Cyanea asplenifolia
(hāhā)

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: *Cyanea asplenifolia* (hāhā)

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5-YEAR REVIEW
***Cyanea asplenifolia* (hāhā)**

1.0 GENERAL INFORMATION

1.1 Reviewers:

Jay Nelson, 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 June 2019. The review was based on the final rule listing this species; the final critical habitat designation; peer reviewed scientific publications; unpublished field observations and species status report by the Service, State of Hawai‘i, and other experienced biologists; unpublished survey reports; notes and communications from other qualified biologists; as well as a review of current, available information.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 by Jay Nelson, 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: *Cyanea asplenifolia*
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 *Cyanea asplenifolia* in one unit in the lowland mesic ecosystem totaling 1,147 acres (ac) [464 hectares (ha)] and 8 units in lowland wet ecosystem totaling 10,086 ac [4,082 ha] (USFWS 2016, pp. 17891-17908).

1.3.4 Review History:
This is the first 5-year review for *Cyanea asplenifolia*.

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) (USFWS 2019, entire).
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. Maui Nui 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, life span, 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.

Cyanea asplenifolia is a short-lived perennial shrub with tendency for decline or fluctuation in numbers. 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. 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, saplings and increasing in number, with a minimum of 150 mature individuals per population.

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

Interim Stage
To meet the interim stage of recovery of *Cyanea asplenifolia*, 900 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, entire) 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 1500 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 1500 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:

Cyanea asplenifolia, a member of the Campanulaceae (bellflower) family, is a short-lived unbranched or sparingly branched perennial shrub 4.5 to 7 ft (1.5 to 2 m) tall. Leaves are pinnately divided, upper surface glabrose, lower surface sparsely pubescent, segments 10 to 15 per side, lanceolate to elliptic 0.5 to 1 inches (in) [10 to 25 millimeters (mm)] wide, margins of the segments irregular lobed, the lobes obtused, petioles 4.5 to 10 centimeters (cm) (2 to 4 in) long. Inflorescences 8 to 15 flowered peduncles 0.7 to 2 in (20 to 50 mm) long. Flowers are 1.2 to 1.5 in (30 to 38 mm) long, sparsely pubescent, with small calyx lobes, the tube suberect to gently curved (NTBG 2009, p. 1). Flowers are often covered with

spikes, sometimes arranged in rows, on the tips and faces of corolla lobes (NTBG 2009, p. 1). Fruit is globose to ovoid, 0.2 to 0.5 in (5 to 14 mm) long, 0.2 to 3 inches (5 to 8 mm) in diameter, pale to bright orange. Fruit is usually crowned by persistent calyx lobes with 50 to 175 seeds; seeds about .02 by .01 in (0.5 mm by about 0.25 mm), yellowish brown, flat, smooth (NTBG 2009, p. 1).

Little to no research has been done on *Cyanea asplenifolia* to understand the individual requirements for this species in the wild. The tube-shaped flowers point to bird-pollination (Cory et al. 2015, pp. 255-256), most likely from the endemic Hawaiian honeycreepers (Drepandidae) or the now extinct ʻōʻō (Mohoidae). Currently, the most likely extant pollinator is the ʻiʻiwi (*Drepanis coccinea*), with secondary pollination likely from the Hawaii ʻamakihi (*Chlorodrepanis virens*) (Aslan et al. 2013, p. 480). The fruits of *C. asplenifolia* were likely dispersed by birds as well (Givnish et al. 2009, p. 416). The now extinct frugivores, the ʻōʻū (*Psittirostra psittacea*) and the olomaʻo (*Myadestes lanaienis*), were probably the primary dispersers in the past. Currently, seed dispersion is likely facilitated by two non-native species: the Japanese white-eye (*Zosterops japonicus*) and the red-billed leothrix (*Leiothrix lutea*). Dispersal in *Cyanea* species was always likely limited due to its reliance on forest-dependent birds (Givnish et al. 2009, p. 408). Since the breeding system of *Cyanea asplenifolia* is unclear, we used the general study conducted by Sakai et al. (1995, p. 2524) to make inferences for this species. Sakai et al. studied the colonists of the flora of the Hawaiian Islands to determine the breeding system of a colonist's lineage, the assumed breeding system of a colonist, the breeding system of the current species, the presumed pollinator of the colonists, and the presumed dispersal method. According to Sakai et al., the breeding system of the colonist's lineage was monomorphic, the breeding system of the colonist was hermaphroditic, and the breeding system of the current species in the *Clermontia* / *Cyanea* / *Delissea* / *Rollandia* genera was hermaphroditic. The presumed pollinator of the colonists were birds and the presumed original long-distance dispersal method was internally by birds. Based on the results of this study, the breeding system for *C. asplenifolia* is hermaphroditic thus flowers have both functional male and female reproductive organs. From other research it is likely that *C. asplenifoia* is similar to many other species of *Cyanea* in being facultative autogamous, a sexual species that is able to reproduce without cross-pollination (Cory et al. 2015, p. 258). We have some information about how long the species' seeds remain viable, as seeds of *C. asplenifolia* have been germinated by the Olinda Rare Plant Facility (ORPF) and plants from these seeds have been translocated to the wild. Some life history information is currently unknown, including information on plant growth stages, longevity, and the length of time it takes to flower. The potential lifespan of *C. asplenifolia* is apparently short at less than 10 years.

