Peperomia subpetiolata
(‘ala‘ala wai nui)

5-Year Review
Summary and Evaluation

U.S. Fish and Wildlife Service
Pacific Islands Fish and Wildlife Office
Honolulu, Hawai‘i

5-YEAR REVIEW

Species reviewed: *Peperomia subpetiolata*
(‘ala‘ala wai nui)

TABLE OF CONTENTS

5-YEAR REVIEW
Peperomia subpetiolata (‘ala‘ala wai nui)

1.0 GENERAL INFORMATION

1.1 Reviewers:

Cheryl Phillipson, Biologist, Pacific Islands Fish and Wildlife Office (PIFWO)
Lauren Weisenberger, Plant Recovery Coordinator, PIFWO
Megan Laut, Conservation and Restoration Team Manager, PIFWO

Lead Regional Office:
Interior Region 12, Portland Regional Office

Lead Field Office:
Pacific Islands Fish and Wildlife Office

Cooperating Field Office(s):
N/A

Cooperating Regional Office(s):
N/A

1.2 Methodology used to complete the review:

This review was conducted by staff of the Pacific Islands Fish and Wildlife Office of the U.S. Fish and Wildlife Service (Service), beginning in October 2019. The review was based on the final rule listing this species; the final critical habitat designation; peer reviewed scientific publications; unpublished field observations by the Service, State of Hawai‘i, and other experienced biologists; unpublished survey reports; notes and communications from other qualified biologists; as well as a review of current, available information. The evaluation of Cheryl Phillipson, Biologist, was reviewed by Lauren Weisenberger, Plant Recovery Coordinator, and Megan Laut, Conservation and Restoration Team Manager.

1.3 Background:

1.3.1 FR Notice citation 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 156 species in Oregon, Washington, Hawaii, Palau, Guam, and the Northern Mariana Islands. Federal Register 88(83): 20088–20092, May 7, 2018.

1.3.2 Listing history:

Original Listing
FR notice: [USFWS] U.S. Fish and Wildlife Service. 2013. Endangered and threatened wildlife and plants; determination of endangered status for 38 species

on Molokai, Lanai, and Maui; final rule. Department of the Interior, Federal Register 78 (102): 32014–32065, May 28, 2013.

Date listed: May 28, 2013
Entity listed: *Peperomia subpetiolata*
Classification: Endangered

Revised Listing, if applicable
FR notice: N/A
Date listed: N/A
Entity listed: N/A
Classification: N/A

1.3.3 Associated rulemakings:

FR notice: [USFWS] U.S. Fish and Wildlife Service. 2016. Endangered and threatened wildlife and plants; designation and nondesignation of critical habitat on Molokai, Lanai, Maui, and Kahoolawe; final rule. Department of the Interior, Federal Register 81 (61): 17790–18110, March 30, 2016.

Critical habitat was designated on Maui for *Peperomia subpetiolata* totaling five units in the montane wet ecosystem (8,556 ha; 21,142 ac) (81 FR 17790).

1.3.4 Review History:

This is the first 5-year review for *Peperomia subpetiolata*

1.3.5 Species' Recovery Priority Number at start of this 5-year review:

5

1.3.6 Current Recovery Plan or Outline:

Name of plan or outline: Recovery Outline for the Islands of Maui, Molokaʻi, Kahoʻolawe, and Lānaʻi (Maui Nui)
Date issued: October 2019
Dates of previous revisions, if applicable: N/A

2.0 REVIEW ANALYSIS

2.1 Application of the 1996 Distinct Population Segment (DPS) policy

2.1.1 Is the species under review a vertebrate?

____**Yes**
__X_**No**

2.1.2 Is the species under review listed as a DPS?

____**Yes**
____**No**

2.1.3 Was the DPS listed prior to 1996?

____Yes
____No

2.1.3.1 Prior to this 5-year review, was the DPS classification reviewed to ensure it meets the 1996 policy standards?

____Yes
____No

2.1.3.2 Does the DPS listing meet the discreteness and significance elements of the 1996 DPS policy?

____Yes
____No

2.1.4 Is there relevant new information for this species regarding the application of the DPS policy?

____Yes
____No

2.2 Recovery Criteria

2.2.1 Does the species have a final, approved recovery plan containing objective, measurable criteria?

____Yes
__X_No

2.2.2 Adequacy of recovery criteria.

2.2.2.1 Do the recovery criteria reflect the best available and most up-to date information on the biology of the species and its habitat?

