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Master Plan for the Rehabilitation and Revitalisation of the Ex-Mega Rice Project Area in Central Kalimantan

GUIDELINE FOR THE REHABILITATION OF DEGRADED PEAT SWAMP FORESTS IN CENTRAL KALIMANTAN

Technical Guideline No. 5

MARCH 2009

Euroconsult Mott MacDonald and Deltares | Delft Hydraulics
in association with
DHV, Wageningen UR, Witteveen+Bos, PT MLD and PT INDEC

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Guidelines for the Rehabilitation of Degraded Peat Swamp Forests in Central Kalimantan

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AusAID	Australian Agency for International Development
BKSDA	Balai Konservasi Sumber Daya Alam
BP-DAS	Balai Pengelolaan Daerah Aliran Sungai
BPK	Balai Penelitian Kehutanan Banjarbaru (Forest Research Institute – Banjarbaru)
BPP	Balai Penyuluhan Pertanian
CA	Cagar Alam (Strict Nature Reserve)
CDM	Clean Development Mechanism
CIMTROP	Centre for International Co-operation in Management of Tropical Peatland; associated with the University of Palangka Raya
CKPP	Central Kalimantan Peatlands Project
DGIS	Directoraat Generaal Internationale Samenwerking (Netherlands Government Overseas Aid Programme)
dbh	diameter at breast height
EMRP	Ex Mega Rice Project
FMU	Forest Management Unit
HL	Hutan Lindung (Protection Forest)
KfW	Kreditanstalt für Wiederaufbau (The German Government's Overseas Aid Programme)
KHDTK	Kawasan Hutan Dengan Tujuan Khusus
KPH	Kesatuan Pengelolaan Hutan (Indonesian for Forest Management Unit - FMU)
LULC	Land Use Land Cover
MRP	Mega Rice Project
NLPSF	Natural Laboratory of Peat Swamp Forest
Norad	The Norwegian Government's Overseas Aid Programme
NP	National Park
PA	Protected Area
PLG	Proyek Lahan Gambut (Indonesian acronym for MRP)
PPT	Potential Plus Trees
SM	Suaka Margasatwa (Wildlife Reserve)
TN	Taman Nasional (National Park)
REDD	Reduced Emissions from Deforestation and Degradation
RESTORPEAT	Restoration of tropical peatland to promote sustainable use of renewable natural resources
STRAPEAT	Strategies for implementing sustainable management of peatlands in Borneo
UGM	Universitas Gajah Mada (Yogyakarta)
UNPAR	University of Palangka Raya
WIIP	Wetlands International – Indonesia Programme

Foreword

These draft *Guidelines for Peat Swamp Forest Rehabilitation* were drawn up following on from – and where possible drawing upon – the workshop on "Rehabilitation of Peat Swamp Forest: A Study and the most Suitable Practice" held at Tangkiling, near Palangkaraya, from 11-13 December 2008. About 25 participants attended this technical workshop – almost all of them practitioners in the field of peat swamp forest (PSF) restoration, rehabilitation and regeneration in Indonesia[1]. The aim of the workshop was to bring together existing information and practical experience on the restoration and rehabilitation of PSF in Indonesia, and provide a basis for a first set of guidelines for rehabilitation.

The workshop and this document focuses on technical aspects of peat swamp forest restoration/rehabilitation related to forestry and ecology only. It does not focus on the socio-economic aspects or institutional aspects (who is to carry out reforestation), which are, however, key to the success of any PSF rehabilitation programme. These are outside the scope of the current guidelines, which had to be modest in its approach. The current guidelines also do not focus on the hydrological aspects of PSF restoration and rehabilitation, which are a prerequisite for reforestation efforts. A separate set of guidelines focussing on hydrological restoration will be produced by the EMRP project.

It was acknowledged at this workshop that we are still a long way from producing a comprehensive document that provides most of the answers to the when, how and why of PSF restoration and rehabilitation. Activities in this field have only just begun after 2000 and most were initiated over the past four years. In Central Kalimantan this has particularly been under the Central Kalimantan Peat Project (CKPP), the sister project of the Master Plan - Ex Mega Rice Project (EMRP), but also by the Centre for International Co-operation in Management of Tropical Peatland (CIMTROP) of the University of Palangkaraya (UNPAR), and as part of the Government of Indonesia (GOI) reforestation programmes such as *Gerhan* and as carried out by the watershed protection agency (BP-DAS), and the Forestry Research Institute – Banjarbaru, both of the Forestry Department. Because of the recent nature of these activities, information and experience is just emerging and much of this still awaits documentation. Hence the initiative of the Master Plan EMRP project to hold the PSF Rehabilitation workshop, as this would provide an opportunity to share information and experiences.

It is the intention that over the coming few years the current document evolves into a more final and useful set of guidelines as additional experience emerges and lessons learned are incorporated. Practitioners in PSF rehabilitation and restoration, scientists and PSF managers are encouraged to respond and provide feedback to the authors.

[1] A list of participants in included in Annex 1, and a programme in Annex 2.

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1 Introduction

Many of the current initiatives on Peat Swamp Forest (PSF) restoration and rehabilitation focus on the Ex-Mega Rice Project (EMRP) area in Central Kalimantan, which was the focus of a massive (and ultimately highly unsuccessful) drive in the mid-1990s towards converting a million hectares of PSF to rice fields (see Box 1). The area is now highly degraded, and relatively unmanaged, it is a major source of carbon emissions (due to oxidation and fires) and poses a health hazard to communities over a wide area. The areas includes 400,000 ha of peat >1m deep that is now without forest cover; much of this will need to be reforested.

In addition to being the focus of the Master Plan – EMRP and Central Kalimantan Peatland Project (CKPP), the EMRP area is the main focus of the National Forest Rehabilitation (Gerhan) and Balai Pengelolaan Daerah Aliran Sungai (BPDAS) programmes, and Centre for International Co-operation in Management of Tropical Peatland (CIMTROP) peat swamp forest (PSF) restoration and rehabilitation activities.

In addition to Government of Indonesia (GOI) funds, significant funds have been pledged by various donors towards PSF restoration and rehabilitation in the EMRP area, including DGIS (the Netherlands), AusAID (Australia; for Reduced Emissions from Deforestation and Degradation/REDD), KfW (Germany), Norad (Norway) and the World Bank, and there is significant pressure from all parties to rapidly commence with replanting programmes.

Box 1. Status of forests in the EMRP area

The area is a river delta of 1.4 million hectares dominated by more than 900,000 ha of peat with roughly 450,000 ha being more than 3m deep. Hydrological assessments indicate that the hydrological function of the peatland has been permanently changed and flooding is a serious problem, especially in the eastern part of the area along the Barito River. Current land cover is estimated to consist of a mix of healthy and degraded forest (37%), severely degraded forest and woodland (14%), shrubland (22%), grassland, ferns and recently burnt land (15%) and agricultural land (12%). Peat swamp forest with high biodiversity value is found in the more remote areas, especially in the north, and healthy stands of mangrove exist in part of the coastal zone. Deep peat (>3m) is protected under Presidential Decree 32/1990 and more than 400,000ha of the peat area >1m deep is now degraded and without forest cover. This area remains a significant source of greenhouse gas emissions.

However, information emerging from ongoing and recent restoration and rehabilitation programmes in the EMRP demonstrates that there is still a lot to learn. Many rehabilitation efforts were not successful, as sites with failed replanting have demonstrated. Some of the main preconditions for successful restoration and rehabilitation are beyond the scope of these guidelines; these are i) community involvement; ii) hydrological restoration and rehabilitation; and iii) fire prevention. The current guidelines focus on the technical (forestry and biological) aspects of restoration and rehabilitation, and not on communities, hydrology and fires. Other outputs of the Master Plan – EMRP include technical annex reports on *Hydrology of the EMRP* *area, and water management implications for peatlands*, *Assessment of dam construction & green engineering, Fire management in the EMRP area,* and *Community Engagement on the EMRP,* along with guidelines on fire management and hydrological restoration.

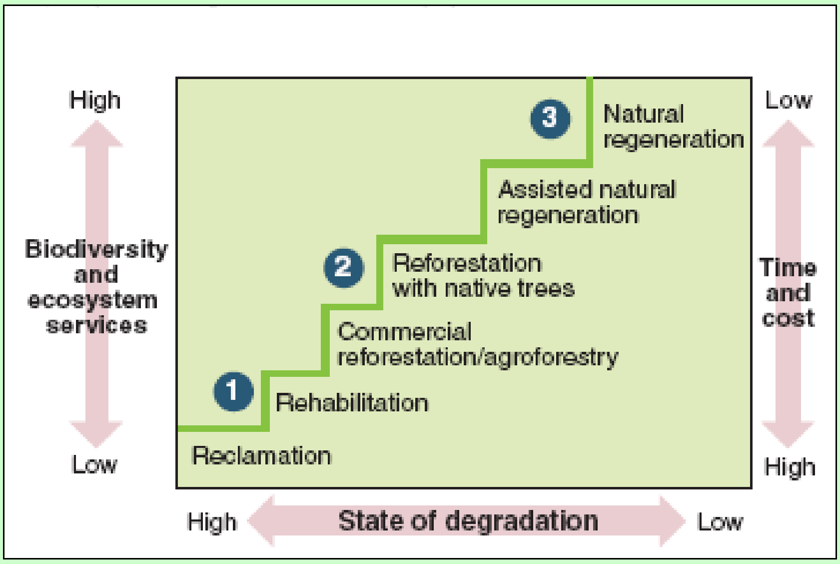
There is some confusion about the various terminology in use in PSF restoration and rehabilitation, and the various terms are clarified/summarised below in Box 2. These draft guidelines provide:

- Summary of degradation types & natural regeneration studies in Indonesia (chapter 2),
- Summary of restoration/rehabilitation attempts in the region (chapter 3.1) and Central Kalimantan (3.2),
- Guiding principles for restoration and rehabilitation (chapter 4), and
- Technical guidelines for PSF restoration and rehabilitation (chapter 5).

Key areas for future research based on a needs assessment carried out during the workshop are included in Annex 3.

Box 2. Clarification of terminology

The figure below illustrates the "degradation staircase" that shows mechanisms by which ecosystems could be returned to (something like) their original state following various levels of degradation. Areas that are only slightly degraded can recover on their own by means of natural regeneration, while heavily degraded areas can rarely fully recover and will require rehabilitation to restore basic functions. The terminology used in these guidelines is described below.



After: Chazdon (2008)

Terms:

- *Reforestation* (reboisasi)*: (re-)planting of trees in an area without trees.*
- *Regreening* (penghijauan)*: often used as a synonym of reforestation.*
- *PSF Regeneration: (natural) recovery of PSF vegetation; assisted regeneration is when some inputs are provided, such as hydrological restoration or fire prevention, so that natural regeneration can take hold.*
- *PSF Restoration: to return peat swamp forests (modified by human use) to their natural state*
- *PSF Rehabilitation: to revive important ecological services of degraded peat swamp forest*

2 Summary of degradation types & natural regeneration studies

2.1 Development of peat swamp forest in Southeast Asia

Palynological studies carried out in peat swamp forests of Southeast Asia indicate at least two possible routes for their development: an origin in freshwater swamps, or one whereby peat formation begins in mangrove areas.

As described by Morley (1981) based on peat core samples taken in the Sebangau peat dome in Central Kalimantan, peat formation in this area began abruptly over a topogenous eutrophic or mesotrophic swamp in which grasses (*Poaceae*) and *Lycopodium cernuum* were conspicuous elements. Other species at this early stage include aquatic species such as *Nymphoides indica* and bladderwort *Utricularia flexuosa.* Most peat swamp trees were probably recruited from local plant communities, since pollen of many of the taxa found in the peat swamp was already present during the grass-dominated phase. Peat swamps in Kutai, East Kalimantan also have a freshwater origin, but rather than being dominated by grasses during the preceding stage, these swamps were dominated by *Pandanus*, which grades upwards to peat swamp dominated by dipterocarps (Hope *et al.,* 2005). This is similar to the situation found in Riau, where Brady (1997) also recorded an initial pandan-dominated stage in peat swamps of Pulau Padang. These peatlands are of recent origin, all being formed during the last glacial period of 6000-10000 years BP. Inland peat swamp forests found in the Danau Sentarum NP in West Kalimantan have a different origin yet again, having formed over inland freshwater swamps, and are much older: 30000-40000 years BP (Anshari *et al.,* 2001; 2004).

Studies by Anderson and Muller (cited by Morley, 1981) indicate that the Marudi peat swamp in Sarawak originated in a mangrove area, having developed over marine clays in the Baram Delta. The Marudi palynological profile shows a gradual change from a mixed mangrove with *Nypa fruticans, Oncosperma tigillaria* and Rhizophoraceae, through a transitional community with *Cyrtostachys lakka, Campnosperma* and *Eleiodoxa,* to a true peat swamp association. A similar history was recorded by Yulianto *et al.* (2005) at Batulicin in South Kalimantan, where sea level rise about 6000-6400 years BP lead to a transition from *Rhizophora*-dominated mangrove to peat swamp forest.

2.2 Degradation seres & regeneration in the region

According to Van Steenis (1957), nothing was known at the time about (fire) seres in peat swamp forests, although Kostermans (1958) tried to rectify this by providing some initial notes. The occurrence of fire seres in humid Southeast Asian peat swamp forests is an anomaly. As Rieley and Ahmad-Shah (1996) point out, most pristine tropical peat swamps are permanently wet, with the water table close to, or above, the surface throughout the year. Fluctuation of the water table in an ombrogenous peat swamp in Sarawak, for example, was 19 centimetres in the centre and 10 centimetres near the edge, throughout the year. Also, relative humidity is high: in wet season this is 90-96% both in forested and gap areas, and in the dry season this is 80-84%. However, it is obvious that fire (and other degradation) seres have emerged, and have been subjected to various studies/targeted by various management regimes during the past decades.

2.2.1 Malaysia

According to Wyatt-Smith (1959) there is a comparative wealth of natural regeneration of all sizes of economic species in the peat swamp forests of Malaysia. He notes, however, that even a slight drop in the mean water table may result in changes to the species composition of the forest, with plants that are more suited to the drier soils succeeding those of the original wetter conditions. Thus *Tetramerista glabra* and *Gonystylus bancanus* often do not regenerate following logging. However, *Koompassia malaccensis, Calophyllum retusum* and *Shorea* spp. do well – so good timber crop can be expected in regenerated forest.

Natural regeneration and reforestation studies in the peat swamp forests of Sarawak by Lee (1979) found that in the *Alan Batu* forest, the amount of *Shorea albida* dropped from 28% to 2% over a period of 17 years, as *S. albida* seedlings are quickly out competed after logging. Fast-growing species such as *Xylopia coriifolia, Litsea* spp. and *Cratoxylum* spp. increase significantly after logging, while those with medium rates of growth such as *Dactylocladus stenostachys, Ganua* spp. and *Shorea inaequilateralis* showed about 20% increase in distribution. Slower growing species such as *Combretocarpus rotundatus, Melanorrhoea* spp. (now *Gluta)*, *Palaquium* spp. and *Gonystylus bancanus* decreased in distribution by about 30%. Silvicultural treatment aimed at eliminating vegetation competing with a potential tree crop, appear to have a stimulating effect (as measured after 10 years) on growth of fast growing species such as *Cratoxylum* spp., *Dryobalanops rappa, Shorea* spp. and *Dactylocladus bancanus*.

Whitmore (1984) describes secondary vegetation types in peat swamp areas. *Melaleuca cajuputi* is an under storey tree that become gregarious after repeated burning, owing to thick, loose, corky bark, and the production of root suckers and coppice shoots. In Malaysia, species commonly associated with *Melaleuca cajuputi* are *Alstonia spathulata, Cratoxylum cochinchinense, Excoecaria agallocha, Fagraea fragrans, Ilex cymosa, Macaranga pruinosa, Ploiarium alternifolium, Randia dasycarpa, Scleria* species and *Stenochlaena palustris*.

Whitmore (1984) found that following logging of *Shorea albida-Gonystylus-Stemonurus* forest in Sarawak, *Shore albida* presence dropped from 28% to 2% as seedlings were killed by competition. In contrast, fast growers such as *Cratoxylum, Litsea* species and *Xylopia coriifolia* had greatly increased; medium growers such as *Dactylocladus stenostachys, Ganua* species and *Shorea inequilateralis* increased by 20%, and slow growers such as *Combretocarpus rotundatus, Gluta* species, *Palaquium* species and *Gonystylus bancanus* decreased by about 30%. In the *Shorea albida-Litsea-Parastemon* forest type, natural regeneration of *Shorea albida*, and other large trees such as *Litsea crassifolia* and *Combretocarpus rotundatus* is mainly vegetative, by suckers or coppice shoots. This forest then has no value for timber, but low extraction costs and high volume makes it valuable for chips or pulp. Extensive pure stands of *Macaranga pruinosa* and *Campnosperma coriacea* in Malaysia of same-sized trees with an even canopy are believed to represent stages in a secondary succession back to mixed swamp forest after clearing (Whitmore, 1984).

Appanah *et al.* (1989) note that in peat swamp forests of Peninsular Malaysia there is an increase in the regeneration of *Shorea* species, *Koompassia malaccensis* and *Calophyllum retusum* after final felling or when the surrounding forest is converted to agriculture. This increase has been attributed to the desiccation of the forest, favouring these species at the expense of species such as *Gonystylus*

According to Bruenig (1990), commercial tree felling results in a drastic shift in species composition in favour of species which are tolerant to sudden change, such as *Cratoxylum arborescens,* but not species such as *ramin Gonystylus bancanus*. The latter is a naturally slow starting species, and in silvicultural trials, reacted poorly to felling and release operations. In regenerating areas with even canopies there is a risk of a dense, slender pole vegetation resulting which is susceptible to wind damage. Another hazard of commercially felled areas is that of nutrient loss by interrupting the nutrient cycle. Growth can be almost static in secondary growth areas in Borneo (e.g. dominated by *Ploiarium*), where monitored secondary forest showed almost zero growth even after 30 years.

