Taxon: Aquilaria crassna Pierre ex Lecomte **Family:** Thymelaeaceae

Common Name(s): agarwood
aloeswood
eaglewood

Synonym(s):

Assessor: Chuck Chimera **Status:** Assessor Approved **End Date:** 26 Sep 2020

WRA Score: -1.0 **Designation:** L **Rating:** Low Risk

Keywords: Tropical Tree, Endangered, Unarmed, Self-Fertile, Coppices

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	n
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	?
301	Naturalized beyond native range	y = 1*multiplier (see Appendix 2), n= question 205	n
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		
403	Parasitic	y=1, n=0	n
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	y=1, n=0	n
409	Is a shade tolerant plant at some stage of its life cycle		

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	n
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		
604	Self-compatible or apomictic	y=1, n=-1	y
605	Requires specialist pollinators	y=-1, n=0	n
606	Reproduction by vegetative fragmentation	y=1, n=-1	n
607	Minimum generative time (years)	1 year = 1, 2 or 3 years = 0, 4+ years = -1	>3
701	Propagules likely to be dispersed unintentionally (plants growing in heavily trafficked areas)	y=1, n=-1	n
702	Propagules dispersed intentionally by people		
703	Propagules likely to disperse as a produce contaminant	y=1, n=-1	n
704	Propagules adapted to wind dispersal	y=1, n=-1	y
705	Propagules water dispersed		
706	Propagules bird dispersed		
707	Propagules dispersed by other animals (externally)		
708	Propagules survive passage through the gut		
801	Prolific seed production (>1000/m2)	y=1, n=-1	y
802	Evidence that a persistent propagule bank is formed (>1 yr)	y=1, n=-1	n
803	Well controlled by herbicides		
804	Tolerates, or benefits from, mutilation, cultivation, or fire	y=1, n=-1	y
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**
	Jensen, A. (2004). Domestication of Aquilaria spp. and rural poverty–socio-economic and genetic aspects of the planting boom. In Wood of the Gods "," Pp. 233-239 in Poverty Reduction and Shifting Cultivation Stabilization in the Uplands of Lao PDR: Technologies, Approaches and Methods for Improving Upland Livelihoods—Proceedings of a Workshop held in Luang Prabang, Lao PDR	[Here, domestication refers to forest cultivation, but there is no evidence that trees have been significantly altered from the wild types] "Aquilaria spp. or may khedsana has been planted in all parts of the Lao PDR over the past three to four years and is, like other NTFP species, as well as teak and eucalyptus, now a plantation species. The planting boom covers all levels of domestication: 1. forest domestication; 2. single-tree planting; 3. agroforestry; 4. woodlots; and 5. plantation establishment, and is solely fueled by an increasing trade demand for agarwood, a resinous wood decay found in Aquilaria trees from natural forests. If plantings become successful, i.e. agarwood is formed in plantation-grown trees, this will have a significant socio-economic impact in rural areas. Due to excessive and indiscriminate harvesting over the past 40 years, the main species found, Aquilaria crassna, is critically endangered and is of high conservation priority. This paper briefly describes the process of natural and artificial agarwood formation and discusses the First International Agarwood Conference held from 10 - 15 November 2003 in Ho Chi Minh City, Vietnam."

102	**Has the species become naturalized where grown?**	
	Source(s)	**Notes**
	WRA Specialist. (2020). Personal Communication	NA

103	**Does the species have weedy races?**	
	Source(s)	**Notes**
	WRA Specialist. (2020). 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**
	Source(s)	**Notes**
	USDA, Agricultural Research Service, National Plant Germplasm System. (2020). Germplasm Resources Information Network (GRIN-Taxonomy). National Germplasm Resources Laboratory, Beltsville, Maryland. https://npgsweb.ars-grin.gov/. [Accessed 23 Sep 2020]	"Native Asia-Tropical INDO-CHINA: Cambodia, Thailand, Vietnam"

Qsn #	Question	Answer
202	**Quality of climate match data**	**High**
	Source(s)	**Notes**
	USDA, Agricultural Research Service, National Plant Germplasm System. (2020). Germplasm Resources Information Network (GRIN-Taxonomy). National Germplasm Resources Laboratory, Beltsville, Maryland. https://npgsweb.ars-grin.gov/. [Accessed 23 Sep 2020]	

203	**Broad climate suitability (environmental versatility)**	**n**
	Source(s)	**Notes**
	Plants for a Future. (2020). Aquilaria crassna. https://pfaf.org. [Accessed 25 Sep 2020]	"USDA hardiness 10-12"
	Oyen, L.P.A & Dung, N. X. (eds.). (1999). Plant Resources of South-East Asia 19, Essential-oil Plants. Prosea Foundation, Bogor, Indonesia	[Occurs in a narrow elevation band in tropical latitudes] "A. crassna occurs scattered in closed forest on rocky soil at 300-900 m altitude."

