stand.

In order to conduct an assessment into the TPTI, extensive PSP datasets comprised of several experimental hectares, where continuous surveys have been conducted over a substantially long period of time, are required (Alder and Synott 1992). This is too expensive both in terms of labour, and financial resources required. Even in terms of time intervals required to complete the survey, it is almost impossible to assess the TPTI in the conventional way. In addition, natural tropical forests are known for their complex systems, both in terms of the size and the species of trees growing in them (Whitmore 1998). This makes the task even more difficult. This is the reason why modelling becomes important, where natural phenomena are represented to build models. The natural phenomena being modelled are recruitment, tree mortality and tree growth.

SYMFOR is as a computer model framework, due to the modularity feature offered in this software. It enables forest managers or policy-makers to assess whether a silvicultural regime being practiced for their concessionary forests, could lead to forest sustainability or not (Young and Muetzelfeldt 1998).

SYMFOR has been calibrated for the Berau PSP dataset – meaning that mathematical equations and the parameter values implemented in the software were obtained using real datasets enumerated from this plot via regression analysis. Using these datasets, a computer simulation using SYMFOR was conducted, and concluded that the TPTI would not lead to sustainable forests (Phillips *et al.* 2003; van Gardingen *et al.* 2003). Therefore, the TPTI needs be revised.

In order to check whether such a conclusion is site specific or not, the model needs to be tested. A PSP dataset gathered from Jambi province Indonesia was utilised to conduct this test. Based on a statistical test that compared the spread of the mean basal area of both datasets, it was concluded that both datasets were not significantly different. Therefore, recalibration of the mathematical equations implemented in the SYMFOR software were not necessary. Both the diameter and family distributions of all trees were presented to prove that the Jambi dataset is appropriate for this purpose. Also, both the Jambi and the Berau plots are categorised as lowland forests.

Material and methods

PSP datasets

Data of individual trees enumerated from a permanent sample plot (PSP) were made available in this study. This six hectare plot was located in Pasirmayang - Muarabungo, Jambi province of Sumatra. Laumonier (1997) indicated that the geographical location of the site is between 1°1'35"–1°5'55" South Latitude and 102°4'35"–102°6'45" East Longitude, at an elevation of about 30-40 meters asl. This 6 ha ((200x300) m^2) plot was established by BIOTROP – a research institute of Bogor Agricultural University (IPB), Bogor.

The dimensions of individuals gathered in each survey were: the tag number; co-ordinates diameter at breast height (dbh) point of measurement and the level of scientific family names were ascertained, with some to the species level. The point of measurement indicates the height of point above ground where the dbh was measured. In this dataset, those greater than 30 cm in dbh were grouped as trees, while the smaller ones, with a dbh between 10 cm and 30 cm were grouped as poles.

Quality control of the dataset

Those categorised as poles ($10 \leq dbh \leq 30$ cm) were listed and details noted in 1987, 1994 and 1998, while those categorised as trees ($dbh > 30$ cm) were listed and details noted in 1985, 1994 and 1998. In this study, both poles and trees groups were overlaid and considered as the initial condition of the stand, despite the measurement time for the first survey over two years, since the dbh increment were unlikely to be significant over such a short period of time.

In total, there are 4154 individuals enumerated in the first survey. In the second measurement, less than 90% of the total was re-measured. This was slightly increased in the third measurement, simply because some individuals were unmeasured in the second time but re-measured in the third measurement. This inconsistency was found to be mostly within the poles category.

In order to show the quality control of this dataset, the individual tree growth was calculated. It was noticed that 87% of the total individuals showed positive dbh increment within the first growing interval i.e. between the first and the second measurements. But only 74% of the total individuals were showing positive dbh increment in the second growing interval i.e., between 1994 and 1998.

The simulation was only conducted for the first measurement, as the number of measured trees was the largest compared to the following measurements. Also, the percentage of trees with positive dbh increments was the highest within the first growing interval i.e., between the first and second measurements.

The dbh class distribution

The dbh class distribution of individuals within the plot in each measurement is shown in Figure 1. This reversed-J shape commonly occurs in primary tropical forests - the number of trees decreased with the diameter class (Whitmore 1998). As shown in Figure 1.a, the number of poles within the 10-15 dbh class is rapidly decreasing with time in the survey. This captured the unmeasured poles beyond the first measurement, as previously explained.

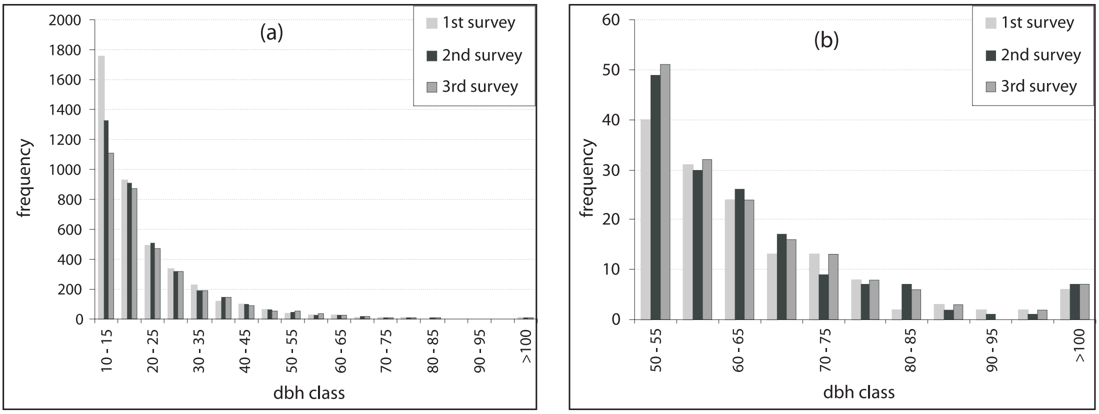

Figure 1. dbh class distribution of all individuals (a), and those above 50 cm in dbh (b)

The distribution of scientific families

More than 95% of the total individuals were identified as being from 58 scientific families. In Figure 2, tree families containing less than 20 individuals were denoted as “Others”, while the “Unknown” are those with scientific family names that could not be identified. The Dipterocarpaceae family dominates the plot, with its total basal area almost 8 m^2 ha^{-1}, which is almost 25% of the stand. This is typical of primary topical forests in South East Asia (Whitmore 1998). Sist, and Saridan (1999) reported the Berau PSP dataset (was used to calibrate SYMFOR) is also dominated by Dipterocarpaceae family.

Furthermore each individual was allocated into a member of particular ecological species group and commercial species group. The commercial groups were based on timber marketing in East Kalimantan (Rombouts 1998; Brash *et al.* 2000), while the ecological groups were established for SYMFOR using the Berau PSP dataset via nonlinear regression. The ecological grouping was intended to capture that each species group responds differently to environment change following logging. For instance, the light demanding species were plausible to be clustered into different group with the shading tolerant species. Phillips *et al.* 2003 established

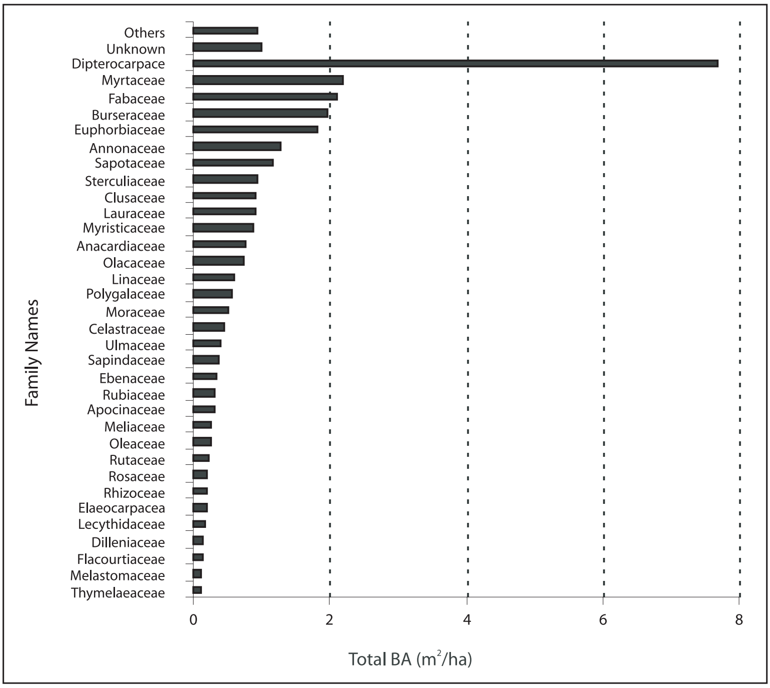

Figure 2. Distribution of scientific families of all individuals in the plot

10 species groups for the Berau dataset. These 10 ecological groups were adopted into the Jambi datasets given that both datasets were not significantly different. See the following section.

Test of similarity

This was conducted to test the similarity between Jambi and Berau datasets, provided both plots were categorised as primary forests (Phillips *et al.* 2003) and had not been logged over the measurement period. The dataset of both sources, which were enumerated in the first survey were utilized in this test.

The average basal area of living trees per hectare was calculated in conjunction with its standard error for each dataset. It was concluded that Berau and Jambi datasets are not significantly different, since error bars overlap the means. This indicates that the confidence limits overlap. Hence the difference between both datasets is considered to be non significant (Parker 1979). See Figure 3.

Setting up the modules in this simulation

The silvicultural methods simulated were TPTI, RIL, RIL8, RIL50 and RIL60. Unlike in the conventional TPTI, in those RIL descendant methods pre-harvesting plans exist, the harvesting process are more careful and felling is directed. Also, the damage to residual stands was expected to be lower for the RIL descendants given

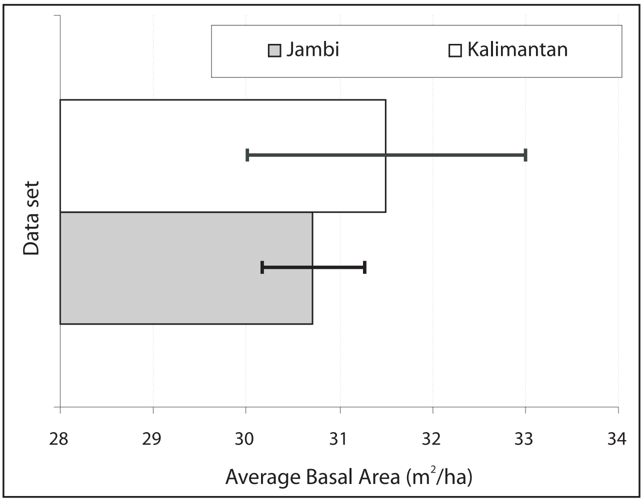

Figure 3. The comparison of basal area means between both data sets

Table 1. Specification of silvicultural regimes set up in this simulation (adapted from van Gardingen *et al.* (2003))

	TPTI	**RIL**	**RIL8 maximum 8 stems/ha**	**RIL50 maximum 50 m³/ha**	**RIL60 maximum 60 m³/ha**
Management modules					
Felling	Undirectional	Directional	Directional	Directional	Directional
Plan skidtrails	Straight	Branched	Branched	Branched	Branched
Management parameters					
Logging specifications					
Dbh threshold (groups 1-5) (cm)	50	50	50	50	50
Proportion of commecial trees (groups 1-5)	0.3	0.3	0.3	0.3	0.3
Max. number of trees extracted	500	500	8	500	500
Max. volume extracted (m^3)	500	500	500	50	60
Skidding (extraction)					
Max. dbh likely to damage (cm)	40	30	30	30	30
Skid prepared radius (m)	5	3	3	3	3
Skid width (m)	7	5	5	5	5

a shorter Skid-prep-radius, narrower Skid-width and less damage to surrounding trees (Maxdbhdamage). Therefore, those RIL descendants are considered more ecologically sound than the conventional TPTI. See Table 1.

The maximum allowable cut assigned for TPTI and RIL was 500 m^3 ha^{-1} while the RIL50 and RIL60 were assigned 50 m^3 ha^{-1} and 60 m^3 ha^{-1} respectively. For the RIL8, the maximum allowable cut was assigned 8 trees ha^{-1}. The RIL8 is considered to be moderately severe logging compared to the conventional TPTI, but more intense than RIL50 and RIL60.

For each of these six hectare plots, the simulation ran for 350 years with 20 replicates, so that multiple harvests were covered and the variability among the runs captured.

The object categories stored were denoted as Livetrees and Felled trees (trees that were logged and extracted from the forest), while the other forest objects were denoted as Stand, describing data relating to the whole stand. Some macro commands in a spreadsheet computer package were developed to manipulate both Livetrees and Felledtrees objects to obtain the amount of timber extracted for each commercial species group as time went on. The Stand object was stored to obtain the quantity response of the residual stand on a particular silvicultural regime. This fluctuate graph will be analysed to assess whether the silviculture applied would lead to sustainable forests or not.

Results and Discussion

Comparison among silvicultural regimes

The total basal area of timber extracted per hectare for each silvicultural method on 35-year cutting cycle, is presented in Figure 4. It was observed that the total quantity of timber rapidly dropped starting from the 2nd cycle to the 4th cycle (year-35 to year-105), then rose again.

Under the TPTI method, the basal area of timber has never reached its first harvest level, despite having run the simulation 10 harvest cycles. This is because logging was too severe in the first iteration. In other words, the maximum allowable cut assigned for this conventional TPTI was too high. As a consequence it will be very difficult to get back to its first-harvest levels, although the simulation was carried out for a substantial long period of time. A similar pattern was depicted for the RIL and RIL8 methods.

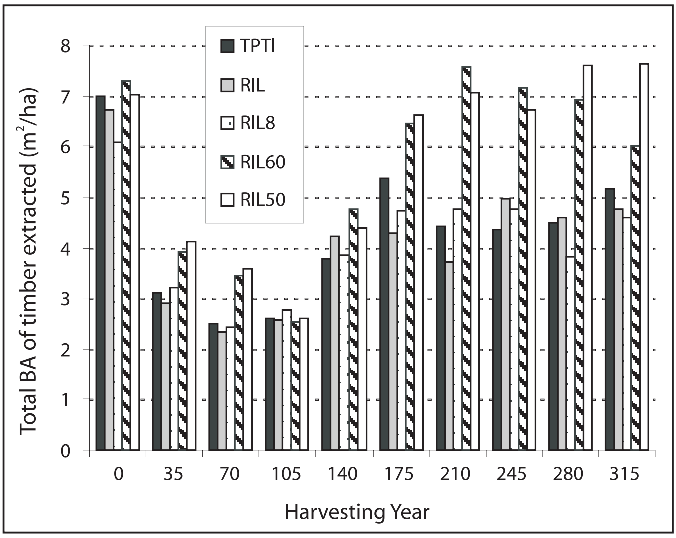

Figure 4. Total basal area of timber extracted per hectare

In contrast, the RIL50 and RIL60 could be considered as "good" alternatives for the TPTI since the basal area of timber extracted is higher under these methods compared to the three methods just mentioned, in most harvesting years. In fact, under these methods, the first harvest level has been slightly exceeded starting from the 7th cycle onwards (year 210 onwards). This was due to the more ecologically sound harvest plan assigned in both methods, compared to the conventional TPTI, and less severe logging compared to the other RIL methods.

It was anticipated that by extending the cycle length the amount of timber extracted would increase as more time allowed for regeneration process. A simulation was conducted particularly for the less performed silvicultural methods i.e., TPTI, RIL and RIL8 with choices of cutting cycles 25, 30, 35, 40 and 45 years long. The system behaves as expected – the amount of timber extracted is gradually increased as the cutting cycle lengthens. In particular, the RIL8 method on 45 years cycle is successfully exceeding its first harvest level. Again, this was due to the less severe logging assigned in this method compared to the TPTI and the RIL methods. See Figure 5.

Effect of logging on residual stands

The response of residual stand on logging could give an indication of forest sustainability under a particular silvicultural regime. In this simulation, the total basal area of the residual stand per hectare is calculated every year for 350 years simulation. The simulation was conducted by applying the conventional TPTI and consecutively with the set of RIL methods. All of them were based on 35 years cutting cycle applied to the Jambi PSP dataset. The results are presented in Figure 6.

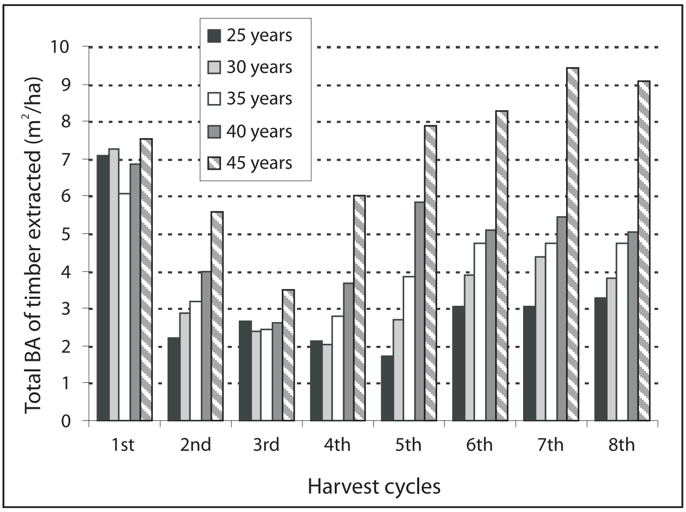

Figure 5. Total basal area of timber extracted in the RIL8 method with cutting cycle altered

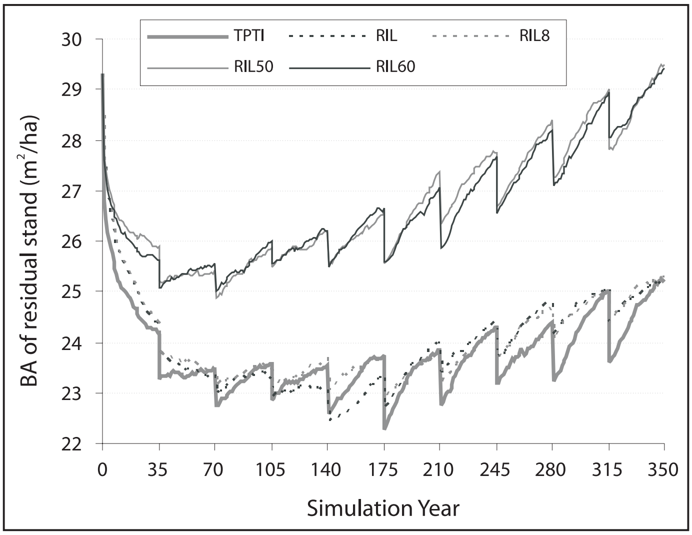

Figure 6. The residual stand's response on 35-years cutting cycle

As discussed previously, both RIL50 and RIL60 are considered to be performing well in terms of the quantity of timber extracted. The same conclusion is drawn here. The total basal area of the residual stand under both silvicultural methods could reach its pre-first harvest level, despite the fact that a long period of time is required.

In Figure 6, the total basal area of the residual stand under the TPTI method is lower than RIL50 and RIL60. This was expected, due to the less ecological sound harvesting modules assigned for the conventional TPTI. Please refer to Table 1. Moreover, the RIL and RIL8 methods tend to be clustered with the TPTI diverged from the initial level of residual stand. Despite both the fact that RIL and RIL8 were assigned to be more careful logging operations compared to the conventional TPTI, the maximum allowable cut assigned in both methods is still too severe compared to the RIL50 and RIL60. This seems to be largely affecting the pattern. The same conclusion was drawn in the simulation of timber extraction, previously discussed.

It is widely accepted that the RIL method is more ecologically sound than the conventional TPTI. Van der Hout (1999) indicated that the number of small trees damaged is higher under the conventional logging compared to the RIL method. But in terms of total basal area of residual stand the difference between both methods is not significant. This finding is consistent with the simulation results obtained in this study. Priyadi *et al.* (2002) indicated that under RIL8, which is considered to be a high felling intensity, the proportion of injured and dead trees was similar to those recorded in conventional logging TPTI. This conclusion was obtained from the 24 ha plots established in Malinau, East Kalimantan province. In Figure 6, the residual stand graph of RIL8 tends to be clustered with the TPTI graph – meaning that the total basal area of the residual stand obtained under both methods is not very different. This simulation result is consistent with Priyadi *et al.* (2002).

Effect of cutting cycle extension on residual stand

Here, a simulation was conducted to assess the effect of extending the length of cutting cycle on residual stand, with one expectation that if the cutting cycle is extended then the residual stand level would eventually approach its initial level, as more time would be would be provided for forest regeneration between two successive harvests.

Under the TPTI methods, it was observed that the extension of the cycle length has no effect to bring back the residual stand to the initial level, despite the cycle length having been extended up to 45 years (See Figure 7). The same pattern observed for the RIL method. But for the RIL8, the forest could get revived, under 45-years cutting cycle (see Figure 8). This relates to the fact that the maximum allowable cut assigned in RIL8 was lower than TPTI and RIL. Apart from anything else, the severity of logging is very important to be assigned down to a moderate level, in order to achieve sustainable forests.

In fact, under the RIL50 method, the system has been successfully recovered back to its initial level starting from the 30-year long harvest cycle. This cycle length is even lower than the cycle length assigned in TPTI. Again, the severity of logging plays a key-role to achieve sustainable forests. See Figure 9. The similar pattern was obtained for the RIL60 method.

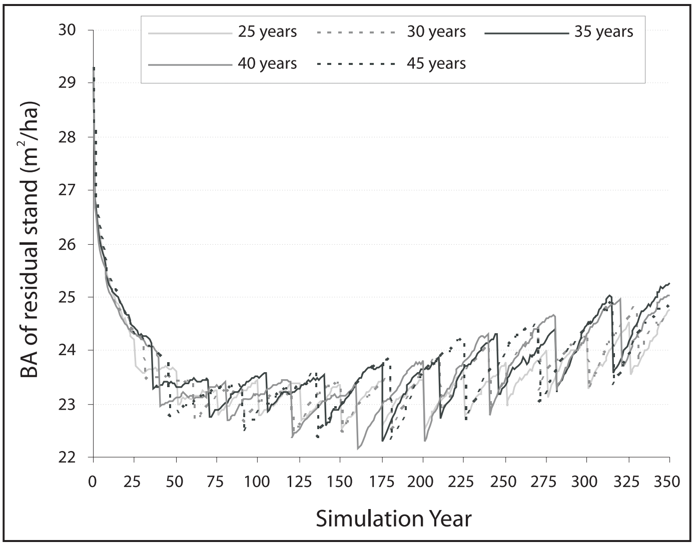

Figure 7. The residual stand's response on altered cutting cycle in the conventional TPTI method

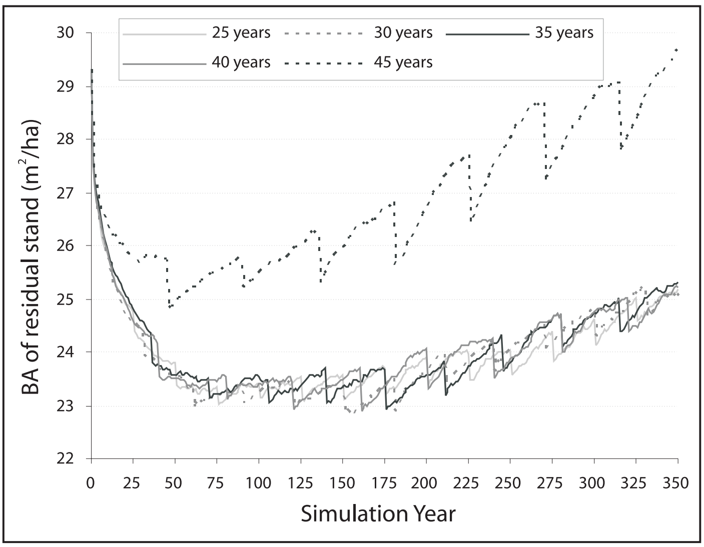

Figure 8. The residual stand's response on altered cutting cycle in the RIL8 method

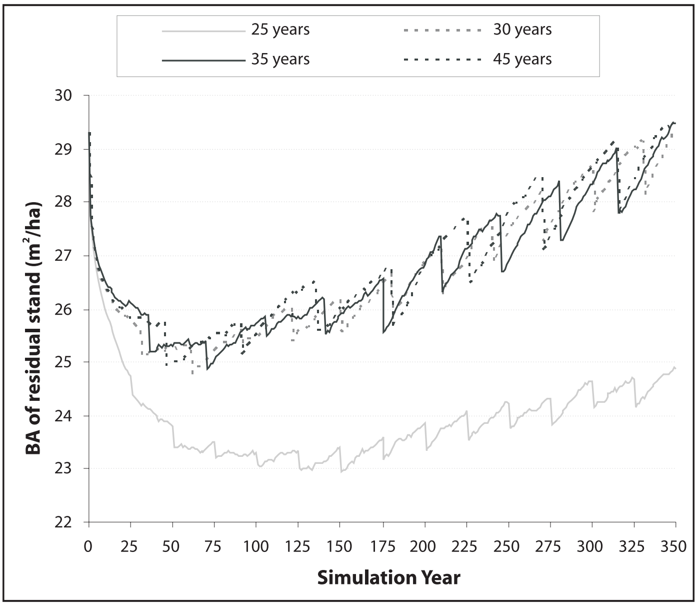

Figure 9. The residual stand's response on altered cutting cycle in the RIL50 method

Conclusions

In order to manage our natural forest in a sustainable manner, the current guidelines for the TPTI need to be revised, since the logging intensity assigned in the guidelines was found to be too severe. The silvicultural methods namely RIL50 and RIL60 are found to be the best alternative to the conventional TPTI, since the quantity of timber extracted per hectare could reach its initial level after a long period of time. It was shown that 35 years harvest cycle is adequate for both alternatives.

Moreover, in terms of the residual stand affected by logging, it was found that under the conventional TPTI the forest system has never reached its initial level, even after a long period of time. The main reason was that too much timber was extracted in the first harvest. The reason seems to be valid for RIL8 method, a more ecologically sound harvest procedure, but logging was still too intense. The severity of logging is found to be the key factor affecting the failure to reach sustainability. The simulation on extending harvest cycle has shown that the forest system fails to be restored back to the initial level of timber extracted and the residual stand.

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Tree growth and forest regeneration under different logging treatments in permanent sample plots of a hill mixed dipterocarps forest, Malinau Research Forest, Malinau, East Kalimantan, Indonesia

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Abstract

Permanent sample plots (PSP) are an important tool in monitoring forest dynamics and change. In Malinau Research Forest, East Kalimantan, 24 PSPs of 1 ha each were established and all trees with dbh ≥ 20 cm were identified and their diameters were measured in 1998 prior to logging operations and were re-assessed in 2000 and 2004. Two logging systems were implemented during that period: reduced-impact logging (RIL) and conventional logging (CNV). A total of 705 tree species with diameter at breast height (dbh) ≥ 20 cm 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. Measurement of diameter increment and forest regeneration were undertaken in 2000 and 2004. In 2000, the mean sapling density calculated from 12 plots (of 5 x 100 m^2 each) was 4,600 stem ha^{-1} both treatments. In the RIL plots, the mean annual increment of dipterocarp species assessed on a per plot basis varied with logging intensity from 0.35 to 0.52 cm/ yr, while in CNV plots, it ranged from 0.42 to 0.62 cm $year^{-1}$. A group of selected non-dipterocarps were also assessed. The relationship between growth (cm $year^{-1}$) and felling intensity (F_I in total number trees ha^{-1})

for dipterocarps and non-dipterocarps showed positive linear regressions: $Dipt_{RIL} = 0.242\ yr^{-1} + 0.0850\ F_I$ (R^2=70.4%) *and* $Non\text{-}Dipt_{RIL} = 0.190 + 0.0683\ F_I$ (R^2=54.3%). *The mean growth rate is less than the growth rate of 1 cm year*$^{-1}$ *assumed by the Indonesian Selective Cutting and Replanting System or TPTI. A longer cutting cycle is needed for sustainable forest management.*

Keywords: PSP, East Kalimantan, Hill mixed dipterocarps forest, Periodic annual diameter increment, RIL, TPTI, logging damage, forest regeneration

Introduction

In December 1995, the Indonesian Ministry of Forestry designated 303,000 ha of forest in East Kalimantan (Indonesian Borneo) for CIFOR to develop into a model forest with long-term research-based management. The creation of this research forest - the first ever in Indonesia - and the agreement with CIFOR grew out of a provision in the host-country agreement granting access to a long-term research site. CIFOR began the search for an appropriate site in 1994 and, in October 1995, submitted a recommendation to the Ministry of Forestry for an area in Malinau district (formerly in Bulungan district) (Figure 1). The Minister of Forestry approved the designation in December 1995.

The tropical forest of Malinau comprises protection forest (14%), conservation forest (25%), permanent production forest (26.5%), limited production forest (17%) and conversion forest (10.5%).

Both conventional and reduced-impact logging systems are currently used in Indonesia. The conventional logging system or logging as typically practiced is often described as unplanned and haphazard timber harvesting. In Indonesia, conventional logging refers to the TPTI system, which has been practiced by timber concession holders or HPH[1] for over three decades. Despite detailed guidelines and requirements in TPTI, including pre-harvest survey and inventory, unplanned and uncontrolled timber harvesting has caused excessive logging damages leading to the imbalance between forest regeneration and production and yield of the forest will accordingly decline (Van der Hout 1999).

