GUIDELINE ON

Peat Swamp Forest Rehabilitation and Planting in Thailand

Tanit Nuyim

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GUIDELINE ON
PEAT SWAMP FORESTS REHABILITATION AND PLANTING IN THAILAND

Research Findings from the
Pikulthong Royal Development Study Project

by Tanit Nuyim

National Park, Wildlife and Plant Conservation Department

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Peat swamps must be conserved because they are of great environmental importance. Currently, the project is being carried out in Khok Nai. Any form of encroachment within the project area is prohibited. We have planted new plant species in the peat swamps within the project area. The view along the walkway is beautiful, with many plant species, including the Oncosperma palm.

H.E. the King's Address
on 9 October 1992

Foreword

(from Thai Edition)

Peat swamp forests are unique ecosystems with features which differ from other types of forests. They are habitat to plants species that grow in areas inundulated with water almost all year round. At present, only 56,477 ha of intact peat swamp forest remain in Thailand, most of which have been degraded. Reforestation of such degraded peat swamp forest, by natural processes, to natural high quality peat swamp forest conditions requires over 200 years.

The National Park, Wildlife and Plant Conservation Department has developed this Manual on Peat Swamp Forests Rehabilitation and Planting to help government organizations, non-government organizations, people and others interested parties to understand and practice the process of planting, nurturing and rehabilitation of peat swamp forest.

The National Park, Wildlife and Plant Conservation Department expects that this manual will be of use as a guidline for plantation and rehabilitation of degraded peat swamp forest to their natural conditions. These processes will increase flora and fauna biodiversity which, as the nation's natural resource base, will become the natural heritage for next generation.

Mr. Somchai Pienstaporn
Director General
National Park, Wildlife and Plant Conservation Department,
Thailand

Foreword

(English Edition)

Thailand has an estimated 64,555 ha of peat swamp forest cover, of which an estimated 30,967 ha occurs in Narathiwas, 18,946 ha in Nakorn Si Thammarat, 4,829 ha in Songkhla, 3,285 ha in Choomphorn, 2,767.50 in Phatthalung, 1,590 ha in Surat Thani, 1,205 ha in Pattani, 190 ha in Yala, 92 ha in Trang, 63 ha in Phuket and 47 ha in Krabi. Remaining peat swamp forests areas are located in the Eastern part of Thailand (573 ha), particularly in Trat (453 ha) and Rayong (120 ha).

Peat swamp forests provide both direct and indirect uses in many aspects related to the agricultural, forestry, and fishery industries. They also give a lot of benefits in terms of natural resources to the people who inhabit the surrounding area and play an important role in the global carbon balance and climate stabilisation. However, much of these natural habitats have been lost to due to indiscriminate human activities. One of the main problems of non-sustainable management of peat swamp forests and other wetlands in Thailand is the lack of knowledge and skills on peat swamp forest restoration techniques, as well as inadequate information and knowledge on peat swamps in general.

Mr. Tanit Nuyim has been conducting research on peat swamp forests restoration for many years. His findings have been compiled and produced in the Thai language. With the regional co-operation under the framework of the ASEAN Peatland Management Initiative (APMI), Wetlands International-Thailand Programme and the Global Environment Centre (GEC) are working to promote these findings by translating into English. I would like to take this opportunity to thank the UNEP-GEF and CIDA for providing financial support for the translation and production of this manual through GEC. I do hope that this manual will contribute to proper restoration techniques towards wise use and conservation of our precious peat swamp forests.

Asae Sayaka
Wetlands International – Thailand Office

Foreword

Thailand has an area of approximately 64,000ha of peat swamp forest, representing about 0.2% of the 30 million ha of peatland in the South East Asia region. However, Thai researchers and government agencies have undertaken a significant amount of work on peatland assessment and management. Thailand is one of the pioneers of peatland rehabilitation. This manual on peatland rehabilitation resulted from the longest running rehabilitation trials in South East Asia region.

In recent years, peatland fires have been a great concern in South East Asia including Thailand because of its increased frequency and intensity. Peatland fires have detrimental consequences on human health, food production, and biodiversity as well as climate. Peatland management in S. E. Asia has reached a critical crossroad where it is vital that degraded peat swamp forests are rehabilitated and remaining peat swamp forests protected and sustainably managed for its multi-purpose functions that benefit humankind. As peat swamp forests are complex ecosystems and have unique features and characteristics, rehabilitation efforts require specific silviculture approaches, as well as care for management of hydrology.

The publication of this manual is indeed timely, given the urgent need to address these issues. Additionally, it contributes to the work of the ASEAN Peatland Management Initiative through which ASEAN member countries develop action plans for wise use and sustainable management of peatlands.

It is hoped that this manual will serve as a guideline, promoting the rehabilitation of degraded and burnt peat swamp forests in the region. This manual was originally published in Thai and is translated into English for regional use. Translation of the original Manual into English was undertaken by Wetlands International -Thailand Office. Editing and publication has been supported by Global Environment Centre with funds provided by UNEP-GEF and CCFPI project in Indonesia.

Faizal Parish
Global Environment Centre

Preface

A peat swamp forest is an extraordinary plant community with features which are different from other types of forests. It is the habitat and breeding ground for various species of aquatic animal and plant life. It is a fishing ground, a source of fuel wood and performs vital ecological functions like flood mitigation. Peat swamp forests are therefore, areas that are ecologically important and provide monetary benefits. As such, they should be conserved. At present, only small areas of peat swamp forests remain, and most are in degraded condition and in need of rehabilitation.

This manual is a compilation of the experiences and findings of studies on peat swamp forests in which the author has been involved during the past 10 years. The information is presented in the form of descriptions, photos and tables to make it easy for readers to read, understand and carry out replanting and rehabilitation of peat swamp forests successfully.

The author is grateful to Khun Pin Kuekool and Khun Sutham Boonmee, pioneers in the experimental plots first established in 1988. Many thanks goes to the Silviculture Reserch Division, Silviculture Research and Botany Office and the Royal Initiatives and Security Projects Division, Planning and Information Office, National Park, Wildlife and Plant Conservation Department , for the support and opportunities provided to the author to indulge in this work. Appreciation also goes to Khun Chavalit Urapheephatthnaphong, former chief of Special Projects Sub-Division, Planning Division, Royal Forest Department, for his continued support and follow-up of the work. Finally, all hired workers of the Phikulthong Peat Swamp Forest Station are acknowledged for their dedication to their work and expertise in the field, and in helping to make this book a success.

Tanit Nuyim

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Chapter 1
INTRODUCTION

1.1 PEAT SWAMP FORESTS AND THEIR IMPORTANCE

The peat swamp forest is a type of wetland, waterlogged almost all year round, with plants growing on the peat surface. A peat swamp forest is characterized by evergreen forest, a type of tropical rainforest. The forest is influenced by the edaphic factor in the soil, where the area has long been clogged with fresh water (Chamlong, Chavalit and Wiwat, 1991; Thawatchai and Chavalit, 1985). From the surveys of peat swamp forests in Thailand, more than 470 plant species are found to grow in these areas. The plants found include 109 families and 437 species of flowering plants, and 15 families and 33 species of ferns (Chamlong, Chavalit and Wiwat, 1991). This is in contrast with the number of plants found growing in the mangrove forests, where 35 families and 74 species (Suntisuk, 1983) have been recorded. This reflects the complexity of the plant communities in the peat swamp forest. The forest also serves as a habitat and breeding ground for various kinds of wild animals. It has long been a fishing ground for villagers and a source of wild items, firewood, and timber. The peat swamp forest is economically important. It can be managed to provide agricultural, forestry, fishery and industrial benefits.

The forest serves to effectively maintain the balance of nature and regulate the ecosystem of the earth (Lappalainen, 1996). It is unfortunate to learn that only very little intact peat swamp forests (9,032 ha), remain in Thailand (Jirasak et al., 1999). Most of these forest areas are located in Phru Toh Daeng, Narathiwat, the last peat swamp forest in the country. It is even more deplorable to learn that at present the peat swamp forests are being encroached upon and converted for agricultural purposes, and trees are cut for timber or charcoal production to the point beyond replacement. The most disturbing problem affecting peat swamp forests is wild fires, which often ravage the area during the dry season. It is a cause for great concern to think that in the future, fertile peat swamp forests might vanish completely from Thailand. Therefore, it is vital we take steps to prevent this from happening.

Rehabilitation through planting of more plant species in the degraded areas of peat swamp forests is an effective way to restore fertility of the area. Planting and rehabilitating degraded peat swamp forests require different techniques and practices from those used for other types of forests (Tanit, 1995). To attain effective results, planters and those who are involved with planting and rehabilitation must have a thorough understanding of such techniques and practices. In addition, the process needs the application of proper technical know-how.

Photo 1.1: Peat swamp forest with trees growing on the surface of the peat in an area where there is water almost all year round.

Usage Type	**Patterns of Uses**
Direct	• A large fishing ground for villagers • A source of edible wild fruits such as *Eleiodoxa conferta, Dialium patens, Nephelium maingayi, Xylopia ferruginea,* and *Mangifera gedebe* • A source of nipah palm leaves, sagu flour, larvae growing in the rotten sagu trunks • A source of honey • A source of edible mushrooms, particularly *Boletus griseipurpureus* • A source of fern leaves for decorating flower vases • A source of edible young fern leaves such as *Blechnum indicum* and *Stenochlaena palustris* • A source of *Licaula spinosa* leaves for wrapping Thai desserts • A source of ornamental fish for rearing and selling • A source wood, firewood and timber • A source of organic or peat soil for plant seedlings and growing plants • Planting economic plants such as oil palm • Serving as a large reservoir for farms and households • A source of seeds of sealing wax palm • A source of fragrant flowering plants, valuable plants and ornamental plants • A grazing place for animals • A source of *Lepironia articulata* and *Pandanus militaris* • A source of *Lygodium salicifolium* and rattan for making basketry
Indirect	• A habitat and breeding ground for various species of wild animals • Sequestration of carbon to reduce global warming • A source for maintaining genetic existence for plants and animals • A catchment area, to help control and prevent floods • A buffer against strong winds • A source for study and research • Serves as a beautiful nature tourism attraction

Table 1.1: Significance and pattern of peat swamp forest usage in Thailand

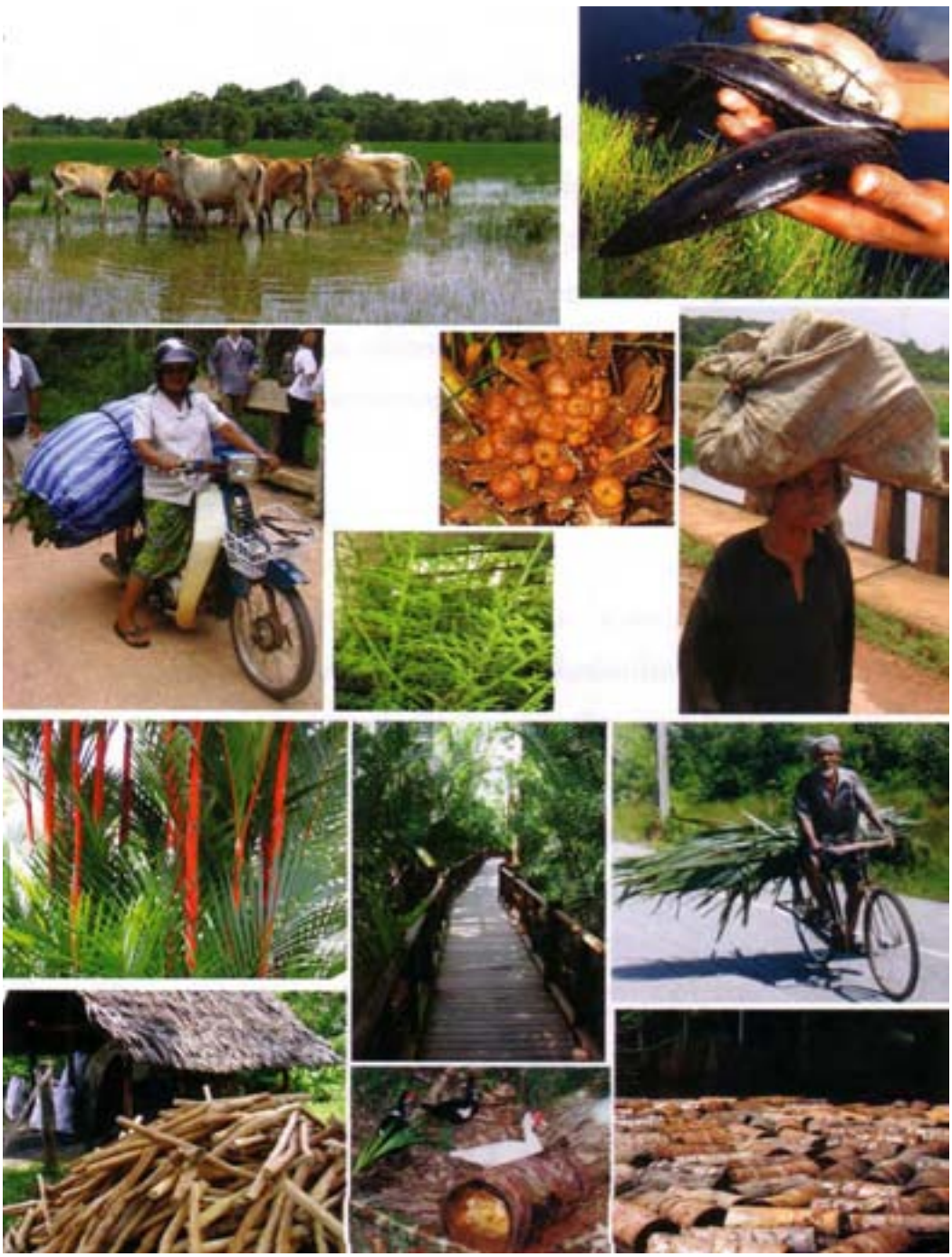


Photo 1. 2: Various forms of utilization of peat swamp forests by local villagers

1.2 DEFINITIONS

The word 'Phru' in Thai refers to a swampy and waterlogged area, filled with peat and very boggy when stepped upon (Thawatchai and Chavalit, 1985). 'Phru' is normally filled with organic matter because there is more organic matter accumulated than degraded (Gore, 1983). 'Phru' is often found in humid areas with high water content in the soil, but with a low level of bacterial activities (Reinikainen, 1976). The Thai word is synonymous with the following English words: peatland, mire, bog, fen, swamp and marsh. All of these words more or less denote the same meaning, but the usage of each word depends on differing features pertaining to geographical factors, soil nutrients, and plant species growing in the area.

Peat refers to an element of carbonized vegetation tissue caused by decomposition of vegetation and moss in the wet condition (Andriesse, 1988). Well-decomposed peat is called 'muck' (Stanek and Worley, 1983). To avoid confusion, peat soil is called organic soil (Addriesse, 1988).

Plantation is defined as 'a forest crop or stand raised artificially, either by sowing or planting'. Foreast type can be termed a afforestation when a new forest is establish on bare land where there has been no forest for at least 50 years. Reforestation refer to land which has carried forest within the last 50 years but where the previous crop is replaced by an essentially different one or by renewal of essentially the same crop as before (Evans, J., 1992)

Rehabilitation refers to a management strategy applied in degraded forest lands that aims at re-establishing site productivity, protective functions and many of the ecological services provided by a functional forest or woodland ecosystem through sowing, planting or human assistance to improve natural breeding.

1.3 DISTRIBUTION OF PEATLANDS

Peatlands in the world cover an area of about 436.2 million ha, mostly located in the temperate zone. Only 35.8 million ha or 8.2% of peatlands worldwide are found in the tropic and subtropic zones. Of these, 47.5% or 17 million ha are found in Indonesia (Andriesse, 1988), mainly in the islands of Sumatra, Kalimantan and Irian Jaya (Simbolon and Mirmanto, 1999), but most of these peatlands have been degraded (Siregar and Sambas, 1999). The country in the tropic zone that has the second largest area of peatlands is Malaysia, with a total of 2.5 million ha (Andriesse, 1988). As for Thailand, a total area of 64,555 ha has been identified as peatlands. This is mainly located in the South of Thailand (63,982 ha), particularly in Narathiwat (30,969 ha), Nakhon Si Thammarat (18,946 ha), Songkhla (4,828 ha), Choomphorn (3,285 ha), Phatthaloong (2,768 ha), Surat Thani (1,542 ha), Pattani (1,205 ha), Yala (190 ha), Trang (85 ha), Phuket (62.5 ha) and Krabi (47 ha). Peatlands are also found in the Eastern part of Thailand (572.5 ha), particularly in Trat (452.5 ha) and Rayong (120 ha). Of the total area of peatlands in Thailand, only 9,031.5 ha are considered intact peat swamp forests, especially in Phru Toh Daeng in Sungei Kolok, Tak Bai and Sungei Padi districts of Narathiwat province. The remaining area of 55,523 ha is considered degraded peat swamp forest (Jirasak et al, 1999).

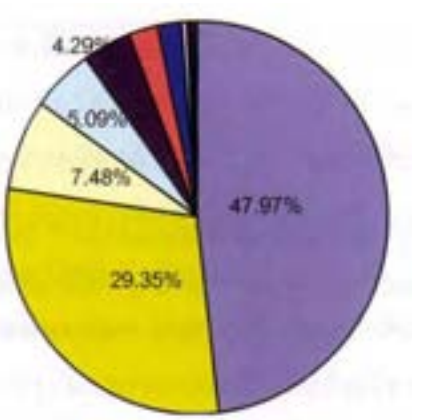


Figure 1.1: Distribution of peat swamp forests (%) in the provinces of Southern Thailand.

Peat swamp forests elsewhere also experience a similar fate like Thailand; very few areas of intact peat swamp forests remain today. In Europe, almost no primary peat swamp forests exist; only a little is found in the southern part of the continent (Brauckmann, 1996).

	Distribution	Fertile Forest (ha)	Degraded Forest (ha)	Total(ha)	Percentage of Total Area (%)
South	Narathiwat	8,978.00	21,991.50	30,969.50	47.97
	Nakhon Si Thammarat	-	18,946.00	18,946.00	29.35
	Songkhla	-	48,28.50	4,828.50	7.48
	Choomphorn	-	3,285.00	3,285.00	5.09
	Phatthaloong	-	2,767.50	2,767.50	4.29
	Surat Thani	47.50	1,542.00	1,589.50	2.46
East	Pattani	-	1,205.00	1,205.00	1.87
	Yala	-	190.00	190.00	0.29
	Trang	6.00	85.56	91.25	0.14
	Phuket	-	62.50	62.50	0.10
	Krabit	-	47.04	47.04	0.07
	Total	9,031.50	54,950.61	63,982.11	99.11
	Trat	-	452.50	452.50	0.70
	Rayong	-	120.00	120.00	0.19
	Total	-	572.50	572.50	0.89
	Whole Country	9,031.50	55,523.11	64,554.62	100.00

Table 1.2: Distribution of peat swamp forests in different provinces of Thailand
Source: *Jirasak et al. (1999)*

Note: Royal Forest Department reported area of peat swamp forests in 2000 as 190,000 rais. (Royal Forest Department, 1999) which is less than the area reported by Jirasak (Jirasak *et al*, 2002). Difference may be attributed to differing technical definitions of peat swamp forest.

1.4 RATIONALE AND NECESSITY FOR PLANTING AND REHABILITATING PEAT SWAMP FORESTS

Peat swamp forests are susceptible to changes (Phicha et al., 1994), particularly degradation (Phisut et al., 1986). The main factor bringing about such changes is the drainage of the peatland area, causing the organic soil to dry up and burn easily when ignited, to cause wild fires (Suzuki and Hara, 1995). The wild fires often cause total damage to plant species. The damaged areas, when left untouched, will be replaced by *Scleria sumatrensis* communities, *Macaranga spp*. communities, and *Melaleuca cajuputi* communities. When left untouched for a longer period of time, part of the damaged area may undergo rehabilitation through natural regeneration. However, such a process takes a long time and is difficult to achieve (Picha et al., 1994) and often only occurs in certain spots of the whole affected area (Chamlong, Chawalit and Wiwat, 1991). This is particularly true when the area is replaced by *Melaleuca cajuputi* stands, which can quickly dominate the area and prevent other species from emerging. This inhibits the regeneration of the original species in the affected area and makes it impossible for the area to return to the former state of primary forests (Chamlong, Chawalit and Wiwat, 1981).

Replanting in the degraded forests may be a viable way to accelerate the successful rehabilitation of the area. Replanting of degraded forests has been carried out for a long time in many countries. In Bavaria, Germany, replanting of degraded peat swamp forests was started in the 19th century (Schuch and Zollner, 1996). Canada started the replanting for peat swamp forests in 1960, but the program was not successful due to unsuitability of the seedlings used, poor soil preparation and ineffective drainage systems (Wells, 1991). At present, the replanting of peat swamp forests has been carried out in many countries in North America. The purpose of the program is to produce wood from these forests for the paper pulp industry (Johnson, Malterer and Maly, 1996). The private sector in Finland has also embarked on replanting peat swamp forests; at least 1.46 million rais (233,600 ha) has been replanted (Kaunisto and Paivanen, 1985). As for Thailand, during the 1982-1986 period, the Royal Forestry Department carried out the planting and rehabilitation of a total of 3,000 rais (480 ha) of peat swamp forests in in Phru Toh Daeng, Narathiwat province. However, the outcome turned out to be unsatisfactory and more studies are required in order to achieve effective planting and rehabilitation. A large wild fire occurred in the peat swamps in Narathiwat in 1998, after which many agencies stepped in to carry out the planting and rehabilitation, resulting in a total of 200-300 rais (32 – 38 ha) being replanted each year.

Photo 1.3: Replanting by man will speed up rehabilitation and reintroduce original plant species.

Chapter 2
GENERAL ENVIRONMENT CONDITIONS OF PEAT SWAMP FOREST

2.1 PLANT COMMUNITIES IN PEAT SWAMP FORESTS

Plant communities in peat swamp forests possess special plant properties, particularly the root systems, which differs from those of other plant communities. Plants in peat swamps have developed their root systems to survive in the loosely deposited peat soil, where there is extremely high water content. The plants have produced special roots in the form of buttress, which is rather large in size, and stilt roots. Because of the long periods of high water level in the soil, plants have developed pneumatophores emerging from the water, resulting in differing shapes and sizes of roots. Plant experts identify species of plants by looking at the types of the roots. For example, pin-shaped roots belong to *Stemonurus secundiflorus*, *Korthalsia laciniosa* and *Eleiodoxa conferta*. Curved loop-shaped roots belong to *Xylopia fusca* and *Calophyllum sclerophyllum*. Knee-shaped roots belong to *Ganua motleyana, Campmnosperma coriaceum* and *Alstonia spathulata*. Finally inverted Y-shaped roots belong to *Elaeocarpus macroerus*.

Compared to those of other countries, peat swamp forests in Thailand have diverse plant species, with more than 470 species and 109 families (Chamlong, Chawalit and Wiwat, 1991). In Kalimantan, Indonesia, 310 species and 78 families of plants have been recorded in the peat swamp forests (Simbolon and Mirmanto, 1999). In Russia, only 55 plant species are found in the peat swamps (Grabovilk, 1996), whereas 250 plant species are identified in all peatlands in central Europe (Brauckmann, 1996). Prominent species are found to differ in their distributions due to different topographic and environmental conditions (Dugan, 1990).

