Canavalia pubescens
(‘āwikiwiki)

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: *Canavalia pubescens* (‘āwikiwiki)

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5-YEAR REVIEW
Canavalia pubescens (‘āwikiwiki)

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 2020. 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on the final rule listing this species; the final critical habitat designation; peer reviewed scientific publications; unpublished field observations and species status report by the Service, State of Hawai‘i, and other experienced biologists; unpublished survey reports; notes and communications from other qualified biologists; as well as a review of current, available information.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 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. 2019. Endangered and threatened wildlife and plants; initiation of 5-year status reviews for 91 species in Oregon, Washington, Hawaii, and American Samoa. Federal Register 84 (112): 27152–27154, June 11, 2019.

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, Tuesday, May 28, 2013.

Date listed: May 28, 2013
Entity listed: *Canavalia pubescens*
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:

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

Critical habitat was designated on Maui for *Canavalia pubescens*, totaling four units in the lowland dry ecosystem (6,815 ha, 16,842 ac) (81 FR 17790, March 30, 2016). In 2012, critical habitat was proposed on Lānaʻi, totaling three units in the coastal ecosystem (399 ha, 985 ac), but was excluded in the final rule because the benefits provided to the species by management actions by the landowner outweighed the benefits of designation of critical habitat (77 FR 34464, June 11, 2012).

1.3.4 Review History:

This is the first 5-year review for *Canavalia pubescens*.

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

2

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, B, C, D, and E) affecting this species is presented in section 2.3.2 and Table 2.

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.

Canavalia pubescens is a short-lived perennial vine. To prevent extinction, which is the first milestone in recovering the species, the taxon must be managed to control threats (e.g., fenced) and have 50 individuals (or the total number of individuals if fewer than 50 exist) from each of three populations represented in *ex situ* (secured off-site, such as a nursery or seed bank) collections that are well managed. In addition, a minimum of three populations should be documented on Maui, Lānaʻi, Kauaʻi, and/or Niʻihau 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 individuals per population.

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

Interim Stage
To meet the interim stage of recovery of *Canavalia pubescens*, 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. Multi-island species should be represented by at least one population on each of the islands from which they were known historically, as long as suitable habitat exists. 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 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. Multi-island species should be represented by at least three populations on each of the islands from which they were known historically as long as suitable habitat exists. 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. Multi-island species should be represented by at least three populations on each of the islands from which they were known historically, as long as suitable habitat exists. 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:

Canavalia pubescens, a member of the Fabaceae (pea) family, is a perennial climber with elliptic leaves, 2.3 to 10.2 centimeters (cm) (2.4 to 5 inches (in)) long and 1.8 to 7.6 cm (0.7 to 3 in) wide, the upper surfaces moderately pubescent, and the lower surfaces densely pubescent. Flowers number 8 to 20 in pseudoracemes (unbranched stalks, blooming from the

bottom up) 3 to 5 cm (1.2 to 2 in) long, with the lowest lobe broadly lanceolate (tapering to a point at each end) and 4 to 6 millimeters (mm) (0.1 to 0.2 in) long. The flower is dark red to pink (rarely white), with a white spot and streaks toward the base. Fruits are compressed pods 12 to 18 cm (4.7 to 7 in) long and 2.5 to 3.2 cm (1 to 1.3 in) wide. Seeds are brown to dark reddish brown, oblong-elliptic, strongly compressed, 15 to 19 mm (0.6 to 0.8 in) long, 10 to 13 mm (0.4 to 0.5 in) wide (Geesink et al. 1999, p. 654). Degener and Degener (1959, 2 pp.) report white to pink flowers for Lānaʻi collections of this species.

