Taxon: Boswellia sacra Flueck. **Family:** Burseraceae

Common Name(s): frankincense **Synonym(s):** Boswellia carteri Birdw.

Assessor: Chuck Chimera **Status:** Assessor Approved **End Date:** 14 Jan 2021

WRA Score: **-3.0** **Designation:** L **Rating:** Low Risk

Keywords: Tree, Unarmed, Palatable, Self-Fertile, Wind-Dispersed

Qsn #	Question	Answer Option	Answer
101	Is the species highly domesticated?	y=-3, n=0	n
102	Has the species become naturalized where grown?		
103	Does the species have weedy races?		
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	y
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	?
301	Naturalized beyond native range	y = 1*multiplier (see Appendix 2), n= question 205	n
302	Garden/amenity/disturbance weed	n=0, y = 1*multiplier (see Appendix 2)	n
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		
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	n
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
409	Is a shade tolerant plant at some stage of its life cycle	y=1, n=0	n
410	Tolerates a wide range of soil conditions (or limestone conditions if not a volcanic island)	y=1, n=0	n

Qsn #	Question	Answer Option	Answer
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	y
602	Produces viable seed	y=1, n=-1	y
603	Hybridizes naturally		
604	Self-compatible or apomictic	y=1, n=-1	y
605	Requires specialist pollinators	y=-1, n=0	n
606	Reproduction by vegetative fragmentation	y=1, n=-1	n
607	Minimum generative time (years)		
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	y
705	Propagules water dispersed	y=1, n=-1	n
706	Propagules bird dispersed	y=1, n=-1	n
707	Propagules dispersed by other animals (externally)	y=1, n=-1	n
708	Propagules survive passage through the gut	y=1, n=-1	n
801	Prolific seed production (>1000/m2)		
802	Evidence that a persistent propagule bank is formed (>1 yr)		
803	Well controlled by herbicides		
804	Tolerates, or benefits from, mutilation, cultivation, or fire	y=1, n=-1	n
805	Effective natural enemies present locally (e.g. introduced biocontrol agents)		

Supporting Data:

Qsn #	Question	Answer
101	**Is the species highly domesticated?**	**n**
	Source(s)	**Notes**
	Al-Harrasi, A., Khan, A. L., Asaf, S., & Al-Rawahi, A. (2019). Biology of Genus Boswellia. Springer Nature, Cham, Switzerland	[Bred to improve seed viability, but not highly domesticated] "Various researchers have tried to increase the germination rate of Boswellia sacra. However, Eslamieh (2017) reported that no significant improvement was found to increase the germination rate of B. sacra from 10% under different techniques. Jason reported that the reason for a lower germination rate is empty pyrenes with no embryos, and genetic aberration plays more of role than sowing techniques. Furthermore, he cross-pollinated various B. sacra clones and observed better results (Eslamieh, 2017). The most prominent super sacra clone produced seeds with 40–60% germination rates following the cross-pollination of three generations."

102	**Has the species become naturalized where grown?**	
	Source(s)	**Notes**
	WRA Specialist. (2021). Personal Communication	NA

103	**Does the species have weedy races?**	
	Source(s)	**Notes**
	WRA Specialist. (2021). Personal Communication	NA

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, Agricultural Research Service, National Plant Germplasm System. (2021). Germplasm Resources Information Network (GRIN-Taxonomy). National Germplasm Resources Laboratory, Beltsville, Maryland. https://npgsweb.ars-grin.gov/. [Accessed 11 Jan 2021]	"Native Africa NORTHEAST TROPICAL AFRICA: Somalia Asia-Temperate ARABIAN PENINSULA: Oman, Yemen Cultivated (also cult.)"

202	**Quality of climate match data**	**High**
	Source(s)	**Notes**
	USDA, Agricultural Research Service, National Plant Germplasm System. (2021). Germplasm Resources Information Network (GRIN-Taxonomy). National Germplasm Resources Laboratory, Beltsville, Maryland. https://npgsweb.ars-grin.gov/. [Accessed 11 Jan 2021]	