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:
Cyanea asplenifolia is known historically in the 1900s from Waiheʻe Valley and Kāʻanapali on west Maui, and Halehaku Ridge on east Maui (Lammers 1990, p. 445; USFWS 2013, p. 32024). Based on surveys from 1998 to 2008, the species occurred in seven populations at (1,850 to 2,900 ft (565 to 884 m) elevation on east and west Maui. Four of these on west Maui at Hononana, Honolua, Honokōhau, and "Pōhakupele" [Pōhakupule], and three on east Maui at Kukuiʻula, Kaʻāpahu and Makawao-Olinda (NTBG 2009, p. 3). Since that time a new population was discovered at Makamaka'ole on west Maui. There are two translocated populations of *C. asplenifolia* at Lelekea and ʻOheʻo in the southeast region of east Maui; however, neither population has been observed to produce seedlings (HALE HRPRG 2018, p. 1).

Currently there are 6 populations on west Maui in four population reference areas: Honanana; Honokōhau (that includes the separate populations - Honokōhau, Kaluanui, and Pohakupule); Makamakaʻole, and ʻĪao Valley. There are five populations on east Maui: one wild population at Makawao-Olinda on the northwest slope of Haleakalā, and two wild populations at Kaukauʻai and Kikuiʻula, and two translocated populations at Lelekea and ʻOheʻo on the southeast slope of Haleakalā. Pigs and goats, rooting and grazing the Kaukauʻai population of *C. asplenifolia* was identified as the primary cause for a catastrophic decline of this population from an estimated 550 plants in 1993 to 14 plants in 2019 (Oppenheimer and Welton 2019a, p. 1; Oppenheimer and Welton 2019b, p. 2). Damage of this magnitude from ungulates has not been observed for other populations. The Kikuiʻula population, in Haleakalā National Park, responded to plastic fencing to exclude feral ungulates in the early 2000s, increasing from 54 to 122 individuals, however has since declined to approximately 10 plants because fencing has not been maintained (Oppenheimer and Welton 2019, p. 2). For this species ungulate browsing by pigs and goats is a major threat driving decline of populations on east Maui. Additionally, introduced *Schinus terebinthifolius* (Christmas berry) and *Clidemia hirta* (Koster's curse or Clidemia) have invaded both the Kaukauʻai and Kikuiʻula populations (Oppenheimer and Welton 2019b, p. 2).

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: N/A

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):
Cyanea asplenifolia occurs within Hawai‘i wet forest, Hawai‘i mesic forest, and Hawai‘i wet shrubland and grassland ecosystems described by Clark et al. (2019, entire), Lowe et al. (2019, entire), and Nelson et al. (2019, entire). Hawai‘i wet forest habitat where *C. asplenifolia* primarily occurs is characterized by the dominant overstory tree, *Metrosideros polymorpha* (‘ōhi‘a), with *Cibotium* spp. (hapu‘u) tree fern, *Cheirodendron trigynum* (‘ōlapa) and *Ilex anomala* (kāwa‘u) subcanopy, and understory comprised of diverse fern species, *Pepperomia* spp., *Vaccinium* spp., and other understory plants (Clark et al. 2019, p. 2).

