Taxon: Armoracia rusticana **Family:** Brassicaceae

Common Name(s): horseradish **Synonym(s):** Armoracia lapathifolia Gilib. ex Usteri
Cochlearia armoracia L.
Nasturtium armoracia (L.) Fr.
Radicula armoracia (L.) B. L. Rob.
Rorippa armoracia (L.) Hitchc.

Assessor: Assessor **Status:** Assessor Approved **End Date:** 2 Sep 2014

WRA Score: 1.0 **Designation:** EVALUATE **Rating:** Evaluate

Keywords: Perennial Herb, Naturalized, Weed, Non-Seeding, Vegetative Spread

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	y
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)	Low
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	n
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	n=0, y = 1*multiplier (see Appendix 2)	y
303	Agricultural/forestry/horticultural weed	n=0, y = 2*multiplier (see Appendix 2)	y
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	y
406	Host for recognized pests and pathogens		
407	Causes allergies or is otherwise toxic to humans		

Qsn #	Question	Answer Option	Answer
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	y
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	y
607	Minimum generative time (years)	1 year = 1, 2 or 3 years = 0, 4+ years = -1	1
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		
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		
801	Prolific seed production (>1000/m2)	y=1, n=-1	n
802	Evidence that a persistent propagule bank is formed (>1 yr)		
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**
	Sampliner, D., & Miller, A. (2009). Ethnobotany of horseradish (Armoracia rusticana, Brassicaceae) and its wild relatives (Armoracia spp.): reproductive biology and local uses in their native ranges. Economic Botany, 63(3): 303-313	"Horseradish (Armoracia rusticana) has been cultivated for its root for over 2,000 years. Today, commercial production takes place primarily in North America and Europe where A. rusticana is propagated exclusively vegetatively. Like many vegetatively-propagated crops, cultivated A. rusticana plants are generally sterile." ... "Armoracia rusticana is propagated vegetatively and is not found in the wild." ... "In contrast to its two congeners, A. rusticana is known only from cultivation, nearly all individuals lack seeds, and it is propagated exclusively vegetatively. These data suggest that sterility may have evolved in A. rusticana as a byproduct of vegetative propagation during the domestication process."

102	**Has the species become naturalized where grown?**	**y**
	Source(s)	**Notes**
	USDA, ARS, National Genetic Resources Program. Germplasm Resources Information Network - (GRIN) [Online Database]. National Germplasm Resources Laboratory, Beltsville, Maryland. URL: http://www.ars-grin.gov/. [Accessed 1 Sep 2014]	Naturalized [See 3.01 for full list of locations]

103	**Does the species have weedy races?**	**y**
	Source(s)	**Notes**
	Sampliner, D., & Miller, A. (2009). Ethnobotany of horseradish (Armoracia rusticana, Brassicaceae) and its wild relatives (Armoracia spp.): reproductive biology and local uses in their native ranges. Economic Botany, 63(3): 303-313	[The cultivated form is itself weedy] "Outside of cultivation, A. rusticana can be found growing in moist habitats, including fields, gardens, weedy areas, farmland, roadsides, ditches, and disturbed areas throughout Europe (Al- Shehbaz 1988)." ... "Further, A. rusticana reproduces aggressively through rhizomes; many respondents indicated A. rusticana is a problematic weed."

201	**Species suited to tropical or subtropical climate(s) - If island is primarily wet habitat, then substitute "wet tropical" for "tropical or subtropical"**	**Low**
	Source(s)	**Notes**
	Smekalova, T. & Maslovky, O. 2013. Armoracia rusticana. The IUCN Red List of Threatened Species. Version 2014.2. www.iucnredlist.org	"Native: Belarus; Estonia; Latvia; Lithuania; Moldova; Russian Federation (Central European Russia, East European Russia, Kaliningrad, North European Russia, Northwest European Russia, South European Russia); Ukraine (Krym, Ukraine (main part))"

Qsn #	Question	Answer
202	**Quality of climate match data**	**High**
	Source(s)	**Notes**
	Smekalova, T. & Maslovky, O. 2013. Armoracia rusticana. The IUCN Red List of Threatened Species. Version 2014.2. www.iucnredlist.org	

203	Broad climate suitability (environmental versatility)	y
	Source(s)	**Notes**
	Learn 2 Grow. 2014. Armoracia rusticana. http://www.learn2grow.com/plants/armoracia-rusticana/. [Accessed 2 Sep 2014]	"AHS Heat Zone: 12 - 1 USDA Hardiness Zone: 3 - 10"
	Dave's Garden. 2014. PlantFiles: Horseradish - Armoracia rusticana. http://davesgarden.com/guides/pf/go/840/. [Accessed 2 Sep 2014]	"Hardiness: USDA Zone 3a: to -39.9 °C (-40 °F) USDA Zone 3b: to -37.2 °C (-35 °F) USDA Zone 4a: to -34.4 °C (-30 °F) USDA Zone 4b: to -31.6 °C (-25 °F) USDA Zone 5a: to -28.8 °C (-20 °F) USDA Zone 5b: to -26.1 °C (-15 °F) USDA Zone 6a: to -23.3 °C (-10 °F) USDA Zone 6b: to -20.5 °C (-5 °F) USDA Zone 7a: to -17.7 °C (0 °F) USDA Zone 7b: to -14.9 °C (5 °F) USDA Zone 8a: to -12.2 °C (10 °F) USDA Zone 8b: to -9.4 °C (15 °F) USDA Zone 9a: to -6.6 °C (20 °F) USDA Zone 9b: to -3.8 °C (25 °F)"

