Department of **Agriculture and Fisheries**
Biosecurity Queensland

Invasive plant risk assessment

Diesel tree

Copaifera langsdorfii

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Contents

Summary

Copaifera langsdorfii is a medium to large-sized evergreen tree native to South America. It prefers mesic tropical rainforest habitats, though it can grow in both wet and dry forests throughout the subtropical and tropical regions of South America.

Copaifera langsdorfii does not have a long history of cultivation outside its native range, but has been used by indigenous South American tribes for a wide range of purposes (e.g. for timber, folk remedies and as a fuel for cooking). The most useful part of the tree is the oily resin (oleoresin) that accumulates in cavities within the trunk, which can be harvested by tapping or drilling holes into the wood. Oleoresin is exported to the industrialised world, where it is used in perfumes and cosmetic preparations, and as a fixative in varnishes, paints and lacquers.

More recently, oleoresin has been promoted as a potential source of biodiesel. Anecdotal accounts of oleoresin yields of 40 L per tree have been reported, and this has led to an increase in the species' cultivation in other parts of the world. However, very recent scientific studies have found oleoresin production is considerably lower.

Copaifera langsdorfii has no known history as a weed in any part of the world and has not yet shown a propensity to become naturalised outside its native range. However, it should be noted that it has been relatively uncommon in cultivation until recent times, and hence its invasive capacity may be largely untested.

While there is currently little or no evidence that *C. langsdorfii* could become a pest plant in Queensland, the climate in its native range is very similar to that found in large parts of northern Australia. The planting of commercial-scale plantations in this region might increase the risk of naturalisation.

If this species became invasive in Queensland, the rainforests and other forests of the wet tropics region, as well as riparian vegetation and wetter sites in the wet–dry tropical savannas, would seem to be most at risk.

Introduction

Identity and taxonomy

Species identity: *Copaifera langsdorfii* Desf.

Common names: amacey, balsam copaiba, Brazilian diesel tree, copaiba, copaiba balsam, diesel tree, kerosene tree, Langsdorf's copaifera, kupa'y [Paraguay], bálsamo [Portuguese], caobi [Portuguese], capaíba [Portuguese], capaúba [Portuguese], coopaíba [Portuguese], copaí [Portuguese], copaíba [Portuguese], copaíba-preta [Portuguese], copaíba-de-várzea [Portuguese], copaíba-vermelha [Portuguese], copaibeira [Portuguese], copaibeira-de-minas [Portuguese], copaúba [Portuguese], óleo-amarelo [Portuguese], óleo-capaíba, [Portuguese], óleo-de-copaíba [Portuguese], óleo-pardo [Portuguese], oleo-vermelho [Portuguese], pau-óleo [Portuguese], cabismo [Spanish]

Synonyms: *Copaiba langsdorfii* (Desf.) Kuntze, *Copaifera langsdorffii* Desf., orth. var., *Copaifera nitida* Hayne, *Copaifera sellowii* Hayne

Family: Caesalpiniaceae

There is a significant amount of variation within this species, with several varieties and forms described by plant taxonomists over the years (Dwyer 1951; Dwyer 1954; Veiga Junior & Pinto 2002). Dwyer (1951) described four varieties separate from the typical form—*Copaifera langsdorfii* Desf. var. *krukovii* Dwyer, *Copaifera langsdorfii* var. *grandifolia* Benth., *Copaifera langsdorfii* var. *laxa* (Hayne) Benth. and *Copaifera langsdorfii* var. *glabra* (Vogel) Benth. These taxa are separated mainly by differences in leaf morphology (i.e. the size, shape and number of leaflets) and the hairiness of the stems, leaves and flower parts.

There are about 35 species in the genus *Copaifera*, all of which are trees native to the tropical regions of America and western Africa (Taylor 2005). The majority of these species come from tropical America, from the region between Mexico and northern Argentina, and many are found only in Brazil (Dwyer 1951; Taylor 2005). In the past, as many as 19 species of *Copaifera* were described from tropical western Africa in the region encompassing Congo, Cameroon, Guinea and Angola. However, many of these plants have recently been moved to other genera (Veiga Junior & Pinto 2002). Only four species belonging to the genus *Copaifera* are now thought to be native to Africa (ILDIS 2005).

Description

The following description is adapted from Dwyer (1951), Duke (1983), Rudd (1991), ICRAF (2001), Veiga Junior and Pinto (2002), Almeida et al. (2006) and Guerra et al. (2006).