The peat swamp forests in Narathiwat account for about 48% of the total peat swamp forests in Thailand. There are two large peat swamp forests in this southern border province, i.e. Phru Toh Daeng and Phru Bacho, the latter being a degraded peat swamp forest (Mahidol University, 1987). Phru Bacho has been converted into a land settlement cooperative and the area developed for agricultural purposes, particularly for oil palm plantations. Phru Toh Daeng constitutes both the degraded area and the area with primary forest (Chamlong, Chavalit and Wiwat, 1991). For ease of management of peat swamp forests in Narathiwat, Pisut et al. (1986) have classified the areas of Phru Toh Daeng into three zones based on the plant and soil conditions.

Preservation Zone
Situated in the middle part of the peat swamp, an area of 9,105 ha in the preservation zone is filled with primary forest where various plant species of different crown heights flourish. Dominant tree species with crown heights as tall as 30 meters include *Eugenia kunstleri, Ganua motleyana,*

Campnosperma coriaceum, Macaranga pruinosa, Calophyllym sclerophyllum, Neesia malayana, Endiandra macrophylla, Eugenia oblata, Sterculia gilva, Stemonurus secundiflorus, and *Eugenia muelleri, Baccaurea bracteata* (Hara et al., 1995; Bunyavajchewin, 1995). Undergrowth include species from the Palmae and Araceae families. Dominant species are *Eleiodoxa coferta, Licuala paludosa,* and *Aglaonema marantifolium.* In addition, parasitic plants such as *Asplinium nidus, Platycerium coronarium* and *Orchidaceae* are also found growing on different levels of the barks of different trees. Among these plant species mentioned, there are numerous medicinal plants growing such as *Croton caudatus,* which is used as analgesic, and *Dalbergia parviflora* for treatment of the heart.

Conservation Zone

The conservation zone is the area where plant communities are in a degraded condition due to damage to original forests caused by the drainage of the peat swamp and ensuing wild fires (Suzuki and Hara, 1995). The zone covers an area of 112,188 rais (17,950 ha). Dominant species are *Melaleuca cajuputi* and grass species. Pioneer species such as *Macaranga spp*. are found growing in certain parts of the area (Suzuki and Hara, 1995). The conservation zone has been implemented according to the Master Plan of the Royal Initiated Project of Phikul Thong Study Center, Narathiwat. The project is aimed at restoring fertile forests in the area.

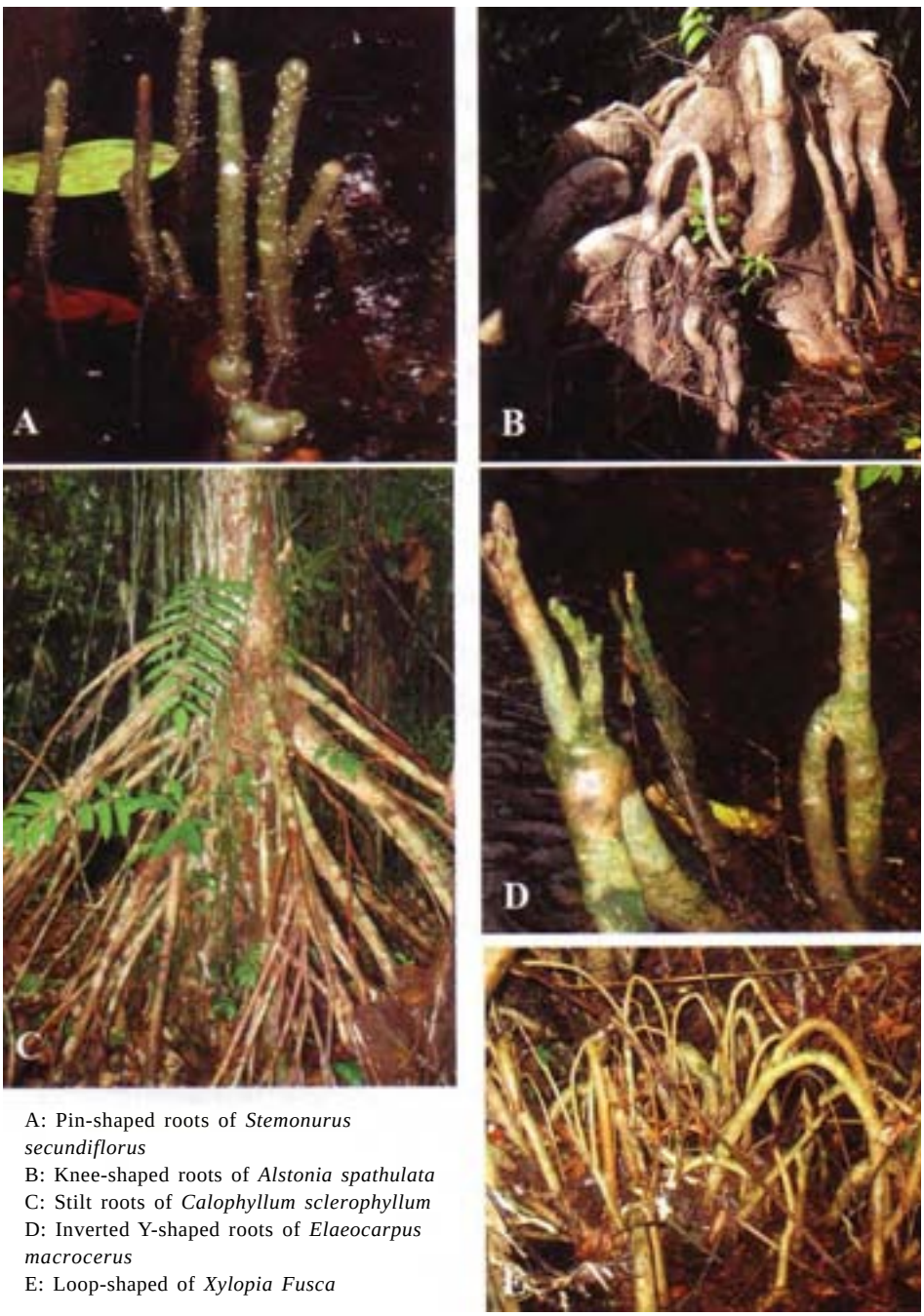
Development Zone

The development zone is the totally altered area, consisting mostly of empty fields without trees. Very little organic soil remains in the earth. The zone is designated for farming purposes or reforestation programs.

Classification of peat swamp forests in other countries is done differently. In Norway, peat swamp forests have been classified into 5 zones, based on the quality of the area (Jerven and Wisth, 1967)

2.2 SOILS IN THE PEAT SWAMP FORESTS

Much of the soil in peat swamp forests is organic or peat soil. The soil is derived from the long deposition of dead plants and animals which have been fully decomposed. Decomposition takes a long time due to the high water content. Soil thickness varies, depending on the length of time of deposition of organic matters and damaging factors such as wild fires. It has been found that the maximum thickness of organic soil in the peat swamp in Thailand is 3.8 meters (GMT Corporation Co., Ltd., 1984). This is in contrast with the much thicker organic soils found elsewhere. However, when the organic soil level has been repeatedly damaged by wild fires, nutrients in the flammable organic soil is completely burned, leaving the mineral soil intact with a high content of pyrite (FeS_2) (Vijarnsorn and Panichapong, 1987). When the top organic soil is turned over, pyrite is oxidized, thus causing the area to become acid sulphate soil, which is not suitable or not cost effective for farming. In addition, the fact that peat swamps are often flooded during the rainy season and dried and cracked up during dry season, makes it almost impossible to exploit the land for farming. The land can be used for farming only if the government invests in constructing an effective water management system or uses lime dust to improve the pH level to make it suitable for farming. But this incurs a rather high investment cost. To prevent the occurrence of acid sulphate soil, it is essential to keep the top level organic soil intact in order to cover the mineral soil beneath. Despite these natural obstacles, the soils in peat swamps are suitable for the growth of several plant species, without much management costs.



A: Pin-shaped roots of *Stemonurus secundiflorus*
B: Knee-shaped roots of *Alstonia spathulata*
C: Stilt roots of *Calophyllum sclerophyllum*
D: Inverted Y-shaped roots of *Elaeocarpus macrocerus*
E: Loop-shaped of *Xylopia Fusca*

Photo 2.1: Special characteristics of root systems of trees in peat swamp forests

A: Primary peat swamp forest (Preservation Zone)

B: Undergrowth in primary peat swamp forest

C: Natural regeneration of *Macaranga spp.* community (Conservation Zone)

D: Natural regeneration of *Melaleuca cajuputi* community (Conservation Zone)

E: Natural regeneration of *Scleria sumatrensis* community and *Stenochlaena palustris* community

Photo 2.2: Plant communities and zoning of the peat swamp forests

As for the properties of the organic soil in peat swamps, it is found that the peat soil in Thailand is of low density, between 0.1-0.2 g/ml. This is in contrast with other soils in general, which have a density of 1.3-1.6 g/ml. From this, it can be concluded that peat swamp soil is not suitable for farming (Team Consulting Engineering Co., Ltd. et al., 1990). The color of peat swamp soil varies with the depth of the soil (Grundling and Mazus, 1996), from dark gray to dark reddish brown (Takai et al., 1987). The soil is categorized as slightly decomposed to semi-decomposed fibric soil (Kyuma, 1995). The soil is highly acidic, with a pH level of 4.4 for the top soil and 4.2 for the subsoil (Takai, 1996). In Finland, the pH of the soil in primary peat swamp forests is as high as 6.1-5.8 (Matti and Viljavuuspalvely, 1982), with a high CEC value of 66-192(+)/1 kg. of soil (Takai et at., 1987). The soil also has a low content of useful phosphorus and a low percentage of base saturation (Kyuma, 1995), with a conductivity of 0.2-0.7 dS/m. It can be considered that organic soil in Narathiwat contains very little sodium content which has no effect on the plants' growth factor (Pisut, 1984). The soil also has a high carbon content (24-80%) and a high water holding capacity (200-1,000%), depending on the decomposition rate. It was also found that the soil in Narathiwat has a low content of useful nitrogen (less than 2%) and low CEC, i.e. the total sum value of Ca, Mg, Na and K of less than cmol(+)/1kg. of soil. The soil is high in acidic exchange capacity with a wide C/N ratio (Takai et al., 1996). The subsoil is a mineral soil with a high content of pyrite (FeS_2) (Vijarnsorn and Panichapong, 1987).

As for nutrients in the soil, in Narathiwat it was found that most nutrients are found not more than 25 centimeters from the surface. B and Mn are secondary nutrients whereas P and K are primary nutrients, all of which are not adequate for supporting the plants' growth (Kyuma, 1995).

Soil is the most important factor for the growth of plants. Plants acquire nutrients and water chiefly from the soil. Therefore, it is necessary to test the properties of the soil before planting.

2.3 WATER IN THE PEAT SWAMP FORESTS

Water is vital for the survival of the peat swamps forests. Water, whether in terms of quantity (water level) or quality, affects the survival and growth of plants. A water level higher than the jutting pneumatophores of the plants disrupts the respiratory and air exchange process of the trees. On the other hand, too low a water level causes organic soil to become dry and prone to damage by wild fires. The result will be the loss of plants which have adapted to the natural water regime in the peat swamp forest. Good management of peat swamp forests requires identification of the proper water level for the peat swamps.

A PVC pipe was used as a water gauge to measure the level of water in the peat swamp forests for a period of 4 years. It was found that the highest water level is 55 centimeters above the soil surface and the lowest level was 76 centimeters below the soil surface (Photos 8 and 9). The highest water level occurs in November each year and the water reaches its low level during the dry season. When the water level falls below the soil surface, peat swamp forest managers should be on the alert and take steps to prevent the occurrence of wild fires.

Water in degraded peat swamp forests has a higher concentration of phenolic compounds than that of primary forests (Panya and Apichart, 1995; Tadano, Pantanahiran and Nilnold, 1992). Tadano, Pantanahiran and Nilnond (1992) found that the concentration of phenolic compounds in degraded peat swamp forests and primary forests is 6.7 mg/l and 2.0 mg/l, respectively. It was also found that the content of dissolved phenolic compounds in the soil is higher than that in the water. In addition, the content of dissolved phenolic compounds is higher in waterlogged areas as compared to the high ground. This fact supports the study by Maciak and Harms (1987) which found that the concentration of phenolic compounds changes in accordance with the physical condition and depth of the soil. The high concentration of phenolic compounds in the water of degraded peat swamp forests retards the growth of roots of paddy stalks, making it difficult for the stalks to produce new roots. This is in

contrast with the water in primary peat swamp forests which has a low concentration of phenolic compounds, thus having no inhibiting effect on the growth of rice stalk roots (Tadano, Pantanahiran and Nilnond, 1992). Panya and Apichart (1995) found that water in degraded forests is inferior in quality due to higher temperature, higher pH level and greater conductivity. On the plus side, the amount of dissolved oxygen is higher. This is due to the fact that water in degraded forests flows faster than that in primary forests. Based on the surveys, the pH level of water in the peat swamp forests generally falls between 5.1- 6.4. The lowest level is 3.7, recorded at the edge of the peat swamp, where the water flowed across acid sulphate soil. However, water in the peat swamp forests can still be used for irrigation and as drinking water for animals.

Photo 2.3: Different characteristics of peat swamp soil

Photo 2.4: Water in the peat swamp forest and a water gauge.

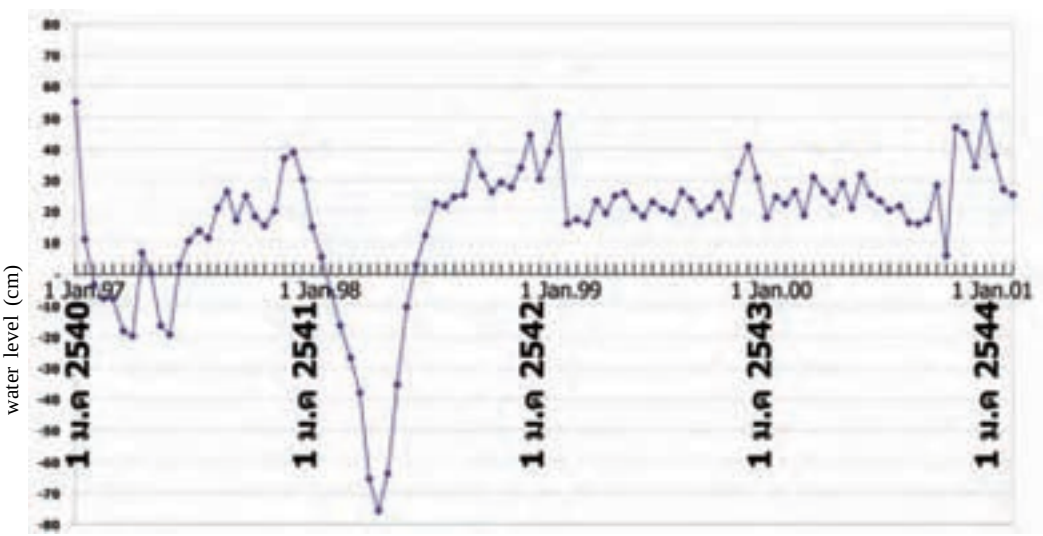


Figure 2.1: Level of water in Phru Toh Daeng measured at Phikulthong Plant Experimental Station, Sungai Kolok District, Narathiwat.

2.4 ANIMALS IN THE PEAT SWAMP FORESTS

Peat swamp forests are found to have a high degree of biodiversity in both plant and animal species. 325 vertebrate animal species have been recorded in the peat swamp forests in Thailand. Most of these animals are well adapted to the environment. Some live at the bases of the trees, in the trunks, in holes in the bark of the trees, and even around the roots of the trees. Some live on the high ground, beyond the reach of floods. It is common to see variation in the level of the ground in peat swamp forests, with some low places filled with water and higher ground areas formed around the protruding or buttress root systems of the trees.

Various aquatic animals live in the water in peat swamps. The water in peat swamps looks like the color of tea and tastes sour or astringent due to the decomposition of dead plants and other organic matter. Despite these conditions, the water in peat swamp forests is an important habitat for various species of aquatic animals. There is an abundance of fishes such as *Channa striata*, *Clarias nieuhoffi*, *Monopterus albus* and *Channa lucius*. A rare fish recently discovered in the peat swamps is *Chaca bankanensis* which has a strangely-shaped head. In addition, 17 species of amphibians have been found, such as *Ploypedates leucomystax*, and *Rana glandulosa*. *Rana glandulosa* often croaks with a high pitch voice upon sensing encroaching visitors. There are more than 196 species of birds, including woodpeckers, black hornbills and lesser adjutants. Other animals recorded for the first time in Thailand are Dayak bat, red-cheeked flying squirrel, Singaporean mouse, rufous-tailed shama, Malaysian blue flycatcher and *Rana glandulosa*. Rare and endangered species recorded include flat-headed cat, otter civet and grey-headed fish-eagle. All three species are found only in the peat swamp forests. The peat swamp forests have abundant mammals. 62 species have been found in the area, including bears, wild boars, panthers, bats, jungle cats, monkeys, langurs and squirrels. A total of 50 species of reptiles inhabit the forests.There are altogether 135 species of vertebrates living in the naturally regenerated *Melaleuca cajuputi* community, of which 89 species are birds and 21 are reptiles (Sirindhorn Peat Swamp Forest Research and Nature Study Center, 1996). Hairy-nosed otters or *Lutra sumatrana*, an endangered species, is also found living exclusively in Phru Toh Daeng (Siriphorn, Bussabong and Thanya, 2001). Other fauna, including insects such as bees and butterflies, spiders, centipedes and millipedes are also found.

Wild animals help to propagate plant species. The mammals and birds which depend on wild fruits as a source of food later drop the seeds to grow in the wild. Insects help in the successful pollination and fertilization of plants. However, wild animals may also retard the reforestation in peat swamp forests. Seeds from selected trees are often eaten and damaged by animals before seed collectors are able to gather them for growing seedlings. In addition, animals, especially monkeys, often plucked the newly planted seedlings. Insects also eat the young leaves of newly planted trees, resulting in retardation or death. Some insects such as wasps and hornets can cause harm to forest planters. Planters must be on the alert for these insects when carrying out surveys, clearance or weeding. These stinging insects with nests attached to branches or leaves are very dangerous to planters if they are disturbed. Planters must also be cautious of other poisonous animals when planting new seedlings.

A: Black and red broadbill help to propagate plant species

B: Dragonfly

C: Scorpion, a poisonous insect

D: Crab-eating macaque

E: Wasps, another poisonous insect that growers must be cautious about

Photo 2.5: Animals in the peat swamp forests

Chapter 3
PLANT SPECIES SUITABLE FOR PLANTING IN THE PEAT SWAMP FORESTS

3.1 INTRODUCTION

Selecting the right plant species for planting in a specific area is the most significant factor for success in reforestation. Planting species suited to the soil is easier, less costly and has a greater chance of success than improving the soil to suit the plants (Charoen et al., 1979). Whether a particular plant species is suited to the soil type depends on such factors as climate, soil condition, water level, the original plant species, occurrence of wild fires and presence of domesticated animals in the area. These environmental factors have strong effects on the growth and survival of the planted trees.

Plant species chosen should be those that can grow and survive in the planting area. If several species are found to be suitable for planting, choose the species that provides the most benefits, has the shortest growth period, meet other requirements and cost the least. These are the factors to be considered when carrying out reforestation. Growers must bear in mind the two purposes of reforestation in general. Protection plantations are meant to provide general benefits to humans. This type of plantation utilises mixed planting of different species. Production or economic plantations, on the other hand, are developed and managed to provide beneficial resources such timber, medicinal plants and raw material for the paper pulp and animal feed industries. Only a few selected species are planted in this type of plantation. Trees may be planted in the model of community forest or community food bank. Factors to be considered in selecting plants for this type of plantation include seedling production capacity, budding capacity of the plants after cutting, resistance to wild fires, planting cost, capacity in regulating propagation and effects on other plant communities.

3.2 SPECIES SUITABLE FOR PLANTING IN PEAT SWAMP FORESTS

The Forestry Unit of Pikulthong Royal Development Study Project has studied planting Peat Swamp Forest species in oreder to select suitable species for rehabilitation of degraded peat swamp forests. The experiment consisted of establishment of experimental plots in 1988 and 1993. Plant species cultivated in the experimental plot of 1988 consisted of 15 species including; *Macaranga pruinosa, Eugenia kunstleri, Ganua motleyana, Sterculia gilva, Stemonurus secundiflorus, Dialium patens, Melaleuca cajuputi, Eugenia oblata, Baccaurea bracteata, Horsfieldia crassifolia, Vatica pauciflora, Acacia mangium, Fagraea fragrans, Polyalthia lateriflora and Salix* sp. Plant species cultivated in the experimental plot of 1993 consisted of 15 species namely; *Cinnamomum rhychophyllum, Alstonia spathulata, Ixora grandifolia, Polyalthia glauca, Mangifer griffithii, Calophyllum sclerophyllum, Neesia malayana, Persea membranacea, Dacryodes incurvata,*

Sandoricum beccarianum, Litsea costata, Campnosperma coriaceum, Garcinia bancana, Aglaia rubiginosa and Xanthophyllum ellipticum.

Studies revealed that indigenous plant species have the best growth potential and are suitable for planting in peat swamp forests. These plant species include *Macaranga pruinosa, Eugenia kunstleri, Eugenia oblata, Sterculia gilva, Baccaurea bracteata, Calophyllum sclerophyllym, Compnosperma coriaceum, Sandoricum beccarianum, Alstonia spathulata* and *Ixora grandifolia* (Tanit, 1990; Tanit et al, 1997). Growth rates of each species differ, with some species having rapid growth rate during the initial stage of planting such as *Acacia mangium, Fagraea fragrans* and *Cinnamomum rhychophyllum* while the others show a slower growth rate during initial stage but the growth rate became rapid when root system has completely developed such as *Aglaia rubiginosa* and *Stemonurus secundiflorus*. Some plant species have contiunously rapid growth rate from initial stage such as *Melaleuca cajuputi, Eugenia oblata, Alstonia spathulata* and *Calophyllum sclerophyllum* while some species have contiunously slow growth rate from initial stage such as *Polyalthia lateriflora*. Three to five years is not enough to assess success of growth of plant species cultivated in peat swamp forests. There is a need of appropriate times such as 15-20 years for this study.

Photo 3.1: Experiment selection plot for planting Peat Swamp Forest plant species

The information on growth rate of plant species from this study has been used as an index to divide Peat Swamp Forest plant species into 3 categories: fast, medium and slow growing trees which display growth rates of less than 30 cm, between 30-60 cm and in excess of 60 cm per year respectively. Results from the study show that *Polyalthia lateriflora, Cinnamomum rhychophyllum, Mangifer griffithii, Polyalthia glauca, Litsea costata* and *Garcinia bancana* are slow growing trees; *Stemonurus secundiflorus, Macaranga pruinosa, Eugenia kunstleri, Ganua motleyana, Sterculia gilva, Dialium patens, Baccaurea bracteata, Horsfieldia crassifolia, Vatica pauciflora, Persea membranacea, Dacryodes incurvata, Sandoricum beccarianum, Campnosperma coriaceum, Aglaia rubiginosa, Xanthophyllum ellipticum, Ixora grandifolia* and *Neesia malayana* display medium growth rates, while rapid growth rate trees consist of *Melaleuca cajuputi, Eugenia oblata, Calophyllum sclerophyllum* and *Alstonia spathulata.* Table 3.1, 3.2 and 3.3 display additional information on botanical and silvicultural charateristics of some of the plant species. Information on growth rates is displayed in Table 3.4 and Graph 1-6.

