United States Department of Agriculture

Animal and Plant Health Inspection Service

May 14, 2012

Version 1

Weed Risk Assessment for *Carex breviculmis* R. Br. (Cyperaceae) – Short-stem sedge

Photograph by Charles Bryson (USDA-ARS).

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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 "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[1]—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 our 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 any area within it. We use a climate matching tool in our WRAs to evaluate those areas of the United States that are suitable for the establishment of the plant. We also use a Monte Carlo simulation to evaluate the consequences of uncertainty on the outcome of the risk assessment. For more information on the PPQ WRA process, please refer to the document, *Introduction to the PPQ Weed Risk Assessment Process*, which is available upon request.

***Carex breviculmis* R. Br. - Short-stem sedge**

Species Family: Cyperaceae

Information Initiation: On March 2, 2010, Charles Bryson with the USDA Agricultural Research Service (ARS), alerted Al Tasker (PPQ National Weeds Program Coordinator) about the weed *Carex breviculmis* (Bryson, 2010). This species was detected for the first time in the United States in Mississippi (Majure and Bryson, 2008). Dr. Tasker asked the Plant Epidemiology and Risk Analysis Laboratory to evaluate this weed.

Foreign distribution: *Carex breviculmis* is native to Australia, New Zealand, and a wide range of countries in southern and eastern Asia (China, India, Japan, Korea, Malaysia, Nepal, Sri Lanka, and Vietnam) (GBIF, 2011; Majure and Bryson, 2008; Ohwi, 1984). It may also be naturalized in Sweden, Finland, and Norway (GBIF, 2011).

U.S. distribution and status: *Carex breviculmis* is naturalized in eight sites in two counties in Mississippi (Bryson, 2010; Majure and Bryson, 2008). Two of the sites are cemeteries: one is the burial site for Romani royalty, and the other is managed by the same company that manages the first cemetery. A third site is near a railroad where migrant people and Romani sometimes camp (Bryson, 2010). We do not know of any management that is being taken against this species.

WRA area: Entire United States, including territories

[1] Koop, A., L. Fowler, L. Newton, and B. Caton. 2012. Development and validation of a weed screening tool for the United States. Biological Invasions 14(2):273-294. DOI:10.1007/s10530-011-0061-4

1. *Carex breviculmis* analysis

Establishment/Spread Potential

Carex breviculmis is a sedge that reproduces sexually through seed production and asexually through vegetative reproduction from rhizomes (Huh et al., 2000). *Carex breviculmis* seeds likely form a persistent seed bank in the soil (Wearne and Morgan, 2006). We found no direct evidence that seeds of *C. breviculmis* are adapted for long-distance dispersal, but evidence about its establishment in the United States suggests that people may unintentionally disperse it (Majure and Bryson, 2008). *Carex breviculmis* has a wide native distribution (Bryson, 2010; Ohwi, 1984), suggesting that it can establish in a variety of climates and habitats. Surprisingly, however, we only found evidence for naturalization in Finland, Sweden, Norway, and the United States (GBIF, 2011; Majure and Bryson, 2008). Somewhat limited information on this species resulted in an above average amount of uncertainty for this risk element.

Risk score = 5 Uncertainty index= 0.27

Impact Potential

In its native range, *C. breviculmis* is considered a weed of natural, production, and disturbed systems, but we found no evidence of specific impacts. In southeast Asia, *C. breviculmis* is listed as a weed in rice (Moody, 1989). In New Zealand, it is a weed in modified grasslands, and in urban areas it is a persistent weed in pavement cracks (Landcare Research, 2011). Beyond those statements, we found no other information about its damage potential. Accordingly, this element had an average amount of uncertainty.