203	**Broad climate suitability (environmental versatility)**	**y**

Qsn #	Question	Answer
	Source(s)	**Notes**
	Iwu, M.M. 2014. Handbook of African Medicinal Plants, Second Edition. CRC Press, Boca Raton, FL	"The propagation of Boswellia sacra trees is difficult, although the plant can adapt to extremely harsh environments. Their ability to grow in environments so unforgiving is considered unusual; they sometimes grow directly out of solid rock."
	Thulin, M., & Warfa, A. M. (1987). The frankincense trees (Boswellia spp., Burseraceae) of northern Somalia and southern Arabia. Kew Bulletin, 42(3): 487-500	[Broad elevation range] "DISTRIBUTION & HABITAT. Known from N Somalia, South Yemen (Hadhramaut) and Oman (Dhofar) (Map I). It may occur just above sea-level' in places where the coast-line is steep and rocky like E of Bereda in NE Somalia or at Ras Fartak in Hadhramaut. The upper known limit in Somalia is 1230 m (measured S of Mait) and the upper limit in Arabia seems to be at about the same level (1800 m in Somalia as given by Hildebrandt (1878: 195) is certainly incorrect). Usually in rocky slopes and gullies, often on limestone boulders, more rarely on vertical rock-faces (Fig. IB) like B. frereana. In Somalia in Acacia-Commiphora woodland in subcoastal zone (Hemming I 966: 201)."

204	Native or naturalized in regions with tropical or subtropical climates	y
	Source(s)	**Notes**
	USDA, Agricultural Research Service, National Plant Germplasm System. (2021). Germplasm Resources Information Network (GRIN-Taxonomy). National Germplasm Resources Laboratory, Beltsville, Maryland. https://npgsweb.ars-grin.gov/. [Accessed 14 Jan 2021]	[Grows in desert climates in tropical regions] "Native Africa NORTHEAST TROPICAL AFRICA: Somalia Asia-Temperate ARABIAN PENINSULA: Oman, Yemen Cultivated (also cult.)"

205	Does the species have a history of repeated introductions outside its natural range?	?
	Source(s)	**Notes**
	Dave's Garden. (2021). Arabian Frankincense - Boswellia sacra. https://davesgarden.com/guides/pf/go/136756/. [Accessed 14 Jan 2021]	"Regional This plant is said to grow outdoors in the following regions: Phoenix, Arizona San Francisco, California Miami, Florida"

301	Naturalized beyond native range	n
	Source(s)	**Notes**
	Al-Harrasi, A., Khan, A. L., Asaf, S., & Al-Rawahi, A. (2019). Biology of Genus Boswellia. Springer Nature, Cham, Switzerland	No evidence
	Imada, C. (2019). Hawaiian Naturalized Vascular Plants Checklist (February 2019 update). Bishop Museum Technical Report 69. Bishop Museum, Honolulu, HI	No evidence
	Randall, R.P. (2017). A Global Compendium of Weeds. 3rd Edition. Perth, Western Australia. R.P. Randall	No evidence

Qsn #	Question	Answer
302	Garden/amenity/disturbance weed	n
	Source(s)	**Notes**
	Randall, R.P. (2017). A Global Compendium of Weeds. 3rd Edition. Perth, Western Australia. R.P. Randall	No evidence

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

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

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

401	Produces spines, thorns or burrs	n
	Source(s)	**Notes**
	Thulin, M., & Warfa, A. M. (1987). The frankincense trees (Boswellia spp., Burseraceae) of northern Somalia and southern Arabia. Kew Bulletin, 42(3): 487-500	"Unarmed tree, 1.5-8 m tall, branching from the base or with a distinct trunk; base of trunk sometimes ± swollen; bark pale brown with some outer flaking papery layers and a thick reddish brown inner resiniferous layer; young shoots tomentose or rarely glabrous; resin copious, milky, drying yellowish brown."

402	Allelopathic	
	Source(s)	**Notes**
	Khalaf Allah, K. A. A. A. (2013). Allelopathic Potentials of Selected Sudanese Plants. MSc Thesis. Sudan University of Science & Technology, Khartoum	[Possibly Yes. Demonstrates allelopathic properties in laboratory trials] "A study was undertaken in the laboratory at the College of Agricultural Studies, Sudan University of Science and Technology . The objective of the investigation was to study the allelopathic potentials and persistence of allelopathic activity of Acacia nilotica (pods), Azadirachta indica (leaves), Boswellia sacra (gum), Calotropis procera (bark), Hibiscus sabdariffa (calyx), Lawsonia inermis (leaves), Nigella sativa (seeds) , Solenostemma argel (leaves), Trigonella foenum-graecum (seeds), and Zingiber officinale (rhizomes)." … "Results from experiments using higher powder levels (25- 150 mg/well) showed that A. nilotica, H. sabdariffa, Z. officinale and B. sacra, reduced lettuce germination by 80- 100%."

