United States Department of Agriculture

Animal and Plant Health Inspection Service

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Version 1

Weed Risk Assessment for *Wikstroemia indica* (L.) C. A. Mey. (Thymelaeaceae) – Tiebush

Left: An individual *Wikstroemia indica* shrub. Top right: *Wikstroemia indica* flowers. Bottom right: *Wikstroemia indica* fruit. Source of images: (Haslam, 2013).

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Introduction Plant Protection and Quarantine (PPQ) regulates noxious weeds under the authority of the Plant Protection Act (7 U.S.C. § 7701-7786, 2000) and the Federal Seed Act (7 U.S.C. § 1581-1610, 1939). A noxious weed is defined as "any plant or plant product that can directly or indirectly injure or cause damage to crops (including nursery stock or plant products), livestock, poultry, or other interests of agriculture, irrigation, navigation, the natural resources of the United States, the public health, or the environment" (7 U.S.C. § 7701-7786, 2000). We use weed risk assessment (WRA)—specifically, the PPQ WRA model (Koop et al., 2012)—to evaluate the risk potential of plants, including those newly detected in the United States, those proposed for import, and those emerging as weeds elsewhere in the world.

Because the PPQ WRA model is geographically and climatically neutral, it can be used to evaluate the baseline invasive/weed potential of any plant species for the entire United States or for any area within it. As part of this analysis, we use a stochastic simulation to evaluate how much the uncertainty associated with the analysis affects the model outcomes. We also use GIS overlays to evaluate those areas of the United States that may be suitable for the establishment of the plant. For more information on the PPQ WRA process, please refer to the document, *Background information on the PPQ Weed Risk Assessment*, which is available upon request.

Species Information

***Wikstroemia indica* (L.) C. A. Mey. – Tiebush**

Family: Thymelaeaceae

Synonyms: *Daphne indica* L., *Wikstroemia viridiflora* (Wall.) Meisn. (NGRP, 2013).

Initiation: On November 25, 2011 Al Tasker (PPQ, National Weeds Program Coordinator) asked the PERAL Weed Team to evaluate *Wikstroemia indica* for potential listing as a Federal Noxious Weed (Tasker, 2011). This species was added to the Not Authorized Pending Pest Risk Analysis (NAPPRA) regulations (APHIS, 2013).

Foreign distribution: *Wikstroemia indica* is native to southeast Asia and Australia (Lorence and Sussman, 1986; Waibel, 2009). It has been introduced to the islands of Mauritius and Rodrigues, where it is invasive (Kell, 1997; Macdonald et al., 2003).

U.S. distribution and status: Present in the Hoomaluhia Botanical Garden in Hawaii (GBIF, 2013). We found no evidence that this species has escaped from cultivation in the United States.

WRA area[1]: Entire United States, including territories.

[1] "WRA area" is the area in relation to which the weed risk assessment is conducted [definition modified from that for "PRA area" (IPPC, 2012).

1. *Wikstroemia indica* analysis

Establishment/Spread Potential

Wikstroemia indica has become widespread in its introduced range on the islands of Mauritius and Rodrigues (Gopal, 2003; Kell, 1997; Macdonald et al., 2003; Virah-Sawmy et al., 2009). This shrub produces bright red or orange fruits (Zhengyi et al., 2012) that are dispersed by birds (Corlett, 1996; Linnebjerg et al., 2010). This species can reproduce by parthenogenesis, with embryos developing even when fertilization does not occur (Winkler, 1905). We had greater than average uncertainty about this risk element because very little information was available about the biology of this species.

Risk score = 5 Uncertainty index = 0.25

Impact Potential

Wikstroemia indica is controlled in pastures because it is toxic to livestock: animals die within one to two days of eating the plants, and children have also died from eating the fruits (Dowling, 1985). This species has caused large losses to dairy herds and deer farms in Australia (Dowling, 1985). *Wikstroemia indica* is controlled by manual weeding in conservation areas on Mauritius (Wittenberg and Cock, 2001) but we found no information on the types of impacts it causes in these systems. We had greater than average uncertainty about this risk element because all but one of the questions relating to impacts in natural systems were answered as unknown.