The concept of reduced-Impact Logging (RIL) surfaced about the middle of the 1990s. It is also referred to as 'low impact logging', 'planned (as opposed to unplanned) logging', 'environmentally sound harvesting' and 'damage controlled logging' (Van der Hout 1999). The RIL system is a collection of forest harvesting techniques and controls, which aims at a low level of damage to the stock of

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[1] *Hak Pengusahaan Hutan*

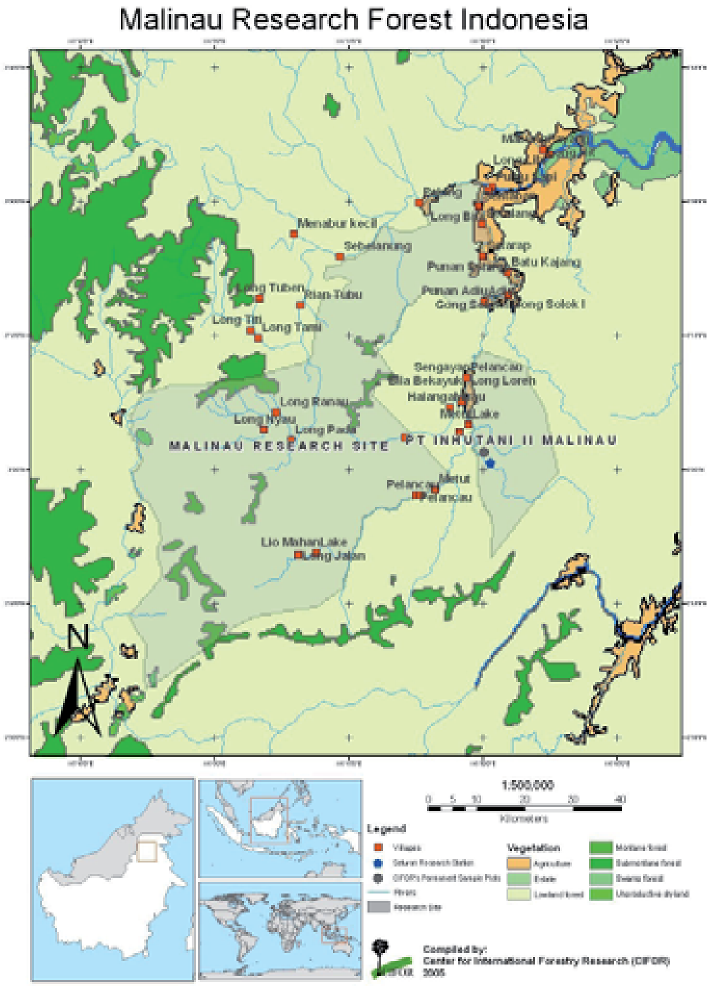


Figure 1. General map of MRF (initially BRF: Bulungan Research Forest), East Kalimantan

residual trees, soil and water, so that the production capacity of the forest after logging is sustained.

The following elements are common to most RIL systems (Sist *et al.* 1998):

- Pre-harvest inventory and mapping of the trees, including provision of topographic maps
- Pre-harvest planning of roads and skid trails
- Climber cutting prior to logging
- Directional felling
- Optimum recovery of utilizable timber
- Winching of logs to planned skid trails

Conventional logging and reduced – impact logging were applied and compared in the Malinau production forest (Sist *et al.* 2003). The subsequent re-measurement of permanent sample plots in these logged-over forests will, therefore, be important in providing information on the biophysical data to assess these silvicultural systems and to determine the growth and yield of these forests.

Objectives of the study

The objective of this study is the revision and improvement of the Indonesian silvicultural system by securing information on dynamics of the forest after CNV and RIL logging through observation of the Permanent Sample Plots (PSPs) to provide:

1. Measurements of forest regeneration
2. An understanding of the stand structure and status of species composition of the logged forests
3. Quantitative data on tree growth that can be linked to site and logging history

Research background and methods

Forest depletion

East Kalimantan is experiencing an ever accelerating loss of primary forest cover. Yet land use and vegetation patterns, both in spatial and temporal contexts, are not well-documented or understood because the conversions have been taking place so rapidly. Up to about four decades ago, the core of the forest area was little disturbed and sparsely populated by indigenous *Dayak* population, who practiced shifting agriculture and harvested various forest products. More intensive forest disturbances began in the late 1960s when commercial logging started. Initially it was small scale tree harvesting with low level of damage but later, large-scale logging operations began.

The need for best forest practice

Any efforts at sustainable management in mixed dipterocarp forest carry considerable risks due to the lucrative short term gains from destructive timber extraction. The question of how to achieve 'sustainable forest management' (in Malinau) is clearly neither purely a biophysical question, nor purely a social or economic one.

In general, logging causes various detectable impacts on the environment, depending on the intensity of disturbance and the extent of cover removed. By the same token, forest clearance and forest conversion to other land use are expected to cause greater impacts on hydrology and soil erosion processes. With the progress towards sustainable forest management, an improved harvesting technique (i.e. RIL) is being implemented and promoted in various regions. The aim of this techniques is to reduce damage to residual trees and soil. (Sist *et al.* 1998 and Elias *et al.* 2001).

The RIL is one of the important elements of sustainable forest management. The present reduced-impact logging studies constitute a development phase within a longer-term research strategy on sustainable forest management in Malinau Research Forest. This work was conducted in the Malinau concession of Inhutani II with technical supervision by CIFOR. Research on the immediate and long term impact of timber harvesting with conventional and RIL techniques from both environmental and economic perspectives was carried out. The overall objective was to promote the integration of RIL into logging techniques at the concession scale.

Location of study site

Malinau concession where the study was conducted is situated in East Kalimantan (2°45’ – 3°15’N, 116°30’ E). The concession area with the size of 48.300 hectares, belongs to PT Inhutani II, a state forest enterprise. The study site is situated in the forest area with the elevation between 100 m to 300 m above sea level with undulating terrain of 10 – 70% slope. The annual rainfall of the area is 3,790 mm with more than nine wet months in one year.

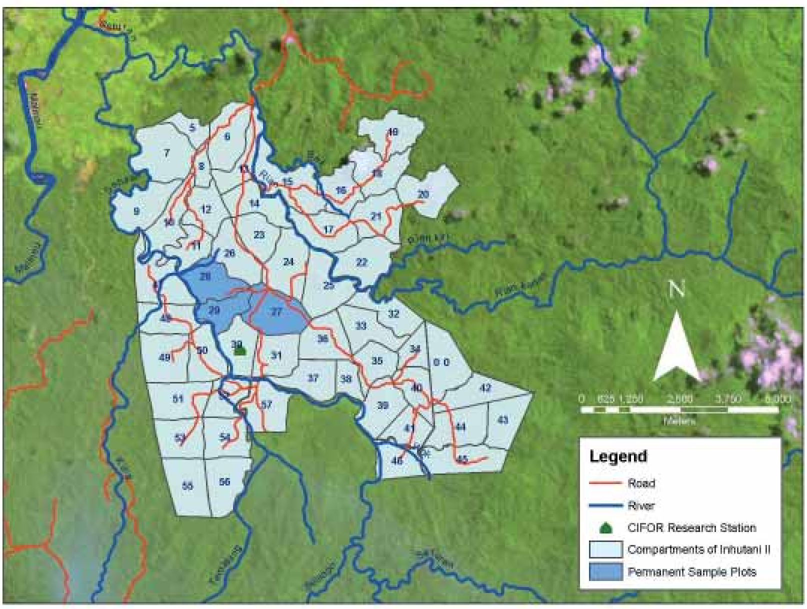


Figure 2. The blocks where PSPs are located in block 28 and 29 for CNV Plots and in block 27 for RIL plots (including control plots)

Two blocks, namely number 28 and 29 with an area of 96 ha and 80 ha respectively, in company's annual coupe (RKT) 1998/99 were selected for the conventional logging study while block 27, in the same annual coupe with an area of 137 ha, was selected for the reduced-impact logging investigation (Figure 2).

Description of plots

Twelve plots were established in the CNV block and another 12 plots in the RIL blocks. Three plots in CNV block and three plots in RIL block was kept unlogged and used them as control plots. Each plot was a square (100 x 100 m), which was further subdivided into 25 subplots of 20 by 20 m each (Figure 3). The plots were aligned following a magnetic-north direction. The plot corners were clearly marked with posts set into mounds and with short ditches running from the corners along each side (about 2 m long and 40 cm deep). Additional posts were located every 20 m (horizontal) interval along each side.

A central stake and a series of marked posts run north, south, east and west from the center. Using these measured posts as a reference, 'hip-chain' threads were used to create the 20 by 20 m grid over the plot (each thread carrier starts out on a compass bearing but is called to the correct post 25m ahead by an individual

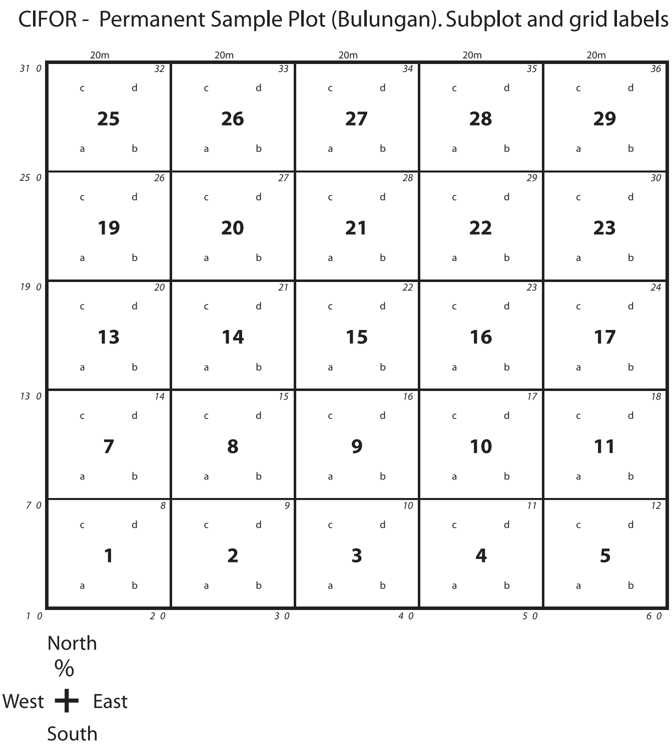


Figure 3. Plot, sub plot and grid label (source: Sheil 1998)

who has a bright marker to wave). Where the threads cross, further posts were established. Each of these posts was sited within a short 30 cm section of painted PVC piping, and a metal-tag indicated the marker's number (each post had a unique number). The south-west post's number was used to denote the number of the subplot. The control plots were surrounded by a 50 m area that was also protected from harvesting activities and took the form of a 200 by 200m square (4 ha) – the perimeter of this area was marked with strings and bright flagging (Sheil 1998)

Regeneration plots

Initial work on regeneration study was carried out in four permanent sample plots (PSPs) in conventional blocks and four other plots in the RIL block. A systematic sampling was implemented in the eight PSPs established in both CNV and RIL block including the plots that were not harvested (undisturbed) as control plots. Regeneration studies were done in the PSPs using 2 subplots of 100 m^2 (20 m x 5 m) in each 1 ha plot (Figure 4), translating into 10 % sampling intensity. The study was carried out in the logged area representing low, medium and high intensity plots.

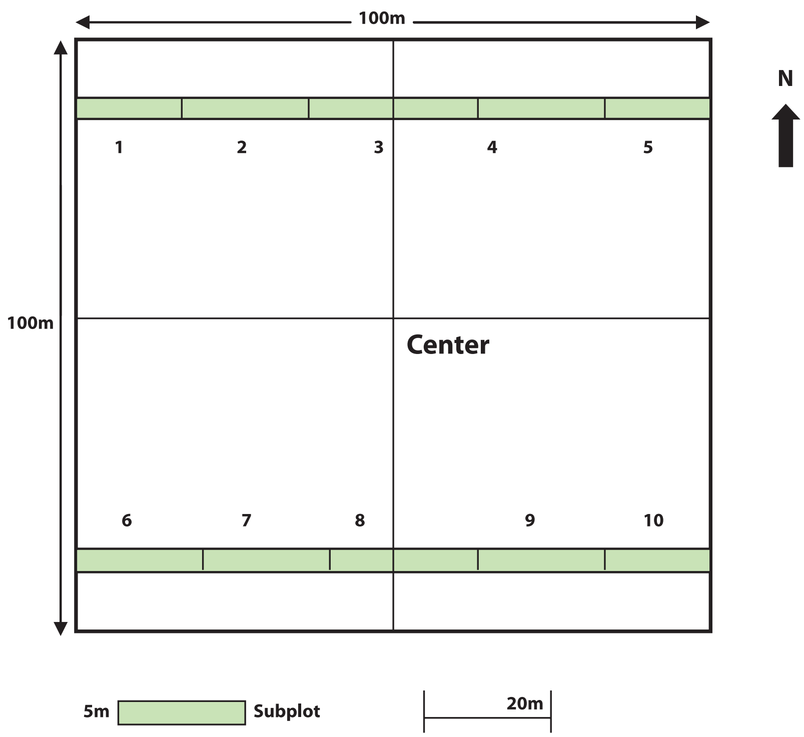


Figure 4. Lay out for the regeneration study of sapling in 1 ha of PSP

In each subplot, all the saplings from 2 to 20 cm dbh were tagged and voucher specimens were collected for identification in the Herbarium Bogoriense, Bogor.

Canopy openness was defined as the proportion of sky hemisphere not obscured by vegetation when viewed from a single point. Canopy openness was measured using a concave spherical densiometer in the middle of every sub plots (5 x 20 m).

Re-measurement

Re-measurement of PSPs was conducted from April to June 2004. This was a third measurement conducted in the Plots. Some forestry students from Faculty of Forestry of Gadjah Mada University, Bogor Agricultural University, Mulawarman University (Samarinda) and University of Nusa Bangsa (Bogor) were involved as interns.

The interns were trained on how to set up PSPs in the field prior to do PSPs re-measurement. They were also trained in using compasses, clinometers, diameter tape, densiometers and data collection related work. In order to have a precise location of the plots, coordinate points of the plots were also measured by using GPS.

Table 1. Schedule of Plot Measurement in CNV plots

Plots CNV No.	First Measurement (t1)	Second Measurement (t2)	Third Measurement (t3)	t3-t2 (days)
1	5 and 7 November 1998	6 and 8 November 2000	5 May 2004	1274
2	22 and 25 October 1998	23 - 24 October 2000	30 April 2004	1284
3	12-14 November 1998	13 - 14 November 2000	24 May 2004	1297
4	10-12 November1998	9 - 10 November 2000	06 May 2004	1273
5	26 and 28 October 1998	30 - 31 October 2000	14 May 2004	1291
6	21 October and 3 November 1998	1 - 2 November 2000	6-7 May 2004	1282
7	6 November and 9 November 1998	6 and 9 November 2000	19 & 24 May 2004	1292
8	27 and 30 October 1998	28 & 30 October 2000	27 & 29 May 2004	1307
9	11 November 1998	11-November 2000	17 - 18 May 2004	1284
10	24 October 1998	27 - 28 October 2000	30 April 2004	1280
11	28 October 1998	31 October-1 November 2000	15 May 2004	1291
12	9 November 1998	8 - 9 November 2000	15 and 17 May 2004	1285

Table 2. Schedule of Plot Measurement in RIL plots

Plots RIL No.	First Measurement (t1)	Second Measurement (t2)	Third Measurement (t3)	t3-t2 (days)
1	9 and 11 March 1999	2 April 2001	10-11 May 2004	1116
2	10 March 1999	2 April 2001	8 May 2004	1113
3	14 March 1999	07 and 09 April 2001	21 May 2004	1119
4	26 February 1999	28 and 31 March 2001	10 -11 May 2004	1118
5	19 and 24 March 1999	9-10 April 2001	21 May 2004	1118
6	11 and 13 May 1999	17 - 18 April 2001	13 May 2004	1102
7	11 and 13 May 1999	5 - 6 April 2001	08 May 2004	1109
8	14 and 18 May 1999	5 and 7 April 2001	22 May 2004	1122
9	14 April 1999	16-17 April 2001	4 - 5 May 2004	1095
10	26 March and 5 May 1999	11 - 12 April 2001	13-14 May 2004	1109
11	3 May 1999	10 - 11 April 2001	28 - 29 April 2004	1095
12	5 April 1999	12 and 16 April 2001	12 May 2004	1102

Until now, three measurements have been undertaken in the plots. The first measurement was conducted in 1998 or before logging. The second one was in 2000 or two years after logging. The third one was just conducted in 2004. Tables 1 and 2 show the series of measurements, including detail calculation of time length (in days) from the second measurement to the last one.

Periodic annual diameter increment

Growth was measured by periodic annual diameter increment (Pd). In this study, the data used was based on measurements from 1998 to 2004. Pd was calculated using the following equation (1):

$$P_d = \frac{dt + k - dt}{k} x365 \qquad (1)$$

Where

Pd = observed periodic annual diameter increment (cm year^{-1})

d_{t+k} = diameter at end of growth period (cm)

d_t = diameter at beginning of growth period (cm)

k = Length of growth period (days)

Treatments

The experimental design was stratified according to stocking which was defined as the density of the harvestable timber trees (dbh≥ 50 cm). Seven different treatments, each with three replicates and control were defined (Figure 2.4) as followed:

- Treatment 1: conventional logging with low intensity (≤ 5 trees/ha)
- Treatment 2: conventional logging with moderate intensity (6-9 trees/ha)
- Treatment 3: conventional logging with high intensity (≥ 10 trees /ha)
- Treatment 4: RIL with low intensity (RIL's intensity refers to CNV above)
- Treatment 5: RIL with moderate intensity
- Treatment 6: RIL with high intensity
- Treatment 7: control, no logging

The location of the plots was selected randomly and treatment was allocated to each of them according to the density of harvestable timber.

Linear Regression

The models to describe a correlation between periodic annual diameter increment and felling intensity as well as the correlation between percentage of trees damage after logging and felling intensity was made by using linear regression as follows:

$$Y_i = \alpha + \beta x + \varepsilon_i$$

Where:

Y_i = percentage of trees damage (%)
X = felling intensity (trees/ha)
α β = true regression parameters
ε = error term
i = observation

Results and discussions

Forest structure and species richness

A total of 705 tree species (≥ 20 cm dbh) were recorded from the permanent sample plots, of which 67 (9.5%) were dipterocarp species (Table 3). Among the widly distributed dipterocarps: *Dipterocarpus lowii*, *D. stellatus*, *Shorea beccariana*, *S. brunescens*, *S. exelliptica*, *S. macroptera*, *S. maxwelliana*, *S. multiflora*, *S. parvifolia*, *S. rubra* and *S. venulosa*.

Altogether, 29 families were represented in the RIL block and CNV block (Kartawinata *et al.* 2006 a & b). The largest families, which each contained more than 10 species and were common to both the RIL and CNV blocks, were *Dipterocarpaceae*, *Euphorbiaceae*, *Myrtaceae*,*Lauraceae*, *Fagaceae*, *Myristicaceae*, *Sapotaceae*, *Clusiaceae*, *Fabaceae*, *Anacardiaceae*, *Ebenaceae*, *Moraceae and Burseraceae*. *Dipterocarpaceae* is the most important family in the study area.

Table 3. Number of Species and Genus within the family

No.	Family	Number species
1	Dipterocarpaceae	67
2	Euphorbiaceae	57
3	Lauraceae	45
4	Fagaceae	37
5	Anacardiaceae	24
6	Burseraceae	24
7	Clusiaceae	24
8	Fabaceae	24
9	Ebenaceae	23
10	Annonaceae	14
11	Bombacaceae	14
12	Elaeocarpaceae	10
13	Flacourtiaceae	10
14	Apocynaceae	7
15	Celastraceae	6
16	Lecythidaceae	6
17	Arecaceae	3
18	Crypteroniaceae	3
19	Dilleniaceae	3
20	Icacinaceae	3
21	Cornaceae	2
22	Erythroxylaceae	2
23	Linaceae	2
24	Alangiaceae	1
25	Aquifoliaceae	1
26	Araucariaceae	1
27	Convolvulaceae	1
28	Gnetaceae	1
29	Junglandaceae	1

Agathis borneensis is a notable timber species in the study area. It is the unique representative of the family Araucariaceae in the lowland and hill mixed dipterocarp forest of Borneo. It was not homogeneously distributed but rather occurred on tops or edges of ridges on well drained soils.

This tree has a very high value in the timber market and is therefore highly appreciated by loggers. The bole shows generally no defect in shape and buttresses are absent. Waste during felling is very low. Hence, the blocks where this species was present were selected.

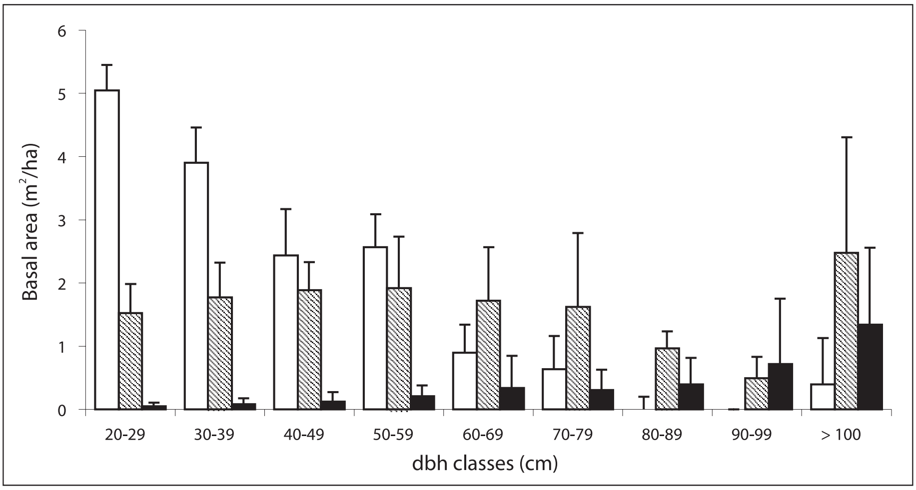


Figure 5. Basal areas of non dipterocarps (left bar), dipterocarps (middle bar) and *Agathis borneensis* (right bar) in the 7 plots of block 28/29 where this species was present before logging

It is worthwhile to note that *Agathis borneensis* has the second largest basal area after dipterocarps, and the largest compared with the other non dipterocarps in dbh above 80 cm (Figure 5). However, its natural regeneration is scarce. In mature populations and plots after logging, seedlings were absent (Provendier 2001). This demonstrates the irregularity of the regeneration process. More surveys on the phenology are necessary, but the irregularity of seedling occurrence under similar populations seems to prove the role of chance in the regeneration process. Knowledge on phenology would permit to plan the dates of logging operations like harvesting during the *Agathis* fruiting season.

Trees with dbh of > 50 cm (commercially harvestable trees) constituted 46.2 % of stems ≥ 20 cm dbh in the RIL block and 50.3% in the CNV block. Trees with dbh > 60 cm were dominated by species *Dipterocarpus* and *Shorea* but non-dipterocarp species, such as *Agathis borneensis* and *Koompassia malaccensis*, were also abundant. Species of the Dipterocarpaceae family were dominant, contributing about 27% of the total tree density and 40% of the basal area (BA). They also formed the main component of the canopy trees. The largest tree recorded was a *Shorea venulosa* with a dbh of 199.6 cm (Priyadi *et al.* 2002).

The main density and basal area of the four additional plots in CNV blocks (243.6 trees/ha, SD=41; 30.4 m^2/ha, SD=4.9) were not distinct from those 12 plots (230 trees/ha, SD=35.8 and 32.8m^2/ha, SD=4.7) set up before logging (t=0.57, df=14, P=0.58 for density, and t=0.87, df=14, P=0.40 for basal area). RIL (n=11) and CNV (n=12) plots showed similar tree densities and basal area (t=0.52, df=21 P=0.60 for density, and t=1.39, P=0.18 as shown in Table 4). The mean density and basal areas in each dbh class were similar in RIL and CNV.

Table 4. Mean density and mean basal areas (+SD) in the RIL and CNV plots before logging (CNV=12 plots, RIL=12 plots)

	dbh (cm)					
	20-29	**30-39**	**40-49**	**50-59**	**≥60**	**All**
RIL plots density (n/ha)	124.3±31.2	52.5±12.9	26.3±7.0	14.9±5.6	22.4±6.2	239.8±53.7
CNV Plots density (n/ha)	123.1±27.0	55.0±9.2	26.2±5.6	15.7±4.9	24.6±5.5	244.7±38.0
Mean density RIL + CNV (n/ha)	128.6±24.7	54.3±9.6	27.2±5.8	15.3±5.4	23.0±5.3	248.8±34.1
RIL Plots basal area (m^2/ha)	6.3±1.0	5.0±0.9	4.4±0.9	3.3±1.4	10.5±2.5	29.6±3.8
CNV Plots basal area (m^2/ha)	5.7±1.2	5.2±0.8	4.1±0.9	3.6±1.1	13.8±4.1	32.4±5.1
Mean Basal area (m^2/ha)	5.9±1.1	5.1±0.9	4.3±0.9	3.5±1.2	12.2±3.7	31.2±4.7

Periodic annual diameter increment

From the last measurement (2004), the periodic annual diameter increment of the stand for Dipterocarps in CNV plots was 0.50 cm year^{-1} (SD = 0.1693), while in non-Dipterocarps it was 0.33 cm year^{-1} (SD = 0.0916). Within the plots of RIL, diameter increment of Dipterocarps was 0.41 cm year^{-1} (SD = 0.0877), while non-Dipterocarps were lower at 0.33 cm year^{-1} (SD = 0.0803). It shows that diameter increment for non-dipterocarps in both logging treatments were comparable. In contrast, growth for dipterocarps was slightly different between treatment, as shown in the following tables:

Table 5. The periodic annual diameter increment in the Plots of RIL

Logging Intensity	**Plot's of RIL**	
	Dipterocarps (cm year^{-1})	**Non-Dipterocarps (cm year^{-1})**
Low Intensity	0.35	0.24
Medium Intensity	0.37	0.36
High Intensity	0.52	0.38

Table 6. The periodic annual diameter increment in the Plots of CNV

Logging Intensity	**Plots of CNV**	
	Dipterocarps (cm year^{-1})	**Non-Dipterocarps (cm year^{-1})**
Low Intensity	0.62	0.33
Medium Intensity	0.47	0.39
High Intensity	0.42	0.28

The tables above show that periodic annual diameter increment for Dipterocarps in CNV plots by using low and medium felling intensities is 0.62 and 0.47 cm $year^{-1}$ respectively. Those increments were higher compared with RIL plots for the same group of species and felling intensity (0.35 cm $year^{-1}$ and 0.37 cm $year^{-1}$).

The same situation also applied to the non-dipterocarps group. In contrast, in the RIL plots in which high felling intensity occurred, the increment was higher compared with CNV (0.52 and 0.38 versus 0.42 and 0.28 cm $year^{-1}$). Logging had a stimulating effect on growth as a consequence of the canopy opening and sudden light inflow into the understorey. This is consistent with an initial study, in which the average canopy openness varied from 4 % (low felling intensity) to 18% (high felling intensity). In other words, more felling intensity creates more gaps or more open canopy.

Correlation between periodic annual diameter increment (y) and felling intensity (F_I) is expressed in the following regression equitation:

$$Dipt_{RIL} = 0.242 + 0.0850\ F_I\ (R^2=70.4\%)$$
$$Non\text{-}Dipt_{RIL} = 0.190 + 0.0683\ F_I\ (R^2=54.3\%).$$
$$Dipt_{CNV} = 0.704 - 0.0985\ F_I\ (R^2=27.4\%)$$
$$Non\text{-}Dipt_{CNV} = 0.370 - 0.0200\ F_I\ (R^{2=}3.9\%)$$

Where:
Y = periodic annual diameter increment for Dipterocarps or Non-dipterocraps
F_I = Felling intensity

The equitations above show that in RIL plots there is a positive correlation between periodic annual diameter increment and felling intensity both for dipterocarp and non-dipterocarp groups (P_{value}= 0.005 and P_{value}=0.024, respectively). Meanwhile, correlation between increment and felling intensity in CNV plots both for dipterocarps and non-dipterocarps could not be positively explained (P_{value}=0.186 and P_{value}=0.724 respectively). In other words, there is no positive correlation between diamater increment and felling intensity in CNV plots for dipterocarps and non dipterocarps.

An initial measurement that was conducted in 2000 shows that the periodic annual diameter increment rate for all species in CNV block two years after logging was 0.28 cm $year^{-1}$ and 0.48 cm $year^{-1}$ for dipterocarps (Priyadi *et al.* 2003). Among the genera within dipterocarps, the fastest increment rates were *Parashorea* (0.59 cm $year^{-1}$) and *Shorea* (0.51 cm $year^{-}$), followed by *Dipterocarpus* (0.35 cm $year^{-1}$) and *Vatica* (0.35 cm $year^{-1}$).

In RIL plots, the periodic annual diameter increment for all species after logging was 0.31 cm year^{-1}. The highest growth rates were *Fagaceae* (0.57 cm year^{-1}), *Clusiaceae* (0.48) and *Dipterocarpaceae* (0.35).

In Malaysia, under the SMS[2], a gross volume growth of 2.0-2.5 m^{3}ha^{-1}yr^{-1} for all species 30 cm dbh and larger is used (Shaharuddin 1997). In Berau, another district in East Kalimantan, the growth rate in unlogged forest was 0.22 cm year^{-1} for all species and 0.3 cm year^{-1} for dipterocarps (Nguyen-The *et al.* 1998). This is similar to the rates found by Manokaran and Khocummen (1987) and Yong Teng Koon (1990) in mixed dipterocarp lowland forest of Peninsular Malaysia, although Nicholson (1965) mentioned an overall growth rate of 0.48 cm year^{-1} in the Sepilok Forest Reserve in Sabah. Growth in primary forest (e.g. unlogged forest) is on the whole very low but also very variable with negative growth as well as records of more than 1 cm reported.

