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. 2009. Endangered and threatened wildlife and plants; initiation of 5-year reviews of 103 species in Hawaii. Federal Register 74(49):11130-11133.

Lead Region/Field Office:

Region 1/Pacific Islands Fish and Wildlife Office (PIFWO), Honolulu, Hawaii

Name of Reviewer(s):

Marie Bruegmann, Plant Recovery Coordinator, PIFWO
Jess Newton, Recovery Program Lead, PIFWO
Assistant Field Supervisor for Endangered Species, PIFWO

Methodology used to complete this 5-year review:

This review was conducted by staff of the Pacific Islands Fish and Wildlife Office of the U.S. Fish and Wildlife Service (USFWS), beginning on March 16, 2009. The review was based on final critical habitat designation for *Marsilea villosa* and other species from the island of Oahu and Molokai (USFWS 2003a, b), as well as a review of current, available information. The National Tropical Botanical Garden provided an initial draft of portions of the review and recommendations for conservation actions needed prior to the next five-year review. The evaluation of Tamara Sherrill, biological consultant, was reviewed by the Plant Recovery Coordinator. The document was then reviewed by the Recovery Program Lead and the Assistant Field Supervisor for Endangered Species before submission to the Field Supervisor for approval.

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).

Application of the 1996 Distinct Population Segment (DPS) Policy:

This Policy does not apply to plants.

Review Analysis:

Please refer to the final critical habitat designation for *Marsilea villosa* published in the Federal Register on March 18 and June 17, 2003 (USFWS 2003a, b) for a complete review of the species’ status (including biology and habitat), threats, and management efforts. No new threats and no significant new information regarding the species biological status have come to light since listing to warrant a change in the Federal listing status of *M. villosa*.

Marsilea villosa was first listed as endangered in 1992 (USFWS 1992). The biology and life history of *Marsilea villosa* is described in some detail in the recovery plan (USFWS 1996), and a 2006 publication describes its population dynamics (Wester *et al.* 2006). This species has an unusual reproductive cycle, in which the reproductive spores are found in hard sided sporocarps that protect the spores during dry periods, and release them after a flooding event has occurred. In the Marsileaceae (water-clover family) the sporocarp is an elaborate structure formed from an entire leaf whose development and form is greatly modified into hairy, short-stalked, bean-shaped structures (usually 3 to 8 millimeters in diameter) with a hardened outer covering which resists drying out, and allows the spores inside to survive desiccation. The sporocarps will open readily in water if conditions are favorable, and spores of some *Marsilea* species have been successfully germinated after being stored for more than 100 years (Wester *et al.* 2006). At the end of each growing season, multiple sporocarps can develop at each node of the rhizome, at the base of leaf stalks (M. Chau, University of Hawaii, pers. comm. 2010). Because *Marsilea villosa* has a clumping growth habit, spreads by rhizomes, dies back when dry, resurrects itself in moist conditions from dormant rhizomes, and reproduces sexually only in flooding conditions, it is difficult to estimate the number of individuals in a clump or population (USFWS 1996). Some of the Molokai populations located near Mokio Point are found growing in non-typical sloped habitat along dry drainages (B. Garnett, Wiliwili Rare Plant Nursery, pers. comm. 2010).

Marsilea villosa is a fern which is endemic to Hawaii. While it has been reported from several islands, when USFWS wrote the recovery plan for *Marsilea villosa* in 1996, it was known to exist only in three populations on Oahu and two small populations on Molokai (USFWS 1996). Currently, there are two naturally occurring and two reintroduced populations on Oahu and ten populations on Molokai containing possibly a total of more than a thousand individuals. On Oahu, it is naturally occurring at Koko Head (Ihiihilauakea Crater) and Lualualei. There are also two reintroduced populations on Oahu, one planted in 2002 at Hanauma Bay, and one planted in the 1980s within its historic range at Makapuu. The reintroduced Hanauma Bay population receives regular watering on the park's lawn, stays green most of the year, and floods during heavy storms. It is a healthy population of several square meters. The reintroduced Makapuu population, where flooding also sometimes occurs, has become well-established and covers a large area (M. Chau, pers. comm. 2010). The total area covered by *Marsilea villosa* at Koko Head in 2004 was reduced from that in earlier reports, in spite of an unusually wet season that produced short-term flooding. The decline occurred despite protection afforded by the creation of a nature reserve, continued surveillance, and management in the form of infrequent mowing and herbicide treatment of competing grasses (Wester *et al.* 2006). Possible reasons for this decline are discussed below.

