Geranium hanaense
(nohoanu)

5-Year Review
Summary and Evaluation

U.S. Fish and Wildlife Service
Pacific Islands Fish and Wildlife Office
Honolulu, Hawi'i

5-YEAR REVIEW

Species reviewed: *Geranium hanaense* (nohoanu)

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5-YEAR REVIEW
Geranium hanaense (nohoanu)

1.0 GENERAL INFORMATION

1.1 Reviewers:

Christina Richards, Biologist, Pacific Islands Fish and Wildlife Office (PIFWO)
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Lead Regional or Headquarters Office:
Interior Region 12, Portland Regional Office

Lead Field Office:
Pacific Islands Fish and Wildlife Office

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 of the U.S. Fish and Wildlife Service (Service), beginning in May 2018. In accordance with section 4(c)(2) of the Endangered Species Act of 1973, as amended (Act), the purpose of a 5-year review is to assess each threatened species and endangered species to determine whether its status has changed and it should be classified differently or removed from the Lists of Threatened and Endangered Wildlife and Plants. The Service evaluated the biology status of Stenogyne kauaulaensis as part of the Species Report to inform this 5-year review. The evaluation by Christina Richards, Biologist, was reviewed by Lauren Weisenberger, Plant Recovery Coordinator, and Megan Laut, Conservation and Restoration Team Manager.

1.3 Background:

1.3.1 FR Notice citation 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.

1.3.2 Listing history

Original Listing
FR notice: [USFWS] U.S. Fish and Wildlife Service. 2013. Endangered and threatened wildlife and plants; determination of endangered status for 38 species on Molokai, Lanai, and Maui; final rule. Department of the Interior, Federal Register 78 (102): 32014–32065, May 28, 2013.

Date listed: May 28, 2013
Entity listed: *Geranium hanaense*
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] U.S. Fish and Wildlife Service. 2016. Endangered and threatened wildlife and plants; designation and nondesignation of critical habitat on Molokai, Lanai, Maui, and Kahoolawe; final rule. Department of the Interior, Federal Register 81 (61): 17790–18110, March 30, 2016.

Critical habitat was designated on Maui for Geranium hanaense totaling ten units in the montane wet ecosystem (3245 ha; 8018 ac) (81 FR 17790).

1.3.4 Review History: This is the first 5-year review for *Geranium hanaense*.

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 Outline for the islands of Maui, Molokaʻi, Kahoʻolawe, and Lānaʻi (Maui Nui)
Date issued: October 2019
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
____ 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,
____ No

2.2 Recovery Criteria

2.2.1 Does the species have a final, approved recovery plan[1] containing objective, measurable criteria?

____ Yes

__X__ **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?

____ **Yes**
____ **No**

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

____ **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 (Listing Factors A, C, and D) affecting this species is presented in section 2.3.2 and Table 2. Listing Factor B (overutilization for commercial, recreational, scientific, or educational purposes) and Listing Factor E (other species-specific threats) are not known to be a threat to this species.

The recovery plan is currently being drafted. However, the Hawai‘i and Pacific Plants Recovery Coordinating Committee (HPPRCC) has outlined the actions and goals for stages leading towards recovery (2011). These stages are described below.

Current information is lacking for many Hawaiian plant species on the status of the species and their habitats, breeding systems, genetics, and propagule storage options. The following downlisting and delisting criteria for plants have therefore been adopted from the revised recovery objective guidelines developed by the HPPRCC (2011). Many of the Hawaiian plant species are at very low numbers, so the Service also developed criteria for avoiding imminent extinction and an interim stage before downlisting, based on the recommendations of the HPPRCC, to assist in tracking progress toward the ultimate goal of recovery. These criteria are assessed on a species-by-species basis, especially as additional information becomes available.

In general, long-lived perennials are those taxa either known or believed to have life spans greater than 10 years; short-lived perennials are those known or believed to have life spans greater than one year but less than 10 years; and annuals are those known or believed to have life spans less than or equal to one year. When it is unknown whether a species is long- or short-lived, the Service has erred on the side of caution and considered the species short-lived. This will

be revised as more is learned about the life histories of these species. Narrow extant range and broad contiguous range are recognized as not needing different numbers of individuals or populations, but that the populations will be distributed more narrowly or more broadly, respectively, across the landscape. Obligate outcrossers are those species that either have male and female flowers on separate plants or otherwise require cross-pollination to fertilize seeds, and therefore require equal numbers of individuals contributing to reproduction as males and females, doubling the number of mature individuals. Species that reproduce vegetatively may reproduce sexually only on occasion, resulting in the majority of the genetic variation being between populations, therefore requiring additional populations. Species that have a tendency to fluctuate in number from year to year require a larger number of mature individuals on average to allow for decline in years of extreme habitat conditions and recuperation in numbers in years of more normal conditions.

