

5-YEAR REVIEW

Short Form Summary

Species Reviewed: *Plantago princeps* (laukahi kuahiwi)

Current Classification: Endangered

Federal Register Notice announcing initiation of this review:

[USFWS] U.S. Fish and Wildlife Service. 2010. Endangered and threatened wildlife and plants; initiation of 5-year status reviews of 58 species in Washington, Oregon, California, and Hawaii. Federal Register 75(226):71726-71729.

Lead Region/Field Office:

Region 1/Pacific Islands Fish and Wildlife Office (PIFWO), Honolulu, Hawaii

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Methodology used to complete this 5-year review:

This review was conducted by staff of the Pacific Islands Fish and Wildlife Office of the U.S. Fish and Wildlife Service (USFWS), beginning on January 31, 2012. The review was based on a review of current, available information since the last 5-year review for *Plantago princeps* (USFWS 2010). The National Tropical Botanical Garden provided an initial draft of portions of the five-year review and recommendations for conservation actions needed prior to the next five-year review. The document was reviewed by the Fish and Wildlife Biologist, Island Team Manager, and Plant Recovery Coordinator, followed by the Recovery Program Lead. It was subsequently reviewed and approved by the Programmatic Deputy Field Supervisor.

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).

Application of the 1996 Distinct Population Segment (DPS) Policy:

This Policy does not apply to plants.

Review Analysis:

Please refer to the previous 5-year review for *Plantago princeps* published on August 27, 2010 (available at http://ecos.fws.gov/docs/five_year_review/doc3308.pdf) for a complete review of the species' status, threats, and management efforts. No significant

new information regarding the species' biological status has come to light since listing to warrant a change in the Federal listing status of *P. princeps*.

This short-lived shrub is endangered and occurs on the islands of Oahu, Kauai, Maui, and possibly still on Molokai. The current status and trends for *Plantago princeps* are provided in the tables below.

New taxonomic information:

- Although the genetic work of Dunbar-Co and others (discussed at length in the last five-year review) suggested revisions of the Hawaiian *Plantago* species, Wagner *et al.* (2012) and Imada (2012), the foremost authorities on the Hawaiian flora, have not yet accepted this new treatment.
- Since Dunbar-Co's treatment of the genus, which suggests a monophyletic origin (common ancestor being a single introduction) from either North America or Rapa (Dunbar-Co *et al.* 2008), a more extensive, worldwide sampling of *Plantago* indicates a temperate North American origin for Hawaiian *Plantago*, with *P. tweedyi* resolved as the closest relative (sister-species) of the Hawaiian clade (Baldwin and Wagner 2010).

New status information:

- *Plantago princeps* var. *anomala* grows on Kauai on Kalalau Valley cliffs where five individuals were also observed in June 2010 (Perlman 2012), and four in 2011 (Kishida 2012). On Mount Kahili, at the top of the Kahili Ridge Trail, five individuals were seen on cliffs in 2011 (Perlman 2012) and six in 2012 (N. Tangalin, National Tropical Botanical Garden [NTBG], pers. comm. 2012).
- *Plantago princeps* var. *longibracteata* exists at several sites on Kauai, with several thousand plants around the Waialeale summit bogs (Ken Wood, NTBG, pers. comm. 2012a, b). About 30 *Plantago princeps* var. *longibracteata* individuals still occur in the back of Wainiha Valley (K. Wood, pers. comm. 2012b). In Hanakoa in 2008, 100 individuals were observed along the riparian edge of the waterfall (Wood 2012b). No new observations were reported since the last five-year review from Waioli, above Hanalei in upper Pohakupele, Namolokama, Iliiula, Hanakapiai, Hanapepe, or Blue Hole.
- Three populations of *Plantago princeps* var. *laxifolia* in Iao Valley, on Maui, were visited since the last 5-year review. In a gulch north of the Iao Needle, 17 individuals were counted, and in the back of Nakalaloa Gulch three individuals were seen at 930 meters (3,050 feet) elevation (Perlman 2012). In Kauaula Valley, nine individuals were seen on the back wall of the upper north fork in 2009 (Wood 2012a). Numbers of surviving reintroduced and wild individuals in Haleakala National Park were not available.
- *Plantago princeps* var. *princeps* occurs on Oahu, scattered throughout the Waianae Mountains and in the Koolau Mountains on the Manoa Cliffs Trail and in the Kalihi and Nuuanu Valleys (Wagner *et al.* 2005). On Army lands at North Mohiakea, Ohikilolo and Pahole there are 22 mature and 17 immature individuals and two seedlings. Outside Army lands seven population units contain 188 mature and 181 immature individuals and 50 seedlings. Only one population,