403	Parasitic	n

Qsn #	Question	Answer
	Source(s)	**Notes**
	Thulin, M., & Warfa, A. M. (1987). The frankincense trees (Boswellia spp., Burseraceae) of northern Somalia and southern Arabia. Kew Bulletin, 42(3): 487-500	"Unarmed tree, 1.5-8 m tall, branching from the base or with a distinct trunk; base of trunk sometimes ± swollen; bark pale brown with some outer flaking papery layers and a thick reddish brown inner resiniferous layer; young shoots tomentose or rarely glabrous; resin copious, milky, drying yellowish brown." [No evidence]

404	Unpalatable to grazing animals	n
	Source(s)	**Notes**
	Hassan, B. A., Glover, E. K., Luukkanen, O., Kanninen, M., & Jamnadass, R. (2019). Boswellia and Commiphora Species as a Resource Base for Rural Livelihood Security in the Horn of Africa: A Systematic Review. Forests, 10(7), 551 doi:10.3390/f10070551	"As multi-purpose tree species, Boswellia and Commiphora species not only provide resins but all their parts are used for dierent purposes. Among the important products of these species are fodder for browsing animals, especially goats and camels, craftwork, dyes, honey, and traditional medicines and rehabilitation of degraded lands [10]."
	Thulin, M. (1998). Boswellia sacra. The IUCN Red List of Threatened Species 1998: e.T34533A9874201. https://dx.doi.org/10.2305/IUCN.UK.1998.RLTS.T34533A9874201.en. [Accessed 11 Jan 2021]	"In Oman the tree is so heavily browsed that it rarely flowers or sets seed. Trees appear to be dying and regeneration is poor."

405	Toxic to animals	n
	Source(s)	**Notes**
	Tropical Plants Database, Ken Fern. (2021). Boswellia sacra. http://tropical.theferns.info/viewtropical.php?id=Boswellia+sacra. [Accessed 11 Jan 2021]	"Known Hazards None known"
	Hassan, B. A., Glover, E. K., Luukkanen, O., Kanninen, M., & Jamnadass, R. (2019). Boswellia and Commiphora Species as a Resource Base for Rural Livelihood Security in the Horn of Africa: A Systematic Review. Forests, 10(7), 551 doi:10.3390/f10070551	[No evidence] "As multi-purpose tree species, Boswellia and Commiphora species not only provide resins but all their parts are used for different purposes. Among the important products of these species are fodder for browsing animals, especially goats and camels, craftwork, dyes, honey, and traditional medicines and rehabilitation of degraded lands [10]."
	Quattrocchi, U. 2012. CRC World Dictionary of Medicinal and Poisonous Plants: Common Names, Scientific Names, Eponyms, Synonyms, and Etymology. CRC Press, Boca Raton, FL	No evidence

406	Host for recognized pests and pathogens	
	Source(s)	**Notes**
	Al-Harrasi, A., Khan, A. L., Asaf, S., & Al-Rawahi, A. (2019). Biology of Genus Boswellia. Springer Nature, Cham, Switzerland	[No specifics on fungal pathogens provided] "Protection from the fungus and other pathogens involves constant moisture environments."

Qsn #	Question	Answer
	Strumia, F., Dapporto, L., Dellacasa, M., & Scaramozzino, P L. (2007). Notes on some Insects associated to Frankincense Tree (Boswellia sacra Flückiger, 1867, Burseraceae) in Dhofar (Sultanate of Oman). Tosc. Sci. Nat., Mem., Serie B, 114, 135-139	[Potential insect pests from native range would likely be absent in introduced range] "Our present results are preliminary since the field observations were limited in time. Nevertheless the Frankincense trees appeared in good health with limited threat by the insect pests. The most dangerous of these appear to be one Buprestidae species (Sphenoptera chalcichroa Obenberger) and two Cerambycidae (Neoplocaederus atlanticus Rungs) and Derolus martini ssp. hayekae Villiers). In addition we found evidence of attacks by Coleoptera Scolitidae. Further observations on the field are needed to investigate and verify the presence of additional pests. If Sphenoptera chalcichroa is a recent arrival in Dhofar a blooming of this pest will are to be expected in the next few years."