Preventing Extinction

Stabilizing (interim), downlisting, and delisting objectives have been updated according to the draft revised recovery objective guidelines developed by the 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 hanaense is a short-lived perennial spreading shrub. 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. In addition, a minimum of three populations should be documented on Maui where they now occur or occurred historically. Each of these populations must be naturally reproducing (i.e., viable seeds, seedlings, saplings), with a minimum of 50 mature individuals per population, for a total of 150 mature individuals.

There is one population totaling an estimated 500 to 700 individuals, and there is no genetic representation in storage or in propagation, and no reintroduction. Most of the population is fenced, but other threats are ongoing. Therefore, this recovery objective has not been met (see Table 1).

Interim Stage

To meet the interim stage of recovery of *Geranium hanaense*, 300 mature individuals are needed in each of three populations and all major threats must be

controlled around the populations designated for recovery at this stage. There should also be demonstrated regeneration of seedlings and growth to at least sapling stage for woody species and documented replacement regeneration within each of the target populations. The populations must be adequately represented in an *ex situ* collection, that is secured and well-maintained, as defined in the Center for Plant Conservation's guidelines (Guerrant *et al.* 2004). Adequate monitoring must be in place and conducted to assess individual plant survival, population trends, trends of major limiting factors, and response of major limiting factors to management.

This recovery objective has not been met (see Table 1).

Downlisting Criteria
In addition to achieving 5 to 10 populations with 500 mature individuals per population and all of the goals of the interim stage, all target populations must be stable, secure, and naturally reproducing for a minimum of 10 years. Species-specific management actions are not ruled out. Downlisting should not be considered until an adequate population viability analysis (PVA) has been conducted to assess needed numbers more accurately based on current management and monitoring data collected at regular intervals determined by demographic parameters of the species, although they should only be one of the factors used in making a decision to downlist. Information necessary for the PVA that should be available through monitoring (ideally annually) includes major limiting factors, breeding system, population structure and density, and proven management methods for major threats.

This recovery objective has not been met (see Table 1).

Delisting Criteria
In addition to achieving 5 to 10 populations with 500 mature individuals per population and all of the goals of the interim and downlisting stages, all target populations must be stable, secure, naturally reproducing, and within secure and viable habitats for a minimum of 20 years. Species-specific management actions must no longer be necessary, but ecosystem-wide management actions are not ruled out if there are long-term agreements in place to continue management. These numbers are initial targets, but may be revised upward as additional information is available, including adequate PVAs for individual species based on current management and monitoring data collected at regular intervals determined by demographic parameters of the species, although they should only be one of the factors used in making a decision to delist. Genetic analyses should be conducted to ensure that adequate genetic representation is present within and among populations compared to the initial variation assessed in the interim stage. Numbers need to be considered on a species-by-species basis.

This recovery objective has not been met (see Table 1).

2.3 Updated Information and Current Species Status

2.3.1 Biology and Habitat

2.3.1.1 New information on the species' biology and life history:
Geranium hanaense (nohoanu) is a small, spreading shrub that is usually less than 2 feet (ft) [0.6 meters (m)] tall with occasional individuals up to 5 ft (1.5 m) tall. The species is usually prostrate with branches rooting as they spread through its native bog habitat. The leaves are covered densely with long, silky hairs on both the upper and lower surfaces. *G. hanaense* produces 3-10 flowered inflorescences, with most having around six flowers. The flowers are white or white with purple-magenta lines radiating throughout (Medeiros and St. John 1988, p. 214).

In its bog habitat, *G. hanaense* flowers during the summer from June through September. The specific pollinators for this species are unknown, but are likely native yellow-faced bees (genus *Hylaeus*), which are common pollinators for *G. cuneatum* and *G. multiflorum* on Haleakalā. However, no visits to flowers of *G. hanaense* have been noted. It's possible that the bowl-like flowers with abundant nectar are also suited to pollination by moths (Lepidoptera) or flies (Diptera) (Medeiros and St. John 1988, p. 219).