Little is known about the life history of *Canavalia pubescens*. This species may fruit and flower all year depending on the habitat conditions and the amount of rainfall received (Oppenheimer and Bogner 2019, pers. comm.). Honey bees (*Apis mellifera*) as well as syrphid flies (*Syrphid* sp.) have been observed visiting flowers of *C. pubescens* and may currently be potential pollinators for this species, but are introduced species that would not have historically pollinated *C. pubescens*. It is unknown at this time whether *C. pubescens* is pollinated by any native species. *Canavalia pubescens* is capable of self-pollination when pollinators are not present, as isolated individuals have been observed to produce viable seeds; botanists have observed an increase in regeneration from the soil seed bank following rain events (Oppenheimer and Bogner 2019, pers. comm.). Seeds are not attached to the hull of the fruit which means that the seeds are not likely dispersed by the wind. It is unknown what used to disperse the seeds of *C. pubescens*, it may have been by dispersed by now extinct Hawaiian rails (Oppenheimer and Bogner 2019, pers. comm.). Water is a potential disperser of fruit but only within a single drainage basin (Oppenheimer and Bogner 2019, pers. comm.). Field botanists noted that leaflets of the species were observed to be upright in full sun and flat when growing in shade (Bishop Museum Herbarium 2020). Based on this observation, individuals of *C. pubescens* are adaptable and able to survive and persist in both full sun and shady conditions.

2.3.1.2 Abundance, population trends (e.g. increasing, decreasing, stable), demographic features (e.g., age structure, sex ratio, family size, birth rate, age at mortality, mortality rate, etc.), or demographic trends:

Historically, *Canavalia pubescens* was known from the islands of Maui, Lānaʻi, Kauaʻi, and Niʻihau (Hawaii Biodiversity and Mapping Program (HBMP) 2010; Oppenheimer 2007, in litt.). On Niʻihau, *C. pubescens* occurred at 91 m (299 ft) on a basalt ledge within a small gorge (Kaumuhonu) in Hāʻao Valley (Hooker and Arnott 1832-1841, p. 81). This population was last observed between 1912 and 1949 (HBMP 2010). On Kauaʻi, *C. pubescens* was known from six populations from Nuʻalolo to Wainiha along the Nā Pali coastline (HBMP 2010). On Lānaʻi, *C. pubescens* was known from several populations from Kaʻena Point to

Huawai Bay (HBMP 2010). On Maui, *C. pubescens* occurred scattered along the southern coast of Haleakalā from Puʻu o kali to Waiʻōpai (Altenberg 2007, pp. 12–13; Altenberg 2010, in litt.). In 2010, these populations totaled between 260 and 500 individuals (HBMP 2010; Starr 2006, in litt.; Oppenheimer 2006, pers. comm., Oppenheimer 2007, in litt.; Altenberg 2007, pp. 12–13; Altenberg 2010, in litt.). The Manawainui Gulch and Waiʻōpai populations were located at the easternmost and highest known elevations and their extirpation greatly reduced the range of this species on east Maui.

Canavalia pubescens is currently known from Maui and Lānaʻi. Populations on Kauaʻi and Niʻihau have likely been extirpated (Hawaiʻi State Parks 2020, entire; Bishop Museum Herbarium 2020; HBMP 2010). Currently, on Maui, there are seven wild populations (Kanaio, ʻĀhihi-Kīnaʻu, Lualaʻilua, Wai Lea-Honuaʻula, and Puʻu o kali; totaling 99 individuals) and two reintroduced populations (Kanaio and Lualaʻilua; totaling 27 individuals) (USFWS 2020, unpublished data). On Lānaʻi there are two wild populations (Paliamanō and Kaʻāpahu; totaling six individuals), and one individual at Puʻumaiekahi, and one reintroduced population (Kānepuʻu; 10 individuals) (Oppenheimer and Bogner 2019, pers. comm.).

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:
Canavalia pubescens was first described by Hooker and Arnott referring to a collection from Niʻihau (1832-1841, p. 81). This species is recognized as a distinct taxon by Geesink et al. (1999, p. 654) in the Manual of the Flowering Plants of Hawaii, the most recently accepted taxonomy.

2.3.1.5 Spatial distribution, trends in spatial distribution (e.g. increasingly fragmented, increased numbers of corridors, etc.), or historic range (e.g. corrections to the historical range, change in distribution of the species' within its historic range, etc.):
See section 2.3.1.2 and 2.3.1.4 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):
Canavalia pubescens occurs on dry, open lava fields and in dryland forest and grassland/shrubland, and in developed areas where habitat conversion has occurred (USFWS 2020, unpublished data). Historically, its habitat range also included mesic forest and grassland/shrubland.

