Species Profiles for Pacific Island Agroforestry
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# *Calophyllum inophyllum* (kamani)

Clusiaceae (syn. Guttiferae) (mangosteen family)

**Alexandrian laurel, beach mahogany, beauty leaf, poon, oil nut tree (English); beach calophyllum (Papua New Guinea), *biyuch* (Yap); *btaches* (Palau); *daog*, *daok* (Guam, N. Marianas); *dilo* (Fiji); *eet* (Kosrae); *feta'u* (Tonga); *fetau* (Samoa); *isou* (Pohnpei); *kamani*, *kamanu* (Hawai'i); *lueg* (Marshalls); *rakich* (Chuuk); *tamanu* (Cook Islands, Society Islands, Marquesas); *te itai* (Kiribati)**

J. B. Friday and Dana Okano

PHOTO: J. B. FRIDAY

**Kamani trees are most commonly seen along the shoreline (Hilo, Hawai'i).**

## IN BRIEF

**Distribution** Widely dispersed throughout the tropics, including the Hawaiian and other Pacific islands.

**Size** Typically 8–20 m (25–65 ft) tall at maturity.

**Habitat** Strand or low-elevation riverine, 0–200 m (660 ft) in Hawai'i, up to 800 m (2000 ft) at the equator; mean annual temperatures 18–33°C (64–91°F); annual rainfall 1000–5000 mm (40–200 in).

**Vegetation** Occurs on beach and in coastal forests.

**Soils** Grows best in sandy, well drained soils.

**Growth rate** May initially grow up to 1 m (3.3 ft) in height per year on good sites, although usually much more slowly.

**Main agroforestry uses** Mixed-species woodlot, windbreak, homegarden.

**Main products** Timber, seed oil.

**Yields** No timber yield data available; 100 kg (220 lb) nuts/tree/yr yielding 5 kg (11 lb) oil.

**Intercropping** Casts a heavy shade, so not suitable as an overstory tree; has been grown successfully in mixed-species timber stands.

**Invasive potential** Low potential to become invasive.

# INTRODUCTION

Kamani is a medium-sized to large evergreen tree that averages 8–20 m (25–65 ft) in height with a broad spreading crown of irregular branches. The tree supports a dense canopy of glossy, elliptical leaves, fragrant white flowers, and large round nuts. It grows along coastal areas and adjacent lowland forests, although it occasionally occurs inland at higher elevations. It is native to east Africa, India, Southeast Asia, Australia, and the South Pacific. It has been widely planted throughout the tropics and is naturalized in the main Hawaiian islands.

The tree is today chiefly valued for its hardiness and beauty as an ornamental tree that provides shade and shelter from the wind on streets, in parks, and in coastal areas. The wood is a prized timber for carving, cabinetmaking, and boat building. In Hawai'i it is traditionally used for food vessels and in Palau for storyboards. Oil from the nuts traditionally has been used for medicine and cosmetics and is today being produced commercially in the South Pacific. It is also used in varnishes and as lamp oil. The fragrant flowers have been prized as an adornment and as a perfume. The tree has been regarded as sacred in some Pacific islands, where it has been planted around altars and mentioned in old chants. Since the tree is tolerant of wind and salt spray, it has been used in coastal stabilization. The dense shade cast by the thick crowns provides shelter but does not favor understory plantings.

Kamani is a useful tree for coastal shelterbelts, windbreaks, and strand reforestation because it grows well despite the wind, salt spray, drought, and occasional flooding common to beach environments. It even withstands typhoons.

It has a shallow root system, prefers sandy or porous soils, and tolerates occasional inundation. The tree grows best in direct sunlight, but it grows slowly. Although wildings occur, it can be moderately difficult to propagate. Its slow growth and large seeds make it unlikely that the tree will become an invasive weed if introduced into new areas.

# DISTRIBUTION

## Native range

The tree is native from East Africa, through India and Southeast Asia to the Philippines, Taiwan, and the Marianas. Southward its range extends through Melanesia to Australia and through southern and eastern Polynesia. The habitat is primarily coastal and adjacent to lowland forests.

## Current distribution

The tree is widely dispersed throughout the tropics, including the Hawaiian and other Pacific islands and the Caribbean. In Hawai'i it is naturalized in coastal zones on Hawai'i, Maui, Moloka'i, O'ahu, and Kaua'i.

# BOTANICAL DESCRIPTION

**Preferred scientific name** *Calophyllum inophyllum* L.
**Family** Clusiaceae (syn. Guttiferae) (mangosteen family)

## Non-preferred scientific names

*Balsamaria inophyllum* (L.) Lour.

