Bidens campylotheca subsp. *waihoiensis*
(koʻokoʻolau)

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: *Bidens campylotheca* subsp. *waihoiensis*
(koʻokoʻolau)

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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 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on the final rule listing this species; the final critical habitat designation; peer reviewed scientific publications; unpublished field observations and species status report by the Service, State of Hawaiʻi, and other experienced biologists; unpublished survey reports; notes and communications from other qualified biologists; as well as a review of current, available information.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 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: *Bidens campylotheca* subsp. *waihoiensis*
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 for *Bidens campylotheca* subsp. *waihoiensis* across 39,539 acres (ac) [16,001 hectares (ha)] in three habitat types: lowland wet forest, montane wet forest, and wet cliffs (USFWS 2016, pp. 17881-17882, 17908, 17910-17911, and 17914). Of the 10 units designated, four of them are currently occupied by *B. campylotheca* subsp. *waihoiensis* (lowland wet unit 1, montane wet unit 3, wet cliff unit 2, and wet cliff unit 4). Many of the units that were designated are outside of the current range of the species and have other climatic conditions (e.g., lower average annual rainfall).

1.3.4 Review History:
This is the first 5-year review for *Bidens campylotheca* subsp. *waihoiensis*.

1.3.5 Species' Recovery Priority Number at start of this 5-year review:
3

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.

Bidens campylotheca subsp. *waihoiensis* 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. 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 individuals per population.

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

Interim Stage
To meet the interim stage of recovery of *Bidens campylotheca* subsp. *waihoiensis*, 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, entire). 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:

Bidens campylotheca subsp. *waihoiensis* (koʻokoʻolau), is a short-lived perennial herb in the sunflower family (Asteraceae) that is found only on the island of Maui (Wagner et al. 1990, p. 273). It is one of three subspecies of *B. campylotheca*. All subspecies are erect, somewhat woody herbs that reach heights between 2 and 13 feet (ft) [0.7 and 4 meters (m)] tall and have sprawling, vine-like lateral branches. The flowers for this subspecies are distinctive in their diffuse (spread out) inflorescences that form only from these lateral branches. Like all Hawaiian *Bidens* species, the flowers are yellow and the fruits are small achenes (dry fruit) (Wagner et al. 1990, p. 268).

Bidens campylotheca subsp. *waihoiensis* differs from the other two subspecies in both leaf shape and in the shape of the achenes. Subspecies *waihoiensis* has tripinnatifid or bipinnate leaves with 5-9 leaflets, which are often split into linear segments, while *B. campylotheca* subsp. *pentamera* has similar leaves that are lobed rather than divided and *B. campylotheca* subsp. *campylotheca* has pinnately compound leaves with only 3-5 leaflets. The fruits of this species also differ from the other two subspecies by having straight achenes with undulating wings along the edges and short awns (bristles) versus irregularly twisted or coiled achenes without wings or awns (Wagner et al. 1990, p. 273). A complete physical description of this subspecies can be found in St. John et al. (1983).

Dispersal for *Bidens* species is usually by mechanical means via attachment to animals, such as birds. However, most *Bidens* species in Hawai‘i (including this species) have lost entirely or have greatly reduced awns (or barbs) that provided the mechanical connection between the achene and animal, which likely leads to a low dispersal ability (Knope 2012, p. 1212). Due to the ease with which this species can be grown from cuttings, it has also been theorized that wild plants may be able to adventitiously root as well (H. Oppenheimer pers. comm. 2019).

Most individuals of this species are associated with gulches, cliffs, and other streamside habitat. However, it is unclear whether that is due to searcher bias or whether individuals prefer these areas, possibly due to a more frequent disturbance regime.

Bidens campylotheca subsp. *waihoiensis* has not been directly studied to ascertain the individual requirements for the species in the wild. Research has been done on other *Bidens* in Hawai‘i, however, including a small amount on *B. campylotheca* subsp. *campylotheca*. While about half of the *Bidens* species in Hawai‘i are gynodioecious (have both hermaphroditic and female-only plants in a population), *B. campylotheca* subsp. *campylotheca* is only known to be hermaphroditic (Sun 1987, p. 327). Outcrossing rates in hermaphroditic species range widely, from 24.2 to 88.7 percent (Sun and Ganders 1988, p. 520). While the rate for *B. campylotheca* was not studied, this species was found to have the highest degree of protandry (time between expression of male versus female characteristics) of any Hawaiian *Bidens* examined, which would lead one to believe that selfing (self-fertilization) is likely low for this species (Sun and Ganders 1988, p. 518).