Konahuanui, contains over 50 mature individuals (Oahu Army Natural Resource Program [OANRP] 2012c). The population in Nuuanu was down to three individuals in 2012, and in April those were rescued by the Plant Extinction Prevention Program (PEPP) and translocated to the Harold L. Lyon Arboretum greenhouse (S. Ching. PEPP, pers. comm. 2012). Subtracting the Nuuanu individuals counted by the Army in 2007, the totals for *Plantago princeps* var. *princeps* are 206 mature and 193 immature individuals and 52 seedlings.

Overall, it is estimated that approximately 3,000 individuals are currently known. Given that accurate counts were not available in the last five-year review, it is not clear if the species is increasing or decreasing.

New threats:

- Climate change – Climate change may pose a threat to this species. However, current climate change analyses in the Pacific Islands lack sufficient spatial resolution to make predictions on impacts to this species. The Pacific Islands Climate Change Cooperative (PICCC) funded climate modeling that will help resolve these spatial limitations. High spatial resolution climate outputs are expected in 2013.

New management actions:

- Ungulate exclosures –In 2010, the Ohikilolo population was considered ungulate free; Ekahanui and North Mokiakea populations were partially ungulate free because they were fenced and some ungulates had been removed. In 2011, Ekahanui was fenced and ungulate free. The Halona population is not protected (U.S. Army Garrison 2010, 2011).
- Invertebrate control – Slug (*Deroceras leave*, *Limax maximus*, *Meghimatium striatum* herbivory and seedling recruitment are monitored and slug exclosures are maintained in the Pahole area (U.S. Army Garrison 2010, 2011).
- Predator / herbivore control - Rats have been known to eat *Plantago princeps* at Ekahanui and Palawai. Rat baiting and trapping is being conducted as of 2013 in the vicinity of nine species of endangered plants managed by OANRP. Eight sites have year-round rat control for the protection of five rare plant species, including *P. princeps* var. *princeps*. These sites were chosen for year- round rat control based on the degree of plant endangerment and/or degree of forest community continuity. Exclosure maintenance is ongoing (Mosher *et al.* 2010; U.S. Army Garrison 2010, 2011).
- Threats research
 - Extensive research on rat control has been conducted by the OANRP (Mosher *et al.* 2010).
 - Diphacinone is the only rodenticide registered in Hawaii for conservation purposes in natural areas (U.S. Army Garrison 2010, 2011). Application methods being tested for diphacinone include bait stations, small-scale bait station grids with rat traps, aerial and hand application (U.S. Army Garrison 2010, 2011).

