TAXON: *Diplazium esculentum (Retz.) Sw.* SCORE: *11.0* RATING: *High Risk*

Taxon: Diplazium esculentum (Retz.) Sw.

Family: Dryopteridaceae

Common Name(s): Hō`i`o
paca
paku-sayur
vegetable fern

Synonym(s): Athyrium esculentum (Retz.) Copeland
Hemionitis esculenta Retz.

Assessor: Chuck Chimera

Status: Approved

End Date: 3 May 2024

WRA Score: 11.0

Designation: H(HPWRA)

Rating: High Risk

Keywords: Edible Fern, Naturalized, Dense Stands, Shade-Tolerant, Spreads Vegetatively

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	y
301	Naturalized beyond native range	y = 1*multiplier (see Appendix 2), n = question 205	y
302	Garden/amenity/disturbance weed	y = 1*multiplier (see Appendix 2), n = 0	y
303	Agricultural/forestry/horticultural weed		
304	Environmental weed		
305	Congeneric weed		
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		
405	Toxic to animals	y = 1, n = 0	n
406	Host for recognized pests and pathogens	y = 1, n = 0	n
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	y

Qsn #	Question	Answer Option	Answer
410	Tolerates a wide range of soil conditions (or limestone conditions if not a volcanic island)	y = 1, n = 0	n
411	Climbing or smothering growth habit	y = 1, n = 0	n
412	Forms dense thickets	y = 1, n = 0	y
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)		
701	Propagules likely to be dispersed unintentionally (plants growing in heavily trafficked areas)		
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	y
706	Propagules bird dispersed	y = 1, n = -1	n
707	Propagules dispersed by other animals (externally)		
708	Propagules survive passage through the gut	y = 1, n = -1	n
801	Prolific seed production (>1000/m2)	y = 1, n = -1	y
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		
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
	Palmer, D.D. (2003). Hawaii's Ferns and Fern Allies. University of Hawaii Press, Honolulu, HI	[No evidence] "This commonly eaten fem from Southeast Asia and the Pacific was probably purposely introduced as a garden vegetable and was first collected on Kaua'i in 1910."

102	Has the species become naturalized where grown?	
	Source(s)	Notes
	WRA Specialist. (2024). Personal Communication	NA

103	Does the species have weedy races?	
	Source(s)	Notes
	WRA Specialist. (2024). 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
	Palmer, D.D. (2003). Hawaii's Ferns and Fern Allies. University of Hawaii Press, Honolulu, HI	"...commonly eaten fern from Southeast Asia and the Pacific..."
	Wu, Z.Y., Raven,P.H. & Hong, D.Y. (eds.). (2013). Flora of China. Vol. 2-3 (Lycopodiaceae through Polypodiaceae). Science Press, Beijing, and Missouri Botanical Garden Press, St. Louis	"Valley forests, beside brooks or streamlets; 100-1200 m. Anhui, Fujian, Guangdong, Guangxi, Guizhou, Hainan, Hunan, Jiangxi, Sichuan, Taiwan, Xizang, Yunnan, Zhejiang [tropical Asia, subtropical and tropical Polynesia]."

202	Quality of climate match data	High
	Source(s)	Notes
	Palmer, D.D. (2003). Hawaii's Ferns and Fern Allies. University of Hawaii Press, Honolulu, HI	"...commonly eaten fern from Southeast Asia and the Pacific..."

203	Broad climate suitability (environmental versatility)	y
	Source(s)	Notes
	Crouch, N. R. (2012). Ferns of Southern Africa. Struik Nature, Cape Town, South Africa	"It grows mostly in disturbed areas, exposed or in partial shade, but always in wet sites such as along streambanks, where it forms large clonal colonies as a result of prolific root budding." ... "Altitude range is 40-1000 m."
	Palmer, D.D. (2003). Hawaii's Ferns and Fern Allies. University of Hawaii Press, Honolulu, HI	"Usually found in large, untidy, straggly stands in shady valleys with wet, swampy soils, often along streams, at lower elevations..."
	Wu, Z.Y., Raven,P.H. & Hong, D.Y. (eds.). (2013). Flora of China. Vol. 2-3 (Lycopodiaceae through Polypodiaceae). Science Press, Beijing, and Missouri Botanical Garden Press, St. Louis	"Valley forests, beside brooks or streamlets; 100-1200 m. Anhui, Fujian, Guangdong, Guangxi, Guizhou, Hainan, Hunan, Jiangxi, Sichuan, Taiwan, Xizang, Yunnan, Zhejiang [tropical Asia, subtropical and tropical Polynesia]." [Occurs in temperate and tropical regions over 1000 m elevation range]

