

*Santalum involutum*  
(‘iliahi)

**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: *Santalum involutum* ('iliahi)

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## **5-YEAR REVIEW** ***Santalum involutum* (‘iliahi)**

### **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 The review was based on the final rule listing this species; peer reviewed scientific publications; unpublished field observations and species status report by the Service, State of Hawai‘i, and other experienced biologists; unpublished survey reports; notes and communications from other qualified biologists; as well as a review of current, available information.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, Hawai‘i, 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. 2016. Endangered and Threatened Wildlife and Plants; endangered status for 49 species from the

Hawaiian Islands; final rule. Department of the Interior, Federal Register 81 (190): 67786–67860, Friday, September 30, 2016.

**Date listed:** September 30, 2016  
**Entity listed:** *Santalum involutum*  
**Classification:** Endangered

Revised Listing, if applicable

**FR notice:** N/A  
**Date listed:** N/A  
**Entity listed:** N/A  
**Classification:** N/A

**1.3.3 Associated rulemakings:**  
N/A

**1.3.4 Review History:**  
This is the first 5-year review for *Santalum involutum*.

**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 Multi-Island Species  
**Date issued:** August 2020  
**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  
 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  
 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.

*Santalum involutum* is a long-lived perennial tree. 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 Kaua‘i where they now occur or occurred historically. Each of these populations must be naturally reproducing (i.e., viable seeds, seedlings, saplings) with a minimum of 25 mature individuals per population.

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

### **Interim Stage**

To meet the interim stage of recovery of *Santalum involutum*, 100 mature individuals are needed in each of three populations and all major threats must be controlled around the populations designated for recovery at this stage. There should also be demonstrated regeneration of seedlings and growth to at least sapling stage for woody species and documented replacement regeneration within each of the target populations. The populations must be adequately represented in an *ex situ* collection as defined in the Center for Plant Conservation’s guidelines (Guerrant et al. 2004, entire) that is secure and well managed. Adequate monitoring must be in place and conducted to assess individual plant survival, population trends, trends of major limiting factors, and response of major limiting factors to management.

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

### **Downlisting Criteria**

In addition to achieving 5 to 10 populations with 200 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 200 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:

*Santalum involutum* is a small tree in the Santalaceae (sandalwood) family, 4 to 8.3 meters (m) (13 to 27 feet (ft)) tall and glabrous with smooth, charcoal-colored bark. Coriaceous (papery), opposite leaves, often drooping, are 5.7 to 8 centimeters (cm) (2.2 to 3 inches (in)) long, 1.4 to 1.8 cm (0.6 to 0.7 inches (in)) wide, linear-elliptic, with sides rolled in so they appear tubular. Cymes (inflorescences with terminal flower blooming first) are 3 to 5 cm (1.2 to 2 in) long, and 5- to 15-flowered; peduncle (flower stalk) 9 to 16 mm (0.4 to 0.6 in) long, with campanulate (flaring) to cylindrical four lobed flowers that are greenish-white (sometimes turning red with age). Drupes (fleshy single-seeded fruit) are 15 to 20 mm (0.6 to 0.8 in) long with an apical ring and slender tip 3 to 5 mm (0.1 to 0.2 in) long (St. John 1984, pp. 220–222; Harbaugh et al. 2010, p. 835).

*Santalum involutum* and *S. pyrularium* are both endemic to Kaua'i (Wood 2015, p. 2). Morphologically, *Santalum involutum* differs from the more common *S. pyrularium* in its shorter, campanulate, white to greenish flowers (occasionally purple-red) and its weeping habit with involute (in-rolled) leaves (St. John 1984, p. 222; Harbaugh et al. 2010, p. 835; Wood 2015, p. 2).

Flowering has been observed in February and August and fruiting in January, April, July, and October (Wood 2015, pp. 10–13; NTBG 1992, 2012, 2015, 2017).