Risk score = 1.5 Uncertainty index = 0.21

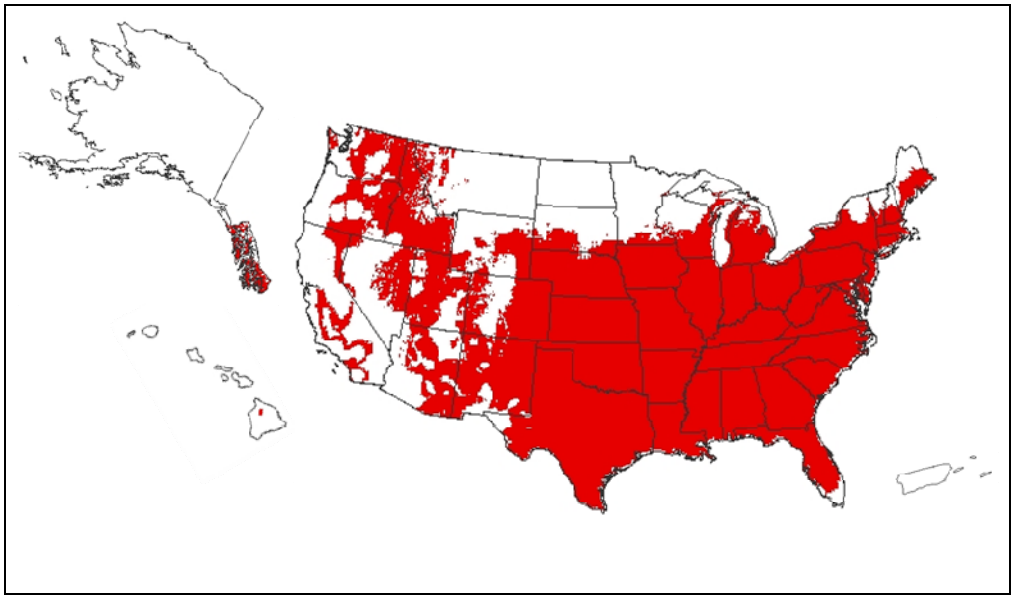
Geographic Potential

We estimate that about 58 percent of the United States is suitable for the establishment of *C. breviculmis* (Fig. 1). We based that on the species' known distribution elsewhere in the world and includes point-referenced localities and areas of occurrence obtained primarily from GBIF (2011). The map for *C. breviculmis* represents the joint distribution of USDA Plant Hardiness Zones 5-10, areas with 10-100 inches of annual precipitation, and the following Köppen-Geiger climate classes: steppe, humid subtropical, humid continental warm summers, humid continental cool summers, and marine west coast.

Entry Potential

Because *C. breviculmis* is naturalized in the United States (Bryson, 2010; Majure and Bryson, 2008), we did not need to assess its entry potential.

Figure 1. Predicted distribution of *Carex breviculmis* 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) = 11.4%
P(Minor Invader) = 69.5%
P(Non-Invader) = 19.1%
Risk Result = Evaluate Further
Secondary Screening = Evaluate Further

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

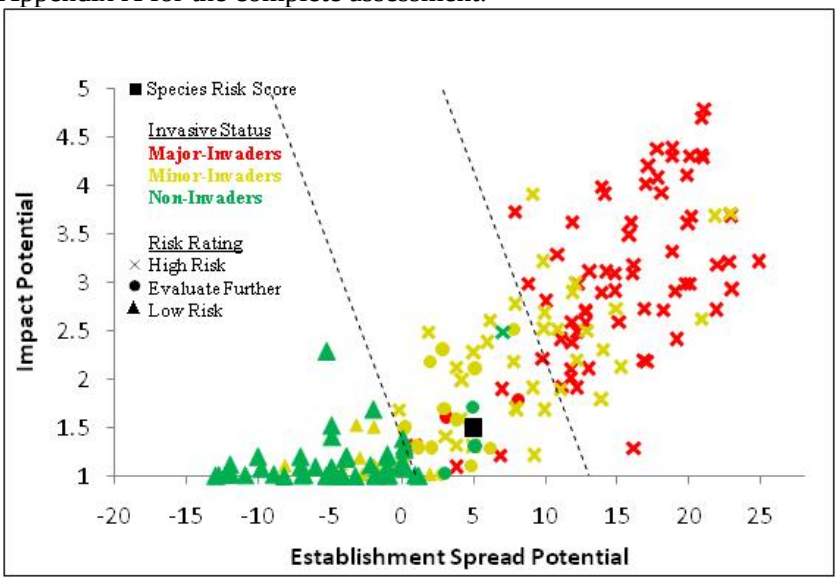
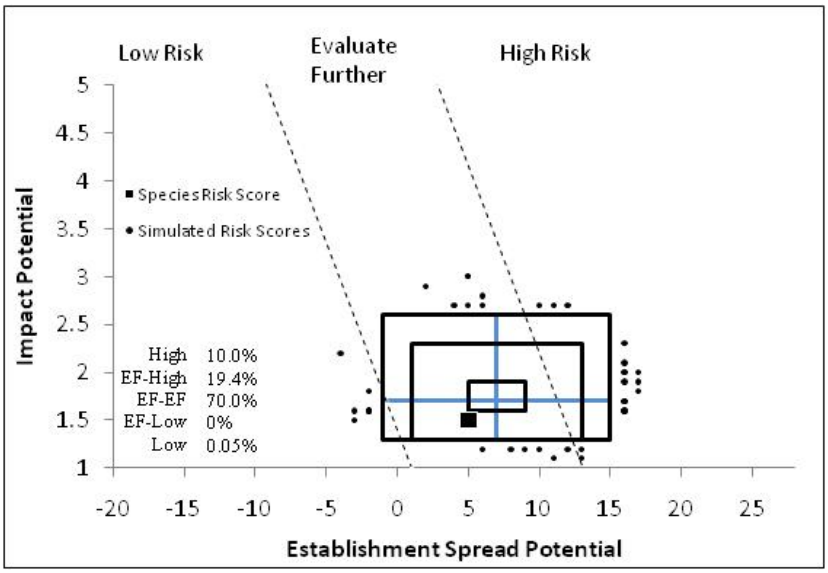