Under post-logging conditions in peat swamp forests in Malaysia, Ibrahim (1996) reports that cleaning operations are required to reduce competition for sunlight and nutrients. Where this does not occur, disturbed peat swamp forests are rapidly dominated by fast growing species such as *Macaranga.* In Sarawak, defective and weakened trees are removed by means of girdling and liberation in the first year after logging, and again after 10 years. Some enrichment planting has been carried out, especially of *Gonystylus bancanus* in Sarawak, but no routine silvicultural treatments are performed in logged-over peat swamp forest in Peninsular Malaysia. Seedlings and small trees of commercial trees tend to cluster around the mother tree, and removal of the latter in uncontrolled logging operations results in serious damage <to progeny>, and reduced opportunities for natural regeneration. Enrichment planting is probably the most logical solution if natural regeneration fails to restock degraded peat swamp forest. The main problems associated with enrichment planting of peat swamp forests is obtaining an adequate seed supply of selected species, the remoteness of planting areas, and a lack of process planting techniques in areas which contain much undecomposed organic matter.

2.2.2 Brunei Darussalam

In his study on secondary succession in logged over peat swamp forest dominated by *Shorea albida,* at Sungei Damit, Belait, Kobayashi (2000) found that natural regeneration of *Shorea albida* forests following logging operations is poor. After a four year recovery period he found that less than 10% of the former *Shorea albida* forests were likely to recover as *S. albida* forest, while more than 80% was found to be heavily colonised by *Pandanus andersonii* and *Nephrolepis biserrata* and developing into a shrub-fern vegetation.

2.2.3 Thailand

Only a relatively small area (64,000 ha) of peat swamp forest remains in Thailand (Hankaew, 2003). Whereas a total of 437 angiosperms were recorded in primary peat swamp forest, only 82 species are found in secondary, degraded peat swamp forests. The latter are dominated by *Melaleuca cajuputi* and are characterised by the presence of many Cyperaceae. Peat swamp forest disturbed by repeated fires loses all or most of its peat layer, and underlying clay soils are invariably potential acid sulphate soils. Upon exposure to the air these become strongly acidic, and this favours *Melaleuca,* which is generally tolerant of such conditions. If fires are not only incidental, *Melaleuca*–dominated communities may be replaced by a further degraded Cyperaceae 'grassland'.

Mixed peat swamp forests are generally of two types, one dominated by *Eugenia kunstleri*, the second dominated by *Ganua motleyana.* Upon opening of the canopy, for example, by felling of trees, the vegetation becomes dominated by *Macaranga pruinosa.* Further disturbance and especially fires then leads to the fourth community type already described, dominated by *Melaleuca cajuputi.* Herbaceous species commonly associated with the latter secondary vegetation are *Cyperus* spp., *Lepironia articulata, Lygodium microphyllum, Medinilla crassifolia, Melastoma decemfidum, Nepenthes gracilis, Stenochlaena palustris* and various grasses.

According to Hankaew (2003), recovery of disturbed peat swamp forests via natural succession occurs via the following stages:

- *Melaleuca cajuputi* community type
- *Macaranga pruinosa* community type
- *Eugenia kunstleri – Goniothalamus giganteus – Macaranga pruinosa* community sub-type
- *Eugenia kunstleri – Ganua motleyana* community sub-type
- *Ganua motleyana – Xylopia fusca* community type.

For natural regeneration to occur, it is most important that fires are prevented, and other factors appear to be secondary to this.

Tomita *et al.* (2000) studied in detail the natural regeneration process of *Melaleuca*–dominated peat swamp forest in southern Thailand following a severe fire. The area studied had been drained, cleared, abandoned and burnt, after which the area was rapidly colonised by *Melaleuca cajuputi,* along with *Melastoma malabathricum,* a host of ferns including *Blechnum indicum, Stenochlaena palustris* and *Lygodium microphyllum,* and the sedges *Lepironia articulata* and *Scleria sumatrana.* According to Tomita *et al.* (2000), who studied dispersal and recovery in great detail, these species either arrived as wind-borne seeds (*Melaleuca*) or from surviving subterranean clones (*Lepironia, Blechnum*). In the three year study, *Melaleuca* was observed to grow very rapidly, increasing to a height of 2-3 metres, covering much of the quadrats analysed, and out-competing other species after only 1.5 years.

2.2.4 Papua New Guinea

According to Eden (1973), the current distribution of savannah and grassland in southern Papua is not wholly consistent with environmental conditions, and he concludes that these habitats have been formed as a result of clearing and burning of peat swamps, perhaps influenced by recent climatic fluctuations.

2.3 Degradation seres and regeneration in Indonesia

2.3.1 Indonesia in general

In their assessment of the TPTI selective logging system in Indonesia, Dwiyono and Rachman (1996) conclude that this system does not always allow regeneration, due to:

- poor felling techniques which severely damage young/valuable trees;
- use of young trees (20-30cm dbh class) to construct logging tracks, ramps, etc…;
- some tree species produce seed only once a decade or so;
- suppression of preferred species by other (less valuable) species;
- luxuriant growth of climbers, creepers or rattans; and
- appropriateness of enrichment planting not examined and suitable species unknown.

As a result of felling, there is a decrease in old and large trees, with higher densities of younger and smaller ones as a result. In peripheral peat swamps, *Shorea* species tend to dominate regrowth, while in most open places (e.g. along extraction routes) *Cratoxylum arborescens, C. glaucum* and *Dactylocladus stenostachys* are pioneer species colonizing newly available space. On the whole, such fast growing trees become dominant in the regenerating peat swamp forest. Regeneration is also often quite patchy, and forest stands are often replaced by low growing species such as ferns and shrubs. Other changes noted by Dwiyono and Rachman are structural changes, a reduced structural diversity, and changes in micro-climate.

2.3.2 Sumatra

Kostermans (1958) regarded the lakes at Kayu Agung in South Sumatra as being the result of peat disappearance due to extensive burning. Giesen and van Balen (1991b) describe the lakes along the Siak Kecil River in Riau, which forms part of a large peat dome where the deepest peat in Indonesia has been recorded – 24 metres. The string of lakes along the Siak-Kecil – like pearls on a string – and the ongoing peat degradation and burning strongly suggest that the lakes are in the process of being formed due to peat degradation.

2.3.3 South Kalimantan

Giesen (1990) considers that virtually all vegetation types in the Sungai Negara wetlands of South Kalimantan are of a secondary nature, derived from primary types by tree felling and burning. Mixed freshwater swamp forests were found to have all been converted to *Melaleuca cajuputi* (*gelam*) [2]dominated swamp forest, sedge and grass swamp or rice paddies, a process that was already observed and noted early in the 20th century. Elsewhere (West Kalimantan, East Kalimantan) freshwater swamp forest is observed to be converted to a vegetation dominated by *Shorea balangeran*. This also appear to have been the case in South Kalimantan, and historic accounts record *gelam* and *S. balangeran* fire seres being replaced by sedge, fern and grass swamps. Giesen (1990) notes that the herb layer of degraded wetlands often dominated by *Stenochlaena palustris* and *Blechnum indicum.*

Giesen (1990) further describes five types of secondary peat swamp forests (fire seres) derived from mixed peat swamp forest that formerly included *Gonystylus bancanus,* dipterocarps and wild mangoes. These five types are:

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[2] *Melaleuca cajuputi* is an understorey tree in the primary swampforest (Whitmore, 1984).

- *Eugenia* – dominated fire/logging sere.
- *Shorea balangeran* – dominated fire/logging sere.
- *Combretocarpus rotundatus* – pure stands; also a fire sere, possibly intermediate between the former two.
- *Melaleuca cajuputi* swamp forest – possibly a next degradation stage, following a long history of fires in peat swamp forests on acid sulphate soils.
- Sedge and grass swamp – final stage of degradation. Many species of sedge (*Cyperus, Scleria, Eleocharis, Fimbristylis, Fuirena, Scirpus, Rhynchospora*) and grass (*Ischaemum, Echinochloa, Phragmites, Rottboellia*), and invasive *Mimosa pigra* shrubs.

2.3.4 Central Kalimantan

Kostermans (1958) reports that species such as *Alstonia, Campnosperma* and *Ctenolophon lophopetalum* only develop alongside *Combretocarpus rotundatus* if burning is not too frequent. Both *Shorea balangeran* and *Combretocarpus rotundatus* appear to be stimulated by fire, and show a marked tendency towards gregariousness, each forming nearly pure stands.

According to Rieley and Ahmad-Shah (1996), Bornean dipterocarps are not only tolerant of shade in early stages of growth, but develop faster under these conditions. Opening up of the canopy during logging operations may therefore have adverse effects on these species. Regeneration of burnt areas may be hampered by falling timber, and Rieley and Ahmad-Shah (1996) found that “since the <Kalimantan> fires ended there has been a constant collapse of burned trees to the forest floor causing damage to new growth.”

In their assessment of the effects of the 1997/98 forest fires and deforestation in Central Kalimantan, D’Arcy and Page (2002) found that mixed peat swamp forest lost about 75% of tree density in burnt areas, compared to a maximum loss of 40% in selectively logged areas. Primary forest had the highest mean number of saplings per plot, while burnt areas had the highest mean dbh. Interestingly, they found that *Combretocarpus rotundatus* is one of the main species able to survive fires. Forest fires can greatly restrict the regeneration of an area through the deterioration of seed banks, the reduction in plants that normally resprout post disturbance, and a decline of soil fertility due to the loss of organic material.

An IPB study of the recovery of a large area of former peat swamp forest at Kelampangan, Central Kalimantan, has produced some interesting results. A 1 ha plot of 100 by 100 metres was studied over the course of several years after the 1997 fires. Immediately after the fires it was concluded that all species had died, apart from two specimens of *jelutung Dyera polyphylla (lowii)* that had miraculously escaped. In the first four months after the fire, very little regeneration occurred except for resprouting of *Combretocarpus rotundatus,* and it was therefore concluded that the seed bank in the peat soil had also been killed. By May 2003, i.e. 6 years after the fires, Simbolon *et al.* (2003) found that there were 1158 individual trees (with a dbh of 15 cm or more) growing in the plot. 103 tree species were identified, dominated by *Combretocarpus rotundatus, Cratoxylum arborescens, Palaquium gutta, Shorea teysmanniana* and *Syzygium ochneocarpa*. Common species (in terms of number) were: C. arborescens (256 indiv.), *S. teysmanniana* (104), *S. ochneocarpa* (50), *Horsfieldia crassifolia* (47) and *Campnosperma squamatum* (46). On the whole, the investigators were surprised by the vigorous regrowth. According to Simbolon (pers. comm., 2003), the seeds did not arrive by wind, as most are too heavy, and they were probably brought by birds and mammals, or by floodwaters. However, the latter happened only once since the IPB team began monitoring the area. One must note, however, that the plot is located only 300 metres from a patch of good peat swamp forest, and the hydrology was reasonably intact (i.e. with limited drainage impact). Simbolon expected dbh to have recovered by 30-40 years, but full floristic recovery would take more than 100 years, and perhaps even several hundred years. In any case, this will depend on the proximity of good forest as a source of propagules.

A WWF-Indonesia team conducted an initial fire impact study in the peat swamp forests of Tanjung Puting National Park, Central Kalimantan in December 1997[3]. They found that the average number of tree species declined from 60 per hectare in unburned areas to fewer than 15 after burning, that the total number of trees that survived the burn is highly correlated with the degree of prior disturbance, and that areas that had burned twice or more generally were devoid of trees. Peat swamps differ from other forests in that fires can travel below the ground surface killing trees by destroying their root systems.

Graham and D'Arcy (2006) found at Sebangau that after the 1997 fires, the dominant tree genera were *Santiria* and *Sterculia,* while *Shorea, Dyera* and *Eugenia* also emerged. Following the second major fires in 2002 diversity dropped, and emerging tree species were low in number, with genera such as *Elaeocarpus, Syzygium* and *Ilex* becoming more dominant. Adult trees of *Combretocarpus rotundatus* (tumih) survived both fires, but saplings were low in number.

D'Arcy and Graham (2007) found in the Sebangau NP area that primary seed dispersers are important for dispersal and maintenance of tree species diversity in these peat swamp forests. However, their population densities are in decline, and especially in burnt areas are likely to play a limiting role in seed dispersal from adjacent intact areas. The implications are that if this decline continues, peat swamp forest may struggle to regenerate naturally in disturbed areas. Ongoing studies on seed dispersal by frugivorous birds at Sebangau NP indicate that, unlike in the Neotropics, seed dispersal by birds plays a less important role (pers. comm. L. Graham, 2008). However, it must be acknowledged that the forests under study (Sebangau NP) have been subjected to disturbance, and numbers of large frugivorous birds such as hornbills are low. Another factor that limits natural regeneration is the virtual absence of s viable seed stock in peat, especially after a fire has swept through an area. In parts of Sebangau NP, lowered water tables (e.g. due to channels constructed for illegal logging) may further exacerbate the problem, as desiccation may further affect propagule viability.

[3] http://www.iffm.or.id/How_are_forests.html

3 Summary of restoration/rehabilitation attempts

3.1 Regional

3.1.1 Peat swamp forest restoration & rehabilitation in Thailand

Although Thailand has little peat swamp forest (<65,000ha) compared to Malaysia and Indonesia, it has the most experience and longest history of peat swamp forest restoration and rehabilitation in the region. Some of these efforts date back to more than 40 years (see below), while those of the Royal Forest Department (RFD) date back more than a decade. In all, about 640 ha had been restored by 1999 (Nuyim, 2000).

Village-based efforts at reforestation have been undertaken in Thailand, for example, at Phru Kantulee[4]. Phru Kantulee was heavily degraded and largely drained for rice paddies, when 40 years ago efforts began to convince local villagers of the importance of restoring this area. Each village household was asked to manage 30-40 'rai' (1 rai measures about 40 by 40 metres), improve by means of planting and prevent outsiders from cutting trees. Almost 400 rai has been revised and reforestation efforts have turned rice paddies and fruit orchards into one of South Thailand's most pristine peat swamp forests. The area is important for supplying water to adjacent orchards, and has become an important area for both fish and wildlife. Reportedly, the project has been so successful that the swamp is now being considered for listing as a wetland of national and international importance.

According to Urapeepatanapong and Pitayakajornwute (1996), programmes initiated by the RFD in the 1990s that are relevant to PSF restoration and rehabilitation include:

- Silvicultural traits of peat swamp forest trees project; this was initiated to identify which species have the greatest potential for regeneration and plantations.
- Species selection experimental project; focused on 15 tree species (*Acacia mangium, Baccaurea bracteata, Dialium patens, Eugenia kunstleri, Eugenia oblata, Fagraea fragrans, Ganua motleyana, Litsea johorensis, Melaleuca* spp., *Polyalthia glauca, Stemonurus secundiflora*), to determine appropriate methods for reforestation.
- Soils improvement for tree planting, examining fertility constraints for five species (*Baccaurea bracteata, Eugenia kunstleri, Eugenia oblata, Macaranga* spp., *Polyalthia glauca*) under different fertiliser conditions.
- Growth rate studies under different plant spacings (1x1, 2x2, 3x3, 4x4 metres) for five species (*Baccaurea bracteata, Blumeodendron kurzii, Eugenia kunstleri, Syzygium oblatum (Eugenia oblata*), *Macaranga* sp.).
- Nursery techniques study, for raising seedlings on forest floor, tested on 4 palm species: *Areca triandra, Cyrtostachys lakka, Eleiodoxa (Salacca) conferta & Licuala spinosa.*
- Relationship between weeds and growth rates study, to study effects of different weeding regimes (every 1,2,4 or 6 months) on growth of *Macaranga* sp. planted in 20x20 m plots.

[4] www.BangkokPost.com, 5 February 2003

In order to develop reforestation techniques for degraded peat swamp and sand dunes in Narathiwat, Southeast Thailand, physiological characteristics of *Melaleuca cajuputi* Powell were studied (Satohoko *et al.,* undated). *Melaleuca cajuputi* is a main pioneer species in peat swamp and sand dune habitats in the Narathiwat region. *M. cajuputi* germinated, survived and grew well under flooding conditions, and its seeds did not lose their germination capacity even after heating to 100°C for one hour. These characteristics are advantageous for *M. Cajuputi* to grow and develop in peat swamps.

According to Nuyim (2003), dominant tree species in primary peat swamp forest are *Syzygium pyrifolium, Ganua motleyana, Campnosperma coriaceum, Macaranga pruinosa, Calophyllum teysmannii, Neesia malayana, Endiandra macrophylla, Syzygium obatum, Sterculia bicolor, Stemonurus secundiflorus, Syzygium muelleri* and *Baccaurea bracteata*. Dominant tree species in secondary peat swamp forest are *Melaleuca cajuputi* and *Macaranga pruinosa.*

Peat swamp forest degradation has mainly occurred due to drainage, followed by subsequent fires. Following fires, three scenarios may follow: i) *Melaleuca cajuputi* regrowth area; ii) *Macaranga* spp. regrowth area, and iii). no tree regrowth. Fruits of *Melaleuca* are opened by the high temperatures that occur during fires, and the seeds are dispersed to the ground, so it is not surprising that this species is a dominant pioneer following fires. The areas dominated by *Macaranga* are a bit puzzling, as *Macaranga* species are rarely found in these areas before fire damage, and Nuyim recommends that *Macaranga*'s seed dispersal system needs to be studied.

Nuyim (2003) found that native palm species (esp. sago, *Metroxylon sagu*) have very strong tolerance to fire and easily recover their growth; he considers that they may be useful as a barrier for fire protection. Areas that a repeatedly burnt, however, are soon dominated by *Melaleuca cajuputi*. Because of this, natural regeneration of deforested (mainly fire damaged) peat swamp areas therefore seems to lead to *Melaleuca* forests, and therefore assisted reforestation is required for recovery of original peat swamp forest.

Reforestation techniques have been developed for peat swamp areas by the Royal Forest Department during the past 10 years, which has replanted a total area of 640 hectares. Experience during these ten years of reforestation has shown that the following species are most suited: *Ganua motleyana, Melaleuca cajuputi, Syzygium oblatum, Syzygium pyrifolium, Sterculia bicolor, Sandoricum beccarianum, Alstonia spathulata, Calophyllum teysmannii, Ixora grandifolia* and *Alstonia spathulata*.

Nuyim (2000) reports that under natural conditions, peat swamp forest trees appear to grow best on naturally occurring mounds. In restoration programmes, the effect of artificial mound construction was tested on five species, and it was found that trees grew better on mounds than the same species planted in untreated areas. Tree height of *Syzygium* species, for example, was found to be almost double on mounds compared to unmounded areas (Nuyim, 2000; 2003). However, as mound construction is expensive, Nuyim recommends further studies before recommending this for larger areas. Application of organic or chemical fertiliser and liming did not have any significant effects on growth. Regular (monthly) weeding, however, significantly improved stem diameter, stem biomass and branch biomass (at rates of 2-6x), but survival percentage, tree height, and width of crown were not affected.