#### 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:**

*Santalum involutum* was first described from a collection on a ridge top near a stream east of Hanakāpī'ai, on the north side of Kaua'i (St. John 1984, p. 222). Plants have not been observed in this area for more than 30 years (Harbaugh et al. 2010, p. 835). Historically, *S. involutum* ranged from Waipā, to Wainiha, Hanakāpī'ai, and to Kalalau (St. John 1984, p. 222; Wood 2015 p. 3). Currently, *S. involutum* is restricted to steep slopes at Ho'olulu (1 individual), Pohakuao-Hanakoa-Waiolaa (<150 individuals), and Kalalau (<50 individuals) totaling approximately 200 individuals (Wood 2015, p. 3; NTBG 2017).

**2.3.1.3 Genetics, genetic variation, or trends in genetic variation (e.g., loss of genetic variation, genetic drift, inbreeding, etc.):**

In 2007, DNA samples were taken from 14 plants at Kalalau for a genetic study (NTBG 2007). Microsatellite data shows that *S. pyrularium* is in a separate group from *S. involutum*, and that *S. involutum* is in the same group as *S. freycinetianum* (Harbaugh et al. 2010, p. 829). It was found that all *Santalum* specimens from Moloka'i, east and west Maui, and Lāna'i belong to the same group, and are separate from all specimens on O'ahu (Harbaugh et al. 2010, p. 829). In summary, the study shows four important revisions are warranted: (1) *S. freycinetianum* is restricted to O'ahu; (2) *S. haleakalae* now includes var. *haleakalae* on east Maui as well as var. *lanaiense*, and the latter includes populations on east and west Maui, Moloka'i, and Lāna'i; (3) *S. freycinetianum* var. *pyrularium* from Kaua'i should be considered *S. pyrularium*; and (4) populations at Kalalau and nearby areas should be regarded as *S. involutum*, an ancient hybrid between the white- and red-flowered *Santalum* clades (Harbaugh et al. 2010, p. 830).

**2.3.1.4 Taxonomic classification or changes in nomenclature:**

*Santalum involutum* was described by St. John (1984, pp. 220–222) with the epithet from the Latin adjective *involutus*, meaning in-rolled, referencing the leaf blade morphology. This taxon as described by St. John was not recognized as distinct from *S. freycinetianum* var. *pyrularium* by Wagner et al. (1999, pp. 1221–1222; Harbaugh et al. 2010, p. 827). The revisionary treatment by Harbaugh et al. (2010, entire), based on molecular data, generated taxonomic changes for the Hawaiian sandalwood species, elevating *S. freycinetianum* var. *pyrularium* to species level, and resurrecting from synonymy those plants on Kaua'i as *S. involutum*. *Santalum involutum* is the currently recognized taxonomy (Wagner et al. 2012, p. 68).

