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Weed Risk Assessment for *Jatropha curcas* L. (Euphorbiaceae) – Physic nut

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Animal and Plant Health Inspection Service

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Version 1

Top left: Inflorescence of *J. curcas*. Top right: Seeds and capsule. Bottom left: Habit. Bottom right: Leaves and fruit (Source:Starr and Starr, 2009-2012).

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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.

***Jatropha curcas* L. – Physic nut**

Species Information

Family: Euphorbiaceae

Synonyms: *Castiglionia lobata* Ruiz & Pav., *Curcas adansonii* Endl., *Cu. curcas* (L.) Britton & Millsp., *C. drastica* Mart., *C. indica* A. Rich., *C. purgans* Medik., *Jatropha acerifolia* Salisb., *J. afrocurcas* Pax, *J. condor* Wall., *J. edulis* Cerv., *J. moluccana* Wall., *J. tuberosa* Elliot, *J. yucatanensis* Briq., *Manihot curcas* (L.) Crantz, *Ricinus americanus* Mill., *R. jarak* Thunb. (Tropicos.org, 2014).

Common names: Physic nut, Barbados nut, curcas bean, purge nut, purging nut (Parsons and Cuthbertson, 2001). Known by many other names in different languages (see NGRP, 2014; Sunil et al., 2013).

Botanical description: *Jatropha curcas* is a deciduous, perennial, somewhat succulent, monoecious shrub or small tree that becomes 8 to 15 meters tall (Dehgan, 2012; Henning, 2007). Leaves are dark green, ivy-like, smooth, heart-shaped, up to 150 mm wide (Parsons and Cuthbertson, 2001). Flowers are yellow to green, unisexual, small and inconspicuous (Parsons and Cuthbertson, 2001). The inflorescence is a terminal or axillary umbel-like cyme, often paired with a solitary female flower terminating each major axis and many male flowers on lateral branches (Henning, 2007). It has a yellow fruit when immature that turns dark brown when ripe (Orwa et al., 2009; Parsons and Cuthbertson, 2001). The fruit is a drupaceous, trilocular, ellipsoid capsule, 23 to 30 mm long by 28 mm wide (Dehgan, 2012). The exocarp of the fruit remains fleshy until the seeds are mature (Orwa et al., 2009). Seeds

are black or black mottled with some white spots, oblong-ellipsoidal, 18 to 20 mm long by 11 to 13 mm wide, with a smooth seed coat (Dehgan, 2012). Refer to Dehgan, 2012) and Reed, 1977) for a detailed botanical description of the taxon.

Initiation: *Jatropha curcas* is a large shrub being promoted as a biofuel feedstock (Carels et al., 2012). On December 23, 2014, the U.S. Environmental Protection Agency asked Jonathan Jones, PPQ Noxious Weeds Policy Manager, if the invasive potential of *Jatropha curcas* might lead the USDA to recommend additional restrictions on its use as a biofuel plant (Lie, 2014). Jones requested that the PERAL Weed Team evaluate this species with a weed risk assessment.

Foreign distribution: *Jatropha curcas* is native to the American tropics, most likely to Mexico, Central America, and the Caribbean (Sunil et al., 2013). It has been widely introduced as a hedge and ornamental plant and is widely cultivated in tropical and subtropical regions in Africa, Asia, and Latin America (GEXSI, 2008; IPCS, 2015; Northern Land Manager, 2011; Parsons and Cuthbertson, 2001).

U.S. distribution and status: *Jatropha curcas* is reported in some counties of southern Florida (Gann et al., 2001-2014; Kartesz, 2014; NRCS, 2014) and "occasionally naturalized" along the east coast of Florida from Brevard County southward (Nelson, 2011). It is also "sparsely naturalized" in Hawaii (Maui) (Wagner et al., 1990). In Puerto Rico it is "[o]n hillsides, on waste grounds and in woodlands, at lower to middle elevations, often planted and spontaneous after cultivation" (Liogier and Martorell, 2000). It occurs in American Samoa, Guam, Northern Mariana Islands (CABI, 2015), and the U.S. Virgin Islands (Más and Lugo-Torres, 2013), but its exact status in those territories is unknown.

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

1. *Jatropha curcas* analysis

Establishment/Spread Potential

Jatropha curcas is a deciduous, perennial plant (Dehgan, 2012; Henning, 2007) that produces viable seeds (Brittaine and Lutaladio, 2010). It has been introduced as a hedge and ornamental plant and is widely cultivated in tropical and subtropical regions in Africa, Asia, and Latin America (GEXSI, 2008; IPCS, 2015; Northern Land Manager, 2011; Parsons and Cuthbertson, 2001) for medicinal purposes (Henning, 2007) and seed oil, which is used for manufacturing soap, lamp oil, lubricant, and more recently as a biofuel feedstock (Henning, 2007). It is naturalized in many countries (IPCS, 2015; Kirtikar, 1903; Maundu and Tengnäs, 2005) and has spread in some others (IPCS, 2015). Some mammals, such as rodents, likely disperse seeds of *J. curcas* by moving seeds to their burrows or other feeding sites, but such

[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).

instances are likely rare (Negussie et al., 2014). *Jatropha curcas* tolerates some mutilation by re-sprouting from its tuberous roots when injured (Northern Land Manager, 2011; Parsons and Cuthbertson, 2001). We had average uncertainty for this risk element.
Risk score = 7 Uncertainty index = 0.16

Impact Potential *Jatropha curcas* is reported as an environmental weed in Australia (Northern Land Manager, 2011; University of Queensland, 2011) and in other countries as a plant of environmental concern (Space and Flynn, 2002; Space et al., 2009). It is a quarantine pest for Australia and South Africa (Brittaine and Lutaladio, 2010; Parsons and Cuthbertson, 2001). Under laboratory conditions it has been shown to be allelopathic (Abugre and Quashie-Sam, 2010; Cremonez et al., 2013; Ma et al., 2011; Reichel et al., 2013; Rejila and Vijayakumar, 2011; Wang et al., 2009), but it is unknown if it has these same effects under field conditions. Under some conditions, *J. curcas* forms thickets that changes habitat structure with negative impacts on wildlife (Northern Land Manager, 2011) and it apparently threatens biodiversity (University of Queensland, 2011). All parts of *J. curcas*, especially the seeds, are generally toxic to humans and animals (Froberg et al., 2007 cited by Ferreira et al., 2011). Animals do not usually eat it, however, (IPCS, 2015), and toxicity depends on both plant variety (Brittaine and Lutaladio, 2010) and animal species (Ferreira et al., 2011; Heller, 1996; University of Queensland, 2011). Although considered a weed of anthropogenic and production systems (Holm et al., 1979; Randall, 2007; University of Queensland, 2011), we found no evidence that *J. curcas* is being managed in either system. We had very high uncertainty for this risk element due to limited detailed accounts of its impacts.
Risk score = 3 Uncertainty index = 0.29

Geographic Potential Based on three climatic variables, we estimate that about 11 percent of the United States is suitable for the establishment of *J. curcas* (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 *J. curcas* represents the joint distribution of Plant Hardiness Zones 9-13, areas with 0-100+ inches of annual precipitation, and the following Köppen-Geiger climate classes: tropical rainforest, tropical savanna, steppe, desert, humid subtropical, and marine west coast.

The area estimated is likely conservative since it only uses 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. *Jatropha curcas* is best adapted to arid and semi-arid conditions (Henning, 2007; Orwa et al., 2009). In its native range it is common in deciduous forests and open spaces (Dehgan, 2012) and occurs in seasonally dry areas including grassland-savannah and thorn forest scrub (Orwa et al., 2009). It also can colonize disturbed areas such as railroads, abandoned sites, wastelands, and disturbed sites (CABI, 2015; Northern Land Manager, 2011; Parsons and Cuthbertson, 2001). It will grow on

degraded, sandy or gravelly, and even saline soils with low nutrient content, but cannot survive in waterlogged terrain (Henning, 2007).