Melaleuca cajuputi, which thrives well in peat swamp forests, is found in the regenerated peat swamp forest, not the in the original forest. In addition, this plant species generally grows in a pure forest stand, not suitable for rehabilitation purpose. However, it can be planted for other purposes such as planting in community forests or economic plantations. Exotic trees such as *Acacia mangium*, are not suitable for peat swamp forest because although they may grow well in the initial stage, they die eventually (Tanit, Somboon and Wirote, 1995). The German experience also proves the same. Contorta pine trees in Germany are also exotic trees for peatlands. The trees grow well at the beginning but later suffer dieback, and are susceptible to diseases and insect damage (Paavilainen and Paivanen, 1995). Planting exotic trees may also alter the conditions of the peat swamp forests.

Certain non-peat swamp plant species thrive well in large scale economic plantations in peatlands where the water level is regulated. *Acasia crassicarpa* has been grown for pulp by the Riau Pulp and Paper (APRIL) Company in Riau, Sumatra, Indonesia and the results have been satisfactory. However, it should be cautioned that drainage of peatlands for such plantations may induce subsidence and fires.

Rehabilitation of the peat swamp forests requires planting of mixed species. Fast growing species should be cultivated for 60-70% of all the seedlings. The aim is to allow the fast growing trees to cover the area as soon as possible. The rapid growth of these trees will decrease the problem of weeds and reduce social pressure from the general public who may view the rehabilitation scheme as a failure, if growth is too slow. In addition, the purpose of rehabilitation is to simulate the natural growth of the plant species as much as possible. Therefore, it is necessary to plant undergrowth species such as *Eleiodoxa conferta* and *L. longecalycata*. During the replacement of the withered seedlings in the following year, more undergrowth species should be planted.

Thirty species were experimented with in the process to identify suitable species for rehabilitation of degraded peat swamp forests by the Phikul Thong Development Study Center (Table 3). The species were planted in 1988 and 1993, the growth and survival rates are shown in Table 4 and 5.

Photo 3.2: *Acacia mangium* thrives well during the initial stage of planting. However, they die off when the trees grow older (about 5 years old).

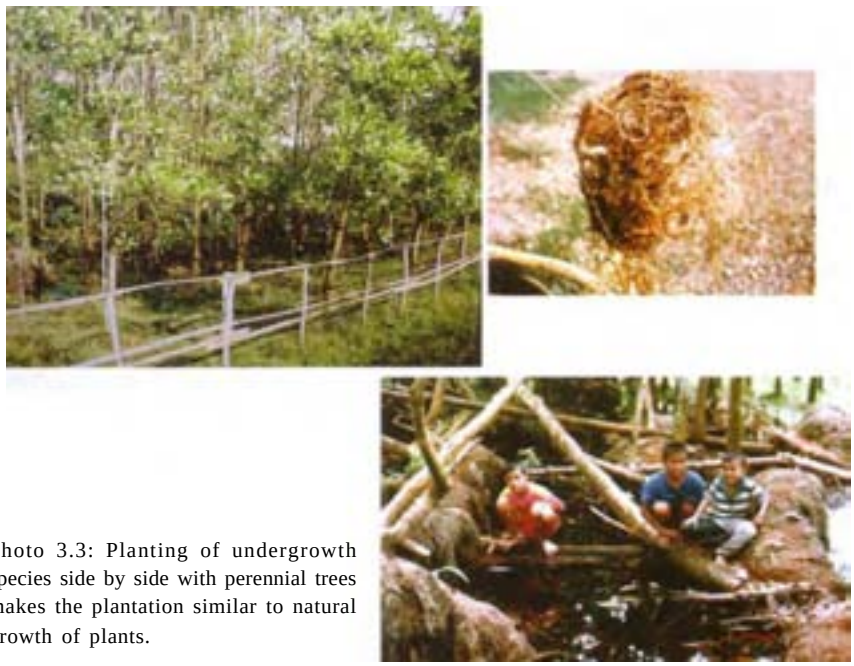


Photo 3.3: Planting of undergrowth species side by side with perennial trees makes the plantation similar to natural growth of plants.

		Species	
No.	**Year of Planting**	**Scientific Name**	**Thai Common Name**
1	1988	*Macaranga pruinosa*	Mahang Yai
2		*Eugenia kunstleri*	Waa hin
3		*Ganua motleyana*	Sa tieo
4		*Sterculia gilva*	Po song si
5		*Stemonurus secundiflorus*	Aai baao
6		*Dialium patens*	Thia
7		*Melaleuca cajuputi*	Samet khaaw
8		*Eugenia oblata*	Waa nam
9		*Baccaurea bracteata*	Ramai paa
10		*Horsfieldia crassifolia*	Lueat khwaai bai yai
11		*Vatica pauciflora*	Sak nam
12		*Acacia mangium*	Kra thin te pha
13		*Fagraea fragrans*	Kan krao
14		*Polyalthia lateriflora.*	Kluai
15		*Salix spp.*	Krai nam
16	1993	*Cinnamomum rhynchophyllum*	Tae yo
17		*Alstonia spathulata*	Ka bui
18		*Ixora grandifolia*	Khem yai
19		*Polyalthia glauca*	Taa raa
20		*Mangifera griffithii*	Mamung raawaa
21		*Calophyllum sclerophyllum*	Tanghon bai yai
22		*Neesua malayana*	Chaang hai
23		*Persea membranacea*	Kathang thuu
24		*Dacryodes incurvata*	Kaap oi
25		*Sandoricum beccarianum*	Sathon nok
26		*Litsea costata*	Kathang paa
27		*Campnosperma coriaceum*	Khee non phru
28		*Garcinia bancana*	Chamuang paa
29		*Aglaia rubiginosa*	Chomphuu samet
30		*Xanthophyllum ellipticum*	Chum saeng nam

Table 3.1: List of plant species cultivated in experimental selection plots in 1988 and 1993 for rehabilitation of the peat swamp forests in Phru Toh Daeng, Narathiwat.

Age (year)	*Macaranga pruinosa*			*Eugenia kunstleri*			*Ganua motleyana*			*Sterculia gilva*			*Stemonurus secundiflorus*		
	D10 (cm)	H (m)	S (%)	D10 (cm)	H (m)	S (%)	D10 (cm)	H (m)	S (%)	D10 (cm)	H (m)	S (%)	D10 (cm)	H (m)	S (%)
1															
2	2.97	1.80	62	2.17	1.35	86	1.83	1.23	92	3.39	1.57	85	1.64	0.83	79
3	4.53	2.42	48	3.75	1.87	82	2.69	1.67	91	4.73	2.18	85	2.59	1.24	73
4	4.83	2.62	48	3.82	1.88	82	2.98	1.78	91	4.84	2.19	85	2.67	1.26	73
5	5.14	2.71	48	5.1	2.15	82	3.67	1.99	91	5.91	2.41	85	3.58	1.50	73
6	5.67	2.79	47	6.96	2.97	82	4.46	2.20	90	6.75	2.70	85	4.62	1.75	73
7	6.31	2.93	47	7.14	3.21	82	5.33	2.37	90	7.22	2.70	84	4.99	1.82	73
8	6.87	3.36	47	8.04	4.03	82	5.97	2.77	90	8.11	3.03	84	5.57	2.16	73
9	8.38	3.93	47	9.3	4.55	82	7.24	3.36	88	9.56	3.73	84	6.93	2.76	72
10	8.83	4.36	47	9.71	5.13	80	7.83	3.58	88	10.28	3.96	84	8.12	3.12	72
11	9.87	5.05	47	10.86	5.92	80	8.52	4.33	88	11.51	4.43	84	8.84	3.56	72
12	11.25	5.88	47	12.21	6.50	78	9.95	5.01	88	12.08	4.81	84	10.3	4.20	71
13	13.33	6.48	47	13.4	6.94	70	11.18	5.87	87	12.69	5.69	84	11.5	4.60	71
14	14.48	6.96	46	13.55	7.38	68	12.42	6.63	87	13.43	5.86	84	12.51	5.17	71

Age (year)	*Dialium patens*			*Melaleuca cajuputi*			*Eugenia oblata*			*Baccaurea bracteata*			*Horsfieldia crassifolia*		
	D10 (cm)	H (m)	S (%)	D10 (cm)	H (m)	S (%)	D10 (cm)	H (m)	S (%)	D10 (cm)	H (m)	S (%)	D10 (cm)	H (m)	S (%)
1															
2	1.6	1.36	81	5.96	3.53	88	3.7	2.15	83	3.67	2.49	89	2.45	1.09	83
3	2.59	2.13	76	7.87	5.05	88	5.57	3.32	83	5.34	2.69	87	3.59	1.57	82
4	2.65	2.19	76	8.24	5.10	88	5.71	3.30	83	5.4	2.73	87	3.66	1.58	82
5	3.04	2.46	76	10.79	5.96	88	6.48	4.05	82	6.15	2.96	87	5.04	1.75	82
6	3.96	2.63	76	12.51	6.67	88	7.67	4.90	81	6.88	3.11	87	6.00	1.93	80
7	4	2.74	76	13.94	6.69	86	7.85	5.06	81	7.02	3.12	87	6.20	2.15	80
8	4.54	3.01	76	14.61	7.34	85	8.77	5.33	81	7.21	3.56	87	6.84	2.69	79
9	5.27	3.82	76	15.84	8.58	83	9.13	5.77	81	8.06	4.04	87	8.72	3.52	79
10	5.63	4.20	76	16.28	8.67	83	9.58	5.83	81	8.39	4.47	87	9.76	4.07	79
11	6.02	4.80	76	18.09	9.22	83	9.71	6.25	81	8.67	5.10	87	10.72	5.05	79
12	6.49	4.93	75	19.21	9.53	78	10.77	6.56	81	9.53	5.94	87	12.57	6.04	79
13	6.87	5.27	74	19.89	9.70	62	11.14	7.10	73	10.66	6.74	86	14.88	6.83	79
14	7.17	5.75	71	20.02	9.90	41	11.69	7.69	68	11.1	7.21	81	15.82	7.63	78

Age (year)	*Vatica pauciflora*			*Acacia mangium*			*Fagraea fragrans*			*Polyalthia lateriflora*			
	D10 (cm)	H (m)	S (%)	D10 (cm)	H (m)	S (%)	D10 (cm)	H (m)	S (%)	D10 (cm)	H (m)	S (%)	
1													
2	1.74	1.48	65	10.94	7.66	78	3.46	1.99	64	1.4	0.69	19	
3	3.05	2.12	49	13.53	10.76	78	4.93	2.87	62	4.93	0.90	17	
4	3.41	2.20	49	13.58	10.73	78	5.14	2.96	62	2.04	0.94	17	
5	3.82	2.29	49				5.16	3.07	60	2.36	0.97	17	
6	4.03	2.36	49				5.19	3.60	58	2.55	1.00	16	
7	4.48	2.47	49				5.26	3.66	48	2.78	1.12	16	
8	5	2.70	49				5.43	3.76	48	3.11	1.26	14	
9	6.18	3.26	49				6.44	4.03	47	3.82	1.56	14	
10	6.67	3.46	49		died		7.12	4.10	46	4.14	1.84	13	
11	7.28	3.81	49				7.49	4.71	45	4.81	2.10	12	
12	8.18	3.94	48				7.95	4.78	43	5.39	2.33	12	
13	8.77	4.14	48				8.54	5.31	27	6.11	2.49	11	
14	9.09	4.25	48				9.32	5.58	24	6.55	2.74	11	

Note: D10 = diameter of trunk at 10 centimeters above the ground; H = height from ground to crown; S = percentage of survival

Table 3.2: Growth and survival rates of seedlings in the experimental selection plot cultivated in 1988 for rehabilitation of the degraded peat swamp forests in Narathiwat.

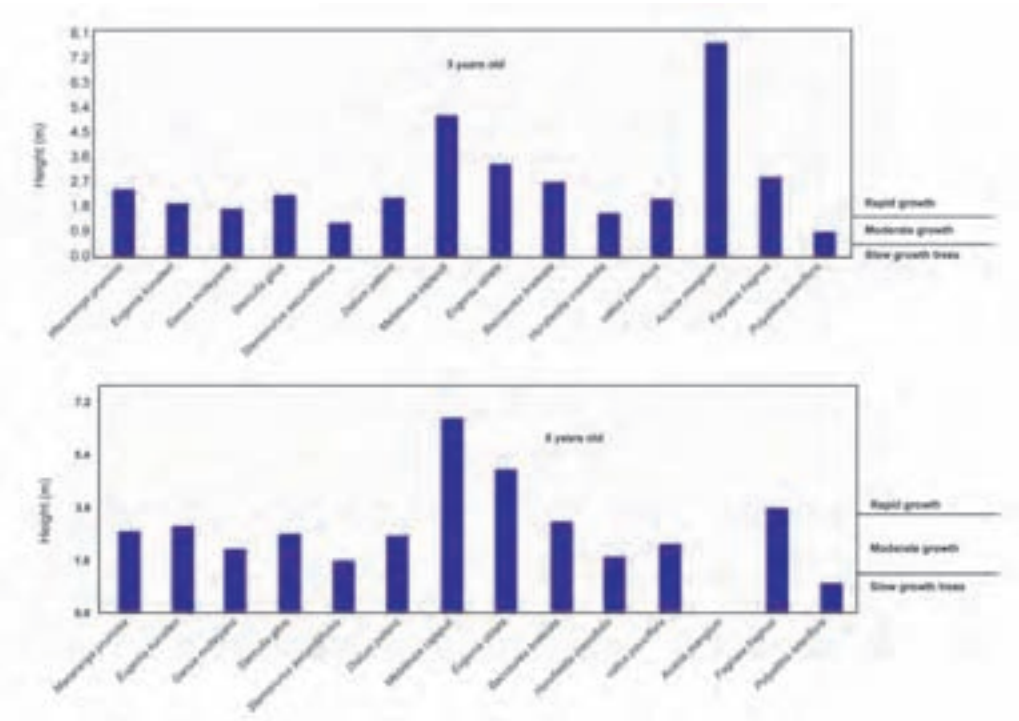
Age (year)	*Cinnamomum rhynchophyllum*			*Alstonia spathulata*			*Ixora grandifolia*			*Polyalthia glauca*			*Mangifera griffithii*		
	D10 (cm)	H (m)	S (%)	D10 (cm)	H (m)	S (%)	D10 (cm)	H (m)	S (%)	D10 (cm)	H (m)	S (%)	D10 (cm)	H (m)	S (%)
1	1.77	0.91	82	3.99	1.22	97	1.47	0.78	97	1.08	0.62	90	1.11	0.05	90
2	3.08	1.26	79	6.65	1.65	97	2.64	1.42	97	1.52	0.82	76	1.74	0.76	81
3	4.16	1.51	79	10.58	1.97	97	3.19	1.85	97	1.83	0.97	76	2.25	0.98	81
4	5.59	1.79	78	13.12	2.46	97	4.2	2.20	97	2.43	1.12	76	2.99	1.11	81
5	7.36	2.19	78	17.98	2.86	97	5.59	2.69	81	3.23	1.42	68	4.03	1.40	81
6	8.37	2.46	78	22.19	3.94	97	5.8	3.17	79	3.6	1.68	66	4.77	1.55	81
7	8.8	2.57	75	27.43	4.76	97	6.41	3.29	79	4.08	1.73	60	5.05	1.60	81
8	9	2.24	73	36.17	5.95	97	6.98	3.32	79	4.68	1.81	60	5.59	1.63	79
9	9.47	2.42	70	39.78	6.72	97	7.48	3.51	79	5	1.90	56	6	1.88	79

Age (year)	*Calophyllum sclerophyllum*			*Nersua malayana*			*Persea membranacea*			*Diacyodes incurvata*			*Sandoricum beccarianum*		
	D10 (cm)	H (m)	S (%)	D10 (cm)	H (m)	S (%)	D10 (cm)	H (m)	S (%)	D10 (cm)	H (m)	S (%)	D10 (cm)	H (m)	S (%)
1	1.37	0.86	96	1.36	0.42	75	0.73	0.46	82	0.69	0.35	35	1.43	0.85	81
2	2.53	1.69	94	2.41	0.86	69	2.29	1.15	72	1.3	0.75	22	2.41	1.43	79
3	3.62	2.55	94	3.24	1.26	67	2.92	1.55	69	1.92	0.91	11	3.39	1.79	78
4	4.91	3.36	94	4.14	1.44	67	3.92	1.91	69	3.24	1.61	11	4.33	2.51	78
5	6.44	4.34	94	5.22	1.85	67	5.4	2.02	69	3.82	1.85	11	5.9	3.15	74
6	7.71	5.02	94	5.99	2.27	65	5.72	2.23	67	4.3	2.17	11	6.58	3.58	72
7	8.36	5.48	93	6.65	2.41	62	5.53	2.47	54	4.73	2.30	10	6.92	3.65	72
8	9.01	6.06	90	7.67	2.52	62	5.78	2.55	41	6.15	3.15	6	7.62	3.88	71
9	9.51	6.50	90	8.2	2.73	60	5.94	2.93	37	7.04	3.26	6	8.11	4.23	71

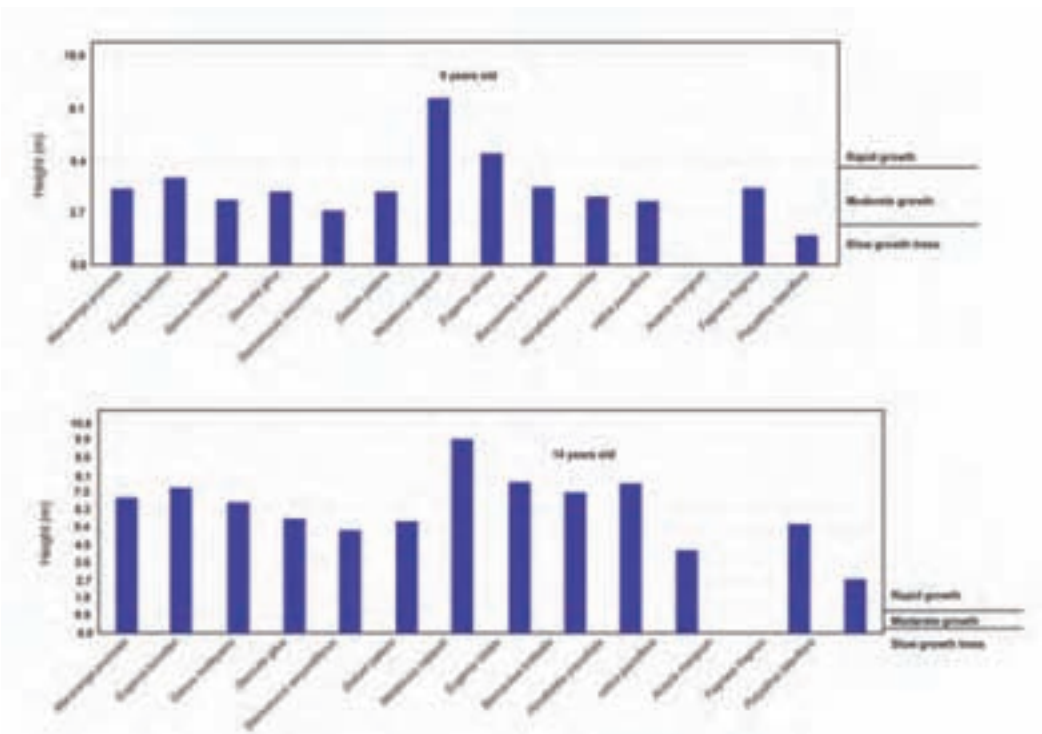
Age (year)	*Litsea costata*			*Campnosperma coriaceum*			*Garcinia hancana*			*Aglaia rubiginosa*			*Xanthophyllum elipticum*		
	D10 (cm)	H (m)	S (%)	D10 (cm)	H (m)	S (%)	D10 (cm)	H (m)	S (%)	D10 (cm)	H (m)	S (%)	D10 (cm)	H (m)	S (%)
1	1.26	0.77	79	2.12	0.34	90	0.71	0.60	63	0.87	0.35	60	0.88	0.51	89
2	1.4	0.79	47	3.94	0.90	88	1.09	0.91	61	1.27	0.60	42	1.46	0.88	81
3	1.48	0.99	29	5.85	1.32	88	1.49	1.15	58	1.72	0.88	24	2.02	1.08	76
4	1.97	1.20	28	7.47	1.74	88	1.94	1.25	53	2.53	1.20	20	2.95	1.63	75
5	2.34	1.35	24	9.41	2.35	88	2.99	1.43	49	4.37	2.19	15	5.33	2.50	61
6	2.71	1.90	18	11.08	3.23	88	4.08	1.68	30	5.44	2.24	15	6.32	3.48	60
7	3.06	1.87	16	12.8	3.76	88	4.13	1.81	25	5.85	2.39	15	7.56	3.60	49
8	3.38	1.73	15	15.83	4.29	88	5.33	2.12	11	3.84	2.73	14	8.79	3.98	36
9	3.83	1.94	14	17.38	4.54	88	5.46	2.74	8	7.05	3.12	14	8.99	4.30	35

Note: D10 = diameter of trunk at 10 centimeters above the ground; H = height from ground to crown; S = percentage of survival

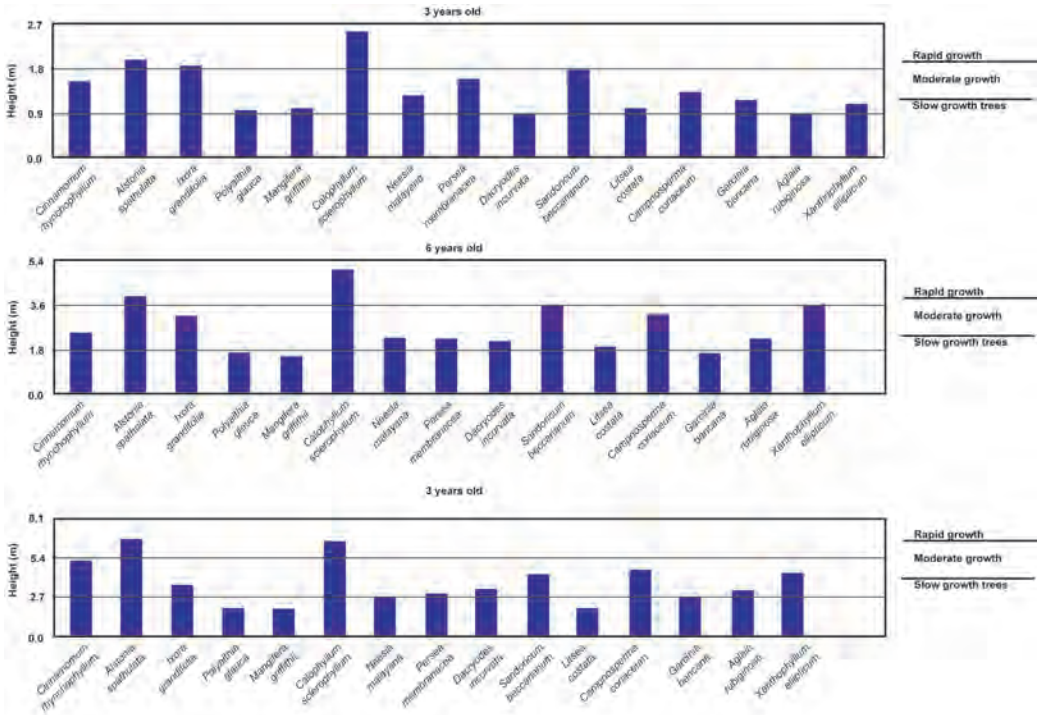
Table 3.3: Growth and survival rates of seedlings in the experimental selection plot cultivated in 1993 for rehabilitation of the degraded peat swamp forests in Narathiwat.



