5-YEAR REVIEW

Short Form Summary

Species Reviewed: *Argyroxiphium sandwicense* subsp. *sandwicense*
(ʻāhinahina, Mauna Kea silversword)
Current Classification: Endangered

Federal Register Notice 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.

Lead Region/Field Office:

Interior Region 12/Pacific Islands Fish and Wildlife Office (PIFWO), Honolulu, Hawaiʻi

Name of Reviewer:

Cheryl Phillipson, Biologist, PIFWO
Lauren Weisenberger, Plant Recovery Coordinator, PIFWO
Megan Laut, Conservation & Restoration Team Manager, PIFWO

Methodology used to complete this 5-year review:

This review was conducted by staff of the Pacific Islands Fish and Wildlife Office (PIFWO) of the U.S. Fish and Wildlife Service (Service) beginning in October 2019. The review was based on a review of current, available information since the last 5-year review for *Argyroxiphium sandwicense* subsp. *sandwicense* (USFWS 2012). The evaluation by Cheryl Phillipson, Biologist, was reviewed by Lauren Weisenberger, Plant Recovery Coordinator, and Megan Laut, Conservation and Restoration Team Manager.

Background:

For information regarding the species' listing history and other facts, please refer to the Fish and Wildlife Service's Environmental Conservation On-line System (ECOS) database for threatened and endangered species (*http://ecos.fws.gov/tess_public*).

Review Analysis:

Please refer to the previous 5-year review for *Argyroxiphium sandwicense* subsp. *sandwicense* published in the Federal Register on August 28, 2012 (available at *https://ecos.fws.gov/docs/five_year_review/doc4091.pdf*) for a complete review of the species' status, threats, management efforts, and references cited. We are not aware of any significant new information regarding the species' biological status since listing to warrant a change in the Federal listing status of *A. sandwicense* subsp. *sandwicense*.

This short-lived monocarpic (or rarely, branched and polycarpic), obligate outcrosser, rosette herbaceous shrub in the Asteraceae (sunflower) family is endangered and known from the island of Hawaiʻi.

New Status Information:

- In 2019, there are two wild populations at Mauna Kea in Pōhakuloa Gulch and Waipāhoehoe Gulch, totaling 15 to 16 individuals. Recruitment was observed in 2017 at Pōhakuloa Gulch under one wild individual (PEPP 2019).
- In 2019, the Service published an amendment to the 1993 Recovery Plan for the Mauna Kea silversword, *Argyroxiphium sandwicense* subsp. *sandwicense* (USFWS 2019). In 1993, to be considered for downlisting, the criteria for *A. sandwicense* subsp. *sandwicense* included at least three large sites on Mauna Kea, an expanding population structure with evidence of consistent and high regeneration, genetic diversity, and all populations protected from threats. To be considered for delisting, the criteria for *A. sandwicense* subsp. *sandwicense* included reestablishment in areas of historic abundance or other areas of maximal potential, and active genetic management to assure its long-term survival. The 2019 amendment criteria are aligned with standards provided based on the subspecies' life history and reproductive biology as described in the Hawai‘i and Pacific Plants Recovery Coordinating Committee's revised recovery objective guidelines (HPPRCC 2011; see Table 1). The downlisting objective of "at least three large sites on Mauna Kea" is replaced by the criterion of 5 to 10 populations of 2,000 individuals each. While the original downlisting objective specifies that the population needs to "have an expanding population structure", the amended criterion is that the populations need to be at least stable, and the time period for that stability is quantified for a minimum of 10 years. The original downlisting objective of having "genetically diverse" populations has been amended to quantify "genetically diverse" by following Guerrant *et al*. (2004). The original downlisting objective lastly specifies that "all known extant populations protected, and have no immediate threats." The amended criterion is revised to state that all major threats are controlled.

Table 1. Downlisting and delisting recovery criteria.

