

Species Report
for
Solanum guamense



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EXECUTIVE SUMMARY

The Species Report is a document that uses the best available data to give an up-to-date report of the condition, population, and distribution trends of the species *Solanum guamense*, a medium-sized shrub in the nightshade family listed as endangered in 2015 (USFWS 2015, entire). The Species Report provides an assessment of the needs of the species, habitat type, and the state of research and looks at the current status, threats, and viability. This document is intended to provide a biological basis for decisions made under the Endangered Species Act and to inform related documents. In and of itself, this document is not regulatory in nature.

For the purposes of this assessment, we define viability as the capacity to maintain populations in natural ecosystems over time. The Species Report uses the conservation biology principles of resiliency, redundancy, and representation (collectively known as the 3Rs) as a lens to evaluate the current condition and viability of the species. The viability analysis of *Solanum guamense* is done by describing what the species needs to be resilient (healthy populations), redundant (numerous populations), and represented (maintain genetic diversity). Resiliency is described based on the metric of population size. Redundancy is based on the metric of the distribution and number of populations across the geographic range of the species. Finally, representation is based on the metric of the number of populations within unique habitat types occupied by the species.

To conduct the assessment of *Solanum guamense*, literature reviews were completed, experts consulted, and data gathered. Much of this information is from government reports and studies funded by the Department of Defense and the U.S. Fish and Wildlife Service. This species is endemic to the Mariana Islands and has limited data and research, likely due to limited access to areas and difficult terrain. Historically, *Solanum guamense* likely occurred on seven islands within the Mariana Archipelago (Guam, Rota, Saipan, Tinian, Asuncion, Guguan, and Maug); however, in recent decades it was only known from the island of Guam. Currently, all known populations have been extirpated. The last known individual on Guam was documented in 1994. Given that suitable habitat still persists on a number of islands and surveys have been limited in scope and frequency, it is possible that populations persist on both Guam and other islands. There are no known seeds or genetic material stored in a seed bank, nursery, garden, or any *ex situ* conservation facility for this species.

Given the relative absence of information on the species, little is known about the species' life history and population needs. Where possible, we use information from the genus *Solanum* to assist in the analysis of this Species Report. Threats to the viability of the species, such as development and feral ungulates, cause declines in habitat quality and quantity. As threats remain largely uncontrolled, the potential to rediscover this species decreases over time. Additional threats include habitat degradation by invasive brown treesnakes, predation by rats, and impacts of climate change, including declines in habitat quality, increased period of droughts, and increased severe storm frequency.

Under historic conditions for *Solanum guamense*, data indicate that there was high quality and quantity of suitable habitat to support the species. Our analysis of the historic condition concludes that the resiliency, redundancy, and representation, for the species were all high. Therefore, we conclude that the viability of *S. guamense* was also high under historic conditions.

For our analysis of the current conditions of *Solanum guamense*, we conclude that the lack of any known populations has compromised the range-wide resiliency, redundancy, and representation of the species. Therefore, we expect that any existing, yet to be discovered, populations of *S. guamense* would be particularly vulnerable to direct and indirect impacts from all of the threats listed above. Given that *Solanum guamense* has not been observed since 1994, and there are no known populations, we conclude that the species' current resiliency, redundancy, and representation are all extremely low. Consequently, we determine that the viability of *Solanum guamense* under current conditions is extremely low.

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INTRODUCTION

Solanum guamense is a small shrub in the nightshade family (Solanaceae). It was previously found on northern Guam as well as on several islands (Rota, Saipan, Tinian, Asuncion, Guguan, and Maug) in the Commonwealth of the Northern Mariana Islands (CNMI) (Fig. 1). However, the last population was seen on Guam in 1994 (Perlman and Wood 1994, pp. 135–136). There are currently no known populations nor any remnant individuals.