3.1.2 Peat swamp forest restoration & rehabilitation in Malaysia

PSF restoration activities in Malaysia are still at an early stage, and to date are limited to trials and small-scale activities undertaken by the Forestry Department and FRIM (pers. comm., Ismail Parlan, FRIM, 2003[5]). The project on *Sustainable Management of Peat Swamp Forest in Peninsular Malaysia* (SMPSF) was initiated in September 1996 and had a duration of 3 years.[6] This was a bilateral project between the governments of Malaysia and Denmark, and was implemented by the Forestry Department of Peninsular Malaysia and DANCED (Danish Cooperation for Environment and Development). The project's main objective was to ensure that sustained social, economic and environmental benefits are derived from the management of the peat swamp forests. Baseline studies were carried out in and around the heavily logged over peat swamp forest areas in North Selangor (70,000 ha) and still untouched peat swamp forests in Pahang (80,000ha). The studies have focused on silviculture and forest management, growth and yield, ecology, hydrology and socio-economics. Field activities have included establishment and monitoring of peat swamp plots, conducting of reduced impact logging trials (RIL), rehabilitation trials in disturbed areas, thinning intensity trials, flora and fauna inventories and collection and monitoring of hydrology data, socio-economic survey and GIS - mapping including forest zoning and infrastructure. Guidelines for integrated, sustainable management of peat swamp forests have been produced, to form the basis for the production of 10 years management plans for the two different peat swamp forests areas.

As part of the SMPSF project, the Forest Research Institute Malaysia (FRIM) has been involved in the production of PSF planting materials, and the rehabilitation of degraded PSF. Planting trials were carried out in previously burnt grassland areas, secondary forests, logging trails, and fern vegetation, in order to provide guidelines to forest managers on PSF restoration. FRIM also has plans for larger scale trials in secondary *Macaranga* forest.

The trials on replanting of *Imperata cylindrica* (alang-alang) grassland areas were carried out on an area of 1.55 ha in the Raja Musa Forest Reserve in Kuala Selangor, Peninsular Malaysia (Ismail *et al.,* 2001). Six indigenous PSF species were used: *Anisoptera marginata* (Mersawa paya), *Calophyllum ferrugenium* (Bintangor gambut), *Durio carinatus* (Durian paya), *Ganua (Madhuca) motleyana* (Nyatoh ketiau), *Gonystylus bancanus* (Ramin melawis) and *Shorea platycarpa* (Meranti paya). Four planting techniques were tried: open planting, open planting with mulching, open planting with topsoil and open planting with nursery trees. These techniques were tried for all six species under three different relative light intensities (RLI): 100%, 70% and 30%. Results show that the most cost effective approach is open planting, using *A. marginata, M. motleyana, G. bancanus* and *S. platycarpa,* which have survival rates of 73-92% under these conditions. Other planting techniques do not result in significantly higher survival rates; also, *C. ferrugineum* and *D. carinatus* have a low survival rate and require low to moderate RLIs.

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[5] FRIM, Malaysia.

[6] http://www.usm.my/bio/peat swamp/abstracts/Palle_Havmoller.html

3.1.3 Peat swamp forest restoration and rehabilitation in Vietnam

Melaleuca-dominated peat swamp forests in the Mekong Delta were largely destroyed during the Vietnam-American war by chemical defoliants, napalm and bombing, and more recently by clearing for agriculture, and draining by canals and for road construction (Maltby *et al.,* 1996). In 1991, the IUCN Wetlands Programme was asked by the Vietnamese authorities to provide technical assistance to rehabilitate *Melaleuca* dominated swamps in An Giang province. Since 1975, considerable efforts were made in re-establishing 50,000ha of *Melaleuca*, but by the mid-1990s only 3,000ha remained, due to a combination of:

- poor management (broadcast seeding; no thinning; build-up of litter leading to fire hazard; canals used as fire breaks provide unwanted access; poor seed stock used),
- social problems (few economic alternatives to exploiting newly established *Melaleuca* stands; intentional fires; preference for agriculture to *Melaleuca*),
- land use conflicts (short-term benefits from even poor rice harvests appear better than long-term benefits from *Melaleuca*; central government support for agriculture and irrigation/drainage; little coordination between government departments), and
- lack of financial resources (insufficient funds for successful rehabilitation and management of *Melaleuca* stands).

The IUCN programme aimed at tackling these issues, for example, by better land use planning, improving inter-agency coordination, improved seed selection, thinning regimes, reduction of fire hazard, improvement of water management, and provision of financial assistance.

U Minh Thuong NP

Building upon efforts initiated by IUCN and the Royal Holloway College, *Melaleuca* peat swamp restoration activities at U Minh Thuong National Park have been carried out with assistance from BirdLife International since 1997 (BirdLife International, 2002). The main problem has been devastation by fires, which was the focus of a workshop held in Ho Chi Minh City in June 2002. Key conclusions reached at this workshop were that:

- no new canals should be constructed in the area, and a new hydrological management regime is needed, in order to keep the peat wet all year round;
- *Melaleuca* forest should be allowed to regenerate by itself. Re-seeding is not necessary, as Melaleuca cajuputi is a robust species, tolerant of fire, drought and poor soils. It rapidly re-grows and colonises areas after fire.
- Fire is part of *Melaleuca* ecology. Hydrological restoration is essential for the proper control, management and use of fire.

3.1.4 PSF restoration & rehabilitation in other Indonesian provinces

Riau, Sumatra

Bogor Agricultural University (Institut Pertanian Bogor/IPB) carried out a restoration programme (Implementation of Native Forest Restoration pilot project) for PT Caltex Pacific Indonesia in 2002, in the Duri and Minas Oil Field Operation areas in Riau province. The programme has five objectives, namely to:

- ensure that the nursery is developed correctly in terms of lay-out, capacity, supporting facilities and equipment; and supporting seedling growth;

- provide technology transfer to CPI's re-vegetation field personnel re-vegetation including native species selection and their planting stock propagation techniques;
- develop a re-vegetation plan and strategy that considers the varied conditions of proposed restoration areas (including degraded peat areas, heavily disturbed secondary forest, moderately disturbed secondary forest);
- provide technical assistance for implementation of the re-vegetation activities for restoration program.
- develop Standard Operating Procedures for key nursery operation, re-vegetation activities and monitoring.

Activities involved a preliminary study on selecting native pioneer species as catalytic species to speed up recolonization of heavily degraded and moderately degraded land (including peat swamp) after oil extraction operations (pers. comm., Yadi Setiadi, 2003[7]). Among the species tested, *Macaranga hypoleuca* (potted seedling) and *Hibiscus* sp. (stem cuttings) seem to be best adapted to poor, degraded peat sites. IPB are still monitoring their survival, growth performance, root development, recolonization of native species, crown recovery and litter production. In addition to this, IPB are also evaluating the mycorrhizal status of pioneer species grown in peat swamps, as this may help early seedling establishment in peatlands. They are also expanding their programme by selecting native pioneer species and developed propagation techniques, as this seems very important in support of the peat rehabilitation programme.

Prior to the activities with IPB (2001-2003), PT Caltex Pacific Indonesia developed activities in the same locations with the private firm PT. Hatfindo Prima. These aimed at establishing and operating the nursery, and developing a plan and strategy for forest restoration by considering variations in local conditions in the degraded areas.

Jambi, Sumatra

PT. Dyera Hutan Lestari (PT. DHL) has a concession area of 8,000 hectares near Sungai Aur, of which 7,200 hectares can effectively be used. The aim of the company is to establish a viable *jelutung Dyera polyphylla (D. lowii)* plantation in a secondary, degraded peat swamp. In the first year of operation, 1991-1992, 60 hectares were planted, followed by 260 hectares in 1992-1993, and 593 hectares in 1993-1994. By 2004, 2121 ha had been planted (Wibisono, 2008). Initially, enrichment line planting in secondary scrub was carried out using *Dyera polyphylla, Gonystylus bancanus* and *Endospermum diadenum* (Muub, 1996), but although relatively successful this was soon switched to clearing followed by line planting. Survival rates have been high – on the whole more than 90%, and growth has been rapid: an average girth increment of more than 2 centimetres per year has been recorded. By 2004, PT DHL had also begun tapping latex, and trials tappings under different regimes have been carried out.

In spite of this apparent success, there have been many pitfalls. Firstly, investments in infrastructure have been high because of the difficulty of access in the peat swamp forest. Secondly, obtaining a sufficient supply of *jelutung* seeds has proven to be difficult, as *Dyera polyphylla* flowers and sets seed only every 4-5 years (i.e. in Jambi; in Central Kalimantan this appears to occur annually, pers. comm.. L. Graham), and during operations seed has been set

[7] Head of Forest Biotechnology Laboratory and Environment, Biotechnology Research Center. Bogor Agriculture University, Campus IPB, PO Box 01. Darmaga Bogor.

only in 1993 and 1997. (In 2004, PT. DHL had a large and professional, 2-hectare nursery at its main field station along the Batanghari River.) Thirdly, security is a problem, and company staff have been threatened and attacked on various occasions, for example, by local illegal loggers caught felling 'mother trees' in the PT DHL concession area. Lastly, there is the issue of wildfires. In 1997, 7000 hectares burnt including 1769 hectares of *jelutung* plantation, due to a fire that began in the adjacent HPH PT. Kamiaka Surya. In June 2003 a second fire raged through PT DHL's concession, burning 5,000 hectares including 1775 hectares of *jelutung* and *pulai* plantation; this fire began at an illegal sawmill located along the Batanghari 1 kilometre upstream of the concession area. Interestingly, not all *jelutung* trees were killed by the 1997 fire, and it was observed that >10% survived. By 2008, the plantation had closed down and PT Dyera had stopped all operations following the halt of assistance from GOI's reforestation fund (Dana Reboisasi; Wibisono, 2008). Interestingly, local communities in nearby transmigration sites Rawa Sari and Simpang Lama were found to be planting *Dyera polyphylla,* following the PT DHL example[8], supporting the premise that local ownership is important if replanted areas are to have value and be protected.

The logging company PT. Putra Duta Indah Wood has its concession east of Berbak NP in Jambi. Efforts at reforestation since 2001 (Lubis, 2002) have focused on planting *meranti rawa Shorea pauciflora, durian burung Durio carinatus, ramin* and *jelutung.* The company has two nurseries where a wide range of indigenous peat swamp forest species are being tended, such as *ramin Gonystylus bancanus, rengas Gluta* (formerly *Melanorrhoea*) *wallichii*, *jelutung Dyera polyphylla, meranti rawa Shorea pauciflora, nyatoh Palaquium* sp., *durian Durio carinatus, tanah-tanah Combreocarpus rotundatus* and *punak Tetramerista glabra.* Most of these seedlings were wildlings gathered as seedlings in the forest. However, the company has put a major emphasis on planting exotic *Acacia crassicarpa* rather than replanting PSF species.

Berbak NP staff replanted small trial plots (plot percobaan) of 1 ha along the Air Hitam Laut River in 2001-2002 (Giesen, 2004). Trees were planted on the burnt peat, and not on mounds. Two species were planted: *jelutung Dyera polyphylla* and *pulai Alstonia pneumatophora*. Seedlings were obtained locally, and from Pemerinta Daerah (Local Government), while locals assisted with the planting. In addition, trial planting (1 ha & 5 ha) was carried out in 2002 by the Forestry Department at the burnt area along the Simpang Melaka river in Berbak NP. At both sites a combination of *pulai, jelutung* and *medang* were planted at a density of one seedling per 10 m². Seedlings were planted directly in the soil, straight into the soil[9], without mound construction. Seedlings were small (in the case of *jelutung* and *medang*), and about 1m tall in the case of *pulai*. Seedlings were not of a high quality as most were from cuttings rather than seeds. The seedlings were taken from the polybag before planting, which occurred in August (1 ha site) and December (5 ha site) 2002. A quick survey of both areas (Giesen 2004) revealed that seedling mortality is close to or at 100%, probably due to long, deep flooding (about 1.2-1.3 m, as observed on marks left on trees).

Under the Climate Change and Fire Prevention in Indonesia project, burnt areas along the Air Hitam Laut River in the central part of Berbak NP were prepared for replanting in August-November 2003. About 20,000 artificial mounds were constructed, each about 0.3-0.5m tall, and extending over 20 ha in all. Mounds were planted in November-December 2003 with

[8] This supports the premise that local ownership is important if replanted areas are to have value and be protected.

[9] Largely mineral, with patches of shallow peat, at the 5 ha site; shallow peat at the first 1 ha site.

14,000+ seedlings of indigenous species of local provenance: *Gonystylus bancanus* (39.5%), *Shorea pauciflora* (10.9%), *Tetramerista glabra* (0.5%), *Gluta (Melanorrhoea) wallichii* (20.3%), *Palaquium* sp. (23.5%), *Combretocarpus rotundatus* (3.2%), *Eugenia* sp. (0.2%), *Dyera polyphylla* (1.6%) and *Alstonia pneumatophora* (0.3%). By February 2004, there was a 65-85% survival rate at all sites and for most species, in spite of 50 cm flooding. In March 2004, however, unusually high (1 in 40-year) floods hit the area and all sites were flooded with 100-150 cm. A subsequent assessment in April 2004 showed <5% survival for the seedlings; best survivors were *Eugenia* (27%) and *Shorea pauciflora* (13%).

3.2 Central Kalimantan

3.2.1 LIPI-JSPS (2000-2001)

The project on *Rehabilitation of peatlands and establishment of sustainable agro-system in Central Kalimantan*, carried out under the LIPI – JSPS Core University Program on "Environmental Conservation and Land Use Management of Wetland Ecosystems in Southeast Asia", focused on the rehabilitation of intensively disturbed peat swamp forest areas in Central Kalimantan (Takahashi *et al.,* 2001). Activities include trial planting of 0.75ha of disturbed PSF under different regimes (with and without clearing, fertilizer application, and mounds) and with different species (*Shorea balangeran, S. pinanga, S. seminis, Peronema canescens, Palaquium* sp.), and observations on natural regeneration in a fixed sample plot of 50m² affected by wildfire, compared with a non-affected reference plot of 100m². Trials indicate that *Shorea balangeran* and *Palaquium* are best suited for replanting, as they have considerably higher survival rates (65-100%) compared to the other species (6-65%), and this seems irrespective of preparation techniques. Also, both species appear to be suited to heavily disturbed areas affected by repeated fires, and do not require innoculation by mycorrhizal fungi.

3.2.2 CIMTROP

At the CIMTROP study area in the northern part of Block C, regreening trials have been carried out with *belangiran* (*Shorea balangeran*) and *jelutung* (*Dyera polyphylla*) in degraded swamp, along with several other species (including *gaharu, Aquilaria* sp. and cashew) on the higher dikes along the excavated canals. Local communities have in addition been provided with *jarak* (*Jatropha*) and rubber (*Hevea*). *Belangiran* trial plantings carried out in 2006 had a 80-90% survival rate, while those with *jelutung* had a 40-50% survival rate. Species tried and monitored by CIMTROP in 2006 are summarised below in Table 1, while Table 2 gives a full list of species tried in the CIMTROP area. In addition to these, *gemor Alseodaphne coriacea, pulai*[10] *Alstonia spathulata, bintangur Calophyllum* sp., *kapur naga Dryobalanops* sp., *manggis hutan Garcinia* sp., *Melaleuca cajuputi* and *Syzygium* were also tried by CIMTROP under the RESTORPEAT programme (Limin, 2007), but monitoring results are not available yet. Natural regeneration in the fern-dominated heavily degraded parts of the CIMTROP study area consisted mainly of *tumih* (*Combretocarpus rotundatus*) and *gerongang* (*Cratoxylum glaucum*), with some *asam-asam* (*Ploiarium alternifolium*).

[10] There is some confusion regarding local names and Indonesia names of *Alstonia pneumatophora* and *Dyera polyphylla.* The Indonesian name for *Alstonia pneumatophora* is pulai, while that for *Dyera polyphylla* is jelutung. In Central Kalimantan, the local name for *Alstonia pneumatophora* is jelutung, while that for *Dyera polyphylla* is pantung.

Table 1 Results of CIMTROP restoration trials

No	Species	Family	Local name	Number planted	Survival rate (%)
1	*Dyera polyphylla*	Apocynaceae	Jelutung, Pantung	100	21
2	*Diospyros evena*	Ebenaceae	Uring pahe	100	92
3	*Gonystylus bancanus*	Thymelidaceae	Ramin	100	78
4	*Palaquium* sp.	Sapotaceae	Hangkang	100	56
5	*Shorea balangeran*	Dipterocarpaceae	Kahui	1073	89
6	*Shorea* sp.	Dipterocarpaceae	Meranti	1290	37

Adapted from Limin (2007)

Table 2 Tree species used in reforestation trials by CIMTROP

No.	Family	Species	Canal Banks	Peatland	Local name & uses
	Apocynaceae	*Alstonia pneumatophora*		+	Pulai; light construction ?
		Dyera polyphylla	+	+	Jelutung (rawa); latex
	Chrysobalanaceae	*Parastemon spicatum*	+	+	Bintangur; timber
	Clusiaceae	*Garcinia sp.*	+	+	Manggis hutan
	Dipterocarpaceae	*Dryobalanops spp.*	+	+	Kapur naga; timber
		Shorea belangeran	+	+	Kahui; timber
		Shorea spp.	+	-	Meranti; timber
	Ebenaceae	*Diospyros evena*	+	+	Uring pahe; timber
	Euphorbiaceae	*Hevea brasiliensis*	+	-	Rubber unggul; latex, timber
	Lauraceae	*Alseodaphne coriacea*	?	+	Gemor
	Myrtaceae	*Melaleuca cajuputi note: does not do well on peat*	+	-	Galam
		Syzygium sp.	+	+	Jambu-jambuan
	Sapotaceae	*Palaquium sp. many species*	+	+	Hangkang (nyatoh ?); timber
	Tetrameristaceae	*Tetramerista glabra*	-	+	Punak; beams & light construction
	Thymelaeaceae	*Aquilaria malaccensis (?)*	+	-	Gaharu; resin
		Gonystylus bancanus	-	+	Ramin; timber

+ = suited for planting / - = not suited for planting

3.2.3 CKPP – Wetlands International

Under CKPP, Wetlands International-Indonesia Programme (WIIP) have planted 250 ha with 100,000 seedlings of *belangiran* (*Shorea balangeran*), *jelutung* (*Dyera polyphylla*), *kepot bajuku* (syn. *pasir-pasir*; *Stemonurus secundiflora*), and *pulai Alstonia pneumatophora*. It was conducted in three phases; 50 ha in the first phase, 150 ha in the second phase and 50 ha in the third phase – location of the three sites in northern Block A is indicated in Figure 1 . In this rehabilitation program, WIIP involved groups each consisting of 20 villagers. Training was conducted by WIIP prior to field implementation in order to improve local capacity. Planting was carried out as strip planting with a line spacing of 5 m x 5 m.