Figure 3. Monte Carlo simulation results (N=5000) for uncertainty around *Carex breviculmis*'s risk scores[a].



[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 *C. breviculmis* is Evaluate Further. Relative to the other 204 species used to develop our predictive model, this species has a set of traits associated with minor-invaders (Fig. 2). Our model indicates it has a 70 percent chance of being a minor-invader, with the remaining 30 percent split equally between the non-invader and major-invader categories. Because of the amount of uncertainty associated with this assessment, additional information could shift its risk score closer to the High Risk region (Fig. 3).

In Mississippi, the investigators who discovered *C. breviculmis* noted that it is morphologically variable, even within populations (Majure and Bryson, 2008). In particular, in sunny mowed lawns, the culms tended to fall over and lay flat on the ground (Majure and Bryson, 2008). This behavior may help *C. breviculmis* escape regular damage caused by mowing, and thereby contribute to its weed potential in lawns. Currently, *C. breviculmis* is known from only eight sites in two counties in Mississippi (Bryson, 2010; Majure and Bryson, 2008). Because it is not cultivated or available for resale, management efforts to contain or eradicate this species may be more successful than a scenario where the species is cultivated in the United States.

4. Literature Cited

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Appendix A. Weed risk assessment for *Carex breviculmis* R.Br. (Cyperaceae). The following information was obtained from the species' risk assessment which was conducted on a Microsoft Excel platform. The information shown below was modified to fit on the page. The original Excel file, the full questions, and the guidance to answer the questions are available upon request.

Question ID	Answer - Uncertainty	Score	Notes (and references)
Establishment/Spread Potential			
ES-1 (Invasiveness elsewhere)	e - low	2	*Carex breviculmis* is native to the Far East from eastern Afghanistan to India, Korea, China, Japan, and Australia, and other countries in between these (Majure and Bryson, 2008; Ohwi, 1984). Native to New Zealand (NZ PCN, 2011). Reported from four sites in Meridian, Lauderdale County, Mississippi, one of which has over 1,000 plants (Majure and Bryson, 2008). Based on population sizes and development, Majure and Bryson (2008) estimate that the plant has been in Meridan for 25 years (Majure and Bryson, 2008). It may also be naturalized in Sweden, Finland, and Norway (GBIF, 2011).
ES-2 (Domesticated to reduce weed potential)	n - negl	0	No evidence of ornamental use was found by Majure and Bryson (2008), but it is suggested as an "[e]xcellent small carex for borders, rockeries, cottage gardens" and is commercially available in Australia (Yarra, 2010). It does not appear in a database of hundreds of nursery catalogues from around the world (Backyard Gardener, 2011).
ES-3 (Weedy congeners)	y - mod	1	No *Carex* species are listed as Federal Noxious Weeds (7 CFR § 360, 2011). Four native species of *Carex* (*C. buchananii*, *C. comans*, *C. flagellifera*, and *C. testacea*) are considered weedy in Australia, primarily in pastures and lucernes, and are spreading due to increasing use as ornamentals (Parsons and Cuthbertson, 2001). Congener *Carex kobomugi* (Japanese sedge, Asiatic sand sedge), from China, is listed as invasive (Zheng et al., 2005). *Carex leporina* is a principle weed in New Zealand (Holm et al., 1979)
ES-4 (Shade Tolerance)	? - max		*Carex breviculmis* is found in sun and shade in Mississippi, growing under moderately shaded conditions under *Quercus* and doing well in another site under deciduous trees (Majure and Bryson, 2008). *Carex breviculmis* is abundant in open fields, and *C. breviculmis* var. *puberula* occurs in "shady hillsides" in two areas of Japan (Ohwi, 1984). In China, it is found in grasslands on mountain slopes, waysides, ditch sides in valleys at elevations from 400-2300 m (Zhengyi et al., 2011). Overall, this species is described as growing in relatively open and sunny habitats; however, where it has been found in the United States, it has been reported from some shaded sites that contain deciduous trees. It is not clear from these descriptions whether the species is able to complete some or all of its life cycle or just "survive" under shade conditions. Consequently, answering unknown.
ES-5 (Climbing or smothering growth form)	n - negl	0	It is an herbaceous perennial (Hoffmann et al., 2010) with densely tufted clumps (Majure and Bryson, 2008). No evidence of a climbing growth habit.