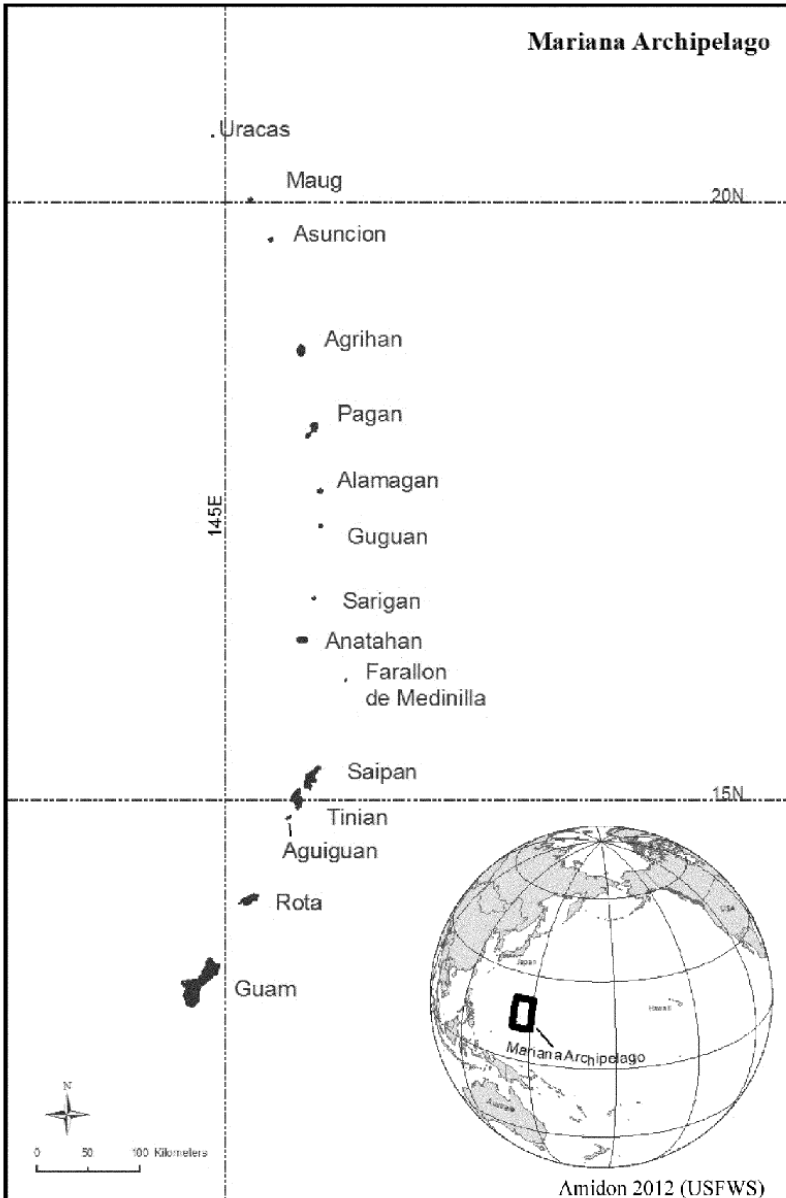


Figure 1. Map of the Mariana Archipelago

Overview

This Species Report (SR) summarizes the biology and current status of *Solanum guamense* and was conducted by the Pacific Islands Fish and Wildlife Office; part of the United States Fish and

Wildlife Service (USFWS). The Species Report provides an in-depth review of the species' biology, factors influencing viability (threats and conservation actions), an evaluation of its current status and viability, and the resources and conditions needed to maintain viability for the long term.

The intent is for the Species Report to be easily updated as new information becomes available, and to support all functions of the Service's Endangered Species Program. As such, the Species Report will be a living document that informed Endangered Species Act (ESA) decisions and related documents such as recovery plans, 5-year reviews, consultations, and species reclassifications.

Regulatory History

Solanum guamense was proposed for listing as an endangered species on October 1, 2014 (79 FR 59364) with a 60 day comment period. Due to requests made during this comment period, the comment period was re-opened on January 12, 2015 (80 FR 1491) for 30 days, during which time we held public hearings on Guam (January 27, 2015) and Saipan (January 28, 2015). Public information meetings were held preceding each of the two public hearings on Guam and Saipan, as well as independently on Rota (January 29, 2015) and Tinian (January 31, 2015). In a final rulemaking published on October 1, 2015 (80 FR 59424), *S. guamense* was added to the List of Endangered and Threatened Plants (CFR §17.12) as an endangered species. To date, no critical habitat has been designated for this species.