204	**Native or naturalized in regions with tropical or subtropical climates**	**y**
	Source(s)	**Notes**
	USDA, Agricultural Research Service, National Plant Germplasm System. (2020). Germplasm Resources Information Network (GRIN-Taxonomy). National Germplasm Resources Laboratory, Beltsville, Maryland. https://npgsweb.ars-grin.gov/. [Accessed 24 Sep 2020]	"Native Asia-Tropical INDO-CHINA: Cambodia, Thailand, Vietnam"
	Imada, C. (2019). Hawaiian Naturalized Vascular Plants Checklist (February 2019 update). Bishop Museum Technical Report 69. Bishop Museum, Honolulu, HI	No evidence
	Randall, R.P. (2017). A Global Compendium of Weeds. 3rd Edition. Perth, Western Australia. R.P. Randall	No evidence

Qsn #	Question	Answer
205	**Does the species have a history of repeated introductions outside its natural range?**	**?**
	Source(s)	**Notes**
	Tropical Plants Database, Ken Fern. (2020). Aquilaria crassna. http://tropical.theferns.info/viewtropical.php?id=Aquilaria+crassna. [Accessed 25 Sep 2020]	"Commonly harvested from the wild, it is also to some extent cultivated; it is frequently planted around temples, houses and home gardens, whilst large scale industrial plantations have been initiated in Vietnam[325]."
	Oyen, L.P.A & Dung, N. X. (eds.). (1999). Plant Resources of South-East Asia 19, Essential-oil Plants. Prosea Foundation, Bogor, Indonesia	"Distribution Cambodia, Thailand and Vietnam." … "Because agar wood is extremely expensive A crassna is overexploited in the natural forests and endangered by extinction."
	Syazwan, S. A., Lee, S. Y., Ong, S. P., & Mohamed, R. (2019). Damaging Insect Pests and Diseases and Their Threats to Agarwood Tree Plantations. Sains Malaysiana, 48(3), 497-507	[Australia] "Agarwood cultivation has become such an attractive industry that it was introduced out of its native geographical region into countries such as Australia in 2010 (López-Sampson et al. 2017). The more commonly planted species in these countries are A. crassna, Aquilaria malaccensis, and Aquilaria sinensis,"
	WRA Specialist. (2020). Personal Communication	Primarily cultivated within native range

301	Naturalized beyond native range	n
	Source(s)	**Notes**
	Imada, C. (2019). Hawaiian Naturalized Vascular Plants Checklist (February 2019 update). Bishop Museum Technical Report 69. Bishop Museum, Honolulu, HI	No evidence
	Randall, R.P. (2017). A Global Compendium of Weeds. 3rd Edition. Perth, Western Australia. R.P. Randall	No evidence

302	Garden/amenity/disturbance weed	n
	Source(s)	**Notes**
	Randall, R.P. (2017). A Global Compendium of Weeds. 3rd Edition. Perth, Western Australia. R.P. Randall	No evidence

303	Agricultural/forestry/horticultural weed	n
	Source(s)	**Notes**
	Randall, R.P. (2017). A Global Compendium of Weeds. 3rd Edition. Perth, Western Australia. R.P. Randall	No evidence

304	Environmental weed	n
	Source(s)	**Notes**
	Randall, R.P. (2017). A Global Compendium of Weeds. 3rd Edition. Perth, Western Australia. R.P. Randall	No evidence

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

Qsn #	Question	Answer
	Randall, R.P. (2017). A Global Compendium of Weeds. 3rd Edition. Perth, Western Australia. R.P. Randall	[Naturalized] "Aquilaria sinensis (Lour.) Spreng. Thymelaeaceae Total N° of Refs: 1 Origin: E Asia Major Pathway/s: Herbal, Ornamental Dispersed by: Humans References: China-N-1374."

