Key Words: Evaluate, Ornamental Tree, Medicinal, Timber, Slow growing, Bird-dispersed

Family: ***Zygophyllaceae***

Taxon: ***Guaiacum sanctum***

Synonym: *Guaiacum guatemalense Planch. ex Rydb.*
Guaiacum multijugum Stokes
Guaiacum parvifolium Nutt.

Common Name: guaiacum
holywood
lignum-vitae

Questionaire : current 20090513 **Assessor:** Chuck Chimera **Designation:** EVALUATE
Status: Assessor Approved **Data Entry Person:** Chuck Chimera **WRA Score 3**

101	**Is the species highly domesticated?**	**y=-3, n=0**	**n**
102	**Has the species become naturalized where grown?**	**y=1, n=-1**	
103	**Does the species have weedy races?**	**y=1, n=-1**	
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**	**n**
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)**	
401	**Produces spines, thorns or burrs**	**y=1, n=0**	**n**
402	**Allelopathic**	**y=1, n=0**	
403	**Parasitic**	**y=1, n=0**	**n**
404	**Unpalatable to grazing animals**	**y=1, n=-1**	
405	**Toxic to animals**	**y=1, n=0**	**n**
406	**Host for recognized pests and pathogens**	**y=1, n=0**	**n**
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**	**y=1, n=0**	**y**
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**	
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**	**y=1, n=0**	**n**
602	**Produces viable seed**	**y=1, n=-1**	**y**
603	**Hybridizes naturally**	**y=1, n=-1**	
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**	**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)**	**y=1, n=-1**	
803	**Well controlled by herbicides**	**y=-1, n=1**	
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)**	**y=-1, n=1**	

Designation: EVALUATE **WRA Score** **3**

Supporting Data:

101	2010. Fuchs, E.J./Hamrick, J.L.. Genetic Diversity in the Endangered Tropical Tree, Guaiacum sanctum (Zygophyllaceae). Journal of Heredity. 101(3): 284-291.	[Is the species highly domesticated? No evidence]
102	2012. WRA Specialist. Personal Communication.	NA
103	2012. WRA Specialist. Personal Communication.	NA
201	1987. Wendelken, P.W./Martin, R. F.. Avian Consumption of Guaiacum sanctum Fruit in the Arid Interior of Guatemala. Biotropica. 19(2): 116-121.	[Species suited to tropical or subtropical climate(s) 2-High] "G. sanctum is a low, gnarled tree with a dense, spreading, rounded crown composed of spreading or drooping branches. G. sanctum inhabits the Florida Keys, the Bahamas, Cuba, Hispaniola, Puerto Rico, the Mexican state of Yucatan, Guatemala, Honduras, Nicaragua, and Costa Rica (Porter 1972)."
202	1987. Wendelken, P.W./Martin, R. F.. Avian Consumption of Guaiacum sanctum Fruit in the Arid Interior of Guatemala. Biotropica. 19(2): 116-121.	[Quality of climate match data 2-High]
203	1998. Riffle, R.L.. The Tropical Look - An Encyclopedia of Dramatic Landscape Plants. Timber Press, Portland, OR	[Broad climate suitability (environmental versatility)? No] "Zones 10-11"