204	Native or naturalized in regions with tropical or subtropical climates	n
	Source(s)	**Notes**
	Sampliner, D., & Miller, A. (2009). Ethnobotany of horseradish (Armoracia rusticana, Brassicaceae) and its wild relatives (Armoracia spp.): reproductive biology and local uses in their native ranges. Economic Botany, 63(3): 303-313	[Cultivated above 1000 m in tropical regions] "A. rusticana is cultivated in Russia, the Caucasus, and Asia, and in some regions above 1,000 m within tropical countries (Bush 1939; Nichols and Jansen 1972; Rosengarten 1969; Small 1997)."
	USDA, ARS, National Genetic Resources Program. Germplasm Resources Information Network - (GRIN) [Online Database]. National Germplasm Resources Laboratory, Beltsville, Maryland. URL: http://www.ars-grin.gov/. [Accessed 2 Sep 2014]	Naturalized in a number of temperate locations. No evidence of naturalization in tropical climates

Qsn #	Question	Answer
205	**Does the species have a history of repeated introductions outside its natural range?**	**y**
	Source(s)	**Notes**
	Smekalova, T. & Maslovky, O. 2013. Armoracia rusticana. The IUCN Red List of Threatened Species. Version 2014.2. www.iucnredlist.org	"The species is a very popular spice known as horseradish and is widely cultivated. Wild populations are potential gene donors to the cultivated form."

301	**Naturalized beyond native range**	**y**
	Source(s)	**Notes**
	Wu, Z.Y. & Raven, P.H. (eds.). Flora of China. Vol. 8 (Brassicaceae through Saxifragaceae). Science Press, Beijing, and Missouri Botanical Garden Press, St. Louis	"Cultivated and naturalized. Hebei, Heilongjiang, Jilin, Jiangsu, Liaoning [native to Europe; cultivated and naturalized elsewhere]."
	Webb, C. J., Sykes, W. R., & Garnock-Jones, P. J. 1988. Flora of New Zealand Volume IV. Botany Division, DSIR, Christchurch, New Zealand	"Horseradish is a garden discard which may persist for a long time, but apparently does not reproduce by seed in N.Z. The sp. has also been referred to in N.Z. as Cochlearia armoracia and as Nasturtium armoracia. "

Qsn #	Question	Answer
	USDA, ARS, National Genetic Resources Program. Germplasm Resources Information Network - (GRIN) [Online Database]. National Germplasm Resources Laboratory, Beltsville, Maryland. URL: http://www.ars-grin.gov/. [Accessed 1 Sep 2014]	"Naturalized: (links to other web resources are provided for some distributions) ASIA-TEMPERATE Caucasus: Armenia Siberia: Russian Federation - Eastern Siberia, Western Siberia Middle Asia: Turkmenistan Russian Far East: Russian Federation - Far East China: China - Hebei, Heilongjiang, Jiangsu, Jilin, Liaoning Eastern Asia: Japan - Hokkaido, Honshu AUSTRALASIA New Zealand: New Zealand EUROPE Northern Europe: Denmark; Finland; Ireland; Norway; Sweden; United Kingdom Middle Europe: Austria; Belgium; Czech Republic; Germany; Hungary; Netherlands; Poland; Switzerland East Europe: Belarus; Estonia; Latvia; Lithuania; Russian Federation - European part; Ukraine Southeastern Europe: Albania; Bosnia and Herzegovina; Bulgaria; Croatia; Greece; Italy; Macedonia; Romania; Serbia; Slovenia; Turkey - Kirklareli Southwestern Europe: France; Spain NORTHERN AMERICA Eastern Canada: Canada - New Brunswick, Nova Scotia, Ontario, Prince Edward Island, Quebec Western Canada: Canada - British Columbia, Manitoba, Saskatchewan Northeastern U.S.A.: United States - Connecticut, Indiana, Maine, Massachusetts, Michigan, New Hampshire, New Jersey, New York, Ohio, Pennsylvania, Rhode Island, Vermont, West Virginia North-Central U.S.A.: United States - Illinois, Iowa, Minnesota, Missouri, Nebraska, North Dakota, South Dakota, Wisconsin Northwestern U.S.A.: United States - Colorado, Idaho, Montana, Oregon, Washington, Wyoming Southeastern U.S.A.: United States - North Carolina, Tennessee, Virginia South-Central U.S.A.: United States - New Mexico Southwestern U.S.A.: United States - California, Utah"

302	Garden/amenity/disturbance weed	y
	Source(s)	**Notes**
	The Royal Horticultural Society. 2014. Armoracia rusticana - Horseradish. https://www.rhs.org.uk/Plants/1601/i-Armoracia-rusticana-i/Details. [Accessed 1 Sep 2014]	"A. rusticana is a vigorous rhizomatous perennial with fleshy, pungently aromatic tap-roots, large, dock-like bright green leaves and panicles of small, white flowers in early summer " ... "Can be invasive"
	Dave's Garden. 2014. PlantFiles: Horseradish - Armoracia rusticana. http://davesgarden.com/guides/pf/go/840/. [Accessed 1 Sep 2014]	"On Jul 30, 2006, pajaritomt from Los Alamos, NM (Zone 5a) wrote: Be warned. Horseradish will take over. I have heard that it should be planted in a bucket so it won't take over your garden. I didn't listen. Now I am fighting to get it out of my lilies. Fresh horseradish is fabulous though."