____Yes
____No

2.2.2.2 Are all of the 5 listing factors that are relevant to the species addressed in the recovery?

____Yes
____No

2.2.3 List the recovery criteria as they appear in the recovery plan, and discuss how each criterion has or has not been met, citing information:
A synthesis of the threats (Listing Factors A, C, D, and E) affecting this species is presented in section 2.3.2 and Table 2. Listing Factor B (overutilization for commercial, recreational, scientific, or educational purposes) is not known to be a threat to this species.

The recovery plan is currently being drafted. However, the Hawai‘i and Pacific Plants Recovery Coordinating Committee (HPPRCC) has outlined the actions and goals for stages leading towards recovery (2011). These stages are described below.

Current information is lacking for many Hawaiian plant species on the status of the species and their habitats, breeding systems, genetics, and propagule storage options. The following downlisting and delisting criteria for plants have therefore been adopted from the revised recovery objective guidelines developed by the HPPRCC (2011). Many of the Hawaiian plant species are at very low numbers, so the Service also developed criteria for avoiding imminent extinction and an interim stage before downlisting, based on the recommendations of the HPPRCC, to assist in tracking progress toward the ultimate goal of recovery. These criteria are assessed on a species-by-species basis, especially as additional information becomes available.

In general, long-lived perennials are those taxa either known or believed to have life spans greater than 10 years; short-lived perennials are those known or believed to have life spans greater than one year but less than 10 years; and annuals are those known or believed to have life spans less than or equal to one year. When it is unknown whether a species is long- or short-lived, the Service has erred on the side of caution and considered the species short-lived. This will be revised as more is learned about the life histories of these species. Narrow extant range and broad contiguous range are recognized as not needing different numbers of individuals or populations, but that the populations will be distributed more narrowly or more broadly, respectively, across the landscape. Obligate outcrossers are those species that either have male and female flowers on separate plants or otherwise require cross-pollination to fertilize seeds, and therefore require equal numbers of individuals contributing to reproduction as males and females, doubling the number of mature individuals. Species that reproduce vegetatively may reproduce sexually only on occasion, resulting in the majority of the genetic variation being between populations, therefore requiring additional populations. Species that have a tendency to fluctuate in number from year to year require a larger number of mature individuals on average to allow for decline in years of extreme habitat conditions and recuperation in numbers in years of more normal conditions.

Preventing Extinction

Stabilizing (interim), downlisting, and delisting objectives have been updated according to the draft revised recovery objective guidelines developed by the 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.

Peperomia subpetiolata is a short-lived perennial herb. 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 three populations should be documented on Maui where they now occur or occurred historically. Each of these populations must be naturally reproducing (*i.e.*, viable seeds, seedlings) with a minimum of 50 mature, reproducing individuals per population.

This recovery objective has not been met (see Table 1).

Interim Stage

To meet the interim stage of recovery of *Peperomia subpetiolata*, 300 mature individuals are needed in each of three populations and all major threats must be controlled around the populations designated for recovery at this stage. There should also be demonstrated regeneration of seedlings and documented replacement regeneration within each of the target populations. The populations must be adequately represented in an *ex situ* collection as defined in the Center for Plant Conservation's guidelines (Guerrant *et al.* 2004) that is secured and well-maintained. Adequate monitoring must be in place and conducted to assess individual plant survival, population trends, trends of major limiting factors, and response of major limiting factors to management.

This recovery objective has not been met (see Table 1).

Downlisting Criteria

In addition to achieving five populations with 500 mature individuals per population and all of the goals of the interim stage, all target populations must be stable, secure, and naturally reproducing for a minimum of 10 years. Species-specific management actions are not ruled out. Downlisting should not be considered until an adequate population viability analysis (PVA) has been conducted to assess needed numbers more accurately based on current management and monitoring data collected at regular intervals determined by demographic parameters of the species, although they should only be one of the factors used in making a decision to downlist. Information necessary for the PVA that should be available through monitoring (ideally annually) includes major limiting factors, breeding system, population structure and density, and proven management methods for major threats.

This recovery objective has not been met (see Table 1).

