Gesneria pauciflora
(no common name)

5-Year Review:
Summary and Evaluation

U.S. Fish and Wildlife Service
Southeast Region
Caribbean Ecological Services Field Office
Boquerón, Puerto Rico

5-YEAR REVIEW
***Gesneria pauciflora* (no common name)**

I. GENERAL INFORMATION

A. Methodology used to complete the review

On August 6, 2018, the U.S. Fish and Wildlife Service (the Service) published a notice in the *Federal Register* (83 FR 38320) announcing the 5-year review of the plant *Gesneria pauciflora* and requesting new information concerning the biology and status of the species. With this notice, we opened a 60-day public comment period but received no new information on *G. pauciflora* from the public.

This 5-year review summarizes new information regarding this plant since the previous 5-year review for the species was completed (USFWS 2013). In conducting this 5-year review (2nd round), we relied on the best available information on historical and current distributions, life histories, habitats, and potential threats to the species. Specific sources included peer reviewed scientific publications/reports; and unpublished field observations by the U.S. Fish and Wildlife Service, in addition to the final rule listing the species under the Endangered Species Act and the Recovery Plan.

B. Reviewers

Lead Region: Kelly Bibb, Southeast Region. (404) 679-7132.

Lead Field Office: Omar A. Monsegur-Rivera, Caribbean Ecological Services Field Office, Boquerón, Puerto Rico. (787) 851-7297, extension 217.

C. Background

1. Federal Register Notice citation announcing initiation of this review:

August 6, 2018; 83 FR 38320.

2. Species Status: Declining

The species is currently known from eight populations (watersheds) associated to the Maricao Commonwealth Forest, Puerto Rico, where it grows in rocky streambeds on wet serpentine rock. Throughout the year, the Caribbean ES Field Office has been very proactive in prioritizing research and surveys prior to Hurricane Maria, and the species was in its way to recovery. Landslides, flash floods, and storm damage (e.g., canopy opening) caused by impacts from Hurricane María in September 2017, severely affected the species habitat, and extirpated some populations. A post-hurricane assessment conducted by Pérez and Meléndez-Ackerman (2018) documented that colonies that were visited from March 21 to April 15, 2018, experienced 70 percent (%) mortality with seedlings experiencing the highest mortality rates relative to non-reproductive individuals and adult plants. Higher mortality rates were associated with higher losses of

percent canopy cover (greater exposure to sunlight and changes in microhabitat conditions), and the effects of flash floods. In addition, five out of seven colonies that went extirpated were located in first order streams, associated with higher volumes of water and sediments. Population growth rates (λ) estimated with IPM (Integral Population Models) and derived from 11 colonies (over 1,500 plants) that have been monitored for two years was about 0.5066 (LL = 0.4657, UL = 0.5546) suggesting that growth rate of these colonies would decrease annually by 50% if current conditions persist. However, similar declines can be extrapolated to all known colonies (Service 2019, unpublished data). A rapid assessment by Service staff (2019) shows habitat conditions and canopy cover remains open, with little seedling recruitment in most of the visited localities following two years of hurricane Maria.

3. **Recovery Achieved: 2** (2=26-50% species' recovery objectives achieved).

4. **Listing History**

   Original Listing
   FR notice: 60 FR 12483
   Date listed: March 7, 1995
   Entity listed: species
   Classification: threatened

5. **Associated rulemakings:** Not applicable.

6. **Review History:** On March 12, 2013 (USFWS 2013), the Service approved the 5-year review for *G. pauciflora*. This serves as a reference point document for this second round review.

7. **Species' Recovery Priority Number at start of review (48 FR 43098):** 11. *G. pauciflora* is recognized as a species with moderate degree of threat and low recovery potential.

8. **Recovery Plan:**
   Name of plan: Recovery Plan for *Gesneria pauciflora*.
   Date issued: October 6, 1998.

II. REVIEW ANALYSIS

A. Application of the 1996 Distinct Population Segment (DPS) policy

The Endangered Species Act (ESA or Act) defines species as including any subspecies of fish or wildlife or plants, and any distinct population segment of any species of vertebrate wildlife. This definition limits listing DPS to only vertebrate species of fish and wildlife. Because the species under review is a plant, the DPS policy is not applicable.

B. Recovery Criteria

1. Does the species have a final, approved recovery plan containing objective, measurable criteria? Although the species has an approved recovery plan with criteria to delist the species, the criteria are not fully measurable. The number of new self-sustainable populations needed to delist the species was not specified at the time the recovery plan was finalized. The Service has drafted amended recovery criteria for delisting, they are in the process of being signed.

2. Adequacy of recovery criteria

a. Do the recovery criteria reflect the best available (most up-to-date) information on the biology of the species and its habitat? No. The recovery plan does not specify the number of self-sustainable populations and number of individuals per population needed to delist the species.

b. Are all of the 5 listing factors that are relevant to the species addressed in the recovery criteria? No.

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.

The recovery plan specifies that *G. pauciflora* may be considered for delisting when:

1. A management plan that considers the protection and recovery of the species has been prepared and implemented for the Maricao Commonwealth Forest (MCF); and

2. New populations capable of self-perpetuation have been established within protected areas, such as other areas in the MCF or in the Susúa Commonwealth Forest.