Risk score = 2.9 Uncertainty index = 0.35

Geographic Potential

Based on three climatic variables, we estimate that about 5 percent of the United States is suitable for the establishment of *W. indica* (Fig. 1). This predicted distribution is based on the species' known distribution elsewhere in the world and includes point-referenced localities and areas of occurrence. The map for *W. indica* represents the joint distribution of Plant Hardiness Zones 9-13, areas with 20-100+ inches of annual precipitation, and the following Köppen-Geiger climate classes: tropical rainforest, tropical savanna, humid subtropical, and marine west coast.

The area estimated likely represents a conservative estimate as it uses only three climatic variables. Other environmental variables, such as soil and habitat type, may further limit the areas in which this species is likely to establish.

Entry Potential

We did not assess the entry potential of *Wikstroemia indica* because it is already present in the United States in the Hoomaluhia Botanical Garden in Hawaii (GBIF, 2013).

Figure 1. Predicted distribution of *Wikstroemia indica* in the United States. Map insets for Alaska, Hawaii, and Puerto Rico are not to scale.

2. Results and Conclusion

Model Probabilities: P(Major Invader) = 22.9%
P(Minor Invader) = 67.8%
P(Non-Invader) = 9.2%

Risk Result = Evaluate Further

Secondary Screening = High Risk

Figure 2. *Wikstroemia indica* risk score (black box) relative to the risk scores of species used to develop and validate the PPQ WRA model (other symbols). See Appendix A for the complete assessment.

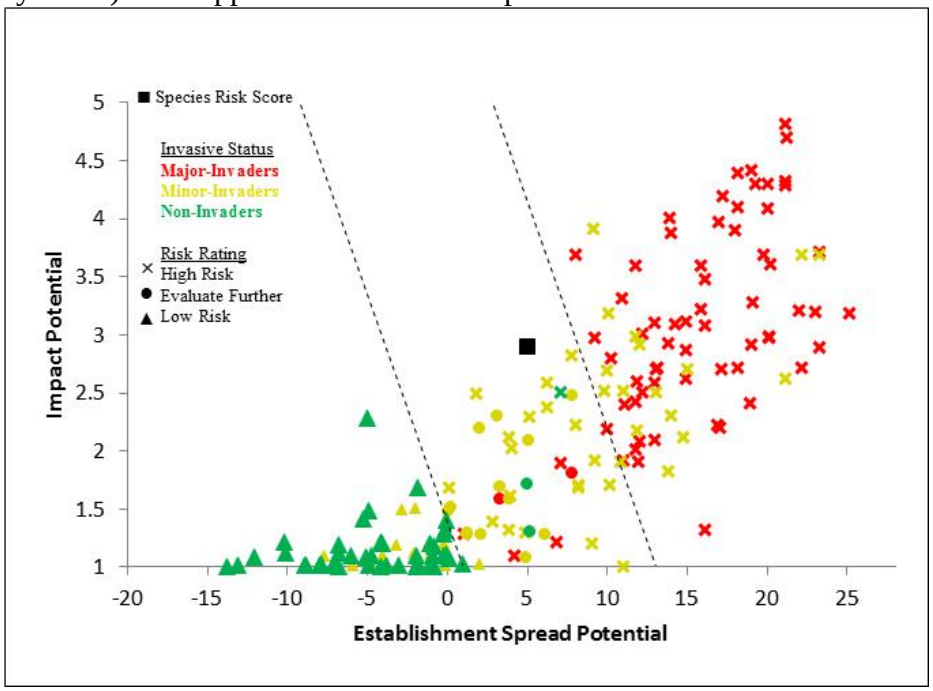
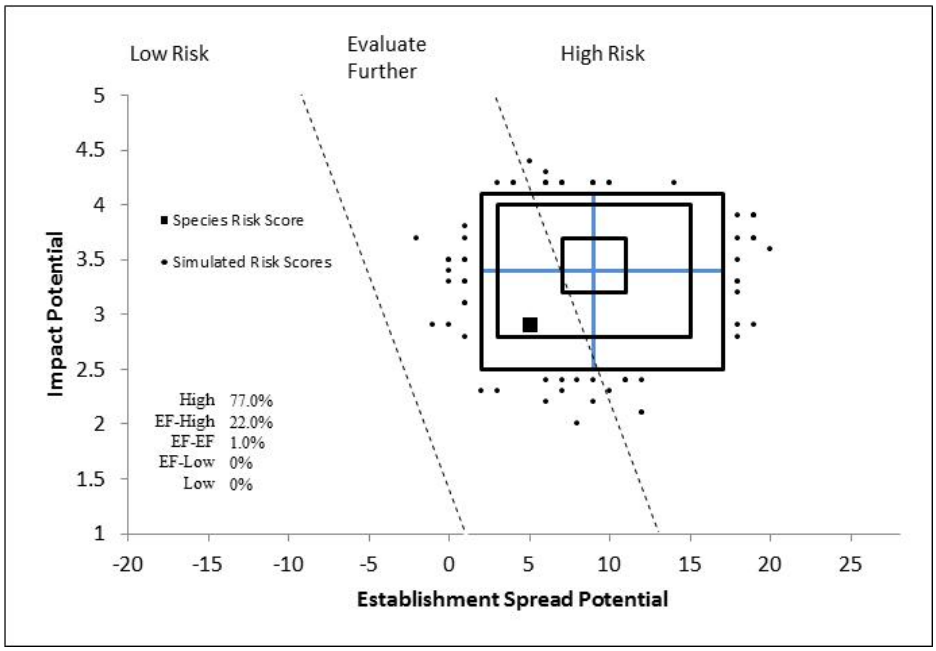