For many *Bidens* species, cross-pollination is important and no seed set occurs if pollinators are not present (Sun and Ganders 1988, p. 522). While unknown for *B. campylotheca* subsp. *waihoiensis*, one would expect this subspecies to be similar. As mentioned above, all populations are also mixed mating, which means they don’t exclusively outcross or self (Sun and Ganders 1988, p. 524). This means that cross-pollination is

important for the maintenance of population structure. Dispersal for *Bidens* species is usually by mechanical means via attachment to animals, such as birds. However, most *Bidens* species in Hawai‘i (including this subspecies) have lost or greatly reduced the awns that provided the mechanical connection, which likely leads to a low dispersal ability (Knope 2012, p. 1212).

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:

Bidens campylotheca subsp. *waihoiensis* occurs in wet ‘ōhia forest between 3,000 and 4,200 ft (940 and 1,310 m) with rainfall above 250 in (6,350 mm) on East Maui. The earliest population estimates are of hundreds of plants along Waiohonu stream in Waiho‘i Valley in 1974 and then around 200 plants scattered over an area of 2.5 miles (mi) [4 kilometers (km)] in Kīpahulu Valley in 2010 (USFWS 2013, p. 32024).

Currently, *Bidens campylotheca* subsp. *waihoiensis* is found in wet forests and on wet cliffs primarily in Waiho‘i and Kīpahulu Valleys. The species forms a semi-contiguous population from the northeastern portion of the lower shelf of Kīpahulu Valley north into the wet forests of Hana Forest Reserve. Within that range, three general population units can be roughly delineated based on geographic variations: Kīpahulu Valley, Waiho‘i Valley, and Hana Forest Reserve north of Waiho‘i. A 1980 report from Kaumakani ridge between Kīpahulu and Waiho‘i Valleys indicates that more individuals may also be found in this area, which has not been surveyed recently (H. Oppenheimer pers. comm. 2019). This would constitute a fourth potential, but unconfirmed, population.

At least 50 plants are known from each of Kīpahulu amd Waiho‘i Valleys (USFWS 2020, unpublished data), but the population may be higher as all suitable habitat has not been searched, especially in Waiho‘i. Due to the sprawling, vine-like nature of the branches of *B. campylotheca* subsp. *waihoiensis*, exact numbers of individuals can be difficult to determine in some areas, with locations noted by the size of the area covered instead. It is also possible that this species adventitiously roots from the branches, making individuals counts even more challenging (H. Oppenheimer pers. comm. 2019). In addition to the populations within the two valleys, two individuals have also been noted from the Hana Forest Reserve north of Waiho‘i, and it is possible that more individuals could be found with surveys in the very rugged wet forests in this area (H. Oppenheimer pers. comm. 2019). Some individuals in Kīpahulu Valley may potentially be hybrids with the closely related *B. campylotheca* subsp. *pentamera* (H. Oppenheimer pers. comm. 2019), which also occurs in the area, though

normally at a slightly higher elevation. For these reasons, current population numbers should be considered approximate.

2.3.1.3 Genetics, genetic variation, or trends in genetic variation (e.g., loss of genetic variation, genetic drift, inbreeding, etc.):
Bidens species in Hawai‘i are all interfertile, though most species do not co-occur, so while hybridization is known, it is not especially common (Wagner et al. 1990, p. 268). However, both *Bidens campylotheca* subsp. *waihoiensis* and *B. campylotheca* subsp. *pentamera* co-occur in Kīpahulu Valley areas of East Maui, and it is possible that hybridization occurs between the subspecies for this location (H. Oppenheimer pers. comm. 2019).