Qsn #	Question	Answer
204	**Native or naturalized in regions with tropical or subtropical climates**	y
	Source(s)	**Notes**
	Staples, G.W. & Herbst, D.R. (2005). A Tropical Garden Flora - Plants Cultivated in the Hawaiian Islands and Other Tropical Places. Bishop Museum Press, Honolulu, HI	"...native to tropical Asia, ranging eastward to the islands of the South Pacific, where it grows near waterways and in moist or wet ground in open, disturbed areas...probably introduced to Hawaii as a food plant in the late 1800s or early 1900s and has since escaped cultivation and become naturalized on the larger islands, typically at lower elevations"
	Palmer, D.D. (2003). Hawaii's Ferns and Fern Allies. University of Hawaii Press, Honolulu, HI	"Usually found in large, untidy. straggly stands in shady valleys with wet, swampy soils. often along streams, at lower elevations, on all major islands except Moloka'i where it may be present but remains undocumented." [Also recorded on Molokai]
	Wu, Z.Y., Raven,P.H. & Hong, D.Y. (eds.). (2013). Flora of China. Vol. 2-3 (Lycopodiaceae through Polypodiaceae). Science Press, Beijing, and Missouri Botanical Garden Press, St. Louis	"Valley forests, beside brooks or streamlets; 100-1200 m. Anhui, Fujian, Guangdong, Guangxi, Guizhou, Hainan, Hunan, Jiangxi, Sichuan, Taiwan, Xizang, Yunnan, Zhejiang [tropical Asia, subtropical and tropical Polynesia]."
	Oppenheimer, H. (2007). New plant records from Moloka'i, Lāna'i, Maui, and Hawai'i for 2006. Bishop Museum Occasional Papers 96:17-34	[Molokai] "Diplazium esculentum (Retz.) Sw. New island record Reported from Kaua'i, O'ahu, Läna'i, Maui, and Hawai'i, Palmer (2003: 125) suspected it also occurred on Moloka'i but remained undocumented. Wilson (1996: 132), also assumed it occurred on Moloka'i, and considered its undocumented presence there as simply the failure of collectors to take a specimen of this weedy fern. Since it is wind dispersed (Staples et al. 2000: 18) it is not surprising that it is also established on Moloka'i. Material examined. MOLOKA'I: Wailau Valley, large clump along Kahawaiiki Stream, 6 m, 12 Aug 2005, Oppenheimer H80503."

205	**Does the species have a history of repeated introductions outside its natural range?**	y
	Source(s)	**Notes**
	Crouch, N. R. (2012). Ferns of Southern Africa. Struik Nature, Cape Town, South Africa	"Diplazium esculentum, the vegetable fern, is native to Asia where it is commonly cultivated and/or harvested for its edible young fronds. However, it is for its rather attractive trunk-like caudex that it has been grown as an ornamental in South Africa. It has become naturalised in South Africa and Zimbabwe as well as in the USA and Australia."
	Hoshizaki, B.J. & Moran, R.C. (2001). Fern Grower's Manual. Revised and Expanded Edition. Timber Press, Portland, OR	"it has been introduced in Florida and Louisiana."
	Palmer, D.D. (2003). Hawaii's Ferns and Fern Allies. University of Hawaii Press, Honolulu, HI	"This commonly eaten fern from Southeast Asia and the Pacific was probably purposely introduced as a garden vegetable and was first collected on Kauai in 1910."

301	**Naturalized beyond native range**	y
	Source(s)	**Notes**
	Ogle, C. C., de Lange, P., Cameron, E. K., Parris, B. S., & Champion, P. D. (2021). Checklist of dicotyledons, gymnosperms and pteridophytes Naturalised or Casual in New Zealand: Additional records 2007-2019. Perspectives in Biosecurity, 5, 45–116	"Cultivation Escape. Initially collected from a garden in Kerikeri where this species had spread rapidly and aggressively. Subsequent collections may have arisen from flood-deposited material washed downstream from plantings (Puhinui Creek), and at Glendowie possibly from a past deliberate planting. In New Zealand, this species has yet to be seen fertile, though it spreads very quickly vegetatively via an extensive underground network of black, wiry, easily detached rhizomes which produce numerous young plants."

Qsn #	Question	Answer
	Crouch, N. R. (2012). Ferns of Southern Africa. Struik Nature, Cape Town, South Africa	"Distribution: To date recorded as naturalised at several sites in the greater Durban region, Pietermaritzburg and near Ongoye Forest in northern KwaZulu-Natal. Ecology & Notes: Diplazium esculentum, the vegetable fern, is native to Asia where it is commonly cultivated and/or harvested for its edible young fronds. However, it is for its rather attractive trunk-like caudex that it has been grown as an ornamental in South Africa. It has become naturalised in South Africa and Zimbabwe as well as in the USA and Australia."
	Crouch, N. R., & Klopper, R. R. (2010). Pteridophyta. Bothalia, 40(1), 71-72	"It has become naturalized in South Africa and Zimbabwe (Roux 2009), as well as in Florida, Louisiana and Hawaii (USA) (Kato 1993; Smithsonian Institution 2009) and Australia (Jones 1998)."
	Morton, J.F. (1976). Pestiferous spread of many ornamental and fruit species in South Florida. Proceedings of the Florida State Horticultural Society 89: 348-353	"Naturalized in moist woods, Dade and DeSoto Counties"
	Palmer, D.D. (2003). Hawaii's Ferns and Fern Allies. University of Hawaii Press, Honolulu, HI	"Naturalized...Usually found in large, untidy, straggly stands in shady valleys with wet, swampy soils, often along streams, at lower elevations, on all major islands except Molokai, where it may be present but remains undocumented."
	Hoshizaki, B.J. & Moran, R.C. (2001). Fern Grower's Manual. Revised and Expanded Edition. Timber Press, Portland, OR	"This Asian species has become naturalized in Louisiana and Florida. It is cultivated in Florida and California."
	Oppenheimer, H. (2007). New plant records from Moloka'i, Lāna'i, Maui, and Hawai'i for 2006. Bishop Museum Occasional Papers 96:17-34	[Molokai] "Diplazium esculentum (Retz.) Sw. New island record Reported from Kaua'i, O'ahu, Läna'i, Maui, and Hawai'i, Palmer (2003: 125) suspected it also occurred on Moloka'i but remained undocumented. Wilson (1996: 132), also assumed it occurred on Moloka'i, and considered its undocumented presence there as simply the failure of collectors to take a specimen of this weedy fern. Since it is wind dispersed (Staples et al. 2000: 18) it is not surprising that it is also established on Moloka'i. Material examined. MOLOKA'I: Wailau Valley, large clump along Kahawaiiki Stream, 6 m, 12 Aug 2005, Oppenheimer H80503."