**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):**

*Santalum involutum* occurs at 122 to 366 meters (m) (400 to 1,200 feet (ft)) in lowland mesic forest and is occasionally observed in lowland wet *Metrosideros* ('ōhi'a) and *Metrosideros-Cheirodendron-Dicranopteris* ('ōhi'a-'ōlapa-uluhe) forest. The lowland mesic forest is dominated by *Diospyros* (lama), *Metrosideros*, and *Acacia* (koa) (St. John 1984, p. 222; Wood 2015, p. 3). *Santalum involutum* has also been observed on steep mesic ridges dominated by matting ferns of *Dicranopteris* and *Diplopterygium* (uluhe lau nui) (Wood 2015, p. 3). Associated native tree species include *Alphitonia ponderosa* (kauila), *Antidesma platyphyllum* (hame), *Bobea brevipes* ('ahakea lau li'i), *Euphorbia haeleeleana*, *Charpentiera densiflora* (pāpala), *Chrysodracon aurea* (hala pepe), *Coprosma waimeae* ('ōlena), *Cyanea hardyi* (hāhā), *Diospyros* spp. (lama), *Dodonaea viscosa* ('a'ali'i), *Elaeocarpus bifidus* (kalia), *Flueggea neowawraea* (mehamehame), *Eugenia reinwardtiana* (nīoi), *Exocarpos luteolus* (heau), *Hibiscus kokio* subsp. *saintjohnianus* (koki'o), *Ilex anomala* (kāwa'u), *Kadua affinis* (manono), *Kokia kauaiensis* (koki'o), *Labordia helleri* (kāmakahala), *Melicope barbigera* (uahi a Pele), *M. clusiifolia* (kūkaemoa), *Metrosideros polymorpha* var. *glaberrima* ('ōhi'a), *Myrsine lanaiensis*, *M. linearifolia* (kōlea), *Neraudia melastomifolia*, *Nestegis sandwicensis* (olopua), *Pipturus albidus* (waimea), *Pisonia sandwicensis* (aūlu), *Pittosporum glabrum* (hō'awa), *P. kauaiense* (hō'awa), *Planchonella sandwicensis* ('āla'a), *Pritchardia minor* (loulu), *P. napaliensis* (loulu), *Psychotria mariniana*, *Pteralyxia kauaiensis* (kaulu), *Rauvolfia sandwicensis* (hao), *Polyscias racemosa*, *Sideroxylon polynesica* (keahi), *Syzygium sandwicensis* ('ōhi'a hā), *Wilkesia gymnoxiphium* (iliau), *Xylosma hawaiiense* (maua), and *Zanthoxylum dipetalum* (kāwa'u). Associated native shrubs, herbs, and vines include *Alyxia stellata* (maile), *Artemisia australis* ('āhinahina), *Bidens sandwicensis* (ko'oko'olau), *Cyrtandra longifolia* (ha'iwale), *C. paludosa* (moa), *Dubautia microcephala* (na'ena'e), *D. laevigata* (na'ena'e), *Euphorbia eleanoriae* ('akoko), *Isodendron laurifolium* (aupaka), *Leptecophylla tameiameiae* (pūkiawe), *Lipochaeta connata* var. *acris* (nehe), *Lobelia niihauensis*, *Lysimachia glutinosa*, *Nototrichium sandwicense* (kulu'i), *Peucedanum sandwicense* (makou), *Schiedea apokremnos*, and *Smilax melastomifolia* (hoi kuahiwi). Associated native grasses and sedges include *Carex meyenii*, *C. wahuensis*, *Eragrostis grandis*, *E. variabilis* (kāwelu), *Gahnia beecheyi*, *Machaerina mariscoides* ('ahanui), and *Panicum lineale*. Associated native ferns include *Cyrtomium caryotideum* (kā'ape'ape), *Dicranopteris linearis* (uluhe), *Diplazium sandwichianum* (hō'i'o), *Diplopterygium pinnatum*

(uluhe lau nui), *Doryopteris decipiens* (kumuniu), *Dryopteris sandwicensis*, *D. unidentata* var. *paleacea* (‘akole), *Microlepia strigosa* (palapalai), *Sphenomeris chinensis* (pala‘ā), and *Tectaria gaudichaudii* (‘iwa‘iwa lau nui) (Wood 2015, p. 3–6; Harbaugh et al. 2010, p. 835).

## 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—Feral pigs (*Sus scrofa*), goats (*Capra hircus*), and black-tailed deer (*Odocoileus hemionus columbianus*), and evidence of their activities are observed at all occurrences of *S. involutum* (Wood 2015, pp. 6–7; Harbaugh et al. 2010, pp. 835–836). 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 by increasing erosion by creating large areas of bare soil (Loope 1998, pp. 747–774; van Riper and van Riper 1982, pp. 34–35).