407	Causes allergies or is otherwise toxic to humans	n
	Source(s)	**Notes**
	Hassan, B. A., Glover, E. K., Luukkanen, O., Kanninen, M., & Jamnadass, R. (2019). Boswellia and Commiphora Species as a Resource Base for Rural Livelihood Security in the Horn of Africa: A Systematic Review. Forests, 10(7), 551 doi:10.3390/f10070551	"As multi-purpose tree species, Boswellia and Commiphora species not only provide resins but all their parts are used for different purposes. Among the important products of these species are fodder for browsing animals, especially goats and camels, craftwork, dyes, honey, and traditional medicines and rehabilitation of degraded lands [10]."
	Tropical Plants Database, Ken Fern. (2021). Boswellia sacra. http://tropical.theferns.info/viewtropical.php?id=Boswellia+sacra. [Accessed 11 Jan 2021]	"Known Hazards None known" ... "An aromatic resin is obtained from the plant. It can be chewed, or manufactured into an essential oil that is used as a flavouring in a wide range of foods[301]."
	Quattrocchi, U. 2012. CRC World Dictionary of Medicinal and Poisonous Plants: Common Names, Scientific Names, Eponyms, Synonyms, and Etymology. CRC Press, Boca Raton, FL	[Medicinal uses] "Abortifacient, astringent, antiinfection, antiinflammatory, oxytocic; antiseptic in wound healing and application for swollen joints."

408	Creates a fire hazard in natural ecosystems	n
	Source(s)	**Notes**
	Al-Harrasi, A., Khan, A. L., Asaf, S., & Al-Rawahi, A. (2019). Biology of Genus Boswellia. Springer Nature, Cham, Switzerland	[Fire identified as a threat to young plants. No evidence that tree increases fire risk in natural ecosystems] "Frankincense is collected from trees and shrubs in the dry tropics of the Arabian Peninsula, the sub-Sahel region in Africa, the Horn of Africa and the Indian subcontinent." ... "These populations are under increasing threats due to unkind cut and maltreatment by unprofessional harvest of the resin. In addition, the young trees are being eaten by cattle, goats, sheep and camels as well as are being burnt by frequent fires."

409	Is a shade tolerant plant at some stage of its life cycle	n
	Source(s)	**Notes**
	Tropical Plants Database, Ken Fern. (2021). Boswellia sacra. http://tropical.theferns.info/viewtropical.php?id=Boswellia+sacra. [Accessed 14 Jan 2021]	"Requires a well-drained, dry soil in full sun"

Qsn #	Question	Answer
	Dave's Garden. (2021). Arabian Frankincense - Boswellia sacra. https://davesgarden.com/guides/pf/go/136756/. [Accessed 14 Jan 2021]	"Sun Exposure: Full Sun"
	LLIFLE - Encyclopedia of living forms. (2021). Boswellia sacra. http://www.llifle.com/. [Accessed 14 Jan 2021]	[Occurs in exposed, presumably high light environments] "Boswellia sacra is abundant in arid woodland, on steep, precariously eroding slopes and gullies, and tolerates the most critical situations and often grows in calcareous soil. It is also found in the 'fog oasis' woodlands of the southern coastal mountains of the Arabian Peninsula. The trees cling to boulders or rock-faces by means of a cushion-like swelling at the base of the trunk. This swollen base helps to stabilise the tree and is most developed in those growing on very steep or exposed rocks."

410	Tolerates a wide range of soil conditions (or limestone conditions if not a volcanic island)	n
	Source(s)	**Notes**
	LLIFLE - Encyclopedia of living forms. (2021). Boswellia sacra. http://www.llifle.com/. [Accessed 14 Jan 2021]	"Boswellia sacra is abundant in arid woodland, on steep, precariously eroding slopes and gullies, and tolerates the most critical situations and often grows in calcareous soil."
	Dave's Garden. (2021). Arabian Frankincense - Boswellia sacra. https://davesgarden.com/guides/pf/go/136756/. [Accessed 14 Jan 2021]	"Soil pH requirements: 7.9 to 8.5 (alkaline)"

411	Climbing or smothering growth habit	n
	Source(s)	**Notes**
	Thulin, M., & Warfa, A. M. (1987). The frankincense trees (Boswellia spp., Burseraceae) of northern Somalia and southern Arabia. Kew Bulletin, 42(3): 487-500	"Unarmed tree, 1.5-8 m tall, branching from the base or with a distinct trunk; base of trunk sometimes ± swollen; bark pale brown with some outer flaking papery layers and a thick reddish brown inner resiniferous layer; young shoots tomentose or rarely glabrous; resin copious, milky, drying yellowish brown."

