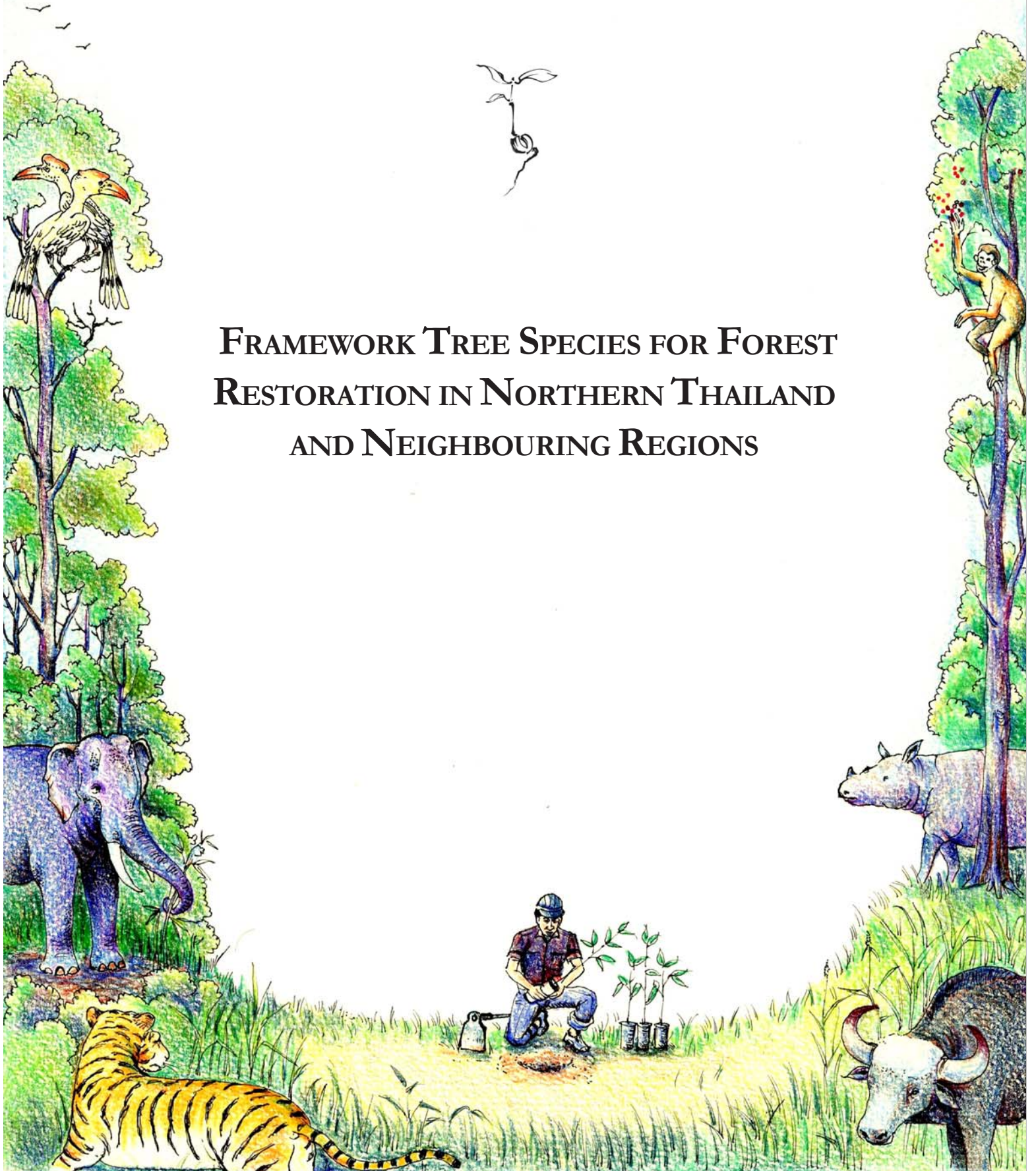


# PART 9

## FRAMEWORK TREE SPECIES FOR FOREST RESTORATION IN NORTHERN THAILAND AND NEIGHBOURING REGIONS



## WHAT MAKES AN EFFECTIVE FRAMEWORK TREE SPECIES?

*High survival and growth rates after planting out in the harsh conditions of deforested sites and development of dense, spreading crowns to shade out herbaceous weeds. Trees below photographed 17 months after planting.*



*Acrocarpus fraxinifolius, 4 metres tall after 17 months.*



*Melia toosendan survival >90%; 5-7 m tall.*



*Gmelina arborea. Large leaves make dense, shady crowns > 3 m broad.*



*Spondias axillaris. Low stem forks result in multiple crowns.*

*Provision of nectar-rich flowers, nutritious fruits or nesting sites to attract seed-dispersing animals at a young age.*



*The nectar-rich flowers of Acrocarpus fraxinifolius (above) act as a magnet to seed-dispersing animals. Erythrina subumbrans (left) flowers within 4 years after planting.*



*Prunus cerasoides flowers, fruits (above left) and provides bird nesting sites (above right) by 3 years after planting.*



### *Easy to grow in nurseries*

*Simple techniques can accelerate tree production. For example nicking the tough coat of Afzelia xylocarpa seeds (above) reduces dormancy from >1 year to 19 days, enabling saplings to be grown to a plantable size within 14 months.*



### *Resilience after fire*

*Spondias axillaris saplings have high survival rates after burning. This one (right) survived a fire just 8 months after planting out. The following rainy season, it grew taller than 2 m.*

*Figs (left) - keystone food for seed-dispersers in planted plots.*



# FRAMEWORK TREE SPECIES FOR FOREST RESTORATION IN NORTHERN THAILAND AND NEIGHBOURING REGIONS

In this Part, we present details of 41 forest tree species, native to N. Thailand, which act effectively as framework tree species, based on the results of FORRU's research program since 1994 (according to the criteria presented in Part 5, Section 1). Before selecting any of the species suggested here for planting, first check to make sure that they are indigenous to the area being planted and that the elevation of the planting site falls within the elevation range of the species selected. FORRU-CMU has tested only about 400 tree species out of the >1,100 recorded for N. Thailand. So, our work is far from complete. We are constantly collecting new data and updating our list of recommended framework species. So, just because a species is not listed here, does not necessarily mean that it should not be planted. For assistance with species selection, based on the latest information, please contact FORRU-CMU directly (see page 200). An explanation of the format of each species entry is provided below.

## Where does it grow?

This information comes from various regional floras and from the CMU Herbarium Database (based on the collections of J. F. Maxwell). For abbreviations of forest types, see Part 2. DBH = diameter at breast height.

## What are its distinguishing characteristics?

Space limitations allow only the most characteristic features of each tree species to be described, based on examination of voucher specimens in the CMU Herbarium. For complete species descriptions, please refer to your country flora or other botanical texts. For an explanation of botanical terminology, please refer to the glossary at the end of the book.

## Why is it a framework species?

Field performance data cited are those from FORRU's experimental plots, mostly from the end of the second rainy season after planting (see Part 5, Section 3). Information on the attractiveness of each species to seed-dispersing wildlife comes from direct observations in plots up to 7 years after planting. RCD=root collar diameter.

## How are saplings grown?

For general advice on growing trees, see Part 6. Here, we present specific techniques for each species, from FORRU's nursery research. For all species, collect seeds from >10 trees, close to the planting site, to maintain genetic diversity. GP=germination percentage; MLD=median length of dormancy (Part 3, Section 5); TNT=total nursery time from seed sowing to planting out.

## How should saplings be planted and cared for?

Follow the planting and after-care methods presented in Part 7. Here, we present a few particular requirements of each species or notable responses to silvicultural treatments, based on data from FORRU's experimental plots.

## What can this species be used for?

As well as promoting biodiversity recovery, framework trees have economic uses. So, a selection of published uses is presented for each species. This information is useful where framework species are used for community forestry. **Do not apply any of the medicinal uses stated, without medical supervision.**



## *Acrocarpus fraxinifolius* Wight ex Arn. (LEGUMINOSAE, CAESALPINIOIDEAE)

Sadao Chang

A very large, light-demanding, deciduous, tree, growing up to 60 m tall (DBH to 2.4 m). The crowns of older trees often emerge above the forest canopy.

### Where does it grow?

In E. India, S. China, Myanmar, Thailand, Laos, Vietnam, Borneo, Sumatra and Java. In N. Thailand, it is rare in EGF at elevations of 1000 to 1200 m.

### What are its distinguishing characteristics?

Larger trees with buttresses. **Bark:** grey, with brown lenticels. **Leaves:** doubly pinnate; leaf segments 4-14 x 2-7 cm, ovate; young ones pink and hairy. **Flowers:** bisexual, in dense panicle clusters on leafless branches, petals red; January to March. **Fruits:** pods, black, elongated and flattened, 8-16 x 1-2 cm; seeds, 10-18 per pod, ovate, light brown 4.6-6.8 x 3.4-4.2 mm; February to May; wind-dispersed.

### Why is it a framework species?

Planted *A. fraxinifolius* saplings grow rapidly (>2 m by end of 2<sup>nd</sup> rainy season) and develop crowns broader than 2 m across, which effectively shade out weeds, but survival is marginal. This species coppices readily and regen-

erates well after fire (70% survival of trees with RCD >20 mm, burnt 21 months after planting). Its nectar-rich flowers attract birds and squirrels and it is favoured by birds as a perching site.

### How are saplings grown?

Collect black pods, March to April. Air-dry them until they split, releasing the seeds. Chip away part of the seed coat with nail clippers or put seeds in sulphuric acid for 5-10 minutes. Sow seeds in trays in full sunlight; GP c.50%; MLD can be reduced to 4 days with above treatments. Seedlings are prone to damping-off and attack by caterpillars, so take appropriate precautions. Pot seedlings after first true-leaf pairs expand and stand containers in sunlight. Saplings usually grow tall enough (>30 cm) for planting out by 2<sup>nd</sup> planting season after seed collection (TNT 15-16 months). Alternatively, store seeds at ambient temperature, then treat and sow them in November.

### How should saplings be planted and cared for?

Survival can be substantially increased by laying cardboard mulch at planting time and by continuing weeding and fertilizer application into the dry season.

### What can this species be used for?

Its durable timber is prized for house construction and furniture and is used as firewood and to make charcoal. The foliage makes good cattle fodder. Planted for shade in coffee plantations; to stabilize river banks and terraces and to increase soil nitrogen content.



## *Azelia xylocarpa* (Kurz) Craib (LEGUMINOSAE, CAESALPINIOIDEAE)

A large, deciduous tree, growing up to 30 m tall (DBH to 1.5 m); listed as an endangered species, due to over-exploitation for its valuable timber.

### Where does it grow?

Throughout Indochina, except S. Thailand. In N. Thailand it is common in BB-DF, at elevations of 350 to 500 m.

### What are its distinguishing characteristics?

Trunks of larger trees have small buttresses. **Bark:** light brown, deeply cracked **Leaves:** once pinnate, with 3-5 pairs of leaflets; leaflet blades 5-9 x 4-5 cm; often leafless January-February. **Flowers:** in panicles, red, 5-15 cm long; from March to April. **Fruits:** pod, woody, dehiscent, elliptical-oblong, black when mature, 12-20 cm long; seeds, black or dark brown, 2 x 1.5 cm, with large, yellow, basal aril; fruiting June to March; animal-dispersed.

### Why is it a framework species?

*A. xylocarpa* saplings, planted in degraded deciduous forest sites, survive well (>80% by end of 2<sup>nd</sup> rainy season), but grow rather slowly. They develop broad, dense crowns, which suppress weed growth and provide bird perches. Due to its nitrogen-fixing capability, this species is suitable for restoring lowland sites, where soil fertility is low.

