Mucuna sloanei var. *persericea*
(sea bean)

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: *Mucuna sloanei* var. *persericea* (sea bean)

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1.0 GENERAL INFORMATION

1.1 Reviewers:

Chelsie Javar-Salas, Biologist, Pacific Islands Fish and Wildlife Office (PIFWO)
Lauren Weisenberger, Plant Recovery Coordinator, PIFWO
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Lead Regional Office:
Interior Region 12, Portland Regional Office

Lead Field Office:
Pacific Islands Fish and Wildlife Office

Cooperating Field Office(s):
N/A

Cooperating Regional Office(s):
N/A

1.2 Methodology used to complete the review:

This review was conducted by staff of the Pacific Islands Fish and Wildlife Office of the U.S. Fish and Wildlife Service (Service), beginning in October 2019. The review was based on the final rule listing this species; the final critical habitat designation; peer reviewed scientific publications; unpublished field observations by the Service, State of Hawai‘i, and other experienced biologists; unpublished survey reports; notes and communications from other qualified biologists; as well as a review of current, available information. The evaluation by Chelsie Javar-Salas, 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: *Mucuna sloanei* var. *persericea*
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 Molokai, Lanai, Maui, and Kahoolawe; final rule. Department of the Interior, Federal Register 81 (61): 17790–18110, March 30, 2016.

A single unit of critical habitat was designated on Maui for *Mucuna sloanei* var. *persericea* in the lowland wet ecosystem (6,507 hectares, 16,079 acres) (81 FR 17888, 17887, 18052).

1.3.4 Review History:

This is the first 5-year review for *Mucuna sloanei* var. *persericea*.

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

5

1.3.6 Current Recovery Plan or Outline:

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

2.0 REVIEW ANALYSIS

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

2.1.1 Is the species under review a vertebrate?

____Yes
__X_No

2.1.2 Is the species under review listed as a DPS?

____Yes
____No

2.1.3 Was the DPS listed prior to 1996?

____Yes
____No

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

____Yes
____No

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

____Yes
____No

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

____Yes
____No

2.2 Recovery Criteria

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

____Yes
__X_No

2.2.2 Adequacy of recovery criteria.

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

____Yes
____No

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

____Yes
____No

2.2.3 List the recovery criteria as they appear in the recovery plan, and discuss how each criterion has or has not been met, citing information:
A synthesis of the threats (Listing Factors A, C, D, and E) affecting this species is presented in section 2.3.2 and Table 3. 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.

Mucuna sloanei var. *persericea* 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. In addition, a minimum of three populations should be documented on the island of Maui 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 3).

Interim Stage

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

This recovery objective has not been met (see Table 3).

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 3).

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 3).

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:

Mucuna sloanei var. *persericea*, a member of the pea family (Fabaceae), is a woody vine that climbs to at least 19.6 feet (ft) (6 meters (m)) tall. Its leaves are alternate, three-foliolate (with three leaflets), and 6.7 to 9.8 inches (in) (17 to 25 centimeters (cm)) long. The inflorescence is a pseudoraceme (a pedicel-like stalk) that is pendent (suspended or hanging down from a support). The peduncle (the stalk of an inflorescence or of a solitary flower) is 1.6 to 3.1 in (4 to 8 cm) long. The calyx (collective term for all of the sepals of a flower) is campanulate (bell-shaped), and 0.9 to 1.1 in (2.5 to 3 cm) long. Flower petals are yellow and 1.4 to 1.6 in (3.5 to 4 cm) long. The wing (lateral) petals are 1.8 to 1.9 in (4.5 to 5 cm) long. The keel (partly connate lower) petals are 1.8 to 1.9 in (4 to 5 cm) long. The fruit are tough and flexible, 3.9 to 4.7 in (10 to 12 cm) wide and 1.5 in (4 cm) long, and the surface has short dense spreading pale fine hairs and irritant red bristles. The fruit margin has a pair of distinct wings. The seeds are never more than 0.9 in (2.5 cm) long. The seeds are brownish black, rugose (wrinkled), and large (0.7 to 1.1 in (2 to 3 cm) in diameter) (Wilmot-Dear 1990, p. 27-29; Moura *et al.* 2012, p. 839).