## Common names

Alexandrian laurel, beach mahogany, beauty leaf, poon, oil nut tree (English)
beach calophyllum (Papua New Guinea)
*biyuch* (Yap)
*btaches* (Palau)
*daog*, *daok* (Guam, N. Marianas)
*dilo* (Fiji)
*eet* (Kosrae)
*feta'u* (Tonga)
*fetau* (Samoa)
*isou* (Pohnpei)
*kamani*, *kamanu* (Hawai'i)
*lueg* (Marshalls)
*rakich* (Chuuk)
*tamanu* (Cook Islands, Society Islands, Marquesas)
*te itai* (Kiribati)

Some common names, e.g., tamanu and beach calophyllum, are used for more than one species of *Calophyllum*, especially when referring to lumber. "Bintangor" is a trade name for timber from other species of *Calophyllum* in Asia, usually not *Calophyllum inophyllum*.

***Calophyllum*, meaning "beauty leaf," is a remarkably apt name.**
PHOTO: C. ELEVITCH


**Flowers and nearly ripe fruits.** PHOTOS: C. ELEVITCH

## Size

Kamani is a medium-sized to large evergreen tree 8–20 m (25–65 ft) in height, sometimes reaching up to 35 m (115 ft). Canopy width is often greater than the tree's height when the tree is grown in open locations.

## Typical form

It has a broad, spreading crown, often with large, gnarled, horizontal branches. The light gray bark shows deep fissures alternating with flat ridges. Sap is milky white.

## Flowers

It bears clusters of 4–15 fragrant white flowers about 2.5 cm (1 in) across and 8–14 mm (0.3–0.6 in) long on long, sturdy stalks in leaf axils. There are 4–8 oblong petals. Trees may flower all year, but flowering is heaviest in late spring/early summer and late fall in the northern hemisphere.

## Leaves

The opposite leaves are dark green, shiny, and hairless with broadly elliptical blades 10–20 cm (4–8 in) long and 6–9 cm (2.4–3.6 in) wide. Both the tip and base of the leaves are rounded. Leaf veins run parallel to each other and perpendicular to the midrib. The scientific name *Calophyllum* comes from the Greek words for "beautiful leaf."

## Fruit

The ball-shaped, light green fruits grow in clusters. Fruits are 2–5 cm (0.8–2 in) in diameter. The skin, which turns yellow and then brown and wrinkled when the fruit is ripe, covers the thin pulp, the shell, a corky inner layer, and a single seed kernel. Fruits are usually borne twice a year. In Hawai'i fruits fall from April–June and October–December.

## Seeds

One large brown seed 2–4 cm (0.8–1.6 in) in diameter is found in each fruit. Seeds are prepared by cleaning off the skin and husk from the shell of the seed; there are 100–200 seeds/kg (45–90 seeds/lb), with shells intact but husks removed.

## Similar species

Tropical almond (*Terminalia catappa,* sea or Indian almond) is sometimes called false kamani in Hawai'i, although it bears little resemblance to the true kamani. There are many other species in the genus *Calophyllum* in the Pacific, including *C. collinum*, *C. euryphyllum, C. laticostatum, C. papuanum, C. pauciflorum,* and *C. suberosum* in Papua New Guinea; *C. peekelii* and *C. vexans* in Papua New Guinea and the Solomons; *C. neo-ebudicum* (syn. *C. vitiense*) in Papua New Guinea, the Solomons, Vanuatu, Fiji, and Tonga; and *C. soulattri* and *C. pelewense* in Palau; *Calophyllum brasiliense* (Santa Maria) is an important timber tree in the Caribbean. Madagascar olive (*Noronhia emarginata*) is another coastal species of the Indian Ocean that is planted in the Pacific and may be confused with kamani.

### How to distinguish from similar species

Tropical almond (*Terminalia catappa*) has egg-shaped leaves with the leaf stems attached at the narrow end. The leaves have branched veins and turn red as they age. Tropical almond fruits are almond-shaped, as the common name suggests. Kamani is generally a larger tree than *Terminalia*, with oval leaves with parallel veins and nearly spherical fruits. *Calophyllum brasiliense* is a straight-stemmed tree in contrast to the usually crooked, leaning kamani tree. *Calophyllum vitiense* is a tall, straight forest tree of the South Pacific. Its leaves are pointed on both ends, unlike the blunt oval leaves of kamani.

Malabar olive (*Noronhia emarginata*) is a smaller tree than kamani with only a few indistinct veins in the leaves, as opposed to the dense, parallel veins in the latter.

**Kamani bark and view from underneath the canopy.** PHOTO: J. B. FRIDAY

## GENETICS

*Calophyllum* is a genus of about 190 species, mostly in Asia and the Pacific. *Calophyllum inophyllum* is common to locally abundant in the Pacific islands. Most other species only occur on the mainland of Asia or in Indonesia, the Philippines, and Papua New Guinea. Kamani has been identified as a priority species for further genetic research by the South Pacific Regional Initiative on Forest Genetic Resources (SPRIG). Named varieties include *C. inophyllum* var. *inophyllum,* var. *takamaka,* and var. *wakamatsui.*

## ASSOCIATED PLANT SPECIES

The tree naturally occurs on beach and coastal forests of tropical Asia, Melanesia, Polynesia, and Australia. It may also occur on riverbanks further inland and is often replaced in lowland forest by other species of the same genus (e.g., *Calophyllum neo-ebudicum* in western Polynesia and eastern Melanesia) (Mueller-Dombois and Fosberg 1998).

