United States Department of Agriculture

Weed Risk Assessment for *Colophospermum mopane* (Kirk ex Benth.) Kirk ex J. Léonard (Fabaceae) – Mopane

United States Department of Agriculture

Animal and Plant Health Inspection Service

October 2, 2013

Version 1

Left: *Colophospermum mopane*, leaves and pods; center: tall tree in habitat; right: flowers (source: Bart Wursten, www.zimbabweflora.co.zw) (Wursten et al., 2013)

Agency Contact:

Plant Epidemiology and Risk Analysis Laboratory
Center for Plant Health Science and Technology

Plant Protection and Quarantine
Animal and Plant Health Inspection Service
United States Department of Agriculture
1730 Varsity Drive, Suite 300
Raleigh, NC 27606

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.

***Colophospermum mopane* (Kirk ex Benth.) Kirk ex J. Léonard – mopane**

Species Information

Family: Fabaceae

Synonyms: *Copaiba mopane* (Kirk ex Benth.) Kuntze, *Copaifera mopane* Kirk ex Benth. (basionym), *Hardwickia mopane* (Kirk ex Benth.) Breteler et al. (NGRP, 2013).

Initiation: *Colophospermum mopane* was identified as a potential threat to U.S. agricultural and natural resources (Parker et al., 2007).

Foreign distribution: *Colophospermum mopane* is native to southern Africa, where it grows in southern Angola, north-eastern Botswana, Malawi, southern Mozambique, northern Namibia, South Africa (far northern parts), Zambia, and Zimbabwe (Aubrey, 2004; ILDIS, 2013; Melusi and Mojeremane, 2012; NGRP, 2013; Wursten et al., 2013). It has been introduced to India (Singh and Rathod, 2007; Tripathi et al., 2013) and Australia (Randall, 2007). Its native range may also include the following Central African countries (World Agroforestry Centre, 2013): Central African Republic, Congo, Democratic Republic of Congo, and Gabon, but that source provided no verifiable citations. We found no other reports for these countries. Considering that and the fact that the climate in those countries is much different (warmer and wetter) than the other areas where *C. mopane* occurs, we did not list these countries as part of its distribution.

U.S. distribution and status: We found two records of *C. mopane* under cultivation in Arizona (in the counties of Yuma and Puma) in the United States (GBIF, 2013; University of Arizona, 2013). One of those was of a single 6 meter tall tree (University of Arizona, 2013). The other record did not describe how many plants were under cultivation (University of Arizona, 2013). In an extensive search of online garden databases (e.g., Dave's Garden, 2013; GardenWeb, 2013), online plant finders (e.g., Backyard Gardener, 2013), and other works (e.g., Bailey and Bailey, 1976; Dirr, 1998; Kartesz, 2011; NGRP, 2013; NRCS,

2013), we found no other evidence that this species is cultivated in the United States.

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

1. *Colophospermum mopane* analysis

Establishment/Spread Potential

Colophospermum mopane is a tall tree or small shrub, depending on environmental conditions (Royal Botanic Gardens Kew, 2013). It produces viable seed that are dispersed via water and wind (Styles and Skinner, 1997). It forms dense monotypic stands, often occurring in almost pure stands known as 'mopane woodland' or 'mopane scrub' (Melusi and Mojeremane, 2012; Van Der Waal et al., 2009). It tolerates fire and can respond vigorously to damage by coppicing (Melusi and Mojeremane, 2012; cited in Mutakela, 2009). Although this tree is in the Fabaceae, it does not fix nitrogen (cited in Mutakela, 2009; Melusi and Mojeremane, 2012; Pokhriyal et al., 1990). We found no evidence that it escapes or establishes outside its native range, despite having been introduced to at least three countries. We had slightly greater than average uncertainty for this element.

Risk score = -5 Uncertainty index = 0.22

Impact Potential

Because it has apparently not established outside its native range, we have little evidence of impact. In its native range, though, increases in *C. mopane* densities have lowered the grazing capacity of certain areas (references cited in Smit and Rethman, 1998; Smit, 2005), resulting in specific control efforts (Smit and Rethman, 1998; West, 1964; references cited in Melusi and Mojeremane, 2012). In addition, it seems allelopathic (Khavhagali and Ligavha-Mbelengwa, 2009; Knapp, 1966) and can strongly compete with plants for water (Melusi and Mojeremane, 2012; Smit and Rethman, 2000). We found no evidence it causes any harm in natural or anthropogenic systems. We had slightly greater than average uncertainty for this element.

Risk score = 2.4 Uncertainty index = 0.21

Geographic Potential

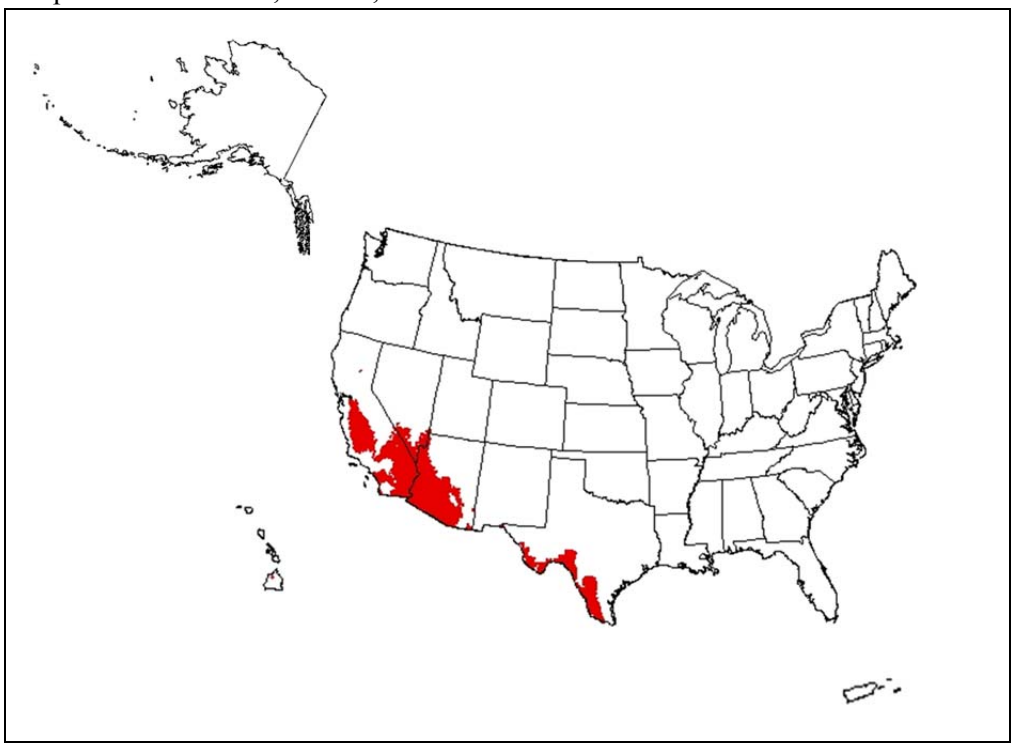
Based on three climatic variables, we estimate that about 4 percent of the United States is suitable for the establishment of *C. mopane* (Fig. 1). This predicted distribution is based on the species' known distribution elsewhere in the world and includes point-referenced localities and areas of occurrence. The map for *C. mopane* represents the joint distribution of Plant Hardiness Zones 9-12, areas with 0-40 inches of annual precipitation, and the following Köppen-Geiger climate classes: steppe and desert.