Established ecosystem-altering invasive plant modification and degradation of habitat—Invasive nonnative plants modify habitat 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). Habitat modification and destruction by invasive nonnative plants negatively affects the only known populations of *Santalum involutum* (Wood 2015, pp. 6–7; Harbaugh et al. 2010, pp. 835–836). The nonnative invasive plants that are the greatest threats include *Adiantum hispidulum* (rough maidenhair fern), *Ageratina riparia* (Hāmakua pāmakani), *Andropogon glomeratus* var. *pumilis* (bushy beardgrass), *Blechnum appendiculatum*, *Bryophyllum pinnatum* (air plant), *Buddleja asiatica* (dog tail), *Christella dentata* (pai‘i‘ihā), *Clidemia hirta* (Koster’s curse), *Cyperus meyenianus*, *Erigeron karvinskianus* (daisy fleabane), *Hedychium gardnerianum* (kāhili ginger), *Lantana camara* (lantana), *Melinis minutiflora* (molasses grass), *Paspalum conjugatum* (Hilo grass), *Psidium cattleianum* (strawberry guava), *P. guajava* (common guava), *Rubus argutus* (prickly Florida blackberry), *R. rosifolius* (thimbleberry), *Setaria parviflora* (yellow foxtail), *Spathoglottis plicata* (Philippine ground orchid), *Sphaeropteris cooperi* (Australian tree fern), *Sporobolus indicus* (West Indian dropseed), and *Stachytarpheta jamaicensis* (Jamaica vervain) (Wood 2015, pp. 6–7; Harbaugh et al. 2010, pp. 835–836).

Landslides destruction or degradation of habitat—Landslides are a threat to *Santalum involutum* as individuals occur on steep slopes (Wood 2015, pp. 6–7). One landslide could extirpate a population by direct destruction.

Landslides, including the erosion associated with them, can destabilize substrate and alter hydrological patterns (Stearns 1985, pp. 99–107, 291–305).

Fire destruction and degradation of habitat—Fire is a threat to the mesic habitat and to individuals of *Santalum involutum* (Wood 2015 pp. 6–7; Harbaugh et al 2010, pp. 835–836). Increasing episodes of drought, expansion of invasive nonnative grass cover, and temperature increases, have led to an increase in the number of wildfires on Kaua‘i (Trauernicht et al. 2015, pp. 439–440). Fire can destroy dormant seeds as well as plants themselves, even in steep or inaccessible areas. Successive fires that burn farther and farther into native habitat destroy native plants and remove habitat for native species by altering microclimate conditions to one more favorable to nonnative invasive plants. Nonnative plants convert native plant communities to nonnative dominated plant communities, contributing to continuation of the fire cycle (D’Antonio and Vitousek 1992, pp. 77–78; Tunison *et al.* 2002, p. 126).

#### **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 feral ungulates—Feral pigs, goats, and black-tailed deer, and evidence of their activities are observed at all occurrences of *Santalum involutum* (Wood 2015, pp. 6–7; Harbaugh et al. 2010, pp. 835–836). These animals damage and destroy plants by direct herbivory, bark stripping, and trampling. In addition, drought events are driving deer farther into forested areas in search of food (Waring 1996, in litt; Nishibayashi 2001, in litt.). Feral pigs have been observed browsing on young shoots, leaves, and fronds of a wide variety of native plants (Diong 1982, p. 144). Feral goats forage in areas of extremely rugged terrain and are instrumental in the decline of native vegetation (Cuddy and Stone 1990, p. 64; van Riper and van Riper 1982, pp. 34–35; Tomich 1986, pp. 153–156).

Herbivory and predation by rats—Herbivory and predation by rats is noted to be a threat to *Santalum involutum* (Wood 2015, pp. 6–7; Harbaugh et al, 2010, pp. 835–836). Rats eat virtually every part of plants and at every stage: fleshy fruits, seeds, flowers, stems, leaves, shoot, seedlings, and roots (Russell 1980, pp. 269–272; Cuddihy and Stone 1990, pp. 34, 67). The effects on plants range from reduced vigor and decreased reproduction to mortality of individuals and complete lack of recruitment.

