5-YEAR REVIEW

Short Form Summary

Species Reviewed: *Geranium arboreum* (nohoanu, Hawaiian red-flowered geranium)

Current Classification: Endangered

Federal Register Notice announcing initiation of this review:

[USFWS] U.S. Fish and Wildlife Service. 2016. Endangered and threatened wildlife and plants; initiation of 5-year status reviews of 76 species in Hawaii, Oregon, Washington, Montana, and Idaho. Federal Register 81(29): 7571–7573.

Lead Region/Field Office:

Region 1/Pacific Islands Fish and Wildlife Office (PIFWO), Honolulu, Hawai‘i

Name of Reviewers:

Cheryl Phillipson, Biologist, PIFWO
Lauren Weisenberger, Plant Recovery Coordinator, PIFWO
Gregory Koob, 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 (USFWS) beginning in August 2017. The review was based on a review of current, available information since the last 5-year review for *Geranium arboreum* (USFWS 2011). The evaluation by Cheryl Phillipson, Biologist, was reviewed by Lauren Weisenberger, Plant Recovery Coordinator, and Gregory Koob, 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 *Geranium arboreum* published in the Federal Register on August 29, 2011 (available at *https://ecos.fws.gov/docs/five_year_review/doc3836.pdf*) for a complete review of the species' status, threats, and management efforts. 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 *G. arboreum*.

This long-lived perennial shrub in the Geraniaceae (geranium) family is endangered and endemic to east Maui. The current status and trends for *Geranium arboreum* are provided in the tables below.

New Status Information:

- In 2011, the 5-year review reported about five populations of *Geranium arboreum* totaling fewer than 50 individuals on east Maui. In 2012, PEPP reported three populations totaling 42 individuals; and in 2014, seven populations totaling 48 individuals (PEPP 2012, 2014). In 2015, Chau *et al*. reported eight subpopulations totaling 40 individuals. Currently, there are wild populations in five locations on east Maui consisting of the following reported individuals: Kanaio (1), Waiohuli (48), Pōhakuokala (5), Waikamoi Gulch (2), and Waiakoa (4) (HBMP 2010; Oppenheimer 2018, in litt.; PEPP 2016, 2017a, 2018). Haleakalā National Park reports two occurrences of two individual clumps (Robertson 2016, in litt.).
- In 2016, four critical habitat units were designated in three ecosystems (montane mesic, montane dry, and subalpine) on east Maui for *Geranium arboreum* (40,358 ac; 16,333 ha) (81 FR 17790, March 30, 2016).

New Threats:

- Drought degradation of habitat—Drought is reported to be a threat to populations of *Geranium arboreum* at Pōhakuokala, Waikamoi Gulch, and Waiakoa (PEPP 2011, 2013, 2017a). Over the last 100 years, the Hawaiian Islands have experienced an annual decline in precipitation of over 9 percent, increasing to as much as 15 percent within the last 20 years (US-NSTC 2008; Chu and Chen 2005; Diaz 2005). Drought affects plants directly by desiccation. The increase in drought frequency and intensity leads to a self-perpetuating cycle of increase in cover of nonnative plants, increase in the number of fires, and an increase of erosion (US-GCRP 2009; Warren 2011). Recent episodes of drought have also driven deer farther into urban and forested areas in search of food, increasing their negative impacts to native vegetation from herbivory and trampling (Waring 1996, in litt; Nishibayashi 2001, in litt.).
- Fire destruction or degradation of habitat—Fire is reported to be a threat to occurrences of *Geranium arboreum* at Waiohuli, Kanaio, Kula-Waiakoa, and Waikamoi (PEPP 2010, 2011, 2012, 2013). Increasing episodes of drought, expansion of invasive grass cover, and temperature increases, have led to an increase in the number of wildfires on Maui (Trauernicht *et al.* 2015). Fire can destroy dormant seeds as well as individual plants. Successive fires burn farther and farther into native habitat and alter microclimate conditions to further alter habitat conditions to favor nonnative plants. Nonnative plants convert native plant communities to nonnative dominated plant communities (D'Antonio and Vitousek 1992; Tunison *et al*. 2002).
- 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 *Geranium arboreum* is highly vulnerable to the impacts of climate change, with a vulnerability score of 0.633 (on a scale of 0 being not vulnerable to 1 being

extremely vulnerable to climate change). Therefore, additional management actions are needed to conserve this taxon into the future.

