Taxon: Santalum album **Family:** Santalaceae

Common Name(s): chandan
Indian sandalwood
white sandalwood

Synonym(s): Sirium myrtifolium L.

Assessor: Chuck Chimera **Status:** Assessor Approved **End Date:** 5 Feb 2015

WRA Score: 5.0 **Designation:** H(HPWRA) **Rating:** High Risk

Keywords: Naturalized Tree, Hemi-parasitic, Fragrant Heartwood, Bird-Dispersed, Root-Suckers

Qsn #	Question	Answer Option	Answer
101	Is the species highly domesticated?	y=-3, n=0	n
102	Has the species become naturalized where grown?		
103	Does the species have weedy races?		
201	Species suited to tropical or subtropical climate(s) - If island is primarily wet habitat, then substitute "wet tropical" for "tropical or subtropical"	(0-low; 1-intermediate; 2-high) (See Appendix 2)	High
202	Quality of climate match data	(0-low; 1-intermediate; 2-high) (See Appendix 2)	High
203	Broad climate suitability (environmental versatility)	y=1, n=0	y
204	Native or naturalized in regions with tropical or subtropical climates	y=1, n=0	y
205	Does the species have a history of repeated introductions outside its natural range?	y=-2, ?=-1, n=0	y
301	Naturalized beyond native range	y = 1*multiplier (see Appendix 2), n= question 205	y
302	Garden/amenity/disturbance weed	n=0, y = 1*multiplier (see Appendix 2)	n
303	Agricultural/forestry/horticultural weed	n=0, y = 2*multiplier (see Appendix 2)	n
304	Environmental weed	n=0, y = 2*multiplier (see Appendix 2)	n
305	Congeneric weed	n=0, y = 1*multiplier (see Appendix 2)	n
401	Produces spines, thorns or burrs	y=1, n=0	n
402	Allelopathic	y=1, n=0	n
403	Parasitic	y=1, n=0	y
404	Unpalatable to grazing animals	y=1, n=-1	n
405	Toxic to animals	y=1, n=0	n
406	Host for recognized pests and pathogens		
407	Causes allergies or is otherwise toxic to humans	y=1, n=0	n
408	Creates a fire hazard in natural ecosystems		
409	Is a shade tolerant plant at some stage of its life cycle	y=1, n=0	y

Qsn #	Question	Answer Option	Answer
410	Tolerates a wide range of soil conditions (or limestone conditions if not a volcanic island)	y=1, n=0	y
411	Climbing or smothering growth habit	y=1, n=0	n
412	Forms dense thickets	y=1, n=0	n
501	Aquatic	y=5, n=0	n
502	Grass	y=1, n=0	n
503	Nitrogen fixing woody plant	y=1, n=0	n
504	Geophyte (herbaceous with underground storage organs -- bulbs, corms, or tubers)	y=1, n=0	n
601	Evidence of substantial reproductive failure in native habitat		
602	Produces viable seed	y=1, n=-1	y
603	Hybridizes naturally	y=1, n=-1	y
604	Self-compatible or apomictic	y=1, n=-1	n
605	Requires specialist pollinators	y=-1, n=0	n
606	Reproduction by vegetative fragmentation	y=1, n=-1	y
607	Minimum generative time (years)	1 year = 1, 2 or 3 years = 0, 4+ years = -1	2
701	Propagules likely to be dispersed unintentionally (plants growing in heavily trafficked areas)	y=1, n=-1	n
702	Propagules dispersed intentionally by people	y=1, n=-1	y
703	Propagules likely to disperse as a produce contaminant	y=1, n=-1	n
704	Propagules adapted to wind dispersal	y=1, n=-1	n
705	Propagules water dispersed	y=1, n=-1	n
706	Propagules bird dispersed	y=1, n=-1	y
707	Propagules dispersed by other animals (externally)	y=1, n=-1	n
708	Propagules survive passage through the gut	y=1, n=-1	y
801	Prolific seed production (>1000/m2)	y=1, n=-1	n
802	Evidence that a persistent propagule bank is formed (>1 yr)		
803	Well controlled by herbicides		
804	Tolerates, or benefits from, mutilation, cultivation, or fire		
805	Effective natural enemies present locally (e.g. introduced biocontrol agents)		

Supporting Data:

Qsn #	Question	Answer
101	**Is the species highly domesticated?**	**n**
	Source(s)	**Notes**
	CAB International, 2005. Forestry Compendium. CAB International, Wallingford, UK	"Genetic variation between S. album populations in India and West Timor has been evaluated by Brand (1994). This study indicates the two populations may be separate varieties or races." ... "Programmes in India and Indonesia have identified in excess of 200 candidate plus trees based on phenotypic selection (Effendi, 1992; Srinivasan et al., 1992). Progeny experiments have been established in southern India to determine the heritability of heartwood formation and oil content. Four seed stands for mass selection have been identified in India for use in planting programmes and clonal seed orchards have been established at two sites to maximise interrelated matings among plus trees (Srinivasan et al., 1992). Srimathi et al. (1995) describe guidelines for the selection of plus trees and establishment of seed stands in India. It is possible to use tissue culture for the rapid multiplication and propagation of selected parent trees (Bapat and Rao, 1979; Bapat et al., 1985). Lakshmi Sita (1991) indicates tissue cultured plants have exhibited heartwood formation at 7 years of age. Lakshmi-Sita and Raghava-Ram (1995) and Bapat and Rao (1984) discuss the usefulness of somatic embryogenesis in S. album multiplication. Investigations into clonal multiplication are continuing (Srinivasan et al., 1992; Bapat et al., 1996). Limited silvicultural knowledge has hindered the development of complex, long term experiments such as progeny experiments. Progeny experiments have been established near Kununurra with seed sourced from India, Indonesia and the NorthernTerritory (Australia)." [Although cultivated in India, Indonesia and elsewhere, no evidence that the cultivated trees are different from the wild.]
	Yusuf, R., 1999. Santalum album L.[Internet] Record from Proseabase. L.P.A. Oyen and Nguyen Xuan Dung (Editors). PROSEA (Plant Resources of South-East Asia) Foundation, Bogor, Indonesia. http://www.proseanet.org. [Accessed 4 Feb 2015]	"Little breeding work has been done, apart from the identification of superior seed trees of Santalum album in India and Indonesia."