Figure 3. Monte Carlo simulation results (N=5,000) for uncertainty around the risk scores for *Wikstroemia indica*[a].



[a] The blue "+" symbol represents the medians of the simulated outcomes. The smallest box contains 50 percent of the outcomes, the second 95 percent, and the largest 99 percent.

3. Discussion

The result of the weed risk assessment for *W. indica* is High Risk; the initial result was Evaluate Further but the rating increased after the secondary screening because the species is known to be invasive (i.e., readily spread) in areas beyond its native range (Macdonald et al., 2003; Kell, 1997; Virah-Sawmy et al., 2009). We had a large amount of uncertainty associated with this risk assessment (Fig. 3) due to the limited information available on this species and the impacts it is causing in conservation areas. Still, we know *W. indica* is invasive and is being controlled in conservation areas on the islands of Mauritius and Rodrigues (Gopal, 2003; Kell, 1997; Wittenberg and Cock, 2001) and it may be especially problematic in tropical island habitats. *Wikstroemia indica* had an impact score comparable to that of other known minor invaders (Fig. 2), because this species is toxic to livestock and fish (Dowling, 1985; Haslam, 2013) and children have died after eating the fruit (Dowling, 1985), and because of known control efforts and impacts in production systems (Blanfort and Orapa, 2008; Dowling, 1985).

We only found one record of this plant occurring in the United States, from the Hoomaluhia Botanical Garden in Hawaii (GBIF, 2013). *Wikstroemia indica* seems likely to be introduced to the mainland United States at some point, however, because it is used medicinally on Mauritius (Chintamunnee and Mahomoodally, 2012), and because U.S. researchers are interested in studying the biochemical properties of the plant (APHIS, 2013).

4. Literature Cited

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Appendix A. Weed risk assessment for *Wikstroemia indica* (L.) C. A. Mey. (Thymelaeaceae). The following information was obtained from the original risk assessment for this species (full responses and all guidance), which is available upon request. We modified the information here to fit on the page.