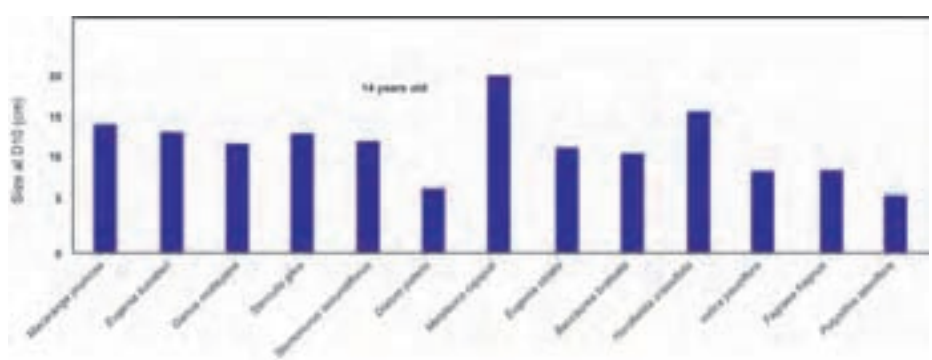
Graph 1: Growth rates of 14 plant species of 3 and 6 years old in the 1988 planting plot



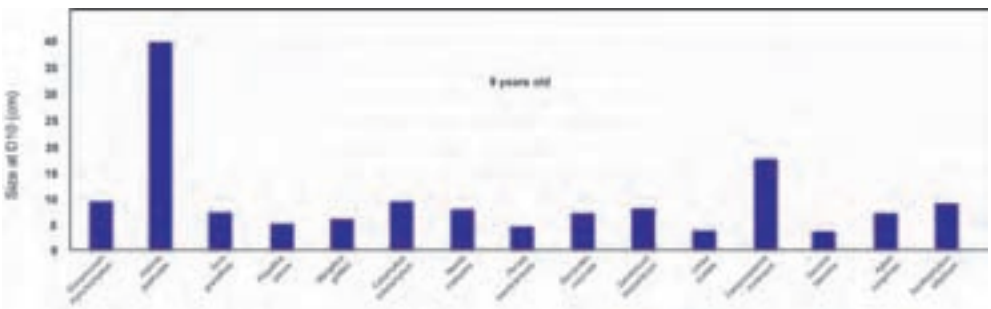
Graph 2: Growth rates of 14 plant species of 9 and 12 years old in the 1988 planting plot



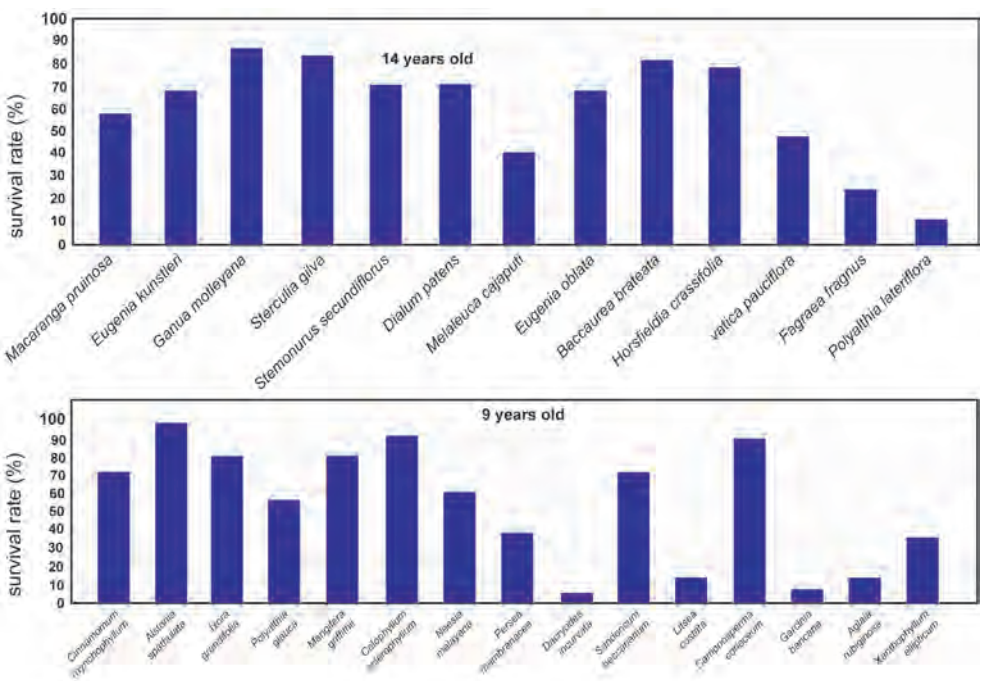
Graph 3: Growth rates of 15 three, six and nine-year old plant species in the 1993 planting plot



Graph 4: Growth rate in diameter-size (m) of 13 fourteen-year old plant species in the 1988 planting plot



Graph 5: Growth rate in diameter-size (m) of 15 nine-year old plant species in the 1993 planting plot



Graph 6: Survival rates of 28 plant species of 14 and 9 years old in the 1988 and 1993 planting plots respectively

categories	3 years	6 years	9 years
Slow growth trees (growth less than 30 cm./year)	**(< 90 cm.)** *Polyalthia lateriflora, Aglaia rubiginosa*	**(< 180 cm.)** *Stemonurus secundiflorus, Polyalthia lateriflora, Garcinia bancana, Polyalthia glauca, Mangifera griffithii*	**(< 270 cm.)** *Polyalthia lateriflora, Cinnamomum rhynchophyllum, Litsea costata, Mangifera griffithii, Garcinia bancana*
Moderate growth trees (growth between 30-60 cm./ year)	**(90-180 cm.)** *Stemonurus secundiflorus, Cinnamomum rhynchophyllum, Polyalthia glauca, Horsfieldia crassifolia, Mangifera griffithii, Neesia malayana, Persea membranacea, Dacryodes incurvata Sandoricum beccarianum, Litsea costata, Campnosperma coriaceum, Garcinia bancana, Xanthophyllum ellipticum*	**(180-360 cm.)** *Macaranga pruinosa, Eugenia kunstleri, Ganua motleyana, Sterculia gilva, Dialium patens, Baccaurea bracteata, Horsfieldia crassifolia, Vatica pauciflora, Fagraea fragrans, Litsea costata, Cinnamomum rhynchophyllum, Ixora grandifolia, Persea membranacea, Dacryodes incurvata, Xanthophyllum ellipticum, Sandoricum beccarianum, Campnosperma coriaceum, Aglaia rubiginosa,*	**(370-540 cm.)** *Macaranga pruinosa, Eugenia kunstleri, Sterculia gilva, Dialium patens, Baccaurea bracteata, Vatica pauciflora,, Horsfieldia crassifolia, Fagraea fragrans, Stemonurus secundiflorus, Ixora grandifolia, Neesia malayana, Dacryodes incurvata, Sandoricum beccarianum, Campnosperma, Aglaia rubiginosa, Xanthophyllum ellipticum*
Rapid growth trees (growth more than 60 cm./year)	**(> 180 cm.)** *Macaranga pruinosa, Eugenia oblata, Eugenia kunstleri, Sterculia gilva, Baccaurea bracteata, Vatica pauciflora, Dialium patens, Acacia mangium, Melaleuca cajuputi, Fagraea, Alstonia spathulata, Ixora grandifolia, Calophyllum sclerophyllum*	**(> 360cm.)** *Eugenia oblata, Melaleuca cajuputi, Alstonia spathulata, Calophyllum sclerophyllum*	**(> 540 cm.)** *Eugenia oblata, Melaleuca cajuputi, Alstonia spathulata, Calophyllum sclerophyllum*

Table 3.4: Growth summary of peat swamp forest plant species categorised by slow, moderate and rapid growth species.

Information on botanical and silvicultural characteristics of some Peat Swamp Forest plant species

Twenty-seven plant species have been planted in selected experimental plots of degraded Peat Swamp Forests at Sungai Kolok District, Narathiwat, for rehabilitation of Peat Swamp forests carried out by Pikulthong Royal Development Study Project (Forestry Unit). Additional information on these species are as below:

1. *Macaranga pruinosa* (Miq.) Muell. Arg.

Thai Name: Mahang yai, Mahang
Family: EUPHORBIACEAE

General Characteristics: A medium-sized perennial tree with buttress and noose-shaped pneumatophores, palm-shaped simple leaves with three-prong apex. Small light green flower, inflorescence, a schizocarp fruit having two sections with two seeds.
Flowering and Fruitage Period: Flowering during the period of March to April, fruits ripen during the period of June to August.
Ecological Characteristics: It is a pioneer plant that regenerates well after wild fires. It can be found in the peat swamp forests in the Southern part of Thailand. Sometimes, it can be found growing densely as monospecific forest stands covering a large area.
Seedling Preparation: Seedlings are prepared from seeds. One kilogram of *Macaranga pruinosa* seeds consists of approximately 163,700 seeds. One kilogram of the fruits contains 15,900 fruits. A seed germinates 50 days after sowing. A five-month old seedling stands 40 centimeters tall, ready to be selected for transplanting in polythene bags. Survival rate is high at almost 100%.
Other Information: *Macaranga spp.* found in the peat swamp forests are of two types: *Macaranga pruinosa* and *Macaranga griffithiana*. *Macaranga pruinosa* has stipule whereas *Macaranga griffithiana* has none. Both types have an extended crown not taller than 5 meters.
Growth Information: It is a fast growing tree that can be cultivated with a good survival rate in the peat swamp forests. The growth rate is shown in Table 4, and Graphs 1 and 3.
Uses: It is a semi-hard wood, used for indoor structures such as flooring and partitions.

Photo 3.4: *Macaranga pruinosa* (Miq.) Muell. Arg.

2. *Eugenia kunstleri* King

Thai Name: Waa hin
Family: MYRTACEAE

General Characteristics: A medium-sized perennial tree with grooved bark and knee-shaped pneumatophores, lanceolate simple leaves budding in opposite directions. Small white flowers bud from flowering branches, in inflorescence; a light green or white fruit has one or two seeds.
Flowering and Fruitage Period: Flowering is during the period of July to September; fruits ripen during the period of October to December.
Ecological Characteristics: It is found in waterlogged areas and in the peat swamp forests in Southern Thailand.
Seedling Preparation: Seedlings are prepared from seeds. One kilogram of the seeds of *Eugenia kunstleri* consists of approximately 370 seeds. One kilogram of the fruits (with skin) contains 138 fruits. A seed germinates 15-25 days after sowing. A 20-month old seedling stands 70 centimeters tall, ready to be pulled for transplanting in the polythene bags and the survival rate is high. Plenty of seeds can be found in the peat swamp forests.
Other Information: It is a fast growing tree with purplish young leaves, very colorful when grown in a large plot.
Growth Information: It is a fast growing tree in the peat swamp forests. The growth rate on mounds is almost double during the first five years of cultivation. Growth rate is shown in Table 5, and Graphs 1 and 3.
Uses: Fruits from *Eugenia kunstleri* are a source of food for animals. The wood is used in general construction work.

Photo 3.5: *Eugenia kunstleri* King

3. *Ganua motleyana* Pierre ex Dubard

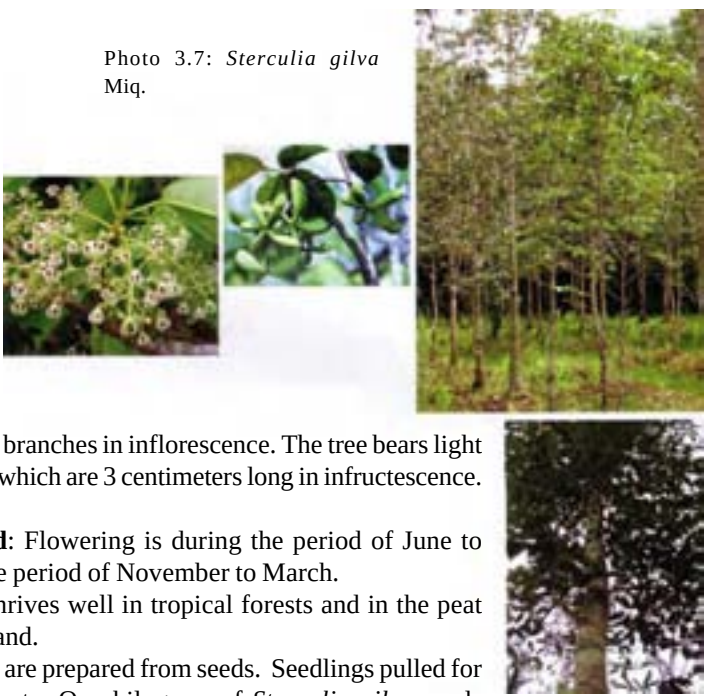
Photo 3.6: *Ganua motleyana* Pierre ex Dubard

Thai Name: Sa tieo
Family: SAPOTACEAE

General Characteristics: A medium to large sized perennial tree with knee-shaped pneumatophores. The bark produces a whitish latex. It has simple leaves budding alternately in opposite directions. The leaf blade is tough and leather-like. The white flower looks similar to the flower of the bullet wood or mimusops, budding from leaf axils and flowering branches in inflorescence. A spherical-shaped fruit has one or two seeds.
Flowering and Fruitage Period: Flowering during the period of May to September; fruits ripen during the period of October to April.
Ecological Characteristics: It thrives well in the lowland, waterlogged tropical forests and in the peat swamp forests in Southern Thailand.
Seedling Preparation: Seedlings are prepared from seeds. A seed germinates 25 days after sowing. A 10-month old seedling stands 55 centimeters tall.
Other Information: It is a plant species that easily adapts to its surroundings with a high survival rate.
Growth Information: Growth rate is slow during the first 10 years. However, it increases after the tenth year as shown in Table 5, and Graphs 1 and 3.
Uses: The wood is used in indoor construction and for dug boats.

4. *Sterculia gilva* Miq.

Photo 3.7: *Sterculia gilva* Miq.



Thai Name: Po song si
Family: STERCULIACEAE

General Characteristics: A medium to large sized perennial deciduous tree with smooth dark gray bark and simple leaves budding in alternate opposite directions. The underside of the leaf blade is slightly hairy. Small creamy white flowers bud from flowering branches in inflorescence. The tree bears light green or white renal-shaped fruits which are 3 centimeters long in infructescence. Each fruit has one or two seeds.
Flowering and Fruitage Period: Flowering is during the period of June to September; fruits ripen during the period of November to March.
Ecological Characteristics: It thrives well in tropical forests and in the peat swamp forests in Southern Thailand.
Seedling Preparation: Seedlings are prepared from seeds. Seedlings pulled for replanting have a high survival rate. One kilogram of *Sterculia gilva* seeds

consists of approximately 1,000 seeds. One kilogram of its fruits (with skin) contains 280 fruits. A seed germinates 7-15 days after sowing. A 10-month old seedling stands 55 centimeters tall.
Other Information: It is a deciduous plant and the leaves are susceptible to attack by insects.
Growth Information: The plants can grow well in degraded peat swamp forests. The growth rate is shown in Table 4, and Graphs 1 and 3.
Uses: Wood from *Sterculia gilva* is used for producing plywood, construction support and paper pulp. The bark contains tough fibers suitable for making ropes.

5. *Stemonurus secundiflorus* Bl.

Thai Name: Aai baao
Family: ICACINACEAE

General Characteristics: A small to medium sized perennial tree with numerous knotty swellings for respiration. Cutting the bark produces sound similiar to uncorking of a soft drink bottle. It has pin-shaped pneumatophores around the base of the tree. Small whitish flowers bud from flowering branches with umbel inflorescence. The fruit is of capsule shape and each fruit has one seed.
Flowering and Fruitage Period: Flowering during the period of July to September; fruits ripen during the period of November to April.
Ecological Characteristics: It thrives well in lowland tropical forests and in the peat swamp forests in Southern Thailand.
Seedling Preparation: An 18-month old seedling stands 60 centimeters tall.
Other Information: The leaves and the young leaves are poisonous. If consumed, it will cause severe stomach ache and diarrhea. Compared to others, this species is more resistant to fire.
Growth Information: The plants have a slow growth rate during the first 5 years. They can grow very fast after the fifth year. The growth rate is shown in Table 4, and Graphs 1 and 3.
Uses: Wood from *Stemonurus secundiflorus* is used for general purposes construction.

Photo 3.8: *Stemonurus secundiflorus* Bl.

6. *Dialium patens* Bak.

Thai Name: Thia
Family: LEGUMINOSAE-CAESALPINIOIDEAE

General Characteristics: A medium to large sized perennial tree with board-like buttresses at the base, and pinnatifid compound leaves budding in alternate opposite directions. Small white flowers bud from leaf axils and flowering branches in inflorescence. An oval shaped fruit becomes dark in colour when it is ripe, and each fruit has one seed.
Flowering and Fruitage Period: Flowering during the period of December to March, and the fruits ripen during the period of March to June.
Ecological Characteristics: It is found growing near the seashore, in waterlogged areas and at the edge of peat swamp forests. It thrives well both in waterlogged and dry areas, including in acidic soil.
Seedling Preparation: Seedlings are prepared from seeds. Seedlings pulled for replanting have a high survival rate. One kilogram of *Dialium patens* seeds consists of approximately 5,368 seeds. One kilogram of the fruits contains 1,646 fruits. A seed germinates 10-20 days after sowing. A 12-month old seedling stands 30 centimeters tall.
Other Information: The fruits from *Dialium patens* are edible. They are in good demand.
Growth Information: The plant's growth rate is low at the initial stage. However, it increases at the later stage as shown in Table 4, and Graphs 1 and 3.
Uses: *Dialium patens* produces a hard and very heavy wood. It is ideal for construction. Young leaves taste sour and are eaten as a vegetable. The fruit possess a sweet and sour flavour and can be made into dessert.

Photo 3.9: *Dialium patens* Bak.

7. *Melaleuca cajuputi* Powell.

Thai Name: Samet kaw
Family: MYRTACEAE

Photo 3.10: *Melaleuca cajuputi* Powell.

General Characteristics: A small to large sized perennial tree, often with a twisted trunk. The bark is white or grayish brown, formed in multiple thin layers. Young leaves possess white shiny hair. 1-3 small white flowers bud from leaf axils. A cup shaped fruit, 4 millimeters in diameter, contains 200 seeds.
Flowering and Fruitage Period: Flowers and bears fruits all year round.
Ecological Characteristics: It is found growing near the seashore, in waterlogged areas and at the edge of peat swamp forests. It thrives well both in water-logged and dry areas, including in acidic soil.
Seedling Preparation: Seedlings are prepared from seeds. One kilogram of *Melaleuca cajuputi* seeds consists of approximately 2,237,920 seeds. One kilogram of the fruits contains 11,360 fruits. A seed germinates 10-15 days after sowing. A 6-month old seedling stands at 50 centimeters tall. Seedlings from the wild can be removed and transplanted in the polythene bags and they have a better survival rate than those from the nursery. Similarly, seedlings from waterlogged areas have a better survival rate than those from high ground.
Other Information: Since *Melaleuca cajuputi* are not found growing in the original or primary forests, they are not recommended for rehabilitation of the peat swamp forests. However, the plants are suitable for planting in community forests or economic plantations.
Growth Information: The growth rate is very high compared to those of other plant species in the peat swamp forests. The growth rate is shown in Table 4, and Graphs 1 and 3.
Uses: *Melaleuca cajuputi* can be used for general construction purposes and for piling. The wood can be made into charcoal. The resin from the bark can be used in boat construction and for making a torch. The leaves can be used to produce essential oil.

8. *Eugenia oblata* Roxb.

Thai Name: Waa nam
Family: MYRTACEAE

General Characteristics: A small to medium sized perennial tree. The bark is greyish brown and the base has stilt roots which are 1-2 meters above the ground. Simple leaves bud at opposite directions with shiny leaf blades. White flowers bud from leaf axils and branch terminals. A ripe fruit is dark green and purple with a spherical shape. Each fruit has 1-2 seeds.
Flowering and Fruitage Period: Flowering is during the period of May to August and fruits ripen during the period of September to December.

Ecological Characteristics: It is found growing near river banks and streams near the sea, as well as in the peat swamp forests in Southern Thailand.
Seedling Preparation: Seedlings are prepared from seeds. One kilogram of *Eugenia oblata* seeds consists of approximately 310 seeds. One kilogram of the fruits contains 205 fruits. A seed germinates 25-30 days after sowing. An 18-month old seedling stands 110 centimeters tall. Seedlings pulled for replanting have a high survival rate.
Other Information: *Eugenia oblata* grows in clumps and bears fruits very fast.
Growth Information: It is a fast growing plant, suitable for flooring. The plants can cover the planting area in a short time. The growth rate is shown in Table 4, and Graphs 1 and 3.
Uses: Ripe fruits are edible. Wood can be used for temporary construction structures and firewood.

Photo 3.11: *Eugenia oblata* Roxb.

9. *Baccaurea bracteata* Muell. Arg.

Thai Name: Ramai paa
Family: EUPHORBIACEAE

General Characteristics: A medium sized perennial tree. The bark is greyish brown, smooth and sometimes cracked. Simple leaves bud at alternately opposite directions. Young leaves are hairy. Small male and female flowers bud from leaf axils near branch terminals. A ripe fruit is dark red or purplish red with an oval shape. Each fruit has 3 seeds, with yellow seed integument.
Flowering and Fruitage Period: Flowering is during the period of June to August and fruits ripen during the period of October to December.
Ecological Characteristics: It is found growing in waterlogged forests and in the peat swamp forests in Southern Thailand.
Seedling Preparation: Seedlings are prepared from seeds. One kilogram of *Baccaurea bracteata* seeds consists of approximately 7,510 seeds. One kilogram of the fruits contains 248 fruits. A seed

germinates 25-50 days after sowing. An 8-month old seedling stands 65 centimeters tall.
Other Information: *Baccaurea bracteata* Muell. grows in clumps and bears fruits very fast.
Growth Information: It can grow fast in degraded peat swamp areas. The growth rate is shown in Table 4, and Graphs 1 and 3.
Uses: Ripe fruits are sour and edible. Wood can be used for temporary construction structure.

Photo 3.12: *Baccaurea bracteata* Muell. Arg.

10. *Horsfieldia crassifolia* (Hook.f.et Th.)Warb.

Thai Name: Lueat khwaai bai yai
Family: MYRISTICACEAE

General Characteristics: A medium sized perennial tree. The bark is reddish brown with longitudinal shallow grooves in the bark. The plant has simple branches. It has noose-shaped pneumatophores with stilt roots 1-2 meters above the ground. Simple leaves bud at alternately opposite directions. The topside of the leaf blades are dark green and shiny, whereas the underside are yellowish brown and flaky. Small round light yellow flowers bud from leaf axils and branches. The oval-shaped dehiscent fruit is dark yellow when ripe. Each fruit produces one seed, with reddish orange seed integument.
Flowering and Fruitage Period: Flowering is during the period of March to June and fruits ripen during the period August to November.
Ecological Characteristics: It is found growing in the peat swamp forests in Southern Thailand.
Seedling Preparation: Seedlings are prepared from seeds. One kilogram of *Horsfieldia crassifolia* seeds consists of approximately 486 seeds. One kilogram of the fruits (with skin) contains 137 fruits. A seed germinates 40-60 days after sowing. An 18-month old seedling stands 65 centimeters tall. Seedlings can be collected from their natural habitat for replanting in plastic bags and the survival rate is high.