Qsn #	Question	Answer
	Sampliner, D., & Miller, A. (2009). Ethnobotany of horseradish (Armoracia rusticana, Brassicaceae) and its wild relatives (Armoracia spp.): reproductive biology and local uses in their native ranges. Economic Botany, 63(3): 303-313	"Outside of cultivation, A. rusticana can be found growing in moist habitats, including fields, gardens, weedy areas, farmland, roadsides, ditches, and disturbed areas throughout Europe (Al- Shehbaz 1988)." ... "Further, A. rusticana reproduces aggressively through rhizomes; many respondents indicated A. rusticana is a problematic weed."
	Rollins, R. C. 1993. The Cruciferae of Continental North America: Systematics of the Mustard Family from the Arctic to Panama. Stanford University Press, Stanford, CA	"Plants of this species are very tenacious and under some circumstances can be a difficult weed. Since it is widely cultivated in home gardens for the roots, which were used as a condiment, its present distribution is a relic of its having escaped from disparate gardens in former times."

303	Agricultural/forestry/horticultural weed	y
	Source(s)	**Notes**
	Rundle, M. F., Walters, S. A., & Young, B. G. (2007). Efficacy of postemergence corn and soybean herbicides on volunteer horseradish (Armoracia rusticana). Weed Technology, 21(2): 501 505	"Horseradish is a hardy perennial (Rubatzky and Yamaguchi 1997) that is grown in an annual production system in Illinois to maximize root yields." ... "numerous roots of various sizes remain distributed throughout the soil profile and produce volunteer plants in subsequent crops (e.g., corn and soybean). Although volunteer horseradish is not thought to be extremely competitive with corn or soybean, the occurrence of volunteer horseradish plants reduces the benefits of crop rotation."

304	Environmental weed	n
	Source(s)	**Notes**
	Randall, R.P. 2012. A Global Compendium of Weeds. 2nd Edition. Department of Agriculture and Food, Western Australia	Garden & agricultural weed

305	Congeneric weed	n
	Source(s)	**Notes**
	Randall, R.P. 2012. A Global Compendium of Weeds. 2nd Edition. Department of Agriculture and Food, Western Australia	"Armoracia macrocarpa" ... "U - Casual Alien These species appear with no direct (apparent) human assistance, survive, possibly set seed, but do not persist. They then may appear again some seasons later, but do not develop persistent populations. (7,002)"

401	Produces spines, thorns or burrs	n
	Source(s)	**Notes**
	Wu, Z.Y. & Raven, P.H. (eds.). Flora of China. Vol. 8 (Brassicaceae through Saxifragaceae). Science Press, Beijing, and Missouri Botanical Garden Press, St. Louis	"Herbs with fusiform or cylindric, fleshy or woody roots. Stems 50–120(–200) cm tall. Basal leaves few; petiole to 60 cm, broadly expanded at base; leaf blade broadly oblong, oblong-lanceolate, or ovate, (10–)20–45(–60) × (3–)5–12(–17) cm, coarsely crenate or rarely pinnatifid. Lower and middle cauline leaves shortly petiolate, pinnatifid or pinnatisect, with oblong to linear-oblong lobes, smaller than basal leaves; upper cauline leaves sessile or shortly petiolate, linear to linear-lanceolate, base cuneate or attenuate, margin serrate, crenate, or rarely entire."

Qsn #	Question	Answer
402	**Allelopathic**	
	Source(s)	**Notes**
	Sipos, M., Blidar, C. F., & Bunta, D. (2012). Allelopathic effects of aqueous extracts from horseradish (Armoracia rusticana L.) metamorphosed roots on several cereals. Romanian Agricultural Research 29: 169-173	[Possibly at higher concentrations] "The germinating ability of triticale, wheat and barley seed was stimulated by the 5% and 15% dilutions of the aqueous extract of the metamorphosed horseradish roots. The increase in the concentration of the aqueous extracts (50%, 75%, and 100%) caused significant and progressive inhibition of germinating ability in all three species."

403	Parasitic	n
	Source(s)	**Notes**
	Sampliner, D., & Miller, A. (2009). Ethnobotany of horseradish (Armoracia rusticana, Brassicaceae) and its wild relatives (Armoracia spp.): reproductive biology and local uses in their native ranges. Economic Botany, 63(3): 303-313	"Herbs perennial with rootstocks." [Brassicaceae]

404	Unpalatable to grazing animals	n
	Source(s)	**Notes**
	Sampliner, D., & Miller, A. (2009). Ethnobotany of horseradish (Armoracia rusticana, Brassicaceae) and its wild relatives (Armoracia spp.): reproductive biology and local uses in their native ranges. Economic Botany, 63(3): 303-313	"Armoracia rusticana leaves can be used as fodder for cows."

