

<b>Taxon:</b> <i>Theobroma cacao</i> L.	<b>Family:</b> Malvaceae
<b>Common Name(s):</b> cacao cocoa	<b>Synonym(s):</b> <i>Theobroma leiocarpum</i> Bernoulli <i>Theobroma pentagonum</i> Bernoulli <i>Theobroma sativum</i> (Aubl.) Lign. & Le <i>Theobroma sphaerocarpum</i> A. Chev.

<b>Assessor:</b> Chuck Chimera	<b>Status:</b> Assessor Approved	<b>End Date:</b> 13 Aug 2018
<b>WRA Score:</b> -2.0	<b>Designation:</b> L	<b>Rating:</b> Low Risk

**Keywords:** Tropical Tree, Domesticated, Seed Crop, Shade-Tolerant, Mammal-Dispersed

Qsn #	Question	Answer Option	Answer
101	Is the species highly domesticated?	y=-3, n=0	y
102	Has the species become naturalized where grown?	y=1, n=-1	y
103	Does the species have weedy races?	y=1, n=-1	n
201	Species suited to tropical or subtropical climate(s) - If island is primarily wet habitat, then substitute "wet tropical" for "tropical or subtropical"	(0-low; 1-intermediate; 2-high) (See Appendix 2)	High
202	Quality of climate match data	(0-low; 1-intermediate; 2-high) (See Appendix 2)	High
203	Broad climate suitability (environmental versatility)	y=1, n=0	n
204	Native or naturalized in regions with tropical or subtropical climates	y=1, n=0	y
205	Does the species have a history of repeated introductions outside its natural range?	y=-2, ?=-1, n=0	y
301	Naturalized beyond native range	y = 1*multiplier (see Appendix 2), n= question 205	y
302	Garden/amenity/disturbance weed		
303	Agricultural/forestry/horticultural weed	n=0, y = 2*multiplier (see Appendix 2)	n
304	Environmental weed	n=0, y = 2*multiplier (see Appendix 2)	n
305	Congeneric weed	n=0, y = 1*multiplier (see Appendix 2)	n
401	Produces spines, thorns or burrs	y=1, n=0	n
402	Allelopathic	y=1, n=0	n
403	Parasitic	y=1, n=0	n
404	Unpalatable to grazing animals	y=1, n=-1	n
405	Toxic to animals	y=1, n=0	y
406	Host for recognized pests and pathogens		
407	Causes allergies or is otherwise toxic to humans	y=1, n=0	n
408	Creates a fire hazard in natural ecosystems	y=1, n=0	n

Qsn #	Question	Answer Option	Answer
409	Is a shade tolerant plant at some stage of its life cycle	y=1, n=0	y
410	Tolerates a wide range of soil conditions (or limestone conditions if not a volcanic island)	y=1, n=0	n
411	Climbing or smothering growth habit	y=1, n=0	n
412	Forms dense thickets	y=1, n=0	n
501	Aquatic	y=5, n=0	n
502	Grass	y=1, n=0	n
503	Nitrogen fixing woody plant	y=1, n=0	n
504	Geophyte (herbaceous with underground storage organs -- bulbs, corms, or tubers)	y=1, n=0	n
601	Evidence of substantial reproductive failure in native habitat	y=1, n=0	n
602	Produces viable seed	y=1, n=-1	y
603	Hybridizes naturally		
604	Self-compatible or apomictic		
605	Requires specialist pollinators	y=-1, n=0	n
606	Reproduction by vegetative fragmentation	y=1, n=-1	n
607	Minimum generative time (years)	1 year = 1, 2 or 3 years = 0, 4+ years = -1	2
701	Propagules likely to be dispersed unintentionally (plants growing in heavily trafficked areas)	y=1, n=-1	n
702	Propagules dispersed intentionally by people	y=1, n=-1	y
703	Propagules likely to disperse as a produce contaminant	y=1, n=-1	n
704	Propagules adapted to wind dispersal	y=1, n=-1	n
705	Propagules water dispersed	y=1, n=-1	n
706	Propagules bird dispersed		
707	Propagules dispersed by other animals (externally)	y=1, n=-1	y
708	Propagules survive passage through the gut	y=1, n=-1	y
801	Prolific seed production (>1000/m <sup>2</sup> )	y=1, n=-1	n
802	Evidence that a persistent propagule bank is formed (>1 yr)	y=1, n=-1	n
803	Well controlled by herbicides	y=-1, n=1	y
804	Tolerates, or benefits from, mutilation, cultivation, or fire	y=1, n=-1	y
805	Effective natural enemies present locally (e.g. introduced biocontrol agents)		

**Supporting Data:**

Qsn #	Question	Answer
101	Is the species highly domesticated?	y
	Source(s)	Notes
	Zhang, D., Figueira, A., Motilal, L., Lachenaud, P., & Meinhardt, L. W. (2011). <i>Theobroma</i> . Pp. 277-296 In <i>Wild Crop Relatives: Genomic and Breeding Resources</i> . Springer, Berlin, Heidelberg	"The ancient cultigens of cacao were only present in Mesoamerica, where cultural elaboration and use of cacao can be traced back several thousand years (Go´mez- Pompa et al. 1990; Sauer 1993; Young 1994; Coe and Coe 1996; Henderson et al. 2007). The use of the sweet pulp that surrounds the seeds for fermented drink is a likely reason for domestication. Recent archeological discoveries in Honduras showed that the Olmec people in the Ulua Valley fermented the sweet pulp of cacao to make an alcoholic drink at least 3,000 years ago, well before the grinding of the bitter seeds to produce a chocolate drink (Henderson et al. 2007). Ultimately, the diverse nature of cacao’s uses as well as its use as currency led to it being widely grown in Mesoamerica before the Spanish arrived (Bergmann 1969; Young 1994). Nevertheless, only a very small fraction of the diversity was dispersed from the Amazon to Mesoamerica and thus the domesticated cacao has a narrow genetic background (Dias 2001; Bartley 2005)."

102	Has the species become naturalized where grown?	y
	Source(s)	Notes
	Randall, R.P. (2017). <i>A Global Compendium of Weeds</i> . 3rd Edition. Perth, Western Australia. R.P. Randall	" <i>Theobroma cacao</i> ... References: Federated States of Micronesia-N-230, Puerto Rico-CW-261, Caribbean-N-707, Africa-W-760, United States of America-N-101, Costa Rica-CN- 872, Laos-N-1102, Gal pagos Islands-CN- 1157, Caribbean-N-1201, Brazil-N-1597, Global-CD-1611, Eastern Caribbean-N- 1742, Sao Tome and Principe-N-1805, Costa Rica-W-1977, Democratic Republic of the Congo-W-1977, Equatorial Guinea- W-1977, Lao People's Democratic Republic-W-1977."

103	Does the species have weedy races?	n
	Source(s)	Notes
	Randall, R.P. (2017). <i>A Global Compendium of Weeds</i> . 3rd Edition. Perth, Western Australia. R.P. Randall	[Included in some weed lists, but subsequent reviews of the literature cited did not corroborate any evidence of impacts] "References: Federated States of Micronesia-N-230, Puerto Rico-CW 261, Caribbean-N-707, Africa-W-760, United States of America-N-101, Costa Rica-CN- 872, Laos-N-1102, Gal pagos Islands-CN- 1157, Caribbean-N-1201, Brazil-N-1597, Global-CD 1611, Eastern Caribbean-N- 1742, Sao Tome and Principe-N-1805, Costa Rica-W-1977, Democratic Republic of the Congo-W-1977, Equatorial Guinea-W-1977, Lao People's Democratic Republic-W-1977."

Qsn #	Question	Answer
	Cosme, S., Cuevas, H. E., Zhang, D., Oleksyk, T. K., & Irish, B. M. (2016). Genetic diversity of naturalized cacao ( <i>Theobroma cacao</i> L.) in Puerto Rico. <i>Tree Genetics &amp; Genomes</i> , 12(5), 88	[Self-compatible plants exist in plants with certain genetic backgrounds. Could be more prone to naturalize & potentially become weedy in certain situations] "Identification of genetically diverse cacao with disease resistance, high productivity, and desirable organoleptic traits is vitally important to the agricultural crop's long-term sustainability." ... "Principal coordinate, cluster, and population structure analysis using the genotype data for both local and reference samples assigned individuals into five distinct genetic backgrounds: Criollo, Trinitario, Amelonado, Upper Amazon Forastero (UAF), and Nacional. Puerto Rican cacao fit into four (Criollo, Trinitario, Amelonado and UAF) of the five genetic backgrounds, being mainly composed of individuals of Criollo ancestry." ... "Criollo and Amelonado genetic backgrounds are known for their homogenous phenotypic traits associated with their ability to self-fertilize (self-compatible) and their highly homozygous genomes." ... "Although Criollo trees are known to self-fertilize, if given the opportunity they would readily cross pollinate and hybridize. Ancient Criollo trees are rare elsewhere and were underrepresented in the current collection at the USDA-ARS TARS."