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:
No information on seed viability, seedling survival, or average lifespan is known for individuals of this species. Ideally, to survive, each individual needs suitable bog habitat, particularly with *Oreobolus furcatus* present, protection from ungulates and invasive weeds, and pollinators to produce viable seed.

Lack of pollination and potentially consequent low seed set seem to be a chronic issue for this species, as it has been noted that in some years no wild plants appear to produce seed. This characteristic has been noted in cultivation as well, possibly suggesting plants require pollination in order to set seeds. However, the ability to reproduce vegetatively seems to be a solution to this problem for *G. hanaense*, as this ability is not shown by other geranium species on Haleakalā, which do produce abundant seed (Medeiros and St. John 1988, pp. 218-219). Plants in cultivation have been grown from cuttings (P. Welton, pers. comm. 2019).

This species is a bog endemic, with nearly all individuals found in two bogs: Mid-Camp Bog and Big Bog, though a few individuals are also known from State Bog (Medeiros and St. John 1988, p. 214, H. Oppenheimer, pers. comm. 2019). The population was estimated at between 500 to 700 plants when described and current estimates are similar, though no systematic surveys have been conducted for this species (Medeiros and St. John 1988, p. 215, H. Oppenheimer and P. Welton, pers. comm. 2019).

2.3.1.3 Genetics, genetic variation, or trends in genetic variation (e.g., loss of genetic variation, genetic drift, inbreeding, etc.):
A study was conducted to better determine phylogeny, radiation pathways, and origin of Hawaiian *Geranium* species (Kidd 2005, entire). This study showed that the Hawaiian *Geraniums* are strongly affiliated with species found in North America. There is no geological evidence for any now-extinct islands which could have served as stepping-stones to the Hawaiian Islands therefore the original colonization was likely on one of the younger Hawaiian Islands (the *Geranium* species on Kaua‘i are a back radiation). The analysis showed there was convergent evolution of traits (node rooting) for bog species. In addition, results indicated that a more diverse sampling of outgroups, specifically those from South America, may provide evidence for a South American origin for the Hawaiian *Geraniums*. Further genetic studies are needed.

2.3.1.4 Taxonomic classification or changes in nomenclature:
Geranium hanaense is one of six species (nine total taxa) of *Geranium* endemic to the Hawaiian Islands. Five of these taxa are found on Maui, with four taxa endemic to East Maui (Medeiros and St. John 1988, p. 216). Two other bog-restricted species are known: *G. hillebrandii* (formerly *G. humile*) and *G. kauaiense*, endemic to West Maui and Kaua‘i, respectively (Wagner *et al.* 1999, p.5). The closest relative of *Geranium hanaense* appears to be *Geranium cuneatum* subsp. *tridens*. Both species have heavy silvery pubescence on both sides of the leaves with reduced serrations. *G. cuneatum* subsp. *tridens* occurs higher in altitude than *G. hanaense* in dry and mesic scrubland (Medeiros and St. John 1988). Both of the other two species known from Haleakalā, *G. multiflorum* and *G. arboreum*, are also found at higher elevations in mesic forest and shrublands at the upper tree-line (Medeiros and St. John 1988, p.218). The key differences between *G. hanaense* and *G. cuneatum* ssp. *tridens* include decumbent habit, larger flowers, more elliptic leaves with slightly less pubescence; all of which are traits that remained true when *G. hanaense* was cultivated with the elevational range of *G. cuneatum* (Medeiros and St. John 1988, p.218).

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.):
See section 2.3.1.2 above for spatial distribution of the species.

2.3.1.6 Habitat or ecosystem conditions (e.g., amount, distribution, and suitability of the habitat or ecosystem):
The species is restricted to montane bogs on the northeast slope of East Maui at an elevation of 5400-5440 ft (1,645-1,660 m), primarily Mid-Camp Bog (3.0 ha) and Big Bog (5.4 ha), with some individuals also present in State Bog (2.1 ha) (Loope *et al.* 1991a, p. 16, USFWS 2013, p. 32023, H. Oppenheimer pers. comm. 2019). These are three of the seven major bogs from 4,640 ft to 7,440 ft (1,415 m