The plan specifies that these criteria are minimum requirements, and could be expanded upon if the regenerative or propagative potential of natural and *ex situ* populations proves insufficient. The plan also indicates that, if new populations of *G. pauciflora* are discovered, it may be preferable to place greater emphasis on protection rather than propagation in order to achieve the minimum number of plants for recovery (number not specified).

Although a specific MCF management plan has not been completed, we believe criterion 1 has been partially met. The Service and the Department of Natural and Environmental Resources (DNER) have a signed Cooperative Agreement under Section 6 of the ESA to establish endangered species programs in Puerto Rico. The species is listed by DNER as vulnerable and Commonwealth laws and regulations appropriately protect the species and their habitats within public forests. All public forests managed by the DNER emphasize on the protection and conservation of species listed by the Commonwealth of Puerto Rico

and the Service. The MCF is also designated as a Critical Wildlife Area (CWA) by the Commonwealth of Puerto Rico. The CWA designation constitutes a special recognition by the Commonwealth with the purpose of providing information to Commonwealth and federal agencies about the conservation needs of these areas and assisting permitting agencies in precluding negative impacts because of permit approvals or endorsements. The MCF is protected by the Law #133-1975, as amended in 2000 ("Ley de Bosques de Puerto Rico" or The Puerto Rico Forest Law). Article 8, Section (a) of the Law protects the species by prohibiting damage to and collection of flora and fauna within public forests.

Criterion 2 has not been initiated. At present time, there is no information on establishment of new self-sustaining populations within protected areas. The recovery plan specifies that habitat requirements must be considered in order to ensure the success and relevance of transplanting propagated material. Propagation techniques for the species have not been developed.

C. Updated Information and Current Species Status

1. Biology and Habitat

a. Specie's abundance, population trends, demographic features, or demographic trends:

G. pauciflora is an endemic small gregarious shrub known to occur only on serpentine derived substrates with little or no soil formation and associated with wet habitats. At the time of listing and when the recovery plan was signed, only three populations of this small shrub were known to exist in the western mountains of Maricao and Sabana Grande municipalities. At present time, eight populations (watersheds) are known to exist in the western mountains of Maricao and Sabana Grande municipalities (Monsegur-Rivera, USFWS 2018-19, unpublished data). Two of the three known populations were located in the Maricao Commonwealth Forest (MCF). The third locality was located on a Lajas River tributary outside of the MCF boundaries. Herbarium specimens indicate that the species has also been collected in the past from the Yagüez River and from "Cerro Las Mesas" in the Mayagüez municipality, but these sites have not been intensively surveyed (USFWS 2013). The largest population along the Maricao River locality has been estimated at approximately 1000 individuals and another population at 50 (Seco River locality; USFWS 2013, USFWS 1998).

In 2018, Pérez and Meléndez-Ackerman (2018) conducted an assessment after Hurricane María. Colonies were visited from March 21 to April 15, 2018. Numbers of individuals at each stage were counted in each colony (seedling, non-reproductive and reproductive). For each individual, the largest branch was measured and the number of inflorescences, flowers, fruits and the frequency of floral herbivory were also recorded. Individuals were considered reproductive if their larger branch was > 15 cm, if smaller individuals presented reproductive structures its largest branch was measured as well. If new colonies were found, these were georeferenced and measurements were taken as well. They

documented 7,853 individuals (8.5% seedlings, 65.2 % non-reproductive and 25.3% potentially reproductive or larger than 15 cm) but only 397 had active reproductive structures. In the 2,068 reproductive adults they observed, they reported 105 developing inflorescences, 375 flower buds, 76 flowers and 1,914 fruits. Plants at localities that were studied for two years, experienced a 70% mortality with seedling experiencing the highest mortality rates relative to non-reproductive individuals and adult plants. Canopy loss and colony location seem to influence plant mortality. Higher mortality rates were associated with higher losses of percent canopy cover. In addition, five out of seven colonies that went extirpated were located in first order streams. Seventy six % of the colonies had plant species that could potentially compete for space following the hurricane disturbance. Population growth rates (λ) estimated with IPM (Integral Population Models) and derived from 11 colonies (over 1,500 plants) that have been monitored for two years were about 0.5066 (LL = 0.4657, UL = 0.5546) suggesting that growth rate of these colonies would decrease annually by 50% if current conditions persist (Pérez and Meléndez-Ackerman 2018). Monitoring of populations along the main river channel and the tributaries prior to hurricane María show a λ ranged from 0.9114 to 0.9865 (Perez et al. 2019). Thus, the findings of Pérez and Meléndez-Ackerman (2018) addressing the status of the species prior to the hurricane show a clear impact from hurricane María on the population's trends and species viability.

Despite the morphology-pollinator syndrome fit, average nectar concentration values were somewhat atypical for hummingbird-pollinated flowers. Nectar concentration range values in *G. pauciflora* (0–13%) were in the lower end of those reported for hummingbird-pollinated species in continental areas (Pérez et al. 2018).

b. Is there relevant new information regarding the species' genetics, genetic variation, or trends in genetic variation (*e.g.*, loss of genetic variation, genetic drift, inbreeding, etc.)? No.

c. Is there relevant new information regarding taxonomic classification or changes in nomenclature? No.