Question ID	Answer - Uncertainty	Score	Notes (and references)
ES-6 (Dense Thickets)	n - low	0	Herbaceous perennial (Hoffmann et al., 2010). No evidence that it forms dense thickets.
ES-7 (Aquatic)	n - negl	0	Terrestrial plant, not an aquatic (Majure and Bryson, 2008; Ohwi, 1984).
ES-8 (Grass)	n - negl	0	Plant in Cyperaceae (Ohwi, 1984; Ross and Walsh, 2003), not Poaceae.
ES-9 (N2-fixer)	n - negl	0	Plant in Cyperaceae (Ohwi, 1984; Ross and Walsh, 2003), not in a nitrogen-fixing family.
ES-10 (Viable seeds)	y - negl	1	Reproduces by seed or vegetatively (Huh et al., 2000). Germinable seeds obtained from seed bank (Wearne and Morgan, 2006). There is a report of mature seeds produced during an experiment testing the effect of climate change on flowering and seed production (Hoffmann et al., 2010).
ES-11 (Self-compatible)	? - max	0	Unknown. The following evidence is inconclusive. Species reproduces "either clonally or sexually via monoecious flowers" (Huh et al., 2000). "...the floral architecture and the fixation index of *C. breviculmis* suggest that populations of this species typically outcross. A small deficit of heterozygotes was found for *C. breviculmis*, indicating that some selfing or biparental inbreeding may occur, or that plants are intermating and dispersing over a smaller scale than was sampled" (Huh et al., 2000).
ES-12 (Special Pollinators)	n - negl	0	No evidence. "Typical of the species, flowers of *C. breviculmis* are monoecious and highly reduced (Lee, 1997; Ford et al., 1998 - as cited by Huh et al., 2000), strongly indicating it is primarily wind-pollinated (Huh et al., 2000), as are most other grasses and sedges.
ES-13 (Min generation time)	c - low	0	*Carex* species do not flower until at least 2 years old (Parsons and Cuthbertson, 2001). Time from budding to flowering and then seed maturation varied over the five-year study, but time to first seed maturation varied from 210 to 230 days (Hoffmann et al., 2010). This indicates the flowering period takes a long time, perhaps too long for it to happen in the first year of the plant's life.
ES-14 (Prolific reproduction)	? - max	0	Unknown
ES-15 (Unintentional dispersal)	y - high	1	It is unlikely this species was intentionally introduced into the United States as it is not cultivated. Based on its location in the United States and site conditions, authors suggested that it might have been moved inadvertently by the Romani people, on railroad or military equipment (Majure and Bryson, 2008). People visiting beaches and dunes for recreation disperse seeds of *C. arenaria* (Maun, 2009). Majure and Bryson (2008) speculate that achenes and live plants are likely dispersed on contaminated mowing, construction, and grave digging equipment.
ES-16 (Trade contaminant)	? - max	0	Unknown
ES-17 (#Natural dispersal vectors)	0 -	-4	0
ES-17a (Wind dispersal)	n - mod		No obvious adaptations for wind dispersal (Majure and Bryson, 2008).
ES-17b (Water dispersal)	? - max		Unknown. *Carex* species native to U.S. marshlands have