Distribution of residual stand

Based on inventory of the regeneration plots after logging in 2000, sapling density calculated from the census of the 12 plots (5 x 100 m^2 each) was more than 4,600 stem/ha on average. The distribution of these stems per diameter class is shown in the Figure 6. The post-harvest distribution of trees by diameter class showed an "inverse-J" distribution typical of uneven-aged, mixed forests. The "inverse-J" distribution was reasonably well maintained in the post-harvest distributions on the cutting blocks.

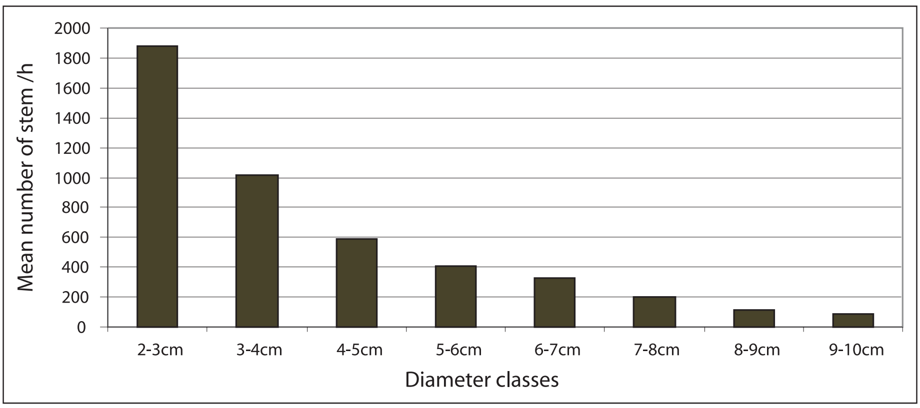


Figure 6. Distribution of the sapling by diameter classes (all plots, all species included)

[2] Selective Management System

The most important families in terms of species composition were Euphorbiaceae, Dipterocarpaceae, Myrtaceae, and Lauraceae which constituted 54.7% of all families in the regeneration plots (Figure 7). There were 57 families and 453 genera found in the combined sapling stock for RIL and CNV plots. However, over 300 of the genera contained more than 10 species. Euphorbiaceae constituted 21.5% of the genera, followed by Dipterocarpaceae 13.3%, Myrtaceae 10.4%, and Lauraceae 9.4%.

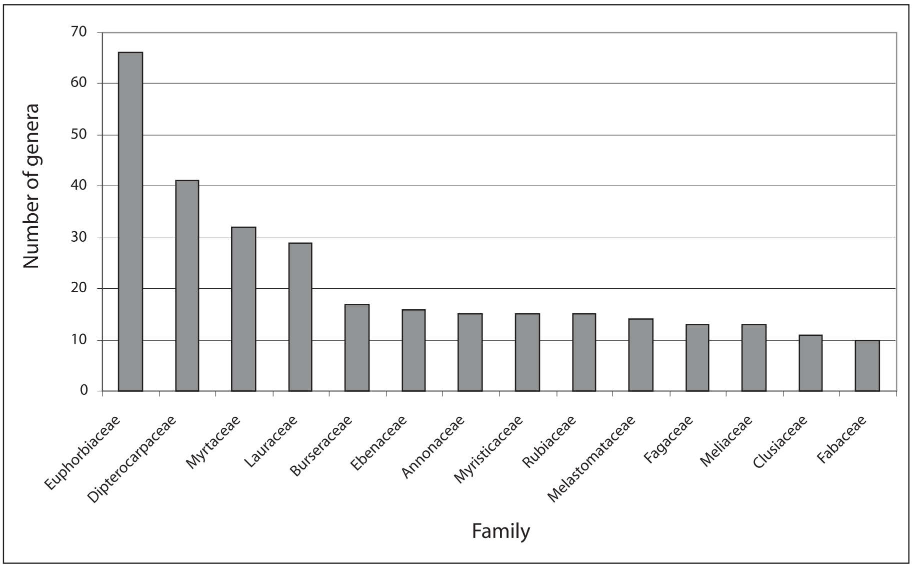


Figure 7. Proportion of the main families and genera in the sapling stock

Canopy opening

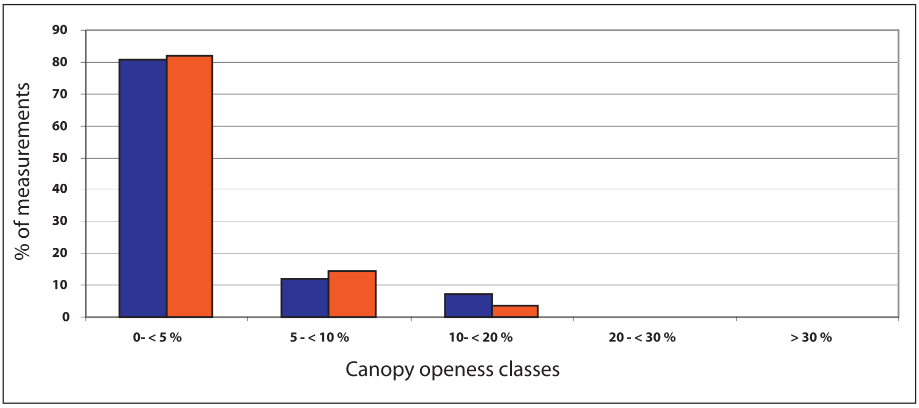
Before logging, the mean canopy openness in CNV (three plots) and RIL (nine plots) was 3.6% and 3.1%, respectively (Chabbert and Priyadi 2001). The distributions of the values according to canopy openness classes in CNV and RIL plots were similar (Table 7 and Figure 8). After logging, the mean canopy openness was 19.2% in CNV (n=9 plots) and 13.3% in RIL (n=8 plots), respectively. There was a higher proportion of measurements in the 0-5% canopy openness class and a lower one in the more open (=30%) RIL than in CNV, as shown in Figure 8. Canopy openness was significantly correlated with felling intensity in RIL but not in CNV (Pearson's R = 0.84, P<0.01, df=7 for RIL, R = 0.33, P=0.38 df= 8 in CNV).

Figures in parenthese in Table 7 show the number measurements in each class before and after logging. Before logging, the measurements in CNV were done in three plots with 108 measurements, and RIL in nine plots with 324 measurements. After logging, the measurements in CNV were done in nine logged plots with 324

Table 7. Percentage of canopy openness in RIL and CNV plots

	Canopy openness (%)				
	0-<5%	**5-<10%**	**10-<20%**	**20-<30%**	**>30%**
Before logging					
CNV	80.6 (87)	12 (13)	7.4 (8)	-	-
RIL	81.8 (265)	14.5 (47)	3.7 (12)	-	-
After Logging					
CNV	26.5 (86)	13.9 (45)	13.9 (45)	11.7 (38)	30.9 (110)
RIL	49.3 (142)	12.2 (35)	14.6 (42)	8.3 (24)	15.6 (45)

(a)



(b)

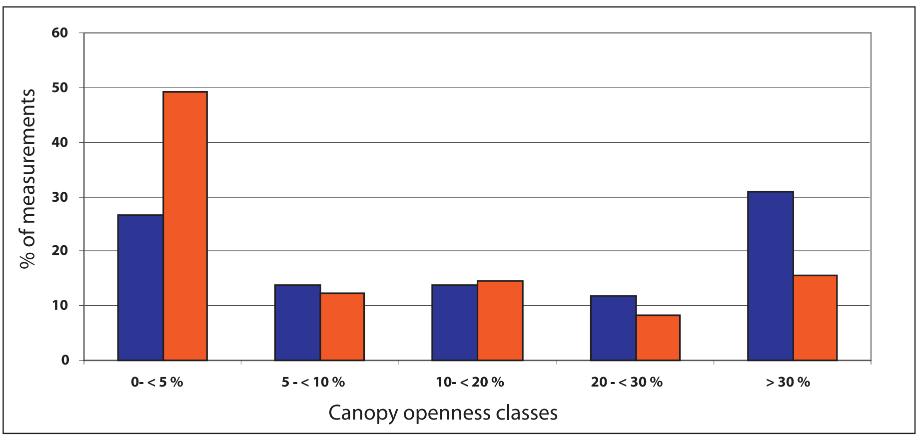


Figure 8. Percentage of canopy openness measurements in each canopy class in CNV (blue bars) and RIL(orange bars): a) before logging b)after logging

measurements, and in RIL in eight logged plots with 288 measurements (before logging, x^2=2.73, P=0.25;after logging x^2=43.56, P<0.001).

TPTI needs to be revised (An analysis and recommendation)

Logging companies are required to follow the TPTI regulation as stipulated by the Ministry of Forestry. One of the conditions is the minimum dbh cutting limit of 50 cm, while in the limited production forest it is 60 cm. However, foresters have debated the effectiveness of this regulation.

Sist (2001) and Sist *et al* (2003) stated that the application of minimum diameter limit (e.g. cut above 60 cm dbh), as practiced in many mixed dipterocarp forests in the Southeast Asia regions, is not sustainable even when RIL is implemented, largely due to the high volume and number of trees harvested.

In Indonesian's forestry issue, the effectiveness of the TPTI in achieving sustainable forest management is being reviewed. The basic assumption on tree diameter increment of 1 cm per year for all species, all forest types and all forest conditions is baseless. The data from PSP measurements showed that the tree diameter increment is varies according to tree species or tree species group and site. From the plot observation in Malinau Research Forest, it is clear that the average stems ≥ 20 cm dbh varies from 0.35 to 0.62 cm year $^{-1}$ and for non-dipterocarps from 0.24 to 0.39 cm year $^{-1}$. In a forest of Berau District, the diameter increment in dipterocarps reached an average of 0.51 cm year $^{-1}$ and in the non-dipterocarps, 0.34 cm year $^{-1}$ (Nguyen-The *et al*. 1998). It proves that assumption on diameter increment stipulated in the TPTI is over-estimated. Suhendang (2003) noted the same phenomenon. Given the fact that the increments found on the ground are far under what TPTI assumed, the cutting cycle of 35 years, therefore, urgently needs to be justified. It is clear that cutting cycle should be determined on the basis of the tree diameter increment. Taking this finding into account, the current practice of using yield regulation method based on standing stock volume, without observing actual tree diameter or stand volume increment, will lead to the wrong conclusion.

Conclusions and recommendations

Conclusions

TPTI needs to be revised because its assumptions are not commensurate with facts on the ground. The periodic annual diameter increment of stand of dipterocarps in the plots with different logging intensities varies from 0.35 cm year $^{-1}$ to 0.62

cm year $^{-1}$ both in RIL and CNV plots . On the other hand, the increment of the non-dipterocarps ranges from 0.24 cm year $^{-1}$ to 0.39 cm year $^{-1}$. These figures negate the basic assumption of the tree diameter increment of 1 cm year $^{-1}$ adopted by the TPTI.

The study showed that the overall density of saplings was 4,600 stems/ha, which were mainly composed of two families: Euphorbiaceae and Dipterocarpaceae. Euphorbiaceae particularly dominated this stand, including the pioneer *Macaranga* species. Nevertheless, the proportion of dipterocarps remained stable, indicating also that canopy opening to some level favoured the dipterocarp's regeneration.

In most classes, Euphorbiaceae dominated the sapling stock in class dbh class 2-10 cm where *Macaranga* spp was the main pioneer. Meanwhile, dipterocarps were the main component of dbh class 10-20 cm , consisting of *Shorea* spp, *Vatica* spp, *Dipterocarpus* spp, and *Hopea* spp., which are high value commercial timber species.

Recommendations

Attention must be paid to the possible changes in species composition after logging, primarily *Agathis borneensis* and most of Dipterocarpaceae family. Moreover, the quality of the injured stems will need further study. In any case, damage reduction by RIL techniques will be a benefit in the long run.

The basic assumption of TPTI on tree diameter increment 1 cm per year for all species, all forest types and all forest conditions is incorrect. Assumptions regarding increment and cutting cycles of 35 years need further review to achieve sustainable forest management.

If dipterocarps can regenerate well two years after logging to an almost reconstituted stock level, systematic planting of seedlings after logging operations may not prove necessary except in wide bare areas such as landing sites and logyards.

PSPs should be well protected, continuously monitored and measured in order to provide good and reliable data to support research on biodiversity, biophysics and silviculture. In this regard, financial supports from donors should be solicited.

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Annex 1. List of dipterocarp species identified in PSPs

No	Species
1	*Anisoptera costata* Korth.
2	*Anisoptera megistocarpa* Slooten
3	*Dipterocarpaceae*
4	*Dipterocarpus caudiferus* Merr.
5	*Dipterocarpus confertus* Sloot.
6	*Dipterocarpus cornutus* Dyer
7	*Dipterocarpus humeratus* Sloot
8	*Dipterocarpus lowii* Hook.f.
9	*Dipterocarpus* sp.
10	*Dipterocarpus stellatus* Vesque
11	*Dipterocarpus tempehes* Sloot.
12	*Hopea* sp. 1
13	*Hopea bracteata* Burck.
14	*Hopea dryobalanoides* Miq.
15	*Parashorea smythiesii* Wyatt-Smith ex Ashton.
16	*Shorea agamii* Ashton
17	*Shorea amplexicaulis* Ashton
18	*Shorea atrinervosa* Sym.
19	*Shorea beccariana* Burck.
20	*Shorea bracteolata* Dyer
21	*Shorea brunnescens* Ashton
22	*Shorea* cf. singkawang (Miq.) Miq.
23	*Shorea exelliptica* Meijer
24	*Shorea fallax* Meijer
25	*Shorea faquetia* Heim
26	*Shorea foxworthyi* Sym.
27	*Shorea gibbosa* Brandis
28	*Shorea hopeifolia* (Heim) Sym
29	*Shorea leprosula* Miq.
30	*Shorea macroptera* Dyer
31	*Shorea maxweliana* King
32	*Shorea multiflora* (Burck.) Sym.
33	*Shorea ochracea* Sym.
34	*Shorea ovalis* (Korth.) Bl.
35	*Shorea parvifolia* Dyer
36	*Shorea parvifolia* Dyer ssp. parvifolia
37	*Shorea parvifolia* Dyer ssp. velutina
38	*Shorea pauciflora* King.
39	*Shorea pinanga* Scheff.
40	*Shorea rubra* Ashton

continued

No	Species
41	*Shorea seminis* Korth.
42	*Shorea* sp.1
43	*Shorea* sp.10
44	*Shorea* sp.11
45	*Shorea* sp.2
46	*Shorea* sp.3
47	*Shorea* sp.4
48	*Shorea* sp.5
49	*Shorea* sp.6
50	*Shorea* sp.7
51	*Shorea* sp.8
52	*Shorea* sp.9
53	*Shorea venulosa* Wood. ex. Meijer
54	*Vatica albiramis* Sloot.
55	*Vatica cauliflora* Ashton
56	*Vatica* cf. granulata Sloot.
57	*Vatica maingayi* Dyer
58	*Vatica micrantha* Sloot.
59	*Vatica oblongifolia* Hook.f.
60	*Vatica rassak* (Korth.) Bl.
61	*Vatica* sp. 2
62	*Vatica* sp. 3
63	*Vatica* sp. 4
64	*Vatica* sp. 5
65	*Vatica* sp.1
66	*Vatica umbonta* (Hook.f.) Burk.
67	*Vatica vinosa* Ashton

Progress on the studies of growth of logged-over natural forests in Papua New Guinea

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Abstract

This is a summation of progress of growth of logged–over natural forests in Papua New Guinea (PNG) since 1992. A total of 126 PSPs (1ha plots) are distributed throughout PNG. A database management system called PERSYST (Permanent Plot System) was developed to analyse and produced a model called PINFORM (PNG/ITTO Natural Forest Model) for predicting the growth and yield of selectively cut natural forests in PNG. A total of 21 cohort species groups cover a range of mean increment and typical diameters for larger trees of the species. These groups represent different growth models. Average annual increment for overall species groups is 0.47 cm/yr regardless of species. Mortality rate, growth rate and typical tree size are inter-related. It was estimated that trees in common species groups have ages around 100 years when they reach a diameter that is 90% quantile of cumulative diameter distribution. Mortality rate of 2.5 % for healthy trees and 6.3% for defective or damaged trees. Recruitment rate depends to some extend on stand density and averages around 41 trees/year. Other studies also found similar results from eight sites in PNG. A total of 186 commercial tree species out of 330 species were encountered in the natural forests of PNG. Six common species; Canarium indicum, Ficus spp, Microcos argentata, Myristica spp, Pimeleodendron amboinicum and Pometia pinnata are common in all the plots studied. Parameters for growth characteristics; ingrowths, mortality, diameter increment coefficients was estimated and was tested and the parameter fitted into a Feedback type Stand growth simulation model using Diameter transition probability (FSD) to predict the diameter distribution of stand at every two years and compared with the observed diameter distributions. Due to shorter *observation period, the diameter distribution was only predicted up to 10 years. The analysis of growth data using the model to predict future diameter distribution from the initial showed mostly Secondary (S) species with higher regeneration rates after selective cutting. Hence, if selective cutting sites are managed without further disturbances, e.g. fire and human activities, the forest may recover with some degree compared to sites not affected. These PSPs need to be monitored for a much longer period to come up with more reliable growth and yield information.*

Keywords: Permanent Sample Plots, Species groups, Growth Model, Diameter distribution, Mortality, Recruitment

Introduction

The tropical rainforest of Papua New Guinea (PNG) comprising an area of 39.3 million hectares, predominantly covering PNG's 46.4 million hectares. Only 11.9 million hectares are identified as production forests (PNGFA 1998). Natural forests in PNG are decreasing at a rate of 120,000 ha per annum through logging, agricultural activities, mining and other land uses (PNGFA 2003).

Harvesting in the natural forests of PNG is selective. Only merchantable species with diameter breast height (DBH) $\geq$ 50 cm are felled. It is anticipated that the log export volume will increase from 1.8 million m^3 in 2002 to 2.19 million m^3 in 2008, reflecting an average annual increase of 4% over this period. It will have the impact of increasing log export revenues from K367 million in 2002 to K831.1 million in 2008, reflecting an annual average increase of 16% over this period. In US dollar terms the log export revenues are expected to increase by a massive 21% over the six years (Sabuin 2003). The taxes and tariffs are a very important source of revenue generated to assist the National Government to fund the social services and infrastructure development in PNG. Due to the reduction in the resource base, log output within the next 10 years may be expected to drop in volume for both log export and local processing (Sabuin 2003).

Stand dynamics of tropical forests in PNG is very little known in any detail, as is quantitative analysis of stand structure and growth of natural forests. The most important points essential for ecologically based management for sustainable harvest requires knowledge of the following three points:

i. Understanding the characteristics of natural regeneration, density and species composition
ii. Dynamics of natural forest stand structure before and after selective cutting
iii. Effects of selective cutting on the residual trees

Sustainable management of these natural forests for timber production has been somewhat difficult. There are several reasons for this. Firstly, little is known about the ecological requirements of the main commercial species. Secondly, little information is available on the growth and yield of natural forests. There have been very few studies on the structure of residual trees after selective logging in PNG (e.g. Alder 1999, Abe *et al.*, 2000; Pokana 2002; Peki 2001; 2004 and Yosi 2004).

The purpose of this paper is to discuss the progress of Permanent Sample Plot (PSP) establishment and provide a progressive report on the status of these plots in PNG.

Brief history of PSPs in PNG

The PSPs program began in 1992. The International Tropical Timber Organization (ITTO) funded the initial stages of the PSPs studies from 1992 to 1999 through ITTO Project Serial No: PD162/91 Rev.1 (F). This is one of a series of projects undertaken by PNG towards achieving Ecological, Economical and Socially Sustainable Tropical Rainforest Use (EESSTRU). The principle objective of the project was to strengthen and expand the PSPs and Timber Stand Improvement (TSI) Plot system established by the PNG Forest Research Institute (PNGFRI) and to provide the mechanism for using the data for forest management planning.

The actual implementation of the project, which was titled Intensification of Growth and Yield Studies in Previously Logged Forest (ITTO Project PD 162/91) commenced with improving and reviewing existing forest sampling systems in PNG. The existing systems showed inadequate information and standard guidelines on forest sampling to continue from. Therefore, the initial task of the project was to develop proper and standard PSP procedures in establishing plots, data collections and data management and development of computer database system(s). The manuals on “PSP standards and Procedures: A permanent sample plot program to predicted growth and yield in previously logged forest; (Parts A – E)” was accomplished in 1994. The PSP establishment and measurement program in PNG by both ITTO funded project and National Forest Services (NFS) funded project were based on the standard procedures produced by Romijn (1994).

Study site

The research sites are located in PNG (Fig.1). A total of 126 permanent sampling plots (1 ha plots) were established since 1992. Of the 126 plots, 72 plots were established by the ITTO funded project (Yosi 2000) and 54 plots by the PNGFRI internaly funded project (Pokana 2002).

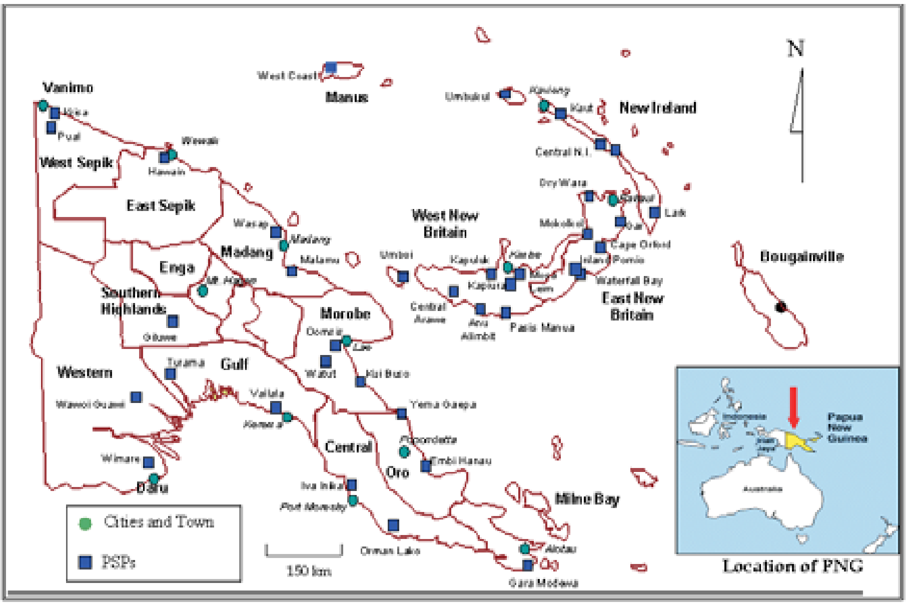

Figure 1. Location of PSPs in Papua New Guinea

Materials and methods

Summary of plot establishment and reassessment

The more detailed information on PSP establishment, plot design, tree assessment and data management techniques are well described by ROMIJN (1994).

Data management and analysis

A computer database system called PERSYST (Permanent Plot System) developed by the ITTO project's first consultant Mr. Klaus Romijn, in Microsoft FoxPro for windows in 1993 and with some modifications in 1997 and 1998 by Dr. Denis Alder (second consultant) incorporated various data analysis programs in the PERSYST. The second version of PERSYST2, also written by Dr. Denis Alder, incorporates PNGFRI and ITTO project data sets together (Fig. 2 & 3).

Results and discussions

PSP data management system

The analysis of the PSP plots in PERSYST program (Romijn 1994, Alder 1997) was directed at developing growth functions for the PINFORM (PNG ITTO

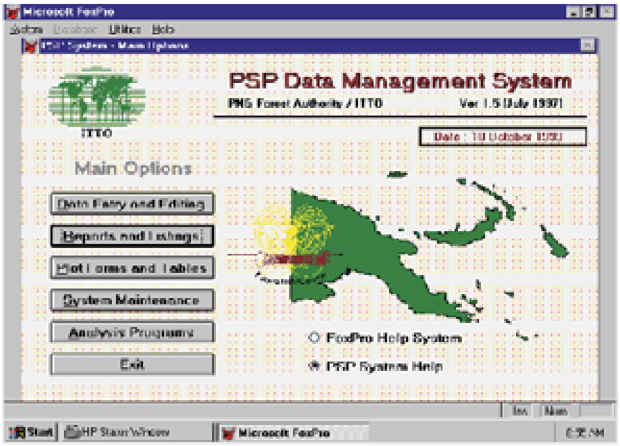

Figure 2. PSP Database PERSYST menu showing main options

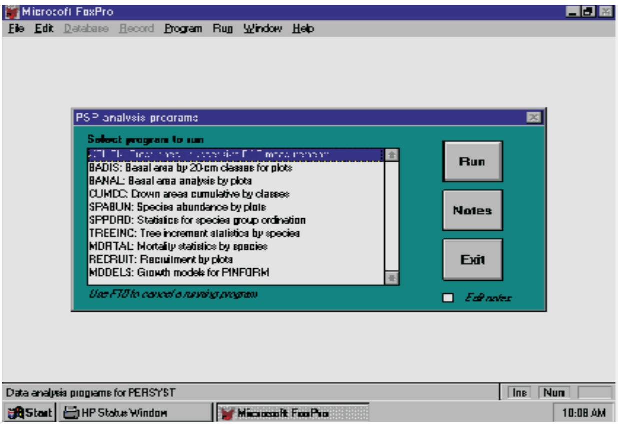

Figure 3. Types of PSP analysis programs in PERSYST database system

Natural Forest Model) stand growth model. The data analysis program model (Fig.3) is designed to generate small summary files from the total dataset of PSPs, which can be analyzed graphically using Microsoft Excel or other programs (Alder 1999). The most detail result of the analysis of the PINFORM stand simulation model could be found in Alder (1999). The result below is a summary of growth and yield information obtained from the PINFORM model.

A total of 417 species and genera are included in the PSP database. Of these, 40 species have more than 100 sample trees, while 300 species have less than 30 sample trees and only 100 species have only one or two sample trees. The species were grouped by mean diameter increment and 90% diameter quantile method (Alder 1995). As a result, 21 groups cover a range of mean increment and typical diameters for larger trees of the species. These species groups represent different cohort growth models (say growth model A – X). This model discusses design of tree growth function, which is unbiased when applied to projections of forest basal area. From this model(s) one could derive information on:

- Average increments for species groups. The overall average increment of 0.47 cm/yr to calculate increment, regardless of species, size, crown position etc.
- Modify by multiplier for stand density derived from stand basal area in the 10 – 30 cm DBH class.
- Growth rate further adjusted by a site multiplier, which can be applied at a provincial level.
- Mortality rate, growth rate and typical tree size are inter-related. It was estimated that trees in common species groups have ages around 100 years when they reach a diameter that is 90% quantile of cumulative diameter distribution. Mortality rate of 2.5 % for healthy trees and 6.3% for defective or damaged trees.
- Recruitment rate depends to some extent on stand density. The recruitment rates average around 41 trees/year. Species composition of recruits is modeled from existing species composition.

Other studies undertaken from the PSPs database

The author used a total of 20 PSP plots (from Ari, Serra, Hawain, Sogeram, Manus, Iva Inika, Gumi and Vudal) in PNG (Fig.1) established by PNGFRI since 1995 for graduate studies in Japan. During that time, the data from ITTO and FRI were kept separate. The data from the FRI PSP database was used for Masters at Tokyo University of Agriculture and Technology (1998 - 2001) and PhD studies at the University of Tokyo (2001 – 2004) respectively (Peki 2001; 2004).

The analysis of structure and growth characteristics of natural forest

The purpose of this study is to evaluate the stand structure and growth characteristics of natural forests.

The results of the analysis showed:

I. Generally, total diameter distribution in all the plots showed an exponential decrease pattern from a lower DBH class to a higher DBH class, suggesting that the inverse J - shape distribution pattern covers much of the tree population. Primary Species (P) and Primary/Secondary (P/S) species closely followed the above pattern, while Secondary (S) species showed a rising growth rate in the lower DBH class and little to none in the mid and upper DBH classes (Figs. 4, 5 & 6).

II. For all the plots, the number of P species is greater than P/S, which, in turn is also greater than S species. A total of 344 and 330 species were encountered in the initial and the last observations respectively for all the plot sites studied.

The most common species were *Syzygium* spp, *Cryptocarya* spp, *Pometia pinnata* J.R. Forster & J.G. Forster, *Myristica* spp, *Macaranga tanarius* (L.) Muell.Arg., *Pouteria chartacea* (F.v. Mueller) Baehni, *Microcos argentata* Burret., *Pimeleodendron amboinicum* Hassk., and *Celtis latifolia* (Blume) Planch. (Table 1). Generally high diameter growth increment for P and P/S species was found to be in the 20 to 50 cm DBH class. The highest for S species was found to be in the 10 to 15 cm DBH class.

III. Based on the results analyzed, especially from the diameter distribution patterns and its transition from one class to the next, about three forest types were tentatively proposed from the 20 plots (Peki 2001; 2004).

Type I. Stands at Ari, Hawain, Serra, Gumi and Manus showed a diameter transition increase from lower DBH class to upper classes (Fig.4).

Type II. Stands at Iva Inika and Sogeram showed that the diameter transition was not normal, decreasing from lower DBH classes to upper classes due to mortality mainly caused by fire and logging damage inflicted during selective cutting (Fig. 5).

Type III. Stands at Vudal showed a high increase in the lower DBH class and only S species revealed an increasing trend from a lower DBH class to the upper classes (Fig.6).