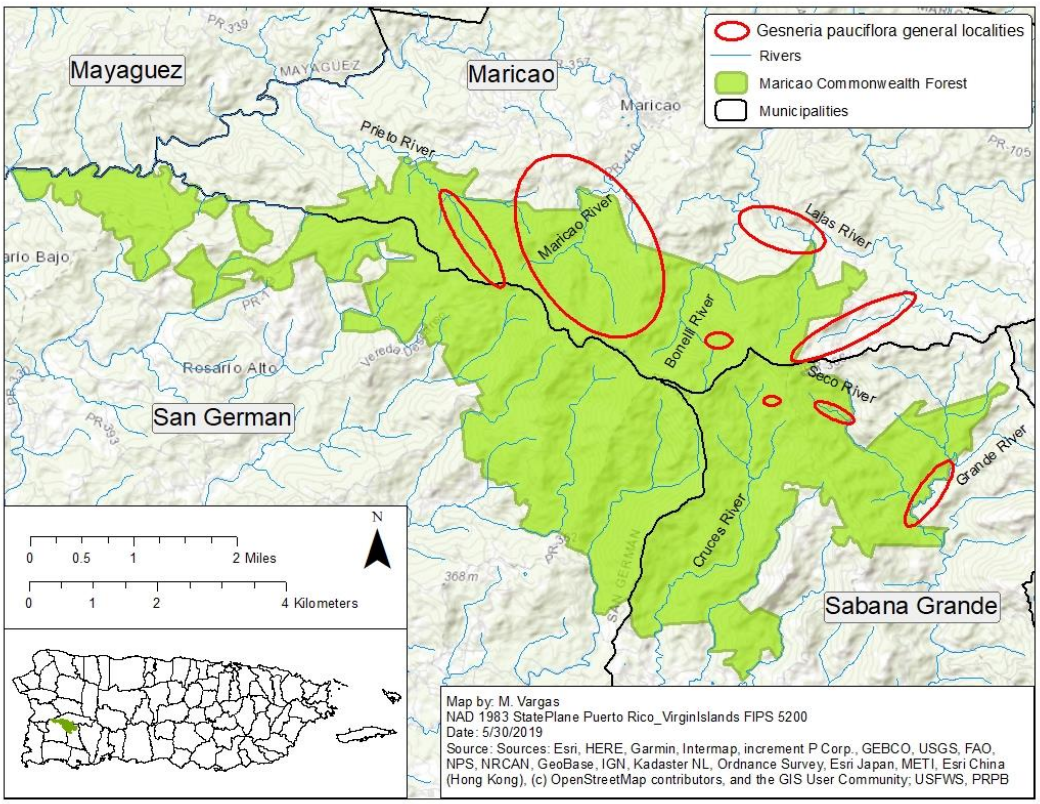
d. **Species' spatial distribution, trends in spatial distribution (*e.g.*, increasingly fragmented, increased numbers of corridors, etc.), or historic range (*e.g.*, corrections to the historical range, change in distribution of the species within its historic range, etc:**
Geographic information gathered prior to Hurricane Maria, indicates that *G. pauciflora* is more widely distributed within the MCF. This information was gathered throughout field surveys conducted by Service staff from the Puerto Rican Parrots Recovery Program in Maricao, and two projects funded by the Service "Population status and gene bank development of *Varronia bellonis*" and: "Biogeography and reproductive biology of the endangered species *Varronia bellonis*" (USFWS unpublished data). These efforts positively resulted in the

finding of new populations of *G. pauciflora* as well as other endangered species listed, in different watershed within MCF, including the Maricao River, Prieto River, Bonelli River, Lajas River and Grande River in the municipality of Sabana Grande. In these watersheds, *G.pauciflora* was found in the main river channels and their tributaries. In September 2017, Hurricane María severely affected these watersheds, causing vegetation damage, landslides, and floods that affected the steep, unstable slopes associated with this species' habitat ((Monsegur-Rivera, USFWS 2017)).

An assessment after Hurricane María conducted by Pérez and Meléndez-Ackerman (2018) documented sixty-eight sites (49 previously known, 12 new and 7 presumed to be extirpated). Colony sizes varied from 4 to 476 individuals with larger colonies concentrated in the upper side of the watersheds. Out of the 61 colonies visited with living plants, one was in a third order stream (in the upper part of the river basins), 27 were in a second order stream, and 35 were in the main channel of the river basins (first order streams). The seven colonies extirpated were mostly located in first order streams. From the 61 live colonies, 21 were located out of the limits of the Maricao Commonwealth Forest. An interesting finding is that some of these colonies had a greater number of plants; thus, the authors recommended to monitor these colonies due to the potential changes in land use by urban development (Pérez and Meléndez-Ackerman 2018). Overall, colonies located in the main channel of the Maricao River scored the highest mortality rate compared with those distributed in tributaries. Out of 68 sites, 26 (41.2%) were either affected or near a landslide. The extirpation of five out of seven colonies were due to landslides associated to Hurricane María.

