5
Plantation Forestry in the Tropics

Shobu Sakurai

5.1 Introduction

There are several tree species that were once called "miracle trees" or "wonder trees," which suggests that people wanted such trees to meet their demands. Unfortunately, as Dr. Julian Evans pointed out in *Plantation Forestry in the Tropics*, (Evans 1992) some environmentalists insist that pine, eucalypts, and wattle, considered miracle trees by some, are "green cancer."

Please imagine, however, vast areas of dry, bare, or eroded land, where no tall trees have been able to develop for a long time. Only a few species can survive and cover the damaged land (Table 1), just as a "scab", which covers a wound, is not real skin but the first important stage in the recovery of a wound. I hope to call these precious trees "curing vegetation for the earth", not "green cancer".

After World War II, especially during the 1970s, the demand for wood in Japan increased substantially, and tropical countries met the demand. At first the Philippines, then Indonesia, and later Malaysia exported wood materials to Japan. As a matter of course, not only Japan but many other countries also consume a great deal of wood resources.

Advances in medical technology have lengthened the life span of humans and the population has increased. This has also accelerated the depletion of forests by overuse and overexploitation of the land to meet these changes. Fuel-wood consumption for everyday use has increased and caused the disappearance of woodlands in many areas of the world. Furthermore, it has become clear that forest depletion has strongly influenced the global environment. Consequently, the recovery of destroyed forests is a very important issue in the world. Many people, not only foresters and scholars but also mere citizens, have an interest in nature conservation. As a matter of course, people who live on land where there is a severe shortage of wood resources are also deeply concerned. We, who are concerned with forests and forest science, must try to meet the demand on forests from outside in order to keep a sound forest and to be able to hand our descendants a fine forest.

Forestry and Forest Products Research Institute, 1 Matsunosato, Tsukuba 305-8687, Japan

Table 1. All assessed tree species and their characteristics (After BFD and JICA 1987)

Fast growing species	Survival	Growth	Remarks
Acacia auriculiformis	++	++	Wide range of adaptability
A. mangium	++	+	Die back in dry land
Paraserianthes falcataria	–	–	
Anthocephalus chinensis	+	+	Die back in dry land
Casuarina equisetifolia	+	+	Die back in dry land
Gliricidia sepium	++	+	Regeneration on slope face
Gmelina arborea	++	++	Wide range of adaptability, fire resistant
Eucalyptus camaldulensis	++	++	Slightly fire resistant, drought resistant
E. citriodora	+	+	Drought resistant
E. deglupta	–	–	Sensitive to site conditions
E. tereticornis	–	–	
E. torrelliana	–	–	
Leucaena leucocephala	+	–	Sensitive to site conditions
Pine species			
Pinus caribaea	+	+	Shoot moth
P. kesiya	++	++	High elevation, shoot moth
P. oocarpa	+	+	Shoot moth
Long-rotation species			
Anisoptera thurifera	+	+	Under/inter planting
Shorea guiso	+	+	Under/inter planting
Vitex parviflora	+	+	Inter planting
Pterocarpus indicus	+	+	Under/inter planting
Swietenia macrophylla	+	+	Under/inter planting
Tectona grandis	++	–	Dieback, fire resistant

++ Generally good, + good depending site conditions, – not good

Planting trial was mainly done from 1979 to 1986 in a degraded grassland at Pantabangan Project site, about 185 km north of Manila, the Philippines

5.2 Why Have the Forests Degraded?

There are various causes and many reasons for forest degradation. The conversion of a forest stand to a cash-crop plantation, such as oil-palm plantations, coconut plantations, pepper fields, fruit orchards, etc., is common. Overexploitation, illegal logging in particular, also damages the sustainability of natural forests. An important cause of damage in Southeast Asia is burning, which typically results in the degradation of forest to grassland. Open land after heavy erosion is also included in this category. It is very common that grassland is used for cattle grazing. Farmers usually set fires to maintain the grassland during the dry season.

We had a similar experience in Japan, especially along the Pacific Ocean side, where scattered pastures had been maintained for more than 1000 years. Year by year, in early spring, when a short dry season occurred, farmers set fire to the grassland. When they did not have enough knowledge about the environment, they believed that burning kept the pasture healthy. Pests and diseases were excluded by burning and the quality of grass became good. This practice continued until the 1950s in several parts of rural Japan.