Growth Information: The growth rate is slow in the first 6 years. After the sixth year, the growth rate increases as shown in Table 4, and Graphs 1 and 3.
Uses: The wood is ideal for construction purposes.

Photo 3.13: *Horsfieldia crassifolia* (Hook.f.et Th.)Warb

11. *Vatica pauciflora* (Korth.) Bl.

Thai Name: Sak nam
Family: DIPTEROCARPACEAE

General Characteristics: A medium sized perennial tree with an inverted conical shaped crown. The bark is greyish brown, cracked and a little flaky. Yellow latex oozes from the cracked bark. Young leaves, young branches and inflorescence have short hair. Simple leaves bud at alternately opposite directions. Both the topside and underside of leaf blades are smooth. Small white flowers bud in inflorescence at leaf axils. The flowers produce a fragrant smell. The oval shaped fruit is brown and each fruit produces one seed.

Photo 3.14: *Vatica pauciflora* (Korth.) Bl.

Flowering and Fruitage Period: Flowering is during the period of May to June and fruits ripen during the period of September to October.
Ecological Characteristics: It is found growing in the lowland area and in the peat swamp forests in Southern Thailand.
Seedling Preparation: Seedlings are prepared from seeds. One kilogram of *Vatica pauciflora* seeds consists of approximately 615 seeds. One kilogram of the fruits (with skin) consists of 340 fruits. A

seed germinates 25-40 days after sowing. A 15-month old seedling stands 50 centimeters tall. Seedlings can be collected from the wild for replanting and the survival rate is high.
Growth Information: The plants grow moderately well. The growth rate is shown in Table 4, and Graphs 1 and 3.
Uses: The wood can be ideal for construction purposes and the plants can be grown for ornamental purposes.

12. *Cinnamomum rhynchophyllum* Miq.

Thai Name: Tae yo
Family: LAURACEAE

General Characteristics: A medium sized perennial tree, with a pagoda-shaped crown. The bark is greyish brown, cracked and a little flaky. Yellow latex oozes from the cracked bark. Young leaves, young branches and inflorescence have cilia. Simple leaves bud at opposite directions. Both topside and underside of leaf blades are smooth. Small yellow flowers bud at leaf axils and at the branch terminals. The flowers produce a fragrant smell. The oval shaped fruit is black when mature and each fruit produces one seed.
Flowering and Fruitage Period: Flowering is during the period of October to January and fruits ripen during the period of February to April.
Ecological Characteristics: It is found growing in lowland waterlogged forests and in the peat swamp forests in Southern Thailand.
Seedling Preparation: Seedlings are prepared from seeds. A seed germinates 20 days after sowing. A 20-month old seedling stands 125 centimeters tall.
Other Information: The plants do not grow well in areas where there is a continued presence of water.
Growth Information: The growth rate is fast in the initial stage. The growth rate is shown in Table 5, and Graphs 2 and 3. In waterlogged areas, its growth rate is slow.
Uses: The tree bark can be used for incense and insect repellent.

Photo 3.15: *Cinnamomum rhynchophyllum* Miq.

13. *Alstonia spathulata* Bl.

Thai Name: Ka bui
Family: APOCYNACEAE

Photo 3.16: *Alstonia spathulata* Bl.

General Characteristics: A small to medium sized perennial tree with an inverted conical-shaped crown. The trunk has grooves with buttress and knee-shaped pneumatophores at the base. Whitish latex oozes from the bark. Simple leaves, inverted and oval-shaped. Small whitish flowers bud in short inflorescence and the flowers are fragrant. Pods have smooth skin and develop in pairs.
Flowering and Fruitage Period: Flowering and bearing pods all year round, particularly during the period of April to July.
Ecological Characteristics: It is a pioneer plant found in waterlogged area and open area around the edge of peat swamp forests.
Seedling Preparation: Seedlings are prepared from seeds. One kilogram of *Alstonia spathulata* seeds consists of approximately 682 seeds. One kilogram of the pods (with skin) contains 682 pods. A seed germinates 10-15 days after sowing. A 7-month old seedling stands 65 centimeters tall. Seedlings can be propagated in large numbers.
Other Information: The plant can be easily transferred for replanting. It is also suitable as an ornamental plant.
Growth Information: Its growth rate is very fast and thrive well in waterlogged areas with a high and sustained water level. The growth rate is shown in Table 5, and Graphs 2 and 3.
Uses: The wood is soft and light, suitable for making floats. It is useful for handicraft purposes. It is also used in place of cloth for sharpening cutters to tap rubber latex. It is also grown as an ornamental plant.

14. *Ixora grandifolia* Zoll. & Mor.

Thai Name: Khem yai
Family: RUBIACEAE

Photo 3.17: *Ixora grandifolia* Zoll. & Mor.

General Characteristics: A small sized perennial tree with greyish brown bark, smooth but sometimes cracked in grooves and flaky. Many tubercles, for respiration, appear on the bark. Simple leaves bud at opposite directions. Both the topside and underside of leaf blades are smooth. A small whitish to light pink flower with 4 petals bud in inflorescence at the branch terminals. A spherical-shaped fruit is red or black when mature and each fruit contains 1-2 seeds.
Flowering and Fruitage Period: Flowering is during the period of September to December and fruits ripen during the period of January to April.
Ecological Characteristics: It is found growing in lowland waterlogged forests and in the peat swamp forests in Southern Thailand.
Seedling Preparation: Seedlings are prepared from seeds. A seed germinates 18 days after sowing. An 18-month old seedling stands 80 centimeters tall.
Other Information: Seedlings can be easily produced.
Growth Information: Its growth rate can be fast. The growth rate is shown in Table 5, and Graphs 2 and 3.
Uses: The flowers are fragrant and the plants can be grown for ornamental purposes.

15. *Polyalthia glauca* (Hassk.) Boerl.

Thai Name: Taa raa
Family: ANNONACEAE

General Characteristics: A medium to large sized perennial tree. It has a smooth bark with thin layers, and whitish to light brown in colour. The trunk has knee-shaped pneumatophores at the base. The plant has simple branches and simple leaves that bud at alternately opposite sides of the branch. The topside of leaf blades is green while the underside of leaf blades is whitish. Small whitish to light

yellow flowers bud in inflorescence at branch terminals. The fruit is dark red or black when mature and each fruit contains 1 seed.
Flowering and Fruitage Period: Flowering is during the period of March to May and fruits ripen during the peirod of July to October.
Ecological Characteristics: It is found growing in lowland waterlogged forests and in the peat swamp forests in Southern Thailand.
Seedling Preparation: Seedlings are prepared from seeds. One kilogram of *Polyalthia glauca* seeds consists of 800 seeds. One kilogram of *Polyalthia glauca* fruits (with skin) contains 500 fruits. A seed germinates 45-80 days after sowing. A 10-month old seedling stands 60 centimeters tall.
Other Information: The whitish underside of leaf blades is conspicuous when the wind blows at the leaves.
Growth Information: Its growth rate is moderately well as shown in Table 5, and Graphs 2 and 3.
Uses: The wood is used for indoor construction purposes.

Photo 3.18: *Polyalthia glauca* (Hassk.) Boerl.

16. *Mangifera griffithii* Hook.f.

Thai Name: Mamuang raa
Family: ANACARDIACEAE

General Characteristics: A medium to large sized perennial tree with a spherical or cylindrical-shaped crown and a straight trunk. The bark is brown, cracked and flaky. Simple leaves bud at alternately opposite directions at the branch terminals. Both the topside and underside of leaf blades are smooth. Small whitish or light yellow flowers bud in inflorescence at branch terminals. The oval-shaped fruit is dark red or blackish when mature.
Flowering and Fruitage Period: Flowering is during the period of January to February and fruits ripen during the period of April to May.

Ecological Characteristics: It is found growing in lowland waterlogged forests and in the peat swamp forests in Southern Thailand.
Seedling Preparation: Seedlings are prepared from seeds. One kilogram of *Mangifera griffithii* seeds accounts for approximately 190 seeds. One kilogram of the fruits (with skin) contains 80 fruits. A seed germinates 15-25 days after sowing. A 10-month old seedling stands 60 centimeters tall.
Other Information: The species can be improved as fruit plants and are suitable for cultivation in peat swamp forests.
Growth Information: The growth rate is moderate as shown in Table 5, and Graphs 2 and 3.
Uses: The wood can be used in construction and made into handles for tools. The fruits are edible.

Photo 3.19: *Mangifera griffithii* Hook.f.

17. *Calophyllum sclerophyllum* Vesque (Sangkaew, 1999)

Thai Name: Tanghon bai yai
Family: GUTTIFERAE

General Characteristics: A large sized perennial tree, with stilt roots of 3-5 meters tall. The trunk has noose-shaped pneumatophores at the base. The bark is dark brown, cracked in thin layers. The plant has simple leaves that bud at the opposite side of the branch. The topside of leaf blades is dark green whereas the underside is whitish. Small whitish flower bud in short inflorescence at leaf axils. The seed of this oval-shaped fruit is hard and each fruit contains 1 seed.
Flowering and Fruitage Period: Flowering is during the period of July to October and fruits ripen during the period of January to March.
Ecological Characteristics: It is found growing in the peat swamp forests in Southern Thailand.
Seedling Preparation: Seedlings are prepared from seeds. One kilogram of *Calophyllum sclerophyllum* seeds consists of approximately 110 seeds. One kilogram of the fruits (with skin) contains 85 fruits. A seed germinates 12-15 days after sowing. A 6-month old seedling stands 25 centimeters tall.

Other Information: A liquid substance can be extracted from the bark for medicinal use. The wood is of high quality and in high demand. The trunk is large, long and straight.
Growth Information: The plant can grow very fast and the growth rate is shown in Table 5, and Graphs 2 and 3. The plants can be grown as an economic plantation in peat swamp forests.
Uses: The wood is brown in colour. It is hard, durable and is used for construction purposes and building dug boats.

Photo 3.20: *Calophyllum sclerophyllum* Vesque (Sangkaew, 1999)

18. *Neesia malayana* Bakh.

Thai Name: Chang hai
Family: BOMBACACEAE

General Characteristics: A large sized perennial tree, with extended buttresses. The trunk has large arc-shaped pneumatophores. The plant has a spherical crown. The bark is dark brown, cracked in long grooves. The plant has simple leaves that bud at alternately opposite sides of the branch. Young leaves are covered with large leaf stipules, which drop at a later stage. Pinkish flowers bud in short inflorescence at leaf axils and branches. An oval-shaped fruit has four segments and the skin is full of tubercles. The seed of the fruit is flat and oval in shape.

Flowering and Fruitage Period: Flowering is during the period of July to December and fruits ripen during the period of November to May.
Ecological Characteristics: It is found growing in the peat swamp forests in Southern Thailand.
Seedling Preparation: Seedlings are prepared from seeds. An 18-month old seedling stands 40 centimeters tall.
Other Information: Cilia around the skin of the fruit may cause irritation to human skin.
Growth Information: The plant has a slow growth rate as shown in Table 5, and Graphs 2 and 3. The plants can be grown as an economic plantation in the peat swamp forests.
Uses: The wood is ideal for construction purposes.

Photo 3.21: *Neesia malayana* Bakh.

19. *Persea membranadea* Kosterm.

Thai Name: Kathang thuu
Family: LAURACEAE

General Characteristics: A medium sized perennial tree with yellowish brown bark. The cracked bark becomes grooved. The crown is pagoda-shaped. Cilia grow on young leaves and inflorescence. The plant has simple leaves budding alternately around the branches. Both the topside and underside of leaf blades are smooth and shiny. Small whitish or yellowish flowers bud at leaf axils near branch terminals. Spherical shaped fruits are black when mature. Each fruit has one seed.
Flowering and Fruitage Period: Flowering is during the period of December to February and fruits ripen in March and April.
Ecological Characteristics: The plant is found growing in the waterlogged areas and the peat swamp forests in Southern Thailand.
Seedling Preparation: Seedlings are prepared from seeds. A 10-month old seedling stands 60 centimeters tall.
Other Information: —
Growth Information: The plants grow rather fast as shown in Table 5, and Graphs 2 and 3.
Uses: The wood is used for making indoor structures.

Photo 3.22: *Persea membranadea* Kosterm.

20. *Dacryodes incurvata* (Engl.) Lamk.

Thai Name: Kaap oi
Family: BURSERACEAE

General Characteristics: A large sized perennial tree with extended buttresses. The bark is dark brown, cracked in flakes. There are cilia on young leaves and inflorescence. The plant has pinnatifid leaves that bud side by side from small to larger leaves. Light green flowers bud in short inflorescence at leaf axils near branch terminals. A twisted oval-shaped fruit, looking like a small mango, is black when mature. Each fruit has one seed.
Flowering and Fruitage Period: Flowering is during the period of October to December and fruits ripen during the period of January to April.
Ecological Characteristics: It is found growing in tropical rainforests and the peat swamp forests in Southern Thailand.

Seedling Preparation: Seedlings are prepared from seeds. One kilogram of *Dacryodes incurvata* seeds consists of approximately 1,930 seeds. One kilogram of the fruits (with skin) contains 1,094 fruits. A seed germinates 35-50 days after sowing. A 12-month old seedling stands 55 centimeters tall.
Growth Information: The plant grows moderately well as shown in Table 5, and Graphs 2 and 3.
Uses: The wood is ideal for making indoor structures.

Photo 3.23: *Dacryodes incurvata* (Engl.) Lamk.

21. *Sandoricum beccarianum* Baill.

Thai Name: Sathon nok
Family: MELIACEAE

Photo 3.24: *Sandoricum beccarianum* Baill.

General Characteristics: A medium to large sized perennial tree. The trunk has knee-shaped pneumatophores. There are cilia on young leaves and inflorescence. The bark is greyish brown. The plant has compound leaves that bud side by side. Old leaves are orange or red. Small white flowers bud in inflorescence. A rather spherical-shaped fruit is yellow or red when mature. Each fruit has 1-3 seeds. Each seed is covered with white integument.
Flowering and Fruitage Period: Flowering is during the period of December to February and fruits ripen during the peirod of March to April.
Ecological Characteristics: It is found growing in lowland waterlogged tropical rainforests and the peat swamp forests in Southern Thailand.
Seedling Preparation: Seedlings are prepared from seeds. One kilogram of *Sandoricum beccarianum* seeds consists of approximately 300 seeds. One kilogram of the fruits (with skin) contains 125 fruits.
Other Information: The trunks are tall with leaves of different colors. The species can be further improved for cultivation purposes for its fruits due to its suitability for planting in the peatland areas.
Growth Information: The plant grows very fast as shown in Table 5, and Graphs 2 and 3.
Uses: The wood is ideal for making indoor structures. Fruits are edible.

22. *Litsea costata* (Bl.) Boerl.

Thai Name: Kathang paa
Family: LAURACEAE

General Characteristics: A medium to large sized perennial tree. The crown is cylindrical or spherical. The bark is cylindrical and dark greyish brown. The plant has simple leaves, oval shaped, that bud alternately at opposite directions. The topside of leaf blades is dark green and shiny, while the underside is light green. Small yellowish flowers bud in capitulum at leaf axils. Male and female flowers bud separately in different trees. An oval-shaped fruit is red or purplish red when mature. Each fruit has 1-3 seeds.
Flowering and Fruitage Period: Flowering is during the period of April to August and fruits ripen during the period of December to February.

Photo 3.25: *Litsea costata* (Bl.) Boerl.

Ecological Characteristics: It is found growing in lowland tropical rainforests and the peat swamp forests in Southern Thailand.
Seedling Preparation: Seedlings are prepared from seeds. An 18-month old seedling grows 105 centimeters tall.
Other Information: Fresh bark and wood may cause irritation, rashes and infection when in contact with human skin.
Growth Information: The plant grows rather fast as shown in Table 5, and Graphs 2 and 3.
Uses: The wood is ideal for construction purposes.

23. *Campnosperma coriaceum* (Jack) Hall.f.ex Steen.

Thai Name: Khee non phru
Family: ANACARDIACEAE

General Characteristics: A large sized perennial tree. The trunk has knee-shaped pneumatophores. The bark is black mixed with yellow and is cracked in longitudinal grooves. The plant has simple leaves that bud side by side at branch terminals. Small white flowers bud in inflorescence at leaf axils. An oval-shaped fruit is black with smooth skin when mature. Each fruit has 1 seed.
Flowering and Fruitage Period: Flowering all year round and fruits ripen during the period of August to October.
Ecological Characteristics: It is found growing well in the peat swamp forests in Southern Thailand.
Seedling Preparation: Seedlings are prepared from seeds. One kilogram of *Campnosperma coriaceum* seeds consists of approximately 9,285 seeds. One kilogram of the fruits (with skin) contains 1,400 fruits. Seeds germinate 20-35 days after sowing. An 18-month old seedling grows 80 centimeters tall.
Other Information: The leaves are large and the crown extends providing shade for undergrowth weeds. The fruits are popular among monkeys; therefore, it is difficult to collect seeds at a large quantity.

Photo 3.26: *Campnosperma coriaceum* (Jack) Hall.f.ex Steen.

24. *Garcinia bancana* Miq.

Thai Name: Chamuang paa
Family: GUTTIFERAE

Photo 3.27: *Garcinia bancana* Miq

General Characteristics: It is a perennial tree with a conical shaped crown. The colour of the bark ranges from dark brown to almost black. The inner bark is red with yellow latex seeping from the bark. The plant has simple leaves that bud side by side at the opposite direction. The leaves are oval or lanceolate shaped. Male and female flowers bud separately. A spherical - shaped fruit is orange and black when dried. Each fruit has 12 seeds.
Flowering and Fruitage Period: Flowering is during the period of March to June and fruits ripen during the period of August to November.
Ecological Characteristics: It is found growing in the tropical rainforests and in the peat swamp forests in Southern and Southeastern Thailand.
Seedling Preparation: Seedlings are prepared from seeds. One kilogram of *Garcinia bancana* seeds consists of approximately 378 seeds. One kilogram of the fruits (with skin) contains 25 fruits. Seeds germinate 15-40 days after sowing. A 6-month-old seedling is around 35 centimeters tall.
Other Information: Young leaves have a sour taste and is used in preparing pork spare-rib soup.
Growth Information: The growth rate is shown in Table 5, and Graphs 2 and 3.
Uses: Young leaves are edible and the wood is ideal for construction purposes.

25. *Aglaia rubiginosa* (Hiern) Pannell.

Thai Name: Chomphuu samet
Family: MELIACEAE

Photo 3.28: *Aglaia rubiginosa* (Hiern) Pannell.

General Characteristics: It is a medium to large perennial tree with an extended crown. The bark is yellowish with whitish latex seeping from it. Its compound leaves are pinnatifid. The topside of the leaf blade is shiny, whereas the underside is red brown and flaky. Reddish-pink flowers bud in inflorescence at leaf axils near young leaves. The fruit is rather spherical in shape and is dark orange in colour when matures. This dehiscent fruit breaks into three segments when ripe. Each fruit has 3 seeds. The seed is brown with yellow integument.
Flowering and Fruitage Period: Flowering during the June to September period and fruits ripen during the January to April period.

Ecological Characteristics: It is found growing in lowland waterlogged forests and in the peat swamp forests in Southern Thailand.
Seedling Preparation: Seedlings are prepared from seeds. One kilogram of *Aglia rubiginosa* seeds consists of approximately 84 seeds. One kilogram of the fruits (with skin) contains 36 fruits. Seeds germinate 15-20 days after sowing. A 6-month old seedling is around 40 centimeters tall.
Other Information: This plant belongs to the same family as "Long Gong." The seeds from the fruits produce a substance that can cause intoxication.
Growth Information: The growth rate of the plant is rather high but with low survival rate. The growth rate is shown in Table 5, and Graphs 2 and 3.
Uses: The wood is ideal for construction purposes and for making farm tool handles.

26. *Xanthophyllum ellipticum* Korth.

Thai Name: Chum saeng nam
Family: XANTHOPHYLLACEAE

General Characteristics: It is a medium sized perennial tree with a cylindrical crown. The bark is light brownish grey, thin and smooth. The plant has simple lanceolate leaves, which are shiny and smooth both on the topside and underside. Small white flowers bud in inflorescence at leaf axils and near the bud terminals. A spherical-shaped fruit is dark orange and yellow when mature. Each fruit has 1 seed.
Flowering and Fruitage Period: Flowering is during the period of August to September and fruits ripen during the period of November to January.
Ecological Characteristics: It is found growing in lowland waterlogged forests and in the peat swamp forests in Southern Thailand.
Seedling Preparation: Seedlings are prepared from seeds. One kilogram of *Xanthophyllum ellipticum* seeds consists of approximately 642 seeds. One kilogram of the fruits with skin contains 512 fruits. Seeds germinate 30-35 days after sowing. A 6-month old seedling grows 35 centimeters tall.
Other Information: The fruits possess a vibrant color.
Growth Information: The growth rate of the plant during the first stage is high. However, its growth rate is lower where there is a high level of water. The growth and survival rates are shown in Table 5, and Graphs 2 and 3.
Uses: The wood is ideal for general construction purposes and for making farm tool handles.

Photo 3.29: *Xanthophyllum ellipticum* Korth.

27. *Metroxylon sagus* Rottb.

Thai Name: Saa khuu
Family: PALMAE

General Characteristics: It a plant species belonging to the *Palmae* family. The trunk initially grows parallel to the ground and then erects with a large bud growing as a trunk of 10-20 meters tall. Compound leaves of pinnafitid type consist of several accessory leaves. Tiny thorns form at the leaf margins. Reddish brown flowers bud in inflorescence. The fruit has a spherical shape and is yellowish brown. The skin of the fruit is scaly.
Flowering and Fruitage Period: The plant species is able to flower and bear fruits at any given time in the year . It only flowers once. Once the fruits ripen, the tree dies.
Ecological Characteristics: It is found growing in Southern Thailand. The plant thrives well near the banks of canals or rivers, waterlogged areas, and the marshes or peat swamps.
Seedling Preparation: Seedlings are prepared from seeds. One kilogram of *Metroxylon sagus* seeds consists of approximately 82 seeds. One kilogram of the fruits with skin contains 42 fruits. Seeds germinate 30-65 days after sowing.

Photo 3.30: *Metroxylon sagus* Rottb.