302	Garden/amenity/disturbance weed	y
	Source(s)	**Notes**
	Barcelona, J. F., Dolotina, N. E., Madroñero, G. S., Granert, W. G., & Sopot, D. D. (2006). The ferns and fern allies of the karst forests of Bohol Island, Philippines. American Fern Journal, 96(1), 1-20.	"Table 2…Diplazium esculentum…Ecology, Frequency, and Location…Terrestrial. Weedy in exposed, disturbed areas." [impacts as a weed unspecified]
	Crouch, N. R. (2012). Ferns of Southern Africa. Struik Nature, Cape Town, South Africa	[Disturbance weed recommended for eradication] "It grows mostly in disturbed areas, exposed or in partial shade, but always in wet sites such as along streambanks, where it forms large clonal colonies as a result of prolific root budding. Sporing in South Africa is evidently rare. Until recently, invasion (as a likely garden escape) by D. esculentum was known only at several sites in the greater Durban region, invariably along watercourses. It is now also known from Zululand and Pietermaritzburg. Once colonies are established, erosive flooding events disperse root buds and plantlets which then establish further downstream, often on sandbanks in seasonally flooded rivers. This is an emerging alien invader that should be eradicated."
	Palmer, D.D. (2003). Hawaii's Ferns and Fern Allies. University of Hawaii Press, Honolulu, HI	[Primarily occurs in disturbed, non-native dominated habitats, but may potentially impact native ecosystems] "Usually found in large, untidy. straggly stands in shady valleys with wet, swampy soils. often along streams, at lower elevations,"

Qsn #	Question	Answer
	Jones, E. J., Kraaij, T., Guerbois, C., & Moodley, D. (2020). An assessment of the invasion status of terrestrial alien ferns (Polypodiophyta) in South Africa. South African Journal of Botany, 131, 64-73	[Proposed for eradication] "A recent global assessment of terrestrial alien true ferns (Polypodiophyta; hereafter alien ferns) showed that alien ferns have a high probability of becoming naturalised or invasive once introduced.We provide the first systematic assessment, based on field surveys, of the invasion status of this large taxon in South Africa. Thirteen species of alien ferns were recorded outside of cultivation and subsequently identified as invasive in South Africa. Surveys were focused in known hotspots of alien and native ferns, with invasion density peaking along the eastern coastal belt of South Africa.Within the surveyed areas, alien ferns commonly occurredwith other invaders, closer towater and often in indigenous forests. The species considered in this study generally occurred in similar habitat types across their native and globally introduced ranges (including South Africa). The potential spread of alien ferns in South Africa appears limited when compared to other major invaders, however, their common occurrence in indigenous forests highlights a concern for native, co-habiting fern species (in terms of competition). Our study provided regulatory insight for 12 previously unregulated alien fern species in South Africa.We propose that eradication remains feasible for Diplazium esculentum, Doodia caudata, Lygodium japonicum, Phlebodium aureum and Platycerium bifurcatum. A risk analysis for Sphaeropteris cooperi classified the species as high risk and comprised the first quantification of risk for any alien fern species (inclusive of aquatics) in South Africa. The information put forward in this study can be used to informrisk analyses for the remaining species in SouthAfrica, aswell as countries with similar habitats and climates. Furthermore, widely traded species need to be identified as candidates for future risk assessment since horticulture is an important introduction pathway for alien ferns globally."

303	Agricultural/forestry/horticultural weed	
	Source(s)	**Notes**
	Kumar, S., & Jacob, J. (2015). Common weeds in rubber plantations in West Bengal. RB Bulletin 33(2): 21-25	"Study records the occurrence of a noxious weed, Ichnocarpus frutescens (L.) W. T. Aiton, and two other dominated species of weeds (Dioscorea bulbifrea and Diplazium esculentum) in natural rubber (NR) plantations in non-traditional region." ... "Weeds are one of the major problems in rubber plantations as they compete with the crop for light, water and nutrients."
	Randall, R.P. (2017). A Global Compendium of Weeds. 3rd Edition. Perth, Western Australia. R.P. Randall	"Weed of: Orchards & Plantations"
	Pradhan, S., & Tamang, J. P. (2015). Ethnobiology of wild leafy vegetables of Sikkim. Indian Journal of Traditional Knowledge 14(2): 290-297	[Aggressive. May impact crops] "Diplazium esculentum is an aggressive fern of wasteland, forest and undisturbed areas in the forest and farm land proximities. It commonly grows in moist and shady places, and is found growing in the field margins and vertical slopes of the terraced crop fields within an altitudinal range of 4000-8000 ft in Sikkim."