### In native habitat

In its native range kamani grows along with fish-poison tree (*Barringtonia asiatica*), ironwood (*Casuarina equisetifolia,* beach she-oak), kou (*Cordia subcordata*), beach hibiscus (*Hibiscus tiliaceus*), screwpine (*Pandanus tectorius*), tropical almond (*Terminalia catappa*, sea almond), and milo (*Thespesia populnea*). Associated shrubs often include naupaka (*Scaevola sericea*) and tree heliotrope (*Tournefortia argentea*). Native herbaceous plants commonly include *Canavalia* spp., beach morning glory (*Ipomoea pes-caprae*), and beach pea (*Vigna marina*) (Mueller-Dombois and Fosberg 1998).

### As aboriginal introduction to Pacific Islands

Pacific islanders introduced coconut (*Cocos nucifera*), kou, beach hibiscus, screwpine, and milo along with kamani in areas where the trees were not native.

### Recent introduction

In Hawai'i the tree is often found growing with the modern introductions ironwood, tropical almond, and tree heliotrope.

## ENVIRONMENTAL PREFERENCES AND TOLERANCES

### Climate

Kamani grows in warm temperatures in wet or moderate conditions. It is not suited to high elevations, cool areas, or very dry conditions.

### Elevation range

0–200 m (660 ft) in Hawai'i; up to 800 m (2000 ft) at the equator

**Although not its favored environment, kamani grows even at higher elevations, here planted on a farm at 440 m (1450 ft) in Kona, Hawai'i, among breadfruit, papaya, and candlenut.** PHOTO: C. ELEVITCH

**Mean annual rainfall**

1000–5000 mm (40–200 in)

**Rainfall pattern**

Kamani prefers climates with summer, winter, or uniform rainfall patterns.

**Dry season duration (consecutive months with <40 mm [1.6 in] rainfall)**

4–5 months

**Mean annual temperature**

18–33°C (64–91°F)

**Mean maximum temperature of hottest month**

22–37°C (72–99°F)

**Mean minimum temperature of coldest month**

12–17°C (54–63°F)

**Minimum temperature tolerated**

8°C (46°F)

## Soils

Kamani tolerates a wide range of soils. It grows best in sandy well drained soils in coastal areas but will tolerate clays, calcareous soils, and rocky soils.

**Soil texture**

It tolerates light to medium soils (sands, sandy loams, loams, and sandy clay loams).

**Soil drainage**

Freely draining as well as soils with impeded drainage or seasonal waterlogging are acceptable.

**Soil acidity**

Neutral to acid soils (pH 7.4–4.0)

**Special soil tolerances**

It tolerates shallow and saline soils.

## Tolerances

Kamani is a hardy tree of tropical coastal areas that tolerates wind, salt spray, drought, and brief periods of waterlogged soil. It does not tolerate much shade nor cold weather.

**Drought**

Kamani can tolerate 4–5 months of drought in its natural littoral and riparian environments.

### Full sun

Kamani prefers full sun, and only light shade is tolerated.

### Fire

Kamani is moderately tolerant of wildfire, once the bark thickens.

### Frost

Kamani grows only in warm climates and does not tolerate frost.

### Waterlogging

Kamani tolerates occasional waterlogging in coastal areas.

### Salt spray and wind

Kamani grows in areas subject to sea breezes and salt spray.

## Abilities

### Regenerate rapidly

The trees drop large amounts of fruit, and wildlings may often be found under mother trees, although growth is slow relative to many weed species.

### Coppice

It regrows dependably but slowly after pruning.

### Pollard

The branches can be pruned back every 2–3 years and they will regrow.

# GROWTH AND DEVELOPMENT

The seedlings start out growing erect and with few branches. Growth slows after the first few years and the trees branch out, often developing multiple stems. Old trees in coastal environments are often bent and twisted by the wind and support many large horizontal branches and multiple stems.

## Growth rate

Young trees in Hawai'i may grow up to 1 m (3.3 ft) in height per year for the first few years, but after that the growth rate slows. In Malaysia one stand of trees attained a diameter of 50 cm (20 in) at breast height in 70 years (Soerlanegara and Lemmens 1994).

## Flowering and fruiting

The tree flowers twice a year in the northern hemisphere, in the late spring/early summer and late fall. In northern Australia, it flowers in January and June. Young trees begin flowering after 7 or 8 years.

## Rooting habit

The tree has a non-aggressive root system.

## Reaction to competition

The tree is only slightly shade tolerant and will not grow under dense forest canopies. It grows slowly in height and may be overwhelmed by weeds in young plantations.

# PROPAGATION

Kamani is moderately easy to propagate by seed, and local seed sources are easily found in the Pacific Islands. Germination and initial growth is slow, however, and seedlings should be started 6 months before they are required. Once outplanted, seedlings are hardy but slow growing. They prefer full sun and tolerate wind, salt spray, and drought.

