

5-YEAR REVIEW

Short Form Summary

Species Reviewed: *Marsilea villosa* ('ihi'ihii)

Current Classification: Endangered

Federal Register Notice announcing initiation of this review:

[USFWS] U.S. Fish and Wildlife Service. 2018. Endangered and threatened wildlife and plants; initiation of 5-year status reviews for 18 species in Hawaii, Oregon, Washington, Idaho, and Canada. Federal Register 83(14): 3014–3015, January 22, 2018.

Lead Region/Field Office:

Region 1/Pacific Islands Fish and Wildlife Office (PIFWO), Honolulu, Hawai'i

Name of Reviewers:

Cheryl Phillipson, Biologist, PIFWO

Lauren Weisenberger, Plant Recovery Coordinator, PIFWO

Gregory Koob, Conservation & Restoration Team Manager, PIFWO

Methodology used to complete this 5-year review:

This review was conducted by staff of the Pacific Islands Fish and Wildlife Office (PIFWO) of the U.S. Fish and Wildlife Service (USFWS) beginning in January 2018. The review was based on a review of current, available information since the last 5-year review for *Marsilea villosa* (USFWS 2011). The evaluation by Cheryl Phillipson, Biologist, was reviewed by Lauren Weisenberger, Plant Recovery Coordinator, and Gregory Koob, Conservation and Restoration Team Manager.

Background:

For information regarding the species listing history and other facts, please refer to the Fish and Wildlife Service's Environmental Conservation On-line System (ECOS) database for threatened and endangered species (http://ecos.fws.gov/tess_public).

Review Analysis:

Please refer to the previous 5-year review for *Marsilea villosa* published in the Federal Register on August 29, 2011 (available at https://ecos.fws.gov/docs/five_year_review/doc3839.pdf) for a complete review of the species' status, threats, and management efforts. We are not aware of any significant new information regarding the species' biological status since listing to warrant a change in the Federal listing status of *M. villosa*.

This short-lived fern in the Marsileaceae (water clover fern) family is endangered and found on Moloka'i and O'ahu, and historically on Ni'ihau. The current status and trends for *Marsilea villosa* are provided in the tables below.

New Status Information:

- The latest review of the species by IUCN in 2016 reported three subpopulations on O‘ahu and three subpopulations on Moloka‘i. Because of its clonal growth form, the number of individuals was not determined (Chau *et al.* 2016).
- In 2012, a report on the O‘ahu and Moloka‘i populations indicated there were at least three populations on Moloka‘i (Kamāka‘ipō, Ka‘a, and Ka‘eo) and at least three populations on O‘ahu (Lualualei, Koko Head, and Makapu‘u) (Chau 2012).
- In 2012, critical habitat was designated in four units in two ecosystems (coastal and lowland dry) on O‘ahu (126 ac, 52 ha) and in 2016 critical habitat was designated in seven units in the coastal ecosystem on Moloka‘i (3,850 ac, 1,562 ha) for *M. villosa* (77 FR 57648, September 18, 2012; 81 FR 17790, March 30, 2016).

New Threats:

- Climate change loss or degradation of habitat—Climate change may pose a threat to this species. Fortini *et al.* (2013) conducted a landscape-based assessment of climate change vulnerability for native plants of Hawai‘i using high resolution climate change projections. Climate change vulnerability is defined as the relative inability of a species to display the possible responses necessary for persistence under climate change. The assessment by Fortini *et al.* (2013) concluded that *Marsilea villosa* is highly vulnerable to the impacts of climate change, with a vulnerability score of 0.872 (on a scale of 0 being not vulnerable to 1 being extremely vulnerable to climate change). In addition, this species has no overlap between current and future climate envelopes, and is unlikely to tolerate expected changes in climate at its current location. This means that this species must persist within suitable microrefugia, or move to newly available climate-compatible areas to avoid extinction. Therefore, additional management actions are needed to conserve this taxon into the future, such as locating key microsites that overlap with current and future climate envelopes for outplanting efforts.

