Species Profiles for Pacific Island Agroforestry
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# *Casuarina equisetifolia* (beach she-oak)
# *C. cunninghamiana* (river she-oak)

Casuarinaceae (casuarina family)

***ʻaito*** **(Societies, Australs), beach she-oak, beefwood, casuarina, ironwood, she-oak (English),** ***burukam*** **(Kiribati),** ***gago*** **(Guam),** ***laash, lach, nach*** **(Yap),** ***mejinoki*** **(Marshall Islands),** ***ngas*** **(Palau),** ***nokonoko*** **(Fiji),** ***paina*** **(Hawaiʻi),** ***toa*** **(Tonga, Samoa, Niue, ʻUvea, Futuna, Cooks, Marquesas),** ***weeku*** **(Chuuk)**

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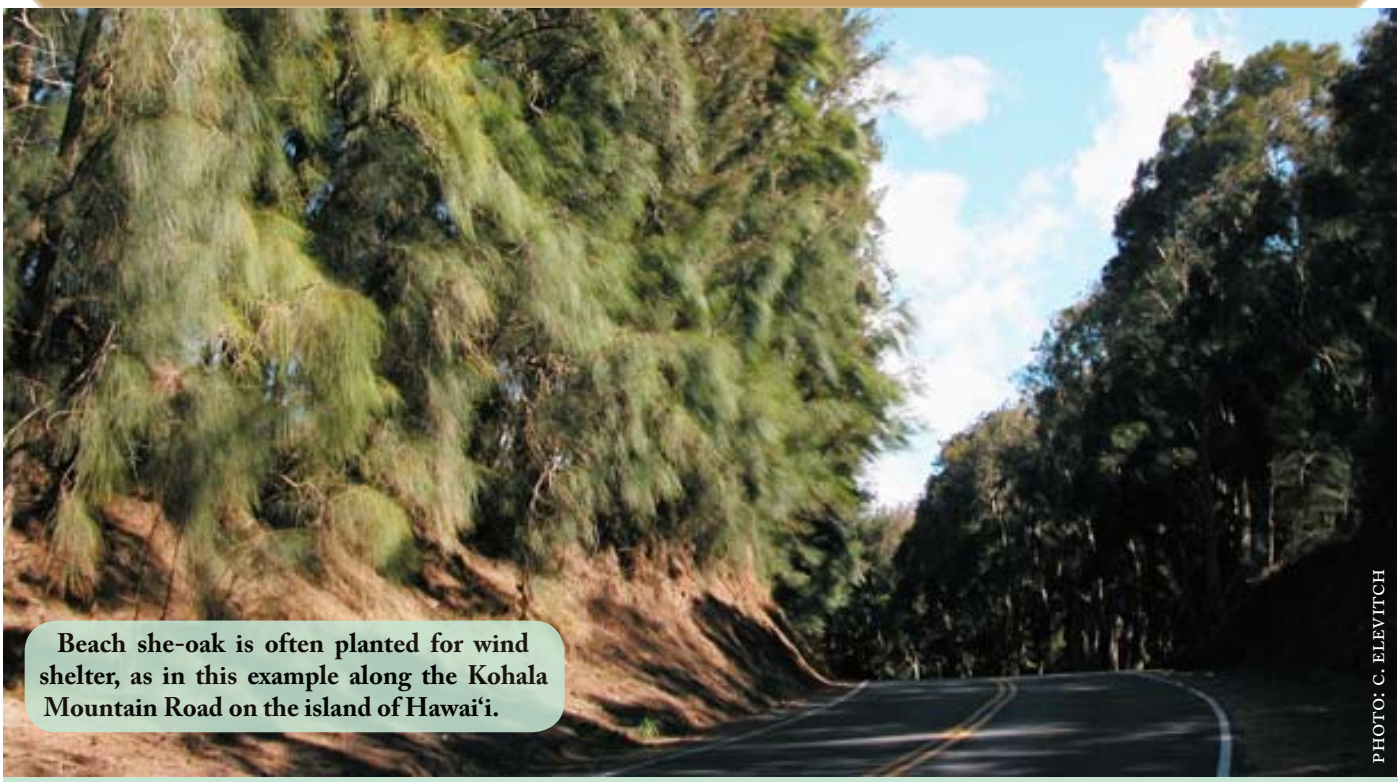


**Beach she-oak is often planted for wind shelter, as in this example along the Kohala Mountain Road on the island of Hawaiʻi.**

PHOTO: C. ELEVITCH

## IN BRIEF (C. EQUISETIFOLIA)

**Distribution** Introduced to most Pacific islands and found throughout the tropics in cultivation.

**Size** Often grows to 20–30 m (65–100 ft).

**Habitat** Typically found near sea level to 800 m (2600 ft), with rainfall of 200–5000 mm (8–200 in); tolerates drought well for 6–8 months.

**Vegetation** Often found growing together with trees common in coastal and lowland areas.

**Soils** Capable of growing on a wide range of soils (coastal and lowland lava flows, poor soil of fernlands, limestone soils); tolerates poor soils because it is a nitrogen fixer.

**Growth rate** Very fast growing; can grow 3 m (10 ft) in the first year.

**Main agroforestry uses** Windbreak, soil stabilization, coastal protection, screen/hedge.

**Main products** Timber, fuelwood, medicine, dye.

**Yields** 37,000–74,000 kg of fuelwood per hectare (40 to 80 tons per acre) in 7–15 years.

**Invasive potential** High invasive potential; naturalized and a pest in many areas where introduced; *C. cunninghamiana* may be a less invasive alternative for many situations.