Entry Potential We did not assess the entry potential of *J. curcas* because it is already present in the United States (Kartesz, 2014; Nelson, 2011; Más and Lugo-Torres, 2013; NRCS, 2014; Wagner et al., 1990).

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

2. Results

Model Probabilities: P(Major Invader) = 33.6%
P(Minor Invader) = 60.7%
P(Non-Invader) = 5.6%
Risk Result = Evaluate Further
Secondary Screening = Evaluate Further

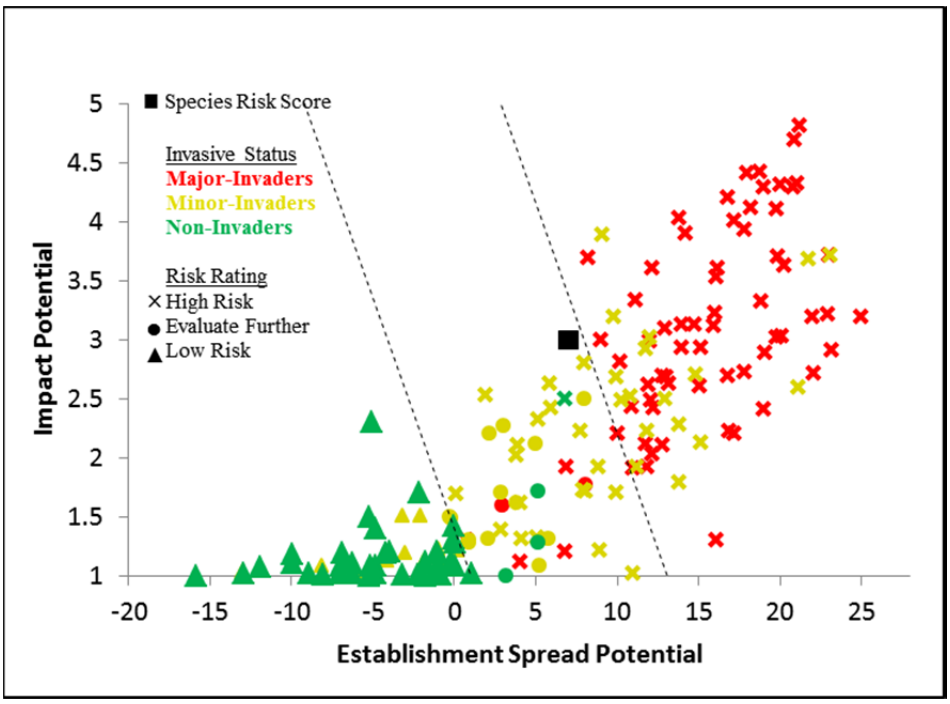

Figure 2. *Jatropha curcas* risk score (black box) relative to the risk scores of species used to develop and validate the PPQ WRA model (other symbols). See Appendix A for the complete assessment.

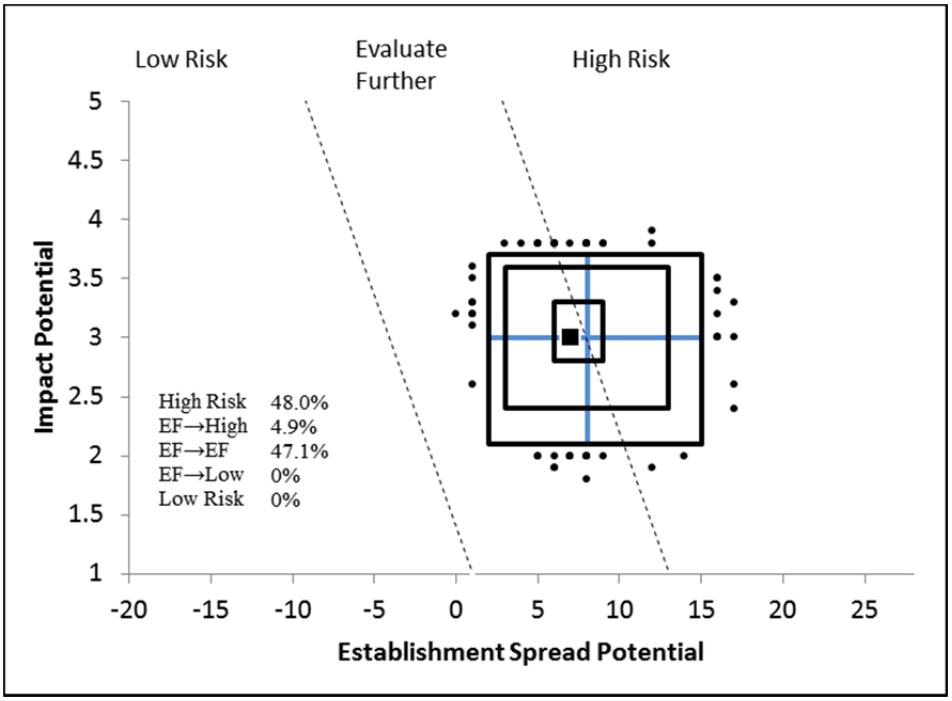

Figure 3. Model simulation results (N=5,000) for uncertainty around the risk score for *Jatropha curcas*. The blue "+" symbol represents the medians of the simulated outcomes. The smallest box contains 50 percent of the outcomes, the second 95 percent, and the largest 99 percent.

3. Discussion

The result of the weed risk assessment for *J. curcas* is Evaluate Further even after secondary screening. This species shares many traits with minor invaders (Fig. 2) and our model indicated a 61 percent probability of it being a minor invader. The risk score for *J. curcas* is very near the High Risk threshold though, with about 53 percent of the simulated risk scores resulting in a determination of High Risk in the uncertainty analysis (Fig. 3). Two different evaluations of *J. curcas* with the Australian Weed Risk Assessment gave this plant a reject outcome (Gordon et al., 2011; PIER, 2006).

The seed oil of this plant is being promoted as a biofuel feedstock (e.g., Beckford, n.d.). Consequently, farmers in the United States may be interested in growing more of this plant (e.g., Davis, 2011). Areas with tropical climates like Hawaii and many U.S. territories are likely to be the most suitable for its production as a biofuel (Jongschaap et al., 2007). *Jatropha curcas* reproduces by seed (Henning, 2007) and seed is the product harvested for biofuel feedstock oil (Carels et al., 2012). Harvesting *J. curcas* for biofuel production will decrease the number of propagules available, which will reduce the likelihood of this plant escaping production fields. In biofuel crops of *J. curcas*, full production is achieved in the fourth or fifth year (Henning, 2007), but under ideal conditions, *J. curcas* can produce seed within the first year (Silip, 2010). If not harvested, this seed could contribute to *J. curcas* escaping from production fields. Additionally, *J. curcas* is a perennial plant with an estimated lifespan of 30 to 50 years (Henning, 2007); any abandoned groves could serve as a seed source for many years. When removing plants, eliminating all of the roots is also recommended because re-sprouting can occur (Northern Land Manager, 2011; Parsons and Cuthbertson, 2001).

4. Literature Cited

7 U.S.C. § 1581-1610. 1939. The Federal Seed Act, Title 7 United States Code § 1581-1610.

7 U.S.C. § 7701-7786. 2000. Plant Protection Act, Title 7 United States Code § 7701-7786.

Abugre, S., and S. J. Quashie-Sam. 2010. Evaluating the allelopathic effect of *Jatropha curcas* aqueous extract on germination, radicle and plumule length of crops. International Journal of Agriculture and Biology 12(5):769-772.

