# *Cyrtandra wagneri*
# (haʻiwale, kanawao keʻokeʻo)

## 5-Year Review
## Summary and Evaluation

**U.S. Fish and Wildlife Service**
**Pacific Islands Fish and Wildlife Office**
**Honolulu, Hawaiʻi**

# 5-YEAR REVIEW

**Species reviewed: *Cyrtandra wagneri* (ha‘iwale, kanawao ke‘oke‘o)**

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## 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 The review was based on the final rule listing this species; peer reviewed scientific publications; unpublished field observations by the Service, State of Hawaiʻi, and other experienced biologists; unpublished survey reports; notes and communications from other qualified biologists; as well as a review of current, available information.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 species status for 15 species on Hawaii Island; final rule. Department of the Interior, Federal Register 78: 63638–64690, October 29, 2013.

**Date listed:** October 29, 2013
**Entity listed:** *Cyrtandra wagneri*
**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:

N/A

### 1.3.4 Review History:

This is the first 5-year review for *Cyrtandra wagneri*.

### 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 Island of Hawai‘i
**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.

*Cyrtandra wagneri* is a short-lived perennial shrub. 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 the island of Hawai‘i where they now occur or occurred historically. Each of these populations must be naturally reproducing (i.e., viable seeds, seedlings, saplings) 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 *Cyrtandra wagneri*, 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 growth to at least sapling stage for woody species 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 secure and well managed. 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 5 to 10 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 5 to 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:

*Cyrtandra wagneri* is a shrub or small tree to 3 meters (m) (9.8 feet (ft)) tall, main stem solitary or sparsely branched, most parts with golden- to dark-brown minute hairs. Leaves of a pair equal or subequal, symmetrical to somewhat asymmetrical, petiole 2.5 to 10 cm (1 to 4 in), densely minutely hairy, blade elliptic to oblong-elliptic, 20–41 x 8–18.5 cm (7.9–16 x 3–7 in) with stem-facing side densely hairy, the underside moderately to densely covered with crinkled hairs, and hairs denser on veins and margin. Leaf venation is prominent and raised, leaf margin toothed, teeth with hair tufts. Stemmed and branched inflorescences of 12 to 25 flowers borne near ground level or up to 2 m (6.6 ft) above, at first erect, becoming pendulous with age. Corolla is white, tube with pale brown hairs. Berries are white, ovoid to ovoid-ellipsoid, 13–16 x 7–8 mm (0.5–0.6 x 0.27–0.3 in), 0.3 mm (0.01 in) and seeds are ellipsoid and pale brown (Lorence and Perlman 2007, pp. 357–359).

*Cyrtandra wagneri* is a distinctive species characterized by its relatively large opposite leaves, stemmed 12- to 25-flowered cymose inflorescences, deeply divided radially symmetric calyx, persistence in fruit, with erect, green, lanceolate to linear-oblong lobes that are internally strigillose (with fine bulbous hairs) distally (Lorence and Perlman 2007, p. 357).

Flowers are observed in May through August, with fruit peaking in August (NTBG 2001, 2002, 2003, 2004; Lorence and Perlman 2007, p. 359).

No data exists for pollination mechanisms in *Cyrtandra*; however, the open, white flowers suggest adaptation for pollination by generalist insects (Cronk *et al.* 2005, p. 1022). Likewise, while fleshy fruits would indicate dispersal by avian species, no observations for dispersal in *Cyrtandra* have been made (Cronk *et al.* 2005, p. 1022).

The species within the genus *Cyrtandra* are comprised of perennial herbs, shrubs, or small trees (Wagner et al. 1990, p. 735). The name *Cyrtandra* is derived from Greek word *kyrtos* which means curved, and *andros* or stamens, in its reference to the spiral curved staminal filaments (Wagner et al. 1990, p. 736). The taxonomic group consists of approximately 50 to 600 species occurring throughout Asia and the Pacific.

Hawaiian *Cyrtandra* are characterized by extensive polymorphism, often occurring within a very limited geographical area. It is not unusual to find two or more species intermingled or occurring within close proximity of one another. In mixed populations that have been observed closely, one can find rare to sometimes common individuals that have intermediate morphological forms and structures, usually between species of different sections. This has been interpreted as putative plant hybrids. As of 1990, a total of 67 hybrid combinations have been described for Hawaiian *Cyrtandra*. The assumption that a plant is a hybrid is based on the intermediate morphological features, the presence of presumed parental species that have the proper combination of features in the same geographical area, and depressed pollen fertility (Wagner et al. 1990, pp. 736–737).