to 2,270 m) in this area of Maui, with some smaller bog patches also present between forested hills at the upper elevations (Loope *et al.* 1991a, p. 16). A few of the bogs at higher elevations and the one that exists at lower elevations along the northeast rift of Haleakalā may have supported this species in the past. However, these bogs do have slight differences in structure and ecology that may limit the species to the area where it is currently found (Vogl and Henrickson 1971, p. 476, Loope *et al.* 1991a, pp.10-12). All other bogs on the northeast slope, except for New Bog, are also smaller than the bogs where it currently survives (Loope *et al.* 1991a, p. 18). Support for this restricted distribution lies in the fact that early botanical inventories of Greensword Bog, one of the geographically closest and most ecologically similar bogs to the occupied habitat (but at a slightly higher elevation), did not include this species, even before feral pigs (*Sus scrofa*) arrived (Loope *et al.* 1991b, p. 9). In addition, early explorations by both C. N. Forbes (1919, entire) as well as Vogl and Henrickson (1971, entire) visited the small bogs and forest openings above Greensword Bog, up to and including Flat Top Bog at 7,440 ft (2,270 m), without encountering *G. hanaense*.

One reason for the restricted distribution might be due to the climate of this area. Mid-Camp Bog, Big Bog, and State Bog are in an area of extremely high rainfall with poor drainage and nearly continuous cloud cover, resulting in waterlogged conditions. Records at Big Bog include over 400 inches (10,160 millimeters) of rain per year, the wettest documented place in Hawaii (Giambelluca *et al.* 2013, p. 2). In addition to this extremely high rainfall, the open bog habitat of this area is maintained by a few other environmental characteristics, including extended periods of high solar radiation and infrequent winter frost and related wind conditions. These environmental factors cause high mortality for woody seedlings and ferns in the bogs, though endemic bog species appeared to be resistant, including *G. hanaense* (Loope *et al.* 1991a, pp. 10-11). The smaller size or higher elevations of the other bogs may preclude similar conditions.

The dominant vegetation components of the East Maui bogs are the sedges *Carex alligata*, *Carex echinata*, and *Oreobolus furcatus*. *O. furcatus* usually occupies slightly raised bog areas, where it forms tussocks, while *C. echinata* occurs in monotypic stands in wetter areas and *C. alligata* occupies the wettest sites, usually with standing water present (Loope et al 1991b, 12). *G. hanaense* appears to be most common in the areas dominated by *O. furcatus* (Medeiros and St. John 1988, pp. 215-216).

2.3.1.7 Other:

2.3.2 Five-Factor Analysis (threats, conservation measures, and regulatory mechanisms)

2.3.2.1 Present or threatened destruction, modification or curtailment of its habitat or range (Factor A):
Ungulate destruction and degradation of habitat— Montane bogs in Hawai‘i are threatened by a variety of stressors (*e.g.* Browning *et al.* 2019, p. 14), many of which impact *Geranium hanaense* directly. The key threat is trampling and herbivory by feral pigs (USFWS 2013, p. 32035). Pigs root through the bogs, not only directly killing *G. hanaense*, but also causing changes to the makeup of the bog community through the invasion of non-native plants and the decrease or extirpation of certain native species (Medeiros *et al.* 1991, p. 22).

Established ecosystem-altering invasive plant modification and degradation of habitat—Invasive introduced plants modify habitats occupied by native plant species by changing the availability of light, altering soil-water regimes, changing nutrient cycling and the fire characteristics of the native plant community (Cuddihy and Stone 1990). Key invasive plants in this area include: *Cyathea cooperi* (Australian tree fern), *Psidium cattleianum* (strawberry guava), *Tibouchina herbacea* (glorybush), *Hedychium gardnerianum* (Himalayan ginger), *Juncus planifolius* (broadleaf rush), *Paspalum* sp., and *Holcus lanatus* (velvetgrass) (H. Oppenheimer and P. Welton pers. comm. 2019, Medeiros *et al.* 1991, p. 28).

Climate change loss or degradation of habitat—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 concluded that *Geranium hanaense* is one of the most vulnerable species in Hawaii to changes in climate, primarily due to its extremely narrow habitat tolerance and the limited potential for additional habitat into the future. It is what they considered a “wink-out” species, one for which 99 percent of their current climate envelope would be lost by 2100 (Fortini *et al.* 2013, pp. 76, 93).