Qsn #	Question	Answer
405	**Toxic to animals**	**y**
	Source(s)	**Notes**
	Spoerke, D.G. & Smolinske, S.C. 1990. Toxicity of Houseplants. CRC Press, Boca Raton, FL	"Animals occasionally become poisoned by grazing on horseradish. Cattle exhibit symptoms of lowing and excitement before death. Six ponies were found dead after eating the leaves and flowering tops of the horseradish. Their stomachs were inflamed, and the animals had struggled violently prior to death, but no other lesions were found on autopsy. Pigs have also been killed after being fed uncooked hotel garbage contaminant 55 to 95 g of grated horseradish root. Postmortem examination showered only inflamed stomach walls."
	Sampliner, D., & Miller, A. (2009). Ethnobotany of horseradish (Armoracia rusticana, Brassicaceae) and its wild relatives (Armoracia spp.): reproductive biology and local uses in their native ranges. Economic Botany, 63(3): 303-313	"Armoracia rusticana leaves can be used as fodder for cows."
	Foster, S. & Hobbs, C. 2002. A Field Guide to Western Medicinal Plants and Herbs. Houghton Mifflin, New York, NY	"Plant tops are a fatal poison to livestock in large amounts."
	Quattrocchi, U.. 2012. CRC World Dictionary of Medicinal and Poisonous Plants: Common Names, Scientific Names, Eponyms, Synonyms, and Etymology. CRC Press, Boca Raton, FL	"Toxic only if large quantities eaten. The plant contains glucosinolates, which can cause toxicity in livestock."

406	**Host for recognized pests and pathogens**	
	Source(s)	**Notes**
	The Royal Horticultural Society. 2014. Armoracia rusticana - Horseradish. https://www.rhs.org.uk/Plants/1601/i-Armoracia-rusticana-i/Details. [Accessed 1 Sep 2014]	"Pests: Generally pest free" "Diseases: May suffer from club root"
	Rundle, M. F., Walters, S. A., & Young, B. G. (2007). Efficacy of postemergence corn and soybean herbicides on volunteer horseradish (Armoracia rusticana). Weed Technology, 21(2): 501 505	[May serve as a host for further horseradish cultivation] "Volunteer horseradish in rotational crops can serve as a host for the major horseradish pathogens (Verticillium dahliae, V. longisporum, and Fusarium solani) that cause internal root discoloration (Babadoost 2006). Elimination of volunteer horseradish may reduce inoculum levels of pathogens for subsequent horseradish production."

407	**Causes allergies or is otherwise toxic to humans**	
	Source(s)	**Notes**
	Foster, S. & Hobbs, C. 2002. A Field Guide to Western Medicinal Plants and Herbs. Houghton Mifflin, New York, NY	"May irritate digestive system or cause blistering if applied directly tc the skin."
	van Wyk, B.-E. 2014. Culinary Herbs and Spices of the World. University of Chicago Press, Chicago, IL	"Notes. Horseradish can be dangerous when taken in large quantities. The mustard oils may irritate the lining of the mouth, throat, nose, digestive system and urinary tract."

408	**Creates a fire hazard in natural ecosystems**	**n**

Qsn #	Question	Answer
	Source(s)	**Notes**
	Sampliner, D., & Miller, A. (2009). Ethnobotany of horseradish (Armoracia rusticana, Brassicaceae) and its wild relatives (Armoracia spp.): reproductive biology and local uses in their native ranges. Economic Botany, 63(3): 303-313	[No evidence, and unlikely given moist habitat] "Outside of cultivation, A. rusticana can be found growing in moist habitats, including fields, gardens, weedy areas, farmland, roadsides, ditches, and disturbed areas throughout Europe (Al- Shehbaz 1988)."
	Wu, Z.Y. & Raven, P.H. (eds.). Flora of China. Vol. 8 (Brassicaceae through Saxifragaceae). Science Press, Beijing, and Missouri Botanical Garden Press, St. Louis	[Unlikely given herbaceous growth habit] "Herbs with fusiform or cylindric, fleshy or woody roots."

409	Is a shade tolerant plant at some stage of its life cycle	n
	Source(s)	**Notes**
	Learn 2 Grow. 2014. Armoracia rusticana. http://www.learn2grow.com/plants/armoracia-rusticana/. [Accessed 2 Sep 2014]	"Give this plant moderately fertile, well-drained soil and full sun."
	Plants for a Future. 2014. Armoracia rusticana. http://www.pfaf.org/user/Plant.aspx?LatinName=Armoracia+rusticana. [Accessed 2 Sep 2014]	"It can grow in semi-shade (light woodland) or no shade. It prefers moist soil." ... "Plants do not thrive if they are in the shade of trees [264]."