412	Forms dense thickets	n
	Source(s)	**Notes**
	Oldfield, S., Lusty, C. & MacKinven, A. 1998. The World List of Threatened Trees. World Conservation Press, Cambridge, UK	[Described as a dominant component, but no evidence of thicket formation] "Boswellia sacra Burseraceae LR/nt Oman, Somalia, Yemen (Former South Yemen) The largest and most widespread occurrence of the species is in northern Somalia. It is also a dominant component of desert-woodland on the escarpment mountains in Dhofar in Oman, extending into Yemen. The resin provides incense, perfume and medicine. In Oman the tree is so heavily browsed that it rarely flowers or sets seed. Trees appear to be dying and regeneration is poor."

Qsn #	Question	Answer
	Thulin, M., & Warfa, A. M. (1987). The frankincense trees (Boswellia spp., Burseraceae) of northern Somalia and southern Arabia. Kew Bulletin, 42(3): 487-500	[No evidence] "DISTRIBUTION & HABITAT. Known from N Somalia, South Yemen (Hadhramaut) and Oman (Dhofar) (Map I). It may occur just above sea-level' in places where the coast-line is steep and rocky like E of Bereda in NE Somalia or at Ras Fartak in Hadhramaut. The upper known limit in Somalia is 1230 m (measured S of Mait) and the upper limit in Arabia seems to be at about the same level (1800 m in Somalia as given by Hildebrandt (1878: 195) is certainly incorrect). Usually in rocky slopes and gullies, often on limestone boulders, more rarely on vertical rock-faces (Fig. IB) like B. frereana. In Somalia in Acacia-Commiphora woodland in subcoastal zone (Hemming I 966: 201). At higher altitudes also penetrating evergreen scrub zone of Hemming (I 966: 217) where associated with trees and shrubs like Buxus hildebrandtii, Dodonaea viscosa, Cadia purpurea and Dracaena schizantha. In the southernmost known locality, the Karkar mountains NE of Gardo (Fig. IA), in a sparse vegetation with Acacia spp., Commiphora spp. and Mimusops angel. In Arabia extending eastwards to Ras Hasik in Dhofar where 'it is most characteristic of the upper desert plateau country behind the coastal monsoon zone, although some trees are reported found also along coastal slopes' (Mandaville 1980)."
	Al-Harrasi, A., Khan, A. L., Asaf, S., & Al-Rawahi, A. (2019). Biology of Genus Boswellia. Springer Nature, Cham, Switzerland	No evidence

501	Aquatic	n
	Source(s)	**Notes**
	Thulin, M., & Warfa, A. M. (1987). The frankincense trees (Boswellia spp., Burseraceae) of northern Somalia and southern Arabia. Kew Bulletin, 42(3): 487-500	[Terrestrial] "It may occur just above sea-level' in places where the coast-line is steep and rocky like E of Bereda in NE Somalia or at Ras Fartak in Hadhramaut. The upper known limit in Somalia is 1230 m (measured S of Mait) and the upper limit in Arabia seems to be at about the same level (1800 m in Somalia as given by Hildebrandt (1878: 195) is certainly incorrect). Usually in rocky slopes and gullies, often on limestone boulders, more rarely on vertical rock-faces (Fig. IB) like B. frereana. In Somalia in Acacia-Commiphora woodland in subcoastal zone (Hemming I 966: 201)."

502	Grass	n
	Source(s)	**Notes**
	USDA, Agricultural Research Service, National Plant Germplasm System. (2021). Germplasm Resources Information Network (GRIN-Taxonomy). National Germplasm Resources Laboratory, Beltsville, Maryland. https://npgsweb.ars-grin.gov/. [Accessed 11 Jan 2021]	Family: Burseraceae

503	Nitrogen fixing woody plant	n
	Source(s)	**Notes**

Qsn #	Question	Answer
	USDA, Agricultural Research Service, National Plant Germplasm System. (2021). Germplasm Resources Information Network (GRIN-Taxonomy). National Germplasm Resources Laboratory, Beltsville, Maryland. https://npgsweb.ars-grin.gov/. [Accessed 11 Jan 2021]	Family: Burseraceae

504	**Geophyte (herbaceous with underground storage organs -- bulbs, corms, or tubers)**	**n**
	Source(s)	**Notes**
	Thulin, M., & Warfa, A. M. (1987). The frankincense trees (Boswellia spp., Burseraceae) of northern Somalia and southern Arabia. Kew Bulletin, 42(3): 487-500	"Unarmed tree, 1.5-8 m tall, branching from the base or with a distinct trunk; base of trunk sometimes ± swollen; bark pale brown with some outer flaking papery layers and a thick reddish brown inner resiniferous layer; young shoots tomentose or rarely glabrous; resin copious, milky, drying yellowish brown."