Copaifera langsdorfii is an evergreen tree commonly growing 6–15 m tall and sometimes reaching 25–40 m in height when growing amongst other vegetation in the rainforest canopy. However, plants subsisting in the savannas of central Brazil (i.e. in the Cerrado) are sometimes only 2 m tall. The main trunk is often 1 m or more in diameter, but can reach 4 m diameter in large specimens. These trunks are covered in a rough, scaly, bark that is usually dark brown in colour. Younger branches and twigs are angular in shape, slightly grooved (i.e. longitudinally striate) and may be either glabrous or pubescent.

The compound leaves (5–13 cm long) are pinnate with 2–4 pairs (rarely to 6 pairs) of leaflets, and no terminal leaflet (i.e. they are paripinnate). They are alternately arranged and borne on pubescent to glabrous petioles 5–9 cm long, with the leaflets being either opposite or semi-alternate. The leaflets (1.5–6 cm long and 0.7–3 cm wide) are glabrous or sub-glabrous above, glabrous or pubescent below, and borne on short stalks (i.e. petiolules). They are usually elliptic or ovate in shape, but may occasionally be ovate–oblong, obovate–oblong, narrowly oblong or oblong–elliptic. Their bases are obtuse and their apices are either obtuse or tapering into a distinct shortly acuminate tip. Young foliage may be reddish in colour.

The numerous small whitish flowers are arranged in axillary panicles (3–11 cm long). These flowers are almost stalkless (i.e. sub-sessile) with four white sepals and no petals. The oblong to ovate–lanceolate sepals (3–4.5 mm long and 1.3–3 mm wide) have glabrous outer surfaces and hirsute inner surfaces, and taper gradually into obtuse or sub-acute apices. Each flower has 10 stamens with oblong anthers (1.1–2 mm long and 0.7–1 mm wide) borne on filaments 4–7 mm long. Their ovaries (1.8–2.5 mm long and 1.3–2.5 mm wide) are smooth with moderately hairy margins and are topped with a style 2.8–4 mm long.

The fruit (2.8–3.5 cm long and about 2.5 cm wide) are egg-shaped in outline and somewhat flattened (i.e. compressed ovoid) to elliptic–oblong or sub-orbicular in shape. As they mature they turn yellowish-brown, reddish-brown or blackish-brown in colour and their surfaces become vaguely to distinctly rugose in texture. Each fruit contains a single large black seed (1–2 cm long and about 0.7–1.3 cm wide) that is oblong in shape and partially covered with a colourful, thick, fleshy aril. This aril is bright yellow to reddish and usually covers about ¾ of the seed. Each of these large seeds weighs approximately 0.45–0.7 g, with the number of seeds per kilogram ranging from 1480 to 2220.

Biology and ecology

Copaifera langsdorfii can live up to 400 years and is classified as a late secondary to climax species (with regard to ecological succession) in its native habitat in the rainforests of tropical America (Veiga Junior & Pinto 2002; Guerra et al. 2006). Plants growing in plantations in South America reach reproductive maturity after five years of growth. In certain climatic conditions *C. langsdorfii* may be partially deciduous (ICRAF 2001), with most leaf fall occurring towards the end of the dry season in south-eastern Brazil (Pedroni et al. 2002).

Flowering usually occurs between June and October and fruiting between July and October in tropical South America, with variation depending on the exact region and climate (Pedroni et al. 2002; Veiga Junior & Pinto 2002).

Flowers are pollinated by insects during the day, mostly in the period between 8 am and 4 pm (Veiga Junior & Pinto 2002). Stingless bees (*Trigona* spp.) and European honey bees (*Apis mellifera* L.) have been found to be prominent pollinators of this species in its native range (ICRAF 2001; Veiga Junior & Pinto 2002).

Seed germination begins approximately five days after sowing (Guerra et al. 2006), with the germination type being epigeal and phanerocotylar (i.e. the cotyledons are borne above the soil surface, are exposed and are photosynthetic). The fleshy cotyledons contain large reserves of energy, which allow for germination and early growth in densely shaded environments (ICRAF 2001). The first true leaves are compound, with 2–3 pairs of relatively small leaflets about 2.7 cm long and 1.4 cm wide (Guerra et al. 2006).

Like the majority of species in the Caesalpiniaceae plant family, *C. langsdorfii* does produce root nodules for nitrogen fixation (Barberi et al. 1998).