The first planting occurred from 13-26 June 2007 in the peat dome area in Block E North where 20,000 seedlings were planted on 50 ha. The site consisted of heavily degraded peat swamp, dominated by a host of ferns: *Blechnum indicum, Gleichenia linearis, Lygodium* and *Stenochlaena palustris.* A broad swathe about 2 metres wide was cleared and the 40-50 cm tall seedlings planted. There was no further tending of the plants. A monitoring survey carried out early in October 2007 showed an average survival rate of 62%. The report does not indicate how many of each species was planted, nor what the survival rate was per species. The second phase of planting was conducted in January 2008, whereby 60,000 seedlings were planted on 150 ha, while the third planting phase was conducted from 7-10 June 2008, with 20,000 seedlings planted on 50 ha.

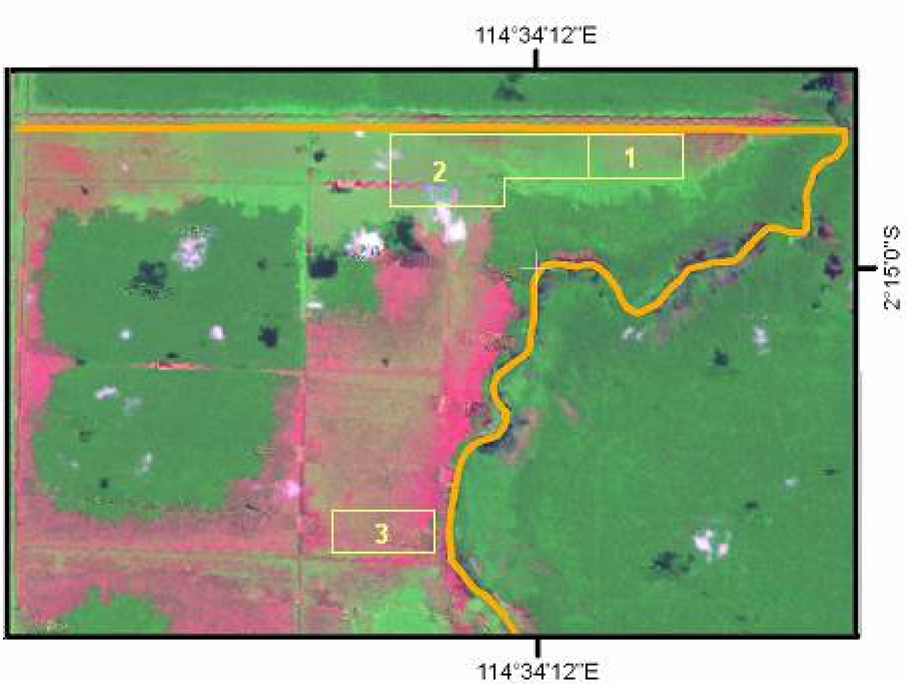


Figure 1 Rehabilitation sites of WIIP-CKPP in Block A North

A second study of the same three species (belangiran, jelutung & kepot bajuku/pasir-pasir) – whereby 350 seedlings of each species were planted in five plots each in the same area in May 2007 – was monitored on a monthly basis Wibisono & Gandrung, 2008). The results – depicted in Figure 2 – shows that belangiran has the best survival rate, with almost 84% surviving after 8 months, while for jelutung this is considerably less favourable (55%). Pasir-pasir did not perform well at all, with less than 1% surviving after 8 months.

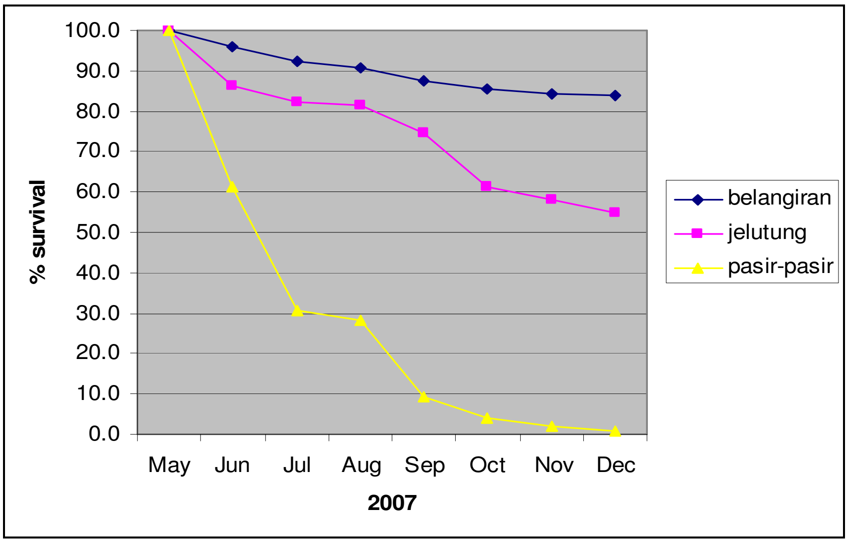


Figure 2 Seedling survival trials Wetlands International

- Belangiran = *Shorea balangeran;* jelutung = *Dyera polyphylla;* pasir-pasir = *Stemonurus secundiflorus* (Data adapted from Wibisono & Gandrung, 2008)

3.2.4 CKPP – WWF

As part of CKPP, WWF Central Kalimantan – which began its programme in the province in 2001 – has established a nursery with a capacity of 100,000 seedlings. This will be expanded to 160,000 this year, and species raised are mainly jelutung *Dyera polyphylla,* belangiran *Shorea balangeran,* hangkang *Diospyros siamang,* tutup kabali *Diospyros pseudomalabarica* and pasir-pasir *Stemonurus secundiflorus.* This year (2008) 20-25,000 were planted along the degraded areas near the SS-1 canal, in the eastern part of the Sebangau dome. The seedlings of most species are doing well, except those of *Stemonurus,* which is susceptible to insect predation.

3.2.5 CKPP – BOS Mawas

The BOS-Mawas project area covers roughly 240,000 ha in Block E. In 12 villages reforestation groups have been formed which are active in setting up nurseries and planting of trees. In total 34 units of village nurseries have been set up, with a total seedling production of around 500,000.

BOS have planted 1900 ha to date, in eastern Block E and Block A. In areas near villages this has been with species that are useful for locals, such as belangiran (*Shorea balangeran*) and pantung (*Dyera polyphylla*), while further into the PSF they have planted species used by orangutan such as tutup kebali (*Diospyros*), pakan (?), rambutan hutan (*Nephelium* sp.) and manggis hutan (*Garcinia* sp.). Species were all locally sourced, and preparation consisted of clearing along a line, no other tending occurred. Planting was carried out by village groups (kelompok masyarakat). They have monitored these every 3 months, and after 6-12 months these species all reportedly have a 70-90% survival rate.

Some of the planted trees are doing well, with reported growth rates (jelutung) of up 2.5-3.0 (even > 4m) tall after 2 years. In other places however growth rates are lower (< 2 m after 2 years) with heavy competition from ferns (both belangiran and jelutung). The different growth rates may be caused by variation in drainage levels (e.g. by nearby canals), and lack of weeding (Giesen 2008).

3.2.6 Forest Research Institute of Banjarbaru (BPK)

The Forest Research Institute (Balai Penelitian Kehutanan Banjarbaru) has carried out several rehabilitation studies on peat swamp forest since 1993. Before 1999, the study area was part of a logging concession (HPH), then after 1999, BPK Banjarbaru established a Peat Swamp Research Forest (Hutan Penelitian Rawa Gambut) at Tumbang Nusa, Central Kalimantan, and began implementing a research programme at this site. In 2005, this area was legally established as a Special Purpose Forest Unit (Kawasan Hutan Dengan Tujuan Khusus, KHDTK), by a decree from the Minister of Forestry[11]. Studies at the site have focused on biophysical conditions of peat swamp forest, silvicultural studies, exploratory and applied studies on mycorrhizae, and agroforestry studies. Some of the results of these studies are summarised below.

Studies of biophysical conditions in peat swamp forest

Soils in the PSF of the Tumbang Nusa study site indicate a very low bulk density in the range of 0.05-0.14, and a low pH in the range of 3-4, a low ash content of 0.8-3.5% and a low fibre content. These physical conditions pose a significant challenge when planting in such areas. Studies of the PSF vegetation at Tumbang Nusa indicate that this consists of secondary forest.
Surveys of the vegetation were conducted on secondary PSF and the important value index (IVI) and diversity value (DV) of each plant species determined. In all, 66 species were recorded. Species with the highest density and evenly spread for all stages of growth are: jambu-jambu (*Syzygium* sp.), malam-malam (*Diospyros malam*), nangka-nangka (*Neoscortechinia kingii*), perupuk (*Melicope* sp.), and meranti (*Shorea teysmanniana*). Commercial species such as ramin (*Gonystylus bancanus*), kapur naga (*Callophyllum macrocarpum*), geronggang (*Cratoxylum arborescens*) and punak (*Tetramerista glabra*) had a low importance value index. The total basal area per hectare for tree with a dbh >10 cm was 15,03 m^2, considerably lower than the average basal area for tropical lowland rainforest in Indonesia (36 m^2/ha) (Rachmanadi *et.al.*, 2008).

Studies of individual species, silviculture & application of mycorrhizae

Result of species elimination trials show that belangeran (*Shorea balangeran*) is one of promising tree species for rehabilitation of degraded PSF.. A full list of species tried in the BPK Banjarbaru area are presented in Table 3. However, the survival rate of the species still shows a great variation among replication plots. Micro-environment heterogenity created by fire, is hypothesized to have an important role on the survival within the *Shorea balangeran* plantation.

The depth to groundwater tables, degree of anaerobic rooting-zone and low raw fibre content (fibric) in the rooting zone showed a high negative correlation with the survival and growth of *Shorea balangeran*, and at certain levels these had a detrimental effect. Endomycorrhizal spores were found to be in all soil samples examined, and all were found to belong to the genus

[11] Surat Keputusan Menteri Kehutanan No. 76/Menhut-II/2005 tanggal 31 Maret 2005.

Glomus. There were two types of ectomycorrhizal infection: a) well developed ectomycorrhizae with thick mantle and b) non developed ectomycorrhizae that showed thin and sparse hyphae. Due to lack of fruiting bodies in the study area, the identification of ectomycorrhizae has not been conducted yet. Mycorrhizae utilization as biofertilizer is needed for seedlings planted in an over burnt peat swamp forest (Lazuardi *et.al.*, 2003).

Table 3 Results of BPK Banjarbaru rehabilitation trials

#	Species	Family	Local name	Number planted	Survival rate (%)	Remarks
1	*Shorea balangeran(7 yr old)*	Dipterocarpaceae	Belangiran	120	80	Planting technique
2	*Shorea balangeran(4 yr old)*	Dipterocarpaceae	Belangiran	190	80	Species trial
3	*Shorea balangeran*	Dipterocarpaceae	Belangiran	256	90	Planting time trial
4	*Tetramerista glabra*	Theaceae	Punak	240	85	
5	*Gonystylus bancanus*	Thymelidaceae	Ramin	240	60	
6	*Shorea* spp.	Dipterocarpaceae	Meranti	240	35	
7	*Dyera polyphylla**	Apocynaceae	Jelutung, Pantung	50	90	
8	*Litsea* spp	Lauraceae	Medang telur	50	76	
9	*Palaquium* sp.	Sapotaceae	Nyatu	50	24	
10	*Calophyllum pulcherimum*	Guttiferae	Bintangur	90	70	
11	*Dacrydium beccarii*	Podocarpaceae	Alau	90	84	
12	*Cotylelobium* spp.	Dipterocarpaceae	Rasak	90	59	
13	*Calophyllum* spp.	Guttiferae	Kapur naga	90	70	

Adapted from Rachmanadi (2008)
* *Jelutung* are often used for agroforestry studies

Agroforestry research

BPK Banjarbaru has established agroforestry plots at 5 locations: Kalampangan (Palangkaraya District), Tumbang Nusa, Purwodadi, Jabiren (all 3 Pulang Pisau District) and Batunindan (Kuala Kapuas District). Mixed cropping has been trialed using jelutung (*Dyera polyphylla*), other tree species such as rambutan (*Nephelium lappaceum*) and several agricultural crop such as maize, rice, peatnut and chinese cabbage (see Figure 3).

Figure 3 ***Dyera polyphylla*** **mixed with maize (left), and rambutan (right)**
Kalampangan and Tumbang Nusa, respectively.

3.2.7 Other Government departments

Forestry & Agriculture departments

The Forestry and Agriculture departments are also carrying out replanting programmes that target degraded peat swamp forest areas; this is linked with the Gerhan (Land Rehabilitation Movement) programme. The focus is mainly on commercial species such as *Jatropha*, rubber and *Jelutung*, which are planted under supervision of Agricultural Extension workers (Balai Penyuluhan Pertanian/BPP) together with local farmers. Little or no follow-up in the form of monitoring is occurring, and seedling survival rates are often low.

BP-DAS Kahayan

The Forestry and Plantation Departments have also implemented rehabilitation programmes for degraded peat swamp forest areas. The Gerhan (Land Rehabilitation Movement) programme focuses on planting, maintenance, protection, and harvesting. Rehabilitation activities funded through DAK-DR and GN-RHL/Gerhan in Indonesia are divided into several stages including site selection and consolidation, technical design, spatial layout, seedling production, design of infrastructure, selection of tools and methodologies, planting design, plant maintenance during establishment and in years 1 & 2 after planting.

However, Wana Khatulistiwa Jaya and BP-DAS Kahayan (2007) report that the impact and benefits of GN-RHL/Gerhan have been limited so far. From the technical aspect the implementation in last three years of the GN-RHL/Gerhan has improved capacity building of involved stakeholders and shareholders, mainly for planning and organization. However, implementation, monitoring and evaluation have not yet benefitted from the Gerhan program. From the economic aspect the impact of Gerhan has been low: the average household income has hardly increased, and also the diversification and improvement on economic infestation to support GN-RHL/Gerhan has remained low. The environmental impact of Gerhan has also been limited so far, partly because the planted trees are still young, but also because many have died. Finally, from the social aspect that GN-RHL/Gerhan gave benefit of community participations, such as the selection of locations and species, setting up nurseries, and training especially at community forest.

In 2007 the Gerhan program in Central Kalimantan covered 78,000 ha with funding of Rp 188 billion (about USD 20 million). However also in Central Kalimantan the impact of the Gerhan rehabilitation program has been limited so far is. Field observations in the EMRP area show that implementation and success rate of Gerhan activities can be locally problematic (e.g. Giesen 2008). During early 2008 several Gerhan sites were visited (e.g. Haparing Hurung, Henda) which had been planted in 2006 and 2007 with Jatropha (250 ha), rubber (125 ha) and jelutung (125 ha). Also, in block E Pulang Pisau District, Kapuas District and Barito Selatan District sites were inspected. It was observed that seedlings were absent for much of the area were they had been planted and it is concluded that survival rates are generally very low in these programs. Lack of weeding was generally thought to be the main cause of the low survival rates. Also observed growth of the surviving jelutung seedlings was minimal.

The Forestry Department's BP-DAS Kahayan is currently formulating a five-year plan for the rehabilitation of forest and land in the EMRP area (2008-2012). Out of a total of 1,454,541 ha in the EMRP area the Forestry Department recommends that 874,453 ha (60%) will be designated as conservation area, while the balance (40%) will be utilised for both forestry and non-forestry purposes (Dep. Kehutanan, 2007). One of the new possibilities for reforestation is HTHR (Hutan Tanaman Hasil Rehabilitasi) - RLPS is now completing the guideline for its implementation.

Three different priority classes for restoration are identified on the basis of land cover, management regime, erosion class, slope class, peat thickness, depth of pyrite layers, flooding and productivity (priority class 1: 588 ha, class 2: 61,939 ha and class 3: 119,607 ha). BP-DAS have identified 39 species to include in this program, but quite a number of these are considered by Giesen (2008) to be inappropriate.

4 Guiding principles for restoration & rehabilitation

From discussions during the workshop it became apparent that along with technical guidelines, a series of Guiding Principles were required that would facilitate the making of choices. Seven main guiding principles were recognised, and these are provided below. Note that the terms used below relate to those developed under the Master Plan EMRP:

- Protection Zone – *Kawasan Lindung*
- Limited Development Zone – *Kawasan Budidaya Terbatas*
- Development Zone – *Kawasan Budidaya*

1. Socio-economics

Local communities will be the key stakeholder involved in replanting, restoration and rehabilitation programmes. Where possible, useful species are to be incorporated in the programmes. These useful species are to be:

- those producing Non-Timber Forest Products (NTFPs) in *Kawasan Lindung* areas where conservation is the main option and where this does not affect biodiversity, and
- species producing timber, species producing NTFPs, and multi-purpose trees (timber plus NTFPs) in limited development and development areas (*Kawasan Budidaya Terbatas* and *Kawasan Budidaya*).

Local communities should be given legal access and user rights to the NTFPs (e.g. between BKSDA or Taman Nasional/National Park and local communities), and there should be a binding benefit sharing agreement (e.g. between Forestry Department and local communities) for harvesting of timber species. Local communities and other stakeholders are to be involved in the planning and decision making stages if restoration or rehabilitation is to be successful.

2. Beneficial species

Much of the EMRP area that is proposed to be rehabilitated or restored will be in *Kawasan Lindung* conservation or deep peat protection areas where logging will not be allowed (or in case of deep peat may be very limited). This means that the focus of replanting should be on species that:

- provide NTFPs (such as *jelutung, gemor* and *tengkawang*) rather than timber species[12] (such as *belangiran, ramin* and *geronggang*) which is now the case; this should closely involve local communities who will be the main beneficiaries; or
- are important as food species for key wildlife such as orangutan, gibbon and hornbills.

[12] This is not a view shared by all stakeholders, although consistent with law protecting deep peat, which in most cases will be affected by logging operations, even if carried out without canal construction (for log extraction).

