

dispersed seeds. The decline of large mammals, over wide areas now prevents dispersal of large-seeded, climax trees into deforested sites. By including some climax forest tree species amongst those planted, it is possible to overcome this limitation and accelerate recovery of climax forest. Fast-growing, pioneer trees rapidly close canopy and shade out weeds, whilst slower growing climax species form an under-storey beneath the pioneer tree crowns, adding structural diversity to the forest and increasing the variety of wildlife resources available. Pioneer trees begin dying 15-20 years after planting. However, by this time, a rising under-storey of climax forest trees is ready to replace them, along with a dense layer of naturally established trees, derived from seeds brought in by wildlife.

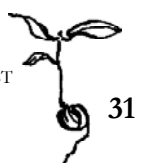
Research, under this project, focussed on identifying such framework tree species, suitable for restoring the forest habitat of Gurney's Pitta. It involved surveying the tree species composition of the forest, carrying out phenology studies (to determining when seeds could be collected), germinating more than 100 tree species in a nursery and establishing 2 field trials. Because data from the field trials is just coming in (first data sets are compiled 18 months after planting) and the project was not long enough to assess attractiveness of the trees to wildlife or biodiversity recovery, it is not possible to present a definitive list of framework tree species for Krabi. However, we have accumulated sufficient data to compile a shortlist of "candidate" species. Below, we present useful notes on the indigenous tree species most likely to act as framework species (on the basis of currently available data), which are recommended for long-term field trials.

### **Selected Candidate Framework Species**

DBH = diameter at breast height; GP = typical germination percentage; MLD = median length of seed dormancy (days); TNT = total nursery time (from collection of seeds or wildlings to planting out).

#### ***Alstonia macrophylla* (Wall.) ex G. Don (APOCYNACEAE) "Tung Fa"**

A medium-sized, evergreen tree of secondary forests. Fruits: thin, elongate pods, 20-40 cm long, green turning brown when ripe, July-November. Seeds: many per pod, reddish brown, 6 x 1.5 mm, with dense, golden-brown hairs 7-10 mm on the tips and one side. This species is very hardy in the harsh conditions of deforested sites. It had the highest survival and growth rates of all species tested in field trials. Flowering and fruiting occurred 2½ years after planting and birds nest in the young trees. The species is strongly associated with GP nesting sites. Dig up wildlings <20 cm tall in September. and grow them on in containers in the nursery. Saplings are ready to planting out by May-June.





Top left - *Antidesma montanum*, growing in the nursery, 12 months old. Top right - *Carallia brachiata*, planted in August 2006, 26 months old. Above left - *Cinnamomum iners*, also 26 months after planting and (bottom right) two natural saplings, 12 months after receive ANR treatments. Above right - a wildling of *Diospyros venosa* grown on in the nursery.



***Antidesma montanum* Bl. var. *montanum* (EUPHOBIACEAE) “Maw”**

Common, understory, pioneer, tree species, 10-20 m tall, often in gaps in disturbed evergreen forests. Fruit: fleshy drupe, elliptic, oblique, red, March to October. Seeds: 1-2 per fruit. This species attracts many birds when fruiting. Collect fruits in September. Remove flesh and sow seeds in baskets. Transfer seedlings into containers after the first two pairs of leaves have fully expanded. GP typically 50%, MLD 40 days, TNT 10 months. This species is popular with local people because the fruits are used to make a high-priced wine.

***Carallia brachiata* (Lour.) Merr. (RHIZOPHORACEAE) “Kor Haeng”**

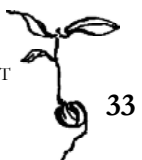
A rare, small, understory, evergreen tree, up to 20 m tall, occasionally with buttresses, in deciduous or evergreen forest types, and freshwater peat swamps. Fruits: fleshy, glabrous, globose, berries, purple-red to black, when ripe, 6-7 x 6-7 mm, with persistent calyx lobes, January to April. Seeds: usually 1 seed per fruit, reddish brown, kidney-shape, approximately 5-6 x 5-6 mm. Attracts many birds when fruiting, easy to propagate in nurseries, with high survival and growth rates when planted out in deforested areas. Collect ripe fruits in March. Remove fruit flesh and sow seeds into baskets. Prick out into plastic bags, when first true leaf pair has expanded. GP >90%, MLD 41 days, TNT 14 months. Alternatively, dig up wildlings in June. Pot into 9" x 2.5" plastic bags and grow on for 11 months.

***Cinnamomum iners* Reinw. ex Bl. (LAURACEAE) “Op Cheuy”**

A rare, medium-sized to large (15- 30 m tall), evergreen tree in the understory of evergreen forests (often found along the forest edge and streams) and in disturbed areas. Fruits: elliptic to ovoid berries, green turning dark purple-black when ripe, 17 x 8 mm, February to May. Seeds: 1 per fruit, ellipsoide, tan to brown, with smooth testa, 9 x 6 mm. Fruits are very attractive to seed-dispersing birds. A dense crown effectively shades out weeds. Germination trials in the nursery failed. Therefore, propagate from wildlings, which are plentiful in the area. Dig up wildlings < 20 cm tall in June. Transfer them to containers and grow them on in the nursery. Saplings are ready for planting the following May.