Downlisting Recovery Criteria
There are 5 to 10 populations in suitable, protected habitat with 2,000 mature individuals per population
All major threats are controlled around the target populations
Populations are represented in an *ex situ* collection as defined in the Center for Plant Conservation guidelines (Guerrant *et al*. 2004) that is secure and well managed
All target populations have been stable, secure, and naturally reproducing for a minimum of 10 years. Species-specific management actions may continue to be necessary
Delisting Recovery Criteria
All of the downlisting criteria have been met
All target populations have been stable, secure, naturally reproducing, and within secure and viable habitats for a minimum of 20 years
Subspecies-specific management actions must no longer be necessary, but an ongoing need for ecosystem-wide management actions may remain if long-term agreements are in place to continue management

- Recent studies of the closely related subspecies on Maui, *Argyroxiphium sandwicense* subsp. *macrocephalum*, by Krushelnycky *et al*. (2012, 2014, and 2020) provide information that could be applied to future management considerations for *A. sandwicense* subsp. *sandwicense*. The first study (Krushelnycky *et al*. 2012) showed a substantial climate-associated decline in numbers of individuals. Annual population growth rates indicated an increasing frequency of lethal water stress, in association with trending warmer temperatures and lower precipitation. This subspecies had previously appeared relatively secure, numbering in the tens of thousands, aided by federal protection (propagation, outplanting, and fencing), however, this long-term demography study showed that this view of population stability is no longer justified. Another study published by Krushelnycky (2014), determined that the reduction of pollinators (caused primarily by the invasion of the nonnative Argentine ant) impacts pollination and reproduction rates of *A. sandwicense* subsp. *macrocephalum*. The effectiveness of insect pollination is strongly influenced by the distance that pollen must be transferred between flowering individuals. If numbers of *A. sandwicense* subsp. *macrocephalum* continue to decline, this will result in fewer synchronously flowering plants, which will result in further population fragmentation (fewer successful pollinations leading to less seed production and fewer germinating plants). Results of the study indicated that management actions that minimize population fragmentation would benefit reproduction, and that cross-pollination distances should be considered in outplanting efforts. The most recent study (Krushelnycky *et al.* 2020) on *A. sandwicense* subsp. *macrocephalum* was designed to test the influences of plant plasticity (response to contrasting soil water availability and atmospheric conditions) and heredity (different seed source elevations) on the development of

functional traits associated with drought resistance and on performance in drought conditions. Research results indicate that only water use efficiency exhibited a plastic treatment response. Survival is positively associated with site elevation matching the current pattern of mortality in the wild populations. Plants that receive high levels of water died more often than those that receive low levels of water. These results also imply that lower elevation plants are less drought resistant than higher elevation plants. The findings suggest that future management should focus on climatically suitable habitat and that clinal variation is important to consider when modeling future vegetation responses to climate change.

New Threats:

- Climate change loss or degradation of habitat—Climate change may pose a threat to this species. Fortini *et al.* (2013) conducted a landscape-based assessment of climate change vulnerability for native plants of Hawai‘i using high resolution climate change projections. Climate change vulnerability is defined as the relative inability of a species to display the possible responses necessary for persistence under climate change. The assessment by Fortini *et al.* (2013) was conducted at the species level, and concluded that *Argyroxiphium sandwicense* is highly vulnerable to the impacts of climate change, with a vulnerability score of 0.536 (on a scale of 0 being not vulnerable to 1 being extremely vulnerable to climate change). However, the two subspecies, *macrocephalum* and *sandwicense*, are endemic to separate islands (Maui and Hawai‘i, respectively) Therefore, additional management actions are needed to conserve *A. sandwicense* subsp. *sandwicense* into the future, such as locating key microsites that overlap with current and future climate envelopes for outplanting efforts.

New Management Actions:

- Surveys and inventories—The Plant Extinction Prevention Program (PEPP) monitors wild and reintroduced populations of *A. sandwicense* subsp. *sandwicense* (PEPP 2010, 2011, 2012, 2015).
- Ungulate monitoring and control—A 2.4-hectare (ha) (6-acre (ac)) fence was constructed to protect the core *A. sandwicense* subsp. *sandwicense* reintroduced population at Waipāhoehoe on Mauna Kea in September and October 2015. The fence was constructed with assistance from Mauna Kea Forest Restoration Project, Mauna Kea Watershed Alliance, and Hawai‘i State Natural Area Reserve System staff. This fence protects the core area of the reintroduced population that represents the greatest genetic diversity of the entire species and is the site of the best natural recruitment seen thus far. This population was threatened in September 2015 by ingress of mouflon and feral pigs into the existing 20-ha (50-ac) exclosure. The old exclosure included a 1.2 meter (m) (4-foot (ft) hogwire fence and new unit, which is a smaller 2.4 ha (6-ac) fence within the larger unit, includes 1.8 m (6-ft) hogwire (PEPP 2016). Since construction of that unit in late 2015, the larger unit has experienced substantial ingress by feral pigs and widespread damage to the reintroduced population. The 20-ha (50-ac) fence is not adequately skirted and pigs continue to find areas of weakness (PEPP 2018). In

response to this continuing problem and to insure that pigs do not get into the smaller "core" unit, PEPP organized an effort to skirt the entire core unit, recruiting help from the State's Natural Areas Reserve program, the Mauna Kea Forest Reserve program, Hawai'i Volcanoes National Park-Resource Management, and the Hawai'i Silversword Foundation. Skirting on the south side of the fencing unit was completed (PEPP 2018).