On Niʻihau, *Canavalia pubescens* was last observed on an exposed basalt ledge at 91 meters (m) (300 feet (ft)). On Kauaʻi, *C. pubescens* occurred in open, mesic and dry forest at 55 to 884 m (180 to 2,900 ft), with the associated native species *Bidens* spp. (koʻokoʻolau), *Euphorbia celestroides* var. *celastroides* (ʻakoko), *Carex wahuensis* ssp. *wahuensis*, *Pandanus tectorius* (hala), *Diospyros sandwicensis* (lama), *Metrosideros polymorpha* (ʻōhiʻa), and *Lipochaeta succulenta* (nehe) (DLNR 2011, pp. 8, 10). On Lānaʻi, *C. pubescens* was observed at 24 to 122 m (80 to 400 ft) growing among sun-scorched lava rocks along a coastal trail at 15 m (50 ft) with *Cordia subcordata* (kou) (Oppenheimer 2007, in litt.). On Maui, *C. pubescens* occurred on recent lava flows in *Erythrina sandwicensis* (wiliwili) lowland dryland forest and shrubland with the associated native species *Capparis sandwichiana* (maiapilo), *Euphorbia celastroides* var. *lorifolia* (ʻakoko), *Dodonaea viscosa* (aʻaliʻi), *Ipomoea* spp., *Sida fallax* (ʻilima), *Rauvolfia sandwicensis* (hao), and *Waltheria indica* (ʻuhaloa) (Geesink et al. 1999, p. 654; HBMP 2010).

Currently, the dry forest and grassland/shrubland on Lānaʻi where *Canavalia pubescens* occurs consists of remnant patches of native *Dodonaea viscosa* and *Heteropogon contortus* (pili) invaded by nonnative *Andropogon virginicus* (broomsedge), *Casuarina equisetifolia* (common ironwood), *Chloris* spp. (fingergrass), *Lantana camara* (lantana), *Panicum* spp., and *Schinus terebinthifolia* (Christmas berry) (Hobdy 1993, p. 208).

On the southern slopes of Haleakalā, east Maui, *Canavalia pubescens* occurs in lowland dry habitat at ʻĀhihi-Kīnaʻu Natural Area Reserve (NAR) with the associated native species *Erythrina sandwicensis* (wiliwili), *Sida fallax* (ʻilima), *Waltheria indica* (ʻuhaloa), *Myoporum sandwicense* (naio), and *Plumbago zeylanica* (ilieʻe). The area is invaded by the nonnative plants *Prosopis pallida* (kiawe), *Leucaena leucocephala* (koa haole), *Bidens pilosa* (kī) and *Lantana camara* (lantana) (PBR Hawaiʻi 2012, p. 92; Natural Area Reserves System 2012, p. 38). Habitat at Kanaio and Lualaʻilua is an assemblage of native grassland/shrubland communities including *Dodonea viscosa* (aʻaliʻi), *Wikstroemia* spp. (ʻākia), and *Dubautia* spp. (naʻenaʻe). Most of these communities are now dominated by invasive *Pennisetum clandestinum* (kikuyu grass), *Lantana camara*, and *Leucaena leucocephala* (koa haole) (Medeiros et al. 1993, pp. 4–5, 9). Habitat at Manawainui Gulch consists of native mixed grassland/shrubland invaded by *Casuarina equisetifolia*, *Urochloa mutica* (California grass), and *Melinis minutiflora* (molasses grass) (Maui Environmental Consulting 2018, p. 26). The populations at Waiʻōpai occurred in relict native, lowland mesic grassland/shrubland on a steep slope (USFWS 2020, unpublished data). The native vegetation has been largely replaced by introduced species like *Prosopis pallida* (kiawe) and pasture grasses. The populations located in Wailea in the Kīhei-Mākena region of Maui adjacent to the Wailea Resort was characterized as dry

forest habitat prior to being developed. The northern two-thirds of the area is now dominated by *Prosopis pallida* and *Cenchrus ciliaris* (buffelgrass), the southern third of the area is ʻaʻā land dissected by a number of gullies. The southern area is charaterized by a mixture of *Prosopis pallida* and a few native plants including *Erythrina sandwicensis* (wiliwili), *Sida fallax* (ʻilima), and *Sicyos pachycarpus* (ʻānunu) in the understory (PBR 2012, p. 21).