***Diospyros venosa* Wall. ex A. DC. (EBENACEAE) “Kumin Reusi”**

An evergreen tree or treelet, up to 20 m tall with straight stem and buttresses, in lowland evergreen forests. Fruits: berries, green, turning black brown when ripe; smooth skin with scarce brown spots and thin fleshy mesocarp, 17 x 15 mm, July to February. Seeds: 6-7 per fruit, light brown, 3 x 14 mm. The fruits of





Top left - *Eugenia cerasiformis* in the nursery and (bottom right) mature seed tree along the trail to Sa Morakot. Top right - *Eugenia grandis*, planted to enrich an ANR experiment (9 months old). Lower left - *E. grandis*, 9 months after planting in a grassy site. Lower right - the same tree 26 months after planting.



this species are highly attractive to seed-dispersing animals. The species is easy to propagate from seeds in the nursery with reasonable seedling growth rates. Collect ripe fruits in February. Remove fruit flesh and sow seeds in baskets. Pot up seedlings, once the first pair of true leaves has fully expanded. GP >50%, MLD 41 days, TNT 13 months. Alternatively, dig up wildlings <20 cm tall in June. Pot into 9 x 2.5" plastic bags and grow on for 11 months. Saplings are ready for planting out the following May.

### **The Genus, Eugenia**

*Eugenia* is represented by at least 11 species in the area. All are probably suitable as framework species, due to their reasonable high survival and growth rates after planting out, dense crowns and fleshy fruits (usually single-seeded berries), which attract seed dispersing animals into planted sites. They are all relatively easy to grow in nurseries, either from seeds or wildlings (which are abundant in remnant forest throughout the site). Species showing particular promise as framework species (on the basis of research data and indigenous knowledge) are detailed below.

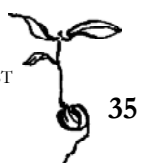
#### ***Eugenia cerasiformis* (Bl.) DC. (Myrtaceae) "Kia Dai"**

A rare, small, understory, evergreen treelet or tree up to 8 m tall (DBH up to 10 cm), only known from along streams in primary evergreen forest remnants. Fruits: fleshy, globose, glabrous, green, berries, turning blackish-purple when ripe, 12-15 x 15-20 mm, edible. Seeds: 1-2 per fruit, sub-globose, brown, 10 x 8 mm. Fruits are attractive to many seed-dispersing animals, including birds and squirrels, during the day time and civets at night. Collect ripe fruits in February. Remove fruit fleshy and sow seeds directly into plastic bags. GP>70%, MLD 34 days, TNT 15 months.

#### ***Eugenia grandis* Wight var. *grandis* (MYRTACEAE) "Mau"**

Synonyms: *Syzygium grande* (Wight) Wight ex Walp.

Evergreen tree, up to 25 m tall (DBH up to 1.5 m), with dense spreading crown, often branching near the base, in open places usually in secondary forest. Fruits: subglobose to globose, green, berries with smooth skins and fibrous pulp, 2-3 cm diameter, January to May, attractive to squirrels and frugivorous bats. Seeds: 1 per fruit, globose, 19 x 17 mm, cream to light green. Collect fruits in May, remove pulp and sow seeds directly into plastic bags. GP>60%, MLD 15 days, TNT 12 months.





Top left - *Eugenia muelleri* in the nursery, ready for planting after 12 months and (top right) 5 months after planting into a grassy site. Above left - *Eugenia oleina* undergoing a seedling growth experiment in the nursery and (bottom right) 6 months after germination. Above right - *Eugenia syzygioides*, 6 months after planting into a grassy site.



***Eugenia muelleri* Miq. (MYRTACEAE) “Mau Bai Lek”**

Large, evergreen, canopy tree, up to 30 m tall, sometimes with small buttresses, in lowland evergreen forest, often near streams. Fruits: green, fleshy berries, round, ellipsoid, 2-2.5 x 2.5-3 cm, December to January. Seeds: 1 per fruit, 16 x 16 mm. Fruits are attractive to squirrels and bats. Collect ripe fruits in January. Remove flesh and sow seeds directly into plastic bags. GP >50%, MLD 40, TNT 16 months.

***Eugenia oleina* Wight (Myrtaceae) “Wah” (high tone)**

A rare evergreen, medium-sized, lower-canopy tree, up to 15 m tall, with a broad crown and sometimes with buttresses. It grows in lowland evergreen forest, often near streams and in peat forests. Fruits: fleshy berries, turning dark red to black when ripe, 7-10 x 5-7 mm, February to June. Seeds: 1 per fruit. Fruits are highly attractive to many bird species. Collect ripe fruits in May. Remove fruit flesh and sow seeds into baskets. Transfer seedlings to plastic bags as soon as the first leaf pair has fully expanded. GP up to 45%, MLD 21 days, TNT 12 months.

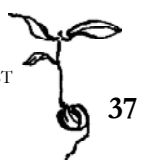
***Eugenia syzygioides* (Miq.) Hend, (MYRTACEAE) “Daeng Kuan”**

Synonyms: *Syzygium syzygioides* (Miq.) Merr. & L. M. Perr

An evergreen canopy tree, of medium crown width, up to 40 m tall (DBH 95 cm) in secondary forest, in both open and shaded places. Fruit: fleshy berry, black when ripe, 6-10 x 6-13 mm, January to April; very attractive to many bird species. *E. syzygioides* is easy to grow in the nursery from seed. Seedlings have high growth rates in the nursery and saplings had high survival and growth rates in field trials, particularly those planted in moderate shade. Collect ripe fruits in March. Remove the fruit flesh; drop seeds into water and discard the non-viable ones which float. Sow seeds in trays in full sunlight. Then move trays into shade, immediately after germination. GP typically >60%, MLD 45 days, TNT 12-14 months.

**The Genus, *Ficus*, Fig Tree Species (MORACEAE) “Sai” or “Madeua”**

The area supports at least 11 *Ficus* spp. All (except *F. globosa* Bl, which grows as a woody climber) can be planted as framework tree species. Some smaller *Ficus* species (e.g. *Ficus hispida* L.f. var. *hispida* and *Ficus callosa* Willd.) naturally colonize deforested areas. If present in sufficient numbers, they need not be planted, but where absent, they are recommended for planting. Fruits: figs are actually the swollen, fleshy stalks of inflorescences (receptacles), which have become





Top left - Naturally established *Ficus hispida* sapling, 6 months after receiving ANR treatments. Top right - developing figs of *Ficus variegata*. Above left - *Garcinia hombroniana* sapling, established naturally beneath the developing canopy of an ANR experimental plot. Above right - young *G. hombroniana* seed tree, along the Sa Morokot trail, showing typical branching pattern and (right) the bark of a more mature tree.