- Monitoring in the Puu Hapapa area indicated seasonality to nonnative snail predation activity, with peak numbers of snails recorded from March through June (U.S. Army Garrison 2011).
- Extensive research on slug and snail control has been conducted by OANRP (U.S. Army Garrison 2010, 2011).
 - Research by Joe (2006) indicated that invasive slugs negatively impacted the regeneration of *Plantago princeps*.
 - In 2009, slug control research using Sluggo, a slug and snail bait, began in the field at the Kahanahaiki management unit on U.S. Army lands (Joe 2011).
 - In October 2010, Sluggo was registered for use by the Hawaii Department of Agriculture (OANRP 2011) for control of slugs and non-native snails in forested areas for the protection of native, threatened, and endangered plants of Hawaii. However, since native snails also exist in areas where threatened and endangered plants occur, additional research is needed to find a control method that can be used in areas where native snail species co-occur with listed plants to prevent non-target effects of treatment.
- Captive propagation for genetic storage and reintroduction
 - Seed collections of *Plantago princeps* var. *anomala* were made in June 2009 from one individual on Kauai, and were sent to Harold L. Lyon Arboretum for seed storage. In October 2009, seed was collected from two individuals and sent to the NTBG for propagation. In June 2010, seed collected from two individuals was sent to Lyon Arboretum for seed storage (Kishida 2012).
 - OANRP collected seeds from ten individuals in the Ekahanui population, a single individual in the Pahole population, and five individuals from the Halona population, for genetic storage and future reintroductions (OANRP 2012a).
 - OANRP has made complete seed collections from 76 individuals in nine populations of *Plantago princeps* var. *princeps* (OANRP 2012a).
 - OANRP (2012b) has six individuals in their nursery.
 - Seed collections of *Plantago princeps* var. *anomala* were made in 2010, 2011, and 2012, on Kauai on cliffs of Mount Kahili and Kalalau Valley (Perlman 2012).
 - The NTBG (2012) nursery has nine individuals of *Plantago princeps* var. *anomala* in their nursery.
 - The Harold L. Lyon Arboretum (2012) has 257 seeds of *Plantago princeps* var. *anomala* and 1,708 seeds of *Plantago princeps* var. *laxifolia* in storage and 17 plants of *Plantago princeps* var. *princeps* originating from Pahole in micropropagation.
 - In 2010, the Haleakala National Park nursery facility had 348 plants and 400 seeds, and in 2011 they had 111 individuals in their nursery, and about 1000 seeds in storage (Haleakala National Park 2010, 2011 a, b).

- Reintroduction / translocation site identification
 - Waieli was identified by the OANRP as a site for reintroduction of *Plantago princeps* var. *princeps*, and at present, 13 mature individuals are growing there from reintroductions (OANRP 2012c).
 - *Plantago princeps* var. *laxiflora* is maintained in living collections at Haleakala National Park. Forty three sites have been planted with 494 individuals (Haleakala National Park 2010; Haleakala National Park 2011a, b).
- Genetic research
 - While focused primarily on the other two Hawaiian *Plantago* species, *P. pachyphylla*, and *P. hawaiiensis*, a study looking at eight microsatellite loci suggested that not only is the genus monotypic, but that interisland dispersal events are rare. Genetic differentiation within islands tended to be higher among populations occurring in contrasting bog and woodland habitats, suggesting ecological barriers to gene flow and the potential role of ecological divergence in population diversification (Dunbar-Co and Wieczorek 2011).
 - Morphological comparison of 46 traits of leaf design among seven morphotypes of *Plantago*, including one *P. princeps* var. *princeps* and one *P. princeps* var. *laxiflora*, indicated a strong correlation between leaf characteristics and ecological type, with bog taxa having smaller and thicker leaves, while taxa from drier sites had higher vein density, and taxa in woodland at higher elevations were typically taller with larger leaves (Dunbar-Co *et al.* 2009).
 - These studies suggest that low genetic diversity within taxa is not necessarily determinative of extinction risk. They emphasize that morphological and genetic differences should be taken into consideration in restoration or augmentation of existing populations to increase both genetic variation and population size. In addition, restoration efforts focusing on genetically structured populations of Hawaiian *Plantago* need to account for this differentiation in management activities because they could be severely hampered adaptively if morphologically similar, yet genetically distinct, individuals were outplanted together (Dunbar-Co and Wieczorek 2011).

Synthesis:

Stabilizing, downlisting, and delisting objectives are provided in the recovery plan for plants from the island of Oahu (USFWS 1998), based on whether the species is an annual, a short-lived perennial (fewer than 10 years), or a long-lived perennial. *Plantago princeps* is a short lived perennial, and to be considered stable, the taxon must be managed to control threats (*e.g.*, fenced) and be 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 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.

The stabilization goals for this species have not been met, since only two populations of 50 or more mature individuals exist (Table 1) and all threats are not being sufficiently managed throughout the populations (Table 2). Therefore, *Plantago princeps* meets the definition of endangered as it remains in danger of extinction throughout its range.