Reproduction and dispersal

Fruit-eating animals, particularly birds, are thought to be mainly responsible for the dispersal of the seeds of this species (Pedroni et al. 2002; Almeida et al. 2006). In the fruiting season in Brazil, *C. langsdorfii* is regularly visited by birds during the daytime hours (Veiga Junior & Pinto 2002). Small rodents also enjoy the fruit and are attracted by the smell of coumarin present in the mature seeds (Veiga Junior & Pinto 2002). The hard seeds of this species have also been found to be a part of the diet of other small mammals, including the collared peccary (*Tayassu tajacu*) in Brazil (Olmos 1993).

Though many subtropical to tropical rainforest species have very short-lived seeds (i.e. non-orthodox or recalcitrant seeds), this species has orthodox seeds (i.e. its seeds maybe stored for long periods at low temperature with a reduced water content). Its seeds have a high initial viability (Ferreira et al. 2004), which is reported to be maintained after eight months storage at 3 °C, with 7.8% seed moisture content (ICRAF 2001).

Origin and distribution

Copaifera langsdorfii is native to Venezuela, Guyana, Brazil, Bolivia, Paraguay and north-eastern Argentina (ICRAF 2001; ILDIS 2005; Guerra et al. 2006; GRIN 2007; MBG 2007)—see Figure 1. It is particularly widespread in Brazil, where it is found from the Amazon Basin in the north to the Santa Catarina region in the far south (Veiga Junior & Pinto 2002). It is most abundant in rainforests in the north of Brazil and in savannas (i.e. the cerrados) in the central region (Junior Veiga & Pinto 2002; Taylor 2005).

Despite being cultivated outside its native range, there does not appear to be any records of escape and naturalisation anywhere else in the world. The species is listed in the *Revised flora of Ceylon*, but is only included in this text as a species that is 'casually introduced but not naturalised' (Rudd 1991).

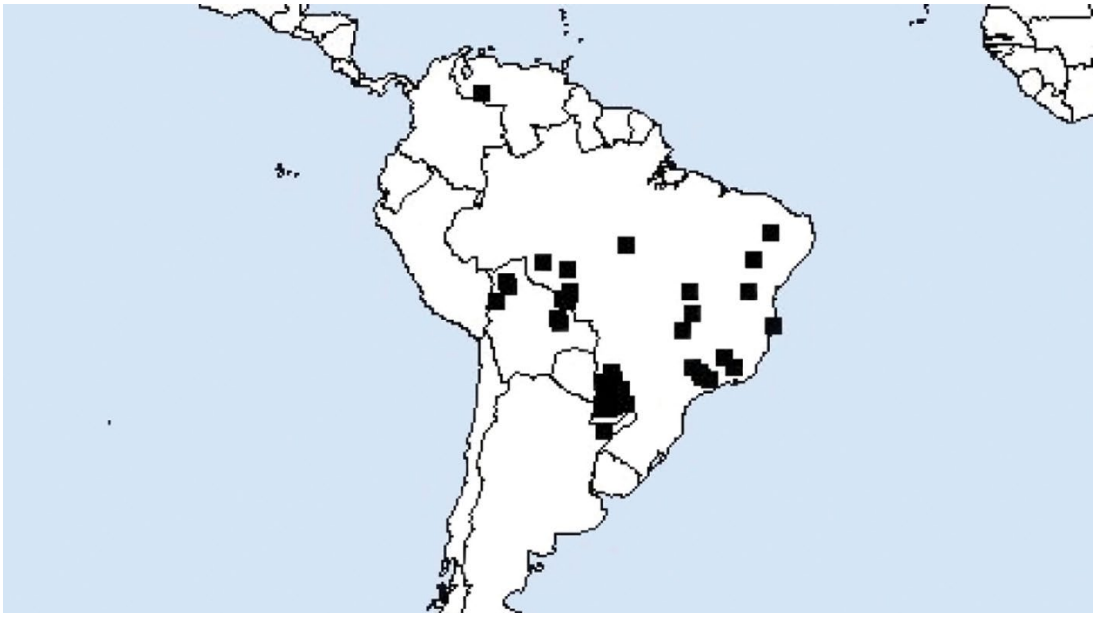

Figure 1. Distribution of *Copaifera langsdorfii* based on herbarium records (MBG 2007)

Status in Australia and Queensland

Copaifera langsdorfii is not reported to be naturalised in Australia.

While it may have been cultivated in the warmer regions of this country for some time, its popularity has recently increased due to its potential as a source of biofuel. For example, a wholesale nursery in the Mackay region recently sold 20 000 seedlings (Marshall 2007).