601	**Evidence of substantial reproductive failure in native habitat**	**y**
	Source(s)	**Notes**
	Iwu, M.M. 2014. Handbook of African Medicinal Plants, Second Edition. CRC Press, Boca Raton, FL	"According to recent surveys, frankincense tree populations are declining, partly due to overexploitation. Heavily tapped trees have been found to produce seeds that germinated at only 16%, while seeds of trees that had not been tapped germinated at more than 80%. It has been further observed that bush burning, grazing, and attacks by the longhorn beetle have reduced the tree population."
	Thulin, M. (1998). Boswellia sacra. The IUCN Red List of Threatened Species 1998: e.T34533A9874201. https://dx.doi.org/10.2305/IUCN.UK.1998.RLTS.T34533A9874201.en. [Accessed 11 Jan 2021]	"In Oman the tree is so heavily browsed that it rarely flowers or sets seed. Trees appear to be dying and regeneration is poor."

Qsn #	Question	Answer
602	**Produces viable seed**	**y**
	Source(s)	**Notes**
	LLIFLE - Encyclopedia of living forms. (2021). Boswellia sacra. http://www.llifle.com/. [Accessed 11 Jan 2021]	"Propagation: By means of seed and cuttings."
	Al-Harrasi, A., Khan, A. L., Asaf, S., & Al-Rawahi, A. (2019). Biology of Genus Boswellia. Springer Nature, Cham, Switzerland	"Variation was observed in the germination rates of different Boswellia species and most can geminate easily. Some species have a high germination rate such as B. nana, while in contrast, B. sacra has one of the lowest germination rates (with the highest seed production). Similarly, the viability of Boswellia seeds also varies with the conditions (humidity, temperature and light), and most seeds can grow after 3 or more years. Various researchers have tried to increase the germination rate of Boswellia sacra. However, Eslamieh (2017) reported that no significant improvement was found to increase the germination rate of B. sacra from 10% under different techniques. Jason reported that the reason for a lower germination rate is empty pyrenes with no embryos, and genetic aberration plays more of role than sowing techniques. Furthermore, he cross-pollinated various B. sacra clones and observed better results (Eslamieh, 2017). The most prominent super sacra clone produced seeds with 40–60% germination rates following the cross-pollination of three generations."

603	**Hybridizes naturally**	
	Source(s)	**Notes**
	Niebler, J., Eslamieh, J., & Buettner, A. (2016). Frankincense Revisited, Part II: Volatiles in Rare Boswellia Species and Hybrids. Chemistry & Biodiversity, 13(5), 630-643	[Possibly yes. Species not identified] "Frequent self-pollination appears to be a problem in particular for B. sacra and leads to a loss of genetic diversity. By contrast, interspecific hybrids of Boswellia species are also known to occur naturally and artificially [6][7]."

604	**Self-compatible or apomictic**	**y**
	Source(s)	**Notes**
	Al-Harrasi, A., Khan, A. L., Asaf, S., & Al-Rawahi, A. (2019). Biology of Genus Boswellia. Springer Nature, Cham, Switzerland	"All Boswellia species usually have perfect flowers, and one plant is sufficient to propagate for seed, but cross-pollination was found to be more useful than self-pollination. Furthermore, some species such as B. nana and B. popoviana cannot produce seeds through self-pollination (Eslamieh, 2017)."

Qsn #	Question	Answer
605	**Requires specialist pollinators**	**n**
	Source(s)	**Notes**
	Al-Harrasi, A., Khan, A. L., Asaf, S., & Al-Rawahi, A. (2019). Biology of Genus Boswellia. Springer Nature, Cham, Switzerland	"Some Boswellia species need more care and attention to yield flowers during cultivation. However, Boswellia flowering is species-specific and depends on the location of the plant (pots or in the ground). Some extra measures should be taken for Boswellia flowers outside of their natural environment (Eslamieh, 2017). For example, in some species such as B. dioscoridis and B. ameero, obtaining flowers is very difficult, while in some species such as B. sacra and B. nana, flowering and pollination are very easy to elicit with the help of pollinators such as bees, ants, etc., or also mechanically."

606	Reproduction by vegetative fragmentation	n
	Source(s)	**Notes**
	LLIFLE - Encyclopedia of living forms. (2021). Boswellia sacra. http://www.llifle.com/. [Accessed 11 Jan 2021]	"Propagation: By means of seed and cuttings."