102	**Has the species become naturalized where grown?**	
	Source(s)	**Notes**
	WRA Specialist. 2015. Personal Communication	NA

103	**Does the species have weedy races?**	
	Source(s)	**Notes**
	WRA Specialist. 2015. Personal Communication	NA

201	**Species suited to tropical or subtropical climate(s) - If island is primarily wet habitat, then substitute "wet tropical" for "tropical or subtropical"**	**High**

Qsn #	Question	Answer
	Source(s)	**Notes**
	CAB International, 2005. Forestry Compendium. CAB International, Wallingford, UK	"The natural distribution of S. album is in the tropical belt of the Indian peninsula, up to an elevation of 1200 m (Rai, 1990), in the highland regions of eastern Indonesia, primarily on the islands of Nusa Tenggara Timur, up to an elevation of 2000 m (Harisetijono and Suriamihardja, 1993), and the coastal areas of northern Australia, near Darwin (Barrett and Fox, 1995). S. album is considered indigenous along the southern islands of the Indonesian archipelago to eastern Java (Harisetijono and Suriamihardja, 1993). The origin of S. album is disputed, and it has been hypothesized that S. album was introduced to India from West Timor (Brand, 1994). However, references to sandalwood utilisation from natural stands in India can be traced back to 2300 years ago (Srinivasan et al., 1992)."

202	Quality of climate match data	High
	Source(s)	**Notes**
	CAB International, 2005. Forestry Compendium. CAB International, Wallingford, UK	

203	Broad climate suitability (environmental versatility)	y
	Source(s)	**Notes**
	CAB International, 2005. Forestry Compendium. CAB International, Wallingford, UK	"In India the natural distribution of S. album is mainly in the dry deciduous forests of the Deccan Plateau, thriving where rainfall is between 500-2000 mm and elevations of 650-1200 m. S. album can occur outside this climatic zone. However, trees sampled in higher rainfall zones have less heartwood (Rai, 1990). S. album tolerates extreme temperatures throughout its distribution from 4º C to 46º C (Singh, 1995). Nusa Tenggara Timur is subject to a 2 to 3 month wet season with an average annual rainfall of 900 mm in the lowlands to 2000 mm in the highlands. In the dry season the average daily temperature reaches a maximum of 31.6º C (Harisetijono and Suriamihardja,1993). In Australia it occurs in the hot humid zone where temperatures are high throughout the year. The average maximum of the hottest month is 32-34º C and the mean minimum of the coolest month is 17-22º C. Rainfall has a strong monsoonal pattern and averages 1000-1500 mm (Doran and Turnbull, 1997). Climatic amplitude (estimates) - Altitude range: 0 - 2000 m - Mean annual rainfall: 400 - 3000 mm - Rainfall regime: summer - Dry season duration: 6 - 7 months - Mean annual temperature: 19 - 32ºC - Mean maximum temperature of hottest month: 21 - 37ºC - Mean minimum temperature of coldest month: 13 - 25ºC - Absolute minimum temperature: 1 - 4ºC"

204	Native or naturalized in regions with tropical or subtropical climates	y

Qsn #	Question	Answer
	Source(s)	**Notes**
	Frohlich, D. & Lau, A. 2008. New plant records from O'ahu for 2007. Bishop Museum Occasional Papers 100: 3-12	"Skolmen (1980) reports over 7500 plantings of Santalum album throughout O'ahu's forest reserves. It was perhaps originally planted in the Diamond Head area, but recently was observed in all size classes and thoroughly established in an abandoned parking area and other empty lots on the mauka slopes surrounding the crater. Santalum album can be distinguished from native species of Santalum by its tree habit, ovate to lanceolate leaves (sometimes with glaucous new growth), and 7 mm long black drupes with a subapical receptacular ring (Wagner et al. 1999). Material examined. O'AHU: Diamond Head (UTM 2352279, 623352), coastal empty residential weed lot, 3 m tall tree thoroughly established in at least the large tracts of abandoned parking and other lots, 21 m (70 ft), 27 Apr 2007, A. Lau & D. Frohlich 2007042701."
	CAB International, 2005. Forestry Compendium. CAB International, Wallingford, UK	"The natural distribution of S. album is in the tropical belt of the Indian peninsula, up to an elevation of 1200 m (Rai, 1990), in the highland regions of eastern Indonesia, primarily on the islands of Nusa Tenggara Timur, up to an elevation of 2000 m (Harisetijono and Suriamihardja, 1993), and the coastal areas of northern Australia, near Darwin (Barrett and Fox, 1995). S. album is considered indigenous along the southern islands of the Indonesian archipelago to eastern Java (Harisetijono and Suriamihardja, 1993). The origin of S. album is disputed, and it has been hypothesized that S. album was introduced to India from West Timor (Brand, 1994). However, references to sandalwood utilisation from natural stands in India can be traced back to 2300 years ago (Srinivasan et al., 1992)."