The area estimated likely represents a conservative estimate as 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. Its habitats include hot, dry, low-lying areas (Aubrey, 2004), especially dry river valleys (Melusi and Mojeremane, 2012), woodland or wooded grassland, and savanna woodlands (Royal Botanic Gardens Kew, 2013).

[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).

Entry Potential We did not assess the entry potential of *Colophospermum mopane* because this species is already present in the United States (GBIF, 2013; University of Arizona, 2013).

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



2. Results and Conclusion

Model Probabilities: P(Major Invader) = 2.0%
P(Minor Invader) = 38.8%
P(Non-Invader) = 59.1%

Risk Result = Low Risk

Secondary Screening = Not Applicable

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

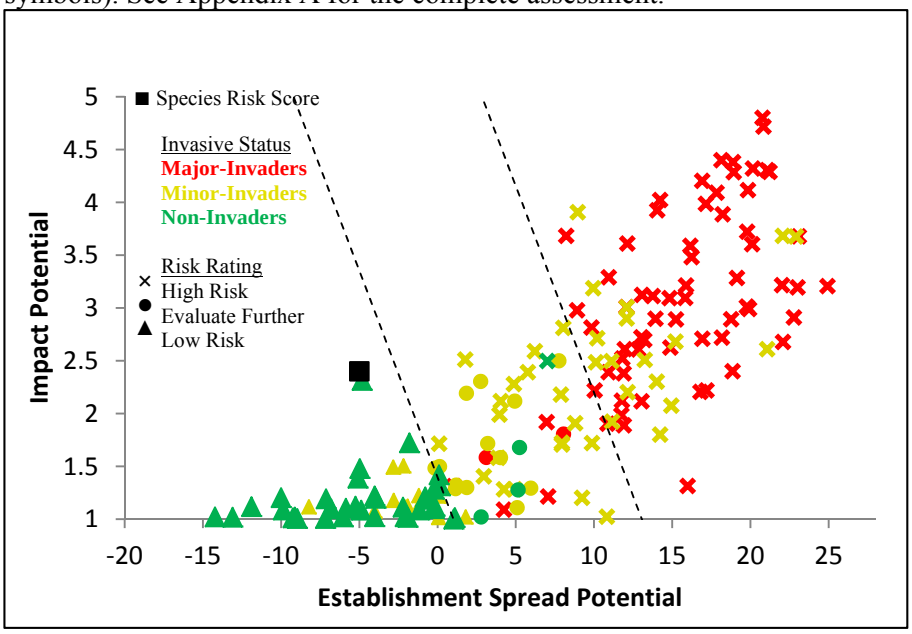
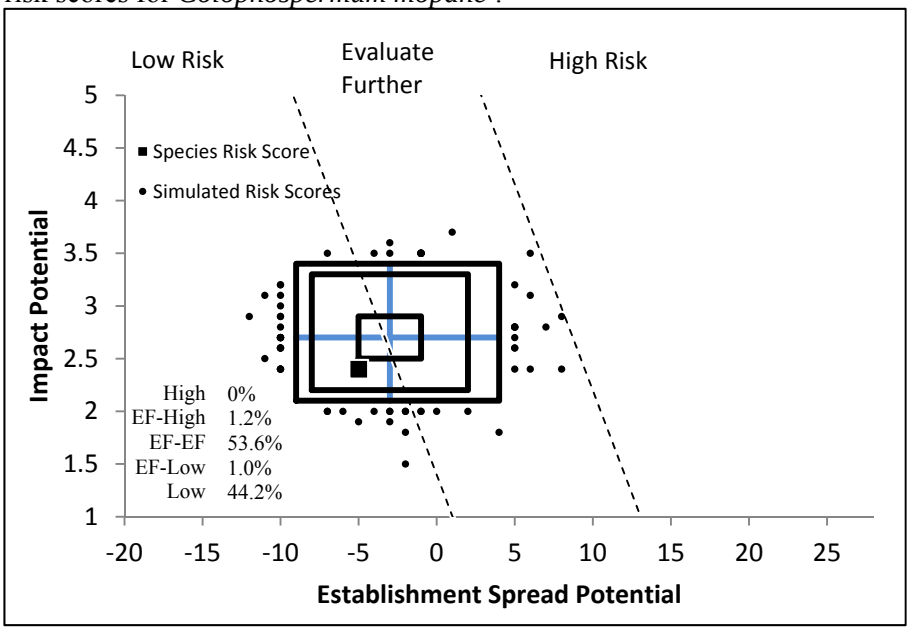


Figure 3. Monte Carlo simulation results (N=5,000) for uncertainty around the risk scores for *Colophospermum mopane*[a].



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

3. Discussion

The result of the weed risk assessment for *Colophospermum mopane* is Low Risk. This species is native to southern Africa, where it is an economically and ecologically important tree dominating the savanna woodlands (Royal Botanic Gardens Kew, 2013; Stevens et al., 2013). It has also been considered a weed of rangeland grazing systems within its native distribution (e.g., references cited in Smit and Rethman, 1998; Smit, 2005). We found no evidence it causes any harm in natural or anthropogenic systems. It is perhaps not surprising it has not caused harm in natural systems considering it has not established outside its native range. It was introduced to India in 1963 (Sharma et al., 1989), where it is planted with climax perennial grass species under silvopasture (Tripathi et al., 2013) and is used for rehabilitation of dry lands (Singh and Rathod, 2007). Despite this history of cultivation in India, we found no evidence that it has escaped or naturalized there. Because the behavior of this species outside of its native range is unknown and because of some gaps in knowledge about its biology, our assessment had slightly higher than average uncertainty. Our uncertainty analysis indicated an above average range of possible scores, but only 1.2 percent of the results were High risk (Fig. 3).