607	Minimum generative time (years)	
	Source(s)	**Notes**
	Swartout, B. T., & Solowey, E. (2018). Increasing Boswellia sacra seeds' germination viability and genetic variability utilizing various methods. Net Journal of Agricultural Science, 6(3), 29-34	[Slow seedling growth rate. Unlikely to reach maturity in <1-2 years, and probably longer] "Belonging to the endemic genus Boswellia (family Burseraceae), B. sacra, commonly known as Frankincense, is a medium sized tree and is medicinally and historically significant with potential for stabilizing and reclaiming land threatened by desertification (Bowen, 1988; Lemenih and Teketay, 2004). Studies have highlighted an extremely low germination rate (<10%), slow seedling growth rate, and difficulty regenerating Boswellia species in both wild and cultivated stands due to intensive tapping to harvest resin, human-induced fire, overgrazing, low genetic variability, lack of dormancy and climatic anomalies (Coppi, 2010; Negussie et al., 2008)."

701	Propagules likely to be dispersed unintentionally (plants growing in heavily trafficked areas)	n
	Source(s)	**Notes**
	Thulin, M., & Warfa, A. M. (1987). The frankincense trees (Boswellia spp., Burseraceae) of northern Somalia and southern Arabia. Kew Bulletin, 42(3): 487-500	"Fruit 3-4(-5)-locular, 8-12 x 3·5-9 mm, narrowly to broadly pyriform, reddish brown, glabrous; pyrene 3·5-5·5 x 2-4·5 mm, obtrullate to subcruciform, trigonous, often ± surrounded by a persistent wing." [No means of external attachment]
	DeCarlo, A., Elmi, A., and Johnson, S. (2018). Sustainable Frankincense Production Systems in Somaliland. 2nd Edition. Conserve the Cal Madow, Hargeisa, Somaliland	"Fruiting may occur in August. The lack of fleshy fruit points to anemochorous seed dispersal."

Qsn #	Question	Answer
702	**Propagules dispersed intentionally by people**	**y**
	Source(s)	**Notes**
	WRA Specialist. (2021). Personal Communication	Plants available online and promoted on some websites

703	**Propagules likely to disperse as a produce contaminant**	**n**
	Source(s)	**Notes**
	DeCarlo, A., Elmi, A., and Johnson, S. (2018). Sustainable Frankincense Production Systems in Somaliland. 2nd Edition. Conserve the Cal Madow, Hargeisa, Somaliland	[No evidence] "Fruiting may occur in August. The lack of fleshy fruit points to anemochorous seed dispersal."

704	**Propagules adapted to wind dispersal**	**y**
	Source(s)	**Notes**
	Daly, D. C., Harley, M. M., Martínez-Habibe, M. C., & Weeks, A. (2010). Burseraceae. In Flowering Plants. Eudicots (pp. 76-104). Springer, Berlin, Heidelberg	[Anemochory] "Burseraceae display two basic dispersal syndromes, zoochory and anemochory. Winged pyrenes have arisen independently in at least four distinct lineages: Beiselia, Aucoumea (Bursera Alliance), Boswellia, and Triomma (Canarium Alliance)."
	Thulin, M., & Warfa, A. M. (1987). The frankincense trees (Boswellia spp., Burseraceae) of northern Somalia and southern Arabia. Kew Bulletin, 42(3): 487-500	[Winged pyrene] "Fruit 3-4(-5)-locular, 8-12 x 3·5-9 mm, narrowly to broadly pyriform, reddish brown, glabrous; pyrene 3·5-5·5 x 2-4·5 mm, obtrullate to subcruciform, trigonous, often ± surrounded by a persistent wing."

705	**Propagules water dispersed**	**n**
	Source(s)	**Notes**
	Daly, D. C., Harley, M. M., Martínez-Habibe, M. C., & Weeks, A. (2010). Burseraceae. In Flowering Plants. Eudicots (pp. 76-104). Springer, Berlin, Heidelberg	[Boswellia sacra not a floodplain species] "Burseraceae display two basic dispersal syndromes, zoochory and anemochory. Winged pyrenes have arisen independently in at least four distinct lineages: Beiselia, Aucoumea (Bursera Alliance), Boswellia, and Triomma (Canarium Alliance). Hydrochory may occur in the few floodplain species but has not been recorded."