The recent findings of at least 7 colonies along the head waters of Grande River (municipality of Sabana Grande) is a significant contribution on the information on the species distribution and habitat as these are the eastern most and southern most localities for the species (O. Monsegur-Rivera, Service, pers. obs. 2018-2019). These localities are exposed to drier conditions, more sunlight and higher temperatures, thus plant material at these sites is adapted to such conditions, and its conservation may be critical for the long-term recovery of the species. However, despite these new findings, the species continue to be restricted to serpentine soils along river margins.

Figure 1. Populations of *G. pauciflora* at Maricao Commonweatlh Forest and adjacent areas. Populations are defined based on watershed (USFWS 2013 and USFWS unpublished data).



e. Habitat or ecosystem conditions (*e.g.*, amount, distribution, and suitability of the habitat or ecosystem).

In the previous 5-year review, all colonies observed were associated with wet environments and most were on steep rock faces. Most had colonized the east side of the river and we observed some individuals submerged along the river's edge. The largest colonies were also located at the headwaters within the Maricao River watershed, an area considered as a remnant of pristine vegetation (USFWS 2013).

During February through August 2017, Service personnel from the Puerto Rican Parrot Recovery Program visited several sites within the MCF to conduct radio telemetry searches and explore areas following the November 2016 parrot release. During the searches at least 38 new sites of *G. pauciflora* were found at the MCF. The new sites were located at Indiera Fria ward (Lajas River watershed), a small creek in road to Salto Curet (Lajas River tributary), a small creek tributary (Maricao River) and Santa Rita's creek (Maricao River tributary). During the visits, each site was marked, GPS location acquired and amount of individuals counted. At Indiera Fria, Service biologists recorded at least 15 sites of this species and they were located within the Lajas River waterhead in Indieras Ward. This locality represents the highest elevation for the species - 771 meters above sea level (J. Ríos-Cruz, Service, pers. obs. 2017, Fig 2). Most of the findings were frequently found in areas associated with wet environments and most were on steep rock faces and in some of the new sites the amount of individuals were too many to count. (J. Ríos-Cruz, Service, pers. obs. 2017, Fig 2).

However, soon after these findings, Hurricane María destroyed some of these areas due to massive landslides and washing off the individuals from the rocks due to the excessive over-flooding of the river. The Service conducted a rapid post-hurricane assessment and determined that at least one of the largest known populations of *G. pauciflora* was affected by deforestation and erosion due to a landslide, resulting in the loss of about 75% area occupied by the species (Pérez and Meléndez-Ackerman 2018). .

In April 2019, Service biologist with researchers from the Kew Botanical Garden and volunteers recorded 7 additional new sites along a portion of the Grande River watershed in Sabana Grande municipality. This locality represents new information for the species. This new information represents the lowest elevation above sea level and the locality is considered the most southern finding of the species (Monsegur pers. comm. 2019).

Figure 2. New site in Rio Lajas headwater found by J. Rios Cruz Service Biologist showing a serpentine wall completely covered with *G. pauciflora* (photo M. López Flores, USFWS).

Although the current habitat for the species has not significantly suffered due to human disturbances, Hurricane María did affect the current habitat and ecosystem conditions in several areas where *G. pauciflora* was observed (Table 1).

Table 1. *G. pauciflora* estimated loss of individuals (%) at known populations (Monsegur-Rivera, USFWS 2017).

Locality Name	Loss of individuals (%)	Note
Río Maricao	80 %	Extensive damage to known populations and no evidence of flower production
Vereda del Infierno	75 %	Remnant cluster of individuals with flowers and appearing healthy
Río Lajas (Salto Curet)	80 %	Extensive damage to population and some remnant individuals flowering
Río Bonelli	70 %	Loss of individuals estimated based on aerial images and evidence of landslides.
Indieras Fria	20 %	Little damage to population and habitat

An evaluation of post-Hurricane Maria aerial images from an area that contained the largest known population of *G. pauciflora* at the headwaters of the Río Maricao, showed that extensive landslides occurred during the hurricane. These observations were validated on December 14, 2017 during a hike along *Vereda Los Viveros* where at least three massive landslides were recorded (Monsegur-Rivera, USFWS 2017). Similarly, habitat damage/modification due to landslides was observed in aerial images of the upper headwaters of the Río Bonelli associated to a population of *G. pauciflora* recently recorded by University of Puerto Rico, Rio Piedras campus (UPRRP) researchers. Although this area was not visited due to its inaccessibility (absence of trails), the Service also anticipated significant loss of individuals as well ((Monsegur-Rivera, USFWS 2017)). The landslide created an opening in the canopy, this species is commonly found and associated with wet environments and most were on steep rock faces. Due to the excessive entrance of sunlight due to the landslides and fallen trees, some of these areas might have been affected by changing the microhabitat conditions of the species increasing temperature and decreasing humidity conditions. In addition, some steep rocks walls might have been affected and the substrate conditions might have been eliminated due to the massive over-flooding of the river. Further information needs to be gathered to determine the current status of these areas and if the forest has recovered sufficiently to provide the needed conditions for the species.