Delisting Criteria
In addition to achieving 10 populations with 500 mature individuals per population and all of the goals of the interim and downlisting stages, all target populations must be stable, secure, naturally reproducing, and within secure and viable habitats for a minimum of 20 years. Species-specific management actions must no longer be necessary, but ecosystem-wide management actions are not ruled out if there are long-term agreements in place to continue management. These numbers are initial targets, but may be revised upward as additional information is available, including adequate PVAs for individual species based on current management and monitoring data collected at regular intervals determined by demographic parameters of the species, although they should only be one of the factors used in making a decision to delist. Genetic analyses should be conducted to ensure that adequate genetic representation is present within and among populations compared to the initial variation assessed in the interim stage. Numbers need to be considered on a species-by-species basis.

This recovery objective has not been met (see Table 1).

2.3 Updated Information and Current Species Status

2.3.1 Biology and Habitat

2.3.1.1 New information on the species' biology and life history:

Peperomia subpetiolata is a short-lived perennial herb. The green stems have reddish purple splotches and are erect to ascending from a very short creeping base. Stems are unbranched or few-branched, 60 to 150 centimeters (cm) (24 to 59 inches (in)) long. The leaf upper surface is dark green, lower surface pale green, 5 to 8 per node, 12 to 20 cm (4.7 to 7.9 in) long. Flower spikes one to several, terminal and axillary with flowers densely congested. Fruit is subglobose about 1 millimeter (mm) (0.04 in) in diameter. This species differs from more common Hawaiian *Peperomia* species (*P. cookiana* and *P. hirtipetiola*) by its large leaves, stems, and shrub-like habit (Wagner *et al.* 1999, pp. 1035–1036).

The specific life history characteristics of *Peperomia subpetiolata* have not been studied and little is known about the phenology and reproduction of this species. The breeding systems of other Piperaceae are known for only very few species: the paleotropical *Piper nigrum* and the neotropical *P. arieianum* which are self-compatible (Martin and Gregory 1962; Marquis 1988; Sasikumar *et al*. 1992) and the paleotropical *P. methysticum* which is self-incompatible (Prakash *et al*. 1994). South American congeners have lightly scented minute flowers which are likely associated with insect pollination (de Figueiredo *et al*. 2000, p. 456). Members of the taxon produce extremely small globose fruits which may be transported by water and wind or by insects (de Figueiredo *et al*. 2000, p. 456).

2.3.1.2 Abundance, population trends (e.g. increasing, decreasing, stable), demographic features (e.g., age structure, sex ratio, family size, birth rate, age at mortality, mortality rate, etc.), or demographic trends:
Historically, this species is known only from the montane wet and mesic forests of the lower Waikamoi and Makawao region of east Maui (Wagner *et al*. 1999, p. 1035). By the early 1990's there were a few scattered, declining, populations in the same region (Wood *et al.* 2012, pp. 96–97). Populations were also observed in 2001 along the Makawao-Koʻolau Forest Reserve boundary, the Waikamoi Flume road, and on Maile trail. By 2013, only hybrid individuals were known (78 FR 32014, September 18, 2013). Currently, there are no known occurrences of pure *Peperomia subpetiolata*, only putative hybrids with *P. cookiana* (NTBG 2001).

2.3.1.3 Genetics, genetic variation, or trends in genetic variation (e.g., loss of genetic variation, genetic drift, inbreeding, etc.):
N/A

2.3.1.4 Taxonomic classification or changes in nomenclature:
Peperomia subpetiolata was described by Yuncker (1933) and is recognized as a distinct taxon in Wagner *et al.* (1999), the most recently accepted Hawaiian plant taxonomy.

2.3.1.5 Spatial distribution, trends in spatial distribution (e.g. increasingly fragmented, increased numbers of corridors, etc.), or historic range (e.g. corrections to the historical range, change in distribution of the species' within its historic range, etc.):
See section 2.3.1.2 above for spatial distribution of the species.