### How are saplings grown?

Collect pods from the ground in May. Sun-dry them until they open and remove the seeds. With a knife, remove the aril (taking care not to damage the embryo) and chip away part of the seed coat, at the opposite end to where the aril was attached. Soak seed in water overnight, then sow them directly into containers (1 per container). Germination starts about 3 weeks after sowing and is synchronous. GP typically

## Makah Mong

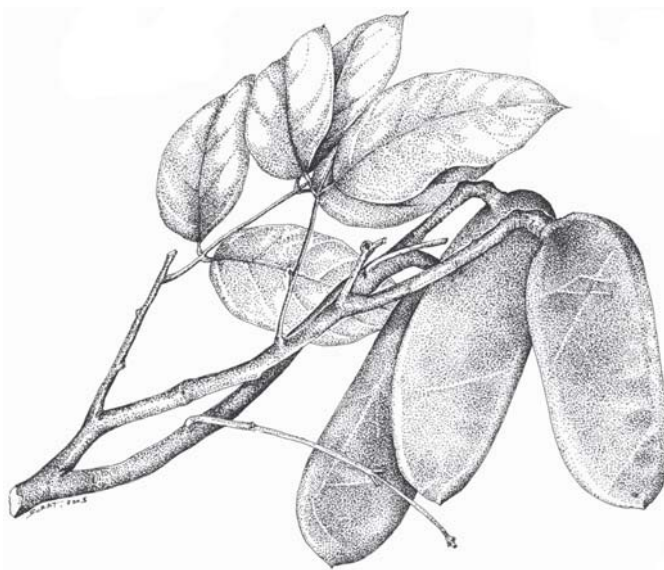
60-70%; MLD 19 days. This species is prone to leaf-eating insects, so take appropriate precautions. Saplings are ready for planting out by the 2<sup>nd</sup> planting season after seed collection (TNT 14 months), when they are about 40-50 cm tall. Seeds may be stored for up to 1 year at ambient temperatures.

### How should saplings be planted and cared for?

Apply a cardboard mulch mat at planting time. Weed and apply fertilizer as necessary. This species is very suitable for direct seeding.

### What can the species be used for?

Its hard, attractive wood is highly valued for high quality furniture, carvings, house construction and flooring. Juice from the bark called "catechol" is used for tanning leather. *A. xylocarpa* fixes nitrogen and is, therefore, suitable for soil improvement and agro-forestry. Various parts of the plant have medicinal properties.



## *Archidendron clypearia* (Jack) Niels. (LEGUMINOSAE, MIMOSOIDEAE)

Mah Kham Pae

A small, understory, shade-tolerant, evergreen tree or treelet, growing up to 15 m tall.

### Where does it grow?

From Sri Lanka, India, Myanmar through S. China, Indochina, Malaysia, Indonesia and the Philippines. In N. Thailand, it is common in secondary EGF, at elevations of 1000 to 1650 m. Naturally colonizes fallow fields from 3 years after cultivation has ceased.

### What are its distinguishing characteristics?

**Bark:** distinctive red-brown, with zig-zag internodal lines. **Leaves:** doubly compound, 15-50 cm long; leaflets opposite, upper ones largest, 4-7 x 2-3 cm; mature blades dark green above, hairy below; petiole ridged/flanged. **Flowers:** in large branched clusters; white or pale yellow; February to March. **Fruits:** pods, orange-brown when ripe, thin-walled, spirally dehiscent to expose glossy black oval-shaped seeds (6-8 per pod); fruiting March to June; wind-dispersed.

### Why is it a framework species?

*A. clypearia* saplings survive well after planting out in ex-EGF sites (>70% survival by end of 2<sup>nd</sup> rainy season). They grow slowly at first, but growth accelerates 2-3 years after planting. They flower and fruit in the 4<sup>th</sup> year after planting and produce second-generation seedlings, which grow well in the shade of framework plots, from 6 years after planting. Recruitment of other tree species, beneath the crowns of *A. clypearia* trees, has been observed from the 3<sup>rd</sup> year after planting. The species' nitrogen-fixing capability makes it suitable for improving soils in degraded areas.

### How are saplings grown?

Collect ripe pods from parent trees from May to June. Remove seeds from pods, soak them in water overnight, and sow them in germination trays in full sunlight. GP typically 50-70%; MLD 14 days. Prick out seedlings after expansion of the first true-leaf pairs. Saplings are ready for planting by the 2<sup>nd</sup> planting season after germination, when they are about 30 cm tall (TNT 13-14 months).



### How should saplings be planted and cared for?

This species responds well to cardboard mulch placed around the trees at planting time.

### What can the species be used for?

Timber for joinery, furniture, fencing, household utensils, crates, boxes and firewood.



***Balakata baccata* (Roxb.) Ess.  
(EUPHORBIACEAE)**

**Salee Nok**

**Synonym:** *Sapium baccatum* Roxb.

A common, large, pioneer, evergreen tree, growing up to 25 m tall (DBH to 60 cm).

**Where does it grow?**

From the eastern Himalayas and N. India to S. China, Myanmar, Thailand and further south-east to peninsular Malaysia, Sumatra and Borneo. In N. Thailand, it is common in MXF and EGF, at elevations of 400 to 1350 m, often along streams at lower elevations.

**What are its distinguishing characteristics?**

**Bark:** thick, roughly, vertically cracked, blackish; large lenticels when young. **Leaves:** spirally arranged, simple; blades ovate to elliptic, often whitish below, 8-18 x 3-8 cm. **Flowers:** minute, unisexual, in branched spike-like clusters; February to August. **Fruits:** drupes, fleshy, globose, dark purple-black when ripe, 14.9 x 14.3 x 12.1 mm; pulp white and fibrous; 1-2 black seeds (5.3 x 4.2 x 4.1 mm) per fruit; April to December; dispersed by squirrels and birds.

**Why is it a framework species?**

Although survival of planted *B. baccata* saplings is sometimes marginal, those that survive usually grow very rapidly, averaging >3 m tall, with 2.5-m-broad crowns, by the end of the 2<sup>nd</sup> rainy season. Branching occurs 0.5 -1.0 m above ground, resulting in dense crowns, which shade out weeds very effectively and provide a secluded habitat for nesting birds as early as the 2<sup>nd</sup> year after planting. Fruits are attractive to birds and mammals. Seedlings of other tree species establish beneath *B. baccata* crowns by the 4<sup>th</sup> year after planting. More research is needed to increase the post-planting survival rate of this species.

**How are saplings grown?**

Collect ripe (purple) fruits in July. Soak them in water for 48 hrs and clean off the flesh. Sundry the pyrenes, then sow them in trays in full sunlight. Germination is asynchronous and continues for 16 weeks. GP up to 70%; MLD typically 60-70 days. Young seedlings are prone to stem breakage, attack by caterpillars and bacterial blight, so take appropriate precautions. Prick out seedlings after expansion of first true leaf pairs. Saplings are usually ready for planting by the 1<sup>st</sup> planting season after germination (TNT 12 months). Pruning kills this species.

**How should saplings be planted and cared for?**

Saplings of this species are often weak-stemmed, so extra care during transportation and staking can reduce post-planting mortality. Never plant *B. baccata* where may become shaded. Suitable for direct seeding.

**What can the species be used for?**

This species has soft non-durable wood, suitable for temporary construction, boxes and crates. Its fruits are edible and its bark is an ingredient in several traditional medicines.



***Bischofia javanica* Bl.**  
**(EUPHORBIACEAE)**

**Dteum**

A large, common, light-demanding, evergreen (or leaf-exchanging) tree, growing up to 35 m tall (DBH to 80 cm).

**Where does it grow?**

From the Himalayas to China, Indochina, East Asia, Malaysia, N. Australia and the Pacific islands of Tonga and Samoa. In N. Thailand, it grows in EGF, MXF and BB-DF, often along streams at elevations of 525 to 1250 m.

**What are its distinguishing characteristics?**

**Bark:** thin, vertically fissured, scaly or flakey, reddish brown; sap dark red. **Leaves:** spirally arranged, trifoliate; blades, ovate or elliptic, hairless, 6.5-14.5 x 3.5-6.5 cm; margin shallowly serrate; leaf-exchanging February to March at low elevations. **Flowers:** numerous in axillary panicles, greenish-yellow, without petals, c.2 mm long; February to March. **Fruits:** slightly fleshy drupes, globose, brown-black when ripe, 5-10 x 5-10 mm; 3 or 4 locules per fruit, each containing up to 2 seeds, 4.6 x 3.3 mm; fruiting June to February; animal-dispersed.



**Why is it a framework species?**

Survival of planted saplings is usually high (60-80% by end of the 2<sup>nd</sup> rainy season), but growth can be slow. Birds nest in this species by the 5<sup>th</sup> year after planting and it fruits within 6 years. Natural recruitment of tree species occurs beneath 6-year-old trees. It coppices and survives well after fire (>80% survival of trees burnt 33 months after planting; RCD>20 mm).

**How are saplings grown?**

Collect ripe fruits in October (the earlier the better). Crush them and extract seeds in a sieve under running water. Sun-dry seeds and sow them shallowly and well-spaced in 1:1 forest soil and sand, to prevent damping-off. Germination is asynchronous, continuing for 6 weeks: GP up to 80%; MLD 26 days. Prick out seedlings after expansion of first true-leaf pairs. Fertiliser application is important for this species. Seedlings are prone to caterpillars, stem gall larvae and sap-sucking mites, which cause leaf curling. Destroy diseased plants and spray survivors. If fertilizer is applied, saplings are ready for planting by the 1<sup>st</sup> planting season (TNT 9 months).

**How should saplings be planted and cared for?**

*B. javanica* responds well to cardboard mulch and fertilizer. Make sure planted saplings do not become shaded by neighbouring trees.

**What can the species be used for?**

Timber used for construction, beams, flooring, furniture, joinery, carving and charcoal. Also used for paper-making. Bark produces a red dye and contains tannin.



***Castanopsis acuminatissima* (Bl.) A. DC.**  
**(FAGACEAE)**

**Gaw Duey**

A medium-sized, shade-tolerant, evergreen tree, growing up to 25 m tall (DBH to 1 m).

**Where does it grow?**

From NE India to China, Taiwan, Thailand, peninsular Malaysia, Java, Sabah, Sulawesi and Papua New Guinea. In N. Thailand, it is abundant in EGF, EGF-PINE and MXF at elevations of 760 to 2100 m.

**What are its distinguishing characteristics?**

**Bark:** grey-brown, thick, vertically cracked.  
**Leaves:** simple, spirally arranged; blades, lanceolate, 10-15 x 3-5 cm; margin serrate towards apex; mature blades, dark green above, light green with sparse, short, white hairs beneath.  
**Flowers:** in dense erect panicles, cream-coloured, fragrant, c.5 mm long; December to February.  
**Fruits:** solitary nuts, 8-10 x 7-8 mm, completely enclosed within a cupule (c.1 cm long), covered in short spines (in widely spaced clusters), light brown when ripe; September to October; animal-dispersed.

**Why is it a framework species?**

*C. acuminatissima* saplings survive well and grow rapidly after planting out (with mulching, >70% survival; >2.5 m tall; canopy >1.3 m broad by end of 2<sup>nd</sup> rainy season). They are used by nesting birds from 2.5 years after planting. This species coppices easily, enabling rapid regeneration after fire.

**How are saplings grown?**

Collect brown fruits in October. Remove the cupules. Drop nuts into water and discard the non-viable ones which float. Sow nuts in germination trays in partial shade. GP typically 50%; MLD 13 days, but germination is asynchronous and may continue for 60 days. Prick

out seedlings after expansion of first true-leaf pairs. Saplings are ready for planting out by the 2<sup>nd</sup> planting season after germination (TNT 21 months).

**How should saplings be planted and cared for?**

This species responds very well to cardboard mulch placed around the trees at planting time.

**What can the species be used for?**

Nuts are edible and leaves can be used as cattle fodder. The timber is suitable for construction and is good firewood. In N. Thailand, cut branches are used to culture mushrooms. The bark contains tannins, used as a laxative and it is sometimes chewed with betel nut.



## *Castanopsis tribuloides* (Sm.) A. DC. (FAGACEAE)

Gaw Bai Liam

A shade-tolerant, medium-sized, evergreen tree, growing up to 18 m tall (DBH to 70 cm).

### Where does it grow?

From the Himalayas to China, Myanmar and Indochina. In N. Thailand, it is abundant in MXF and EGF-PINE, often as a late successional species at elevations of 650 to 1650 m.