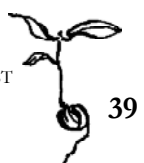




inverted to enclose many tiny flowers or fruits within. The whole structure is termed a “syconium”. Seeds: 1 per fruit, small, brown. Two main characteristics make most *Ficus* tree species excellent framework tree species. Firstly, their very dense root systems enable them to survive and grow well under the harshest of conditions and to grow back rapidly after burning or slashing. Such root systems allow most species to retain their leaves throughout the dry season, by tapping into soil moisture deep underground. This makes *Ficus* trees excellent for preventing soil erosion and stabilizing stream banks. Secondly, figs are an essential food for a wide range of seed-dispersing animals, including many species of birds and bats, as well as primates, civets, squirrels, bears, deer and wild pig. Most species produce figs within 6 years after planting. *Ficus* species are well-known as “keystone species” *i.e.* their figs sustain populations of fruit-eating animals, when other foods are scarce. Thus, they help to maintain viable populations of seed-dispersers, which are vital for recovery of tree species richness in regenerating forest. Cut figs from *Ficus* spp trees when they are fully ripe (*i.e.* when birds or squirrels begin to feed on them). Break open figs and scrape out the tiny, light brown, fruits (achenes), each of which contains a single seed. Drop achenes into water and select the viable ones, which sink. Spread them out on paper and leave them to dry in the sun for 1-2 days; then sow them sparsely into germination trays, containing a mix of forest soil and sand (50:50). Fig seedlings are tiny and prone to damping-off. Forest soil provides microbes that may help seedlings to resist damping-off. Apply a fungicide (Captan) to the soil surface when seeds are sown and again 1 month afterwards. Place germination trays in light shade. GPs typically high (often >80%); MLDs usually short (15-60 days, depending on species). Seedlings of most species must be grown for 5-10 months before they are robust enough for pricking-out. After potting, saplings of most *Ficus* species grow rapidly, but most are not ready for planting until the 2nd planting season after germination (TNT 18-22 months). Consequently, propagation by cuttings is now being investigated.

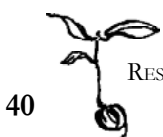
### ***Garcinia hombroniana* Pierre (GUTTIFERAE) “Wah” (mid tone)**

An evergreen tree or treelet up to 8 m tall (DBH up to 15 cm), with a relatively broad, dense crown, in climax forest or secondary growth. Dioecious, flowering from January to February. Fruits: fleshy, globose, with tough, fibrous mesocarp, 50 mm in diameter, yellow to pink, May to June. Seeds: 7-8 seeds per fruit, 23 x 7 mm. This species is tolerant of adverse soil and climatic conditions, growing in sandy and rocky soils in its native habitat. It also grows well in acidic soils and tolerates drought, as well as high rainfall. It produces a dense crown, capable of rapidly shading out weeds. Monkeys like to eat the aril of the fruit. Collect fruits in March, extract seeds and remove the sticky aril from the seeds. Sow seeds





Top left - Fruits and seeds of *Hydocarpus anthelminthica* with young seedlings (above left). Top right - *Irvingia malayana* sapling, 9 months after planting into a grassy site. Above right - young *Lepisanthes rubiginosa* seedlings 3 months after sowing and right saplings, 9 months after planting.



immediately, without drying, directly into plastic bags. GP 45%; MLD 32 days; TNT 12-14 months. May be suitable for direct seeding.

***Hydnocarpus anthelminthica* Pierre ex. Lanes. (FLACOURTIACEAE) “Krabau”**

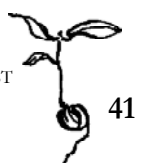
Medium-sized evergreen tree, 10-20 m tall, with straight stem and broad, dense crown in lowland evergreen forests. Fruits: globose, light brown, capsules, 8-9 x 8-9 cm, with hard exocarp and gelatinous endocarp, January to February. Seeds: 4-10 per fruit, hard, black and fused together, 7 x 15 mm. Fruits are highly attractive to seed-dispersing animals, most notably porcupines. Collect ripe fruits in February. Open the fruit, clean off the gelatinous pulp, from the seed clumps, separate the seeds (if possible) and sow them directly into plastic bags. GP about 50%, MLD 36 days, TNT 15 months. Famous as providing a cure for leprosy.

***Irvingia malayana* Oliv. ex Benn. (IRVINGIACEAE) “Bok duak”**

A common, evergreen or briefly deciduous, canopy tree, up to 40 m tall, in deciduous and evergreen forest. Fruits: drupes, 5 x 3-4 cm, with thick pulpy-fibrous mesocarp, thick stony endocarp and smooth green exocarp, December to July. Seeds: large, 1 per pyrene, which retains brown endocarp. Fruits are eaten by medium sized to large mammals; wild cattle, wild pigs, deer, civets etc. Collect fruits in December to January. Strip away the fibrous mesocarp and sow the large pyrenes directly into containers. Seedlings can be ready for late planting by August. Otherwise, saplings must be kept in the nursery until following planting season. Accelerate seedling growth by applying Osmocote. GP >50%, MLD 61 days, TNT 8 months.