- Captive propagation for genetic storage and reintroduction—
    - The Volcano Rare Plant Facility (VRPF) reports collection and storage of 24,000 seeds from the Pōhakuloa Gulch population, and 52,000 seeds from the Waipāhoehoe population (VRPF 2019).
    - Hawai'i Island PEPP staff continued to collaborate with conservation partner Rob Robichaux of the Hawai'i Silversword Alliance and facilitated pollen exchange between the known founders of *A. sandwicense* subsp. *sandwicense* at Waipāhoehoe with the flowering founders at Pōhakuloa Gulch on Mauna Kea (PEPP 2015). This effort has been conducted over the last several years. The plants were marked and are monitored for seed set. In 2016, collections were made from six cross-pollinated founders from two separate populations (PEPP 2016).
- Reintroduction and translocation—PEPP reports reintroduction and survival of 35 immature plants of *A. sandwicense* subsp. *sandwicense* at Mauna Kea (Ice Age site) in 2014 and more than 12,000 reintroduced individuals at a second population at Mauna Kea, and nine mature individuals at Waipāhoehoe Gulch with a second reintroduced population there of 1,000 individuals in 2017. In 2018, PEPP reintroduced an additional 425 plants at the Mauna Kea reintroduction site from a mix of founders (PEPP 2017, 2019).

Table 2. Status and trends of *Argyroxiphium sandwicense* subsp. *sandwicense* from listing through current 5-year review.

Date	No. wild individuals	No. outplanted	Downlisting Criteria identified in Recovery Plan	Downlisting Criteria Completed?
1986 (listing)	15	83 mature 107 immature 132 seedlings	Three large populations	No
			Populations consisting of genetically diverse individuals reproducing and expanding	No
			All populations protected with no immediate threats	Partially, exclosures constructed but not secure

1993 (recovery plan)	38	9 mature 51 immature 7 seedlings	Three large populations	No
			Populations consisting of genetically diverse individuals reproducing and expanding	No
			All populations protected with no immediate threats	Partially, exclosures not secure
2013 (5-year review)	27	ca 10,000 survival uncertain	Three large populations	Partially, one population
			Populations consisting of genetically diverse individuals reproducing and expanding	Partially, no reproduction
			All populations protected with no immediate threats	Partially, exclosures not secure
Date	**No. wild individuals**	**No. outplanted**	***Preventing Extinction Criteria identified by HPPRCC**	***Preventing Extinction Criteria Completed?**
2020 (5-year review)	16	13,460	All threats managed in all 5 populations	Partially, one population fenced
			Complete genetic storage	Complete for 3 populations
			Reproduction (i.e. viable seeds, seedlings) at all 5 populations	Partial; seedlings observed at 1 site
			5 populations with 2,000 mature individuals each	No; 2 small remnant populations + outplants

* The new Preventing Extinction Criteria Stage was established in 2011 and the Recovery Criteria for *Argyroxiphium sandwicense* subsp. *sandwicense* was amended in 2019.

Table 3. Threats to *Argyroxiphium sandwicense* subsp. *sandwicense* and ongoing conservation efforts.

Threat	Listing factor	Current Status	Conservation/ Management Efforts
Climate change degradation or loss of habitat including drought	A	Ongoing	Partial, monitoring for drought stress
Ungulate predation or herbivory	C	Ongoing	Partial, all populations fenced
Rodent predation or herbivory	C	Ongoing	None
Invertebrate predation or herbivory	C	Ongoing	None
Lack of adequate hunting regulations	E	Ongoing	Partial, populations fenced
Competition by nonnative invasive plant species	E	Ongoing	None
Lack of pollinators	E	Ongoing	Partial, research ongoing
Hybridization	E	Ongoing	None
Reduced viability due to low numbers, high seedling mortality, and need for outcrossing	E	Ongoing	Partial, research ongoing

Synthesis:
Currently there are 15 to 16 wild individuals of *Argyroxiphium sandwicense* subsp. *sandwicense* on Mauna Kea on the island of Hawai‘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 *A. sandwicense* is highly vulnerable to the effects of climate change. All populations of *A. sandwicense* subsp. *sandwicense* are provided protection from feral ungulates by fencing; however, ungulate pressure on fencing is high. Hand pollination, seed collection, propagation, and reintroduction are ongoing for this subspecies.