As described in the 2009 National Tropical Garden report (NTBG 2009, pp. 2-3), *C. asplenifolia* on west Maui is found with associated native trees and shrubs including *Metrosideros polymorpha* (‘ōhi‘a), *Syzygium sandwicensis* (‘ōhi‘a ha), *Cheirodendron trigynum* (‘ōlapa), and *Ilex anomala* (kāwa‘u). Other associates include *Alyxia stellata* (maile), *Antidesma platyphyllum* (hame), *Broussaisia arguta* (kanawao), *Cibotium spp*. (hāpu‘u) tree fern, *Elaphoglossum spp.* (ferns), *Freycinetia arborea* (‘ie‘ie), *Clermontia kakeana* (hāhā), *C. grandiflora ssp. munroi* (‘ōhāwai), *Melicope clusiifolia* (kolokolo mokihana), *Mecodium recurvum* (‘ōhi‘a ku), and *Sadleria pallida* (‘ama‘u) fern.

In the southeast region of east Maui native plant associates include *Alyxia stellata* (maile), *Antidesma platyphyllum* (hame), *Bobea sp.*, *Broussaisia arguta* (pū‘ahanui), *Carex wahuensis*, *Charpentiera ovata* (pāpala), *Cheirodendron trigynum* (‘ōlapa), *Clermontia arborescens* (‘ōhāwai), *C. kakeana* (hāhā), *Coprosma foliosa* (pilo), *Cyrtandra grayi* (ke‘oke‘o ha‘iwale), and *Labordia tinifolia* (kāmakahala). Additional species include *Leptecophylla tameiameiae* (pūkiawe), *Kadua affinis* (manono), *Machaerina mariscoides* (‘uki), *Melicope molokaiensis* (alani), *M. peduncularis* (alani), *Psychotria hawaiiensis* (kōpiko), *P. mariniana* (kōpiko), *Syzygium sandwicense* (‘ōhi‘a ha), *Tetraplasandra kavaiensis* (‘ohe‘ohe), *Vaccinium* sp. (‘ōhelo), and *Wikstroemia oahuensis* (‘ākia).

Native ferns associated in this area include *Asplenium normale*, *Athyrium microphyllum* (ʻākōlea), *Cibotium spp*. (hāpuʻu), *Dicranopteris linearis* (uluhe), *Diplazium sandwichianum* (hōʻiʻo), *Dryopteris spp*. (ʻakole, kīlau, or hohiu), *Elaphoglossum spp*., *Nephrolepis cordifolia*, *Phlegmariurus mannii* (clubmoss), and *Sadleria cyatheoides* (ʻamaʻu). In the lowest layers of the canopy are native sedges such as *Carex alligata*, *Uncinia uncinata*, and the herb *Peperomia tetraphylla* (ʻalaʻala wai nui). Other associated species include *Clermontia samuelii* (ʻōhā wai), *Ctenitis squamigera* (pauoa), *Cyanea copelandii* (hāhā), *C. glabra* (hāhā), *C. elliptica* (hāhā), *C. hamatiflora* (hāhā), *Huperzia mannii*, *Melicope ovalis* (alani), *Plantago princeps* (laukahi kuahiwi), and *Streblus pendulinus* (aʻiaʻi).

In the northwest region of east Maui *Cyanea asplenifolia* is observed to grow in one area in dense shade of a remnant *Acacia koa* (koa)/*Metrosideros polymorpha* mesic forest. Associated native species include *Alyxia stellata*, *Antidesma platyphyllum platyphyllum*, *Asplenium contiguum*, *Broussaisia arguta*, *Cheirodendron trigynum*, *Cibotium glaucum* (hāpuʻu), *C. menziesii* (hāpuʻu ʻiʻi), *Clermontia kakeana*, *Cyrtandra grayi*, *Diplazium sandwichianum*, *Dryopteris wallichiana* (ʻiʻo nui), *Freycinetia arborea* (ʻieʻie), *Peperomia cookiana* (ʻalaʻala wai nui), *Perrottetia sandwicensis* (olomea), *Pipturus albidus* (mamake), *Psychotria mariniana* (kopiko) and *Streblus pendulinus* (aiai). This area of occurrence is surrounded by historic forestry plantings, mostly Eucalyptus species (NTBG 2009, p. 3).