Methodology

We used the best scientific and commercial data available to us, including peer-reviewed literature, grey literature (government, academic, business, and industry reports), and expert elicitation. *Solanum guamense* has not been observed often and has only been included in surveys to document threatened and endangered species on land set for development, generally on Department of Defense (DoD) lands. Because little information is available about *S. guamense*, we also asked local experts for their recommendations on whether there was information on other closely related species that could help fill in the data gaps.

The SR assesses the ability of *Solanum guamense* to maintain viability over time. The viability of a species is its ability to sustain a population over time, *i.e.*, likelihood of avoiding extinction. To assess the viability of *S. guamense*, we used the three conservation biology principles of resiliency, redundancy, and representation, or the "3Rs" (USFWS, 2016, entire). We evaluate the viability of a species by describing what the species needs to be resilient, redundant, and represented, and compare that to the status of the species in its current condition.

For the purposes of this report, a population was defined as a group of conspecific individuals that are in close proximity to each other (*i.e.*, less than 3281 ft (1000 m) and are presumed to be genetically similar and capable of sexual (recombinant) reproduction (HPPRCC 2011, p.8). If the groups of individuals are within < 3281 ft (1000 m) but separated by watersheds or any geographic or topographic features such as a cliff or a steep hillside that prevent gene flow, then we considered them as separate populations. Based on this working definition of populations and in an effort to protect the sensitivity of species data, we created maps with symbol markers rather than displaying species points or polygons. We created the symbols in steps. First, we added a 1640 ft buffer (500 m) around each individual species point and polygon. We then dissolved all

buffer areas intersecting each other into a single shape. Finally, we created a centroid (*i.e.*, point representing the center of a polygon) within each dissolved buffer area. The symbol marker represents the centroid. All points and polygons were used in this process, regardless of observation date or current status (historical, current, extant, or extirpated), to represent the known range of the species.

Definitions

Resiliency is the capacity of a population or a species to withstand the more extreme limits of normal year-to-year variation in environmental conditions such as temperature and rainfall extremes, and unpredictable but seasonally frequent perturbations such as fire, flooding, and storms (*i.e.*, environmental stochasticity). Quantitative information on the resiliency of a population or species is often unavailable. However, in the most general sense, a population or species that can be found within a known area over an extended period of time (e.g., seasons or years) is likely to be resilient to current environmental stochasticity. If quantitative information is available, a resilient population or species will show enough reproduction and recruitment to maintain or increase the numbers of individuals in the population or species, and possibly expand the range of occupancy. Thus, resiliency is positively related to population size and growth rate, and may also influence the connectivity among populations.

Redundancy is having more than one resilient population distributed across the landscape, thereby minimizing the risk of extinction of the species. To be effective at achieving redundancy, the distribution of redundant populations across the geographic range should exceed the area of impact of a catastrophic event that would otherwise overwhelm the resilient capacity of the populations of a species. In the report, catastrophic events are distinguished from environmental stochasticity in that they are relatively unpredictable and infrequent events that exceed the more extreme limits of normal year-to-year variation in environmental conditions (*i.e.*, environmental stochasticity), and thus expose populations or species to an elevated extinction risk within the area of impact of the catastrophic event. Redundancy is conferred upon a species when the geographic range of the species exceeds the area of impact of any anticipated catastrophic event. In general, a wider range of habitat types, a greater geographic distribution, and connectivity across the geographic range will increase the redundancy of a species and its ability to survive a catastrophic event.

Representation is having more than one population of a species occupying the full range of habitat types used by the species. Alternatively, representation can be viewed as maintaining the breadth of genetic diversity within and among populations, in order to allow the species to adapt to changing environmental conditions over time. The diversity of habitat types, or the breadth of the genetic diversity of a species, is strongly influenced by the current and historic biogeographical range of the species. Conserving this range should take into account historic latitudinal and longitudinal ranges, elevation gradients, climatic gradients, soil types, habitat types, seasonal condition, etc. Connectivity among populations and habitats is also an important consideration in evaluating representation.