- Lack of adequate hunting regulations—Two of the five populations of *Geranium arboreum* occur in State hunting areas on east Maui. Habitat destruction and modification, and predation by pigs, goats, axis deer, and cattle have been noted as threats to the species. A few individuals in these areas are fenced; however, fences must be continually monitored and repaired. In addition, public hunting areas are not fenced and game mammals have unrestricted access to most areas across the landscape, regardless of underlying land use designation; therefore, any unfenced populations are at risk (DLNR 2010).

New Management Actions:

- Surveys and population monitoring—The Plant Extinction Prevention Program (PEPP) surveys for new and previously known populations and for reintroduction sites in areas in the Kula Forest Reserve (PEPP 2010, 2011, 2012, 2013). In 2016, 56 wild individuals were found at Waiohuli but by 2017 only 48 remained (PEPP 2017a).
- Invasive plant monitoring and control—PEPP conducts weed control at populations of *Geranium arboreum* they monitor in the Kula Forest Reserve, Pohakuokala, Waiakoa, and at Waikamoi (PEPP 2010, 2012, 2013, 2017a).
- Ungulate monitoring and control—
    - Fences have been constructed to protect some populations of *G. arboreum* at Waiakoa, Kanaio, Waiohuli, and Pohakuokala (PEPP 2010, 2011, 2012, 2013).
    - Several small subpopulations and reintroductions of *G. arboreum* in Haleakalā National Park are provided protection from habitat destruction and predation by ungulates because of fencing and Park monitoring efforts (NPS 2012).
- Captive propagation for genetic storage and reintroduction—
    - Currently, these founders have been collected from: one from Kanaio, four from Waiakoa, 55 from Waiohuli, and seven from Waikamoi Gulch (PEPP 2017b).
    - Lyon Arboretum Micropropagation Laboratory reports 72 containers of propagules from Waiakoa (Lyon Arboretum 2017), though these explants have since been sent to Olinda rare Plant Facility (Lyon Arboretum 2018). The Lyon Seed Conservation Laboratory reports 300 seeds in collection from ten wild individuals at Waiohuli (Lyon Arboretum 2017).
    - Between 2013 and 2017, Haleakalā National Park has propagated over 300 plants representing 37 wild individuals, and has outplanted at least 50 individuals (HNP 2013, 2015, 2017).
    - In 2013, the Olinda Rare Plant Facility (ORPF) reported propagation of 38 potted plants from 14 individuals (two of which were reintroduced to Pohakuokala); and propagation of nine cuttings, four of which were outplanted at Pohakuokala and Haleakalā NP. 81 potted plants grown from 17 individuals were reintroduced to Kanaio, 15 to Waikamoi, two to Puu Pahu, and five to Pu‘umāhoe. In 2014, ORPF propagated and reintroduced

20 individuals to Pōhakuokala, four to Waikamoi Gulch, two to Koʻolau Gap, and four to Haleakalā-Pāpaʻanui (ORPF 2014). In 2017, ORPF propagated three plants from Kanaio and two from Waiohuli (ORPF 2017). Currently, there are 72 plants at ORPF, and 17 were outplanted in 2018 (ORPF 2018).

- PEPP collects seeds, cuttings, and pollen for propagation at ORPF and Lyon Arboretum. PEPP reported outplanting 50 individuals in 2013, 68 individuals in 2014, and 23 individuals in 2015 (representing 20 new founders). In 2016, previous outplantings were monitored, and additional plants were reintroduced at Waiakoa (6) and Honomanu (1). PEPP reports a loss of a few outplanted individuals at Waikamoi (from 11 to 10 individuals) and at Waiakoa (from 30 to 27 individuals) (PEPP 2018).

Synthesis:
Currently, there are approximately 60 wild individuals of *Geranium arboreum* on east Maui. A landscape-based assessment of climate change vulnerability for native plants of Hawaiʻi using high resolution climate change projections was made by Fortini *et al.* (2013) and their analysis showed that *G. arboreum* is highly vulnerable to the effects of climate change, in that there will be a smaller area of suitable habitat available for the species in the near future. Populations at sites in the Kula FR and Haleakalā National Park may be provided protection by fencing and ongoing ungulate control and nonnative plant control. Seed, cuttings, and pollen collection and storage efforts are ongoing. Almost 300 individuals have been outplanted at seven sites.

Stabilizing (interim), downlisting, and delisting objectives were provided in the Recovery Plan for the Maui Plant Cluster (USFWS 1997), and have been updated according to the draft revised recovery objective guidelines developed by the Hawaiʻi 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.

Geranium arboreum is a long-lived perennial shrub. 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 *ex situ* (secured off-site, such as a nursery or seed bank) collections. In addition, a minimum of three populations should be documented on east Maui. Each of these populations must be naturally reproducing (i.e., viable seeds, seedlings, saplings) and increasing in number, with a minimum of 25 mature, reproducing individuals per population.