# INTRODUCTION

Beach she-oak (*Casuarina equisetifolia*) is native from Australia eastward into Melanesia and westward to coastal Southeast Asia, but it was also an ancient introduction over a much larger range. It is a tall, fast-growing tree that can, in as little as 12 years, reach a height of 20 m (66 ft). It has a very hard, heavy, dark red-brown wood, hence one of the common names, ironwood. In the past, its wood was used extensively for making house parts, posts, fish hooks, and various other tools and artifacts. However, its extreme hardness makes it difficult to be sawn or worked with tools, and it is therefore unsuitable timber for carving when other more favorable woods are available. Because it is very strong and needs little processing, it is ideal for posts and rough house construction. It is also useful for fencing, piling, and roofing shingles. The rapid growth of the tree and the fine quality fuelwood it produces (it is one of the best firewoods in the world) makes it excellent for use in fuelwood plantations, its main commercial importance today, especially in Asia and Africa. It burns with little smoke, produces little ash, and is excellent for making charcoal. It is also an important species for the control of erosion, especially on coasts (its natural habitat) and sand dunes, and on poor inland soils, where it does well because of its ability to fix nitrogen. This latter ability makes it ideal for interplantings with other crops to enrich the soil and provide light-to-moderate shade. The tree is important culturally since its bark is widely used in traditional medicines for treating digestive tract problems and other ailments. The tree can be very invasive, however, as it is a pioneer species in some habitats (e.g., new lava flows), so care must be taken when introducing this tree to new places.

# DISTRIBUTION

## Native range

The native range of beach she-oak is uncertain, but the tree probably originated in Australia as a littoral species. It appears to be native westward from Australia to Thailand and the Nicobar and Andaman Islands.

## Current distribution

Beach she-oak was carried by ancient voyagers eastward into the Pacific as far as the Marquesas but is a modern introduction to Hawai'i and probably Micronesia and, in more recent times, throughout the tropics, where it is now one of the most common trees on beaches, fernlands, and other inland areas of poor soil. In the U.S., it is naturalized in Florida and Hawai'i.

# BOTANICAL DESCRIPTION

**Preferred scientific name** *Casuarina equisetifolia* L.

**Family** Casuarinaceae (casuarina family)

**Non-preferred scientific names**
*Casuarina litorea* L.

## Common names

**Pacific islands:**

*'aito* (Societies, Australs)
beach she-oak, beefwood, horsetail casuarina, ironwood, she-oak, (English)
*burukam* (Kiribati)
*gago* (Guam)
*laash, lach, nach* (Yap)
*mejinoki* (Marshall Islands)
*ngas* (Palau)
*nokonoko* (Fiji)
*paina* (Hawai'i)
*toa* (Tonga, Samoa, Niue, 'Uvea, Futuna, Cooks, Marquesas)
*weeku* (Chuuk)

**Other regions:**

*agoho* (Philippines)
*arbe de fer, bois de fer, filao, pin d'Australie* (French)
*arbol de hierro* (Spanish)
*filao* (Vietnam, West Africa, West Indies)
*ru* (Malaysia)

## Size

Reaches up to 30 m (100 ft) or more in height and up to 1 m (39 inches) in basal diameter, with a symmetrical or irregular conical crown.

## Form

Monopodial with upward-curving branches when young but with an open, irregular crown when mature; buttresses variable, thin, and plank-like. The species exhibits a high degree of variation in characters such as shape of crown, angle of branches, length of branchlets, size and shape of cones, and production of cones. The tree tends to be more branchy and crooked on exposed shores and tall and straight with a single trunk in protected environments.

## Bark

The bark is light gray-brown, smooth on younger trees, turning rough and deeply furrowed on older trees.

**Buttresses on beach she-oak.** PHOTO: C. ELEVITCH

## Flowers

Inflorescence of unisexual flowers occur in pistillate heads and staminate spikes; the trees are monoecious. Female heads are ovoid to subglobose, up to ca. 1 cm (0.4 in) long, many-flowered, borne laterally at the nodes of the branches, each flower subtended by one bract and two bracteoles, perianth absent; ovary superior, with a bifid style bearing two elongate, red, linear stigmas; male flowers are sometimes present on the peduncle. Staminate spikes elongate, 8–70 mm (0.3–2.8 in) long, borne mostly at the ends of the branches, with each flower subtended by two awl-shaped bracteoles and two tepals; one stamen, exserted. Flowering apparently occurs throughout the year.

## Leaves

Leaves are reduced to lanceolate scales 0.5–1 mm (1/50 to 1/25 of an inch) long, united at the base into sheath-like whorls of about seven around the nodes.

## Fruit

Fruit is a woody, ovoid to subglobose, cone-like head 1.2–2.2 cm (0.5–0.9 in) long, formed from the persistent, valve-like bracteoles pubescent on the outside, these separating at maturity to release the nut.

**Fruit and flower, approximately life size.** PHOTO: C. ELEVITCH

## Seeds

Seed is enclosed within a nut borne in the cone; it is 4–5 mm (ca. 0.2 in) long, most of it a membranous wing called a samara.