The viability of a species is derived from the combined effects of the 3Rs. A species is considered viable when there are a sufficient number of self-sustaining populations (resiliency)

distributed over a large enough area across the range of the species (redundancy) and occupying a range of habitats to maintain environmental and genetic diversity (representation) to allow the species to persist indefinitely when faced with annual environmental stochasticity and infrequent catastrophic events. Common ecological features are part of each of the 3Rs. This is especially true of connectivity among habitats across the range of the species. Connectivity sustains dispersal of individuals, which in turn greatly affects genetic diversity within and among populations. Connectivity also sustains access to the full range of habitats normally used by the species, and is essential for re-establishing occupancy of habitats following severe environmental stochasticity or catastrophic events (see Fig. 2 for more examples of overlap among the 3Rs). Another way the three principles are inter-related is through the foundation of population resiliency. Resiliency is assessed at the population level, while redundancy and representation are assessed at the species level. Resilient populations are the necessary foundation needed to attain sustained or increasing representation and redundancy within the species. For example, a species cannot have high redundancy if the populations have low resiliency. The assessment of viability is not binary, in which a species is either viable or not, but rather on a continual scale of degrees of viability, from low to high. The health, number and distribution of populations were analyzed to determine the 3Rs and viability. In broad terms, the more resilient, represented, and redundant a species is, the more viable the species is. The current understanding of factors, including threats and conservation actions, will influence how the 3Rs and viability are interpreted for *S. guamense*.