706	**Propagules bird dispersed**	**n**
	Source(s)	**Notes**
	Thulin, M., & Warfa, A. M. (1987). The frankincense trees (Boswellia spp., Burseraceae) of northern Somalia and southern Arabia. Kew Bulletin, 42(3): 487-500	"Fruit 3-4(-5)-locular, 8-12 x 3·5-9 mm, narrowly to broadly pyriform, reddish brown, glabrous; pyrene 3·5-5·5 x 2-4·5 mm, obtrullate to subcruciform, trigonous, often ± surrounded by a persistent wing."
	DeCarlo, A., Elmi, A., and Johnson, S. (2018). Sustainable Frankincense Production Systems in Somaliland. 2nd Edition. Conserve the Cal Madow, Hargeisa, Somaliland	"Fruiting may occur in August. The lack of fleshy fruit points to anemochorous seed dispersal."

Qsn #	Question	Answer
707	**Propagules dispersed by other animals (externally)**	**n**
	Source(s)	**Notes**
	DeCarlo, A., Elmi, A., and Johnson, S. (2018). Sustainable Frankincense Production Systems in Somaliland. 2nd Edition. Conserve the Cal Madow, Hargeisa, Somaliland	"Fruiting may occur in August. The lack of fleshy fruit points to anemochorous seed dispersal."

708	**Propagules survive passage through the gut**	**n**
	Source(s)	**Notes**
	DeCarlo, A., Elmi, A., and Johnson, S. (2018). Sustainable Frankincense Production Systems in Somaliland. 2nd Edition. Conserve the Cal Madow, Hargeisa, Somaliland	"Fruiting may occur in August. The lack of fleshy fruit points to anemochorous seed dispersal."

801	**Prolific seed production (>1000/m2)**	
	Source(s)	**Notes**
	Iwu, M.M. 2014. Handbook of African Medicinal Plants, Second Edition. CRC Press, Boca Raton, FL	[Possibly No] "According to recent surveys, frankincense tree populations are declining, partly due to overexploitation. Heavily tapped trees have been found to produce seeds that germinated at only 16%, while seeds of trees that had not been tapped germinated at more than 80%. It has been further observed that bush burning, grazing, and attacks by the longhorn beetle have reduced the tree population."
	DeCarlo, A., Elmi, A., and Johnson, S. (2018). Sustainable Frankincense Production Systems in Somaliland. 2nd Edition. Conserve the Cal Madow, Hargeisa, Somaliland	[Unknown] "No data exist on the seed set or fertility of either species, though congeners boast abundant, fertile seeds (Lemenih and Kassa 2011). High levels of insect attack and overtapping may significantly reduce fecundity (Ogbazghi et al. 2006, Rijkers et al. 2006). Percentage recruitment levels are unknown but likely to be extremely low."

802	**Evidence that a persistent propagule bank is formed (>1 yr)**	
	Source(s)	**Notes**
	Swartout, B. T., & Solowey, E. (2018). Increasing Boswellia sacra seeds' germination viability and genetic variability utilizing various methods. Net Journal of Agricultural Science, 6(3), 29-34	"Boswellia species in both wild and cultivated stands due to intensive tapping to harvest resin, human-induced fire, overgrazing, low genetic variability, lack of dormancy and climatic anomalies (Coppi, 2010; Negussie et al., 2008)."

803	**Well controlled by herbicides**	
	Source(s)	**Notes**
	WRA Specialist. (2021). Personal Communication	Unknown. No information on herbicide efficacy or chemical control of this species

Qsn #	Question	Answer
804	**Tolerates, or benefits from, mutilation, cultivation, or fire**	**n**
	Source(s)	**Notes**
	Al-Harrasi, A., Khan, A. L., Asaf, S., & Al-Rawahi, A. (2019). Biology of Genus Boswellia. Springer Nature, Cham, Switzerland	[Presumably does not tolerate fire] "In addition, the young trees are being eaten by cattle, goats, sheep and camels as well as are being burnt by frequent fires."

805	**Effective natural enemies present locally (e.g. introduced biocontrol agents)**	
	Source(s)	**Notes**
	WRA Specialist. (2021). Personal Communication	Unknown

Summary of Risk Traits:

High Risk / Undesirable Traits
• Broad elevation range
• Grows in arid, tropical climates
• Potentially allelopathic
• Reproduces by wind-dispersed seeds
• Self-compatible

Low Risk Traits
• No reports of invasiveness or naturalization, but limited information on cultivation outside native range
• Unarmed (no spines, thorns, or burrs)
• Palatable to browsing animals
• Grows in full sun (dense shade may limit ability to spread)
• Not reported to spread vegetatively