**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:**

*Cyrtandra wagneri* was first documented in 2003 from a collection in the Laupāhoehoe Natural Area Reserve (NAR) on the island of Hawai‘i (Lorence and Perlman 2007, p. 359). The only known individuals at Kīlau and Kaiwilahilahi were separated by 1 kilometer (km) (0.6 miles (mi)) of degraded wet forest (Lorence and Perlman 2007, p. 359). At the Kīlau stream locality the population consisted of approximately 150 plants (ca 50 adults and 100 juveniles) observed in 2002. The number of individuals at the Kaiwilahilahi stream population was initially estimated to be about 10 sterile plants. By 2013; however, there were no individuals remaining at Kaiwilahilahi stream (78 FR 64638, October 29, 2013). In 2010, there were eight individuals at Kīlau stream, but by 2014, it was estimated that the larger numbers seen (ca 50) were hybrids with *C. tintinnabula* (PEPP 2010, 2014). In 2017, only four individuals at Kīlau stream showed the phenology of pure *C. wagneri* (PEPP 2017). In 2017, one immature and

two mature plants were found in Humu‘ula drainage, northwest of Laupāhoehoe NAR (PEPP 2017).

**2.3.1.3 Genetics, genetic variation, or trends in genetic variation (e.g., loss of genetic variation, genetic drift, inbreeding, etc.):**
Unpublished molecular phylogenetic evidence places *Cyrtandra wagneri* as sister to *C. tintinnabula* with 95 percent support in a clade with other Hawaiian species (Clark, pers. comm. in Lorence and Perlman 2007, p. 359). Although the two species are closely related based on molecular evidence, morphological differences between them are considerable. *Cyrtandra tintinnabula* differs by its leaves with petioles 35 percent to 70 percent as long as the blade, broadly ovate to broadly elliptic with a rounded base, densely hairy covering of reddish brown, bulbous-tipped hairs, consistently axillary inflorescences of 2- to 4-flowered umbelliform cymes subtended by a pair of broadly ovate or cordate bracts and externally glandular-hairy corollas with a shorter tube and smaller lobes. These two species flower approximately concurrently and may occasionally form hybrids. One possible explanation for the sympatric existence of these two closely related species may be exploitation of different pollinators, but pollination of *Cyrtandra* is unknown. Another possible explanation for the molecular results is that this rare species may now be restricted to a small area in sympatry with *C. tintinnabula* and may have been strongly influenced by occasional hybridization followed by introgression (Lorence and Perlman 2007, p. 361). It may be necessary to identify the extent of interspecific cross-pollination to fully identify the genetic structure of pure *C. wagneri.* This will also allow for the quantification of impacts to hybridization to this taxon.

**2.3.1.4 Taxonomic classification or changes in nomenclature:**
The type specimen for *Cyrtandra wagneri* was collected in 2003 and was named for Warren Wagner in recognition of his extensive contributions to the systematic studies of the Hawaiian genus *Cyrtandra* (Lorence and Perlman 2007, p. 361). *Cyrtandra wagneri* is the currently accepted taxonomy for this species (Wagner et al. 2012, p. 45).

**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):**
*Cyrtandra wagneri* is restricted to steep slopes (up to about 45 degrees) of stream banks at 823 to 869 m (2,700 to 2,851 ft) elevation, rooting in rocky brown clay soil substrate, in moderate to dense shade of wet forest