201	Species suited to tropical or subtropical climate(s) - If island is primarily wet habitat, then substitute "wet tropical" for "tropical or subtropical"	High
	Source(s)	Notes
	USDA, ARS, Germplasm Resources Information Network. 2018. National Plant Germplasm System [Online Database]. <a href="http://www.ars-grin.gov/npgs/index.html">http://www.ars-grin.gov/npgs/index.html</a> . [Accessed 10 Aug 2018]	"Native Northern America SOUTHERN MEXICO: Mexico [Chiapas (s.), Tabasco] Southern America CENTRAL AMERICA: Belize, Guatemala NORTHERN SOUTH AMERICA: French Guiana, Guyana, Suriname BRAZIL: Brazil, [Amazonas] Brazil (n.w.) [Amazonas] WESTERN SOUTH AMERICA: Colombia, Peru, [Loreto] Peru [Loreto]"

202	Quality of climate match data	High
	Source(s)	Notes
	USDA, ARS, Germplasm Resources Information Network. 2018. National Plant Germplasm System [Online Database]. <a href="http://www.ars-grin.gov/npgs/index.html">http://www.ars-grin.gov/npgs/index.html</a> . [Accessed 10 Aug 2018]	

203	Broad climate suitability (environmental versatility)	n
	Source(s)	Notes
	Orwa C., Mutua, A., Kindt R., Jamnadass, R., & Anthony, S. 2009 Agroforestry Database: a tree reference and selection guide version 4.0. <a href="http://www.worldagroforestry.org">http://www.worldagroforestry.org</a> . [Accessed 13 Aug 2018]	"Altitude: 100-300 m, Mean annual temperature: 26 deg. C, Mean annual rainfall: 1 000-3 000 mm"

Qsn #	Question	Answer
	Lim, T.K. (2012). Edible Medicinal and Non-Medicinal Plants. Volume 3, Fruits. Springer, New York	"Cocoa flourishes in a hot, wet, humid tropical regime. It is grown within 20°N and 20°S of the Equator in the lowlands usually below 300 m but is also found but in sheltered valleys of Colombia at 900 m. Temperature varying between 30–32°C mean maximum and 18–21°C mean minimum but around 25°C is considered to be a favourable. It can't be grown commercially in areas where the minimum temperature fall below 10°C and annual average temperature is less than 21°C. It prefers areas with mean annual rainfall of 1,250–3,000 mm. and preferably between 1,500 and 2,000 mm."
	Duke, J.A. 1983. Handbook of Energy Crops - Theobroma cacao. <a href="https://hort.purdue.edu/newcrop/duke_energy/Theobroma_cacao.html">https://hort.purdue.edu/newcrop/duke_energy/Theobroma_cacao.html</a> . [Accessed 13 Aug 2018]	"Ranging from Subtropical Dry to Wet through Tropical Very Dry to Wet Forest Life Zones, cacao is reported to tolerate annual precipitation of 4.8 to 42.9 dm (mean of 109 cases = 16.3), annual temperature of 18.0 to 28.5°C (mean of 108 cases = 25.3), and pH of 4.3 to 8.7 (mean of 43 cases = 6.4) (Duke, 1978). Grown from 20°N to 20°S with the bulk between 10°N and 10 S, usually below 300 m, but in sheltered valleys of Colombia at 900 m. Requires uniformly high temperatures with recommended mean of 26.6°C. Trees are wind-intolerant and therefore are often planted on hillsides for wind protection and good drainage. Being drought-intolerant, cacao thrives in climates with high humidity and rainfall. Plants are shade-tolerant, and thrive in rich, organic, well-drained, moist, deep soils. Shallow laterite soils are said not to be suitable. Maximum temperature of 33.5°C and minimum 13°C, with diurnal temperature variation between 33.5 and 18°C are suggested (Reed, 1976)."

204	<b>Native or naturalized in regions with tropical or subtropical climates</b>	<b>y</b>
	<b>Source(s)</b>	<b>Notes</b>
	USDA, ARS, Germplasm Resources Information Network. 2018. National Plant Germplasm System [Online Database]. <a href="http://www.ars-grin.gov/npgs/index.html">http://www.ars-grin.gov/npgs/index.html</a> . [Accessed 10 Aug 2018]	"Native Northern America SOUTHERN MEXICO: Mexico [Chiapas (s.), Tabasco] Southern America CENTRAL AMERICA: Belize, Guatemala NORTHERN SOUTH AMERICA: French Guiana, Guyana, Suriname BRAZIL: Brazil, [Amazonas] Brazil (n.w.) [Amazonas] WESTERN SOUTH AMERICA: Colombia, Peru, [Loreto] Peru [Loreto]"

205	<b>Does the species have a history of repeated introductions outside its natural range?</b>	<b>y</b>
	<b>Source(s)</b>	<b>Notes</b>
	Lim, T.K. (2012). Edible Medicinal and Non-Medicinal Plants. Volume 3, Fruits. Springer, New York	"Besides Latin America, cocoa is grown extensively in West Africa (Ghana, Nigeria, Cameroon and Cote D'Ivoire) based on the Trinitario, Amelonado and Forastero cocoa materials; and in Indonesia, Malaysia and Papua New Guinea Trinitario and Forastero materials were introduced from the Caribbean and south America."

301	<b>Naturalized beyond native range</b>	<b>y</b>
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Qsn #	Question	Answer
	Source(s)	Notes
	<p>Mack, R. N. (1996). Biotic barriers to plant naturalization. Pp. 39-46 In Y.C. Moran and J.H. Hoffmann (eds). Proceedings of the IX International Symposium on Biological Control of Weeds. University of Cape Town, Stellenbosch, South Africa</p>	<p>"For some aliens these new barriers are so extreme as to repeatedly preclude naturalization (e.g. <i>Theobroma cacao</i> in western Africa)." ... "The destruction of Theo/Jrorna cacao by CSSV (cacao swollen shoot virus) in western Africa is a well-known case of an alien plant acquiring a virulent pathogen native to the new range. Cacao, a native of South America, is now widely-grown in western Africa. These plantations occur within the home ranges of native trees belonging to several closely-related families, one of which (Sterculiaceae) includes <i>T. cacao</i> ( Baker 1978). Apparently, CSSV has long parasitized native members of these families without major damage (e.g. <i>Cola chlamydantha</i>, <i>Sterculia tragacantha</i>). In common with the epidemiology of many other plant pathogens, the spread of CSSV among hosts is aided by an insect vector, a mealybug (<i>Planococcoidcs njalensis</i>). Establishment of large stands of closely-spaced cacao trees would have aided the insects' movements. As a result, losses to CSSV were devastating until procedures for the prompt removal of diseased trees were implemented (Leston 1970; Posnette 198 1 ). Clearly, cacao naturalization in western Africa remains extremely improbable because of this native virus."</p>
	<p>Cosme, S., Cuevas, H. E., Zhang, D., Oleksyk, T. K., &amp; Irish, B. M. (2016). Genetic diversity of naturalized cacao (<i>Theobroma cacao</i> L.) in Puerto Rico. <i>Tree Genetics &amp; Genomes</i>, 12(5), 88</p>	<p>"Having been introduced during colonial times, naturalized cacao in Puerto Rico could serve as an unexplored source of genetic diversity in improvement programs. An island-wide survey was carried out to identify naturalized trees and to determine their genetic associations to reference cacao accessions." ... "Naturalized Puerto Rican cacao is composed of four genetically distinct groups: Criollo, Trinitario, Amelonado, and UAF hybrids." ... "Puerto Rico's naturalized cacao trees are mostly of limited and highly uniform genetic backgrounds when compared with those of other Caribbean islands like the Dominican Republic (Boza et al. 2013) and Cuba (Bidot Martínez et al. 2015)."</p>
	<p>Randall, R.P. (2017). <i>A Global Compendium of Weeds</i>. 3rd Edition. Perth, Western Australia. R.P. Randall</p>	<p>"<i>Theobroma cacao</i> ... Micronesia-N-230, Puerto Rico-CW-261, Caribbean-N-707, Africa-W-760, United States of America-N-101, Costa Rica-CN- 872, Laos-N-1102, Galapagos Islands-CN- 1157, Caribbean-N-1201, Brazil-N-1597, Global-CD-1611, Eastern Caribbean-N- 1742, Sao Tome and Principe-N-1805, Costa Rica-W-1977, Democratic Republic of the Congo-W-1977, Equatorial Guinea-W-1977, Lao People's Democratic Republic-W-1977."</p>