Question ID	Answer - Uncertainty	Score	Notes (and references)
ESTABLISHMENT/SPREAD POTENTIAL			
ES-1 (Status/invasiveness outside its native range)	f - low	5	Native to southeast Asia and Australia (Lorence and Sussman, 1986; Waibel, 2009). One of the "most widespread" plants on Rodrigues Island (Kell, 1997). *Wikstroemia indica* is listed as "frequently occurring" on Rodrigues Island (Showler et al., 2002). "[A]lien herb introduced to Rodrigues in 1828 is widespread...in the higher areas of the island" (Waibel, 2009). Virah-Sawmy et al. (2009) measured the number of exotic and native plant seedlings in research plots on Mauritius and determined that *Wikstroemia indica* was the fourth most dominant exotic plant species in their plots (Virah-Sawmy et al., 2009). Listed as "very invasive" on Mauritius and Rodrigues Islands (Macdonald et al., 2003). In its native habitat of Australia, *Wikstroemia indica* spreads into pastureland after wet seasons (Dowling, 1985). Lorence and Sussman (1986) reported that *Wikstroemia indica* plants were only found in low to moderate densities in their research sites on Mauritius (Lorence and Sussman, 1986). Because *Wikstroemia indica* is frequently occurring and able to invade conservation areas on Mauritius and Rodrigues Islands, we are answering "f" with low uncertainty. Our alternate answers for the Monte Carlo simulation are both "e."
ES-2 (Is the species highly domesticated)	n - mod	0	No evidence that any breeding programs or cultivars of *Wikstroemia indica* exist.
ES-3 (Weedy congeners)	n - mod	0	Holm et al. (1979) lists *W. ganpi* as a weed in Japan with an unknown ranking of importance. Randall (2012) lists *W. ganpi* and *W. chamaedaphne* as weeds. Answering no with moderate uncertainty because we were unable to find any impact information for these species.
ES-4 (Shade tolerant at some stage of its life cycle)	n - low	0	Not listed as a shade-tolerant plant by Duan et al. (2010). This species grows in open, sunny environments. It is found on "steep slopes and hill crests with shorter trees and less shading as well as tree falls, forest margins and clearings" on Mauritius (Lorence and Sussman, 1986). It grows in open habitats on Rodrigues Island (Waibel, 2009).
ES-5 (Climbing or smothering growth form)	n - negl	0	*Wikstroemia indica* is a 0.5 to 2 meter tall branched shrub (Zhengyi et al., 2012).
ES-6 (Forms dense thickets)	? - max	0	*Wikstroemia indica* is a 0.5 to 2 meter tall branched shrub (Zhengyi et al., 2012). Pictures of *Wikstroemia indica* show that single plants can have a dense growth form (Haslam, 2013), but we were unable to find information about the population structure of multiple *Wikstroemia indica* plants. Thus, answering unknown.
ES-7 (Aquatic)	n - negl	0	Terrestrial, 1-2 meter tall branched shrub in the family Thymelaeaceae (Dowling, 1985; NGRP, 2013).
ES-8 (Grass)	n - negl	0	Not in the family Poaceae. Branched shrub in the family Thymelaeaceae (Dowling, 1985; NGRP, 2013).
ES-9 (Nitrogen-fixing woody	n - low	0	No evidence. *Wikstroemia indica* is a shrub in the family