304	Environmental weed	
	Source(s)	**Notes**
	Palmer, D.D. (2003). Hawaii's Ferns and Fern Allies. University of Hawaii Press, Honolulu, HI	[Primarily occurs in disturbed, non-native dominated habitats, but may potentially impact native ecosystems] "Usually found in large, untidy. straggly stands in shady valleys with wet, swampy soils. often along streams, at lower elevations,"
	Staples, G.W., Herbst, D.R & Imada, C.T. 2000. Survey of invasive or potentially invasive cultivated plants in Hawai'i. Bishop Museum Occasional Papers 65: 1-35	Potential environmental weed

Qsn #	Question	Answer
305	Congeneric weed	
	Source(s)	Notes
	Randall, R.P. (2017). A Global Compendium of Weeds. 3rd Edition. Perth, Western Australia. R.P. Randall	Possibly. Diplazium japonicum listed as an agricultural weed of unknown impacts

401	Produces spines, thorns or burrs	n
	Source(s)	Notes
	Palmer, D.D. (2003). Hawaii's Ferns and Fern Allies. University of Hawaii Press, Honolulu, HI	"Plants medium-sized, terrestrial. Caudices erect, usually unbranched, slender, to 1.5 m tall, to S cm diam. Stipes to 50 cm long. stout, dark brown. glabrous. Blades of 2 types: small blades l-pinnate with deeply lobed. broad pinnae; larger blades 2-pinnate, becoming l-pinnate then pinnatifid distally. to 1+ m long. Pinnae stalked, to 50+ cm long. Ultimate segments subsessile to short-stalked, simple. 3-8 x 0.5-2 cm, margins serrate to crenate or lobed, tips often acute. Veins prominent, pinnately branched, forming ribs adaxially. lower 2-4 branches anastomosing to form zigzag excurrent veins to sinuses. Sori linear along veins, forming a herringbone pattern." [No evidence]

402	Allelopathic	
	Source(s)	Notes
	WRA Specialist. (2024). Personal Communication	Unknown. No evidence found

403	Parasitic	n
	Source(s)	Notes
	Hoshizaki, B.J. & Moran, R.C. (2001). Fern Grower's Manual. Revised and Expanded Edition. Timber Press, Portland, OR	"A medium-sized fern, to 60 cm (2 ft.) tall, with erect rhizomes that can become trunk-like on older plants." [No evidence]

404	Unpalatable to grazing animals	
	Source(s)	Notes
	Palmer, D.D. (2003). Hawaii's Ferns and Fern Allies. University of Hawaii Press, Honolulu, HI	"This commonly eaten fem from Southeast Asia and the Pacific was probably purposely introduced as a garden vegetable and was first collected on Kaua'i in 1910." [Palatability to animals unknown]

405	Toxic to animals	n
	Source(s)	Notes
	Staples, G.W. & Herbst, D.R. (2005). A Tropical Garden Flora - Plants Cultivated in the Hawaiian Islands and Other Tropical Places. Bishop Museum Press, Honolulu, HI	"Diplazium esculentum, on the other hand, is not known to have any harmful properties; in fact, it is reported to be an excellent source of phosphorus." [No evidence]

406	Host for recognized pests and pathogens	n
	Source(s)	Notes
	Hoshizaki, B.J. & Moran, R.C. (2001). Fern Grower's Manual. Revised and Expanded Edition. Timber Press, Portland, OR	No evidence

Qsn #	Question	Answer
	Jones, D. L. (1987). Encyclopedia of Ferns. Timber Press, Portland, OR	No evidence
	Staples, G.W. & Herbst, D.R. (2005). A Tropical Garden Flora - Plants Cultivated in the Hawaiian Islands and Other Tropical Places. Bishop Museum Press, Honolulu, HI	No evidence

407	Causes allergies or is otherwise toxic to humans	n
	Source(s)	**Notes**
	Jones, D. L. (1987). Encyclopedia of Ferns. Timber Press, Portland, OR	"The developing croziers and young fronds of this fern are eaten as a cooked vegetable or raw in salads in many countries of the Pacific regions and are even sold in local markets."
	Jones, D. L. (1987). Encyclopedia of Ferns. Timber Press, Portland, OR	"The developing croziers and young fronds of this fern are eaten as a cooked vegetable or raw in salads sold in local markets."
	Staples, G.W. & Herbst, D.R. (2005). A Tropical Garden Flora - Plants Cultivated in the Hawaiian Islands and Other Tropical Places. Bishop Museum Press, Honolulu, HI	"Two common names correctly applied to other edible fern species have been incorrectly (though widely) applied to D. esculentum, which could be a source of confusion…Of greater concern is the misapplication of the Japanese name warabi for the shoots of D. esculentum. In Japan, warabi refers to the fiddleheads of the bracken fern, Pteridium, which are available fresh in markets and sometimes exported in pickled or dried form. Pteridium leaves are known to be carcinogenic and to contain a nerve poison, and their consumption should be avoided. Diplazium esculentum, on the other hand, is not known to have any harmful properties; in fact, it is reported to be an excellent source of phosphorus."