2.3.1.6 Habitat or ecosystem conditions (e.g., amount, distribution, and suitability of the habitat or ecosystem):
Historically, this species was found scattered throughout the upper elevation wet and mesic forest of east Maui (Hawaii Biodiversity and Mapping Program (HBMP) 2010; The Nature Conservancy of Hawaiʻi (TNCH) 2007; Oppenheimer 2019, pers. comm.) dominated by *Metrosideros* (ʻōhiʻa)-*Acacia koa* (koa)-*Cheirodendron* (ʻōlapa) and with the associated native species *Alyxia stellata* (maile), *Athyrium microphyllum* (ʻākōlea), *Carex alligata* (NCN), *Clermontia arborescens* (ʻohā wai nui), *Coprosma foliosa* (pilo), *Diplazium sandwichianum* (hōʻiʻo, pohole), *Hydrangea arguta* (kanawao), *Leptecophylla tameiameiae* (pūkiawe), *Peperomia cookiana* (ʻalaʻala wai nui), *Rubus hawaiiensis* (ʻākala), and *Sticherus owhyhensis* (uluhe) (HBMP 2010).

2.3.2 Five-Factor Analysis (threats, conservation measures, and regulatory mechanisms)

2.3.2.1 Present or threatened destruction, modification or curtailment of its habitat or range (Factor A):

Ungulate destruction and degradation of habitat— Habitat destruction and modification by feral pigs (*Sus scrofa*) is a threat to *Peperomia subpetiolata*. These ungulates are highly destructive to the native vegetation by eating young trees and young shoots of plants before they can become established, causing erosion by creating trails that damage native vegetative cover through substrate destabilization and creation of gullies that alter hydrology (Cuddihy and Stone 1990, pp. 25–26, 63–64). These activities also promote the invasion of nonnative plants that will outcompete *P. subpetiolata* for space, water, light and nutrients. Additionally, these ungulates may consume *P. subpetiolata* when foraging for food, and directly damage roots and seedlings.

Currently, all reintroduced populations consisting of putative hybrids occur in fenced areas; however, fencing must be monitored for ingress by feral pigs (HBMP 2010; Oppenheimer 2019, pers. comm.).

Established ecosystem-altering invasive plant modification and degradation of habitat—Invasive introduced plant species modify habitat occupied by native plant species by changing the availability of light, altering soil-water regimes, modifying nutrient cycling, and changing the fire characteristics of the native plant community (Cuddihy and Stone 1990, p. 74). Habitat modification and destruction by invasive nonnative plants negatively affects all occurrences of *Peperomia subpetiolata* (HBMP 2010). Nonnative plants with the greatest impacts on *P. subpetiolata* include *Eucalyptus* spp., *Fraxinus uhdei* (tropical ash), and *Hedychium gardnerianum* (kāhili ginger) (HBMP 2010). The dense invasion of *H. gardnerianum* below a nonnative forest canopy of *Eucalyptus* has left little open soil for herbaceous terrestrial species such as *P. subpetiolata* to survive (Wood 2012, pp. 96–97).

Treefall—The only known occurrences of *Peperomia subpetiolata* are in an area invaded by large nonnative invasive *Eucalyptus* trees which fall or drop large branches in wind and weather events, damaging or destroying *P. subpetiolata* plants (PEPP 2013, 2016, 2017).

Drought destruction and degradation of habitat—Drought was observed to be a threat to *Peperomia subpetiolata* at its last known occurrence (PEPP 2018, 2019). Over the last 100 years, the Hawaiian Islands have experienced an annual decline in precipitation of over 9 percent, increasing to as much as 15 percent within the last 20 years (US-NSTC 2008, p. 61; Chu and Chen 2005, pp 4881–4900; Diaz *et al.* 2005, pp 1–3).

Drought affects plants directly by desiccation. The increase in drought frequency and intensity leads to a self-perpetuating cycle of increase in cover of nonnative plants, increase in the number of fires, and an increase of erosion (US-GCRP 2009, pp. 18, 24; Warren 2011, pp. 221–226).

Climate change loss or degradation of habitat—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 concluded that *Peperomia subpetiolata* is highly vulnerable to the impacts of climate change with a vulnerability score of 0.803 (on a scale of 0 being not vulnerable to 1 being extremely vulnerable to climate change). In addition, *P. subpetiolata* 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 within its current envelope, or move to newly available climate-compatible areas to avoid extinction. Therefore, additional management actions are needed to conserve tis taxon into the future.