Qsn #	Question	Answer
302	<b>Garden/amenity/disturbance weed</b>	
	<b>Source(s)</b>	<b>Notes</b>
	Murphy, M. 2018. Plant Pono Specialist. BIISC Early Detection Technician. personal communication. 10 August	"A farmer said cocoa grows like "weed"."
	Randall, R.P. (2017). A Global Compendium of Weeds. 3rd Edition. Perth, Western Australia. R.P. Randall	[Included in some weed lists, but subsequent reviews of the literature cited did not corroborate any evidence of impacts] "References: Federated States of Micronesia-N-230, Puerto Rico-CW-261, Caribbean-N-707, Africa-W-760, United States of America-N-101, Costa Rica-CN- 872, Laos-N-1102, Gal pagos Islands-CN- 1157, Caribbean-N-1201, Brazil-N-1597, Global-CD-1611, Eastern Caribbean-N- 1742, Sao Tome and Principe-N-1805, Costa Rica-W-1977, Democratic Republic of the Congo-W-1977, Equatorial Guinea-W-1977, Lao People's Democratic Republic-W-1977."

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

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

305	<b>Congeneric weed</b>	n
	<b>Source(s)</b>	<b>Notes</b>
	Randall, R.P. (2017). A Global Compendium of Weeds. 3rd Edition. Perth, Western Australia. R.P. Randall	No evidence

401	<b>Produces spines, thorns or burrs</b>	n
	<b>Source(s)</b>	<b>Notes</b>
	Lim, T.K. (2012). Edible Medicinal and Non-Medicinal Plants. Volume 3, Fruits. Springer, New York	[No evidence] "Evergreen, small tree, usually 4–8 m , rarely to 20 m high with a short, thick trunk, dark gray-brown bark , slender branches (Plates 1 and 2 ) and 2 m long tap root and a mass of surface-feeding roots. Branches occurs in whorls of 5, dimorphic; vertical chupons growing from the trunk have leaves arranged in five eighths phyllotaxy and the lateral branches (fans) have one half phyllotaxy. Branchlets are brown and puberulent. Stipules linear, caduceus. Leaves are large, alternate, distichous on normal branches, green, coriaceous or chartaceous on pubescent or tomentose petiole thickened pulvinate at ends (Plates 1 and 2 ). Leaf blade simple, entire, narrowly ovate to obovate-elliptic, 20–30 × 7–10 cm, both surfaces glabrous colour (Plates 1 , 2 , 3 and 4 ), with fruit wall (husk) up to 2 cm thick."

Qsn #	Question	Answer
402	<b>Allelopathic</b>	<b>n</b>
	<b>Source(s)</b>	<b>Notes</b>
	Fujii, Y., Parvez, S. S., Parvez, M., Ohmae, Y., & Iida, O. 2003. Screening of 239 medicinal plant species for allelopathic activity using the sandwich method. <i>Weed Biology and Management</i> , 3(4): 233-241	"Leaf litter of 239 medicinal plant species were collected from the Izu Experimental Station for Medicinal Plants, National Institute of Health Sciences, Shizuoka, Japan, and these were subjected to analysis of their allelopathic effects using the sandwich method" [Extracts from <i>Theobroma cacao</i> did not show significant inhibitory activity greater than the mean]
	Orwa C., Mutua, A., Kindt R., Jamnadass, R., & Anthony, S. 2009 <i>Agroforestry Database: a tree reference and selection guide version 4.0.</i> <a href="http://www.worldagroforestry.org">http://www.worldagroforestry.org</a> . [Accessed 13 Aug 2018]	[No evidence. Regarded as beneficial to soil & other plants] "Soil improver: There is considerable nutrient cycling through the development of a deep leaf litter under the cocoa canopy. Intercropping: Cocoa has traditionally been established in thinned forest following logging and 1-3 years of food-crop production before the canopy closes. Crops such as maize, cocoyam, yams and plantain are commonly intercropped with cocoa in Ecuador, Jamaica and West Africa."

403	Parasitic	n
	<b>Source(s)</b>	<b>Notes</b>
	Lim, T.K. (2012). <i>Edible Medicinal and Non-Medicinal Plants. Volume 3, Fruits.</i> Springer, New York	[No evidence] "Evergreen, small tree, usually 4–8 m , rarely to 20 m high with a short, thick trunk, dark gray-brown bark , slender branches" [Family: Malvaceae. Altfamily: Sterculiaceae]

404	Unpalatable to grazing animals	n
	<b>Source(s)</b>	<b>Notes</b>
	Walkden-Brown, S. W., & Banks, D. J. D. (1986). Integrated small ruminant and cropping systems in Fiji with health as a major constraint. Pp. 289-310 In <i>Small Ruminant Production Systems in South and Southeast Asia: Proceedings of a workshop held in Bogor, Indonesia, 6-10 Oct. 1986.</i> IDRC, Ottawa, Canada	"The 3550 ha of cocoa plantations in Fiji are not integrated with livestock at all because of the palatability of cocoa leaves and bark. There is no utilization of cocoa pods for livestock feed because of the small-scale nature of the industry at present and the problems of drying pods in the high-rainfall cocoa areas."
	Orwa C., Mutua, A., Kindt R., Jamnadass, R., & Anthony, S. 2009 <i>Agroforestry Database: a tree reference and selection guide version 4.0.</i> <a href="http://www.worldagroforestry.org">http://www.worldagroforestry.org</a> . [Accessed 13 Aug 2018]	[Pods used as fodder] "Fodder: The cocoa-pod husk has a low alkaloid content, while tannin is practically absent. The crude fibre content is low; it is completely unligified and compares favourably with <i>Panicum maximum</i> and <i>Centrosema pubescens</i> ."

405	Toxic to animals	y
	<b>Source(s)</b>	<b>Notes</b>
	Drolet, R., Arendt, T. D., & Stowe, C. M. (1984). Cacao bean shell poisoning in a dog. <i>Journal of the American Veterinary Medical Association</i> , 185(8): 902	"Cacao bean shells contain potentially toxic quantities of theobromine, a xanthine compound similar in effects to caffeine and theophylline. A dog, which ingested a lethal quantity of garden mulch made from cacao bean shells, developed severe convulsions and died 17 hours later. Analysis of the stomach contents and the ingested cacao bean shells revealed the presence of lethal amounts of theobromine."

Qsn #	Question	Answer
	<p>KewScience. 2018. Plants of the World Online - <i>Theobroma cacao</i>.  <a href="http://powo.science.kew.org/taxon/urn:lsid:ipni.org:names:320783-2">http://powo.science.kew.org/taxon/urn:lsid:ipni.org:names:320783-2</a>. [Accessed 10 Aug 2018]</p>	<p>"Chocolate is considered a delicacy for humans, but cocoa solids contain the alkaloid theobromine, which is toxic to pets such as cats and dogs."</p>
	<p>Knight, A. 2007. <i>A Guide to Poisonous House and Garden Plants</i>. CRC Press, Boca Raton, FL</p>	<p>"Cocoa seeds contain the methylxanthine alkaloids theobromine and caffeine. These alkaloids are rapidly absorbed from the digestive tract and act to block the adenosine receptor which is critical to cyclic AMP and other cell functions [1,2]." ... "Since dogs find chocolate quite palatable and chocolate is commonly available in the household, the potential for poisoning is always present. Cocoa bean hulls have been used as garden mulches and in at least one case dogs became intoxicated by eating the cocoa hulls [5,6]." ... "Vomiting, diarrhea, increased urination, hyperexcitability, fast heart and respiratory rates are signs of poisoning in dogs. An increased body temperature, muscle tremors, and seizures may also occur. Hematuria, bradycardia, coma, and death may occur in severe cases [1]. Dogs known or suspected of eating chocolate should be evaluated by a veterinarian."</p>

