

5-YEAR REVIEW

Short Form Summary

Species Reviewed: *Haplostachys haplostachya* (honohono)

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, Hawai‘i

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 *Haplostachys haplostachya* (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 *Haplostachys haplostachya* published in the Federal Register on August 28, 2012 (available at https://ecos.fws.gov/docs/five_year_review/doc4081.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 *H. haplostachya*.

This short-lived perennial woody herb in the Lamiaceae (mint) family is endangered and found on the island of Hawai‘i. Occurrences on Maui and Kaua‘i are extirpated. The current status and trends for *Haplostachys haplostachya* are provided in the tables below.

New Status Information:

- At the time of the 5-year review in 2012 there was estimated to be more than 10,000 wild individuals of *Haplostachys haplostachya* on the island of Hawai‘i. Currently, there are 14 populations totaling a little more than an estimated 24,000 individuals at Pōhakuloa Training Area (PTA) and Pu‘u Anahulu, distributed across more than 2,428 ha (6,000 ac) on the island of Hawai‘i (U.S. Army Garrison 2015, entire, U.S. Army Garrison 2020, p. 56).
- *Haplostachys haplostachya* have fragrant white flowers associated with insect pollination and produce dry fruits. While no pollinator vector has been identified, moths are suspected because of plant structure, and moths and other insects have been observed on and around flowers. The nonnative insect floral visitors most observed include the keyhole wasp (*Pachodynerus nasidens*), pea blue butterfly (*Lampides boeticus*), Western honey bee (*Apis mellifera*), hoverfly (family Syrphidae), and unidentified moths (*Lepidoptera* spp.) (Aslan et al. 2019, p. 320). The flowering period has been reported from February through July, but plants with flowers and fruit have also been observed in August and September (SNMNH 1980, SNMNH 1994, NTB G 2001, Native Plants 2020).
- Chloroplast genetic analyses among Hawaiian mints have revealed low levels of genetic variability among genera (Welch et al. 2016, p. 16). Genetic analyses performed by Morden and Loeffler (1999) revealed that there are subpopulations of *H. haplostachya* that are undergoing a loss in detectable genetic variation, and that increased genetic homozygosity could lead to genetic drift and inbreeding depression (Welch et al. 2016, p. 622). Small populations, specifically, the Pu‘u ka Pele and Pu‘u Leilani subpopulations, show evidence of genetic differentiation and loss of genetic heterozygosity (Welch et al. 2016, p. 623). Plants found within the Pu‘u Leilani subpopulation appear to have separated from the larger population which has become both physically and reproductively isolated over time. This population reflects evidence of highly disturbed habitat with poor flowering and no evidence of recruitment. Loss of genetic heterozygosity in small populations is linked to inbreeding depression, as well as higher disease susceptibility (Welch et al. 2016, p. 623).

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) concluded that *Haplostachys haplostachya* is vulnerable to the impacts of climate change, with a vulnerability score of 0.32 (on a scale of 0 being not vulnerable to 1 being extremely vulnerable to climate change). 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.

- Fire—On July 18, 2018, a wildland fire was ignited from military training activities and burned approximately 60 hectares (ha) (149 acres (ac)) (U.S. Army Garrison 2018, p. 4). Seven percent of the *Haplostachys haplostachya* occurrences (228 locations) were within the burn area (U.S. Army Garrison 2020, p. 9). Of the more than 3,000 individuals of *H. haplostachya* occurring here, only 444 individuals were observed after the fire. A post-fire survey a few years later indicated some recovery. This area is also protected by fencing and prevents browsing of the new growth by ungulates, aiding in their recovery (U.S. Army Garrison 2020, p. 10).
- Predation and herbivory by rats and mice—Another barrier to recruitment and growth of *H. haplostachya* not previously mentioned is the presence of seed predators, which have been well documented in PTA (USFWS 1993, pp.19–20). Small mammalian predators such as rats (*Rattus rattus*) and mice (*Mus domesticus*) eat and destroy seeds and seedlings of plants, preventing recruitment of native species (Daehler et al. 2005, p. 205). In addition, the presence of these predators has the potential to shift the vegetative composition of the habitat, allowing for the encroachment of nonnative species into *H. haplostachya* habitat.
- Lack of pollinators—A reduction in the number of native pollinators may also put *H. haplostachya* at risk. A study of insects visiting *H. haplostachya* throughout its flowering season at different times of the day revealed insects visiting the flowers are primarily nonnative, as mentioned above (Aslan et al. 2019, p. 319). Aslan et al. (2019, p. 322) noted that *H. haplostachya* exhibits pollen limitation which can reduce reproductive success, including reduced seed quantity and quality. Nonnative pollinators do not pollinate native plants in the mint family as efficiently, resulting in reduced seed quantities. This suggests that these native mints are strongly dependent upon native pollinators for survival and reproduction, and that they may face ecological extinction as a result of their absence (Aslan et al. 2019, p. 2).