Preferred habitats

This species grows naturally in both wet and dry forests in subtropical and tropical regions (Duke 1983). Its habitat ranges from the drier savannas of the Cerrado to the wetter rainforests of the Amazon Basin and the montane semi-deciduous forests in the south-east of Brazil (ICRAF 2001; Carvalho & Oliveira 2004; Guerra et al. 2006). However, in the drier parts of its range it prefers to grow in riparian zones where soil moisture is greater (Guerra et al. 2006). *Copaifera langsdorfii* grows best on dark-red latosols and lithosols and will tolerate a soil pH between 4.5 and 7.5 (ICRAF 2001).

Copaifera langsdorfii is native to areas with a mean annual precipitation between 1000 and 4000 mm and a mean annual temperature of 20–27 °C (ICRAF 2001). However, optimal conditions for growth are probably toward the upper ranges of these values (i.e. a mean annual precipitation of 3500 mm or more and a mean annual temperature of about 27 °C) (Duke 1983). It can tolerate some soil waterlogging, but is thought to be susceptible to frost (ICRAF 2001).

History as a weed elsewhere

Copaifera langsdorfii is not listed as a weed anywhere. In fact, the only species in the genus *Copaifera* that has shown any sign of weediness is copaiba (*Copaifera officinalis*), and even then its impact appears very minor (Randall 2002). *Copaifera officinalis* is reported to be naturalised in Puerto Rico (Kairo et al. 2003; USDA 2007) and is described as invasive in the Dominican Republic, where it was introduced for reforestation purposes (Garcia 2003; Kairo et al. 2003). Because of this, *Copaifera officinalis* is regarded as a potentially invasive species in the Caribbean region (Kairo et al. 2003).

Uses

The timber of *C. langsdorfii* is highly resistant to natural decay and is used in carpentry (Rudd 1991; ICRAF 2001). The wood is used in the construction of houses (e.g. for beams, floorboards, slats, doors and windows) and for the manufacture of furniture (Almeida et al. 2006). It is also used for a variety of other purposes, including for the wooden handles of tools and brooms (Almeida et al. 2006).

However, by far the most useful part of the *Copaifera langsdorfii* tree is the oily resin (i.e. oleoresin) that is produced in the trunk. It accumulates in cavities within the trunk, and is harvested by tapping or drilling holes into the wood of the trunk and collecting the watery resin that drips out (Taylor 2005; Oliveira et al. 2006). This oleoresin is known as 'copaiba', 'copal' or 'balsam' (ICRAF 2001). In fact the name *Copaifera* means 'copaiba-bearer', being derived from 'copaiba' and the Latin 'fero' (i.e. to bear). The oleoresin, which is made up of hydrocarbons, is thin and clear when it is tapped from the tree. However, it thickens and darkens upon contact with air, and soon acquires a yellowish tinge (ICRAF 2001).

It has long been employed by South American indigenous tribes, particularly as a medicine, but also as a fuel for cooking and for a variety of other non–energy related purposes. Medicinally, it is employed as a stimulant, diuretic, carminative and laxative, and in large doses it can also be used as a purgative (ICRAF 2001). It has been used as a folk remedy in the treatment of ulcers, wounds, bleeding, insect bites, eczema, dermatosis, hemorrhoids, sinusitis, bronchitis, cystitis, leucorrhoea and diarrhoea (Veiga Junior & Pinto 2002; Taylor 2005). In Brazilian herbal

medicine the resin is still used as a strong antiseptic and expectorant for the respiratory tract (for treating bronchitis and sinusitis), as an anti-inflammatory and antiseptic for the urinary tract (for treating bladder and kidney infections) and as an anti-inflammatory agent for all types of skin problems (Taylor 2005). It is also commonly used to control sexually transmitted diseases, particularly gonorrhoea, in which case it is often combined with other substances (ICRAF 2001; Veiga Junior & Pinto 2002).

More recently, the copaiba resin has been employed by the industrialised world for other purposes. It is exported, particularly to the United States, where it is used mostly as a component in perfumes and in cosmetic preparations (e.g. in soaps, bubble baths, detergents, creams, hair conditioners and lotions) for its fragrance, antibacterial, anti-inflammatory and emollient (i.e. soothing and softening) properties (Taylor 2005). The oleoresin is also widely used in industries as a fixative, particularly in varnishes, paints and lacquers (van der Werf et al. 2000; Veiga Junior & Pinto 2002; Almeida et al. 2006). The oil that is present in the seeds may also be used for the same purposes (Stupp et al. 2008).