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 introduced feral goats (*Capra hircus*) and pigs (*Sus scofra*) is a threat to *Cyanea asplenifolia*. These introduced ungulates are highly destructive to the native vegetation by eating young trees and young shoots of plants before they can become established, contribute to erosion by creating trails that damage native vegetative cover through substrate destabilization and creation of gullies that alter hydrology, and by dislodging stones from ledges that can cause rockfalls and landslides damaging or destroying vegetation below (Cuddihy and Stone 1990, pp. 25–26, 63–64). These activities promote the invasion of nonnative plants that outcompete this species for space, water, light and nutrients. Additionally, these ungulates may consume *C. asplenifolia* when foraging for food, and directly damage roots and seedlings of *C. asplenifolia* (USFWS 2013, p. 32042). For *C. asplenifolia* ungulate browsing by pigs

and goats is a major threat driving decline of populations particularly in southeast region of east Maui.

Established ecosystem-altering invasive plant modification and degradation of habitat—Habitat destruction and degradation and competition by invasive nonnative plant species are threats to *Cyanea asplenifolia*. Invasive nonnative plant species are responsible for modifying the availability of light; altering soil-water regimes; modifying nutrient cycling; altering the fire regime affecting native plant communities; and ultimately, converting native-dominated plant communities to nonnative plant communities (Cuddihy and Stone 1990, p. 74; D'Antonio and Vitousek 1992, p. 73; Vitousek et al. 1997, p. 6). Introduced *Schinus terebinthifolius* (Christmas berry) and *Clidemia hirta* (Koster's curse or Clidemia) have invaded both the Kaukau'ai and Kukui'ula populations of the southeast region (Oppenheimer and Welton 2019b, p. 2).

Flooding, landslides, rockfalls, and treefalls destruction or degradation of habitat—Flooding, landslides, rockfalls, and treefalls destabilize substrates, damage and destroy individual plants, and alter hydrological patterns, which result in changes to native plant and animal communities (Clark et al. 2019, p. 11). Due to the steep topography of much of the areas on Maui where *Cyanea asplenifolia* remain, erosion and disturbance caused by heavy rain and flooding, has the potential to negatively affect this species. For those species that occur in small numbers in highly restricted geographic areas, such events have the potential to eradicate all individuals of a population, or even all populations of a species, resulting in extinction. Monitoring data suggest *C. asplenifolia* faces threats from landslides, falling rocks, and treefalls, as the species is found in landscape settings susceptible to these events (e.g., steep slopes and cliffs) (USFWS 2013, pp. 32045, 32058).

Climate change loss or degradation of habitat, including hurricanes—"Climate" refers to the mean and variability of different types of weather conditions over time, with 30 years being a typical period for such measurements, although shorter or longer periods also may be used (IPCC 2007, p. 78). The term "climate change" refers to a change in the mean or variability of one or more measures of climate (e.g., temperature or precipitation) that persists for an extended period, typically decades or longer, whether the change is due to natural variability, human activity, or both (IPCC 2007, p. 78). Various types of changes in climate can have direct or indirect effects on species. These effects may be positive, neutral, or negative and they may change over time, depending on the species and other relevant considerations, such as the effects of interactions of climate with other variables (e.g., habitat fragmentation) (IPCC 2007, pp. 8–14, 18–19; Clark et al. 2019, p. 11). 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 *Cyanea asplenifolia* is vulnerable to the impacts of climate change with a vulnerability score of 0.579 (on a scale of 0 being not vulnerable to 1 being extremely vulnerable to climate change) (Fortini et al. 2013, p. 70).

In the main Hawaiian Islands, predicted changes associated with increases in temperature include a shift in vegetation zones upslope, shift in species' ranges, changes in mean precipitation with unpredictable effects on local environments, increased occurrence of drought cycles, and increases in the intensity and number of hurricanes (Loope and Giambelluca 1998, pp. 514-515; Nelson et al. 2019, p. 7). The warming atmosphere is creating increase in tropical storm frequency and intensity (e.g., tropical storms and hurricanes), and altered precipitation patterns that contribute to regional increases in floods, heat waves, drought, and wildfires that also displace species and alter or destroy natural ecosystems (USFWS 2013, p. 32047; Clark et al. 2019, p. 11). Data on precipitation in Hawai‘i show a steady and significant decline of about 15 percent over the last two decades of the 20th century (Chu and Chen 2005, pp. 4881-4900; Diaz et al. 2005, pp. 1-3). Downscaling of global climate models indicates that wet-season (winter) precipitation will decrease by 5 percent to 10 percent, while dry-season (summer) precipitation will increase by about 5 percent (Timm and Diaz 2009, pp. 4261-4280). These data are supported by a steady decline in stream flow beginning in the early 1940s (Oki 2004, p. 1). Altered seasonal moisture regimes can have negative impacts on plant growth cycles and overall negative impacts on natural ecosystems (US-GCRP 2009, p. 79).