205	**Does the species have a history of repeated introductions outside its natural range?**	**y**
	Source(s)	**Notes**
	CAB International, 2005. Forestry Compendium. CAB International, Wallingford, UK	"Experimental introductions have been made in China (Li and Yu, 1984), Fiji (Bulai, 1995), New Caledonia (Chauvin, 1988), Hawaii (Merlin and VanRavensway, 1990), Tonga (Kaufusi, 1995), Papua New Guinea (Paul, 1990), Nepal (Neil, 1990), Sri Lanka (Tennakoon, personal communication), East Indonesia (Harisetijono and Suriamihardja, 1993) and North Queensland, Australia (Keenan, personal communication). Commercial irrigated plantations are currently being established near Kununurra, northern Western Australia (Radomiljac et al., 1998a). S. album was introduced to Kenya, Nigeria, Zimbabwe, Tanzania and Uganda with varied success (Streets, 1962). "
	Frohlich, D. & Lau, A. 2008. New plant records from O'ahu for 2007. Bishop Museum Occasional Papers 100: 3-12	"Skolmen (1980) reports over 7500 plantings of Santalum album throughout O'ahu's forest reserves."

301	**Naturalized beyond native range**	**y**
	Source(s)	**Notes**
	Nelson, G. 2010. The Trees of Florida. A Reference and Field Guide. 2nd Edition. Pineapple Press Inc, Sarasota, FL	"Distribution: Disturbed sites; rarely naturalized in Miami-Dade County."

Qsn #	Question	Answer
	Balasubramanian, P., Aruna, R., Anbarasu, C., & Santhoshkumar, E. 2011. Avian frugivory and seed dispersal of Indian Sandalwood Santalum album in Tamil Nadu, India. Journal of Threatened Taxa, 3(5): 1775-1777	"Santalum album (Santalaceae) fis a medfium sfized evergreen tree found fin dry forest tracts of the Deccan Penfinsula, where the major sandal growfing tracts are located fin Karnataka and Tamfil Nadu. Sandal fis also dfistrfibuted fin parts of Maharashtra, Andhra Pradesh and Kerala. The specfies was fintroduced to several areas of central and northern Indfia, where fit has naturalfized and spread."
	Frohlich, D. & Lau, A. 2008. New plant records from O'ahu for 2007. Bishop Museum Occasional Papers 100: 3-12	"Skolmen (1980) reports over 7500 plantings of Santalum album throughout O'ahu's forest reserves. It was perhaps originally planted in the Diamond Head area, but recently was observed in all size classes and thoroughly established in an abandoned parking area and other empty lots on the mauka slopes surrounding the crater. Santalum album can be distinguished from native species of Santalum by its tree habit, ovate to lanceolate leaves (sometimes with glaucous new growth), and 7 mm long black drupes with a subapical receptacular ring (Wagner et al. 1999). Material examined. O'AHU: Diamond Head (UTM 2352279, 623352), coastal empty residential weed lot, 3 m tall tree thoroughly established in at least the large tracts of abandoned parking and other lots, 21 m (70 ft), 27 Apr 2007, A. Lau & D. Frohlich 2007042701."
	Thomson, L.A.J. 2006. Santalum austrocaledonicum and S. yasi (sandalwood), ver. 2.1. In: Elevitch, C.R. (ed.). Species Profiles for Pacific Island Agroforestry. Permanent Agriculture Resources (PAR), Hōlualoa, Hawai'i. http://www.traditionaltree.org. [Accessed]	"To date, S. album has been little planted in the Pacific islands (Fiji, Tonga, Cook Islands, Samoa, and New Caledonia). The species is in the process of becoming naturalized near old trial plots in northwest Viti Levu, Fiji, and has naturally hybridized with S. yasi where the two species have been planted together."

302	Garden/amenity/disturbance weed	n
	Source(s)	**Notes**
	Randall, R.P. 2012. A Global Compendium of Weeds. 2nd Edition. Department of Agriculture and Food, Western Australia	No evidence

303	Agricultural/forestry/horticultural weed	n
	Source(s)	**Notes**
	Randall, R.P. 2012. A Global Compendium of Weeds. 2nd Edition. Department of Agriculture and Food, Western Australia	No evidence

304	Environmental weed	n
	Source(s)	**Notes**
	Randall, R.P. 2012. A Global Compendium of Weeds. 2nd Edition. Department of Agriculture and Food, Western Australia	No evidence

305	Congeneric weed	n
	Source(s)	**Notes**

Qsn #	Question	Answer
	Thomson, L.A.J. 2006. Santalum austrocaledonicum and S. yasi (sandalwood), ver. 2.1. In: Elevitch, C.R. (ed.). Species Profiles for Pacific Island Agroforestry. Permanent Agriculture Resources (PAR), Hōlualoa, Hawai'i. http://www.traditionaltree.org. [Accessed 4 Feb 2015]	"Pacific island sandalwoods have not become naturalized outside of their native range. Sandalwood species generally have a capacity for invasiveness in disturbed, open plant communities, but this is not considered a problem because of their very high value and because they do not dominate or appear to modify such communities in any substantial way. There is a risk that some planted host species, especially exotic leguminous trees, might become invasive. Accordingly, it is recommended that local plant species are screened first for suitability as hosts and used preferentially as hosts, especially in and around areas of high biodiversity conservation value."
	Randall, R.P. 2012. A Global Compendium of Weeds. 2nd Edition. Department of Agriculture and Food, Western Australia	No evidence

401	Produces spines, thorns or burrs	n
	Source(s)	**Notes**
	Orwa C,, Mutua, A., Kindt R,, Jamnadass, R, & Anthony, S. 2009 Agroforestree Database: a tree reference and selection guide version 4.0. http://www.worldagroforestry.org/sites/treedbs/treedatabases.asp. [Accessed 4 Feb 2015]	[No evidence] "Santalum album is a small evergreen tree that grows to 4 m in Australia, but in India it is much larger and can grow to a height of 20 m; girth of up to 2.4 m, with slender drooping branchlets. Bark is tight, dark brown, reddish, dark grey or nearly black, smooth in young trees, rough with deep vertical cracks in older trees, red inside. Leaves thin, usually opposite, ovate or ovate elliptical, 3-8 x 3-5 cm, glabrous and shining green above, glaucous and slightly paler beneath; tip rounded or pointed; stalk grooved, 5-15 cm long; venation noticeably reticulate."