f. **Other relevant information**. Perez et al. (2018) documented an overall low visitation rate of pollinators (hummingbirds), averaging 0.07 visits/plant/hour. Observations conducted outside the month of September and October did not capture any flower visits by pollinators. Zumbador Verde (*Anthracocorax viridis)* and Zumbadorcito de P.R. (*Chlorostilbon maugaeus)* were the only pollinators recorded visiting flowers of *G. pauciflora* during field

observations. Hummingbirds visited flowers only in the morning from 7:00 to 11:00 AM with a maximum visit time length of approximately three seconds. Hummingbird species were observed flying around all sites most of the time (determined by sight or sound) resting, bathing, or foraging on other species during scheduled and non-scheduled observations periods (Perez et al. 2018). The rationale for this might be that there are temporal differences in flower nectar concentration in *G. pauciflora* and that might explained why hummingbirds only visited flowers in the morning (Perez et al. 2018).

As part of his studies in the reproductive biology and ecology of *G. pauciflora* Pérez-Pérez (2018) found that seed germination rate is high (> 55%, under laboratory conditions), which could facilitate the development of propagation protocols using seeds to establish recovery strategies when needed. Although the time needed to reach a reproductive size (reproductive adult) would be higher using this propagation technique, the use of the seed could help to promote higher genetic diversity within the populations.

Pérez-Pérez (2018) indicates that the presence of autogamy (or self- pollination) may represent a mechanism of reproductive assurance from unpredictable environmental factors (low pollinator visitation rates, flash floods or hurricane disturbances). Despite this, he found *G. pauciflora* was pollinated by two hummingbird species and that visitation rates were low, likely due to low nectar rewards. Pérez-Pérez (2018) indicates fruit set and seed production were significantly higher in flowers when pollen was artificially delivered (self- and cross-pollination) compared to when it was not (control and autogamy), suggesting that reproduction is pollen-limited. Therefore, data indicates *G. pauciflora* is a self-compatible species capable of producing fruits and seeds via autogamy (Pérez et al. 2018). In the wild, individual plants produce an average of 140.3 (±26.2) healthy seeds with germination rate under laboratory conditions estimated at 67.5% (±8.1%; Pérez et al., 2018). Flowering and fruiting occur throughout the year; however, peaks occur during the wet and dry season, respectively (Pérez et al., unpublished data).

2. Five-Factor Analysis

(a) Present or threatened destruction, modification, or curtailment of its habitat or range:

Of the eight currently known populations, five populations are located within the MCF and three populations are within private land properties. Habitat destruction and modification caused by anthropogenic activities in 5 of the 8 populations (63 % of the populations) are not anticipated since the areas are managed for conservation by the PRDNER.

One of the sites located in a privately-owned property at Indiera Fria Ward was visited in December 2017, to continue documenting the effects of Hurricane

Maria. Although neither the species' habitat nor the known colonies there were severely affected by hurricane, the site adjacent to the river is currently threatened by a privately-owned quarry. The river basin and species habitat are being affected by earth movement and ground cuts at the quarry. We observed that as result of the earth movements, gravel material is thrown to the river basin where the species is present (J. Ríos-Cruz pers. obs. 2017). During the site visit, we observed that PVC pipelines have been used to provide a source of water for the communities near the area. This practice may affect individuals if PVC pipelines are installed without knowledge of the presence of the species at the site. In addition, we documented the use of some of the areas as garbage dumping sites, affecting the habitat were the species is located. The site overall is a mosaic of privately- owned serpentine habitat, some extent of agricultural lands, rural development and the quarry. Due to the agricultural practices the use of pesticides, fertilizer, movement of terrain and erosion might be affecting the current habitat for the species in the watershed. (J. Ríos-Cruz, Service pers. obs. 2017).

On April 2017, while conducting radio telemetry on released parrots, the Lajas River tributary was visited to observe the *G. pauciflora* habitat. The Lajas River is a privately owned land outside of the boundary of the forest. The presence of PVC pipe structures at the river were documented in the 2013 5year review and during the 2017 site visit. This structure was used as source of water intake for the communities near this river. The main problem with this type of structure is that the landowners damage and modified the vegetation surrounding the pipelines while conducting maintenance and repair activities. We observed the use of machete while clearing the area, and we documented damage to another endangered species (i.e., *Crescentia portoricensis*) due to this type of activity (J. Ríos-Cruz, Service, pers. obs. 2017). The dirt road leading up to the tributary is open to the public and we observed five all-terrain vehicles heading up the road, possibly contributing to erosion on that locality (USFWS 2013). This locality is adjacent to a highly visited waterfall and natural pool area known as "Salto Curet". The human activities in the area may contribute to erosion of the small tributary and may modify the habitat conditions needed by the species. If the access to the "Salto Curet" area is expanded, or amenities are developed, these activities may affect the individuals at this locality. Currently these threats are still present in this site as seen in the most recent visit to the area (USFWS 2013).

Based on the above, we believe that the species continues to be threatened by habitat destruction and modification.

(b) Overutilization for commercial, recreational, scientific or educational purposes:

At present time, we are not aware of overutilization of this species for commercial, recreational, scientific or educational purposes. We believe that this factor should not be considered a threat for the species.