dominated by the native trees *Acacia koa* (koa) and *Metrosideros polymorpha* (ʻōhiʻa). Other native associated species include *Astelia menziesii* (paʻiniu), *Ilex anomala* (kāwaʻu), *Pipturus albidus* (māmaki), *Freycinetia arborea* (ʻieʻie), *Cheirodendron trigynum* (ʻōlapa), *Cyanea platyphylla* (hāhā), *Cibotium glaucum* (hāpuʻu), *Coprosma* spp. (pilo), *Hydrangea arguta* (kanawao), *Kadua axillaris* (manono), *Melicope clusiifolia* (alani), *Myrsine lessertiana* (kōlea lau nui), *Perrottetia sandwicensis* (olomea), *Psychotria hawaiiensis* (kōpiko), *Rubus hawaiensis* (ʻākala), *Phyllostegia macrophylla* (no common name), *Clermontia parviflora* (ʻohā wai), *Touchardia latifolia* (olonā), *Antidesma platyphyllum* var. *platyphyllum* (hame), and *Platydesma remyi* (no common name). Various terrestrial ferns, including *Diplazium sandwichianum* (hōʻiʻo) and *Dicranopteris linearis* (uluhe) are abundant in the understory, and *Peperomia* species (ʻalaʻala wai nui) and bryophytes prevail in the ground flora. *Cyrtandra wagneri* is observed growing sympatrically with *C. tintinnabula* (Lorence and Perlman 2007, p. 359; Marie Selby Botanical Gardens 2002, 2003; National Tropical Botanical Garden (NTBG) 2006).

### 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—Destruction and degradation of habitat by feral pigs and cattle is a threat to the wet forest habitat known to support *Cyrtandra wagneri* (Lorence and Perlman 2007, p. 359). Feral ungulates are highly destructive to native vegetation, and contribute to erosion by eating young trees and young shoots of plants before they can become established, creating trails that damage native vegetative cover, promoting erosion by destabilizing substrate and creating gullies that convey water, and dislodging stones from ledges that can cause rockfalls and landslides and damage vegetation below (Cuddihy and Stone 1990, pp. 63–64).

Established ecosystem-altering invasive plant modification and degradation of habitat—Invasive introduced plants modify habitat occupied by native plant species by changing the availability of light, altering soil-water regimes, changing nutrient cycling and the fire characteristics of the native plant community (Cuddihy and Stone 1990, pp. 73–91). Habitat destruction and degradation by invasive nonnative plants negatively affect populations of *Cyrtandra wagneri* (77 FR 63928, October 17, 2012; PEPP 2010). The nonnative invasive plants with the greatest impacts on *C. wagneri* include *Clidemia hirta* (Koster's curse), *Erigeron karvinskianus* (daisy fleabane), *Hedychium gardnerianum* (kahili

ginger), *Psidium cattleianum* (strawberry guava), and *Setaria palmifolia* (palmgrass) (Lorence and Perlman 2007, p. 359).

Flooding degradation and destruction of habitat—Field survey data presented by Lorence and Perlman (2007, p. 359) indicates that heavy rains and erosion threaten the known population *Cyrtandra wagneri* on a stream bank in the Laupāhoehoe NAR. Heavy rains and erosion could lead to near extirpation or even extinction of this species by direct destruction of the individual plants and mechanical damage that could destablize the stream bank habitat. In the open sea near Hawai‘i, rainfall averages 25 to 635 to 762 mm (30 in) per year, yet the islands may receive up to 15 times this amount in some places, caused by orographic features (physical geography of mountains) (Wagner *et al.* 1999, pp. 36–44). During storms, rain may fall at 76 mm (3 in) per hour or more, and sometimes may reach nearly 1,000 mm (40 in) in 24 hours, causing destructive flash-flooding in streams and narrow gulches (Wagner *et al.* 1990, pp. 36–44).

Climate change loss or degradation of habitat, including hurricanes—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. This assessment was not conducted specifically for *Cyrtandra wagneri.* However, the analysis was conducted for *C. tintinnabula*, with a vulnerability score of 0.206 (on a scale of 0 being not vulnerable to 1 being extremely vulnerable to climate change). This species co-occurs sympatrically with *C. wagneri* at Laupāhoehoe NAR. Considering that threats such as habitat destruction and degradation by ungulates and nonnative plants, susceptibility to flooding and erosion, predation by ungulates, rats, and slugs are increasing, and the number of individuals is fewer than 10, it is likely that climate change could affect this species' ability to persist. Therefore, additional management actions may be needed to conserve *C. wagneri* into the future, such as ensuring that adequate viable genetic storage is maintained, identifying suitable microsites where climate change effects are anticipated to occur more slowly, and considering suitable habitat in areas outside of its known range.