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):

Agriculture and urban development—Land use practices have resulted in little or no native vegetation below 600 m (2,000 ft) throughout the Hawaiian Islands (The Nature Conservancy (TNC) 2007; Kosaka 1990, in litt.). Large tracts of former agricultural lands are being converted into residential areas or left fallow (Hawaii Department of Business, Economic Development and Tourism (HDBEDT) 2011, in litt.). Fallow areas are prone to invasion by nonnative plant species that can outcompete native species (Cuddihy and Stone 1990, p. 30). Occurrences of *Canavalia pubescens* in the Pālāwai Basin of Lānaʻi and along the coast near a golf course have been impacted by agriculture and development, and occurrences on east Maui from Puʻu o kali to Wailea have been impacted by urban development.

Ungulate destruction and degradation of habitat—Feral ungulates modify and degrade habitat by disturbing and destroying vegetative cover, trampling plants and seedlings, reducing or eliminating plant regeneration by damaging seeds and seedlings, and increasing erosion by creating large areas of bare soil (Loope 1998, pp. 747–774; van Riper and van Riper 1982, pp. 34–35). Feral pigs (*Sus scrofa*), goats (*Capra hircus*), mouflon (*Ovis aries musimon*), axis deer (*Axis axis*), black-tailed deer (*Odocoileus hemionus*), and cattle (*Bos taurus*) and evidence of their activities are observed at or more of the populations (and in areas of historic occurrences) of *Canavalia pubescens* (Oppenheimer and Bogner 2019, pers. comm.). Recent drought conditions have driven axis deer further into native vegetation in search of food and have caused a decline in shrub and vine species on Maui (Medeiros 2010, pers. comm.).

Established ecosystem-altering invasive plant modification and degradation of habitat—Invasive introduced plant species modify habitats occupied by native plant species by changing the availability of light, altering soil-water regimes, modifying nutrient cycling, and changing the fire characteristics of the native plant community (Cuddihy and Stone 1990, p. 74). Habitat modification and destruction by invasive nonnative

plants negatively affects all occurrences of *Canavalia pubescens*. The nonnative plants with the greatest impacts on *C. pubescens* include *Prosopis pallida*, *Lantana camara*, *Leucaena leucocephala*, *Acacia farnesiana* (klu), *Urochloa maxima* (guinea grass), and *Digitaria insularis* (sour grass) (Oppenheimer and Bogner, pers. comm. 2020).

Fire destruction and degradation of habitat—*Canavalia pubescens* is at risk of negative impacts by fire because it occurs in disturbed dry habitat and in or near areas that were burned in previous fires. On Lānaʻi, a wildfire in 2006 burned 243 hectares (ha) (600 ac) between Mānale Road and Palawai Basin (The Maui News 2006, in litt.). In 2007, a brush fire burned an estimated 12 ha (30 ac) and in 2008 another 405 ha (1,000 ac) burned in the Pālāwai Basin (The Maui News 2007, in litt.; KITV Honolulu 2008, in litt.). In 2010, a large fire consuming more than 2,509 ha (6,200 ac) adversely impacted individuals and habitat of this species (Maui Now 2010, in litt.). Fire damages and destroys native vegetation, including dormant seeds, seedlings, juvenile and adult plants. Many nonnative invasive plants, particularly fire-tolerant grasses, outcompete native plants and inhibit their regeneration (D'Antonio and Vitousek 1992, pp. 70, 73–74; Tunison et al. 2002, p. 122). Successive fires burn farther into native habitat and alter microclimatic conditions creating conditions favorable to nonnative plants. The threat from fire is unpredictable but is increasing in frequency in ecosystems that have been invaded by nonnative plants and fire-tolerant nonnative grasses.

