

5-YEAR REVIEW

Short Form Summary

Species Reviewed: *Marsilea villosa* (‘ihi‘ihi)

Current Classification: Endangered

Federal Register Notice announcing initiation of this review:

[USFWS] U.S. Fish and Wildlife Service. 2021. Endangered and Threatened Wildlife and Plants; Initiation of 5-Year Status reviews for 77 Species in Oregon, Washington, Idaho, and Hawaii. Federal Register 86(120): 33726–33728, June 25, 2021.

Lead Region/Field Office:

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

Name of Reviewer:

Cheryl Phillipson, Biologist, PIFWO

Lauren Weisenberger, Plant Recovery Coordinator, Acting Recovery 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 (Service) beginning in October 2022. The review was based on a review of current, available information since the last 5-year review for *Marsilea villosa* (USFWS 2018). The evaluation by Cheryl Phillipson, Biologist, was reviewed by Lauren Weisenberger, Plant Recovery Coordinator, and Acting Recovery 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/ecp/species/2169>).

Review Analysis:

Please refer to the previous 5-year reviews for *Marsilea villosa* published in the Federal Register on August 29, 2011, and October 23, 2018 (available at https://ecos.fws.gov/docs/tess/species_nonpublish/1782.pdf and https://ecos.fws.gov/docs/tess/species_nonpublish/2643.pdf) for a complete review of the species’ status, threats, management efforts, and references cited. 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 perennial fern in the Marsileaceae (water clover) family is endangered and occurs on Moloka‘i and O‘ahu. This species has not been observed on Ni‘ihau since 1949. The status and trends for *Marsilea villosa* are provided in the tables below.

New Status Information:

- Currently, there are three wild populations of *Marsilea villosa* on Molokaʻi at Kaʻeo, Kaʻa, and Kamākaʻipō (Chau and Kwon 2016). The largest numbers are at Kaʻa within Mokio Preserve (Molokaʻi Land Trust 2023). On Oʻahu, there are two wild populations: one consisting of six subpopulations in the Naval Radio Transmitter Facility (NRTF) at Lualualei possibly totaling from 1,000 to 3,500 individuals (in clumps or clusters), and one at Koko Head within ʻIhiʻihilauākea crater (Waiʻanae Mountains Watershed Partnership [WMWP] 2022a, 2022b, 2022c, 2022d; 2022e; Chau and Kwon 2016). There is one translocated population (two patches) at Makapuʻu, Oʻahu (Chau 2012). Numbers are highly dependent upon the individuals that may be clonal and the amount of seasonal rainfall and flooding that affects the dormancy (and visibility) of the populations.
- Currently, there are 21 founders (wild plants) from two populations on Oʻahu, and possibly four founders from unspecified populations on Molokaʻi, represented in *ex situ* storage and propagation.

New Threats:

- None reported.

New Management Actions:

- Monitoring and surveys—The WMWP implements management actions for the Navy’s compliance with the Integrated Natural Resources Management Plan (INRMP) on Oʻahu. Subpopulations of *Marsilea villosa* within the Lualualei NRTF are monitored quarterly and flooding and heavy rain events are noted (WMWP 2022a, 2022b, 2022c, 2022d, 2022e).
- Ungulate monitoring and control—In 2022, the Plant Extinction Prevention Program (PEPP) reported checking the status of a fence on Molokaʻi and stated that evidence of much deer activity was observed (PEPP 2022, pp. 7, 28).
- Invasive nonnative plant control—In 2022, the WMWP conducted nonnative plant control (without herbicide) at three subpopulations in Lualualei (WMWP 2022a, p. 3, 2022b, p. 2, 2022e, p. 2). After monitoring, the *Marsilea villosa* population in the south west corner, the weed mat (used to suppress invasive grasses and fire during the dry months) was removed in the wet season to allow rhizomes to spread naturally (WMWP 2022a, p. 2).
- Fire management—The wildfire management plan was finalized and the first Lualualei Wildland Fire Management Working group meeting was held (Naval Facilities Engineering Systems Command [NAVFAC] 2022). Plans were made to set up a roadside vegetation management committee and interdepartmental drills.
- Rodent control—In 2022, the WMWP conducted rodent control at two subpopulations of *M. villosa* in Lualualei (WMWP 2022b, p. 2, 2022e, p. 3).
- Collection and propagation for genetic storage and translocation—
 - In 2021, the Maui Nui Botanical Garden (MNBG) reported one *ex situ* plant representing one founder from Mokio, Molokaʻi, in a living collection, and 13 plants propagated from cuttings of nursery material sourced from Mokio (MNBG 2021).
 - In 2022, the National Tropical Botanical Garden (NTBG) reported one clone of an individual stored at Lyon Arboretum (representing one founder from