### What are its distinguishing characteristics?

**Bark:** dark grey-black or brown, thick, vertically cracked. **Leaves:** spirally arranged, simple; blades oblong to lanceolate, margin shallowly serrate towards apex, glossy dark green above, light silvery green or yellow below, 10-16 x 2.5-5.5 cm. **Flowers:** unisexual, in erect axillary panicles; males numerous, fragrant; females inconspicuous; April to May. **Fruits:** nut, subglobose, brown when ripe, 7.2 x 6.4 x 5.9 mm, completely enclosed in a spiny cupule with rigid spines 3-5 mm long; one seed per nut; fruiting most commonly September to November, but not every year; dispersed by civets and other animals.



### Why is it a framework species?

Saplings of *C. tribuloides* achieve excellent survival rates and acceptable growth rates after planting out (>70% survival; >1.5 m tall, by end of 2<sup>nd</sup> rainy season). Although, initially, crowns are rather narrow, they effectively shade out weeds. The species flowers from the 3<sup>rd</sup> year after planting and fruits from the 5<sup>th</sup>. It is highly resilient after fire, readily coppicing. It also regenerates well from seed. It is very shade-tolerant and ideal for enrichment planting beneath an established forest canopy.

### How are saplings grown?

Collect brown nuts in September. Remove cupules, drop nuts into water and remove the non-viable ones, which float. Sow nuts in germination trays in partial shade. GP usually >80%; MLD 31 days; germination asynchronous, continuing for up to 80 days. Prick out seedlings after expansion of first true-leaf pairs. Containerized saplings grow slowly and must be kept in nurseries until the second planting season after germination (TNT 22 months). To produce planting stock more quickly, try cultivating wildlings in the nursery (see Box 6.2).

### How should saplings be planted and cared for?

Plant in shady places. This species responds particularly well to cardboard mulch.

### What can the species be used for?

Timber can be used for light construction and firewood. Nuts are edible. Leaves are suitable for animal fodder. Decaying wood is used for mushroom cultivation.

***Elaeocarpus lanceifolius* Roxb.**  
**(ELAEOCARPACEAE)**

**Ma Meun, Pee Pai**

A medium-sized, shade-tolerant, evergreen tree, growing up to 20 m tall (DBH to 40 cm).

**Where does it grow?**

From Yunnan and India, across Indochina to Indonesia. In N. Thailand, it is common in EGF at elevations of 900 to 1550 m.

**What are its distinguishing characteristics?**

**Bark:** grey, thin, slightly rough. **Leaves:** spirally arranged, simple; blades narrowly elliptic or lanceolate, 8-17 x 4-7 cm, tapering at both ends. **Flowers:** bisexual, in axillary racemes, 5-12 cm long; sepals 5, lanceolate, 4-5 mm; petals 5, cream or white, obovate, slightly longer than sepals, margin ciliate; June to July. **Fruits:** drupes, ovoid, brown or cream when ripe, 3.5 x 2-3 cm; October to November; animal-dispersed.

**Why is it a framework species?**

Saplings of *E. lanceifolius* achieve excellent survival rates and acceptable growth rates after planting out (>80% survival; >1.8 m tall by end of 2<sup>nd</sup> rainy season). They grow dense crowns (>1 m across), which accelerate early site recapture. Many of bird and mammal species are attracted to the fleshy fruits of this species.

**How are saplings grown?**

Collect ripe fruits from the ground in October or November. Soak them in water overnight; then rub off the flesh. Scarify the pyrenes with a knife; then soak them overnight again. Remove any non-viable ones which float. Sow the pyrenes in germination trays in shade. GP usually low, 25-50%; MLD typically 250-260 days. Germination can be increased by collecting aged pyrenes from the ground under parent trees or storing them (in a bucket with no lid at ambient temperatures) for several months prior

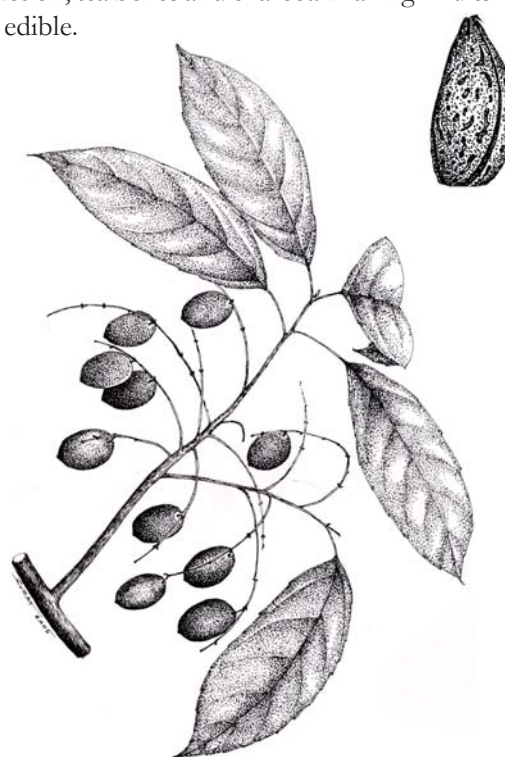
to sowing. Prick out seedlings after expansion of first true-leaf pairs. Seedlings should be ready for planting in the field by the 2<sup>nd</sup> planting season after germination (TNT 20-21 months). Planting stock may be produced more rapidly from leafy cuttings.

**How should saplings be planted and cared for?**

Cardboard mulch mats, placed around saplings at planting time, significantly reduce post-planting mortality of this species. Seeds are highly susceptible to predation by rodents, so it is not suitable for direct seeding.

**What can the species be used for?**

The wood is soft and used for light construction, tea boxes and charcoal making. Fruits are edible.



## *Erythrina subumbrans* (Hassk.) Merr. Tawng Lahng Bah (LEGUMINOSAE, PAPILIONOIDEAE)

A medium-sized, pioneer, deciduous tree, growing up to 25 m tall (DBH to 86 cm).

### Where does it grow?

From India, Myanmar and Indochina to Malaysia, Fiji and Samoa. In N. Thailand, it grows sparsely in EGF and MXF at elevations of 500 to 1680 m.

### What are its distinguishing characteristics?

**Bark:** soft, grey, with spine-tipped black tubercles. **Leaves:** spirally arranged, trifoliate; leaflet blades ovate, margin entire, terminal leaflet 10-14 x 8-12 mm. **Flowers:** bisexual, 4-5 cm long; petals bright red; December to March, often when leafless. **Fruits:** pods, brown, 15.5 x 1 cm; seeds smooth, dark brown, kidney-shaped, 1 x 0.9 cm; March to April; pods wind-dispersed.

### Why is it a framework species?

*E. subumbrans* saplings achieve excellent survival and growth rates after planting out (>80% survival; >2.5 m tall, crowns 2.6-2.8 m across, by end of 2<sup>nd</sup> rainy season). Their broad, deciduous, crowns produce dense leaf litter, creating

excellent conditions for germination of tree seeds on the forest floor. They flower, fruit and attract nesting birds from the 4<sup>th</sup> year after planting. The vivid scarlet flowers produce nectar, which attracts many bird and squirrel species. The seed rain from these animals results in natural recruitment of many tree species around *E. subumbrans* trees within 5 years. As a legume, this species adds nitrogen to nutrient-poor soils.

### How are saplings grown?

Collect seeds from fallen pods in March. Soak them in water overnight. Sow those that start to swell and discard any non-viable ones, which float. Sow seeds directly into containers, in full sunlight, and use wire mesh to protect them from rats and squirrels. GP typically 40-60%; MLD 7-14 days. Take precautions against leaf-folding caterpillars (Lepidoptera, Pyralidae), which defoliate seedlings in the late rainy season. Do not apply fertilizer or prune this species. Saplings can be planted out when 30 cm tall, usually 3-4 months after germination.

### How should saplings be planted and cared for?

*E. subumbrans* saplings have weak stems, so care is needed when handling them. Staking can reduce post-planting mortality. They respond well to fertilizer application and mulching after planting. However, planted trees are susceptible to a stem-boring insect pest, which can kill even mature trees. Do not plant *E. subumbrans* tree where they might become shaded.

### What can the species be used for?

Cut branches of *E. subumbrans* root well, when planted in soil, so they are used to construct "living fences". Its lightweight timber is used for carving and for making various utensils. Its foliage is used for cattle fodder.



## *Eugenia fruticosa* (DC.) Roxb. (MYRTACEAE)

## Wa Kee Gwang

A small to medium-sized, pioneer, evergreen tree, growing up to 12 m tall.

### Where does it grow?

In India, Myanmar, China and Thailand. In N. Thailand, it is common in EGF-PINE, DOF and BB-DF, at elevations of 350 to 1525 m. It frequently establishes in deforested sites and is one of the most common recruit species establishing in framework plantings aged 4 years or older.

### What are its distinguishing characteristics?

**Bark:** dark brown, flaking. **Leaves:** simple, opposite; blades 7.5-11.5 x 3.5-6.5 cm; petiole slightly winged. **Flowers:** corolla greenish yellow; calyx cup 2-3 mm, outer stamens and style 2-4.5 mm; March to April. **Fruits:** berry, globose or ovoid, blackish purple when ripe, 8 x 13 mm, pericarp juicy; seed, one per fruit, green or light brown, 8 x 6-7 mm; May to July; animal-dispersed.

### Why is it a framework species?

Planted *E. fruticosa* saplings achieve acceptable survival and growth rates (60-70% survival; >1.6 m tall; crowns >1 m broad, by end of 2<sup>nd</sup> rainy season). Their dense crowns effectively shade out weeds. Deer and bulbuls eat the fruits and nectar-rich flowers attract many birds and squirrels. However, this species takes longer than 7 years to commence flowering.

### How are saplings grown?

Collect ripe fruits from the ground in May. 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 >90%; MLD 27-35 days. Young seedlings are prone to attack by aphids and

caterpillars, so take precautions. Prick out seedlings after expansion of first true-leaf pairs. Seedlings grow to a plantable size by the 2<sup>nd</sup> planting season after germination (TNT 14 months).

### How should saplings be planted and cared for?

Planted *E. fruticosa* trees respond well to cardboard mulch. They grow slowly at first, but growth accelerates 4-5 years after planting. Suitable for direct seeding.

### What can the species be used for?

Fruits are edible, by both humans and wild animals, and they are traditionally used to make an alcoholic beverage.



### *Eugenia albiflora*

**Duth. ex Kurz** is a closely related species, requiring a similar propagation protocol and having similar framework characteristics. It fruits within 4 years after planting out.



**Ficus species  
(MORACEAE)**

**Fig Tree Species  
Sai, Madeua**

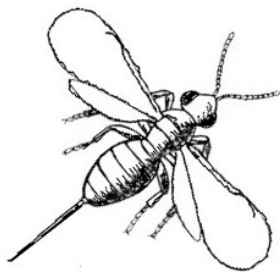
*Ficus* species can grow as vines, woody climbers, shrubs, treelets or large forest trees. Most function well as framework species, except for the climbers, which should not be planted, at least during the initial phases of forest restoration. Since most *Ficus* tree species share similar properties, they are grouped together here.

**Where do *Ficus* species grow?**

The genus (>1,000 species) is distributed mostly throughout tropical and subtropical America, Africa, Asia and Australasia. At least 35 different fig tree species are distributed amongst all the forest types of N. Thailand, although more species (22) grow in evergreen forests than in deciduous forest types (13). Some species can grow to an enormous size, particularly “stranglers” such as *F. altissima*, whereas a few smaller species grow on rocks along streams (e.g. *F. heteroplura*). Some smaller *Ficus* species (e.g. *F. hispida*, *F. hirta* and occasionally *F. semicordata*) naturally colonize deforested areas. If present in sufficient numbers, they need not be planted, but where absent, they are recommended for planting.

**What are the distinguishing characteristics of *Ficus* spp trees?**

Figs are the most characteristic feature of mature *Ficus* spp trees. They are usually highly visible, often on trunks or branches, for long periods every year. Often referred to as “fruits”, figs are actually the swollen stalks of inflorescences (receptacles), which have become inverted to enclose many tiny flowers or fruits within. The whole structure is termed a “syconium”. Flowers within the figs are pollinated by fig wasps; usually a different wasp species for each *Ficus* species. Female wasps enter figs via a small hole at the apex and lay their eggs in infertile, “gall” flowers, simultaneously pollinating fertile, female fig flowers. Male wasps hatch first and mate with the females as they emerge. Mated female wasps pick up pollen from male flowers inside the figs, before flying to another *Ficus* tree, of the same species, to lay



Female fig wasps pollinate fig flowers. They lay eggs in the gall flowers, then die.