In 2004, Joel Lau of the Hawaii Biodiversity and Mapping Program estimated the total number of mature plants at Lualualei to be in the thousands or even tens of thousands (Hawaii Biodiversity and Mapping Program 2009). These individuals of *Marsilea villosa* are found within four subpopulations. The Naval installation at Lualualei reported that the population there has essentially remained unchanged during the years 1994 to 2004, and estimated one population contained between 100 to 150 individuals (Hawaii Natural

Heritage Program 2004). In December 2008, heavy storms flooded the Lualualei population for over two weeks. By January 2009, the largest subpopulation, which had been approximately 100 meters (328 feet) in length, had expanded to over 130 meters (427 feet). Isolated young sporophyte plants were observed, indicating that sexual reproduction is occurring (M. Chau, pers. comm. 2010).

Ten populations are noted to exist on Molokai. A small population was discovered in 1989 at Kamakaipo, north of Laau Point on southwestern Molokai, which was visited in 2004 when about 40 individuals were observed at 3 meters (10 feet) elevation (Wood 2010). The same patch of *Marsilea villosa* plants was observed in 2006 along the road to Laau Point, at 6 meters (20 feet) elevation (Perlman 2010). Another group of populations were rediscovered in 1994 near Mokio Point on northwestern Molokai (USFWS 1996). The Plant Extinction Prevention Program's Molokai Coordinator, Ane Bakutis, estimated in 2009 that there were five populations of *Marsilea villosa* at Ilio Point and Mokio Point, and in February 2009, Bill Garnett mapped a total of nine populations in the same area, in patches from 6 square meters (20 square feet) to over 0.8 hectares (2 acres) in size (S. Aruch, Natural Resources Data Solutions, pers. comm. 2010; A. Bakutis, Plant Extinction Prevention Program, pers. comm. 2009; B. Garnett, pers. comm. 2010).

Marsilea villosa has not been reported from the island of Niihau since 1949, when it was observed by Harold St. John at Loe Lake, 3.2 kilometers (2 miles) north of Puuwai, the principal settlement on the island (USFWS 1996). The coastal area which is periodically flooded, which is the most appropriate habitat for this fern, is also the area of most settlement (M. DeMotta, National Tropical Botanical Garden, pers. comm. 2010).

A study to assess genetic variation in *Marsilea villosa* is currently being conducted at the University of Hawaii, but results have been inconclusive thus far. Since *M. villosa* is dispersed primarily by water, it is hypothesized that genetic variation will be high among populations. High levels of differentiation might indicate restricted gene flow between populations, and are also often associated with high levels of clonal growth and/or inbreeding. Knowledge of genetic structure will be essential to any efforts to restore *M. villosa* by reintroduction or augmentation (M. Chau, pers comm. 2010).

Marsilea villosa is found in areas that flood periodically, such as small depressions and flood plains with clay soils. Standing water is required for sexual reproduction, and drying is required for new plant establishment and for sporocarp maturation (see below). This species is restricted to low elevations. Shading by canopy trees has been noted to reduce its vigor (USFWS 1996).

On Molokai's southwest corner at Kamakaipo near Laau Point, the habitat where *Marsilea villosa* occurs is dominated by introduced invasive herbs and grasses, and is connected to a coastal dry mixed *Prosopis pallida* (kiawe) and *Verbesina encelioides* (golden crown-beard) community with grassland and herbs along the shoreline with native plant species such as *Cressa truxillensis* (no common name [NCN]), *Gossypium tomentosum* (mao), *Heteropogon contortus* (pili grass), *Jacquemontia ovalifolia* subsp. *sandwicensis* (pau-o-Hiiaka), *Sida fallax* (ilima), and *Waltheria indica* (uhaloa) (Wood

2010). In the populations near Mokio Point on Molokai, *M. villosa* is associated with native plant species such as *Schenkia sebaeoides* (awiwi), *Sida fallax* (iima), *Panicum torridum* (kakonakona), and *Heteropogon contortus* (B. Garnett, pers. comm. 2010). On Oahu the only native associated plant species reported to occur with *M. villosa* is *Sida fallax* (Hawaii Natural Heritage Program 2004).