(c) Disease or predation:

Ongoing monitoring studies under the Cooperative Agreement with the University of Puerto Rico, Rio Piedras campus has shown that bud and flower predation is not uncommon in *G. pauciflora.* A total of 119 buds distributed across 15 plants were monitored and 24.37% were parasitized by a plume moth of the family Pterophoridae. Future phenology studies, currently on planning stage, will help us identify the extent by which this herbivore is capable of affecting reproduction in *G. pauciflora.* At this time, we believe that this factor should not be considered a threat to the species since additional information is needed to determine the degree of flower predation on *G. pauciflora,* and the potential risk for this species (limiting fruit production).

Approximately twelve percent from the 131 plants used in the breeding system experiment exhibited some degree of floral herbivory by the plume-moth *Postplatyptilia caribica* or by other unidentified insects (Pérez et al. 2018, Matthews and Pérez 2014).

(d) Inadequacy of existing regulatory mechanisms:

At the present time, this plant is protected under Commonwealth's Law No. 241-1999 (12 L.P.R.A. Sec. 107), known as *Nueva Ley de Vida Silvestre de Puerto Rico* (New Wildlife Law of Puerto Rico). The purpose of this law is to protect, conserve and enhance both native and migratory wildlife species; declare property of Puerto Rico all wildlife species within its jurisdiction, regulate permits, regulate hunting activities, and regulate exotic species among others activities. This law also has provisions to protect habitat for all wildlife species, including plants. In 2004, the PRDNER approved Regulation 6766 or *Reglamento para Regir el Manejo de las Especies Vulnerables y en Peligro de Extinción en el Estado Libre Asociado de Puerto Rico* (Regulation 6766: To govern the management of threatened and endangered species in the Commonwealth of Puerto Rico). Article 2.06 of Regulation 6766 prohibits collecting, cutting, removing, among other activities, listed plant individuals within the jurisdiction of Puerto Rico (DRNA 2004, p. 11). The provisions of Law No. 241-1999 and Regulation 6766 extend to private lands. However, the protection of listed species on private lands is challenging as landowners may damage those species (*e.g.*, by cutting, pruning, or mowing) unaware they are protected species. At present, DNER designated *G. pauciflora* as vulnerable. Regulation 6766 under Article 2.06 prohibits collecting, cutting, removing, among other activities, listed plant individuals within the jurisdiction of Puerto Rico.

G. pauciflora in both public and private lands, sometimes the enforcement of such legal mechanisms on private lands is challenging. For example, accidental damage to individuals may occur due to lack of knowledge of the species by

private landowners or their contractors while cleaning vegetation, installing PVC lines at the river or constructing trails within their properties. On other hand, the knowledge of natural range of this species has increased since the time of listing, and the species has been recorded in new areas, subject to disturbance adjacent to riparian habitats. In such cases, despite the existence of regulatory mechanisms, habitat modification could have occurred in these newly documented areas (e.g., Indiera Fria, Salto de Curet). Thus, current regulatory mechanisms ameliorate the potential adverse impacts on private lands, but enforcement of such mechanisms continues to be a challenge. Thus, this factor is considered to be a threat to the species.

(e) Other natural or manmade factors affecting its continued existence:

In the 2013 *G. pauciflora* 5-year status review, we indicated that the species habitat may affected by natural disturbances such as heavy rains, floods, landslides and storm damage, and that these effects further aggravated by tropical storms and hurricanes in Puerto Rico. On September 20, 2017, Hurricane Maria had a direct impact on the island of Puerto Rico, and the area of MCF was affected by sustained winds of approximately 115 mph. Modeling of the wind impacts from Hurricane Maria indicates it caused the mortality or severe damage to 23 to 31 million trees, thus causing catastrophic damages to the forest structure (Feng et al. 2018). In addition, a post hurricane assessment of the MCF showed that watersheds were subject to catastrophic landslides that altered the river margins due to erosion and sedimentation (Monsegur-Rivera, USFWS 2017)). Data from the pluviometer (instrument to measure precipitation over time) at the PRDNER Fish Hatchery (MCF), recorded the instrument over-flooded at its maximum capacity of 25 inches (J. Rios-Cruz 2017, pers obs.). On November 2, 2017, a field visit was conducted by an Interagency team (i.e., PRDNER and Service) to survey the habitat along the Río Maricao (upstream from the PRDNER Fish Hatchery) to document the impacts of Hurricane Maria on *G. pauciflora*, *Varronia bellonis* and *Crescentia portoricensis*. Further habitat assessments along Río Lajas (Salto Curet) and the upper watershed of the Río Lajas towards road PR 366 (above a water intake from the Puerto Rico Sewage and Aqueducts Authority (PRASA) (Indieras Fria) were conducted on December 6-7, 2017 by Service biologist. An additional survey was conducted on December 14 by a Service biologist to evaluate the headwaters of the Río Maricao along the trail known as *Vereda Los Viveros*. Along the margins of the Río Maricao, flash floods and landslides adversely affected all known populations, losing about 80% of the individuals or area covered by the species tagged during the University of Puerto Rico study for this species (Perez et al. 2018, Monsegur-Rivera, USFWS 2017)). Furthermore, evaluation of post-Hurricane Maria aerial images from an area that contained the largest known population of *G. pauciflora* at the headwaters of the Río Maricao, showed extensive landslides associated to Hurricane Maria. These observations were validated at *Vereda Los Viveros* where at least three massive landslides were recorded by Service staff. The area containing one of the largest known populations of *G. pauciflora* was deforested

and eroded due to a landslide, resulting in the loss of about 75% area occupied by the species. Similarly, habitat damage/modification due to landslides was observed in aerial images of the upper headwaters of the Río Bonelli associated to a population of *G. pauciflora* recently recorded by UPRRP researchers ((Monsegur-Rivera, USFWS 2018)).