410	Tolerates a wide range of soil conditions (or limestone conditions if not a volcanic island)	y
	Source(s)	**Notes**
	Learn 2 Grow. 2014. Armoracia rusticana. http://www.learn2grow.com/plants/armoracia-rusticana/. [Accessed 2 Sep 2014]	"Soil pH: Acidic, Neutral Soil Drainage: Well Drained Soil type: Clay, Loam"
	Plants for a Future. 2014. Armoracia rusticana. http://www.pfaf.org/user/Plant.aspx?LatinName=Armoracia+rusticana. [Accessed 2 Sep 2014]	"Suitable for: light (sandy), medium (loamy) and heavy (clay) soils and prefers well-drained soil. Suitable pH: acid, neutral and basic (alkaline) soils and can grow in very alkaline soils."

411	Climbing or smothering growth habit	n
	Source(s)	**Notes**
	Wu, Z.Y. & Raven, P.H. (eds.). Flora of China. Vol. 8 (Brassicaceae through Saxifragaceae). Science Press, Beijing, and Missouri Botanical Garden Press, St. Louis	"Herbs perennial with rootstocks. Trichomes absent. Stems erect, branched above. Basal leaves long petiolate, rosulate, simple, entire or crenate. Cauline leaves petiolate or uppermost sessile, crenate, laciniate, pinnatifid, or pinnatiscent."

412	Forms dense thickets	n
	Source(s)	**Notes**
	Wu, Z.Y. & Raven, P.H. (eds.). Flora of China. Vol. 8 (Brassicaceae through Saxifragaceae). Science Press, Beijing, and Missouri Botanical Garden Press, St. Louis	[No evidence] "The plant is also a weed that is very difficult to eradicate."
	Foster, S. & Hobbs, C. 2002. A Field Guide to Western Medicinal Plants and Herbs. Houghton Mifflin, New York, NY	[No evidence] "Where Found: Moist fields. Throughout. Alien (Europe), it persists after cultivation."

Qsn #	Question	Answer
501	**Aquatic**	**n**
	Source(s)	**Notes**
	Smekalova, T. & Maslovky, O. 2013. Armoracia rusticana. The IUCN Red List of Threatened Species. Version 2014.2. www.iucnredlist.org	"Systems: Terrestrial"

502	**Grass**	**n**
	Source(s)	**Notes**
	USDA, ARS, National Genetic Resources Program. Germplasm Resources Information Network - (GRIN) [Online Database]. National Germplasm Resources Laboratory, Beltsville, Maryland. URL: http://www.ars-grin.gov/. [Accessed 29 Aug 2014]	Brassicaceae

503	**Nitrogen fixing woody plant**	**n**
	Source(s)	**Notes**
	USDA, ARS, National Genetic Resources Program. Germplasm Resources Information Network - (GRIN) [Online Database]. National Germplasm Resources Laboratory, Beltsville, Maryland. URL: http://www.ars-grin.gov/. [Accessed 29 Aug 2014]	Brassicaceae

504	**Geophyte (herbaceous with underground storage organs -- bulbs, corms, or tubers)**	**n**
	Source(s)	**Notes**
	Wu, Z.Y. & Raven, P.H. (eds.). Flora of China. Vol. 8 (Brassicaceae through Saxifragaceae). Science Press, Beijing, and Missouri Botanical Garden Press, St. Louis	"Herbs with fusiform or cylindric, fleshy or woody roots. Stems 50–120(–200) cm tall."
	Gordon, D. R., Mitterdorfer, B., Pheloung, P. C., Ansari, S., Buddenhagen, C., Chimera, C., ... & Williams, P. A. 2010). Guidance for addressing the Australian Weed Risk Assessment questions. Plant Protection Quarterly, 25(2): 56-74	"This question relates to perennial plants with tubers, corms or bulbs. This question is specifi cally to deal with plants that have specialized organs and should not include plants merely with rhizomes/ stolons..."

601	**Evidence of substantial reproductive failure in native habitat**	**n**
	Source(s)	**Notes**
	Smekalova, T. & Maslovky, O. 2013. Armoracia rusticana. The IUCN Red List of Threatened Species. Version 2014.2. www.iucnredlist.org	"Armoracia rusticana is widely distributed and the population is stable to increasing. It often occurs as a ruderal plant in anthropogenic habitats and faces no major threats. It is therefore assessed as Least Concern."