Achten, W. M. J., L. R. Nielsen, R. Aerts, A. G. Lengkeek, E. D. Kjær, A. Trabucco, J. K. Hansen, W. H. Maes, L. Graudal, F. K. Akinnifesi, and B. Muys. 2010. Towards domestication of *Jatropha curcas* L. Biofuels 1(1):91-107.

Anonymous. n.d. Insect pests and diseases of *Jatropha* in east Africa. DEG KEF Bankengruppe, Jatropha Support Programme, http://www.jatropha.pro/PDF%20bestanden/Pests%20and%20Disease%

20Cards.pdf.
Armstrong, W. P. 1999. Blowing In The Wind: Seeds & Fruits Dispersed By Wind. Last accessed January 6, 2015, http://waynesword.palomar.edu/plfeb99.htm.
Beckford, F. B. n.d. *Jatropha curcas* questions and answers. University of Florida, Lee County Extension Service, Agriculture & Natural Resources, Fort Myers, Florida. http://lee.ifas.ufl.edu/AgNatRes/Pubs/Jatropha_Q_and_A2.pdf.
Brittaine, R., and N. Lutaladio. 2010. *Jatropha*: A Smallholder Bioenergy Crop. The Potential for Pro-Poor Development. Food and Agriculture Organization of the United Nations, Rome, http://www.fao.org/docrep/012/i1219e/i1219e.pdf.
CABI. 2015. Invasive Species Compendium. Commonwealth Agricultural Bureau International (CABI). http://www.cabi.org/isc/. (Archived at PERAL).
Carels, N., M. Sujatha, and B. Bahadur. 2012. *Jatropha*, Challenges for a New Energy Crop. Volume 1: Farming, Economics and Biofuel. Springer New York.
Costa, N. V., E. A. L. Erasmo, P. A. Queiroz, D. F. Dornelas, and B. F. Dornelas. 2009. Efeito da deriva simulada de glyphosate no crescimento inicial de plantas de pinhão-manso. Planta Daninha 27:1105-1110.
Cremonez, P. A., A. Feiden, R. F. Santos, D. Bassegio, E. Rossi, W. C. Nadaleti, A. J., and F. Tomassoni. 2013. Allelopathic influence of the aqueous extract of *Jatropha curcas* L. leaves on wild *Cichorium intybus*. African Journal of Agricultural Research 8(49):6575-6578.
Davis, J. 2011. New California Center to Focus on *Jatropha* Biodiesel. Domestic Fuel. Last accessed January 22, 2015, http://domesticfuel.com/2011/01/11/new-california-center-to-focus-on-jatropha-biodiesel/.
Dehgan, B. 2012. *Jatropha* (Euphorbiaceae). Flora Neotropica Monograph 110:1-273.
Divakara, B. N., H. D. Upadhyaya, S. P. Wani, and C. L. L. Gowda. 2010. Biology and genetic improvement of *Jatropha curcas* L.: A review. Applied Energy 87(3):732-742.
Ferreira, O. R., S. S. Brito, F. C. S. Chagas, A. T. Ramos, F. Y. M. Hosomi, F. G. de Lima, P. C. Maiorka, V. L. Araújo, J. N. M. Neiva, M. C. S. Fioravante, and V. M. Maruo. 2011. Poisoning of sheep by shells of *Jatropha curcas* seeds. Pages 472-476 *in* F. Riet-Correa, J. Pfister, A. L. Schild, and T. Wierenga, (eds.). Poisoning by plants, mycotoxins and related toxins. CABI International.
Froberg, B., D. Ibrahim, and R. B. Furbee. 2007. Plant Poisoning. Emergency Medicine Clinics of North America 25(2):375-433.
Gann, G. D., K. A. Bradley, and S. W. Woodmansee. 2001-2014. The Floristic Inventory of South Florida Database Online. The Institute for Regional Conservation. http://regionalconservation.org/ircs/database/search/QuickSearch.asp.

(Archived at PERAL).
GEXSI. 2008. Global Market Study on Jatropha (Final Report). The Global Exchange for Social Investment (GEXSI), London/Berlin http://www.jatropha-alliance.org/fileadmin/documents/GEXSI_Global-Jatropha-Study_FULL-REPORT.pdf. 187 pp.
Gosse, P. H. 1847. Birds of Jamaica. John Van Voorts, Paternoster Row, London. 447 pp.
Gordon, D. R., K. J. Tancig, D. A. Onderdonk, and C. A. Gantz. 2011. Assessing the invasive potential of biofuel species proposed for Florida and the United States using the Australian Weed Risk Assessment. Biomass and Bioenergy 35(1):74-79.
Heap, I. 2014. The international survey of herbicide resistant weeds. Weed Science Society of America. www.weedscience.com. (Archived at PERAL).
Heide-Jorgensen, H. S. 2008. Parasitic Flowering Plants. Brill, Leiden, The Netherlands. 438 pp.
Heller, J. 1996. Physic nut, *Jatropha curcas* L. Promoting the conservation and use of underutilized and neglected crops. 1. Institute of Plant Genetics and Crop Plant Research, Gatersleben/ International Plant Genetic Resources Institute, Rome. 66 pp.
Henning, R. K. 2007. *Jatropha curcas* L. . *in* H. A. M. van der Vossen and G. S. Mkamilo, (eds.). Prota 11(1): Medicinal plants/Plantes médicinales 1. [CD-ROM]. Plant Resources of Tropical Africa (PROTA), Wageningen, Netherlands. .
Holm, L. G., J. V. Pancho, J. P. Herberger, and D. L. Plucknett. 1979. A Geographical Atlas of World Weeds. Krieger Publishing Company, Malabar, Florida, U.S.A. 391 pp.
IPCS. 2015. INCHEM: Chemical Safety Information from Intergovernmental Organization. International Programme on Chemical Safety (IPCS). http://www.inchem.org/. (Archived at PERAL).
IPPC. 2012. International Standards for Phytosanitary Measures No. 5: Glossary of Phytosanitary Terms. Food and Agriculture Organization of the United Nations, Secretariat of the International Plant Protection Convention (IPPC), Rome, Italy.
Jingura, R. M. 2012. Chapter 4. Socio-Economy, Agro-Ecological Zones, Agronomic Practices and Farming System of *Jatropha curcas* L. in Sub-Saharan Africa. Pages 53-70 *in* N. Carels, M. Sujatha, and B. Bahadur, (eds.). *Jatropha*, Challenges for a New Energy Crop. Volume 1: Farming, Economics and Biofuel. Springer New York.
Jongschaap, R. E. E., W. J. Corré, P. S. Bindraban, and W. A. Brandenburg. 2007. Claims and Facts on *Jatropha curcas* L. Plant Research International, Wageningen, The Netherlands.
Juhász, A. C. P., S. Pimenta, B. O. Soares, D. L. B. Morais, and H. O. Rabello. 2009. Biologia floral e polinização artificial de pinhão-manso no norte de Minas Gerais [Floral biology and artificial pollination in physic nut in the north of Minas Gerais state, Brazil]. Pesquisa Agropecuaria