- Moloka‘i) and 35 plants propagated from the same founder and stored in the nursery (NTBG 2022). In addition, NTBG reported 32 *ex situ* plants sourced from Moloka‘i in a living collection at the Southshore Garden (NTBG 2022).
- In 2018, the Lyon Arboretum Seed Conservation Laboratory reported storage of 67 sporocarps representing one founder at Koko Head, O‘ahu, 333 sporocarps representing 11 founders at one subpopulation at Lualualei, O‘ahu, and 133 sporocarps representing 9 founders at a second subpopulation at Lualualei (Lyon Arboretum 2022).
 - In 2018, the Waimea Arboretum reported storage of four individuals sourced from O‘ahu (Waimea Arboretum). In 2022, the arboretum reported storage of two plants sourced from Moloka‘i, and in 2022, an additional four plants from a nursery source (Waimea Arboretum 2022).

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 6 populations	No
			Two successive floods resulting in sexual reproduction	Unknown
			6 geographically distinct self-sustaining populations	No
2011 (5-year review)	1,000s	Unknown	All threats managed in all 6 populations	No
			Two successive floods resulting in sexual reproduction	Partially
			6 geographically distinct self-sustaining populations	No

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 3 populations	Partially
			Reproduction (i.e., viable seeds, seedlings) at all 3 populations	Unknown
			Complete genetic storage	Partially
			3 populations with 150 mature individuals each	Partially, 1 population each on O‘ahu and
2023 (5-year review)	1,000–3,500 (O‘ahu) 1,000+ (Moloka‘i)		All threats managed in all 3 populations	Partially, some nonnative plant control
			Complete genetic storage	Partially
			Natural reproduction at all 3 populations	Unknown
			3 populations with 300 mature individuals each	Partially, Lualualei (O‘ahu) and Ka‘a (Moloka‘i)

* 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 stage after Preventing Extinction).

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

Threat	Listing factor	Current Status	Conservation/ Management Efforts
Destruction and degradation of habitat by feral ungulates	A	Ongoing	Partial, 1 O‘ahu population in a managed area

Established ecosystem altering invasive plant species degradation of habitat	A	Ongoing	Partial, invasive nonnative plant control at Mokio Preserve and Lualualei
Destruction and degradation of habitat by development	A	Ongoing	None
Climate change degradation or loss of habitat	A	Ongoing	None
Destruction and degradation by fire	A	Ongoing	Partial, fire management plan for Lualualei
Destruction and degradation by drought	A	Ongoing	None
Human disturbance—Trampling by hikers and off-road vehicles	E	Ongoing	Partial, barrier and signage at Koko Head on O‘ahu, management at Mokio Preserve
Reduced viability due to low numbers	E	Ongoing	Partial, sporocarp and living collections

Synthesis:

Currently, there are two wild populations on O‘ahu and three wild populations on Moloka‘i. Numbers of individuals are difficult to estimate as local hydrologic conditions vary from place to place and from year to year, with plants not visible during the dry season. Lualualei subpopulation estimates may currently be higher reflecting an increase in survey efforts. Threats including habitat degradation by feral ungulates, and impacts of nonnative invasive plants, and low numbers, are only partially addressed. Drought events are increasing and may affect populations, numbers of individuals, and reproduction. Sporocarp collection from wild individuals from living collections is ongoing; however, genetic representation is incomplete with fewer than 25 founders represented. No translocations or augmentations are conducted.