Climate change loss or degradation of habitat, including hurricanes and drought—Fortini et al. (2013) conducted a landscape-based assessment of climate change vulnerability for native plants of Hawaiʻi 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 *Canavalia pubescens* is highly vulnerable to the impacts of climate change with a vulnerability score of 0.596 (on a scale of 0 being not vulnerable to 1 being extremely vulnerable to climate change). Therefore, additional management actions may be needed to conserve this taxon into the future, such as locating key microsites that overlap with current and future climate envelopes for outplanting efforts.

In September 1992, Hurricane Iniki, a category 4 hurricane with maximum sustained wind speeds recorded at 140 mph (225 kph), passed directly over the island of Kauaʻi, causing great economic damage to the State (Blake et al. 2007, pp. 9, 20, 24). Many forest trees were destroyed which opened the canopy and facilitated the invasion of nonnative plants. 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 to extinction in a single event. Hurricanes

destroy native vegetation and habitat by opening the canopy and modifying the availability of light, and by creating disturbed areas conducive to invasion by nonnative species. 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. 4317; 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).

In 2006, Maui County was designated a primary disaster area because of a severe drought from April to September 2006 (Pacific Disaster Center, 2010). More recently, the U.S. Department of Agriculture has designated Maui County as a primary natural disaster area due to losses caused by an ongoing drought, beginning January 1, 2012 (*http://www.fsa.usda.gov/FSA,* accessed 17 JAN 2013). Over the last 100 years, the Hawaiian Islands have experienced an annual decline in precipitation of over 9 percent, increasing to as much as 15 percent within the last 20 years (US-NSTC 2008, p. 61; Chu and Chen 2005, pp. 4812–4813; Diaz 2005, 4 pp.). Drought affects plants directly by desiccation. In addition, the increase in drought frequency and intensity leads to a self-perpetuating cycle of increase in cover of nonnative plants, increase in the number of fires, and an increase of erosion (US-GCRP 2009, pp. 18, 24; Warren 2011). Recent episodes of drought have also driven deer farther into urban and forested areas in search of food, increasing their negative impacts to native vegetation from herbivory and trampling (Waring 1996, in litt; Nishibayashi 2001, in litt.).

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 mouflon and axis deer—Field observations indicate that herbivory by mouflon and axis deer is a threat to *Canavalia pubescens* on Maui and Lānaʻi (Oppenheimer and Bogner 2019, pers. comm.; Medeiros 2010, pers. comm.).

Herbivory and predation by nonnative insects—Predation and herbivory by insects, particularly lace wing bugs (*Corythucha* sp.) (SWCA 2020, p. 5), spider mites (species unknown), and seed borers (species unknown) have been observed on *Canavalia pubescens*. Lace bugs and spider mites are known to damage the leaves of this species. Damage by spider mites is characterized by the whitening of leaves, which becomes a search image to relocate or discover new individuals of *C. pubescens* (Oppenheimer and Bogner 2019, pers. comm.). Seed borers have been observed in the seeds

of *C. pubescens*, decreasing their viability (Akau 2020, pers. comm.).

2.3.2.4 Inadequacy of existing regulatory mechanisms (Factor D): Lack of adequate hunting regulations—Nonnative feral ungulates are an ongoing threat to this species through destruction and modification of habitat and direct herbivory and predation. Three occurrences on east Maui are fenced, and one inter situ occurrence on Lānaʻi is fenced; however, goats have been observed within a fenced area on Maui. Public hunting areas are not fenced and game mammals have unrestricted access across the landscape, regardless of underlying land use designation; therefore, any unfenced populations of *C. pubescens* are at risk (DLNR 2010).