Brasileira 44(9):1073-1077.
Kartesz, J. T. 2014. The Biota of North America Program (BONAP). Chapel Hill, N.C. http://www.bonap.org. (Archived at PERAL).
Kartesz, J. T. 2015. The Biota of North America Program (BONAP). Chapel Hill, N.C. http://www.bonap.org. (Archived at PERAL).
Kirtikar, K. R. 1903. The poisonous plants of Bombay: *Jatropha curcas* , Linn. Journal of the Bombay Natural History Society 15(1):56-69.
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.
Lie, S. 2014. Communications requesting weed risk assessment of *Jatropha curcas*. Personal communication to J. M. Jones on December 23, 2014, from S. Lie (Environmental Protection Agency). Archived at the PERAL library, Raleigh, NC.
Liogier, H. A., and L. F. Martorell. 2000. Flora of Puerto Rico and adjacent islands: a systematic synopsis (2nd ed.). Editorial de la Universidad the Puerto Rico, San Juan, Puerto Rico.
Low, T., and C. Booth. 2007. The Weedy Truth About Biofuels. Invasive Species Council, Melbourne, Australia.
Ma, Y., J. Chun, S. Wang, and F. Chen. 2011. Allelopathic potential of *Jatropha curcas*. African Journal of Biotechnology 10(56):11932-11942.
Martin, P. G., and J. M. Dowd. 1990. A protein sequence study of the dicotyledons and its relevance to the evolution of the legumes and nitrogen fixation. Australian systematic botany 3:91-100.
Más, E. G., and M. d. L. Lugo-Torres. 2013. Malezas Comunes en Puerto Rico & Islas Vírgenes Americanas/Common Weeds in Puerto Rico & U.S. Virgin Islands. United States Department of Agriculture Natural Resources Conservation Service, Caribbean Area and University of Puerto Rico, Mayagüez Campus, Puerto Rico. 395 pp.
Maundu, P., and B. Tengnäs. 2005. Useful trees and shrubs for Kenya. Technical Handbook No. 35. International Centre for Research in Agroforestry (ICRAF), ICRAF-ECA, Nairobi, Kenya. 269 pp.
Negussie, A., W. M. J. Achten, R. Aerts, L. Norgrove, T. Sinkala, M. Hermy, and B. Muys. 2013a. Invasiveness risk of the tropical biofuel crop *Jatropha curcas* L. into adjacent land use systems: from the rumors to the experimental facts. GCB Bioenergy 5(4):419-430.
Negussie, A., W. M. J. Achten, L. Norgrove, M. Hermy, and B. Muys. 2013b. Invasiveness risk of biofuel crops using *Jatropha curcas* L. as a model species. Biofuels, Bioproducts and Biorefining 7(5):485-498.
Negussie, A., S. Nacro, W. J. Achten, L. Norgrove, M. Kenis, K. Hadgu, E. Aynekulu, M. Hermy, and B. Muys. 2014. Insufficient Evidence of *Jatropha curcas* L. Invasiveness: Experimental Observations in Burkina Faso, West Africa. BioEnergy Research:1-11.
Nelson, G. 2011. The Trees of Florida: A Reference and Field Guide (2nd Edition). Pineapple Press, Inc., Sarasota, Florida. 403 pp.
NGRP. 2014. World Economic Plants in GRIN (Germplasm Resources

Information Network). United States Department of Agriculture, Agricultural Resources Service, National Germplasm Resources Laboratory (NGRP). http://www.ars-grin.gov/cgi-bin/npgs/html/taxecon.pl?language=en. (Archived at PERAL).

Nickrent, D. 2012. Parasitic plant classification. Southern Illinois University Carbondale, Carbondale, IL, U.S.A. Last accessed March 3, 2014, http://www.parasiticplants.siu.edu/ListParasites.html.

Northern Land Manager. 2011. Managing weeds for wildlife conservation - Physic Nut, *Jatropha curcas*. Territory Natural Resource Management / Charles Darwin University. http://www.landmanager.org.au/managing-weeds-wildlife-conservation-physic-nut-jatropha-curcas. (Archived at PERAL).

NRCS. 2014. The PLANTS Database. United States Department of Agriculture, Natural Resources Conservation Service (NRCS), The National Plant Data Center. http://plants.usda.gov. (Archived at PERAL).

NRCS. 2015. The PLANTS Database. United States Department of Agriculture, Natural Resources Conservation Service (NRCS), The National Plant Data Center. http://plants.usda.gov. (Archived at PERAL).

Orwa, C., A. Mutua, R. Kindt, R. Jamnadass, and A. Simons. 2009. Agroforestree Database: a tree reference and selection guide version 4.0 http://www.worldagroforestry.org/af/treedb/. (Archived at PERAL).

Ovando-Medina, I., L. Adriano-Anaya, A. Vázquez-Ovando, S. Ruiz-González, M. Rincón-Rabanales, and M. Salvador-Figueroa. 2013. Genetic Diversity of *Jatropha curcas* in Southern Mexico. Pages 219-250 *in* B. Bahadur, M. Sujatha, and N. Carels, (eds.). Jatropha, Challenges for a New Energy Crop. Volume 2: Genetic Improvement and Biotechnology. Springer New York.

Parsons, W. T., and E. G. Cuthbertson. 2001. Noxious Weeds of Australia (Second). CSIRO Publishing, Collingwood. 698 pp.

PIER. 2006. Australian/New Zealand Weed Risk Assessment adapted for Hawai‘i, *Jatropha curcas*. Pacific Island Ecosystems at Risk (PIER), http://www.hear.org/Pier/wra/pacific/jatropha_curcas_htmlwra.htm.

Randall, J. M. 2007. The introduced flora of Australia and its weed status. CRC for Australian Weed Management, Department of Agriculture and Food, Western Australia, Australia. 528 pp.

Randall, R. P. 2012. A Global Compendium of Weeds, 2nd edition. Department of Agriculture and Food, Western Australia, Perth, Australia. 1107 pp.

Reed, C. F. 1977. Economically Important Foreign Weeds. Pages 746 *in* Agriculture Handbook No. 498. Agricultural Research Service, United States Department of Agriculture., U.S.A.

Reichel, T., J. Fernanda Barazetti, S. Stefanello, R. Paulert, and P. da Costa Zonetti. 2013. Allelopathy of leaf extracts of jatropha (*Jatropha curcas* L.) in the initial development of wheat (*Triticum aestivum* L.). IDESIA (Chile) 31(1).

Rejila, S., and N. Vijayakumar. 2011. Allelopathic effect of *Jatropha curcas* on selected intercropping plants (green chilli and sesame). Journal of

Phytology 3(5):01-03.

Ricketts, T. H., E. Dinerstein, D. M. Olson, C. J. Loucks, W. Elchbaum, D. DellaSala, K. Kavanagh, P. Hedao, P. T. Hurley, K. M. Carney, R. Abell, and W. S. 1999. Terrestrial Ecoregions of North America: A Conservation Assessment. Island Press, Washington D.C. 485 pp.

Ridley, H. N. 1930. The Dispersal of Plants Throughout The World. Ashford, L. Reeve & Co. Ltd. . 744 pp.

Santi, C., D. Bogusz, and C. Franche. 2013. Biological nitrogen fixation in non-legume plants. Annals of Botany 111(5):743-767.

Silip, J. J. 2010. Lifecycle Duration and Maturity Heterogeneity of *Jatropha curcas* Linn. Journal of Sustainable Development 3(2):291-295.

Solomon Raju, A. J., and B. Bahadur. 2013. Breeding Systems and Pollination in *Jatropha curcas*: An overview. Pages 27-43 *in* B. Bahadur, M. Sujatha, and N. Carels, (eds.). *Jatropha*, Challenges for a New Energy Crop. Volume 2: Genetic Improvement and Biotechnology. Springer New York.

Solomon Raju, A. J., and V. Ezradanam. 2002. Pollination ecology and fruiting behavior in a monoecious species, *Jatropha curcas* L. (Euphorbiaceae). Current Science 83(11):1395-1398.

Space, J. C., and T. Flynn. 2002. Report to the government of Samoa on invasive plant species of environmental concern. USDA Forest Service, Honolulu, HI, U.S.A. 80 pp.