## Similar species

The tree is often mistaken for a conifer. However, it can be distinguished by the stems (that look superficially like pine needles) that bear whorls of about seven tiny lanceolate scales. The needle-like stems can be pulled apart at the nodes, unlike pine needles, which have no nodes. Two similar species are found in the Pacific, *Casuarina glauca* (longleaf casuarina) and *Casuarina cunninghamiana* (river she-oak). The three species can be distinguished from each other as follows:

### *Casuarina equisetifolia*

**Distribution** Common to locally abundant throughout the Pacific.

**Cones** Nearly round to elongate, 1.2–2 cm (0.5–0.8 in) in diameter.

**Branches** Pineneedle-like, 23–38 cm (9–15 in) long, ca. 1 mm (1/25 in) wide, with 6–9 (usually 7) lengthwise ridges ending in a ring of tiny, teeth-like scale leaves.

### *Casuarina glauca*

**Distribution** Occasional to locally common in scattered places in Hawai'i, but uncommon elsewhere in the Pacific islands.

**Cones** Nearly round, flat-topped, 0.7–1.3 cm in diameter.
**Branches** Pineneedle-like, 30–40 cm (12–16 in) long, ca. 2 mm (1/16 in) wide, with 10–18 lengthwise ridges ending in a ring of tiny, teeth-like scale leaves. The twigs are longer

and thicker than the other two species.

***Casuarina cunninghamiana*** **(see pages 12–14 for more information about this species)**

**Distribution** Native to Australia, but of scattered distribution in the Pacific. It is present in Hawai'i, but not reported to be naturalized there.

**Cones** Nearly round to elongate, 0.7–1.3 cm (0.3–0.5 in) in diameter. This species has smaller cones than the other two.

**Branches** Pineneedle-like, 7.5–18 cm (3–8 in) long, ca. 1 mm (1/25 in) wide, with 8–10 lengthwise ridges ending in a ring of tiny, teeth-like scale leaves.

In summary, if the pineneedle-like branches are thin and average less than 20 cm (8 in) long and the cones are small, then the species is *C. cunninghamiana*. If the branches are more than 20 cm long, relatively thick, and are marked by 10–18 lengthwise ridges, then the species is *C. glauca*. If the branches are more than 20 cm long and are marked by 6–8 lengthwise ridges, then the species is *C. equisetifolia*, by far the most common and widespread of the three species.

## GENETICS

### Variability of species

Two subspecies are known, var. *equisetifolia* (the common one) and var. *incana* (restricted mostly to Australia). Much of the variability present in different places is probably due to differences in soil and climate. The tree is known to hybridize with other species of the genus.

### Known varieties

No named varieties are recognized.

### Culturally important related species in the genus

This species is the only one of cultural importance, but *Casuarina junghuhniana* and *Casuarina grandis* have potential as fast-growing timber trees. *Casuarina glauca* is planted and naturalized in Hawai'i, and *Casuarina cunninghamiana* is also planted there but is not reported to be naturalized (see text inset box on *C. cunninghamiana*)

### Genetic resources

Collections of beach she-oak are stored at CSIRO in Australia. Seeds are readily obtained, however, throughout the range of the species.

## ASSOCIATED PLANT SPECIES

In its native habitat, beach she-oak is associated with littoral vegetation. In fernlands, where it is often common (as on Rarotonga and Hawai'i), it is often the dominant tree (and sometimes virtually the only tree) in a matrix of false-staghorn fern (*Dicranopteris linearis*). It is also a pioneer species on new lava flows, where it is often the dominant species.

### Associated species commonly found in native habitats

In its native habitat, beach she-oak is a littoral tree found together with trees such as sea almond (*Terminalia catappa*), *Guettarda speciosa*, *Barringtonia asiatica*, beauty leaf (*Calophyllum inophyllum*), etc.

### Species commonly associated in modern times or as recent introduction

It grows with other common lowland and coastal trees, such sea almond, leucaena (*Leucaena leucocephala*), coconut (*Cocos nucifera*), etc. It is also found with *Miscanthus floridulus* on acid soils (e.g., in Guam), and with naupaka (*Scaevola sericea*) on beaches.

## ENVIRONMENTAL PREFERENCES AND TOLERANCES

### Climate

Beach she-oak is found throughout the tropics and is able to tolerate a wide extreme of warm climates. It is limited to the tropics and subtropics since it is intolerant of frost, and it occurs between 22° N and 32° S (although one source mentions "extensive plantations" of it in Portugal). Although it prefers a seasonal climate (in its natural habitat there is often a 6–8 month dry season), it can tolerate dry climates (particularly if it has access to ground water supplies) with as little as 200–300 mm (8–12 in), and wet climates with as much as 5000 mm (200 in) of annual precipitation.

#### Elevation range

Lower: near sea level
Upper: 800 m (2700 ft) or more, but plantations of it have been reported up to 1500 m (5000 ft) or more.

#### Mean annual rainfall

Lower: 200 mm (8 in)
Upper: 5000 mm (200 in) or more

### Rainfall pattern

It does well in most rainfall regimes but prefers a seasonal rainfall pattern.

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

Its native range can have 6-8 months of dry season.

### Mean annual temperature

10–30°C (50–86°F). It is not known to be limited by high temperature.

### Mean maximum temperature of hottest month

30–40°C (86–104°F)

### Mean minimum temperature of coldest month

10–24°C (50–75°F)

### Minimum temperature tolerated

>5°C (41°F). It is intolerant of frost.

## Soils

It is capable of growing in a wide range of soil conditions but is particularly common on coastal and lowland lava flows, poor soils of fernlands, and on limestone soils near the shore. Since the tree is able to fix nitrogen in a symbiotic association with the bacteria *Frankia* sp., it can also grow in infertile lateritic soils, mine tailings, sand dunes, calcareous soils, coastal lava rocks, and other places where other tree species cannot. It is also able to tolerate a wide range of soil pH, up to 9.5 in some cases, as well as relatively saline groundwater.