Stabilizing (interim), downlisting, and delisting objectives are 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, an obligate outcrosser, and is dependent on water and flooding for sexual reproduction. To prevent extinction, which is the first milestone 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 that are well managed. In addition, a minimum of a total of three populations should be documented on O‘ahu and Moloka‘i where they now occur or occurred historically. Each of these populations must be naturally reproducing (i.e., viable seeds, seedlings) with a minimum of 300 mature, reproducing individuals per population.

The preventing extinction goals for this species have not been met. Although there may be one population each on O‘ahu and Moloka‘i of 300 mature, reproducing plants, the number of individuals is difficult to determine because of clonal vegetative growth and visibility and sexual reproduction dependent on flooding events (Table 1). Genetic representation is incomplete with fewer than 25 founders represented (Table 1). There are no current translocation or augmentation efforts ongoing. Not all threats are being managed at all populations including feral ungulates, nonnative invasive plants, drought, fire, climate change, and the small number of individuals and populations (Table 2). Therefore, *Marsilea villosa* meets the definition of Endangered as it remains in danger of extinction throughout its range.

Recommendations for Future Actions:

No significant new information regarding the species’ biological status has been reported since the last 5-year review in 2018. Thus, the following recommendations for future actions are updated or reiterated for the 5-year review for 2023.

- Surveys and monitoring—Continue to survey for additional populations of *Marsilea villosa* in areas of potentially suitable habitat and monitor known populations through seasonal fluctuations.
- Ungulate monitoring and control—Construct and maintain fencing to protect individuals from the negative impacts of feral ungulates.
- Invasive nonnative plant monitoring and control—Continue to control established ecosystem-altering nonnative invasive plant species around all populations.
- Climate change adaptation strategy—Assess the modeled effects of climate change on this species to determine future landscape required for its recovery and research the suitability of habitat for translocation efforts.
- Fire prevention and control—Continue to develop and implement fire prevention and management plans for all populations on O‘ahu and Moloka‘i.
- Captive propagation for genetic storage and reintroduction—
 - Continue collection and propagation efforts for maintenance of genetic stock and for translocation.

- 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 storage viability of sporocarps.
- Translocation and augmentation—
 - Augment current populations and translocate individuals into suitable habitat within historic range that is being managed for known threats to this species.
 - Research best management practices including the use of mowing to reduce competition with invasive nonnative grasses.
 - Continue to study population biology to determine the best strategies for translocation and assurance of flooding events for sexual reproduction as well as clonal growth.
- Build resiliency, redundancy, and representation—Increase numbers of populations and individuals throughout historic range to reduce impacts of drought, reduced viability, and continued loss of suitable habitat.
- Alliance and partnership development—Continue to work with partners and other land managers in planning and implementation of ecosystem-level restoration and management to benefit this taxon.

References:

- 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>.
- [HPPRCC] Hawai'i and Pacific Plants Recovery Coordinating Committee. 2011. Revised recovery objective guidelines. 8 pp.
- Lyon Arboretum. 2022. Report on controlled propagation of listed species, as designated under the U.S. Endangered Species Act. Unpublished report submitted to the U.S. Fish and Wildlife Service, Pacific Islands Fish and Wildlife Office, Honolulu, Hawai'i.
- [MNBG] Maui Nui Botanical Garden. 2021. Report on controlled propagation of listed species, as designated under the U.S. Endangered Species Act. Unpublished report submitted to the U.S. Fish and Wildlife Service, Pacific Islands Fish and Wildlife Office, Honolulu, Hawai'i.