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.):
Bidens campylotheca subsp. *waihoiensis* is found entirely within the very wet moisture zone as delineated by Price et al. 2012 (p. 313). Rainfall in the range of this subspecies is over 300 inches (in) [7,620 millimeters (mm)] year (Giambelluca et al. 2013, p. 313), and the average annual temperature ranges between 14°-17° C (57°-63° F) (Giambelluca et al. 2014, entire). *Bidens campylotheca* subsp. *waihoiensis* has a very narrow elevational range, especially compared to the other two *Bidens campylotheca* subspecies. All records and known individuals are found in mid-elevation ‘ōhia (*Metrosideros polymorpha*) forests between 3,000 and 4,200 ft (940 and 1,300 m), with most records from below 3,600 ft (1,125 m) (USFWS 2020, unpubl. data). Associated species for *B. campylotheca waihoiensis* include ‘ōhia, *Cheirodendron trigynum* (‘ōlapa), *Kadua* spp., *Myrsine* spp. (kolea), *Coprosma* spp. (pilo), *Perrottetia sandwicensis* (olomea), *Melicope* spp. (alani), *Acacia koa* (koa), *Labordia* spp., *Dicranopteris linearus* (uluhe) fern, *Dubautia* spp. (na‘ena‘e), *Pipturus albidus* (māmaki) and *Broussaisia arguta* (kanawao) (NTBG 2019, entire).

2.3.1.6 Habitat or ecosystem conditions (e.g., amount, distribution, and suitability of the habitat or ecosystem):

While habitat destruction and herbivory by feral ungulates was likely the biggest threat to *Bidens campylotheca* subsp. *waihoiensis* in the past, most populations now are within fenced units. Fencing and removal of feral ungulates has allowed native ecosystems that support *B. campylotheca* subsp. *waihoiensis* to recover somewhat from damage caused by feral

ungulates. Although *B. campylotheca* subsp. *waihoiensis* is found today only in very wet native forest, it is uncertain whether the species occurred historically in habitats with less precipitation.

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 pigs (*Sus scofra*), goats (*Capra hircus*) and Axis deer (*Axis axis*) is a threat to *Bidens campylotheca* subsp. *waihoiensis* in areas where ungulates are not fenced. 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 *B. campylotheca* subsp. *waihoiensis* for space, water, light and nutrients. Additionally, these ungulates may consume *B. campylotheca* subsp. *waihoiensis* when foraging for food, and directly damage roots and seedlings of *B. campylotheca* subsp. *waihoiensis* (USFWS 2013, p. 32053).

Established ecosystem-altering invasive plant modification and degradation of habitat—Habitat destruction and degradation and competition by invasive nonnative plant species are threats to *Bidens campylotheca* subsp. *waihoiensis*. 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 invasive weeds including strawberry guava (*Psidium cattleinum*), Koster's curse (*Clidemia hirta*) and kahili ginger (*Hedychium gardnerianum*) are a particular threat to *B. campylotheca* subsp. *waihoiensis* because these invasive species form monotypic stands of vegetation excluding all native species (USFWS 2013, p. 32031).

Flooding, landslides, rockfalls, and treefalls destruction or degradation of habitat— *Bidens campylotheca* subsp. *waihoiensis* faces threats from flooding, landslides, rockfalls, and treefalls (USFWS 2013, pp. 32048 and 32052) that damage and destroy individual plants, and alter hydrological patterns, which result in changes to native plant and animal communities

Clark et al. 2020, p. 11). Due to the steep topography of much of the areas on Maui where *Bidens campylotheca* subsp. *waihoiensis* remain and the species apparent preference to grow in steep gulches and along streams, erosion and disturbance caused by heavy rain and flooding, has the potential to negatively affect this subspecies. 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.

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. 2020, 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 included *Bidens campylotheca* (at the species level). Vulnerability score for *B. campylotheca* (on a scale of 0 being not vulnerable to 1 being extremely vulnerable to climate change) is 0.267, moderately low (Fortini et al. 2013, p. 67). However, this may be lower than scores for the subspecies because species range of *B. campylotheca* includes O‘ahu and greater diversity of habitat types and range of temperature and precipitation.

In the main Hawaiian Islands, predicted changes associated with increasing temperature include 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 in addition is causing 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. 2020, 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 indicate 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 *Bidens campylotheca* subsp. *waihoiensis* 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). *Bidens campylotheca* subsp. *waihoiensis* persists in small isolated populations and hurricane landfall potentially could lead to the extirpation of individual populations.

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. 32055; H. Oppenheimer 2019, pers. comm.). Slugs impact native Hawaiian plants 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 and are a threat to this species (Atkinson and Atkinson 2000, p. 23; USFWS 2013, p. 32056).

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. 32058).