Lack of adequate biosecurity regulations—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 (U.S. CBP 2020, *cbp.gov/about*). The U.S. Department of Agriculture-Animal and Plant Health Inspection Service-Plant Protection and Quarantine (USDA-APHIS-PPQ) inspects propagative plant material, provides identification services for arriving plants and pests, and conducts pest risk assessments among other activities. (HDOA 2009, p. 1). 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 (Convention on International Trade in Wild Fauna and Flora) violations. The State of Hawaiʻi allows the importation of most plant taxa, with limited exceptions (Hawaii Legislative Reference Bureau (HLRB) 2002; U.S Department of Agriculture-Animal and Plant Health Inspection Service-Plant Protection and Quarantine (USDA-APHIS-PPQ) 2010; CGAPS 2009). It is likely that the introduction of most nonnative invertebrate pests to the State has been and continues to be accidental and incidental to other intentional and permitted activities. Many invasive weeds established on Hawaiʻi have currently limited but expanding ranges. Resources available to reduce the spread of these species and counter their negative ecological effects are limited. Control of established pests 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 pests remains limited in scope (CGAPS 2009). Adequate staffing, facilities, and equipment for Federal and State pest inspectors and identifiers in Hawaii devoted to invasive species interdiction are critical biosecurity gaps (HLRB 2002; USDA-APHIS-PPQ 2010; CGAPS 2009).

2.3.2.5 Other natural or manmade factors affecting its continued existence (Factor E):
Not a threat.

Current Management Actions:

- Surveys and monitoring—PEPP regularly monitors occurrences of *Canavalia pubescens* on Maui and Lānaʻi (PEPP 2012, 2013, 2015, 2016, 2017, 2018, 2020).
- Ungulate control—On Maui, small exclosures protect 13 wild and 25 reintroduced individuals of *C. pubescens* at Auwahi (east Maui), one individual at Puʻu Hōkūkano, six individuals at ʻĀhihi-Kīnaʻu NAR, three individuals at Lualaʻilua, and a few individuals at Puʻu o kali (Akau 2020, pers. comm.; Natural Area Reserves Systems 2012, p. 39; PEPP 2020). One TNC management unit on Lānaʻi may have protection by an ungulate exclosure.
- Ecosystem-altering invasive nonnative plant control—Pūlama Lānaʻi regularly controls nonnative plants at occurrences of *Canavalia pubescens* at Kaʻāpahu, Paliamano, and Maunalei (Pūlama Lānaʻi 2021). On Maui, nonnative plant control is also ongoing at the exclosure maintained by the Native Hawaiian Plant Society (NHPS), in two areas of ʻUlupalakua Ranch (through the Auwahi Wind Energy project and the Leeward Haleakala Watershed Restoration Partnership), at ʻĀhihi-Kīnaʻu NAR, and at the exclosure at Lualaʻilua (NHPS 2020; Natural Area Reserves Systems 2012, p. 39; PEPP 2020)
- Fire management—The Auwahi Wind Farm project follows a fire management plan (Tetra Tech 2019, 161 pp.). The Department of Hawaiian Home Lands has documented steps to mitigate the threat of fire through their Maui Island Plan that was prepared by PBR Hawaiʻi in 2004 (at Lualaʻilua) (PBR Hawaiʻi 2004, entire). Honuaʻula Partners, LLC will implement a fire control program in coordination with the Maui County Department of Fire and Public Safety resource agencies, which will include fire breaks, to help protect the project area and a population of *C. pubescens* (PBR Hawaiʻi 2012, p. 67). The Nature Conservancy manages a 3 to 4 m- (10 to 15 ft-) wide swath of cleared vegetation along the fenceline of each management unit on Lānaʻi for fire prevention (TNC 2016, p. 18).
- Management of predation and herbivory feral ungulates—See "Ungulate control," above.
- Captive propagation for genetic storage and reintroduction—
    - The Lyon Arboretum Seed Conservation Laboratory reports (from Maui) 2,054 seeds in storage representing three founders at Kanaio, 3,049 seeds in storage representing 13 founders from ʻĀhihi-Kīnaʻu, 726 seeds representing more than nine founders from Lualaʻilua, 1,398 seeds in storage representing four founders at Puʻu o kali; and from Lānaʻi, 73 seeds in