Chapter 4
PREPARATION OF SEEDLINGS FOR PEAT SWAMP FORESTS

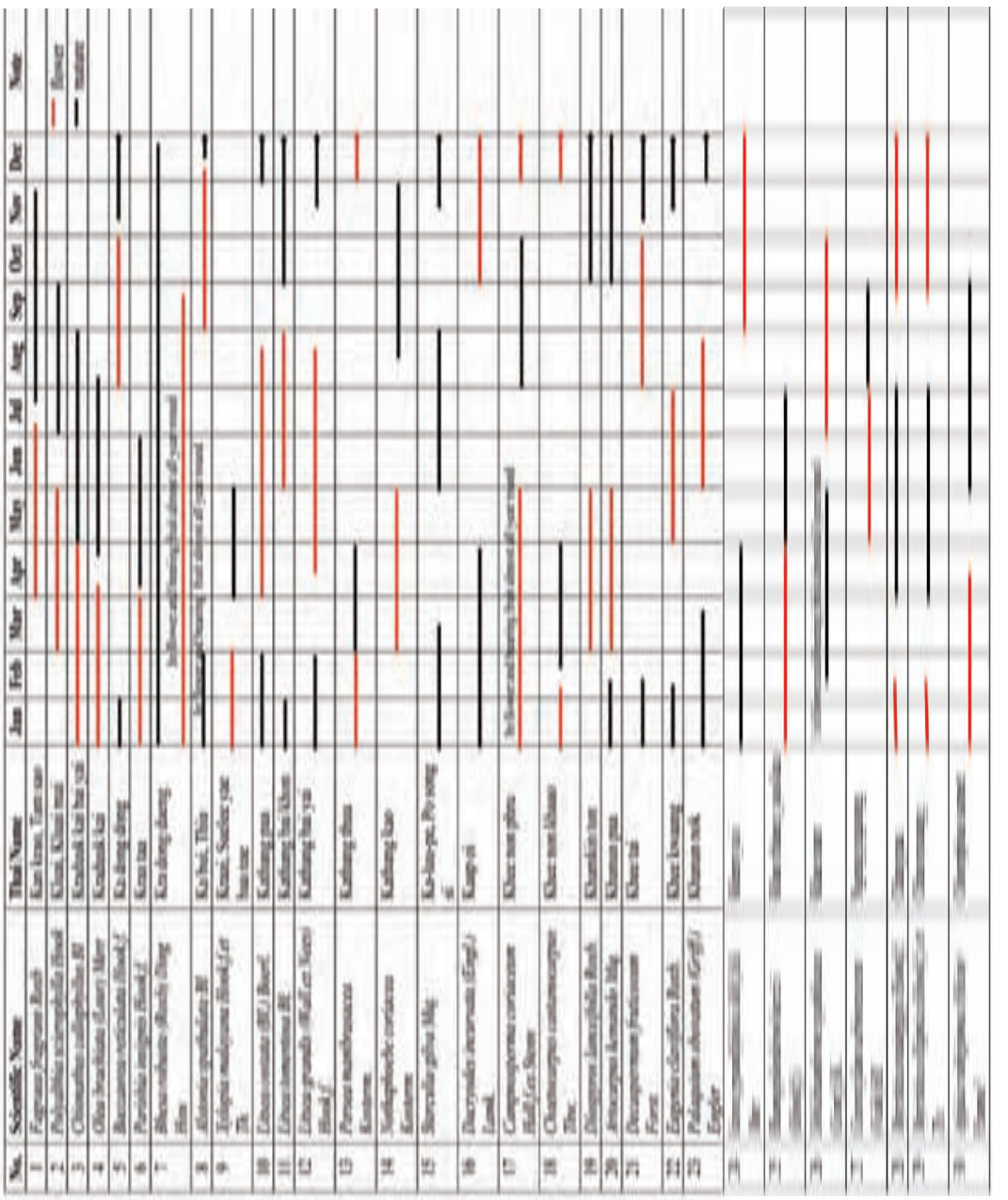
4.1 INTRODUCTION

The choice of seedling is one of the major factors which determine the success or failure of reforestation efforts. Planting healthy, strong and proper-sized seedlings increase their chance to survive and grow into large trees whereas planting unhealthy seedlings have lesser chance to survive, thus waste resources in terms of the preparation and will require additional time for replacement planting. Poor planning during the preparation of seedlings may also result in shortage of seedlings for replanting for a particular year, causing a great loss to the rehabilitation program. Leaving the prepared plots vacant without planting any seedlings will give rise to the speedy growth of weeds, especially in the rich soil of the peat swamp forests with adequate water supply and proper sunlight. As such these weeds will dominate the prepared plots. Within a period of 3 to 4 months, the plots will return to their former state, as it was before preparation work was carried out. To carry out replacement planting, the plots have to be prepared all over again.

4.2 PLANNING FOR SEEDLING PREPARATION

Planning to ensure an adequate supply of quality seedlings requires planners to be well-informed of the types of seedlings to be used for planting. Requirements include prior knowledge about the quantity of seedlings required for planting and replacement planting, size and height of seedlings suitable for planting, time for planting, as well as planting patterns and conditions. In addition, good planning for quality seedlings requires the planners to make additional plans for collecting seeds, determining seed sources and the collection season. Certain seeds have to be sought from distant areas. Planning for the production of seedlings of wild plant species requires more attention than the preparation of fruit tree seedlings or seedlings of species for economic purposes. Seedlings of fruit trees and economic plants are commonly found and can be acquired from other sources too. Wild plant seedlings are cultivated by only a few nurseries. For reference, information on seed collection, flowering and fruitage seasons of certain perennial trees in TohToh Daeng peat swamp forests collected over a period of 10 years is illustrated in Table 4.1. This information reflects that from other peat swamp forests in Thailand, most of which are located within the Southern region.

Table 4.1:
Flowering and Fruiting Periods of Certain Perennial Plants in Peat Swamp Forests in Narathiwat



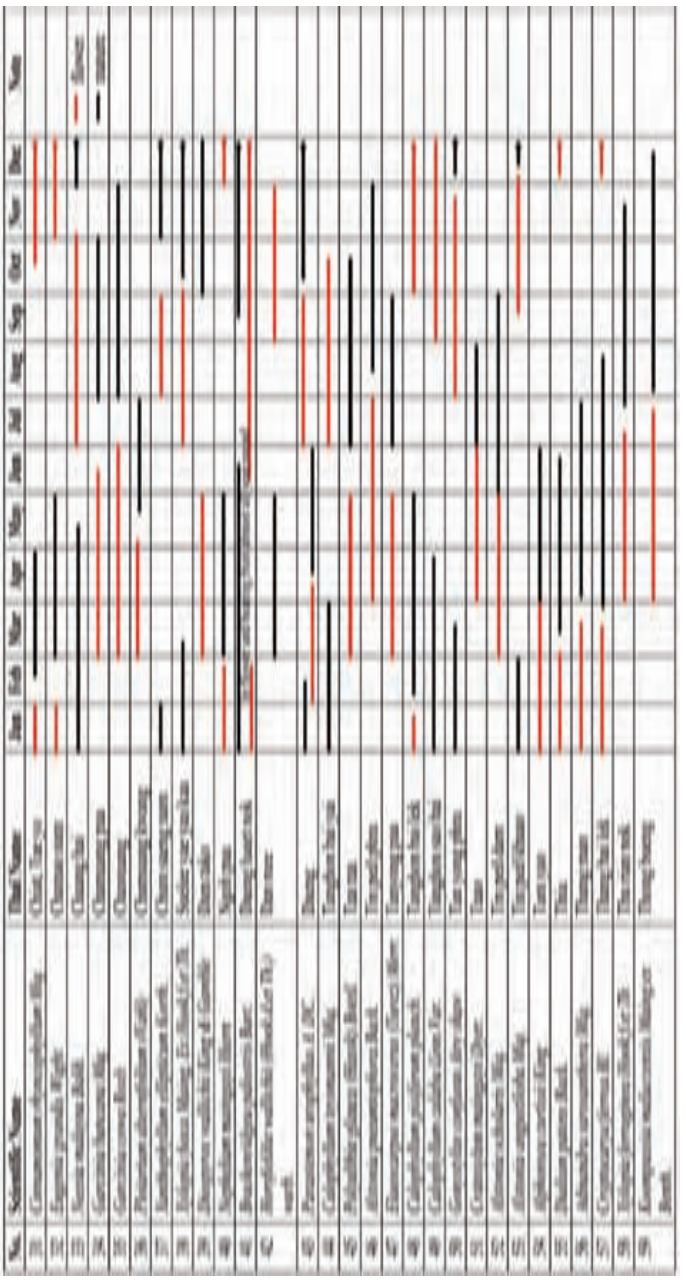


Table 4.1:
Flowering and Fruiting Periods of Certain Perennial Plants in Peat Swamp Forests in Narathiwat (continued)

Table 4.1:
Flowering and Fruiting Periods of Certain Perennial Plants in Peat Swamp Forests in Narathiwat (continued)

Table 4.1:
Flowering and Fruiting Periods of Certain Perennial Plants in Peat Swamp Forests in Narathiwat (continued)

4.3 SELECTING PLOTS FOR SEEDLING NURSERY

A critical criterion for selecting a suitable plot for a seedling nursery is that the plot should be located on a plain outside the peat swamp forest, or the plot area must not be waterlogged. Such a plot provides convenience in carrying out nursery work. Another factor to be considered is that the area must have easy access to water all year round, whether from the peat swamp or other natural sources such as marshes, canals or wells. Utilizing tap water would be too costly. If possible, a temporary water storage tank should be built and connected to the water source using a pipe with a diameter of about 2 inches (5.08 cm). The size of the pipe can be varied depending on the distance from the tank to the water source. A water hose for sprinklers and for watering should be ¾ inch (1.9 cm) in diameter. Using the smaller-sized hose requires more time in watering. The use of a good quality water pump makes the temporary storage tank unnecessary. More importantly, the plots for the seedling nursery should be accessible to vehicles all year round and equipped with electricity. In addition, labor should be easily available in the area. The plot for the seedling nursery should have soil with sandy loam. If necessary, sand can be put on top of the soil to prevent the nursery plot from being soggy.

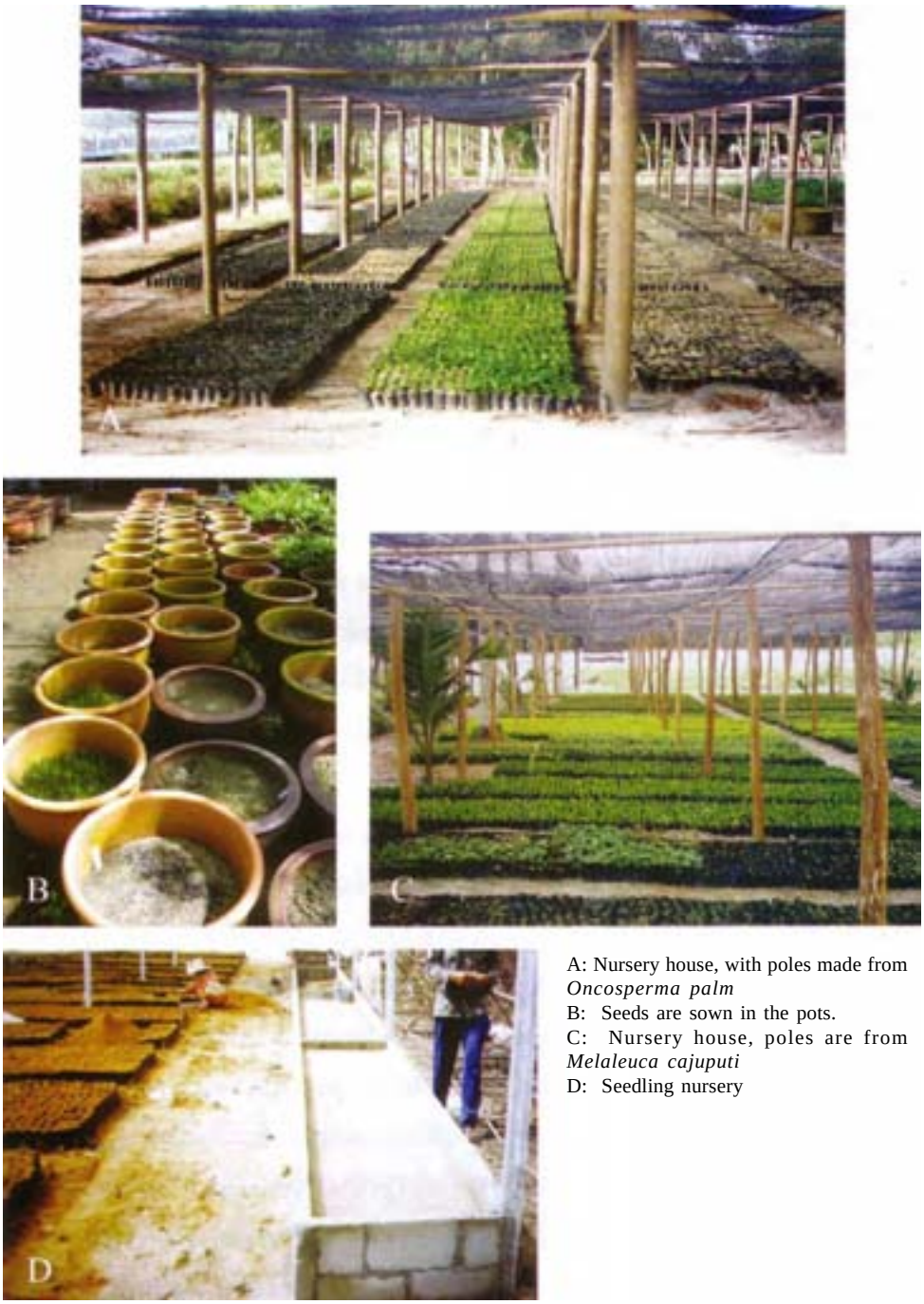
4.4 CONSTRUCTION OF NURSERY HOUSE AND SEEDLING NURSERY

After selecting the site for a seedling nursery, another criterion to consider is adequate shade and sunlight for the seedlings. Sunlight is an important factor in regulating growth and promoting the health of plants. Sunlight also contribute to protect seedlings from diseases and insects. Sunlight should be able to penetrate all seedling storage areas, and at least 50% of the open spaces. If there is little sunlight, seedlings will not have healthy growth. Seedlings that lack exposure to sunlight grow very tall and young branches break easily. It is necessary to prune the branches to allow more sunlight to go through. Afterwards, grasses are weeded and pests are removed. Then, the area must be leveled and the nursery house is built on the space. Large and strong poles should be used for building the nursery house. The poles must be stuck at least 40 centimeters under the ground. Poles can be obtained from *Melaleuca cajuputi* or *Oncosperma palm*. However, if *Oncosperma palm* is used, cement should be applied at both ends of the poles so that water cannot pass through and the poles can last for 3-5 years. The distance between two poles should be 3-4 meters and bamboo stalks or metal pipes of ½ inch (1.27 cm) in diameter should be placed on the top ends of the poles. Once the bamboo stalks or metal pipes are connected to the top ends of all poles, the top view looks like a chessboard. Then, a shading plastic panel is attached on top of these stalks or pipes. A roll of shading plastic panel is 2 meters wide and 100 meters long - it can cover an area of 200 square meters. Each roll of shading plastic panel can be connected to another by manual sewing with nylon thread or metal wire. There are plastic panels of different colors such as black and green. The shading capacity ranges from 30% to 50% and 70%. For nursing of seedlings, a 50% shading panel is applied. In addition to providing shading, the plastic panel also serves to prevent fallen leaves and branches from high atop trees around the nursery from damaging the seedlings.

A seedling nursery can be built using cement bricks, producing a structure that looks like a topless box. Each side of the cement box should be 60 cm high and 3-5 m long. The box is filled with sandy loam or crushed coconut fiber to a thickness of 30 cm. This is for sowing seeds. Sometimes, the cement box is used for storing seedling pots filled with the prepared soil, instead of sowing seeds directly into the soil. Sowing the seeds into the pots makes it convenient to change the soil materials which are in the individual pots.

4.5 ESTABLISHMENT OF WATER PROVISION

A temporary water tank should be constructed in forest nurseries. Piping, of at least 2-inch diameter, should be joined with the temporary water tank and pipin of reducing diameter used



A: Nursery house, with poles made from *Oncosperma palm*
B: Seeds are sown in the pots.
C: Nursery house, poles are from *Melaleuca cajuputi*
D: Seedling nursery

Photo 4.1: Nursery houses and seedling nurseries for peat swamp forests should be located on high ground, a criterion similar to preparation of greenhouses and nurseries for normal reforestation.

acccording to distance from the tank to the pipe network. The diameter of the watering hose should be larger than 6 ËØ¹to avoid unecessary time comsumption during watering. However, other methods of water provision are practicable, such as the use of a good quality water pump rather than a temporary water tank, and through inexpensive sprinkler systems, which are easily available and make significant labour savings.

4.6 SOWING THE SEEDS AND REPLANTING THE SEEDLINGS

Most seeds of plant species in the peat swamp forests are rather large (with the exception of certain plants such as *Melaleuca cajuputi* and *Fagraea racemosa*). Large seeds are easier to sow than small seeds. The seeds must first be sown in the prepared seed pans. Seeds should be distributed evenly in the pan and not too close together. Fine sand is topped on the seeds and watering is carried out morning and afternoon, using a watering can with a fine rose. If the sown seeds are small, the seedling pan should be covered with a transparent plastic sheet to prevent raindrops from dispersing the seeds. A label should be attached to the pan, stating the date of sowing and the plant species. The information should be recorded in the logbook. After the seeds germinate, the young seedlings are then transplanted in the polythene bags filled with pot soil. It should be noted that seedlings from small seeds should be allowed to grow at least one inch tall before they can be selected for transplanting. For the purpose of genetic diversity, seeds should be collected from good plant stocks. The seeds of different stocks should be mixed when sowing. Therefore, the replanted seedlings in the plots are of different stocks and this helps lessen the inbreeding among plants from the same stock.

Certain seeds are difficult to acquire or they can be acquired only in a small quantity, which is not adequate for planting requirements. It is a good idea to cultivate the plant stocks in the natural forests or in the prepared plots. The stocking plots should be properly managed so that the required seeds are acquired. Sometimes, when the seed collection is done too late, the wild seeds on the ground will germinate. It is found that almost all seedlings naturally grown in the wild can be transplanted into polythene bags and nursed in the nursery with a high survival and growth rate. Pricked-off seedlings from the wild can shorten the normal seedling preparation period.

4.7 PREPARATION OF POLYTHENE BAGS

The size of polythene bags should be 5" x 8" (12.7 cm x 20.32 cm). This is because seedlings for planting in the peat swamp forest should be large enough, taller than the highest water level. A water level beyond the crown of the seedlings often results in the death of the seedlings. However, it was found that seedlings survive although the base of the seedlings was under water for a period of as long as 18 months (Tanit, 2003). It should be noted that the transfer of seedlings to planting is rather burdensome. Using the large bags can be cumbersome for transportation. It is advisable to use polythene bags of mixed sizes ranging from 4" x 6" (10.16 cm x 15.24 cm) to 5" x 8" (12.7 cm x 20.32 cm) and 8" x 10" (20.32 cm x 25.4 cm). One kilogram of each size contains 420, 280 and 150 bags respectively, depending on the thickness of the bags. A 4" x 6" bag refers to a bag when filled with soil and has a diameter of 4 inches (10.16 cm) and is 6 inches (15.24 cm) tall. Before filling the bags with soil, holes should be made on the bags. However, if the purchased product already has holes, there is no need to make new ones.

4.8 SOIL USED FOR FILLING THE POLYTHENE BAGS

Trees and seedlings growing in the peat swamps thrive well on organic soil. A study revealed that top soil from outside the peat swamp areas mixed with rice husk and manure can be used for cultivating seedlings in the polyethene bags and the seedlings seem to grow faster than those grown

A: Use of climbing device for collecting seeds.
B: *Fagraea racemosa* seeds.
C: Transplanting of seedlings pricked off from the wild.
D: Seeds of *Alphonsea curtisii* King.
E. Seeds of *Alstonia spathulata* Bl.

Photo 4.2: Seed collecting and transplanting

in the bags filled with organic soil. There is no need to use organic soil for transplanting in the polythene bags. To acquire the organic soil, one has to wait for the soil to become dry, and it is difficult to dig for it. When exposed to water, the soil drips and become dirty. At present, topsoil can be purchased directly from suppliers and delivered by lorries. This is cheaper than having workers dig for topsoil. Before filling the bags, workers simply pick out gravel, stones and pieces of leaves and branches. The soil is then mixed well with rice husk and manure, filled in the bags, compressed, and put in rows. An area of 110 centimeters wide and 1 meter long can store 288 seedling bags of size 4" x 6", 156 seedling bags of size 5" x 8", and 72 seedling bags of size 8" x 10". Storing blocks should have a space of 30 centimeters at both ends in order for nursery hands to do the weeding and watering. From the data collected by nursery hands, it was found that on average, a nursery hand was able to fill 1,500, 1,000 and 500 bags of sizes 4" x 6", 5" x 8" and 8" x 10" per day, respectively.

A: Top soil used for filling the polythene bags
B: Polythene bags
C: Soil mixed with rice husk for filling the polythene bags
D: Filling the polythene bags with the prepared soil
E: Filled polythene bags are settled in rows

Photo 4.3: Materials used for sowing the seeds and rows of filled polythene bags

4.9 NURTURING SEEDLINGS

Seedlings should be watered thoroughly twice a day, mornings and afternoons. Weeding should be done once a month. The bags with seedlings should be moved once every three months to prevent the roots of the seedlings from penetrating into the ground. Height grading should be carried out so that all seedlings are exposed to sunlight and that shorter seedlings are not suppressed. These procedures will help accelerate growth and make it more convenient for selecting the seedlings for planting. The seedlings are selected according to their height. Tall seedlings should be removed for planting first. Nursery hands should look for diseases and pests. If pests are found, the seedlings should be sprayed with chemicals. If there is a need for accelerating the growth of the seedlings for planting, they should be treated with urea fertilizer - the formula consists of one handful of urea dissolved with 5 liter of water. One month before the planting season, the shading panel should be taken out so that all seedlings are fully exposed to sunlight, thus promoting the hardening of the seedlings. If it is not possible to take out the shading panel, all seedling bags should be taken out

into the open, close to the main road. This will help to harden the seedlings and accustom them to real planting conditions and prepare them to be transported to the planting plots.

Photo 4.4: Seedlings of *Metroxylon sagu* Rottb.

Chapter 5
PREPARATION OF CULTIVATION PLOTS AND PLANTING OF THE SEEDLINGS

5.1 INTRODUCTION

Procedures and practices in the preparation of cultivation plots, planting and nurturing of the plantation are very important. The success rates of replanting and rehabilitation depends mostly on the work done during these stages. Different cultivating locations require different treatments. For example, in Finland, sowing seeds for planting is done on soil that is quite fertile. For the fertile soil, planting is done through cultivating bare root plants (Paivanen, 1975). In Sweden, organic soil in the peat swamp area is turned over before planting the seedlings, and as a result, the trees have increased growth rates (Sundstrom, 1991). In the British Isles, a machine was used to drain the soil and the planting beds were raised. It was found that the plants cultivated on the raised beds grew faster than the ones planted in ordinary soil (Zehetmayr, 1954). Zehetmayr's findings have been supported by the results from Heikurianen and Kuusela's (1962) study, which revealed that various plant species, particularly the small ones, had a faster growth rate after water was drained from the peat swamps.

As for the peat swamp forests in Thailand, proper procedures and practices in planting and rehabilitation have been developed to suit the conditions of the peat swamp forests in the country. The procedures adopted, as described in the following sections, are aimed at lowering operational costs.

5.2 SITE SURVEY FOR PREPARATION OF PLANTATION

After the site for the plantation has been decided upon, the first stage is for the person/s responsible for planting to survey the plots. A preliminary survey should be made to collect basic information on the area, such as location, boundary, site history, distribution of plant and weed species, and signs of wild fires and domesticated animals. Surveyors should make recommendations and present the baseline data to their superiors for consideration. Before starting the operation, a thorough survey should be made to designate the exact location of the plot. Planning should be done for the temporary walkway, digging ditches, firebreak, calculation of the number of seedlings required and other necessary preparations. Measurements should be taken of the boundary and boundary posts should be erected to prevent encroachment. The planting location should be plotted on a map with a scale of 1:50,000. A more detailed map showing planting plots should be drawn on a letter-size paper (A4) with a scale of 1:500 to 1:5,000 depending on the sizes of the planting areas. The map should include details about the permanent physical features of the landscape such as roads, canals and other details. A preliminary survey provides surveyors with information on suitable plant species to be cultivated and the quantity required for planting. An area with large trees already growing

should be planted with species that do not need much sunlight. Similarly, a waterlogged area should be planted with tall seedlings that are well-suited for growth in the water.