203	2009. González-Rivas, B./Tigabu, M./Castro-Marín, G./Odén, P.C.. Seed germination and seedling establishment of Neotropical dry forest species in response to temperature and light conditions. Journal of Forestry Research. 20(2): 99-104.	[Broad climate suitability (environmental versatility)? No] "Its natural distribution extends from the Greater Antilles to southern Florida, eastern Mexico, along the west coast of Central America, to northern South America at elevations ranging from 10 to 200 m a.s.l in Costa Rica and up to 700 m in Nicaragua. It is limited to lowland deciduous dry tropical forest (Marín et al. 1999). G. sanctum is considered an endangered species in Nicaragua."
203	2011. Stafford, M.J.. Zygophyllaceae. Flora Mesoamericana. 3(1): 1-13. http://www.tropicos.org/docs/meso/zygophyllaceae.pdf	[Broad climate suitability (environmental versatility)? No evidence] "0-800 m. (United States [S. Florida], E. Mexico, Mesoamerica, West Indies.)"
204	1987. Wendelken, P.W./Martin, R. F.. Avian Consumption of Guaiacum sanctum Fruit in the Arid Interior of Guatemala. Biotropica. 19(2): 116-121.	[Native or naturalized in regions with tropical or subtropical climates? Yes] "G. sanctum is a low, gnarled tree with a dense, spreading, rounded crown composed of spreading or drooping branches. G. sanctum inhabits the Florida Keys, the Bahamas, Cuba, Hispaniola, Puerto Rico, the Mexican state of Yucatan, Guatemala, Honduras, Nicaragua, and Costa Rica (Porter 1972)."
205	2005. CAB International. Forestry Compendium. CAB International, Wallingford, UK	[Does the species have a history of repeated introductions outside its natural range? No evidence] "List of countries: Central America & Caribbean Guatemala natural Honduras natural Nicaragua natural Panama natural North America [USA] Florida natural"
205	2005. Staples, G.W./Herbst, D.R.. A Tropical Garden Flora - Plants Cultivated in the Hawaiian Islands and Other Tropical Places. Bishop Museum Press, Honolulu, HI	[Does the species have a history of repeated introductions outside its natural range? No evidence] "rare in Hawaii"
301	2012. Randall, R.P.. A Global Compendium of Weeds. 2nd Edition. Department of Agriculture and Food, Western Australia	[Naturalized beyond native range? No evidence]
301	2012. Sand, J.. Honolulu Botanical Gardens. Pers. Comm. 10 Oct. 2012.	[Naturalized beyond native range? Yes] "We were surprised to see this one naturalize. I guess with the slow growth we didn't realize it was even naturalizing far from mother plants until they became visible up the crater walls! Robin has actually been climbing up the slopes and has poisoned all of the offspring and we are down to the mother plants now. You can see them yellowing up on the crater walls now. I can't believe the locations he is getting accessing in order to stop the spread. I guess the danger involved in the crater location makes us more eager to be proactive regarding what we grow on the crater basin floor. "
302	2012. Randall, R.P.. A Global Compendium of Weeds. 2nd Edition. Department of Agriculture and Food, Western Australia	[Garden/amenity/disturbance weed? No evidence]
303	2012. Randall, R.P.. A Global Compendium of Weeds. 2nd Edition. Department of Agriculture and Food, Western Australia	[Agricultural/forestry/horticultural weed? No evidence]
304	2012. Randall, R.P.. A Global Compendium of Weeds. 2nd Edition. Department of Agriculture and Food, Western Australia	[Environmental weed? No evidence]

