Solanum sandwicense
(Popolo ʻaiakeakua)

5-Year Review
Summary and Evaluation

U.S. Fish and Wildlife Service
Pacific Islands Fish and Wildlife Office
Honolulu, Hawaii

5-YEAR REVIEW

Species reviewed: *Solanum sandwicense* (Popolo ʻaiakeakua)

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5-YEAR REVIEW
Solanum sandwicense/ Popolo ʻaiakeakua

1.0 GENERAL INFORMATION

1.1 Reviewers

Lead Regional Office:
Region 1, Endangered Species Program, Division of Recovery, Jesse D'Elia, (503) 231-2071

Lead Field Office:
Pacific Islands Fish and Wildlife Office, Gina Shultz, Deputy Field Supervisor, (808) 792-9400

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 (PIFWO) of the U.S. Fish and Wildlife Service (USFWS) beginning on March 8, 2007. The Bernice P. Bishop Museum provided most of the updated information on the current status of *Solanum sandwicense*. The evaluation of the status of the species was prepared by the lead PIFWO biologist and reviewed by the Plant Recovery Coordinator. The document was then reviewed by the Recovery Program Leader and acting Assistant Field Supervisor for Endangered Species, and Deputy Field Supervisor, before submission to the Field Supervisor for approval.

1.3 Background:

1.3.1 Federal Register (FR) Notice citation announcing initiation of this review:

USFWS. 2007. Endangered and threatened wildlife and plants; initiation of 5-year reviews of 71 species in Oregon, Hawaii, Commonwealth of the Northern Mariana Islands, and Territory of Guam. Federal Register 72(45):10547-10550.

1.3.2 Listing history

Original Listing
FR notice: USFWS. 1994. Endangered and threatened wildlife and plants; determination of endangered or threatened status for 24 plants from the island of Kauai, HI. Federal Register 59(38):9304-9329.
Date listed: February 25, 1994
Entity listed: Species
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. 2003a . Endangered and threatened wildlife and plants; final designation or nondesignation of critical habitat for 95 plant species from the islands of Kauai and Niihau, HI; final rule. Federal Register 68(39):9116-9479.

USFWS. 2003b. Endangered and threatened wildlife and plants; final designation or nondesignation of critical habitat for 101 plant species from the island of Oahu, HI: final rule. Federal Register 68(116):35949-35998.

Critical habitat was designated for *Solanum sandwicense* in two units totaling 2,692 hectares (6,651 acres) on Kauai (USFWS 2003a) and three units totaling 328 hectares (811 acres) on Oahu (USFWS 2003b). These designations includes habitat on State and private lands (USFWS 2003a, b).

1.3.4 Review History:

Species status review [FY 2008 Recovery Data Call (September 2008)]:
Stable

Recovery achieved:
1 (0-25%) (FY 2008 Recovery Data Call)

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 plan for the Kauai plant cluster. U.S. Fish and Wildlife Service, Portland, Oregon. 270 pages, plus appendices.
Date issued: September 20, 1995.

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***
__X_ ***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***
__X_ ***No***

2.2 Recovery Criteria

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

__X_ ***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?

__X_ ***Yes***

____ ***No***

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

__X_ ***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 (Factors A, B, C, D, and E) affecting this species is presented in section 2.4.

Stabilizing, downlisting, and delisting objectives are provided in the recovery plan for the Kauai plants (USFWS 1995), based on whether the species is an annual, a short-lived perennial (fewer than 10 years), or a long-lived perennial. *Solanum sandwicense* is a short-lived perennial, and to be considered stable, the taxon must be managed to control threats (*e.g*., fenced, weeding, etc.) and be represented in an *ex situ* (off-site) collection. In addition, a minimum of three populations should be documented on islands where they now occur or occurred historically. Each of these populations must be naturally reproducing and increasing in number, with a minimum of 50 mature individuals per population.

This recovery objective has been partially met.

For downlisting, a total of five to seven populations of *Solanum sandwicense* should be documented on islands where they now occur or occurred historically. Each of these populations must be naturally reproducing, stable or increasing in number, and secure from threats, with a minimum of 300 mature individuals per population. Each population should persist at this level for a minimum of five consecutive years before downlisting is considered.