In its native range, *C. mopane* provides browse for elephants and other herbivorous animals (Royal Botanic Gardens Kew, 2013; Smit, 2001). Its increased density (i.e., bush encroachment) in grazing systems is thought to be due in part to the elimination of mega herbivores, notably elephants (Smit, 2001). It is unknown how this tree would behave in non-native areas, in particular in areas such as the United States that would lack the pressure of herbivory by elephants.

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.

APHIS. 2013. Phytosanitary Certificate Issuance and Tracking System (PCIT). United States Department of Agriculture, Animal and Plant Health Inspection Service (APHIS). https://pcit.aphis.usda.gov/pcit/faces/index.jsp. (Archived at PERAL).

Aubrey, A. 2004. *Colophospermum mopane* (J.Kirk ex Benth.) J.Kirk ex J.Léonard South African National Biodiversity Institute. Last accessed September 12, 2013, http://www.plantzafrica.com/plantcd/colomopane.htm.

Backyard Gardener. 2013. Plant Finder [online database]. BackyardGardener.com. http://www.backyardgardener.com/plantbuddysearch.html. (Archived at PERAL).

Bailey, L. H., and E. Z. Bailey. 1976. Hortus Third: A Concise Dictionary of Plants Cultivated in the United States and Canada (revised and expanded by The Staff of the Liberty Hyde Bailey Hortorium). Cornell University. 1290 pp.

Cleghorn, W. B., A. D. McKay, and C. H. Cronin. 1958. Results of preliminary arboricide and herbicide trials on a number of species limiting livestock carrying capacity of veld in Southern Rhodesia. 1st African Weed Control Conference, Victoria Falls, Livingstone, Southern Rhodesia, July 1958.

Cowling, R. M., D. M. Richardson, and S. M. Pierce (eds.). 1997. Vegetation of

Southern Africa. Cambridge University Press, Cambridge, U.K. 615 pp.
Dave's Garden. 2013. Dave's Garden. http://davesgarden.com/. (Archived at PERAL).
Dirr, M. 1998. Manual of Wood Landscape Plants: Their Identification, Ornamental Characteristics, Culture, Propagation and Uses. Stipes Pub., Champaign, Illinois. 1187 pp.
GardenWeb. 2013. GardenWeb: The Internet's Garden and Home Community. http://www.gardenweb.com/. (Archived at PERAL).
GBIF. 2013. GBIF, Online Database. Global Biodiversity Information Facility (GBIF). http://data.gbif.org/welcome.htm. (Archived at PERAL).
Heap, I., H. Glick, L. Glasgow, and W. Vencill. 2012. International Survey of Herbicide Resistant Weeds. Herbicide Resistance Action Committee, the North American Herbicide Resistance Action Committee, and the Weed Science Society of America. http://www.weedscience.org/In.asp. (Archived at PERAL).
Heide-Jorgensen, H. S. 2008. Parasitic Flowering Plants. Brill, Leiden, The Netherlands. 438 pp.
Hrabar, H., D. Hattas, and J. T. Du Toit. 2009. Differential effects of defoliation by mopane caterpillars and pruning by African elephants on the regrowth of *Colophospermum mopane* foliage. Journal of Tropical Ecology 25(3):301-309.
ILDIS. 2013. Legume Web, ILDIS World Database of Legumes, version 10.01. International Legume Database & Information Service (ILDIS). http://www.ildis.org/LegumeWeb. (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.
Jordaan, A., and D. C. J. Wessels. 1999. The aril of *Colophospermum mopane*. Its role during seed germination and fruit opening [Abstract]. South African Journal of Botany 65(5-6):392-397.
Jordaan, A., D. C. J. Wessels, and H. Krüger. 2002. Structure of the style and wet non-papillate stigma of *Colophospermum mopane*, Caesalpinioideae: Detarieae. Botanical Journal of the Linnean Society 139(3):295-304.
Kartesz, J. T. 2011. North American Plant Atlas [maps generated from Kartesz, J.T. 2010. Floristic Synthesis of North America, Version 1.0. Biota of North America Program (BONAP). (in press)]. The Biota of North America Program (BONAP), Chapel Hill, N.C. http://www.bonap.org/. (Archived at PERAL).
Khavhagali, V. P., and M. H. Ligavha-Mbelengwa. 2009. Assessment of plant species richness within and outside *Androstachys johnsonii* and *Colophospermum mopane* woodlands of Makuya Nature Reserve, Limpopo Province. Grassroots: Newsletter of the Grassland Society of Southern Africa 9(1):26-30.
Knapp, R. 1966. Influence of litter of some African grasses and xerophytic trees upon germination [Abstract]. Berichte der deutschen botanischen gesellschaft 79(7):329-335.
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.
Lloyd, B. V., D. M. Bromwich, and L. McNeill. 1979. Bush control; the control of

Brachystegia boehmii and *Colophospermum mopane* in Rhodesia using a picloram/2,4-D mixture. Proceedings of the Annual Congresses of the Grassland Society of Southern Africa 14(1):125-129.

Melusi, R., and W. Mojeremane. 2012. *Colophospermum mopane* (Benth.) J.Léonard. Record from PROTA4U. Lemmens, R.H.M.J., Louppe, D. and Oteng-Amoako, A.A. (Editors). PROTA (Plant Resources of Tropical Africa/Ressources Végétales de l'Afrique Tropicale), Wageningen, Netherlands. Last accessed September 5, 2013, http://www.prota4u.org/protav8.asp?h=M4&t=Colophospermum,mopane&p=Colophospermum+mopane.

Mlambo, D. 2005. BFA Seminar Series No. 35: Current Research into Mopane. Biodiversity Foundation for Africa (BFA). Last accessed September 13, 2013, http://www.biodiversityfoundation.org/documents/s35.pdf.

Mlambo, D., and P. Nyathi. 2004. Seedling recruitment of *Colophospermum mopane* on the Highveld of Zimbabwe. Southern African Forestry Journal (202):45-53.