305	2012. Lau, A./Frohlich, D.. New plant records from O'ahu for 2009. Bishop Museum Occasional Papers. 113: 7-26.	[Congeneric weed? Guaiacum officinale sparingly naturalized] "Though not thoroughly established, it is documented here as very sparingly naturalized along a roadside in dry open grassland in Kalaeloa, presumably having spread from a planted individual though none were seen in the immediate area. it has also been noted in West loch, similarly growing along a roadside in dry kiawe forest. Material examined: O'AHU: Kalaeloa, UTM 595313, 2358058. Dry lowland weedy shrubland. Sapling about 3 ft tall, corolla lobes persistent as young fruits develop, 12 Jun 2009, OED 2009061201."
305	2012. Randall, R.P.. A Global Compendium of Weeds. 2nd Edition. Department of Agriculture and Food, Western Australia	[Congeneric weed? Unknown. Guaiacum officinale referred to as a weed, but no further evidence was found to corroborate these references, and no negative impacts have been specified.]
401	1964. Little, Jr. E.L./Wadsworth , F.H.. Common trees of Puerto Rico and the Virgin Islands. Agriculture Handbook No. 249. USDA Forest Service, Washington, D.C	[Produces spines, thorns or burrs? No] "An evergreen tree 15-30 feet high with short stout trunk 8 inches or more in diameter, and dense round crown of spreading or drooping branches. The light gray bark is rough. Inner bark is light brown and slightly bitter. Sapwood is light yellow and very hard. The light gray twigs are enlarged at nodes, slightly angled, and green and minutely hairy when young."
401	1997. Gilman, E.F.. Trees for urban and suburban landscapes. Delmar Publishers, Albany, NY	[Produces spines, thorns or burrs? No] "no thorns"
402	2012. WRA Specialist. Personal Communication.	[Allelopathic? Unknown]
403	2007. Kubitzki, K./Bayer, C./ Stevens, P.F.. The families and genera of vascular plants: Volume IX. Flowering Plants. Eudicots. Springer-Verlag, Berlin, Heidelberg, New York	[Parasitic? No] "Shrubs or small bushy trees to 10m high, with hard resinous wood." [Zygophyllaceae]
404	1987. Wendelken, P.W./Martin, R. F.. Avian Consumption of Guaiacum sanctum Fruit in the Arid Interior of Guatemala. Biotropica. 19(2): 116-121.	[Unpalatable to grazing animals? Unknown. Possibly unpalatable] "Much of the forest is subjected to grazing and varies from dense to very open; even in heavily grazed, open areas, G. sanctum often is abundant."
405	2008. Wagstaff, D.J.. International poisonous plants checklist: an evidence-based reference. CRC Press, Boca Raton, FL	[Toxic to animals? No reports of poisoning of animals]
406	1997. Gilman, E.F.. Trees for urban and suburban landscapes. Delmar Publishers, Albany, NY	[Host for recognized pests and pathogens? No evidence] "Pest Problems: Pest Free"
406	2011. Gilman, E.F./Watson, D.G.. Guaiacum sanctum: Lignumvitae. Publication #ENH445. Environmental Horticulture, Florida Cooperative Extension Service, IFAS, University of Florida, Gainesville, FL http://edis.ifas.ufl.edu/pdffiles/ST/ST28600.pdf	[Host for recognized pests and pathogens? No evidence] "Pest resistance: free of serious pests and diseases" … "No pests or diseases of concern."
407	2008. Wagstaff, D.J.. International poisonous plants checklist: an evidence-based reference. CRC Press, Boca Raton, FL	[Causes allergies or is otherwise toxic to humans? No evidence]
407	2010. Fuchs, E.J./Hamrick, J.L.. Genetic Diversity in the Endangered Tropical Tree, Guaiacum sanctum (Zygophyllaceae). Journal of Heredity. 101(3): 284-291.	[Causes allergies or is otherwise toxic to humans? No evidence, despite medicinal uses and utilization of wood] "Also known as Lignumvitae, G. sanctum has one of the densest woods known and was commonly harvested to manufacture propeller shafts for steam ships. Currently, even under the protection of the CITES convention (CITES 2000), G. sanctum is still used as an ornamental wood and for handicrafts. Additionally, G. sanctum's bark produces a resin called guaiacin, which possesses antibiotic properties and has been used since the 1500s to cure sexually transmitted diseases, such as gonorrhea and syphilis (Voeks 2004). Its extensive use has led to a significant reduction in population sizes, and presently, large continuous populations"