Space, J. C., D. H. Lorence, and A. M. La Rosa. 2009. Report to the Republic of Palau: 2008 update on invasive plant species. United States Department of Agriculture - Forest Service, Pacific Southwest Research Station, Institute of Pacific Islands Forestry, Hilo, Hawai‘i, USA. 233 pp.

Starr, F., and K. Starr. 2009-2012. Plants of Hawaii: *Jatropha curcas*. Starr Environmental. http://www.starrenvironmental.com/images/search/?q=Jatropha+curcas&o=plants. (Archived at PERAL).

Sunil, N., V. Kumar, and K. Varaprasad. 2013. Origin, Domestication, Distribution and Diversity of *Jatropha curcas* L. Pages 137-151 *in* B. Bahadur, M. Sujatha, and N. Carels, (eds.). Jatropha, Challenges for a New Energy Crop. Volume 2: Genetic Improvement and Biotechnology. Springer New York.

Tropicos.org. 2014. *Jatropha curcas* L. Missouri Botanical Garden. http://www.tropicos.org/Name/12800067. (Archived at PERAL).

University of Queensland. 2011. Weeds of Australia. Biosecurity Queensland Edition. Queensland Government, Australia. http://keyserver.lucidcentral.org/weeds/data/03030800-0b07-490a-8d04-0605030c0f01/media/Html/Index.htm. (Archived at PERAL).

Vos, P. 2004. Case studies on the status of invasive woody plant species in the western Indian Ocean: 2. The Comoros Archipelago (Union of the Comoros and Mayotte). Forest Health & Biosecurity Working Papers FBS/4-2E. Forestry Department, Food and Agriculture Organization of the United Nations, Rome, Italy.

Wagner, W. L., D. R. Herbst, and S. H. Sohmer. 1990. Manual of the flowering plants of Hawai'i, 2 vols. University of Hawaii Press, Bishop Museum, Honolulu.

Wang, J. C., Y. Wu, Q. Wang, Y. L. Peng, K. W. Pan, P. Pluo, and N. Wu. 2009. Allelopathic effects of *Jatropha curcas* on marigold (*Tagetes erecta* L.). Allelopathy Journal 24(1):123-130.

Wang, Z. 2012. Chapter 6. Producing *Jatropha* Biodiesel in China: Policies, Performance and Challenges. Pages 95-124 *in* N. Carels, M. Sujatha, and B. Bahadur, (eds.). *Jatropha*, Challenges for a New Energy Crop. Volume 1: Farming, Economics and Biofuel. Springer New York.

Appendix A. Weed risk assessment for *Jatropha curcas* L. (Euphorbiaceae). Below is all of the evidence and associated references used to evaluate the risk potential of this taxon. We also include the answer, uncertainty rating, and score for each question. The Excel file, where this assessment was conducted, is available upon request.

Question ID	Answer - Uncertainty	Score	Notes (and references)
ESTABLISHMENT/SPREAD POTENTIAL			
ES-1 [What is the taxon's establishment and spread status outside its native range? (a) Introduced elsewhere =>75 years ago but not escaped; (b) Introduced <75 years ago but not escaped; (c) Never moved beyond its native range; (d) Escaped/Casual; (e) Naturalized; (f) Invasive; (?) Unknown]	e - mod	2	*Jatropha curcas* is native to the American tropics, most likely Mexico and Central America (Sunil et al., 2013). It has been introduced to and is widely cultivated in tropical and subtropical regions in Africa, Asia, and Latin America as a hedge and ornamental plant (GEXSI, 2008; IPCS, 2015; Northern Land Manager, 2011; Parsons and Cuthbertson, 2001). *Jatropha curcas* has "become spontaneous in many countries" where it is cultivated (Dehgan, 2012). Is now naturalized in drier areas in many African countries (Maundu and Tengnäs, 2005). *Jatropha curcas* "naturalized in bushlands and along rivers in the western, central and coastal parts of Kenya" (Maundu and Tengnäs, 2005). Naturalized in India (Kirtikar, 1903). It is grown occasionally in warmer parts of Australia and is naturalized in a few places in Queensland and the Northern Territory (IPCS, 2015), and it is now found in the Darwin rural area and at Kapalga in Kakadu National Park (Northern Land Manager, 2011). Elsewhere, it has been reported to colonize disturbed areas along tracks and riverbanks (Northern Land Manager, 2011). In the United States, "occasionally naturalized" along the east coast of Florida (Nelson, 2011). It is also "sparsely naturalized" in Hawaii (Maui) (Wagner et al., 1990). In southern Africa, the species has spread from Mozambique through Zambia to the Transvaal and Natal (IPCS, 2015), this is the only evidence supporting spread but we were not able to confirm the source. Alternate answers for the Monte Carlo simulation are "f" and "d."
ES-2 (Is the species highly domesticated)	n - low	0	*Jatropha curcas* is probably a plant in the process of domestication. *Jatropha curcas* can still be considered a (semi-) wild, undomesticated plant showing considerable performance variability (Achten et al., 2010). Genetic improvement of *J. curcas* for increasing seed and oil yield per unit area is still in its infancy (Divakara et al., 2010). Currently, *J. curcas* breeding and genetic improvement programs are carried out for various traits, such as growth rate, flowering phenology, and fruit and seed morphology, which could potentially increase invasion success (Negussie et al., 2013b). Thus we answered no with low uncertainty.
ES-3 (Weedy congeners)	y - negl	1	The genus *Jatropha* contains approximately 170 known species (Heller, 1996). A dozen of these are considered weeds (Randall, 2012). *Jatropha gossypiifolia* is regarded as an important environmental weed in the Northern Territory, Queensland, and the northern parts of Western Australia, and is ranked among the top 200 most invasive plant species in south-eastern Queensland (University of Queensland, 2011).

Question ID	Answer - Uncertainty	Score	Notes (and references)
ES-4 (Shade tolerant at some stage of its life cycle)	n - negl	0	*Jatropha curcas* is unsuited to growing in shade (Brittaine and Lutaladio, 2010). The plant is well adapted to conditions of high light intensity (Jongschaap et al., 2007).
ES-5 (Climbing or smothering growth form)	n - negl	0	*Jatropha curcas* is neither a vine nor forms tightly appressed basal rosettes. *Jatropha curcas* is an erect shrub or small tree with one to several stems that are 2 to 15 meters tall (Parsons and Cuthbertson, 2001; Dehgan, 2012).
ES-6 (Forms dense thickets)	y - negl	2	In Australia, *Jatropha curcas* forms dense thickets or colonies (University of Queensland, 2011; Northern Land Manager, 2011). In Queensland, Australia, large infestations have been reported in a couple of sites, with the largest thicket being 100 m long and 50 m wide (Low and Booth, 2007).
ES-7 (Aquatic)	n - negl	0	*Jatropha curcas* is a terrestrial plant. It can grow on degraded, sandy or gravelly, and even saline soils with low nutrient content, but cannot survive in waterlogged terrain (Henning, 2007).
ES-8 (Grass)	n - negl	0	*Jatropha curcas* is not a grass; it is in the Euphorbiaceae family (Dehgan, 2012).
ES-9 (Nitrogen-fixing woody plant)	n - negl	0	*Jatropha curcas* is in the Euphorbiaceae, which is not one of the families known to contain nitrogen-fixing species (Martin and Dowd, 1990; Santi et al., 2013).
ES-10 (Does it produce viable seeds or spores)	y - negl	1	*Jatropha curcas* produces viable seeds (Brittaine and Lutaladio, 2010; Henning, 2007; University of Queensland, 2011).
ES-11 (Self-compatible or apomictic)	y - negl	1	The plants are self-compatible (Juhász et al., 2009).
ES-12 (Requires special pollinators)	n - negl	0	In India and other parts of the world, many insects are reported to effectively pollinate *J. curcas* (Ovando-Medina et al., 2013; Solomon Raju and Bahadur, 2013), including, bees, ants, flies and thrips (Solomon Raju and Ezradanam, 2002).
ES-13 [What is the taxon's minimum generation time? (a) less than a year with multiple generations per year; (b) 1 year, usually annuals; (c) 2 or 3 years; (d) more than 3 years; or (?) unknown]	b - high	1	In a field study conducted in Malaysia, *J. curcas* took 120 to 176 days from seeding to dry fruit (Silip, 2010). In contrast, *J. curcas* seed germinates in around 10 days. The plant may reach one meter and flower within five months under good conditions. Fruit need 90 days from flowering until seeds mature (Heller, 1996). Seeds are produced in the first or second year of growth (Brittaine and Lutaladio, 2010). We answered "b." Alternate answers for the Monte Carlo simulation were both "c."
ES-14 (Prolific reproduction)	n - low	-1	*Jatropha curcas* is a woody shrub or small tree (Parsons and Cuthbertson, 2001). *Jatropha curcas* seed yields are highly variable (Heller, 1996; Jingura, 2012). Nevertheless, in a survey to characterize seed yields of cultivated *J. curcas* (Wang, 2012), trees with a crown width (or diameter) of 4.5 meters produced 1,000 fruits. Each fruit normally can have 3 seeds. Based on these data, we estimate that *J. curcas* can produce close to 189 seeds per square meter. This was under cultivated conditions and not considering seed viability. This information indicates that even under the most favorable conditions (e.g., under