3. Drainage

There should not be any artificial drainage in the *Kawasan Lindung* (conservation and peat protection) areas as this will ultimately lead to loss of peat. In *Kawasan Budidaya Terbatas* areas on the edges of peat domes, drainage should be very strictly limited because the effects of drainage will spread to the dome. Therefore, only species that do not require any drainage should be used in rehabilitation programmes, and the emphasis should be on hydrological rehabilitation/restoration prior or at least parallel to replanting programmes. Hydrological rehabilitation may consist of dam construction or canal infilling to raise water levels (to near previous levels) in peat land. Reforestation will serve to raise soil humidities and reduce fire risks in desiccated peat land.

4. Biodiversity

Increase diversity in number of species used in PSF rehabilitation and restoration programmes as much as possible, as this will:

- Enhance overall biodiversity and increase/restore the biodiversity function of the PSF system.
- Reduce the pest threat, as pests are more inclined to attack monocultures.

Note: this means that smallholders are more likely to be involved in the programmes, as commercial plantations prefer large scale approaches that require monocultures. A higher diversity of species utilised will spread livelihood risks, as pests and diseases are less likely to take hold, and sources of income are spread more throughout the year.

5. Exotic tree species

In Protection Zones (*Kawasan Lindung*) only native species should be used in restoration and rehabilitation programmes in biodiversity conservation areas, and the use of exotics should be curbed; in deep peat protection areas the use of exotics should be limited as much as possible. In Limited Development Zones (*Kawasan Budidaya Terbatas/KBT*) the use of non-native species may be an option, provided that these do not require alteration of the hydrology as in most *KBT* areas it is desirable to reduce the impacts on hydrology to a minimum.

6. Costs

The overall budget required for restoration and rehabilitation of the EMRP area is likely to be enormous and run in the many billions of US dollars. Although available and promised financial resources appear large, they pale in significance compared to overall costs. Therefore, restoration and rehabilitation programmes must opt for the most cost-effective solutions – the end result must of course be successful restoration and/or rehabilitation, as this should not be compromised. REDD and carbon credits can play a role here by providing necessary funding; the cost of rehabilitation is low when compared with the GHG reductions[13]. even at 5$/tonne/ha CO2 saved

[13] This is even the case then carbon trading levels are low, such as the current 5$/tonne/ha CO_2.

7. Measuring success

Many past programmes have measured their impacts and rate of success on the number of planted seedlings or the hectares of degraded land that has been replanted. However, these are only input related criteria, and it is much more important to assess success on the real impact (medium- to long-term) of restoration and rehabilitation. Agencies should therefore not only be held accountable for use of funds for planting trees and working over xxx hectares, but be responsible for survival of tracts of replanted or rehabilitated PSF. <Except perhaps in case of fires or long-term drought> This means that monitoring and maintenance of replanted areas should be part and parcel of every restoration/rehabilitation programme and form the basis of measuring the rate of success.

5 Technical guidelines for PSF restoration & rehabilitation

Four stages can be recognised in restoration and rehabilitation programmes, namely:

1. Planning stage
2. Preparing stage
3. Implementation stage
4. Follow-up stage

These are described below in parts 5.1 – 5.4.

5.1 Planning stage

5.1.1 Identification of state of degradation & type of intervention required

Stages of degradation are to be identified for the EMRP area, as this will allow for a better assessment of the situation in the field, better matching of species selected for replanting and a selection of more appropriate interventions in general. What is available at present in terms of recognition of stages of degradation are only general descriptions or based on a few observations only (e.g. Biodiversity & the EMRP report). More and systematic fieldwork will be required to develop a degradation typology for the area. Fieldwork should involve recording species composition, vegetation structure (including seedlings, saplings, trees) and densities, but also other parameters such as peat depth and maturity, light intensity, nutrient availability, site hydrology and fire history. Seedling plots recorded for 2-3 years would provide information about natural regeneration in these areas

The characteristics of various stages of degradation types are listed in Table 4, which has been adapted from ITTO (2002), who define three broad classes of degraded forests:

1. **Degraded primary forests**, which retain many of the physical (soil, humidity) and structural characteristics of the former primary forest, as well as a generally heterogeneous species composition. Without silvicultural interventions, natural succession in degraded primary forests will eventually restore most of the characteristics of primary forests;

2. **Secondary forests** that comprise various stages in the process of succession. The dominant trees of the initial colonizing phase are short-lived, fast-growing pioneers; structure and species composition are changing in the course of one to two centuries. Depending on site quality restoration of the full range of species may require several centuries.

3. **Degraded forest lands** that are characterized by eroded or nutrient-deficient soils, hydrologic instability, reduced productivity and low biological diversity. Persistent physical, chemical and biological barriers prevents natural succession. Many factors like low propagule availability, seed & seedling predation, lack of suitable microhabitats for plant establishment, low soil nutrient availability, and fire prevent natural forest regeneration.

These three categories usually exist in complex mosaics that are constantly changing, which makes it sometimes difficult to distinguish between them. There are generally clear differences between the three different categories, relating for instance to the intensity and cause of the disturbance, and the vegetation development process. Most forests in the EMRP area would classify as degraded forest lands and secondary forest, with some degraded primary forest.

Table 4 Differences between 3 major categories of degraded & secondary forests

	Degraded primary forest	Secondary forest	Degraded forest land
Intensity of disturbance	▪ Slight to moderate intensity within the range of common natural disturbances	▪ Severe intensity, caused by the clearing of at least 90% of the original forest cover	▪ Drastic and repeated intensity with complete removal of the forest stand, loss of topsoil, and change in microclimate
Common causes of disturbance (human-induced or natural)	▪ Excessive wood exploitation ▪ Over-harvesting of non-wood forest products ▪ Destructive natural disturbances such as forest fires, storms ▪ Over-grazing	▪ Clear-cutting, burning and subsequent abandonment of an area ▪ Catastrophic large-scale natural disturbances: eg fire, flooding, storms, landslides	▪ Repeated over-use, repeated fire, grazing, or ecological mismanagement on fragile soils ▪ Soil erosion
Vegetation development process	▪ Relatively small changes in growth and regeneration dynamics, except where over-grazing prevents natural regeneration ▪ Relic trees are often damaged (crown, stem), or are potential 'losers' unable to achieve dynamic regrowth or are phenotypically inferior ▪ Recovery mainly through autogenous and spontaneous cycle replacement regeneration, usually complemented by coppice and seed bank ▪ Species composition change with over-exploitation of timber ▪ Successional changes are limited to more intensively affected areas	▪ A sequence of successional changes takes place after the perturbation. In this process, several phases or stages with specific floristic, structural and dynamic characteristics can be distinguished. Plant species composition changes in dominance gradually from early to late successional species ▪ Start of a highly dynamic growth process, with high rates of carbon assimilation and biomass aggregation	▪ There is only very sluggish successional development after the cessation of the main disturbance ▪ The process generally leads directly from forest cover to grassland or bushland, or, in extreme cases, to barren soil surface
Characteristics	▪ Forest structure not significantly damaged ▪ In forests subject to over-grazing, poor understorey development and absence of young age classes of the canopy species ▪ Light-demanding species regenerating after the disturbance are usually similar to those in the original forest stand	▪ Regrowing forest differs in species composition and in physiognomy from primary forest. Species are highly light-demanding	▪ Forest vegetation is lacking; single or small groups of pioneer trees and shrubs may or may not occur

Based on the aforementioned characterisation of degraded PSF in the EMRP area, a more simple typology could be developed, for example analogous to that developed for degraded PSF in Berbak NP by van Eijk and Leenman (2004; see Figure 4).

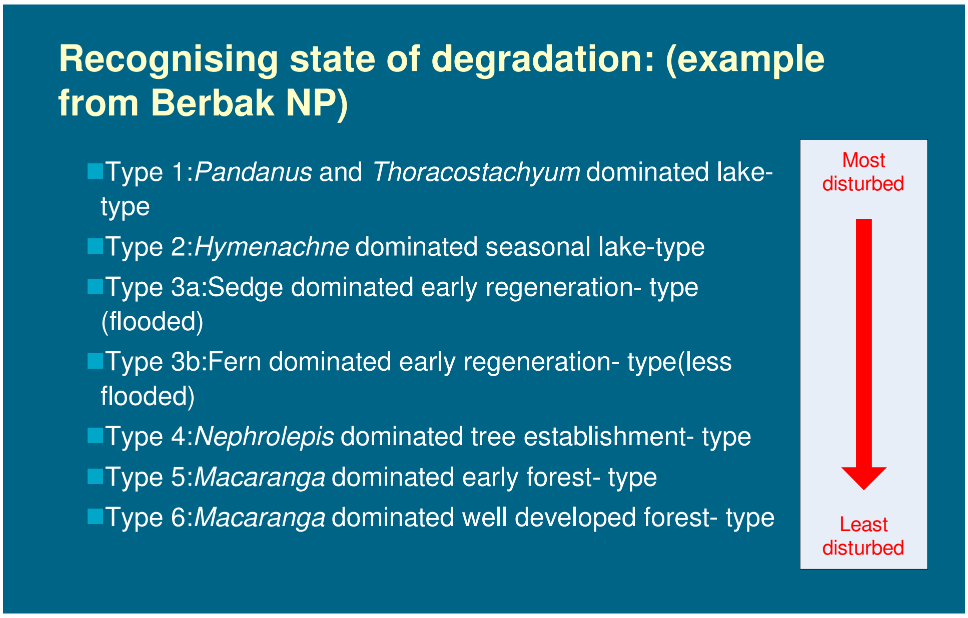


Figure 4 Recognising the state of degradation: indictors species in Berbak NP

From the typology follows a recognition of the **intervention type** required (see Box 2), which in the EMRP area can range from a) none required, for example in areas already regenerating naturally or in areas that are a lost case (e.g. former peat areas that have become deep lakes), to b) assisted natural regeneration (e.g. hydrological rehab, prevention fires), c) restoration or d) rehabilitation.

5.1.2 Mapping degradation

Mapping of the EMRP area needs to be at the level of detail (and recent enough) to allow recognition and delineation of the various stages of degradation at a landscape level. The mapping should recognise units that require rehabilitation, restoration, assisted regeneration, natural regeneration and those that do not require any intervention. The Land Use / Land Cover (LULC) mapping carried out by SarVision for CKPP and the Master Plan – EMRP recognised 22 LULC classes (see Annex 4), and provides an approximation of what is required. Sixteen of these classes refer to vegetation types that are either (degraded) forest, or are vegetation types which are the result of severe forest disturbance or forest clearance. These 16 vegetation classes can be grouped into the following 4 categories:

- Forest (including logged-over forest) with tree cover > 10%;
- Severely degraded forest with a tree cover <10%;
- Shrubland with vegetation cover > 10%;
- Open shrub with vegetation cover < 10%, including grasslands and land covered with ferns.

The remaining 5 classes have been grouped under the category “other“ (e.g. non-forest) classes, including agriculture, tree crops, and settlements. Table 5 summarises the data in the LULC map. From this we can conclude that if the entire EMRP is to be reforested, about

540,000 ha is likely to require assisted natural regeneration (i.e. the forest classes), 270,000 ha will require restoration interventions (i.e. the severely degraded forest classes), and about 470,000 ha will require rehabilitation interventions (i.e. the classes shrubland and sedge/fern/scattered shrubs). However, this overlooks the fact that about 295,000 of the EMRP area is Development Zone and 353,000 ha is Limited Development Zone (LDZ); some of these areas may be reforested (e.g. plantations in the LDZ), but others may not. This level of detail approaches what is required, but is not quite accurate enough, as tree and shrub cover classes are still quite broad, and mapping not always 100% accurate due to limited ground truthing.

Table 5 LULC classes & cover, including forests

#	LULC legend class (2008)	Ha	%	Tree cover classes (%)		
				<11	11-50	>50
	Forest classes (including degraded)					
1	Riverine-Riparian forest (cover >11%)	72,235	4.94		4.94	
2	Peat swamp forest (cover >11%)	226,626	15.50		15.50	
12	Low pole forest (cover >11%)	208,130	14.23		14.23	
20	Swamp forest (cover >11%)	28,004	1.92		1.92	
15	Mangrove (cover >10%)	6,482	0.44			
	subtotals	**541,476**	**37.03**			
	Severely degraded forest classes					
3	Woodland-degraded vegetation (cover 1-10%)	173,385	11.86	11.86		
11	Burnt forest and bare	59,830	4.09	4.09		
13	Low pole forest (cover 1-10%)	22,894	1.57	1.57		
14	Mangrove (cover 1-10%)	13,564	0.93			
	subtotals	**269,672**	**18.44**			
	Shrubland					
4	Shrubland (cover>50%) non flooded	136,629	9.34			9.34
5	Shrubland (cover >50%) flooded	38,374	2.62			2.62
6	Shrubland (cover 11-50%) flooded and non flooded	77,603	5.31		5.31	
	subtotals	**252,605**	**17.27**			
	Sedges, ferns, scattered shrubs					
7	Shrubland (cover 1-10%)	63,094	4.31	4.31		
8	Grassland and ferns	49,354	3.38	3.38		
10	Burnt shrubs and bare	107,026	7.32	7.32		
16	Sedges temporarily flooded	2,412	0.16	0.16		
	subtotals	**221,885**	**15.17**			
	Other classes					
9	Water (excluding the area of large rivers)	6,883	0.47			
18	Sawah	69,833	4.78			
19	Dryland agriculture	82,363	5.63			
21	Tree crops	15,520	1.06			
22	Settlement	2,058	0.14			
	subtotals	**176,657**	**12.08**			
	TOTAL	**1,462,296**	**100.00**	32.69	41.90	11.96

Note: the fish ponds (class 17) are still merged with the Water Class

Source: SarVision (2008) for Master Plan – EMRP

5.1.3 Rapid survey of site conditions

Rapid surveys will be required in addition to mapping, to assessment the site conditions, and the possible causes of degradation. This will result in a further refining of information available about a site, so that the intervention can target what is required.

Site physico-chemical conditions & interventions

Physico-chemical conditions need to be rapidly surveyed in each mapped intervention unit (see 5.1.2), and this may result in a further refinement of the map, or at least a better understanding of the conditions at a given site. Parameters that need to be assessed include:

- water depth/availability, flooding depth/duration, distance from river bank,
- micro-topography (hillocks and depressions: what is the range, height and elevation),
- exposure (to sunlight; depends on existing tree/shrub cover, height and density),
- peat depth and maturity,
- occurrence, depth and pyrite concentration of Potential Acid Sulphate (PAS) soils,
- nutrient availability, and pH of each of the mapped units.

Cause(s) of degradation

Rarely will there be only one cause of degradation and in most cases, the cause of degradation will be drainage and felling of trees, in combination with one or more fires. The history of each site will determine what is required as (a) precondition(s) prior to rehabilitation or restoration of the PSF. This will in almost all cases include restoration or rehabilitation of the hydrology and prevention of fires. Following or parallel to this, the replanting programme may begin.

The assessment of site conditions and cause(s) of degradation will lead to an identification of interventions required to address the conditions and cause of degradation (e.g. channel blocking, fire breaks, provision of nutrients, etc…). This should then be mapped out at a manageable scale (see example in Figure 5).

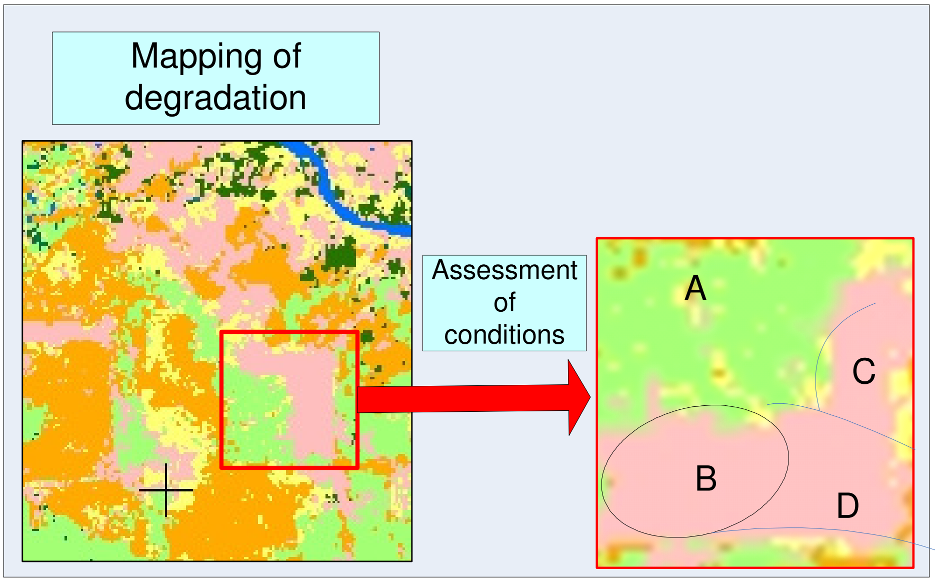


Figure 5 Mapping degradation and site conditions

A = deeply (1.5 m) flooded peat (2x burnt, 1.5 m peat disappeared); B = moderately deep flooding (1m), 1x burnt, 1m peat disappeared; C = shallowly flooded (0.5 m), 1x burnt, 0.5 m peat disappeared; D = as C, but with riverine influence (nutrients, current, some erosion).

5.1.4 Identification of suitable species

The selection of (woody) species for PSF restoration and rehabilitation should in the first place be guided by the suitability of the species for the conditions of the site that is to be restored or rehabilitated. Certain PSF tree species appear to be more characteristic of deep peat while others occur on peat of shallower depth, while other species again seem to occur along the range of peat depths (Page and Waldes, 2005; Table 6).

Table 6 Main tree species & peat depth

Principal tree species occurring in three peat swamp forest communities on peat of increasing depth across a peatland dome in the Sebangau catchment, Central Kalimantan (adapted from Page & Waldes 2005).