We now know that modern science denies such a theory. Furthermore, burning is dangerous as fire can easily spread to neighboring forests. Consequently, farmers have now stopped burning. Burning is now strictly limited. We also know that forests produce various properties, so farmers never set fires.

Once ground cover is removed, strong raindrops in the area hit the surface and flush the precious thin soil downstream. Fertile soil is lost rapidly. Subsequent grazing compacts the ground harder.

Usually, fire and grazing will produce *Imperata cylindrica* (cogon, alan-alan, lalang) grassland, and heavier fire and grazing will change the vegetation from *I. cylindrica* to *Saccharum spontaneum* or *Themeda triandra*, finally resulting in bare land. The site quality of *I. cylindrica* land is not so poor, but sites supporting the other two species are poor (Sakurai and de la Cruz LU 1993).

5.3 How Do We Prevent Fire?

If grassland changes into forest or tree plantations, farmers lose their pasture. So it is very difficult to stop a fire. As I already mentioned, however, if farmers know the advantage of the forest, they may stop it. I will introduce several trials to recover the forest by Japanese re/afforestation activities.

Japanese experts who engaged in re/afforestation activities under the Republic of the Philippnes (RP) – Japan forestry development project of the Pantabangan area by Bureau of Forest Development (BFD), the Department of Environment and Natural Resources (DENR), and Japan International Cooperation Agency (JICA) gave a lot of attention to fire prevention. They constructed two or more watch-towers to detect fire by a triangular surveying technique as soon as they started the project, and then set up wide firelines. They organized the fire brigade with a fire engine if they had the budget. Sometimes, they held a poster-drawing contest at rural schools during fire prevention week and gave prizes to the students who participated in the contest. They planted fruit trees for the community and gave many seedlings of useful trees to the villagers. They expected that these activities would bear the fruits of fire prevention in the minds of the future (BFD and JICA 1987).

The forest that gives no benefit to the people or their community, or is believed to bear no benefit, is easily destroyed. The forest that does not produce continuous profit for the people is also easily destroyed for momentary gain.

Advanced countries like the United Kingdom (UK) have a severe history of forest degradation. Oak forests were formerly very important in the UK. They produced fuel wood, charcoal, barrels, furniture, construction, and so on. In particular, they supported the strongest navy, being used for making warships. Until the 18th century, much wood went into Thames river as the British warships that commanded every sea in the world. The industrial revolution occurred in the 19th century. Coal became the leading actor instead of wood, and steel made warships. Then, forests were destroyed rapidly, and most of the forests in the UK were lost. The forest area in the UK in the early 20th century was only 7% of the total land. At that time, the existence of forestland was evidence of a lack of civilization. The other European countries also lost vast amounts of forestland. Recently, environmental issues have changed the trend. People now realize the value of forests and the percentage of forest to total land area in the UK has increased to 11.6% (FAO 2001).

In Japan, forests were also very important for everyday use until the early 1960s. They provided energy, and litter for agricultural fields, children's playfields, and nature education material. However, the modern industrialized atmosphere changed the value of the forest. The brilliance of industrial products, such as stainless ware and plastic ware attracted people. Japanese believed at that time that natural ware was inferior to industrially-produced wares. Science was better than tradition. Peoples' labor for managing forests decreased, and the demands/interests on forests became small. No one wanted the shrubs and litter in the forest. No one wanted the dead trees, which, for example, were attacked by pine nematode diseases. Forests around the urban areas changed into housing areas or dumping grounds.

Efficiency is required in the modern age. So, natural-hardwood forests in Japan were converted to highly productive coniferous plantations. Certainly, such coniferous-tree species also hold the capacity for environmental conservation. However, serious problems, such as insect attack, pollen allergy, loss of biodiversity, and imbalance of wildlife habitat, causing serious damage to the forest, became apparent. Recently, we gradually noticed that efficiency often damages the environment. When the problem has become clear, every measure against it is too late to correct the failure. Usually, the damage costs more to restore than that earned by earlier increased efficiency. This may teach us that endurance/tolerance may be important in some cases. These experiences are applicable to tropical forest management.