406	Host for recognized pests and pathogens	
	Source(s)	Notes
	<p>Matsunaga, J. N. &amp; Chun, S. G. (2018). <i>Acalolepta aesthetica</i> (Olliff), a longhornedbeetle (Coleoptera: Cerambycidae). New Pest Advisory No. 18-02. Plant Pest Control Branch, Hawaii Department of Agriculture, Honolulu. <a href="https://hdoa.hawaii.gov">https://hdoa.hawaii.gov</a>. [Accessed 13 Aug 2018]</p>	<p>"Adult feeding habits remain unknown although they likely feed on leaves, petioles or bark of plants, without causing significant damage. Damage to trees is caused by the larvae which feed and tunnel within the woody portion of the host, compromising the structural integrity of the branches and trunk. Larval feeding creates entry points for pathogens, making the host plant more susceptible to secondary disease infections and attack by additional wood boring pests, further compromising host plant health. Heavy infestation of already weakened trees may lead to plant death. Because cerambycid larvae are wood borers which feed within dead or dying trees, infestation of by other species of longhorn beetles may be mistakenly attributed to <i>A. aesthetica</i>." ... "Hosts confirmed in Hawaii thus far include breadfruit (<i>Artocarpus altilis</i>), kukui (<i>Aleurites moluccanus</i>), queen sago (<i>Cycas circinalis</i>), Citrus spp., and cacao (<i>Theobroma cacao</i>). Gunpowder tree (<i>Trema orientalis</i>) is a probable host, as early instar larvae were extracted from a tree exhibiting key infestation symptoms (exit holes, girdling, etc.) but still needs to be verified. Avocado (<i>Persea americana</i>) is another possible host, however, HDOA could not confirm that the submitted sample truly came from an avocado tree branch and this still needs to be verified."</p>

Qsn #	Question	Answer
	<p>Duke, J.A. 1983. Handbook of Energy Crops - Theobroma cacao.  <a href="https://hort.purdue.edu/newcrop/duke_energy/Theobroma_cacao.html">https://hort.purdue.edu/newcrop/duke_energy/Theobroma_cacao.html</a>. [Accessed 13 Aug 2018]</p>	<p>"Cacao grows in areas with high humidity; several hundred fungi have been reported as attacking this tree. However, the most important fungi that cause diseases which must be controlled include the following: <i>Armillaria mella</i> (Collar crack), <i>Botryodiplodia theobromae</i> (Pod rot), <i>Botryobasidium salmonicolor</i> (Pink disease), <i>Calonectria rigidiuscula</i> (Green point cushion gall), <i>Cephaleuros virescens</i> (Algal spot), <i>Ceratobasidium stevensii</i> (Thread blight), <i>Ceratocystis fimbriata</i> (Canker), <i>Corticium incisum</i> (Thread blight), <i>Fomes lamaensis</i> (Brown rot), <i>F. lignosus</i> (White rot), <i>F. noxius</i> (Brown crust), <i>Marasmius byssicola</i> (Brown thread), <i>M. perniciosus</i> (South American witches broom), <i>M. scandens</i> (White thread), <i>M. trichorrhizus</i> (Brown thread), <i>Monilia roleri</i> (Gray pod rot), <i>Nectria cacaoicola</i> (Pod rot), <i>Phytophthora palmivora</i> (Black pod), <i>Rosellinia bunodes</i> (Root rot), <i>R. pepo</i> (Root rot), <i>Septobasidium tanakae</i> (Felt fungus), <i>Sphaerostilbe repens</i> (Violet root rot), <i>Taphrina bussei</i> (Witches broom), <i>Thielaviopsis paradoxa</i> (pod rot), <i>Trachysphaera fructigena</i> (Mealy pod), <i>Ustilina zonata</i> (Collar rot), and <i>Verticillium dahliae</i> (Sudden death). Bacteria known to cause disease in cacao include: <i>Agrobacterium tumefaciens</i>, <i>Bacillus megatherium</i>, <i>B. subtilis</i>, <i>B. undulatus</i>, <i>Bacterium accendens</i>, <i>B. aceti</i>, <i>B. orleanense</i>, <i>B. xyloneum</i>, <i>B. xylmoides</i>, and <i>B. xylum</i>. Golden (p.c. 1984) lists the following nematodes: <i>Aphasmatylenchus nigeriensis</i>, <i>Criconemella goodeyi</i>, <i>Helcotylenchus cavenessi</i>, <i>H. concavus</i>, <i>H. microcephalus</i>, <i>H. multicinctus</i>, <i>Hoplolaimus seinhorst</i>, <i>Meloidogyne incognita</i>, <i>M. incognita acrita</i>., <i>M. javanica</i>, <i>M. sp.</i>, <i>Paratylenchus arculatus</i>, <i>Pratylenchus brachyurus</i>, <i>P. coffeae</i>, <i>P. sp.</i>, <i>Rotylenchulus reniformis</i>, <i>Scutellonema clathricaudatum</i>, <i>Tylenchorhynchus annulatus</i>, <i>T. nudus</i>, <i>Xiphinema ebriense</i>, <i>X. elongatum</i>, <i>X. ifacolum</i>, <i>X. nigeriense</i>, and <i>X. setariae</i>. Viruses isolated from cacao include: Akaran, Apoplectic disease, Asalu, Ilesha, Konongo, Kpeve cacao, Mottle leaf, Necrosis, New Juaben (B.C.), New Juaben cacao, Offa Igbo (Nigeria) cacao, Offa Igbo 1 and 2, Olanla 1 and 2, Red mottle, Swollen-shoot, Trinidad cacao, Vein clearing, and Viruses 1A, 1B, 1C, and 1M. Cacao trees may be parasitized by <i>Cuscuta campestris</i>, <i>C. cubinclusa</i>, and <i>Phthirusa theobromae</i>. "</p>
	<p>Orwa C., Mutua, A., Kindt R., Jamnadass, R, &amp; Anthony, S. 2009 Agroforestry Database: a tree reference and selection guide version 4.0.  <a href="http://www.worldagroforestry.org">http://www.worldagroforestry.org</a>. [Accessed 13 Aug 2018]</p>	<p>"Pests include cacao mirids, which feeds on pods and branches, earia (<i>Earias biplaga</i>), mealybugs, stem borers and shot-hole borers. Diseases that attack cocoa, causing considerable damage, include the swollen shoot disease, a viral disease spread by mealybugs, whose symptoms appear as stem and root swellings; black pod disease caused by <i>Phytophthora palmivora</i>, causing rotting both large and small pods in the wet season; charcoal rot caused by <i>Botryodiplodia theobromae</i>; root rots caused by <i>Armillaria mellea</i>, <i>Fomes noxius</i> and <i>F. lignosus</i>; twig and leaf diseases such as pink disease caused by <i>Corticium salmonicolor</i>, thread blight disease caused by <i>Marasmius scandens</i>, calonectria die-back caused by <i>Calonectria rigidiuscula</i>; and cushion gall disease caused by the same organism."</p>

Qsn #	Question	Answer
	Smith, G. K., Gering, E., Guerrero, R. F., McTavish, E. J. & Lydgate, T. (2009). <i>Theobroma Cacao</i> L. (Malvaceae) Agroecology in Kauai: A Case Study. <i>Pacific Agriculture and Natural Resources</i> , 1: 21-26	[Affected by widespread insect pest] "Abstract: <i>Theobroma cacao</i> L. ( <i>cacao</i> ) is a widely cultivated tree of Neotropical origin and the source of cocoa beans and chocolate. Limited cocoa production is currently underway on the islands of Hawaii, but the factors that control <i>T. cacao</i> 's survival and fecundity outside of its native range remain poorly studied. Here we assess deficiencies in current knowledge of <i>cacao</i> ecology, and we establish research priorities for developing a profitable and renewable Hawaiian <i>cacao</i> farming program. We also present baseline data on fruit yield, herbivory, and insect community structure from a recently established organic <i>cacao</i> farm on the island of Kauai. Our observations indicate that nonnative organisms, including the common agricultural pest, the Chinese rose beetle ( <i>Adoretus sinicus</i> ), may greatly affect the health and performance of Hawaiian <i>cacao</i> trees in both antagonistic and mutualistic ways." ... "The Chinese rose beetle, an herbivorous scarab beetle, was first documented on Oahu in 1891, and likely arrived from Japan. Within Hawaii, <i>A. sinicus</i> feeds on over 500 plant species including major crops such as taro, corn and beans (Tsutsumi et al. 1994)."
	WRA Specialist. 2018. Personal Communication	Several pests & pathogens impact <i>Theobroma cacao</i> , but it is unclear if <i>T. cacao</i> is a significant host of any of these, given its relative importance as a crop in the Hawaiian Islands

407	Causes allergies or is otherwise toxic to humans	n
	Source(s)	Notes
	KewScience. 2018. Plants of the World Online - <i>Theobroma cacao</i> . <a href="http://powo.science.kew.org/taxon/urn:lsid:ipni.org:names:320783-2">http://powo.science.kew.org/taxon/urn:lsid:ipni.org:names:320783-2</a> . [Accessed 10 Aug 2018]	"Cocoa is known to have minor or moderate interactions with certain drugs, and it may cause adverse reactions when eaten or applied to the skin. Chocolate is considered a delicacy for humans, but cocoa solids contain the alkaloid theobromine, which is toxic to pets such as cats and dogs. Excessive amounts of chocolate and cocoa may be harmful during pregnancy and breastfeeding."