***Lepisanthes rubiginosa* (Roxb.) Leenh. (SAPINDACEAE) “Kumchum”**

A medium-sized, evergreen tree, up to 10 m tall (DBH up to 20 cm), with a dense crown, branching low down, in shaded places in secondary forest. Fruits: ellipsoid drupes, 12-15 x 10-13 mm, with thin exocarp, fleshy, juicy mesocarp and thin, tough endocarp. Immature fruits are yellow, turning orange, red and purple and finally black when ripe, February to March. Fruits have 2-3 lobes, each lobe with 1 ellipsoid, 1-seeded pyrene, 8-10 x 7-9 mm. This species is very attractive to seed-dispersing birds and squirrels. Fast growth, along with broad crown and high survival rates after planting out make *L. rubiginosa* an ideal framework species. Collect seeds February to March, extract and clean the pyrenes and sow immediately in baskets in full sunlight. GP >90%; MLD 11-24 days; TNT 12-14 months.





Top left - A naturally established *Macaranga denticulata* sapling, 9 months after receiving ANR treatments and - top right - a mature tree flowering. Above left - nursery-raised saplings of *Oroxylon indicum*, ready for planting after 5 months. Above right - nursery-raised *Pajanelia longifolia* saplings, ready for planting after 15 months and (right) the species' extraordinary capule fruits.



***Macaranga denticulata* (Bl.) M. –A. (Euphorbiaceae) “Tawng Taep”**

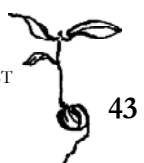
A medium-sized, pioneer, evergreen, tree, growing up to 20 m tall (DBH 40 cm). Fruits: capsules, septicidal, smooth, light brown to blackish brown on ripening, 3-5 x 5-6 mm, April. Seeds: 1 per locule, globose, black, 3-4 x 3-4 mm. An excellent framework species, *M. denticulata* establishes well on degraded land. On average, it grows taller than 2.5 m, by the end of the 2<sup>nd</sup> growing season after planting. Its large leaves form a dense crown which shades out weeds very effectively and deposits large quantities of leaf litter into the soil. It can flower by the 2<sup>nd</sup> year after planting and its fruits attract seed-dispersing birds. Collect fruits in October, when they start to split. Sun-dry them, clean off sticky coating from seeds, then sun-dry the seeds for a further 1-2 days. After that, place seeds in concentrated sulphuric acid for 2 minutes, wash off acid and sow seeds shallowly in trays in sunlight. Germination is rapid and synchronous; GP 90%; MLD 19 days. Prick out seedlings when the first true leaf pairs expand. Saplings can be planted when 30 cm tall *i.e.* by the 1<sup>st</sup> planting season after seed collection (TNT 7 months). This species has delicate saplings, which must be handled carefully to prevent high post-planting mortality. It responds well to cardboard mulching, but is not particularly fire-resilient.

***Oroxylon indicum* (L.) Kurz (BIGNONIACEAE) “Paegah Pah”**

Deciduous tree, growing to about 12 m tall in secondary forest. Fruits: curved, elongate, dehiscent capsules (scimitar-like), about a metre long, January to February. Seeds: many per fruit, with papery white wings about 11 x 9 mm, wind-dispersed. Bats pollinate the flowers, which are rich in nectar and thus attract many birds and insects. Fast growth rate and high survival after planting out. Collect capsules, in early February, just before they begin opening. Leave them in sunlight to dry out and split open. Extract the seeds and sow them directly into plastic bags. Apply Osmocote fertilizer. GP >90%, MLD 18 days, TNT 5 months.

***Pajanelia longifolia* (Willd.) K. Sch. (BIGNONIACEAE) “Ebong”**

An evergreen or briefly deciduous, medium-sized tree, up to 36 m tall (DBH up to 115 cm) with few branches and no buttresses. Locally common in primary but more often in secondary lowland evergreen forest. Fruits: elongate, dehiscent capsules, 390 x 85 mm, brown, January to February. Seeds: many per pod in several rows, with white papery wings, very thin, 11 x 9 mm, wind-dispersed. *P. longifolia* is a very fast growing tree, sun-loving pioneer tree species, which effectively and rapidly suppresses weed growth. It is also a favoured perching





Top left - Bat-pollinated, nectar-rich flowers of *Parkia timoriana*. Top right - 2-month-old seedlings, ready for potting. Above left - *P. timoriana* trees are massive, with large buttresses. Above right - *Pometia pinnata* sapling, 9 months after planting to enrich an ANR plot. Right - 18-month-old *P. pinnata* saplings in the nursery, nearly ready for planting out and - below - fruits.



site for birds. Collect pods just before they open in February. Leave on a bench to dry and split open naturally. Extract the seeds and sown into baskets. Transfer seedlings to containers once the first leaf pair has expanded. Leaves of saplings are often eaten by caterpillars, which must be controlled. Germination data: not available. TNT 15 months (may be reduced to 5 months with use of Osmocote fertilizer).

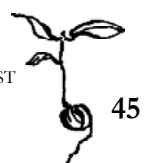
***Parkia timoriana* (DC.) Merr. (LEGUMINOSAE) “Riang”**

A very large, buttressed, briefly deciduous, emergent, climax tree species, up to 50 m tall, in primary forest, often surviving as isolated remnant trees. Fruits: pods, up to 50 cm long (including the stalk) by 4-5.5 cm broad, October to March. Valves, woody, rarely twisted. Seeds: 12-19 per pod, black with brown edges, 6 x 13 mm, edible. The edible seeds of this tree are very attractive to seed dispersing mammals, and the nectar-rich flowers attract bats (which pollinate them). *P. timoriana* can survive and grow well in the hot, dry, sunny conditions of deforested sites. Collect pods, just before they open, in late March. Leave them to dry and extract the seeds when the pods split open. Use a knife or secateurs to chip away the seed coat (at the end opposite to the embryo). Then sow seeds directly into plastic bags. GP c.90%, MLD 6 days, TNT 13 months.