Principal tree species	Mixed swamp forest at the edge of the peat dome	Low pole forest nearer to the centre of the peat dome	Tall interior forest on the central peatland dome
Palaquium ridleyi	x		
Calophyllum hosei	x		
Mesua sp.	x		
Mezzettia parviflora	x		
Combretocarpus rotundatus	x	x	
Syzygium		x	
Tristaniopsis obovata		x	
Shorea teysmanniana		x	x
Palaquium leiocarpum			x
Stemonurus secundiflorus			x
Mezzettia parviflora			x
Neoscortechinia kingii	x		x
Palaquium cochlearifolium	x		x

Depending on the degree of degradation, conditions may differ considerably from the original PSF conditions, and this should be given due consideration. Former PSF areas that have been drained will be a lot drier than in the original state, while areas that have been subjected to (repeated) burning may also be subject to prolonged and/or deep flooding. Also, most degraded sites are also (much) less shaded than in the original PSF state. On the whole, species used for reforestation of degraded areas will usually have to be able to cope with: i) more exposure to direct sunlight, ii) desiccation in the dry months, and iii) some degree of flooding in the wet season. Many species of mature PSF will therefore not be suitable for replanting of degraded peatland, and the choice of species should during initial planting focus largely on those with a broad ecological tolerance, such as pioneer species (see Table 7) – or as described by van der Laan (1925) 'the weed species of wet areas'.

Many of the trials and PSF reforestation attempts to date have failed because the species used were unsuitable for the conditions at the specific location. Table 8 gives an overview of the species tried to date in Southeast Asia, and the degree of success. As the degree of dryness and flooding can vary considerably (e.g. at various distances from a canal or burn scar), local conditions must be accurately mapped beforehand to guide species selection (see 5.1.3).

Table 7 Pioneer/secondary PSF species in Sumatra & Kalimantan

#	Family	Species	Local name	References **
1	Anacardiaceae	*Campnosperma coriacea*	terentang	7
2	Anacardiaceae	*Campnosperma macrophylla*	terentang	1, 2
3	Anacardiaceae	*Gluta renghas*	rengas	4
4	Anacardiaceae	*Gluta wallichii*	rengas manuk	4
5	Anisophylleaceae	*Combretocarpus rotundatus*	tumih, prapat, tanah tanah	1, 2, 5, 6, 7
6	Apocynaceae	*Alstonia penumatophora*	pulai	5, 6
7	Apocynaceae	*Dyera polyphylla*	pantong, jelutung	2, 5
8	Arecaceae	*Licuala paludosa*	?	5, 6
9	Arecaceae	*Nenga pumila*	?	6
10	Arecaceae	*Pholidocarpus sumatranus*	?	5, 6
11	Caesalpiniaceae	*Koompassia malaccensis*	kempas merah	4
12	Dipterocarpaceae	*Shorea balangeran*	belangiran	1, 2
13	Ebenaceae	*Diospyros siamang*	eang	6
14	Elaeocarpaceae	*Elaeocarpus petiolatus*	?	5, 6
15	Euphorbiaceae	*Austrobuxus nitidus*	?	4
16	Euphorbiaceae	*Glochidion rubrum*	?	6
17	Euphorbiaceae	*Macaranga amissa*	?	6
18	Euphorbiaceae	*Macaranga pruinosa*	mahang	5, 6
19	Euphorbiaceae	*Mallotus muticus*	perupuk	5, 6
20	Euphorbiaceae	*Mallotus sumatranus*	?	7
21	Euphorbiaceae	*Pimelodendron griffithianum*	?	3
22	Hypericaceae	*Cratoxylum arborescens*	geronggang	4
23	Hypericaceae	*Cratoxylum formosum*	?popakan	4
24	Hypericaceae	*Cratoxylum glaucum*	?bentaleng	4
25	Icacinaceae	*Stemonurus scorpioides*	pasir pasir	4
26	Lauraceae	*Actinodaphne macrophylla*	?	6
27	Lecythidaceae	*Barringtonia macrostachya*	?	6
28	Lecythidaceae	*Barringtonia racemosa*	?	6
29	Leeaceae	*Elaeocarpus petiolatus*	?	1, 5
30	Melastomaceae	*Melastoma malabathricum*	senduduk	6, 7
31	Melastomaceae	*Pternandra galeata*	?	6
32	Mimosaceae	*Archidendron clypearia*	?	4, 6
33	Moraceae	*Artocarpus gomeziana*	?	6
34	Moraceae	*Ficus deltoidea*	ara	7
35	Moraceae	*Ficus virens*	?	6
36	Myristiaceae	*Knema laytericia*	pirawas	2
37	Myrtaceae	*Eugenia spicata*	ubah, kayu lalas	5, 6, 7
38	Myrtaceae	*Melaleuca cajuputi*	gelam	1
39	Myrtaceae	*Syzygium cerina*	?	5
40	Myrtaceae	*Syzygium zippeliana*	?	6
41	Pandanaceae	*Pandanus helicopus*	rasau	2, 5, 6
42	Rubiaceae	*Neolamarckia cadamba*	bengkal	5
43	Rubiaceae	*Timonius salicifolius*	?	7
44	Rutaceae	*Melicope accedens*	?	4
45	Theaceae	*Ploiarium alternifolium*	asam-asam	7
46	Ulmaceae	*Trema cannabina*	?	7
47	Ulmaceae	*Trema orientalis*	lenduhung	1

** References are as follows: 1 = van der Laan (1925), 2 = Giesen (1990), 3 = Bodegom *at al.* (1999), 4 = Kessler (2000), 5 = Giesen (2004), 6 = van Eijk & Leenman (2004), 7 = Giesen (2008)

Table 8 Species used in restoration trials in Southeast Asia

Adapted from Giesen (2008)

No	Species	Family	Locations/ countries	Occurs at EMRP	Perform -ance	Refer- ence
1	*Alstonia spathulata*	Apocynaceae	Jambi	?+	■	5
2	*Anisoptera marginata*	Dipterocarpaceae	Malaysia		■	2
3	*Baccaurea bracteata*	Euphorbiaceae	Thailand	+	■	1
4	*Calophyllum ferrugineum*	Guttiferae	Malaysia		o	2
5	*Combretocarpus rotundatus*	Rhizophoraceae	Jambi	+	■	5
6	*Dialium patens*	Leguminosae	Thailand	+	o	1
7	*Diospyros evena*	Ebenaceae	Kalimantan	+	■	6
8	*Durio carinatus*	Bombaceae	Jambi, Malaysia	+	o, o	2, 5
9	*Dyera (lowii) polyphylla*	Apocynaceae	Jambi Kalimantan	+	■, o, ■	5, 6, 7
10	*Eugenia kunsterli*	Myrtaceae	Thailand		■	1
11	*Ganua motleyana* (syn. *Madhuca motleyana*)	Sapotaceae	Thailand, Malaysia	+	■, ■	1,2
12	*Gluta wallichii*	Anacardiaceae	Jambi		■	5
13	*Gonystylus bancanus*	Thymelidaceae	Jambi, Malaysia Kalimantan	+	■, ■, ■	2, 5, 6
14	*Hibiscus* sp.	Malvaceae	Riau		■	5
15	*Litsea johorensis*	Lauraceae	Thailand		o	1
16	*Macaranga hypoleuca*	Euphorbiaceae	Riau		■	5
17	*Macaranga* sp.	Euphorbiaceae	Thailand		■	1
18	*Melaleuca cajuputi*	Myrtaceae	Thailand, Vietnam	+	■, ■	2,3
19	*Palaquium* sp.	Sapotaceae	Jambi, Kalimantan	+	■, ■	5, 6
20	*Peronema canescens*	Verbenaceae	Kalimantan	+	o	4
21	*Polyalthia glauca*	Annonaceae	Thailand		■	1
22	*Shorea balangeran*	Dipterocarpaceae	Kalimantan	+	■, ■, ■	4, 6, 7
23	*Shorea pauciflora*	Dipterocarpaceae	Jambi		■	5
24	*Shorea pinanga*	Dipterocarpaceae	Kalimantan	+	o	4
25	*Shorea platycarpa*	Dipterocarpaceae	Malaysia		■	2
26	*Shorea seminis*	Dipterocarpaceae	Kalimantan		o	4
27	*Shorea* sp.	Dipterocarpaceae	Kalimantan	+	o	6
28	*Stemonurus secundiflorus*	Icacinaceae	Thailand, Kalimantan	+	o, o	1, 7
29	*Syzygium oblatum* (syn. *Eugenia oblata)*	Myrtaceae	Thailand		■	1
30	*Tetramerista glabra*	Theaceae	Jambi	+	o	5

■ = good to very good (or >50% survival) o = poor to fair (or <50% survival)

1 = Urapeepatanapong & Pitayakajornwute (1996) 2 = Ismail *et al.* (2001)
3 = Maltby *et al.* (1996) 4 = Takahashi *et al.* (2001)
5 = Giesen (2004) 6 = Limin (2007)
7 = Wibisono & Gandrung (2008)

In Central Kalimantan, BP-DAS Kahayan have identified 39 tree species for their replanting programme in the EMRP area, including for mangroves (e.g. *Avicennia, Rhizophora, Bruguiera, Excoecaria, Xylocarpus* and *Sonneratia*) and mineral soil areas (*e.g. Melaleuca cajuputi*). In addition to the mangrove species and *Melaleuca*, species listed by BP-DAS that are unsuitable for PSF areas are:

- *Dacrydium* species require shading.
- *Lagerstroemia speciosa* is a riparian species, and does not grow in swamp forest or peat swamp forest areas.
- *Dyera costulata* is a dryland species; the jelutung that occurs in peat swamp areas is *Dyera polyphylla* (formerly known as *D. lowii*).
- *Macaranga maingayi* probably does not occur in the area.
- *Diospyros malam* does not occur in the area, and this should probably be *Diospyros siamang, Diospyros pseudomalabarica* or *Diospyros evena.*
- *Alstonia scholaris* is a dryland species, should be *A. spathulata.*
- *Metroxylon sagu* is a notoriously difficult species to cultivate, and has resisted attempts in spite of extensive trials in Sarawak.
- *Fragraea crenulata* is a (near) coastal swamp species, occurring on mineral soils, and may be suitable for such specific areas only.

Replanting trials in the EMRP area have used only a limited number of species, often planted in single-species groups rather than in mixed assemblages. This makes replanted areas more vulnerable, for example to insect predation, and virtual monocultures appear artificial for longer periods. Insect predation has already proven to be an issue with *Stemonurus secundiflorus* in reforestation attempts by CKPP.

There have been few studies on flood tolerance of PSF species or freshwater swamp forest species in Indonesia. It is known that prolonged flooding due to changes in physical conditions (e.g. canal construction or discharge of water) will eventually kill flood tolerant PSF and swamp forest species such as pulai *Alstonia pneumatophora* (NWC *et al.,* 1994). In their studies on regeneration of PSF degraded by fires in Berbak NP, Van Eijk and Leenman (2004) noted flooding depth and estimated flood duration from a series of remote sensing images. Subsequently, they were able to correlate the presence of pioneer species under various flood conditions and identify their tolerance of flooding (Table 9). Many of these species also occur in the EMRP area or can be expected in the area.

Based on field experience and several surveys in the EMRP area, Giesen (2008) provides a preliminary list of species that have potential for peat swamp restoration attempts, allocating these into four different flooding regimes:

1. Deepwater areas (deeply flooded for long periods),
2. Deeply flooded areas (frequently deeply flooded areas),
3. Moderately flooded areas (regularly, shallowly flooded areas), and
4. Rarely flooded areas.

For each of these flooding types, a suite of potentially suitable species is listed (Table 10). The same suite can also be used for channel blocking programmes, with type 1 being equivalent to deep-sided channels, type 2 partially infilled channels, type 3 largely infilled channels, and type 4 completely infilled channels. Figure 6 illustrates how these canal green-engineering types appear. Over time, these types will naturally evolve from one into another. Studies in peat swamp forests elsewhere (see 2.1) show that deeper peat layers largely consist of *Pandanus* roots and stems, indicating that infilling of deeper waters may be an initial stage in natural peat formation in at least some areas. In deeply flooded former peat swamp forest areas in the EMRP area, a similar succession may be attempted. In type 4, once pioneer species have established a canopy, shade tolerant or requiring species can be planted as well, hastening the succession towards mixed peat swamp.

Table 9 Pioneer species & flooding tolerance in Berbak NP, Jambi

Family	Species	Shallow & brief flooding	Moderately deep & long flooding	Deep/ prolonged flooding	Very deep & prolonged flooding
Anisophyllaceae	*Combretocarpus rotundatus*			+	
Apocynaceae	*Alstonia pneumatophora*	++	++	r	
Arecaceae	*Licuala paludosa*		+	+	
Arecaceae	*Nenga pumila*	+	+		
Arecaceae	*Pholidocarpus sumatranus*	+	+	+	
Ebenaceae	*Diospyros siamang*			+	
Elaeocarpaceae	*Eleaocarpus petiolatus*	+			
Euphorbiaceae	*Glochidion rubrum*	+			
Euphorbiaceae	*Macaranga amissa*	++	+		
Euphorbiaceae	*Macaranga pruinosa*	++	++	r	
Euphorbiaceae	*Mallotus muticus*		++	++	r
Fabaceae	*Archidendron clypearia*		+		
Lauraceae	*Actinodaphne macrophylla*		+		
Lecythidaceae	*Barringtonia macrostachya*	+	++		
Lecythidaceae	*Barringtonia racemosa*		+	++	r
Melastomaceae	*Melastoma malabanthricum*	+	+	+	
Melastomaceae	*Pternandra galeata*	+	++		
Moraceae	*Artocarpus gomeziana*	++			
Moraceae	*Ficus* sp.1	+			
Moraceae	*Ficus* sp.2	++			
Moraceae	*Ficus virens*	+	+		
Myrtaceae	*Eugenia spicata*		+		
Myrtaceae	*Syzygium zippeliana*		++	++	++
Pandanaceae	*Pandanus helicopus*			r	++

Adaped from Van Eijk & Leenman (2004)

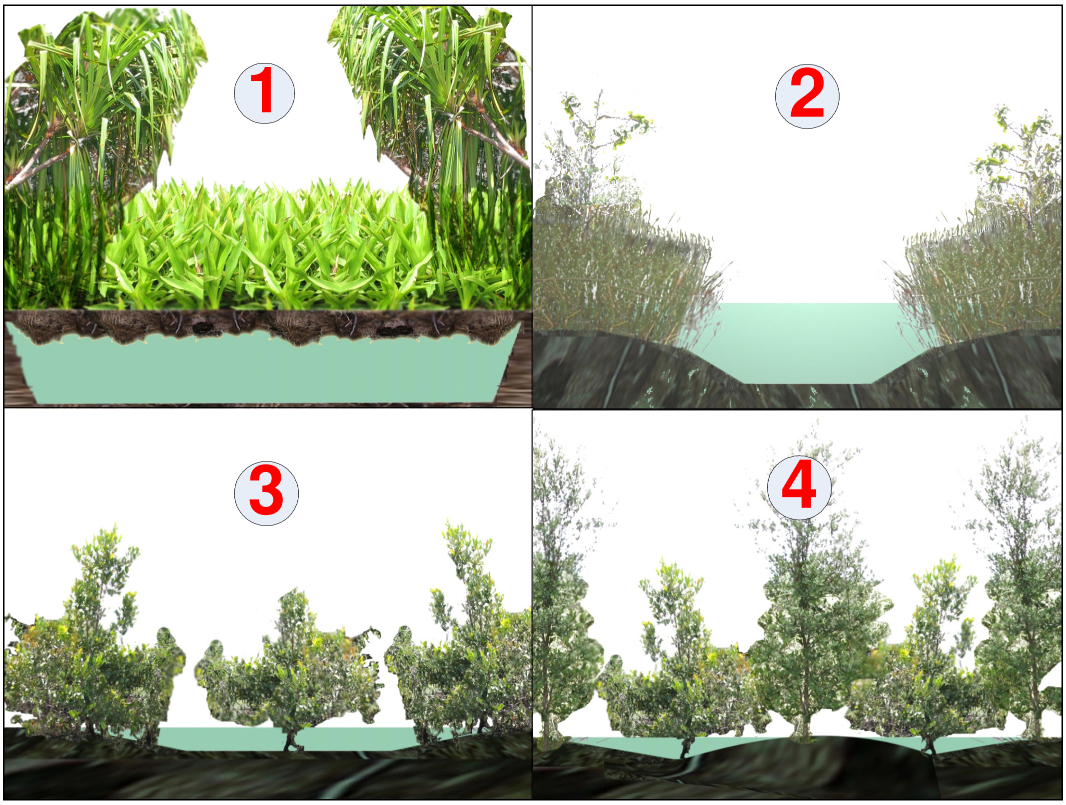
r = rare; + = present; ++ = common

Table 10 PSF species suitable for rehabilitation programmes under various flooding regimes

No	Green canal blocking	PSF restoration	Engineering species	Species	local name
1	Steep sided canals	PSF areas deeply flooded for long periods	***Group-1: deep water*** • *Hanguana malayana* • *Pandanus helicopus*	• *Hanguana malayana* • *Hypolytrum nemorum* • *Pandanus helicopus*	• *bakung* • *?* • *rasau*
2	Sloping sides of (eroded or backfilled) canals	Frequently deeply flooded PSF areas	***Group-2: deeply flooded*** • *Combretocarpus rotundatus* • *Lepironia articulata*	• *Combretocarpus rotundatus* • *Lepironia articulata* • *Mallotus sumatranus* • *Morinda philippensis* • *Psychotria montensis* • *Stenochaena palustris*	• *tumih* • *purun* • *perupuk* • *?* • *?* • *Kiapak*
3	Largely infilled canals, with shallow pools	Regularly (shallowly) flooded PSF areas	***Group-3: moderately flooded*** • *Cratoxylum glaucescens* • *Ploiarium alternifolium* • *Shorea balangeran*	• *Blechnum indicum* • *Cratoxylum glaucescens* • *Ploiarium alternifolium* • *Shorea balangeran* • *Stenochlaena palustris*	• *?* • *gerongang* • *asam-asam* • *belangiran/kahui* • *Kiapak*
4	Infilled canals	Flooding rare or absent in these PSF areas	***Group-4: rarely flooded*** • *Alstonia spathulata* • *Dyera polyphylla*	• *Alstonia spathulata* • *Blechnum indicum* • *Dyera polyphylla* • *Macaranga* sp. • *Stenochlaena palustris*	• *pulai* • *?* • *jelutung/ patung* • *mahang* • *Kiapak*
	as above, with shade trees	*as above, with shade trees*	***Group-4b: rarely flooded, shade requiring***	• *Alseodaphne coriacea** • *Baccaurea bracteata* • *Dialium patens ** • *Diospyros evena* • *Durio carinatus ** • *Ganua motleyana* • *Gonystylus bancanus* • *Peronema canescens ** • *Shorea pinanga ** • *Syzygium* spp. • *Tetramerista glabra **	• *gemor* • *rambai* • *?* • *uring pahe* • *durian hutan* • *?* • *ramin* • *?* • *?* • *?* • *punak*

* Note: these species require testing, as they have not performed well in earlier tests, but this may be because of lack of shading.. Adapted from Giesen (2008)

Figure 6 Canal rehabilitation/infilling using PSF species



Adapted from Giesen (2008)

Once a suite of suitable species (i.e. species suited to the conditions of a site) have been selected, species selection can further be guided by guiding principles 2 *Selection of beneficial species* and 5 *Avoiding use of exotic species* (see Chapter 4). Beneficial species should be utilised where possible when the degraded areas that are being rehabilitated are located near villages, or belong to traditional land of a particular community. The focus should not only be on timber species, as has often been the case to date, but on species that provide Non-Timber Forest Products (NTFPs). This should especially be the case in protected areas (*Kawasan Lindung*), where widespread logging would be undesirable. A preliminary list of potentially beneficial species – both for timber and NTFPs – is included in Table 11. **Exotic species should only be utilised under plantation-type situations and avoided near conservation areas as these could compete with local species and impinge on the biodiversity value of the site**. UGM has experience with oil producing illipe nuts (*tengkawang*) in peat in West Kalimantan (Box 3), which may be considered in Central Kalimantan as well, at least on a trial basis.