401	Produces spines, thorns or burrs	n
	Source(s)	**Notes**
	Oyen, L.P.A & Dung, N. X. (eds.). (1999). Plant Resources of South-East Asia 19, Essential-oil Plants. Prosea Foundation, Bogor, Indonesia	[No evidence] "Tree, 15-30 m tall, with a straight, grey trunk up to 1 m in diameter. Leaves alternate; petiole 4-5 mm long; blade elliptical-lanceolate, 8--12.5 cm x 3.5--5.5 cm, with swollen marginal vein. Inflorescence an axillary umbel; flowers yellow, fine-haired; pedicel up to 1 cm long; floral tube campanulate, about 4 mm long; calyx lobes 5, ovate, accrescent, 12---15 mm x 11-12 mm, with 10 small petaloid appendages; stamens 10 in two whorls; pistil with 1 mm long style and blackish, globose stigma."

402	Allelopathic	
	Source(s)	**Notes**
	Mohamed, R. (Ed.). (2016). Agarwood: Science Behind the Fragrance. Springer, Singapore	Unknown. No evidence found

403	Parasitic	n
	Source(s)	**Notes**
	Oyen, L.P.A & Dung, N. X. (eds.). (1999). Plant Resources of South-East Asia 19, Essential-oil Plants. Prosea Foundation, Bogor, Indonesia	"Tree, 15-30 m tall, with a straight, grey trunk up to 1 m in diameter.' [No evidence]

404	Unpalatable to grazing animals	n
	Source(s)	**Notes**
	Tan, C. S., Isa, N. M., Ismail, I., & Zainal, Z. (2019). Agarwood induction: current developments and future perspectives. Frontiers in Plant Science, 10, 122: doi: 10.3389/fpls.2019.00122	"Naturally, agarwood formation is often linked to the physical wounding or damage of Aquilaria trees caused by thunder strike, animal grazing, pest and disease infestations"
	Zhang, L., Brockelman, W. Y., & Allen, M. A. (2008). Matrix analysis to evaluate sustainability: The tropical tree Aquilaria crassna, a heavily poached source of agarwood. Biological Conservation, 14 (6), 1676-1686	"This is likely to be due to grazing or predation by deer and other herbivores, which we suspect varies greatly among trees in response to density."

405	Toxic to animals	n
	Source(s)	**Notes**

Qsn #	Question	Answer
	Plants for a Future. (2020). Aquilaria crassna. https://pfaf.org. [Accessed 25 Sep 2020]	"Known Hazards None known"
	Tropical Plants Database, Ken Fern. (2020). Aquilaria crassna. http://tropical.theferns.info/viewtropical.php?id=Aquilaria+crassna. [Accessed 25 Sep 2020]	"Known Hazards None known"
	Quattrocchi, U. 2012. CRC World Dictionary of Medicinal and Poisonous Plants: Common Names, Scientific Names, Eponyms, Synonyms, and Etymology. CRC Press, Boca Raton, FL	No evidence

406	Host for recognized pests and pathogens	
	Source(s)	**Notes**
	Syazwan, S. A., Lee, S. Y., Ong, S. P., & Mohamed, R. (2019). Damaging Insect Pests and Diseases and Their Threats to Agarwood Tree Plantations. Sains Malaysiana, 48(3), 497-507	"To date, a total of 19 insect pest species, derived from 16 different families of five different orders, have been recorded (Table 1). The majority of the insect pests (nine out of 19) are sap suckers from the order Hemiptera, followed by leaf defoliators and wood borers from the order Coleoptera and Lepidoptera (four out of 19, respectively); and one leaf defoliator and one sapsucker from order Orthoptera and Heteroptera, respectively."... "To date, a total of six categories of plant disease, consist of 12 different diseases were recorded (Table 2). While most diseases are derived from a single causal pathogen; two are caused by more than one causal pathogen, namely the damping-off disease (six causal pathogens) and the root-knot nematode disease (three causal pathogens). These diseases were reportedly found in China, India and Malaysia. Most diseases are minor; while three imposed moderate level of damage: Phytophthora root rot (root colonizing that eventually causes tissue destruction when necrotrophic), white rot disease (interrupting nutrient uptake by spreading from roots to collar region with no age preference) and root-knot nematode (killing trees without age preference, including seedlings in polybags)." [Unknown]