- Moloka‘i Land Trust. 2023. Mokia Preserve. <https://molokailandtrust.org/the-mokia-preserve>.
- [NTBG] National Tropical Botanical Garden. 2022. Report on controlled propagation of listed species, as designated under the U.S. Endangered Species Act. Unpublished report submitted to the U.S. Fish and Wildlife Service, Pacific Islands Fish and Wildlife Office, Honolulu, Hawai‘i.
- [NAVFAC] Naval Facilities Engineering Systems Command. 2022. Progress report: Lualualei management goals, reporting period October 2021-March 2022. 2 pp.
- [PEPP] Plant Extinction Prevention Program. 2022. Plant Extinction Prevention Program fiscal year 2022 interim performance report (October 1, 2021-September 30, 2022), Cooperative Agreement F19AC00532 (Interim report), U.S. Fish and Wildlife Service CFDA Program #15.657 Endangered Species Conservation—Recovery Implementation Funds, University of Hawai‘i at Mānoa, Pacific Cooperative Studies Unit, Plant Extinction Prevention Program. 50 pp.
- [USFWS] U.S. Fish and Wildlife Service. 1996. Recovery Plan for *Marsilea villosa*. 54 pp.
- [USFWS] 2011. *Marsilea villosa* 5-year review summary and evaluation. USFWS Pacific Islands Fish and Wildlife Office, Honolulu, HI.
https://ecos.fws.gov/docs/tess/species_nonpublish/1782.pdf.
- [USFWS] 2018. *Marsilea villosa* 5-year review summary and evaluation. USFWS Pacific Islands Fish and Wildlife Office, Honolulu, HI.
https://ecos.fws.gov/docs/tess/species_nonpublish/2643.pdf.
- [USFWS] 2021. Endangered and Threatened wildlife and plants; initiation of 5-year status reviews for 77 Species in Oregon, Washington, Idaho, and Hawaii. Federal Register 86(120): 33726–33728, June 25, 2021.
- [WMWP] Wai‘anae Mountains Watershed Partnership. 2022a. Navy T & E quarterly report, performance progress report SF-PPR, January 31. Federal Grant @9126G-21-2-0024, September 2021-September 2022, C. Morden, University of Hawai‘i, Pacific Cooperative Studies Unit, Honolulu. 19 pp.
- [WMWP] 2022b. Navy T & E quarterly report, performance progress report SF-PPR, March 31. Federal Grant @9126G-21-2-0024, September 2021-September 2022, C. Morden, University of Hawai‘i, Pacific Cooperative Studies Unit, Honolulu. 13 pp.
- [WMWP] 2022c. Navy T & E quarterly report, performance progress report SF-PPR, June 30. Federal Grant @9126G-21-2-0024, September 2021-September 2022, C.

- Morden, University of Hawai'i, Pacific Cooperative Studies Unit, Honolulu. 20 pp.
- [WMWP] 2022d. Draft *Marsilea villosa* management plan. Prepared for Navy Region Hawaii, Lualualei Naval Magazine Pearl Harbor, Naval Radio Transmitter Facility, August 2022 draft. 28 pp.
- [WMWP] 2022e. Navy T & E quarterly report, performance progress report SF-PPR, October 31. Federal Grant @9126G-21-2-0024, September 2021-September 2022, C. Morden, University of Hawai'i, Pacific Cooperative Studies Unit, Honolulu. 15 pp.
- Waimea Arboretum. 2018. Report on controlled propagation of listed species, as designated under the U.S. Endangered Species Act. Unpublished report submitted to the U.S. Fish and Wildlife Service, Pacific Islands Fish and Wildlife Office, Honolulu, Hawai'i.
- Waimea Arboretum. 2022. Report on controlled propagation of listed species, as designated under the U.S. Endangered Species Act. Unpublished report submitted to the U.S. Fish and Wildlife Service, Pacific Islands Fish and Wildlife Office, Honolulu, Hawai'i.

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

_____ Date _____