Mucuna sloanei var. *persericea* has been observed flowering in the summer through fall (Oppenheimer 2019, pers. comm.; Maui Nui PEPP 2019; NTBG 2020). Fruit has been collected during the months of January to May. In May, the seedpods open and expose themselves to weevils,

which bore holes into the seeds and damage them. April is the best month to collect seeds, because there is less damage from weevils (Oppenheimer 2019, pers. comm.; Maui Nui PEPP 2019). Other life history information is currently unknown, including information on plant growth stages, longevity, and the length of time it takes to flower.

The breeding system of *Mucuna sloanei* var. *persericea* is believed to be self-compatible, which means it is capable of producing viable seed following self-pollination. This is based on the observation of individual plants of *M. sloanei* var. *persericea* producing viable seeds, despite being isolated from other individuals of *M. sloanei* var. *persericea* (Oppenheimer 2019, pers. comm.).

The seeds of *Mucuna sloanei* var. *persericea* are thought to be dispersed by the wind or water (floatation). This assumption is based on the large, winged fruit and large seed size of *Mucuna* species that are often characterized under seeds dispersed by the wind or water (floatation) (Carlquist 1967, p. 147).

Flowers of *Mucuna sloanei* var. *persericea* are suspected to be pollinated by birds. This is supported by the occurrence of papilionaceous flowers, which are common in the genus *Mucuna*, and are often adapted for bird pollination (Geesink *et al.* 1999, p. 688). A papilionaceous flower is a zygomorphic (bilaterally symmetrical) flower of the Fabaceae family. It is characterized by the usual presence of bracteoles (specialized leaf born on a pedicel). The upper petal overlaps others when in bud and spreads wide as it blooms. The two lateral wing petals cover and are similar to the lower two keel petals. There are usually 10 stamens and they are distinct or often connate into a tube.

Similarly, the length of the peduncle on an inflorescence is, to a certain degree, related to how species within the *Mucuna* genus are pollinated. Those with short pedunculated inflorescences are typically pollinated by birds, whereas those with long pedunculated inflorescences (more than 3.2 ft (1 m) long) are generally pollinated by bats (Moura *et al.* 2016, p. 77). In the case of *Mucuna sloanei* var. *persericea*, it has a short pedunculated inflorescence at 4 to 8 cm long, and thus, falls within the category of bird pollinated.

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, *Mucuna sloanei* var. *persericea* was known on east Maui from Makawao to Wailua Iki (Moura *et al.* 2012, p. 839). Currently, *M. sloanei* var. *persericea* is known from ʻUlalena Hill, Honomāʻele,

Makapipi, and Pi‘ina‘au-Ke‘anae Valley (NTBG 2020; Oppenheimer 2020a, pers. comm.). These locations are identified by four population units called Honomā‘ele, Makapipi, Pi‘ina‘au-Ke‘anae Valley, and Honopou, which refers to the geographic reference areas they fall within (USFWS 2020).

In 2012, when *Mucuna sloanei* var. *persericea* was recognized as a distinct species, it was known from four locations and occupied an area less than 5,000 square kilometers. Its distribution was noted to be highly fragmented and in decline, mainly due to the lack of collections for this species since 1961 and degradation of habitat by development and invasive nonnative species (Moura *et al*. 2012, p. 839).

When this species was listed in 2013, there were possibly a few hundred individuals in five occurrences: Ulalena Hill, north of Kawaipapa Gulch, lower Nahiku, Koki Beach, and Piinau [correct spelling is Pi‘ina‘au] Road on east Maui (USFWS 2013, p. 32024).

Currently, there are approximately 100 to 200 total wild individuals of *Mucuna sloanei* var. *persericea* located within four populations units (Oppenheimer 2019, pers. comm.; Oppenheimer 2020a, pers. comm.; USFWS 2020; Maui Nui PEPP 2019). We do not have estimates for the number of individuals per population, but know that there are possibly less than five wild individuals at Pi‘ina‘au-Ke‘anae Valley and Honopou (Oppenheimer 2019, pers. comm.; Oppenheimer 2020a, pers. comm.; Maui Nui PEPP 2019).