408	Creates a fire hazard in natural ecosystems	n
	Source(s)	**Notes**
	Palmer, D.D. (2003). Hawaii's Ferns and Fern Allies. University of Hawaii Press, Honolulu, HI	"Usually found in large, untidy, straggly stands in shady valleys with wet, swampy soils, often along streams, at lower elevations…" [No evidence, and unlikely moist habitats]

409	Is a shade tolerant plant at some stage of its life cycle	y
	Source(s)	**Notes**
	De Winter, W.P. and Amoroso, V.B. (eds.). (2003). Plant Resources of South-East Asia No 15(2). Cryptogams: Ferns and fern allies. Backhuys Publishers, Leiden, The Netherlands	"D. esculentum absolutely needs wet conditions and shade in dry periods during planting."
	Crouch, N. R., & Klopper, R. R. (2010). Pteridophyta. Bothalia, 40(1), 71-72	"growing in semi-shade to full sun"
	Crouch, N. R. (2012). Ferns of Southern Africa. Struik Nature, Cape Town, South Africa	"It grows mostly in disturbed areas, exposed or in partial shade, but always in wet sites such as along streambanks, where it forms large clonal colonies as a result of prolific root budding."
	Trail, P., Danmalidoi, Y., Bicksler, A., & Burnette, R. (2021). Production of vegetable fern (Diplazium esculentum Reytz.) under varying levels of shade. ECHO Asia Notes. AN Issue #45	"Results from our field trials indicate that the cultivation of vegetable fern on farm can in fact be productive, both in the rainy and dry seasons. Production was higher during rainy season compared to dry season months, even when adequate irrigation was provided throughout the year. Our results indicate that shade does play an important role in a managed production system, with shaded plots out-performing those that were unshaded in almost every instance (Figure 3). Ferns grown under partial shade structures (50% shade) yielded more than those under higher shade (80%) in both trial runs, though differences between the two were small compared to having shade and no shade in general."

Qsn #	Question	Answer
410	Tolerates a wide range of soil conditions (or limestone conditions if not a volcanic island)	n
	Source(s)	**Notes**
	Maheshwari, J.K. (1996). Ethnobotany in South Asia. Scientific Publishers, Jodhpur, India	"Common on damp, marshy soil and under the shade. Found throughout the country ascending to about 1800 m."
	Dave's Garden. (2024). Diplazium Species, Vegetable Fern Diplazium esculentum. http://davesgarden.com/guides/pf/go/54948/. [Accessed 2 May 2024]	"Other details: Requires consistently moist soil; do not let dry out between waterings. Soil pH requirements: 5.6 to 6.0 (acidic) 6.1 to 6.5 (mildly acidic) 6.6 to 7.5 (neutral)"
	Palmer, D.D. (2003). Hawaii's Ferns and Fern Allies. University of Hawaii Press, Honolulu, HI	"Usually found in large, untidy. straggly stands in shady valleys with wet, swampy soils"

Qsn #	Question	Answer
411	Climbing or smothering growth habit	n
	Source(s)	**Notes**
	Hoshizaki, B.J. & Moran, R.C. (2001). Fern Grower's Manual. Revised and Expanded Edition. Timber Press, Portland, OR	"A medium-sized fern, to 60 cm (2 ft.) tall, with erect rhizomes that can become trunk-like on older plants."

Qsn #	Question	Answer
412	Forms dense thickets	y
	Source(s)	**Notes**
	Chaudhuri, A.B. (1993). Forest plants of eastern India. Ashish Publishing House, New Delhi, India	"Deep soil where grazing is heavy - Such areas are very common in Central and South Diana. Principal weeds are Diplazium esculentum and Mikania cordata which form thick impenetrable low masses with grazing tracts zigzagged in between Clerodendrum viscosum which has scattered distribution and is conspicuous."
	Crouch, N. R., & Klopper, R. R. (2010). Pteridophyta. Bothalia, 40(1), 71-72	"forms clonal colonies by vegetative increase from root buds"
	Palmer, D.D. (2003). Hawaii's Ferns and Fern Allies. University of Hawaii Press, Honolulu, HI	"Usually found in large, untidy. straggly stands in shady valleys with wet, swampy soils. often along streams,"

Qsn #	Question	Answer
501	Aquatic	n
	Source(s)	**Notes**
	Palmer, D.D. (2003). Hawaii's Ferns and Fern Allies. University of Hawaii Press, Honolulu, HI	"Plants medium-sized, terrestrial" ... "Usually found in large, untidy. straggly stands in shady valleys with wet, swampy soils. often along streams,"

Qsn #	Question	Answer
502	Grass	n
	Source(s)	**Notes**
	Hoshizaki, B.J. & Moran, R.C. (2001). Fern Grower's Manual. Revised and Expanded Edition. Timber Press, Portland, OR	"A medium-sized fern, to 60 cm (2 ft.) tall, with erect rhizomes that can become trunk-like on older plants."
	Gallaher, T.J., Brock, K., Kennedy, B.H., Imada, C.T., Imada, K., & Walvoord, N. (2024). Plants of Hawai'i. http://www.plantsofhawaii.org. [Accessed 2 May 2024]	Athyriaceae

Qsn #	Question	Answer
503	Nitrogen fixing woody plant	n
	Source(s)	Notes
	Hoshizaki, B.J. & Moran, R.C. (2001). Fern Grower's Manual. Revised and Expanded Edition. Timber Press, Portland, OR	"A medium-sized fern, to 60 cm (2 ft.) tall, with erect rhizomes that can become trunk-like on older plants."