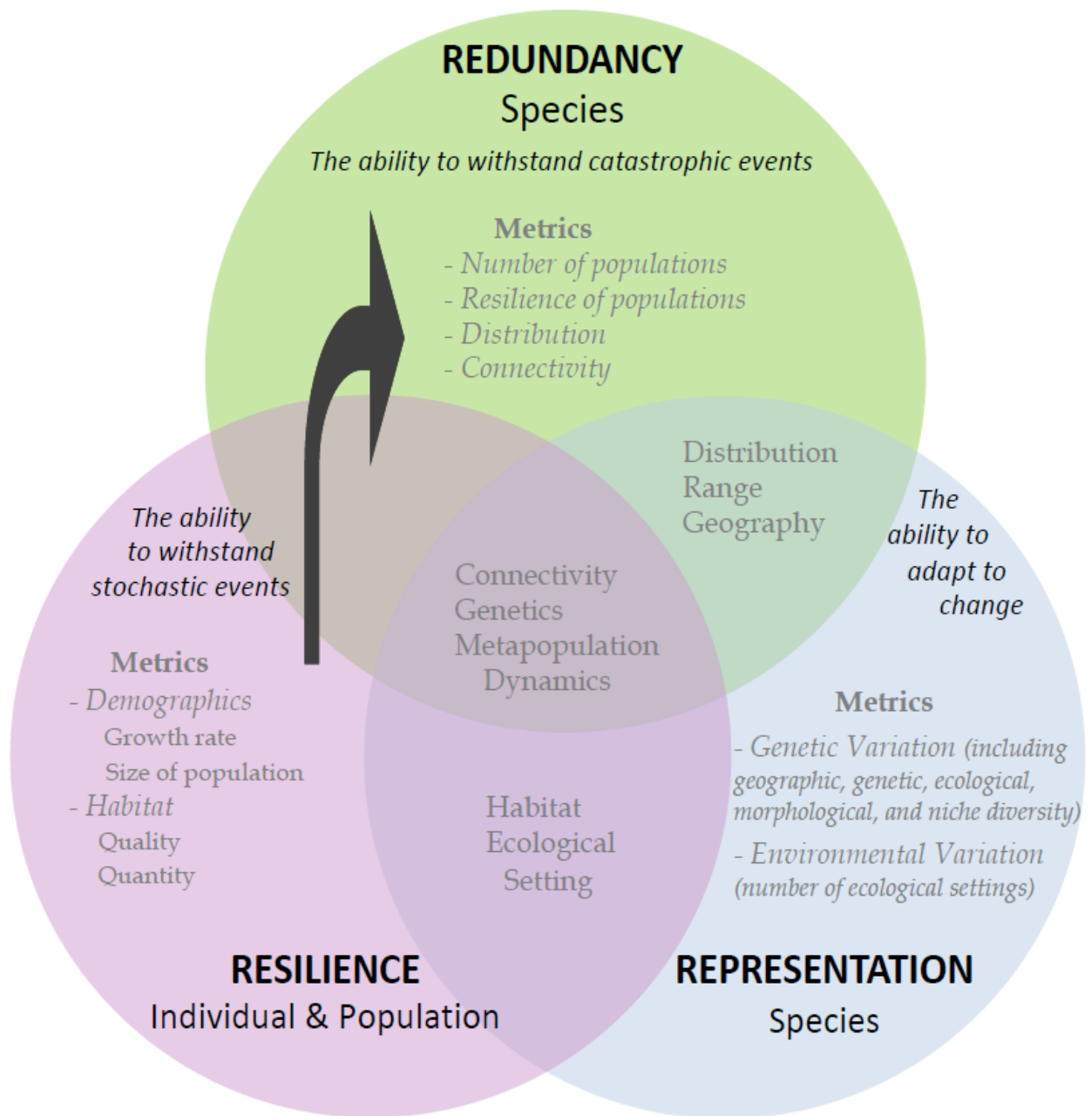


Figure 2. 3R's Visualization

SPECIES NEEDS / ECOLOGY

Species Description

Solanum guamense (Chamorro Name: berenghenas hãlom tâno') is endemic to the Mariana Islands. This medium-sized (2m) shrub in the nightshade family (Solanaceae) has a stellate-tomentose form with stellate hairs covering the stems (3-4mm thick), white flowers, small red tomato-like fruit (5-7mm wide), and thorns on the undersides of the papery, ovate to elliptic-oblong leaves (150mm long and 110mm wide (GPEPP, 2019, entire; Costion and Lorence, 2012, p. 89). Flowers are borne on a hairy forking inflorescence that can be with or without spura-axillary. The corolla is white with boat lobes (12mm broad) and has yellow blunt anthers (GPEPP, 2019, entire). The seeds are flat (2mm long) and subreniform (nearly kidney-shaped) to elliptic.

The Solanaceae includes diverse plants such as tobacco, tomato, eggplant and potato. The genus *Solanum* has 1,200-1,700 species (Costion and Lorence, 2012, p. 89).



Figure 3. *Solanum guamense*

There is currently no information on the viability of seeds or in the soil seed bank, or under what conditions they germinate. Other life history information on *Solanum guamense* that are unknown include information on the specifics plant growth stages, longevity, and the length of time it takes to flower. The flowers of Solanaceae are generally bisexual but in certain species are dioecious. *Solanum guamense* produces red tomato-like fruit and is assumed to be pollinated by insects. Seeds may be dispersed by birds or mammals that eat the fruit (Gawel *et al.* 2018, entire).

Habitat, Ecology and Distribution

The habitat types for the last known plants in this species were in forests with limestone soils and limestone karst (Perlman and Wood 1994, pp. 135–136.; Stone 1970, p. 521). Herbarium records document *Solanum guamense* inhabiting areas with volcanic substratum in the northern islands; however, little details exist beyond that. It is unknown whether this species has any habitat correlations other than the presences of limestone soils to limestone karst. There are three confirmed locations from herbarium vouchers; two are limestone cliffs (420 feet; 128m) and one is a limestone outcrop on a narrow peninsula with much lower elevation (< 40 feet; 12.2m), all on Guam (Appendix B). *Solanum guamense* have a tendency to be found on limestone cliff edges (Perlman and Wood 1994, pp. 135–136). There is less ungulate browsing pressure along the edge of the cliff due to the karst itself a challenge for ungulates to traverse and this may be

why the last known individual was found on a limestone karst cliff face. A detailed description of these habitats can be found in the Mariana Islands Forest Habitat Status Assessment (Willsey *et al.* 2019, entire).