2.3.2.5 Other natural or manmade factors affecting its continued existence (Factor E):
Reduced viability due to low numbers—As remaining populations are few and numbers low, they all could be impacted by low population size

dynamics, including inbreeding depression and increased impacts from stochastic events, which is made worse by the low dispersal ability of the species. Hybridization with the closely related *Bidens campylotheca* subsp. *pentamera* might also be a threat for populations in Kīpahulu Valley, where these two subspecies co-occur (H. Oppenheimer pers. comm. 2019). 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. The population in Hana Forest Reserve is estimated to only have two individuals, so impacts of low numbers could be a potential threat to *Bidens campylotheca* subsp. *waihoiensis.*

Loss of native pollinators and seed dispersal agents—*Bidens* species are mixed mating, which means they do not exclusively cross-pollinate (exchange pollen between individual plants) or self-pollinate (plant pollinates itself) (Sun and Ganders 1988, p. 524). This means that cross-pollination within a population is important for the maintenance of population structure for these species. The native pollinator for *Bidens campylotheca* subsp. *waihoiensis* is unknown but may have been native yellow-faced bees (*Hylaeus* spp.) that have declined dramatically and habitat for some of these species overlap subspecies *waihoiensis* current range (USFWS 2016a, pp. 67811-67817), Most pollination in the genus it is theorized is now facilitated by non-native honeybees (Sun and Ganders 1988, p. 516). Therefore a loss of mutualistic interactions could be a potential threat to *Bidens campylotheca* subsp. *waihoiensis.*

Hybridization—Hybridization occurs in *Bidens* species, as all Hawaiian species are interfertile (Wagner et al. 1990, p. 267). Some individuals in Kīpahulu Valley may potentially be hybrids with the closely related *Bidens campylotheca* subsp. *pentamera* (H. Oppenheimer pers. comm. 2019), which also occurs in the area, though normally at higher elevations. This is a potentially serious problem for the Kīpahulu population, especially if climate change pushes subspecies *waihoiensis* into higher elevation areas (USFWS 2013, p. 32061).

Current Management Actions:

The majority of known individuals of *B. campylotheca* subsp. *waihoiensis* are within units fenced to exclude feral ungulates. The Kīpahulu Valley

population is completely fenced, however, some feral pigs have re-invaded these areas (H. Oppenheimer pers. comm. 2019). In Waihoʻi, the upper portion of the valley is fenced and ungulate-free, but many individuals of this species remain below this fenced unit and are subject to disturbance from ungulates. Surveys in this area have been extremely limited, so it is unclear how many individuals would be susceptible to this threat. Similarly, of the two known individuals in Hana Forest Reserve, one is inside a fenced unit and one remains outside (USFWS 2020, unpublished data). All populations are threatened by introduced invasive weeds, changes to climate, and predation and herbivory from rats and slugs.

Ex situ conservation efforts for *B. campylotheca* subsp. *waihoiensis* are being conducted primarily by Haleakalā National Park (HALE) through seed storage and cultivation. Approximately 280 seeds were collected from the Kīpahulu population in 2017 (HALE 2017, p. 7) and 123 juvenile plants were translocated at ʻOheʻo in 2018 (HALE 2018, p. 7). Juvenile survival for plants translocated at ʻOheʻo was good, however long-term survival of translocated plants is unknown (HALE 2018, p. 7). Twenty-one seeds of *B. campylotheca* subsp. *waihoiensis* are also being stored at Lyon Arboretum from an individual in cultivation at Olinda Rare Plant Facility (H. Oppenheimer pers. comm. 2019) and five plants are in cultivation at the Olinda Rare Plant Nursery (ORPF 2019, p. 1).

- Surveys and monitoring—The Plant Extinction Prevention Program (PEPP) and HALE monitors occurrences of *Bidens campylotheca* subsp. *waihoiensis* on Maui (H. Oppenheimer pers. comm. 2019; HALE 2017, p. 4).
- Ungulate monitoring and control—All populations except lower portion of Waihoʻi and a single individual in Hana Forest Reserve are currently fenced, however introduced ungulates have gained access to some fenced areas.
- Ecosystem-altering invasive nonnative plant control**—**Fenced units help prevent the spread of invasive plants within fenced areas, however, other measures to control invasive plants are not being implemented.
- Rat predation and slug herbivory—All populations remain at risk from rat predation and slug herbivory, neither of which has been controlled within the range of this taxon.
- Captive propagation for genetic storage and reintroduction—Collection of seeds for genetic storage and cultivation have been made from Kīpahulu population.
- Reintroduction and translocation—123 juvenile plants were translocated at ʻOheʻo in 2018 and a small number of plants are in nursery cultivation.