2.3.2.2 Overutilization for commercial, recreational, scientific, or educational purposes (Factor B):
Not a threat.

2.3.2.3 Disease or predation (Factor C):
Herbivory and predation by slugs, rats, and mice—Research and field observations indicate that herbivory by slugs, rats, and mice is a threat to *Peperomia subpetiolata* (HBMP 2010; Oppenheimer 2019, pers. comm.). Rats (*Rattus* sp.) and mice (*Mus musculus*) eat virtually every part of plants and at every stage: fleshy fruits, seeds, flowers, stems, leaves, shoot, seedlings, and roots (Russell 1980, pp. 269–272; Cuddihy and Stone 1990, pp. 34, 67). Slugs inhibit plant reproduction by consuming seedlings (Joe 2006, pp. 3, 50). The effects on plants range from reduced vigor and decreased reproduction to mortality of individuals and complete lack of recruitment.

Herbivory and predation by ungulates—Herbivory by feral pigs is noted as a threat to *Peperomia subpetiolata*. Reintroduced populations are fenced, but these fences must be monitored regularly for ingress by ungulates.

2.3.2.4 Inadequacy of existing regulatory mechanisms (Factor D):
The last known occurrences of *Peperomia subpetiolata* were found within or adjacent to a State hunting area. Nonnative feral ungulates pose a significant ongoing threat to native species through destruction and modification of habitat, and through direct herbivory or predation. The

State of Hawai‘i provides game mammal (feral pigs and goats, axis deer) hunting opportunities (e.g., “sustained yield”) in public hunting areas on Maui (DLNR 2012). Public hunting areas are not fenced and game mammals have unrestricted access for most areas across the landscape, regardless of underlying land use designation; therefore, any unfenced populations of *P. subpetiolata* are at risk (DLNR 2010).

Habitat degradation and destruction, and competition, by ecosystem-altering nonnative plants are threats to *Peperomia subpetiolata*. Currently, four agencies are responsible for inspection of goods arriving in Hawai‘i (CGAPS 2009). The Hawai‘i Department of Agriculture (HDOA) inspects domestic cargo and vessels and focuses on pests of concern to Hawai‘i, especially insects or plant diseases. The U.S. Department of Homeland Security-Customs and Border Protection (CBP) is responsible for inspecting commercial, private, and military vessels and aircraft and related cargo and passengers arriving from foreign locations, focusing on non-propagative plant materials, and internationally regulated commercial species under the Convention in International Trade in Endangered Species (CITES). Also included are federally listed noxious seeds and plants, soil, and pests of concern for forests and agriculture. The U.S. Department of Agriculture-Animal and Plant Health Inspection Service-Plant Protection and Quarantine (USDA-APHIS-PPQ) inspects propagative plant material, provides identification services for arriving plants and pests, and conducts pest risk assessments among other activities (HDOA 2009). The Service inspects arriving wildlife products, enforces the injurious wildlife provisions of the Lacey Act (18 U.S.C. 42; 16 U.S.C. 3371 et seq.) and prosecutes CITES violations. The State of Hawai‘i allows the importation of most plant taxa, with limited exceptions. Many invasive plants established in Hawai‘i have expanding ranges. Resources available to reduce the spread of these species and counter their negative ecological effects are limited. Control of established nonnative invasive plants is largely focused on a few invasive species that cause significant economic or environmental damage to public and private lands, and comprehensive control of an array of invasive plants remains limited in scope. The introduction of new invasive plant species to the State of Hawai‘i is a significant risk to *P. subpetiolata* and other federally listed species.

2.3.2.5 Other natural or manmade factors affecting its continued existence (Factor E):

Reduced viability due to low numbers—Small, isolated populations often exhibit reduced levels of genetic variability, which diminishes the species’ capacity to adapt and respond to environmental changes, thereby lessening the probability of long-term persistence (Barrett and Kohn 1991, pp. 3, 7; Newman and Pilson 1997, pp. 354–355). The problems associated with

small population size and vulnerability to random demographic fluctuations or natural catastrophes are further magnified by synergistic interactions with other threats, such as anthropogenic impacts like habitat loss from human development or predation by nonnative species. Very small plant populations may experience reduced reproductive vigor due to ineffective pollination or inbreeding depression. The wild population of *Peperomia subpetiolata* is believed to be extirpated. There are four reintroduced populations (all on east Maui), sourced from one founder line, and all are believed to be hybrids. This makes the species susceptible to threats from habitat degradation or loss by erosion, flooding, landslides, or tree falls, or a combination of these, because of their limited distribution (PEPP 2009, pp. 23–24, 49–58).