This recovery objective has not been met.

For delisting, a total of eight to ten populations of *Solanum sandwicense* should be documented on islands where they now occur or occurred historically. Each of these populations must be naturally reproducing, stable or increasing in number, and secure from threats, with 300 mature individuals per population for short-lived perennials. Each population should persist at this level for a minimum of five consecutive years before delisting is considered.

This recovery objective has not been met.

2.3 Updated Information and Current Species Status

In addition to the status summary table below, information on the species' status and threats was included in the final critical habitat rule referenced above in section 1.3.3 ("Associated Rulemakings") and in section 2.4 ("Synthesis") below, which also includes any new information about the status and threats of the species.

Table 1. Status of *Solanum sandwicense* (Popolo 'aiakeakua) from listing through 5-year review.

Date	No. wild individuals	No. outplanted	Stabilization Criteria identified in Recovery Plan	Stabilization Criteria Completed?
1994 (listing)	20	0	All threats managed in all 3 populations	No
			Complete genetic storage	No
			3 populations with 50 mature individuals each	No
1995 (recovery plan)	20	0	All threats managed in all 3 populations	Partially
			Complete genetic storage	Partially
			3 populations with 50 mature individuals each	No
2003 (critical habitat)	14	Unknown	All threats managed in all 3 populations	Partially
			Complete genetic storage	Partially
			3 populations with 50 mature individuals each	No
2008 (5-year review)	18-20	446	All threats managed	Partially
			Complete genetic storage	Partially
			3 populations with 50 mature individuals each	No

2.3.1 Biology and Habitat [see note in section 2.3]

2.3.1.1 New information on the species' biology and life history:

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:

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

2.3.1.4 Taxonomic classification or changes in nomenclature:

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.):

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

2.3.1.7 Other:

2.3.2 Five-Factor Analysis (threats, conservation measures, and regulatory mechanisms) [see note in section 2.3]

2.3.2.1 Present or threatened destruction, modification or curtailment of its habitat or range:

2.3.2.2 Overutilization for commercial, recreational, scientific, or educational purposes:
No new information.

2.3.2.3 Disease or predation:

2.3.2.4 Inadequacy of existing regulatory mechanisms:
No new information.

2.3.2.5 Other natural or manmade factors affecting its continued existence:

2.4 Synthesis

Historically, *Solanum sandwicense* was known from both Kauai and Oahu. On Kauai, it was historically reported from locations in the Kokee region bounded by Kalalau Valley, Milolii Ridge, and Kawaikoi, and extending to the Hanapepe River. On Oahu, *S. sandwicense* occurred in both the Waianae and Koolau Ranges (USFWS 1994). Bernice P. Bishop Museum herbarium vouchers show that the species was collected in the late 1800s in Manoa and Nuuanu Valleys, but not since. The species

was also last collected in the northern Koolau Mountains along the Castle Trail in Punaluu in 1911 (C. Imada, Research Specialist, Bernice P. Bishop Museum, pers. comm. 2008). In the Waianae Mountains, the species ranged from Makaha in the north to Palikea in the south. When *S. sandwicense* was federally listed as endangered, only four of 12 known populations were still extant on both islands (one on Oahu and three on Kauai), totaling about 20 individuals (USFWS 1994). The last wild individual on Oahu died in North Palawai Gulch (Honouliuli Preserve) in the 1990s. Seeds from the last remaining Oahu individual were collected prior to its death (Wood *et al*. 2002) and were subsequently used for reintroducing several populations within its historical range on Oahu (The Nature Conservancy (TNC) 2006; Plant Extinction Prevention Program 2008).

Currently, there are five wild populations on Kauai consisting of 18 to 20 individuals (Wood *et al*. 2002; Perlman 2006; USFWS 2008) on private and State lands (Kokee State Park, Kuia Natural Area Reserve, and Na Pali-Kona Forest Reserve) at Kahuamaa Flats, Honopu, Awaawapuhi, Nualolo, Kumuwela Ridge, Kawaiiki, Waialae Valley, and Mokuone Stream.