5.3 CLEARING THE VEGETATION

Clearing the vegetation is the first step in the preparation of the planting area. Clearing workers should be properly dressed, wearing long-sleeved shirts and shoes, particularly made from rubber (Photo 5.1). Rubber shoes last longer because they are resistant to water and they are also cheap. Necessary tools for clearing include long-handled machetes and whetstones. The machetes should be sharpened so that their edges are sharp all the time. The sharp-edged machetes can be used for clearing bushes and trees for 3-4 hours, after which they will need sharpening again. The machetes are of different shapes and users have to find the right shape to suit individual preferences.

Clearing of the area for planting and rehabilitation of the peat swamp forests require weeding of certain plants such as *Scleria sumatrensis, Blechnum indicum* and *Stenochlaena palustris*. This must be done with care so as not to damage the seedlings growing along with the weeds. Most of the seedlings are difficult to locate because they are overgrown by weeds. Workers should use knives to cut the weeds as close to the ground as possible. The practice of burning to clear the weeds should be avoided. This is because once fire breaks out, it is not easy to control and extinguish the fire. Cutting only the upper parts of the weeds will allow the remainder of the plant to rapidly regrow, making it difficult for the seedlings to survive. The bases of the replanted seedlings must be buried. In order for the seedlings to be able to outgrow the weeds, it is recommended that the seedlings to be replanted should be more than one meter tall. But cutting the weeds close to the ground requires a lot of labor and a specific technique. Firstly, the workers have to slash the weeds vertically to cut the parts that cover other plants. Secondly, they have to cut the weeds horizontally, as close to the ground as possible. The cut weeds are then broken into small pieces and stepped on to level on the ground surface. This complicated procedure makes the preparation cost for planting in the peat swamp forest higher than that for other types of forests. Climbing weeds on large naturally occurring trees should be cut and pulled down to allow the trees to grow freely. Extended and cumbersome crowns of original trees should be pruned to allow sunlight to reach newly planted seedlings. Seedlings exposed to more sunlight grow better. About 10 workers are required to clear a half-hectare area in one day. In areas where weeds do not grow too densely, workers can use grass cutting machines for the preparation of the planting plots.

Preparation of planting plots damaged by forest fires can be difficult, particularly when there are a large number of fallen trees. The most viable and economical way is to wait 2-3 years for the dead branches to decompose before starting any preparation work.

5.4 CONSTRUCTING A TEMPORARY WALKWAY INTO THE PLANTING PLOTS

As peat swamp forests are waterlogged and peat soil is loose and very sodden, the movements of laborers, tools or seedlings into the planting site is rather difficult. For a planting area of more than 50 rai (8 ha), or if it is necessary to enter the planting site often, there is a need to construct a temporary walkway to the site. Bamboo poles and fallen tree branches are laid on the ground to make the walkway. A small canal should be dug to serve as a route to an especially large planting site or one that requires frequent entries. The canal provides an access for moving facilities to the site. Without a walkway or a canal, it would be difficult to access the site. Hardship faced by workers while accessing the site will discourage the workers because they have to wade waist deep in water in some places and get soaked from the beginning of their operation. The temporarily constructed walkway or canal provides convenience in transporting seedlings and other materials to the site.

Photo 5.1: Tools and materials used in the replanting of degraded peat swamp forests

5.5 POLING FOR PLANTING AND PLANTING SPACE

Very few studies have been carried out to determine the appropriate planting space for peat swamp forests; therefore, there has not been any specific formula. Setting proper planting space between trees is important because this will determine the operating cost. Planting space also dictates the number of seedlings required for planting. For example, a planting space of 1 x 1 metre between trees requires 10,000 seedlings per hectare (10,000 sq m) ; 2 x 2 meter planting space requires 2,500 seedlings per ha; and 4 x 4 planting space needs 625 seedlings per ha. The number of seedlings dictates the

number of positioning poles and pits to be dug for planting. A narrow space between trees means a larger number of seedlings is required, and a higher operating cost per ha as a result. The space between trees is determined by the crown size. For example, *Compnosperma coriaceum* Hall.f.ex Stenn has an extended crown. A planting space of 2 x 4 meters results in cramping of the crowns within 4 years. For the same planting space, it will take 15 years for the crowns of *Calophyllum sclerophyllum* Vesque to cram. Therefore, the planting space of each plant species differs. On average, the most appropriate number of seedlings to be planted in the peat swamp forests is 1,250 seedlings per hectare. Planting of the seedlings should not be fixed in a straight line or in a row. For 1,250 seedlings, the planting space should be 2 x 4 meters or 3 x 3 meters.

Calculation Method for Determining Number of Seedlings Per Hectare (based on planting space)
1 hectare (ha) is equivalent to 10,000 square meters
If planting space for 1 tree is 2 x 2 meters or 4 sq. meters; therefore 1 ha requires = 10,000/4 = 2,500 seedlings/ha.
If planting space for 1 tree is 4 x 4 meters or 16 sq. meters; therefore, 1 ha requires = 10,000/16 = 625 seedlings/ha.

The advantage of poling the planting spot is that it makes it easier to notice the pit to be planted. A seedling is set beside each pole before planting. By tying the seedling to the pole, the pole also serves as the support for the seedling to grow upright. Also, the pole is an indicator for the location of the planted seedling. This makes it convenient for workers to find the location of the seedling during weeding. The poles make it easy for the workers to survey the seedlings for growth, survival or replacement planting. In economic plantations where seedlings are planted in rows, it is necessary to use planting poles, often made from Johnson grass or *Arundo donax* obtained from outside the peat swamp forests; these plants can last for 6 months. In certain areas, young *Melaleuca cajuputi* are used as planting poles. These young trees often thrive naturally after forest fires; in an area of one rai (0.16 ha), there are as many as 100 young *Melaleuca cajuputi* that are ready to be used as planting poles. Cutting *Melaleuca cajuputi* for use as planting poles requires selective cutting. Random cutting often results in replanting, which is a waste of time. In areas where bamboo is accessible, using it as poles for planting is the most practical application; bamboo stalks can last for 2-3 years. The length of the pole should be 1.5 meters.

5.6 PREPARATION OF PLANTING PITS AND PLANTING

Good planting pits are essential for the survival of seedlings. They should be at the same level as the original soil. Topping the weeds with organic soil can be a problem when the water level recedes. The organic soil becomes dry, the roots of the plants become dehydrated and the plants eventually die. Growing certain plant species on a small soil mound at an elevated level above the water surface resulted in a significantly better growth rate than growing at normal ground level. These plants include *Eugenia kunstleri, Eugenia oblata, Baccaurea bracteata,* and *Decaspermum fruitcosum*. Only two species, i.e. *Sterculia gilva* and *Alstonia spathulata* did not show much difference. However, constructing such mounds adds cost to the operation. One worker is able to complete 50-70 mounds per day. To reduce costs, it is not necessary to grow every seedling on a mound. For planting 1,250 seedlings in an area of one ha, only 300-600 mounds are required.

In certain areas, a drainage technique may be applied instead of constructing mounds. Both of these techniques share the same principle, i.e. mounds allow the roots of the seedlings to grow in soil above the water level, whereas drainage lowers the water level in the soil so that the roots are not in the water. For large-scale planting, drainage is a more convenient and less costly technique. However, this brings with it the risk of subsidence and fire.

A:Slashing the weeds horizontally, as close to the ground as possible
B:Slashing the weeds that cover large naturally occurring trees
C:A column of workers slashing weeds
D: Second clearing of weeds with thorough slashing
E:Condition of the forest after first clearing of weeds
F:Condition of the forest after thorough clearing of weeds
G:Forests in this condition should be left for 2-3 years to allow branches to decompose before any rehabilitating effort.

Photo 5.2 : Clearing of Forests

Photo 5.3: In certain areas, naturally-occurring trees grow densely but cannot be seen because they are covered by thick weeds. Slashing the weeds allow native trees survive and grow well.

The dry season is a good time for making mounds as water level in the peat swamp is low. The plantation manager or chief often mobilizes the workforce to build mounds for the whole plantation during this season. The seedlings are planted early in the rainy reason. Such a practice differs from planting methods in other forests where the seedlings are planted immediately after making the planting holes or pits. In planting the seedlings, use a knife to cut the polythene bag and remove it. Make a planting hole of the right size with a stick. Carefully put the seedling into the hole; do not cause the soil covering the roots of the seedling to break. After that, cover and compress the base of the seedling with the soil. If there are weeds around the planting hole, remove them first. Tie the seedling to the planting pole at 70% of the seedling height above the ground. This will help the seedling to grow upright. When tying the string, tie one end loosely to the seedling to allow it to grow freely and tie the other end tightly to the pole to prevent it from falling to the base. Removed polythene bags should be disposed outside the plantation to keep the environment clean and prevent wild animals from accidentally ingesting them as the bags may be mistaken for something edible. Before planting the next seedling, scoop water from around the planting hole and pour it onto the base of the newly planted seedling.

As for planting at ground level, use a machete to weed the chosen location in a 50-centimeter radius around the planting pole. Use a pole of 6 centimeters in diameter and 1 meter long to make a lead hole. In order to grow trees in a straight line, it is important to be consistent in making a lead hole, either to the left or to the right of the planting pole, so that the rows of the grown trees will be in straight lines. The next step is to remove the polythene bag from the seedling, and carefully put the soil-covered seedling into the prepared hole. Similarly, tie one end of the string loosely to the seedling and the other end tightly to the planting pole to prevent slanting of the trunk. Water the seedling the same way as was done in the mound method.

To ensure that no planting poles are missed during the planting process, the seedlings should be planted in a row starting from the edge of one side of the plantation toward the opposite end. Supervisors should make random but systematic inspections of the area. Since the quality of the planting is very critical for the survival of the trees, it is recommended not to contract out the planting stage of the operation to external contractors. Instead it is better to hire workers on a daily basis and closely supervise them to do the job.

Photo 5.4: A temporary walkway or canal is necessary for planting in an area of 8 ha and above

Photo 5.5: Preparation of elevated planting levels and non-elevated planting holes.

Photo 5.6: Planting of seedlings in the peat swamps.

5.7 SEEDLING TRANSPORTATION

The transporting of seedlings is a procedure that needs special attention. The well-prepared seedlings can be damaged while being transported due to lack of knowledge and improper attention in handling. Healthy seedlings may have dried or leaf abscission and roots broken. It should be noted that transporting seedlings takes a short time but it may affect the seedlings that have been prepared for a long time. Another point worth noting regarding transporting of seedlings is time. Seedlings should be transported from the nursery to the planting area in the shortest time possible. A logistic plan should be mapped out carefully to avoid delay in transportation. The proper handling technique is to put seedlings into large plastic bags with straps. Each large plastic

Photo 5.7: When transporting seedlings from nurseries, it is recommended to put the seedlings in large plastic bags for easier handling and loading onto the truck.

bag should contain 25 seedlings planted in polythene bags (size: 4 inches x 6 inches), with a total weight of about 10 kilograms. The plastic bags are then loaded on a truck; careful layering the seedlings on top of each other is permitted. Upon reaching the site, the bags are unloaded and transported to the planting area – carried by hand, on shoulders or by boat. Carrying seedlings in a large plastic bag is faster than picking up the seedlings one by one, which can save as much as 25 times the number of trips required. Throughout the whole process of transportation, the use of large plastic bags can help to reduce by as much as 100 times the amount of handling work required. A plastic shading panel is required to cover the seedlings when being transported by truck. This is to prevent the leaves from being damaged by the force of strong wind while the vehicle is moving. Without a shading panel, the seedlings being transported may suffer leaf abscission, which requires months for recovery. In transporting large plants of *Palmae* species, it is recommended that all the leaves are tied together before beginning the journey. This handling technique will prevent the seedlings from being disturbed. It should be noted that at every stage of seedling transportation, only the plastic bags should be handled, not the seedlings. Touching the seedlings may cause the covered soil at the base to break off, an action which may result in the death of the seedlings.

Photo 5.8: Modes of carrying seedlings into the planting area.

5.8 PLANTING IN SOIL WITH HIGH ACID SULPHATE CONTENT

Preparation of soil with a high content of acid suphate, e.g. peat swamp forests with little amount of peat left, can be easier than preparation of organic soil. In preparing the planting area, make mounds around the planting poles, using a hoe to heap the soil 30 meters above the ground. It was found that almost all plant species grow faster on these mounds. Also, building mounds on acid sulphate soil is easier than on organic soil.

A: Raising soil level for planting seedlings allows the plants to grow faster and have a higher survival rate.

B: A one-year old *Melaleuca cajuputi* plantation at Narathiwat.

C: An eight-year old *Melaleuca cajuputi* plantation at Cha-uat District, Nakhon Si Thammarat.

Photo 5.9: Planting in soil with a high acid sulphate content

Chapter 6
NURTURING OF PLANTS AND PREVENTION OF FOREST FIRES

6.1 REPLACEMENT PLANTING

The time for determining whether a seedling will survive or die is one month after planting. This means that under normal climate conditions and without pests or diseases, most seedlings that survive the first month can further grow into large trees. Main reasons for seedlings not able to survive after one month are: they are unhealthy; damaged by the planting procedure; not properly planted by the planters; or the soil is not arable. Seedlings wither if dehydrated, or the leaves will fall when submerged in the water and eventually the seedlings will die. Symptoms of dying can be seen within 2 or 3 days for certain plants, whereas for others it takes time for the signs to surface. In order for the replaced seedlings to grow along with the original seedlings, it is advisable to carry out the replacement planting as soon as possible after a seedling is found dead. For large scale planting, it is rather impractical and costly to make a survey of the newly planted area every day. So, replacement planting should be carried out one month after the first planting of the seedlings. A certain number of seedlings should be set aside for replacement and these seedlings should be nurtured in the nursery to grow along with the ones planted. Using the reserved seedlings of the same lot for replacement is a good idea, because the original seedlings and the replaced seedlings will be growing at about the same height. This has the advantage of helping to prevent the replaced seedlings from being dominated or overshadowed by the originally planted seedlings.

Most seedling species from the peat swamp forests grow slowly. By moving these seedlings in the polythene bags twice a year, it is possible to prevent the roots of the seedlings stored in the nursery from penetrating into the ground. If the roots are firmly established in the ground, it would be harmful to prick off the seedlings for replanting. The nurtured seedlings are suitable for replacement planting in the second and third year. The success of reforestation depends significantly on natural factors, particularly the climate. Regular rainfall provides water required by the plants, resulting in a high rate of survival. On the other hand, a drought often results in a low survival rate for the plants. Replacement planting in favorable climate for three consecutive years will ensure the success of reforestation.

6.2 WEEDING THE PLANTING PLOTS

A Randomised Block Design (RBD) experimental weeding scheme involving 20 plots of *Macaranga pruinosa* was conducted. The experiment involved five blocks of the plants, each consisting of 5 plots. Weeding was carried out in the following manner. The 1st plot was weeded once a month; the 2nd plot twice a month, the 3rd plot every six months. Weeding was not applied to the 4th plot. This

experiment was conducted over five years. By taking the plant's growth rate and weeding cost into account, it was found that weeding twice a month was the most optimum practice (Tanit, 1995). The peat swamp forest has adequate water and sunlight, which promotes the growth of certain weeds such as *Blechnum indicum*, *Stenochlaena palustris*, and some types of *Scleria sumatrensis*. Weeds will dominate the area if weeding is not done for 2-3 months and the condition of the area will return to a similar state as the pre-weeding period. Weeds are one of the major problems in planting and rehabilitating peat swamp forests.

In weeding areas where there are fairly large sized trees, the use of a hand-held grass cutting machine makes weeding 3 times faster than cutting with a machete. The cutting blade should be thick and the grass cutter should wear a protective mask to prevent wooden pieces from getting into the eyes. In the case where the seedlings are still small, aged 1-2 years old, grass cutting machines are not suitable. Grass cutting machines are also not suitable where trees in the rehabilitating area are not grown in a row or straight line. This is because the blades may cut or damage the young trees easily. In this case, it is suitable to use a machete to cut the weeds instead. Spraying weeds with chemical pesticides should be strictly avoided to prevent water in the peat swamp from contamination - a disaster for the environment and a hazard for both fauna and flora.

Photo 6.1:
Weed, weeding the planting plots and replacement planting plot

6.3 MAKING FIREBREAKS AND EXTINGUISHING WILD FIRES

Most peat swamp forests existing in the world are degraded. The major cause of degradation of primary forests is wildfire. Dry peat becomes easily flammable when dried. Peat soils from Phru Toh Daeng in Narathiwat were collected and baked for experiments. It was found that completely dried peat soil from the primary forest with an area of 0.16 ha and at a depth of one metre weighed 440.88 tonnes. In the degraded forest, however, the same amount of the peat soil weighed 616.73 tonnes (Table 7). In certain areas, the peat soil is 3.5 metres deep. This indicates that Phru Toh Daeng, which has a land area of more than 16,000 ha, contains a large volume of fuel ready to ignite when it is dried. In addition, one rai of degraded forests accumulates a volume of 43.88 tonnes of weeds per ha (dry weight). These dried weeds are active combustibles. This is the reason why it is easy for wild fires to break out but difficult to extinguish in peat swamp forests. Fires burn both above and below the ground's surface. The fire above the ground may be put out but those underground may continue to burn or smolder. When the fire spreads to a large area causing fires at different points, aggravated by a very low water level, extinguishing the fires through human intervention will be almost futile, although it may be possible to simply delay the spreading of the fire. To do this, it is recommended that heavy machinery be used to dig a ditch as a firebreak to prevent the fires from spreading. A complete extinguishing of the fire can be accomplished through filling the peat soil with water. However, using water pumps to raise the water level in the planting area to put out underground fires is a long and very costly procedure. Wild fires often break out during the dry season when the water level in the peat swamp forests is low. The only occasion where it is feasible to use water pumps is when there is a large reservoir next to the peat swamp forest. Where water sources are not readily available, using natural or artificial rain can be the answer for extinguishing the fires. The success of using artificial rain to put out fires was demonstrated during the wild fires in Phru Toh Daeng in Narathiwat in 1998. In this incident, His Majesty the King himself led a team of experts and mapped out plans to combat the fires. Artificial rains, induced over the area, successfully helped to put out the fires. The 1998 fires caused massive and severe damage to the peat swamp forests. A fire that ravaged the primary forest resulted in 100% damage to the trees. Some burnt trees fell, while others eventually died. Ultimately, prevention is the best strategy to manage fires in peat swamp forests.

Prevention of wild fires is essential for the maintainence and nurturing of a peat swamp plantation. The occurrence of wild fires means a total loss to the plantation. It is ideal to divide the plantation into blocks of 500 x 500 meters and each block is surrounded by a water ditch 2 meters wide by 2 meters deep. The ditches should be blocked where the water may flow out of the plantation area. For a small-scale plantation, ditches of 1 meter wide by 1 meter deep are constructed, along with water wells in certain spots. This scheme can be carried out using manual labor in order to store water for use in extinguishing fires. The best time to dig the ditches and wells is during the dry season when the water level in the peat swamp is low.

In case of an outbreak of wild fires in the plantation, water pails are used to throw water onto an area 10 meters wide at the edge of the fire. This will serve as a barrier when the fire reaches the wet spot, thus reducing the intensity of the fire. Then the fire can be put out by human intervention. Extinguishing or barricading fires in the morning, late afternoon or at night is easier to handle than during hot weather, or during the hotter part of the day. In the case where the fire is too intense, sometimes it is advisable to withdraw from the blazing area and start new firebreaks or save energy for combating the fire in the evening or at night.

The most important point is that planters must realize that a wild fire is the most destructive occurrence that could befall the plantation. The best prevention policy is the construction of firebreaks and appointing watchmen to be on alert for fires. Other useful measures when there is fire incidence are providing swift accessibility to the affected area and immediate action and control of the

fire. Such measures will lessen the severity of the fire and enable fire extinguishers to control it. If the fire is allowed to damage the area on a large scale, controlling of the fire in peat swamp forests will be difficult to manage.

Photo 6.2: Tools used in extinguishing wild fires

A, B: Firebreaks constructed using heavy machinery to stop fires
C: Firebreaks along with water wells constructed using manual labor
D: Using a fire hose to extinguish a fire

Photo6.3: Firebreaks and extinguishing fires in the peat swamp forests

Forest Condition	Type of Fuels	Depth(cm.)	Weight: Fresh (tonne/ha)	Moisture (%)	Weight: Dried (tonne/ha)
Primary Peat Swamp Forest	Weeds	Above soil surface	73.25	85.94	10.31
	Peat soil	0 - 30	11,575	88.99	427.88
		30 - 60	13,400	77.85	957.38
		60 - 100	15,250	73.07	1,359.94
		Subtotal	40,225		2,745.19
		Total	40,298.25		2,755.5
Degraded Peat Swamp Forest	Weeds	Above soil surface	1,568.5		43.88
	Peat soil	0 - 30	10,050	91.64	501.13
		30 - 60	10,825	85.13	933.25
		60 - 100	15,775	74.24	2,376.31
		Subtotal	36,650	54.10	3,810.69
		Total	38,218.5		3,854.57

Table 6.1: Amount of fuel derived from weeds and peat stored in the soil of Phru Toh Daeng, Narathiwat

6.4 PREVENTION OF DISEASE AND INSECT INFESTATION

Problems of disease and insect infestation in the peat swamp plantations in Thailand are not severe. This may be because of the planting strategy for the peat swamp forests where mixed species are planted in the same plots. Such a practice more or less helps to prevent insects and diseases from affecting the plants. In addition, as most of the plantations are of small scale and isolated, there is less risk of severe attacks by insects or diseases

Some effects from diseases and insects which affect the plants during the planting stage are rotten roots in the seedlings in the nurseries, termites devouring the bark of *Melaleuca cajuputi* seedlings and grasshoppers devouring young leaves of *Metroxylon sagu* seedlings. Although diseases and insects have not severely damage plants in the plantations so far, it is important to be aware of the potential threats from diseases and insects, and to conduct studies on their effects.

Chapter 7
EVALUATION OF PEAT SWAMP PLANTATIONS AND THE SETTING UP OF PLANT GROWTH STUDY PLOTS

7.1 EVALUATING THE SURVIVAL OF SEEDLINGS

To evaluate seedling survival, a survey should be carried out immediately after weeding. In evaluating the seedlings, evaluators simply walk along the planting plots in a systematic pattern for an area equivalent to 10% of the total planting area and record the survival and death rates of each plant species. The record can be used in calculating the number of seedlings required for replacement planting.

7.2 SETTING UP OF THE PLANTS' GROWTH STUDY PLOTS

Study plots for examining the growth of plants are useful and essential. The information acquired from the study plots can be used for evaluation of the plantations and for identification of plant species suitable for planting in specific areas. The information acquired can also be used to determine the selection and improvement of the plant species to be used for the following year's planting. Technical information can be disseminated through lectures and publications to agencies or individuals interested in peat swamp plantations.

A plot for studying plant growth should be a permanent plot of 40 x 40 meters. One plantation should have at least 4 study plots, sited at different locations in the plantation. Each plant in the plot is labeled with an identification number. The trunk size and crown height of each plant are measured. The trunk size is measured at 20 centimeters above the ground. A mark with red paint is made around the measurement point on the trunk. When the plant grows taller, measure the trunk at 1.3 meters above the ground. Repeat the measurement every year. A plan should be mapped out before collecting the data; all necessary tools such as notebooks should be prepared beforehand. A data record sample is given in Table 7.1. Other information that should be collected includes a description of general surroundings, flowering and fruiting period, and diseases and insects found. To obtain reliable data on water, surveyors should install a water gauge and measure the water level monthly.