Threats to *Marsilea villosa* are destruction of natural hydrology, narrow habitat requirements, and small population sizes (Listing Factor E) (USFWS 1996). Two populations on Oahu, at Mokapu and one at Lualualei, burned in fires in 2005 (Listing Factor E) (Wester *et al.* 2006). Fire in the dry areas of West Molokai is a threat, and a major fire occurred in that region in 2009.

Trampling by cattle (*Bos taurus*) (Listing Factor A) was considered a threat in Lualualei. Feral axis deer (*Axis axis*) and cattle are also a threat in some areas of West Molokai (Listing Factors A, C, and D) (USFWS 1996). The relationship between cattle and *Marsilea villosa* is debated among ecologists. In Australia, a different *Marsilea* species was negatively affected by cattle grazing. But a subpopulation at Lualualei did poorly when cattle were removed, and thrived after the cattle returned. Cattle appeared to be selectively eating grasses and did not eat *M. villosa*. It is possible that *M. villosa* benefits more from the reduced competition as taller-growing grasses are grazed, and suffers less from the effects of being eaten (Wester *et al.* 2006). Another observer however, notes that of the two habitats on Niihau where *M. villosa* may be presumed to have grown in the past, the one which is most impacted by cattle tramping through deep water is the one least likely to support the development of new plants. However, regular visits and monitoring of these areas of Niihau by botanists rarely occur, thus no reports have been made of recent rediscoveries of *M. villosa* on Niihau, although appropriate habitat still exists (M. DeMotta, pers. comm. 2010).

Competition from invasive introduced plant species and soil erosion due to cattle grazing before 1941 (Listing Factors A and E) have been particularly problematic, in that few native species still exist in these areas where *Marsilea villosa* occurs. The relationship of some of these species to *M. villosa* has changed with changing hydrology over time. Ecological changes may have altered the rate at which the soil dries, which affects the frequency of flooding events essential to *M. villosa* reproduction. In Koko Head, *M. villosa* grew under a canopy of *Prosopis pallida* (kiawe). Over time, stands of *Prosopis pallida* have become fragmented. No new seedlings have been seen in recent surveys, possibly due to the removal of cattle after many decades. With the decline of *P. pallida*, perennial grasses such as *Urochloa maximum* (guinea grass) and *Cenchrus ciliaris* (buffelgrass) began to replace the open space in the bottom of the crater. These two grasses are speculated to increase water loss by transpiration, while the deep-rooted canopy tree species *P. pallida* is more likely to be drawing on different sources of moisture than the shallow-rooted grasses. An increased rate of water loss by transpiration causes the soil to dry faster, reduce soil moisture content, and increase the soil's capacity to absorb extreme rainfall events. As a result, soil surface accumulation and flooding events would decline, which are essential in preventing the establishment of invasive grasses and for spores of *M. villosa* to germinate. While *M. villosa* apparently co-exists

well with lower growing introduced grass *Cynodon dactylon* (Bermuda grass), at this site it depends on extreme flooding events to eliminate *Urochloa maximum* and *Cenchrus ciliaris*. Ephemeral pools resist the invasion of introduced plants better than many other habitats, and thus ferns in the genus *Marsilea* have a competitive advantage in areas that flood regularly. However, in contrast to the relatively consistent seasonal rainfall in North America, the highly irregular occurrence of flooding rains on the dry lowlands of the Hawaiian Islands means that *M. villosa* only rarely has this advantage over its competitors. Flooding events that lasted several weeks at Ihiihilauakea Crater in 2006 virtually eliminated all competitive vascular plants and encouraged *M. villosa* to reproduce both sexually and vegetatively. As long as viable sporocarps are present, the species should be able to reestablish during similar flooding events. *Marsilea villosa* produces long-stemmed, floating leaves when it grows in pools and will also form a dense mat of free-standing leaves and stems at the edge of water bodies as they contract. Once this mat is established over a saturated or moist substrate, seedlings of competing species do not seem to be able to establish themselves. Dense mats of leaves and stems of *M. villosa* that are formed within one year seem to persist over a subsequent dry season, and are able to resist the invasion by competing species the following year (Wester *et al.* 2006).