storage representing two founders from Kānepuʻu (Lyon Arboretum 2020).
    - The Maui Nui Botanical Garden (MNBG) reports 100 seeds in storage representing two founders at Puʻu o kali and one seed in storage representing one founder from Kanaio (MNBG 2019).
    - Pūlama Lānaʻi reports three plants in storage representing one founder from Kalama Iki. with seeds collected and pooled; seedlings recruiting representing one individual at Kaʻāpahu; (Pūlama Lānaʻi 2021).
- Reintroduction and translocation—
    - The Olinda Rare Plant Facility (ORPF) reports propagation of three plants for *inter situ* use (ORPF 2019).
    - Pūlama Lānaʻi reports propagation and reintroduction of individuals at Paliamano; however, this reintroduction failed within a year. Another reintroduction was conducted at Maunalei of eight plants sourced from Puʻumaiekahi (Pūlama Lānaʻi 2021).

Table 1. Status and trends of *Canavalia pubescens* 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 50 mature individuals each	No, may only exist at a single location
2016 (critical habitat)	<200	0	All threats managed in all 3 populations	No
			Complete genetic storage	No
			3 populations with 50 mature individuals each	No, may only exist at a single location
2021 (5-year review)	106	37	All threats managed in all 3 populations	Partially, ungulate exclosures at 5 sites on Maui, one site on Lānaʻi
			Complete genetic storage	Partially, 25 Maui founders and 1 Lānaʻi founder

				represented by seeds and plants in collections
			3 populations with 50 mature individuals each	No, no single population totals 50 mature individuals
			Each population naturally reproducing	Partially, 1 population at Ka'āpahu observed to be naturally recruiting

Table 2. Threats to *Canavalia pubescens* and ongoing conservation efforts.

Threat	Listing Factor	Current Status	Conservation/Management Efforts
Destruction and degradation of habitat by agriculture and urban development	A	Ongoing	None
Destruction and degradation of habitat by ungulates	A	Ongoing	Partial, small exclosures at 5 locations on Maui and 1 location on Lānaʻi
Destruction and degradation of habitat by established ecosystem-altering invasive plants	A	Ongoing	Partial, some nonnative plant control within exclosures
Fire	A	Ongoing	Partial, fire management plans for 3 areas on Maui and 1 area on Lānaʻi
Climate change degradation or loss of habitat—including hurricanes and drought	A	Ongoing	None
Predation and herbivory by ungulates	C	Ongoing	Partial, small exclosures at 5 locations on Maui and 1 location on Lānaʻi
Predation and herbivory by nonnative insects	C	Ongoing	None
Inadequacy of regulatory mechanisms—hunting and biosecurity	D	Ongoing	None

2.4 Synthesis

There are 99 wild individuals of *Canavalia pubescens* on Maui and seven individuals on Lānaʻi. A landscape-based assessment of climate change vulnerability for native plants of Hawaiʻi using high resolution climate change projections was made by Fortini et al. (2013) and their analysis showed that *C. pubescens* is highly vulnerable to the effects of climate change. There are more than 6,000 seeds in storage representing 25 founders from Maui and 73 seeds in storage representing two founders from Lānaʻi. There are a few plants in storage representing three founders from Lānaʻi, with 10 plants reintroduced on Lānaʻi and 27 plants reintroduced on Maui.

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 total should be documented on Maui, Lānaʻi, Kauaʻi, and/or Niʻihau 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 no populations totaling 50 mature individuals and only partial genetic representation (Table 1). Numbers of wild individuals continue to decline. In addition, all threats are not being sufficiently managed throughout the range of the species (Table 2). Therefore, *Canavalia pubescens* 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 *Canavalia pubescens* 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. pubescens*.
- Fire management—Implement fire management plans for all wild and reintroduced populations.
- Climate change adaptation strategy—Research suitability of habitat in the future due to the impacts of climate change.
- Captive propagation for genetic storage and reintroduction—Continue to collect seeds 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 hurricanes and drought.
- 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 *Canavalia pubescens*
(‘āwikiwiki)

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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