5.4 Afforestation Trial in *Imperata cylindrica* Grassland in Benakat, South Sumatra Island

I. cylindrica grasslands are widely distributed throughout Indonesia. The total area of grassland in Indonesia was about 24 million ha in 1978 (Tanimoto 1981) and 35 million ha before 1985 (Ishi 1985). These data show the rapid incremental increase of grassland in Indonesia.

A Japan-Indonesia afforestation project was started in Benakat, about 130 km west of Palembang city, Sumatra Island, in December, 1980. Desiccation during the dry season in this area is not so severe. Various species' planting trials were undertaken, using mechanical land-cultivation techniques by tractor that had been examined and developed by the Pantabangan Project in the Philippines (BFD and JICA 1987). This project clarified that the productivity of the site occupied by tall *I. cylindrica* (more than 1 m in height) was not so poor. I measured the size of planted trees in April, 1992 (Sakurai et al. 1994). The height of 8-year-old *Acacia mangium* exceeded 20 m, with a diameter of around 20 cm. Eleven-year-old *Swietenia*

Table 2. Description of forests in Benakat, surveyed in April, 1992 (After Sakurai et al. 1994)

Examined tree species	Age (year)	Average dbh (cm)	Average Height (m)	Per hectare No. (m^2)	Per hectare BA (m^3)	Per hectare Volume (m^3)	Total volume
Swietenia macrophylla	11	20.0	16.4	640	21.2	188	209
		10.8	11.7	300	3.0	21	
Acacia mangium	8	19.2	21.3	664	20.1	232	255
		11.1	14.5	248	2.6	23	
Peronema canescens	11	11.7	11.8	856	14.1	99	102
		6.0	8.4	160	0.5	3	

Upper rows indicate dominant trees and lower rows suppressed trees

dbh: diameter at breast height

BA: Total basal area at 1.3 m above ground surface

Stem volumes were estimated from the volume table for Japanese natural Akitasugi

macrophylla was 16 m tall and had a diameter of 20 cm. The annual increment in stem volume per hectare for these species was as follows: *S. macrophylla*, 19 m^3; *A. mangium*, 32 m^3; and *Peronema canescens*, 9 m^3 (Table 2). We could see monkeys playing on the planted trees. Grassland afforestation recovered the wildlife habitat.

5.5 Influence of the Private Sector

The results of the afforestation trial conducted at Benakat strongly influenced others. A private enterprise started to establish an industrial plantation of *Acacia mangium* around the project site in 1990s. They established more than 150 000 ha of *A. mangium* plantation in less than 5 years (Kato 1995). This work was led by former staff of the early period of the project. We must know that when the private sectors began to plant as a business, the power of re/afforestation was very large. When the private sector notices that forest farming produces enough profit, re/afforestation might be strongly implemented. Therefore, I want to point out that if people begin to develop forests for their own interests, the result will be a huge area of forestland. The Japan International Cooperation Agency (JICA) project planted only 3,100 ha over 8 years in south Sumatra (Kato 1993) and about 10,600 ha in the Pantabangan area in the Philippines over 16 years (Masuko 1998), but the private sector established more than 150 000 ha in less than 5 years (Kato 1995).

Certainly, severe problems can occur in such a wide area of monocultural forestland. I worry about diseases, like heart rot, insect attack, and decline in soil productivity due to short rotation, in addition to the decline in biodiversity. To avoid these problems, mixed forests and indigenous-species plantings should be examined. We must develop sustainable forest-management techniques through experimentation, because we are yet to have techniques that keep widespread-monocultural forests healthy.

Table 3. Description of man-made forests in the experimental forest of UPLB (After Sakurai et al. 1994)

Age is about 70 years	Average		Per hectare			
Planted tree species in each stand	dbh (cm)	Height (m)	No.	BA (m^2)	Volume (m^3)	Total volume (m^3)
Swietenia macrophylla	43.4	29.1	281	44.6	636	
	18.5	16.8	521	16.1	158	795
Swietenia macrophylla	52.3	31.7	224	52.0	764	
	18.2	17.1	181	5.7	56	897
Parashorea malaanonan	44.8	30.1	188	31.0	444	
and	23.3	18.9	200	9.2	94	
Anisoptera thurifera	46.8	30.4	50	9.1	131	
	20.0	17.3	131	4.9	50	800
Parashorea malaanonan	42.9	28.7	81	13.9	200	
and	18.5	15.9	30	1.1	11	
Dipterocarpus grandiflorus	26.9	23.8	200	12.2	153	
	13.4	14.2	390	6.6	58	440