408	Creates a fire hazard in natural ecosystems	n
	Source(s)	Notes
	Orwa C., Mutua, A., Kindt R., Jamnadass, R. & Anthony, S. 2009 <i>Agroforestry Database: a tree reference and selection guide</i> version 4.0. <a href="http://www.worldagroforestry.org">http://www.worldagroforestry.org</a> . [Accessed 13 Aug 2018]	"In its natural habitat, <i>T. cacao</i> is an understorey plant of forest in the wet humid tropics." [No evidence. Unlikely given wet, humid habitat]

409	Is a shade tolerant plant at some stage of its life cycle	y
	Source(s)	Notes
	Lim, T.K. (2012). <i>Edible Medicinal and Non-Medicinal Plants</i> . Volume 3, Fruits. Springer, New York	"In its native habitat, cocoa is an understorey tree, growing best with partial overhead shade and uniformly high humidity."
	Duke, J.A. 1983. <i>Handbook of Energy Crops - Theobroma cacao</i> . <a href="https://hort.purdue.edu/newcrop/duke_energy/Theobroma_cacao.html">https://hort.purdue.edu/newcrop/duke_energy/Theobroma_cacao.html</a> . [Accessed 13 Aug 2018]	"Plants are shade-tolerant, and thrive in rich, organic, well-drained, moist, deep soils."

Qsn #	Question	Answer
	FAO. 1986. Food and fruit-bearing forest species 3: Examples from Latin America. FAO Forestry Paper, 44(3). Food & Agriculture Organization of the United Nations, Rome	"Theobroma cacao is a native of the uplands and higher flood plains of the high forests of the western .Amazon, growing in shaded situations" ... "Rusticly grown cocoa under shade and without fertilizer may yield 500 kg/ha."

410	Tolerates a wide range of soil conditions (or limestone conditions if not a volcanic island)	n
	Source(s)	Notes
	Duke, J.A. 1983. Handbook of Energy Crops - Theobroma cacao. <a href="https://hort.purdue.edu/newcrop/duke_energy/Theobroma_cacao.html">https://hort.purdue.edu/newcrop/duke_energy/Theobroma_cacao.html</a> . [Accessed 13 Aug 2018]	"Plants are shade-tolerant, and thrive in rich, organic, well-drained, moist, deep soils. Shallow laterite soils are said not to be suitable."
	Orwa C., Mutua, A., Kindt R., Jamnadass, R, & Anthony, S. 2009 Agroforestry Database: a tree reference and selection guide version 4.0. <a href="http://www.worldagroforestry.org">http://www.worldagroforestry.org</a> . [Accessed 13 Aug 2018]	"Soil type: Cocoa is a tap-rooted plant and requires deep well-drained soils, free from iron concretions, high in nutrient content and a topsoil rich in organic matter."
	Lim, T.K. (2012). Edible Medicinal and Non-Medicinal Plants. Volume 3, Fruits. Springer, New York	"The tree thrives in rich, organic, well-drained, moist, deep soils. An ideal cocoa soil should be at least 1.5 m deep, clay content 30–40%, with top soil having v 2% carbon, a cation exchange capacity of 120 mmol/kg and a base saturation of 35%. Such soils include well drained entisols (alluvial soils), deep and well-drained inceptisols (volcanic and other origins), red or yellowish ultisols and alfisols (mineral rich forest soils). Clay loams and sandy loams are also suitable. Shallow lateritic soils should be avoided. Cocoa is grown on soils with a wide range of pH from 6 to 7.5 where major nutrients and trace elements will be available. Cocoa does not do well in coastal sandy soils where coconut flourish."

411	Climbing or smothering growth habit	n
	Source(s)	Notes
	Lim, T.K. (2012). Edible Medicinal and Non-Medicinal Plants. Volume 3, Fruits. Springer, New York	"Evergreen, small tree, usually 4–8 m , rarely to 20 m high with a short, thick trunk, dark gray-brown bark , slender branches"

Qsn #	Question	Answer
412	Forms dense thickets	n
	Source(s)	Notes
	Lim, T.K. (2012). Edible Medicinal and Non-Medicinal Plants. Volume 3, Fruits. Springer, New York	[No evidence from natural or introduced ranges. Widely cultivated] "Recent studies of <i>Theobroma cacao</i> genetics indicated that the plant originated in the upper basin of the Amazon and its headwaters in Peru, Ecuador, Columbia and Brazil. It was distributed by humans throughout Central America and Mesoamerica. Wild cocoa population are also present in the lower Amazon basin as well as along the Orinoco river basin in Venezuela and in the Guyanas." ... "Besides Latin America, cocoa is grown extensively in West Africa (Ghana, Nigeria, Cameroon and Cote D'Ivoire) based on the Trinitario, Amelonado and Forastero cocoa materials; and in Indonesia, Malaysia and Papua New Guinea Trinitario and Forastero materials were introduced from the Caribbean and south America."

501	Aquatic	n
	Source(s)	Notes
	Orwa C., Mutua, A., Kindt R., Jamnadass, R., & Anthony, S. 2009 Agroforestry Database: a tree reference and selection guide version 4.0. <a href="http://www.worldagroforestry.org">http://www.worldagroforestry.org</a> . [Accessed 13 Aug 2018]	[Terrestrial] " <i>Theobroma cacao</i> is cauliflorous and semi-deciduous. The tree is low, reaching an average height of 5-10 m." ... "In its natural habitat, <i>T. cacao</i> is an understory plant of forest in the wet humid tropics."

502	Grass	n
	Source(s)	Notes
	USDA, ARS, Germplasm Resources Information Network. 2018. National Plant Germplasm System [Online Database]. <a href="http://www.ars-grin.gov/npgs/index.html">http://www.ars-grin.gov/npgs/index.html</a> . [Accessed 10 Aug 2018]	Family: Malvaceae Subfamily: Byttnerioideae Tribe: Theobromateae

503	Nitrogen fixing woody plant	n
	Source(s)	Notes
	USDA, ARS, Germplasm Resources Information Network. 2018. National Plant Germplasm System [Online Database]. <a href="http://www.ars-grin.gov/npgs/index.html">http://www.ars-grin.gov/npgs/index.html</a> . [Accessed 10 Aug 2018]	Family: Malvaceae Subfamily: Byttnerioideae Tribe: Theobromateae

504	Geophyte (herbaceous with underground storage organs -- bulbs, corms, or tubers)	n
	Source(s)	Notes

Qsn #	Question	Answer
	Nair, K. P. P. (2010). <i>The Agronomy and Economy of Important Tree Crops of the Developing World</i> . Elsevier, London	"Cocoa has a tap root that grows predominantly downward with only few branches. When the soil is deep and the growing conditions are favorable, the tap root can grow to a depth of about 150 cm. The primary function of these roots is anchorage. The main feeding roots are those which arise from the tap root and grow laterally. Most of these roots are concentrated just below the soil surface up to a depth of 15–20 cm (Wahid et al., 1989). The lateral spread of such roots will be up to a depth of about 120–150 cm around an adult cocoa plant. As the bulk of feeding roots is concentrated near the soil surface, any form of digging around the cocoa plant can harm the plant."

601	Evidence of substantial reproductive failure in native habitat	n
	Source(s)	Notes
	KewScience. 2018. <i>Plants of the World Online - Theobroma cacao</i> . <a href="http://powo.science.kew.org/taxon/urn:lsid:ipni.org:names:320783-2">http://powo.science.kew.org/taxon/urn:lsid:ipni.org:names:320783-2</a> . [Accessed 13 Aug 2018]	[No evidence] "Cocoa is native to Mexico, Central America and northern South America (Colombia, Ecuador, Venezuela, Brazil, Guyana, Surinam and French Guiana). It has also been introduced as a crop plant into many tropical African and Asian countries."