402	Allelopathic	n
	Source(s)	**Notes**
	CAB International, 2005. Forestry Compendium. CAB International, Wallingford, UK	[No evidence] "Due to its hemi-parasitic nature S. album grows best in association with, but not dominated by other tree species. Sandalwood requires a host which is neither too vigorous and out competes the tree, nor too weak so that the host is exhausted (Havel and McKinnell, 1993)."

403	Parasitic	y
	Source(s)	**Notes**
	CAB International, 2005. Forestry Compendium. CAB International, Wallingford, UK	"Due to its hemi-parasitic nature S. album grows best in association with, but not dominated by other tree species. Sandalwood requires a host which is neither too vigorous and out competes the tree, nor too weak so that the host is exhausted (Havel and McKinnell, 1993)."
	Staples, G.W. & Herbst, D.R. 2005. A Tropical Garden Flora - Plants Cultivated in the Hawaiian Islands and Other Tropical Places. Bishop Museum Press, Honolulu, HI	"Indian sandalwood has been found to favor diverse hosts, including herbaceous plants, grasses, and woody plants."

404	Unpalatable to grazing animals	n

Qsn #	Question	Answer
	Source(s)	**Notes**
	Orwa C,, Mutua, A., Kindt R,, Jamnadass, R, & Anthony, S. 2009 Agroforestree Database: a tree reference and selection guide version 4.0. http://www.worldagroforestry.org/sites/treedbs/treedatabases.asp. [Accessed 4 Feb 2015]	"Fodder: Trees are sometimes lopped for fodder; the foliage of S. album is palatable to grazing animals such as rabbits, sheep, goats, cattle, pigs, horses and camels."

405	Toxic to animals	n
	Source(s)	**Notes**
	Orwa C,, Mutua, A., Kindt R,, Jamnadass, R, & Anthony, S. 2009 Agroforestree Database: a tree reference and selection guide version 4.0. http://www.worldagroforestry.org/sites/treedbs/treedatabases.asp. [Accessed 4 Feb 2015]	[No evidence] "Fodder: Trees are sometimes lopped for fodder; the foliage of S. album is palatable to grazing animals such as rabbits, sheep, goats, cattle, pigs, horses and camels."

406	Host for recognized pests and pathogens	
	Source(s)	**Notes**
	CAB International, 2005. Forestry Compendium. CAB International, Wallingford, UK	"There are several pests and diseases of sandalwood (Pathak et al., 1992; Venkatesha, 1992). Sen-Sarma (1977) and Srinivasan et al. (1992) give detailed descriptions and control measures of these. The most serious and widely known disease is spike disease (Iyengar, 1960), which has not been detected outside India so far. Spike disease, caused by a phytoplasma-type organism, causes trees to produce small, stiff needle-like leaves and as a result disrupts the trees' metabolism (Iyengar, 1972a); ultimately tree death results. Iyengar (1972b), Srinivasan et al. (1992), and Luna (1996) give detailed accounts of the theories proposed in the incidence, spread and control of spike disease in India." ... An epidemic outbreak of Kerria lacca was reported on S. album and other host trees in Karnataka, India during 1994 to 1995. Nearly 24.5% of the trees were heavily infested, 28.5% had medium attack and 50% were pest-free. The removal and burning of affected branches, and the use of insecticide sprays proved effective control measures (Sivaramakrishnan and Remadevi, 1996). The attack of arboreal termites Odontotermes spp. leads to loss of bark, poor health, and infestation of stem-boring insects (Remadevi et al., 1998c). Infestation is higher in the winter and the use of chloropyrifos gave adequate protection. The main sap-sucking insects belonging to the family Coccidae are Saissetia sp., Inglisia bivalvata, Ceroplastes ceriferus and K. lacca. These are crucial because they are deleterious to the normal health, growth and reproduction of S. album (Ramadevi et al., 1998a, b)."
	Orwa C,, Mutua, A., Kindt R,, Jamnadass, R, & Anthony, S. 2009 Agroforestree Database: a tree reference and selection guide version 4.0. http://www.worldagroforestry.org/sites/treedbs/treedatabases.asp. [Accessed 4 Feb 2015]	[Possible that S. album could host pests or pathogens that could affect native Santalum species] "Spike disease that shortens the internodes, reduces the leaf size, kills haustoria, blocks vascular tissue and eventually kills trees, is a serious pathogen in India. Nursery pests include pathogenic fungi, Fusarium and Phytophthora and nematodes. A wide range of insect pests is reported on this species in India."

Qsn #	Question	Answer
407	**Causes allergies or is otherwise toxic to humans**	**n**
	Source(s)	**Notes**
	Burdock, G. A., & Carabin, I. G. 2008. Safety assessment of sandalwood oil (Santalum album L.). Food and Chemical Toxicology, 46(2): 421-432	"Sandalwood (Santalum album L.) is a fragrant wood from which oil is derived for use in food and cosmetics. Sandalwood oil is used in the food industry as a flavor ingredient with a daily consumption of 0.0074 mg/kg. Over 100 constituents have been identified in sandalwood oil with the major constituent being a-santalol. Sandalwood oil and its major constituent have low acute oral and dermal toxicity in laboratory animals. Sandalwood oil was not mutagenic in spore Rec assay and was found to have anticarcinogenic, antiviral and bactericidal activity. Occasional cases of irritation or sensitization reactions to sandalwood oil in humans are reported in the literature. Although the available information on toxicity of sandalwood oil is limited, it has a long history of oral use without any reported adverse effects and is considered safe at present use levels."
	CAB International, 2005. Forestry Compendium. CAB International, Wallingford, UK	[No evidence] "Sandalwood oil is extensively used in the perfumery and cosmetics industries." ... "Some villagers use fresh bark as a substitute for betel-nuts (Gupta, 1993). Leaves are used for fodder and green manure." ... "Fruits and kernels are edible and may have potential as a horticultural crop until mature trees are harvested (Barrett, 1989)."