Tropical cyclone frequency and intensity are projected to change as a result of climate change over the next 100 to 200 years (Vecchi and Soden 2007, p. 4137; Emanuel *et al.* 2008, p. 348; Yu *et al.* 2010, pp. 1369–1372). In the central Pacific, modeling projects an increase of up to two additional tropical cyclones per year in the main Hawaiian Islands by 2100 (Murakami *et al.* 2013, pp. 1–6). Hurricanes pose an ongoing and ever-present threat because they can happen at any time. A destructive hurricane holds the potential of driving a localized endemic species such

as *Cyrtandra wagneri* to extinction in a single event (78 FR 64638, October 29, 2013).

**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):**
Rodent predation and herbivory—Herbivory by rats is noted to be a threat to *Cyrtandra wagneri* at all populations (78 FR 64638, October 29, 2013; Lorence and Perlman 2007, p. 359; NTBG 2003, 2004). Rats eat virtually every part of plants and at every stage: fleshy fruits, seeds, flowers, stems, leaves, shoot, seedlings, and roots (Abe and Umeno 2011, p. 35; Russell 1980, pp. 269–272; Cuddihy and Stone 1990, pp. 68–69). The effects on plants range from reduced vigor and decreased reproduction to mortality of individuals and complete lack of recruitment.

Slug and nonnative snail herbivory—Evidence of slug damage has been reported at occurrences of *Cyrtandra wagneri* (Lorence and Perlman 2007, p. 359). Slugs eat leaves and stems of younger plants and seedlings (Lorence and Perlman 2007, p. 359; NTBG 2004; 78 FR 64638 October 29, 2013). The effects on plants range from reduced vigor and decreased reproduction to mortality of individuals and complete lack of recruitment (Joe 2006, pp. 4, 50–52, Joe and Daehler 2008, p. 253). In a report by the Oʻahu Army Natural Resource Program, slug damage has been observed on another Hawaiian *Cyrtandra*, *C. dentata*, a rare species found within the Koʻolau Mountains of Oʻahu (ANRP 2018, p. 7).

**2.3.2.4 Inadequacy of existing regulatory mechanisms (Factor D):**
Lack of adequate hunting regulations—Both wild populations of *Cyrtandra wagneri* occur in a State hunting area. The State of Hawaiʻi provides game mammal hunting opportunities (e.g., "sustained yield") in public hunting areas on the island of Hawaiʻi (DLNR 2012). Nonnative feral ungulates pose a major ongoing threat to native species through destruction and modification of habitat, and through direct herbivory or predation. This population is fenced; however, the fence must be maintained and monitored for ungulate ingress. In addition, public hunting areas are not fenced and game mammals have unrestricted access to most areas across the landscape, regardless of underlying land use designation; therefore, any unfenced wild and reintroduced populations are at risk (DLNR 2010).

Currently, four agencies are responsible for inspection of goods arriving in Hawaiʻi (CGAPS 2009). The Hawaiʻi Department of Agriculture (HDOA) inspects domestic cargo and vessels and focuses on pests of concern to Hawaiʻi, 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 2010) 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 *Cyrtandra wagneri* and other federally listed species.

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

Low numbers of populations and individuals—*Cyrtandra wagneri* is a single-island endemic species with fewer than 50 individuals known at the time of listing (78 FR 64638, October 29, 2013). 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. The limited numbers of populations (two) and few individuals (five) within these populations is a serious and ongoing threat to *C. wagneri*. The species occurs only in the Hilo district of Hawai‘i, and is susceptible to threats from habitat degradation or loss by feral pigs, nonnative plants, flooding, and predation by feral pigs, rats, and slugs, which are compounded by this species’ limited distribution.

Hybridization—Hybridization is considered a threat to *Cyrtandra wagneri* because it can lead to the loss of the species (78 FR 64638, October 29, 2013). Putative hybrids of *C. wagneri* with *C. tintinnabula* were observed at the Laupāhoehoe NAR population. Hybridization is a phenomenon of cross-pollination between two species in which there is a transfer of genetic information between the two species (introgression). This can lead to the formation of a new species or a decline or loss of a genetically-distinct taxon. If one of the two hybridizing species are more abundant or vigorous than the other, and the hybrid individuals are also vigorous, the rarer species could become extinct after several generations of outcrossing and backcrossing among the other parent species and the hybrids (78 FR 64638, October 29, 2013).