New Management Actions:

- Surveys and monitoring—Comprehensive surveys for rare plants in the Lualualei Radio Transmitting Facility were conducted by the U.S. Navy in 2011, including for *Marsilea villosa* (Williams 2011, in litt.). Two new small subpopulations were identified in the western field of the facility. The larger population covered an area of about 2.5 ac (1 ha).
- Ungulate monitoring and control—In response to the proposal of critical habitat, the U.S. Navy’s addendum to the Integrated Natural Resources Management Plan (INRMP) for Joint Base Pearl Harbor-Hickam (JBPHH) (2012) includes an objective to monitor, control, and exclude feral ungulates (install fencing) from the Navy’s Special Management Areas on O‘ahu, including the area in Lualualei where *M. villosa* occurs.
- Invasive plant monitoring and control—The U.S. Navy’s addendum to the JBPHH INRMP (2012) also outlines strategies to meet management goals at Lualualei on O‘ahu and indicates plans to install fencing and remove invasive species to protect endemic plant species, including *M. villosa*.

- Captive propagation for genetic storage and reintroduction—
 - The Lyon Arboretum Seed Conservation Laboratory reports more than 300 sporocarps in storage collected from a population at Koko Head and more than 700 sporocarps in storage collected from three subpopulations at Makapu‘u on O‘ahu (Lyon Arboretum 2017).
 - The Division of Forestry and Wildlife’s Dillingham Nursery reports one plant in storage from Kaiwi (Makapu‘u) on O‘ahu (Dillingham 2015).
 - Maui Nui Botanical Garden (MNBG) reports 20 individuals from O‘ahu and Moloka‘i populations in 2013; 12 in 2014; five plants from Moloka‘i at the garden in 2015, and currently 25 plants from Moloka‘i in 2018 (MNBG 2013, 2014, 2015, 2018).
 - Waimea Valley Arboretum reports four plants from O‘ahu and Moloka‘i in storage in 2017 (Waimea Arboretum 2017).
- Population biology research—A study showed that the combination of flooding and shade treatments promoted the greatest increase in growth and the effect increased over time (Chau 2012). The study also showed that there were likely two colonization events for this species, the first on O‘ahu and the second on Moloka‘i (likely from the O‘ahu source) (Chau 2012). The maintenance of moderately high levels of variation within populations (as well as subpopulations) is likely the result of interplay between rare to occasional dispersal and extensive clonal growth (Chau 2012).
- Habitat and natural process management and restoration—*Marsilea villosa* occurs at Ka‘a seasonal wetland on the Mokio Preserve on northwest Moloka‘i (Moloka‘i Land Trust 2011, in litt.). Restoration efforts for this area are ongoing, and removal of nonnative plants will benefit *M. villosa*.

Synthesis:

Currently, there are approximately three populations of *Marsilea villosa* on Moloka‘i and two wild populations and one introduced population (at Makapu‘u) on O‘ahu. A landscape-based assessment of climate change vulnerability for native plants of Hawai‘i using high resolution climate change projections was made by Fortini *et al.* (2013) and their analysis showed that *M. villosa* is highly vulnerable to the effects of climate change, in that there will be a smaller area of suitable habitat available for the species in the near future. In addition, this species has no overlap between current and future climate envelopes, and is unlikely to tolerate expected changes in climate at its current location and must persist within suitable microrefugia, or move to newly available climate-compatible areas to avoid extinction. Most populations are represented in collections.

Stabilizing (interim), downlisting, and delisting objectives were provided in the Recovery Plan for *Marsilea villosa* (USFWS 1996), and have been updated according to the draft revised recovery objective guidelines developed by the Hawai‘i and Pacific Plants Recovery Coordinating Committee (HPPRCC 2011). The HPPRCC identifies an additional initial objective, the Preventing Extinction Stage, in addition to the Interim Stabilization, Delisting, and Downlisting objectives. Furthermore, life history traits such as breeding system, population size fluctuation or decline, and reproduction type (sexual or vegetative), have been included in the calculation of goals for the number of

populations and reproducing individuals for each stage. The goals for each stage remain grouped by life span defined as annual, short-lived perennial (fewer than 10 years), or long-lived perennial.

Marsilea villosa is a short-lived perennial fern with sexual reproduction (obligate outcrosser) dependent on seasonal flooding. To prevent extinction, which is the first step in recovering the species, the taxon must be managed to control threats (*e.g.*, fenced) and have 50 individuals (or the total number of individuals if fewer than 50 exist) from each of three populations represented in *ex situ* (secured off-site, such as a nursery or seed bank) collections. In addition, a minimum of three populations should be documented on Moloka‘i and O‘ahu. Each of these populations must be naturally reproducing (*i.e.*, viable gametophytes, spores, sporophytes) and increasing in number, with a minimum of 150 mature, reproducing individuals per population.