plant)			Thymelaeaceae (NGRP, 2013), and Thymelaeaceae is not listed as a family containing nitrogen-fixing species by Martin and Dowd (1990).
ES-10 (Does it produce viable seeds or spores)	y - negl	1	Regenerates from seed on Rodrigues Island (Kell, 1997). Produces seed by apomixis (Zhengyi et al., 2012).
ES-11 (Self-compatible or apomictic)	y - low	1	"[A]pomictic species" (Zhengyi et al., 2012). Parthenogenesis, where embryos develop even when pollination is prevented, occurs in *Wikstroemia indica* (Winkler, 1905).
ES-12 (Requires special pollinators)	n - low	0	Pollinated by pyralid moths in its native habitat in New Caledonia (Kato and Kawakita, 2004).
ES-13 (Minimum generation time)	c - high	0	Fruits take 94 days to develop from anthesis to ripe fruit (Corlett, 1996). *Wikstroemia pulcherrima* plants can be planted outside 8-12 months after sowing seeds (KWP, 2011). Very little information is available about generative time for this shrub, but based on the available information, answers "a" and "d" seem unlikely. Thus, answering "c" with high uncertainty and using "b" for both alternate answers for the Monte Carlo simulation.
ES-14 (Prolific reproduction)	? - max	0	Unknown. There is one seed in each *Wikstroemia indica* fruit (Waibel, 2009), but we were unable to find any additional information about the number of seeds produced.
ES-15 (Propagules likely to be dispersed unintentionally by people)	n - mod	-1	No evidence.
ES-16 (Propagules likely to disperse in trade as contaminants or hitchhikers)	n - mod	-1	No evidence.
ES-17 (Number of natural dispersal vectors)	1	-2	Fruit and seed description for ES17a-17e: "[F]ruits are egg shaped and about 6 mm long or slightly longer. They are bright red or orange-red when ripe and because of this are very conspicuous. The unripe fruits are a pale green" (Dowling, 1985). Seeds have an average diameter of 3.6 mm (Corlett, 1996).
ES-17a (Wind dispersal)	n - negl		Fruit do not possess traits (e.g., wings, plumes, etc.) associated with wind-dispersed species (see description under ES-17).
ES-17b (Water dispersal)	? - max		Unknown.
ES-17c (Bird dispersal)	y - negl		Fruits are dispersed by birds (Corlett, 1996). The red-whiskered bulbul, *Pycnonotus jocosus*, consumes *Wikstroemia indica* seeds on Mauritius and may aid in dispersal (Linnebjerg et al., 2010). *Wikstroemia indica* seeds are dispersed by flying fauna (White et al., 2004). "Brown pigeons enjoy this fruit" (Haslam, 2013).
ES-17d (Animal external dispersal)	n - mod		No evidence.
ES-17e (Animal internal dispersal)	n - high		*Wikstroemia indica* fruits are consumed by the Aldabran giant tortoise (*Aldabrachelys gigantea*), but the germination rate for seeds after digestion is very low. Thus, fruit consumption by tortoises might constrain the spread of *Wikstroemia indica* (Waibel, 2009). The fruits are toxic to deer and livestock (Dowling, 1985). Based on this evidence, answering no with high uncertainty.
ES-18 (Evidence that a persistent (>1yr) propagule bank (seed bank) is formed)	n - high	-1	Germination capacity of *Wikstroemia* spp. seeds declined quickly in laboratory studies, with only 50 percent of seeds germinating after seven months of storage (Corcolon et al., 1991). Based on this evidence, answering no, but with high

			uncertainty.
ES-19 (Tolerates/benefits from mutilation, cultivation or fire)	? - max	0	Unknown.
ES-20 (Is resistant to some herbicides or has the potential to become resistant)	n - mod	0	No evidence. Sensitive to herbicides (Gilles and Milner, 2010). Not listed by Heap (2013).
ES-21 (Number of cold hardiness zones suitable for its survival)	5	0	
ES-22 (Number of climate types suitable for its survival)	4	2	
ES-23 (Number of precipitation bands suitable for its survival)	9	1	
IMPACT POTENTIAL			
General Impacts			
Imp-G1 (Allelopathic)	? - max		Unknown.
Imp-G2 (Parasitic)	n - negl	0	No evidence. *Wikstroemia indica* is a shrub in the family Thymelaeaceae, which is not a family known to contain parasitic plants (Heide-Jørgensen, 2008; Nickrent, 2009).
Impacts to Natural Systems			
Imp-N1 (Change ecosystem processes and parameters that affect other species)	? - max		Unknown.
Imp-N2 (Change community structure)	? - max		*Wikstroemia indica* is a 0.5 to 2 meter tall shrub (Haslam, 2013; Zhengyi et al., 2012), but we were unable to find information about the population structure of multiple *Wikstroemia indica* plants. *Wikstroemia indica* is managed in conservation areas in Mauritius (Wittenberg and Cock, 2001), which suggests that it could have an impact in natural areas. However, we were unable to find any information about the types of impacts that *Wikstroemia indica* has in natural areas. Thus, answering unknown.
Imp-N3 (Change community composition)	? - max		Unknown. Included in a list of invasive plant species on Mauritius that "form monospecific stands" and "[hamper] the natural regeneration of the natives" (Gopal, 2003) but it is unclear what degree of impact *Wikstroemia indica* has on native species versus the other species listed.
Imp-N4 (Is it likely to affect Federal Threatened and Endangered species)	? - max		Unknown. Invades native forests of Mauritius (Gopal, 2003) and is controlled in conservation areas (Wittenberg and Cock, 2001). However, we were unable to find information about specific impacts that this shrub has on native plant species.
Imp-N5 (Is it likely to affect any globally outstanding ecoregions)	? - max		Unknown. Invades native forests of Mauritius (Gopal, 2003) and is controlled in conservation areas (Wittenberg and Cock, 2001). However, we were unable to find information about specific impacts that this shrub has on native plant species.
Imp-N6 (Weed status in natural systems)	c - low	0.6	Manual weeding is used to remove *Wikstroemia indica* from conservation management areas in Mauritius (Wittenberg and Cock, 2001). Reunion Island prohibits the entry of *Wikstroemia indica* (EPPO, 2012). Alternate answers for the Monte Carlo simulation are both "b."
Impact to Anthropogenic Systems (cities, suburbs, roadways)			
Imp-A1 (Impacts human	n - mod	0	No evidence.