On Oahu, other invasive introduced plants species occurring within *Marsilea villosa* habitat include *Amaranthus spinosa* (spiny amaranth), *Bidens pilosa* (Spanish needle), *Cenchrus ciliaris*, *Echinochloa* sp. (NCN), *Leonotis* sp. (lion's ear or lion's tail), *Merremia* sp. (hairy convolvulus vine), *Setaria* sp. (foxtail or palmgrass), and *Xanthium strumarium* (cocklebur) (Listing Factors A and E) (Hawaii Biodiversity and Mapping Program 2009; Perlman 2010). At Lualualei on Oahu, there are no native plant species associated with *M. villosa*, but there are at least 24 invasive introduced species (representing 11 plant families), with the most dominant being *Prosopis pallida* (kiawe), *Dichanthium aristatum* (angleton bluestem grass), *Chloris barbata* (swollen fingergrass), and *Leonotis nepetifolia* (lion's tail). Ecological surveys at Lualualei are currently ongoing as part of a research study at the University of Hawaii (M. Chau, pers comm. 2010).

On Molokai, invasive introduced plant species include *Abutilon incanum* (hoary abutilon), *Ageratum conyzoides* (billygoat weed), *Anagallis arvensis* (scarlet pimpernel), *Cenchrus ciliaris*, *Chamaecrista nictitans* (partridge pea), *Digitaria insularis* (sourgrass), *Eragrostis ciliaris* (lovegrass), *E. tenella* (lovegrass), *Lantana camara* (lantana), *Portulaca pilosa* (pigweed), *Prosopis pallida*, *Stachytarpheta jamaicensis* (Jamaica vervain), and *Verbesina encelioides* (Listing Factors A and E) (B. Garnett, pers. comm. 2010; Hawaii Biodiversity and Mapping Program 2009; Wood 2010).

At Koko Head and Makapuu on Oahu, off-road vehicles and increased foot traffic from recreational hiking are impacts to *Marsilea villosa* because the plants often occurs where water pools in depressions created by the tires of vehicles (Listing Factor E) (Hawaii Biodiversity and Mapping Program 2009; USFWS 1996). A sign and barrier have been erected at the entrance to the crater to deter off-road vehicle use of this area (USFWS 1996). This deterrent has been successful, but constant monitoring is needed to maintain

the barriers as traffic from hikers and vehicles can easily disrupt the rhizomes of *M. villosa* and eventually kill the plants (M. Bruegmann 2010).

The greatest threat to the Kamakaipo population on the southwest coast of Molokai was a proposed housing development (Listing Factor E). The proposed development at Laau Point, which could have impacted this species, has been delayed for a number of years (Associated Press 2007). Ilio Point has recently been approved as a new state Natural Area Reserve (Hawaii Department of Land and Natural Resources 2009). This will potentially help protect the habitat of *Marsilea villosa* in this area.

At Koko Head on Oahu, rainfall and the extent of populations of *Marsilea villosa* was carefully tracked from 1988 to 2004. Monitoring results indicated that the area covered by *Marsilea villosa* has decreased during the period of 1988 to 2004 to one percent of what had been recorded a decade before (Wester *et al.* 2006). As discussed previously, hydrology heavily interacts with the ecology of *M. villosa* and its associated species. What additional effects and interactions global climate change might have with seasonal hydrological changes are unknown.

Climate change may also pose a threat to this species (Listing Factors A and E). However, current climate change analyses in the Pacific Islands lack sufficient spatial resolution to make predictions on impacts to this species. The Pacific Islands Climate Change Cooperative (PICCC) has currently funded climate modeling that will help resolve these spatial limitations. We anticipate high spatial resolution climate outputs by 2013.

At Ihiihilauakea Crater (Koko Head) by Hanauma Bay on Oahu, *Marsilea villosa* is monitored and managed as a preserve by volunteers under a cooperative agreement between the City of Honolulu and the County of Oahu, who owns the land and helps to provide necessary materials. In addition, the Nature Conservancy oversees the management of the preserve. Labor is supplied by volunteers from the Ihiihi Protection Team, led by Larry Abbott (Army Environmental Division) and Marian Chau (University of Hawaii), and in collaboration with Hanauma Bay, Oahu Invasive Species Committee, and Sierra Club Hawaii. Volunteers have created and maintained a firebreak around the crater, and continue to manage weeds within the population on a monthly basis (M. Chau, pers. comm. 2010). An educational sign and barrier was erected at the entrance to the crater (USFWS 1996).

The seed storage facility at Lyon Arboretum currently has 12 sporocarps in long-term storage (Center for Conservation Research and Training Seed Storage Facility 2009). The Oahu Division of Forestry and Wildlife has propagules from the reintroduced Makapuu population growing in their nursery (Oahu Division of Forestry and Wildlife Nursery 2009). The Maui Nui Botanical Gardens and the Waimea Valley Arboretum contain plants from both Oahu and Molokai populations (Maui Nui Botanical Gardens 2009; Waimea Valley Arboretum 2009).