Upper rows in each stand indicate dominant trees and lower rows indicate suppressed trees

Total volume includes the other tree species in the stand

dbh: diameter at breast height

BA: Total basal area at 1.3m above ground surface

Stem volumes were estimated from the volume table for Japanese natural Akitasugi

I have another anxiety, which is the friction among such vast monocultural-planting activities, inhabitants, and government. The people in rural areas/forests who gain non timber benefits from forests, and the enterprises who want wood resources, are not same. The administration sector of the country may often give critical regulations to the weak rural people; sometimes they are the first nations in the forest. If trouble happens, re/afforestation activities will be greatly damaged. Consequently, it is very important to build up a consensus among inhabitants.

5.6 Man-Made Forests of Long-Rotation Species and Indigenous Species

Fast-growing species are widely employed as plantation species due to their economic advantages. However, I worry about the degradation of soil productivity and environmental conservation by the monoculture of a fast-growing species. If enough valuable long-rotation species forest or indigenous-species forest is established, its economic value and ability to conserve the environment may be higher than a fast-growing species forest. For instance, *Tectona grandis* forests in Thailand, Malaysia, Indonesia, and elsewhere are good examples of such forests.

Table 4. Description of man-made forests in the Dramaga experimental forest (After Sakurai et al. 1994)

Examined tree species	Age (year)	Average dbh (cm)	Average Height (m)	Per hectare No.	Per hectare BA (m^2)	Per hectare Volume (m^3)	Per hectare Total volume (m^3)
Dipterocarpus retusus	35	43.7	40.0	196	30.4	563	
		23.1	22.4	232	11.2	151	714
Shorea seranica	34	52.8	43.3	184	42.3	829	
		32.6	29.7	60	5.2	81	910

Upper rows indicate dominant trees and lower rows suppressed trees

dbh: diameter at breast height

BA: Total basal area at 1.3 m above ground surface

Stem volumes were estimated by the volume table for Japanese natural Akitasugi

There are several such forests in the experimental forests of the University of the Philippines at Los Baños (UPLB), and Haurbentes and Dramaga experimental forests of the Nature Conservation and Forest Research and Development Centre (Psat Penelitan dan Pengembangan Hutan; NCFRDC), Bogor, Indonesia. We can see fine stands of *Swietenia macrophylla*, *Parashorea malaanonan*, *Anisoptera thurifera*, and *Dipterocarpus grandiflorus* in UPLB. *Shorea stenoptera*, *S. seranica*, *D. retusus* and many other such species are found in the experimental forest of NCFRDC, Bogor. Since the Centre of International Forestry Research (CIFOR) was founded in the Dramaga experimental forest in 1993, visiting this forest has become easier.

These trees in UPLB reach more than 30 m in height and are 40 to 50 cm in diameter. The ages of the stand in the UPLB forest are not clear, so I assumed that they were about 70 years old when I measured them in 1991, because the University was established in 1909 (Brown 1919), and afforestation might go well after 10 years. On this assumption, the average yearly stem-volume increment of *S. macrophylla* ranged from 11.5 to 13 m^3 per hectare (Table 3). This range is almost equivalent to the value of a 70-year-old fine *Cryptomeria japonica* stand (12.6 m^3), which has very high productivity in Japan.

Heights exceeding 40 m and diameters of 40 to 60 cm were found in the experimental forests of NCFRDC, Bogor (Table 4). The annual stem volume increment ranged from 20 to 27 m^3 per hectare. Those well-developed forests contain many other tree species in them.

These results show the marvelous future of forestry. If these trees endure without cutting for 50 to 100 years they will grow big enough to use, and the forest can be sustainably managed. High-quality wood can also be harvested, while wildlife and biodiversity can coexist.

5.7 Another Aspect of Forest Decline and Multi-Storied Forests

Decline in the species components of a forest by selective cutting is another form of degradation. Even if the composition of the remaining forest declines, its role in environmental conservation and wildlife habitat maintenance will remain. Fuel-wood supply will also be kept. This type of degradation is caused by logging. If suitable treatments are applied to such a forest, the quality of the forest will be recovered. Appropriate tending techniques, derived from a shelterwood system, are valuable. For that purpose, multi-storied forest trials are useful.