602	**Produces viable seed**	**y**
	Source(s)	**Notes**

Qsn #	Question	Answer
	Wu, Z.Y. & Raven, P.H. (eds.). Flora of China. Vol. 8 (Brassicaceae through Saxifragaceae). Science Press, Beijing, and Missouri Botanical Garden Press, St. Louis	"Mature fruit rarely produced, ovate, oblong, or suborbicular,4–6 mm, few seeded; style obsolete or to 0.5 mm; stigma capitate, well developed. Seeds not seen."
	The Royal Horticultural Society. 2014. Armoracia rusticana - Horseradish. https://www.rhs.org.uk/Plants/1601/i-Armoracia-rusticana-i/Details. [Accessed 1 Sep 2014]	"Propagate by seed or by division in winter"
	Plants for a Future. 2014. Armoracia rusticana. http://www.pfaf.org/user/Plant.aspx?LatinName=Armoracia+rusticana. [Accessed 2 Sep 2014]	"Seed - this is seldom produced on plants in cultivation[200]. If seed is obtained then it is best sown in situ during the spring[238]."
	Webb, C. J., Sykes, W. R., & Garnock-Jones, P. J. 1988. Flora of New Zealand Volume IV. Botany Division, DSIR, Christchurch, New Zealand	"Silicle abortive, narrow-cylindric, 2-3 mm long." ... "Horseradish is a garden discard which may persist for a long time, but apparently does not reproduce by seed in N.Z."
	Sampliner, D., & Miller, A. (2009). Ethnobotany of horseradish (Armoracia rusticana, Brassicaceae) and its wild relatives (Armoracia spp.): reproductive biology and local uses in their native ranges. Economic Botany, 63(3): 303-313	[Yes, but rarely] "In commercial cultivation, A. rusticana is grown exclusively from cuttings. It has been reported that A. rusticana is sterile, although some researchers have succeeded in producing viable seeds (Rhodes et al. 1965; Stokes 1955; Weber 1949)." ... "Armoracia rusticana produces few if any seeds (usually none, at most ≤6 per seed pod; Fig. 2a- 2)."

603	Hybridizes naturally	
	Source(s)	**Notes**
	Peter, K.V. (e.d.). 2004. Handbook of Herbs and Spices, Volume 2. Woodhead Publishing, Cambridge, UK	"Horseradish may be an interspecific hybrid and is reportedly genetically sterile (Anon., 2001)."

604	Self-compatible or apomictic	
	Source(s)	**Notes**
	Sampliner, D., & Miller, A. (2009). Ethnobotany of horseradish (Armoracia rusticana, Brassicaceae) and its wild relatives (Armoracia spp.): reproductive biology and local uses in their native ranges. Economic Botany, 63(3): 303-313	[Possibly Self-Incompatible] "Armoracia rusticana individuals generally lack seeds and have smaller fruits than either of their wild relatives. Armoracia rusticana is propagated vegetatively with few reports of sexual reproduction coming from breeders (Courter and Rhodes 1969; Walters 2008). Clonal propagation of A. rusticana may have resulted in increased sterility due to 1) the accumulation of deleterious mutations in gene regions associated with seed production, 2) reproduction of sterile individuals derived from an interspecific hybridization event, or 3) self-incompatibility mechanisms precluding fertilization between widespread, genetically-identical clones."
	Winiarczyk, K., & Bednara, J. (2008). The progamic phase and seed formation in Armoracia rusticana. Plant Breeding, 127(2): 203 207	[Possibly Yes] "Morphological symptoms of the reaction of self-incompatibility, typical for some species of the Brassicaceae family, are observed on the stigma of A. rusticana. Incompatible pollen grains do not undergo hydration; they remain in a dormant state and the few hydrated ones germinate and form short and twisted pollen tubes. The incompatibility reactions in A. rusticana were typical of representatives of the family Brassicaceae. In those flowers of A. rusticana where pollen tubes did reach the ovary tissue, they failed to penetrate the ovules. This finding suggests that ovules do not release a hormonal signal to the pollen tubes. It is therefore possible that this taxon has lost the ability to be fertilized."

Qsn #	Question	Answer
605	**Requires specialist pollinators**	**n**
	Source(s)	**Notes**
	Roubik, D.W. 1995. Pollination of cultivated plants in the tropics. FAO Services Bulletin 118. FAO, Rome, Italy	[No evidence of specialized pollinator requirements, but irrelevant, as most plants don't produce seeds regardless of pollination] "Pollinators - Insect" (p. 169)

606	Reproduction by vegetative fragmentation	y
	Source(s)	**Notes**
	Tucker, A.O. & DeBaggio, T. 2009. The Encyclopedia of Herbs: A Comprehensive Reference to Herbs of Flavor and Fragrance. Timber Press, Portland, OR	"Once you grow horseradish, you'll have this hardy perennial forever; even the smallest piece of horseradish root can grow a new plant, and whenever you are absolutely sure you've eradicated the horseradish bed this time, lo and behold, it comes back."
	Sampliner, D., & Miller, A. (2009). Ethnobotany of horseradish (Armoracia rusticana, Brassicaceae) and its wild relatives (Armoracia spp.): reproductive biology and local uses in their native ranges. Economic Botany, 63(3): 303-313	"Respondents reported that the plant is propagated from a root with leaves sprouting on the head (Fig. 2a-1). Others reported that a piece of root cut and left in the soil will make a new plant and that the plant persists in the garden for a lifetime once planted. None of the respondents reported growing A. rusticana from seeds."
	Learn 2 Grow. 2014. Armoracia rusticana. http://www.learn2grow.com/plants/armoracia-rusticana/. [Accessed 2 Sep 2014]	"This hardy, coarse, deep-rooted perennial is the source of horseradish, the familiar, fiery condiment. It grows as a clump of large, toothed, puckered, dark-green leaves on long stems arising from a fleshy root that divides vigorously into offshoots and sends out tunneling stems to start new plants with such vigor that one plant soon becomes many. Unless dug out regularly, the new plants can become invasive pests. Even a tiny fragment of root left in the ground will grow a new plant."