Identifying individual plants of *Mucuna sloanei* var. *persericea* is difficult due to its growth habit, property access, and accurate identification (Oppenheimer 2020a, 2020b, pers. comm.). The growth habit of this species, which is a vine species that tangles together, makes it especially troublesome to identify individual plants from each other. Field staff chose not to untangle vines, as it would damage individual plants. Some plants cannot be monitored as they are located on private property with no landowners currently occupying the parcel to ask for permission or some have hostile owners that do not want people accessing their property. Additionally, *M. sloanei* var. *persericea* is often misidentified as a weed species and goes unnoticed and unaccounted. This often occurs because there are ten or more similar looking introduced vines also located in this area. Taking into account all of the reasons mentioned above, makes it difficult to provide an accurate population estimate for this species. There potentially could be more or less individuals than the estimated 100 to 200 individuals of *M. sloanei* var. *persericea* provided as the current population status. Nonetheless, the range of 100 to 200 individuals is conservative and our best estimate for *M. sloanei* var. *persericea.*

An effort to reintroduce *Mucuna sloanei* var. *persericea* within the Kahanu National Tropical Botanical Garden was conducted in previous years; however, the current status of this reintroduced population is unknown (Oppenheimer 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:
Mucuna sloanei var. *persericea* was first described by C.M. Wilmot-Dear in 1990 (Wilmot-Dear 1990, pp. 27–29) and listed as Endangered under this taxonomic name (USFWS 2013, p. 32015). The holotype was collected by Otto Degener and H. Wiebke from Keanae Valley on Maui in July of 1922 (Wilmot-Dear 1990, pp. 27–29). Of note, the publication by Wilmot-Dear (1990, p. 27) misspelled the locality as "Keauae"; however, the label of the holotype is spelled correctly as "Keanae."

When Wilmot-Dear recognized *Mucuna sloanei* var. *persericea* as a separate variety, it was based on the difference of leaf indumentum (covering of fine hairs or bristles) when compared to *M. sloanei* var. *sloanei*. In addition, the separate variety of *Mucuna sloanei* var. *persericea* was supported by its restricted range to the island of Maui (Wilmot-Dear 1990, p. 29).

In 2012, T.M. Moura *et al.* (2012, entire) conducted a complete study of the genus *Mucuna* focusing on species found in Hawai‘i. Moura *et al.* (2012, p. 837) identified additional differences between the two varieties of *M. sloanei* (var. *persericea* and var. *sloanei*). These differences lead to the separation of these varieties into separate species called *Mucuna persericea* and *M. sloanei*. The new combination for this species is *Mucuna persericea* in the most recent taxonomic treatment in the checklist of Hawaiian flora (Smithsonian Institution 2020). This taxonomic change does not affect the range or endangered status of this species. We will refer to this species as *Mucuna persericea* throughout the following sections of this document.

Mucuna persericea varies from *M. sloanei* in their internode length, rachis of the inflorescence length, length of hairs on the underside of the leaflets, and flower length (Moura *et al.* 2012, p. 839) (see Table 1 for specific differences).

Table 1. **The plant characteristics that differentiate *Mucuna persericea* from *Mucuna sloanei* (Moura *et al*. 2012, p. 839).**

Characteristics	*Mucuna persericea*	*Mucuna sloanei*
Internode length	1 to 1.5 cm	0.2 to 0.5 cm
Rachis of the inflorescence length	10 to 13 cm	1 to 2 cm
Abaxial surface of leaflets, with longer hairs	0.1 to 0.2 cm	Mostly less than 0.1 cm
Flower length	4 to 5 cm	5.5 to 7.5 cm

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):
Mucuna persericea is an endemic species to east Maui. This species is typically found between the elevations of 21 to 149 m (69 to 489 ft) in gulches and disturbed areas of remnant wet forest, mesic grassland and shrubland, and developed habitat types (USFWS 2020; NTBG 2020; Oppenheimer 2019, pers. comm.; Oppenheimer 2020a, pers. comm.).

The habitat of *Mucuna persericea* at Honomā‘ele is described as a nonnative wet forest (NTBG 2020). Associated nonnative plant species may include *Spathodea campanulata* and *Aleurites moluccana* (USFWS 2020).

The habitat occupied by *Mucuna persericea* at Makapipi is described as a wet nonnative forest. Associated plant species may include *Hibiscus tiliaceus*, *Mangifera indica*, *Cordyline fruticosa*, and *Ardisia elliptica* (NTBG 2020).

The habitat of *Mucuna persericea* at Pi‘ina‘au-Ke‘anae Valley is classified as developed. Associated nonnative plant species may include *Mangifera indica* and *Spathodea campanulata* (USFWS 2020).

The habitat of *Mucuna persericea* at Honopou is described as developed. Associated nonnative plant species may include *Aleurites moluccana* and *Psidium guajava* (USFWS 2020).