Downlisting and delisting objectives are provided in the *Marsilea villosa* recovery plan (USFWS 1996). For *Marsilea villosa* to be downlisted from endangered to threatened status, a total of at least six geographically distinct, self-sustaining populations (three on Oahu and three on Molokai or three on Oahu, two on Molokai, and one on Niihau) must be adequately protected (managed to control threats) and have been maintained through two successive floods resulting in sexual reproduction. A population will be considered to be self-sustaining when it is observed to be successfully reproducing, both vegetatively and sexually, and the population size is stable or increasing.

The downlisting goals for this species have not been met, as threats have been managed for only one population (Table 2), it is unknown if any of the populations are reproducing sexually as well as vegetatively, and population sizes have not been shown to be self-sustaining (stable or increasing) (Table 1). Therefore, *Marsilea villosa* meets the definition of endangered as it remains in danger of extinction throughout its range.

Recommendations for Future Actions:

- Collect sporocarps for genetic storage.
- Collect sporocarps and plants for propagation for reintroduction.
- Work with Hawaii Division of Forestry and Wildlife, Hawaii State Parks, U.S. Navy, The Nature Conservancy Hawaii, and other land managers to initiate planning and contribute to implementation of ecosystem-level restoration and management to benefit this species.
- Continue to monitor current populations through seasonal fluctuations, year after year.
- Research best management practices, including the use of mowing to reduce competition from taller-growing grasses.
- Conduct genetic analyses to determine best strategies for reintroduction and augmentation of populations, and to determine whether populations are reproducing sexually as well as vegetatively.
- Reintroduce new populations in appropriate habitat within its former range to augment genetic representation in each site.
- Assess the modeled effects of climate change on this species, and use to determine future landscape needed for the recovery of the species.
- Research long-term viability of *Marsilea villosa* spores to determine if they are as long-lived as those of some other *Marsilea* species.
- Develop and implement wildfire management plans for each population.

References:

Associated Press. 2007. Molokai Ranch withdraws EIS for Laau Point. Honolulu Advertiser, Honolulu, Hawaii. November 17, 2007.

Bruegmann, M.M. 2010. Memo to the files: *Marsilea villosa* impact from off-road vehicles. U.S. Fish and Wildlife Service, Honolulu, Hawaii. 1 page. Unpublished.

Center for Conservation Research and Training Seed Storage Facility. 2009. Seed storage lab database report. University of Hawaii at Manoa, Honolulu, Hawaii. Unpublished.

Hawaii Biodiversity and Mapping Program. 2009. Element occurrence records for *Marsilea villosa*. Program database. University of Hawaii at Manoa, Honolulu, Hawaii. Unpublished.

Hawaii Department of Land and Natural Resources. 2009. Proposal for the Ilio Point Natural Area Reserve, Division of Forestry and Wildlife, Natural Area Reserves Commission. Honolulu, Hawaii. Available online at <http://hawaii.gov/ltgov/news/files/2009/Natural%20Area%20Reserve%20Proposal.pdf>. Accessed 13 January 2009.

Hawaii Natural Heritage Program. 2004. Flora and fauna survey of Naval magazine Pearl Harbor, Lualualei Branch, Lualualei Valley, Oahu, Hawaii, prepared for Commander, Navy Region Hawaii. University of Hawaii at Manoa, Honolulu, Hawaii. 101 pages. Unpublished.

Maui Nui Botanical Gardens. 2009. Controlled propagation report to U.S. Fish and Wildlife Service. Maui Nui Botanical Gardens, Kahului, Hawaii. 15 pages. Unpublished.

Oahu Division of Forestry and Wildlife Nursery. 2009. Controlled propagation report to U.S. Fish and Wildlife Service. Dillingham, Hawaii. 16 pages. Unpublished.

Perlman, S. 2010. *Marsilea villosa*. National Tropical Botanical Garden, Kalaheo, Hawaii. 2 pages. Unpublished.

[USFWS] U.S. Fish and Wildlife Service. 1992. Endangered and threatened wildlife and plants; determination of endangered status for *Marsilea villosa* (ihi‘ihi). Federal Register 57(120):27863-27867.