407	Causes allergies or is otherwise toxic to humans	n
	Source(s)	**Notes**
	Plants for a Future. (2020). Aquilaria crassna. https://pfaf.org. [Accessed 25 Sep 2020]	"Known Hazards None known"
	Tropical Plants Database, Ken Fern. (2020). Aquilaria crassna. http://tropical.theferns.info/viewtropical.php?id=Aquilaria+crassna. [Accessed 25 Sep 2020]	"Known Hazards None known"
	Quattrocchi, U. 2012. CRC World Dictionary of Medicinal and Poisonous Plants: Common Names, Scientific Names, Eponyms, Synonyms, and Etymology. CRC Press, Boca Raton, FL	No evidence

408	Creates a fire hazard in natural ecosystems	n
	Source(s)	**Notes**

Qsn #	Question	Answer
	Oyen, L.P.A & Dung, N. X. (eds.). (1999). Plant Resources of South-East Asia 19, Essential-oil Plants. Prosea Foundation, Bogor, Indonesia	[No evidence] "A. crassna occurs scattered in closed forest on rocky soil at 300-900 m altitude. It flowers in February and fruits in May. Because agar wood is extremely expensive A crassna is overexploited in the natural forests and endangered by extinction."

409	Is a shade tolerant plant at some stage of its life cycle	
	Source(s)	**Notes**
	Plants for a Future. (2020). Aquilaria crassna. https://pfaf.org. [Accessed 25 Sep 2020]	[Possibly can establish in shade, but may not do well unless light levels are increased] "Requires a sunny position according to some reports[325 , 404], whilst others say that it can tolerate some shade [404]. Young plants grow well in some shade, but require more light as they grow larger[404 , 598]."
	Page, T., & Awarau, W. (2012). Performance of agarwood (Aquilaria crassna) seedling transplants improved by shade and fertiliser. Forest Ecology and Management, 265: 258-269	[Seedlings can be grown in 50% shade] "Seedlings in the shade treatment were significantly taller than those exposed to full-sun after 60-weeks but no significant differences were found for mean basal diameter. With the exception of one treatment (fertiliser with antitranspirant) it is evident that taller seedlings with thicker stems have a greater survival after transplanting than shorter seedlings with thinner stems. This study reveals that the planting of A. crassna seedlings with mean height and stem diameter of 35 cm and 4.0 mm respectively and providing fertiliser and shade after planting can reduce transplant stress and improve survival and growth of this species. Areas requiring further research including other potential factors influencing transplant stress are explored in this report."

410	Tolerates a wide range of soil conditions (or limestone conditions if not a volcanic island)	n
	Source(s)	**Notes**
	Plants for a Future. (2020). Aquilaria crassna. https://pfaf.org. [Accessed 26 Sep 2020]	"... can grow in nutritionally poor soil. Suitable pH: acid and neutral soils and can grow in very acid soils."
	Loc, H. T., & Luu, N. D. T. (2002). Conservation and use of Aquilaria crassna in Vietnam: a case study. FORSPA Publication 31. FAO, Bangkok	"A. crassna grows on deep sandy clay soils at elevations of 300-800m."

411	Climbing or smothering growth habit	n
	Source(s)	**Notes**
	Oyen, L.P.A & Dung, N. X. (eds.). (1999). Plant Resources of South-East Asia 19, Essential-oil Plants. Prosea Foundation, Bogor, Indonesia	"Tree, 15-30 m tall, with a straight, grey trunk up to 1 m in diameter.'

Qsn #	Question	Answer
412	**Forms dense thickets**	**n**
	Source(s)	**Notes**
	Oyen, L.P.A & Dung, N. X. (eds.). (1999). Plant Resources of South-East Asia 19, Essential-oil Plants. Prosea Foundation, Bogor, Indonesia	[No evidence] "A. crassna occurs scattered in closed forest on rocky soil at 300-900 m altitude. It flowers in February and fruits in May. Because agar wood is extremely expensive A crassna is overexploited in the natural forests and endangered by extinction."