Table 1. Common species encountered

No.	Genus species	Family	Spp Grp	Plots found
1	*Syzygium* **spp**	Myrtaceae	P	19
2	*Cryptocarya* **spp**	Lauraceae	P	18
3	*Ficus* **spp**	Moraceae	P/S	17
4	*Pometia pinnata* **J.R. Forster & J.G. Forster.**	Sapindaceae	P/S	16
5	*Myristica* **spp**	Myristicaceae	P	14
6	*Gnetum gnemon* **L.**	Gnetaceae	P	14
7	*Canarium indicum* **L.**	Burseraceae	P	14
8	*Pouteria chatacea* **(F.v. Mueller) Baehni.**	Sapotaceae	P	13
9	*Micronos argentata* **Burret.**	Tiliaceae	P/S	13
10	*Dysoxylum gaudichaudianum* **(A. Juss.) Miq.**	Meliaceae	P	13
11	*Pimeleodendron amboinicum* **Hassk.**	Euphorbiaceae	P/S	12
12	*Chisochenton erythrocarpus* **Hiern.**	Meliaceae	P	12
13	*Macaranga tanarius* **(L.) Muell. Ang.**	Euphorbiaceae	S	11
14	*Cerbera floribunda* **K. Schumann.**	Apocynaceae	P/S	11
15	*Sterculia ampla* **Bakh. f.**	Sterculiaceae	P/S	11

The analysis of stand growth model

Model concept

The growth model here originated from a model developed by Ishibashi (1989a) for predicting stand growth of natural forest at Tokyo University Forest in Hokkaido. The model tries to describe numerous biological relationships in the forest through the use of various mathematical equations. The empirical observations of the transformation of natural forest stem diameter distribution supported predictions made using a process called **F**eedback type **S**tand growth simulation model using **D**iameter transition probability (FSD) (Ishibashi 1989b, 1990). To make a prediction using the FSD, all that is needed is data regarding initial diameter distribution. Using this data, FSD performs a number of calculations to determine diameter transition matrix. The diameter transition probability is equivalent to predicted stand growth. In order to predict growth for the next period, the predicted diameter distribution by the FSD is fed back into the model and the process repeated. Prediction for subsequent periods may be derived in turn using this feedback method. Fig. 7 illustrates a general flow diagram depicting processes involved in predicting diameter distribution from the initial diameter distribution to the end of the period.

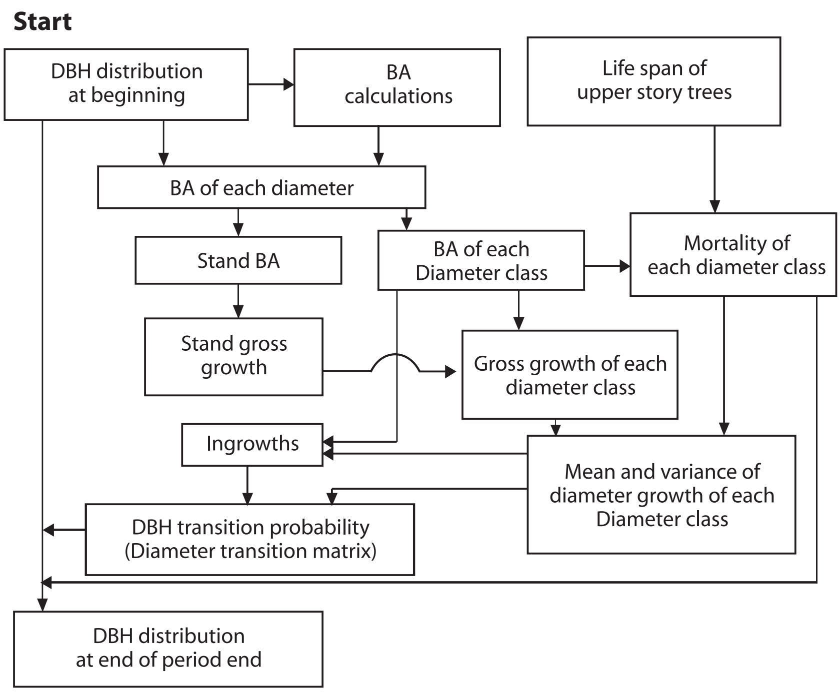

Figure 7. Flowchart of FSD Model
(Modified from: Ishibashi 1989 a & b)

Parameter estimation

The relationships tested to determine parameters needed for applying to FSD model included;

(a) Relationship between initial stand basal area and mean annual gross growth of stand

The relationship between initial stand basal area and the mean annual gross growth of stand in total and each species group respectively, and from this relationship upper and lower limit of stand gross growth were determined.

Upper limit
gGu = 0.00718 BA2– 0.01436 BA
(BA < $15m^2$)
gGu = 0.7 (BA >= $15m^2$)
lower limit
gGl = 0.00103 BA2 – 0.00205 BA
(BA < $15m^2$)
gGl = 0.2 (BA >= $15m^2$)

where:

gGu : upper limit of stand gross growth
gGl : lower limit of stand gross growth
BA : initial stand basal area

(b) Relationship between initial total basal area and mean annual gross growth in each diameter class

The relationship between initial total basal areas and mean annual gross growth in each diameter class. From these relationships, upper limit of gross growth in each diameter class was determined.

upper limit in small-sized tree
gGus = -0.063 BAs2 + 1.0702 BAs
upper limit in mid-sized tree
gGum = 0.66 BAm
upper limit in large-sized tree
gGul = -0.0149 BAl2 + 0.6316 BAl

where:

gGus : upper limit in small-sized tree
gGum : upper limit in mid-sized tree
gGul : upper limit in large-sized tree

BAs : initial total basal area in small-sized tree
BAm : initial total basal area in mid-sized tree
BAl : initial total basal area in large-sized tree

The lower limit of gross growth in each diameter class was determined from the value of the lower limit of stand gross growth and the upper limit of gross growth in each diameter class.

lower limit in small-sized tree
gGls = gGus/(gGus + gGum + gGul) *gGl
lower limit in mid-sized tree
gGlm = gGum/(gGus + gGum + gGul) *gGl
lower limit in large-sized tree
gGll = gGul/(gGus + gGum + gGul) *gGl

where :

gGls : lower limit in small-sized tree
gGlm : lower limit in mid-sized tree
gGll : lower limit in large-sized tree

(c) Mean annual growth and coefficient of variation in each diameter class
Mean annual growth
The relationship between initial total basal area in mid-sized and large-sized trees and the mean annual diameter increment in small-sized trees by species group respectively. From this relationship, the mean annual diameter increment in each diameter class was determined.

Mean annual diameter increment in S species
Dis_s= -0.0211 × (BAm + BAl) + 0.8984
Mean annual diameter increment in P/S species
Dis_p_s= -0.0198 × (BAm + BAl) + 0.723
Mean annual diameter increment in P species
Dis_p= -0.0154 × (BAm + BAl) + 0.6488

where:

Dis_s: mean annual diameter increment in S species in small-sized tree
Dis_p_s: mean annual diameter increment in P/S species in small-sized tree
Dis_p : mean annual diameter Increment in P species in small-sized tree
BAm : initial total basal area in mid-sized tree
BAl : initial total basal area in large-sized tree

The relationship between initial total BA in large-sized trees and the mean annual diameter increment in mid-sized trees by species group respectively. From this relationship, the mean annual diameter increment in each diameter class was determined.

Mean annual diameter increment in S species

$Dim\_s = 0.06377 \times BAl + 0.393$

Mean annual diameter increment in P/S species
$Dim\_p\_s = -0.0166 \times BAl + 0.6188$

Mean annual diameter increment in P species
$Dim\_p = -0.0117 \times BAl + 0.5522$

Where:

Dim_s : mean annual diameter increment in S species in mid-sized tree
Dim_p_s : mean annual diameter increment in P/S species in mid-sized tree
Dim_p : mean annual diameter increment in P species in mid-sized tree
BAl : initial total basal area in large-sized tree

Mean annual diameter growth in large-sized tree was assumed constant independently of species group.

Mean annual diameter increment
$Dil = 0.40$ cm

Where:

Dil: mean annual diameter increment in large-sized tree

(d) Coefficient of variation
The relationship between initial total basal area in mid-sized and large-sized trees and the coefficient of variation of mean annual diameter increment in small-sized class. From this relationship, the coefficient of variation of mean annual diameter increment in each diameter class was determined.

Coefficient of variation of mean annual diameter increment in small-sized tree
$CVs = 0.7 \times (BAm + BAl) + 78.5$

Where:

CVs: coefficient of variation of mean annual diameter increment
in small-sized tree
BAm : initial total basal area in mid-sized tree
BAl : initial total basal area in large-sized tree

The relationship between initial total basal area in large-sized trees and the coefficient of variation of mean annual diameter increment in mid-sized class. From this relationship, the coefficient of variation of mean annual diameter increment in each diameter class was determined.

Coefficient of variation of mean annual diameter increment
in mid-sized tree
$CVm = 0.65 \times BAl + 78.87$

where:

CVm : coefficient of variation of mean annual diameter increment in mid-sized tree
BAl : initial total basal area in large-sized tree

The relationship between initial total basal area in large-sized trees and the coefficient of variation of mean annual diameter increment in large-sized class. From this relationship, coefficient of variation of mean annual diameter increment in each diameter class was determined.

Coefficient of variation of mean annual diameter increment
in large-sized tree
$CVl = 2 \times BAl + 50$

where:

CVl : coefficient of variation of mean annual diameter increment in large-sized tree
BAl : initial total basal area in large-sized tree

(e) Relationship between initial total basal area and mortality
The relationship between initial total basal area in mid-sized and large-sized trees and mortality in small-sized class. Mortality was assumed constant in small-sized trees for each species group respectively, because there was no relationship to initial total basal area in mid-sized and large-sized trees.

Mortality in S species in small-sized tree
Pms_s = 0.20
Mortality in P/S species in small-sized tree
Pms_p_s = 0.89
Mortality in P species in small-sized tree
Pms_p = 2.32

where:

Pms_s : mortality in S species in small-sized tree
Pms_p_s : mortality in P/S species in small-sized tree
Pms_p : mortality in P species in small-sized tree

The relationship between initial total basal area in large-sized trees and mortality in mid-sized class. Mortality was assumed constant in mid-sized trees in each species group respectively, because there was no relationship to initial total basal area in large-sized trees.

Mortality in S species in mid-sized tree
Pmm_s = 0.11
Mortality in P/S species in mid-sized tree
Pmm_p_s = 0.61
Mortality in P species in mid-sized tree
Pmm_p = 1.77

where :

Pmm_s : mortality in S species in mid-sized tree
Pmm_p_s : mortality in P/S species in mid-sized tree
Pmm_p : mortality in P species in mid-sized tree

The relationship between initial total basal area in large-sized trees and mortality in large-sized class. Mortality in large-sized class was assumed constant independently of species group.

Mortality in large-sized tree
Pml = 2.26

where:

Pml : mortality in large-sized tree

(f) Ingrowths

The relationship between initial total basal area in mid-sized and large-sized trees and number of ingrowths by species group respectively. From this relationship, number of ingrowths was determined.

Number of ingrowths in S species
ni_s = -0.400 × (BAm + BAl) + 18.13
Number of ingrowths in P/S species
ni_p_s = -0.296 × (BAm + BAl) + 8.40
Number of ingrowths in P species
ni_p = -0.677 × (BAm + BAl) + 22.24

where :

ni_s : number of ingrowths in S species
ni_p_s : number of ingrowths in P/S species
ni_p : number of ingrowths in P species
BAm : initial total basal area in mid-sized tree
BAl : initial total basal area in large-sized tree

(g) Calculation of diameter transition probability and diameter distribution in the end of period

Using above mean annual diameter increment and coefficient of variation of mean annual diameter increment, diameter transition probability in each diameter class was calculated by species group respectively (Ishibashi 1989a; Peki 2004).

The way to calculate diameter distribution in the end of the period is showed below:

1) Species group calculated using above mortality number of trees that remain at the end of the period in each diameter class respectively.
2) Using the above diameter transition probability, remaining trees were divided into the diameter class at the end of the period. For example, some trees in 10cm class stay in 10cm class at the end of period, some trees in 10cm class grow up to 15cm class and the other trees in 10cm class grow up to 20cm class.
3) Number of trees in 10cm class (least diameter class) was calculated by adding ingrowth and trees that remained from the initial of period.

Diameter distribution prediction from the FSD model

The FSD model adopted to predict parameters from data collected in the PNG showed promising results, from this preliminary analysis, which showed most data from observed and predicted showed a somewhat similar pattern. This is seen more clearly on the plot sites that were selectively cut, especially from the areas where there were no major disasters (natural or man-made) (Figs. 8 & 9). It was found that the diameter frequency increased especially in the P and P/S species. Hence, the numbers of trees increased from the beginning to the end of the period. It was also observed that there was an increase in Secondary (S) species too in the small-sized trees. The plots that have being affected by fire, e.g. Sogeram and Iva Inika, showed decreased distributions in observed, but on the predicted showed an increased pattern. The Vudal plots showed normal increment pattern especially from the predictions, but from observation there was a high increasing trend mostly in the smaller sized trees. Vudal may have a more similar pattern as those sites not affected by fire and human activities than selective cutting (Fig. 10). The FSD model should be applied and used in PNG once more quality data is available so that reliable parameters could be estimated for prediction of the growth of selectively cut areas and in predicting cutting cycles so that maximum Annual Allowable Cut (AAC) could be deduced (Peki 2004). Fig. 11 showes examples of the results of diameter predicted up to 10years in Manus, Gumi and Vudal plots.

Conclusion

The importance of Establishing PSPs in the natural forest of PNG by ITTO and PNGFRI since 1992 and 1995 respectively has provided some preliminary results on the growth and yield of logged-over natural forests in PNG.

The ITTO initiated project had come up with a PINFORM model. This model is a cohort model, based on simple average growth and mortality rates for functional groups of species. The groups are derived statistically for species of similar growth rate and maximum size. Increment is modified by a stand density multiplier derived from basal area and a growth index is derived from residual analysis for groups of plots. Mortality rates differ between sound and defective trees in each species group. Recruitment depends on stand density five years earlier, and varies in species composition depending on the degree of disturbance. These functions are empirically derived from the 72 ITTO PSPs, whose establishment and measurement have formed the core activity of the project since 1992. The use of the PINFORM model should provide some thought–provoking insights into the best way to manage PNG lowland rainforests (Alder 1999).

From the author’s study of 20 PSPs in PNG, it was concluded that:

- Stand structure and growth characteristics just after selective cutting did not experience high damage by logging
- Recruitment of many trees in small-sized trees of Secondary species was predicted by the FSD growth model
- The careful monitoring of PSPs is required
- Disturbances by human activities and fire had severe effects on the stand structure and growth

- The FSD growth model to predict future stand structure is a useful tool for forest management purposes.

For both models, it was recommended that they should be improved and modified as further data becomes available for forest management and planning tools.

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The utilization of growth and yield data to support sustainable forest management in Indonesia

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Abstract

Illegal logging and wide circulation of wood without legal documents are indicators of the annual decrease in wood product caused by unstable forest planning as determined according to the Annual Allowable Cutting (AAC). Sustainable management of forest resources can be realized if every effort on forest utilization is based on and referred to sustainable forest management planning . One of the key information needed in forest planning is growth and yield data, and this valid data can be obtained if collected through Permanent Sample Plots (PSP) measurement. Basically, there are three things resulted from PSP, namely diameter increment, volume increment and stand stucture dynamics. Generally, diameter increment is used to determine the cutting cycle, cutting diameter limit and main tree diameter limit. While volume increment is used to determine the sustainable production quantity. Whereas stand sturucture dynamics can be used to know stand structure condition in the future.

Keywords: Growth and yield data, AAC, PSP

Introduction

The first step in the sustainable forest management is forest management planning, in which economic and ecological aspects must be integrated in order to achieve the planned forest utilization characteristics i.e. rational, optimal and sustained. One of the principal requirements is the availability of long term forest management planning which produces regulation as the main component, while the information on growth and yield monitoring is key in yield regulation.

It is well known that a silvicultural system called Selective Cutting (*tebang pilih*) is applied for forest management in Indonesia. This system regulates for example the diameter limitation for logging (50 cm up for forest production and 60 cm up for limited forest production), such the that volume produced may not exceed the amount of stand increment. Meanwhile, before data and information on growth and yield are available, the determination is done by assuming that diameter increment is 1 cm/year and volume increment is 1m^3/ha/year.

Nonetheless, based on the data and information of forest management obtained to date, the assumption proved to be incompatible to be re-used. Some study results showed that growth and yield in the natural forest are highly varied, depending on the site specifics and its management intensity. Therefore, growth and yield monitoring as a base tool of constructing a rational and optimum yield regulation are needed in order to realize the expectation of sustainable forest management.

Policy of growth and yield monitoring

The importance of growth and yield monitoring has been realized since the beginning of forest production utilization by undertaking studies at some logging concession company (HPH) locations conducted by the Forestry Research and Development Agency (FORDA), universities or the HPH itself. Generally, the results agree that annual increment and stand structure dynamics are influenced by site specifics and quality of management in logged-over forest areas.

Considering the importance of growth and yield data as basic datafor a more rational and sustainable forest management and utilization, the Ministry of Forestry established decree number 237/Kpts-II/95, and it is compulsory for each forest management unit to do monitoring of growth and yield by means of Permanent Sample Plots (PSPs). The result shall be reported each year to the Ministry of Forestry through FORDA, which shall do the monitoring and analysis.

FORDA has established the manual to conduct PSP and monitoring method (Decree of Director General of FORDA Number:38/1993) according to the handbill of the Director General of Forest Utilization Number: 1825/1995.

PSP data position in the sustainable forest management

Basically, sustainable forest management arranges how to utilize forest with the amount of certain products harvested continuously. To realize this management planning, the most important tool is the existence of growth and yield data and information obtained from each forest management unit, considering that growth and yield data are site specific.

Growth and yield monitoring can be done with sampling techniques with the PSP at the representative location. And then the results are used as a basis of sustainable forest management.

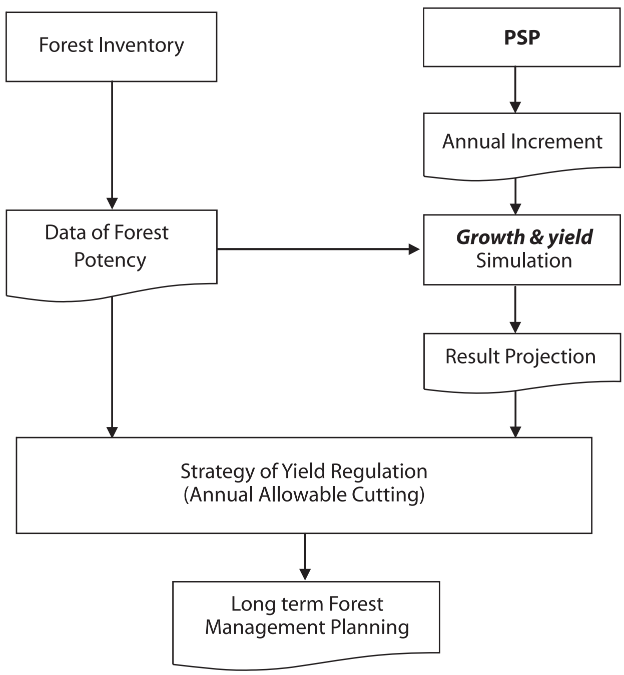

Figure 1. The position and function of PSP in Long term Forest Management Planning

PSP utilization in sustainable forest management

Principally, there are three important points obtained by PSP, namely diameter increment, stand volume increment and stand structure dynamic. The practical purpose of the diameter increment is to determine the cutting cycle, diameter limit for harvesting and diameter limit of main trees. Volume increment can be used to determine sustainable production, while stand stucture dynamic can be used to project stand stucture condition (number of trees distribution for each diameter class) in the future.

Preliminary results of diameter and volume increment from PSP data of HPHs in Indonesia is shown in Table 1 and Table 2.

Table 1. Mean annual increment of diameter (cm/year) in Indonesia

No.	Province	Commercial	Non-Commercial	All Species
1	Central Kalimantan	0.05	0.40	0.49
2	East Kalimantan	0.58	0.50	0.55
3	West Kalimantan	0.52	0.46	0.50
4	South Kalimantan	0.90	0.91	0.90
5	Maluku	0.58	0.52	0.56
6	Jambi	0.69	0.62	0.67
7	Papua	0.77	0.64	0.77
8	Central Sulawesi	0.67	0.66	0.66
9	North Sulawesi	0.79	0.78	0.79
10	South Sulawesi	1.20	1.10	1.10
11	Aceh	0.60	0.52	0.57
12	Riau	0.45	0.36	0.39
13	South Sumatra	0.80	0.80	0.80
Average		0.70	0.64	0.67

Table 2. Mean annual increment of volume (m^3/ha/year) in Indonesia

No.	Province	Commercial	Non-Commercial	All Species
1	Central Kalimantan	2.207	0.198	2.324
2	East Kalimantan	2.503	0.629	2.956
3	West Kalimantan	1.878	0.215	2.094
4	South Kalimantan	1.922	0.318	2.240
5	Maluku	2.254	0.480	2.733
6	Jambi	2.170	0.326	2.404
7	Papua	2.262	0.486	2.748
8	Central Sulawesi	1.276	0.252	1.528
9	North Sulawesi	1.294	0.591	1.885
10	South Sulawesi	1.483	1.690	0.772
11	Aceh	0.088	0.009	0.097
12	Riau	1.358	0.130	1.488
13	South Sumatra	0.484	0.288	0.772
Average		1.629	0.432	1.849

By using this simple method, the purpose of diameter increment can be formulated as follow:

R = (LDT – LDI)/Rd

LDT = LDI + (Rd * R)

LDI = LDT – (Rd * R)

Where R is the cutting cycle, LDT is the cutting diameter limit, LDI is the main tree diameter and Rd is the diameter increment.
Example:
1. If the cutting diameter limit is 50 cm and the main tree diameter limit is 20 cm, the **cutting cycle =** (cutting diameter limit – main tree diameter limit)/diameter increment

(50 - 20)/*0,70* = 42,25 years or 43 years

2. If the cutting cycle is 35 years and the cutting diameter limit is 50 cm, the main tree **diameter limit =**(cutting diameter limit -(cutting cycle x diameter increment)

(50 - (35x*0,70*) = 25,15 cm or 26 cm

3. If the cutting cycle is 35 years and the main tree diameter limit is 20 cm, the **cutting diameter limit =**(main tree diameter limit +(cutting cycle x diameter increment)

(20 + (35 x *0,70*) = 44,85 cm or 45 cm

Meanwhile for AAC estimation based on volume increment, the simple way is by using the following formula:

AAC = Vast allowable x Vpr x fp x fe

Vast allowable = 1/cutting cycle x Forest area
Vpr = Vti x (Rv x tp)
Where, AAC : Annual Allowable Cutting
Vpr : Stand potential per hectare at the end of cycle which counted based on volume increment of PSP
Vt : Stand potential of inventory result at **t** year
tp : Projection year
fp : Safety factor (0,8)
fe : Exploitation factor (0,7)

Besides that simple method, a simulation model of the stand structure dynamic can also be used. It is an equal function which can be used to project stand structure currently and in the future (next cyle cutting). Many approaches can be used to obtain the best model of stand stucture, one of them is by using a matrix model which integrates in-growth function, up-growth and mortality of early condition of stand structures.

Table 3. Example of AAC estimation based on volume increment of commercial species as 1,629 m^3/ha/year (for cutting cycle of 35 years and cutting diameter limit of 50 cm)

Area of LOA	Area	Potency *)	Increment **)	Projection ***)	Total Projection	AAC of RKT	AAC/ ha
in RKL	(ha)	(m^3/ha)	(m^3/ha/th)	(m^3/ha)	RKL Potency m^3)	(m^3)	(m^3)
I	2,000	60	1.629	64.073	128145.000	14352.240	35.881
II	1,000	55	1.629	67.218	67217.500	7528.360	37.642
III	1,400	50	1.629	70.363	98507.500	11032.840	39.403
IV	1,200	48	1.629	76.508	91809.000	10282.608	42.844
V	1,400	45	1.629	81.653	114313.500	12803.112	45.725
VI	1,600	44	1.629	88.798	142076.000	15912.512	49.727
VII	1,700	40	1.629	92.943	158002.250	17696.252	52.048
Total	10300				800070.750		43.324

Remarks:
LOA : Logged Over Area
RKL : Five Annual Work Plan
AAC : Annual Allowable Cutting
RKT : Annual Work Plan
*) Average potency for trees with diameter more than cutting diameter limit which allowed to harvest
**) Average volume increment as national
***) Potency projection until the end of cycle = RKL potency + (volume increment x remain time until the end of cycle)

PSP monitoring development and future plan

Since the Decree of Ministry of Forestry number 237/Kpts-II/95 was released, each forest management unit showed a positive response. Until 1998, 208 HPH have reported data and PSP reports. Not all of them are done according to the procedure. One of the reasons why HPH are not serious enough to do PSP monitoring is because PSP is no longer required in the Annual Work Plan (RKT).

Since 1999 ("reformation" era), almost all HPH no longer report their PSP measurement results. This case is probably caused by the fact that its concession is not extended or removed, the PSP was damaged by fire, illegal logging and there is no guarantee on certainty of areas managed for HPH organizer, hence they are inattentive to PSP.

Based on PSP data collected, a simple database, temporary increment calculation and stand structure models are made. Many representative increment estimations or increment estimation models are not obtained yet because of lack of time for PSP measurement. The average increment diameter and stand volume for every province are attached.

Considering the importance of PSP data for sustainable forest management, there is a serious need for PSP making and measuring and also its security. Therefore, an immediate overall policy of sustainable forest management is needed, in which PSP monitoring results serve as one of the references of sustainable forest management, especially on forest management planning.

In order to achieve a valid and steady result in the way of PSP data handling and management, it is deemed necessary to establish a national growth and yield network. A recommendation team as the result of increment monitoring on each unit forest management can be used as the base of the policy in order to determine the level of wood which may be exploited. The network is formulated in Figure 2.

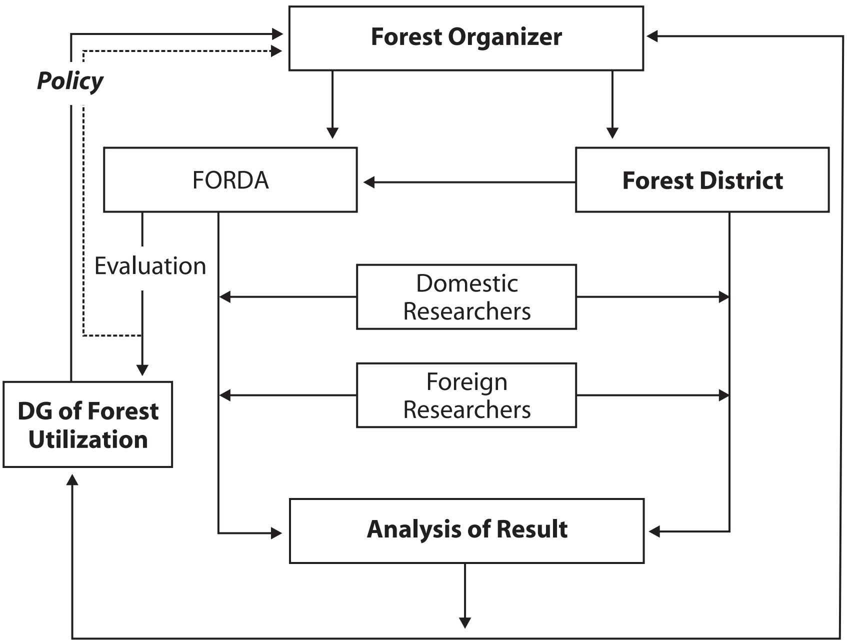

Figure 2. Growth and yield network

Conclusions

Growth and yield monitoring is obligatory if we want to realize sustainable forest management. Therefore, forest product utilization must be based on yield regulation planning constructed according to stand increment data of PSP monitoring from each forest management unit (HPH).

It is hoped that this paper can give us a good understanding of the importance of PSP (growth and yield research) and also its relationship with sustainable forest management. With a better understanding, it is hoped that the appreciation and support from the stakeholders to the implementation of Decree Number 237/ Kpts-II/95 will increase, so that one of sustainable forest management obstacles (increment information availability) can be overcome.

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Current status of permanent sample plots in Lao PDR

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Abstract

This paper summarizes the present status of PSPs in Lao PDR during the past 10 years after initiating the establishment of permanent sample plots for Lao's forestry sector. Three main forest types, namely mixed deciduous forest (MDF), dry dipterocarp forest (DDF) and dry evergreen forest (DEF), with different structure of diameter classes, seedlings, plot topographic features and location and subplot sizes are used to estimate tree growth and to predict yield for future sustainable forest management and planning system (SFMS). However, results of studies from PSPs have not been completed prior to the introduction of forest management systems.

Keywords: Lao PDR, permanent sample plots PSP, mixed deciduous forest, dry dipterocarp forest and dry evergreen forest

Introduction

According to a nation wide reconnaissance survey in 1992, the forest area in 1992 in Lao PDR was about 11.2 million ha, or about 47% of the total land area. The forest area was divided into state production forests (SPF), which covered approximately 2 million ha. Most of the SPFs are located in the central and southern parts of the country.