408	2006. Otterstrom, S.M./Schwartz, M.W.. Responses to Fire in Selected Tropical Dry Forest Trees. Biotropica. 38(5): 592-598.	[Creates a fire hazard in natural ecosystems? No evidence, but fire may be important to seed germination] "Guaiacum sanctum was one of the more conspicuous species observed post fire in locations that had burned as hotspots. Seeds of this avian dispersed plant are hard, black ellipsoids (Wendelken andMartin 1987) and fire scarification may be a mechanism facilitating germination. In a Costa Rican dry forest, G. sanctum populations have reduced regeneration (Jimenez 1999). At this Costa Rican site, fire has been excluded during the past 15 yr. For the two species of conservation concern, fire did not have an adverse effect on any adult and juvenile stems within study plots, thus possibly indicating a resistance to fire. Swietenia humilis trees near the study area had obvious thick bark and deciduous leaves. At other sites, mahogany stems have shown elevated fire survival due to thick bark (Snook 1993)."
409	1997. Gilman, E.F.. Trees for urban and suburban landscapes. Delmar Publishers, Albany, NY	[Is a shade tolerant plant at some stage of its life cycle?] "Light Requirement: flowers best in full sun"
409	2008. López-Toledo, L./Burslem, D.F.R.P./Martínez-Ramos, M./García-Naranjo, A.. Non-detriment findings report on Guaiacum sanctum in México. NDF Workshop Case Studies WG 1 – Trees. Case Study 7.	[Is a shade tolerant plant at some stage of its life cycle? Yes] "Guaiacum sanctum can be classified as a shade tolerant and slow-growing species over its life cycle."
409	2009. González-Rivas, B./Tigabu, M./Castro-Marín, G./Odén, P.C.. Seed germination and seedling establishment of Neotropical dry forest species in response to temperature and light conditions. Journal of Forestry Research. 20(2): 99-104.	[Is a shade tolerant plant at some stage of its life cycle? Yes] "Survival of G. sanctum seedlings was 70% beneath the canopy and 80% in the open, and its relative growth rate in collar diameter was 1.88 mm/month in the open and 1.42 mm/month in the understory. Survival was generally poor for C. odorata, particularly in the understory. We concluded that light is an absolute requirement for the germination of C. candidissimum seeds while germination of C. odorata and G. sanctum seeds are more sensitive to temperature. Owing to its high survival rate on open site, G. sanctum could serve as a candidate species for reforestation of degraded sites."
410	1997. Gilman, E.F.. Trees for urban and suburban landscapes. Delmar Publishers, Albany, NY	[Tolerates a wide range of soil conditions? Yes] "Soil Tolerances: all textures; alkaline to acidic; wet soils; salt and drought."
410	2011. Gilman, E.F./Watson, D.G.. Guaiacum sanctum: Lignumvitae. Publication #ENH445. Environmental Horticulture, Florida Cooperative Extension Service, IFAS, University of Florida, Gainesville, FL http://edis.ifas.ufl.edu/pdffiles/ST/ST28600.pdf	[Tolerates a wide range of soil conditions? Yes] "Soil tolerances: clay; sand; loam; alkaline; acidic; extended flooding; well-drained"
411	2011. Fuchs, E.J./Hamrick, J.L.. Mating system and pollen flow between remnant populations of the endangered tropical tree, Guaiacum sanctum (Zygophyllaceae). Conservation Genetics. 12: 175-185.	[Climbing or smothering growth habit? No] "Guaiacum sanctum L. (Sapindales: Zygophyllaceae) is a slow growing tropical and subtropical tree distributed from Costa Rica to northern Mexico and Florida, and throughout the Greater Antilles (Holdrige and Poveda 1975). Trees grow to 10–15 m, and are usually found on limestone outcrops in tropical dry forests (Gonzalez Rivas et al. 2006). Trees have opposite, compound, evergreen leaves about 7–12 cm long, with oblong to lanceolate leaflets."
412	1964. Little, Jr. E.L./Wadsworth , F.H.. Common trees of Puerto Rico and the Virgin Islands. Agriculture Handbook No. 249. USDA Forest Service, Washington, D.C	[Forms dense thickets? A component of thicket vegetation in Puerto Rico] "In thickets and forests in the dry coastal and dry limestone regions of Puerto Rico from Ponce to Cabo Rojo. Also in Mona."
412	2008. López-Toledo, L./Burslem, D.F.R.P./Martínez-Ramos, M./García-Naranjo, A.. Non-detriment findings report on Guaiacum sanctum in México. NDF Workshop Case Studies WG 1 – Trees. Case Study 7.	[Forms dense thickets? Dense seedling recruitment in areas] "The regeneration of G. sanctum along its distribution range is highly variable. For example, in the centre of the range regeneration in undisturbed forest was very high, with densities of 1,500-15,000 seedlings ha-1, whereas near the limits of its distribution (Oaxaca, Yucatan and Quintana Roo) densities of only 23 142 seedlings ha-1 were found. The underlying causes of these differences are not known, but it is clear that the more marginal populations require monitoring and protection from land use in order to ensure their long term persistence."
501	2007. Kubitzki, K./Bayer, C./ Stevens, P.F.. The families and genera of vascular plants: Volume IX. Flowering Plants. Eudicots. Springer-Verlag, Berlin, Heidelberg, New York	[Aquatic? No] "Shrubs or small bushy trees to 10mhigh,with hard resinous wood."
502	2007. Kubitzki, K./Bayer, C./ Stevens, P.F.. The families and genera of vascular plants: Volume IX. Flowering Plants. Eudicots. Springer-Verlag, Berlin, Heidelberg, New York	[Grass? No] Zygophyllaceae