Wingless male wasps hatch first. They mate with the females, while the females are hatching, then die.

SPECIES	HABIT	LEAFING	HABITAT*	ELEVATION (m)
<i>F. altissima</i> Bl.	T (st)	E	BB-DF MXF	350-1050
<i>F. benjamina</i> L. var. <i>benjamina</i>	T L (st)	E	MXF EGF	350-1400
<i>F. callosa</i> Willd.	T	D	EGF	790-1400
<i>F. fistulosa</i> Reinw. ex Bl.	T L	ED	Disturbed areas in BB-DF MXF EGF	350-1400
<i>F. glaberrima</i> Bl.	T	E	Near streams in BB-DF MXF EGF	450-1200
<i>F. hirta</i> Vahl var. <i>hirta</i>	L	E	Disturbed areas in BB-DF MXF EGF	350-1150
<i>F. hispida</i> L. f. var. <i>hispida</i>	T L	E	Disturbed areas in BB-DF EGF	350-1525
<i>F. microcarpa</i> L. f.	T (st)	E	Streams in BB-DF MXF EGF	350-1050
<i>Ficus racemosa</i> L.	T	D	MXF especially along streams	350-500
<i>F. semicordata</i> B.-H. ex J.E. Sm.	T L	D	Disturbed areas in BB-DF EGF EGF-PINE	350-1550
<i>F. subincisa</i> J.E. Sm.	L S	E	Disturbed areas in MXF EGF	825-1400
<i>F. superba</i> (Miq.) Miq.	T	D	MXF EGF	750-1350

T=tree; L=treelet; (st)='strangler'; E=evergreen; D=deciduous; \*habitat abbr. see Part 2

their eggs. Figs are therefore vital nurseries for their pollinators, so each *Ficus* and wasp species rely on each other for reproduction. The life cycle of the wasp is short so, somewhere in the forest, figs of each species must be available nearly all year round. Otherwise the wasps would die out, leaving *Ficus* trees unable to reproduce.

Another characteristic of all *Ficus* trees is exudation of white, sticky latex from any cut surface; a feature also shared with other genera in the family, Moraceae.

The large roots of some *Ficus* trees are often exposed above ground. Finer, but very tough and fibrous, adventitious roots are produced in a very dense network.

The bark of *Ficus* trees is usually smooth, often pale grey or brown. Leaf arrangement and shapes are very variable.

the dry season, by tapping into soil moisture deep underground. This makes *Ficus* trees excellent for preventing soil erosion and stabilizing river 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. One species (*F. subincisa*) produces figs in the first year after planting out, whereas most others do so by around 6 years after planting. In tropical ecology, *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. Fig trees also seem to be fairly resistant to insect attack.

### Why do *Ficus* trees function so well as framework species?

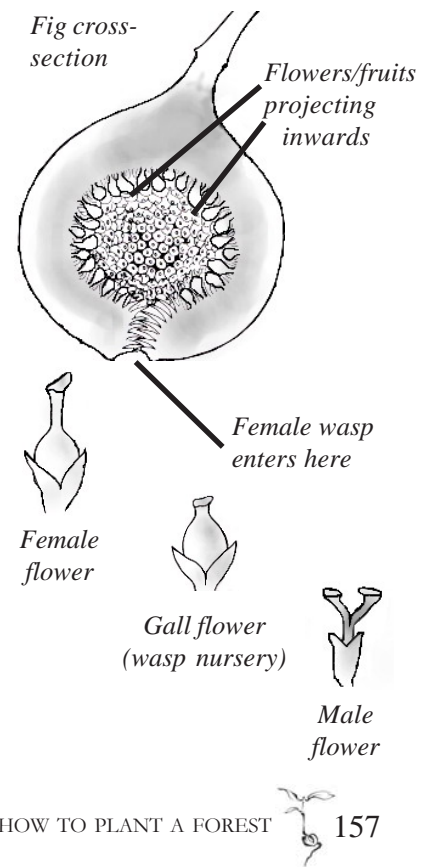
Two main characteristics make most *Ficus* tree species excellent framework tree species. Firstly, their very dense root systems enable them to survive and grow well under the harshest of conditions and to grow back rapidly after burning or slashing. Such root systems allow most species to retain their leaves throughout

### How are saplings grown?

Cut figs from *Ficus* 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

SEED COLLECTION	GP (%)	MLD (days)	SURVIVAL	GROWTH	NOTES
Oct-Mar	60-90	25-58	E	A	Shades out weeds. Resilient after fire. Attractive to animals from 2-3 y after planting.
Nov-Jan	>80	49-67	E	E	Figs from 6 <sup>th</sup> year. Attractive to animals from 2 <sup>nd</sup> year. Dense crown shades out weeds well.
Aug	>90	15	E	A	
Dec-Feb	>60	16	A	E	Figs from 6 <sup>th</sup> year after planting. Very attractive to seed-dispersing birds.
Dec-Jan	70-80	39	E	E	Excellent weed suppressor, but slow to produce figs.
Sep	>35	19	A	E	Often colonizes deforested sites naturally.
May	>90	18	E	A	Figs from 3 y after planting. Excellent weed suppressor. Resilient after fire.
Aug	74-85	22	E	E	Figs from 6 y after planting.
Feb	80-90	20-27	E	E	Excellent weed suppressor. Resilient after fire. Figs from 4 years after planting. Attractive to animals from 2 years after planting.
Dec-Mar	>80	52	M	E	Figs prolifically from 3 <sup>rd</sup> year after planting.
Aug	>70	50-60	E	E	Figs from 1 <sup>st</sup> year after planting. Very attractive to animals.
Nov-Feb	>80	36	M	E	Figs from 4.5 years after planting.

E=excellent; A=acceptable; M=marginal



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 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 2<sup>nd</sup> planting season after germination (TNT 18-22 months). Consequently, propagation by cuttings has been recommended to produce planting stock within a year. The method described in Box 6.2 works well with *F. hirta* and *F. superba* (applying IBA 3000 ppm to stimulate rooting of the former and IBA:NAA 2:1 for the latter) (Vongkamjan, 2003). Experiments with vegetative propagation of other *Ficus* species are encouraged.

### How should saplings be planted and cared for?

Some *Ficus* tree species begin life as epiphytes, growing on other trees e.g. *F. altissima*. These so-called “strangling” figs, grow a basket-like network of roots around the supporting tree, which eventually dies. When planting such species for forest restoration, do not plant them on other trees. They also grow well when planted directly into soil, provided that they do not become shaded. Most *Ficus* tree species are hardy and perform well with minimal care.

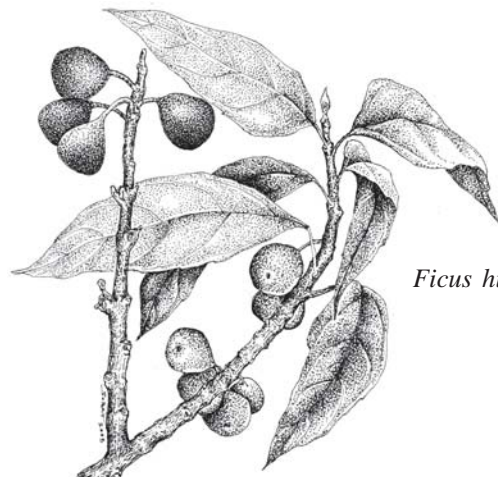
### What can *Ficus* tree species be used for?

*Ficus* trees are rarely exploited for their wood. However, timber of a few species is sometimes used for light construction, crates, small household items and firewood. Latex has been used to make rubber, as a sealant and as a substitute for wax for dyeing batik. Medicinally, latex is applied to cover wounds. Figs of some species are edible by humans. *Ficus* tree species in general and *F. religiosa* in particular have special cultural and religious significance for Thai people, so they are unlikely to be felled.

*Ficus racemosa*



*Ficus hispida*



*Ficus altissima*



*Ficus glaberrima*





***Glochidion kerrii* Craib  
(EUPHORBIACEAE)**

**Krai**

A shade-tolerant, understorey treelet, growing up to 7 m tall (DBH to 7 cm).

**Where does it grow?**

From the Himalayas, through India, S. China to Myanmar, Thailand and Indochina. In N. Thailand, it is locally common in EGF and BB-DF, at elevations of 550 to 1450 m.

**What are its distinguishing characteristics?**

**Bark:** thin, smooth, slightly flaking, light brown to grey. **Leaves:** alternate, simple; petiole 1-3 mm, with white, narrowly triangular stipules at base; blades ovate 2.2-9 x 1.4-4.5 cm, hairy along mid-vein on both sides. **Flowers:** in fascicles, light green; male flowers, 4.5-5.5 mm across; female flowers, c.2.5 mm across, 3-4 locular; February to May. **Fruits:** capsules, round, apically and basally flattened, 7-8 x 3.5-4 mm, becoming maroon; walls very thin; seeds, 3-6 seeds per fruit, hemispherical, 3.2-3.3 x 2.2-2.8 x 3-3.1 mm, covered in an orange-red aril; fruiting erratic, often prolonged, but mostly September to February; animal-dispersed

**Why is it a framework species?**

This species does not have exceptional field performance, (40-50% survival; 75 cm tall by end of 2<sup>nd</sup> rainy season), although slow growth in the first 2 years after planting accelerates markedly from the 3<sup>rd</sup> year onwards. Despite low initial performance, *G. kerrii* is worth planting because it is very effective at shading out weeds; it attracts wildlife at a young age and it adds structural diversity to the understorey. Flowering and fruiting occur in the 3<sup>rd</sup> year after planting. Many species of recruit tree seedlings establish naturally around planted *G. kerrii* trees, aged 5 years or older. This species coppices readily, providing resilience after fire (70% survival of trees burnt 21 months after planting, RCD >15 mm).

**How are saplings grown?**

Collect ripe fruits from trees in September or October. Remove seeds from capsules. Seeds are commonly attacked by borer insects, so carry out a flotation test to remove non-viable ones. Sow seeds in trays in partial shade. GP typically 40-50%; MLD 134 days. Prick out seedlings after expansion of first true-leaf pairs. Seedling growth in containers is slow, fertilizer application is important. Saplings must be kept in the nursery until the 2<sup>nd</sup> planting season after germination (TNT 21-22 months).

**How should saplings be planted and cared for?**

Apply standard planting and after-care procedures (Part 7).

**What can the species be used for?**

Hot-burning firewood.



## *Gmelina arborea* Roxb. (VERBENACEAE)

Saw

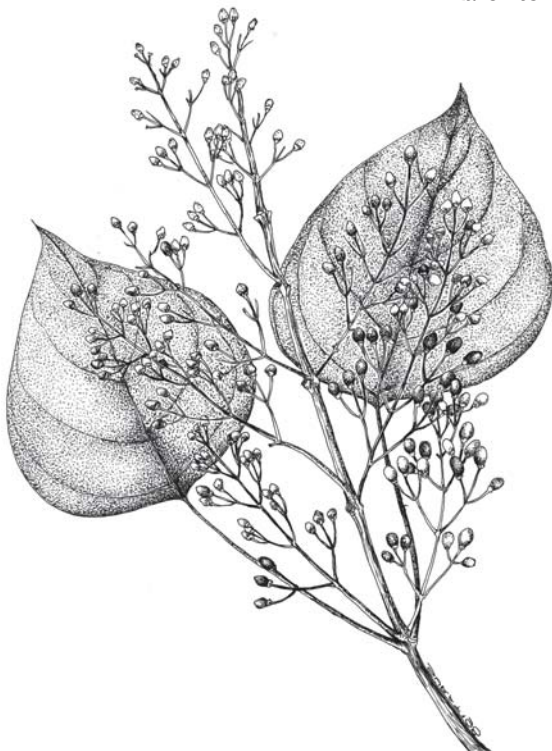
A briefly deciduous, pioneer tree, growing up to 30 m tall (DBH to 64 cm).