The oleoresin obtained from the trunk contains up to 15% volatile oil, with the remaining materials being resins and acids (Taylor 2005). Tests have shown that the liquid from the tree can be placed directly in the fuel tank of a diesel-powered car, as long as it has been filtered (Duke 1983). A yield of 40 L of hydrocarbon per tree per year has commonly been quoted, and it has been suggested that an acre of 100 mature trees might be able to produce 25 barrels of fuel per year (Duke 1983; ICRAF 2001). In the current environment, with the demand for alternative fuel sources such as biodiesels beginning to increase, this has lead to great interest in the commercial cultivation of *Copaifera langsdorfii* for this purpose.

However, anecdotal accounts of copaiba oleoresin yields, from a variety of *Copaifera* species, range from 2.5 to 62 L per tree (Plowden 2003). More recently, Plowden (2003) conducted a scientific study on the production of oleoresin in several *Copaifera* species, including *C. langsdorfii*, in a small area of the Brazilian Amazon. He did this to determine the economic value of the extracted oleoresin from the trees for the native peoples who inhabit those areas. He found that oleoresin production was much lower than in the anecdotal accounts, with none of the trees yielding more than 1 L of oleoresin in any of the samplings, and some trees produced no oleoresin at all (Plowden 2003). Medium-sized trees with a diameter at breast height (DBH) of 55–65 cm produced the most oleoresin. The average amount of liquid drained from this size class tree was 247 mL on the first sampling, and the totals decreased with each subsequent sampling. Larger trees yielded less oleoresin than medium-sized trees, and trees with DBH less than 35 cm yielded no oleoresin at all (Plowden 2003). This was because oleoresin is derived almost exclusively from the inner heartwood of the tree. This zone is not developed in younger trees, while older trees become hollow and lose this zone (see Figure 8).

Oliveira et al. (2006), studying other *Copaifera* species, found similarly low yields of oleoresin. They also found that the amount of oleoresin present varied throughout the year, and that spring was the best time for its collection. Based on these findings, a recent report into potential biodiesel crops in Hawaii suggested that *C. langsdorfii* is unlikely to be an efficient producer of readily extractable oleoresins, and that its cultivation should probably not be pursued to meet Hawaii's biodiesel needs (Poteet 2006).

Copaifera langsdorfii trees are also grown for amenity purposes in Brazil as it provides good shade (Guerra et al. 2006a). It has also been employed in rural and urban afforestation programs in this country (Guerra et al. 2006a). As European honey bees are major visitors to the tree for pollen, *C. langsdorfii* can also play a useful role in apiculture (ICRAF 2001). An extract from the bark produces a yellow dye, which is used in homemade dyes to colour cotton yarn in regional areas (Almeida et al. 2006). The balsamiferous wood burns readily, perhaps even when green, and is often used as a fuel wood (ICRAF 2001).

Pest potential in Queensland

Copaifera langsdorfii has not yet become a pest plant anywhere in the world, and has not shown a propensity to become naturalised beyond its native range. While this species is common in certain vegetation types, and can make up a significant portion of the forest canopy within its natural range, it is largely a climax species of forest habitats and is generally not regarded as being weedy. These historical and ecological observations would suggest that *C. langsdorfii* poses little or no threat to agricultural industries in Queensland.

However, it should be noted that *C. langsdorfii* does have some characteristics that are often associated with invasive species of natural habitats. Firstly, it is very shade tolerant in the seedling stage. This character may enable a species to invade relatively intact forest ecosystems. Secondly, the fleshy arils on its hard seeds are associated with dispersal by birds and other animals. This character is common to many of the most invasive tree species in Australia, and it is often an important factor in their ability to rapidly spread from cultivation into natural habitats.

The climate in the native range of *C. langsdorfii* is very similar to that found in large parts of northern Australia. Hence, this species has the potential to survive in the northern parts of Queensland. Based on its preferred habitat in its native range, the ecosystems that would be most at risk from invasion in Queensland would be the rainforests and other forests of the wet tropics region, as well as riparian vegetation and wetter sites in the wet–dry tropical savannas.

While this species has not yet shown a propensity to invade natural ecosystems in Australia, or any other part of the world, it should be noted that it has been relatively uncommon in cultivation until recent times. Also, the majority of those trees that are in cultivation are unlikely to have reached reproductive maturity, meaning that its invasive capacity may be largely untested. The planting of commercial-scale plantations in Australia and other parts of the world will no doubt increase the likelihood that it will become naturalised in the future.

Hence, while there is currently little or no evidence that *C. langsdorfii* could become a pest plant in Queensland, the possibility that it could become invasive in natural ecosystems cannot be ruled out entirely.

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