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):

Agricultural and urban development destruction or degradation of habitat—Destruction and degradation of habitat by agricultural and urban development is a threat to *Mucuna persericea* at all populations (Maui Nui PEPP 2019; Oppenheimer 2020a, pers. comm.; Oppenheimer 2019, pers. comm.; PEPP 2013, pp. 147-149). Landowners directly affect the growth, regeneration, and potentially reproduction of individuals of *M. persericea* by trimming vines with weed whackers or machetes, as they are maintaining their yards or conducting agricultural activities on their properties. Some landowners are conducting these activities oblivious to the fact that *M. persericea* is listed as endangered and a very rare plant species. Additionally, the identity of *M. persericea* is cryptic and can be easily misidentified as a weed species. Landowners often lack the botanical skills needed to identify *M. persericea* against ten or more similarly looking vine species known from the area (Oppenheimer 2020b, pers. comm.).

Ungulate destruction and degradation of habitat—Destruction and degradation of habitat by feral pigs (*Sus scrofa*) and cattle (*Bos taurus*) are a threat to *Mucuna persericea* at all populations (USFWS 2013, p. 32051; Maui Nui PEPP 2019; PEPP 2013, p. 148). 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; van Riper and van Riper 1982). Ecosystem degradation occurs at all populations by nonnative pigs (USFWS 2013, p. 32051; Maui Nui PEPP 2019).

Established ecosystem-altering invasive plant modification and degradation of habitat—Invasive 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, entire). Habitat modification and destruction by invasive nonnative plants negatively affects all occurrences of *Mucuna persericea* (Maui Nui PEPP 2019; PEPP 2013, p. 148; PEPP 2012, p. 128). Nonnative plants with the greatest impacts on *M. persericea* include *Schizostachyum glaucifolium* (bamboo), *Spathodea campanulata* (African tuliptree), *Psidium guajava* (guava), and *Ardisia elliptica* (shoebutton ardisia, inkberry) (Oppenheimer 2019, pers. comm.; NTBG 2020; USFWS 2020).

Habitat destruction and degradation by landslides and erosion—Due to the steep topography occupied by *Mucuna persericea*, erosion increases the potential for landslides and rockfalls, which negatively impact this species. Field survey data presented by the Maui Nui PEPP suggest that landslides (erosion) and tree falls are possible at one population of *M. persericea* located along a stream corridor (Maui Nui PEPP 2019). Landslides, including tree falls and erosion associated with them, can have a significant effect on small populations by destabilizing substrate, altering hydrological patterns, and by damaging and destroying individual plants (Maui Nui PEPP 2019; PEPP 2013, p. 147; Stearns 1985).

Fire destruction and degradation of habitat—Fire is noted as a threat to *Mucuna persericea* (Maui Nui PEPP 2019). Wildfires are increasing in frequency in habitat occupied by *M. persericea*. Fire can destroy dormant seeds as well as individual plants. Successive fires burn farther and farther into native habitat and alter microclimate conditions to further alter habitat conditions to favor nonnative plants. Nonnative plants convert native plant communities to nonnative dominated plant communities (D'Antonio and Vitousek 1992; Tunison *et al*. 2002). Increasing episodes of drought, expansion of invasive grass cover, and temperature increases, have led to an increase in the number of wildfires on Maui (Trauernicht *et al.* 2015, pp. 427–440).

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 Hawai‘i using high resolution climate change projections. Climate change vulnerability is defined as the relative inability of a species to display the possible responses necessary for persistence under climate change. This assessment was not conducted specifically for *Mucuna persericea*; however, the analysis was conducted for two other apparently secure native *Mucuna* species, *M. gigantea* and *M. sloanei*, with vulnerability scores of 0.339 and 0.334, respectively (on a scale of 0 being not vulnerable to 1 being extremely vulnerable to climate change). *Mucuna persericea* is restricted to an area of less than 19.3-km (12-mi) on the east side of Maui. Considering that threats such as habitat destruction and degradation by ungulates, nonnative plants, landslides, fire, drought; predation by ungulates, inverts, rats, and slugs are increasing, and the number of individuals are 100 to 200, it is likely that climate change could affect its ability to persist. Therefore, additional management actions may be needed to conserve this taxon into the future, such as ensuring that adequate viable genetic storage is maintained, identifying suitable microsites where climate change effects are anticipated to occur more slowly, and considering suitable habitat in areas outside of its known range.

Tropical cyclone frequency and intensity are projected to change as a result of climate change over the next 100 to 200 years (Vecchi and Soden 2007; Emanuel *et al.* 2008; Yu *et al.* 2010). 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). 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.