### Where does it grow?

From Nepal, Pakistan, India, Sri Lanka and Myanmar across Indochina to S. China and Vietnam. In N. Thailand, this species grows sparsely in DOF, BB-DF, MXF and EGF-PINE, at elevations of 350 to 1475 m. It also establishes naturally in deforested sites.

### What are its distinguishing characteristics?

**Bark:** thin, smooth, brown with conspicuous lenticels, becoming grey and peeling with age. **Leaves:** opposite, simple; blades, ovoid with pointed apex, 13-21 x 13-16 cm; upper surface dark green with 2 basal glands, lower surface silvery grey and hairy. **Flowers:** numerous in terminal inflorescences; flowers have 5-lobed, tubular, yellow corollas, 2.5-4.0 cm; February to March when leafless. **Fruits:** drupes, ovoid, yellow when ripe, averaging 26 x 18 mm, each containing a pyrene with 4 (rarely 5) chambers, of which rarely more than two contain seeds 6-9 mm long; fruiting; March to May; animal-dispersed.



### Why is it a framework species?

*G. arborea* is an excellent framework species. Saplings survive well and grow rapidly after planting out in both lowland and upland sites, (>70% survival; 160-180 cm tall by end of 2<sup>nd</sup> rainy season). Their dense crowns shade out weeds well and support nesting birds by the 3<sup>rd</sup> year. Flowering and fruiting commence in the 5<sup>th</sup> year after planting. Fruits attract many bird and mammal species. The trees are resilient after fire (83% survival of trees burnt 21 months after planting, RCD >90 mm).

### How are saplings grown?

Collect yellow fruits in April-June. Soak them in water overnight, then scrape off fruit flesh. Sun-dry the pyrenes for 1-2 days. Drop them into water and discard non-viable ones, which float. Put viable pyrenes into airtight containers with silica gel. Store at room temperature for 6 months. Sow pyrenes in mid-October in germination trays in full sunlight. Guard against seed predators. GP >60%; MLD 15-35 days. Prick out seedlings after expansion of first true-leaf pairs. Seedlings are prone to stem-boring beetles and leaf miners. Use insecticide and prune back affected tissues. Saplings ready for planting by June (TNT, excluding seed storage 8 months).

### How should saplings be planted and cared for?

Do not plant this species where it is likely to become shaded. Cardboard mulch mats significantly increase survival of planted saplings. This species is prone to defoliation by beetles.

### What can the species be used for?

*G. arborea* wood is used for pulp, plywood, and veneer; carpentry, light construction, boats, tools and carving. The wood makes good charcoal and firewood.



## *Heynea trijuga* Roxb. ex Sims (MELIACEAE)

## Dta Sua Toong

**Synonym:** *Trichilia connaroides* (Wight & Arn.) Benth.

A small, evergreen tree, growing up to 15-20 m tall (DBH to 45 cm).

### Where does it grow?

From India to Indochina, S. China, peninsular Malaysia, Sumatra, Borneo and the Philippines. In N. Thailand, it grows sparsely in MXF, EGF, and EGF-PINE, mostly above 1000 m elevation.

### What are its distinguishing characteristics?

**Bark:** with lenticels, dark brown, shallowly cracked. **Leaves:** spirally arranged, imparipinnate; leaflets opposite; blades ovate or elliptic, 12-22 x 5-9 cm; margin entire or sinuous; young leaves red. **Flowers:** inflorescences axillary, paniculate; flowers small, numerous white or cream; February to March. **Fruits:** capsules, globose, thinly fleshy, dark red, 13.4 x 12.2 x 11.8 mm; septicidal with two valves, each containing 1 seed; seed glossy, black, 10.4 x 9.6 x 8.9 mm, covered in a white, fleshy aril; August to November; animal-dispersed.

### Why is it a framework species?

*H. trijuga* is ranked as an acceptable framework species. Planted saplings achieve excellent survival rates and acceptable growth rates (>70% survival; 1-2 m tall by end of 2<sup>nd</sup> rainy season). They contribute structural diversity to the understory and shade out weeds effectively. Flowering and fruiting commence by the 3<sup>rd</sup> year after planting. Seedlings of recruit forest tree species establish around planted *H. trijuga* trees by 6 years after planting. The species is moderately resilient after fire (67% survival of trees, burnt 21 months after planting; RCD>50 mm).

### How are saplings grown?

Cut ripe fruits (beginning to split) from trees in November. Remove white aril and wash seeds. Sow them in germination trays in partial shade. Germination is slow (MLD 96 days) and asynchronous, but final GP is high (up to 80%). Early seedling growth is slow, but can be accelerated by applying fertilizer. Prick-out seedlings after expansion of first true-leaf pairs. Seedlings are prone to leaf-wrinkle virus (control by sterile pruning), stem-boring flies and caterpillars. Saplings are ready for planting-out by the 2<sup>nd</sup> planting season after seed sowing (TNT 20 months).

### How should saplings be planted and cared for?

Apply standard planting and aftercare procedures (Part 7).

### What can the species be used for?

Timber used as firewood. Bark and leaves used in traditional Thai medicines. Fruits edible.



## *Hovenia dulcis* Thunb. (RHAMNACEAE)

## Mawn Hin

A large, briefly deciduous tree, growing up to 30 m tall (DBH to 50 cm).

### Where does it grow?

From the Himalayas, to N. Thailand, China, Japan and Korea. In N. Thailand, it is a recently discovered, rare species (Maxwell, 1994) in EGF often along streams, at elevations of 1025 m to 1325 m.

### What are its distinguishing characteristics?

**Bark:** thick, with broad, longitudinal, grey or brown ridges, separated by narrow brick-red fissures. **Leaves:** spirally arranged, simple; blades, thin, ovate to elliptic, 11-14 x 5-9 cm; margin serrulate. **Flowers:** in cymes, numerous, light green and cream, small (2.5 mm); March to May. **Fruits:** fruit stalks (pedicels) very thin and curving for 2-3 mm above each fruit, but further along, swollen and fleshy, green when fruits are unripe, turning red-brown or black as fruits ripen; capsules septicial, brown or black and drying out when ripe, 7-8.5 x 6-7.5 mm, usually 3-lobed with 1 smooth, glossy, black seed (5-6 x 5-6 mm) per locule; August to February; bird-dispersed, particularly by pigeons (Hitchcock and Elliott, 1999).



### Why is it a framework species?

An excellent framework species, *H. dulcis* saplings survive well (>80% by end of 2<sup>nd</sup> rainy season) and grow rapidly (>1.5 m tall) after planting out. They develop broad crowns, which effectively shade out weeds and attract nesting birds by the 4<sup>th</sup> year. This species' deciduous habit protects it against drought. It is particularly resilient after chopping or fire (72% survival of trees burnt 21 months after planting; RCD >42 mm). *H. dulcis* fruits and the swollen axes of the infructescence are very attractive to birds, but flowering does not commence <8 years after planting.

### How are saplings grown?

Cut brown or black fruits from trees in October-November (as soon as ripe). Remove seeds from capsules and drop them into water. Discard those that float. Sow seeds immediately into trays in shade (about 25% full sunlight) and protect them from rats. Germination variable, but usually synchronous. GP 50-70%; MLD 45-90 days. Water seedlings well and prick them out as soon as first true-leaf pairs expand (ideally January or February). Apply fertilizer frequently, saplings grow rapidly in containers, reaching a plantable size of 30 cm by the 1<sup>st</sup> planting season after seed collection (TNT 8-9 months).

### How should saplings be planted and cared for?

This species thrives, even where aftercare procedures are neglected, but responds particularly well to fertilizer application.

### What can the species be used for?

Wood is suitable for pulp and fibre. The swollen axes of the infructescence are used traditionally to alleviate hangovers.

***Lithocarpus elegans* (Bl.) Hatus. ex Soep.      Gaw Mawn**  
**(FAGACEAE)**

A small to medium-sized, shade-tolerant, evergreen tree, growing up to 15 to 20 m tall.

**Where does it grow?**

From N. India, Nepal, Pakistan and Myanmar, through Yunnan, Indochina, Thailand, peninsular Malaysia, Indonesia and Borneo. In N. Thailand, it is very common in BB-DF, MXF and EG-PINE at elevations of 450 to 1450 m. It re-establishes well in degraded DOF, protected from fire.

**What are its distinguishing characteristics?**

**Bark:** thick, vertically cracked, grey or grey-brown. **Leaves:** spirally arranged, simple; blades elliptical to oblong, glabrous, leathery, 10-20 x 4-8 cm; margin entire. **Flowers:** in upright, slender clusters, males and females in separate clusters on same tree; flowers, tiny, cream coloured; March to October. **Fruits:** nuts, densely clustered without stalks, globose, depressed, brown when ripe, 1.5-2.5 cm, scaly cupule, with distinct rings covers less than half of fruit; July to October; animal-dispersed.

**Why is it a framework species?**

Planted *L. elegans* saplings achieve acceptable survival rates and excellent growth rates after planting out (56% survival; >2.2 m tall by end of 2<sup>nd</sup> rainy season). Crowns are narrow but dense and effectively shade out weeds. The nuts (particularly immature ones) are relished by squirrels, wild pigs, deer and other seed dispersers, but this species does not flower within 4 years after planting.

**How are saplings grown?**

Collect nuts from the ground in September. Remove cupules and drop nuts into water. Sow the viable ones (which sink) into germination trays in partial shade. Cover trays with wire mesh

to prevent rats from eating the nuts. Germination, slow, asynchronous, continuing for 270 days. GP 50-70%; MLD 140 days. Prick out seedlings intermittently, after expansion of first true-leaf pairs. Early seedling growth is slow, but can be accelerated with fertilizer. Saplings are usually ready for planting by 2<sup>nd</sup> planting season after germination (TNT 21 months).

**How should saplings be planted and cared for?**

Apply standard planting and aftercare procedures (Part 7), except that cardboard mulch should not be used, as it significantly reduces field performance of this species.

**What can the species be used for?**

Timber is durable and is suitable for construction, firewood, charcoal making and mushroom culture.



## *Macaranga denticulata* (Bl.) M. -A. (EUPHORBIACEAE)

## Tawng Taep

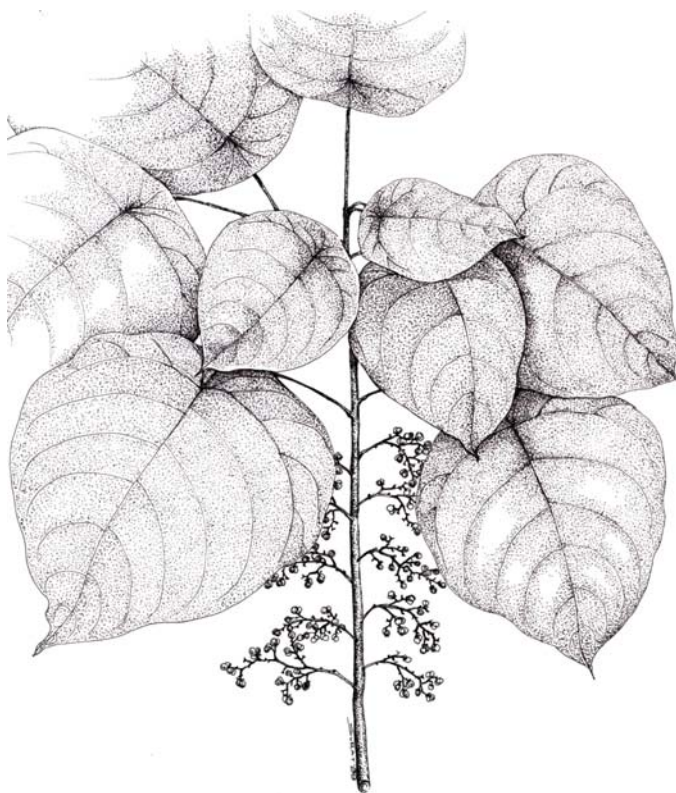
A medium-sized, pioneer, evergreen, tree, growing up to 20 m tall (DBH 40 cm).