### Soil texture

Beach she-oak tolerates light to heavy textured soils (sands, sandy loams, loams, sandy clay loams, sandy clays, clay loams, and clays).

### Soil drainage

Grows in soils with free drainage.

### Soil acidity

pH 4.5–9.5

### Special soil tolerances

It can grow in shallow, saline, and infertile soils.

## Tolerances

### Drought

It is very tolerant of dry climates, especially if it has time to establish and its roots can grow down to the water table.

### Full sun

It is very tolerant and in fact prefers sunny places (as evidenced by its dominance as a pioneer species on new lava flows).

### Shade

The tree is intolerant of shade.

### Fire

It is intolerant of fire, and in some places, its extent in wetlands (the Florida Everglades) and fernlands (e.g., in Guam) is limited by periodic fires.

### Frost

It is intolerant of frost, which limits it to the tropics and subtropics.

### Waterlogging

Beach she-oak is somewhat tolerant of waterlogging, as evidenced by its sometimes being found on coastal rocks submerged during part of the time in sea water.

### Salt spray

It is very tolerant of salt spray, and it is often one of the trees growing closest to the coastline. This is at least partly due to the protected location of the stomata (aeration pores) within furrows on the leafless stems. Excessive salinity may, however, decrease growth.

### Wind

Beach she-oak is very tolerant of wind and is oftentimes planted as a windbreak. Unlike most other trees, it has the ability to grow upright on windswept coasts.

## Abilities

### Fix nitrogen

The tree forms woody, spherical nodules up to 10 cm (4 inches) in diameter, in which are found a filamentous bacterium, *Frankia* sp., which fixes nitrogen. This allows it to thrive in areas of nutrient-poor soil.

### Regenerate rapidly

The tree is able to regenerate by seed in areas favorable to its growth.

### Coppice

It coppices only very weakly.

### Pollard

The tree is sometimes planted in rows and trimmed to make a dense, attractive hedge.

## GROWTH AND DEVELOPMENT

The seeds germinate shortly after they are mature and released, and the young growth is very rapid (up to 3 m or 10 ft in the first year), which allows it to outgrow most weeds (although not if the weeds are already established). Rapid growth continues throughout the first 10 years, and in one study, biomass production peaked after 12 years. Some studies suggest that the trees are not very long-lived (plantations on coastal dunes in Senegal began dying within 20–40 years after establishment).

### Growth rate

Based upon experiments done in China, trees planted from seed can reach 3 m (10 ft) in height in a year. After 4 years, they averaged 7–8 m (ca. 25 ft) in height and 13–17 cm (5.2–6.8 in) in diameter. Based on experimental plantings carried out in coastal Kenya, trees 9 years old attained a mean height of 20 m (66 ft) and a diameter of 12 cm (4.8 in). In an experimental planting carried out in Indonesia over the period from 11 to 13.5 years of age, the trees averaged 1.8–2.1 m (ca. 6 ft) annual height increase and 1.6–2 cm (0.6–0.8 in) in diameter increase.

### Flowering and fruiting

Flowering and fruiting occur throughout the year, although not at a constant rate. The cones mature 18–20 weeks after anthesis. Peak flowering in the Northern Hemisphere is usually from April to June, and the opening of the fruits there occurs mostly from September to December.

### Yields

In experimental plantings done along the coast in India, plantations harvested on a 7–15 year rotation yielded 37,000–74,000 kg of fuelwood per hectare (40–80 tons/acre).

### Rooting habit

Beach she-oak can root on the surface, as when it is on hard substrates such as lava flows, but in softer soil it forms a taproot that can grow down to the water table.

### Reaction to competition

Beach she-oak can do well in competition with other trees, especially in areas of poor soil where its symbiotic association with nitrogen-fixing bacteria gives it an advantage, but it does not do so well when the competition trees shade it out. The seedlings likewise do not compete well with established and dense weeds.

### Diseases and pests

Since the tree has been grown in commercial plantations, much is known about its diseases and pests. The most serious disease is the fungus *Trichosporum versiculorum* (black blister disease), which causes stem and leaf wilt, cracking of the bark, and formation of black blisters on the trunk. The fungus *Botryosphaeria dothidea* causes basal and trunk cankers, a yellowing of the crown changing to red, and eventual death. It is believed that the host must be predisposed to infection by drought-induced stress. A wilt disease caused by the bacterium *Pseudomonas solanacearum* attacks the roots of trees grown in Chinese plantations. Another disease caused by a fungus, *Phomopsis* sp., reportedly attacks seedlings in China. Insects, such as *Lymantria xylina*, *Zeuzera multistrig*, and *Brachytrupes portentosus*, are also reported to damage *Casuarina* trees in China. Other insects, including the twig borer *Oncideres cingulata*, the spittlebug *Clastoptera undulata*, and the leaf notcher weevil *Artipus floridanus*, are reported to attack these trees in Florida. Termites and ants are reported to eat the seeds, and the termites to attack adult trees. Elsewhere, the Australian pine borer *Chrysobothris tranquebarica*, the borer *Macroteoma palmata*, the black borer *Apate monachus*, and the larva of *Coleosterna scabrata*, *Arbela tetraonis*, and *Phassus malabaricus* damage the trees. Other pests include some caterpillars and crickets.