Hurricane destruction or degradation of habitat—Hurricane frequency and intensity are projected to change as a result of climate change over the next 100 to 200 years (Emanuel *et al.* 2008, p. 365; Yu *et al.* 2010, p. 1371). Modeling for the Central Pacific projects an increase of up to two additional tropical cyclones per year in the main Hawaiian Islands by 2100 (Murakami *et al.* 2013, p.1). Hurricanes destroy native vegetation and the habitat of *Geranium hanaense* by opening the canopy and thus modifying the availability of light, and creating disturbed areas conducive to invasive by nonnative pest species. Gaps in the canopy also allow for the establishment of nonnative plants, which may be present as plants or as seeds incapable of growing under shaded conditions (USFWS 2013, p. 32045). A destructive hurricane holds the potential of driving a localized endemic species such as *Geranium hanaense* to extinction with a single event.

2.3.2.2 Overutilization for commercial, recreational, scientific, or educational purposes (Factor B):
Not a threat.

2.3.2.3 Disease or predation (Factor C):
Ungulate predation or herbivory degradation of habitat—Montane bogs in Hawai‘i are threatened by a variety of stressors (*e.g.* Browning *et al.* 2019, p. 14), many of which impact *Geranium hanaense* directly. The key threat is trampling and herbivory by feral pigs (USFWS 2013, p.32035). Pigs root through the bogs, not only directly killing *G. hanaense*, but also causing changes to the makeup of the bog community through the invasion of non-native plants and the decrease or extirpation of certain native species (Medeiros *et al.* 1991, p.5).

2.3.2.4 Inadequacy of existing regulatory mechanisms:
The Federal and State regulations in Hawai‘i are not enough to mitigate the effects of introduced pests, such as ungulates and weeds, or prevent the spread between islands. Many habitat-altering nonnative plants and ungulates established on Maui are of concern, especially with the limited resources available. Control and management of an array of invasive species remains limited in scope (USFWS 2013, p. 32056).

2.3.2.5 Other natural or manmade factors affecting its continued existence:
Not a threat.

Current Management Actions:

- Ungulate control—The majority of the population of *G. hanaense* lies within the boundaries of Haleakalā National Park (Mid-camp Bog and Big Bog) with the remainder in the State of Hawai‘i’s Hana Forest Reserve (State Bog). The National Park Service has fenced both Mid-Camp (1987) and Big Bog (1988) to protect them from feral pigs (Medeiros *et al.* 1991, p. 5). More recently, the Hana Forest Reserve portion of the range was also fenced by the East Maui Watershed Partnership (DOFAW 2018). Bogs severely damaged by pig rooting, then fenced, have shown excellent recovery of native vegetation in five years (Loope *et al.* 1991b, p. 9). Conversely, unfenced bogs show a chronic reduction in the cover of native plant species accompanied by an increase in cover and number of alien species (Medeiros *et al.* 1991, p. 11). Feral pigs still get inside the fence units, so fence maintenance and ungulate removal are actions needed to keep ungulates excluded from fenced habitat over the long-term.

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

Date	No. wild individuals	No. outplanted	Preventing Extinction Criteria identified by HPPRCC	Preventing Extinction Criteria Completed?
2013 (listing)	500-700	0	All threats managed in all 3 populations	Partially, ungulate fencing installed
			Complete genetic storage	No
			3 populations with 50 mature individuals each	Yes
2016 (critical habitat)	500-700	0	All threats managed in all 3 populations	Partially, ungulate fencing installed
			Complete genetic storage	No
			3 populations with 50 mature individuals each	Yes
2020 (5-year review)	500-700	0	All threats managed in all 3 populations	Partially, ungulate fencing installed
			Complete genetic storage	No
			3 populations with 50 mature individuals each	Partially

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

Threat	Listing Factor	Current Status	Conservation/Management Efforts
Ungulate degradation of habitat	A	Ongoing	Partial, most of population fenced
Established ecosystem-altering invasive plant modification and degradation of habitat	A	Ongoing	None
Climate change degradation or loss of habitat, including hurricanes	A	Ongoing	None
Hurricane destruction	A	Ongoing	None
Ungulate predation or herbivory degradation of habitat	C	Ongoing	Partial, most of population fenced
Inadequate regulatory mechanisms	D	Ongoign	None

2.4 Synthesis

There is one population of *Geranium hanaense* totaling an estimated 500 to 700 individuals. Numbers are estimated not to have changed significantly over the past 30 years. However, no systematic surveys have been conducted for this species to verify this number. *Geranium hanaense* is not currently being propagated *ex situ*. 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 *G. hanaense* is highly vulnerable to the effects of climate change. Most of the population is provided some protection from ungulates within fencing.