503	2007. Kubitzki, K./Bayer, C./ Stevens, P.F.. The families and genera of vascular plants: Volume IX. Flowering Plants. Eudicots. Springer-Verlag, Berlin, Heidelberg, New York	[Nitrogen fixing woody plant? No] Zygophyllaceae
504	2007. Kubitzki, K./Bayer, C./ Stevens, P.F.. The families and genera of vascular plants: Volume IX. Flowering Plants. Eudicots. Springer-Verlag, Berlin, Heidelberg, New York	[Geophyte (herbaceous with underground storage organs -- bulbs, corms, or tubers)? No] "Shrubs or small bushy trees to 10m high, with hard resinous wood."
601	1987. Wendelken, P.W./Martin, R. F.. Avian Consumption of Guaiacum sanctum Fruit in the Arid Interior of Guatemala. Biotropica. 19(2): 116-121.	[Evidence of substantial reproductive failure in native habitat? No] "G. sanctum trees are conspicuous due to their retention of foliage during the dry season when most other elements of the dry scrub forest are leafless; they also are conspicuous when displaying their blue flowers and while bearing ripened fruit. Much of the forest is subjected to grazing and varies from dense to very open; even in heavily grazed, open areas, G. sanctum often is abundant."
601	2011. Fuchs, E.J./Hamrick, J.L.. Mating system and pollen flow between remnant populations of the endangered tropical tree, Guaiacum sanctum (Zygophyllaceae). Conservation Genetics. 12: 175-185.	[Evidence of substantial reproductive failure in native habitat? Rare due to habitat conversion and over-exploitation] "Guaiacum sanctum has been heavily exploited because of its extremely dense wood and medicinal value. Decoctions from G. sanctum bark are believed to cure syphilis, and reports of its use date to the sixteenth century (Voeks 2004). Currently, most populations of G. sanctum have suffered drastic reductions due to logging and habitat loss. In Costa Rica, G. sanctum is distributed throughout the dry forests of the northwest Pacific coast, but many sites suitable for G. sanctum populations have been converted to agricultural fields or pastures (Janzen 1988). Continuous populations of G. sanctum in Costa Rica are rare, and generally restricted to national parks or reserves which continue to be threatened by habitat loss, fire or exploitation (Oldfield et al. 1998). Because of its restricted distribution and reduced population sizes, Guaiacum sanctum is now included in Appendix I of the CITES convention (CITES 2000) and is also termed ‘‘Endangered’’ in the World List of Threatened Trees (Oldfield et al. 1998)."
602	1999. Stebbins, M.. Flowering Trees of Florida. Pineapple Press Inc., Sarasota, FL.	[Produces viable seed? Yes] "As a cultured specimen, Lignum Vitae will grow faster with frequent watering and improved (well-drained) soil. It is easy to grow from seed and has no major pests."
602	2008. López-Toledo, L./Burslem, D.F.R.P./Martínez-Ramos, M./García-Naranjo, A.. Non-detriment findings report on Guaiacum sanctum in México. NDF Workshop Case Studies WG 1 – Trees. Case Study 7.	[Produces viable seed? Yes] "In contrast, we have detected isolated reproductive trees in areas of the Central Depression of Chiapas that have high fruit production and up to 70-80% seed viability indicated by seed germination and x-ray seed tests. However, the density of seedlings in this area is very low, which likely indicates predator effects on seeds or seedlings (Gutierrez & Lopez unpub. data)."
603	2008. López-Toledo, L./Burslem, D.F.R.P./Martínez-Ramos, M./García-Naranjo, A.. Non-detriment findings report on Guaiacum sanctum in México. NDF Workshop Case Studies WG 1 – Trees. Case Study 7.	[Hybridizes naturally? Possibly] "The taxonomy of the genus is still unclear and identification problems might appear where G. sanctum and G. coulteri are both present due to the high degree of similarity between them. If reproductive structures are not present is very difficult to tell them apart. As well, some taxonomists indicate that these species may be hybridize, further complicating their identification. In the Yucatan Peninsula, only G. sanctum has been collected. Genetic studies will provide information on the taxonomy of the genus and may help to differentiate populations. However, timber of both species may be practically indistinguishable and illegal logging of G. coulteri cannot be ignored as it may be traded as G. sanctum."
603	2011. Stafford, M.J.. Zygophyllaceae. Flora Mesoamericana. 3(1): 1-13. http://www.tropicos.org/docs/meso/zygophyllaceae.pdf	[Hybridizes naturally? Potentially] "Porter (1972: 549) has suggested that G. sanctum and G. coulteri may hybridize in Mesoamerica."
604	2011. Fuchs, E.J./Hamrick, J.L.. Mating system and pollen flow between remnant populations of the endangered tropical tree, Guaiacum sanctum (Zygophyllaceae). Conservation Genetics. 12: 175-185.	[Self-compatible or apomictic? Yes] "Bawa et al. (1985) suggested that self fertilization is uncommon in tropical tree species, due mainly to widespread self incompatibility systems. Nonetheless, selfing in G. sanctum occurs since in PVNP 30% of the progeny resulted from self fertilization."
605	2010. Fuchs, E.J./Hamrick, J.L.. Genetic Diversity in the Endangered Tropical Tree, Guaiacum sanctum (Zygophyllaceae). Journal of Heredity. 101(3): 284-291.	[Requires specialist pollinators? No] "Pollination of G. sanctum is performed mostly by bees and wasps, which are capable of transporting pollen over large distances (Janzen 1971; Frankie et al. 1976)."
605	2011. Fuchs, E.J./Hamrick, J.L.. Mating system and pollen flow between remnant populations of the endangered tropical tree, Guaiacum sanctum (Zygophyllaceae). Conservation Genetics. 12: 175-185.	[Requires specialist pollinators? No] "The perfect, conspicuous, blue-purple flowers occur between March and July, and although some trees flower every year, the species' phenology is best characterized as supraannual. In Costa Rica the main pollinators are Africanized bees, but wasps and solitary bees have also been observed visiting flowers (Jimenez 1993)."