501	**Aquatic**	**n**
	Source(s)	**Notes**
	Oyen, L.P.A & Dung, N. X. (eds.). (1999). Plant Resources of South-East Asia 19, Essential-oil Plants. Prosea Foundation, Bogor, Indonesia	[Terrestrial] "A. crassna occurs scattered in closed forest on rocky soi at 300-900 m altitude."

502	**Grass**	**n**
	Source(s)	**Notes**
	USDA, Agricultural Research Service, National Plant Germplasm System. (2020). Germplasm Resources Information Network (GRIN-Taxonomy). National Germplasm Resources Laboratory, Beltsville, Maryland. https://npgsweb.ars-grin.gov/. [Accessed 23 Sep 2020]	Family: Thymelaeaceae Alternate family(ies): Aquilariaceae

503	**Nitrogen fixing woody plant**	**n**
	Source(s)	**Notes**
	USDA, Agricultural Research Service, National Plant Germplasm System. (2020). Germplasm Resources Information Network (GRIN-Taxonomy). National Germplasm Resources Laboratory, Beltsville, Maryland. https://npgsweb.ars-grin.gov/. [Accessed 23 Sep 2020]	Family: Thymelaeaceae Alternate family(ies): Aquilariaceae

504	**Geophyte (herbaceous with underground storage organs -- bulbs, corms, or tubers)**	**n**
	Source(s)	**Notes**
	Oyen, L.P.A & Dung, N. X. (eds.). (1999). Plant Resources of South-East Asia 19, Essential-oil Plants. Prosea Foundation, Bogor, Indonesia	"Tree, 15-30 m tall, with a straight, grey trunk up to 1 m in diameter.'

601	**Evidence of substantial reproductive failure in native habitat**	
	Source(s)	**Notes**
	WRA Specialist. (2020). Personal Communication	Unknown

602	**Produces viable seed**	**y**

Qsn #	Question	Answer
	Source(s)	**Notes**
	Tropical Plants Database, Ken Fern. (2020). Aquilaria crassna. http://tropical.theferns.info/viewtropical.php?id=Aquilaria+crassna. [Accessed 25 Sep 2020]	"Propagation Seed - it has a very short viability of less than 10 weeks and needs to be sown as soon as possible after harvesting[325]. No pre-treatment is required. Sow in a nursery seedbed, only just covering the seed and leaving the tail above soil level. Germination usually starts within 10 days and can be spread over one month [325]."
	Lata, A. (2007). Investigation of seed longevity and viability and cutting propagation for Aquilaria crassna. Literature Review. James Cook University, Cairns	"The fresh green fruits of A. crassna are thick with soft pericarp and when collected fresh must be dried under the shade for 4-5 days (Luu et al. 2001). As the fruits mature, they change from green to brown and open on the tree to allow the seeds to fall (Jensen 2000). The brownish-black seed is an oval shape and a diameter of 0.5- 0.8 cm (Koskela et al. 2002). The fully matured seeds can stay on the tree for up to 2 weeks (Jensen 2000). The author reported that the moisture content of a fresh seed is 49% (recalcitrant) and will desiccate further to 25% with germination of 33%. The optimum storage condition with seeds dried to 25% mc can be stored at 8 °C with germination of 22% after two months storage (Luu et al. 2001)."

603	Hybridizes naturally	
	Source(s)	**Notes**
	López-Sampson, A., & Page, T. (2019). Reproductive phenology, floral biology and breeding system of aquiliaria crassna in tropical Australia. Journal of Tropical Forest Science, 31(2), 211-221	[Possibly. Unknown if natural hybrids occur] "Hybridisation between A. crassna and A. baillonii was achieved in the controlled pollination experiments, indicating a possible lack of or incomplete reproductive barrier between them."