607	Minimum generative time (years)	1
	Source(s)	**Notes**
	Shoot Gardening. 2014. Armoracia rusticana (Horse radish). http://www.shootgardening.co.uk/plant/armoracia-rusticana . [Accessed 2 Sep 2014]	[Able to reproduce vegetatively at an early age] "1-2 years To maturity"

Qsn #	Question	Answer
701	**Propagules likely to be dispersed unintentionally (plants growing in heavily trafficked areas)**	**n**
	Source(s)	**Notes**
	Sampliner, D., & Miller, A. (2009). Ethnobotany of horseradish (Armoracia rusticana, Brassicaceae) and its wild relatives (Armoracia spp.): reproductive biology and local uses in their native ranges. Economic Botany, 63(3): 303-313	[Rarely produces seeds. Unlikely to be dispersed accidentally by root fragments] "Outside of cultivation, A. rusticana can be found growing in moist habitats, including fields, gardens, weedy areas, farmland, roadsides, ditches, and disturbed areas throughout Europe (Al Shehbaz 1988)." ..."Respondents reported that the plant is propagated from a root with leaves sprouting on the head (Fig. 2a-1). Others reported that a piece of root cut and left in the soil will make a new plant and that the plant persists in the garden for a lifetime once planted. None of the respondents reported growing A. rusticana from seeds."

702	Propagules dispersed intentionally by people	y
	Source(s)	**Notes**
	Smekalova, T. & Maslovky, O. 2013. Armoracia rusticana. The IUCN Red List of Threatened Species. Version 2014.2. www.iucnredlist.org	"The species is a very popular spice known as horseradish and is widely cultivated. Wild populations are potential gene donors to the cultivated form."

703	Propagules likely to disperse as a produce contaminant	n
	Source(s)	**Notes**
	Sampliner, D., & Miller, A. (2009). Ethnobotany of horseradish (Armoracia rusticana, Brassicaceae) and its wild relatives (Armoracia spp.): reproductive biology and local uses in their native ranges. Economic Botany, 63(3): 303-313	[Rarely produces seeds. Unlikely to be dispersed accidentally by root fragments] "Outside of cultivation, A. rusticana can be found growing in moist habitats, including fields, gardens, weedy areas, farmland, roadsides, ditches, and disturbed areas throughout Europe (Al Shehbaz 1988)." ..."Respondents reported that the plant is propagated from a root with leaves sprouting on the head (Fig. 2a-1). Others reported that a piece of root cut and left in the soil will make a new plant and that the plant persists in the garden for a lifetime once planted. None of the respondents reported growing A. rusticana from seeds."

704	Propagules adapted to wind dispersal	n
	Source(s)	**Notes**
	Wu, Z.Y. & Raven, P.H. (eds.). Flora of China. Vol. 8 (Brassicaceae through Saxifragaceae). Science Press, Beijing, and Missouri Botanical Garden Press, St. Louis	[Seeds, if produced, would probably be gravity dispersed] "Mature fruit rarely produced, ovate, oblong, or suborbicular, 4–6 mm, few seeded; style obsolete or to 0.5 mm; stigma capitate, well developed. Seeds not seen."

Qsn #	Question	Answer
705	**Propagules water dispersed**	
	Source(s)	**Notes**
	Hickman, J.C. 1993. The Jepson Manual: Higher Plants of California. University of California Press, Berkeley	[Possible that root fragments may be moved by water] "Ditches, roadsides, moist places."
	Smekalova, T. & Maslovky, O. 2013. Armoracia rusticana. The IUCN Red List of Threatened Species. Version 2014.2. www.iucnredlist.org	[Root fragments possibly moved by water in riparian habitats] "It grows along riverbanks and in other damp places. Ruderal plants are mainly confined to secondary anthropogenic habitats; for example, near arable land, in urban areas and in rural gardens."

706	Propagules bird dispersed	n
	Source(s)	**Notes**
	Wu, Z.Y. & Raven, P.H. (eds.). Flora of China. Vol. 8 (Brassicaceae through Saxifragaceae). Science Press, Beijing, and Missouri Botanical Garden Press, St. Louis	[Fruits, if produced, not fleshy or adapted to attract birds] "Mature fruit rarely produced, ovate, oblong, or suborbicular, 4–6 mm, few seeded; style obsolete or to 0.5 mm; stigma capitate, well developed. Seeds not seen."

707	Propagules dispersed by other animals (externally)	n
	Source(s)	**Notes**
	Wu, Z.Y. & Raven, P.H. (eds.). Flora of China. Vol. 8 (Brassicaceae through Saxifragaceae). Science Press, Beijing, and Missouri Botanical Garden Press, St. Louis	[Fruits & seeds, if produced, lack means of external attachment] "Mature fruit rarely produced, ovate, oblong, or suborbicular, 4–6 mm, few seeded; style obsolete or to 0.5 mm; stigma capitate, well developed. Seeds not seen."