Herbivory by slugs—Herbivory by slugs may impact *Santalum involutum* though mechanical damage, destruction of plant parts, and direct mortality

(Wood 2015, pp. 6–7). The effects of slug herbivory range from reduced reproductive vigor to complete lack of recruitment (Joe 2006, pp. 3, 50).

Predation by nonnative invertebrates—The black twig borer (*Xylosandrus compactus*) is known to infest both crops and native plants, and may affect *Santalum involutum* (Wood 2015, pp. 6–7). The black twig borer burrows into branches, introduces a pathogenic fungus as food for its larvae, and lays its eggs. The fungus infects the xylem and prevents the flow of water and nutrients in the plant. Twigs, branches, and entire plants can be damaged or killed from an infestation (Davis 1970, pp. 38–39; Extension Entomology and UH-CTAHR IPMP 2006).

#### **2.3.2.4 Inadequacy of existing regulatory mechanisms (Factor D):**

Lack of adequate hunting regulations—Nonnative feral ungulates pose threat to *Santalum involutum* through destruction and degradation of the species’ habitat, and directly by predation and herbivory, but regulatory mechanisms are inadequate to address this threat. The State of Hawai‘i provides game mammal hunting opportunities in State-designated public hunting areas (DLNR 2010). However, the State’s management objectives for game animals range from maximizing public hunting opportunities (i.e., “sustained yield”) in some areas to removal by State staff, or their designees (State of Hawai‘i, H.A.R. 13-123). The only known occurrences of *S. involutum* are within a public hunting area. Public hunting areas are not fenced and game mammals have unrestricted access for most areas across the landscape, regardless of underlying land use designation; therefore, any unfenced populations of *S. involutum* are at risk (DLNR 2010).

Lack of adequate biosecurity legislation—Introduction of nonnative plants and insects—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 and invertebrate species to the State of Hawai‘i is a significant risk to federally listed species including any remaining wild or outplanted individuals of *Santalum involutum*.

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

Reduced viability due to low numbers—Small, isolated populations often exhibit reduced levels of genetic variability, which diminishes the species’ capacity to adapt and respond to environmental changes, thereby lessening the probability of long-term persistence (Barrett and Kohn 1991, pp. 3,7; Newman and Pilson 1997, pp. 354–355). The problems associated with small population size and vulnerability to random demographic fluctuations or natural catastrophes are further magnified by synergistic interactions with other threats, such as anthropogenic impacts like habitat loss from human development or predation by nonnative species. Very small plant populations may experience reduced reproductive vigor due to ineffective pollination or inbreeding depression. *Santalum involutum* may experience reduced reproductive vigor as there are only three known occurrences totaling approximately 200 individuals (Wood et al. 2015, pp. 6–7; Harbaugh et al 2010, pp. 835–836).

Climate change loss or degradation of habitat—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. Vulnerability is ranked on a scale of 0 being not vulnerable to 1 being extremely vulnerable to climate change. The assessment was conducted under the epithet *S. freycinetianum*, before the taxonomic change of the Kaua‘i plants to *S. pyrularium* and *S. involutum*, with a vulnerability ranking of 0.311. 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.

Current Management Actions:

- Surveys and monitoring—Occurrences of *Santalum involutum* were last surveyed in 2015 (all known sites) and in 2017 (at Ho‘olulu) by NTBG botanists (Wood 2015, entire; NTBG 2017).
- Ungulate control—Nā Pali Coast State Wilderness Park is managed for recreational use and for sustained hunting of feral pigs and goats, with hunting opportunities provided to provide some ungulate control for watershed protection (DLNR 2019, in litt.; DLNR 2020, in litt.). The daily bag limit for goats is six animals and for pigs is four animals during hunting season.
- Captive propagation for genetic storage and reintroduction—
  - The National Tropical Botanical Garden (NTBG) reports and uncounted number of seeds in storage representing one individual from above the falls at Pohakuao and from one individual at Pohakuao below Manono ridge (Wood 2015, p. 3).
  - NTBG reports planting of one individual at the Limahuli Garden representing one founder from Pohakuao (NTBG 2020).