One of the multi-storied forest experiments started in 1992, as a joint project between the Forestry Department of Peninsular Malaysia and JICA, near Ipoh city, Malaysia (FDPM et al. 1999). The experimental site near Ipoh was established in an approximately 4-year-old *Acacia mangium* forest, where lowland dipterocarp forest was clear-cut in 1988 and 1989.

Experimental plots were established using five different strip widths in the 4-year-old *A. mangium* plantation. Five treatments were employed for this experiment: (1) cutting and retaining one row; (2) cutting and retaining two rows; (3) cutting and retaining four rows; (4) cutting and retaining eight rows; and (5) cutting and retaining sixteen rows. Thirteen species were planted. Among the species measured in 1992, *Shorea leprosula, S. parvifolia, and Neobalanocarpus heimii* were reported (Iwasa et al. 1993). Favorable values of relative illuminance on top of the planted seedlings were 30% to 70% (one-, two-, and four-row cut sites). *S. leprosula* and *S. parvifolia* showed better height growth than *N. heimii*. I observed this experimental forest in 1994 and 2001, and found that the height of these planted trees reached more than 4 m in 1994, and was 7.2 m for *S. leprosula*, 6.7 m for *S. parvifolia* and 3.8 m for *N. heimii* after 6 years. Indigenous long rotation tree-species forests can be established easily by multi-storied forest techniques in a fast growing tree-species plantation.

5.8 Activities of NGOs/NPOs for Plantation Making

There are many Japanese NGOs/NPOs engaged in re/afforestation in the tropical countries.

The Research Association for Reforestation of Tropical Forest (RETROF) is a unique organization among them. This association is composed of private companies. The Government of Japan offers 50% of the research budget to the member companies and a secretariat. The members are Komatsu, Kansai Environmental Engineering Center, Sumitomo Forestry, Ishinomaki Plywood, Toyoboseki, Mitsui-Norin, Toyota, Gifu-Serakku, Oji Paper, and Nissho-Iwai Corporation.

The members contribute the research reports of their activities to the Bio-Refor Program and exchange information. Bio-Refor is a program of IUFRO/SPDC, and is financially supported by the Japanese Ministry of Foreign Affairs. The program was started in 1992 under an agreement among Southeast Asian researchers in the Philippines, Taiwan, Malaysia, Indonesia, Thailand, and Japan. The objectives of Bio-Refor are to provide the opportunity for information exchange and a discussion table to foresters and forest science researchers that enable and accelerate re/afforestation in Southeast Asia and the Pacific region through biotechnology development. The members of RETROF are important members of Bio-Refor. They join the Bio-Refor Workshop and present their research.

Toyoboseki constructed a simple and cheap pond to preserve water for the dry season in Borneo Island. Komatsu staff developed a tissue culture of Dipterocarpaceae spp. (*Shorea leprosula*, *S. laevis*, *S. parvifolia*, *S. pauciflora*, *Dryobalanops lanceolata*, *and D. beccarii*) in Bogor with the Nature Conservation and Forest Research and Development Centre, and established an experimental plantation, using cuttings of *Shorea* spp., near the campus of CIFOR, to clarify the result of the experiment. Ishinomaki Plywood developed propagation techniques for *S. albida* by cuttings, and they obtained a high survival ratio of cuttings of *S. albida* in their trial. The study was done with the staff of the Forest Department of Sarawak. Kansai Environmental Engineering Center developed an effective usage of mycorrhizal fungi with the staff of Gadjah Mada University, Indonesia. Mycorrhizal fungi have also been studied by Sumitomo Forestry in Borneo with PT. Kutai Timber, Indonesia. This group is also developing methods for the propagation of many indigenous-tree species by cuttings and out-planting trials. Their objective is to recover the dipterocarp forest that was lost by the big fire in the early 1980s. Other companies are also advancing forest-related activities and are developing techniques for the sustainable management of forests (RETROF 1997; Ministry of Forestry, Republic of Indonesia et al. 1993, 1994).

The activities of the private sector are very important for the future of forest resources and environmental conservation. During the implementation of such re/afforestation works, some companies became involved with social forestry trials, and they noticed that good human relations were very important to the success of the experiment. Everywhere there is forest, there are people who live and work in it. If they want to keep their activities for a long time, the private sector must get their agreement and cooperation. Such experiments are very important for future coexistence.