***Pometia pinnata* J. R. Forst. & G. Forst. (SAPINDACEAE) “Sai Nam”**

A very large evergreen, canopy or emergent tree, up to 50 m tall, in lowland evergreen primary or secondary forest. Fruits: indehiscent drupes, round to elliptical, 3-4 x 2-3 cm, black, August to October. Seeds: 1-3 per fruit, black with tough outer coat, with fleshy, gelatinous, white or cream coloured aril, which is sweet and edible, dispersed by bats and birds. The fruits attract squirrels, birds and bats. *P. pinnata* is fast growing in the nursery and in the field, rapidly developing a dense crown. The species grows on a wide range of different soil types. Cut ripe fruits from trees in September. Clean off fruit pulp and remove the aril, then sow seeds into baskets immediately. Seed viability falls rapidly, if sowing is delayed. Transfer seedlings into pots after c. 35 days. Compensate for low germination rate by collecting many fruits. GP about 10%, MLD 10 days, TNT 20 months.





Top left - A sapling of *Salacca wallichiana*, thriving in the shade of an ANR plot, 9 months after planting and - top right - thorny stems of a mature specimen, potentially a nesting site for Gurney's Pitta. Above left - a *Sandoricum koetjape* sapling, 9 months after planting and - right - wildlings growing on in the nursery. Above right - a *Spondias pinnata* wildling, 5 months after being dug up, with fruits in the foreground.





***Salacca wallichiana* Mart. (PALMAE) Ragum**

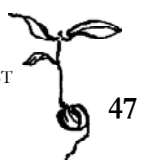
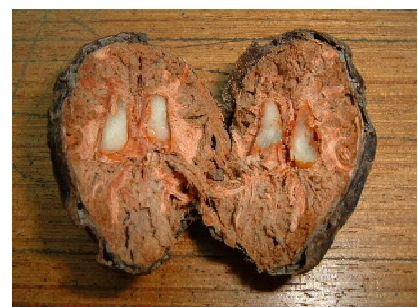
A small, dioecious, creeping and tillering palm, up to 4 m tall, growing in clumps with very spiny leaves in lowland evergreen forest and seasonally dry areas. A favoured nesting tree of Gurney's Pitta. Fruits: red, spiny, oval, drupes, about 2.5 cm long, occurring in dense heads, May. The exocarp consists of red-orange-brown scales. Seeds: 1-3 seeds per fruit. The edible fruits are attractive to seed dispersing animals, and birds like to nest in this tree. It can withstand drought very well. Fresh seed germinates readily. Collect ripe fruits in May. Remove seeds and sow them directly into plastic bags. GP >80%, MLD 56 days, TNT 12 months. Standard vegetative propagation methods have also been published. Cut stem sections of 1-2 m length from old palms. Bury them in mulch (e.g. rice straw) and keep moist. Cut away plantlets, growing from buds on the stem sections, and transfer them to plastic bags for growing on for 12-14 months, before planting out. In the plots, this species performed best in shaded sites.

***Sandoricum koetjape* (Burm. f.) Merr. (MELIACEAE) "Kraton Pah"**

Large, evergreen, canopy tree, up 45 m tall (DBH 50 cm), having buttresses and a broad crown when older, usually growing in secondary forests. Fruits: fleshy drupes, 3 x 4 cm, green turning to yellow when ripe, with thick, tough, leathery exocarp, thin, edible pulpy sweet-sour mesocarp and thin stony endocarp, June to July. Seeds: 4-5 per pyrene, brown, 2 x 1 cm. This species is relatively fast-growing, with a dense crown and with fruits that are highly attractive to mammalian seed dispersers, particularly squirrels and wild pigs. Dig up wildlings (<20 cm tall) in November and pot them directly into 9" x 2.5" plastic bags. Trim the roots to fit the container. Trees are ready for planting by the following May-June.

***Spondias pinnata* (L. f.) Kurz (ANACARDIACEAE) "Ma Gok Pah"**

Common, briefly deciduous tree, growing up to 20 m tall, in both secondary and primary forest. Fruits: fleshy drupes, up to 4.5 cm in diameter, green, turning yellow when ripe January to February. Fruits enclose one large, woody pyrene, with 5 locules (commonly 1 to 3 seeds). This species flowers and fruits at an early age and wild pigs and deer are attracted to the fruits. Dig up wildlings (< 20 cm tall) in November and grow them on in plastic bags in the nursery. Saplings are ready for planting by the following May.



## Growing trees from seed

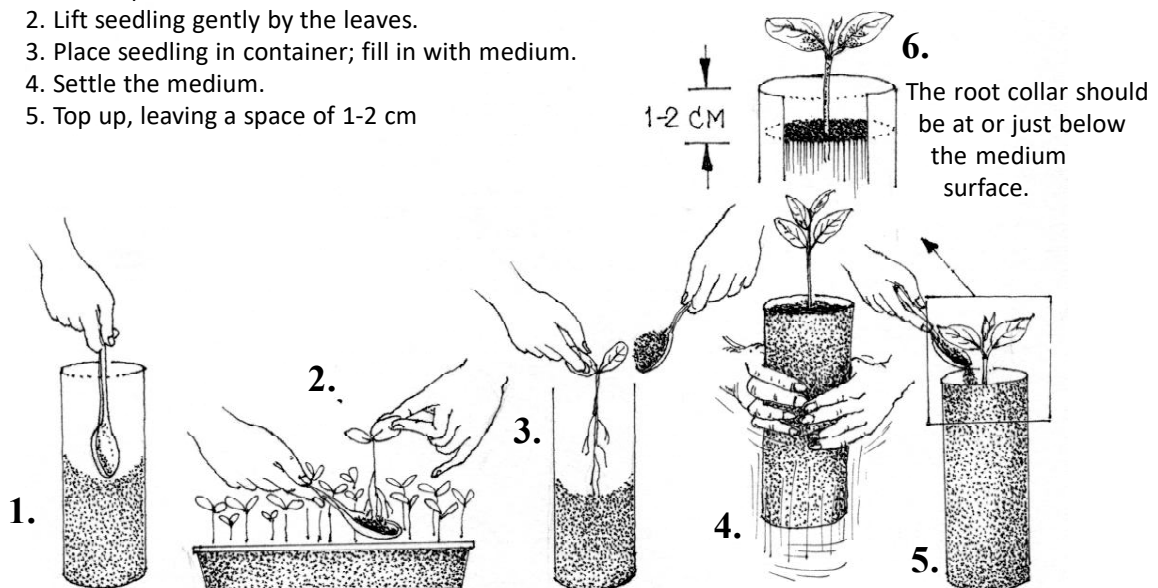
Detailed techniques for growing framework tree species in nurseries are provided in Part 6 of FORRU, 2006. A summary of the main point is extracted below.