604	Self-compatible or apomictic	y
	Source(s)	**Notes**
	López Sampson, A. (2017). Growth physiology and productivity of cultivated Aquilaria crassna Pierre ex Lecomte (Thymelaeaceae) in tropical Australia and its reproduction biology PhD Dissertation, James Cook University, Townsville	"Hand-pollination experiments showed that A. crassna is self-compatible and that there is no pollen limitation for fruit production in its new environment."
	López-Sampson, A., & Page, T. (2019). Reproductive phenology, floral biology and breeding system of aquiliaria crassna in tropical Australia. Journal of Tropical Forest Science, 31(2), 211-221	[Possible, but with very low seed set] "None (0%) of flowers set fruit when A. crassna was tested for spontaneous self-pollination (bagged but not pollinated) and hand self-pollination in 2014. In 2015, 1.4% of fruit production was recorded in self-pollination experiments and 2.2% for hand self-pollination performed in open flowers"

605	Requires specialist pollinators	n
	Source(s)	**Notes**
	Chen, G., Liu, C., & Sun, W. (2016). Pollination and seed dispersal of Aquilaria sinensis (Lour.) Gilg (Thymelaeaceae): an economic plant species with extremely small populations in China. Plant Diversity, 38 (5), 227-232	"More than 100 insect species visited flowers of A. crassna, and Endotricha species were the most abundant and frequent visitors of A. crassna (Soehartono and Newton, 2001). The study also indicated that pollen transfer from anthers to stigma by vectors was required for fruit setting of A. crassna flowers."

Qsn #	Question	Answer
	López Sampson, A. (2017). Growth physiology and productivity of cultivated Aquilaria crassna Pierre ex Lecomte (Thymelaeaceae) in tropical Australia and its reproduction biology PhD Dissertation, James Cook University, Townsville	"Principal pollinators reported for A. crassna, A. filaria, A. malaccensis and A. microcarpa are nocturnal insects belonging to Pyralidae and Lymantridae family, also diurnal visitors have been reported belonging to Euminidae and Specidae family (Soehartono & Newton, 2001b; Tasen et al., 2009). Other insects recorded as visitors of Aquilaria flowers are bees belonging to Apidae and Halictidae families (Hymenoptera), and butterflies of the Pieridae family (Lepidoptera) (Tasen et al., 2009). Tasen et al. and Soehartono & Newton also reported that natural pollinators tended to visit the flowers mainly at night and early morning."

606	Reproduction by vegetative fragmentation	n
	Source(s)	**Notes**
	Tropical Plants Database, Ken Fern. (2020). Aquilaria crassna. http://tropical.theferns.info/viewtropical.php?id=Aquilaria+crassna. [Accessed 25 Sep 2020]	"Propagation. Seed - it has a very short viability of less than 10 weeks and needs to be sown as soon as possible after harvesting [325]. No pre-treatment is required. Sow in a nursery seedbed, only just covering the seed and leaving the tail above soil level. Germination usually starts within 10 days and can be spread over one month[325]. Root cuttings are easy if rooting hormones are used[325]. Air layering works well if rooting hormones are used [325]."

607	Minimum generative time (years)	>3
	Source(s)	**Notes**
	Lata, A. (2007). Investigation of seed longevity and viability and cutting propagation for Aquilaria crassna. Literature Review. James Cook University, Cairns	"A study in Vietnam revealed that A. crassna trees commence flowering at an age of 6-8 years, between the months of March and April with fruiting taking place between June and July (Koskela et al. 2002)."

701	Propagules likely to be dispersed unintentionally (plants growing in heavily trafficked areas)	n
	Source(s)	**Notes**
	Oyen, L.P.A & Dung, N. X. (eds.). (1999). Plant Resources of South-East Asia 19, Essential-oil Plants. Prosea Foundation, Bogor, Indonesia	"Fruit a flattened, suborbicular capsule, 3-4 cm x 3 cm, yellow-haired, opening with 2 valves. Seeds 1-2, glossy black." [No means of attachment]

702	Propagules dispersed intentionally by people	
	Source(s)	**Notes**
	WRA Specialist. (2020). Personal Communication	An endangered species regulated for import into the United States by both the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and the Endangered Species Act (ESA). Seeds could be imported with proper permits, but the introduction and dissemination of this species is limited by regulation

703	Propagules likely to disperse as a produce contaminant	n

Qsn #	Question	Answer
	Source(s)	**Notes**
	López Sampson, A. (2017). Growth physiology and productivity of cultivated Aquilaria crassna Pierre ex Lecomte (Thymelaeaceae) in tropical Australia and its reproduction biology PhD Dissertation, James Cook University, Townsville	[An endangered tree that reaches maturity in 6-8 years. No evidence, and unlikely that seeds will ever become a contaminant of produce] "Given the limited seed dispersal found for other species of Aquilaria (Soehartono & Newton, 2001b), it may be assumed that the primary method of dispersal is wind and gravity. In a sub-montane rain forest in the Philippines it was found that fruit dispersed by the effect of wind or gravity had largest period of fruiting matching with season of heavy rain (typhoon season) (Hamann, 2004)."