606	1998. Riffle, R.L.. The Tropical Look - An Encyclopedia of Dramatic Landscape Plants. Timber Press, Portland, OR	[Reproduction by vegetative fragmentation? No evidence] "Propagation by seed"
606	2008. López-Toledo, L./Burslem, D.F.R.P./Martínez-Ramos, M./García-Naranjo, A.. Non-detriment findings report on Guaiacum sanctum in México. NDF Workshop Case Studies WG 1 – Trees. Case Study 7.	[Reproduction by vegetative fragmentation? No evidence] "A high proportion (~80%) of individuals cut or damaged during harvesting were able to re-sprout, but this response depended on the diameter and height at which damage occurred. We have observed that individuals cut higher up the stem were more able to re-sprout than individuals cut at the base. Individuals >10 cm dbh were unable to re-sprout. In the case of G. sanctum, sprouting may help to minimize the negative impacts of logging." [Resprouts, but no evidence of vegatative spread]
607	1997. Gilman, E.F.. Trees for urban and suburban landscapes. Delmar Publishers, Albany, NY	[Minimum generative time (years)? Probably 4+] "Lignumvitae is an extremely slow-growing evergreen that ultimately reaches 8 to 20 feet in height and casts light shade, but few people have seen plants of this size because it is not extensively available in nurseries."
607	2008. López-Toledo, L./Burslem, D.F.R.P./Martínez-Ramos, M./García-Naranjo, A.. Non-detriment findings report on Guaiacum sanctum in México. NDF Workshop Case Studies WG 1 – Trees. Case Study 7.	[Minimum generative time (years)? Probably >30+] "Guaiacum sanctum can be classified as a shade tolerant and slow-growing species over its life cycle. For example, in two different sites during three years of measurement in central Campeche, we found height growth for seedlings (<50 cm height) of 2-4 cm year-1 and for juveniles (50-150 cm height and <1 cm dbh) a height growth of 3-8 cm year-1. For adults 1-40 cm dbh we measured growth rates of 1.5-2.3 mm year-1. Based on these measurements, we estimate that the age of trees 35-40 cm dbh is between 280-390 years." … "The smallest reproductive trees are 1 cm dbh, which corresponds to an age of 30-70 years according to the age-size estimates presented above."
607	2010. Fuchs, E.J./Hamrick, J.L.. Genetic Diversity in the Endangered Tropical Tree, Guaiacum sanctum (Zygophyllaceae). Journal of Heredity. 101(3): 284-291.	[Minimum generative time (years)?] "Guaiacum sanctum L. (Sapindales: Zygophyllaceae) is a slow growing tropical and subtropical dry forest tree, distributed from southern Central America to northern Mexico and Florida and throughout the Greater Antilles (Holdridge and Poveda 1975)." … "G. sanctum is a long-lived species with individuals surviving up to a 1000 years (Wilson and Eisner 1968), it is likely that the adult trees analyzed in this study were alive before most of the habitat fragmentation occurred."
701	2011. Stafford, M.J.. Zygophyllaceae. Flora Mesoamericana. 3(1): 1-13. http://www.tropicos.org/docs/meso/zygophyllaceae.pdf	[Propagules likely to be dispersed unintentionally (plants growing in heavily trafficked areas)? No] "Capsules 1.2–1.6 × 1.2–2 cm, broadly obovoid, pointed at the apex, glabrous, prominently 5 lobed, 1 or more lobes becoming thick and rounded, yellow or orange at maturity; seeds 0.9–1.1 × 0.5–0.6 cm, black, with a red aril." [No evidence, and no means of external attachment]
702	1987. Wendelken, P.W./Martin, R. F.. Avian Consumption of Guaiacum sanctum Fruit in the Arid Interior of Guatemala. Biotropica. 19(2): 116-121.	[Propagules dispersed intentionally by people? Yes] "In some residential areas, it has been retained or planted as an ornamental."
702	1998. Riffle, R.L.. The Tropical Look - An Encyclopedia of Dramatic Landscape Plants. Timber Press, Portland, OR	[Propagules dispersed intentionally by people? Yes] "The two species listed below are probably the world's most beautiful blue-flowered trees." [Ornamental]
703	2011. Stafford, M.J.. Zygophyllaceae. Flora Mesoamericana. 3(1): 1-13. http://www.tropicos.org/docs/meso/zygophyllaceae.pdf	[Propagules likely to disperse as a produce contaminant? No evidence] "Capsules 1.2–1.6 × 1.2–2 cm, broadly obovoid, pointed at the apex, glabrous, prominently 5-lobed, 1 or more lobes becoming thick and rounded, yellow or orange at maturity; seeds 0.9–1.1 × 0.5–0.6 cm, black, with a red aril." [Unlikely that relatively large fruits and seeds would become a contaminant of produce. Not grown with produce]
703	2012. WRA Specialist. Personal Communication.	[Propagules likely to disperse as a produce contaminant? No evidence]
704	1987. Wendelken, P.W./Martin, R. F.. Avian Consumption of Guaiacum sanctum Fruit in the Arid Interior of Guatemala. Biotropica. 19(2): 116-121.	[Propagules adapted to wind dispersal? No] "The fruit is a 4- or 5-lobed, broadly obovoid capsule with one arilloid (arillate seed) per locule (Porter 1972, Standley & Steyermark 1946)."
705	1987. Wendelken, P.W./Martin, R. F.. Avian Consumption of Guaiacum sanctum Fruit in the Arid Interior of Guatemala. Biotropica. 19(2): 116-121.	[Propagules water dispersed? Bird dispersed] "In Guatemala, it is abundant on the plains and rocky hillsides of the middle Motagua valley in the departments of EI Progreso and Zacapa (the type locality)." [Not regularly distributed along riparian corridors]