Plant Species …… Year …… Plot No. …… Age……
Date: …… Month …… Year…… Other Notes: ……
Data Collectors: 1…… 2…… 3…… 4……

No.	ID No.	D10 (cm)	D130 (cm)	H (m)	Crown Width		Flowering-Fruiting		Note
					E-W	N-S	Flower	Fruit	
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									
17									
18									
19									
20									
21									
22									
23									
23									
25									
26									
27									
28									
29									
30									
Av.									
SD									

N = ……. Trees Survival Rate = …… %

Note:
Tree No.1 starts from Tree No. …….. Row …… forward to the direction of …….. for a total of ……. trees and then restart measuring the next row again.

Table 7.1: Plant Growth Evaluation Form

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APPPENDIX
Estimate Costs of Peat Swamp Reforestation

Data on climate of Narathiwat

Procedure	Planting in Degraded Peat Swamp Forests					Planting of Peat Swamp Forests on Raised Beds				
	Unit	Unit Cost (Baht)	Quantity (Labor)	Cost (Baht)	Note	Unit	Unit Cost (Baht)	Quantity (Labor)	Cost (Baht)	Note
1. Surveying and boundary measurement	Wk	178.00	0.2	35.60	1. 2m x 4 m. planting space; 200 trees/rai	Wk	178.00	–	–	Plant on rows of raised beds 2 meters apart and planting is extended another 2 meters along the path of tractors; the planting spots are 4 meters wide, using a total of 100 seedlings of Melaleuca sapor (bark) per rai. Planting of mixed species of 100 large seedlings not in rows and straight lines per rai, a total of 200 trees per rai. - a distance of 1 km equals 4 m x 1,000 m = 4,000 sq. meters = 2.5 rai.
2. Weed slashing	Wk	178.00	5.0	890.00		Wk	178.00	3.0	534.00	
3. Collecting seedlings	Wk	178.00	3.0	534.00	2. Use large seedlings contained in 5" x 8" polythene bags	Wk	178.00	1.5	267.00	
4. Setting planting pattern	Wk	178.00	2.5	445.00		Wk	178.00	2.5	445.00	
5. Digging hod at planting point	Wk	178.00	4.0	712.00		Wk	178.00	2.5	445.00	
6. Transportation of seedlings	Wk	178.00	3.0	534.00		Wk	178.00	3.0	534.00	
7. Weeding	Wk	178.00	3.0	534.00	3. 25% of seedlings are reserved for replacement planting in the first year and 10% for next year	Wk	178.00	3.0	534.00	
8. Firebreak zone	Wk	178.00	4.0	712.00		Wk	178.00	–	–	
9. Assess survival rate and replace failed seedlings	Wk	178.00	1.0	178.00	4. Raise 100 elevated levels	Wk	178.00	1.0	178.00	
Total labor cost per rai	Wk	–	25.7	4,574.60		Wk	–	16.5	2,937.00	
10. Seedling costs	Sdls.	3.00	270	810.00		Sdls	5.00	270	1,350.00	
11. Material costs		–	–	140.00					140.00	
12. Miscellaneous		–	–	60.00					60.00	
Total cost per rai	Baht	–	–	5,584.60		Baht			4,487.00	

Note: Wk = worker; Sdl. = Seedling

Table 1: Estimated expenditure in the first year of planting of 0.16 ha of peat swamp forest in Narathiwat

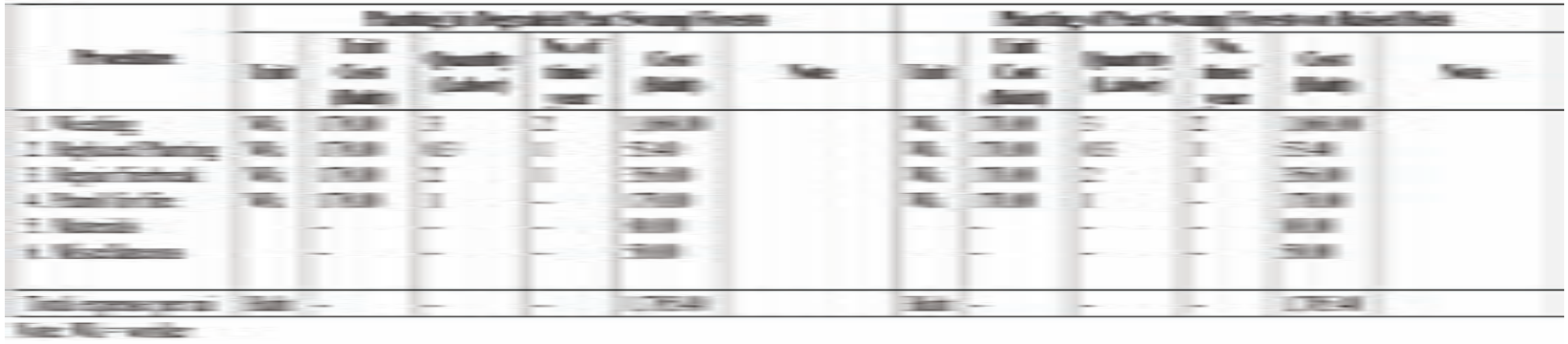

Table 2: Estimated expenditure in the second year of planting of 0.16 ha of peat swamp forest in Narathiwat

Procedure	Planting in Degraded Peat Swamp Forests						Planting of Peat Swamp Forests on Raised Beds					
	Unit	Unit Cost (Baht)	Quantity (Labor)	No. of time/ year	Cost (Baht)	Note	Unit	Unit Cost (Baht)	Quantity (Labor)	No. time/ year	Cost (Baht)	Note
1. Weeding	Wk	178.00	3	2	1,068.00		Wk	178.00	3	2	1,068.00	
2. Repair firebreak	Wk	178.00	2	1	356.00		Wk	178.00	2	1	356.00	
3. Patrol for fire	Wk	178.00	1	-	178.00		Wk	178.00	1	-	-	
4. Materials		-	-	-	80.00			-	-	-	50.00	
5. Miscellaneous		-	-	-	50.00			-	-	-	30.00	
Total expense per rai	Baht	-	-	-	1,732.00		Baht	-	-	-	1,504.00 .	

Note: Wk = worker

Table 3: Estimated expenditure in the third year of planting of 0.16 ha of peat swamp forest in Narathiwat

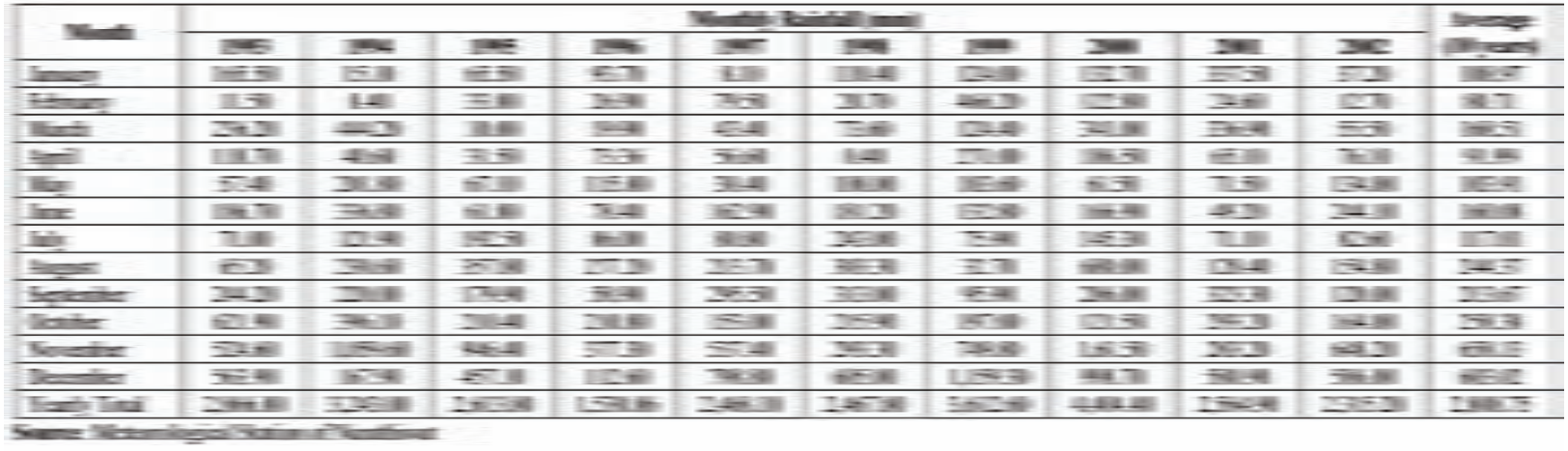

Table 4: Amount of monthly rainfall (mm) recorded by Meteorological Station of Narathiwat, Muang District, Narathiwat, 1993-2002

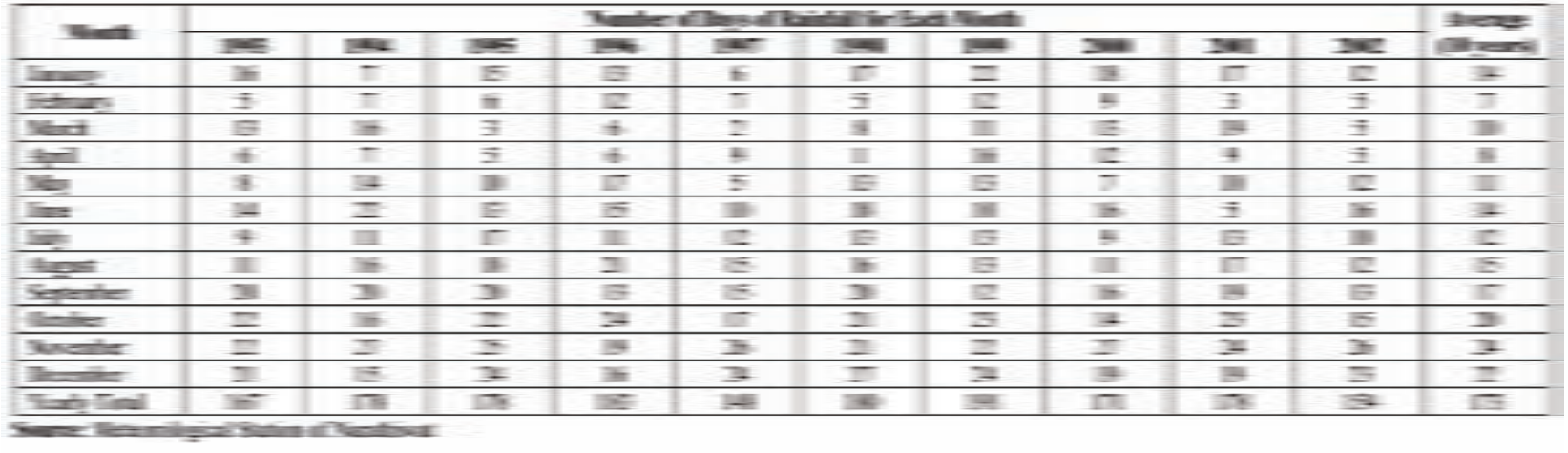

Table 5: Number of days of rainfall for each month recorded by Meteorological Station of Narathiwat, Muang District, Narathiwat, 1993-2002

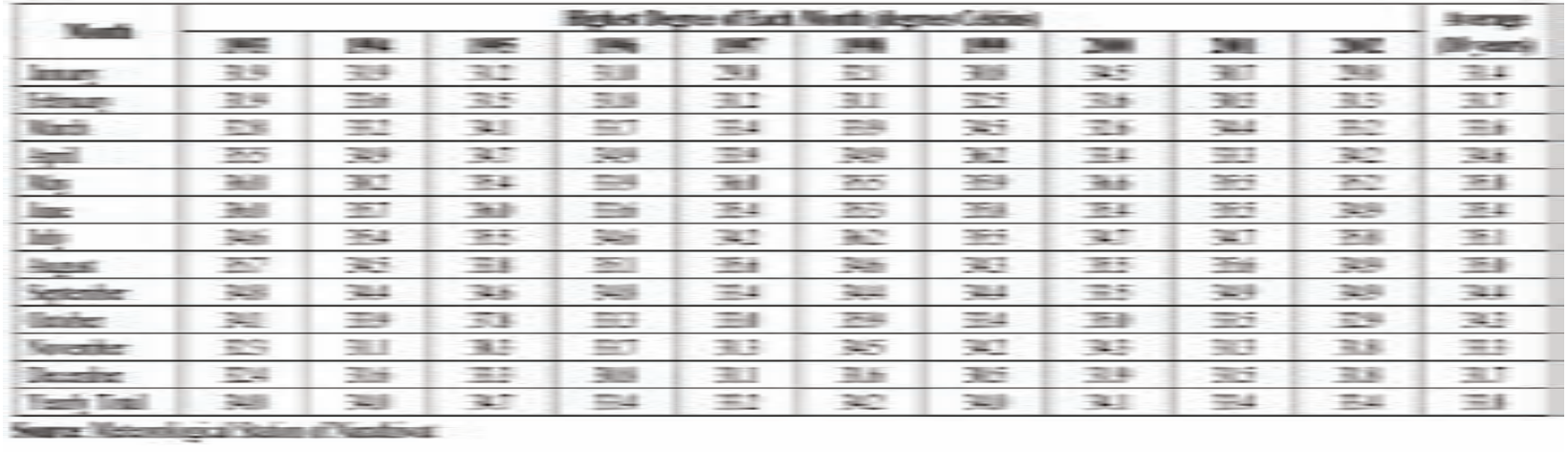

Table 6: Highest temperature of each month (degrees Celcius) recorded by Meteorological Station of Narathiwat, Muang District, Narathiwat, 1993-2002

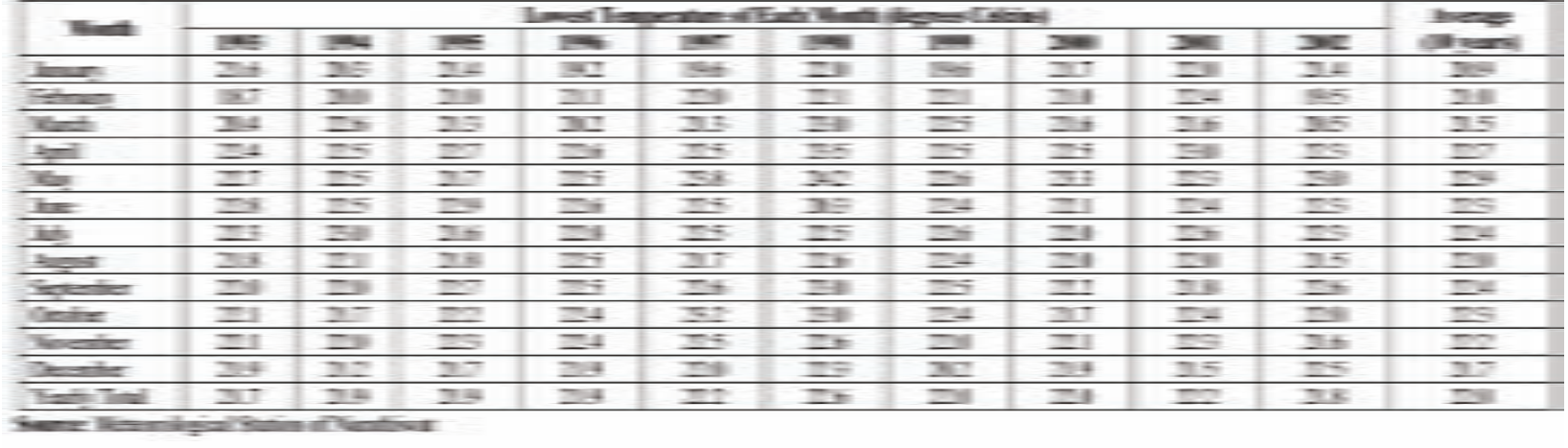

Table 7: Lowest temperature of each month (degrees Celcius) recorded by Meteorological Station of Narathiwat, Muang District, Narathiwat, 1993-2002

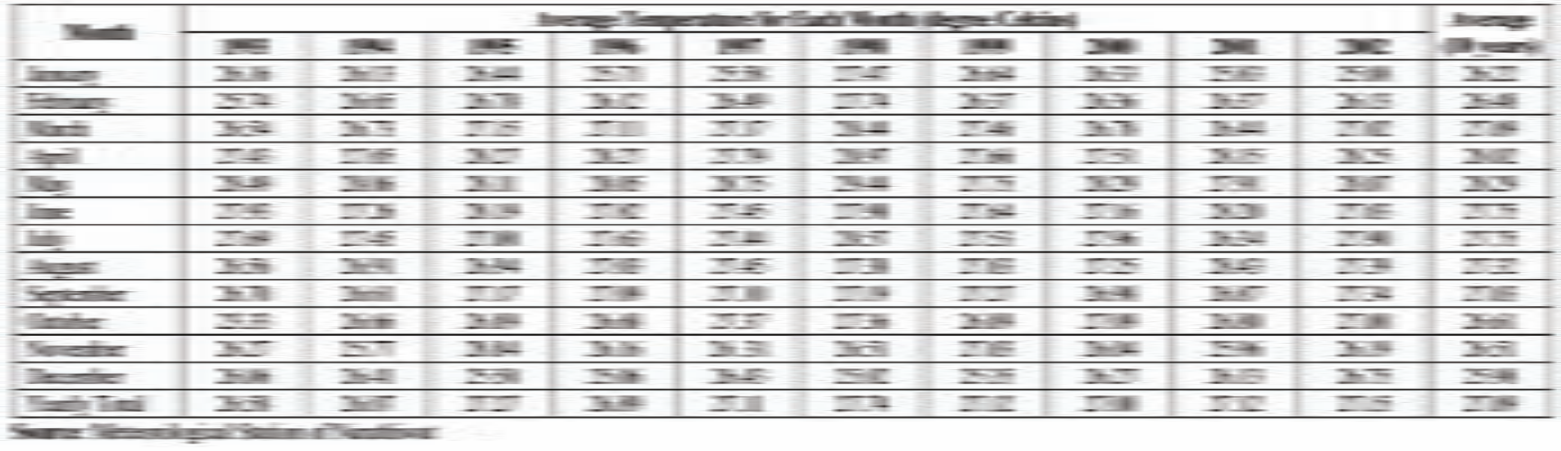

Table 8: Average temperature for each month (degrees Celcius) recorded by Meteorological Station of Narathiwat, Muang District, Narathiwat, 1993-2002

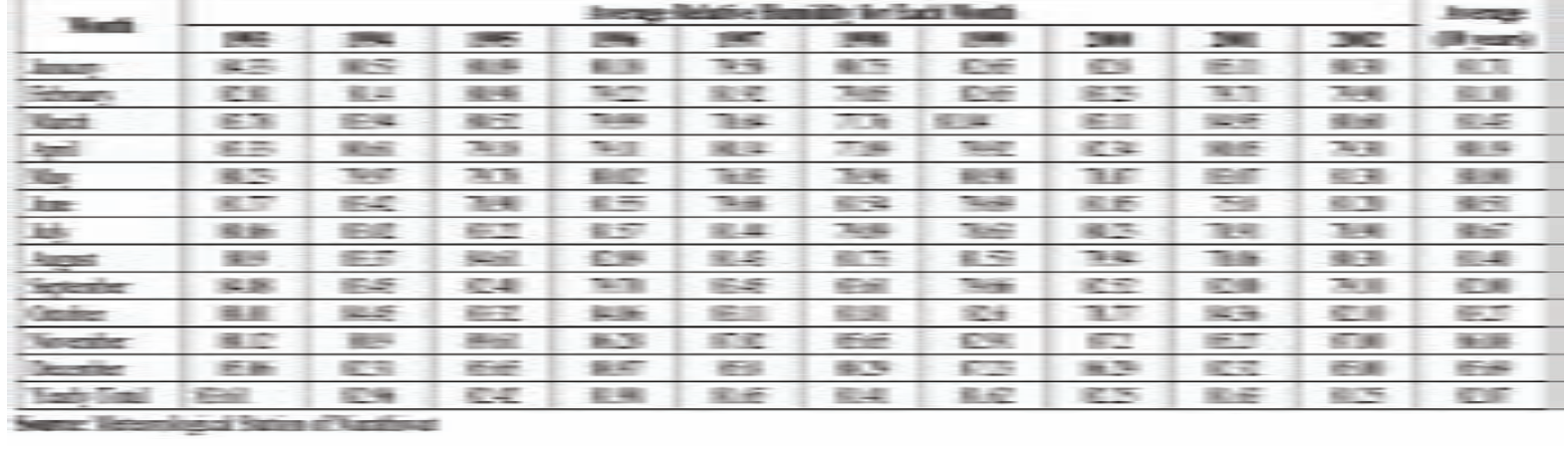

Table 9: Average relative humidity for each month recorded by Meteorological Station of Narathiwat, Muang District, Narathiwat, 1993-2002

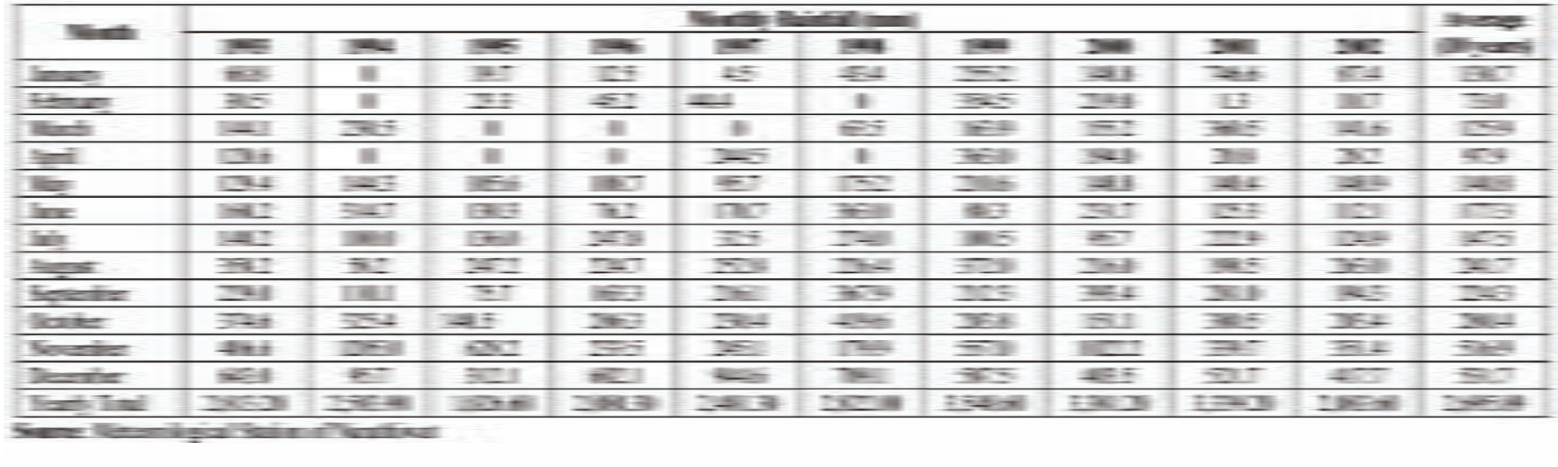

Table 10: Amount of monthly rainfall (mm) recorded by Meteorological Station of Narathiwat, Muang District, Narathiwat, 1993-2002

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