### LORE

In Tahiti, the tree was the emblem of warriors and the warrior god Oro, whose images were made from its hard wood. According to Neal, Tahitians claim it sprang from the bodies of warriors, with the red sap representing their blood and the pineneedle-like branches their hair. There is a Cook Island legend (from the island of Mangaia) that the tree, which had great evil powers, was brought there from Tonga. It caused the death of several men who tried to cut it down in order to rid the island of its demonic powers. Finally, a god from Tonga, Ono, came and destroyed the demon in the tree.

## PROPAGATION

Beach she-oak can be propagated by seed, stem cutting, and air-layering. It is most commonly propagated by seeds, however, as these are readily available and this method is less labor intensive than the others.

### Propagation by seed

#### Seeds collection

The seeds are collected from the maturing (brown) cones, before they fully ripen and release the seeds. The cones are

either picked by hand or shaken onto canvas sheets and later processed. The seeds are usually ready about 18–20 weeks after flowering, which occurs at various times of the year depending upon location and climate. Larger cones and seeds are often selected, as they are believed to produce individuals that have the highest vigor, although this has not been substantiated.

### Seeds processing

Cones collected from the tree can be dried in racks in the sun or in ovens or kilns to open the cones, and the seeds are then extracted. Screens are sometimes used to separate the seeds from cone debris.

### Seed storage

The seeds start losing their viability starting within 2 weeks from being released. If they are to be stored, the typical methods of storage are used, i.e., at near-freezing or subfreezing (–6°C, 21°F) temperatures. The seeds can be stored from 6 months to a year in this condition.

### Pre-planting propagule treatments

No special propagule treatments are standard, but the seeds are sometimes soaked for 24 hours before planting in water or in 1.5% KNO or 7.5% $CaOCl_2$ to stimulate germination. Fungicides are not needed if sterile soil or an artificial medium is used. Seed predation by ants can sometimes be a major problem, but these pests can be controlled by an application of a carbolic acid solution or other insecticides.

### Growing area

The seeds are usually planted in well lighted places, but in brighter climates some shading may be needed. Light, well drained soils should be used to prevent increased susceptibility to diseases and pests.

### Germination

Germination rates often range from 30 to 90% for fresh seeds and much less for seeds stored under ideal (cool) conditions for up to a year, and germination starts after 4–22 days after sowing, or up to 40 days according to some authors.

### Media

The seeds are then sown in trays under about 5 mm (0.2 in) of sterilized nursery soil or artificial growing medium, which prevents attack by fungi, preferably at 215–320 seeds/$m^2$ (20–30 seeds/$ft^2$). A mixture of sand and peat moss is often used for this purpose.

### Time to outplanting

Seedlings are usually planted out when 3–4 months old, typically with 1 x 1 m (3.3 x 3.3 ft) spacing, and are thinned out in the second year to 2.5 x 2.5 m (8 x 8 ft). Some sources recommend as much as 4 x 4 m (13 x 13 ft) spacing, but the closer spacing will allow earlier returns.

### Approximate size for outplanting

The seedlings are typically 30–50 cm (12–20 in) in height when they are outplanted.

### Other comments on propagation

In areas where the tree is not native, the roots must be inoculated with a culture of the bacterium *Frankia* sp. Several techniques have been used successfully. In one simple method, surface soil collected from under beach she-oak trees is mixed with the medium used as potting soil. In another more complicated method, root nodules from established trees are collected and then soaked in 70% ethanol for a few seconds to eliminate pathogenic organisms. The nodules are then washed and crushed, and the suspension is filtered before being applied to the roots of seedlings or injected into the soil. More complicated techniques can be used, but they require expensive equipment and expertise. Beach she-oak trees also form symbiotic associations with ectomycorrhizal and endomycorrhizal fungi (particularly with the genus *Glomus*), which are needed for good growth. Mycorrhizae inoculant can be introduced in the growing medium to speed early growth in the field.

## Propagation by stem cutting

Seedlings are the preferred method of growing beach she-oak, but cuttings are sometimes used instead. Cuttings have the disadvantage of being more labor intensive, but when the resulting offspring are desired to be identical to some superior form of the tree, cuttings are preferential. Shoot cuttings can be taken from stems 1–2 mm (0.04–0.08 in) in diameter and 10–15 cm (4–6 in) long. Any one of several rooting hormones can be used to enhance rooting. The rooted cuttings should be inoculated with the bacterium *Frankia* sp. when introducing the tree to new areas. Stem cuttings can be rooted in sunlight, but in brighter climates some shading is needed. Light, well drained soils should be used to prevent increased susceptibility to diseases and pests. The cuttings can be outplanted when they form roots, which takes 4–6 weeks.

# DISADVANTAGES

The tree grows poorly on sites with impeded drainage. It is intolerant of fire, does not compete well with weeds, and has poor coppicing ability. The tree is relatively short-lived, with peak biomass production (growth) around 12 years of

age, which makes it unsuitable where long-lived trees are desired. Few of these trees live beyond 50 years. Although the wood is hard and heavy, it is not easily worked and is not favored for carving or for timber. The tree can be invasive, especially in areas of poor soils (which is not always a bad thing).

### Potential for invasiveness

The tree can be very invasive, especially in marginal habitats. It is readily dispersed by means of wind-blown seeds. This spreading can be useful in areas where few other trees grow, such as on sand dunes needing protection from soil erosion, but harmful in areas of native vegetation. It can also spread by rooting along branches that touch the ground. It has been reported to be an invasive weed in Hawai'i, the Bahamas, Florida, Nauru, and elsewhere in the tropics.

### Susceptibility to pests/pathogens

It is susceptible to a number of pathogens, but perhaps no more than other tree species.