Hybridization—Hybridization adversely impacts *Peperomia subpetiolata* through reduced representation and may lead to its extinction as a genotypically distinct species. On east Maui, historically wild *P. subpetiolata* populations are now believed to be extirpated due to hybridization with the more abundant *P. cookiana* and *P. hirtipetiola* (Wagner *et al.* 1999; Wood *et al* 2012, p. 96–97; Oppenheimer 2019, pers. comm.). Natural hybridization is a frequent phenomenon in plants and can lead to the formation of new species (Orians 2000, p. 1949), or sometimes to the decline of species "through genetic assimilation or introgression" (Ellstrand 1992, pp. 77, 81; Levin *et al*. 1996, pp. 10–16; Rhymer and Simberloff 1996, p. 85). Hybridization, however, is especially problematic for rare species such as *P. subpetiolata* that come into contact with species that are abundant or more common (Rhymer and Simberloff 1996, p. 83).

Current Management Actions:

- Surveys and monitoring—The Plant Extinction Prevention Program (PEPP) conducts extensive surveys for *Peperomia subpetiolata* in areas where wild populations were known to exist historically (PEPP 2018).
- Ungulate control— PEPP has installed fencing to protect reintroductions of *P. subpetiolata* from feral ungulates.
- Established ecosystem-altering invasive plant control—PEPP conducts control of nonnative plants at reintroduction sites (PEPP 2017).
- Captive propagation for genetic storage and reintroduction—
    - The Lyon Arboretum Micropropagation Laboratory reports 72 explants of *Peperomia subpetiolata* in storage representing one individual from Makawao (Lyon Arboretum 2019). The Lyon Arboretum Seed Conservation Laboratory reports collection and storage of 202 seeds representing one individual from Waikamoi (Lyon Arboretum 2019).
    - The Olinda Rare Plant Facility (ORPF) reports propagation of 59 plants for future reintroduction, the founder source is

Makawao, but individual plants are not identified (ORPF 2019).

- Reintroduction—The Plant Extinction Prevention Program (PEPP) reintroduced individuals at eight locations of hybrids of *P. subpetiolata,* between 2007 and 2019, totaling 48 mature individuals, 27 immature individuals, and 27 seedlings (PEPP 2019).
- Population biology research—PEPP has identified hybrid populations and is developing management tools with the goal of selecting for *P. subpetiolata* traits via controlled breeding (Weisenberger 2019, pers. comm.).

Table 1. Status and trends of *Peperomia subpetiolata* from listing through 5-year review.

Date	No. wild individuals	No. outplanted	Preventing Extinction Criteria identified by HPPRCC	Preventing Extinction Criteria Completed?
2013 (listing)	0, all hybrids	7 mature 4 immature 4 seedlings	All threats managed in all 3 populations	Partially, reintroductions are fenced
			Complete genetic storage	Partially, all hybrid collections
			3 populations with 50 mature individuals each	No
2016 (critical habitat)	0, all hybrids	43	All threats managed in all 3 populations	Partially, reintroductions are fenced
			Complete genetic storage	Partially, all hybrid collections
			3 populations with 50 mature individuals each	No
2020 (5-year review)	0, all hybrids	47 remain	All threats managed in all 3 populations	Partially, reintroductions are fenced
			Complete genetic storage	Yes
			3 populations with 50 mature individuals each	No

Table 2. Threats to *Peperomia subpetiolata* and ongoing conservation efforts.

Threat	Listing Factor	Current Status	Conservation/Management Efforts
Ungulate destruction and degradation of habitat	A, C	Ongoing	Partial, reintroductions are fenced

Established ecosystem-altering invasive plant modification and degradation of habitat	A	Ongoing	Partial, nonnative plant management in fenced areas
Climate change degradation or loss of habitat, including drought and erosion	A	Ongoing	Partial, some landscape-scale nonnative plant management
Treefall damage and destruction	A	Ongoing	None
Predation and herbivory by rats and slugs	C	Ongoing	None
Inadequacy of existing regulatory mechanisms	D	Ongoing	Partial, reintroductions are fenced
Reduced viability due to small populations and low numbers	E	Ongoing	Partial, propagation of available hybrid material
Hybridization	E	Ongoing	Partial, development of controlled breeding program