Question ID	Answer - Uncertainty	Score	Notes (and references)
			seeds encased in bladder-like cases (utricles) that float (Starr et al., 2009). *Carex breviculmis* produces its nutlets in utricles (Wilson, 2009). *Carex* seeds and propagules disperse through sea water (Maun, 2009).
ES-17c (Bird dispersal)	n - mod		No evidence.
ES-17d (Animal external dispersal)	n - mod		No evidence.
ES-17e (Animal internal dispersal)	n - mod		No evidence
ES-18 (Seed bank)	y - mod	1	In a study of the soil seed bank under *Cytisus scoparius*, graminoids, such as *Carex breviculmis*, represented the majority of germinable seed bank species (Wearne and Morgan, 2006). Although this study does not directly demonstrate that seeds exhibit a long- term persistence, germinable seeds of *C. breviculmis* were obtained from sites that had been invaded by *Cytisus scoparius* for about 25 years. *Carex breviculmis* was one of the most important species recovered from the seed bank across all plots. This study strongly suggests *C. breviculmis*' seeds can persist a long time in the seed bank.
ES-19 (Tolerance to loss of biomass)	? - max	0	Unknown. Tolerant of trampling and rarely grazed (Landcare Research, 2011); this is insufficient evidence for a yes, but noted here.
ES-20 (Herbicide resistance)	n - mod	0	No evidence. Not listed in Heap (2011).
ES-21 (# Cold hardiness zones)	6	0	
ES-22 (# Climate types)	5	2	
ES-23 (# Precipitation bands)	9	1	
Impact Potential			
General Impacts			
Imp-G1 (Allelopathic)	n - high	0	No evidence.
Imp-G2 (Parasitic)	n - negl	0	Cyperaceae (Ohwi, 1984; Ross and Walsh, 2003) is not known to contain parasitic plants (Heide-Jorgensen, 2008; Nickrent, 2009).
Impacts to Natural Systems			
Imp-N1 (Ecosystem processes)	n - mod	0	No evidence.
Imp-N2 (Community structure)	n - mod	0	No evidence that this plant will change the community structure.
Imp-N3 (Community composition)	n - mod	0	No evidence.
Imp-N4 (T&E species)	n - low	0	No evidence.
Imp-N5 (Globally outstanding ecoregions)	n - low	0	No evidence.
Imp-N6 (Natural systems weed)	b - high	0.2	Species is native to New Zealand, but considered a significant weed in modified tussock grasslands (Landcare Research, 2011; Simpson and Inglis, 2001). Using high uncertainty as we are not sure how disturbed these grasslands are and if the habitat is better categorized as anthropogenic. There was no other evidence about weediness in natural systems.
Impact to Anthropogenic areas (cities, suburbs, roadways)			