Question ID	Answer - Uncertainty	Score	Notes (and references)
			cultivation) *J. curcas* does not meet the threshold yes response for a woody species, which is 1,000 or more viable seeds per square meter.
ES-15 (Propagules likely to be dispersed unintentionally by people)	? - max	-1	While Parsons and Cuthbertson (2001) state that "longer distance [seed] spread is... in mud adhering to…vehicles," propagules of *J. curcas* lack morphological dispersal adaptations (i.e., burrs, sticky seeds) that facilitate unintentional dispersal by human activity. Seeds of *J. curcas* are smooth coated and relatively large, 18 to 20 mm long by 11 to 13 mm wide (Dehgan, 2012). Propagules (e.g., seeds) of *J. curcas* have been intentionally spread by humans for cultivations (Brittaine and Lutaladio, 2010; Heller, 1996). Thus we answered unknown.
ES-16 (Propagules likely to disperse in trade as contaminants or hitchhikers)	n - mod	-1	We found no evidence.
ES-17 (Number of natural dispersal vectors)	1	-2	Fruit and seed description for ES-17a through ES-17e: The fruit is a drupaceous, trilocular, ellipsoid capsule, 23 to 30 mm long by 28 mm wide, tardily dehiscent (Dehgan, 2012). The exocarp of the fruit remains fleshy until the seeds are mature (Orwa et al., 2009). Seeds are black or black mottled with some white spots, oblong-ellipsoidal, 18 to 20 mm long by 11 to 13 mm wide, with a smooth seed coat (Dehgan, 2012).
ES-17a (Wind dispersal)	n - negl		Seeds of *J. curcas* lack morphological features that would facilitate wind dispersal (e.g., Armstrong, 1999). We found no evidence that *J. curcas* propagules are dispersed by wind, and it seems unlikely given their size.
ES-17b (Water dispersal)	n - mod		Parson and Cuthbertson (2001) state seeds disperse long distances in water flow. We found no further evidence that water is a typical means of dispersal. On the contrary, in a field study conducted by Negussie et al. (Negussie et al., 2013a) in Zambia “natural processes such as gravity, water, and sediment flows are ineffective vectors for dispersal of *J. curcas*, at least under the studied soil and relatively flat slope conditions.” Furthermore, *J. curcas* is intolerant of waterlogged conditions (Brittaine and Lutaladio, 2010). Thus we answered no with moderate uncertainty.
ES-17c (Bird dispersal)	n - high		The doves *Turtur leucopterus* and *Chaemaepelia passerine* reportedly eat *J. curcas* seeds in Jamaica (Gosse, 1847 cited by Ridley, 1930). However, Ridley (1930) said it is doubtful whether the seeds passed through the bird’s digestive tract in good enough condition to germinate. We answered no, with high uncertainty, because we found no additional evidence that seeds of this plant are dispersed by birds.
ES-17d (Animal external dispersal)	y - high		Parsons and Cuthbertson (2001) state that "longer distance [seed] spread is... in mud adhering to animal hooves..." In a field study in Zambia, Negussie et al. (2013a) discovered that toxic *J. curcas* seeds are frequently dispersed by some rodents and shrews. The authors report that these animals take the seeds to their burrows, but none germinate due to predation or deep burying. Still, some seeds may be

Question ID	Answer - Uncertainty	Score	Notes (and references)
			dropped in route to the burrows or other feeding sites, or some may be removed and never eaten. We answered yes, with high uncertainty.
ES-17e (Animal internal dispersal)	n - low		We found no evidence that *J. curcas* propagules are dispersed internally by animals. The large seeds of *J curcas* are unlikely to survive mastication. For instance in a field study in Zambia, significant amounts of predated *J. curcas* seed were found in the burrows of small mammals (Negussie et al., 2013a). Furthermore, many animals typically do not eat the seed because it is toxic (Heller, 1996). Thus, its propagules are unlikely to be dispersed internally by animals.
ES-18 (Evidence that a persistent (>1yr) propagule bank (seed bank) is formed)	n - mod	-1	According to Negussie et al. (2014) no seed dormancy has been reported for *J. curcas*.
ES-19 (Tolerates/benefits from mutilation, cultivation or fire)	y - low	1	Some suckering occurs from the tuberous roots, particularly when plants are injured (Parsons and Cuthbertson, 2001). It is recommended that "[i]solated plants and small infestations [of *J. curcas*] should be dug out, being careful to remove all of the roots, from which the plant can resprout" (Northern Land Manager, 2011).
ES-20 (Is resistant to some herbicides or has the potential to become resistant)	n - low	0	We found no evidence that *J. curcas* is resistant to herbicides. Control recommendations include the use of picloram + 2,4-D or picloram + triclopyr mixture in water. Also, the use of hexazinone as a soil injection and with glyphosate, triclopyr and imazapyr applied as overall sprays (Parsons and Cuthbertson, 2001). In a study to evaluate the effect of simulated glyphosate drift on the initial growth of *J. curcas* plants under greenhouse conditions, plants showed some tolerance to simulated glyphosate drift up to a dose of 22.5 g ha-1 (Costa et al., 2009). However, drift doses above 45.0 g ha-1 of this herbicide can severely harm the initial development of *J. curcas*. Furthermore, this species is not listed as an herbicide-resistant plant (Heap, 2014).
ES-21 (Number of cold hardiness zones suitable for its survival)	5	0	
ES-22 (Number of climate types suitable for its survival)	6	2	
ES-23 (Number of precipitation bands suitable for its survival)	11	1	
IMPACT POTENTIAL			
General Impacts			
Imp-G1 (Allelopathic)	y - high	0.1	*Jatropha curcas* produces allelopathic chemicals that inhibit the growth of other plants (Abugre and Quashie-Sam, 2010; Cremonez et al., 2013; Ma et al., 2011; Reichel et al., 2013; Rejila and Vijayakumar, 2011; Wang et al., 2009). We answered yes with high uncertainty because the evidence have been derived from studies using artificial concentrations of plant tissue extracts and not studies derived from field studies under natural conditions.
Imp-G2 (Parasitic)	n - negl	0	We found no evidence that this species is or is not parasitic. This species is not a member of a plant family