The preventing extinction goals for this species have not been met, there are only two populations of at least 150 individuals, genetic representation is not complete (Table 1), and all threats are not being sufficiently managed throughout the range of the species (Table 2). Therefore, *Marsilea villosa* meets the definition of Endangered as it remains in danger of extinction throughout its range.

Recommendations for Future Actions:

We are not aware of any new threats or significant new information regarding the species’ biological status since the last 5-year review in 2011. Thus, the following recommendations for future actions are reiterated for the 5-year review for 2018.

- Population viability and monitoring—Continue to monitor known localities and suitable habitat areas on Moloka‘i and O‘ahu through seasonal fluctuations.
- Ungulate monitoring and control—Construct and maintain exclusion fences to protect *Marsilea villosa* from the impacts of feral ungulates on O‘ahu and Moloka‘i.
- Invasive plant monitoring and control—Continue to control established ecosystem-altering nonnative invasive plant species around all populations.
- Captive propagation for genetic storage and reintroduction—
 - Continue collection of genetic resources for storage, propagation, and reintroduction into protected suitable habitat within historical range.
 - Evaluate genetic resources currently in storage to determine the need to place additional material into long-term storage due to this species’ vulnerability to climate change.
 - Research long-term viability of *M. villosa* spores.
 - Continue to research population biology to determine the best strategies for reintroduction and assurance of sexual reproduction as well as clonal growth.
- Reintroduction and translocation—

- Augment current populations and reintroduce individuals into suitable habitat within historical range that is being managed for known threats to this species.
- Research best management practices including the use of mowing to reduce competition by invasive grasses.
- Fire destruction or degradation of habitat—Develop and implement fire prevention and management plans for O‘ahu and Moloka‘i.
- Climate change adaptation strategy—Research the suitability of habitat for reintroducing this species in the future due to impacts of climate change. Develop a strategy for preventing the extinction of this species if no suitable habitat is predicted in the future.
- Alliance and partnership development—Work with the Hawai‘i Division of Forestry and Wildlife, the U.S. Navy, The Nature Conservancy, Moloka‘i Land Trust, and other land managers to initiate planning and contribute to the implementation of ecosystem-level restoration and management to benefit this species.

Table 1. Status and trends of *Marsilea villosa* from listing through current 5-year review.

Date	No. wild individuals	No. outplanted	Stability Criteria identified in Recovery Plan	Stability Criteria Completed?
1992 (listing)	Unknown number in 7 x 25-ft area	0	All threats managed in all six populations	No
			Two successive floods resulting in sexual reproduction	Unknown
			Six geographically distinct self-sustaining populations	No
1996 (recovery plan)	Unknown, area totaling 6–10 acres	Unknown	All threats managed in all six populations	No
			Two successive floods resulting in sexual reproduction	Unknown
			Six geographically distinct self-sustaining populations	No

2003 (critical habitat, none designated)	Unknown	Unknown	All threats managed in all six populations	No
			Two successive floods resulting in sexual reproduction	Unknown
			Six geographically distinct self-sustaining populations	No
2011 (5-year review)	1,000s	Unknown	All threats managed in all six populations	No
			Two successive floods resulting in sexual reproduction	Unknown
			Six geographically distinct self-sustaining populations	Unknown, not self-sustaining
2012 (critical habitat)	Unknown (O'ahu)	0	All threats managed in all six populations	No
			Two successive floods resulting in sexual reproduction	Unknown
			Six geographically distinct self-sustaining populations	No
2016 (critical habitat)	1,000s (Moloka'i)	0	All threats managed in all six populations	No
			Two successive floods resulting in sexual reproduction	Partially
			Six geographically distinct self-sustaining populations	Yes, but not self-sustaining
Date	No. wild individuals	No. outplanted	*Preventing Extinction Criteria identified by HPPRCC	*Preventing Extinction Criteria Completed?

2018 (5-year review)	Unknown (O‘ahu) 1,000+ (Moloka‘i)	0	All threats managed in all three populations	Partially
			Complete genetic storage	Partially
			Reproduction (<i>i.e.</i> viable sporocarps) at all three populations	Unknown
			Three populations with 150 mature individuals each	Partially, one large population each on Moloka‘i and O‘ahu

* The Preventing Extinction Stage was established in 2011. Prior to 2011, the Interim Stabilization Stage was the first stage towards recovery (now it is the second after Preventing Extinction).