## Seed collection

Ripe fruits are most easily collected from the ground under trees. Fruits fall twice a year in most locations.

## Seed storage

Seed storage is intermediate. In other words, fresh seeds may keep for a few months stored cool and dry, usually with the husk removed.

## Pre-planting treatments

Seed germination is slow if the entire fruit is planted. Ripe

**Ripe fruit (left), cracked shell showing seed kernel inside (middle), and dry seed (right).** PHOTO: J. B. FRIDAY

fruits (skin is yellow or brown and wrinkled) may be soaked overnight to remove skin. Just prior to planting it is best to crack shells or shell seeds entirely using a mallet, pliers, or hammer. No additional treatments are required.

### Growing area

Plants may be started in containers at least 6 cm (2.4 in) in diameter, of sufficient size to accommodate the fairly large seeds. Partial shade is useful during the first few weeks in hot areas. Seedlings should be grown in full sun after 1–2 months.

### Germination

Seeds germinate gradually, and shelled seeds germinate faster than seeds in their shells. One study found average germination times of 22 days for seeds fully shelled, 38 days for seeds in cracked shells, and 57 days for seeds still in their shells (Parras undated). Germination rates for fresh seeds are greater than 90%.

### Media

The tree grows in any well drained medium.

### Time to outplanting

The seedlings are ready for outplanting 20–24 weeks after germination. Seedlings should be hardened-off in full sun before outplanting.

### Approximate size at time of outplanting

Seedlings should have a well developed root plug and be 20–30 cm (8–12 in) tall at the time of outplanting.

### Guidelines for outplanting

Survival is typically high, although the seedlings grow slowly at first and need to be protected from weeds during the first several years of growth.

### Other comments on propagation

Because of its large seed, the tree may also be grown by direct-seeding. Seeds should be sown about 2.5 cm (1 in) deep. Wildlings may also be transplanted from under mother trees.

**Nursery seedlings in various stages of development, grown in containers measuring 6 x 6 x 13.3 cm (2.4 x 2.4 x 5.25 in).** PHOTO: C. ELEVITCH

## DISADVANTAGES

Drawbacks of kamani include

- Kamani is a slow-growing tree. Plantings must be kept free of weeds for the first few years. Small seedlings are vulnerable to drought and mechanical damage.
- The wood shrinks appreciably upon drying and is difficult to work.
- The tree fruits prolifically and the round, hard, golf ball-sized nuts may be poisonous if eaten.
- The oil extracted from the nuts, while useful when applied externally, is mildly poisonous and should not be ingested.

### Potential for invasiveness

Because of its slow growth and large, water-distributed seeds, the tree is not likely to become an invasive pest. Since the fruits are not carried by the wind or birds, they are not likely to be carried into inland forests. Kamani naturalizes along coasts and beaches, but its slow growth means that it is not likely to outcompete native vegetation. While it was introduced to Hawai'i hundreds of years ago, it remains uncommon outside of cultivation.

### Diseases and pests

Leaves and young shoots are susceptible to attack by various insects, and fungus rot may occur in adult trees. Young leaves are susceptible to attack from thrips, but trees usually outgrow infestations. Deer have damaged young trees on Guam by rubbing with their antlers.

### Host to crop pests/pathogens

The tree is a host to the fruit fly *Bactrocera facialis* in Tonga. In Micronesia, it is host to a weevil (*Trigonops inusitata*), a psyllid (*Leptynoptera sulfurea*), a planthopper (*Lamenia caliginea*), and a palm scale (*Hemiberlesia palmae*). None are serious pests and trees usually recover quickly from attacks.

### Other disadvantages or design considerations

While the tree is a valuable timber, lack of growth and yield data discourage people from planting it as an investment.

**Kamani is a popular street tree and ornamental throughout the tropics (Dili, East Timor).** PHOTO: J. B. FRIDAY

## AGROFORESTRY/ ENVIRONMENTAL PRACTICES

### Mulch/organic matter

Kamani's thick, waxy leaves decay slowly and form a thick layer of litter under kamani stands.

### Soil stabilization

Kamani is a good tree for soil stabilization in coastal areas.

### Fire control

Kamani is being planted for firebreaks on Guam, as it shades out fire-prone grasses, is moderately tolerant of fire itself, and is resistant to typhoons.

### Crop shade/overstory

The tree casts a dense shade and usually does not transmit enough light to allow understory crops to thrive in a multistory system.

### Homegardens

It is grown as part of the mixed garden agroforestry systems in many Pacific islands. In the Solomons, kamani has been traditionally retained or planted along with other trees such as breadfruit, sago palm, *Terminalia, Burckella, Pometia*, and *Canarium* in fallow yam and sweetpotato fields (Yen 1976).

### Boundary markers

Kamani may be used to mark the location of temples, altars, and sacred sites in Pacific islands.