### Other disadvantages or considerations for using this plant in agroforestry

Many people believe that beach she-oak is competitive with crops, because it can lay down a thick layer of needles that often excludes ground cover species.

**Many *Casuarina* species are considered highly invasive, and should not be introduced to new areas. Here beach she-oak invades open pasture, Waimea, island of Hawai'i.** PHOTO: C. ELEVITCH

## AGROFORESTRY/ENVIRONMENTAL PRACTICES

### Mulch/organic matter

The trees produce a copious leaf, stem, and cone litter, which often stifles germination of other seedlings. This is used for fuel in India.

### Soil stabilization

The trees are often planted on eroded hillsides of poor soil, as few other trees can survive in this habitat. It is particularly good for coastal sand dunes, where few other tree species can survive.

### Crop shade/overstory

Not usually used for this purpose because it has a thin canopy, but in New Guinea it has been used as a shade tree in coffee plantations.

### Homegardens

It can easily be grown around houses for local fuel consumption or, as is probably often the case, for use of the bark in traditional medicines.

### Improved fallows

Since the plant produces nitrates in association with a symbiotic bacterium, it is a useful tree to improve soil.

### Living fences

It can be used for this purpose, and is sometimes trimmed into hedges.

### Fence posts

The wood can be used for fence posts with moderate longevity.

### Boundary markers

It can be used for this purpose, but its relatively short life span may be a drawback.

### Windbreaks

It makes excellent windbreaks, even in harsh conditions where other trees wouldn't survive. It can maintain erect growth in windy places where other trees become bent.

### Silvopasture

Not typically used in silvopasture, but its nitrogen-fixing capability may make it desirable for improving soil in pas-

**Windbreak spacing is typically 2 x 2 m (6 x 6 ft).** PHOTO: C. ELEVITCH

**Noni (*Morinda citrifolia*) growing under beach she-oak.** PHOTO: M. BONIN

tures.

### Animal fodder

Not useful for animal fodder.

### Woodlot

It is fast growing and is useful for firewood (and its debris for kindling).

### Coastal protection

It is a very useful tree for coastal protection, as this is its native habitat and it does well in areas of salty sea winds. It is particularly useful on coastal sand dunes.

### Ornamental

Its form is often straggly and unattractive, but it can be trimmed into a pleasant, dense hedge.

## USES AND PRODUCTS

The very hard, heavy, red wood was traditionally favored for making house timber, posts, war clubs, tool handles, spears, tapa beaters, digging sticks, throwing discs, large fish hooks, canoe parts, and other artifacts throughout the Pacific islands, but other woods (some of them imported or introduced) are favored for these purposes today. The tree makes a good fuelwood, commonly used in Asia rather than the Pacific islands. The bark of the tree still has important uses for traditional medicine, especially for treating digestive tract ailments. The plant found minor use as a dye plant, and is still used for this purpose to a small degree.

### Medicinal

In Tonga, an infusion of the bark is commonly taken as a potion or squeezed into the mouth of infants with mouth infections. It has an emetic effect, which induces vomiting or coughing to bring up phlegm. It is also sometimes used there for treating stomachache. Minor medicinal uses are also reported from Samoa (possibly since the tree is uncommon there). In the Cook Islands, the grated inner bark is made into a solution for treating thrush and urinary tract problems, and at stronger concentrations, it is taken to induce vomiting. In Fiji, an extract of the bark is taken internally for treating rheumatism or as an emetic. In Yap (Ulithi), the inner bark is used to treat diarrhea and other digestive tract ailments.

### Timber

The heartwood is heavy and dark red-brown. The wood is very hard and heavy, and when dry it is difficult to work with because of this density and hardness. It is moderately durable when used as posts in the ground and when exposed to the weather. The heartwood is resistant to dry-

**Beach she-oak makes a very good hedge, visual barrier, or windbreak, and can be repeatedly pruned as is done here in Nuku'alofa, Tonga.** PHOTO: C. ELEVITCH

wood termites. Poles are used as masts for fishing boats, boat oars, piles, and posts.

### Fuelwood

The wood makes excellent firewood and charcoal.

### Craft wood/tools

The hard, heavy, red wood was traditionally favored for making house timber, posts, war clubs, tool handles, spears, tapa beaters, digging sticks, throwing discs, large fish hooks, canoe parts, and other artifacts throughout Polynesia and in Fiji, but is not easily worked because of its hardness.

### Canoe/boat/raft making

The wood is too heavy for making canoe hulls or outriggers, but is sometimes used for other parts of canoes where strength is needed and weight is not a drawback.

### Tannin/dye

The tree was valued as a dye plant in some parts of Polynesia because of its dark red sap. Two forms of the tree were recognized in Tahiti—a dwarf form called 'aito hiri that grows on the hills, and the taller one called 'aito ra'u hiri that grows in forest. A deep red dye called hiri was made from the former and was used to dye cloth, nets, and fishing lines by steeping these in a cold solution of the dye. The plant was used to produce a brown dye for staining house posts in Tonga. Elsewhere in the Pacific the tannin in the bark is still used to tan fishing nets and dye fabrics a dull reddish color.

### Ceremonial/religious importance

In Tahiti, the tree was the emblem of warriors and the warrior god Oro, whose images were made from its hard wood. Elsewhere in Polynesia, the tree is called toa, which is the same word as for warrior.

## COMMERCIAL PRODUCTS

The main use of the tree is for its very hard, heavy, red wood that was traditionally favored for making house timber, posts, war clubs, tool handles, spears, tapa beaters, digging sticks, throwing discs, large fish hooks, canoe parts, and other artifacts throughout the Pacific. Because of its hard wood that is worked only with difficulty, it is not often used for cut timber.