706	1987. Wendelken, P.W./Martin, R. F.. Avian Consumption of Guaiacum sanctum Fruit in the Arid Interior of Guatemala. Biotropica. 19(2): 116-121.	[Propagules bird dispersed? Yes] "Data are provided on consumption of the fruit of the Guayacan (Guaiacum sanctum, Zygophyllaceae) by 19 avian species of 17 genera in 8 families in the arid interior of Guatemala. G. sanctum is an abundant evergreen tree of the dry deciduous scrub forest of the Motagua River valley in the Departments of Zacapa and El Progreso. Arilloids were exposed in conspicuous displays during 2 distinct fruiting periods, each lasting about 2 mo. During a fruiting period, individual trees bore ripe fruit continuously for as long as 6 wk. Diverse harvesting and handling procedures of Guayacan arilloids were employed by avian consumers, both intra and interspecifically; these are characterized and harvesting procedures are related to tree morphology. Arils and/or arilloids were consumed and/or transported by adult birds to nestlings and fledglings. Thirteen species transported seeds away from G. sanctum parent trees and did not drop seeds beneath these; two other species transported a portion of the seeds they handled away from parent trees." … "In Guatemala, G. sanctum experiences at least 2 fruiting periods per year; each period lasts for about 2 mo. Individual trees bear ripe fruit continuously for as long as 6 wk and may bear fruit without apparent depletion for as long as 1 mo."
706	2010. Fuchs, E.J./Hamrick, J.L.. Spatial genetic structure within size classes of the endangered tropical tree Guaiacum sanctum (Zygophyllaceae). American Journal of Botany. 97(7): 1200-1207.	[Propagules bird dispersed? Yes] "Populations of G. sanctum are established and maintained by bird-mediated, moderate- to long-distance seed dispersal, which results in a mixture of seeds from unrelated maternal individuals, effectively eliminating SGS. Proximity between individuals is, therefore, a poor predictor of family structure in this species. Long-distance seed dispersal, coupled with estimates of high genetic diversity, suggests that this endangered species has the potential for natural regeneration and restoration given the availability of suitable habitats."
706	2011. Fuchs, E.J./Hamrick, J.L.. Mating system and pollen flow between remnant populations of the endangered tropical tree, Guaiacum sanctum (Zygophyllaceae). Conservation Genetics. 12: 175-185.	[Propagules bird dispersed? Yes] "Fruiting occurs from May to November, fruits are 5-lobed ovoid capsules, with one arilloid seed per locule. Seeds are dark brown to black, oblong and measure 1–2 cm in length. Mature seeds are covered by a bright red aril, which attracts frugivorous birds, the main dispersers. In Costa Rica seed dispersal is mostly performed by birds belonging to the Momotidae, Trogonidae, and Tyranidae (Fuchs and Hamrick 2010a), e.g., Trogon melanocephalus, T. elegans, Tityra semifasciata, Pitangus sulphuratus, and Calocitta formosa (Fuchs and Hamrick 2010b)."
707	2011. Stafford, M.J.. Zygophyllaceae. Flora Mesoamericana. 3(1): 1-13. http://www.tropicos.org/docs/meso/zygophyllaceae.pdf	[Propagules dispersed by other animals (externally)? No evidence] "Capsules 1.2–1.6 × 1.2–2 cm, broadly obovoid, pointed at the apex, glabrous, prominently 5 lobed, 1 or more lobes becoming thick and rounded, yellow or orange at maturity; seeds 0.9–1.1 × 0.5–0.6 cm, black, with a red aril." [No means of external attachment. Adapted for consumption and internal dispersal]
708	1987. Wendelken, P.W./Martin, R. F.. Avian Consumption of Guaiacum sanctum Fruit in the Arid Interior of Guatemala. Biotropica. 19(2): 116-121.	[Propagules survive passage through the gut? Presumably Yes] "The fruit is a 4- or 5 lobed, broadly obovoid capsule with one arilloid (arillate seed) per locule (Porter 1972, Standley & Steyermark 1946)." … "Dehiscent fruit capsules and their exposed arilloids often hang down from twigs, but because of the species' branching pattern, many arilloids also are presented within the reach of avian frugivores perched upright atop branches." … "The hard, black, ellipsoid seeds are roughly 10 mm long (Standley & Steyermark 1946) and completely enveloped by a fleshy, red, ellipsoid aril, easily detached from the seed. The intact arilloid is approximately 12-13 mm long and 6-7 mm wide. The arilloid, seed, and aril average 0.4, 0.2,and 0.2 g, respectively (N = 50)." … "Most ' of the 19 species appear to be potential seed dispersers. Thirteen species transported seeds away from the parent trees and were not observed to drop seeds beneath them (Table 2) . Seed transport was by 3 modes: the bird ingested the seed, the bird flew off with the intact arilloid in its bill, or a parent bird transferred the intact arilloid to a fledgling that swallowed the arilloid and subsequently flew from the parent tree. In 12 of the 13 species, the seed always was ingested as part of the intact arilloid. The remaining species, A. albifrons (a probable seed digester, following Howe & Estabrook 1977), swallowed many arilloids whole, but in some instances, may have dropped the aril and swallowed the seed."
708	2008. López-Toledo, L./Burslem, D.F.R.P./Martínez-Ramos, M./García-Naranjo, A.. Non-detriment findings report on Guaiacum sanctum in México. NDF Workshop Case Studies WG 1 – Trees. Case Study 7.	[Propagules survive passage through the gut? Presumably Yes] "...many birds and mammals eat the fruits and seeds of G. sanctum, or trees are used for perches, nesting or protection."