### Windbreaks

Kamani is tolerant of wind and salt spray and makes a very good coastal windbreak tree.

### Woodlot

Kamani's beautiful and highly prized wood could make it a valuable addition to a woodlot.

### Coastal protection

The tree grows in coastal areas right down to the high tide mark and is highly tolerant of salt spray. It protects coastlines and stabilizes dunes, and the dense foliage shelters more sensitive plants from salt spray.

### Ornamental

Kamani is a favorite ornamental tree in the Pacific. Its tolerance of poor soil conditions, salt spray, and poor air quality make it hardy in urban conditions. The large size makes it an impressive plant along wide avenues, but it is not suited to confined spaces.

## USES AND PRODUCTS

### Fruit

The mature fruit is burned for mosquito repellent.

### Nut/seed

Oil derived from the seeds was used as an alternative to candlenut oil in lamps by some Polynesians. It may also be used for massage or hair oil, particularly when scented. The oil is also used to finish wooden bowls.

### Medicinal

Oil from the seed is used for cosmetic and topical applications for healing of burns and skin diseases. The latex or a decoction of the bark is also sometimes used medicinally. A decoction of the leaves was used to treat eye ailments over much of Polynesia and westward into Malaysia.

### Beautiful/fragrant flowers

Flowers are used in leis (garlands), to scent hair, and to scent bark cloth.

### Timber

The beautiful wood has a fine, lustrous texture that shows a distinctive interlocked grain. It is white and red when fresh cut and ages to a reddish brown. Because of this interlocked grain, sawn surfaces tend to be woolly. The wood is moderately dense, specific gravity 0.6–0.8, and is somewhat difficult to work due to the interlocked grain. In Hawai'i the tree provides one of the most valuable woods on the market, although timber is often unavailable. It has been used for paneling and furniture. Elsewhere the wood is used for general cabinetry, construction, and boat building. It has, however, been variously described as vulnerable or resistant to termite attack (Grace and Tome 1995, Little and Skolmen 1989).

### Craft wood/tools

The wood is particularly useful for food platters and calabashes, as it imparts no taste to the food. It is also prized for handicrafts because of its beauty. In Palau it is a favorite wood for carving traditional storyboards.

### Canoe/boat/raft making

The tree has traditionally been used in boat building.

### Thatch/roofing/mats

The bark is used as shingles for house walls in Yap.

### Resin/gum/glue/latex

Latex from the cut bark has been made into a poison to kill rodents and stun fish.

**Top: Kamani platter and bowl. Middle: Story board from Palau.** PHOTOS: J. B. FRIDAY **Bottom: Typical wood grain, actual size.** PHOTO: C. ELEVITCH

### Body ornamentation/garlands

The nuts are hollowed out and the shells are used in making leis. In ancient times whistles were made from the hollowed-out shells.

### Dye

In ancient Hawai'i, a brownish-mauve dye for tapa or bark cloth (*kapa*) was made from the fruit husks. The bark contains tannins that have been used to toughen fish nets.

### Cosmetic/soap/perfume

The flowers and the sap were used to scent bark cloth (*kapa*) in old Hawai'i.

### Oil/lubricant

The seed oil is used as a wood finish.

### Illumination/torches

The seed oil can be used as lamp oil.

### Ceremonial/religious importance

The tree is a sacred tree in some Pacific island traditions and has been planted alongside temples. The tree is mentioned in old Hawaiian chants, and they were planted around altars in ancient times.

### Ornamental

The tree is a favorite ornamental in the Pacific. The tree's tolerance of poor soil conditions, salt spray, and poor air quality make it hardy in urban conditions. The tree's large size is impressive along wide avenues, but it is not well suited to confined spaces.

**Kamani growing as beach ornamental on 'Upolu, Samoa.** PHOTO: C. ELEVITCH

## URBAN AND COMMUNITY FORESTRY

Kamani is an excellent urban forestry tree for large spaces in coastal areas. The tree's large, spreading crown and horizontal branches make it a good shade tree and focal point for parks and other open areas. Its distinctive glossy leaves have earned it the English name "beauty leaf" in some countries. Kamani thrives in coastal environments where other trees suffer from wind, flooding, and salt spray. Since the tree is adapted to the shallow, often flooded soils found in coastal areas, it is hardy in urban settings where similar environmental conditions occur.

The kamani tree is important to native cultures throughout the Pacific. Planting the tree helps celebrate and sustain island cultures.

### Size

Kamani can become a huge tree and is best suited for growing in open spaces. The tree can reach 20 m (65 ft) in height, although planted specimens are usually 12–15 m (40–50 ft). In open areas the canopy is oval or umbrella-shaped and as wide as the tree is tall. Trunks of very old trees can be over 1 m (3.3 ft) in diameter. Given enough room, kamani trees are only a little smaller than rain tree (*Samanea saman*), although kamani grows much more slowly. Kamani may be pollarded or repeatedly pruned back to control its size.