The only populations of *G. pauciflora* that showed little or no disturbance due to flashfloods or landslides were located along the upper watershed of Río Lajas (Indiera Fria Ward), above the PRASA water intake. Service staff identified at least three big populations on the steep margins of the river. This branch of the watershed was less affected by landslides and flooding probably because of its small size. Nonetheless, this population remains threatened by habitat modification due to development and agriculture (See Factor A.).

The upper watershed of Lajas River in the Indiera Ward in comparison with other river basin in MCF was less affected than other sites visited after Hurricane Maria. We did not observe evidence of extirpation of any known populations. However we suspect that in the Lajas River upper watershed one of the main reasons why the species did not suffer as much as other sites, might be because this is a short river segment (i.e., 1 kilometer length) and provides less catchment area, thus resulting in smaller flash floods affecting *G. pauciflora* (J. Ríos-Cruz pers. obs. 2017).

It has been documented that hurricanes may reduce vertebrate pollinators and be a selective force favoring breeding mechanisms that provide reproductive assurance (Rivera-Marchand and Ackerman 2006; Rojas-Sandoval and Meléndez-Ackerman 2011). A study conducted after Hurricane Hugo with hummingbirds populations at El Yunque National Forest showed dramatically decrease in northeast Puerto Rico (Wunderle 1995). However, different findings were reported at the MCF following Hurricane Georges (a category 3 hurricane) showing an increase in hummingbird capture rates two years after the hurricane event even when other bird populations decreased or disappeared from the study site (Tossas 2006). Although these studies provide conflicting information, it is very difficult to rule out that an event at a larger magnitude like Hurricane Maria may definitely lower hummingbird populations and create even worse conditions for possible pollinators. This may be even more critical for *G. pauciflora* than for other *Gesneria* in Puerto Rico since this species exhibits higher pollination limitation index and lower auto-fertility of all tubular species combined and may explain its rarity (Perez et al. 2018).

Pérez and Mélendez-Ackerman (2018), suggested that hurricanes and extreme events alike may threaten population persistence through direct (floods, landslides) and indirect (e.g. habitat change, changes in plant-herbivore interactions) effects. It has been suggested that population models and the trend of *G. pauciflora* using pre-hurricane data were slowing decreasing but that the number of individuals per colony was highly variable and in some cases very

small (patch size range: 1-200; Perez et al. unpublished). Small patchy populations may be more susceptible to extinction than large patches (Mortelliti et al. 2014) but these risks may also be influenced by how exposed were individual populations to hurricane impacts. Understanding how different population size changes in response to an extreme atmospheric event like Hurricane María is very relevant to address the optimal population sizes as a way to cope with hurricane hazards (Pérez and Mélendez-Ackerman 2018).

Based on the above, we believe that the species is currently threatened by other natural and manmade factors.

3. Synthesis

G. pauciflora is an endemic small gregarious shrub known to occur only on serpentine derived substrates with little or no soil formation and associated with wet habitats. It was listed as threatened in 1995 because of an extremely limited distribution and because of habitat threats.

At the time of listing and when the recovery plan was signed at least 1,050 individuals in three populations were known to exist in the western mountains of Maricao and Sabana Grande municipalities. At present, new populations, sites and record of distribution of the species have been recorded demonstrating that the species is more widely distributed in the MCF and adjacent suitable habitats. The species is currently known from eight populations (watersheds) within and adjacent to the MCF with an estimated population of 7,853 individuals prior to Hurricane María. Population assessments conducted after Hurricane Maria, documented severe damage to populations, and documented extirpation in first order streams. *G. pauciflora* experienced a 70% mortality with seedlings experiencing the highest mortality rates relative to non-reproductive individuals and adult plants. Higher mortality rates were associated with higher losses of percent canopy cover. Estimated population growth rates (λ) derived from 11 colonies that have been monitored for two years suggest that growth rate of these colonies would decrease annually by 50% if current conditions persist.

The species is currently threatened by Factor A, D and E. Human activities that cause habitat disturbance may adversely affect susceptible colonies, particularly those outside of the MCF boundaries. Landslides, storm damage and floods adversely affect the species' habitat and resulted in significant loss of individuals and its habitat. Thus, the Service continues to believe that the species meet the definition of a threatened species.