property, processes, civilization, or safety)			
Imp-A2 (Changes or limits recreational use of an area)	n - mod	0	No evidence.
Imp-A3 (Outcompetes, replaces, or otherwise affects desirable plants and vegetation)	n - mod	0	No evidence.
Imp-A4 (Weed status in anthropogenic systems)	a - mod	0	No evidence that *Wikstroemia indica* is considered a weed or controlled in urban/suburban settings. Alternate answers for the Monte Carlo simulation are both "b."
Impact to Production Systems (agriculture, nurseries, forest plantations, orchards, etc.)			
Imp-P1 (Reduces crop/product yield)	y - low	0.4	In Australia, *Wikstroemia indica* has "caused catastrophic losses, particularly to dairy herds" and has killed deer on deer farms (Dowling, 1985).
Imp-P2 (Lowers commodity value)	y - high	0.2	Dowling (1985) recommends that livestock farmers treat *Wikstroemia indica* plants with herbicides or manually dig out the plants (Dowling, 1985). We did not find economic values to estimate the cost of *Wikstroemia indica* control, but plant removal from grazing areas would likely increase production costs, so answering yes with high uncertainty.
Imp-P3 (Is it likely to impact trade)	n - mod	0	No evidence.
Imp-P4 (Reduces the quality or availability of irrigation, or strongly competes with plants for water)	n - mod	0	No evidence.
Imp-P5 (Toxic to animals, including livestock/range animals and poultry)	y - negl	0.1	All parts of the plant are toxic (Dowling, 1985). Symptoms of *Wikstroemia indica* poisoning in cattle include lethargy, weakness, blood-stained urine and feces, extensive hemorrhaging, and death. Death occurs within one to two days after livestock eat the plants (Dowling, 1985). Used as a fish poison (Haslam, 2013).
Imp-P6 (Weed status in production systems)	c - low	0.6	Biological control programs are used against *Wikstroemia indica* in pastoral areas in the Pacific (Blanfort and Orapa, 2008). Listed as a major pasture weed in New Caledonia (Blanfort and Orapa, 2008). Alternate answers for the Monte Carlo simulation are both "b."
GEOGRAPHIC POTENTIAL			Below, p.s. refers to Point Source data (i.e., geo-referenced data points) and occ. refers to occurrence-only data (i.e., presence in a region).
Plant cold hardiness zones			
Geo-Z1 (Zone 1)	n - negl	N/A	No evidence.
Geo-Z2 (Zone 2)	n - negl	N/A	No evidence.
Geo-Z3 (Zone 3)	n - negl	N/A	No evidence.
Geo-Z4 (Zone 4)	n - negl	N/A	No evidence.
Geo-Z5 (Zone 5)	n - negl	N/A	No evidence.
Geo-Z6 (Zone 6)	n - low	N/A	No evidence.
Geo-Z7 (Zone 7)	n - mod	N/A	No evidence.
Geo-Z8 (Zone 8)	n - high	N/A	No evidence.
Geo-Z9 (Zone 9)	y - negl	N/A	Australia, Taiwan (GBIF, 2013, p.s.)
Geo-Z10 (Zone 10)	y - negl	N/A	Australia, China (GBIF, 2013, p.s.)
Geo-Z11 (Zone 11)	y - negl	N/A	Australia, Taiwan (GBIF, 2013, p.s.)