5.9 Conclusion

Plantation forestry has become a worldwide concept for increasing the stock of timber resources. Many plantation activities have been instigated. Many of them choose fast-growing species for their industrial plantations. Through many trials, suitable fast-growing tree species and silvicultural techniques for plantation establishment have been developed, and such trees are important planting stock now. Wood characteristics have also been clarified, but some problems still remain. Heart rot disease of *Acacia mangium* and life-span control for many fast-growing species are important objectives that require clarification.

To conserve the environment, including wildlife habitats and biodiversity, reforestation by indigenous species has attracted a great deal of attention. Some private companies are becoming involved in setting up plantations and taking account of environmental effects. Even if the purpose is not for a timber-resource forest, mature and well-tended forests produce enough good-wood resources. Even if the species employed are exotic, fast-growing species are important for the begining of rehabilitation of degraded-forest land. Once the degraded land has changed into forest, a second generation of fast-growing tree species forest can be changed into the advanced phase of the forest, such as long-rotation species forest and indigenous-tree species forest. So, such a trend is very important.

We saw that private enterprise has established huge fast-growing species plantations in Sumatra. If the private sector realizes that plantations produce big benefits, they will start to plant trees. If many people know this, planting power will increase. We must manage forests sustainably, recover the degraded forest, and hand down fine forests to our descendants.

References

BFD, JICA (1987) Technical reports on afforestation, Japan International Cooperation Agency, Tokyo

Brown WH (1919) Vegetation of Philippine mountains. Department of Agriculture and Natural Resources, Bureau of Science, Manila

Evans J (1992) Plantation forestry in the tropics, 2nd edn. Clarendon, Oxford

FAO (2001) The global forest resources assessment. In: 2000 summary report committee on forestry, item 8(b) of the provisional agenda, Fifteenth Session, Rome, Italy, 12–16 March 2001

Forest Department Peninsular Malaysia (FDPM), Perak State Forestry Department (PSFD), JICA (1999) Proceedings of 2nd seminar on the multi-storied forest management project, FDPM, PSFD & JICA

Ishi H (1985) Worm-eaten-like depletion of the forest (In Japanese). Asahi Shimbunsha, Tokyo

Iwasa M, Ariffin RB, Yusof MBM (1993) The establishment of multi-storied forest in peninsular Malaysia. In: Abstracts of the Bio-Refor proceedings of YokYakarta workshop, 66–68, Bio Refor

Kato R (1993) Reforestation on Alang-alang grassland in South Sumatra (in Japanese). The tropical forestry 28, 37–44, Japan international forestry promotion and cooperation center

Kato T (1995) The role of trial plantation established at Benakat, South Sumatra at seven years after termination of the project (in Japanese). The tropical forestry 34, 24–31, Japan international forestry promotion and cooperation center

Masuko H (1998) Undoubted change for the rehabilitation of tropical forest - recent situation in the forestry development project in Pantabangan (in Japanese). The tropical forestry 42, 36–42, Japan International Forestry Promotion and Cooperation Center

Ministry of Forestry Republic of Indonesia, PT Kutai Timber Indonesia, Sumitomo Forestry, The University of Tokyo (1993) Research report on the Sebulu experimental forest. Sumitomo forestry & P.T. kutai timber Indonesia

Ministry of Forestry Republic of Indonesia, PT Kutai Timber Indonesia, Sumitomo Forestry, The University of Tokyo (1994) Research report on the Sebulu experimental forest. Sumitomo forestry & P.T. kutai timber Indonesia

RETROF (1997) RETROF research report (In Japanese)

Sakurai S, de la Cruz LU (1993) Growth of trees planted in degraded forest land, JARQ 27:61–69, Japan International Research Center for Agricultural Research (JIRCAS)

Sakurai S, Ragil RSB, de la Cruz LU (1994) Tree growth and productivity in degraded forest land. In: JIRCAS international symposium series 1, 64–71, JIRCAS

Tanimoto T (1981) Vegetation of the Alang-alang grassland and its succession in the Benakat district of South Sumatra, Indonesia. Bul. For. & For. Prod. Res. Inst. 314:11–19