**Left: Kamani's shallow roots may damage pavement if the tree is planted too close to sidewalks, streets, or parking lots.** PHOTO: J. B. FRIDAY **Right: Pollarded tree after 2 years of regrowth.** PHOTO: C. ELEVITCH

## Rate of growth in a landscape

Newly planted kamani trees, if well cared for and planted in full sun, can grow 1 m (3.3 ft) in height and 60 cm (2 ft) in canopy spread per year for the first 5 years. Growth is slower thereafter.

## Roots

Because it is adapted to shallow and occasionally flooded soils along coasts, kamani has a shallow, spreading root system. Its large woody roots spread at least as far as the canopy. If kamani trees are planted so that the canopy will eventually overhang buildings, streets, or parking lots, the roots may damage the pavement or walls. The roots also rise up above the surface of the soil, making it difficult to mow grass under the trees.

## Products commonly used in a Pacific island household

Kamani furnishes a beautiful timber that is much in demand for carving, furniture making, boat building, and other uses. A medicinal oil is extracted from the nuts. The sweet-scented flowers have been used to impart fragrance to bark cloth and for personal adornment.

## Light requirements

Kamani trees grow best in full sunlight. The trees cast a dense shade, so little grows underneath their canopies. Young kamani trees need to be kept weeded until they grow well above the surrounding weeds.

## Water/soil requirements

Kamani prefers well drained, sandy soils but can grow in clay, rocky, or calcareous soils as well. The tree tolerates poor soil drainage and can grow right down to the water line. Kamani tolerates poor, compacted soils of urban areas and can grow in acid to neutral soils. Once established, it tolerates dry seasons of up to 4 months.

## Expected life span in a homegarden

Although there is no data available, it is a long-lived tree that can be expected to live many decades in an urban environment.

## Varieties favored for use in an urban environment

There are many species of *Calophyllum*, most of which are forest trees. Kamani is the only commonly grown coastal species in the genus.

## Seasonality of leaf flush, flowering, fruiting

Kamani flowers twice a year in most locations. Flowers, green fruits, and ripe fruits may sometimes be seen on trees simultaneously.

## Exceptional ornamental values

The flowers have a sweet scent, but their fragrance does not permeate the air the way scents from some other flowering trees do. The flowers are modestly showy. The chief attraction of the tree is its glossy green leaves.

## Use as living fence, hedge, or visual/noise barrier

Kamani's dense crown makes a good visual barrier for buildings or other structures. Trees must be planted far enough away so that they do not damage buildings as they grow. The tree's large size makes it impractical as a living fence, although young trees have been pruned to make view screens in Florida.

## Maintenance requirements

Relatively large container-grown trees may be outplanted in urban or park settings. Trees 3 m (10 ft) tall with a 10 cm (4 in) stem diameter can be successfully established. The planting hole should be dug twice as wide as the tree's root ball but no deeper. Roots that have begun to spiral in the container should be cut or separated so that they do not eventually strangle the rest of the root system.

Fertilizer can boost kamani's initial growth. While there are no specific fertilizer recommendations for kamani, seedlings have grown well with 50–170 g (2–6 oz) of a complete fertilizer such as 15-15-15 applied per seedling at planting and again after 6 months. Young, actively growing trees benefit from application of fertilizers containing 1–3 kg N per 100 $m^2$ of canopy or planting bed area (2–6 lb N per 1000 $ft^2$) per year. Fertilizers containing N and K are best applied in several small applications over the course of the year rather than all at once and best placed in holes dug around the drip line of the canopy of the trees. Alternately, or in addition to chemical fertilizers, well composted manures or other organic fertilizers can be added to the planting hole and spread around the base of the tree occasionally. A more effective fertilizer strategy can be developed by first testing the soil of the planting site. Trees benefit from mulching, but deep mulch should be kept out of direct contact with the trunk.

As with all ornamental trees, proper pruning is important to achieve good tree form. Dead branches should be removed promptly. Multiple main stems should be removed so that only one remains, especially if the timber will eventually be harvested. Although the canopy tends to spread laterally, side branches may be removed to encourage more upright growth. Kamani's large horizontal branches are unusually strong and do not need to be removed unless tree form or space is an issue.

The size of kamani trees may be controlled by a specialized pruning process known as pollarding. Pollarding a tree properly starts when a tree is young. A framework for the tree's growth is established. Young branches are cut back to this framework periodically, usually every growing season. Eventually, woody pollard heads develop at the branch ends. Pollarding is not the same as "topping" or "hat racking" in which large branches are cut and most of the tree's canopy is destroyed. When this is done, the tree is starved and becomes vulnerable to infections and dieback. Young branches that sprout after a tree is topped will be weaker than the original branches. If neglected and allowed to grow out, pollarded trees may become unsightly and develop weak branches. In general, it is better to plant kamani trees where they will have room to grow to their full size and select smaller trees for confined spaces.