602	Produces viable seed	y
	Source(s)	Notes
	KewScience. 2018. <i>Plants of the World Online - Theobroma cacao</i> . <a href="http://powo.science.kew.org/taxon/urn:lsid:ipni.org:names:320783-2">http://powo.science.kew.org/taxon/urn:lsid:ipni.org:names:320783-2</a> . [Accessed 10 Aug 2018]	"Cocoa can be propagated by seed, using a propagator set to a temperature of 22 to 23 °C. Germination should take between 10 and 14 days. The seedlings grow very quickly and require regular potting up."
	Lim, T.K. (2012). <i>Edible Medicinal and Non-Medicinal Plants</i> . Volume 3, Fruits. Springer, New York	"Seeds (beans) embedded in white mucilaginous, acid sweet, edible pulp, 12–14 seeds per cell, ovoid, slightly flattened, 2.5 × 1.5 cm with leathery testa and white or purple cotyledons."
	FAO. 1986. <i>Food and fruit-bearing forest species 3: Examples from Latin America</i> . FAO Forestry Paper, 44(3). Food & Agriculture Organization of the United Nations, Rome	"The general practice is to raise cocoa from hybrid seed, although cuttings and grafting are also used."

603	Hybridizes naturally	
	Source(s)	Notes
	Zhang, D., Figueira, A., Motilal, L., Lachenaud, P., & Meinhardt, L. W. (2011). <i>Theobroma</i> . Pp. 277-296 In <i>Wild Crop Relatives: Genomic and Breeding Resources</i> . Springer, Berlin, Heidelberg	"Although, natural hybrids between the species of <i>Theobroma</i> are rare, there are reports of occurrence, mainly between species of the <i>Glossopetalum</i> section (Silva et al. 2004)." ... "Successful interspecific crosses involving <i>T. cacao</i> have been obtained according to reports (Silva et al. 2004), as hybrid pods between <i>T. cacao</i> × <i>T. mammosum</i> , <i>T. cacao</i> × <i>T. simiarum</i> and <i>T. cacao</i> × <i>T. speciosum</i> ; as hybrid seedlings from <i>T. cacao</i> × <i>T. microcarpum</i> and <i>T. cacao</i> × <i>T. angustifolium</i> ; and adult hybrid plants from <i>T. cacao</i> × <i>T. grandiflorum</i> (Martinson 1966)."

Qsn #	Question	Answer
	Nair, K. P. P. (2010). <i>The Agronomy and Economy of Important Tree Crops of the Developing World</i> . Elsevier, London	[Natural hybridization between types of <i>T. cacao</i> ] "Natural hybridization between criollo and forastero led to the origin of Trinitario. It has been reported that the criollo population from Venezuela and the Amelonado-type forastero from Guayana could have been involved in hybridization leading to the production of Trinitario."

604	Self-compatible or apomictic	
	Source(s)	Notes
	Orwa C., Mutua, A., Kindt R., Jamnadass, R., & Anthony, S. 2009 <i>Agroforestry Database: a tree reference and selection guide version 4.0</i> . <a href="http://www.worldagroforestry.org">http://www.worldagroforestry.org</a> . [Accessed 13 Aug 2018]	"Cacao is naturally out-breeding, and various insects are associated with its pollination, the main ones being thrips, midges, ants and aphids. It has a complex system of self-incompatibility."
	Cosme, S., Cuevas, H. E., Zhang, D., Oleksyk, T. K., & Irish, B. M. (2016). Genetic diversity of naturalized cacao ( <i>Theobroma cacao</i> L.) in Puerto Rico. <i>Tree Genetics &amp; Genomes</i> , 12(5), 88	[Self-compatible plants exist in plants with certain genetic backgrounds] "Identification of genetically diverse cacao with disease resistance, high productivity, and desirable organoleptic traits is vitally important to the agricultural crop's long-term sustainability." ... "Principal coordinate, cluster, and population structure analysis using the genotype data for both local and reference samples assigned individuals into five distinct genetic backgrounds: Criollo, Trinitario, Amelonado, Upper Amazon Forastero (UAF), and Nacional. Puerto Rican cacao fit into four (Criollo, Trinitario, Amelonado and UAF) of the five genetic backgrounds, being mainly composed of individuals of Criollo ancestry." ... "Criollo and Amelonado genetic backgrounds are known for their homogenous phenotypic traits associated with their ability to self-fertilize (self-compatible) and their highly homozygous genomes." ... "Although Criollo trees are known to self-fertilize, if given the opportunity they would readily cross pollinate and hybridize. Ancient Criollo trees are rare elsewhere and were underrepresented in the current collection at the USDA-ARS TARS."
	Nair, K. P. P. (2010). <i>The Agronomy and Economy of Important Tree Crops of the Developing World</i> . Elsevier, London	[Some types incompatible] "A unique feature of cocoa plant is its self-incompatibility in some types, first reported by Harland in 1925. Upper Amazon and Ecuador types introduced in Trinidad were self-incompatible. Most of the self-incompatible plants were also cross-incompatible. Most of the homozygous types, such as West African Amelonados, are self-incompatible. Though the self-incompatible types may have the advantage of better fruit set under varied situations, self-incompatibility is important in commercial hybrid seed production. Incompatibility in cocoa is unique in that the site of incompatibility is the embryo sac (Cope, 1962)."

605	Requires specialist pollinators	n
	Source(s)	Notes

Qsn #	Question	Answer
	Allen, T. C. (1963). Biology, behavior and control of insects attacking <i>Theobroma cacao</i> . American Cocoa Research Institute	"Cacao is largely pollinated in nature by small flower-inhabiting and sometimes flower-feeding insects. These include thrips, aphids, ants, and, most important in cross-pollination, ceratopogonid midges. Natural pollination is adequate or excessive in many of the cocoa producing areas of the world, but in others (Costa Rica and Ecuador) increased pod set is desirable."
	Orwa C., Mutua, A., Kindt R., Jamnadass, R., & Anthony, S. 2009 Agroforestry Database: a tree reference and selection guide version 4.0. <a href="http://www.worldagroforestry.org">http://www.worldagroforestry.org</a> . [Accessed 13 Aug 2018]	"Cacao is naturally out-breeding, and various insects are associated with its pollination, the main ones being thrips, midges, ants and aphids. It has a complex system of self-incompatibility. After successful pollination, fertilization takes place within 36 hours; the sepals, petals and staminodes drop away and the stamens and pistil wither."
	KewScience. 2018. Plants of the World Online - <i>Theobroma cacao</i> . <a href="http://powo.science.kew.org/taxon/urn:lsid:ipni.org:names:320783-2">http://powo.science.kew.org/taxon/urn:lsid:ipni.org:names:320783-2</a> . [Accessed 10 Aug 2018]	"Fruit: In the wild, cocoa trees are pollinated by midges, and only about 5% of flowers receive enough pollen to start fruit development. When they are pollinated there is a dramatic change as the tiny flowers develop into massive fruits." ... "Flowers are borne on the old wood of the tree, and are pollinated by ants at Kew, although hand-pollination using a paintbrush is possible."

606	Reproduction by vegetative fragmentation	n
	Source(s)	Notes
	Duke, J.A. 1983. Handbook of Energy Crops - <i>Theobroma cacao</i> . <a href="https://hort.purdue.edu/newcrop/duke_energy/Theobroma_cacao.html">https://hort.purdue.edu/newcrop/duke_energy/Theobroma_cacao.html</a> . [Accessed 13 Aug 2018]	"Propagation may be by cuttings, buddings or graftings, but seeding is cheaper."

607	Minimum generative time (years)	2
	Source(s)	Notes
	dos Santos Dias, L. A., & Kageyama, P. Y. (1998). Repeatability and minimum harvest period of cacao ( <i>Theobroma cacao</i> L.) in Southern Bahia. <i>Euphytica</i> , 102 (1), 29-35	"For cacao, a period of two years can be considered short. It is necessary to bear in mind that the cacao tree shows an extensive juvenile period, as a result of which yield records generally begin from the 5th year of planting."
	Almeida, A. A. F. D., & Valle, R. R. (2007). Ecophysiology of the cacao tree. <i>Brazilian Journal of Plant Physiology</i> , 19(4), 425-448	[18 months - 3-5 years] "Flowering, for instance, in some cacao hybrids can begin 18 months after planting in the field, while in other genotypes it might be initiated after three to five years (Sena Gomes and Kozłowski, 1986)."