Geo-Z12 (Zone 12)	y - negl	N/A	Papua New Guinea (GBIF, 2013, p.s.), Myanmar (NGRP, 2013, occ.)
Geo-Z13 (Zone 13)	y - low	N/A	Papua New Guinea (GBIF, 2013, p.s.)
Köppen-Geiger climate classes			
Geo-C1 (Tropical rainforest)	y - negl	N/A	Papua New Guinea, Australia (GBIF, 2013, p.s.)
Geo-C2 (Tropical savanna)	y - negl	N/A	Australia (GBIF, 2013, p.s.)
Geo-C3 (Steppe)	n - mod	N/A	No evidence.
Geo-C4 (Desert)	n - mod	N/A	No evidence.
Geo-C5 (Mediterranean)	n - mod	N/A	No evidence.
Geo-C6 (Humid subtropical)	y - negl	N/A	China, Taiwan, Australia (GBIF, 2013, p.s.)
Geo-C7 (Marine west coast)	y - low	N/A	Australia (GBIF, 2013, p.s.)
Geo-C8 (Humid cont. warm sum.)	n - low	N/A	No evidence.
Geo-C9 (Humid cont. cool sum.)	n - low	N/A	No evidence.
Geo-C10 (Subarctic)	n - negl	N/A	No evidence.
Geo-C11 (Tundra)	n - negl	N/A	No evidence.
Geo-C12 (Icecap)	n - negl	N/A	No evidence.
10-inch precipitation bands			
Geo-R1 (0-10 inches; 0-25 cm)	n - mod	N/A	No evidence.
Geo-R2 (10-20 inches; 25-51 cm)	n - high	N/A	No evidence.
Geo-R3 (20-30 inches; 51-76 cm)	y - negl	N/A	Australia (GBIF, 2013, p.s.)
Geo-R4 (30-40 inches; 76-102 cm)	y - negl	N/A	Australia (GBIF, 2013, p.s.)
Geo-R5 (40-50 inches; 102-127 cm)	y - negl	N/A	Australia (GBIF, 2013, p.s.)
Geo-R6 (50-60 inches; 127-152 cm)	y - negl	N/A	Australia, China (GBIF, 2013, p.s.)
Geo-R7 (60-70 inches; 152-178 cm)	y - negl	N/A	Australia, New Caledonia (GBIF, 2013, p.s.)
Geo-R8 (70-80 inches; 178-203 cm)	y - negl	N/A	Taiwan (GBIF, 2013, p.s.)
Geo-R9 (80-90 inches; 203-229 cm)	y - negl	N/A	Papua New Guinea, Taiwan (GBIF, 2013, p.s.)
Geo-R10 (90-100 inches; 229-254 cm)	y - negl	N/A	Papua New Guinea (GBIF, 2013, p.s.)
Geo-R11 (100+ inches; 254+ cm))	y - low	N/A	Malaysia (GBIF, 2013, p.s.)
ENTRY POTENTIAL			
Ent-1 (Plant already here)	y - high	1	Present in the Hoomaluhia Botanical Garden in Hawaii (GBIF, 2013). Listed as not in cultivation in the United States by Parker et al. (2007). We did not find any other evidence of *Wikstroemia indica* being cultivated in the United States. Thus, answering yes, but with high uncertainty.
Ent-2 (Plant proposed for entry, or entry is imminent)		N/A	
Ent-3 (Human value & cultivation/trade status)		N/A	Cultivated on Mauritius where the leaves are used in medicinal infusions for anemia (Chintamunnee and Mahomoodally, 2012).
Ent-4 (Entry as a			

contaminant)	
Ent-4a (Plant present in Canada, Mexico, Central America, the Caribbean or China)	N/A
Ent-4b (Contaminant of plant propagative material (except seeds))	N/A
Ent-4c (Contaminant of seeds for planting)	N/A
Ent-4d (Contaminant of ballast water)	N/A
Ent-4e (Contaminant of aquarium plants or other aquarium products)	N/A
Ent-4f (Contaminant of landscape products)	N/A
Ent-4g (Contaminant of containers, packing materials, trade goods, equipment or conveyances)	N/A
Ent-4h (Contaminants of fruit, vegetables, or other products for consumption or processing)	N/A
Ent-4i (Contaminant of some other pathway)	N/A
Ent-5 (Likely to enter through natural dispersal)	N/A