408	**Creates a fire hazard in natural ecosystems**	
	Source(s)	**Notes**
	CAB International, 2005. Forestry Compendium. CAB International, Wallingford, UK	"In India the natural distribution of S. album is mainly in the dry deciduous forests of the Deccan Plateau," [Unlikely to increase fire risk on its own, but could grow in fire prone areas and increase fuel load]

409	**Is a shade tolerant plant at some stage of its life cycle**	**y**
	Source(s)	**Notes**
	CAB International, 2005. Forestry Compendium. CAB International, Wallingford, UK	"A tree to 15-18 m in height, typically with a straight stem and a high bushy crown when grown in dense shade." ...
	Orwa C,, Mutua, A., Kindt R,, Jamnadass, R, & Anthony, S. 2009 Agroforestree Database: a tree reference and selection guide version 4.0. http://www.worldagroforestry.org/sites/treedbs/treedatabases.asp. [Accessed 4 Feb 2015]	"It is a partial parasite that attaches to the roots of other trees, it needs 'nurse' species in the area of planting out. Host plants that fix nitrogen and provide light shade are preferred."

Qsn #	Question	Answer
	Barrett, D. R., & Fox, J. E. D. (1994). Early growth of Santalum album in relation to shade. Australian Journal of Botany, 42(1), 83-93	"Morphological features of the hemi-parasite Santalum album Linn. (Indian sandalwood) were examined on tree seedlings raised under different shade treatments. Treatment levels were full sun and 32, 50, 70 and 8 0 8 shade. The level of shade significantly affected many morphological characteristics. Leaf area was least in full sun and greater under all shade levels. Leaves were thlcker, shorter and narrower in full sun than in 80% shade. Leaf length/width ratio was greater when shade exceeded 50%. Petioles were shorter in 50% and more shade. Leaves in 80% shade had more chlorophyll and were of greater weight. Stomata1 numbers were higher and internodes longer in 80% shade than in full sun. None of the following showed significant differences: plant heights, leaf numbers, crown widths and stem diameters. Chlorophyll concentrations are within the range of those possessed by non-parasitic land plants. On balance 808 shade plants had adaptive attributes more favourable to growth than plants from less shade. Survival was least in full sun."

410	**Tolerates a wide range of soil conditions (or limestone conditions if not a volcanic island)**	**y**
	Source(s)	**Notes**
	CAB International, 2005. Forestry Compendium. CAB International, Wallingford, UK	"Site specificity of S. album is highly variable (Jain, 1968), and it is capable of growing on a range of soil types from laterite, loam, sand, clay and black cotton soils. The most common soil type in India is the red ferruginous loam, with underlying gneiss (Luna, 1996). The red ferruginous loam nutrient status is poor (Rangaswamy et al., 1986a). It is able to tolerate soils with a pH up to 9.0 but is unable to tolerate waterlogged sites." ... "- Soil texture: light; medium; heavy" ... "- Soil reaction: neutral; alkaline" ... "- Soil types: alfisols; alkaline soils; vertisols; clay soils; granite soils; red soils; sandy soils"

411	**Climbing or smothering growth habit**	**n**
	Source(s)	**Notes**
	CAB International, 2005. Forestry Compendium. CAB International, Wallingford, UK	"A tree to 15-18 m in height, typically with a straight stem and a high bushy crown when grown in dense shade. It is evergreen, with slender drooping branchlets. Bark reddish-brown to dark brown, smooth in young trees, rough and fissured in older trees (Luna, 1996)."

Qsn #	Question	Answer
412	**Forms dense thickets**	**n**
	Source(s)	**Notes**
	Orwa C,, Mutua, A., Kindt R,, Jamnadass, R, & Anthony, S. 2009 Agroforestree Database: a tree reference and selection guide version 4.0. http://www.worldagroforestry.org/sites/treedbs/treedatabases.asp. [Accessed 4 Feb 2015]	[No evidence] "The principal sandal tracts are most parts of Karnataka and adjoining districts of Maharashtra, Tamil Nadu and Andhra Pradesh in India. The species is mostly found in dry deciduous and scrub forests in this region. The vegetation type is a typical monsoon vine thicket growing on pure sand. It has been recorded on coastal sand dunes immediately above the normal high water mark and close to the mangroves."
	CAB International, 2005. Forestry Compendium. CAB International, Wallingford, UK	No evidence

501	Aquatic	n
	Source(s)	**Notes**
	Orwa C,, Mutua, A., Kindt R,, Jamnadass, R, & Anthony, S. 2009 Agroforestree Database: a tree reference and selection guide version 4.0. http://www.worldagroforestry.org/sites/treedbs/treedatabases.asp. [Accessed 4 Feb 2015]	[Terrestrial Tree] "The species is mostly found in dry deciduous and scrub forests in this region. The vegetation type is a typical monsoon vine thicket growing on pure sand. It has been recorded on coastal sand dunes immediately above the normal high water mark and close to the mangroves. It also grows on low lateritic cliffs above the beach."