### Where does it grow?

From E. Himalayas to Sri Lanka and Indochina, S. China, Thailand, Laos, peninsular Malaysia, Sumatra and Java. In N. Thailand, it is common in disturbed forest areas and secondary growth in EGF, MXF and BB-DF, often along roadsides and river banks at elevations of 500 to 1400 m.

### What are its distinguishing characteristics?

**Bark:** thin, light brown, cracked, with pustular lenticels. **Leaves:** spirally arranged, simple; petiole red; blades peltate. **Flowers:** unisexual; males in small panicles, globose, about 6 per cluster; females in dense racemes; March to August. **Fruits:** capsules, septical, smooth, light brown to blackish brown on ripening, 3-5 x 5-6 mm; seeds, 1 per locule, globose, black, 3-4 x 3-4 mm; July to December; dispersed by birds and small mammals.



### Why is it a framework species?

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 and taller than 4 m by the end of the 4<sup>th</sup>. Its large leaves form a dense crown (>4 m broad by 4<sup>th</sup> growing season), which shades out weeds very effectively. It can flower by the 2<sup>nd</sup> year after planting and its fruits attract seed-dispersing birds. Tapirs relish the leaves.

### How are saplings grown?

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. If black-spot fungus is seen on shoots, destroy infected plants and spray healthy ones with fungicide. Saplings can be planted when 30 cm tall *i.e.* by the 1<sup>st</sup> planting season after seed collection (TNT 9 months).

### How should saplings be planted and cared for?

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; so only plant it where fire prevention is effective.

### What can the species be used for?

Timber can be used for temporary and light construction and packing cases. On fallow fields, dense stands of *M. denticulata* enrich the soil and increase rice yields, when the fallow is subsequently cleared for rice cultivation.



***Machilus kurzii* King ex Hk.f.**  
**(LAURACEAE)**

**Tong Hawm**

An medium-sized evergreen tree or treelet, growing approximately 15 m tall (DBH 60 cm).

**Where does it grow?**

From India to S. China (Tibet, Yunnan) and Indochina. In N. Thailand, it is common in MXF, EGF and EGF-PINE, often in secondary growth, at elevations of 550 to 1550 m.

**What are its distinguishing characteristics?**

**Bark:** brown, cracked. **Leaves:** spirally arranged, simple; blades lanceolate or narrowly elliptic, thin, leathery, smooth, tapering at both ends; midrib prominent on lower part of blade. **Flowers:** in long clusters, small, white-cream; February to April. **Fruits:** drupes, ovoid, glossy black on ripening; persistent calyx; seed, one per fruit, 6 x 7 mm; June to September; animal-dispersed.

**Why is it a framework species?**

*M. kurzii* saplings survive well and grow rapidly after planting out (>65% survival; averaging >1.8 m tall by end of 2<sup>nd</sup> rainy season). They develop acceptably broad crowns, which are moderately effective at shading out weeds. Flowering and fruiting commence in the 3<sup>rd</sup> year after planting and the fleshy fruits attract seed-dispersing animals. Birds use this species for nesting from the 5<sup>th</sup> year after planting. *M. kurzii* seedlings commonly establish naturally in 5-6 year-old framework species plots.

**How are saplings grown?**

Collect fallen, black fruits in July. Remove fruit flesh, drop seeds into water and discard non-viable ones, which float. Air-dry the seeds; then sow them in germination trays in shade. Germination is asynchronous. GP often low (c.30%), so collect more seeds to compensate; MLD 108-178 days. Prick out seedlings inter-

mitently, after expansion of first true-leaf pairs. Saplings grow slowly and are not ready for planting until the 2<sup>nd</sup> planting season after seed collection (INT 23 months). More research is needed to accelerate sapling production.

**How should saplings be planted and cared for?**

Apply standard planting and after-care procedures (Part 7), but continue weeding into the dry season.

**What can the species be used for?**

An excellent firewood. In India it is semi-domesticated to produce leaves fed to silk worms (*Antherea assama*), which produce golden yellow silk.



## *Magnolia baillonii* Pierre (MAGNOLIACEAE)

## Jahmbee Bah

Synonyms: *Michelia baillonii* (Pierre) Fin & Gagnep., *Paramichelia baillonii* (Pierre) Hu

A large, briefly deciduous tree, growing up to 35 m tall (DBH to 1 m).

### Where does it grow?

Yunnan and Indochina (Myanmar, Thailand, Cambodia, Vietnam). In N. Thailand, it grows at medium abundance in MXF and EGF, at elevations of 650 to 1350 m.

### What are its distinguishing characteristics?

**Bark:** thick, brown, flaking, longitudinally cracked. **Leaves:** spirally arranged, simple; blades elliptic, ovate-elliptic, or lanceolate, 6-22 x 4-8 cm. **Flowers:** solitary, axillary, fragrant; tepals 18-21, 6 per whorl, cream; June to October. **Fruits:** aggregates of capsules, 6-10 x 4-5 cm; mature carpels fall off irregularly, leaving behind the vascular framework; seeds black, 9 x 2 mm, with bright red-orange arils; March to August; dispersed by birds.

### Why is it a framework species?

*M. baillonii* is an excellent framework species. Planted saplings achieve acceptable survival rates and excellent growth rates (averaging >65%

survival and >2 m tall by end of 2<sup>nd</sup> rainy season). Their broad crowns (>1.5 m) suppress weed growth well. Fragrant flowers attract insects and birds eat the seeds, but flowering has not been observed <5 years after planting. This species recovers well after burning (>70% survival of trees burnt 21 months after planting; RCD >5 cm). *M. baillonii* establishes naturally in framework species plots 5 years or older.

### How are saplings grown?

Cut fruits from trees in July-August, just as parts of the fruits are beginning to fall. Soften the fruits in water, then remove the seeds. Rub off the red-orange arils and soak seeds in water for 24 h. Remove any non-viable ones, which float. Sun-dry seeds for 1-2 days, then sow them shallowly in trays in sunlight in 1:1 forest soil:sand to prevent damping-off. Protect trays from rodents. Germination is slow and asynchronous. GP c. 30%; MLD 100 days. Prick out seedlings after expansion of first true-leaf pairs. If aphids are observed attacking this species, destroy infested plants and spray survivors with insecticide. Containerized plants grow rapidly in the nursery and are usually ready for planting by the 1<sup>st</sup> planting season after seed collection (TNT 11 months).

### How should saplings be planted and cared for?

This species responds very well to cardboard mulch placed around trees at planting time.

### What can the species be used for?

Timber can be used for construction and furniture. Its fragrant flowers make *M. baillonii* a popular garden tree.





## *Manglietia garrettii* Craib (MAGNOLIACEAE)

## Monta Daeng

A medium-sized, evergreen or leaf-exchanging tree, up to 20 m tall (DBH to 41 cm).

### Where does it grow?

From S. China and Thailand to Vietnam. In N. Thailand, this species grows at medium abundance in primary EGF at elevations of 1050 to 1600 m.

### What are its distinguishing characteristics?

**Bark:** thin, smooth, grey, becoming markedly pustular-lenticellate. **Leaves:** spirally arranged, simple; blades leathery, elliptic to obovate, 18-34 x 8-12; stipules large, hairy; stipule scars on stems prominent after leaf fall; petioles 3-5 cm with brown hairs. **Flowers:** terminal, solitary, bisexual, 5.5-6.5 cm long; tepals 9, dark pink-purple; peduncle 1.5-4 cm long; stamens and carpels numerous; March to April. **Fruits:** aggregates of many capsules, light yellow-green when unripe, maroon to brown and woody when ripe, 95 x 60 mm; seeds, one per capsule, black, 10 x 4 mm, covered in a red aril, attached to fruit by thin thread; September to November; seeds dispersed by birds.

### Why is it a framework species?

*M. garrettii* is a marginally effective framework species, but can be planted on ex-EGF sites to add structural diversity to the forest canopy. Planted saplings survive poorly (c. 50%), but survivors grow well (c.1.5 m and >5 m tall by end of 2<sup>nd</sup> and 5<sup>th</sup> rainy seasons respectively), developing broad, dense crowns, which effectively shade out weeds. *M. garrettii* seeds attract birds and squirrels, but fruiting does not commence within 7 years after planting. Nevertheless, younger trees do attract seed-dispersing wildlife, since seedlings of several animal-dispersed tree species establish around *M. garrettii* crowns by the 6<sup>th</sup> year after planting.

### How are saplings grown?

Collect fruits, as they start to split open, in October (cut from trees). Sun-dry them and remove the seeds. Rub off the red aril and drop the black seeds into water. Discard non-viable ones, which float. Sun-dry seeds for 1 day, then sow them in trays in partial shade. Protect seeds from squirrels and rats. Germination is usually slow and asynchronous. GP 65-75%; MLD 47-81 days. Prick out seedlings after expansion of first true-leaf pairs. Containerized saplings grow large enough for planting out (*i.e.* 50 cm) by the 2<sup>nd</sup> planting season after seeds are sown (TNT 20 months).

### How should saplings be planted and cared for?

Planted *M. garrettii* saplings respond well to placement of cardboard mulch at planting time and frequent fertilizer application. More research is needed to increase post-planting survival rates.

### What can the species be used for?

Lightweight hardwood, for construction, furniture, veneer, plywood and carving.



## *Melia toosendan* Sieb. & Zucc. (MELIACEAE)

Lien

A medium-sized, briefly deciduous, pioneer tree, growing up to 25 m tall (DBH to 47 cm).

### Where does it grow?

From Myanmar, through N. Thailand, Indochina, S. China and Japan. In N. Thailand, it is characteristic of secondary growth in EGF and MXF, at elevations of 700 to 1450 m.

### What are its distinguishing characteristics?

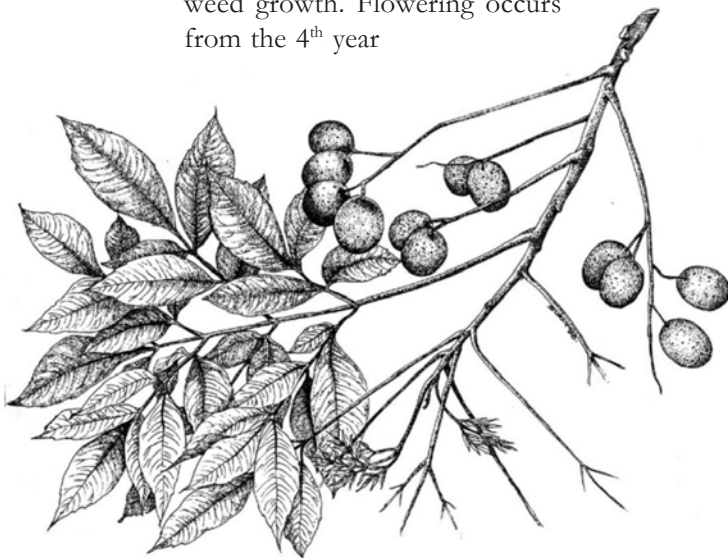
**Bark:** thin, grey-brown, with shallow fissures.

**Leaves:** spirally arranged, doubly pinnate or tripinnate; leaflet blades ovate, 3-7 x 1-2 cm, with acuminate tip, margin often toothed.

**Flowers:** inflorescences axillary and paniculate; flowers numerous, corollas white (c.10 mm); January to March. **Fruits:** drupe, yellow when ripe, 25 x 22 mm; ridged, woody pyrene contains up to 5 seeds; seeds black, 6 x 3 mm; October to March; animal-dispersed.

### Why is it a framework species?

An excellent framework species, *M. toosendan* is the fastest growing tree species tested by FORRU so far. Planted saplings achieve survival rates of >90% and grow 5-7 m tall by end of 2<sup>nd</sup> rainy season. They develop very broad crowns (>2.5 m), which contribute substantially to forest canopy cover and suppress weed growth. Flowering occurs from the 4<sup>th</sup> year



after planting and fruiting from the 5<sup>th</sup>. Barking deer eat the fruits. This species is very attractive to birds, with 24 species recorded as regular visitors, including 5 bulbul species, which are important seed-dispersers. Its fragrant flowers attract many insects. It is highly resilient after burning (70-100% survival of trees burnt 21-33 months after planting; RCD >5 cm).