In the past 10 years there have been several projects which have supported the establishment of PSPs. Under the Forest Management and Conservation Project in 1995-2000 (FOMACOP), Forestry Department (DOF) initiated the establishment of PSPs in Dong Sithouan State Production Forest in Savannakhet Province in the southern part of Lao PDR. FOMACOP was funded by the Government of Finland and the World Bank. Another two initiatives to establish permanent sample plots were undertaken between 1998-2001 by DOF-LSFP (Lao Swedish Forestry Programme), and are being undertaken in 2004-2007 by NAFES/SUFORD (National Agriculture and Forestry Extension Service/ Sustainable Forest and Rural Development Project) funded by the Government of Lao-Finnida-World Bank.

Materials and tools

- Land Use and Forest Types Map
- Map of State Production Forest areas
- Forest types: mixed deciduous forest, dry dipterocarp and dry evergreen forest
- Tape 50 or 30 m, diameter tape, clipboard, haga, clinometer, compass, tripod, machete, pocket calculator, exercise book, graph papers, binoculars, PVC pipes, saw, wood, sign board, raffia, aluminium nails, tags, no. punch, paint, hammers, brush, camping materials, pencils, pens, pencil eraser, oil drums, papers, printing costs, maps, medical kit, cooking utensils, field clothes, etc.

Study sites

Site I: Dong Sithouan, state production area located in Thapangthong District, Savannakhet Provinces. Total area is 212,000 ha

Site II: Dong Kapho state production area located in Phin and Phalanxai Districts, Savannakhet Province. The total area selected from production forest area is 9,600 ha.

PSP design

Site I: Dong Sithouan State Production Forest Area

- Natural High Forest (NHF), Dry Evergreen Forest (DEF), Mixed Deciduous Forest (MDF) and Dry Dipterocarp Forest (DDF)
- 249 plots
- Plot design: circular plot with 20 m radius

- Main plot size: radius 20 m for tree DBH >= 60 cm, NTFPs and epiphytes
- Subplot size: radius 15 m for tree DBH 30-59 cm, NTFPs and epiphytes
- Subplot size radius 10 m for tree DBH 15-29 cm, NTFPs and epiphytes
- Subplot size: radius 5 m for tree DBH >= 5-14 cm, NTFPs, regeneration, epiphytes
- Biodiversity evaluation was also included

Site II: Dong Kapho State Production Forest Area

- Natural High Forest (NHF), Dry Evergreen Forest (DEF), Mixed Deciduous Forest (MDF) and Dry Dipterocarps Forest (DDF)
- 27 plots, plot size 100m x 100m, plot design: square shape
- 673 subplots, 20m x 20 m plots for tree DBH >=10 cm
- 243 subplots, 5 m x 5 m, for tree DBH <10 cm - 1.5 m height (saplings and poles)
- 243 subplots, 2 m x 2 m, for tree >0.3 m - <1.5 m height (seedlings)

Tree species names based on Vidal, 1959, NAFRI, 2001 and Callaghan, 2003.

Results

Proper data from previous (FOMACOP, LSFP) studies is still lacking/ inadequate.

- 1995-2000 project produced some basic data and reports
- 1998-2001 data have been used to developed GIS software for assessment of species, diameter classes, tree growth and regeneration, etc.
- 2004/05 two sites have been re-measured and data entry is in the process/ completed: site I: MDF 84 plots, DDF 74 plots and DEF 5 total 163 plots; **site II:** MDF 16 plots

Discussion

- PSP plays an important role in SFM.
- After the completion of the present project, Forest Department/DoF, NAFRI and NAFES should continue providing support and funds for researchers to follow up and maintain PSP network, otherwise the valuable work done so far will be lost.
- Protection of PSPs should be given high priority (e.g. logging prohibited).
- Besides development of PSPs, volume table development and biodiversity monitoring should also be included.
- Silvicultural systems need more improvement for SFM.

Conclusions

Permanent Sample Plots play a very important role in the forestry sector in sustainable management and planning practices. Although the development of PSP has been started in Lao PDR, it has to be further improved. Financial support for capacity building, field activities and protecting PSP sites are the key issues to be solved. National and international cooperation and networking will be also needed to gain experience from different areas, countries and organizations.

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The importance of *STREK* plots in contributing sustainable forest management in Indonesia

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Abstract

Successful implementation of sustainable forest management in the operational level relies on the understanding of the process which occurs in natural forest and the response of the forest due to intervention. Indonesia is fortunate enough to have a vast natural forest in which the forests have been managed for more than three decades, but the knowledge of such process and reaction of the forest (before and after logging) is still very scarce. Through the development of STREK (Silvicultural Techniques for the Regeneration of Logged Over Forest in East Kalimantan) Plot, such knowledge and understanding is expected to improve. These include knowledge of basic ecological patterns such as tree species richness and distribution, tree growth, tree mortality and regeneration, stands structure as well as forest dynamics. Improved knowledge will lead to the improvement of forest planning, particularly in the sustainability of production.

In order to provide the reliable data and information, STREK plots were designed in such a way so that the data and information available will meet the need to improve forest management. STREK Plots of 1,000 hectares each were developed in two sites, namely in the RKL-1 and RKL-4 of PT. Inhutani I, District Berau, East Kalimantan. In the first site (RKL-1), six plots of 4 ha each were set up where two different silvicultural treatments were tested. On the second site (RKL-4), 12 plots of 4 ha each were set up where three different logging treatments were implemented; two Reduced Impact Logging (RIL) with two different diameter limits to be cut (> 50 cm and >60cm), and conventional logging (similar to Indonesian Selective Cutting System/TPI). All trees in the Plot which have diameters (dbh) >10 cm were measured, numbered and mapped with a scale of 1: 200. Physical features such as topography and soil were assessed in *each plot. For the purpose of species identification, tree leaves and fruits were collected and deposited in the herbarium. All data collected from the field has been recorded and well organized. The database organization consists of gathering data and information, recording and storing in files.*

Until now, 49,959 trees with dbh of 10 cm have been recorded in the STREK database (covering 35,830 life trees and 14,129 dead trees), with the composition of 671 tree species in 71 families. This database is one of the largest in Indonesia and combined with the time frame of measurement, the STREK Plot is one of the best Plot in the world besides the similar Plot in the Salomon Islands. The above data and information provided by STREK Plot has been used to develop growth and yield studies and calibrate simulation models of natural forest stands, such as Yield Scheduling System (YSS) and Sustainable Yield Management for Tropical Forest (SYMFOR).

Keywords: STREK, database, silvicultural treatment, Berau, East Kalimantan

Introduction

After more than three decades of management of tropical forest in Indonesia, the forest condition is now experiencing degradation at an alarming rate. There is growing concern that sustainable forest management will not be achieved unless revolutionary effort in forest management takes place. The latest data from the Indonesian Ministry of Forestry shows that the rate of degradation was 2.8 million/ha/ year over the last five years, while the degraded forest already reach 59.7 millions ha. Illegal logging, forest fire, forest land encroachment and over exploitation are all contributing to the declining forest productivity and forest degradation. Besides, political, socio-economic and technical constraints have persisted to curb sustainable forest management though national commitment emerges.

Realizing the problem, the Indonesian Government strives to implement sustainable forest management both in the national scope and unit management level. Through the Decree No. 4795 and 4796 year 2002, the Minister of Forestry set up criteria and indicators of Sustainable Production Forest in the management unit level. This was the major breakthrough in assessing performance of Sustainable Forest Management conducted by concession holders in the field.

The success of managing forest production very much depends on many scientific and technical factors. In the production aspect, for instance, efforts should be directed to produce logs in a sustainable way by reducing negative impacts on biodiversity, erosion and environment. Post logging management will be required to assess dynamic growth of vegetation and growth rate of regeneration to estimate the yield in the next harvesting cycle. In short, the concept of sustainable management was used as the basic philosophy to manage forest which covers three functions on production (economic), environment (ecosystem) and social.

In the context of sustainable management of forest production in the unit level described above, we will investigate the contribution of STREK PLOT in providing data and information to support conditions.

STREK plot history and objectives

STREK is an acronym of "Silvicultural Techniques for the Regeneration of Logged Over Forest in East Kalimantan". The Plot was built under the STREK project in 1989 by the Forestry Research and Development Agency (FORDA) in Cooperation with PT Inhutani I and supported by the CIRAD-Foret of France. Besides funds, CIRAD-Foret also provided technical expertise in designing the plot. It was established to investigate the characteristics and the evolution of the forest stand under different treatments. The objective of the development of the STREK Plot was therefore to give the Ministry of Forestry several options of silvicultural techniques based on a scientific and technical knowledge. Since 1996, the project was continued and became part of the Berau Forest Management Project (BFMP), a project under the cooperation between the Directorate General of Production Forest, the Ministry of Forestry of Indonesia and the European Union (EU). There were some questions raised which need to be addressed in time when the STREK Plot was established, namely: (1) How does the growth rate of natural forest stands look like due to several treatments and logging operation, (2) what is the dynamic growth of forest stands after logging and treatment in terms of recruitment rate and mortality and (3) what is the magnitude and type of injuries suffered by stands during logging and how fast will the stands recover. Those questions were expected to be addressed through monitoring of the Plot from time to time. The data collected from the Plot might also serve as valuable input in making strategy and choice on selecting appropriate silvicultural techniques and rotation for the next harvesting.

STREK plot design

STREK Plot is located in the concession of PT Inhutani I of Labanan in the province of East Kalimantan. Figure 1 and 2 show the site of STREK Plot which is very accessible, either by plane, water or land.

Figure 1 and 2 show that STREK Plot was designed under the two main activities located in the unit which corresponds to 5- year development plan (RKL) -1 with the total area of 24 ha and RKL-4 with total area of 48 ha.

Treatments

- RKL-1, a unit consisting of 1,000 ha logged in 1978/1979. The RKL-1 consists of six plots and each plot covers an area of 4 ha. The treatment applied in this

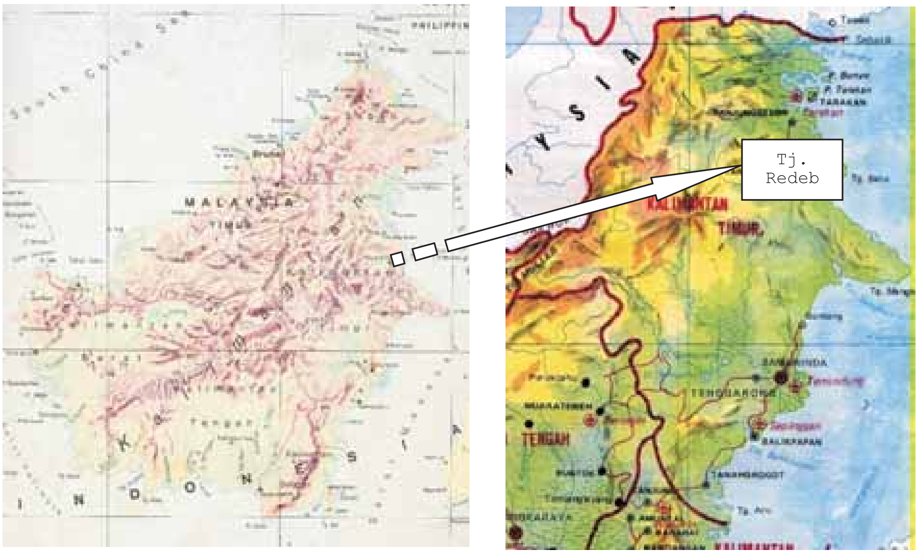

Figure 1. Location of STREK Plot in East Kalimantan, Indonesia

unit is silvicultural sytem: systematic liberation thinning (2 plots), liberation thinning focused on potential crop trees (2 plots) and control (2 plots).

- RKL-4, a zone which formerly was virgin forest in 1989/1990 and selected to experiment with Reduced Impact Logging (RIL). RKL-4 consists of 12 plots and each plot covers an area of 4 ha. The treatment applied in this unit is Reduced Impact Logging with difference in the minimum diameter of the trees to be logged, 50 cm and 60 cm dbh respectively. The other treatment is conventional logging (TPTI) method and control plot. Every treatment has three replications.

The distribution of Plot in RKL-1 and RKL-4 can be seen in the figure 3.
In RKL-1, three treatments were applied: the first was the control without any intervention; the second treatment was systematic liberation thinning in which 30% of basal area of non-commercial species was removed; the third was liberation thinning which focused on the removal of non-intended species around potential crop trees.

In RKL-4, four different treatments were applied; the first was the control without any treatment; the second was the conventional logging method where diameter of trees more than 60 cm can be logged; and the other two were Reduced Impact Logging (RIL) with different diameter of trees to be felled at 50 cm and 60 cm respectively.

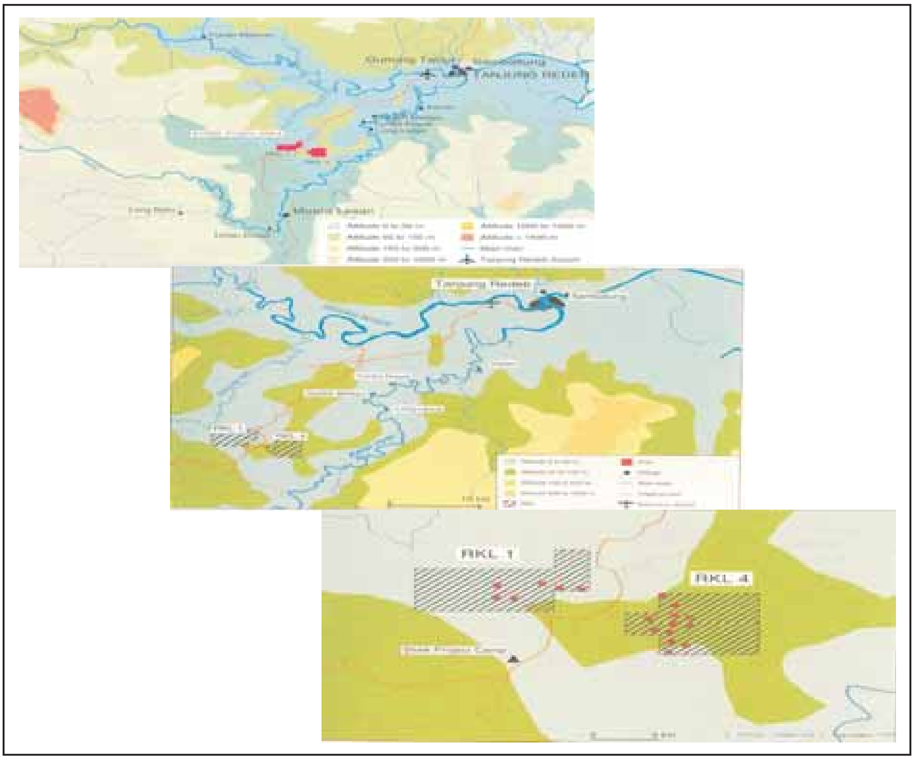

Figure 2. Area of STREK Plot and detail sites

Tabel 1. Design STREK plot

RKL	No. Plot	Treatment
1	4, 5	Control
	1, 6	Systematic Liberation
	2, 3	Potential Crop Tree
4	1, 4, 10	Control
	2, 3, 12	RIL with dbh 50 cm
	5, 6, 7	RIL with dbh 60 cm
	8, 9, 11	Conventional logging 60 cm

Data collection and organization

All trees in all plots with dbh of 10 cm were measured, numbered and mapped. These included: girth measurement (position), dead trees (mortality) and the crown position (using Dawking 1958), as well as the collection of leaf samples for identification purposes. This is particularly important for incoming trees which reach the minimum diameter to be measured. Monitoring and measurement are conducted periodically, once in two years.

Figure 3. Distribution of STREK Plots in Labanan

All data collected from the field are recorded and well organized. The database organization consists of gathering data and information, recording and storing into files. Before data analysis, such data is checked in terms of accuracy and its reliability. There are main files to store tree parameter records

- The first file called SPECIE is the list of the tree species identified in the plots with their respective equation.
- The second file, called SITREE_P (Permanent File) records the species names and the coordinate of the trees in each square. Each plot therefore has a different Permanent File.
- The third file, called SITREE_D (Dynamic File), records all the variables gathered during measurement. This data includes girth, mortality, crown position, crown form, etc.

By using Visual FoxPro (Vfp) software database, all information gathered in the field can be recorded into main files (SPECIE, SITREE_P, SITREE_D) and ExtCamp software to verify through a checking procedure. For the purpose of analysis, the data can be processed using the program provided by Visual FoxPro

(Vfp). The results include basic characteristics such as number of stems, basal area, volume, mortality and diameter increment. With a graphic program, all tree spatial distribution can also be performed. This will assist in more indepth studying of the relationships between species in the specific sites.

Results and discussion

STREK Plots have existed for 16 years. The Plot is measured periodically once every two years using the same method. The consistency of measurement is to guarantee the production of high quality data in terms of reliability and accuracy. There might be questions about why measurements are not conducted annually. It was suggested that the tree growing in natural forest does not show significant increment both in diameter and height in a year. This consideration also applies to recruitment tree (ingrowth).

Plot data and information obtained from the continuous forest inventory of the Plot are among others: number of stands and basal area, potential of stand volumes (m^3/ha), in-growth rate, mortality, information on condition of vegetation after logging (treatment), etc.

Preliminary results from the measurement and monitoring of the STREK Plot includes:

Tree species

Continuous monitoring and measurement of the Plots have been conducted; eight measurements for RKL-4 and seven measurements for RKL-1. Preparation for the next measurement has been made for RKL-1 this month, which usually takes place over three months involving 20 persons. Until now, 49,959 trees with dbh of 10 cm have been recorded in the STREK database (covering 35,830 live trees and 14,129 dead trees), with composition of 671 tree species in 71 families. This database is one of the largest in Indonesia and combined with the time frame of measurement, the STREK Plot is one of the best Plot in the world besides similar Plot in the Salomon Islands.

The continuation of the monitoring of the trees in the Plot will provide valuable information for forest management. Reliable data gathered from the field combined with basic information such as the magnitude of area and biodiversity damage, topography, soil characteristics, crown forms and position and climate will be beneficial for modelling purposes.

Forest stand dynamics

In RKL-4, it was observed that nine years after logging either with Convention or RIL, the forests show recovery. Forest stand dynamics are reflected by tree growth, in-growth and mortality. These three aspects also shape the stand structure. It was found that the population of trees per hectare (n/ha) is very high, as indicated by diameter distribution. Stand structure of every Plot shows differences due to different treatments, and this also occurs in growth patterns which shows shifting due to intervention.

In general, there is a positive correlation between forest stand dynamics or stand structure and treatment. The stand structure will fluctuate if the intensity of intervention applied to the stands is high.

In-growth and mortality

One of the most important aspects in determining growth function of forest stands is the rate of in-growth and mortality. There is a tendency that the rate of in-growth in early measurement (two years) after logging is smaller (5-15 trees/ha) as compared to that of measurement of nine years after logging (23-54 tree/ha), while in virgin forest, in-growth is relatively constant (5-15 trees/ha).

In terms of mortality, the effect of treatment in the first year is very significant. Mortality is calculated by summing up the total dead trees and the removal of trees from the forest due to logging. The total mortality of trees ranges from 73-157 trees/ha. The rate of mortality will decrease while forest stands continue to recover from damages. After nine years, the rate of mortality reaches 12-19 trees/ha, similar to what happens in virgin forest (11-19 trees/ha).

Stand volumes

Potential stand volume is determined by several aspects namely the number of trees per ha (n/ha), basal area and volume (m^3). Potential per hectare of forest stands is one the most crucial points in the production planning. Based on observation, the condition of STREK Plot after logging (nine years) is very encouraging in the sense that the potential volume amounts to 270-390 m^3/ha, though this volume is slightly smaller than the volume before logging (340-460 m^3/ha).

In virgin forest, the average growth rate in tree diameter for all species was 0.22 cm per year, with dipterocarps species growing faster (0.3 cm per year). After the forests were logged, the growth rates doubled: 0.39 cm per year for all species, 0.52 cm per year for dipterocarp species. There is a correlation between growth and intensity of logging. It was revealed that for small-diameter trees the growth increase is faster (50%) as compared to 20% in large-diameter trees.

Conclusion

The advantage of having STREK Plot was inevitable. Although monitoring and measurement of STREK Plot has been done in quite a short period of time, the data and information provided by the STREK Plot represents valuable observations, and will increase significantly through time with continued consistency in data gathering and recording. The database provided by the STREK has served as a valuable input for forest management in the country for modeling.

From the observations it was found that whatever intervention (type of logging) was sustained, the forest stands will recover within nine years. However, for the purpose of sustainable logging, Reduced Impact Logging would be preferred since it causes less damage to forest stands in comparison to the conventional ones. The crucial point would be how to protect the forest from destructive activity, such as re-logging, encroachment and fire, so that forest will produce more yield in the next rotation.

Contribution of permanent sample plots to the sustainable management of tropical forests: what rules to warrant the long-term recovery of timber-logged species?

Elements from STREK, Bulungan (Indonesia), Paracou (French Guiana) and Mbaïki (Republic of Central Africa)

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Abstract

From 1977 to 1989, the Forestry Department of CIRAD has contributed to the settlement of several large PSPs in tropical regions worldwide, in collaboration with national forest services and/or agronomic research institutes: Mopri/Téné/Irobo in Ivory Coast, Mbaïki in Republic of Central Africa (RCA), Paracou in French Guiana, ZF2 in Brazil, Ngouha II in Congo-Brazzaville, Oyan in Gabon, STREK and Bulungan in Indonesia. The detailed objectives varied according to the particular situations encountered, but the most important, common to all sites, was to assess the impact of logging and possibly complementary silvicultural treatments on the dynamics of commercial species. With increasing experience, the experimental designs were improved and gained in "testability" of the effects of disturbance on many aspects of dynamics. As silvicultural practices and questioning evolved, so did silvicultural treatments tested. As an illustration, RIL techniques rather than complementary thinning were at the core of the experiments led in Indonesia on the STREK and Bulungan sites.

Data gathered on three of those sites – Mbaïki, Paracou and STREK – have been allowing the Forestry Department of CIRAD to develop and calibrate various models of forest dynamics since 1992: distribution-based models (density dependent and independent matrix models), single-tree based models (distance dependent and distance independent). Those models have been used so far both to make predictions

on the development of stands and populations after various intensities of logging, to look for "sustainable scenarios" enabling the long-term maintenance of commercial populations and to test hypotheses on the detailed behaviour of particular species.

In this presentation, we particularly focus on lessons drawn from the STREK and Bulungan experiments. Two main conclusions were driven:

1) *The efficiency of RIL techniques depends on the intensity of logging. In the rich Dipterocarp forests encountered in North-East Kalimantan, no more than 8 trees/ha should be felled: adopting RIL techniques should allow to limit damages to less than 40% of the remaining trees in the stands.*
2) *Looking for the shortest felling cycle which could allow a sustainable production of timber over the long-term, we found that this duration correlated well with the intensity of logging. A good scenario to recommend would be the regular felling of 8 trees/ha every 40 years, which could yield 67 m^3 at each cut, ie an annual yield of 1.6 m^3.*

More generally, general conclusions driven from our studies on the other sites are the following:

1) *Nowhere can volume at first cut, as currently realised, be recovered within ongoing durations of felling cycles (resp. 35 years, 40 years and 30 years in Indonesia, French Guiana and RCA): no more than 70% to 80% could.*
2) *RIL should be systematically implemented to reduce damages on the residual stand, and first of all to preserve future crop trees.*
3) *The actual three combined criteria: duration of felling cycles, diameter cutting limit and logging intensity probably are unsustainable for most of the timber species.*
4) *However, lengthening felling cycles beyond 40 years may not be a good solution: financial return will be too low, timber volume can be lost through natural mortality and stand closure will both slow down the growth of remaining trees while being counterproductive for the regeneration of many commercial species.*
5) *More species should be logged less intensively, and their ecological requirements should be taken into account.*
6) *Logging will unavoidably induce a change in the floristic composition of the stands.*

We feel that it is time, and possibilities exist, to drive a thorough comparison between all the sites where PSP were implemented, in order to identify general trends and look for the possibilities of general conclusions and recommendations to forest managers in the tropics.

Keywords: Permanent Sample Plots, reduced-impact logging, silviculture, models of forest dynamics

Permanent sample plots in damar and rubber agroforests of Sumatra and use of the data for the spatially explicit individual based forest simulator (SExI-FS)

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[1] ICRAF-SEA, IRD
[2] IRD

Abstract

With the loss of natural forest in Sumatra, the farmer planted and managed agroforests are gaining in importance as source of timber, in additional to their role as supplier of resins, latex and fruit. Long term sample plots have been established in the Damar agroforests of Krui (West Lampung) and the rubber agroforest of Muara Bungo (Jambi). Design of the plots follows the principles of long term forest sample plots. The design of the associated data base included options for parameterization and calibration of the SExI-FS model of growth in mixed tree stands. After calibration the model can be used for exploring management scenarios, timber yields and carbon stocks, as well as for giving visual impressions of stand development. The model is available from the www. ICRAF.org/SEA <file://www.ICRAF.org/SEA> site.

Keywords: Agroforestry, Rubber Agroforest, Damar Agroforest, System Dynamic, SExI-FS, Model and Simulation

The importance of permanent sample plot network for climate change projects

Daniel Murdiyarso

Center for International Forestry Research

Abstract

Permanent Sample Plot (PSP) has been to some extent standardized in order to ease data and information sharing among developers and users. The community has traditionally been networked for silvicultural and wider forest management purposes. Even if there are differences in terms of format and components reported, there are substantial commonalities and rooms for improvement as far as data exchanges are concerned.

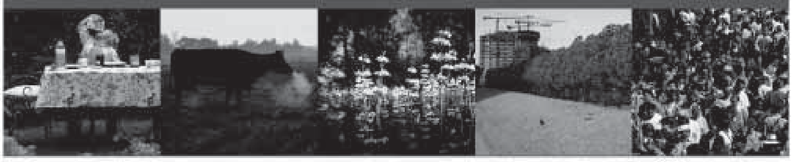
There has been an increasing demand for data and information collected from PSP for accounting purposes in carbon sequestration projects under climate change agreements. Such information would support the development of the so-called baseline and additionality scenarios presented in the project development design. Needless to say that the use of long-term measurements provided by PSP would increase the project profile and credibility.