Table 1. Status and trends of *Bidens campylotheca* subsp. *waihoiensis* from listing through 5-year review.

Date	No. wild individuals	No. outplanted	Preventing Extinction Criteria identified by HPPRCC	Preventing Extinction Criteria Completed?
2013 (listing)	Approx. 200	0	All threats managed in all 3 populations	No
			Complete genetic storage	No
			3 populations with 50 mature individuals each	No
2016 (critical habitat)	Approx. 200	0	All threats managed in all 3 populations	No
			Complete genetic storage	No
			3 populations with 50 mature individuals each	No
2020 (5-year review)	Approx. 100	123 juveniles in 2018	All threats managed in all 3 populations	Partial, some protection from ungulates
			Complete genetic storage	Limited
			3 populations with 50 mature individuals each	Partial, 2 populations estimated at 50, maturity unknown and numbers approximate

Table 2. Threats to *Bidens campylotheca subsp. waihoiensis* and ongoing conservation efforts.

Threat	Listing Factor	Current Status	Conservation/Management Efforts
Ungulate degradation of habitat	A	Ongoing	All populations fenced (lower Waihoʻi and single individual in Hana Forest Reserve)
Established ecosystem-altering invasive plant modification and degradation of habitat	A	Ongoing	Fenced populations are less at risk of spread of invasive plants by feral ungulates
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	None
Reduced viability due to low numbers	E	Ongoing	Partial, seed collections, translocation, and small number plants in *ex situ* cultivation
Loss of pollinators and dispersal agents	E	Ongoing	None

2.4 Synthesis

There are approximately 100 wild plants of *Bidens campylotheca* subsp. *waihoiensis* in 3 populations on East Maui. Some individuals of the Kīpahulu population however may be hybrids with the closely related *B. campylotheca* subsp. *pentamera*. All known wild plants are within a small geographic region on the extreme east slope of East Maui. One-hundred twenty-three juvenile plants were translocated at ʻOheʻo on East Maui in 2018. Short term survival of young plants was good, however long-term survival is unknown. There are approximately only a few hundred seeds of the taxon in *ex situ* genetic storage and approximately 5 plants in cultivation at the Olinda Rare Plant Facility.

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 50 mature, reproducing individuals per population.

The preventing extinction goals for this species have not been met. There are only approximately 100 plants in the wild (Table 1). Two wild populations are approximately 50 individuals each, however the third population is only two known individuals and the number of individuals reproducing or mature for any of the populations is unknown. Genetic representation goals have not been met, and not all threats are being controlled at the three populations (Table 2). Therefore, *Bidens campylotheca* subsp. *waihoiensis* 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 *Bidens campylotheca* subsp. *waihoiensis* in historical locations and potentially suitable habitat.
- Hybridization—Monitor populations in Kīpahulu Valley of *Bidens campylotheca* subsp. *waihoiensis* and *B. campylotheca* subsp. *pentamera* where the two subspecies co-occur to determine whether hybridization is occurring.
- 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—Control established ecosystem-altering nonnative invasive plant species and those that compete with *B. campylotheca* subsp. *waihoiensis*.
- Climate change adaptation strategy—Research suitability of habitat in the future due to the impacts of climate change.

- Rat and slug predation and herbivory—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—Continue reintroduction efforts in suitable habitat on Maui to increase numbers of populations and individuals to reduce the impacts of climate change and low numbers.
- Some critical habitat areas differ (primarily less annual rainfall) from areas where the species is currently found. Surveys are needed to determine locations suitable for reintroductions and whether plants currently occupy those areas.
- 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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Personal Communication

Hank Oppenheimer, Maui Nui Coordinator, Plant Extinction Prevention Program, Telephone call on June 24, 2019.

U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW of *Bidens campylotheca* subsp. *waihoiensis*
(koʻokoʻolau)

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:
Jay Nelson, 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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Date: 2020.09.25 15:36:37 -10'00'

for _____

Field Supervisor, Pacific Islands Fish and Wildlife Office