TNC (2006), in its 2006 final report to the State Landowner Incentive Program on rare plant reintroduction and management in the Honouliuli Preserve, reported 424 reintroduced individuals of *S. sandwicense* at four reintroduction sites in the preserve (all fenced sites in Kaluaa, Hapapa, Ekahanui, Palikea, and Pualii), along with 196 plants in controlled propagation. At that time, no recruitment was observed, probably due to introduced slug predation on seedlings, but the plants were not yet fully mature and not yet producing large quantities of viable seed. An experimental seed-sowing trial in the preserve resulted in four successful seedlings in 40 plots, suggesting that recruitment from seed was still a viable possibility in the wild.

Outplantings along ridgelines and in gulch bottoms in Honouliuli have not survived long, sometimes dying after a year or so, and habitat preference seems to favor middle and lower slopes in moderate to full sunlight with an open understory and deep, granular soil (TNC 2006). TNC (2006) also reported that the species is easily propagated from seeds, and that the seeds are fairly long-lived in storage as seeds collected in the 1990s from last remaining Oahu population germinated in 2005.

Herbarium vouchers at Bernice P. Bishop Museum (C. Imada, pers. comm. 2008), the herbarium database at the National Tropical Botanical Garden (2008a), and data from Hawaii Biodiversity and Mapping Program (2007) reveal that the species was observed in flower on Kauai from February to March and from May to September; fruiting was observed in all months except for April and November. On Oahu, flowering was observed from March to August, and from October to November; fruiting was observed in every month except January. TNC (2006) reports that plants appear quite capable of self-fertilization, and that plants are relatively short-lived, with outplants and nursery stock surviving for only three years in less-than-ideal habitat. However, the last wild plant on Oahu was at least six years old, and wild plants probably live for four to eight years. Outplantings start producing large

amounts of fruit in about two years, but under nursery conditions with heavy fertilization can mature and produce fruit in five months.

TNC (2006) notes that *Solanum sandwicense* plants from Kauai have markedly larger and wider leaves than Oahu plants, perhaps meriting varietal separation.

The major threats to *Solanum sandwicense* on Kauai are habitat degradation by feral pigs (*Sus scrofa*), goats (*Capra hircus*), mule deer (*Odocoileus hemionus*) (Factor A, and D), predation from rats (*Rattus* spp.) (Factor C); and competition with introduced invasive plant species such as *Hedychium gardnerianum* (kalihi ginger), *Lonicera japonica* (Japanese honeysuckle), *Passiflora tarminiana* (banana poka), *Psidium cattleianum* (strawberry guava), *Kalanchoe pinnata* (air plant), *Erigeron karvinskianus* (daisy fleabane), *Grevillea robusta* (silk oak), *Myrica faya* (fire tree), *Mariscus meyenianus* (Meyen's flatsedge), *Lantana camara* (lantana), *Setaria parviflora* (perennial foxtail), and *Rubus argutus* (Florida prickly blackberry) (Factor E); fire (Factor E); human disturbance and development (Factor E) (USFWS 1994, 1995, 2003a, 2008; Wood *et al*. 2002). The major threats to *S. sandwicense* on Oahu are habitat degradation by feral pigs (Factor A and D); predation on seedlings by various species of introduced invasive slugs (Factor C); competition with the introduced invasive plant species *Passiflora suberosa* (corky passionflower), *Clidemia hirta* (Koster's curse), *Toona ciliata* (Australian red cedar), *Lantana camara*, *Psidium* spp. (guavas), and *Schinus terebinthifolius* (Christmasberry) (Factor E); and fire (Factor E) (USFWS 1994, 1995, 2003b, 2007, 2008; The Nature Conservancy 2006).

On both islands, the species continues to be vulnerable to extinction caused by randomly occurring natural events (*e.g*., landslides or hurricanes) (Factor E) or reduced reproductive vigor due to small population size and a limited number of populations (Factor E), and overcollection for scientific purposes (Factor B) (USFWS 1994, 1995, 2003a,b, 2007; Wood *et al*. 2002).