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, entire; Emanuel et al. 2008, entire; Yu et al. 2010, entire). 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. 749-750). Hurricanes destroy native vegetation and the habitat of *Cyanea asplenifolia* by opening the canopy and thus modifying the availability of light, and creating disturbed areas conducive to invasion by nonnative pest species. Gaps in the canopy also allow for the establishment of nonnative plants, which may be present as plants or as seeds incapable of growing under shaded conditions (Harrington et al. 1997, pp. 539–540). *Cyanea asplenifolia* persists in populations distributed across both east and west Maui. Hurricane landfall on either east or west Maui potentially could lead to extirpation of this species from region receiving brunt of hurricane effects.

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 and rats—Predation by introduced slugs (*Derocerus* sp. and possibly *D. laeve*) is a threat to this species (USFWS 2013, p. 32053). Slugs impact individuals of *Cyanea asplenifolia* through mechanical damage, destruction of plant parts, and direct mortality (Joe and Daehler 2008, p. 252). Rats impact native plants by eating seeds, flowers, leaves, roots, and other plant parts (Atkinson and Atkinson 2000, p. 23), and can negatively impact regeneration. Plants with fleshy fruits such as *C. duvalliorum* are particularly susceptible to rat predation (Cuddihy and Stone 1990, pp. 67–69). Although rats have not been observed to consume the fruits and seeds of *C. asplenifolia* directly they are likely threat to this species.

2.3.2.4 Inadequacy of existing regulatory mechanisms (Factor D):
Existing Federal, State, or local laws, treaties, or regulations do not adequately address threats to this species (USFWS 2013, p. 32014).

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, p. 4; Newman and Pilson 1997, p. 361). 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 of outcrossing species may experience reduced reproductive vigor due to ineffective pollination or inbreeding depression. There are only approximately 61 individual plants of *Cyanea asplenifolia* distributed among 9 populations making the species vulnerable to reduced viability due to low numbers of individual plants, reduced reproductive vigor, and other effects associated with small population size in the wild.

Loss of native pollinators and seed dispersal agents—*Cyanea* and other lobelioids coevolved with nectarivorous Hawaiian honeycreepers (Drepanididae) and honeyeaters (Meliphagidae) that served as plant pollinators, and native thrushes (*Myadestes*) and other frugivorous birds, such ʻOʻu (*Psittirostra pittacea*), that served as seed dispersers (Lunau 2004, p. 210; Banko and Banko 2009, pp. 30-31). Since human

colonization of Hawai‘i, nectarivorous and frugivorous birds and native plant species that depend on them for pollination and seed dispersal have undergone wide-scale declines and extinctions, including extinction on Maui of all native frugivorous birds and many species of native nectarivorous birds (Banko and Banko 2009, pp. 30–36; Cory *et al.* 2015, p. 255). For the most part avian malaria (*Plasmodium relictum*), which is transmitted in Hawai‘i by the mosquito species (*Culex quinquefaciatus*), has restricted remaining Hawaiian honeycreepers to higher elevations where average temperatures are too cold for mosquitoes to persist (LaPointe et al. 2012, p. 216-217). Loss of native forest birds that aided in pollination and seed dispersal likely was contributing factor to the decline historically of *Cyanea asplenifolia* at middle and lower elevations. Fortini et al. 2015 (pp. 7-10) predict by mid-century with continued increasing temperatures that remaining native bird-pollinators of *C. asplenifolia* will survive only at high elevations, overlapping only high elevation populations of *C. asplenifolia* (Fortini et al. 2015, pp. 7-10).