Stabilizing (interim), downlisting, and delisting objectives were provided in the Recovery Plan, Mauna Kea Silversword, *Argyroxiphium sandwicense* subsp. *sandwicense* (USFWS 1993), and have been updated according to the draft revised recovery objective guidelines developed by the HPPRCC (2011; USFWS 2019). 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. In addition, consideration was given to the specific biological needs of *Argyroxiphium sandwicense* subsp. *sandwicense*. While it is a long-lived species, it is monocarpic (*i.e.,* flowering only once before dying) and an obligate outcrosser (USFWS 1993). Therefore, for these purposes, it will be treated effectively as an annual that grows, flowers once, and dies, although over a longer period of time than an annual. The subspecies does not behave biologically as a long-lived perennial, which could grow and flower annually and repeatedly for over 10 years prior to dying. *Argyroxiphium sandwicense* subsp. *sandwicense* is also self-incompatible and is treated as an obligate outcrosser, incapable of self-pollinating to produce viable seeds (Carr *et. al*. 1986).

To attain preventing extinction goals, 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 five populations should be documented on the island of Hawai‘i where they now occur or occurred historically and each of these populations must be naturally reproducing (i.e., viable seeds, seedlings), with a minimum of 2,000 mature, reproducing individuals per population.

The preventing extinction goals for this species have not been met. Although genetic storage is complete for three populations (Table 2), there are no populations totaling at least 2,000 reproducing individuals, and all threats are not being managed (Table 2, Table 3). While the number of outplants are high, there has been no documented natural regneration at these augmentations. Therefore, *Argyroxiphium sandwicense* subsp. *sandwicense* meets the definition of Endangered as it remains in danger of extinction throughout its range.

Recommendations for Future Actions:
We are not aware of any new threats or other significant new information regarding the species' biological status since the last 5-year review in 2013. Thus, the following recommendations for future actions are reiterated for the 5-year review for 2020.

- Surveys and inventories—
    - Continue to survey historical range for a thorough assessment of the subspecies' status.
    - Continue to monitor reintroduced populations for signs of significant population decreases and other signs of distress.
- Ungulate monitoring and control—Continue to monitor and modify exclosures to prevent ungulate ingress. Control ungulates if present in fenced areas.
- Invasive plant monitoring and control—Control established ecosystem-altering nonnative invasive plant species at all populations, especially within exclosures.

- Climate change adaptation strategy—Assess the modeled effects of climate change on this subspecies and use to determine future landscape needed for its recovery.
- Collection—Develop and implement effective measures to reduce the impact of collection.
- Predator and herbivore monitoring and control—
    - Implement effective control methods for rodents.
    - Continue to research the effects of nonnative invertebrates on *A. sandwicense* subsp. *sandwicense*. Determine and implement effective control methods is needed.
- Captive propagation for genetic storage and reintroduction—
    - Continue collection and propagation efforts for maintenance of genetic stock and for reintroduction.
    - Continue hand-pollination efforts to establish representation of genetic diversity.
- Reintroduction and translocation—Continue to reintroduce individuals into suitable habitat within historic range that is being managed for known threats to these species to build resiliency and redundancy to reduce impacts of loss of viability.
- Population biology research—
    - Continue to investigate techniques to improve seed and seedling viability to improve natural recruitment.
    - Continue to research which sites are most suitable for reintroduction efforts with climate change effects taken into consideration.
- Alliance and partnership development—Continue to work with partners in planning and implementation of ecosystem-level restoration and management to benefit these species.

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U.S. FISH AND WILDLIFE SERVICE
SIGNATURE PAGE for 5-YEAR REVIEW of *Argyroxiphium sandwicense* subsp. *sandwicense* (ʻāhinahina, Mauna Kea silversword)

Pre-1996 DPS listing still considered a listable entity? N/A

Recommendation resulting from the 5-year review:

_____	Delisting
_____	Reclassify from Endangered to Threatened status
_____	Reclassify from Threatened to Endangered status
X	No Change in listing status

For **Field Supervisor, Pacific Islands Fish and Wildlife Office**

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