New Management Actions:

- Ungulate monitoring and control—In 2012, the Hawai‘i Department of Land and Natural Resources (DLNR) proposed aerial shooting and public hunting as methods for removing ungulates from critical habitat for the native bird, palila (*Loxioides bailleui*), on the slopes of Mauna Kea (Stephens 2014, p. 57). While palila critical habitat does not directly overlap with known populations of *Haplostachys haplostachya*, removal of ungulates from the adjacent habitat is expected to have a positive benefit on all native plant populations in the area. Ungulate removal is ongoing, but large populations of feral sheep remain. Only one of the two populations at Pu‘u Anahulu are fenced (PEPP 2020).
- Disease—University of Hawaii researchers conducted a study testing the effects of inoculation of propagules with a mycorrhizal fungi and an endophytic mycoparasite and effects on disease severity in a related species in the Lamiaceae (mint) family, *Phyllostegia kaalaensis* (Koko et al. 2018, 4 pp.). They found that the endophyte alone performed well in protecting plants from powdery mildew, and that the best time to treat plants would be while they were grown in the greenhouse. Probiotic fungal cultures have been applied at reintroduction sites for

- other native *Phyllostegia* species with some success at protecting individuals from powdery mildew (Zahn and Amend 2017, p. 1).
- Captive propagation for genetic storage and reintroduction—
 - As of 2019, the U.S. Army Garrison at PTA collected and stored approximately 42,500 seeds representing 849 founders and another 40,000 seeds stored representing an additional 64 founders (U.S. Army Garrison 2019, p. 10, U.S. Army Garrison 2017, p. 63). Propagation by cuttings is relatively easy for this species, and many mints reproduce asexually by producing roots along the lateral stems (U.S. Army Garrison 2015, p. 17).
 - From 2013 to 2019, the Volcano Rare Plant Facility (VRPF) reported collection and storage of more than 4,500 seeds representing 17 founders from Puu ka Pele at PTA (VRPF 2013–2019). The overall total of seeds collected since 2002 is more than 29,000 (VRPF 2019).
 - In 2019, Hawai‘i Volcanoes National Park (HVNP) reported propagation of more than 5,500 individuals representing at least 15 founders (HVNP 2019).
 - Reintroduction—
 - In 2014, there were 70 individuals of *Haplostachys haplostachya* remaining in a reintroduced population with evidence of natural recruitment at Kīpuka ‘Alalā South (KAS) (U.S. Army Garrison 2015, pp. 22–23). A total of 81 individuals were reintroduced at three sites at Pu‘uwa‘awa‘a (Pu‘uhuluhulu, Pu‘uwa‘awa‘a, and Kīpuka ‘Owē‘owē) and follow-up surveys in 2014 determined that there were seven individuals remaining at Pu‘uhuluhulu, 58 individuals at Pu‘uwa‘awa‘a with signs of recruitment, and only a single individual remaining at Kīpuka ‘Owē‘owē (U.S. Army Garrison 2015, pp. 24–27). No individuals remain at a reintroduction site at Nohona O Hae when surveyed in 2014 (U.S. Army Garrison 2015, p. 10). After multiple populations were established from 2008 to 2012 in the West Hawaii Veteran’s Cemetery, a survey in 2014 revealed no surviving individuals present (U.S. Army Garrison 2015, p. 28). However, because reports exist demonstrating the reemergence of individuals after periods of drought, fire, and presumed death, this site is still considered a potentially viable outplanted population (U.S. Army Garrison 2015, p. 73, Shaw 1995, p. 28).
 - In 2014, a population of *H. haplostachya* was established within the HVNP, with 50 individuals within one of the upper elevation Kahuku exclosures. In 2015, a total of 60 plants were reintroduced at HVNP near the top of the Mauna Loa strip road (HVNP 2020, p. 15). It is uncertain how many are extant.
 - Population biology—PTA conducted 20 seed germination trials using 701 seeds that produced three seedlings (less than one percent germination rate) (U.S. Army Garrison 2020, p. 40). This low level of germination is likely due to unknown dormancy and germination requirements. The treatments that yielded some success, albeit low, were a 1000 parts per million treatment of gibberellic acid on filter paper (one seed, four percent success rate) and a 4-day soak in growth

chamber plus vermiculite and greenhouse mixture soil (two seeds, five percent success rate) (U.S. Army Garrison 2020, pp. 112–113).