Recommendations for Future Actions:

- Captive propagation for genetic storage and reintroduction - Continue to collect seeds from all existing populations and send to at least two or three different facilities for propagation and storage.
- Reintroduction / translocation
 - While surveying for new populations or reintroduced populations, determine which sites are least invaded by invasive introduced plant species and which appear to have the highest likelihood of maintaining new reintroductions.
 - Continue to reintroduce the species back into its known historical range.
- Ungulate exclosures – Construct and monitor ungulate-proof exclosures around all populations.
- Ecosystem-altering invasive plant species control – Control invasive introduced plant species around all populations.
- Predator / herbivore control – Implement effective control methods for rodents and slugs/snails.
- Surveys / inventories – Survey geographical and historical range for a thorough current assessment of the species’ status, particularly on Kauai.
- Site / area / habitat protection – Develop and implement effective measures to reduce the impact of landslides, flooding and military activities.
- Fire protection – Develop and implement fire management plans for all wild and reintroduced populations.
- Alliance and partnership development - Initiate planning and contribute to implementation of ecosystem level restoration and management to benefit this taxon.
- Genetic research – Assess genetic variability within extant populations.
- Threats research – Assess the modeled effects of climate change on this species, and use to determine future landscape needed for the recovery of the species.
- Federal Register update – Update the listed entity on 50 CFR 17 to match the currently recognized taxonomy.

Table 1. Status of *Plantago princeps* from listing through current 5-year review.

Date	No. wild individuals	No. outplanted	Stabilization Criteria identified in Recovery Plan	Stabilization Criteria Completed?
1994 (listing)	300-1,200	0	All threats managed in all 3 populations	No
			Complete genetic storage	No
			3 populations with 50 mature individuals each	Unknown
1999 (recovery plan)	640-1,750	0	All threats managed in all 3 populations	Partially
			Complete genetic storage	Partially
			3 populations with 50 mature individuals each	Unknown
2003 (critical habitat)	795-973	0	All threats managed in all 3 populations	Partially
			Complete genetic storage	Partially
			3 populations with 50 mature individuals each	Unknown
2010 (5-yr review)	Several thousand		All threats managed in all 3 populations	Partially
			Complete genetic storage	Partially
			3 populations with 50 mature individuals each	No
2013 (5-yr review)	<i>v. anomala</i> : 5-10 <i>v. longibracteata</i> : several 1,000 <i>v. laxifolia</i> : 29 +? <i>v. princeps</i> : 206 mature, 193	1,1	All threats managed in all 3 populations	Partially (see Table 2)

Date	No. wild individuals	No. outplanted	Stabilization Criteria identified in Recovery Plan	Stabilization Criteria Completed?
	immature and 52 seedling = ~3,000 total			
			Complete genetic storage	Partially
			3 populations with 50 mature individuals each	Partially, 2 populations

Table 2. Threats to *Plantago princeps* and ongoing conservation efforts.

Threat	Listing factor	Current Status	Conservation/ Management Efforts
Ungulates – Goats and pigs degrade habitat and eat plants	A, C, D	Ongoing	Partially: Fencing on Oahu is Goats controlled at Makua
Landslides	A	Ongoing	Partially: Weed control at Keawapilau to West Makaleha PU and Kahanahaiki to Pahole PU
Rodent predation or herbivory – Rats	C	Ongoing	Partially: Rat control by Army on Oahu
Introduced slugs and snails - herbivory	C	Ongoing	Army has some baiting programs in place
Chinese rose beetle (<i>Adoretus sinicus</i>), and black twig borer (<i>Xylosandrus compactus</i>)	C	Ongoing on Oahu	Unknown
Military training related fire	A, E	Ongoing on Oahu	No
Established invasive plant species competition	A, E	Ongoing	Partially – on Oahu by Army Natural Resources staff, elsewhere unknown
Low numbers	E	Ongoing	Partially: Captive propagation and genetic storage, reintroduction / translocation implementation, and monitoring
Climate change	A, E	Increasing	No

References:

See previous 5-year review for a full list of references (USFWS 2010). Only references for new information are provided below.

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U.S. FISH AND WILDLIFE SERVICE

SIGNATURE PAGE for 5-YEAR REVIEW of *Plantago princeps* (laukahi kuahiwi)

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
- No Change in listing status

acting deputy

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Date *2013-08-12*