[USFWS] U.S. Fish and Wildlife Service. 1996. Marsilea villosa recovery plan. U.S. Fish and Wildlife Service, Portland, Oregon. 55 pages. Available online at <http://www.fws.gov/pacificislands/recoveryplans.html>.

[USFWS] U.S. Fish and Wildlife Service. 2003a. Endangered and threatened wildlife and plants; final designations and nondesignations of critical habitat for 42 plant species from the island of Molokai, Hawaii; final rule. Federal Register 68(52):12982-13141.

[USFWS] U.S. Fish and Wildlife Service. 2003b. Endangered and threatened wildlife and plants; final designations or nondesignations of critical habitat for 101 plant species from the island of Oahu, Hawaii; final rule. Federal Register 68(116):35949-36406.

Waimea Valley Arboretum. 2009. Controlled propagation report to U. S. Fish and Wildlife Service. Waimea Valley, Hawaii. 16 pages. Unpublished.

Wester, L., J. Delay, L. Hoang, B. Iida, N. Kalodimos, and T. Wong. 2006. Population dynamics of *Marsilea villosa* (Marsileaceae) on Oahu, Hawaii. Pacific Science 60(3):385-402.

Wood, K.R. 2010. Notes on *Marsilea villosa*. National Tropical Botanical Garden, Kalaheo, Hawaii. 1 page. Unpublished.

Personal Communications:

Aruch, Sam N.R. 2010. Natural Resource Data Solutions, Haiku, Hawaii. E-mail to Tamara Sherrill, dated July 24, 2010. Subject: Molokai populations of *Marsilea villosa*.

Bakutis, Ane. 2009. Plant Extinction Prevention Program, Kaunakakai, Hawaii. E-mail to Margaret Clark, National Tropical Botanical Garden, dated August 10, 2009. Subject: 5-year review list and schedule.

Chau, Marion. 2010. Department of Botany, University of Hawaii at Manoa, Honolulu, Hawaii. E-mail to Margaret Clark, National Tropical Botanical Garden, dated January 26, 2010. Subject: *Marsilea villosa*.

DeMotta, Michael. 2010. National Tropical Botanical Garden, Kalaheo, Hawaii. E-mail to Margaret Clark, National Tropical Botanical Garden, dated January 15, 2010. Subject: *Marsilea villosa*.

Garnett, Bill. 2010. Wiliwili Rare Plant Nursery, Kalae, Hawaii. E-mail to Margaret Clark, National Tropical Botanical Garden, dated January 16, 2010. Subject: 5-year review comments for *Marsilea villosa*.

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

Date	No. wild indivs	No. outplanted	Downlisting Criteria identified in Recovery Plan	Downlisting Criteria Completed?
1992 (listing)	Unknown		All threats managed in all 6 populations	No
			Two successive floods resulting in sexual reproduction	Unknown
			6 geographically distinct, self-sustaining populations	No
1996 (recovery plan)	Unknown	Unknown	All threats managed in all 6 populations	No
			Two successive floods resulting in sexual reproduction	Unknown
			6 geographically distinct, self-sustaining populations	No
2003 (critical habitat)	Unknown	Unknown	All threats managed in all 6 populations	No
			Two successive floods resulting in sexual reproduction	Unknown
			6 geographically distinct, self-sustaining populations	No
2010 (5-year review)	thousands	unknown	All threats managed in all 6 populations	No (Table 2)
			Two successive floods resulting in sexual reproduction	Unknown
			6 geographically distinct, self-sustaining populations	Unknown if any of the populations are reproducing sexually or vegetatively, and population sizes are not self-sustaining

Table 2. Threats to *Marsilea villosa*.

Threat	Listing factor	Current Status	Conservation/ Management Efforts
Ungulates – habitat modification and herbivory	A, C, D	Ongoing	No
Development at Kamakaipo	E	Ongoing	No
Trampling by hikers and off-road vehicles	E	Ongoing	Partially: barrier and sign installed at Ihiihilauakea Crater
Changes in natural hydrology	A, E	Ongoing	No
Fire	E	Ongoing	Partially: only at Ihiihilauakea Crater
Small population size	E	Ongoing	Partially: sporocarps and propagules collected and in storage
Invasive introduced plants	A, E	Ongoing	Partially: only at Ihiihilauakea Crater
Climate change	A, E	Increasing	No

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

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
__X__ No Change in listing status

Field Supervisor, Pacific Islands Fish and Wildlife Office

Date 8/29/11