502	Grass	n
	Source(s)	**Notes**
	Wagner, W.L., Herbst, D.R.& Sohmer, S.H. 1999. Manual of the flowering plants of Hawaii. Revised edition. University of Hawai'i Press and Bishop Museum Press, Honolulu, HI.	Santalaceae

503	Nitrogen fixing woody plant	n
	Source(s)	**Notes**
	CAB International, 2005. Forestry Compendium. CAB International, Wallingford, UK	"Under natural conditions S. album preferentially parasitizes nitrogen-fixing species (Rai, 1990). Under plantation conditions S. album growth is greater when parasitising leguminous species than non-leguminous species (Radomiljac et al., 1998c)." [Santalaceae]

504	Geophyte (herbaceous with underground storage organs -- bulbs, corms, or tubers)	n
	Source(s)	**Notes**
	CAB International, 2005. Forestry Compendium. CAB International, Wallingford, UK	"A tree to 15-18 m in height, typically with a straight stem and a high bushy crown when grown in dense shade. It is evergreen, with slender drooping branchlets. Bark reddish-brown to dark brown, smooth in young trees, rough and fissured in older trees (Luna, 1996)."

601	Evidence of substantial reproductive failure in native habitat	

Qsn #	Question	Answer
	Source(s)	**Notes**
	Asian Regional Workshop (Conservation & Sustainable Management of Trees, Viet Nam, August 1996) 1998. Santalum album. The IUCN Red List of Threatened Species. Version 2014.3. www.iucnredlist.org	[Possibly. Vulnerable in native range due to overexploitation] "Red List Category & Criteria: Vulnerable A1d ver 2.3" ... "Fire, grazing and most importantly exploitation of the wood for fine furniture and carving and also oil are threatening the species. Smuggling has assumed alarming proportions."

602	Produces viable seed	y
	Source(s)	**Notes**
	Staples, G.W. & Herbst, D.R. 2005. A Tropical Garden Flora - Plants Cultivated in the Hawaiian Islands and Other Tropical Places. Bishop Museum Press, Honolulu, HI	"It is easily propagated by seed, but the seedlings should be planted in the ground at an early age to ensure that their roots contact those of a host."
	CAB International, 2005. Forestry Compendium. CAB International, Wallingford, UK	"Seed germination has been extensively studied (Ovcharov, 1977; Nagaveni and Srimathi, 1981; 1985; Nagaveni and Ananthapadmanabha, 1986; Ananthapadmanabha et al., 1986; 1988b; Nagaveni et al., 1989; Brand et al., 1993; Fox et al., 1995a). In India direct sowing seeds under potential hosts plants is commonly practised (Rai and Kulkarni, 1986). "

603	Hybridizes naturally	y
	Source(s)	**Notes**
	Rugkhla, A., McComb, J. A., & Jones, M. G. K. 1997. Intra- and inter specific pollination of Santalum spicatum and S. album. Australian Journal of Botany, 45(6): 1083-1095	"Hybridisation between S. album and S. spicatum is difficult because of strong incompatibility barriers. Attempts to produce mature inter-specific hybrid fruit were unsuccessful, probably as a result of genetic barriers as well as physiological factors causing flower and immature fruit abscission, which also occurred in intra-specific crosses."
	Wagner, W.L., Herbst, D.R.& Sohmer, S.H. 1999. Manual of the flowering plants of Hawaii. Revised edition. University of Hawai'i Press and Bishop Museum Press, Honolulu, HI.	"Hybrids obtained between S. album and S. freycinetianum are currently being grown at Lyon Arboretum."
	Lau, J. 2013. Santalum album x ellipticum. Photo Taken on March 5, 2013. https://www.flickr.com/photos/53193377@N02/13184943924/in/set 72157642417629345. [Accessed 4 Feb 2015]	"The naturalized alien sandalwood S. album has been hybridizing with the native Hawaiian endemic S. ellipticum on Le`ahi (Diamond Head) for perhaps the last five decades. At the Le`ahi occurrence of S. ellipticum I am familiar with, which is on the northern side of the outer slope of Le`ahi on the upslope side of the main access road into Le`ahi Crater, plants that look like pure S. ellipticum are now far outnumbered by the S. album x S. ellipticum hybrids."
	Thomson, L.A.J. 2006. Santalum austrocaledonicum and S. yasi (sandalwood), ver. 2.1. In: Elevitch, C.R. (ed.). Species Profiles for Pacific Island Agroforestry. Permanent Agriculture Resources (PAR), Hōlualoa, Hawai'i. http://www.traditionaltree.org. [Accessed]	"The species is in the process of becoming naturalized near old trial plots in northwest Viti Levu, Fiji, and has naturally hybridized with S. yasi where the two species have been planted together."

604	Self-compatible or apomictic	n
	Source(s)	**Notes**

Qsn #	Question	Answer
	CAB International, 2005. Forestry Compendium. CAB International, Wallingford, UK	"Although the flower structure is designed for self-pollination S. album is a predominantly outbreeding species (Bagchi and Veerendra, 1987; Bhaskar, 1992; Jyothi et al., 1991; Rugkhla et al., 1997)."
	Rugkhla, A., McComb, J. A., & Jones, M. G. K. 1997. Intra- and inter specific pollination of Santalum spicatum and S. album. Australian Journal of Botany, 45(6): 1083-1095	"The results indicated that pre- and post-fertilisation mechanisms control self-incompatibility and inter-specific incompatibility between the sandalwood species." ... "Analysis of pollen tube growth and fruit set indicates that both S. spicatum and S. album are obligate out-crossing species." ... "Gene-controlled self-incompatibility in sandalwood seemed to be expressed at many levels to encourage outbreeding success."

605	Requires specialist pollinators	n
	Source(s)	**Notes**
	CAB International, 2005. Forestry Compendium. CAB International, Wallingford, UK	"Pollinating agents are bees, butterflies and beetles (Veerendra and Padmanabha, 1996)."