### How are saplings grown?

Collect yellow fruits from the ground in October-November. Sun-dry them, then crack open the woody pyrenes with a knife to remove the seeds. Sow seeds shallowly in sunlight in 1:1 forest soil and sand to prevent damping-off. Germination is rapid. GP 70%; MLD 15 days. Prick out seedlings after expansion of first true-leaf pairs (ideally in January). Take precautions against caterpillars and fungal infection and do not prune or apply fertilizer (except if symptoms of nutrient deficiency develop). Saplings grow rapidly to 30 cm tall (ready for planting) by the 1<sup>st</sup> planting season after seed collection (TNT 7-8 months). Harden them in sunlight and reduce watering 6 weeks before planting.

### How should saplings be planted and cared for?

Saplings are delicate and require extreme care during transportation. *M. toosendan* grows well with minimal aftercare, but it is particularly responsive to cardboard mulching. Excellent results have been achieved with direct seeding.

### What can the species be used for?

The timber is used as firewood. The fruit extract is an insecticide and is used as Chinese medicine. It is an analgesic, anti-helminthic, anti-fungal and anti-inflammatory, but therapeutic doses are close to toxic doses. Consumption of 5-6 fruits can be lethal to adult humans.

***Nyssa javanica* (Bl.) Wang.**  
**(NYSSACEAE)**

**Kang Khak**

A large, evergreen or leaf-exchanging tree, growing 30-40 m tall (DBH to 90 cm).

**Where does it grow?**

From India and Myanmar to Thailand, Indochina and south to peninsular Malaysia, Sumatra, Java and Borneo. In N. Thailand, it is common in EGF and MXF, especially along streams at elevations of 550 to 1400 m.

**What are its distinguishing characteristics?**

**Bark:** thick, vertically cracked, often flaking, brown-grey. **Leaves:** spirally arranged, simple; blades elliptic to oblong, 13-22 x 6-12 cm; young ones covered in dense silvery hairs; no stipules. **Flowers:** inflorescences axillary; male and bisexual on different trees; flowers tiny, yellow-green; February to April. **Fruits:** drupe, ovate, juicy, dark red-orange when ripe, 18-20 x 12-15 mm; pyrene contains single seed; seed light brown, flattened, 15 x 8-10 mm, covered by a red aril; April to August; animal-dispersed.

**Why is it a framework species?**

*N. javanica* is ranked as an acceptable framework species. Planted saplings have rather low survival rates, but excellent growth rates after planting out in deforested sites (c. 50-60% survival; 2-2.8 m tall by end of 2<sup>nd</sup> rainy season). They develop dense, broad crowns (>160-200 cm across), which shade out weeds. Birds favour the trees as perching sites and the fleshy fruits of mature trees are eaten by birds and mammals. Although fruiting does not occur until >7 years after planting, younger trees are attractive to seed-dispersing wildlife, since seedlings of several animal-dispersed tree species establish beneath *N. javanica* crowns by the 6<sup>th</sup> year after planting.

**How are saplings grown?**

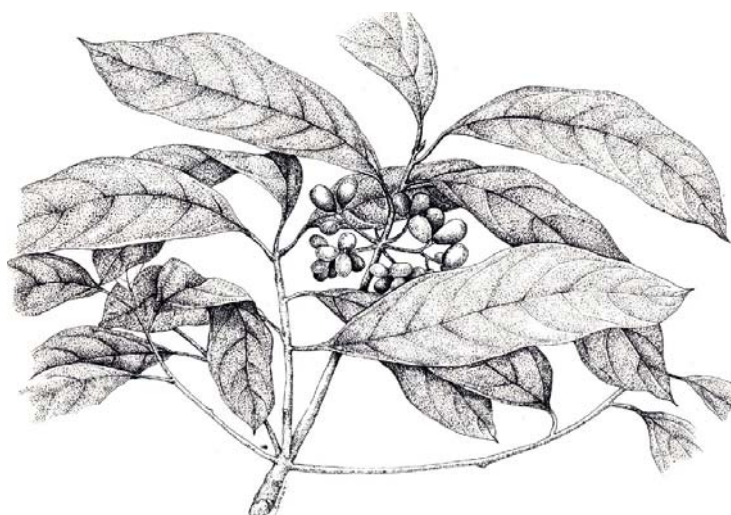
Collect fallen fruits in August or September. Rub fruits on a sieve to remove the fruit flesh and scrape off the aril under running water. Sow seeds in trays in 1:1 forest soil:sand to prevent damping-off. If damping-off does occur, remove and destroy infected seedlings and spray survivors with fungicide. Protect sown seeds from predation by rats. Germination is asynchronous and prolonged (up to 100 days). GP typically c.70%; MLD 40 days. Prick out seedlings after expansion of first true-leaf pairs. Saplings grow rapidly and are usually large enough for planting out by the 1<sup>st</sup> planting season after seed collection (TNT 9-10 months).

**How should saplings be planted and cared for?**

This species responds well to cardboard mulching and vigorous weeding into the early dry season. It is not very resilient after burning, so plant it where fire prevention is effective.

**What can the species be used for?**

Timber is dense and is suitable for house construction, furniture, packing cases, veneer and plywood. Fruit is edible.



## *Peltophorum dasyrhachis* (Miq.) Kurz Nonsi Bah or Arang (LEGUMINOSAE, CAESALPINIOIDEAE)

A small to medium-sized, light demanding, deciduous tree, growing up to 30 m tall.

### Where does it grow?

From Indochina (Thailand, Cambodia, Laos and Vietnam) to Malaysia and Indonesia. In central and SW Thailand, it grows in degraded areas in BB-DF and lowland EGF at elevations of 80 to 900 m.

### What are its distinguishing characteristics?

**Bark:** smooth, brown. **Leaves:** doubly pinnate, 18-25 cm long; large pectinate stipules at bases of petioles. **Flowers:** in unbranched, axillary clusters 5-35 cm long; petals bright yellow, 1.5-2 cm across; March to April. **Fruits:** pods, indehiscent, elliptical, tapering at both ends, dull brown on ripening, 10-15 x 2-3.5 cm; 4-5 flat seeds per pod; fruiting October-January; pods wind-dispersed.

### Why is it a framework species?

*P. dasyrhachis* is an acceptable framework species for restoring both deciduous and evergreen forest types, in central or SW Thailand;

particularly highly degraded sites or those with saline soils. Although survival rates can be low, planted saplings achieve acceptable growth rates and develop dense crowns, which shade out weeds. Their nectar-rich flowers attract insects, birds and squirrels. Being a legume, it can increase the nitrogen content of the soil and is suitable for agro-forestry.

### How are saplings grown?

Collect brown pods from trees in September or October. Sun-dry them until they split open and release the seeds. Soak the seeds in water overnight. Sow those that begin to swell and discard any non-viable ones, which float. Sow seeds shallowly in germination trays in full sunlight. Prevent seed predation by covering trays in wire mesh. Germination is usually low GP c.42%; MLD 84 days. Prick out seedlings once the first true leaf pair has expanded. Containerized saplings grow slowly and are not large enough for planting out until the 2<sup>nd</sup> rainy season after seed collection (TNT 21 months).

### How should saplings be planted and cared for?

Use standard planting procedures described in Part 7. This species responds well to cardboard mulching.

### What can the species be used for?

This species is useful as a shade tree and as a fallow crop due to its nitrogen fixing properties. Timber can be used for firewood. The bark and wood of *P. dasyrhachis* are used to make a red or yellowish brown dye. Its flowers are important for honey bee culture. Tolerant of saline soils. Intercropped with maize in agro-forestry systems.



***Prunus cerasoides* D. Don**  
**(ROSACEAE)**

**Nang Paya Sua Krong**

A medium-sized, pioneer, deciduous tree, growing up to 16 m tall (DBH to 38 cm).

**Where does it grow?**

From the Himalayas and S. China to Myanmar and N. Indochina. In N. Thailand, it is rare in EGF, MXF and EGF-PINE, often in disturbed areas, at elevations of 1040 to 2400 m.

**What are its distinguishing characteristics?**

**Bark:** shiny, red-brown, with large, raised, brown lenticels; outer layer peeling horizontally. **Leaves:** spirally arranged, simple; blades 9-12 x 3-5 cm; margin finely serrate; 1-2 dark red, stalked, glands where petiole meets blade. **Flowers:** in axillary clusters, 1-2.5 cm across, petals, 5, pink; on leafless trees December to January. **Fruits:** drupes (small cherries), ovoid, red when ripe, 1-1.5 cm, each containing a single-seeded pyrene; March to May; dispersed by birds, squirrels and other small mammals.

**Why is it a framework species?**

*P. cerasoides* is an excellent framework species. Planted saplings survive very well and grow rapidly when planted out (>80% survival and >3 m tall by end of 2<sup>nd</sup> rainy season). They develop broad crowns (>2.4 m across), which effectively shade out weeds and they flower, fruit and provide bird nest sites by the 3<sup>rd</sup> year after planting. Birds such as, Sunbirds, Spider-hunters and White-eyes feed on the nectar, whilst bulbuls eat the fruits.

**How are saplings grown?**

Collect ripe fruits mid-March. Scrape off the fruit pulp with a knife, under running water to expose the woody pyrene. Sun-dry the pyrenes. Place them in airtight containers with silica gel for 2 days, then change the silica gel and store the containers in a refrigerator at 5 degrees

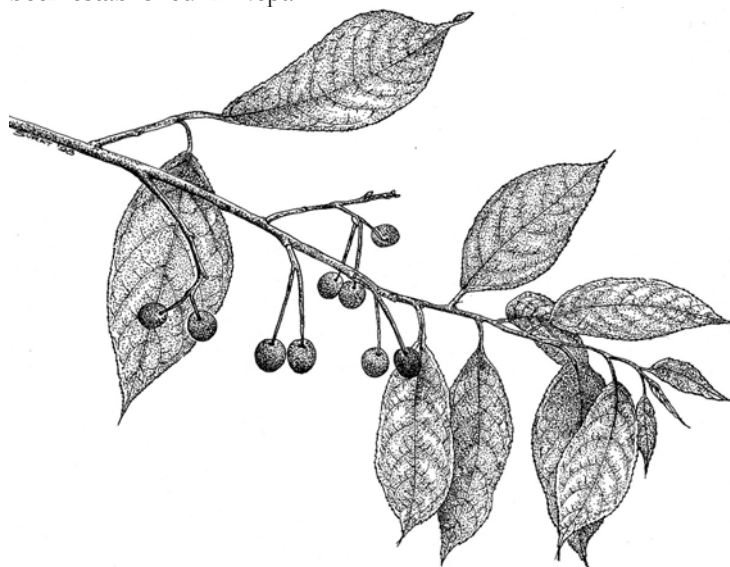
centigrade. The following January, take the pyrenes out of storage and sow them in germination trays in full sunlight. GP typically >70%; MLD 48-52 days. Prick out seedlings when they are 5-7 cm tall, with 4-5 leaves (usually 7-10 days after germination). Apply no fertiliser, unless nutrient deficiency symptoms develop and if necessary, prune the plants to prevent them from outgrowing their containers. Saplings are ready for planting, when 30 cm tall (TNT 5 months, excluding seed storage).

**How should saplings be planted and cared for?**

*P. cerasoides* responds well to cardboard mulching, repeated for two years. The species is also suitable for direct seeding. Prepare and store pyrenes as described above, then sow them directly into deforested sites at the beginning of the rainy season. (see Part 4).

**What can this species be used for?**

Wood used for construction, furniture, cabinet-work, interior finish and firewood. Leaves for fodder. A popular ornamental tree in gardens and along roadsides. Plantations have been established in Nepal.



## *Quercus semiserrata* Roxb. (FAGACEAE)

## Gaw Dtah Mu Luang

Synonym: *Cyclobalanopsis semiserrata* (Roxb.) Oersted

A large, evergreen tree, growing up to 30 m tall (DBH to 1 m).

### Where does it grow?

From India, Bangladesh, Myanmar and S. China to Indochina. In N. Thailand, it is common in EGF, MXF and EGF-PINE, at elevations of 800 to 1675 m.

supports birds' nests from the 2<sup>nd</sup> year after planting. Fruiting can occur as early as 1.5 years after planting, but this is very rare. Most trees do not flower until they are >5 years old. Squirrels and wild pigs eat the nuts.