Qsn #	Question	Answer
701	Propagules likely to be dispersed unintentionally (plants growing in heavily trafficked areas)	n
	Source(s)	Notes
	Lim, T.K. (2012). Edible Medicinal and Non-Medicinal Plants. Volume 3, Fruits. Springer, New York	[No evidence. Seeds in mucilage, but relatively large & unlikely to be accidentally dispersed] "Fruit a drupe, variable in shape and colour, ovoid, oblong, ellipsoid sometimes pointed and constricted at the base or almost subglobose, with 5–10 furrows, green ripening to yellow, red or purplish ripening to same colour (Plates 1 , 2 , 3 and 4 ), with fruit wall (husk) up to 2 cm thick. Seeds (beans) embedded in white mucilaginous, acid sweet, edible pulp, 12–14 seeds per cell, ovoid, slightly flattened, 2.5 × 1.5 cm with leathery testa and white or purple cotyledons."

702	Propagules dispersed intentionally by people	y
	Source(s)	Notes
	Lim, T.K. (2012). Edible Medicinal and Non-Medicinal Plants. Volume 3, Fruits. Springer, New York	"Besides Latin America, cocoa is grown extensively in West Africa (Ghana, Nigeria, Cameroon and Cote D'Ivoire) based on the Trinitario, Amelonado and Forastero cocoa materials; and in Indonesia, Malaysia and Papua New Guinea Trinitario and Forastero materials were introduced from the Caribbean and south America."
	Staples, G.W. & Herbst, D.R. 2005. A Tropical Garden Flora - Plants Cultivated in the Hawaiian Islands and Other Tropical Places. Bishop Museum Press, Honolulu, HI	"Cacao was first recorded under cultivation in Hawai'i in 1831, when F. Meyen saw It growing on Don Francisco de Paula Marin's estate near Pearl Harbor ... Today cacao Is grown locally as a curiosity by a few botanical gardens and commercially on a limited scale."
	Hawaii Chocolate & Cacao Association. (2018). Frequently Asked Questions. <a href="https://hawaiichocolate.org">https://hawaiichocolate.org</a> . [Accessed 13 Aug 2018]	"Who are Hawaii's cacao growers? There are many "mom and pop" cacao growers in Hawaii who may grow anywhere from 2-20 trees on their property. But state-wide, there are currently 5 large-scale growers and a handful of medium-size growers."

703	Propagules likely to disperse as a produce contaminant	n
	Source(s)	Notes
	KewScience. 2018. Plants of the World Online - <i>Theobroma cacao</i> . <a href="http://powo.science.kew.org/taxon/urn:lsid:ipni.org:names:320783-2">http://powo.science.kew.org/taxon/urn:lsid:ipni.org:names:320783-2</a> . [Accessed 13 Aug 2018]	"The 'pod' contains 30 to 40 seeds, each of which is surrounded by a bitter-sweet white pulp. In the wild the seeds are dispersed and eaten by different mammals like agutis and monkies."
	WRA Specialist. 2018. Personal Communication	Intentionally cultivated. Seeds are valued for cocoa production, are relatively large, and are not likely to become a contaminant of other produce

704	Propagules adapted to wind dispersal	n
	Source(s)	Notes
	KewScience. 2018. Plants of the World Online - <i>Theobroma cacao</i> . <a href="http://powo.science.kew.org/taxon/urn:lsid:ipni.org:names:320783-2">http://powo.science.kew.org/taxon/urn:lsid:ipni.org:names:320783-2</a> . [Accessed 13 Aug 2018]	"The 'pod' contains 30 to 40 seeds, each of which is surrounded by a bitter-sweet white pulp. In the wild the seeds are dispersed and eaten by different mammals like agutis and monkies"

Qsn #	Question	Answer
705	<b>Propagules water dispersed</b>	<b>n</b>
	<b>Source(s)</b>	<b>Notes</b>
	KewScience. 2018. Plants of the World Online - <i>Theobroma cacao</i> . <a href="http://powo.science.kew.org/taxon/urn:lsid:ipni.org:names:320783-2">http://powo.science.kew.org/taxon/urn:lsid:ipni.org:names:320783-2</a> . [Accessed 13 Aug 2018]	[Possible that fruits or seeds could be water dispersed in riparian habitats, but unlikely, as trees are intentionally cultivated for their seeds, which are harvested before dispersal can occur] "The 'pod' contains 30 to 40 seeds, each of which is surrounded by a bitter-sweet white pulp. In the wild the seeds are dispersed and eaten by different mammals like agutis and monkeys"

706	<b>Propagules bird dispersed</b>	
	<b>Source(s)</b>	<b>Notes</b>
	Roth, I. (1987). Stratification of a Tropical Forest as Seen in Dispersal Types. Dr W. Junk Publishers, Dordrecht	"Many tropical squirrels are fruit-eaters and may bury the seeds, e.g. of <i>Gustavia augusta</i> , <i>Theobroma cacao</i> . Of the latter they eat the inner fruit flesh (endocarp), not the "sarcotesta- pulp" (Pijl 1972), as there is no sarcotesta (Roth 1977). The endocarp pulp is sweet and also eaten by man." [Not listed among bird-dispersed plants]
	Greenberg, R., Bichier, P., & Angón, A. C. (2000). The conservation value for birds of cacao plantations with diverse planted shade in Tabasco, Mexico. <i>Animal Conservation Forum</i> 3(2): 105-112	[Cacao distinguished from bird-dispersed plants as mammal-dispersed] "Natural regrowth on disturbed lands consists of an abundance of plants with bird-dispersed fruits (Martin, 1985). Tabascan cacao farmers remove many of these weedy perennials. The understory of cacao plantations is managed for a single mammal-dispersed and human harvested species (cacao) and most of the dominant shade trees are not bird dispersed."
	Berthol, B. (1992). Survey on Birds' Damage to Fruits in Tobago. IICA	[Unknown if parrots disperse large seeds, or merely feed on pulp] "But when they can choose, they prefer certain fruits such as pommecythere, pommerac, cocoa which are sweet and easier to eat. They also eat them preferably when they are ripe and seem to be attracted by the colour." ... "The favorite food of Orange-winged Parrots is cocoa."

707	<b>Propagules dispersed by other animals (externally)</b>	<b>y</b>
	<b>Source(s)</b>	<b>Notes</b>
	Emamdie, D., & Warren, J. (1993). Varietal Taste Preference for Cacao <i>Theobroma cacao</i> L. by the Neotropical Red Squirrel <i>Sciurus granatensis</i> (Humboldt). <i>Biotropica</i> , 25(3), 365-368	"In addition to monkeys and rats, squirrels are considered to be among the natural seed dispersal agents of <i>T. cacao</i> (Toxopeus 1985). In commercial plantations, however, squirrels may be a serious pest of cacao (Lawrence 1991)." [Squirrels act as both predators & dispersers]
	Roth, I. (1987). Stratification of a Tropical Forest as Seen in Dispersal Types. Dr W. Junk Publishers, Dordrecht	"Many tropical squirrels are fruit-eaters and may bury the seeds, e.g. of <i>Gustavia augusta</i> , <i>Theobroma cacao</i> . Of the latter they eat the inner fruit flesh (endocarp), not the "sarcotesta- pulp" (Pijl 1972), as there is no sarcotesta (Roth 1977). The endocarp pulp is sweet and also eaten by man."

708	<b>Propagules survive passage through the gut</b>	<b>y</b>
	<b>Source(s)</b>	<b>Notes</b>

Qsn #	Question	Answer
	Thomas, E., van Zonneveld, M., Loo, J., Hodgkin, T., Galluzzi, G., & van Etten, J. (2012). Present spatial diversity patterns of <i>Theobroma cacao</i> L. in the neotropics reflect genetic differentiation in Pleistocene refugia followed by human-influenced dispersal. <i>PLoS One</i> , 7(10), e47676	"Although sporadic seed dispersal under natural conditions has been reported to be mediated by monkeys, birds, squirrels and even deer [27], this does not seem to have been very efficient [4], possibly because its original megafauna dispersal agent(s) went extinct [31]."
	Beck, H. (2005). Seed predation and dispersal by peccaries throughout the Neotropics and its consequences: a review and synthesis. Pp. 77-115 in Forget, P-M. et al. (eds.). <i>Seed Fate: Predation, Dispersal and Seedling Establishment</i> . CABI Publishing, Wallingford, UK	"Appendix 6.3. Summary of studies on fruit consumption, seed predation and seed dispersal by both peccary species ( <i>Pecari tajacu</i> and <i>Tayassu pecari</i> ) throughout the Neotropics." [ <i>Theobroma cacao</i> - Seed fate - A, alive and potentially dispersed; ND, not determined]
	KewScience. 2018. Plants of the World Online - <i>Theobroma cacao</i> . <a href="http://powo.science.kew.org/taxon/urn:lsid:ipni.org:names:320783-2">http://powo.science.kew.org/taxon/urn:lsid:ipni.org:names:320783-2</a> . [Accessed 13 Aug 2018]	"The 'pod' contains 30 to 40 seeds, each of which is surrounded by a bitter-sweet white pulp. In the wild the seeds are dispersed and eaten by different mammals like agutis and monkeys"