The preventing extinction goals for this species have not been met as there are no populations of at least 25 reproducing individuals, and, although genetic representation is nearing completion (Table 1), all threats are not being sufficiently managed throughout the range of the species (Table 2). Therefore, *Geranium arboreum* meets the definition of Endangered as it remains in danger of extinction throughout its range.

Recommendations for Future Actions:
Drought and fire are reported as new threats to *Geranium arboreum*. We are not aware of any significant new information regarding the species' biological status since the last 5-year review in 2011. Thus, the following recommendations for future actions are added or reiterated for the 5-year review for 2018.

- Population viability and monitoring—Continue to monitor the wild populations and survey for new populations on east Maui.
- Ungulate monitoring and control—Continue to construct and maintain exclusion fences to protect *Geranium arboreum* from the impacts of feral ungulates.
- Invasive plant monitoring and control—Continue to control established ecosystem-altering nonnative invasive plant species around all populations.
- Fire monitoring and control—Develop and implement fire prevention management plans.
- Predator and herbivore monitoring and control—
    - Implement effective control methods for rodents at wild and reintroduced populations.
    - Develop and implement effective control methods for slugs and ants.
- Captive propagation for genetic storage and reintroduction—
    - Continue collection of genetic resources for storage, propagation, and reintroduction into protected suitable habitat within historical range.
    - Evaluate genetic resources currently in storage to determine the need to place additional material into long-term storage due to this species' vulnerability to climate change.
- Reintroduction and translocation—Continue reintroduction of individuals into suitable habitat within historic range that is being managed for known threats to this species.
- Population biology research—Further studies are needed to clarify the mechanisms used by predators of this species, how they affect its ability to regenerate in the wild, and methods needed to mitigate this threat.
- Climate change adaptation strategy—Research the suitability of habitat for reintroducing this species in the future due to impacts from climate change.
- Alliance and partnership development—Initiate planning and contribute to implementation of ecosystem-level restoration and management to benefit this taxon.

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

Date	No. wild individuals	No. outplanted	Stability Criteria identified in Recovery Plan	Stability Criteria Completed?
1992 (listing)	300	0	All threats managed in all three populations	No
			Complete genetic storage	No
			Three populations with 25 mature individuals each	No
1997 (recovery plan)	300	0	All threats managed in all three populations	No
			Complete genetic storage	No
			Three populations with 25 mature individuals each	No
2003 (critical habitat)	158	0	All threats managed in all three populations	No
			Complete genetic storage	No
			Three populations with 25 mature individuals each	No
2011 (5-year review)	< 50	54	All threats managed in all three populations	No
			Complete genetic storage	No
			Three populations with 25 mature individuals each	No
2016 (critical habitat)	< 30	189	All threats managed in all three populations	Partially, ungulate and nonnative plant management

			Complete genetic storage	Partially
			Three populations with 25 mature individuals each	No
Date	**No. wild individuals**	**No. outplanted**	***Preventing Extinction Criteria identified by HPPRCC**	***Preventing Extinction Criteria Completed?**
2018 (5-year review)	ca 60	ca 300	All threats managed in all three populations	Partially, ungulate and nonnative plant management
			Complete genetic storage	Partially
			Reproduction (*i.e.* viable seeds, seedlings) at all three populations	No
			Three populations with 25 mature individuals each	No

* 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 after Preventing Extinction).

Table 2. Threats to *Geranium arboreum* and ongoing conservation efforts.

Threat	Listing factor	Current Status	Conservation/ Management Efforts
Ungulate degradation of habitat	A	Ongoing	Partial, some fencing
Established ecosystem altering invasive plant species degradation of habitat	A	Ongoing	Partial, Park management
Drought degradation of habitat	A	Ongoing	None
Fire degradation of habitat	A	Ongoing	None
Climate change degradation or loss of habitat	A	Ongoing	None
Ungulate predation or herbivory	C	Ongoing	Partial, some fencing
Rodent predation or herbivory	C	Ongoing	Partial, some trapping at one population
Invertebrate predation or herbivory	C	Ongoing	None
Lack of adequate hunting regulations	D	Ongoing	Partial, some fencing in hunting areas
Fire mortality and reduced viability	E	Ongoing	None
Loss of mutualists—Loss of pollinators and seed dispersers	E	Ongoing	None
Stochastic events—Reduced viability due to small populations	E	Ongoing	Partial, seed collection, propagation, and reintroduction are ongoing

References:

See the previous 5-year review for a full list of references (USFWS 2011). 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 *Geranium arboreum* (nohoanu, Hawaiian red-flowered geranium)

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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