The species historically had a larger range including Guam, Rota, Saipan, Tinian, Asuncion, Guguan, and Maug (Stone 1970, p.521; USFWS 2015, p. 59438). The last known individual of the species was on Guam - one documented individual was seen on Andersen Air Force Base (AAFB) in 1994 (Perlman and Wood 1994, pp.135-136; USFWS 2015, p. 59438). The area has since been resurveyed and no individuals were located (GPEPP 2019, *in litt.*).

Summary of Individual, Population and Species Requirements

Individual Needs

Little is known about the life history of *Solanum guamense*. Some suspected needs for survival potentially include pollinators, seed dispersers, water availability consistent with native limestone forests, levels of sunlight consistent with the limestone forest habitat, limestone substrate, and relatively constant temperatures averaging 22.8°C to 30°C and range from 18 to 35 °C (66-95 °F). Along with a relatively constant temperature range, there are seasonal precipitation weather fluctuations, including a drier season from November through June and a rainy season from July to October with an average 96 in (218 cm) of rain per year (Ohba 1994, pp.13–69; Mueller-Dombois and Fosberg 1998).

Population Needs

For a species to be viable, it needs resilient populations that have good representation where traits are not limited to a single population. A species viability also depends on the redundancy of a sufficient number of resilient populations so that if one is lost to a catastrophic event it will not lose representation throughout its range. The foundation for species viability is resilient populations. In order to be resilient, populations must have stable or increasing population growth to withstand environmental perturbations. Table 1 outlines what a population needs to be successful and resilient.

Table 1. Population Needs- Resiliency (adequate abundance and habitat)

Population Health (fitness)	Element	Importance
Healthy demography	Sufficient number of individuals	To maintain a breeding population
	Sufficient age class structure	To promote population stability and growth
Habitat to support a healthy demography	Sufficient forest health	Quantity of seed dispersers & pollinators
	Area free from ungulates	Reduce browsing pressure and allow seedlings to establish
	Adequate rainfall	Individual plant growth and survival

A population needs to have these elements with adequate numbers of individuals, ecological mutualisms (if applicable), and adequate population structure to recover from stochastic events

such as seasonal droughts and storms (Brodie *et al.* 2014; entire; Fricke *et al.* 2017, entire; Wandrag *et al.* 2015, entire). Loss of genetic variation in a population below a stable population size can be subject to allele loss just due to genetic drift. These consequences lead to reduced resiliency in the population due to lack of genetic diversity to adapt to changing environments.

Species' Needs/ Ecology

For the species to survive there needs to be a number of genetically-represented populations that can exchange genes among populations. This ensures representation in the species and preserves the genetic diversity within the species. Having these populations spread over a distance and in a variety of habitat types protects the species from catastrophic events, such as typhoons or fires, and helps to ensure redundancy within the species. These ideas are summarized within Table 2.

Table 2. Species Needs- Representation and Redundancy

Species Needs	Element	Importance
Representation	Maintain ability of species to adapt to change	Maintain all genetic diversity and phenotypic diversity with traits not isolated to a single population
	Maintain ability of species to persist in all environmental conditions it has occupied	Maintain environmental diversity by having more than one population occupy each habitat type
Redundancy	Sufficient distribution of populations to spread risk	Sufficient distribution to guard against catastrophic events wiping out portions of the species adaptive diversity, i.e., to reduce covariance among populations
	Sufficient number of sustainable populations	Adequate number of healthy populations to buffer against catastrophic losses of adaptive diversity

PRE-HUMAN CONDITION

Historical Distribution

Solanum guamense is endemic to the Mariana Islands. *S. guamense* historically was found on Guam, Rota, Saipan, Tinian, Asuncion, Guguan, and Maug; however, by 1994 it was only documented on the island of Guam (Table 3; CPH 2020, entire). Based on voucher specimens, *S. guamense* had been distributed throughout the island of Guam (Figure 4); one population in the north on Pati Point was where the last known individual occurred. The species had a wide range throughout the island.