**Table 1. Status and trends of *Santalum involutum* from listing through 5-year review.**

Date	No. wild individuals	No. outplanted	Preventing Extinction Criteria identified by HPPRCC	Preventing Extinction Criteria Completed?
2016 (listing)	50–100	0	All threats managed in all 3 populations	No
			Complete genetic storage	No
			3 populations with 25 mature individuals each	Partially, possibly >25 individuals at Pohakuao-Hanakoa-Waiolaa and at Kalalau
2021 (5-year review)	ca 200	0	All threats managed in all 3 populations	No
			Complete genetic storage	No
			3 populations with 25 mature individuals each	Partially, possibly >25 individuals at Pohakuao-Hanakoa-Waiolaa and at Kalalau
			Each population naturally reproducing	Not reported

**Table 2. Threats to *Santalum involutum* and ongoing conservation efforts.**

Threat	Listing Factor	Current Status	Conservation/Management Efforts
Destruction and degradation of habitat by ungulates	A	Ongoing	Partial, hunting allowed in Nā Pali Coast State Wilderness Park
Destruction and degradation of habitat by established ecosystem-altering invasive plants	A	Ongoing	None
Destruction and degradation of habitat by landslides	A	Ongoing	None
Predation and herbivory by rats	C	Ongoing	None
Herbivory by slugs	C	Ongoing	None
Predation by nonnative invertebrates—Black twig borer	C	Ongoing	None
Inadequacy of regulatory mechanisms	D	Ongoing	Partial, hunting allowed in Nā Pali Coast State Wilderness Park
Low numbers	E	Ongoing	Partial, seed collections in storage
Climate change degradation or loss of habitat	E	Ongoing	None

#### 2.4 Synthesis

There are estimated to be approximately 200 individuals of *Santalum involutum* on Kaua‘i. A landscape-based assessment of climate change vulnerability for native plants of Hawai‘i using high resolution climate change projections was made by Fortini et al. (2013) and their analysis showed that *S. involutum* (as *S. freycinetianum*) is vulnerable to the effects of climate change. Seed collection efforts are being conducted.

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 Kaua‘i 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 25 mature, reproducing individuals per population.

The preventing extinction goals for this species have not been met as, although two populations may total at least 25 mature individuals, their current status is unknown and no natural recruitment has been reported. Seed collections were conducted in 2014 and 2015 (Table 1); however, not all threats are being sufficiently managed throughout the range of the species (Table 2). Therefore, *Santalum involutum* 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

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 *Santalum involutum* in current and potentially suitable habitat.
- Ungulate monitoring and control—Construct and maintain fenced exclosures to protect individuals from the negative impacts of feral ungulates.
- Nonnative invasive plant management—Develop and implement nonnative plant control plans.
- Fire management—Develop and implement a fire management plan for all populations.

- Predation and herbivory control—Develop and implement rat, slug, and invertebrate control methods.
- Captive propagation for genetic storage and reintroduction—Continue collection efforts and begin propagation efforts for maintenance of genetic stock.
- Reintroduction and translocation—Reintroduce individuals to managed suitable habitat to increase numbers of populations and individuals in suitable habitat to build resiliency and redundancy and reduce the impacts of habitat destruction, nonnative plant competition, predation, low numbers, and climate change.
- 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 *Santalum involutum***  
**(‘iliahi)**

**Current Classification:** Endangered

**Recommendation resulting from the 5-Year Review:**

- Downlist to Threatened
- Uplist to Endangered
- Delist
- No change needed

**Appropriate Listing/Reclassification Priority Number, if applicable:** \_\_\_\_\_

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**FIELD OFFICE APPROVAL:**

for

\_\_\_\_\_  
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