It should be remembered that restoration of peatland hydrology is one of the key guiding principles (#3; see chapter 4), and that exotic species that require drainage are incompatible with this principle in *Kawasan Lindung* areas and on margins of peat domes. Exotics used to date in peatland cultivation and plantations such as oil palm, *Acacia, Aloe vera, Hevea* rubber and pineapple generally require some degree of drainage (leading to fires and increased GHG emissions) and are therefore unsuitable for non-drained peatland.

Table 11 PSF species for timber & NTFPs

#	Family	Species	Local name	Timber*	NTFP
	Anacardiaceae	*Mangifera havilandii*	rasak rawa	+	
	Anisophyllaceae	*Combetocarpus rotundatus*	tumih	+	fuelwood
	Apocynaceae	*Alstonia spathulata*	jelutung**	+	
	Apocynaceae	*Dyera polyphylla*	pantong**	+	latex
	Araucariacea	*Agathis borneensis*	pilau	++	
	Bombaceae	*Durio carinatus*	durian huten	+	edible fruit
	Dipterocarpaceae	*Dipterocarpus verrucosus*	karuing	+	
	Dipterocarpaceae	*Dryobalanops* sp.	kapurnaga	+	
	Dipterocarpaceae	*Hopea* sp.	lentang bangkirai	+	
	Dipterocarpaceae	*Shorea balangeran*	belangiran	++	
	Dipterocarpaceae	*Shorea leprosula*	lentang	+	
	Dipterocarpaceae	*Shorea pallidifolia*	meranti batu	+	
	Dipterocarpaceae	*Shorea rubra*	meranti bahandang	+	
	Dipterocarpaceae	*Shorea smithiana*	lentang mahambung	+	
	Dipterocarpaceae	*Shorea uliginosa*	lentang bajai	+	
	Dipterocarpaceae	various species***	tengkawang	++	ilipe nuts
	Euphorbiaceae	*Baccaurea bracteata*	rambai		edible fruit
	Guttiferaceae	*Callophyllum grandiflorum*	bintangur	+	
	Guttiferaceae	*Garcinia* spp.	manggis hutan	+	edible fruits?
	Hypericaceae	*Cratoxylum* sp.	gerunggang	+	
	Lauraceae	*Alseodaphne coriacea*	gemor		bark for mosquito coils
	Myrtaceae	*Melaleuca cajuputi* #	gelam	+	fuelwood, oil, honey
	Myrtaceae	*Tristaniopsis maingayi*	palawan/balawan	+	
	Podocarpaceae	*Dacrydium pectinatum*	alau	++	
	Sapotaceae	*Ganua motleyana* #	katiau	+	
	Sapotaceae	*Palaquium rostratum*	nyatu/nyatuh		latex
	Sapotaceae	*Palaquium leiocarpum*	hangkang		latex
	Theaceae	*Ploiarium alternifolium*	asam-asam		edible young leaves
	Thymelaeaceae	*Gonystylus bancanus*	ramin	++	-

* good timber species = + excellent/valuable timber = ++

** Pantong is the local name for the Indonesian 'jelutung' (*Dyera*); confusingly, locals use the name jelutung for the Indonesian pulai (*Alstonia*).

*** Needs to be surveyed; tengkawang is produced and marketed in West Kalimantan, and UGM specialists consider that PSF dipterocarp species probably also include a number of species producing ilipe nuts.

\# *Melaleuca cajuputi* is often incorrectly recorded as *Melaleuca leucadendron* or *M. leucadendra*
Ganua motleyana is often incorrectly recorded as *Madhuca motleyana*

Box 3. Illipe nut (tengkawang) establishment on peat

Based on experiences from development of tengkawang on peatland at a forest management unit in West Kalimantan (Faculty of Forestry UGM and PT Inhutani 1) 2003-2008, it was concluded that it is possible to develop tengkawang on peatland.

Development of tengkawang in peatland is possible due to existing supports/techniques :

- *(i) seed sources,*
- *(ii) nursery techniques (except cutting still achieve 35% success),*
- *(iii) tolerance to high water table/flooding*

Some lessons-learned could be considered :

- *a. tolerance to flood esp. with running water*
- *b. tolerance to shading is low, esp. one year post-planting*
- *c. late-sapling (min 75 cm high) guarantees higher survival*
- *d. tolerant to variable peat depth (from shallow-peat with quartz underlying soil to deep peat down to 3 m)*

5.1.5 Planning for succession

Restoration and rehabilitation planting programmes should take a succession-based approach, first utilising pioneer species with a broad ecological tolerance, later adding climax species/ species of mature/mixed PSF if this is appropriate. The latter would be appropriate if, for example, the aim is to increase the density of certain beneficial species characteristic of mature PSF, or if the aim is to increase biodiversity value if the area is adjacent, near or forms part of a conservation area.

Palynological studies of succession in peat usually show a historic transition from either a freshwater swamp (with *Pandanus*) or mangrove to a mixed PSF (see 2.1). In terms of coping with increased flooding in degraded peat (e.g. after subsidence or loss of peat after fires), the approach would be to mimic the historic succession and start once again with very flood tolerant species such as *Pandanus helicopus.* Once a location becomes shallower or partially infilled, species that have some flood tolerance such as *Combretocarpus rotundatus* can be added. Possible suites of species with differing flood tolerance are listed in Table 10/illustrated in Fig. 6.

As peat accumulates over time, a particular site may develop a mixed PSF. Although less biodiverse than lowland dipterocarp forests, mixed PSF can attain a canopy height of 35-40 metres and include anywhere from 30-130 tree species at a given location (Giesen, 2004). Up to 80 tree species have been recorded in 1-ha plots of LIPI/Bogor Herbarium near Kelampangan (northern Block C, EMRP area; pers. comm. Edi Mirwanto). In large domes that have developed over a long period, a species-poor pole forest with an open canopy may develop in the central part of the dome due to the extremely nutrient deficient conditions that prevail. Pole forests (sometimes called 'padang' forest) have a lower canopy (usually max. of 15-25 metres) and the trees have considerably smaller boles (max. 35-40 cm). In Sumatra, pole forests on deep peat are dominated by *Calophyllum* and *Syzygium* species and may have only about 12-17 tree species (Giesen & van Balen, 1991a), while in Central Kalimantan these are dominated by *Combretocarpus rotundatus, Syzygium, Tristaniopsis obovata* and *Shorea teysmanniana* (Page & Waldes, 2005; see Table 6).

Light conditions in peatland vegetation also vary over time. In degraded conditions, light conditions will be harsh and shade requiring species more common in mature PSF will not flourish. In pole forest, light penetration is greater than in mixed/mature PSF, and once again light conditions may be more harsh and contribute to unfavourable conditions for certain species. Little is known about light requirements of PSF tree species, but one may assume that pioneer species have a high tolerance, while species that occur only in the lower canopy of mature-mixed and relatively undisturbed PSF are likely to be less tolerant.

5.2 Preparation stage

5.2.1 Introduction

Seedling choice is an important factor which determines the success of reforestation activities. Vigorous, robust seedlings of the proper size and the right species are crucial in getting good growth and survival rates of seedlings planted in rehabilitation areas. Using the right materials and techniques (nursery, potting materials, etc...) is important in creating good planting material for reforestation activities. Also, timing of planting is important, both in relation to getting enough seedlings as well as in terms of growing conditions for the freshly planted seedlings. Below we provide an overview of the various aspects that need to be addressed when preparing for reforestation activities in the EMRP area.

5.2.2 Planning for seed and seedling supply

General information on the reforestation plan in terms of location, area, status of existing vegetation, and anticipated timing of activities will determine the various requirements related to seedlings supply, i.e.:

- Required number of seedlings
- Preferred size and height of seedlings
- Preferred planting time
- Planting patterns / conditions
- Species choice
- Location of seed sources and collection season.

Seeds can be harvested by local people, or seed collection missions can be organised when seed supply is very concentrated and abundant. Felling of trees for seed collection is to be actively discouraged. Information on the flowering and fruiting seasons of preferred tree species is needed to determine the right season for collecting. This data needs to be collected locally as phenology of species may vary within their natural distribution, depending for instance on the timing and length of the rainy season[14]. If possible, local provenances need to be used as these are best adapted to local circumstances. However, if these local sources have been depleted provenances, may be used from other locations in Kalimantan, or from outside Kalimantan (if this does not counter legal restrictions).

[14] In Jambi, for example, *Dyera polyphylla* flowers and fruits only every 3-4 years (Giesen, 2004), while in Central Kalimantan this occurs annually, and because of variation throughout the province, fruits can be obtained virtually all year round (Graham, pers. comm. 2009).

Seeds should be collected as much as possible from "Potential Plus Trees" (PPT). Local protocols have to be developed for the selection of these PPTs (height, crown form, straightness of crown, etc...). For long term supply of seeds the establishment of seed orchards (e.g. progeny and off spring trials and experiments) could be further explored in order to maximise out-breeding and use progenies originating from potential plus trees.

Vegetative propagation and selection of trees can help if seed supply is scarce. Genetic improvement can be used to multiply superior trees (PPTs). To maintain genetic diversity a mixture of clones may be used; however, cloning technology is probably too advanced for current conditions in Central Kalimantan. Techniques need to be developed further locally.

Use of wildlings can be an option as well, but this may be difficult because it requires areas with non-logged forest, which are rare in the EMRP area. It also requires knowledge and monitoring on timing and location of regeneration of the required species. Finally, using wildlings is labour intensive and depends on season and seedlings can only be harvested when relatively small.

Seeds and wildlings may also be sourced in adjacent areas with good to reasonable forest, and Sebangau NP management has suggested that, under controlled conditions, some may be sourced within the park (pers. comm., TN staff, PSF Rehab workshop).

5.2.3 Setting up of nurseries

The nursery should be located on non-peat soils outside the peat areas, or at an area which is not water-logged. It must have year round easy access to water. Also, the nursery should be accessible to cars (and preferably boats) year round, and should have electricity. Adequate shading should be provided for the seedlings, and nursery beds should preferably be at least 40 cm above the ground. Setting up of nurseries can possibly be outsourced to local communities (e.g. village nurseries) or outsourced to commercial companies.

Alternatively, if transportation of seedlings is more difficult than taking seeds to a nursery on site or close to it, a (temproary) nursery may be established on-site. The requirements under such conditions would of course be different, and not necessarily include road access and electricity.

5.2.4 Growing the seedlings

As many seeds of PSF species are quite large, seeds should first be sown in prepared seed pans with a mixture of sand/peat. Humidity is a key factor, along with the need to control temperatures. Certain tropical rainforest species need different temperatures at different times, but this is not fully known for PSF species[15]. After the seeds germinate seedlings should be transplanted into polythene bags. Size of the bags should be 5''x 8'' (12.7 x 20.3 cm) as seedlings should be relatively large[16] when they are planted to reach above highest water level (e.g. Nuyim 2005). Trials at Sebangau suggest that small seedlings can survive a full wet season with little damage (even below the water level), provided that they are the right species and well looked after (Graham, unpublished data). Holes should be made in bags for proper

[15] Some of the information regarding rainforest species on this topic may be relevant to PSF species. .

[16] Not always true and not everyone agrees as this depends on site conditions; a fast growing small plant is better than one that is large and grown under stress (pers. comm. G. Applegate, 2009).

drainage. Use of root trainer tubes should however be investigated need to have raised beds and pots that enable root/air pruning and straight and vertical (downward) growth (Bathgate 2008).

The medium used can be local peat soil although a mixture of mineral soil and peat can give better growth for certain species. This needs to be tested locally. Fertilisation with either ash or charcoal can be used to stimulate initial growth although results are not consistent yet (e.g. de Wilde 2008). Slow release fertiliser granules (e.g. 15 g Osmocot^{+}) could possibly increase growth rates, but this needs to further tested before general guidelines can be given for the use of fertilisers. However, a balanced mix of NPK and trace minerals is most likely suitable for now; many rainforest species benefit from trace minerals and specific micronutrients.

Seedlings should be regularly watered (morning & afternoon), but only when rain is insufficient. Work at Sebangau indicates that watering is usually not necessary during the wet season (pers. comm, L. Graham, 2009). Weeding should be done once a month. The bags should be moved once every three months to avoid roots penetrating the ground. Height grading should be done to avoid suppression of smaller seedlings. Seedlings need to be checked for pests and diseases regularly.

Depending on species and desired planting height seedlings will be grown in the nursery for around 3-6 months. One month before planting the shade panels should be gradually removed so that seedlings have full exposure to sunlight (Nuyim 2005). Also, watering frequency should be gradually reduced to once a day during this period to further harden-off the seedlings.

The number of seedlings is being determined by the planting area and planting density (see below). On top of that, extra seedlings need be raised for replacement plantings; a replacement rate of about 10-30% of the number of plants needed for the original planting is probably a more usual figure (depends on species and experience).

5.2.5 Site preparation

Once the site for replanting has been selected a preliminarily survey should be made, collecting base-line information on access and ownership, exact location, boundary, site history, abundance of vegetation, signs of wild-fires and domestic animals (Nuyim 2005). Planning should be made for a temporary walkway, firebreaks, and other necessary preparations. The planting location should be plotted on a map (1:10,000), which should also include information on infrastructure and vegetation cover types. Wells should be dug or installed every 100 meters (i.e. 4 per ha) to provide water both for watering and in case of fires (pers. comm. Marinus Harun, LITBANGHUT Banjarbaru, PSF Rehab workshop).

Weeding[17] of the area should be done to kill the competition shortly before planting (end of dry season). In *Kawasan Lindung* weeding should be carried out as strip line weeding, but in *Kawasan Budidaya / Kawasan Budidaya Terbatas* the approach to weeding would depend on the purpose (for timber production or not). However, even in the latter, strip line weeding may be better than total weeding as the costs are lower. Weeding should be done manually or

[17] Clearing by just cutting the vegetation is next to useless and one needs to kills the competition – this is not well understood by many researchers in Indonesia (pers. comm. G. Applegate, 2009).

chemically without using fires. Care should be taken to leave tree seedlings. Climber cutting on existing trees should be considered as essential in young plantings.

5.2.6 Preparation for planting

Putting planting stakes (ajir / poles) at the planting locations makes it easier for workers to find the planting pits. They also serve to re-locate the seedlings during weeding, and make it easier to monitor growth and survival and give the location for replacement planting when needed. Poles[18] can be made of *Melaleuca cajuputi* (gelam) and should be about 1.5 m in length. Clearing of weeds in a radius of 50-75 cm around the planting stake will decrease competition and increase growth and survival rate of the planted seedlings. For areas with high densities of ferns or shrubs, strip planting can be chosen as an option for planting.

Few studies have been carried out to determine the appropriate planting spacing in PSF reforestation activities (Nuyim 2005). Optimal spacing is dictated by both economic and ecological factors. For instance 1x1m spacing may give a dense stand of trees blocking most weeds in a short period of time, but this requires 10,000 seedlings per hectare. A more open spacing of for instance 3x3m requires only 1,111 seedlings per hectare[19]. For most PSF species a planting space of 1250 plants/ha is recommended (2 x 4 m or 3 x 3 m; Nuyim 2005). APRIL uses 3 x 2.5 m (1333 plants/ha) for pulp-wood plantation with fast-growing *Acacia mangium*. They recommend higher stockings for slower growing species and/or poorer sites, for instance to avoid extra weeding (Bathgate 2008). However, spacing should be determined by management objectives, and APRIL are growing a short rotation species that slows down after age 4 years.

Good planting pits are essential for good seedling growth and possibly for increasing survival rates[20]. Certain PSF (but not all) species benefit from the construction of small soil mounds (Nuyim 2005). However, mound construction is laborious and expensive, and further research is needed to give general guidelines. In addition local micro-topography could be used to plant seedlings there of the relevant species (*Eugenia kunstleri, E. oblate, Baccaurea bracteata, Decaspermum fruitcosum*; Nuyim 2005).

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[18] It was suggested at the workshop that using poles contributed to deforestation, and that this should be kept to a minimum, for example, by not using poles at the location of each individual seedling or by using tape to mark a transect. The use of stakes may not be necessary, as pits are easy to see as they are or should be 2-3 m apart and if dug correctly to the specifications are readily seen

[19] It s always a compromise between cost of seedlings and cost of mantenance until canopy closure. Better to have close between trees and wider spacing between rows for cost effective weed control (pers. comm. G. Applegate, 2009).

[20] Not yet well understood on peat; this holds for mineral soils.

5.3 Implementation stage

5.3.1 Seedling selection for planting

Species choice
Depending on existing vegetation cover, local hydrology, and peat depth, the species groups listed in Table 12 (below) should be used for planting.

Seedling form and size
To have the best chance for establishing and maturing into healthy trees seedlings have to meet following criteria (after Upton & de Groot, 2008):

- Undamaged, disease and pest free specimens
- Single, vigorous main stem
- Symmetrical growing branches
- Undamaged root systems

Generally seedlings should be around 30-50 cm in height when planted out, although the preferred size may differ locally depending on species and site conditions. Generally smaller seedlings establish faster, have higher survival rates, and are easier and cheaper to transport than larger seedlings. However, in water-logged conditions planting small seedlings will be sub-merged for a long period which may cause increased mortality rates. Seedlings should not been too small, however, and they certainly need to be "hardened off" before they are transported and/or transplanted, as survival rates will be considerably lower with unhardened specimens. Hardening off is required so that the seedling adapts from the nursery conditions to the real conditions in the planting area and is strongly recommended to be carried out 1-2 months prior to planting. It can be simply conducted by reducing watering and shading gradually until the seedlings are able to stand independently without watering and shading. Without this, seedlings will get stressed after being planted in field and mortality levels may be high. In many cases, this activity is unfortunately forgotten by field implementer.