Collect ripe fruits from healthy, vigorous trees with dense, spreading crowns, when fruits are just beginning to disperse naturally. Collect fruits from as many different individual trees (of each species) as possible to maximize genetic diversity. Seeds of most of the tree species tested during this project germinated easily with short dormancy periods and without the need of pre-sowing treatments. This is typical of lowland tropical evergreen forest tree species. Instructions for pre-sowing treatments for the few species that require them are included in the descriptions above. In general, clean off fleshy fruit parts and remove seeds. Leave pods or dry capsules to dry out and split open naturally. Remove wings from winged seeds.

Sow most seeds in germination baskets, 6-10 cm deep with plenty of drainage holes, filled with a mixture of two thirds forest soil with one third coconut husk. Do not add fertilizer to the germination mix. Place seeds just below the surface; a general rule is twice their diameter below the surface. Place trays in the shade beneath a roof. Do not expose them to rain. Water the trays lightly after sowing the seeds and daily thereafter, with a watering can or spray bottle, to avoid disturbing the surface of the germination mix. Larger seeds with high germination rates can be sown directly into individual containers, filled with potting mix.

## Pricking-out

1. Make space for the roots.
2. Lift seedling gently by the leaves.
3. Place seedling in container; fill in with medium.
4. Settle the medium.
5. Top up, leaving a space of 1-2 cm



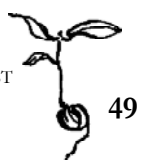
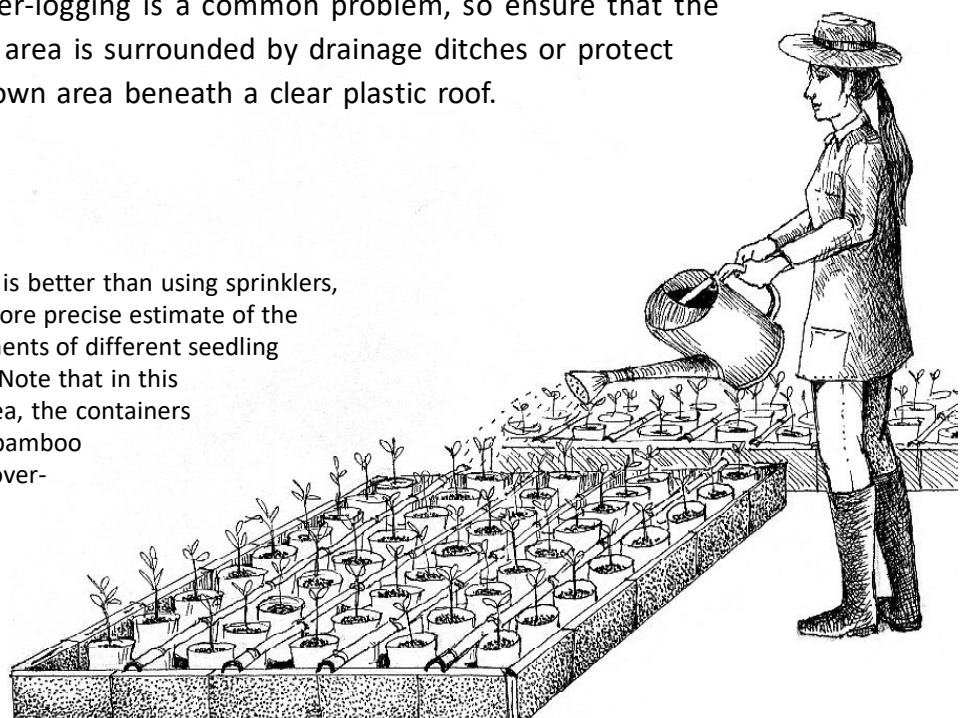
Monitor the seedlings for 'damping off' - fungal diseases which make the seedlings look like they have been pinched at the base of the stem. Once a seedling becomes infected, immediately remove it to prevent spread of the disease to neighboring seedlings. If damping off becomes a serious problem, the seedlings can be sprayed with a fungicide such as Captan.

Transfer seedlings into plastic bags, filled with potting mix, when the first pair of true leaves has fully opened. Prepare the potting medium, by mixing forest soil with peanut husk and coconut husk in the ratio of 2:1:1. Other forms of fibrous organic matter can be substituted for the coconut and peanut husks. Black plastic bags 2 ½ x 9" (8 x 25 cm) are cost effective and have been used successfully with a wide range of species. Taller plastic bags, used locally to propagate rubber tree seedlings, can also be modified, by cutting them down to about 25 cm tall and by punching drainage holes in the bottom.

Fill containers with potting mix. Then make a hole in the mix, deep and wide enough to accept the seedling without bending the roots. Hold a seedling by a true leaf, between the thumb and fore-finger and gently prize it out of the germination tray with a spoon. Place the seedling in the hole in the potting mix and close the hole, if necessary by adding a little more potting mix. After potting, water the seedlings and stand them in shade.

At Krabi, seedlings exposed to rain are watered naturally nearly every day. Watering by hand is only necessary during dry spells, particularly October to March. Water-logging is a common problem, so ensure that the standing down area is surrounded by drainage ditches or protect the standing down area beneath a clear plastic roof.