USFWS (2007), in a reinitiation of a biological opinion on Makua Military Reservation on Oahu, found that critical habitat for *Solanum sandwicense* in the northeast portion of Makua (105 hectares (258 acres)) would not be adversely affected by ongoing military activity. The habitat is rated in the "low" and "very low" fire risk zones of the military action area. In addition, 98 per cent of the critical habitat in the action area was in the Army's Pahole, Kapuna subunit, or Upper Kapuna management units. Immediately adjacent on the western side nearest the action area is the Kahanahaiki management unit, which may serve as a buffer due to its fuel reduction management practices.

The Honouliuli Preserve on Oahu is currently leased for management by The Nature Conservancy through the James Campbell Company LLC (Campbell Estate), which is in the process of selling off much of its agricultural landholdings in the Honouliuli area. The Nature Conservancy, along with the State Department of Land and Natural Resources, The Trust for Public Land, and the Department of the Army are working

to raise funds for acquisition of the preserve so that it can be permanently protected (Department of Land and Natural Resources 2008).

The National Tropical Botanical Garden (2007, 2008b) reported 101,399 seeds and 19 plants in the greenhouse for genetic storage and controlled propagation purposes, as well as four cuttings, all from a single individual from the population in Kokee. In addition, 12 individuals were outplanted in their living collections (at Limahuli and Lawai) and *inter-situ* (sites not within historical range but within reasonably suitable habitat, used to increase seed sources). The Center for Conservation Research and Training Seed Storage Laboratory (2008) reported 2,288 seeds in storage and 2,481 sown for test purposes, all from propagated sources. Two plants representing one individual from the Oahu population were cultivated for genetic storage and research purposes at the Waimea Arboretum until 2007, but unfortunately they did not survive (Waimea Botanic Garden 2007, 2008). The Pahole Rare Plant Mid-Elevation Facility received five large potted plants of *S. sandwicense* from TNC when the latter's Kunia nursery was closed down (Plant Extinction Prevention Program 2008). The Hawaii Division of Forestry and Wildlife, Kauai Office (2007, 2008) reported 38 plants from the Kalalau exclosure source material in controlled propagation. In 2007 the Hawaii Division of Forestry and Wildlife reintroduced 11 plants into the Nualolo exclosure and in 2008 they reintroduced five individuals in Wailua and six in Kalalau exclosures.

The stabilization goals for *Solanum sandwicense* have not been met as there are fewer than 20 wild individuals and 22 reintroduced on Kauai. Approximately 400 have been reintroduced on Oahu, but natural recruitment has not yet been observed in this population, and not all threats are being managed (see Table 1). Therefore, *S. sandwicense* meets the definition of endangered as it remains in danger of extinction throughout its range.

3.0 RESULTS

3.3 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: N/A

Brief Rationale:

3.3 Listing and Reclassification Priority Number: N/A

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

- Continue collection of fruit and plant material from wild individuals on Kauai and reintroduced individuals on Oahu for future reintroductions.

- Construct exclosure fences to protect individuals from the negative impacts of feral ungulates on Kauai, and eradicate invasive introduced plant species within the exclosures on Kauai and Oahu.

- Establish reintroduced populations within protected habitats.

- Augment current natural populations.

- Initiate planning and contribute to implementation of ecosystem-level management and restoration to benefit this species.

- Survey geographical and historical range for a thorough current assessment of the species.

- Assess genetic variability within extant populations.

- Study *Solanum sandwicense* populations with regard to population size and structure, geographical distribution, flowering cycles, pollination vectors, seed dispersal agents, specific environmental requirements, limiting factors, and threats.

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U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW of *Solanum sandwicense* (Popolo `aiakeakua)

Current Classification: E

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:
Christian Torres-Santana, Student Trainee Biologist
Marie Bruegmann, Plant Recovery Coordinator
Marilet A. Zablan, Recovery Program Leader and acting Assistant Field Supervisor for Endangered Species
Gina Shultz, Deputy Field Supervisor

Approved _____ Date 21 July 2009
Acting Field Supervisor, Pacific Islands Fish and Wildlife Office