Drought is observed to be a threat to *Mucuna persericea* at Pi‘ina‘au-Ke‘anae Valley (Maui Nui PEPP 2019). Over the last 100 years, the Hawaiian Islands have experienced an annual decline in precipitation of over 9 percent, increasing to as much as 15 percent within the last 20 years (US-NSTC 2008, p. 61; Chu and Chen 2005, pp. 4812–4813; Diaz *et al*. 2005, entire). Drought affects plants directly by desiccation. The increase in drought frequency and intensity leads to a self-perpetuating cycle of increase in cover of nonnative plants, increase in the number of fires, and an increase of erosion (US-GCRP 2009, pp. 18, 24; Warren 2011, pp. 221–223).

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):
Invertebrate predation or herbivory—Unknown seed borers or weevils are noted as a threat to *Mucuna persericea* (Maui Nui PEPP 2019; Oppenheimer 2019, pers. comm.; PEPP 2013, pp. 147-149). The seed borer or seed weevil damages the seeds of *M. persericea* by drilling holes into them, thereby, eliminating the reproductive process for this species, and prohibiting the creation of new offspring.

Ungulate predation and herbivory—Feral pigs and cattle may consume *Mucuna persericea* directly when foraging for food, and damage roots and seedlings (Loope 1998, pp. 752–753; van Riper and van Riper 1982, p. 25). There have been direct observations of the activities of feral pigs and goats at all populations of *M. persericea* (USFWS 2013, p. 32051; Maui Nui PEPP 2019; PEPP 2013, p. 148).

Rodent predation and herbivory—Herbivory by rats is noted to be a threat to *Mucuna persericea* at Makapipi (PEPP 2013, p. 147). Rats eat virtually every part of plants and at every stage: fleshy fruits, seeds, flowers, stems, leaves, shoot, seedlings, and roots (Abe and Umeno 2011, p. 35; Russell 1980, pp. 269–272; Cuddihy and Stone 1990, pp. 68–69). The effects on plants range from reduced vigor and decreased reproduction to mortality of individuals and complete lack of recruitment.

Slug herbivory—Herbivory by slugs is noted to be a threat to *Mucuna persericea* at all populations (PEPP 2013, p. 148). Slug herbivory can prevent regeneration through death of individual seedlings and small plants (Joe and Daehler 2008).

2.3.2.4 Inadequacy of existing regulatory mechanisms (Factor D): Lack of adequate hunting regulations—Nonnative feral ungulates are an ongoing threat to *Mucuna persericea* through destruction and modification of habitat and by direct herbivory or predation. The State of Hawai‘i provides game mammal (feral pigs and goats) hunting opportunities (e.g., “sustained yield”) in public hunting areas on Maui (DLNR 2012). Public hunting areas are not fenced and game mammals have unrestricted access to most areas across the landscape, regardless of underlying land use designation; therefore, any unfenced populations of *M. persericea* are at risk (DLNR 2010).

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

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

Established invasive plant species competition—Nonnative plant species including *Schizostachyum glaucifolium* (bamboo), *Spathodea campanulata* (African tuliptree), *Psidium guajava* (guava), and *Ardisia elliptica* (shoebutton ardisia, inkberry) compete with *Mucuna persericea* for water, light, and nutrients (Oppenheimer 2019, pers. comm.; NTBG 2020; USFWS 2020).

Current Management Actions:

- Surveys and monitoring—The Maui Nui PEPP monitors occurrences of *Mucuna persericea* (Maui Nui PEPP 2019; PEPP 2016, pp. 164-165; PEPP 2013, pp. 147-149).
- Captive propagation for genetic storage and reintroduction—
  - The Lyon Arboretum Seed Conservation Laboratory reported more than 1,600 seeds in storage from 17 accessions of *Mucuna persericea* from populations located at Kūhiwa, Makapipi, Honomāʻele, Haneoʻo, Manawaikeae, and Kapiʻa (Lyon Arboretum 2018).
  - The National Tropical Botanical Garden (2019) has more than 125 seeds of *Mucuna persericea* in storage representing individuals from Kūhiwa and Honomāʻele.
  - The Olinda Rare Plant Facility had two potted plants of *Mucuna persericea* growing in their nursery from plants collected from Makapipi (Olinda Rare Plant Facility 2018).
- Outreach and education—The Maui Nui PEP program provided resources and handouts to landowners explaining the differences between *Mucuna persericea* and similar vines that could be present on their property to prevent landowners from mistakenly cutting down this listed species (Oppenheimer 2019, pers. comm.; PEPP 2013, pp. 147-148).
- Reintroduction and translocation—Seedlings grown from seed viability germination trials at the Lyon Arboretum Seed Conservation Laboratory were translocated to the Kahanu Garden of the National Tropical Botanical Garden on Maui in May 2019 (Maui Nui PEPP 2019). These translocated individuals did not grow well and when last observed, they were in poor condition. The status of these individuals is unknown (Oppenheimer 2019, pers. comm.).