Table 2. Threats to *Marsilea villosa* and ongoing conservation efforts.

Threat	Listing factor	Current Status	Conservation/ Management Efforts
Ungulate degradation of habitat	A	Ongoing	None
Established ecosystem altering invasive plant species degradation of habitat	A	Ongoing	Partially, some nonnative plant control
Development destruction and degradation of habitat	A	Ongoing	None
Climate change degradation or loss of habitat	A	Ongoing	None
Fire destruction and degradation of habitat	A	Ongoing	Partially, at Koko Head on Oahu
Drought degradation of habitat	A	Ongoing	None
Human disturbance—Trampling by hikers and off-road vehicles	E	Ongoing	Partially, barrier and signage at Koko Head on O‘ahu
Stochastic events—Reduced viability due to low numbers	E	Ongoing	Partial, cuttings and sporocarp collection and storage

References:

See the previous 5-year review for a full list of references (USFWS 2011). Only references for new information are provided below.

Chau, M.M. 2012. Conservation of the endangered Hawaiian fern ‘Ihi‘ihilauakea (*Marsilea villosa*): a synthesis of experimental restoration, community ecology, and population genetics. Dissertation submitted to the graduate division of the University of Hawai‘i at Mānoa in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Botany. Committee members T.A. Ranker, C. Lepczyk, C. Morden, T. Ticktin, L. Wester. 101 pp.

Chau, M. and J. Kwon. 2016. *Marsilea villosa*. The IUCN Red List of Threatened Species 2016: e.T78777071A115494515. <http://dx.doi.org/10.2305/IUCN.UK.2016-1.RLTS.T78777071A78777074.en>.

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Fortini, L., J. Price, J. Jacobi, A. Vorsino, J. Burgett, K. Brinck, F. Amidon, S. Miller, S. Gon II, G. Koob, and E. Paxton. 2013. A landscape-based assessment of climate change vulnerability for all native Hawaiian plants. Technical report HCSU-044. Hawai‘i Cooperative Studies Unit, University of Hawai‘i at Hilo, Hawai‘i. 134 pp.

[HPPRCC] Hawai‘i and Pacific Plants Recovery Coordinating Committee. 2011. Revised recovery objective guidelines. 8 pp.

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[MNBG] Maui Nui Botanical Garden. 2013. Controlled propagation report.

[MNBG] 2014. Controlled propagation report.

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[MNBG] 2018. Controlled propagation report.

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<http://molokailandtrust.org/mokio.php>.

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https://ecos.fws.gov/docs/five_year_review/doc3839.pdf.

[USFWS] 2012. Endangered and threatened wildlife and plants; Endangered status for 23 species on Oahu and designation of critical habitat for 124 species; final rule. Department of the Interior, Federal Register 77 (181): 57648–57862, September 18, 2012.

[USFWS] 2016. Endangered and threatened wildlife and plants; designation and nondesignation of critical habitat on Molokai, Lanai, Maui, and Kahoolawe for 135 species; final rule. Federal Register 81 (61): 17790–18110, March 30, 2016.

[USFWS] 2018. Endangered and threatened wildlife and plants; initiation of 5-year status reviews for 18 species in Hawaii, Oregon, Washington, Idaho, and Canada. Federal Register 83(14): 3014–3015, January 22, 2018.

U.S. Navy. 2012. Addendum to the integrated natural resource management plan. Joint Base Pearl Harbor-Hickam, Navy Munitions Command East Asia Division Detachment Joint Base, Pearl Harbor-Hickam Lualualei Annex, Naval Radio Transmitter Facility Lualualei, and Kalaeloa (former Naval Air Station Barber’s Point), Oahu, State of Hawaii. 7 pp.

Waimea Arboretum. 2017. Controlled propagation report.

Williams 2011, in litt., Endangered plant survey, NCTAMS Radio Transmitting Facility, Lualualei, HI. 7 pp.

U.S. FISH AND WILDLIFE SERVICE
SIGNATURE PAGE for 5-YEAR REVIEW of *Marsilea villosa* ('ihi'ih)

Pre-1996 DPS listing still considered a listable entity? N/A

Recommendation resulting from the 5-year review:

- Delisting
- Reclassify from Endangered to Threatened status
- Reclassify from Threatened to Endangered status
- No Change in listing status

For Field Supervisor, Pacific Islands Fish and Wildlife Office