In this connection CIFOR is very keen to facilitate data and information exchanges by providing a web-based platform, by which potential users may be directed to the originating institutions. This way violation of intellectual property right may be avoided. ***CarboFor©*** *will appear at the CIFOR main page to serve both forestry and climate change communities.*

Keywords: PSP, climate change and CarboFor©

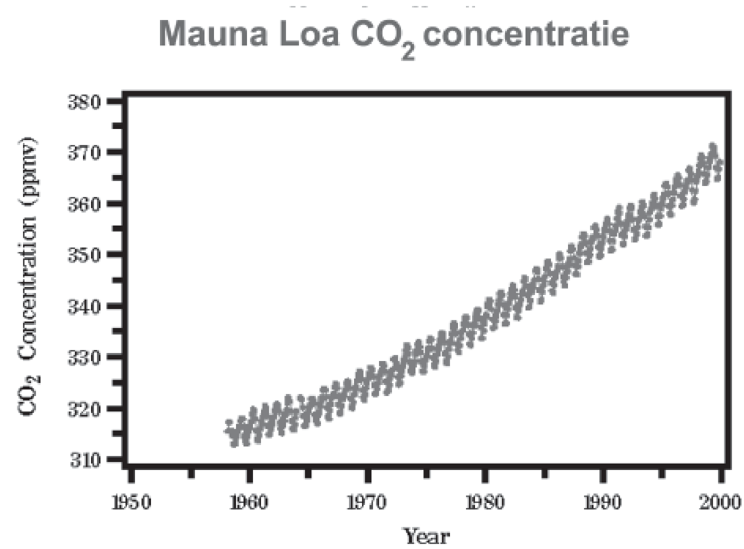
Carbon Sequestration and Climate Change

Frits Mohren
Forest Ecology and Forest Management Group
Wageningen University and Research Centre

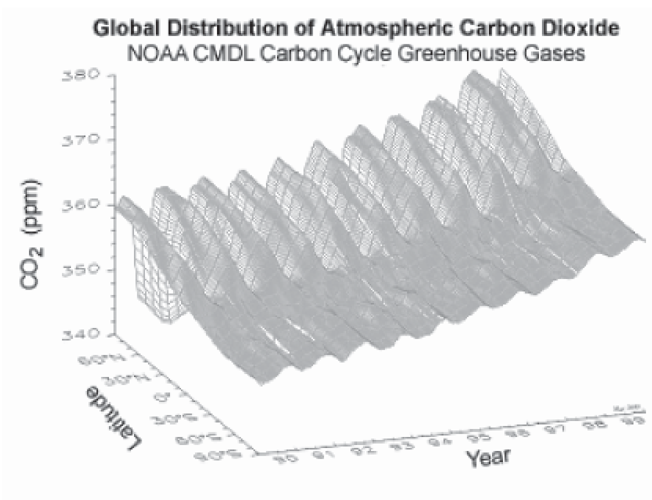


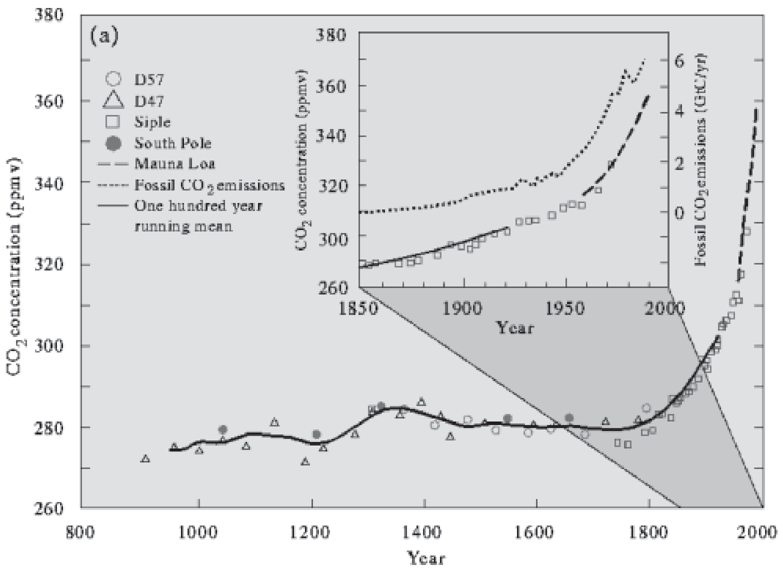
Carbon Sequestration and Climate Change

- The Issue: carbon in forests and the role of forests in the global carbon budget
- Dynamics of carbon budgets in forests
- Models and data needs (CO2FIX)
- Relevance of growth and yield studies, and of underlying PSP's



Source: Dave Keeling and Tim Whorf (Scripps Institution of Oceanography)




(a)
D57
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South Pole
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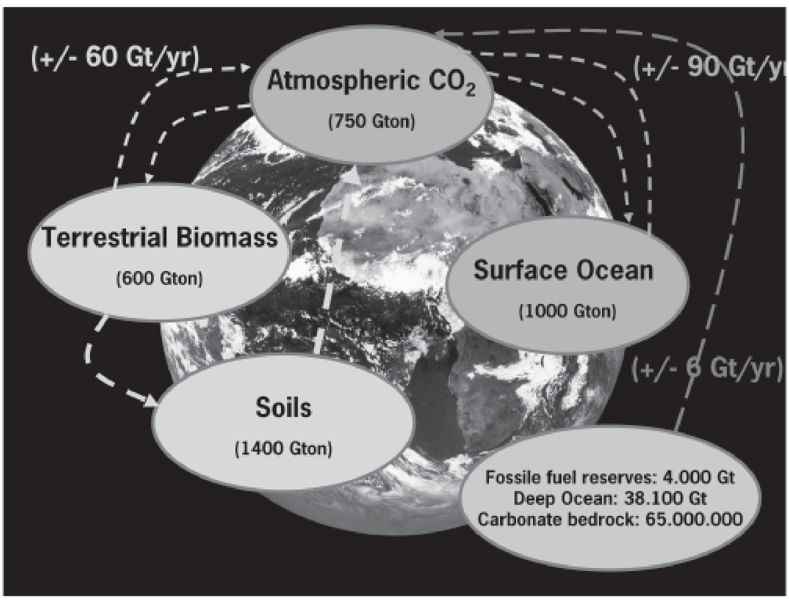
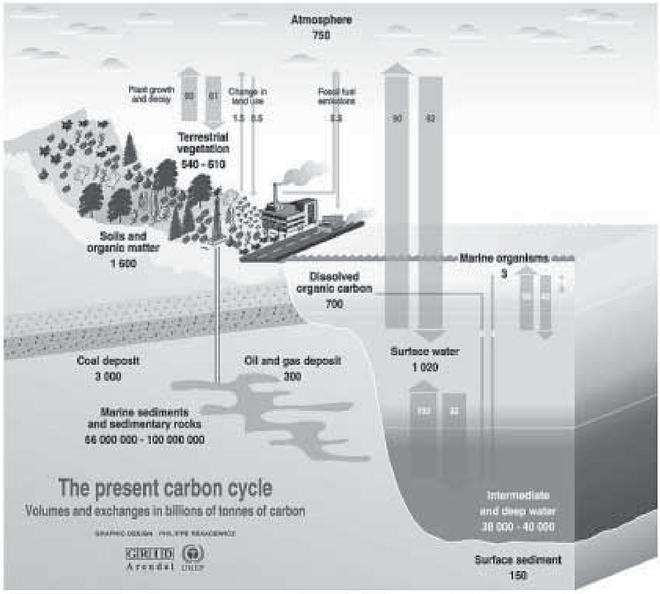
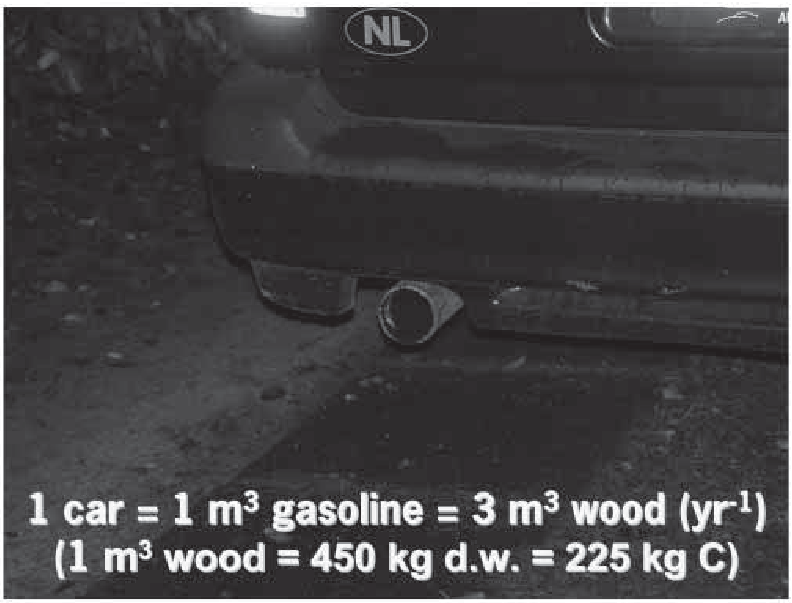
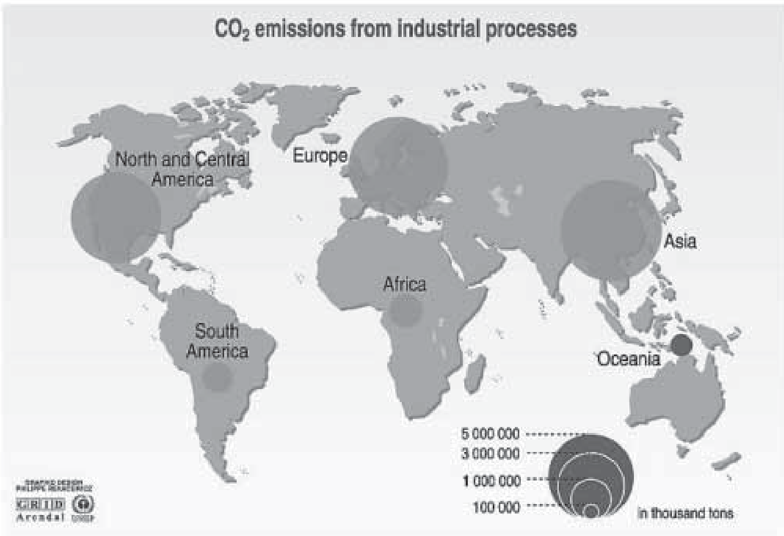
Fossil CO2 emissions
One hundred year running mean
CO2 concentration (ppmv)
Year
Fossil CO2 emissions (GtC/yr)


(+/- 60 Gt/yr)
Atmospheric CO2
(750 Gton)
(+/- 90 Gt/y
Terrestrial Biomass
(600 Gton)
Surface Ocean
(1000 Gton)
(+/- 6 Gt/yr)
Soils
(1400 Gton)
Fossile fuel reserves: 4.000 Gt
Deep Ocean: 38.100 Gt
Carbonate bedrock: 65.000.000

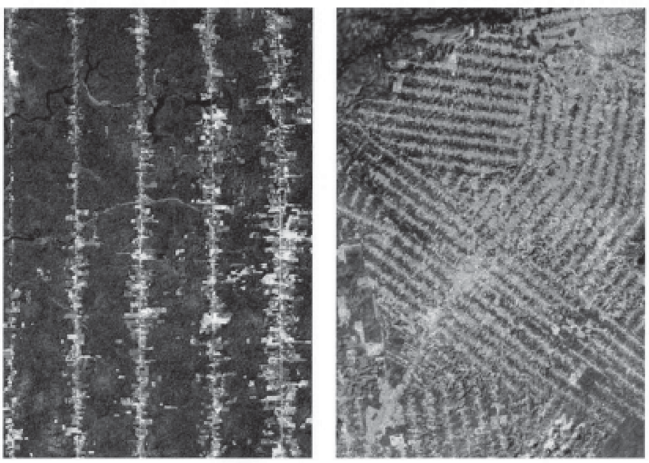

Atmosphere
750
Plant growth and decay
Change in land use
Fossil fuel emissions
Terrestrial vegetation
540 - 610
Soils and organic matter
1 600
Dissolved organic carbon
700
Marine organisms
3
Coal deposit
3 000
Oil and gas deposit
300
Surface water
1 020
Marine sediments and sedimentary rocks
66 000 000 - 100 000 000
The present carbon cycle
Volumes and exchanges in billions of tonnes of carbon
Intermediate and deep water
38 000 - 40 000
Surface sediment
150

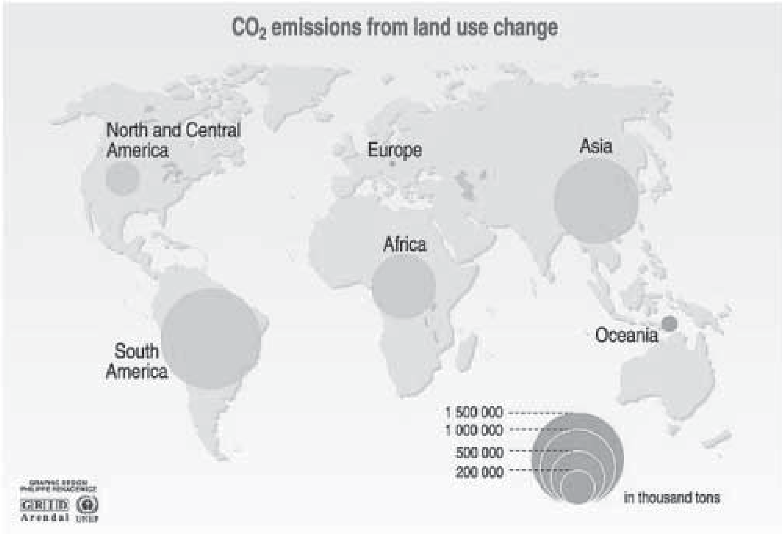

NL
1 car = 1 m^3 gasoline = 3 m^3 wood (yr^{-1})
(1 m^3 wood = 450 kg d.w. = 225 kg C)



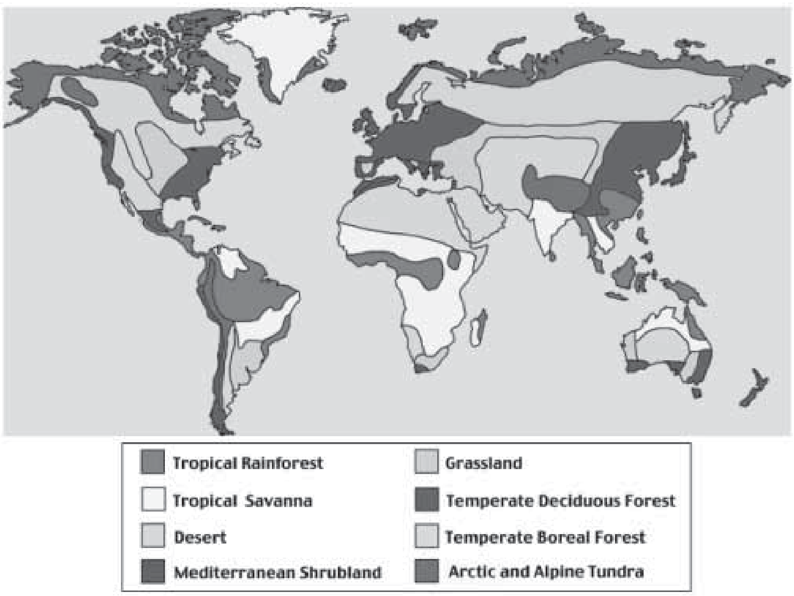
Source: United Nations framework convention on climate change (UNFCCC).

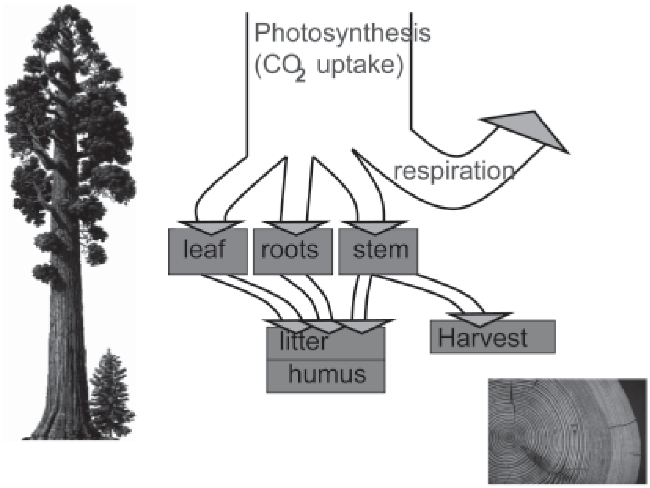
Changes in land use (notably deforestation) contribute about 25-30% to the rate of CO_2 increase

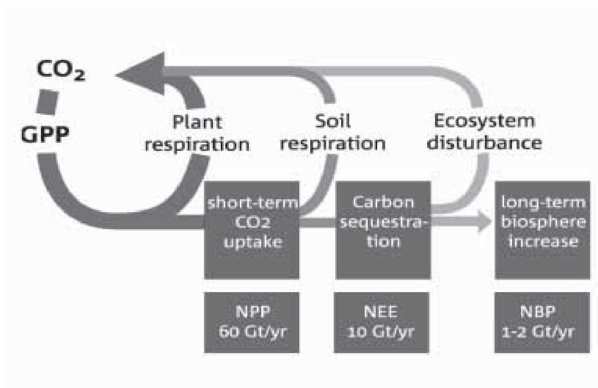




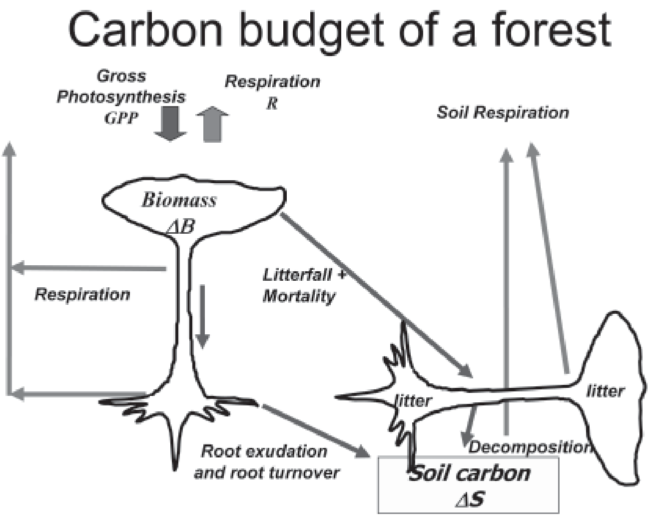
Source : Climate Change Information kit, UNEP IUC, 1997.







(IGBP Carbon Working Group, Science, Vol. 280, pp. 1393-1394, 29 May 1998)



<u>*Eddy covariance*</u>

Based on covariance of concentrations of water and CO2 and vertical windspeed measurements; turbulent flux equals:

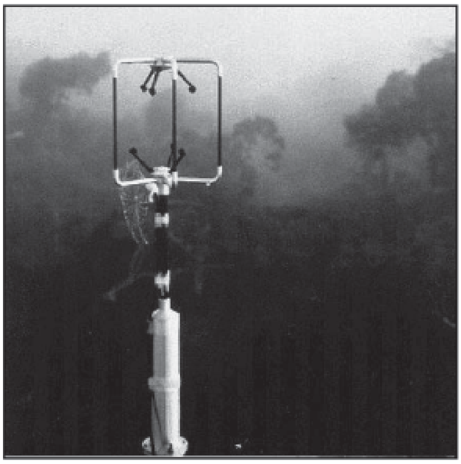
$$Fc = \overline{\rho}\,\overline{w} + \overline{\rho' w'}$$

Eddy Correlation Flux Measurement

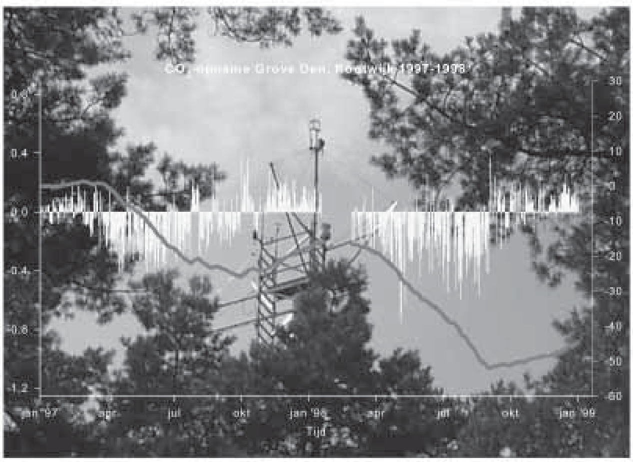
Direct estimate of net exchange of CO2 and H2O of a forest canopy

Measurements over an area of some km²

Continuous, automatic measurements of high time resolution



CO2 uptake in Kootwijk, NL



Eddy-covariance flux measurements

- Intensive, complicated research facility for ecological research
- Very high resolution, covering mainly short-term dynamics (NEE: Net Ecosystem Exchange)
- Long-term Net Biosphere Productivity (NBP) remains to be estimated

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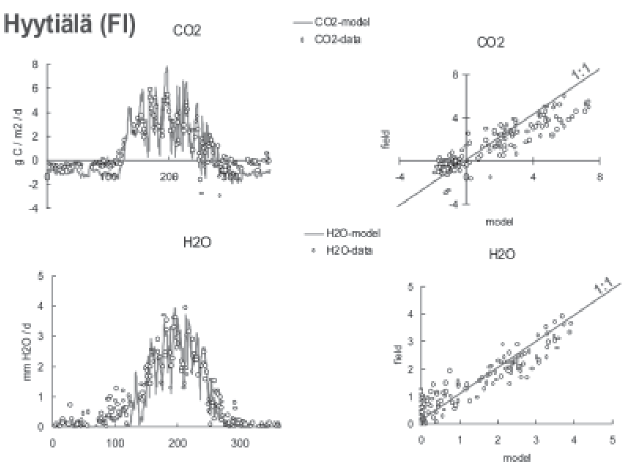
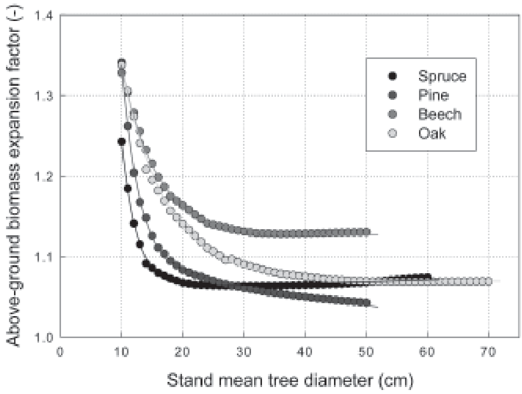


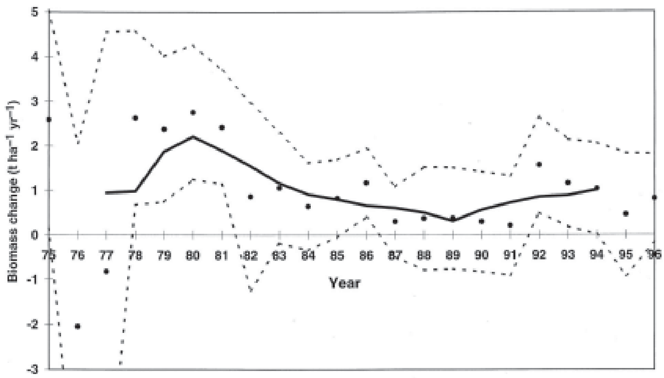
Traditional forest inventory:

Advantage: simple measurements, many data available for comparison

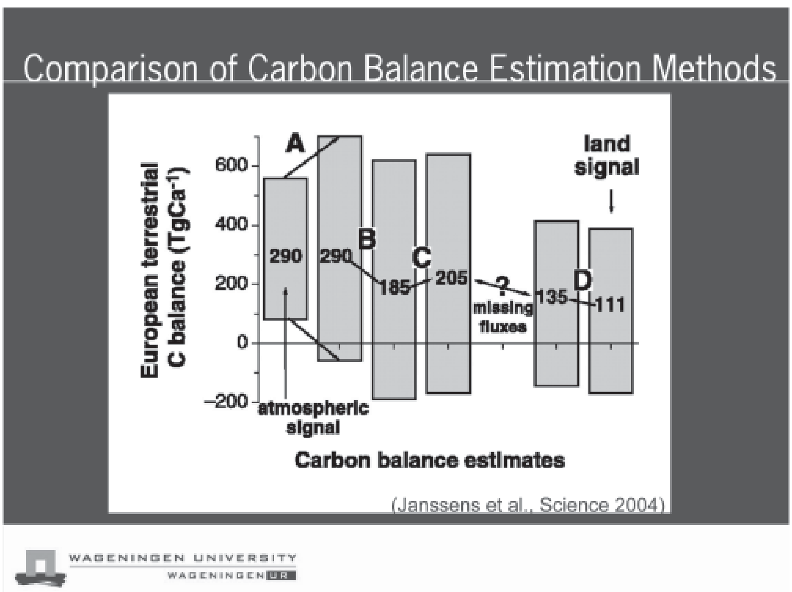
Drawbacks: only stem volume estimates, biomass expansion factors for conversion to biomass and carbon needed

Exampe of species-specific expansion factors in relation to tree dimension





(Phillips et al., Science 1998)



Differences between estimation methods

- Short-term vs. long-term estimates
- Missing fluxes:
  - Decomposition of harvested timber
  - Emission following large-scale disturbance
  - Export of carbon by rivers
  - Accumulation (or decrease) in soil organic matter

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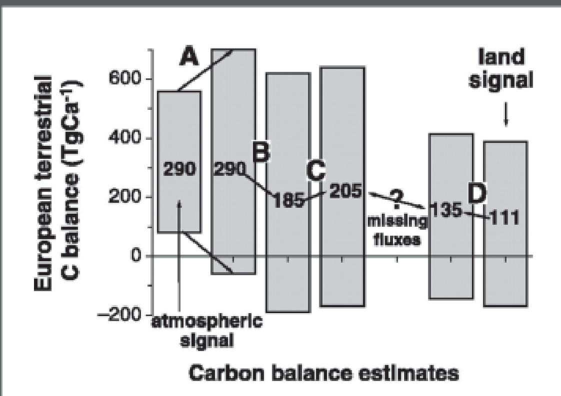
Comparison of Carbon Balance Estimation Methods



(Janssens et al., Science 2004)

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EU-CASFOR project (1998-2004)

G.M.J. Mohren, Wageningen University, NL (co-ordinator)
G.J. Nabuurs, M.J. Schelhaas, Alterra, Wageningen, NL
O. Masera et al., UNAM, Pátzcuaro, MX
M. Kanninen et al., CATIE, Turrialba, CR
T. Karjalainen / M. Lindner et al., EFI, Joensuu, FI

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(www.efi.fi/projects/casfor/)

CASFOR-II Objectives:

- to develop a general model for estimating carbon balance and carbon sequestration capacity in forested landscapes or regions
- to develop a web-based user interface

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(www.efi.fi/projects/casfor/)

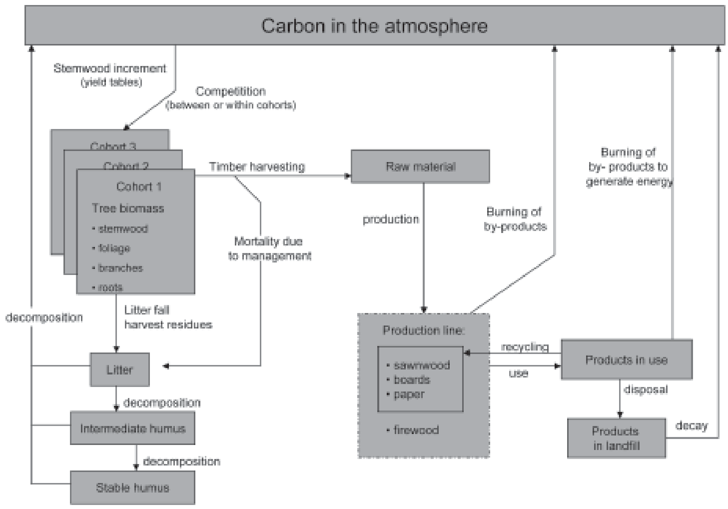
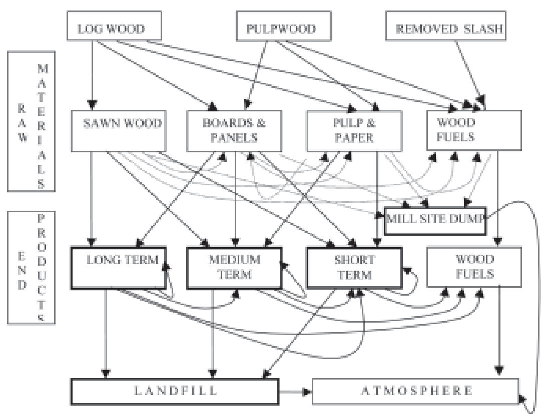
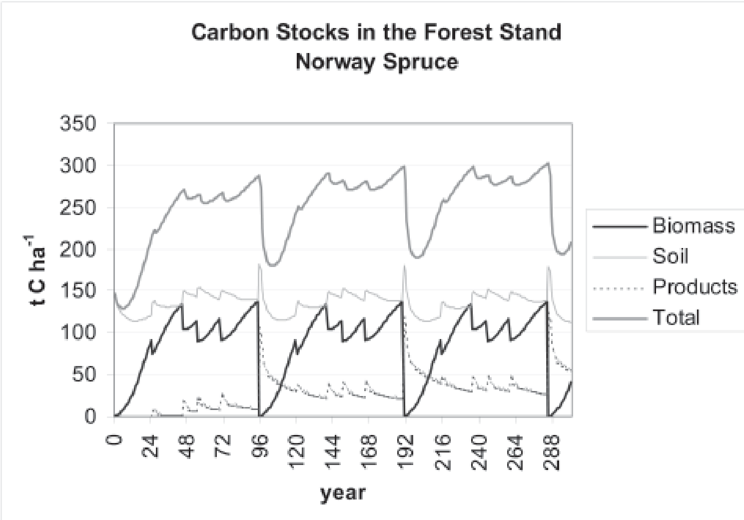
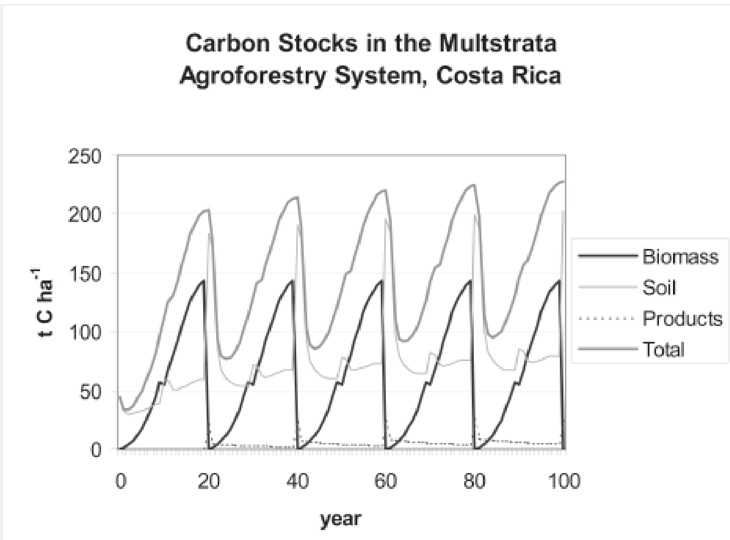


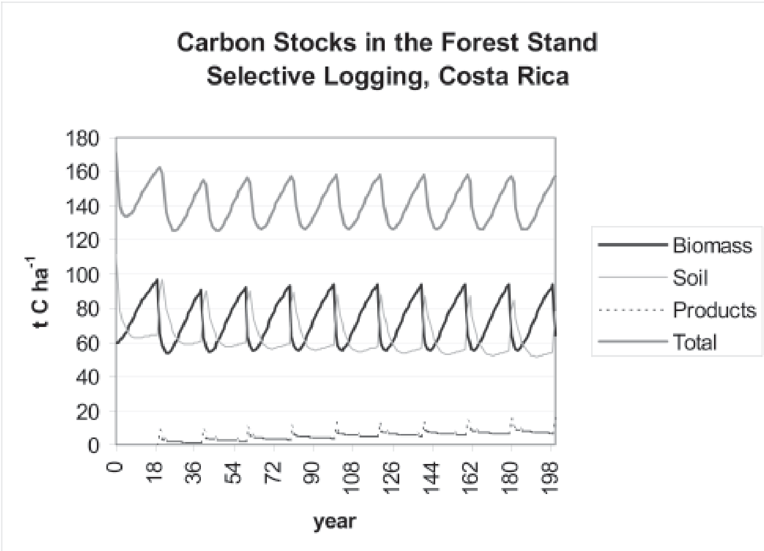
Figure.1.Carbon fluxes/processes (arrows)and carbon stocks (boxes) in a forest ecosystem and its wood products as distinguished in CO2FIXv2. (Note: the size of the boxes does not represent the absolute size of the carbon stock).