Mutakela, P. S. 2009. Biomass prediction models for *Colophospermum mopane* (mopane) in Botswana (Master's Thesis). University of Stellenbosch. xiii + 35 pp.

NGRP. 2013. Germplasm Resources Information Network (GRIN). United States Department of Agriculture, Agricultural Research Service, National Genetic Resources Program (NGRP). http://www.ars-grin.gov/cgi-bin/npgs/html/index.pl?language=en. (Archived at PERAL).

Nickrent, D. 2009. Parasitic plant classification. Southern Illinois University Carbondale, Carbondale, IL, U.S.A. Last accessed June 12, 2009, http://www.parasiticplants.siu.edu/ListParasites.html.

NRCS. 2013. 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).

Parker, C., B. P. Caton, and L. Fowler. 2007. Ranking nonindigenous weed species by their potential to invade the United States. Weed Science 55:386-397.

Pokhriyal, T. C., H. C. Bhandari, D. S. Negi, S. P. Chaukiyal, and B. B. Gupta. 1990. Identification of some fast growing leguminous tree species for nitrogen fixation studies. Indian Forester 116(6):504-507.

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. 1115 pp.

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 S. Walters. 1999. Terrestrial Ecoregions of North America: A Conservation Assessment. Island Press, Washington D.C. 485 pp.

Royal Botanic Gardens Kew. 2008. Seed Information Database (SID) Version 7.1. http://data.kew.org/sid/. (Archived at PERAL).

Royal Botanic Gardens Kew. 2013. Plants & Fungi. Royal Botanic Gardens Kew. http://www.kew.org/plants-fungi/index.htm. (Archived at PERAL).

Sharma, B. D., J. C. Tewari, I. C. Gupta, and L. N. Harsh. 1989. *Colophospermum mopane*, an exotic tree for the arid-zone. Indian farming 39(6):5-6.

Singh, G., and T. R. Rathod. 2007. Growth, production and resource use in *Colophospermum mopane*-based agroforestry system in north-western

India. Archives of Agronomy and Soil Science 53(1):75-88.
Smit, G. N. 2001. The influence of tree thinning on the vegetative growth and browse production of *Colophospermum mopane*. South African Journal of Wildlife Research 31(3-4):99-114.
Smit, G. N. 2005. Tree thinning as an option to increase herbaceous yield of an encroached semi-arid savanna in South Africa. BMC (BioMed Central) Ecology 5(4):1-15.
Smit, G. N., and N. F. G. Rethman. 1998. The influence of tree thinning on the reproduction dynamics of *Colophospermum mopane*. South African Journal of Botany 64(1):25-29.
Smit, G. N., and N. F. G. Rethman. 2000. The influence of tree thinning on the soil water in a semi-arid savanna of southern Africa. Journal of Arid Environments 44(1):41-59.
Stevens, N., A. M. Swemmer, L. Ezzy, and B. F. Erasmus. 2013. Investigating potential determinants of the distribution limits of a savanna woody plant: *Colophospermum mopane*. Journal of Vegetation Science.
Styles, C. V., and J. D. Skinner. 1997. Mopane diaspores are not dispersed by epizoochory. African Journal of Ecology 35(4):335-338.
Tripathi, G., R. Deora, and G. Singh. 2013. The influence of litter quality and micro-habitat on litter decomposition and soil properties in a silvopasture system. Acta Oecologica 50:40-50.
University of Arizona. 2013. ARIZ, the University of Arizona Herbarium http://ag.arizona.edu/herbarium/. (Archived at PERAL).
van der Pijl, L. 1982. Principles of Dispersal in Higher Plants (3 ed.). Springer-Verlag, Berlin. 214 pp.
Van Der Waal, C., W. F. De Boer, I. M. A. Heitkönig, H. J. De Knegt, F. Van Langevelde, S. E. Van Wieren, E. M. Kohi, E. Mwakiwa, H. H. T. Prins, H. De Kroon, A. K. Skidmore, R. C. Grant, B. R. Page, and R. Slotow. 2009. Water and nutrients alter herbaceous competitive effects on tree seedlings in a semi-arid savanna. Journal of Ecology 97(3):430-439.
Walker, R. 2010. Parasitic Plants Database http://www.omnisterra.com/bot/pp_home.cgi. (Archived at PERAL).
West, O. 1964. Progress report of the Standing Sub-committee on Bush Control [Abstract]. 9th meeting South African Reg. Conference Conserv. Utills. Soil.
World Agroforestry Centre. 2013. Agroforestree Database. World Agroforestry Centre. http://www.worldagroforestrycentre.org/resources/databases/agroforestree. (Archived at PERAL).
Wursten, B., M. Hyde, and P. Ballings. 2013. Flora of Zimbabwe. http://www.zimbabweflora.co.zw/. (Archived at PERAL).

Appendix A. Weed risk assessment for *Colophospermum mopane* (Kirk ex Benth.) Kirk ex J. Léonard (Fabaceae). The following information came from the original risk assessment, which is available upon request (full responses and all guidance). We modified the information to fit on the page.