606	Reproduction by vegetative fragmentation	y
	Source(s)	**Notes**
	CAB International, 2005. Forestry Compendium. CAB International, Wallingford, UK	[Produces root suckers] "Natural regeneration can be profuse, through both seed germination and root-suckers, if there are suitable host plants present, there is a low incidence of vigorous weed species, lateral shading is provided from hosts, protection from grazing and fire, provision for expansion of the crown and limited water stress (Gupta, 1993; Luna, 1996)."

607	Minimum generative time (years)	2
	Source(s)	**Notes**
	CAB International, 2005. Forestry Compendium. CAB International, Wallingford, UK	"Fruiting begins around 2 to 3 years of age."
	Staples, G.W. & Herbst, D.R. 2005. A Tropical Garden Flora - Plants Cultivated in the Hawaiian Islands and Other Tropical Places. Bishop Museum Press, Honolulu, HI	"Santalum album grows faster than the natives, reaching 25' in height."
	Orwa C,, Mutua, A., Kindt R,, Jamnadass, R, & Anthony, S. 2009 Agroforestree Database: a tree reference and selection guide version 4.0. http://www.worldagroforestry.org/sites/treedbs/treedatabases.asp. [Accessed 4 Feb 2015]	"Viable seed production occurs when the tree is 5 years old."

701	Propagules likely to be dispersed unintentionally (plants growing in heavily trafficked areas)	n
	Source(s)	**Notes**
	CAB International, 2005. Forestry Compendium. CAB International, Wallingford, UK	"The drupe is 7 to 8 mm in diameter. The mesocarp is creamy yellow, endocarp more or less spherical, up to about 6 to 8 mm diameter and smooth." [No evidence, and no means of external attachment]

Qsn #	Question	Answer
702	**Propagules dispersed intentionally by people**	**y**
	Source(s)	**Notes**
	Staples, G.W. & Herbst, D.R. 2005. A Tropical Garden Flora - Plants Cultivated in the Hawaiian Islands and Other Tropical Places. Bishop Museum Press, Honolulu, HI	"...the only species of Santalum likely to be encountered in gardens is Indian sandalwood; it is grownin a few private gardens, on older estates, or on public property surrounding schools or public buildings, as well as in botanical gardens."
	Neal, M.C. 1965. In Gardens of Hawaii. Bishop Museum Press, Honolulu, HI	"This species was introduced to Hawaii from India by the Hawaiian Board of Agriculture and Forestry, who, in 1932, planted more than 1,000 seedlings, setting them out near host trees of koa and casuarina. Because they have since thrived and have even grown much faster than Hawaiian sandalwoods, it has been suggested that the sandalwood trade might be revived by raising more of the Indian trees."

703	**Propagules likely to disperse as a produce contaminant**	**n**
	Source(s)	**Notes**
	CAB International, 2005. Forestry Compendium. CAB International, Wallingford, UK	"The drupe is 7 to 8 mm in diameter. The mesocarp is creamy yellow, endocarp more or less spherical, up to about 6 to 8 mm diameter and smooth." [Unlikely. Fruit/seed relatively large]

704	**Propagules adapted to wind dispersal**	**n**
	Source(s)	**Notes**
	CAB International, 2005. Forestry Compendium. CAB International, Wallingford, UK	[No adaptations for wind dispersal] "Drupe globose, the size of a small cherry, dark red, purple to black when ripe, single-seeded (Doran and Turnbull, 1997). Fruiting begins around 2 to 3 years of age. The drupe is 7 to 8 mm in diameter. The mesocarp is creamy yellow, endocarp more or less spherical, up to about 6 to 8 mm diameter and smooth. The kernel is firm and white (Barrett and Fox, 1995)."

705	**Propagules water dispersed**	**n**
	Source(s)	**Notes**
	CAB International, 2005. Forestry Compendium. CAB International, Wallingford, UK	[No evidence, and unlikely. Adapted for bird dispersal, and occurs in dry habitats] "The drupe is 7 to 8 mm in diameter. The mesocarp is creamy yellow, endocarp more or less spherical, up to about 6 to 8 mm diameter and smooth." ... "Natural regeneration is via bird dispersal of seeds..."

706	**Propagules bird dispersed**	**y**
	Source(s)	**Notes**

Qsn #	Question	Answer
	Balasubramanian, P., Aruna, R., Anbarasu, C., & Santhoshkumar, E. 2011. Avian frugivory and seed dispersal of Indian Sandalwood Santalum album in Tamil Nadu, India. Journal of Threatened Taxa, 3(5): 1775-1777	"A total of 217 birds belonging to eight species visited Santalum album (Table 1) in Anaikatty Hills, Western Ghats. These included three species of bulbuls, Pycnonotus sp., Brahminy Starling Sturnus pagodarum, Common Myna Acridotheres tristis, Asian Koel Eudynamys scolopacea, White-headed Babbler Turdoides affinis and Small Green-Billed Malkoha Phaenicophaeus viridirostris. Highest proportion of feeding visits was contributed by Red whiskered Bulbul, Pycnonotus jocosus (20.3%) followed by White-headed Babbler (16.7%) and Asian Koel (16.3%). Among the various avian families, Pycnonotidae (bulbuls) made the majority of the visits (43.6%) followed by Sturnidae (mynas) (21.6%)."