Preventing extinction, interim stabilization, downlisting, and delisting objectives are provided in HPPRCC's Revised Recovery Objective Guidelines (2011). 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 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 Maui where they now occur or occurred historically and each of these populations must be naturally reproducing (i.e., viable seeds, seedlings, or saplings) with a minimum of 50 mature, reproducing individuals per population.

The preventing extinction goals for this species have not been met. The species has only one population, there is no genetic representation (Table 1), and all threats are not being sufficiently managed throughout the range of the species (Table 2). Therefore, *Geranium hanaense* meets the definition of endangered as it remains in danger of extinction throughout its range.

3.0 RESULTS

3.1 Recommended Classification:

____ Downlist to Threatened
____ Uplist to Endangered
____ Delist (*Indicate reasons for delisting per 50 CFR 424.11):*
____ *Extinction*
____ *Recovery*
____ *Original data for classification in error*
__X__ No change is needed

3.2 New Recovery Priority Number:

Brief Rationale:

3.3 Listing and Reclassification Priority Number,** if reclassification is

recommended

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 –

- Surveys and inventories—Continue to monitor known populations and conduct surveys for *Geranium hanaense* in historical locations and potentially suitable habitat.
- Ungulate monitoring and control—Continue to construct and maintain fenced exclosures to protect wild and reintroduced individuals from the negative impacts of feral ungulates.
- Invasive plant monitoring and control—Control established ecosystem-altering nonnative invasive plant species and those that compete with *G. hanaense* at all populations.
- Captive propagation for genetic storage and reintroduction—Collect seeds and other propagative materials for storage and begin propagation efforts for maintenance of genetic stock.
- Reintroduction and translocation—Increase the number of populations and individuals in suitable habitat to reduce the impacts of predation, hurricanes, and climate change.
- Climate change adaptation strategy—Research suitability of habitat in the future due to the impacts of climate change.
- Alliance and partnership development—Continue to contribute to planning and implementation of ecosystem-level restoration and management to benefit this taxon.

5.0 REFERENCES

Browning, J. H., J. C. Charrier, M. Reeves, F. Amidon, and S. Miller. 2019. Hawaii: the wetland system of Hawaii. Earth Systems and Environmental Sciences. U.S. Fish and Wildlife Service, Pacific Islands Fish and Wildlife Office, Honolulu, HI. 24 pp.

Cuddihy, L.W. and C. P. Stone 1990. Alteration of native Hawaiian vegetation: effects of humans, their activities and introductions, Cooperative National Park Resources Studies Unit, University of Hawai‘i, Honolulu. 138 pp.

[DOFAW] State of Hawai‘i Department of Land and Natural Resources Division of Forestry and Wildlife. 2018. Relating to the Natural Area Reserves System, Natural Area Partnership Program, and the Financial Condition of the Natural

Area Reserve Fund. Report to the Thirtieth Legislature State of Hawai‘i 2019 Regular Session. https://dlnr.hawaii.gov/wp-content/uploads/2018/12/FW19-NARS-FY18.pdf

Emanuel, K., R. Sundararajan, and J. Williams. 2008. Hurricanes and global warming. American Meteorological Society: March. Pp. 347–367.

Forbes, C. N. 1919. Regarding the exploration of the montane bogs of northeast Haleakalā, August 20-23, 1919. Appendix I: The field notes of C. N. Forbes In: Loope, L. L., A. C. Medeiros, and B. H. Gagne. 1991a. Aspects of the History and Biology of the Montane Bogs. Studies in Montane Bogs of Haleakalā National Park. Cooperative National Park Resource Studies Unit, University of Hawaii at Manoa. Technical Report No. 76.

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. Hawai‘i Cooperative Studies Unit, University of Hawai‘i at Hilo, Hawai‘i. 134 pp.

Giambelluca, T.W., Q. Chen, A.G. Frazier, J.P. Price, Y.-L. Chen, P.-S. Chu, J.K. Eischeid, and D.M. Delparte, 2013: Online Rainfall Atlas of Hawai‘i. Bull. Amer. Meteor. Soc. 94, 313-316, doi: 10.1175/BAMS-D-11-00228.1.