### Spacing for commercial production

Spacing of 2 x 2 m (6.6 x 6.6 ft) to 4 x 4 m (13 x 13 ft) is recommended for the trees when grown in plantations, depending upon how fast the yield is desired and the local climate (especially rainfall or groundwater).

### Management objectives

The trees are often thinned after a few years. Fertilizer is

sometimes used in infertile soils, particularly for phosphorus, which promotes growth. Nitrogen is not needed in the fertilizer, because the tree produces its own nitrates. The information on the effect of competition of weeds is not clear, but weeding may be needed to control grasses at the early stages of *Casuarina* growth. It does not self prune, and pruning may be needed to make the plantations accessible.

### Advantages and disadvantages of growing in polycultures

The tree is advantageously used in polycultures because its ability to fix nitrogen enriches the soil. However, when too densely planted, its leaf litter can inhibit the growth of low plants. The litter may contain toxic amounts of selenium, silica, and salt.

### Estimated yields

In monoculture trials in coastal India, plantings harvested on a 7–15-year rotation yielded 37,000–74,000 kg of fuelwood per hectare (40–80 tons per acre).

### Markets

The wood is rarely taken to market and even more rarely exported; it is mostly used locally for firewood, house posts, and some carving.

## INTERPLANTING/FARM APPLICATIONS

**Example** (Midgley et al. 1983)

### Location

India

### Description

*Casuarina* firewood plantations are interplanted during the first year with groundnut, sesame, pulses, cucumbers, and melons. Bananas and cassava are planted where irrigation is available. Returns are greater than *Casuarina* alone.

### Crop/tree interactions

The trees share the benefits from the cultural practices given to the crop plants and provide wind protection to the crops. The *Casuarina* trees improve the soil. On sterile coastal sand, agricultural cropping is done after removal of the trees. But for silvicultural purposes, agriculture would not be possible.

### Spacing

Densities of 1600–10,000 trees/ha (5280–13,200 trees/ac) are planted with 1–2.5 m (3.3–8.3 ft) between trees. Rotations of 5–15 years are achieved, depending on spacing.

Yields are 50–200 mt/ha (22–90 t/ac).


**A dense planting of beach she-oak makes a good woodlot for fuelwood and charcoal.** PHOTO: C. ELEVITCH

# *Casuarina cunninghamiana* (River she-oak)

**river she-oak, river oak, creek oak, Cunningham casuarina, ironwood, small cone ironwood, Australian pine (English)**

River she-oak (*C. cunninghamiana*) is a long-lived, relatively fast-growing, and handsome tree to 35 m (120 ft). Its agroforestry uses include windbreaks for crops and livestock, riverbank stabilization, and woodlots. It tolerates moderate droughts, periodic waterlogging, acidic to moderately alkaline soils, moderate salinity, and even occasional sub-freezing temperatures. Its green-gray, pendulous foliage is considered to be ornamental by many. Because of the tendency of beach she-oak (*Casuarina equisetifolia*) to become invasive, river she-oak may be a suitable alternative in many environments. River she-oak has been widely planted in Hawai'i but is not reported to be naturalized.

## DISTRIBUTION

### Native range and current distribution

River she-oak is native to Australia, from New South Wales through Queensland into the Northern Territory. The endemic latitudinal range is 12–38° S. Because of its wide adaptability, it has been introduced for reforestation throughout the world in Africa, Asia, and in Central, South, and North America, and throughout Australia, New Zealand, and elsewhere. In the Pacific region it has been encouraged for use in windbreaks in Hawai'i.

## BOTANICAL SUMMARY

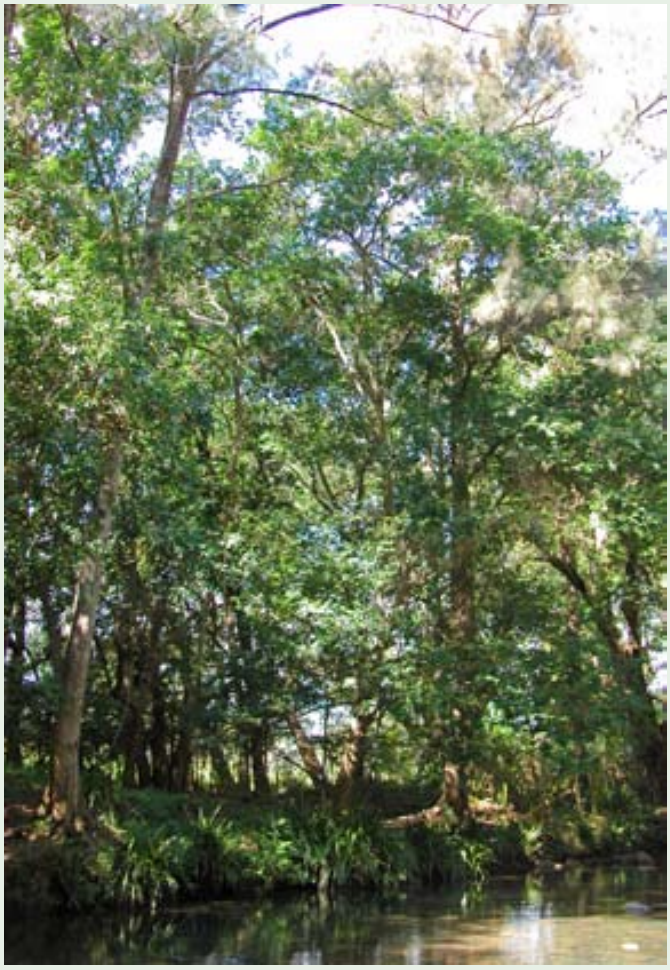
**Preferred scientific name** *Casuarina cunninghamiana* Miq.