801	2008. López-Toledo, L./Burslem, D.F.R.P./Martínez-Ramos, M./García-Naranjo, A.. Non-detriment findings report on Guaiacum sanctum in México. NDF Workshop Case Studies WG 1 – Trees. Case Study 7.	[Prolific seed production (>1000/m2)? Unlikely, unless high densities of large trees fruit simultaneously] "Fruit production increases exponentially with tree size, with the smallest trees (1-4.9 cm dbh) producing about 10 fruits and the largest trees (>35 cm dbh) producing >10,000 fruits." … "Every fruit has two to four lobes that potentially produce one seed each, but fruits from low adult density areas usually produce only one seed. Fruits in high adult density areas have a mean of 2.5 seeds." … "The regeneration of G. sanctum along its distribution range is highly variable. For example, in the centre of the range regeneration in undisturbed forest was very high, with densities of 1,500-15,000 seedlings ha-1, whereas near the limits of its distribution (Oaxaca, Yucatan and Quintana Roo) densities of only 23 142 seedlings ha-1 were found. The underlying causes of these differences are not known, but it is clear that the more marginal populations require monitoring and protection from land use in order to ensure their long term persistence."
801	2010. Fuchs, E.J./Hamrick, J.L.. Spatial genetic structure within size classes of the endangered tropical tree Guaiacum sanctum (Zygophyllaceae). American Journal of Botany. 97(7): 1200-1207.	[Prolific seed production (>1000/m2)? Unlikely] "Only a few individuals flower each year, with most adults displaying a supra-annual phenology (E. J. Fuchs and J. L. Hamrick, unpublished manuscript)."
802	2006. Otterstrom, S.M./Schwartz, M.W.. Responses to Fire in Selected Tropical Dry Forest Trees. Biotropica. 38(5): 592-598.	[Evidence that a persistent propagule bank is formed (>1 yr)? Unknown. Possible if not scarified by fire] "Seeds of this avian dispersed plant are hard, black ellipsoids (Wendelken and Martin 1987) and fire scarification may be a mechanism facilitating germination."
802	2008. Valverde-Cerdas, L./Rojas-Vargas, A./Hine-Gómez, A.. In vitro Propagation of Albizia guachapele, Cedrela odorata, Platymiscium pinnatum and Guaiacum sanctum. Plant Tissue Cult. & Biotech.. 18(2): 151-156.	[Evidence that a persistent propagule bank is formed (>1 yr)? Unknown. In vitro recalcitrance] "The results obtained from the Albizia guachapele, Guaiacum sanctum and Platymiscium pinnatum species demonstrate their recalcitrance in vitro and the necessity of conducting more studies to establish an efficient in vitro regeneration system for these species."
803	2012. WRA Specialist. Personal Communication.	[Well controlled by herbicides? Unknown] No information on herbicide efficacy or chemical control of this species.
804	1994. Loope, L./Duever, M./Herndon, A./Snyder, J./Jansen, D.. Hurricane Impact on Uplands and Freshwater Swamp Forest. BioScience. 44(4): 238-246.	[Tolerates, or benefits from, mutilation, cultivation, or fire? Resprouts after hurricane damage] "This forest is particularly notable for large-diameter trees and, in particular, for its many large individuals of lignum vitae (Guaiacum sanctum, Zygophyllaceae). Some of these trees have been repeatedly windthrown by hurricanes but resprouted."
804	2006. Otterstrom, S.M./Schwartz, M.W.. Responses to Fire in Selected Tropical Dry Forest Trees. Biotropica. 38(5): 592-598.	[Tolerates, or benefits from, mutilation, cultivation, or fire? Possibly] "Guaiacum sanctum was one of the more conspicuous species observed post fire in locations that had burned as hotspots. Seeds of this avian dispersed plant are hard, black ellipsoids (Wendelken and Martin 1987) and fire scarification may be a mechanism facilitating germination. In a Costa Rican dry forest, G. sanctum populations have reduced regeneration (Jimenez 1999). At this Costa Rican site, fire has been excluded during the past 15 yr. For the two species of conservation concern, fire did not have an adverse effect on any adult and juvenile stems within study plots, thus possibly indicating a resistance to fire."
804	2008. López-Toledo, L./Burslem, D.F.R.P./Martínez-Ramos, M./García-Naranjo, A.. Non-detriment findings report on Guaiacum sanctum in México. NDF Workshop Case Studies WG 1 – Trees. Case Study 7.	[Tolerates, or benefits from, mutilation, cultivation, or fire? Yes] "A high proportion (~80%) of individuals cut or damaged during harvesting were able to re-sprout, but this response depended on the diameter and height at which damage occurred. We have observed that individuals cut higher up the stem were more able to re-sprout than individuals cut at the base. Individuals >10 cm dbh were unable to re-sprout. In the case of G. sanctum, sprouting may help to minimize the negative impacts of logging."
805	2012. WRA Specialist. Personal Communication.	[Effective natural enemies present locally (e.g. introduced biocontrol agents)? Unknown]

Summary of Risk Traits

High Risk / Undesirable Traits

- Naturalizing in Koko Crater, Oahu, Hawaiian Islands
- Native to and thrives in tropical climates
- Shade tolerant (could establish in intact forest understory)
- Tolerates many soil conditions (and potentially able to exploit many different habitat types)
- Viable seeds dispersed by birds and possibly small mammals
- Self-compatible
- Able to resprout after cutting or damage from hurricanes, and possibly fire

Low Risk / Desirable Traits

- No records on naturalization or invasiveness reported elsewhere in the world
- Unarmed (no spines, thorns or burrs)
- Non-toxic (but medicinal properties to caution is advised)
- Ornamental value
- Timber tree
- Slow growth rate and long time (30+ years) to reproductive maturity
- No evidence of spread by vegetative means