707	Propagules dispersed by other animals (externally)	n
	Source(s)	**Notes**
	CAB International, 2005. Forestry Compendium. CAB International, Wallingford, UK	"The drupe is 7 to 8 mm in diameter. The mesocarp is creamy yellow, endocarp more or less spherical, up to about 6 to 8 mm diameter and smooth." [Unlikely. Adapted for bird dispersal, but seed predators such as rodents may cache seeds that escape predation]

708	Propagules survive passage through the gut	y
	Source(s)	**Notes**
	Balasubramanian, P., Aruna, R., Anbarasu, C., & Santhoshkumar, E. 2011. Avian frugivory and seed dispersal of Indian Sandalwood Santalum album in Tamil Nadu, India. Journal of Threatened Taxa, 3(5): 1775-1777	"Most often, bulbuls ate the fruit in piecemeal and dropped the seeds under the canopy itself. Occasionally, small fruits were swallowed by them." ... "Three-striped Palm Squirrel Funambulus palmarum also visited the plant to eat fruit. While koel and myna consumed the whole fruit, parakeets ate the seeds. Three-striped Squirrel ate the pulp and dropped the seeds." ... "Birds that are beneficial to sandalwood dispersal and regeneration were Koel, Common Myna, Brahminy Starling, Brown-headed Barbet, White-headed Babbler and Indian Grey Hornbill. These species visited the fruit crop more frequently and swallowed the fruit wholly. Hence, these species could be considered as major seed dispersers."

801	Prolific seed production (>1000/m2)	n
	Source(s)	**Notes**
	CAB International, 2005. Forestry Compendium. CAB International, Wallingford, UK	"Drupe globose, the size of a small cherry, dark red, purple to black when ripe, single-seeded (Doran and Turnbull, 1997)." ... "The drupe is 7 to 8 mm in diameter. The mesocarp is creamy yellow, endocarp more or less spherical, up to about 6 to 8 mm diameter and smooth." [Unlikely. Single-seeded, & relatively large]

802	Evidence that a persistent propagule bank is formed (>1 yr)	
	Source(s)	**Notes**

Qsn #	Question	Answer
	Orwa C,, Mutua, A., Kindt R,, Jamnadass, R, & Anthony, S. 2009 Agroforestree Database: a tree reference and selection guide version 4.0. http://www.worldagroforestry.org/sites/treedbs/treedatabases.asp. [Accessed 4 Feb 2015]	[Unknown under field conditions] "Seed storage behaviour is orthodox; no loss in viability after 2 years storage at room temperature (seed longevity declines rapidly at room temperature); viability is reduced from 90- 15% after 3 years storage at 7 deg. C with 30-45% r.h. Seeds tolerate desiccation to 2% mc, and no loss in viability is observed after 16 months hermetic storage at 4 deg. C with 3-10% mc."

803	Well controlled by herbicides	
	Source(s)	**Notes**
	WRA Specialist. 2015. Personal Communication	Unknown. Regarded as a valuable species where grown, with no information on herbicide efficacy or chemical control.

804	Tolerates, or benefits from, mutilation, cultivation, or fire	
	Source(s)	**Notes**
	Thomson, L.A.J. 2006. Santalum austrocaledonicum and S. yasi (sandalwood), ver. 2.1. In: Elevitch, C.R. (ed.). Species Profiles for Pacific Island Agroforestry. Permanent Agriculture Resources (PAR), Hōlualoa, Hawai'i. http://www.traditionaltree.org. [Accessed]	"Plants of some sandalwood species will regrow from coppice following fire; e.g., S. austrocaledonicum and younger specimens of S. album."
	CAB International, 2005. Forestry Compendium. CAB International, Wallingford, UK	[Coppices at a young age. Intolerant of fire and grazing] "S. album has good coppicing ability at an early age, however this capacity decreases with increasing age. Young trees are sensitive to fire (Singh, 1995) and grazing animals (Doran and Turnbull, 1997)."

805	Effective natural enemies present locally (e.g. introduced biocontrol agents)	
	Source(s)	**Notes**
	Frohlich, D. & Lau, A. 2008. New plant records from O'ahu for 2007. Bishop Museum Occasional Papers 100: 3-12	[Unknown, but plants in the Hawaiian Islands do not appear to be affected by any natural enemies] "Skolmen (1980) reports over 7500 plantings of Santalum album throughout O'ahu's forest reserves. It was perhaps originally planted in the Diamond Head area, but recently was observed in all size classes and thoroughly established in an abandoned parking area and other empty lots on the mauka slopes surrounding the crater."

Summary of Risk Traits:

High Risk / Undesirable Traits
• Elevation range exceeds 1000 m, demonstrating environmental versatility
• Thrives in tropical climates
• Naturalized on Oahu, Hawaiian Islands, and naturalizing in Florida, and Viti Levu, Fiji
• Hemi-parasite
• Could act as a host of pests or pathogens that might affect native Santalum species
• Shade-tolerant
• Tolerates many soil types
• Produces viable seeds
• Hybridizes with Santalum ellipticum in the Hawaiian Islands and S. yasi in Fiji. Could potentially hybridize & threaten the genetic integrity of other Santalum species
• Unspecialized pollinator requirements
• Able to reach maturity in 2+ years
• Spreads vegetatively through root-suckers
• Seeds dispersed by birds & intentionally by people
• Orthodox seeds able to be stored for extended periods; May form a persistent seed bank
• Younger trees able to coppice & resprout after cutting

Low Risk Traits
• Unarmed (no spines, thorns or burrs)
• Provides fodder for livestock (palatable to a variety of animals)
• Ornamental, medicinal, and cultural uses
• Predominantly outbreeding & largely self-incompatible
•

Second Screening Results for Tree/tree-like shrubs

(A) Shade tolerant or known to form dense stands?> Yes. Shade-tolerant. Not reported to form dense stands in native or introduced range
(B) Bird-dispersed?> Dispersed by birds (e.g. bulbuls & mynas)
(C) Life cycle <4 years? Yes. Able to reach maturity in as little as two years
Outcome = Reject (High Risk)