**Family** Casuarinaceae, Casuarina family

**Non-preferred scientific names**
*Casuarina tenuissima* Sieb. ex Spreng.

### Common names

river she-oak, river oak, creek oak, Cunningham casuarina, ironwood, Australian pine (English)
*casuarine de Cunningham* (French)
*pino australiano*, *pino de Australia* (Spanish)



**River she-oak is at home along watercourses, although it is widely adaptable. Queensland, Australia.** PHOTO: C. ELEVITCH

### Characteristics

River she-oak is the largest species in the genus Casuarina in Australia. There are two recognized subspecies. Attaining heights of 20–35 m (66–120 ft) and stem diameters up to 1.5 m (5 ft), subsp. *cunninghamiana*, is a riverine species that attains its best development in southeastern Australia. Subsp. *miodon* from the Northern Territory and northwestern Queensland is a shorter tree, reaching 12 m (39 ft) in height with a straggly appearance. The bark of river she-oak is finely fissured, scaly, and gray-brown.

The branches are pineneedle-like, 7.5–18 cm (3–8 in) long, ca. 1 mm (1/25 in) wide, with 8–10 lengthwise ridges ending in a ring of tiny, teeth-like scale leaves. The cones are nearly round to elongate, 0.7–1.3 cm (0.3–0.5 in) in diameter. This species has smaller cones than *C. equisetifolia*. River she-oak is mostly dioecious, with individuals bearing unisex flowers in an approximate 1:1 mix of both sexes

**Left: Fruits and female flowers of *C. cunninghamiana*. Right: Male and female river she-oak. The males appear brownish when in flower. Queensland, Australia.** PHOTOS: C. ELEVITCH

## ENVIRONMENTAL PREFERENCES

River she-oak is found in its native range at 0–1000 m (0–3300 ft). It is typically a riverine species growing along freshwater streams and rivers. The annual rainfall is 360–2200 mm (14–87 in) a year, although since the tree often grows along watercourses, rainfall alone is not an indication of moisture availability. The tree is mainly found in the warm subhumid climatic zone with the mean maximum temperature of the hottest month of 25–40°C (77–104°F), and the mean minimum of the coldest month of 0–15°C (32–59°F). It tolerates up to 50 frosts per year and temperatures down to –8°C (17°F).

### Soils

It generally occurs on well drained, light-textured sandy or gravelly soils, although it is occasionally found growing in clayey soils. The pH is acidic to neutral. The tree

**A windbreak of *C. cunninghamiana* protecting crop land. Waimea, island of Hawai'i.** PHOTO: C. ELEVITCH

is moderately tolerant of salt. It reportedly becomes chlorotic when growing on highly calcareous soils.

### Vegetation types

River she-oak is often a dominant species in riverine vegetation. In its native habitat, surrounding vegetation types are open forest, woodland, and open woodland eucalypts together with *Melaleuca*. In introduced environments, the tree is widely adaptable and grows together with numerous cultivated species.

## PROPAGATION

The tree is usually propagated by seed using the same methods as used for *C. equisetifolia*, although it can also be propagated vegetatively using cuttings.

## AGROFORESTRY/ ENVIRONMENTAL PRACTICES

Agroforestry uses are similar to those of *C. equisetifolia*. Because river she-oak is currently presumed to be less of a risk of invasiveness, it is the preferred tree for windbreaks and other practices in Hawai'i.

## USES AND PRODUCTS

The wood makes an excellent fuelwood and charcoal. Although very difficult to work, the wood can be sawn into planks and cured using special methods. The wood has also been used for casks, tool handles, turnery, flooring, and as a general utility farm timber. Particleboard has also been made from the wood. The heartwood is said to be durable in contact with the ground for 15–25 years. The foliage can be used as a low-grade animal fodder during times of shortage. A dye can be made from the leaves. The flowers are an important source of pollen for bees. A recent introduction to Pacific islands, there are no known traditional uses in the region.

**Clear, straight trunk of an older river she-oak.** PHOTO: C. ELEVITCH

## DISADVANTAGES

Seedlings require protection from browsing animals and fire when young. River she-oak is not as tolerant of saline and calcareous soils as *C. equisetifolia*.

## PUBLIC ASSISTANCE AND AGROFORESTRY EXTENSION

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

## INTERNET

*Casuarina equisetifolia*: <http://www.hort.purdue.edu/newcrop/duke_energy/Casuarina_equisetifolia.html>

*Casuarina equisetifolia:* an old timer with a new future: <http://www.winrock.org/forestry/factpub/FACTSH/C_equisetifolia.html>

*Casuarina equisetifolia* (Casuarinaceae): <http://members.lycos.co.uk/WoodyPlantEcology/docs/web-sp2.htm>

*Casuarina cunninghamiana*: <http://www.winrock.org/forestry/factpub/FACTSH/C_cunninghamiana.html>

*Casuarina glauca*: <http://www.winrock.org/forestry/factpub/FACTSH/C_glauca.html>

Invasive nature of beach she-oak: <http://www.hear.org/pier/species/casuarina_equisetifolia.htm>

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

# *Casuarina equisetifolia* (beach she-oak)
# *C. cunninghamiana* (river she-oak)

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