704	Propagules adapted to wind dispersal	y
	Source(s)	**Notes**
	Oyen, L.P.A & Dung, N. X. (eds.). (1999). Plant Resources of South-East Asia 19, Essential-oil Plants. Prosea Foundation, Bogor, Indonesia	"Fruit a flattened, suborbicular capsule, 3-4 cm x 3 cm, yellow-haired, opening with 2 valves. Seeds 1-2, glossy black."
	López Sampson, A. (2017). Growth physiology and productivity of cultivated Aquilaria crassna Pierre ex Lecomte (Thymelaeaceae) in tropical Australia and its reproduction biology PhD Dissertation, James Cook University, Townsville	"Given the limited seed dispersal found for other species of Aquilaria (Soehartono & Newton, 2001b), it may be assumed that the primary method of dispersal is wind and gravity. In a sub-montane rain forest in the Philippines it was found that fruit dispersed by the effect of wind or gravity had largest period of fruiting matching with season of heavy rain (typhoon season) (Hamann, 2004)."

705	Propagules water dispersed	
	Source(s)	**Notes**
	López Sampson, A. (2017). Growth physiology and productivity of cultivated Aquilaria crassna Pierre ex Lecomte (Thymelaeaceae) in tropical Australia and its reproduction biology PhD Dissertation, James Cook University, Townsville	[Possibly if growing in riparian habitats] "Given the limited seed dispersal found for other species of Aquilaria (Soehartono & Newton, 2001b), it may be assumed that the primary method of dispersal is wind and gravity. In a sub-montane rain forest in the Philippines it was found that fruit dispersed by the effect of wind or gravity had largest period of fruiting matching with season of heavy rain (typhoon season) (Hamann, 2004)."
	Tropical Plants Database, Ken Fern. (2020). Aquilaria crassna. http://tropical.theferns.info/viewtropical.php?id=Aquilaria+crassna. [Accessed 26 Sep 2020]	[Possibly] "Scattered in primary and secondary forests on rocky, shallow ferralitic soil, often along the sides of streams, at elevations up to 1,000 metres[325, 598]"

706	Propagules bird dispersed	
	Source(s)	**Notes**
	Zhang, L., Brockelman, W. Y., & Allen, M. A. (2008). Matrix analysis to evaluate sustainability: The tropical tree Aquilaria crassna, a heavily poached source of agarwood. Biological Conservation, 14 (6), 1676-1686	[Possibly yes] "The clumping of adult trees is likely to be partly due to the low dispersal distance. No animal dispersers were observed although it was suspected that birds are the most important agent for long-distance dispersal – the seeds are too fragile to be stored by squirrels."

Qsn #	Question	Answer
	López Sampson, A. (2017). Growth physiology and productivity of cultivated Aquilaria crassna Pierre ex Lecomte (Thymelaeaceae) in tropical Australia and its reproduction biology PhD Dissertation, James Cook University, Townsville	[Presence of an aril may attract bird dispersers. No direct evidence] "Given the limited seed dispersal found for other species of Aquilaria (Soehartono & Newton, 2001b), it may be assumed that the primary method of dispersal is wind and gravity. In a sub-montane rain forest in the Philippines it was found that fruit dispersed by the effect of wind or gravity had largest period of fruiting matching with season of heavy rain (typhoon season) (Hamann, 2004). Observations made during this study of different insects (ants, beetles and cockroaches) consuming and fungi growing from (during periods of high humidity) the seed's fleshy aril suggest it may be energy rich and have a possible role in seed dispersal."

707	Propagules dispersed by other animals (externally)	
	Source(s)	**Notes**
	López Sampson, A. (2017). Growth physiology and productivity of cultivated Aquilaria crassna Pierre ex Lecomte (Thymelaeaceae) in tropical Australia and its reproduction biology PhD Dissertation, James Cook University, Townsville	[Unknown. Aril may possibly contribute to external dispersal] "Given the limited seed dispersal found for other species of Aquilaria (Soehartono & Newton, 2001b), it may be assumed that the primary method of dispersal is wind and gravity. In a sub-montane rain forest in the Philippines it was found that fruit dispersed by the effect of wind or gravity had largest period of fruiting matching with season of heavy rain (typhoon season) (Hamann, 2004). Observations made during this study of different insects (ants, beetles and cockroaches) consuming and fungi growing from (during periods of high humidity) the seed's fleshy aril suggest it may be energy rich and have a possible role in seed dispersal."