504	Geophyte (herbaceous with underground storage organs -- bulbs, corms, or tubers)	n
	Source(s)	Notes
	Hoshizaki, B.J. & Moran, R.C. (2001). Fern Grower's Manual. Revised and Expanded Edition. Timber Press, Portland, OR	"A medium-sized fern, to 60 cm (2 ft.) tall, with erect rhizomes that can become trunk-like on older plants."

601	Evidence of substantial reproductive failure in native habitat	n
	Source(s)	Notes
	Wu, Z.Y., Raven,P.H. & Hong, D.Y. (eds.). (2013). Flora of China. Vol. 2-3 (Lycopodiaceae through Polypodiaceae). Science Press, Beijing, and Missouri Botanical Garden Press, St. Louis	[No evidence] "Valley forests, beside brooks or streamlets; 100-1200 m. Anhui, Fujian, Guangdong, Guangxi, Guizhou, Hainan, Hunan, Jiangxi, Sichuan, Taiwan, Xizang, Yunnan, Zhejiang [tropical Asia, subtropical and tropical Polynesia]."
	Jones, D. L. (1987). Encyclopedia of Ferns. Timber Press, Portland, OR	No evidence

602	Produces viable seed	y
	Source(s)	Notes
	Diddell, M. W. (1948). Diplazium esculentum in Florida. American Fern Journal, 38(1), 16-19	"A few months later, in midsummer, the sporophylls appeared, so it seems that the plant when deprived of its means of vegetative propagation starts to produce spores."
	De Winter, W.P. and Amoroso, V.B. (eds.). (2003). Plant Resources of South-East Asia No 15(2). Cryptogams: Ferns and fern allies. Backhuys Publishers, Leiden, The Netherlands	"Diplazium ferns grow easily from spores ."
	Crouch, N. R., & Klopper, R. R. (2010). Pteridophyta. Bothalia, 40(1), 71-72	"in South Africa is evidently rare; close examination of large colonies at Kirstenbosch (Cape Town), Pietermaritzburg and Durban surrounds over several years has revealed only three plants bearing sori."
	Staples, G.W. & Herbst, D.R. (2005). A Tropical Garden Flora - Plants Cultivated in the Hawaiian Islands and Other Tropical Places. Bishop Museum Press, Honolulu, HI	"Vegetable fern needs no special care in Hawaii and is easily propagated by spores."

603	Hybridizes naturally	
	Source(s)	Notes
	Takamiya, M., Takaoka, C., & Ohta, N. (1999). Cytological and reproductive studies on Japanese Diplazium (Woodsiaceae; Pteridophyta): apomictic reproduction in Diplazium with evergreen bi-to tripinnate leaves. Journal of Plant Research, 112, 419-436	"Three putative hybrids were examined here. Their hybridity were presumed from intermediate morphological characteristics of their putative parents in texture of leaves, form and position of sori, and color and form of scales (Kurata 1961,1968)." [Unknown. No evidence that D. esculentum forms hybrids]

604	Self-compatible or apomictic	

Qsn #	Question	Answer
	Source(s)	**Notes**
	Takamiya, M., Takaoka, C., & Ohta, N. (1999). Cytological and reproductive studies on Japanese Diplazium (Woodsiaceae; Pteridophyta): apomictic reproduction in Diplazium with evergreen bi-to tripinnate leaves. Journal of Plant Research, 112, 419-436	"...Diplazium ammianum and D. esculentum are sexual diploids (2n= 82, n=41)..." [Not apomictic, but self-compatibility of gametophytes unknown]

605	Requires specialist pollinators	n
	Source(s)	**Notes**
	Palmer, D.D. (2003). Hawaii's Ferns and Fern Allies. University of Hawaii Press, Honolulu, HI	Pteridophyte

606	Reproduction by vegetative fragmentation	y
	Source(s)	**Notes**
	Hoshizaki, B.J. & Moran, R.C. (2001). Fern Grower's Manual. Revised and Expanded Edition. Timber Press, Portland, OR	"New plants frequently arise from root buds."
	Jones, D. L. (1987). Encyclopedia of Ferns. Timber Press, Portland, OR	"Plants grow vigorously and are spread by stolons."
	De Winter, W.P. and Amoroso, V.B. (eds.). (2003). Plant Resources of South-East Asia No 15(2). Cryptogams: Ferns and fern allies. Backhuys Publishers, Leiden, The Netherlands	"Vegetative propagation is possible by runners and rhizome parts with buds in D. esculentum and by bulbils in D. proliferum."