Question ID	Answer - Uncertainty	Score	Notes (and references)
			known to contain parasitic plant species (Heide-Jorgensen, 2008; Nickrent, 2012).
Impacts to Natural Systems			
Imp-N1 (Change ecosystem processes and parameters that affect other species)	? - max		Unknown.
Imp-N2 (Change community structure)	y - low	0.2	*Jatropha curcas* forms thickets that can completely transform open woodland or grassland into shrubland, making habitat unsuitable for a range of wildlife (Northern Land Manager, 2011). If it establishes widespread populations, it may threaten some of Australia's rangeland communities (University of Queensland, 2011).
Imp-N3 (Change community composition)	y - low	0.2	*Jatropha curcas* reportedly threatens biodiversity in the Einasleigh and Desert Uplands bioregion in inland northern Queensland (University of Queensland, 2011).
Imp-N4 (Is it likely to affect federal Threatened and Endangered species)	y - high	0.1	*Jatropha curcas* can change habitat structure and alter biodiversity (see Imp-N2 and N3), possibly affecting Federal Threatened & Endangered (T&E) species.
Imp-N5 (Is it likely to affect any globally outstanding ecoregions)	n - high		We found no evidence *J. curcas* is likely to negatively affect globally outstanding ecoregions. *Jatropha curcas* is reported to invade coastal forest and intermediate-altitude forests in the islands of the Comoro Archipelago (Vos, 2004). In Northern Australia, it occurs in humid and subhumid tropical shrublands (Parsons and Cuthbertson, 2001). It can change habitat structure and threaten biodiversity (see Imp-N2 and N3), but we found no evidence of it transforming entire ecosystems. Also, *J. curcas* has been present a long time in Florida without demonstrating any significant impact (Beckford, n.d.), even though the state is part of a globally outstanding ecoregion (i.e., Florida Sand Pine Scrub) (Ricketts et al., 1999).
Imp-N6 [What is the taxon's weed status in natural systems? (a) Taxon not a weed; (b) taxon a weed but no evidence of control; (c) taxon a weed and evidence of control efforts]	c - mod	0.6	*Jatropha curcas* has invaded coastal forest and intermediate-altitude forest in all the islands of the Comoro Archipelago (Vos, 2004). It is regarded as an environmental weed or potential environmental weed in many parts of northern Australia (University of Queensland, 2011). It is called a significant environmental weed in the Australian Northern Territory Parks and Conservation Masterplan. This plant is found in the Darwin rural area and at Kapalga in Kakadu National Park. A stand at Mount Wells, near Pine Creek, has been eradicated (Northern Land Manager, 2011). We answered "c," with moderate uncertainty because we found only one case or no further evidence of its control. Alternate answers for the Monte Carlo simulation were both "b."
Impact to Anthropogenic Systems (cities, suburbs, roadways)			
Imp-A1 (Impacts human property, processes, civilization, or safety)	n - mod	0	We found no evidence.
Imp-A2 (Changes or limits recreational use of an area)	n - mod	0	We found no evidence.
Imp-A3 (Outcompetes, replaces, or otherwise affects desirable plants and vegetation)	n - mod	0	We found no evidence.

Question ID	Answer - Uncertainty	Score	Notes (and references)
Imp-A4 [What is the taxon's weed status in anthropogenic systems? (a) Taxon not a weed; (b) Taxon a weed but no evidence of control; (c) Taxon a weed and evidence of control efforts]	b - mod	0.1	*Jatropha curcas* is a weed of tropical and sub-tropical environments that is found in disturbed sites, waste areas, abandoned gardens and along roadsides (University of Queensland, 2011). It colonizes disturbed areas along tracks (Northern Land Manager, 2011.) It occurs as relict shrubs on abandoned mine and homestead sites (Parsons and Cuthbertson, 2001). However, we found no evidence it is specifically managed for its impact in these areas. It is also widely cultivated (GEXSI, 2008). We answered "b"; alternate answers for the Monte Carlo simulation were "a" and "c."
Impact to Production Systems (agriculture, nurseries, forest plantations, orchards, etc.)			
Imp-P1 (Reduces crop/product yield)	y - high	0.4	In Australia, *J. curcas* "competes with pasture plants and dense thickets may reduce pasture productivity" (University of Queensland, 2011). It "may act as an alternative host for plant pests, such as the cotton insect pest, *Caidea dreggi*, in Tanzania" (Parsons and Cuthbertson, 2001). We found that cultivated *J. curcas* has a number of pests that can be pests of other crops (Anonymous, n.d.; Heller, 1996). However, we found no evidence that these pests migrate to other crops to cause significant issues.
Imp-P2 (Lowers commodity value)	n - mod	0	We found no evidence.
Imp-P3 (Is it likely to impact trade)	n - low	0	*Jatropha curcas* is a declared noxious weed in Australia's Northern Territory and Western Australia; consequently, it is not permitted entry and must be eradicated when found in the state (Parsons and Cuthbertson, 2001; University of Queensland, 2011). South Africa bans commercial production of *J. curcas* due to environmental concerns (Brittaine and Lutaladio, 2010). However, because we found no evidence that *J. curcas* propagules can disperse through traded commodities, we answered no.
Imp-P4 (Reduces the quality or availability of irrigation, or strongly competes with plants for water)	n - mod	0	We found no evidence.
Imp-P5 (Toxic to animals, including livestock/range animals and poultry)	y - low	0.1	All parts of *J. curcas* are toxic, especially the seeds, which are generally toxic to humans and animals (Froberg et al., 2007 cited by Ferreira et al., 2011). Varieties commonly found growing in Africa and Asia have seeds that are toxic to humans and animals, whereas some varieties found in Mexico and Central America are known to be non-toxic (Brittaine and Lutaladio, 2010). Toxicity has been demonstrated on feeding trials with various mammal species and chickens, but effects vary by animal species (Ferreira et al., 2011; Heller, 1996). It is toxic to livestock, though few instances of stock poisoning have been reported in Australia (University of Queensland, 2011). *Jatropha curcas* is not usually eaten by animals, but might be if drought conditions cause a shortage of forage (IPCS, 2015). We answered yes, but used low uncertainty because while this species is toxic, plants are unlikely to be consumed under normal circumstances.