Question ID	Answer - Uncertainty	Score	Notes (and references)
Imp-A1 (Affects property, civilization, ...)	n - mod	0	Grows in cracks in concrete (Majure and Bryson, 2008), but it is unknown if it helped cause the cracks. Seems unlikely that a grass would cause the breaks.
Imp-A2 (Recreational use)	n - low	0	No evidence and unlikely as this is a short species.
Imp-A3 (Affects ornamental plants)	? - max		Unknown. Populations are large in cemeteries and disturbed areas (Majure and Bryson, 2008).
Imp-A4 (Anthropogenic weed)	b - low	0.1	Species occurs in disturbed areas (Majure and Bryson, 2008). It is a persistent weed in cracks in concrete and is hard to kill (Landcare Research, 2011). No other evidence of control was found. The evidence suggests it is controlled in anthropogenic areas, but it isn't very conclusive.
Impact to Production systems (agriculture, nurseries, forest plantations, orchards, etc.)			
Imp-P1 (Crop yield)	n - mod	0	No evidence.
Imp-P2 (Commodity Value)	n - mod	0	No evidence.
Imp-P3 (Affects trade)	n - mod	0	No evidence.
Imp-P4 (Irrigation)	n - mod	0	No evidence.
Imp-P5 (Animal toxicity)	n - mod	0	No evidence of toxicity to animals or poultry. It is rarely grazed (Landcare Research, 2011), suggesting it may not be palatable (which is not evidence of toxicity).
Imp-P6 (Production system weed)	b - low	0.2	Native to New Zealand, but considered a significant patch-forming weed in reverting pastures in the country (Landcare Research, 2011). A weed of rice in southeast Asia, again where it is native (Moody 1989 cited in Majure and Bryson, 2008). No evidence of control.
Geographic Potential			Unless otherwise noted, all data was obtained from GBIF (2011). PS=Point Source data; Occ=occurrence data
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 - mod	N/A	No evidence.
Geo-Z5 (Zone 5)	y - negl	N/A	Point Source (PS): Japan, China
Geo-Z6 (Zone 6)	y - negl	N/A	Point Source (PS): Japan, China
Geo-Z7 (Zone 7)	y - negl	N/A	Point Source (PS): Japan, China
Geo-Z8 (Zone 8)	y - negl	N/A	PS: New Zealand; Occurrence (Occ): Mississippi
Geo-Z9 (Zone 9)	y - negl	N/A	PS: Australia, China
Geo-Z10 (Zone 10)	y - negl	N/A	PS: Australia, China (Taiwan); Occ: Myanmar
Geo-Z11 (Zone 11)	n - negl	N/A	No evidence.
Geo-Z12 (Zone 12)	n - negl	N/A	No evidence.
Geo-Z13 (Zone 13)	n - negl	N/A	No evidence.
Koppen-Geiger climate classes			
Geo-C1 (Tropical rainforest)	n - low	N/A	No evidence.
Geo-C2 (Tropical savanna)	n - high	N/A	No evidence.
Geo-C3 (Steppe)	y - low	N/A	Occ: (Zhengyi et al., 2011)
Geo-C4 (Desert)	n - negl	N/A	No evidence.
Geo-C5 (Mediterranean)	n - mod	N/A	No evidence.

Question ID	Answer - Uncertainty	Score	Notes (and references)
Geo-C6 (Humid subtropical)	y - negl	N/A	PS: Japan, Nepal, Mississippi
Geo-C7 (Marine west coast)	y - negl	N/A	PS: China
Geo-C8 (Humid cont. warm sum.)	y - negl	N/A	PS: Japan, South Korea
Geo-C9 (Humid cont. cool sum.)	y - low	N/A	PS: Japan, China
Geo-C10 (Subarctic)	n - mod	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")	n - high	N/A	No evidence.
Geo-R2 (10-20")	y - negl	N/A	PS: Australia
Geo-R3 (20-30")	y - negl	N/A	PS: Australia
Geo-R4 (30-40")	y - negl	N/A	PS: Australia
Geo-R5 (40-50")	y - negl	N/A	PS: New Zealand
Geo-R6 (50-60")	y - negl	N/A	PS: New Zealand; Occ: Mississippi
Geo-R7 (60-70")	y - negl	N/A	PS: New Zealand
Geo-R8 (70-80")	y - negl	N/A	By default yes because it grows in wetter and drier precipitation bands.
Geo-R9 (80-90")	y - negl	N/A	PS: New Zealand
Geo-R10 (90-100")	y - negl	N/A	PS: Papua New Guinea
Geo-R11 (100"+)	n - high	N/A	No evidence.
Entry Potential			
Ent-1 (Already here)	y - negl	1	Present in Meridian, Lauderale County, Mississippi (Majure and Bryson, 2008)
Ent-2 (Proposed for entry)	-	N/A	
Ent-3 (Human value & cultivation/trade status)	-	N/A	
Ent-4 (Entry as a Contaminant)			
Ent-4a (In MX, CA, Central Amer., Carib., or China)	-	N/A	
Ent-4b (Propagative material)	-	N/A	
Ent-4c (Seeds)	-	N/A	
Ent-4d (Ballast water)	-	N/A	
Ent-4e (Aquaria)	-	N/A	
Ent-4f (Landscape products)	-	N/A	
Ent-4g (Container, packing, trade goods)	-	N/A	
Ent-4h (Commodities for consumption)	-	N/A	
Ent-4i (Other pathway)	-	N/A	
Ent-5 (Natural dispersal)	-	N/A	