607	Minimum generative time (years)	
	Source(s)	**Notes**
	De Winter, W.P. and Amoroso, V.B. (eds.). (2003). Plant Resources of South-East Asia No 15(2). Cryptogams: Ferns and fern allies. Backhuys Publishers, Leiden, The Netherlands	"Diplazium ferns grow easily from spores . Vegetative propagation is possible by runners and rhizome parts with buds in D. esculentum and by bulbils in D. proliferum." ... "When grown from spores, 2-3-year-old Diplazium plants can be harvested. When grown from runners, harvesting might start after 6 months." [Unknown, but may reproduce vegetatively prior to sexual maturity]

701	Propagules likely to be dispersed unintentionally (plants growing in heavily trafficked areas)	
	Source(s)	**Notes**
	Palmer, D.D. (2003). Hawaii's Ferns and Fern Allies. University of Hawaii Press, Honolulu, HI	"Usually found in large, untidy. straggly stands in shady valleys with wet, swampy soils. often along streams," [No evidence, although spores may potentially be inadvertently dispersed]
	WRA Specialist. (2011). Personal Communication	[Propagules likely to be dispersed unintentionally?} No evidence, although spores may potentially be inadvertently dispersed

702	Propagules dispersed intentionally by people	y
	Source(s)	**Notes**
	Staples, G.W. & Herbst, D.R. (2005). A Tropical Garden Flora - Plants Cultivated in the Hawaiian Islands and Other Tropical Places. Bishop Museum Press, Honolulu, HI	"...probably introduced to Hawaii as a food plant in the late 1800s or early 1900s...It is a frequent volunteer in gardens, making it difficult to ascertain how often it is cultivated deliberately."

703	Propagules likely to disperse as a produce contaminant	n

Qsn #	Question	Answer
	Source(s)	**Notes**
	Staples, G.W. & Herbst, D.R. (2005). A Tropical Garden Flora - Plants Cultivated in the Hawaiian Islands and Other Tropical Places. Bishop Museum Press, Honolulu, HI	"…bunches of young fiddleheads can be purchased in produce markets in Honolulu as well as at the local farmer's markets…" [No evidence that ferns have contaminated other produce]
	Randall, R.P. (2017). A Global Compendium of Weeds. 3rd Edition. Perth, Western Australia. R.P. Randall	"Major Pathway/s: Crop, Herbal, Ornamental Dispersed by: Humans, Escapee"

704	Propagules adapted to wind dispersal	y
	Source(s)	**Notes**
	Staples, G.W. & Herbst, D.R. (2005). A Tropical Garden Flora - Plants Cultivated in the Hawaiian Islands and Other Tropical Places. Bishop Museum Press, Honolulu, HI	"Vegetable fern needs no special care in Hawaii and is easily propagated by spores." [Spores presumably wind dispersed]

705	Propagules water dispersed	y
	Source(s)	**Notes**
	Staples, G.W. & Herbst, D.R. (2005). A Tropical Garden Flora - Plants Cultivated in the Hawaiian Islands and Other Tropical Places. Bishop Museum Press, Honolulu, HI	"…grows near waterways and in moist or wet ground in open…is easily propagated by spores." [Spores likely transported by water]
	Boonkerd, T., & Pollawatn, R. (2006). Pteridophyte Flora of Thong Pha Phum National Park, Kanchanaburi Province, Thailand. The Natural History Journal of Chulalongkorn University, 6(1): 17-30	"Along stream banks, where air humidity is high, large terrestrial ferns or tree ferns, such as Angiopteris evecta, Cibotium barometz and Cyathea gigantea typically grow. Cyclosorus interruptus, Pronephrium nudatum, and Diplazium esculentum were found on wet ground, especially along stream banks where sunlight can penetrate to the forest floor."
	Wilson, K.A. (1996). Alien Ferns in Hawaii. Pacific Science 50(2): 127-141	"Diplazium esculentum grows in large stands in wet areas, such as along stream banks; for instance, it occurs abundantly in valleys along the Hamakua Coast of Hawai'i and in wet areas of Pu'u 'Ohi'a and Manoa Valley, O'ahu."
	Chaudhuri, A.B. (1993). Forest plants of eastern India. Ashish Publishing House, New Delhi, India	"Diplazium esculentum Sw...grow along water courses."
	Crouch, N. R., & Klopper, R. R. (2010). Pteridophyta. Bothalia, 40(1), 71-72	"Until recently, invasion by Diplazium esculentum was known only from several sites in the greater Durban region, where it seems to have escaped from gardens and established along watercourses. Once colonies are established, erosive flooding events disperse root buds and plantlets which establish downstream."

706	Propagules bird dispersed	n
	Source(s)	**Notes**
	Staples, G.W. & Herbst, D.R. (2005). A Tropical Garden Flora - Plants Cultivated in the Hawaiian Islands and Other Tropical Places. Bishop Museum Press, Honolulu, HI	"...easily propagated by spores." [Although possible, there is no evidence that bird dispersal is a likely dispersal vector]

707	Propagules dispersed by other animals (externally)	
	Source(s)	**Notes**
	WRA Specialist. (2024). Personal Communication	Possibly. Spores may adhere to mud in hooves, feet of fur, but no direct evidence found

708	Propagules survive passage through the gut	n

Qsn #	Question	Answer
	Source(s)	**Notes**
	Crouch, N. R. (2012). Ferns of Southern Africa. Struik Nature, Cape Town, South Africa	"Once colonies are established, erosive flooding events disperse root buds and plantlets which then establish further downstream, often on sandbanks in seasonally flooded rivers."
	WRA Specialist. (2024). Personal Communication	Unlikely. No evidence of internal dispersal