Rapid ʻŌhiʻa Death (ROD)—Two fungus species (both in the genus *Ceratocystis*) impact the dominant canopy tree species of forests in Hawaiʻi, *Metrosideros polymorpha*, impacting tree health and causing mortality (Department of Agriculture 2020, in litt.). This disease is known as rapid ʻōhiʻa death or ROD. The *M. polymorpha* tree is a keystone native forest tree occurring from sea level to montane cloud forest that defines forest succession and ecosystem function, and provides habitat for native plant and animal species (Clark et al. 2019, p. 11). *Metrosideros polymorpha* is often the dominant canopy tree species within lowland wet forest where populations of *Cyrtandra wagneri* occur and its loss could affect the remaining populations of *C. wagneri* (VanDeMark 2020, pers. comm.).

Current Management Actions:

- Surveys and monitoring—Surveys for new populations and monitoring of the two known wild populations are ongoing (Plant Extinction Prevention Program (PEPP) 2010, 2013, 2015, 2016, 2017).
- Feral ungulate control—PEPP constructs and maintains fencing at one wild and one reintroduced population of *C. wagneri* (PEPP 2010, 2013, 2019). The State Department of Land and Natural Resources manages the Laupāhoehoe NAR to protect its watershed values, the natural plant and animal communities, and support sustainable forestry which may also provide some protection to *C. wagneri* (DLNR 2016, pp. 4–5).
- Control of established ecosystem-altering invasive plants—DOFAW prioritizes nonnative plant control within rare plant exclosures, along roadsides, and other areas, implementing 30 person-days per year (DLNR 2016, p. 49).
- Captive propagation for genetic storage and reintroduction—
    - The Lyon Arboretum Micropropagation Laboratory reports storage of 63 explants representing one founder at Laupāhoehoe NAR. The Lyon Arboretum Seed Conservation Laboratory reported that in 2003, a total of 4,494 seeds were stored from two plants, however,

these seeds were not sown until 2007. We speculate that they were of poor quality due to unfavorable storage conditions for four years, as no germination occurred (Lyon Arboretum 2020). In 2017, another 2,307 seeds were collected from the same two plants; these seeds were stored at Lyon Arboretum. Fifty of these seeds were sown and had 70 percent germination, 2,257 seeds remain (Lyon Arboretum 2019). Seeds from a third plant in the Laupāhoehoe NAR were collected in 2014, the first collection totaled 3,422 seeds of which 100 were sown resulting in 82 percent germination. The second collection totaled 6,872 seeds, 100 of which were sown resulting in 85 percent germination. A total of 3,322 and 6,772 seeds remain in storage, respectively (Lyon Arboretum 2020).

  - The Volcano Rare Plant Facility (VRPF) reported 10 plants in their inventory representing two founders from Humuʻula (VRPF 2020). In addition, there are four plants in their inventory representing one to two founders from Laupāhoehoe NAR (VRPF 2020).
  - Pahole Rare Plant Facility tested propagation using leaf cuttings from other *Cyrtandra* species and was successful (PRPF 2020). Because of the concern of hybridation between *C. wagneri* and *C. tintinnabula* and the possibility that the flowers are pollinated by *C. tintinnabula*, staff have refrained from relying on fruit collections to secure species of *Cyrtandra* in genetic storage (germplasm) collections. As species of *Cyrtandra* can root easily from leaves, they are able to grow into plants and probably are best for representing the genetics of a pure form of *Cyrtandra* with increased certainty that hybrid genotypes would not be used in reintroduction and recovery efforts. Once these stock plants flower, nursery staff can conduct hand pollinations and produce fruit that are pure *C. wagneri*, then the seeds can be germinated and more plants propagated for outplanting or storage (Weisenberger 2020, pers. comm.).
  - PEPP reports collection of cuttings from three wild individuals at Laupāhoehoe NAR for storage and propagation; however, only two have successfully rooted (PEPP 2016, 2017, 2019; VRPF 2020).

- Reintroduction—In 2019, PEPP outplanted six individuals (representing one founder) in the Kīlau Uka exclosure in Laupāhoehoe NAR (PEPP 2019).