Guerrant, E.O., K. Havens, and M. Maunder. 2004. *Ex Situ* Plant Conservation: Supporting Species Survival in the Wild. Island Press, Washington, D.C. 504 pp.

[HBMP] Hawaii Biodiversity and Mapping Program. 2010. Plant species GIS data and Access database.

[HPPRCC] Hawai‘i and Pacific Plants Recovery Coordinating Committee. 2011. Revised recovery objective guidelines. 8 pp.

Hillebrand, WF. 1888. Flora of the Hawaiian Islands, a description of their phanerogams and vascular cryptogams. Carl Winter, University-Bookseller, Heidelberg, London, New York. P. 56.

Kidd, S.E. 2005. Molecular phylogenetics of the Hawaiian geraniums. Thesis for Master of Science, Graduate College of Bowling Green, Michaels, H.J., S.O. Rogers, and J.L. Bouzat (committee advisors). 62 pp.

Loope, L. L., A. C. Medeiros, and B. H. Gagne. 1991a. Aspects of the History and Biology of the Montane Bogs. Studies in Montane Bogs of Haleakalā National Park. Cooperative National Park Resource Studies Unit, University of Hawaii at Manoa. Technical Report No. 76.

Loope, L. L., A. C. Medeiros, and B. H. Gagne. 1991b. Recovery of Vegetation of a Montane Bog Following Protection from Feral Pig Rooting. Studies in Montane Bogs of Haleakalā National Park. Cooperative National Park Resource Studies Unit, University of Hawaii at Manoa. Technical Report No. 77.

Medeiros, A. C. and H. St. John. 1988. *Geranium hanaense* (Geraniaceae), a new species from Maui, Hawaiian islands. Brittonia 40:214-220.

Medeiros, A. C., L. L. Loope, and B. H. Gagne. 1991. Degradation of Vegetation in Two Montane Bogs: 1982-1988. Studies in Montane Bogs of Haleakalā National Park. Cooperative National Park Resource Studies Unit, University of Hawaii at Manoa. Technical Report No. 78.

Murakami, H., B. Wang, T. Li, and A. Kitoh. 2013. Projected increase in tropical cyclones near Hawaii. Nature Climate Change, 5 MAY 2013, DOI: 10.1038/NCLIMATE1890.

[USFWS] U.S. Fish and Wildlife Service. 2013. Endangered and threatened wildlife and plants; determination of endangered status for 38 species on Molokai, Lanai, and Maui; final rule. Department of the Interior, 78 FR 32014, May 28, 2013.

[USFWS] U.S. Fish and Wildlife Service. 2016. Endangered and threatened wildlife and plants; designation and nondesignation of critical habitat on Molokai, Lanai, Maui, and Kahoolawe; final rule. Department of the Interior, Federal Register 81 FR 17790, March 30, 2016.

[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. Federal Register 88 FR 20088, May 7, 2018.

[USFWS] 2019. Recovery outline for the islands of Maui, Molokaʻi, Kahoʻolawe, and Lānaʻi (Maui Nui). October, 2019.

Vecchi, G.A. and B.J. Soden. 2006. Global warming and the weakening of the tropical circulation. Journal of Climate 20: 4316–4340.

Vogl, R. J. and J. Henrickson. 1971. Vegetation of an alpine bog on East Maui, Hawaii. Pacific Science 25:475-483.

Wagner, W. L., D. R. Herbst, and S. H. Sohmer. 1999. Manual of the Flowering Plants of Hawaii. 1919 pp. in 2 volumes.

Yu, J., Y. Wang, and K. Hamilton. 2010. Response to tropical cyclone potential intensity to a global warming scenario in the IPCC AR4 CGCMs. Journal of Climate 23: 1354–1373.

U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW of *Geranium hanaense* (nohoanu)

Current Classification:

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:
Christina Richards, Fish and Wildlife Biologist, PIFWO
Lauren Weisenberger, Plant Recovery Coordinator, PIFWO
Megan Laut, Conservation and Restoration Team Manager, PIFWO

FIELD OFFICE APPROVAL:

MEGAN LAUT Digitally signed by MEGAN LAUT
Date: 2020.09.28 12:21:05 -10'00'
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for **Lead Field Supervisor, Fish and Wildlife Service**