801	Prolific seed production (>1000/m2)	y
	Source(s)	**Notes**
	Ogle, C. C., de Lange, P., Cameron, E. K., Parris, B. S., & Champion, P. D. (2021). Checklist of dicotyledons, gymnosperms and pteridophytes Naturalised or Casual in New Zealand: Additional records 2007–2019. Perspectives in Biosecurity, 5, 45–116	"In New Zealand, this species has yet to be seen fertile, though it spreads very quickly vegetatively via an extensive underground network of black, wiry, easily detached rhizomes which produce numerous young plants."
	Staples, G.W. & Herbst, D.R. (2005). A Tropical Garden Flora - Plants Cultivated in the Hawaiian Islands and Other Tropical Places. Bishop Museum Press, Honolulu, HI	"Vegetable fern needs no special care in Hawaii and is easily propagated by spores." [Spores presumably produced in great abundance]
	Crouch, N. R., & Klopper, R. R. (2010). Pteridophyta. Bothalia, 40(1), 71-72	[Rare in South Africa] "It grows mostly in disturbed areas, exposed or in partial shade but always in wet sites such as streambanks (Roux 2001), where it forms large clonal colonies due to prolific root budding. Sporing in South Africa is evidently rare; close examination of large colonies at Kirstenbosch (Cape Town), Pietermaritzburg and Durban surrounds over several years has revealed only three plants bearing sori."

802	Evidence that a persistent propagule bank is formed (>1 yr)	
	Source(s)	**Notes**
	WRA Specialist. (2024). Personal Communication	Unknown

803	Well controlled by herbicides	
	Source(s)	**Notes**
	WRA Specialist. (2024). Personal Communication	Unknown. No information on herbicide efficacy or chemical control of this species

804	Tolerates, or benefits from, mutilation, cultivation, or fire	
	Source(s)	**Notes**
	Crouch, N. R. (2012). Ferns of Southern Africa. Struik Nature, Cape Town, South Africa	"Once colonies are established, erosive flooding events disperse root buds and plantlets which then establish further downstream, often on sandbanks in seasonally flooded rivers." [Ability to spread and establish from vegetative fragments following flooding suggests this fern will tolerate other physical damage associated with mechanical control efforts]
	De Winter, W.P. and Amoroso, V.B. (eds.). (2003). Plant Resources of South-East Asia No 15(2). Cryptogams: Ferns and fern allies. Backhuys Publishers, Leiden, The Netherlands	"Vegetative propagation is possible by runners and rhizome parts with buds in D. esculentum" [Unknown, but may be able to recover from physical damage]

805	Effective natural enemies present locally (e.g. introduced biocontrol agents)	

Qsn #	Question	Answer
	Source(s)	**Notes**
	Oppenheimer, H. (2007). New plant records from Molokaʻi, Lānaʻi, Maui, and Hawaiʻi for 2006. Bishop Museum Occasional Papers 96:17-34	[Probably not. Widely established. Limiting factors likely climatic, rather than biotic] "Reported from Kauaʻi, Oʻahu, Länaʻi, Maui, and Hawaiʻi, Palmer (2003: 125) suspected it also occurred on Molokaʻi but remained undocumented. Wilson (1996: 132), also assumed it occurred on Molokaʻi, and considered its undocumented presence there as simply the failure of collectors to take a specimen of this weedy fern. Since it is wind dispersed (Staples et al. 2000: 18) it is not surprising that it is also established on Molokaʻi. Material examined. MOLOKAʻI: Wailau Valley, large clump along Kahawaiiki Stream, 6 m, 12 Aug 2005, Oppenheimer H80503."

Summary of Risk Traits:

Diplazium esculentum (vegetable fern) is a fern native to tropical Asia, ranging eastward to the islands of the South Pacific, where it grows near waterways and in moist or wet ground in open, disturbed areas. The tender young uncoiling fronds are served raw in salads, cooked as a vegetable, or added to stir-fried dishes or stews. The most commonly eaten fern throughout its native range, vegetable fern was probably introduced to Hawai'i as a food plant in the late 1800s or early 1900s and has since escaped cultivation and become naturalized on the larger islands. Although it can spread aggressively by rhizomes and spores, and form large, untidy, straggly stands in shady valleys with wet, swampy soils, it is typically found in lower, non-native dominated ecosystems where its impacts on native biodiversity may be limited.

High Risk / Undesirable Traits
• Thrives and spreads in regions with tropical climates
• Naturalized on Kauai, Oahu, Molokai, Lanai, Maui, and Hawaii (Hawaiian Islands) and elsewhere in the tropics
• An aggressive, weedy fern that may impact agriculture or the natural environment
• May compete with or impact certain endangered plants in the Hawaiian Islands, although not conclusively implicated in specific, detrimental effects
• Other Desmodium species are invasive weeds
• Shade tolerant
• Forms dense, monotypic stands
• Reproduces by spores and vegetatively by rhizomes and fragments
• Spores dispersed by wind and intentional cultivation
• Rhizomes and fragments dispersed by water and intentional cultivation

Low Risk Traits
• Occurs primarily in lower elevation, non-native dominated habitats in the Hawaiian Islands, where impacts to native ecosystems and species may be limited
• Unarmed (no spines, thorns, or burrs)
• Valued for its edible fronds
• Non-toxic