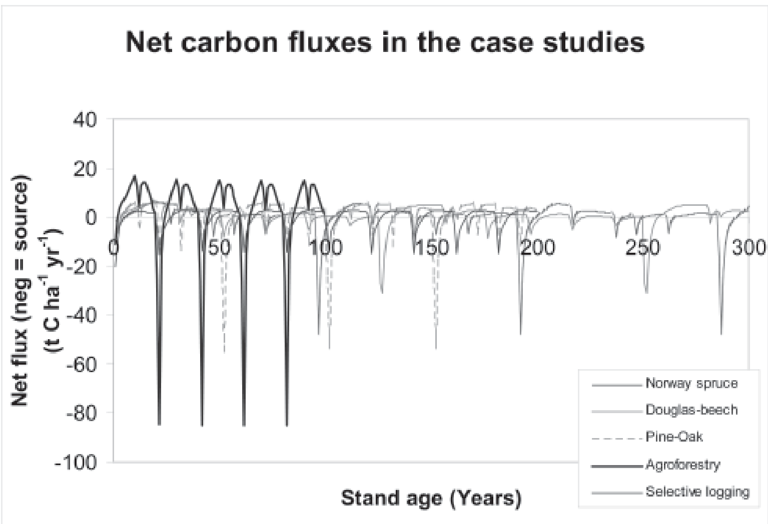
PRODUCTS MODULE

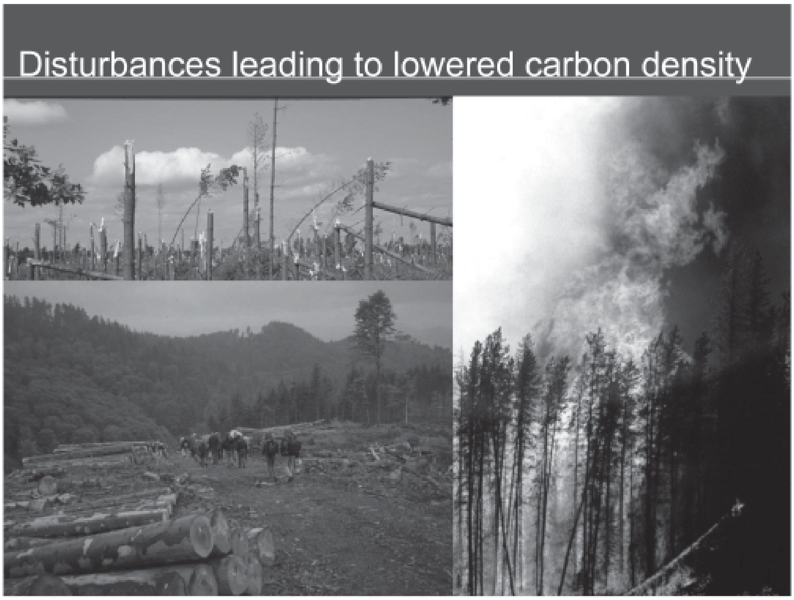


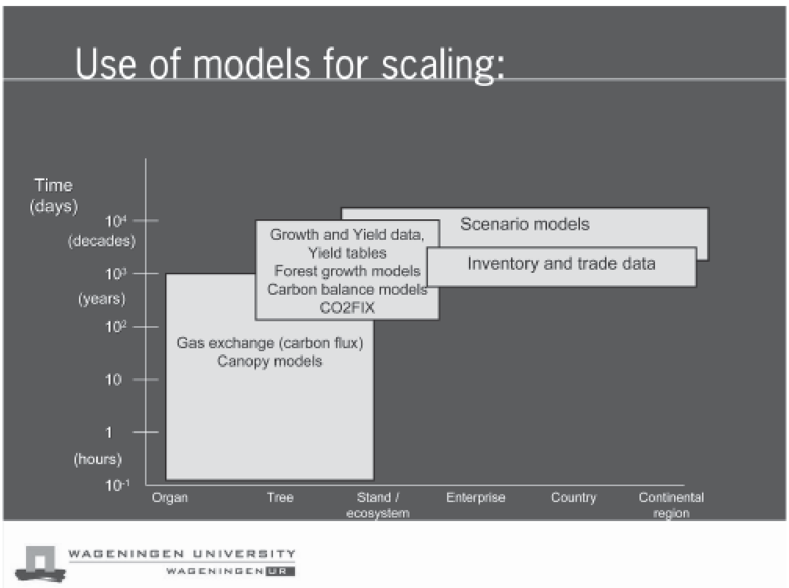

Carbon Stocks in the Forest Stand
Norway Spruce
350
300
250
200
150
100
50
0
t C ha-1
0
24
48
72
96
120
144
168
192
216
240
264
288
year
Biomass
Soil
Products
Total


Carbon Stocks in the Multstrata
Agroforestry System, Costa Rica
250
200
150
100
50
0
t C ha-1
0
20
40
60
80
100
year
Biomass
Soil
Products
Total


Carbon Stocks in the Forest Stand
Selective Logging, Costa Rica
180
160
140
120
100
80
60
40
20
0
t C ha-1
0
18
36
54
72
90
108
126
144
162
180
198
year
Biomass
Soil
Products
Total


Net carbon fluxes in the case studies
40
20
0
-20
-40
-60
-80
-100
Net flux (neg = source)
(t C ha-1 yr-1)
0
50
100
150
200
250
300
Stand age (Years)
Norway spruce
Douglas-beech
Pine-Oak
Agroforestry
Selective logging


Disturbances leading to lowered carbon density


Use of models for scaling:
Time
(days)
10⁴
(decades)
10³
(years)
10²
10
1
(hours)
10⁻¹
Scenario models
Growth and Yield data,
Yield tables
Forest growth models
Carbon balance models
CO2FIX
Inventory and trade data
Gas exchange (carbon flux)
Canopy models
Organ
Tree
Stand / ecosystem
Enterprise
Country
Continental region
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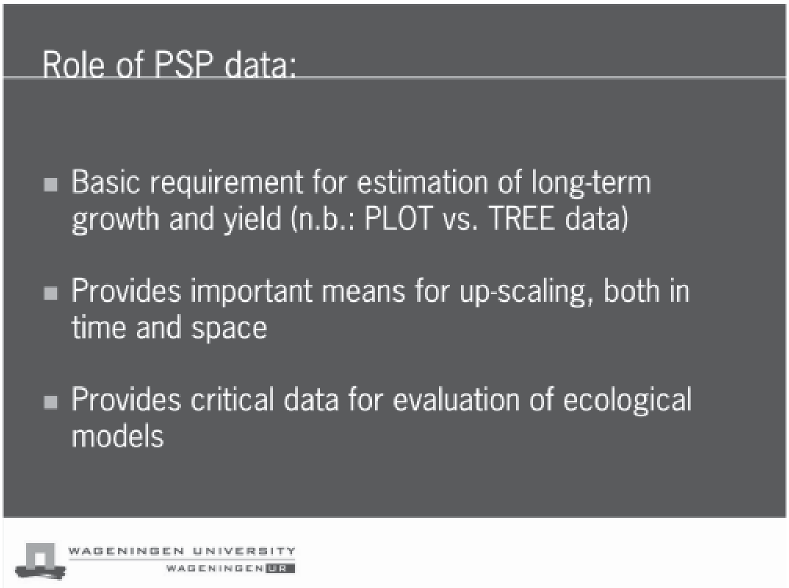
Role of PSP data:
Basic requirement for estimation of long-term growth and yield (n.b.: PLOT vs. TREE data)
Provides important means for up-scaling, both in time and space
Provides critical data for evaluation of ecological models
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Out Line

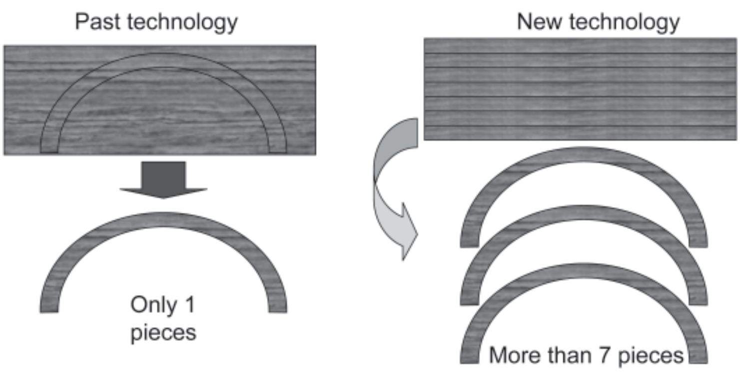
- RDU for Biomaterial – LIPI (Indonesian Institute of Sciences)
- Net work establishment in the field of Wood Science and Technology
- New Project: Humanospheric Science
- Collaborative research project among RISH, RDUB and MHP「Sustainable Forest Management, Forest Products and Regional Environment
- Acacia mangium bark industry

Objective

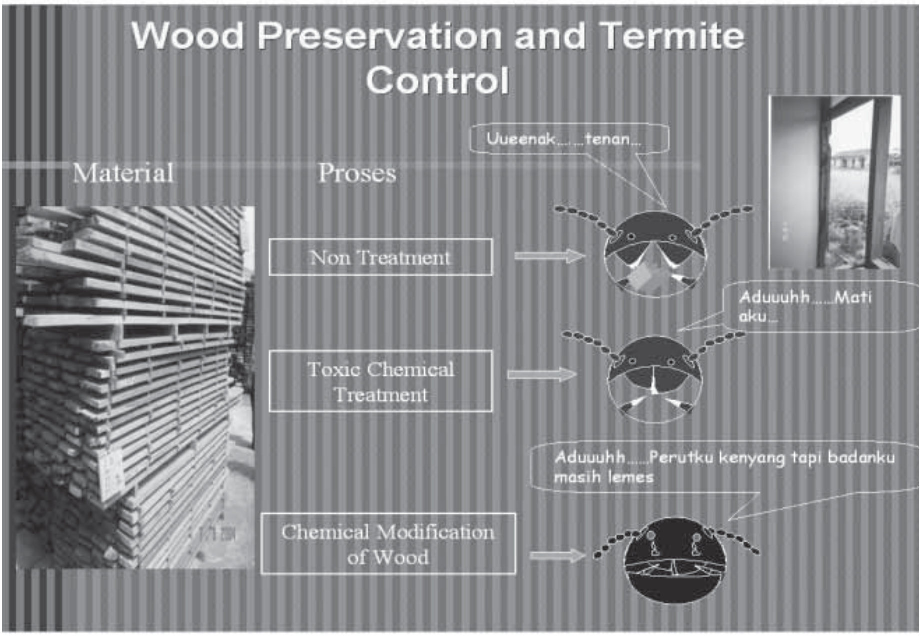
Research and development technology for establishing sustainable industry post Indonesian forest industry crisis

- **R & D on increasing efficiency utilization of wood**
- **R & D on improving wood quality**
- **R & D on alternative of raw materials**
- **R & D on alternative products**

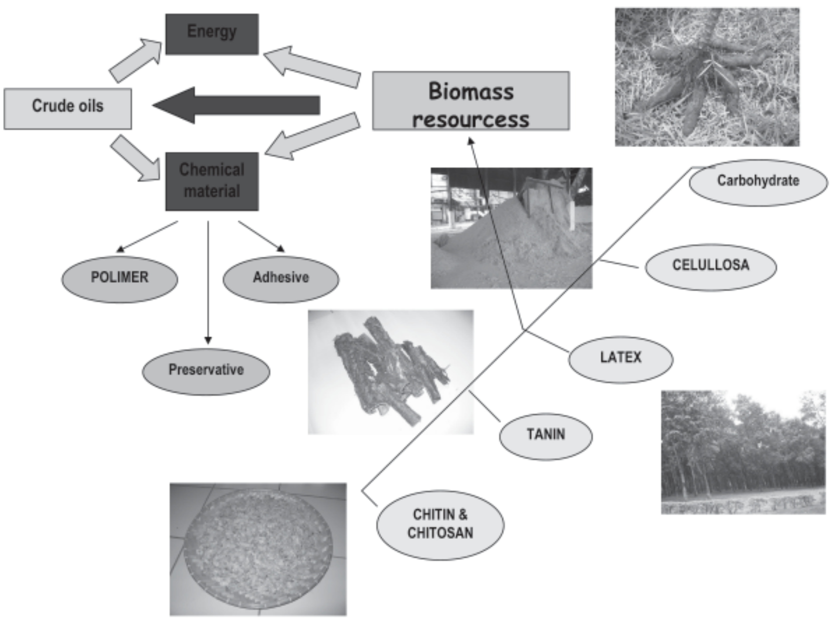
R & D on increasing efficiency utilization of wood using bent technology

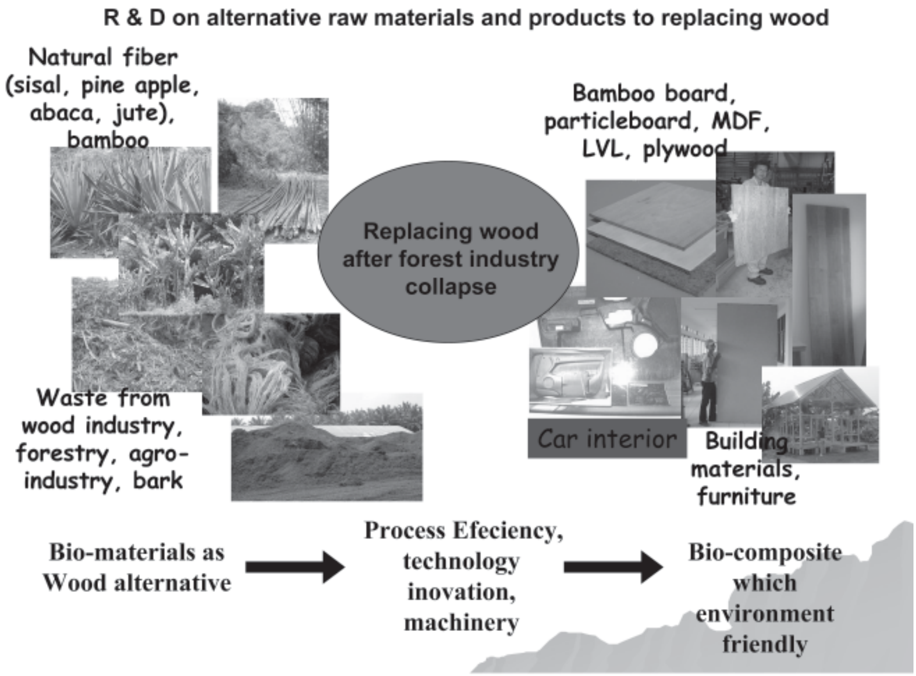


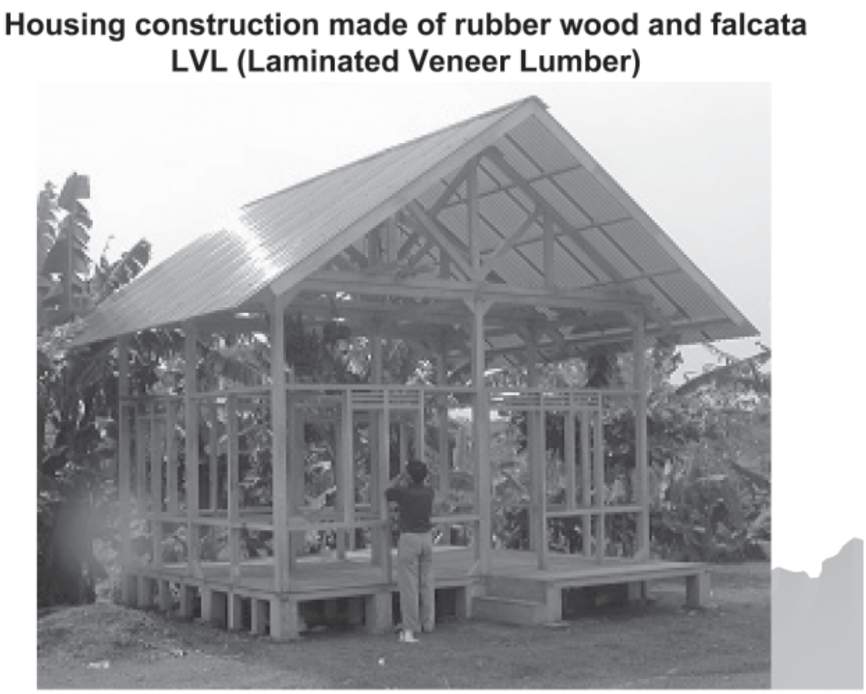
R & D on improving wood quality



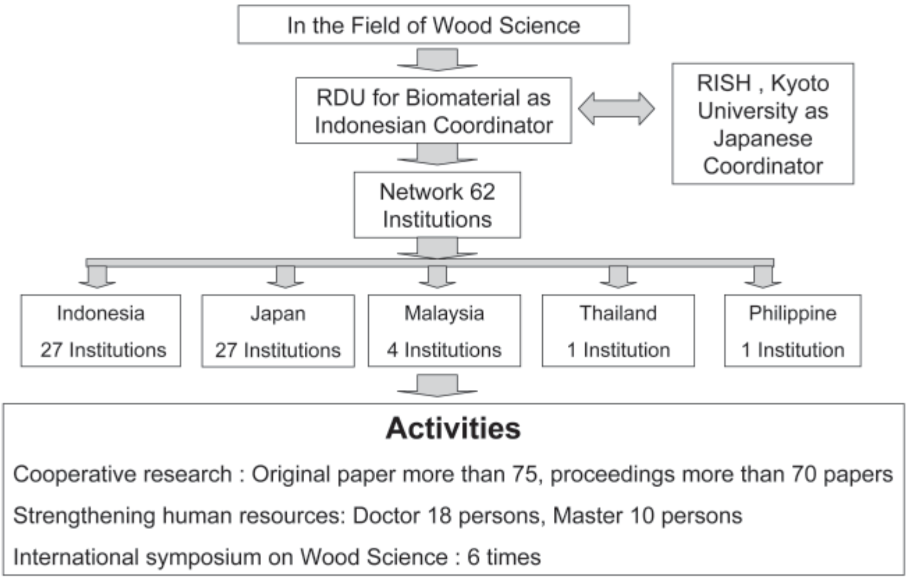
R & D on alternative of raw materials to replacing crude oils



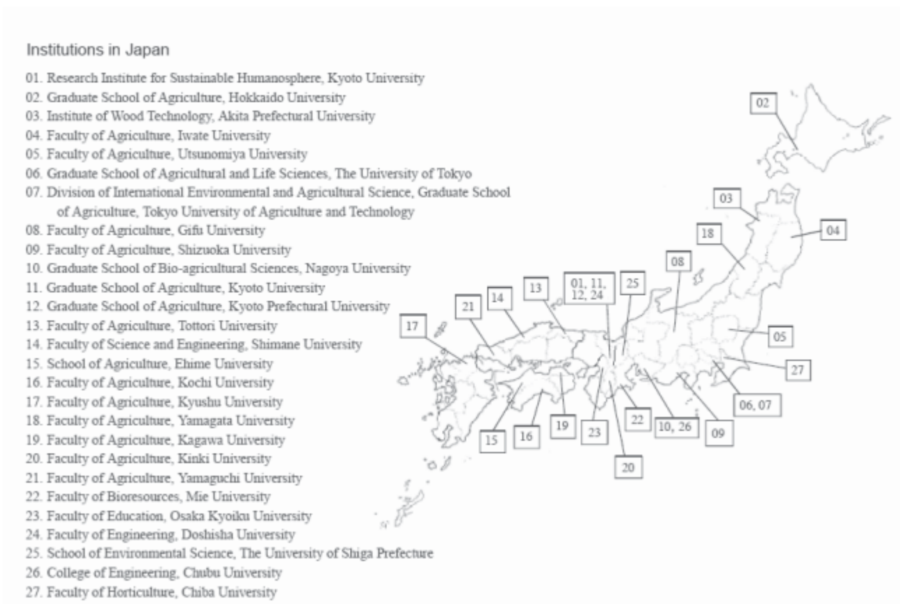

R & D on alternative raw materials and products to replacing wood
Natural fiber (sisal, pine apple, abaca, jute), bamboo
Bamboo board, particleboard, MDF, LVL, plywood
Replacing wood after forest industry collapse
Waste from wood industry, forestry, agro-industry, bark
Car interior
Building materials, furniture
Bio-materials as Wood alternative
Process Efeciency, technology inovation, machinery
Bio-composite which environment friendly


Housing construction made of rubber wood and falcata LVL (Laminated Veneer Lumber)

LIPI – JSPS Core University Program



Partner Institutions in Japan



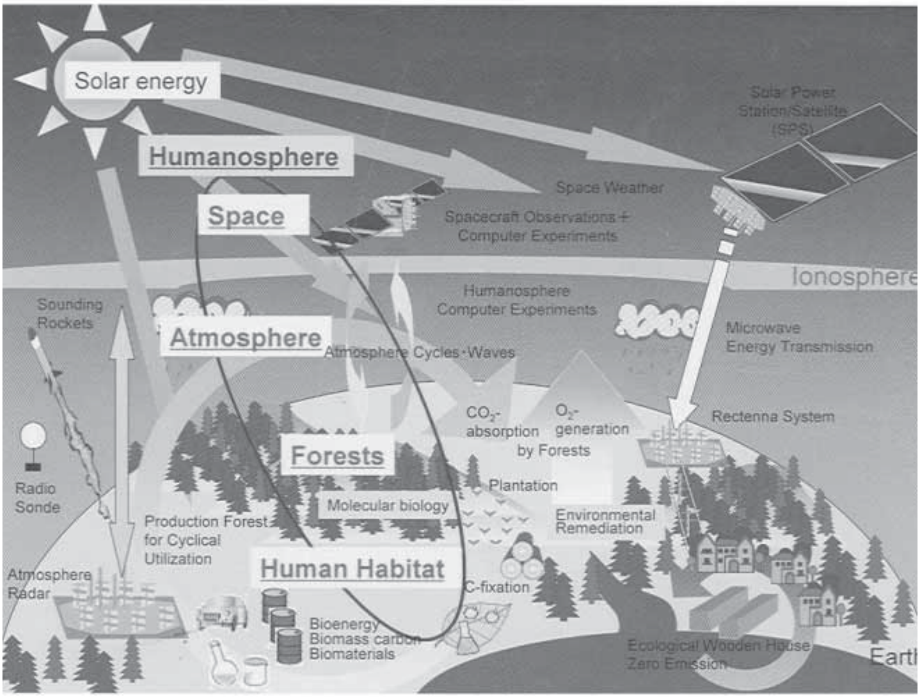
Partner Institutions in ASEAN

Institutions in Indonesia, Malaysia, Philippines and Thailand

28. Indonesian Institute of Sciences
29. Research and Development Unit for Biomaterials, Indonesian Institute of Sciences
30. Research Center for Physics, Indonesian Institute of Sciences
31. Research Center for Chemistry, Indonesian Institute of Sciences
32. Technical Implementation Unit for Chemical Processing of Materials, Indonesian Institute of Sciences
33. Research Center for Biotechnology, Indonesian Institute of Sciences
34. Research Center for Biology (Botany Division), Indonesian Institute of Sciences
35. Research Institute of Human Settlements Technology
36. Research and Development Center for Forest Products Technology
37. Bogor Agricultural University
38. Biotechnology Research Unit for Estate Crops
39. Research Center for Pulp and Paper
40. Research Center for Chemical and Packaging, Ministry for Industry Trade
41. Faculty of Forestry, Gadjah Mada University
42. Center for Research and Development of Isotopes and Radiation Technology, National Nuclear Energy Agency
43. Faculty of Forestry, Mulawarman University
44. Faculty of Forestry, Winaya Mukti University
45. Faculty of Forestry, Tanjungpura University
46. Forestry Department, Hasanuddin University
47. The University of North Sumatera
48. Department of Forestry, Faculty of Agriculture, Bengkulu University
49. Environment Research Center, Lambung Mangkurat University
50. Civil Engineering Department, Sriwijaya University
51. Forestry Department, Faculty of Agriculture, The State University of Papua
52. Environmental Engineering Department, Bandung Institute of Technology
53. Faculty of Engineering, Syiah Kuala University
54. Ministry of Research and Technology, Sub. Division of Research and Technology Assessment and Economic Growth
55. Forest Department, Faculty of Forestry, Pattimura University
56. Dept. of Forest Production, Faculty of Forestry, Universiti Putra Malaysia
57. School of Biological Sciences, Universiti Sains Malaysia
58. Forest Research Institute, Malaysia
59. Faculty of Civil Engineering Universiti Teknologi Mara
60. Forest Products Research and Development Institute, Department of Science and Technology
61. Dept. of Forest Products, Faculty of Forestry, Kasetsart University

New Project between Research Institute for Sustainable Humanosphere (RISH), Kyoto University and RDU for Biomaterial LIPI

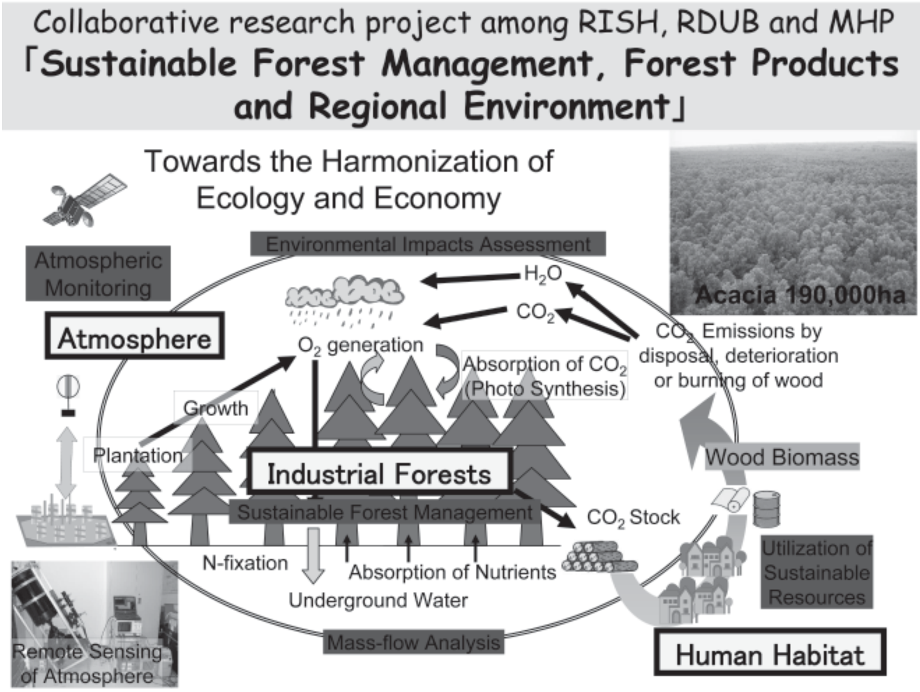
- Name of Project: Humanospheric Science
- Humanospheric Science is defined as an interdisciplinary field of study that examines the humanosphere, which is composed of four vertical regions of earth in which human activity takes places.
- These vertically connected regions are the ground human-habitat, the forest-sphere (arbor-sphere), the atmosphere, and space
- It is particularly concerned with providing academic and technological solutions to issues which critically affect the viability of *Homo sapiens* and human civilization such as energy, population, global warming, and resource shortage problem.