Table 1. Status and trends of *Haplostachys haplostachya* from listing through current 5-year review.

Date	No. wild individuals	No. outplanted	Stabilization Criteria identified in Recovery Plan	Stabilization Criteria Completed?
1991 (listing)	Unknown	Unknown	Secure and manage existing habitat on Hawai‘i Island	No
			Secure and manage three additional populations on Maui and Kaua‘i	No
1993 (recovery plan, draft)	10,241	Unknown	Secure and manage existing habitat on Hawai‘i Island	Partially
			Secure and manage three additional populations on Maui and Kaua‘i	No
2012 (5-year review)	>10,000	370	Secure and manage existing habitat on Hawai‘i Island	Partially
			Secure and manage three additional populations on Maui and Kaua‘i	No
Date	No. wild individuals	No. outplanted	*Preventing Extinction Criteria identified by HPPRCC	*Preventing Extinction Criteria Completed?
2020 (5-year review)	ca 24,000	>136	All threats managed in all 3 populations	Partially
			Complete genetic storage	Partially, founders represented but viability uncertain

			Reproduction (i.e. viable seeds, seedlings) at all 3 populations	Partially, little successful recruitment
			3 populations with 50 mature individuals each	Yes

* The Preventing Extinction Stage was established in 2011. Prior to 2011, the Interim Stabilization Stage was the first stage towards recovery (now it is the second stage after Preventing Extinction).

Table 2. Threats to *Haplostachys haplostachya* and ongoing conservation efforts.

Threat	Listing factor	Current Status	Conservation/ Management Efforts
Ungulate destruction and degradation of habitat and herbivory	A, C, D	Ongoing	Partial, ungulate exclosures and control at PTA
Established ecosystem-altering invasive plant species degradation of habitat and competition	A, E	Ongoing	Partial, some nonnative plant control at PTA
Agricultural and urban development	A	Ongoing	Partial, compliance and partnership development at PTA
Drought destruction and degradation	A	Ongoing	None
Fire destruction and degradation of habitat	A	Ongoing	Partial, nonnative plant control efforts and firebreaks at PTA, fire management plan implementation
Climate change degradation and loss of habitat	A	Ongoing	None
Invertebrate predation and herbivory	C	Ongoing	None
Rodent predation and herbivory	C	Ongoing	None
Disease—Powdery mildew	C	Ongoing	Partial, research into use of anti-fungal treatments

Inadequacy of regulatory mechanisms	D	Ongoing	Partial, populations at PTA, Pu‘uwa‘awa‘a and HVNP within exclosures
Hiking and trail maintenance	E	Ongoing	Partial, at PTA
Military activities	E	Ongoing	Partial, compliance enforcement at PTA

Synthesis:

Currently, there are more than 20,000 wild individuals of *Haplostachys haplostachya* that occur within PTA and Pu‘u Anahulu on the island of Hawai‘i. There are no wild or reintroduced populations on the islands of historic occurrence (Maui and 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 *H. haplostachya* is vulnerable to the effects of climate change. Of the 12 plant groups that are present at PTA, all are enclosed by ungulate proof fencing. Half of the Pu‘u Anahulu population is fenced. While this fencing protects against feral sheep, cattle, and goats, it does not protect against seed predators such as rats and mice. The protection provided by these fences, combined with increased survey effort, have resulted in increases in total numbers over time. Seed collections have been made from 100s of individuals, but seed storage as a viable method for *ex situ* representation is currently unknown due to low germinates rates. Reintroduction efforts have increased the number of populations at areas outside of PTA, including two sites at Hawai‘i Volcanoes National Park, three sites at Pu‘uwa‘awa‘a (Pu‘uhuluhulu, Pu‘uwa‘awa‘a, and Kīpuka ‘Owē‘owē), and at the West Hawai‘i Veteran’s Cemetery. Research for control methods for powdery mildew and germination trials are ongoing.

Stabilizing (interim), downlisting, and delisting objectives were provided in the draft Recovery Plan for *Haplostachys haplostachya* and *Stenogyne angustifolia* var. *angustifolia* (USFWS 1993), and have been updated according to the draft revised recovery objective guidelines developed by the Hawai‘i and Pacific Plants Recovery Coordinating Committee (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.

Haplostachys haplostachya is a short-lived perennial woody herb. 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 the islands of Hawai‘i and at least one other island (Maui, Kaua‘i) where they now occur or occurred historically and each of these populations must be naturally reproducing (i.e., viable seeds, seedlings, saplings), with a minimum of 50 mature, reproducing individuals per population.