III. RESULTS

A. Recommended Classification:

__X__ No change is needed

B. New Recovery Priority Number: No change.

IV. RECOMMENDATIONS FOR FUTURE ACTIONS

Develop propagation techniques, establish *ex situ* populations in botanical gardens, and introduce individuals in protected areas.

Establish a once a year monitoring schedule for known populations and after any significant weather event (i.e. hurricanes).

Conduct studies of the known populations to determine intra- and inter-population genetic diversity.

Conduct studies to evaluate the degree of threat that flower predation in *G. pauciflora* represents a potential risk for this species (limiting fruit production).

Conduct studies to evaluate if common pioneer species of riparian areas are potential habitat competitors for *G. pauciflora*.

Select appropriate sites for population reintroduction in areas that exhibit the serpentine habitat requirements outside the MCF.

Explore the opportunity to enter into a Service Partner's for Fish and Wildlife Agreement with the landowner to conserve the area and restore suitable habitat for the species (e.g. Indieras Ward site).

IV. REFERENCES

Breckon, G.J. and D.A. Kolterman. 1994. Final Report on *Gesneria pauciflora*. Cooperative Agreement No. 1448-0004-93-973 between the U.S. Fish and Wildlife Service and the University of Puerto Rico, Mayagüez Campus.

Breckon, G.J. and D.A. Kolterman. 1996. Final Report on *Gesneria pauciflora*. Cooperative Agreement No. 1448-0004-94-9113 between the U.S. Fish and Wildlife Service and the University of Puerto Rico, Mayagüez Campus.

Center for Plant Conservation. 1992. Report on the rare plants of Puerto Rico. Center for Plant Conservation, Missouri Botanical Garden, St. Louis, Missouri.

Department of Natural and Environmental Resources. 2004. Reglamento para Regir el Manejo de las Especies Vulnerables y en Peligro de Extinción en el Estado Libre Asociado de Puerto Rico. 60pp.

Feng, Y, R. I. Negron-Juarez, C. M. Patricola, W D. Collins, M. Uriarte, J.S. Hall, N. Clinton, J. Q. Chambers. 2018. Rapid remote sensing assessment of impacts

from hurricane Maria on forests of Puerto Rico. Preprint at https://peerj.com/preprints/26597/.

Matthews, D. L. and M. E. Perez. 2014. Description of the natural history and immature stages of *Postplatyptilia caribica Gielis* in Puerto Rico (Lepidoptera: Pterophoridae). Zootaxa 3821 (3): 363–372pp.

Monsegur-Rivera, O. A. 2017. Assessment on the impacts caused by Hurricane Maria on the known populations of *Gesneria pauciflora* in the Maricao Commonwealth Forest and adjacent lands. Us Fish and Wildlife Service. 10pp.

Mortelliti, A., G. Sozio, D.A. Driscoll, L. Bani, L. Boitani, D.B. Lindenmayer. 2014. Population and individual-scale responses to patch size, isolation and quality in the hazel dormouse. Ecosphere 5(9): 17 http://dx.doi. org/10.1890/ES14-00115.1.

Pérez-Pérez, M. 2018. Threatened or naturally rare? Assessing the reproductive biology and ecology of Gesneria pauciflora, and endemic plant species from Puerto Rico. Ph. D. Thesis. University of Puerto Rico. 129pp.

Pérez, M. and E. Meléndez-Ackerman. 2018. Post María Assessment of Gesneria pauciflora, a threatened herbaceous species endemic to the Maricao Forest Reserve, Puerto Rico. Final Report Agreement No. F16AC00894. 22pp.

Pérez, M. E, E. Meléndez-Ackerman and O. A. Monsegur-Rivera. 2018. Breeding system and pollination of Gesneria pauciflora (Gesneriaceae), a threatened Caribbean species. Flora 242; 8-15 pp.

Rojas-Sandoval, J., Meléndez-Ackerman, E., 2011. Wind-facilitated self-pollination in Harrisia portoricensis (Cactaceae): a mechanism for reproductive assurance. Int. J. Plant Reprod. Biol. 3, 1–5.

Rivera-Marchand, B., Ackerman, J.D., 2006. Bat pollination breakdown in the Caribbean columnar cactus Pilosocereus royenii. Biotropica 38, 635–642.

Tossas, A., 2006. Effects of hurricane Georges on the resident avifauna of Maricao State Forest, Puerto Rico. Caribb. J. Sci. 42, 81–87

U.S. Fish and Wildlife Service. 1998. Recovery Plan for *Gesneria pauciflora*. Atlanta, Georgia. 16pp.

Wunderle Jr., J.M., 1995. Responses of bird populations in a Puerto Rican forest toHurricane Hugo: the first 18 months. Condor 97, 879–896.

U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW of *Gesneria pauciflora* (No common name)

Current Classification: Threatened

Recommendation resulting from the 5-Year Review:

_____ **Downlist to Threatened**
_____ **Uplist to Endangered**
_____ **Delist**
_X_ **No change is needed**

Review Conducted By: Jesús M. Ríos-Cruz Caribbean Ecological Services Field Office

FIELD OFFICE APPROVAL:

Edwin E. Muñiz, Lead Field Supervisor, U.S. Fish and Wildlife Service

Approved By: Edwin Muñiz Date 9/11/2019