5.3.2 Seedling transport

Seedlings transport from the nursery to the planting site should be as fast and secure as possible to avoid damage and stress. They must also be sufficiently moist, to limit possible desiccation. A logistic plan can help to reduce handling and transport time. After arrival at the planting site seedlings should be kept cool (i.e. shaded) and moist till they are planted out. Here too plants should be planted out as soon as possible.

Table 12 Parameters & species choice

Vegetation cover	Water logged	Peat depth	Species
>50 %	> 3 mo	> 3 m	PSF climax species • *Alseodaphne coriacea* • *Baccaurea bracteata* • *Dialium patens* • *Diospyros evena* • *Durio carinatus* • *Ganua motleyana* • *Gonystylus bancanus* • *Peronema canescens** • *Shorea pinanga* • *Tetramerista glabra*
10-50 %	> 3 mo	> 3 m	Late successional PSF species • *Alstonia spathulata* • *Campnosperma coriacea* • *Dacrydium pectinatum* • *Diospyros siamang* • *Dyera polyphylla* • *Stemonurus scorpioides*
< 10%	> 3 mo	> 3 m	PSF Pioneers • *Combretocarpus rotundatus* • *Cratoxylum glaucescens* • *Eugenia spicata* • *Glochidion rubrum* • *Mallotus sumatranus* • *Ploiarium alternifolium* • *Shorea balangeran* • *Syzygium* spp.
>50 %	< 3 mo	< 3 m	Climax species (non PSF) • Wide range of dipterocarps
10-50 %	< 3 mo	< 3 m	Late successional species (non PSF) • *Dacrydium pectinatum*
< 10%	< 3 mo	< 3 m	Pioneers (non PSF) • *Fragraea crenulata* • *Macaranga* spp. • *Melaleuca cajuputi* • *Shorea balangeran* • *Trema cannabina* • *Trema orientalis*

5.3.3 Planting

The best time for planting in the EMRP area is the start of the wet season (Oct-Dec) when water and temperature are causing least stress. Given the lower temperatures and higher humidity, late afternoon and (early) mornings are the best time to plant.

At each planting location (indicated by the pole) an appropriate hole is made in the soil with a knife. The seedling is taken out of its bag and placed in the hole and covered with soil. Weeds around the planting hole are removed, and the seedling is tied to the pole (at 70% of its height; Nuyim, 2005). The base of the newly planted seedling should be wetted with water from around the planting hole. The application of organic or chemical fertiliser and/or liming could possibly stimulate growth. The APRIL plantation at Sumatra uses Potassium fertiliser to stimulate root growth, and recommends Phosphate, Cu, Zn, and Boron to stimulate growth (Bathgate, 2008). However local soil conditions need to be analysed before definite recommendations for the use of fertilisers can be given. Planting trials at Sebangau have done well using slow-release nutrient tablets (Graham, unpublished data).

Tawaraya *et al,* (2003) found that inoculation of some tree species grown in peat swamp forests with arbuscular mycorrhizal fungi could possibly improve the early growth of PSF species. However it needs to be tested in the field to assess if this is essential for increasing growth and mortality of seedlings in the EMRP area, as these trials were carried out under controlled nursery conditions. Early results of trials at Sebangau, however, indicate that they are important under field conditions as well (unpublished data, Tawaraya & Graham). Studies by BPK – Banjarbaru show that endomycorrhizae in PSF at Tumbang Nusa (near Kalampangan, Central Kalimantan) are all of the genus *Glomus* (Lazuardi *et al*., 2003).

5.4 Follow-up stage

5.4.1 Replacement or replenishment plantings

Nuyim (2005) indicates that when PSF seedlings survive for one months under normal circumstance (e.g. no pests and diseases, no major droughts or flooding) they have a high chance to develop into mature trees. Seedling survival should be undertaken at 1-2 months after planting, using a representative sample. Survival depends on the time of the year, however, as weather conditions can exert a significant influence. At Sebangau, *Shorea balangeran* seedlings planted at the start of the wet season had a 95% survival rate during the first six months, but then experienced 20% mortality during the dry season (Graham, unpublished data). As weeding is proposed for the first two years, monitoring of mortality/survival rates could be combined with weeding activities.

When mortality is < 10 % no replacement planting is needed. If the mortality in the sample > 10% a replacement planting needs to be done, replacing all dead seedlings in the whole planting area. If possible, seedlings used for the replacement planting should be from the same lot as used in the original planting.

5.4.2 Weeding

Weeds are one of the major problems in PSF rehabilitation. Therefore frequent weeding is needed around all seedlings at regular intervals during the first 2 years after planting. Weeding will depend on local competition and on how the around aprund each seedling has bene pretreated (manually, chemically). Often, weeding may be required after 3, 6, 12, and 24 months, but the frequency should be adapted to local conditions. In areas with large densities of ferns, competition and regrowth may be high, and more frequent weeding may initially be required until the seedling is about 1 metre tall. When trees have reached a height of 2 metres weeding is not needed anymore.

5.4.3 Monitoring growth (including pests & diseases)

Growth and health of planted seedlings should be monitored on permanent sample plots. Plots should be at least 40x40 m (e.g. Nuyim, 2005). Monitoring plots need to be established at different locations per plantation; the number of plots will depend on the size of the planted area, and on the species planted. Plots should be monitored every year, either by a forestry institute or skilled forester. Measurements include growth and survival of planted seedlings, but should also look at phenology and health characteristics of the seedlings.

5.4.4 Prevention of wildfires

Prevention of wildfires is essential for the maintenance of replanted PSF. Fire-breaks of 5-10 m wide should be established around each planted area. Nuyim (2005) recommends such fire breaks around each planted block of 500 x 500 m. These fire-breaks can be used for patrolling and monitoring as well, and should be cleared once a year at the beginning of the dry season. Some agencies (e.g. Balai Penelitian Kehutanan Banjarbaru) recommend the construction of wells at strategic points, which can be used in early fire fighting.

5.4.5 Enrichment plantings

When the original planted seedlings have formed a closed canopy, enrichment plantings with more shade tolerant PSF species could be considered. Depending on local circumstances and species availability. enrichment planting can be done either systematically (e.g. in lines every 30-50 meters) or in more random patterns.

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Annex 2 Programme of the PSF Rehabilitation workshop

December 11th 2008

09.30 - 10.00	Arrival in Palangkaraya (Garuda GA550, Jakarta-Palangka Raya)
10.00 - 10.30	Convene at EMRP project office at Bappeda
10.30 - 17.00	Field Trip
18.00	Move to Hotel KMC
19.00	Dinner

December 12th 2008

08.00	Opening
Session 1:	Brief individual presentations of agency experience (10-20 minutes) regarding to research and study of each of the institute
Session 2:	Knowledge and Study of Peat Swamp's Rehabilitation. What have we learned to date? what works & what doesn't? (groups & plenary)

December 13th 2008

Session 3:	The Most Suitable Practice and Research Needs. est practice guidelines for PSF rehab based on current knowledge (presentation & discussions)
Session 4:	Research Priority and Conclusion of the best Practice. Gaps in our understanding & identification of research needs
	Wrap-up

December 14th 2008

08.00	Checking out from KMC and leaving to Tjilik Riwut airport
10.00	Leaving to Jakarta (Garuda GA 551)

Annex 3 PSF Rehabilitation Research needs assessment

On the last afternoon of the workshop a research needs assessment was conducted among the participants. Participants were invited to note research topics – one per sheet – and group these under the headings ‘biological’, ‘physico-chemical’ and ‘people-oriented’. Each person was given three sheets for each heading; most filled out three topics per heading, some only 1-2, others as many as four. These sheets were subsequently entered into a spreadsheet (one for each heading), and during the second half of the session a priority ranking was established per topic. Participants were asked per topic if this was considered ‘very important’, ‘important’, ‘moderately important’ or ‘unimportant’, and the topics were given a score ranging from 1 (unimportant) to 4 (very important). The list and ranking provided in the tables on the next page is the result of this research needs assessment. Some items listed were judged not to be appropriate research topics; this is indicated as such in the tables. This was more the case under the people-oriented heading, as many were related to assisting local communities or managing their impacts.

Phyisco-chemical topics

The top 9 physico-chemical topics recorded all score quite closely, ranging from only 50-55 points, while the remaining 10 topics range from 30 points upwards. The topics identified as being most important topics are: i) Dams - where to put them and when; ii) Species that can tolerate flooding/drought - especially root structure; iii) Loss of peat: rates and problems; iv) Site characteristics for peat; v) Monitoring of hydrology - for at least a yearl vi) Species in relation to peat depth and maturity; vii) Data needed for carbon crediting; viii) Light: species that can tolerate higher levels; and ix) Criteria for land use and level of degradation.

Biological topics

The top 9 biological topics recorded all score quite closely, ranging from only 49-54 points, while the remaining 14 topics range from 36 points upwards. The topics identified as being most important topics are: i) Plant species in relation to with peat characteristics; ii) Identifying species that can tolerate flooding; iii) Creating permenant plots to learn about biodiversity; iv) Identifying which local species are appropriate for each (type of) site; v) Learning about the phenology of tree species and thus seed distribution; vi) Gemur and other potential NTFP species – finding the skills to mass-produce; vii) Identifying plant species that can cope with high light levels; viii) Learning more about the symbiotic species with trees (mycorrhizae, N-fixing etc…); and ix) Improving and learning about present silviculture techniques.

People-oriented topics

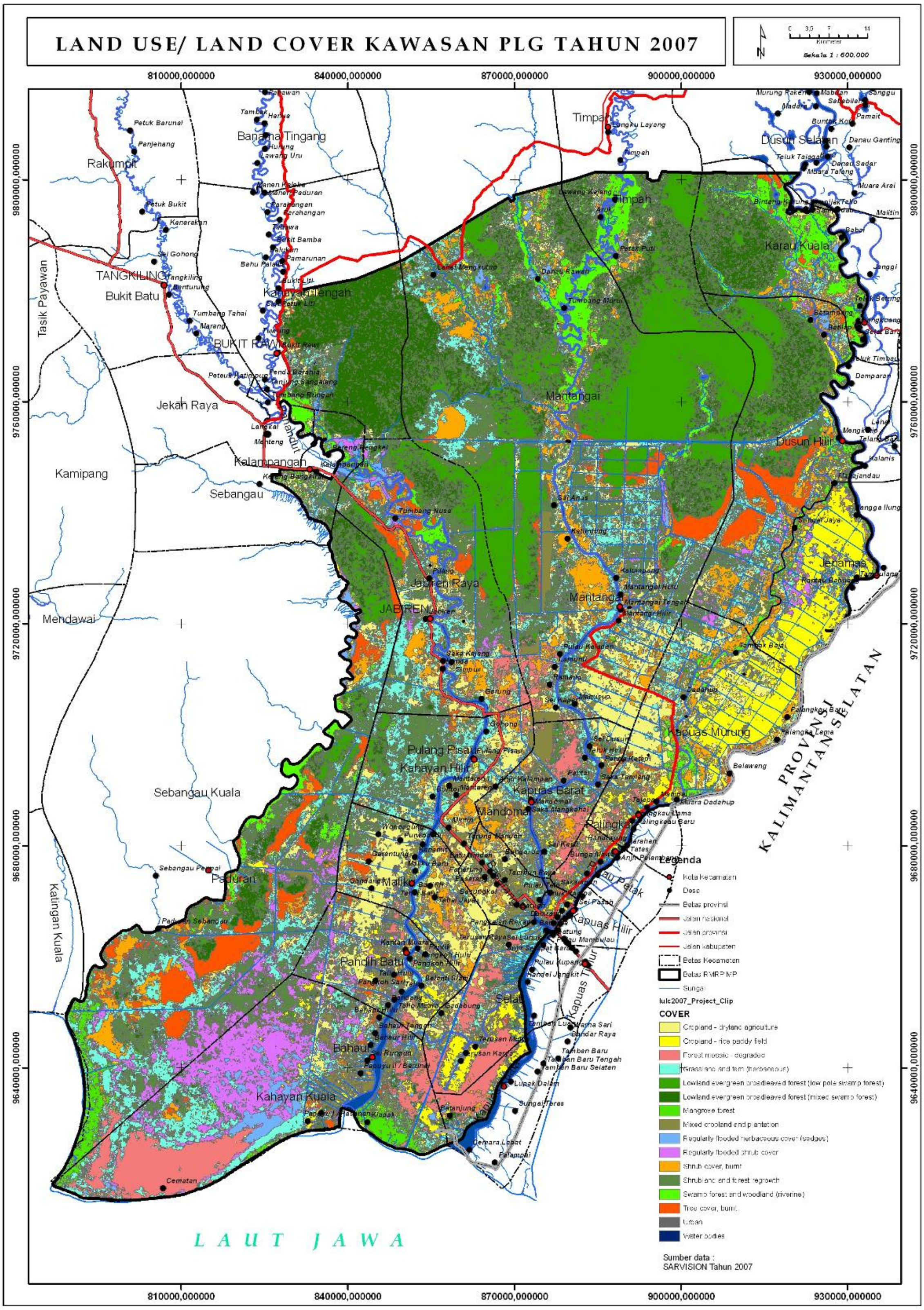
The top 9 people-oriented topics recorded score from 45-52 points, while the remaining 6 topics either scored very little or were deemed inappropriate. The topics identified as being most important topics are: i) Valuation study of NTFPs; ii) Local perceptions regarding restoration; iii) Integration agro-fisheries and forestry; iv) Providing incentive models, improving livelihood, and finances; v) How to manage NTFPs, including after harvesting (collection, storage, process, selling); vi) Gain understanding of the dependence of local people on NTFPs/ Ethnobotany and ethnoecology study; which NTFP species are best for local people (finance, yields etc) ?; vii) Learning and incorporating local knowledge; viii) Developing methods and documenting community participation; and ix) Developing agroforestry systems.

	Physico-chemical			
			Times repeated	Score
18	Water	Dams - where to put them and when	1	55
19	Water	Species that can tolerate flooding/drought - especially root structure (3)	3	55
12	Loss of peat	rates and problems	1	54
2	Peat	Site characteristics for peat (6)	6	53
16	Water	Monitoring hydrology - for year (3)	2	53
1	Peat	Species that relate to peat depth and maturity (4)	4	51
10	Carbon	more data needed fo carbon crediting	1	51
13	Light	species that can tolerate it (2)	2	51
7	Criteria for land use and level of degradation		1	50
3	Peat	Do we need fertiliser? Is the organic nutrients in peat enough? (6)	6	44
17	Water	Effectiveness of dams	1	44
5	Peat	Toxicity of peat, from PAS (2)	2	43
6	Natural indicators (floral spp) for peat types		1	39
15	Water	effect of chemicals on water ecosystem, including species	2	36
4	Peat	Chemical composition of peat	1	35
11	Limnology	lack of research	1	34
9	Alleliopathy		1	30
14	Water	Water management (general) (2)	2	too broad
8	Map of land use and level of degradation (peat age), (make plot every 250Ha?) (2)		2	Research practice

	Biological			
			Repeated on board	Scores
3	In the field	Plant species fit with peat characteristics (3)	3	54
11	Natural ecosystem	Find species that can tolerate flooding	1	53
12	Natural ecosystem	Create permenant plots to learn biodiversity	1	53
9	Natural ecosystem	Identifying which *local* species are appropriate for each site	1	51
10	Natural ecosystem	Learn the phenology of tree species and thus seed distribution (4)	4	51
25	Specific	Gemur, and others - skills to mass-produce	1	50
7	In the field	Plant species that cope with light	1	49
13	Natural ecosystem	Learn more about the symbiotic species with trees (mycorrhizae, N-fixing etc)	2	49
22	Nursery	Improve and learn on present silviculture techniques	2	49
17	Natural ecosystem	Taxonomic study of TPSF plant spp	1	47
6	In the field	Which seasons work for which species (planting calender)	1	46
2	Human element	How do we collect enough good quality seeds? Management.	1	44
8	Natural ecosystem	Increase knowledge of flora and vegetation, especially on tranplant candidate species (2)	2	44
20	Nursery	Uniform and appropriate (light and compact) nursery media (3)	3	43
16	Natural ecosystem	Increase knowledge regarding root systems (2)	2	41
1	Human element	Identification of medicinal plants	1	40
4	In the field	Plant species that cope with fire	1	40
18	Natural ecosystem	Increase knowledge of relationship trees species to key/umbrella species e.g. orangutan.	1	39
19	Nursery	How to protect the seedlings from pests and disease	1	39
5	In the field	Figuring out which species to mix	1	38
23	Nursery	Improve knowledge on parent trees	1	37
24	Nursery	When do we plant the seedlings? How long before hardening? Is this needed for all spp.? (3)	3	37
15	Natural ecosystem	Increase knowledge of competition between species (3)	3	36

	Community				
			Repeated on board	Score	
3	Valuation study of NTFP		1	52	
12	Surveying local community	Their perseptions of restoration (2)	2	52	
7	Involving the community	Integration agro-fisheries and forestry	1	49	
4	Involving the community	Providing incentive models, improving livelihood, and finances (5)	5	48	
9	Involving the community	How to manage the NTFP after harvesting (storage, process, selling)	1	48	
13	Surveying local community	Better understand interdependancy of local people and NTFP, Ethnobotany and ethnoecol	3	48	
15	Local knowledge	Learn and encorporate local knowledge (6)	6	48	
5	Involving the community	Developing methods and documenting community participation (5)	5	46	
2	Develop agroforestry system		1	45	
6	Involving the community	Dealing with issues of ownership and land rights, and land use planning (2)	2	34	
8	Involving the community	Eco-tourism?	1	27	
1	Training for local foresters and facilitators (2)		2	Study not research	
10	Involving the community	Arranging farmer groups for restoration (2)	2	Study not research	
11	Involving the community	Establishing permanant positions of work for local people; fisheries, farming (crops and live	1	Study not research	
16	Local knowledge	Establish education for local community (2)	2	Study not research	

Annex 4 LULC map of EMRP 2007



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