### What are its distinguishing characteristics?

**Bark:** thick, grey-brown, vertically cracked. **Leaves:** spirally arranged, simple; blade ovate-oblong, glabrous, leathery, 13-25 x 3-8 cm; margin serrate towards the apex. **Flowers:** in axillary unisexual clusters, male flowers light yellow, female flowers light green, maturing to yellow; March to April. **Fruits:** nut, oblong-oval, hairy, 3.5-4 x 2 cm; cupule encloses lower third; one seed per nut; masting December to July, every 2-3 years; animal-dispersed.

### How are saplings grown?

Collect nuts as they begin to fall from the trees (ideally June-July). Remove cupules and drop the nuts into water. Remove the non-viable ones which float. Sow nuts on their side, 2-3 cm apart, directly into deep containers (to prevent root deformities after germination), in partial shade. Germination is reliably high and synchronous. GP 85-92%; MLD 18 days. Leaf pruning once in the first 6 months may increase sapling growth rates. Saplings usually grow large enough for planting out by the 1<sup>st</sup> planting season after seed collection (TNT 11-12 months).

### Why is it a framework species?

Planted *Q. semiserrata* saplings achieve high survival and growth rates (>70% survival and averaging 115 cm tall by end of 2<sup>nd</sup> rainy season). Branching occurs near the base within the first year and trees develop a dense but narrow crown, which effectively shades out weeds and

### How should saplings be planted and cared for?

This species grows better in partially shaded conditions. Allow weeds to grow up around planted trees towards the end of the rainy season, so that they shade the young trees during the dry season. Do not apply cardboard mulch. *Q. semiserrata* does not survive well after fire, so only plant it where fires are effectively excluded.

### What can the species be used for?

Timber for construction, posts, beams, agricultural tools, furniture, interior finish and firewood. It is also used for mushroom cultivation. Leaves used to raise silk worms in India.



***Rhus rhesoides* Craib**  
**(ANARCARDIACEAE)**

**Gawk Gun**

A medium-sized, pioneer, deciduous tree, growing up to 25 m tall (DBH to 30 cm).

**Where does it grow?**

N. Vietnam and N. Thailand. In N. Thailand, it is moderately common in EGF, MXF and EGF-PINE, at elevations of 650 to 1550 m.

**What are its distinguishing characteristics?**

**Bark:** cracked, brown-grey, with brown lenticels; sap causes skin rashes. **Leaves:** spirally arranged, pinnate; leaflets in 4-5 opposite pairs plus terminal one; leaflet blades, lanceolate to oblong, 9-15 x 2.5-5 cm; margin entire or sinuous. **Flowers:** inflorescences axillary, open panicate, 30-45 cm long; flowers unisexual and bisexual, 1.5 mm long, light yellow-greenish; July to August. **Fruits:** drupe asymmetrically ovoid, dark brown on ripening, 8 x 5 x 3 mm; mesocarp thin, almost dry; pyrene contains a single seed; seed brown and flattened, 3 x 2.5 x 0.5 mm; September to December; dispersed by squirrels and birds.

**Why is it a framework species?**

*R. rhesoides* is an excellent framework species. Planted saplings achieve very high survival and growth rates (>80% survival and averaging >3 m tall by end of 2<sup>nd</sup> growing season). Although, this species develops only a moderately broad crown, it effectively suppresses weed growth. It withstands moderate fires well (>90% survival of trees burnt 21 months after planting; RCD >80 mm). Prolific flowering and fruiting from the 2<sup>nd</sup> year after planting attracts many seed-dispersing animals as well as nesting birds.

**How are saplings grown?**

Use gloves when handling fruits of this species as they may cause an allergic reaction. Collect dark brown fruits from trees from September to October. Remove the thin cover-

ing from the pyrenes and drop them into water. After discarding non-viable pyrenes, which float, sun-dry remaining ones and sow them in trays in full sunlight. GP typically 50-60%; MLD 24 days. Germination is asynchronous, so prick out intermitently as seedlings expand their first true-leaf pairs. Take precautions against aphids and fungal, die-back diseases, which attack young seedlings in the cool season. Water the seedlings well. Use a nutrient-rich medium, or apply fertilizer frequently, to ensure saplings grow tall enough by the 1<sup>st</sup> planting season after seed sowing (TNT 8-9 months).

**How should saplings be planted and cared for?**

This species thrives in hot, dry, sunny conditions, even on degraded sites. Weed frequently and into the start of the dry season. Responds well to cardboard mulching.

**What can the species be used for?**

The sap can be used for making lacquerware.



## *Sapindus rarak* DC. (SAPINDACEAE)

## Mah Sak

A medium-sized, light-demanding, deciduous tree, growing up to 25 m tall (DBH 25 cm).

### Where does it grow?

In India (Assam), Myanmar, Indochina, and Indonesia. In N. Thailand, it is common in EGF and MXF, often on disturbed sites or along streams, at elevations of 625 to 1620 m.

### What are its distinguishing characteristics?

**Bark:** grey or light brown, becoming fissured with age. **Leaves:** spirally arranged, bipinnate, 38-44 cm long; leaflets 8-10, mostly opposite; leaflet blades asymmetrically lanceolate to oblong, 7-13 x 2.5-3.5 cm. **Flowers:** inflorescences terminal, 23-35 cm long; flowers numerous, bisexual, 4 mm long, petals white; March to April. **Fruits:** drupes, globose, leathery and wrinkled; yellow-brown when ripe, 25 x 23 mm; seed, one per drupe, black 16 x 15 mm; July to January; animal-dispersed.

### Why is it a framework species?

*S. rarak* is an acceptable framework species. Planted saplings achieve excellent survival rates and acceptable

growth rates (c.80% survival; averaging 1.25 m tall, by end of 2<sup>nd</sup> rainy season). Despite a narrow crown, the species effectively suppresses weed growth. It fruits prolifically, but takes longer than 7 years before fruiting commences. Its fruits are eaten by wild pigs and deer. This species survives moderate fires and regenerates well after burning (100% survival of trees burnt 33 months after planting; RCD >10 mm).

### How are saplings grown?

Cut fruits from trees as soon as ripe ones are first seen (ideally August). Remove fruit flesh. Put pyrenes in water and discard non-viable ones, which float. Sow those that sink, in germination trays in full sunlight. GP usually >80%; MLD 45-52 days. Germination is asynchronous, continuing for >130 days. Prick out seedlings at frequent intervals after expansion of first true-leaf pairs. If fertilizer is applied, containerized saplings usually grow tall enough for planting out by 1<sup>st</sup> planting season after seed collection (TNT 10 months).

### How should saplings be planted and cared for?

Standard planting and after-care procedures (Part 7), with cardboard mulching, usually yield good results. *S. rarak* grows best in moist but sunny locations. If surrounded by faster-growing tree species, shade suppresses growth. It is susceptible to attack by white aphids.

### What can the species be used for?

Saponins, from the fruits, are used to make soaps and shampoos and have antibacterial properties. The fruits are also used to make insecticides. *S. rarak* wood can be used for general construction and furniture, but it is not durable. Seeds can be used for buttons or beads.





***Sarcosperma arboreum* Bth.**  
**(SAPOTACEAE)**

**Mah Yang**

A medium-sized, shade tolerant, evergreen tree, growing up to 25 m tall (DBH to 50 cm).

**Where does it grow?**

In S. China, NE. India, Myanmar and Thailand. In N. Thailand, it is common in EGF and MXF, at elevations of 650 to 1400 m.

**What are its distinguishing characteristics?**

**Bark:** greyish brown, thin, flaking with shallow fissures; sap white. **Leaves:** opposite or sometimes alternate; blades oblong, 10-26 x 4-8 cm; both surfaces glabrous. **Flowers:** in panicles; small 2-4 mm, sepals rust-coloured, corolla yellow; December to February. **Fruits:** drupes, purple-black when ripe, oblong, 15-25 x 7-15 mm; seeds, 1 per fruit, light brown or cream, 18 x 12 mm; fruiting April to August; animal-dispersed.

**Why is it a framework species?**

*S. arboreum* is an excellent framework species. Planted saplings achieve very high survival rates and acceptable growth rates (>70% survival; >100 cm tall by end of 2<sup>nd</sup> rainy season), although their narrow crowns do not suppress weed growth very well. Flowering and fruiting commence in the 5<sup>th</sup> year after planting. Several bird species and barking deer eat the fruits. This species regenerates well after moderate fires (>80% survival of trees burnt 33 months after planting; RCD >22 mm).

**How are saplings grown?**

Collect fallen, blackish-purple fruits in July. Remove fruit flesh and clean the seeds. Place seeds in water and discard the non-viable ones, which float. Air-dry the seeds, then sow them directly into plastic bags or root trainers, using standard potting mix. Place containers in shade, water them frequently and protect them from

rats and squirrels, which like to eat the seeds. GP c.60%; MLD 60-67 days. Saplings usually grow slowly and are not large enough for planting out until the 2<sup>nd</sup> planting season after seed collection (TNT 23 months). To produce plantable trees within a year, experiment with increased fertilizer application or cultivating wildlings (see Box 6.1).

**How should saplings be planted and cared for?**

*S. arboreum* should be planted in fairly shady, moist sites. Apply standard planting and after-care procedures (Part 7). As it has poor weed suppression capabilities, weeding around *S. arboreum* trees may have to be continued for longer than usual. Successful results have been achieved with direct seeding for this species.

**What can the species be used for?**

No recorded uses.



## ***Spondias axillaris* Roxb. (ANARCARDIACEAE)**

**Ma Kak**

Synonym: *Choerospondias axillaris* (Roxb.) Burtt & Hill

A medium-sized, deciduous tree, growing up to 25 m tall (DBH to 50 cm).

### **Where does it grow?**

From NE. India and China through Indochina to S. Japan. In N. Thailand, it is common in EGF, EGF-PINE and MXF, at elevations of 700 to 1600 m.

### **What are its distinguishing characteristics?**

**Bark:** grey-brown, thin, vertically cracked. **Leaves:** spirally arranged, compound, once pinnate, 25-40 cm long; leaflet blades opposite or sub-opposite, ovate to ovate-lanceolate, 4-12 x 2-4.5 cm; apex acuminate. **Flowers:** male inflorescences 4-10 cm long; male corollas dark reddish purple, 0.4-0.5 cm; females solitary in upper leaf axils; January to March. **Fruits:** drupes, oval-shaped, with yellow leathery exocarp when ripe, 2.5-3 x 2 cm across, each containing a single pyrene with 5 locules; June to August; animal-dispersed.

### **Why is it a framework species?**

*S. axillaris* is an excellent framework species. Planted saplings achieve very high survival and growth rates (>70% survival; averaging >2.5

m tall by end of 2<sup>nd</sup> rainy season). The trunks tend to fork low down, resulting in multiple crowns, which shade out weeds very effectively. Flowering and fruiting occur from the 4<sup>th</sup> year after planting. The trees support nesting birds from the 5<sup>th</sup> year after planting. The fruits are eaten by deer, wild pigs and bears. This species is very resilient after fire (100% survival of trees burnt 33 months after planting; RCD >35 mm).

### **How are saplings grown?**

Collect ripe fruits from the ground in July or August. Soak them in water for 1 week to soften flesh, then remove the flesh by rubbing fruits in a coarse sieve under running water. Drop pyrenes into water and discard those that float. Sun-dry those that sink for 2-3 days. Store them in open containers until October, then sow them at low density in trays in sunlight. Do not attempt to remove seeds from the pyrenes. Up to 5 seeds may germinate from each pyrene. Mean GP 42%; MLD 90 days. Germination is asynchronous, requiring intermittent pricking-out. Saplings grow tall enough (*i.e.* >30 cm) by the 1<sup>st</sup> planting season after seed collection (TNT 8 months, excluding seed storage).

### **How should saplings be planted and cared for?**

*S. axillaris* saplings respond well to cardboard mulch, applied for 2 growing seasons. The species is also suitable for direct seedling.

### **What can the species be used for?**

Its wood is used for interior finish, carvings, packing crates, plywood, firewood and pulp for paper. Leaves can be used as cattle fodder.