Question ID	Answer - Uncertainty	Score	Notes (and references)
ESTABLISHMENT/SPREAD POTENTIAL			
ES-1 (Status/invasiveness outside its native range)	b - high	-2	*Colophospermum mopane* is native to southern Africa, where it grows in southern Angola, north-eastern Botswana, Malawi, southern Mozambique, northern Namibia, South Africa (far northern parts), Zambia, and Zimbabwe (Aubrey, 2004; GBIF, 2013; Melusi and Mojeremane, 2012; NGRP, 2013). It has been introduced to India, where it is planted with climax perennial grass species under silvopasture (Tripathi et al., 2013) and used for rehabilitation of dry lands (Singh and Rathod, 2007). It has also been introduced to Australia (Randall, 2007). We also found two records of *C. mopane* under cultivation in Arizona (in the counties of Yuma and Puma) in the United States (GBIF, 2013; University of Arizona, 2013). It was introduced to India in 1963 (Sharma et al., 1989), but we found no evidence regarding when it was introduced to Australia or the United States. We found no evidence to suggest that it has naturalized or escaped in areas where it has been introduced; but it is possible it has escaped or naturalized but just has not been reported yet because the plant is viewed favorably. The alternate answers for the Monte Carlo simulation were "d" and "e."
ES-2 (Is the species highly domesticated)	n - low	0	We found limited evidence that this plant is cultivated and no evidence that it has been bred to reduce its likelihood of becoming a weed. This species is listed as "cultivated"(Randall, 2012); in particular, it has been cultivated in India (Singh and Rathod, 2007; Tripathi et al., 2013). However, in Africa, there are no reports of artificial *C. mopane* plantations, "except for plantings of a few or single trees for shade in homesteads" and "small collections in botanical gardens in southern Africa" (Melusi and Mojeremane, 2012).
ES-3 (Weedy congeners)	n - negl	0	The only species in the genus is *Colophospermum mopane* (Aubrey, 2004; Melusi and Mojeremane, 2012; Mutakela, 2009).
ES-4 (Shade tolerant at some stage of its life cycle)	n - negl	0	We found no evidence that it is shade tolerant. Seedlings are "light demanding", requiring increased light intensities for growth (Melusi and Mojeremane, 2012), and "appear to be shade-intolerant" (Mlambo and Nyathi, 2004). Seedling survival is mediated by shade (Stevens et al., 2013). "Full sun" is recommended on a gardening site (Dave's Garden, 2013).
ES-5 (Climbing or smothering growth form)	n - negl	0	It is neither a vine nor an herb with a basal rosette. Depending on local environmental conditions, it ranges from being a small stunted shrub, usually not more than 2 m tall, to a tree of 20 m (Royal Botanic Gardens Kew, 2013). It can be a shrub or a tree up to 30 m tall, depending on soil conditions and water availability (Aubrey, 2004).

Question ID	Answer - Uncertainty	Score	Notes (and references)
ES-6 (Forms dense thickets)	y - negl	2	It forms “mono-dominant stands” (Stevens et al., 2013) and “dense monotypic stands" (Van Der Waal et al., 2009). It grows gregariously, many individuals growing together to the near or complete exclusion of other plant species (Royal Botanic Gardens Kew, 2013). It is often gregarious, occurring in almost pure stands known as ‘mopane woodland’ or ‘mopane scrub’ (Melusi and Mojeremane, 2012). When it coppices, it “sometimes forms almost impenetrable thickets." (Melusi and Mojeremane, 2012).
ES-7 (Aquatic)	n - negl	0	*Colophospermum mopane* is not an aquatic species. It is a terrestrial plant and the dominant species in arid savanna communities (Cowling et al., 1997). It grows in hot, dry, low-lying areas (Aubrey, 2004). Although it tolerates moist and temporarily waterlogged soils (Melusi and Mojeremane, 2012(Mutakela, 2009), it will not germinate in waterlogged soils (Sharma et al., 1989).
ES-8 (Grass)	n - negl	0	This plant is in the Fabaceae family (NGRP, 2013).
ES-9 (Nitrogen-fixing woody plant)	n - low	0	It is a woody plant in the Fabaceae family (NGRP, 2013; Royal Botanic Gardens Kew, 2013) but evidence indicates it does not fix nitrogen. In a study evaluating multiple tree species, *C. mopane* was one of the non-nitrogen fixing species (Pokhriyal et al., 1990). Although mycorrhizae are often present on the roots of *C. mopane*, nitrogen-fixing nodules have not been found (Melusi and Mojeremane, 2012). It "does not have symbiotic nitrogen-fixing rhizobium within its roots, i.e. it does not fix nitrogen" (cited in Mutakela, 2009). Because this plant is in the family Fabaceae and we found only one study that specifically looked at whether *C. mopane* fixes nitrogen, we used low instead of negligible uncertainty.
ES-10 (Does it produce viable seeds or spores)	y - negl	1	It reproduces from seed (Aubrey, 2004; Melusi and Mojeremane, 2012). In germination tests, seeds had 75 to 90 percent germination rates (Royal Botanic Gardens Kew, 2008), and in the field, seed germination exceeded 70 percent (Mlambo and Nyathi, 2004). Lastly, germination of field-collected seed ranged from 34 to 82 percent (Smit and Rethman, 1998).
ES-11 (Self-compatible or apomictic)	? - max	0	Some pollen grains “were probably carried by wind and may induce selfing due to the relatively ineffective long distance distribution of pollen by wind" (Jordaan et al., 2002). They seem to just be speculating, and we found no other evidence indicating whether or not this plant is capable of producing seed without out-crossing, therefore we answered unknown.

Question ID	Answer - Uncertainty	Score	Notes (and references)
ES-12 (Requires special pollinators)	n - mod	0	We found no evidence that *C. mopane* requires specialist pollinators. “The pollen is thought to be carried on the wind”(Royal Botanic Gardens Kew, 2013). "Apparently anemophilous (wind pollinated)” (Melusi and Mojeremane, 2012). A number of wind-pollination indicators are present in *C. mopane*: “flowers with a reduced perianth, anthers and stigmas that are highly exposed, pollen grains that are smooth and dry and produced in great quantities, and one ovule per ovary” (Jordaan et al., 2002). However, the authors propose that pollen are probably also distributed “by insects such as mopane bees”; the mopane bee (*Apis mellifera*) gathers in large numbers on flowers to collect pollen. We found no definitive evidence that this species requires specialized pollinators, and we think that is unlikely because of the evidence for wind pollination and visitation of flowers by the common honeybee.
ES-13 (Minimum generation time)	d - negl	-1	Flowering begins when the trees are 5 years old (Melusi and Mojeremane, 2012; World Agroforestry Centre, 2013). The alternate answers for the Monte Carlo simulation are both "c".
ES-14 (Prolific reproduction)	? - max	0	Unknown; we found no quantitative evidence to help us answer this question. Flowering "can be erratic with no flowers at all for several years" (Melusi and Mojeremane, 2012). "In some years there is heavy crop of seeds while in others only a few are produced" (Sharma et al., 1989).
ES-15 (Propagules likely to be dispersed unintentionally by people)	n - mod	-1	We found no evidence that propagules are likely to be dispersed unintentionally by people. Although the pods are sticky (Smit and Rethman, 1998), they are relatively large [6 cm by 3 cm (Royal Botanic Gardens Kew, 2013)], decreasing their likelihood of being dispersed unintentionally by people.
ES-16 (Propagules likely to disperse in trade as contaminants or hitchhikers)	n - mod	-1	We found no evidence of this occurring. The pods are relatively large [6 cm by 3 cm (Royal Botanic Gardens Kew, 2013)], making them unlikely to be dispersed in trade as a contaminant or hitchhiker.
ES-17 (Number of natural dispersal vectors)	2	0	Seed and pod description used for ES-17a through ES-17e: The pods are flattened, more or less kidney shaped, deeply and irregularly furrowed, having many reddish sticky resin glands, and up to 6 cm long and 3 cm wide (Royal Botanic Gardens Kew, 2013(World Agroforestry Centre, 2013). Each pod contains a single seed that almost fills the pod, is flat, sticky, and dotted with a copious amount of resin glands (Smit and Rethman, 1998; Melusi and Mojeremane, 2012).