Watering by hand is better than using sprinklers, since it allows a more precise estimate of the different requirements of different seedling species for water. Note that in this standing-down area, the containers are separated by bamboo strips to prevent over-crowding.



Most species respond well to application of 10 granules of slow-release Osmocote fertilizer NPK 15:15:15 to the medium surface per container every 3 months. Lift containers regularly and prune back any protruding roots with secateurs.

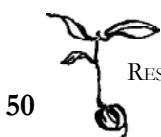
To control pests and diseases:

1. check the nursery regularly, looking for health and hygiene problems;
2. treat affected seedlings immediately with the most appropriate action (remove insects by hand, destroy affected plants or plant parts, or apply chemicals, as appropriate).
3. remove weeds from containers and from around the nursery and
4. ensure adequate air movement.

At least 3 months before planting, gradually reduce shade until the seedlings are in full sunlight. Reduce the frequency of watering. Watch seedlings closely and wait until they begin to wilt before watering them. Most seedling species are ready for planting out when they are about 40-50 cm tall, provided they look healthy and are growing vigorously. Some fast-growing pioneer species can be planted out when only about 30 cm tall.

### **Growing Trees from Wildlings**

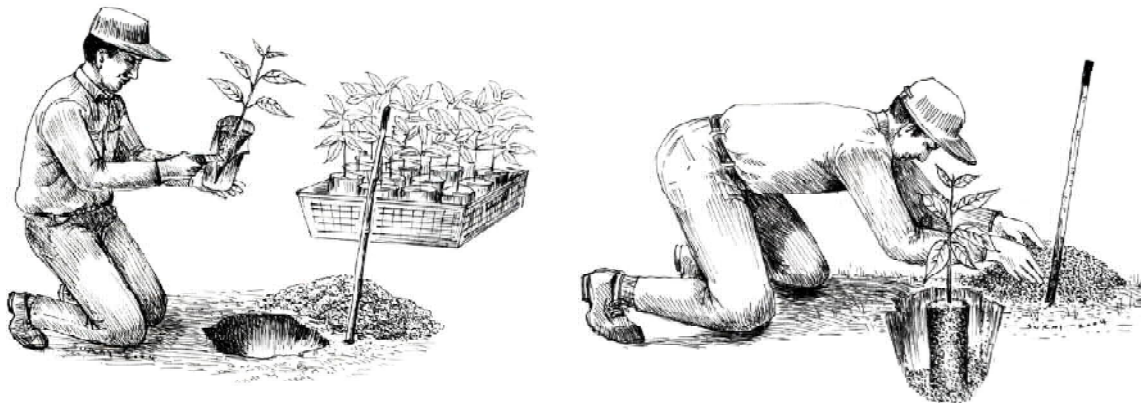
Producing planting stock from wildlings (seedlings growing wild in the forest) can usually be done more rapidly than from seed. Dig up healthy seedlings, no taller than 20 cm (larger ones have high mortality due to severe transplantation shock), within a 5-m radius of the parent tree (those seedlings would die anyway from competition with the parent tree). To minimize damage to the root system, do this during the rainy season, when the soil is soft. Protect the root system by retaining plenty of soil around the roots to make a "root ball". Pack the plants carefully between layers of wet cloth or tissue paper, carefully transport them to the nursery. Prune the shoots to compensate for lost or damaged roots during lifting to prevent wilting. Cut back the stem by one third to one half. Make a 45° cut about 5 mm above an axillary bud and cut back remaining leaves by about 50%. Trim secondary roots until seedlings can be potted easily into 9 x 2½-inch plastic bags, filled with the standard potting mix described above, without bending the tap root. Keep the potted wildlings under deep shade (20% of normal sunlight) for about 6 weeks. Then, follow the same procedures described above for care and hardening-off saplings grown from seed. Compared with producing planting stock from seed, these techniques can shorten the time needed to grow trees to a plantable size by several months to a year.



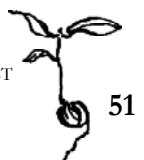
## Planting Trees

The optimum time for planting at Krabi is May. This allows maximize time for root system growth before onset of the subsequent dry season in November. Planting and maintenance procedures are described in detail in Part 7 of FORRU, 2006. A summary is extracted below:

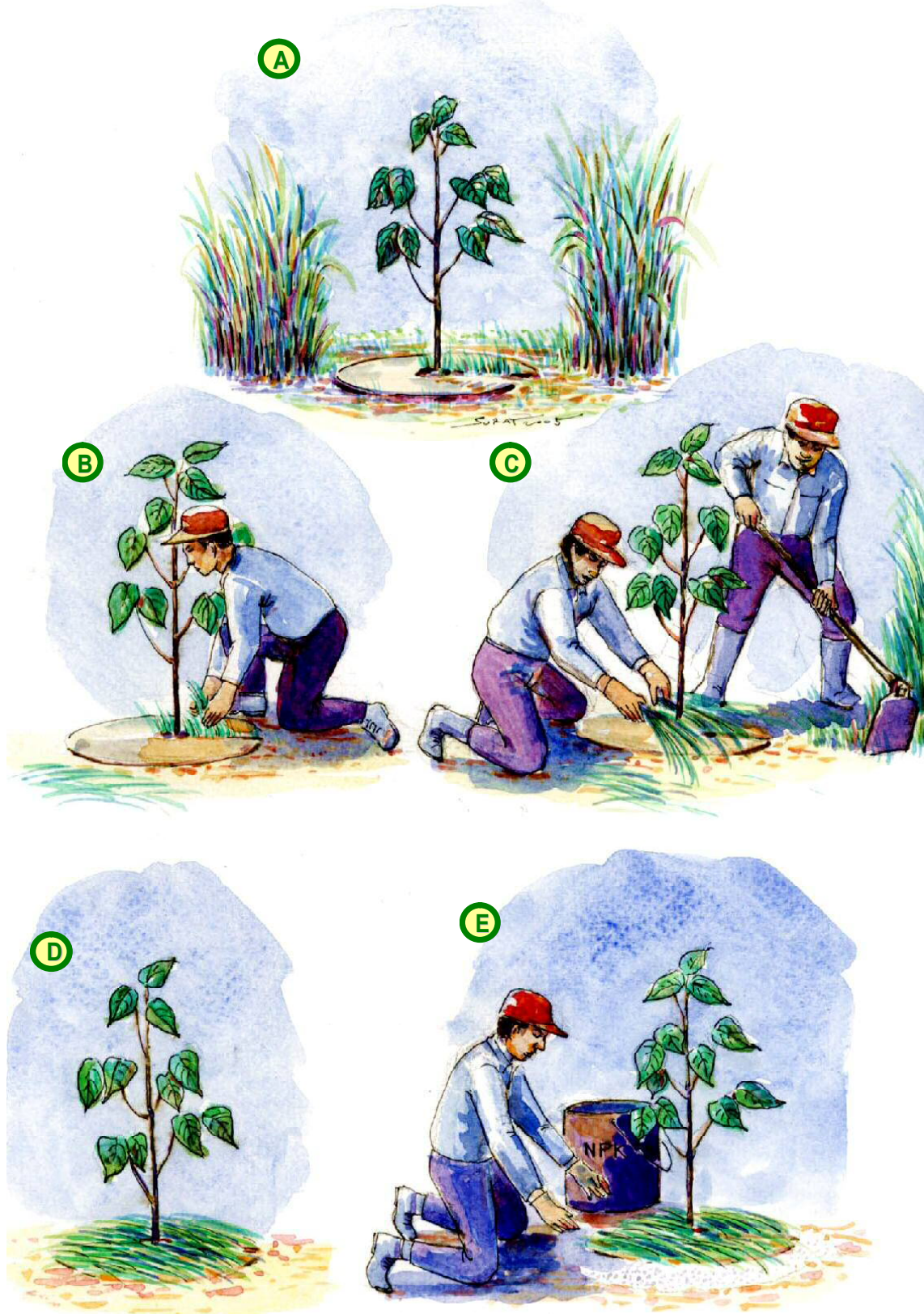
1. Six to eight weeks before planting, measure out the plots.
2. Then slash weeds down to ground level (except in non-planted control plots), but avoid cutting any naturally established tree seedlings and saplings and coppicing shoots (mark them beforehand with coloured poles or flags).
3. One month before planting, apply a non-residual herbicide (e.g. glyphosate) to kill sprouting weeds.
4. Plant trees about 6-8 weeks after the first rains.
5. Plant about 20-30 of the species listed above, spaced on average 1.8 m apart. Randomly mix the species across each plot.
6. Lay a corrugated cardboard mulch mat around each planted tree.
7. Apply 50-100 g of NPK 15:15:15 fertilizer in a ring, about 20 cm away from the stems of planted trees at planting time.
8. During the first rainy season, repeat the fertilizer treatment and weed around the trees (using hand tools) at least 3 times, 6-8 weeks apart (adjust according to the rainfall and rate of weed regrowth).
9. At the start of the first dry season after planting, cut fire breaks around the plots and implement a fire prevention and suppression program.
10. Repeat weeding and fertilizer application during the second rainy season after planting.
11. At the beginning of the 3rd rainy season, assess the need for further maintenance operations.
12. Monitor the planted trees for survival, growth and health, 2 weeks after planting and at the end of each rainy season for 3-5 years.



Slash open plastic bag and remove saplings, keeping root ball intact. Place the sapling in the hole (about twice as big as the container), without bending the roots, and fill in with loose soil.



## WEEDING AND FERTILIZER APPLICATION ARE ESSENTIAL

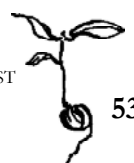


Weeding is essential during the first two rainy seasons after planting. A cardboard mulch mat can help keep weeds down to a minimum immediately around the tree stem (A). Pull out any weeds growing near the tree base by hand (wear gloves) to avoid damaging the tree roots (B). Try to keep the mulch mat intact. Next, use a hoe to root out weeds in a circle around the mulch mat (C) and lay the uprooted weeds on top of the mulch mat (D). Finally, apply fertilizer (50-100 gm) in a circle around the mulch mat (E).



## Recommendations

1. This document presents “best practices” for forest restoration, based on data currently available from research carried out under the project “Gurney’s Pitta Research and Conservation in Thailand and Myanmar”, in 2005-08. Many more tree species remain to be tested and data from field trials are still at an early stage. Therefore, we recommend continuance of this research program and modification of this working document as results are accumulated.
2. We believe that the information in this document represents a good starting point, on which to base current actions to restore GP habitat in the near future. Therefore, the tree species recommended in this document should be grown in larger numbers for planting in appropriate mixtures as soon as possible and an “adaptive management” approach adopted to gradually improve practices.
3. Existing restored plots and those to be restored over the next few years should be closely monitored, so that we can learn from mistakes.
4. Initially, restoration activities should focus on establishing forest corridors to rejoin fragments of forest habitats, which have become isolated. Riparian strips along streams where GP formerly nested are particularly recommended.
5. The DNP should identify such areas suitable for restoration, in collaboration with local people, as soon as possible, taking into consideration GIS information and location of critical sites for GP nesting.
6. The nursery, established under the original Darwin project, should be expanded to grow more trees, particularly of the species listed above, for i) GP habitat restoration, carried out by the DNP and ii) distribution to the local community.
7. Facilities, established under the project, should be used for education and demonstration purposes, to build support for habitat restoration among local communities and to provide an example for other forest restoration projects in S. Thailand to follow.



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# How to PLANT a FOREST:

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