801	Prolific seed production (>1000/m2)	n
	Source(s)	Notes
	Duke, J.A. 1983. <i>Handbook of Energy Crops - Theobroma cacao</i> . <a href="https://hort.purdue.edu/newcrop/duke_energy/Theobroma_cacao.html">https://hort.purdue.edu/newcrop/duke_energy/Theobroma_cacao.html</a> . [Accessed 13 Aug 2018]	"fruits usually considered drupes but referred to as pods, indehiscent, variable in size and shape, 10–32 cm long, spherical to cylindrical, pointed or blunt, smooth or warty, with or without 5 or 10 furrows; pods white, green or red, ripening to green, yellow, red or purple; seeds 20–60 per pod, arranged in 5 rows, variable in size, 2–4 cm long, 1.2–2 cm broad, ovoid or elliptic" ... "Seeds/kg 625–1125" ... "Seeds germinate at maturity, and are viable only a short time." ... "Yields of 3,375 kg/ha of dry beans are possible on good plantations." [Up to 1125/kg; Up 3,796,875 seeds/10,000 m2; Up to 379.7 seeds/m2]

802	Evidence that a persistent propagule bank is formed (>1 yr)	n
	Source(s)	Notes
	KewScience. 2018. Plants of the World Online - <i>Theobroma cacao</i> . <a href="http://powo.science.kew.org/taxon/urn:lsid:ipni.org:names:320783-2">http://powo.science.kew.org/taxon/urn:lsid:ipni.org:names:320783-2</a> . [Accessed 10 Aug 2018]	"As the seeds of the cocoa tree are recalcitrant (meaning that the seeds are not amenable to long term frozen storage as they would not survive drying to the required levels in the seed bank), it is not possible store this kind of seed in a seed bank. Conservation of cocoa varieties therefore rely entirely on live trees in plantations and in the wild."
	FAO. 1986. <i>Food and fruit-bearing forest species 3: Examples from Latin America</i> . FAO Forestry Paper, 44(3). Food & Agriculture Organization of the United Nations, Rome	"The hybrid seeds are produced from known crosses of superior high-yielding trees and are planted shortly after being collected because the seed viability is rapidly lost in storage, so much so that 10 days without special care will cause the loss of all viability."

803	Well controlled by herbicides	y
	Source(s)	Notes
	Pereira, R. C., Marcondes, D. A. S., Fontes, J. L., Chahata, A. N., & Geraldo, E. R. (1980). Effect of post-em. herbicides in cocoa crops. In <i>Resumos XIII Congresso Brasileiro de Herbicidas e Ervas Daninhas</i> , Bahia, 1980. (pp. 30-31)	"Treatments containing glyphosate killed the apical buds of the cocoa plants."

Qsn #	Question	Answer
	Nivia, E., & Gips, J. (1993). Drug Control and Herbicide Spraying in Columbia. <i>The Global Pesticide Campaigner</i> , 3 (1): 14	[The use of glyphosate in marijuana and coca [ <i>Erythroxylum coca</i> ] eradication was halted after damage to coffee, cocoa] "Se discute la aspersión aérea de herbicidas para destruir los cultivos de droga en Colombia. Los planes de usar el Glifosato para erradicar el cultivo ilegal de opio / <i>Papaver somniferum</i> / han generado preocupación acerca del consecuente daño al medio ambiente y a la salud. La aplicación de Glifosato para la erradicación de cultivos de mariguana fue aprobada en 1984 pero en 1986 se despendió el plan para el uso de Glifosato para la erradicación de mariguana y coca / <i>Erythroxylum coca</i> / después de que se observaron daños en café, cacao y otros cultivos, también se reportaron los posibles efectos contrarios en la salud humana. Sin embargo, los planes para la erradicación aérea de drogas usando Glifosato Aún continúan. Se sugiere que los programas anteriores de erradicación no han tenido éxito debido a problemas sociales y económicos complejos asociados con el comercio internacional de estupefacientes. "

804	Tolerates, or benefits from, mutilation, cultivation, or fire	y
	Source(s)	Notes
	Fongkeng, E. E. (2014). Cocoa yield evaluation and some important yield factors in small holder <i>Theobroma cacao</i> agroforests in Bokito-centre Cameroon. PhD Dissertation, University of Dschang, Dschang, Cameroon	[Coppices] " The positive relationship between the average number of trunks per cocoa tree and the average basal area per tree, due to the coppicing of senescent cocoa trees, appears to have an important role in the long term maintenance of cocoa yields (CIRAD, 2009)."

805	Effective natural enemies present locally (e.g. introduced biocontrol agents)	
	Source(s)	Notes
	Smith, G. K., Gering, E., Guerrero, R. F., McTavish, E. J. & Lydgate, T. (2009). <i>Theobroma Cacao</i> L. (Malvaceae) Agroecology in Kauai: A Case Study. <i>Pacific Agriculture and Natural Resources</i> , 1: 21-26	[Chinese rose beetles may limit production] "Abstract: <i>Theobroma cacao</i> L. (cacao) is a widely cultivated tree of Neotropical origin and the source of cocoa beans and chocolate. Limited cocoa production is currently underway on the islands of Hawaii, but the factors that control <i>T. cacao</i> 's survival and fecundity outside of its native range remain poorly studied. Here we assess deficiencies in current knowledge of cacao ecology, and we establish research priorities for developing a profitable and renewable Hawaiian cacao farming program. We also present baseline data on fruit yield, herbivory, and insect community structure from a recently established organic cacao farm on the island of Kauai. Our observations indicate that nonnative organisms, including the common agricultural pest, the Chinese rose beetle ( <i>Adoretus sinicus</i> ), may greatly affect the health and performance of Hawaiian cacao trees in both antagonistic and mutualistic ways." ... "The Chinese rose beetle, an herbivorous scarab beetle, was first documented on Oahu in 1891, and likely arrived from Japan. Within Hawaii, <i>A. sinicus</i> feeds on over 500 plant species including major crops such as taro, corn and beans (Tsutsumi et al. 1994)."

Qsn #	Question	Answer
	<p>Matsunaga, J. N. &amp; Chun, S. G. (2018). <i>Acalolepta aesthetica</i> (Olliff), a longhorn beetle (Coleoptera: Cerambycidae). New Pest Advisory No. 18-02. Plant Pest Control Branch, Hawaii Department of Agriculture, Honolulu. <a href="https://hdoa.hawaii.gov">https://hdoa.hawaii.gov</a>. [Accessed ]</p>	<p>[Unknown whether or not <i>A. aesthetica</i> will act as a limiting factor]                      "Adult feeding habits remain unknown although they likely feed on leaves, petioles or bark of plants, without causing significant damage. Damage to trees is caused by the larvae which feed and tunnel within the woody portion of the host, compromising the structural integrity of the branches and trunk. Larval feeding creates entry points for pathogens, making the host plant more susceptible to secondary disease infections and attack by additional wood boring pests, further compromising host plant health. Heavy infestation of already weakened trees may lead to plant death. Because cerambycid larvae are wood borers which feed within dead or dying trees, infestation of by other species of longhorn beetles may be mistakenly attributed to <i>A. aesthetica</i>." ... "Hosts confirmed in Hawaii thus far include breadfruit (<i>Artocarpus altilis</i>), kukui (<i>Aleurites moluccanus</i>), queen sago (<i>Cycas circinalis</i>), Citrus spp., and cacao (<i>Theobroma cacao</i>)."</p>

**Summary of Risk Traits:**

## High Risk / Undesirable Traits

- Thrives in tropical climates
- Reported to be naturalized in Puerto Rico, & possibly other locations
- Toxic to cats & dogs
- Potential host of pests & pathogens
- Tolerates many soil types
- Shade tolerant (could establish in intact forest understories)
- Reproduces by seeds (facilitating possible naturalization)
- Some genetic types may be self-compatible
- Seeds dispersed by frugivorous mammals & intentionally by people
- Able to coppice

## Low Risk Traits

- Despite widespread cultivation, no confirmed reports of invasiveness outside native range
- Unarmed (no spines, thorns, or burrs)
- Palatable to grazing animals
- Valued for seeds (used in cocoa production)
- Several genetic types are self-incompatible
- Not reported to spread vegetatively
- Large seeds valued for cocoa & unlikely to be accidentally dispersed
- Sensitive to herbicides (could provide effective control if needed)