Question ID	Answer - Score Uncertainty	Notes (and references)
ES-17a (Wind dispersal)	y - low	Multiple sources state that the propagules are wind dispersed (Melusi and Mojeremane, 2012; Sharma et al., 1989; Styles and Skinner, 1997; World Agroforestry Centre, 2013). In a field study, the authors concluded that "experimentation shows the most likely agents of dispersal of mopane diaspores to be water and wind" (Styles and Skinner, 1997). The diaspore has the following general adaptations to wind dispersal: a high surface area-to-volume ratio, relatively low specific gravity, light weight, and uneven edges which enable air to flow underneath "lifting it and exposing the large, flat surface area to the prevailing winds" (Styles and Skinner, 1997 and references therein). The authors of the field study observed that the strong winds which precede a savanna-region's typical thunderstorm "were accompanied by much movement of diaspores", and they "regularly observed mopane diaspores being 'bowled' along for distances in excess of 50 m" (Styles and Skinner, 1997).
ES-17b (Water dispersal)	y - low	The propagules are dispersed by water (Melusi and Mojeremane, 2012; Sharma et al., 1989). In a field study, the authors concluded that " the most likely agents of dispersal of mopane diaspores to be water and wind," and flotation was an important means of dispersal (Styles and Skinner, 1997). Furthermore, "[a] characteristic of the summer rainfall period is the subsequent sheetflow of water along the surface of the ground"; this run-off collects masses of mopane diaspores and deposits them in piles along the drainage lines. We answered yes with low uncertainty because multiple references mention dispersal by water, it has broad pods that could likely float easily, and flooding occurs yearly in its native habitat.
ES-17c (Bird dispersal)	n - low	We found no evidence for bird dispersal. The propagules are likely too large for this type of dispersal.
ES-17d (Animal external dispersal)	? - max	Multiple references state that the sticky pods or seeds of *C. mopane* cling to the hooves of passing animals (van der Pijl, 1982; World Agroforestry Centre, 2013; cited in Melusi and Mojeremane, 2012) and can be dispersed in this manner (World Agroforestry Centre, 2013). The mode of dispersal "has always been ascribed to epizoochory due the slightly sticky nature of mopane diaspores", but that was "disproved" in a field study (Styles and Skinner, 1997). That was because the seeds were not sticky enough to adhere to the hoof of a mammalian ungulate. Diaspores only adhered to hooves when an agent facilitating attachment (e.g., wet feces) was present, but even then dispersal never exceeded 4m. Furthermore, pressure from the hoof "causes extensive structural damage", making seeds unlikely to germinate (Styles and Skinner, 1997). Because of conflicting evidence, we answered unknown.

Question ID	Answer - Uncertainty	Score	Notes (and references)
ES-17e (Animal internal dispersal)	n - low		It is a pasture plant (Randall, 2012). It is browsed by elephants and other herbivorous animals (Royal Botanic Gardens Kew, 2013). However, "endozoochory can be excluded as a mode of dispersal", because large seeds like these very rarely escape mastication, "their resinous nature and strong turpentine smell make them unattractive to mammals", and seedlings are never seen germinating in animal feces (Styles and Skinner, 1997 and references therein).
ES-18 (Evidence that a persistent (>1yr) propagule bank (seed bank) is formed)	n - negl	-1	No dormancy appears to exist in *C. mopane* seeds (Smit and Rethman, 1998). In natural conditions, seeds seldom remain viable for more than a year and pericarps of fruits usually completely degrade after one year (Jordaan and Wessels, 1999). Mopane showed little seed bank viability in germination trials of seeds collected from under fruiting trees (Mlambo, 2005). Seeds that fail to germinate during the rainy season tend to decay, thus "seedling recruitment is reliant on annual seed production" (Mlambo, 2005).
ES-19 (Tolerates/benefits from mutilation, cultivation or fire)	y - mod	1	"Mopane woodlands seem to be somewhat resistant to elephant impacts through the ability…to coppice or persist in a shrub stage" (Cowling et al., 1997). After lopping, new shoots rapidly regrow (Melusi and Mojeremane, 2012). In one study, browsing by elephants and simulated pruning resulted in shoots being up to 160 percent and 125 percent longer (Hrabar et al., 2009). Coppice growth in response to damage (e.g., mechanical clearing) can be vigorous (Melusi and Mojeremane, 2012). Its "tolerance of fire and fire-induced 'coppicing' are thought to favour its permanent encroachment on perennial grasslands" (cited in Mutakela, 2009). However, in some areas of southern Africa an increase in *C. mopane* tree density ("bush encroachment") is thought to be in part "due to the elimination of mega herbivores, notably elephant, and the exclusion of sporadic hot fires" (Smit, 2001).
ES-20 (Is resistant to some herbicides or has the potential to become resistant)	n - mod	0	We found no evidence that *C. mopane* is resistant to herbicides or can acquire herbicide resistance. Heap et al. (2012) do not list this species as having herbicide resistance.
ES-21 (Number of cold hardiness zones suitable for its survival)	4	0	
ES-22 (Number of climate types suitable for its survival)	2	-2	
ES-23 (Number of precipitation bands suitable for its survival)	4	-1	