Table 2. Status and trends of *Mucuna persericea* from listing through 5-year review.

Date	No. wild individuals	No. outplanted	Preventing Extinction Criteria identified by HPPRCC	Preventing Extinction Criteria Completed?
2013 (listing)	~Few hundred	0	All threats managed in all 3 populations	None
			Complete genetic storage	Partially
			3 populations with 50 mature individuals each	Partially
2016 (critical habitat)	~Few hundred	0	All threats managed in all 3 populations	None
			Complete genetic storage	Partially
			3 populations with 50 mature individuals each	Partially
2020 (5-year review)	100–200	0	All threats managed in all 3 populations	None
			Complete genetic storage	Partially
			3 populations with 50 mature individuals each	Partially

Table 3. Threats to *Mucuna persericea* and ongoing conservation efforts.

Threat	Listing Factor	Current Status	Conservation/Management Efforts
Ungulate degradation of habitat	A	Ongoing	None
Agricultural and urban development destruction or degradation of habitat	A	Ongoing	Partial, outreach and education to landowners
Established ecosystem-altering invasive plant modification and degradation of habitat	A	Ongoing	None
Degradation and destruction of habitat by landslides and erosion	A	Ongoing	None
Fire destruction and degradation of habitat	A	Ongoing	None
Climate change loss or degradation of habitat, including hurricanes and drought	A	Ongoing	None

Threat	Listing Factor	Current Status	Conservation/Management Efforts
Ungulate predation or herbivory	C	Ongoing	None
Predation or herbivory by rats	C	Ongoing	None
Herbivory by slugs	C	Ongoing	None
Predation or herbivory by nonnative invertebrates	C	Ongoing	None
Inadequacy of existing regulatory mechanisms	D	Ongoing	None
Established invasive plant species competition	E	Ongoing	None

2.4 Synthesis

There are between 100 to 200 individuals of *Mucuna persericea* within four wild population units on east Maui. A landscape-based assessment of climate change vulnerability for native plants of Hawai‘i using high resolution climate change projections was not conducted by Fortini *et al*. (2013); however, the analysis shows that other rare and endangered *Mucuna* species are vulnerable to the effects of climate change; therefore, *M. persericea* may also be vulnerable to the effects of climate change. There are seeds and propagules in collection. Collection, propagation, and translocation are ongoing.

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 the three populations represented in *ex situ* (at other than the plant's natural location, such as a nursery or arboretum) 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, 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 four populations with 100 to 200 total individuals (level of reproduction within populations is unknown; Table 2), genetic storage goals have not been met (Table 2), and all threats are not being sufficiently managed throughout the range of the species (Table 3). Therefore, *Mucuna persericea* 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 assess the status of known occurrences of *Mucuna persericea* in historical locations and potentially suitable habitat.
- Ungulate monitoring and control—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 *M. persericea*.
- Predation and herbivory by rats and slugs—Implement effective control measures for rats and slugs at all populations.
- Predation and herbivory by invertebrates—Research and implement effective control measures for nonnative invertebrates at all populations.
- Captive propagation for genetic storage and reintroduction—Continue to collect seeds and other propagative materials for storage and reintroduction.
- Reintroduction and translocation—Increase numbers of populations and individuals in suitable habitat to build resiliency and redundancy and reduce the impacts of habitat degradation by feral ungulates, nonnative plants, fire, agricultural and urban development, and events associated with climate change; and predation/herbivory by feral ungulates, rats, and slugs.
- Stochastic events—Build resiliency and redundancy—Increase numbers of populations and individuals to reduce the impacts of landslides and erosion.
- Climate change adaptation strategy—Research suitability of habitat in the future due to the impacts of climate change.
- 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 *Mucuna sloanei* var. *persericea*
(sea bean)

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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FIELD OFFICE APPROVAL:

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