**Table 1. Status and trends of *Cyrtandra wagneri* from listing through 5-year review.**

| Date | No. wild individuals | No. outplanted | Preventing Extinction Criteria identified by HPPRCC | Preventing Extinction Criteria Completed? |
|---|---|---|---|---|
| 2013 (listing) | 8 expressing pure | 0 | All threats managed in all 3 populations | No |

| | | | | |
|---|---|---|---|---|
| | phenotype | | | |
| | | | Complete genetic storage | No |
| | | | 3 populations with 50 mature individuals each | No |
| 2020 (5-year review) | 5 | 6 | All threats managed in all 3 populations | Partially, two exclosures protect 2 wild and 6 reintroduced individuals |
| | | | Complete genetic storage | Almost complete |
| | | | 3 populations with 50 mature individuals each | No |

**Table 2. Threats to *Cyrtandra wagneri* and ongoing conservation efforts.**

| Threat | Listing Factor | Current Status | Conservation/Management Efforts |
|---|---|---|---|
| Ungulate degradation of habitat | A | Ongoing | Partial, wild and reintroduced populations in 2 exclosures |
| Degradation of habitat by established ecosystem-altering invasive plant species | A | Ongoing | None |
| Flooding and erosion destruction and degradation of habitat | A | Ongoing | None |
| Climate change degradation or loss of habitat, including hurricanes | A | Ongoing | None |
| Predation and herbivory by rodents and slugs | C | Ongoing | None |
| Inadequacy of regulatory mechanisms | D | Ongoing | Partial, wild and reintroduced populations in 2 exclosures |
| Reduced viability due to low numbers | E | Ongoing | Partial, collection, propagation, and outplanting ongoing |

| | | | |
|---|---|---|---|
| Hybridization | E | Ongoing | Partial, propagation from leaves and hand pollination |
| Rapid ohia death (ROD) | E | Ongoing | Partial, proper sanitation methodology implemented |

### 2.4 Synthesis

There are five wild individuals in two small populations of *Cyrtandra wagneri* at Laupāhoehoe NAR (two individuals) and Humuʻula drainage (three individuals) on the island of Hawaiʻi. A landscape-based assessment of climate change vulnerability for native plants of Hawaiʻi using high resolution climate change projections was not conducted by Fortini *et al.* (2013); however, the analysis shows that a sympatric species, *C. tintinnabula*, is vulnerable to the effects of climate change, therefore, *C. wagneri* may also be vulnerable to the effects of climate change. One wild and one outplanted population in Laupāhoehoe NAR are fenced. Collection, storage, propagation, and outplanting are ongoing, with the reintroduced population totaling six individuals. Hybridization with the sympatric species, *C. tintinnabula,* is a threat to *C. wagneri*, therefore, propagation from leaf material and hand pollination are being implemented.

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 the island of Hawaiʻi where they now occur or occurred historically and each of these populations must be naturally reproducing (i.e., viable seeds, seedlings, or saplings) with a minimum of 50 mature, reproducing individuals per population.

The preventing extinction goals for this species have not been met. There are only two very small wild populations totaling five individuals. Genetic representation is almost complete for these individuals (Table 1); however, threats are not being sufficiently managed throughout the range of the species (Table 2). Therefore, *Cyrtandra wagneri* 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 suitable habitat for individuals of *Cyrtandra wagneri* in recent and historical locations.
- Ungulate monitoring and control—Continue to construct and maintain fenced exclosures to protect wild and reintroduced individuals from the negative impacts of feral ungulates.
- Invasive plant monitoring and control—Control established ecosystem-altering nonnative invasive plant species and those that compete with *C. wagneri* at all populations.
- Predation and herbivory by ungulates—Continue to construct and maintain fenced exclosures to protect wild and reintroduced individuals from the negative impacts of feral ungulates.
- Predation and herbivory by rats and slugs—Implement effective control measures for rats and slugs at all populations.
- Captive propagation for genetic storage and reintroduction—Continue to collect seeds and cuttings for storage and propagation efforts.
- Reintroduction and translocation—Augment wild populations and cross pollinate to increase numbers of populations and individuals in suitable habitat to reduce the impacts of hybridization, predation, climate change, and hurricanes.
- Climate change adaptation strategy—Research suitability of habitat in the future due to the impacts of climate change.
- Alliance and partnership development—Continue to collaborate with partners in planning and implementation of ecosystem-level restoration and management to benefit this species.

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**U.S. FISH AND WILDLIFE SERVICE**
**5-YEAR REVIEW of *Cyrtandra wagneri***
**(haʻiwale, kanawao keʻokeʻo)**

**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:**

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for _____
**Field Supervisor, Pacific Islands Fish and Wildlife Office**