Question ID	Answer - Uncertainty	Score	Notes (and references)
IMPACT POTENTIAL			
General Impacts			
Imp-G1 (Allelopathic)	y - high	0.1	"*C. mopane* secrete[s] secondary or allelopathic compounds that suppress the establishment and hence growth and development of other species under their canopies" (cited in Khavhagali and Ligavha-Mbelengwa, 2009); however, we could not verify the cited literature. "Although *C. mopane* is believed to release secondary compounds, its effect seems to be less intense than that found under [*Androstachys johnsonii*] stands" (Khavhagali and Ligavha-Mbelengwa, 2009). Litter of *C. mopane* "inhibits germination of various annuals" (Knapp, 1966) [abstract only]. Because of the quality of the evidence, we used high uncertainty.
Imp-G2 (Parasitic)	n - negl	0	We found no evidence that *C. mopane* is parasitic. It does not belong to a family known to contain parasitic plants (Heide-Jorgensen, 2008; Nickrent, 2009; Walker, 2010).
Impacts to Natural Systems			
Imp-N1 (Change ecosystem processes and parameters that affect other species)	n - high		We found no direct evidence that *C. mopane* negatively affects natural areas by changing ecosystem processes and parameters. We answered no but with high uncertainty based on the following considerations: it has been suggested it could promote soil erosion (Mutakela, 2009); it has been introduced to India for sand-dune stabilization (World Agroforestry Centre, 2013); it has not naturalized outside its native range; and in its native range it is controlled in part by mega herbivores, notably elephants (Smit, 2001), and it is unknown how it would behave if established in an area without these herbivores.
Imp-N2 (Change community structure)	n - high		We found no evidence that it is causing this impact in natural systems. We answered no but with high uncertainty based the following considerations: it forms dense monotypic stands (which can affect structural diversity) in its natural habitat (e.g., Melusi and Mojeremane, 2012) and in pastoral rangeland areas (e.g., Van Der Waal et al., 2009); and it has not naturalized beyond its native range, and therefore it is unknown how it would behave in non-native areas, in particular without the pressure of herbivory by elephants.
Imp-N3 (Change community composition)	n - high		We found no evidence of *C. mopane* changing community composition in natural areas. In one study high species richness was found within *C. mopane* woodlands on sandy soils (Khavhagali and Ligavha-Mbelengwa, 2009). In that study *C. mopane* may have acted as a refuge for plant species that could not tolerate direct sunlight or allelochemicals. We answered no but with high uncertainty based the following considerations: at high population densities in rangelands it outcompetes herbaceous plants and can prevent or suppress their establishment (Smit and Rethman, 2000; cited in Smit and Rethman, 1998); it has not naturalized beyond its native range, and therefore it is unknown how it would behave in non-native areas, in particular without the pressure of herbivory by elephants.

Question ID	Answer - Uncertainty	Score	Notes (and references)
Imp-N4 (Is it likely to affect federal Threatened and Endangered species)	n - high		Because we found no evidence of *C. mopane* changing community composition in natural areas, we answered no but with high uncertainty for the same reasons described in Imp-N3.
Imp-N5 (Is it likely to affect any globally outstanding ecoregions)	n - high		Its predicted distribution in the United States includes globally outstanding ecoregions as defined by Ricketts et al. (1999, p. 34, Fig. 3.1). But we answered no because we found no evidence of landscape level impacts in natural systems, and used high uncertainty as this species has not naturalized beyond its native range, and therefore it is unknown how it would behave in non-native areas, in particular without the pressure of herbivory by elephants.
Imp-N6 (Weed status in natural systems)	a - mod	0	We found no evidence. The 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 - low	0	We found no evidence of it causing this type of impact. There are no known hazards associated with *C. mopane* (Royal Botanic Gardens Kew, 2013).
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.
Imp-A4 (Weed status in anthropogenic systems)	a - mod	0	We found no evidence. The alternate answers for the Monte Carlo simulation were both "b".
Impact to Production Systems (agriculture, nurseries, forest plantations, orchards, etc.)			
Imp-P1 (Reduces crop/product yield)	y - low	0.4	In southern Africa, in certain areas with extensive cattle and game farming, an increase in *C. mopane* tree density ("bush encroachment") in recent history has resulted in "low grazing capacity of large parts of the Mopani veld" (cited in Smit and Rethman, 1998). Bush encroachment can often cause profitable livestock properties to become unprofitable (Smit, 2005). On the other hand, in a study in India looking at the effect of tree integration and cropping pattern on land productivity, the authors concluded that *C. mopane* "enhances land productivity through increased system production and agriculture yield in the initial 4 – 5 years" (Singh and Rathod, 2007). Because it seems clear that yield can be affected at least in some systems, we answered yes but with low uncertainty, not negligible uncertainty, based on the study results in India.
Imp-P2 (Lowers commodity value)	y - mod	0.2	Shrub mopane areas may "have little value for grazing animals and their browse value is limited to a few months in the dry season" (Melusi and Mojeremane, 2012)."Measures like tree thinning are often considered as an option to restore the herbaceous production potential of affected areas of the Mopani veld", where cattle and game farming is practiced (Smit and Rethman, 1998). Because of the decrease in grazing capacity caused by *C. mopane*, "tree thinning or even total clearing is considered" (Smit, 2005). Such control measures would be highly likely to increase production costs.