The preventing extinction goals for this species have not been met. Although there are three populations of 50 mature individuals and genetic representation is complete for at least 945 founders, seed storage as a viable method to meet these goals is unknown due to the low germination rates (Table 1). Also, all threats, including drought, predation by rodents, invertebrates, and the effects of disease, are not being managed (Table 1, Table 2). Therefore, *Haplostachys haplostachya* meets the definition of Endangered as it remains in danger of extinction throughout its range.

Recommendations for Future Actions:

Predation by rodents and the inadequacy of regulatory mechanisms are new threats to this species. We are not aware of any significant new information regarding the species’ biological status since the last 5-year review in 2012. Thus, the following recommendations for future actions are added or reiterated for the 5-year review for 2020.

- Surveys and inventories—Continue to conduct thorough surveys of all current and historical range for a current assessment of the species’ status.
- Ungulate monitoring and control—Continue to construct, monitor, and maintain fenced exclosures to protect individuals from the negative impacts of habitat destruction and degradation, and browsing and trampling by ungulates.
- Established ecosystem-altering invasive plant monitoring and control—Continue to control established ecosystem-altering nonnative invasive plant species, and those that compete with *Haplostachys haplostachya* at all populations.
- Fire monitoring and control—Continue to develop and implement fire management plans for all wild and reintroduced populations.
- Drought monitoring and control—Continue to monitor and control other threats to protect and increase vigor of *H. haplostachya* during times of drought.
- Climate change adaptation strategy—Assess the modeled effects of climate change on this species and use to determine future landscape needed for the recovery of the species.
- Site/area/habitat protection—Develop and implement effective measures to reduce the impacts of urban and agricultural development, hiking and trail maintenance, and military activities.
- Predation and herbivore control—
 - Implement effective control methods for rodents.
 - Conduct research on the damaging effects of nonnative insects on of *H. haplostachya* and if necessary, develop and implement effective control measures.

- Disease—Continue to research effects of powdery mildew and effective methods of control for nursery and field use if necessary.
- Captive propagation for genetic storage and reintroduction—Continue collection and propagation efforts for maintenance of genetic stock and for reintroduction into protected suitable habitat within historical range.
- Reintroduction and translocation—Determine optimal sites for reintroduction, especially on Maui and Kaua‘i, and continue to reintroduce individuals into these areas that are managed for known threats.
- Population biology research—Continue germination and propagation research and implement best management practices.
- Finalize a revised recovery plan to include additional recovery criteria based on current information for species recovery.
- Alliance and partnership development—Continue to work with the U.S. Army Garrison, the Department of Land and Natural Resources, and other partners and land managers in planning and implementation of ecosystem-level restoration and management to benefit this species.

References:

- Aslan, C.E., A.B. Shiels, W. Haines, and C.T. Liang. 2019. Non-native insects dominate daytime pollination in a high-elevation Hawaiian dryland ecosystem. *American Journal of Botany* 106(2): 313–324, doi:10.1002/ajb2.1233.
- Daehler, C.C. 2005. Upper-montane plant invasions in the Hawaiian Islands: Patterns and opportunities. *Perspectives in Plant Ecology, Evolution and Systematics* 7: 203–216.
- Fortini, L., J. Price, J. Jacobi, A. Vorsino, J. Burgett, K. Brinck, F. Amidon, S. Miller, S. Gon II, G. Koob, and E. Paxton. 2013. A landscape-based assessment of climate change vulnerability for all native Hawaiian plants. Technical report HCSU-044. Hawaii Cooperative Studies Unit, University of Hawai‘i at Hilo, Hawai‘i. 134 pp.
- [HPPRCC] Hawai‘i and Pacific Plants Recovery Coordinating Committee. 2011. Revised recovery objective guidelines. 8 pp.
- [HVNP] Hawai‘i Volcanoes National Park. 2019 Annual report to the USFWS threatened and endangered plants HAVO permit TE-018078-21. 26 pp.
- [HVNP] 2020. Report on controlled propagation of listed species, as designated under the U.S. Endangered Species Act. Unpublished report submitted to the U.S. Fish and Wildlife Service, Pacific Islands Fish and Wildlife Office, Honolulu, Hawai‘i.
- Koko, J., C. Egan, and N. Hynson. 2018. Testing the effects of inoculation with arbuscular mycorrhizal fungi and the foliar endophytic mycoparasitic yeast *Moeziomyces aphidis* on the disease severity from *Neoerysiphe galeopsidis* in