## Drawbacks

Kamani's chief drawback as an ornamental tree is its large size (although it can be kept smaller with regular pruning as noted above). Few yards or streets have room for such a large tree, which may eventually interfere with overhead wires. The spreading roots may damage pavement and structures.

## Nuisance issues

In Hawai'i, kamani trees growing in public parks and private lands with public road frontage have been cut down by thieves who steal the wood.

## Hazards

The fruits are mildly poisonous if many are eaten. The medicinal oil extracted from the seed is used externally for skin diseases and injuries and is toxic if taken internally. Kamani is a prolific seeder, and the hard, golf ball-size fruits must be frequently cleaned up if they fall on sidewalks, streets, lawns or other areas where slipping on a seed can be very hazardous.

## Common pest problems

Kamani does not have many pest problems. Thrips may

attack new leaves, but the trees usually outgrow the infestation and no treatment is needed.

## COMMERCIAL PRODUCTS

### Timber

The primary product harvested from the tree is the timber. Many species of the genus *Calophyllum* are traded, and a given batch of lumber may contain wood from several species of trees. A trade name for *Calophyllum* lumber in general in Southeast Asia is "bintagor." Commercial quantities are produced in Melanesia and the South Pacific. In Hawai'i the wood is much rarer, and retail sawn lumber prices for kamani range from $6.00 to $15.00/bf with logs fetching $3/bf. Wholesale lumber prices elsewhere in the Pacific may be $6.00 to $8.00 per board foot.

#### Spacing for commercial production

Most kamani timber is harvested from wild stands. Since kamani is a large tree, a relatively wide spacing (3–3.5 m, 10–12 ft) is a good distance between trees for planted stands. Kamani has done well when intercropped with the nitrogen-fixing tree *Acacia mangium* on Guam. The intercropping seems to have reduced damage from deer.

#### Management objectives

While clear lumber is valued, kamani trees tend to be branchy. Frequent pruning of young trees is recommended.

#### Design considerations

Planting trees in dense stands would promote straight growth and maximum timber production. Planted as shelterbelts or windbreaks in rows along shorelines or as border plantings to farms or agroforests, the tree form is often irregular and branchy, which is more effective for windbreaks but yields less clear timber.

#### Yield

No data are available for timber yields.

#### Processing required

Large trees may have large, horizontal branches that contain much useful wood. Care must be taken in harvesting these trees to avoid splitting the branches or stems when the trees are felled. Cut lumber longer than 3 m (10 ft) tends to warp.

#### Market

Hawai'i is currently importing the wood for high-quality flooring, moldings, and cabinetry. Elsewhere in the Pacific, the tree may be mixed with other, lower-value species of *Calophyllum* as an industrial or general-purpose timber.

### Oil

The oil extracted from the nuts, called tamanu or dilo oil, is offered on the Internet at prices as high as US$360/l (US$1440/gal). This oil is produced in Vanuatu, Tahiti, and other South Pacific islands. Kamani nut oil is offered for sale in Hawai'i for $11.00 for a 250 ml (4 oz) bottle.

#### Spacing for commercial production

Widely spaced trees would yield the most nuts. Nuts today are mostly harvested from wild stands.

#### Design considerations

Nuts may be harvested from trees planted for other purposes, such as shelterbelts or ornamentals.

#### Yield

Five kg (11 lb) of oil may be extracted from 100 kg (220 lb) nuts. 100 kg of nuts is the approximate annual yield of a mature tree.

#### Processing required

The nuts are cracked and the kernels are extracted. The seeds need to be sun-dried on racks 1–2 months in order for the oil to form. Kernels will turn from creamy white to brown during this process. Any moldy nuts should be discarded. The oil is then extracted by cold-pressing and filtration.

#### Market

Tamanu oil is offered through various herbal and botanical companies on the Internet. Prices are as high as US$360/l (US$340/qt). Commercial production occurs in Tahiti and Vanuatu.

## INTERPLANTING/FARM APPLICATIONS

### Example 1

#### Location

'Ōpae'ula, O'ahu, Hawai'i

#### Description

A plantation was established May 16, 1997 on a deep, acid soil (Humoxic Tropohumult in the USDA classification) at 380 m (1250 ft) elevation, 2000 mm (80 in) rainfall. Trees were fertilized and weeded as needed.

### Yields

Initial growth was rapid, with seedlings reaching 75 cm (30 in) height at 1 year and 190 cm (75 in) height and 1.5 cm (0.6 in) diameter at breast height in 2.5 years. Survival in the first 2 years was almost 100%.

### Growth data

| | 9/16/97 | 5/12/98 | 12/9/98 | 5/24/99 | 11/23/99 |
|---|---|---|---|---|---|
| Height | 32 cm | 76 cm | 123 cm | 154 cm | 192 cm |
| DBH | - | - | - | - | 1.5 cm |

### Crop/tree interactions

Adjacent stands were planted with kou (*Cordia subcordata*) and milo (*Thespesia populnea*).

### Spacing

Trees were planted in solid blocks at 3 x 3 m (10 x 10 ft) spacing; no interplanting was done.