708	Propagules survive passage through the gut	
	Source(s)	**Notes**
	Zhang, L., Brockelman, W. Y., & Allen, M. A. (2008). Matrix analysis to evaluate sustainability: The tropical tree Aquilaria crassna, a heavily poached source of agarwood. Biological Conservation, 14 (6), 1676-1686	[Possibly yes] "The clumping of adult trees is likely to be partly due to the low dispersal distance. No animal dispersers were observed although it was suspected that birds are the most important agent for long-distance dispersal – the seeds are too fragile to be stored by squirrels."

801	Prolific seed production (>1000/m2)	y
	Source(s)	**Notes**
	Zhang, L., Brockelman, W. Y., & Allen, M. A. (2008). Matrix analysis to evaluate sustainability: The tropical tree Aquilaria crassna, a heavily poached source of agarwood. Biological Conservation, 14 (6), 1676-1686	[Yes, once trees reach sufficient size and maturity] "On the basis of the seed trap and germination results, with on average 18,400 seeds per tree (2 seeds per fruit), one would expect to see around 400 recruits per fruiting tree. The much lower observed value of 8.4 was most likely due to seed and seedling predation which was not directly measured."

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

Qsn #	Question	Answer
	Tropical Plants Database, Ken Fern. (2020). Aquilaria crassna. http://tropical.theferns.info/viewtropical.php?id=Aquilaria+crassna. [Accessed 25 Sep 2020]	"Seed - it has a very short viability of less than 10 weeks and needs to be sown as soon as possible after harvesting[325]. No pre-treatment is required. Sow in a nursery seedbed, only just covering the seed and leaving the tail above soil level. Germination usually starts within 10 days and can be spread over one month[325]."
	Lata, A. (2007). Investigation of seed longevity and viability and cutting propagation for Aquilaria crassna. Literature Review. James Cook University, Cairns	"The fully matured seeds can stay on the tree for up to 2 weeks (Jensen 2000). The author reported that the moisture content of a fresh seed is 49% (recalcitrant) and will desiccate further to 25% with germination of 33%. The optimum storage condition with seeds dried to 25% mc can be stored at 8 °C with germination of 22% after two months storage (Luu et al. 2001)."

803	**Well controlled by herbicides**	
	Source(s)	**Notes**
	WRA Specialist. (2020). Personal Communication	Unknown. No evidence that this species has ever been controlled with herbicides, or any other chemical or mechanical methods

804	**Tolerates, or benefits from, mutilation, cultivation, or fire**	**y**
	Source(s)	**Notes**
	Jensen, A., & Meilby, H. (2012). Assessing the population status of a tree species using distance sampling: Aquilaria crassna (Thymelaeaceae) in Northern Laos. International Journal of Forestry Research, 2012, Article ID 265831	[Coppices] "About half of the stumps, 46%, had started to coppice, and the share of felled trees with signs of agarwood formation was 43%."

805	**Effective natural enemies present locally (e.g. introduced biocontrol agents)**	
	Source(s)	**Notes**
	WRA Specialist. (2020). Personal Communication	Unknown

Summary of Risk Traits:

High Risk / Undesirable Traits
• Thrives in tropical climates, and could potentially spread in regions with similar climates
• Seedlings are somewhat shade tolerant, but adult trees require higher light levels
• Reproduces by seeds
• Self-compatible, although seed set is very low from self-pollinated plants
• Seeds may be dispersed by wind, gravity, and possibly birds or other animals
• Mature trees capable of prolific seed production
• Able to coppice and resprout after cutting

Low Risk Traits
• An endangered tree with no reports of invasiveness or naturalization, but no evidence of widespread introduction outside native range
• Unarmed (no spines, thorns, or burrs)
• Palatable to browsing and grazing animals
• Not reported to spread vegetatively
• Reaches maturity in 6-8 years
• Seeds lose viability quickly; not known to form a persistent seed bank