- infected *Phyllostegia kaalaensis* plants. Appendix ES-6 in 2018 Status Report for the Makua and Oahu Implementation Plans.
- Native Plants Hawaii. 2020. Plant profile for *Haplostachys haplostachya*. http://nativeplants.hawaii.edu/plant/view/Haplostachys_haplostachya, Accessed 29 JUL 2020.
- [NTBG] National Tropical Botanical Garden. 2001. Herbarium specimen detail for *Haplostachys haplostachya*. PTBG 1000001794. https://plants.jstor.org/stable/10.5555/al.ap.specimen.ptbg1000001794?searchUri=filter%3Dname%26so%3Dps_group_by_genus_species%26Basic%26Query%3DHaplostachys%2Bhaplostachya. Accessed 29 JUL 2020.
- [PEPP] 2020. Plant Extinction Prevention Program. 2020. Database for endangered and threatened plants status.
- Shaw, R. 1995. The influence of wildland fire on the recovery of endangered plant species study project. U.S. Army cooperative agreement: DAMD17-94-V-4038. 53 pp.
- [SNMNH] Smithsonian National Museum of Natural History. 1980. SNMNH database herbarium specimen details for *Haplostachys haplostachya*. 2973596. <http://n2t.net/ark:/65665/3901aac0b-3184-4485-b55c-aaabb763a6d7>. Accessed 29 JUL 2020.
- [SNMNH] 1994. SNMNH database herbarium specimen details for *Haplostachys haplostachya*. 00477693. <http://n2t.net/ark:/65665/m3537acf35-4158-4e2e-9eced39ca0788532>, Accessed 29 JUL 2020.
- Stephens, R.M. 2014. Eradication efforts for hybrid-mouflon sheep in palila critical habitat on Mauna Kea. Proceedings of the Vertebrate Pest Conference, 26(26) (R.M. Timm and J.M. O'Brien, (eds.), University of California Davis. Pp. 56–60.
- U.S. Army Garrison. 2015. FY 2014 Annual letter report for the natural resources office, Pōhakuloa Training Area, Island of Hawai‘i. 78 pp.
- U.S. Army Garrison. 2017. Pōhakuloa Training Area natural resources botanical program genetic conservation and outplanting plan. February 2017. 115 pp.
- U.S. Army Garrison. 2018 Technical report and post-disturbance assessment, July 2018 Wildland Fire Training areas 18, 19, and 22. Pōhakuloa Training Area, Island of Hawai‘i. 14 pp.
- U.S. Army Garrison. 2019. 2017 Annual report for Pōhakuloa Training Area. Recovery Permit TE-40123A-2, August 2019, Prepared by Colorado State University. 19 pp.

- U.S. Army Garrison. 2020. 2019 Annual report for Pōhakuloa Training Area, Hawai‘i Island, Hawai‘i. Recovery Permit TE-40123A-2, Prepared by Colorado State University, Center for Environmental Management of Military Lands, January 2020. 190 pp.
- [USFWS] U.S. Fish and Wildlife Service. 1993. Draft recovery plan for *Haplostachys haplostachya* and *Stenogyne angustifolia* var. *angustifolia*. Portland. 55 pp.
- [USFWS] 2012. *Haplostachys haplostachya* 5-year review summary and evaluation. USFWS Pacific Islands Fish and Wildlife Office, Honolulu, HI. https://ecos.fws.gov/docs/five_year_review/doc4081.pdf.
- [USFWS] 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. 88 FR 20088, May 7, 2018.
- [VRPF] Volcano Rare Plant Facility. 2013-2019. Summary of reports on controlled propagation of listed species, as designated under the U.S. Endangered Species Act. Unpublished report submitted to the U.S. Fish and Wildlife Service, Pacific Islands Fish and Wildlife Office, Honolulu, Hawai‘i.
- Welch, A.J., K. Collins, A. Ratan, D.I. Drautz-Moses, S.C. Schuster, and C. Lindqvist. 2016. The quest to resolve recent radiations: plastid phylogenomics of extinct and endangered Hawaiian endemic mints (Lamiaceae). *Molecular Phylogenetics and Evolution*. 99:16–33.
- Zahn, G. and A.S. Amend. 2017. Foliar microbiome transplants confer disease resistance in a critically-endangered plant. *PeerJ* 5ce4020;DOI 10.7717/peerj.4020, 16 pp.

U.S. FISH AND WILDLIFE SERVICE

SIGNATURE PAGE for 5-YEAR REVIEW of *Haplostachys haplostachya* (honohono)

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

For Field Supervisor, Pacific Islands Fish and Wildlife Office

_____ Date _____