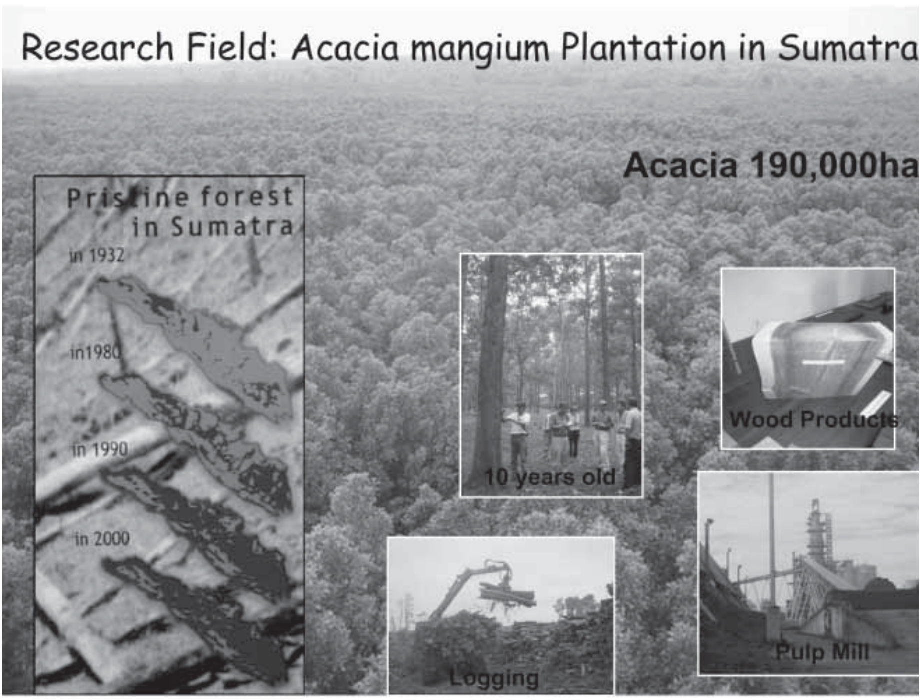
Collaborative research project among RISH – RDUB-MHP

Implementation of humanospheric science

Sustainable Forest Management, Forest Products and Regional Environment

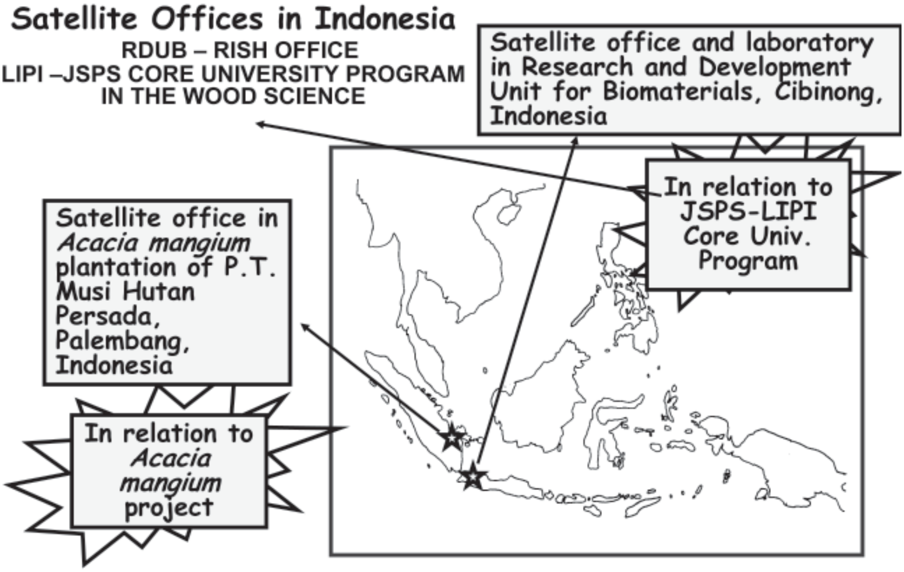


Collaborative research project among RISH, RDUB and MHP
「Sustainable Forest Management, Forest Products and Regional Environment」
Towards the Harmonization of Ecology and Economy
Environmental Impacts Assessment
Atmospheric Monitoring
Atmosphere
H_2O
CO_2
O_2 generation
Absorption of CO_2 (Photo Synthesis)
CO_2 Emissions by disposal, deterioration or burning of wood
Acacia 190,000ha
Growth
Plantation
Industrial Forests
Sustainable Forest Management
Wood Biomass
CO_2 Stock
N-fixation
Absorption of Nutrients
Underground Water
Utilization of Sustainable Resources
Mass-flow Analysis
Human Habitat
Remote Sensing of Atmosphere

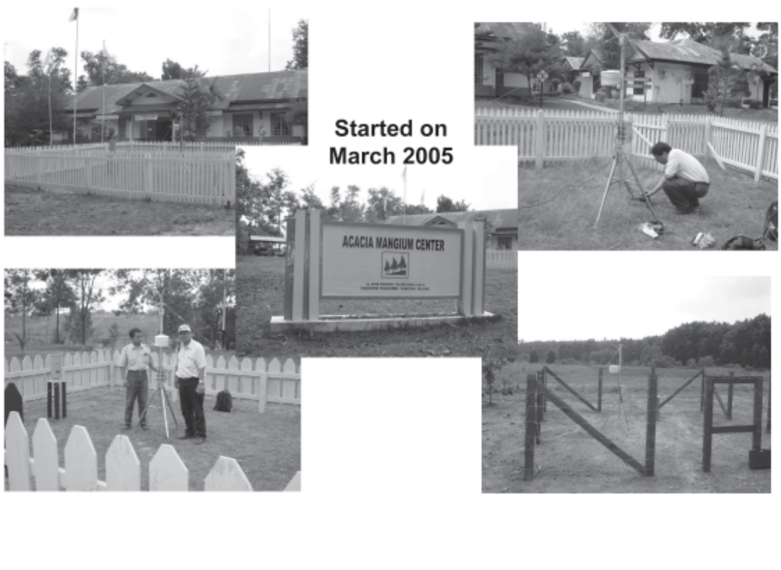


Research Field: Acacia mangium Plantation in Sumatra
Acacia 190,000ha
Pristine forest in Sumatra
in 1932
in1980
in 1990
in 2000
10 years old
Wood Products
Logging
Pulp Mill

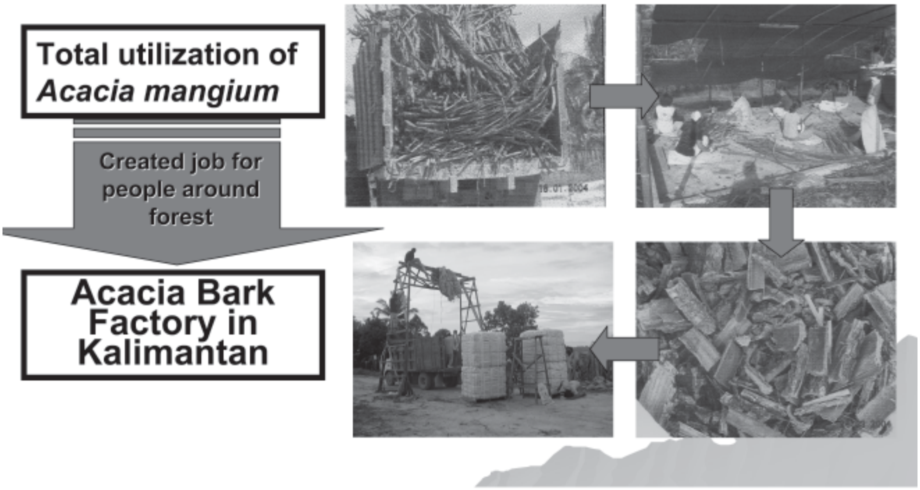
Establishing Satellite office to make intensive communications



Micro Climate Equipment in *Acacia mangium* Plantation Palembang



Contribution of Cooperative Project to Industries in Indonesia




18.01.2004


29.06.2004









The importance of permanent plots to biodiversity assessment: case study in Jawa, Sumatra and Kalimantan

E. Mirmanto, H. Simbolon, R. Abdulhadi & Y. Purwanto

Research Centre for Biology,
Indonesian Institute of Sciences

Permanent plots

Permanent plots
- Permanently demarcated area of forest
- Size typically 1 ha
- Periodically re-measured

Studies on:
- Vegetation analyses → Forest structure, Floristic composition, Diversity
- Forest dynamics → Growth-rate, Mortality-rate, Recruitment-rate
- Nutrient cycling → Litterfall, Nutrient content, Decomposition
- Phenology → Flowering season, Fruiting season
- Habitat preference
- Ethnobotanical study
- Species ecology

Study sites

Sources of data

Vegetation → Kartawinata, et al. (1981), Abdulhadi, Mirmanto & Yusuf (1989), Abdulhadi & Yusuf (1991), Abdulhadi (1991), Mirmanto et al (1992), Mirmanto (1996), Suzuki et al. (1998), Mirmanto et al. (2000), Partomihardjo et al. (2000), Purwaningsih (2000), Suzuki et al. (2000), Yusuf et al. (2001), Djarwaningsih, et al. 2003, Simbolon (2004), Yusuf, (2004), Yusuf, (2005),

Forest dynamics → Mirmanto (1996), Suzuki et al (1997), Suzuki et al. (1998), Mirmanto & Polosakan (2000), Mirmanto et al. (2002), Simbolon (2003a), Simbolon (2003b), Simbolon et al. (2003); Simbolon (2004a), Simbolon (2004b), Simbolon (2005)

Nutrient cycling → Mirmanto (1996), Mirmanto (1999a), Mirmanto (1999b); Rahajoe et al. (2004), Rahajoe et al. (2004), Rahajoe et al. (2000),

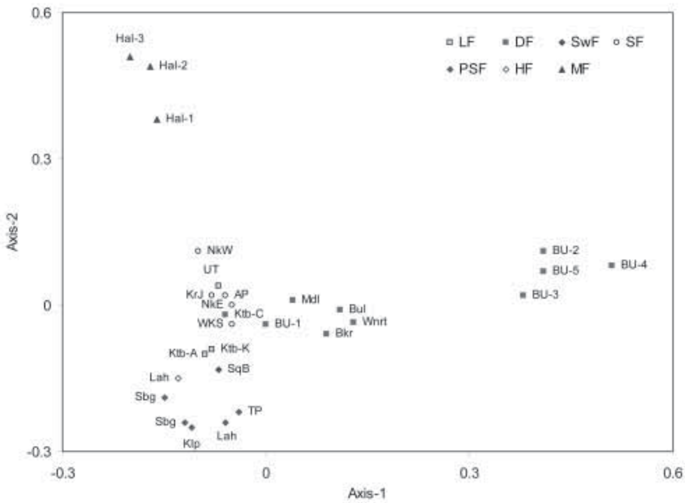
Phenology

Habitat preference

Ethnobotanical study → Waluyo et al. (2003)

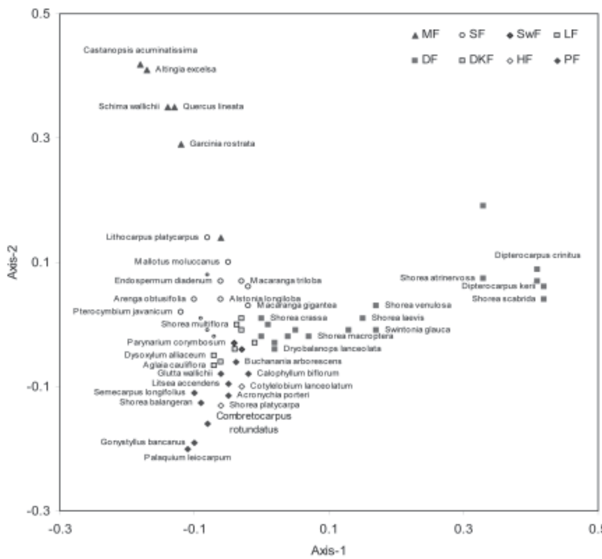
Species ecology

Ordination of permanent plots based on ten most common tree species in each plot

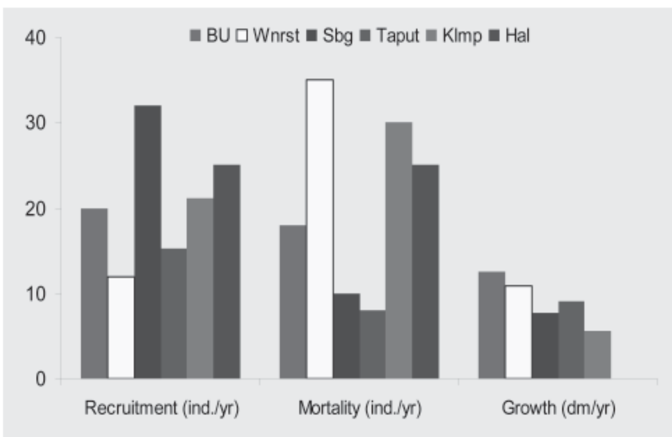


Ordination of permanent plots based on the structural parameter of each plot.

Some species indicator of each forest community



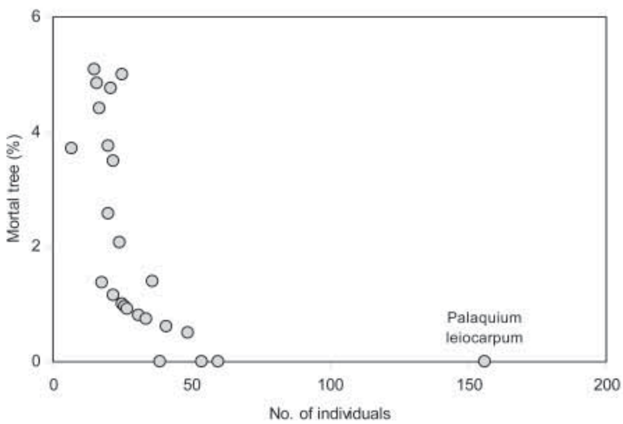
Growth, mortality and recruitment of tree species in six permanent plots



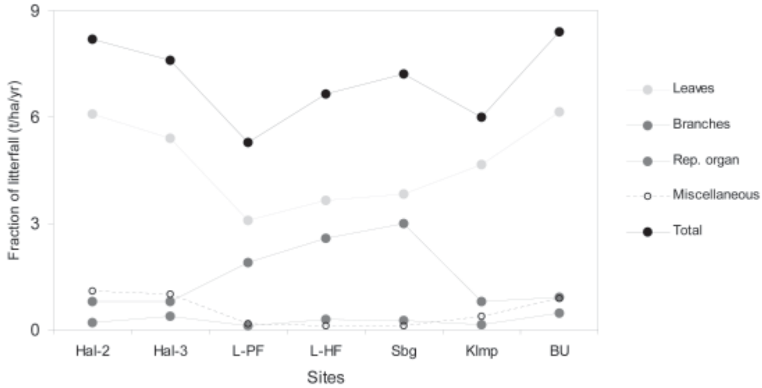
Vegetation change over period of study in 6 study sites

		Basal area					
		Kelampangan	Sebangau	Halimun	Tg. Puting	Barito Ulu	Wanariset
Beginning	m^2/ha	20.58	18.23	39.64	25.28	46.87	28.60
	%	100	100	100	100	100	100
Decrease by death	m^2/ha	-0.57	-0.18	-0.85	-0.38	-1.02	-22.70
	%	-2.77	-0.99	-2.14	-1.52	-2.18	-79.37
Increase by growth	m^2/ha	0.22	0.42	0.89	0.47	0.96	1.00
	%	1.05	2.28	2.25	1.86	2.05	3.50
Increase by recruitment	m^2/ha	0.09	0.14	0.49	0.61	0.39	6.70
	%	0.45	0.78	1.24	2.40	0.83	23.43
End	m^2/ha	20.32	18.60	40.17	25.97	47.20	13.60
	%	98.74	102.07	101.34	102.74	100.70	47.55
		Density (ind/ha)					
		Kelampangan	Sebangau	Halimun	Tg. Puting	Barito Ulu	Wanariset
Beginning	ind./ha	934	893	995	521	879	955
	%	100	100	100	100	100.00	100
Decrease by death	ind./ha	-30	-10	-25	-8	-18	-805
	%	-3.19	-1.15	-2.51	-1.61	-2.05	-84
Increase by recruitment	ind./ha	21	32	25	15	20	278
	%	2.26	3.58	2.51	2.92	2.28	29.11
End	ind./ha	926	915	995	528	881	428
	%	99.11	102.44	100.00	101.27	100.23	44.82

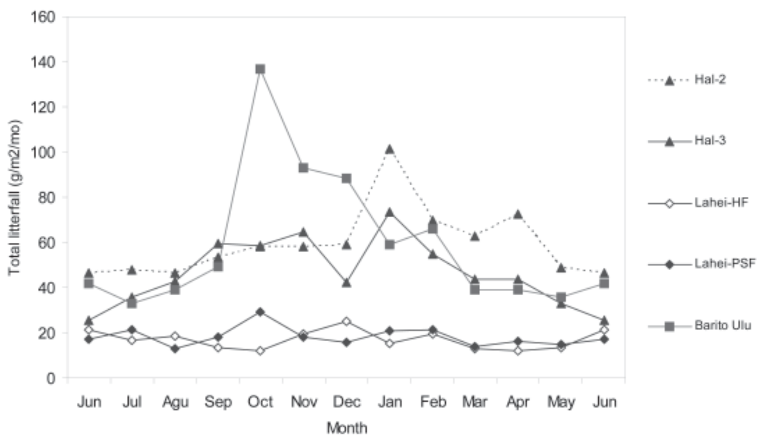
The percentage of mortal tree species and their density

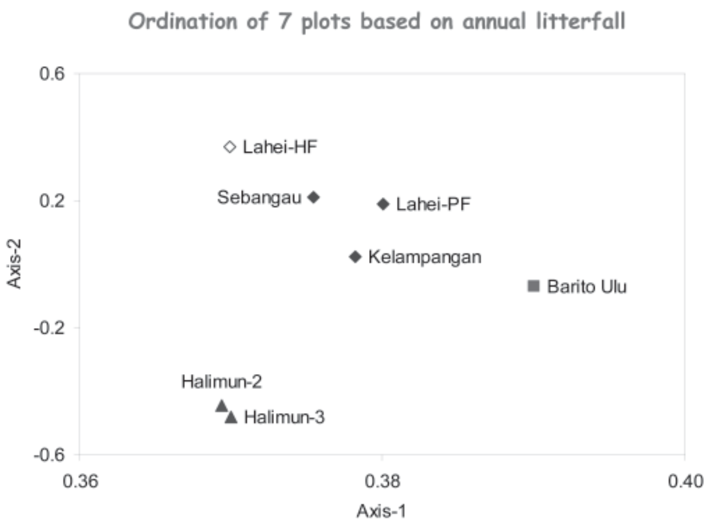


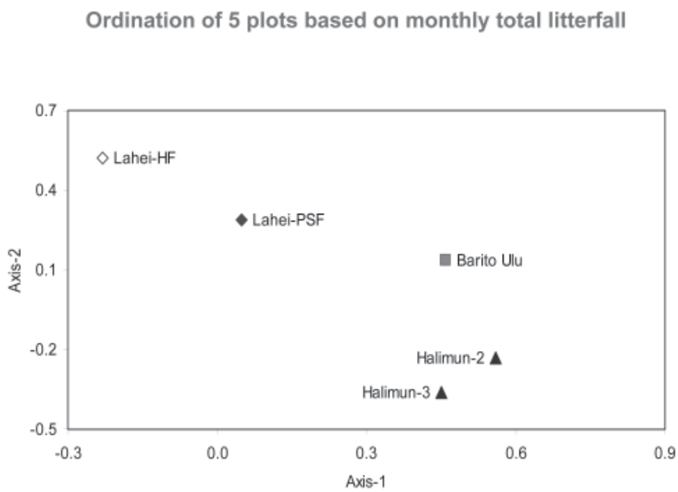
Annual production of fractions of litterfall in 7 study sites



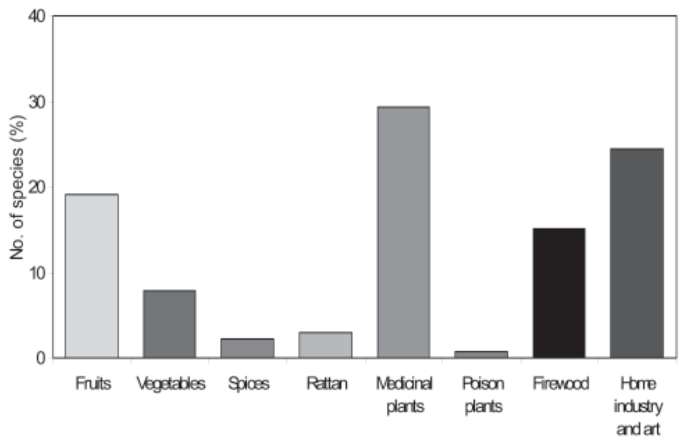
Monthly production of total litterfall in 5 study sites




Ordination of 7 plots based on annual litterfall
0.6
0.2
-0.2
-0.6
Axis-2
Lahei-HF
Sebangau
Lahei-PF
Kelampangan
Barito Ulu
Halimun-2
Halimun-3
0.36
0.38
0.40
Axis-1


Ordination of 5 plots based on monthly total litterfall
0.7
0.4
0.1
-0.2
-0.5
Axis-2
Lahei-HF
Lahei-PSF
Barito Ulu
Halimun-2
Halimun-3
-0.3
0.0
0.3
0.6
0.9
Axis-1

Number of species (%) according to category of plant use



Ordination of plant use category based on the similarity plant species

List of participants

No	Name	Institution
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2	Dr. Andry Indrawan	Faculty of Forestry IPB - Bogor Indonesia Phone: +62 251 620 280 Fax: +62 251 621256 Email: *ecology@indo.net.id* or *andrecol1@yahoo.com*
3	Dr. Ir. Anita Firmanti, MT	Departemen Pekerjaan Umum Badan Penelitian dan Pengembangan Pusat Penelitian dan Pengembangan Pemukiman Jl. Panyaungan Cileunyi Wetan Kabupaten Bandung 40393 Indonesia Phone: +62 22 7798393 Fax: +62 21 7798392 Email: *kapuskim@bdg.centrin.net.id*
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Workshop agenda

Day 1. Wednesday, 3 August 2005

08.00 am	Arrival of Participants
09.00 am	Opening Remarks by Dr. Petrus Gunarso, Coordinator Malinau Research Forest, CIFOR
09.10 am	Welcoming Address by Dr. Markku Kanninen, Director Environmental Services and Sustainable Use of Forests, CIFOR
09.20 am	Keynote Speech by Indonesian Ministry of Forestry HE. MS. Kaban and Launching Officiation
09.30 am	Coffee break and Exhibition (Posters Session)

Session 1: Overview of Sustainable Forest Management

Chair person 1:	Mr. Arthur Klassen (Tropical Forest Foundation)
10.15 am	Presentation 1: An Overview on Sustainable Forest Management in Peninsular Malaysia by Dr. Abd. Rahman Kassim
10.35 am	Presentation 2. Making Sustainability Work for Complex Forests: Towards Adaptive Forest Yield Regulation By Dr. Herry Purnomo
10.55 am	Presentation 3 :A brief note on TPTJ (Modified Indonesia Selective Cutting System) from experience of PT Sari Bumi Kusuma (PT SBK) timber concessionaire by Ir. Gusti Hardiyansah MSc
11.15 am	Presentation 4: Determination of sustainable forest management in Indonesia: a simulation study by Dr. Paian Sianturi
11.35 am	Question and Answer
12.15 pm	Lunch

Session 2: Permanent sample plots and the study on Growth and yield

Chair person 2:	Dr. Barita Manulang (Conservation International-Indonesia)
13.15 pm	Presentation 1: Contribution of permanent sample plots to the sustainable management of tropical forests: what rules to warrant the long-term recovery of timber-logged species? Elements from STREK, Bulungan (Indonesia), Paracou (French Guiana) and Mbaïki (Republic of Central Africa) by Dr. Sylvie Gourlet-Fleury
13.35 pm	Presentation 2: Tree Growth and Forest Regeneration under Different Logging Treatments in Permanent Sample Plots of a Hill Mixed Dipterocarps Forest, Malinau Research Forest, Indonesia by Ir. Hari Priyadi, MSc

13.55 pm	Presentation 3: Progress on the studies of growth of logged-over natural forests in Papua New Guinea by Mex M. Peki
14.15 pm	Presentation 4:The Utilization of growth and yield data to support of sustainable forest management in Indonesia by Ir. Joko Wahyono, MSc, Ir. Rinaldi
14.35 pm	QA
15.15 pm	Coffee break

Session 3: The Importance of Permanent Sample Plots

Chairperson 3	Dr. Paian Sianturi
15.30 pm	Presentation 1: The importance of permanent sample plots for biodiversity Assessment: Case study for Java, Kalimantan and Sumatera By Drs. Edi Mirmanto
15.45 pm	Presentation 2: The Role of RDU for Biomaterial – LIPI in the Development Sustainable Wood Industries Post Forest Industry Crisis in Indonesia by Dr. Bambang Subyanto
16.00 pm	Presentation 3: Permanent sample plots in damar and rubber agroforests of Sumatra and use of the data for the spatially explicit individual based forest simulator (SExI-FS) by Degi Hardja, Gregoir Vincent and Laxman Joshi
16.15 pm	Presentation 4: Current Status of Permanent Sample Plots in Lao PDR by Mr Chansamone and Mr. Phonesavan
16.30 pm	Presentation 5: The importance of STREK Plots in contributing Sustainable Forest Management in Indonesia By Ir. Sulistyo A Siran, MSc
16.45 pm	QA
18.00 pm	Welcoming dinner

Day 2. Thursday, 4 August 2005

Session 4 : Carbon Sequestration and Climate Change

Chairperson 4:	Dr. Upik Rosalina
08.45 am	Presentation 1: Carbon Sequestration and Climate Change by Prof. Dr. Frits Mohren
09.10 am	Presentation 2: The importance of Permanent Sample Plot Network for Climate Change Projects By Prof. Dr. Daniel Murdiyarso
09.30 am	QA
10.30 am	Coffee Break
Working Group	
10.30 am	Briefing for Working Group: Dr. Petrus Gunarso
	WG 1: Data sharing from different sites (Facilitated by Dr. Herry Purnomo)
	WG 2: Developing a Network of PSPs (Facilitated by Dr. Petrus Gunarso)
	WG 3: Recommendation of silvicultural changes (Facilitated by Dr. Sofyan Warsito)
12.30 pm	Lunch
Plenary and Closing Remarks	
14.00 pm	Working Group Report: Dr. Sofyan Warsito
14.30 pm	Closing Remarks: Dr. Petrus Gunarso

Day 3. Friday, 5 August 2005

Visit to Bogor Botanical Garden

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Pictures

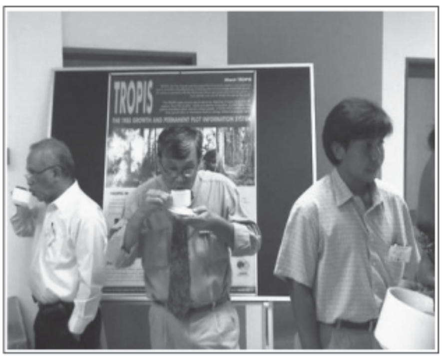
International Workshop on Promoting Permanent Sample Plot in Asia and the Pacific Region: *A Photo session (documentations were taken by Haris Iskandar, CIFOR)*

Opening speech from the Minister of Forestry of Indonesia, H.M.S. Kaban by DG FORDA, Dr. Hadi S. Pasaribu

Director of Env. and Sustainable Use of Forests of CIFOR, Dr. Markku Kanninen, welcome all participants

Dr. Petrus Gunarso gave brief information on MRF-CIFOR ITTO activities in Malinau to Dr. Hadi S. Pasaribu

Coffee break and Posters session at August 3, 2005



Coffee break and Poster session at August 3, 2005

Dr. Herry Purnomo from IPB-CIFOR was delivering his presentation on "*Making Sustainability Work for Complex Forests*".

Participants follow the presentation

Dr. Paian Sianturi was delivering his presentation on "*a simulation study on sustainable forest management in Indonesia*"

Gusti Hardiansyah MSc. from PT. Alas Kusuma Group, was delivering his presentation

In depth discussion during Q & A Session

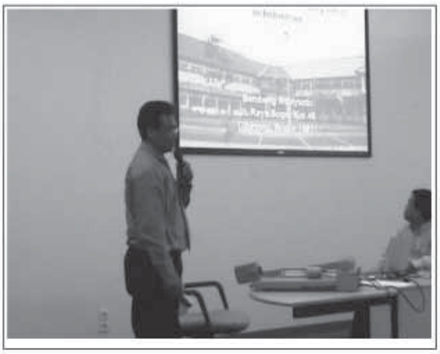
In depth discussion during Q & A Session

Dr. Sylvie Gourlet from CIRAD Foret - France, was delivering her presentation on PSP distribution issue.

Dr. Sylvie Gourlet from CIRAD Foret - France, was delivering her presentation on PSP distribution issue.

Rinaldi, S.Hut. from FORDA was delivering his presentation on their experiences to collect and manage PSPs data

Mr. Edi Mirmanto, LIPI was delivering his presentation



Dr. Bambang Subiyanto from Lab. Biomaterial LIPI was delivering his presentation

Degi Hardja, ICRAF was delivering his presentation

Dr. Chanhsamone Phongoudom_NAFRI Laos was delivering his presentation on PSP related issue in Lao PDR.

Dr. Sulistyo A. Siran was delivering his presentation

Session 2. The discussion

Session 2 of the discussion

In depth discussion during Q & A Session

Dr. Kuswata Kartawinata in depth discussion during Q & A Session

Dr. Sylvie Gourlet from CIRAD Foret in depth discussion during Q & A Session

Prof. Sofyan in depth discussion during Q & A Session

Dr. Meine van Nordwijk, ICRAF in depth discussion during Q & A Session

Dr. A.R. Kassim from FRIM at the discussion session

Prof. Frits Mohren was delivering his presentation

Prof. Frits Mohren still in action

Prof. Frits Mohren in action

Prof. Daniel Murdiyarso, CIFOR, was delivering his presentation

Prof. Daniel Murdiyarso, CIFOR, was continuing his presentation

Panel of presenters at the discussion session

Dr. Upik Rosalina, moderator of the third session

Dr. Sulistyo A. Siran in depth discussion during Q & A Session

Working group discussion activities

Dr. Petrus Gunarso, moderator for the plenary group discussion

In depth discussion during Q & A Session

Dr. Sylvie Gourlet from CIRAD Foret in depth discussion during Q & A Session

Welcoming dinner at CIFOR campus

Permanent Sample Plots (PSP) are an important tool to monitor forest dynamics and changes, long term growth and yield and to provide critical data for evaluation of ecological models. For silvicultural purposes PSP supply data on diameter and volume increment as well as stand structure dynamics. This data is very useful for calculating Annual Allowable Cut (AAC) in a forest management unit. In addition, there has been increasing demand for data and information collected from PSP for accounting purposes in carbon-sequestration projects; the use of long-term measurements provided by PSP would increase the profile and credibility of such projects.

PSP will become more important in the future. They will likely be used in measures to indicate forest health, for instance, and those related to the services provided by forests, such as the provision of water and carbon storage. One of the reasons for convening the workshop was to strengthen collaboration between institutions already working with PSP with the aim of building a network in Southeast Asia and beyond.

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