708	Propagules survive passage through the gut	
	Source(s)	**Notes**
	WRA Specialist. 2014. Personal Communication	Unknown. Seeds rarely produced. Spreads vegetatively & by root fragments. Unknown if consumption by animals would result in dispersal of viable seeds or root fragments.

801	Prolific seed production (>1000/m2)	n
	Source(s)	**Notes**
	Sampliner, D., & Miller, A. (2009). Ethnobotany of horseradish (Armoracia rusticana, Brassicaceae) and its wild relatives (Armoracia spp.): reproductive biology and local uses in their native ranges. Economic Botany, 63(3): 303-313	"Armoracia rusticana produces few if any seeds (usually none, at most ≤6 per seed pod; Fig. 2a- 2)."

Qsn #	Question	Answer
802	**Evidence that a persistent propagule bank is formed (>1 yr)**	
	Source(s)	**Notes**
	Royal Botanic Gardens Kew. 2008. Seed Information Database (SID). Version 7.1. http://data.kew.org/sid/. [Accessed 2 Sep 2014]	[Unknown. Seeds rarely produced in wild or cultivation] "Storage Behaviour: Orthodox Storage Conditions: Seeds maintained for 2-3 years in commercial storage conditions (Priestley, 1986)"

803	**Well controlled by herbicides**	**y**
	Source(s)	**Notes**
	Rundle, M. F., Walters, S. A., & Young, B. G. (2007). Efficacy of postemergence corn and soybean herbicides on volunteer horseradish (Armoracia rusticana). Weed Technology, 21(2): 501 505	[Certain herbicides provide effective control] 'Viable horseradish roots of various sizes remain in the soil after harvest and can develop into volunteer plants in subsequent crops. Experiments were conducted to evaluate POST herbicides on volunteer horseradish control and to determine if efficacy is dependent upon horseradish root segment size, herbicide rate, horseradish cultivar, or horseradish shoot size at application. In the greenhouse, horseradish root segment size did not affect herbicide efficacy. Chlorimuron, cloransulam, imazamox, (2,4-dichlorophenoxy)acetic acid (2,4-D) amine, halosulfuron, and imazethapyr plus imazapyr provided greater than 95% foliar control of volunteer horseradish. Chlorimuron, halosulfuron, and 2,4-D amine were also among the herbicides that provided the greatest reduction in horseradish root biomass (69% or greater). Glyphosate provided little foliar control (76%) and root biomass reduction (57%) after one application. The efficacy of 2,4-D amine on horseradish foliage and root biomass increased with increasing herbicide rate; however, the response of horseradish to halosulfuron was similar for all rates evaluated. Root biomass reduction of the horseradish cultivar '1573' was less responsive to 2,4-D amine and halosulfuron applications compared with '1038' and '1722'. However, foliar injury from 2,4-D amine and halosulfuron was less for the horseradish cultivar '1038' compared with '1573' and '1722'. In field studies, 2,4-D amine applied to 15- and 30-cm-tall horseradish and halosulfuron applied to 15-cm-tall horseradish resulted in the greatest foliar and root biomass reduction. This study indicated that in-season control of volunteer horseradish in rotational crops may be achieved through proper herbicide selection."

Qsn #	Question	Answer
804	**Tolerates, or benefits from, mutilation, cultivation, or fire**	**y**
	Source(s)	**Notes**
	Rundle, M. F., Walters, S. A., & Young, B. G. (2007). Efficacy of postemergence corn and soybean herbicides on volunteer horseradish (Armoracia rusticana). Weed Technology, 21(2): 501 505	[Tolerates tillage to some degree] "Although research has shown that tillage is an effective practice for controlling some perennial plants (Lemieux et al. 1993), tillage may also add to the problem of volunteer horseradish management by increasing the number of horseradish root segments in the soil. Tillage can also bury the root segments deeper into the soil, causing nonuniform emergence. Burke and Hopen (1983) documented horseradish plant emergence up to 130 d after burial of root segments and from depths up to 90 cm."

805	**Effective natural enemies present locally (e.g. introduced biocontrol agents)**	
	Source(s)	**Notes**
	WRA Specialist. 2014. Personal Communication	Unknown

Summary of Risk Traits:

High Risk / Undesirable Traits
• Broad climate suitability (able to grow in 5+ hardiness zones)
• Can grow in tropical climates at higher elevations
• Widely naturalized
• Weedy in gardens & cultivated settings
• Agricultural weed
• Potentially allelopathic
• Can poison livestock if consumed in large quantities
• May be an irritant to humans & potentially toxic if consumed in large quantities
• Tolerates many soil types
• Seeds dispersed intentionally by people (but rarely seeds)
• Able to spread vegetatively & from root fragments
• Can reproduce in one growing season
• Able to resprout after cutting & tilling

Low Risk Traits
• Despite weediness, long history of cultivation & use by humans for food
• Unarmed (no spines, thorns or burrs)
• Provides fodder for livestock (palatable despite reports of toxicity)
• Possibly shade intolerant
• Rarely sets seed
• Lack of seed production limits dispersal capability
• Herbicides provide effective control

Second Screening Results for Herbs

(A) Reported as a weed of cultivated lands? Yes
(B) Unpalatable to grazers or known to form dense stands> No
Outcome = Evaluate