## Example 2

### Location

Moloka'i, Hawai'i

### Description

An alley cropping demonstration was planted by the University of Hawai'i on former agricultural land on the island of Moloka'i in 1995 with kamani, kou (*Cordia subcordata*), milo (*Thespesia populnea*), and candlenut (*Aleurites moluccana*). The site is dry and windy, with only 460–530 mm (18–21 in) of rainfall annually, and is 150 m (500 ft) above sea level. The soil is classed as a Typic Torrox in the USDA classification. Soil pH is 6.5. Alfalfa for forage was grown between the trees until the canopies closed; after that a number of shade-tolerant crops were planted, including ornamental ginger, edible mushrooms, kava, and cacao.

### Yields

Tree growth was satisfactory; kamani trees averaged 7.1 m (23 ft) in height with the tallest growing 9 m (30 ft) in 7 years. The constant high winds have caused the trees to lean over, however, and the effect of the stress on wood quality is unknown. Crop production is less than would be expected in full sun but nonetheless appreciable.

### Crop/tree interactions

Crop yield, even for the shade-tolerant crops (except for the edible mushrooms), is reduced because of shading. Kava grew tall and spindly under the dense canopy of the kamani. However, the trees also serve as windbreaks, without which fragile crops such as kava would not grow at all. The crops receive supplemental irrigation, which also benefits the trees.

### Spacing

The trees were planted in wide rows 5 m (15 ft) apart with 3 m (10 ft) spacing within the rows.

## Example 3

### Location

Kīpū, Kaua'i, Hawai'i

### Description

A new plantation was established in 1998 on a deep, acid, clay soil (Typic Umbriorthox, USDA classification); elevation 125 m (415 ft); windy; average annual rainfall 1100 mm (43 in); temperature range 18–30°C (65–86°F). Trees were weeded as needed and given fertilizer for the first 3 years.

### Yields

Trees at age 52 months averaged 5.2 m (17 ft) in height, maximum 6.1 m (20 ft); diameter at breast height averaged 5.8 cm (2.3 in), maximum 6.6 cm (2.6 in)

### Crop/tree interactions

Trees were planted in a single-species stand adjacent to stands of milo (*Thespesia populnea*), cocobolo (*Dalbergia retusa*), red bead tree (*Adenanthera pavonina*), and bamboo (*Bambusa arundinacea*). Kamani trees developed a lean toward the light and away from the shading red bead tree and bamboo.

### Spacing

Trees were planted in a double row at 1.8 x 3.4 m (6 x 11 ft) spacing.

## Example 4

### Location

Waiākea, Hilo, Hawai'i

### Description

A new plantation was established in 1995 on thin, acid soil derived from organic matter over 'a'ā lava rock, elevation 180 m (600 ft), rainfall 4000 mm (160 in). The soil is a Typic Tropofolist in the USDA soil classification.

### Yields

Trees were managed for timber. The trees were 116 cm (45 in) height after 1 year. After 5 years, they reached an average height of 470 cm (15 ft) and diameter at breast height

of 7 cm (2.8 in) while still showing 100% survival. After 8 years, the average tree height was 7.2 m (24 ft) and diameter was 9.9 cm (3.9 in), with the largest tree reaching 9.8 m (32 ft) in height with a diameter of 13 cm (5.2 in).

**Crop/tree interactions**

Adjacent single-species blocks were planted with kou (*Cordia subcordata*), koa (*Acacia koa*), and milo (*Thespesia populnea*). After 8 years, all the other species had failed.

**Spacing**

Trees were planted at 1.5 x 3 m (5 x 10 ft) spacing.

## PUBLIC ASSISTANCE AND AGROFORESTRY EXTENSION

Extension offices for agroforestry and forestry in the Pacific: <http://www.traditionaltree.org/extension.html>.

## INTERNET

Canoe plants of ancient Hawai'i: <http://www.canoeplants.com>.

Native Plant Network Propagation Protocol Database: <http://www.nativeplantnetwork.org/network/search.asp>.

Agroforestree database, World Agroforestry Centre (ICRAF): <http://www.worldagroforestrycentre.org/Sites/TreeDBS/AFT/AFT.htm>.

University of Hawai'i College of Tropical Agriculture and Human Resources Landscape Series publications on pruning, fertilizing, watering, and more: <http://www.ctahr.hawaii.edu/freepubs>.

How to Prune Trees, USDA Forest Service: <http://www.na.fs.fed.us/spfo/pubs/howtos/ht_prune/prun001.htm>.

Advice on pollarding from the Royal Horticultural Society: <http://www.rhs.org.uk/advice/profiles0204/pollarding.asp>.

A description of pollarding: <http://www.passionfortrees.co.uk/html/pollard.html>.

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traditional tree initiative

**Traditional Tree Initiative—Species Profiles for Pacific Island Agroforestry (www.traditionaltree.org)**

# *Calophyllum inophyllum* (kamani)

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