Current Management Actions:

- Surveys and monitoring—The Plant Extinction Prevention Program (PEPP) regularly monitors wild and translocated populations of *Cyanea asplenifolia* on Maui (PEPP 2019).
- Ungulate monitoring and control—*Cyanea asplenifolia* occurs on state, Federal and private lands. Currently, west Maui populations are fenced, or approximately half the total population. Populations on Federal lands on east Maui are largely unprotected because ungulate fencing has not been maintained.
- Ecosystem-altering invasive nonnative plant control—PEPP conducts nonnative plant control at some populations of *Cyanea asplenifolia* (PEPP 2019, p. 1).
- Captive propagation for genetic storage and reintroduction—The species has 357 seeds and 126 explants from two wild individuals in genetic storage at Lyon Arboretum Seed Conservation and Micropropagation Laboratories (Lyon 2019). There are approximately 30 plants in *ex situ* propagation at the Olinda Rare Plant Facility (ORPF) and 3 plants at Haleakalā National Park (HALE). Plants at the ORPF are from a single wild founder (HALE HRPRG 2018, p. 1; Oppenheimer and Welton 2019b, p. 2; ORPF 2019, p. 3).
- Reintroduction and translocation—there are two translocated populations on east Maui, totaling approximately 18 individuals but it is not known translocated plants are producing fruits and self-reproducing (HALE HRPRG 2018, p. 1; ORPF 2019, p. 1).

Table 1. Status and trends of *Cyanea asplenifolia* from listing through 5-year review.

Date	No. wild individuals	No. outplanted	Preventing Extinction Criteria identified by HPPRCC	Preventing Extinction Criteria Completed?
2013 (listing)	< 200	0	All threats managed in all 3 populations	No
			Complete genetic storage	No
			3 populations with 150 mature individuals each	No
2016 (critical habitat)	< 200	0	All threats managed in all 3 populations	No
			Complete genetic storage	No
			3 populations with 150 mature individuals each	No
2020 (5-year review)	61	18	All threats managed in all 3 populations	No
			Complete genetic storage	Limited (two wild individuals)
			3 populations with 150 mature individuals each	No

Table 2. Threats to *Cyanea asplenifolia* and ongoing conservation efforts.

Threat	Listing Factor	Current Status	Conservation/Management Efforts
Ungulate degradation of habitat	A	Ongoing	Partial, some populations fenced
Established ecosystem-altering invasive plant modification and degradation of habitat	A	Ongoing	Partial, nonnative plant management at some sites
Landslides and treefalls	A	Ongoing	None
Climate change degradation or loss of habitat, including hurricanes	A	Ongoing	None
Slug herbivory	C	Ongoing	None
Rat predation and herbivory	C	Ongoing	Partial, traps set at some sites

Reduced viability due to low numbers	E	Ongoing	Partial, seed and cuttings collections, propagation, and reintroduction efforts
Loss of pollinators and dispersal agents	E	Ongoing	None

2.4 Synthesis

There are nine wild populations consisting of approximately 61 individuals total of C*yanea asplenifolia* and two translocated populations. Translocated populations are not known to be naturally reproducing. Species wild populations have declined dramatically in the last three decades, primarily from damage caused by feral ungulates. 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 *C. asplenifolia* is vulnerable to the effects of climate change. The species has over 350 seeds in genetic storage and approximately 30 plants in *ex situ* propagation. Nonnative plant control is conducted periodically at wild and translocated populations.

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, or saplings) with a minimum of 150 mature, reproducing individuals per population.

The preventing extinction goals for this species have not been met. There are only approximately 61 wild individuals total, genetic representation is incomplete (Table 1), and not all threats are being sufficiently managed throughout the range of the species (Table 2). Therefore, *Cyanea asplenifolia* 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 conduct surveys for *Cyanea asplenifolia* in historical locations and potentially suitable habitat.
- Ungulate monitoring and control—Continue to construct and maintain fenced exclosures to protect 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 *C. asplenifolia*.
- Climate change adaptation strategy—Research suitability of habitat in the future due to the impacts of climate change.
- Rat and slug predation and herbivory—Continue to implement effective control methods for rats, and develop and implement effective control methods for slugs.
- Captive propagation for genetic storage and reintroduction—Continue to collect seeds and cuttings for storage and propagation efforts for maintenance of genetic stock.
- Reintroduction and translocation—Increase numbers of populations and individuals in suitable habitat to build resiliency and redundancy and reduce the impacts of climate change and low numbers.
- Alliance and partnership development—Continue to contribute to planning and implementation of ecosystem-level restoration and management to benefit this taxon.

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U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW of *Cyanea asplenifolia* (hāhā)

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:
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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