Question ID	Answer - Uncertainty	Score	Notes (and references)
Imp-P6 [What is the taxon's weed status in production systems? (a) Taxon not a weed; (b) Taxon a weed but no evidence of control; (c) Taxon a weed and evidence of control efforts]	b - mod	0.2	*Jatropha curcas* is categorized as a weed of agriculture (Randall, 2007). In Puerto Rico, it is reported as a "common weed" in a crop (Holm et al., 1979). It is also reported "present as a weed" in crops in Brazil, Fiji, Honduras, India, Jamaica, Panama, and El Salvador, "but its rank of importance is unknown" (Holm et al., 1979). This species is widely cultivated as a crop in some countries of Africa, Asia, and Latin America (GEXSI, 2008). We answered "b" because we found no evidence that it is specifically managed for its impact in crops or agriculture. Alternate answers for the Monte Carlo simulation were "a" and "c."
GEOGRAPHIC POTENTIAL			Unless otherwise indicated, the following evidence represents geographically referenced points obtained from the Global Biodiversity Information Facility (GBIF).
Plant hardiness zones			
Geo-Z1 (Zone 1)	n - negl	N/A	We found no evidence that it occurs in this zone.
Geo-Z2 (Zone 2)	n - negl	N/A	We found no evidence that it occurs in this zone.
Geo-Z3 (Zone 3)	n - negl	N/A	We found no evidence that it occurs in this zone.
Geo-Z4 (Zone 4)	n - negl	N/A	We found no evidence that it occurs in this zone.
Geo-Z5 (Zone 5)	n - negl	N/A	We found no evidence that it occurs in this zone.
Geo-Z6 (Zone 6)	n - negl	N/A	We found no evidence that it occurs in this zone.
Geo-Z7 (Zone 7)	n - mod	N/A	Although three records exist in China and one in Argentina, *J. curcas* is a tropical and subtropical species that is intolerant of frost (Brittaine and Lutaladio, 2010) and very low temperatures (<7°C) (Carels et al., 2012). The few points we found for Zone 7 may be plants growing in protected areas or errors in the maps. Thus, we answered no with low uncertainty.
Geo-Z8 (Zone 8)	n - high	N/A	We found a few points in Mexico and China, but they were on the edge of Plant Hardiness Zones 9 and 10. *Jatropha curcas* is a tropical and subtropical plant that is intolerant of frost (Brittaine and Lutaladio, 2010) and very low temperatures (<7°C) (Carels et al., 2012). The few points we found for Zone 8 may be plants growing in protected areas or errors in the maps.
Geo-Z9 (Zone 9)	y - negl	N/A	Mexico, South Africa, China, Argentina, and Bolivia. Reported in the United States in Polk County, Florida (Kartesz, 2015).
Geo-Z10 (Zone 10)	y - negl	N/A	Mexico, South Africa, Australia, China, Paraguay, and Peru. Reported in the United States in Brevard, Broward, Miami Dade, Lee, Manatee and Polk counties in Florida (Kartesz, 2015).
Geo-Z11 (Zone 11)	y - negl	N/A	Mexico, Guatemala, Honduras, Nicaragua, Madagascar, Tanzania, Australia, and Peru. Reported in the United States in Miami Dade, Lee, and Manatee counties in Florida (Kartesz, 2015).
Geo-Z12 (Zone 12)	y - negl	N/A	Mexico, Guatemala, Honduras, Nicaragua, and Peru. Reported in the United States in Miami Dade, Lee, and Manatee counties in Florida (Kartesz, 2015).
Geo-Z13 (Zone 13)	y - negl	N/A	Mexico, Guatemala, Honduras, Nicaragua, the Philippines, and Ecuador. Reported in the United States in Maui, Oahu,

Question ID	Answer - Uncertainty	Score	Notes (and references)
			and Niihau in Hawaii (NRCS, 2015; Wagner et al., 1990).
Köppen -Geiger climate classes			
Geo-C1 (Tropical rainforest)	y - negl	N/A	Nicaragua, Panama, Colombia, Peru, the Philippines, the Democratic Republic of Congo, and Brazil. Reported in the United States in Hawaii (NRCS, 2015) and in Broward, Miami Dade, and Lee counties in Florida (Kartesz, 2015).
Geo-C2 (Tropical savanna)	y - negl	N/A	Mexico, El Salvador, Honduras, Nicaragua, Ecuador, Peru, Brazil, Australia, and Ethiopia. Reported in the United States in Maui, Oahu, and Niihau in Hawaii (NRCS, 2015; Wagner et al., 1990).
Geo-C3 (Steppe)	y - low	N/A	Mexico (few), Ecuador, Peru, Madagascar, Tanzania, Cameroon, and Australia.
Geo-C4 (Desert)	y - high	N/A	One point each for Egypt, Yemen, Mauritania, Peru, and Ecuador. Grown in Cape Verde (Heller, 1996). *Jatropha curcas* is best adapted to arid and semi-arid conditions. It is reported to withstand “years without rainfall in Cape Verde" (Heller, 1996).
Geo-C5 (Mediterranean)	n - mod	N/A	We found one point in Ethiopia, but answered no because this plant may be growing in a protected area.
Geo-C6 (Humid subtropical)	y - negl	N/A	Mexico, South Africa, Australia, and China. Reported in the United States in Brevard, Broward, Miami Dade, Lee, Manatee, and Polk counties in Florida (NRCS, 2015).
Geo-C7 (Marine west coast)	y - negl	N/A	Mexico, South Africa, Madagascar, and China.
Geo-C8 (Humid cont. warm sum.)	n - negl	N/A	We found no evidence that it occurs in this zone.
Geo-C9 (Humid cont. cool sum.)	n - negl	N/A	We found no evidence that it occurs in this zone.
Geo-C10 (Subarctic)	n - negl	N/A	We found no evidence that it occurs in this zone.
Geo-C11 (Tundra)	n - negl	N/A	We found no evidence that it occurs in this zone.
Geo-C12 (Icecap)	n - negl	N/A	We found no evidence that it occurs in this zone.
10-inch precipitation bands			
Geo-R1 (0-10 inches; 0-25 cm)	y - mod	N/A	Few points in Peru, Senegal, Egypt, and Mauritania. *Jatropha curcas* is best adapted to arid and semi-arid conditions. It is reported to withstand “years without rainfall in Cape Verde" (Heller, 1996).
Geo-R2 (10-20 inches; 25-51 cm)	y - negl	N/A	Mexico, Peru, Mali, Burkina Faso, Senegal, South Africa, and the United States in Hawaii (Maui, Oahu, Niihau).
Geo-R3 (20-30 inches; 51-76 cm)	y - negl	N/A	Mexico, Peru, Bolivia, China, Burkina Faso, Ghana, and Tanzania.
Geo-R4 (30-40 inches; 76-102 cm)	y - negl	N/A	Mexico, Bolivia, Australia, China, and Nigeria.
Geo-R5 (40-50 inches; 102-127 cm)	y - negl	N/A	Mexico, Bolivia, Australia, China, Paraguay, and the United States in Florida (Miami Dade, Lee, Manatee).
Geo-R6 (50-60 inches; 127-152 cm)	y - negl	N/A	Mexico, Nicaragua, Australia, China, Madagascar, and the United States in Florida (Miami Dade, Lee, Manatee).
Geo-R7 (60-70 inches; 152-178 cm)	y - negl	N/A	Mexico, Nicaragua, China, and the United States in Florida (Miami Dade, Lee, Manatee, Polk).
Geo-R8 (70-80 inches; 178-203 cm)	y - negl	N/A	El Salvador, Nicaragua, China, the Democratic Republic of Congo, and in the United States in Florida (Brevard, Miami Dade, Polk).
Geo-R9 (80-90 inches; 203-229 cm)	y - negl	N/A	Nicaragua, Costa Rica, Australia, China, and in the United States in Florida (Broward, Miami Dade).
Geo-R10 (90-100 inches; 229-254 cm)	y - negl	N/A	Mexico, Nicaragua, Costa Rica, Panama, and China, Madagascar.

Question ID	Answer - Uncertainty	Score	Notes (and references)
Geo-R11 (100+ inches; 254+ cm)	y - negl	N/A	Mexico, Nicaragua, Costa Rica, Panama, and China.
ENTRY POTENTIAL			
Ent-1 (Plant already here)	y - negl	1	*Jatropha curcas* is reported in some counties of southern Florida (Kartesz, 2014; NRCS, 2014) and "occasionally naturalized" along the east coast of Florida from about Brevard County southward (Nelson, 2011). It is also "sparsely naturalized" in Hawaii (Maui) (Wagner et al., 1990). Reported in Puerto Rico and the U.S. Virgin Islands (Más and Lugo-Torres, 2013).
Ent-2 (Plant proposed for entry, or entry is imminent)	-	N/A	
Ent-3 (Human value & cultivation/trade status)	-	N/A	
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	