Question ID	Answer - Uncertainty	Score	Notes (and references)
Imp-P3 (Is it likely to impact trade)	n - low	0	Namibia and South Africa list this plant as a "harmful organism" (APHIS, 2013). It is a noxious (declared) weed (somewhere in the world), which is a legal category that "may take the form of a prohibition on entry, sale and movement to requirements to eradicate or control" (Randall, 2007). However, we found no evidence of it being a contaminant of trade. Based on the size of its pods (see ES-16), it is unlikely to be dispersed in trade as a contaminant or hitchhiker.
Imp-P4 (Reduces the quality or availability of irrigation, or strongly competes with plants for water)	y - low	0.1	The root system of *C. mopane* is shallow but extensive, and well adapted to arid conditions (Melusi and Mojeremane, 2012). The roots of *C. mopane* can utilize soil water at a lower matric potential [a component of water potential] than that of grasses, which enables this tree species "to compete successfully with herbaceous plants and to prevent their establishment at high tree densities" (Smit and Rethman, 2000). In southern Africa in certain areas with extensive cattle and game farming, "severe competition" for available soil water is considered the main reason for why an increase in *C. mopane* tree density resulted in the suppression of herbaceous plants and low grazing capacity (cited in Smit and Rethman, 1998).
Imp-P5 (Toxic to animals, including livestock/range animals and poultry)	n - negl	0	We found no evidence it is toxic to animals. It is used as a "pasture" plant, i.e., "specifically grown for grazing or fodder production" (Randall, 2012). "Domestic animals find the pungent leaves unpalatable at first but will feed on them once used to the taste"; "[t]he young leaves have a higher protein content and are more palatable but even the dry, fallen leaves yield valuable protein for stock and game" (Aubrey, 2004).
Imp-P6 (Weed status in production systems)	c - negl	0.6	*Colophospermum mopane* is a weed of agriculture (Randall, 2007; Randall, 2012), and evidence exists of its control by people. Control measures that have been used, considered, or tested have included the following: using goats to keep the shrubs under control (West, 1964; cited in Melusi and Mojeremane, 2012); tree thinning or clearing (Smit, 2005; Smit and Rethman, 1998); and herbicides (Cleghorn et al., 1958; Lloyd et al., 1979). The alternate answers for the Monte Carlo simulation were both "b."
GEOGRAPHIC POTENTIAL			Unless otherwise indicated, all geographic information used below was obtained from the Global Biodiversity Information Facility (GBIF) (2013) and is based on point-source data (geo-referenced data points).
Plant cold hardiness zones			
Geo-Z1 (Zone 1)	n - negl	N/A	We found no evidence it occurs in this zone.
Geo-Z2 (Zone 2)	n - negl	N/A	We found no evidence it occurs in this zone.
Geo-Z3 (Zone 3)	n - negl	N/A	We found no evidence it occurs in this zone.
Geo-Z4 (Zone 4)	n - negl	N/A	We found no evidence it occurs in this zone.
Geo-Z5 (Zone 5)	n - negl	N/A	We found no evidence it occurs in this zone.
Geo-Z6 (Zone 6)	n - negl	N/A	We found no evidence it occurs in this zone.
Geo-Z7 (Zone 7)	n - negl	N/A	We found no evidence it occurs in this zone.
Geo-Z8 (Zone 8)	n - low	N/A	We found no evidence it occurs in this zone.

Question ID	Answer - Uncertainty	Score	Notes (and references)
Geo-Z9 (Zone 9)	y - low	N/A	South Africa (7 points). Although "[e]arly studies suggest that *C. mopane* does not occur where the average July temperature is below 5 °C" (Stevens et al., 2013), another author notes that individual trees (probably dispersed to there by humans) grow in the southern part of Botswana about 200km away from the mopane southern limit, which "contravenes the theory of 'frost', which states that the ecological boundaries of mopane are largely controlled by the occurrence of frost" (cited in Mutakela, 2009).
Geo-Z10 (Zone 10)	y - negl	N/A	Namibia, Angola, Botswana, Zimbabwe, South Africa, Zambia.
Geo-Z11 (Zone 11)	y - negl	N/A	Namibia, Angola, Mozambique, Australia.
Geo-Z12 (Zone 12)	y - low	N/A	Namibia, Angola; Namibia (occurrence data).
Geo-Z13 (Zone 13)	n - low	N/A	We found no evidence it occurs in this zone.
Köppen-Geiger climate classes			
Geo-C1 (Tropical rainforest)	n - negl	N/A	We found no evidence it occurs in this zone.
Geo-C2 (Tropical savanna)	n - low	N/A	We found no evidence it occurs in this zone.
Geo-C3 (Steppe)	y - negl	N/A	Namibia, Angola, Botswana, South Africa, Zimbabwe, Zambia, Mozambique
Geo-C4 (Desert)	y - negl	N/A	Namibia, Angola, Botswana, South Africa, Zimbabwe
Geo-C5 (Mediterranean)	n - low	N/A	We found no evidence it occurs in this zone.
Geo-C6 (Humid subtropical)	n - negl	N/A	We found no evidence it occurs in this zone.
Geo-C7 (Marine west coast)	n - negl	N/A	We found no evidence it occurs in this zone.
Geo-C8 (Humid cont. warm sum.)	n - negl	N/A	We found no evidence it occurs in this zone.
Geo-C9 (Humid cont. cool sum.)	n - negl	N/A	We found no evidence it occurs in this zone.
Geo-C10 (Subarctic)	n - negl	N/A	We found no evidence it occurs in this zone.
Geo-C11 (Tundra)	n - negl	N/A	We found no evidence it occurs in this zone.
Geo-C12 (Icecap)	n - negl	N/A	We found no evidence it occurs in this zone.
10-inch precipitation bands			
Geo-R1 (0-10 inches; 0-25 cm)	y - negl	N/A	Namibia, Angola, Botswana, South Africa. The following evidence applies to this whole section on precipitation bands: It grows well in areas with 20-45 cm annual rainfall (Sharma et al., 1989). The mean annual rainfall range for *C. mopane* is 10 cm to 80 cm (Mutakela, 2009). While areas receiving less than 45 cm of rain per annum are "considered to be the true ecological niche of mopane", most mopane woodland is found in the 40-70 cm annual rainfall zones (Mutakela, 2009).
Geo-R2 (10-20 inches; 25-51 cm)	y - negl	N/A	Namibia, Angola, Botswana, South Africa.
Geo-R3 (20-30 inches; 51-76 cm)	y - negl	N/A	Namibia, Botswana, Zimbabwe, Zambia, South Africa, Mozambique.
Geo-R4 (30-40 inches; 76-102 cm)	y - low	N/A	Zimbabwe (1 point on edge of the 20-30 inch zone), South Africa (1 point).
Geo-R5 (40-50 inches; 102-127 cm)	n - low	N/A	We found no evidence it occurs in this zone.
Geo-R6 (50-60 inches; 127-152 cm)	n - negl	N/A	We found no evidence it occurs in this zone.

Question ID	Answer - Uncertainty	Score	Notes (and references)
Geo-R7 (60-70 inches; 152-178 cm)	n - negl	N/A	We found no evidence it occurs in this zone.
Geo-R8 (70-80 inches; 178-203 cm)	n - negl	N/A	We found no evidence it occurs in this zone.
Geo-R9 (80-90 inches; 203-229 cm)	n - negl	N/A	We found no evidence it occurs in this zone.
Geo-R10 (90-100 inches; 229-254 cm)	n - negl	N/A	We found no evidence it occurs in this zone.
Geo-R11 (100+ inches; 254+ cm))	n - negl	N/A	We found no evidence it occurs in this zone.
ENTRY POTENTIAL			
Ent-1 (Plant already here)	y - low	1	We found two records of *C. mopane* under cultivation in Arizona (in the counties of Yuma and Puma) in the United States (GBIF, 2013; University of Arizona, 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	