2.4 Synthesis

There are no pure wild individuals of *Peperomia subpetiolata* on east Maui, all remaining or reintroduced individuals are hybrids. 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 *P. subpetiolata* is highly vulnerable to the effects of climate change. Seeds and propagules in collections are hybrids; however, reintroduction is ongoing for preservation of available material. Fencing provides protection from habitat degradation and browsing by feral ungulates. Surveys, a controlled breeding program, and molecular conservation genetics research are critical to produce individuals of pure or mostly pure *P. subpetiolata* to preserve this distinct taxon for future recovery efforts.

Preventing extinction, interim stabilization, downlisting, and delisting objectives are provided in HPPRCC’s Revised Recovery Objective Guidelines (2011). 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 an *ex situ* (at other than the plant’s natural location, such as a nursery or arboretum) collection. In addition, a minimum of three populations should be documented on Maui where they now occur or occurred historically and each of these populations must be naturally reproducing (*i.e*., viable seeds, seedlings) with a minimum of 50 mature, reproducing individuals per population.

The preventing extinction goals for this species have not been met. There are no known remaining pure wild individuals (Table 1), collected materials and propagules are hybrids, and all threats are not being sufficiently managed throughout the range of the species (Table 2). Therefore, *Peperomia subpetiolata* meets the definition of endangered as it remains in danger of extinction throughout its range.

3.0 RESULTS

3.1 Recommended Classification:

____Downlist to Threatened
____Uplist to Endangered
____Delist
____*Extinction*
____*Recovery*
____*Original data for classification in error*
__X__**No change is needed**

3.2 New Recovery Priority Number:

Brief Rationale:

3.3 Listing and Reclassification Priority Number:

Reclassification (from Threatened to Endangered) Priority Number:____
Reclassification (from Endangered to Threatened) Priority Number:____
Delisting (regardless of current classification) Priority Number:____

Brief Rationale:

4.0 RECOMMENDATIONS FOR FUTURE ACTIONS

- Surveys and inventories—Continue to search historical locations and potentially suitable habitat for *Peperomia subpetiolata*.
- Ungulate monitoring and control—Continue to construct and maintain fenced exclosures to protect reintroduced individuals from the negative impacts of feral ungulates.
- Invasive plant monitoring and control—Continue to control established ecosystem-altering nonnative invasive plant species and those that compete with *P. subpetiolata*.
- Climate change adaptation strategy—Research suitability of habitat in the future due to the impacts of climate change
- Predation and herbivory by rodents—Implement effective control methods for rats and slugs at all reintroduced populations.
- Captive propagation for genetic storage and reintroduction—

    - Continue to collect seeds for storage and propagation efforts for maintenance of genetic stock, and keep track of individual founders.
    - Develop management tools with the goal of selecting for *P. subpetiolata* via controlled breeding and confirm success via molecular research.
- Reintroduction and translocation—Continue to reintroduce propagated individuals to provide materials for controlled breeding.
- Alliance and partnership development—Continue to contribute to planning and implementation of ecosystem-level restoration and management to benefit this taxon.

5.0 REFERENCES

Barrett, S.C.H. and J.R. Kohn. 1991. Genetic and evolutionary consequences of small population size in plants–implications for conservation. *In* Genetics and Conservation of Rare Plants, D.A. Falk and K.E. Holsinger (eds.), Oxford University Press, New York and Oxford, Pp. 3–30.

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U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW of *Peperomia subpetiolata*
(‘ala‘ala wai nui)

Current Classification: Endangered

Recommendation resulting from the 5-Year Review:

____Downlist to Threatened
____Uplist to Endangered
____Delist
_X__No change needed

Appropriate Listing/Reclassification Priority Number, if applicable: _____

Review Conducted By:
Cheryl Phillipson, Fish and Wildlife Biologist, PIFWO
Lauren Weisenberger, Plant Recovery Coordinator, PIFWO
Megan Laut, Conservation and Restoration Team Manager, PIFWO

FIELD OFFICE APPROVAL:

for MEGAN LAUT Digitally signed by MEGAN LAUT Date: 2020.08.18 11:51:53 -10'00'

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Field Supervisor, Pacific Islands Fish and Wildlife Office