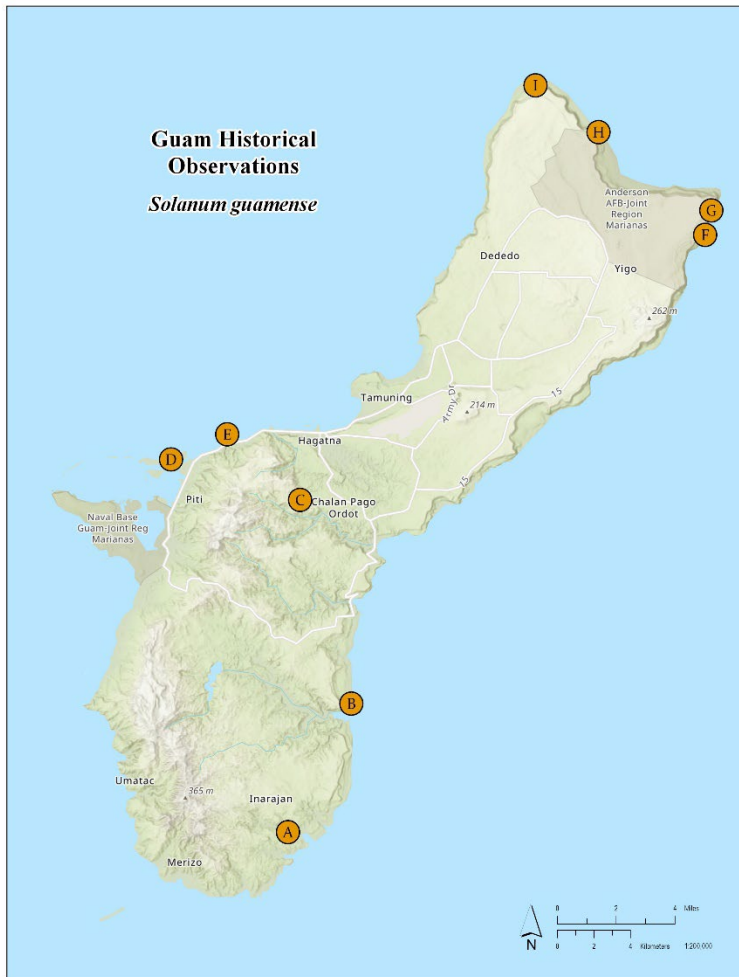


Figure 4. Map of Guam Historical Observations of *Solanum guamense*

Table 3. Islands of Occupancy for *Solanum guamense* (USFWS 2015, p 59427)

Historical	Last Known Location (1994)
Guam, Rota (H), Saipan (H), Tinian (H), Asuncion (H), Guguan (H), Maug (H).	Guam
(H) = historical occurrence (last seen in CNMI in 1975 (BISH 1976)).	

Historical Viability

Historically, *Solanum guamense* was endemic to the occurred on many islands throughout the Mariana Islands, starting from the southernmost island of Guam to as far north as Maug (Raulerson and Rinehart 1992, p. 94; Kanerhira 1931, pp. 327-352). Historically, the species was found on several different parts of Guam. This included locations on limestone outcroppings and cliffs. The species had several more populations in other areas of the island that were last observed in the 1980's and 1990's. The multiple populations added redundancy to the species and the intact, abundant native habitat would have also increased the species resiliency and

representation. Prior to human contact in the Marianas Archipelago, we postulate that *S. guamense* was more common on limestone cliffs and outcroppings, given the former distribution patterns on Guam and its historical presence on other islands. There is no way to know for sure the extent or number of populations prior to human contact, but the species likely was strongly tied to the extent and amount of limestone forest habitat. In the absence of human introduced threats (such as invasive ungulates), and forest degradation (including effects due to the brown-tree snake), the species likely had sufficient resiliency, redundancy and representation to recover after stochastic or catastrophic events. With the best available knowledge, it is likely that the limestone forest habitat in which the species lives had high resiliency, redundancy, and representation throughout its home range. For a deeper description, please see Habitat Assessment of the Mariana Islands (Willsey *et al.* 2019; entire).

Because the habitat would have been able to support many individuals and populations, it would be likely that the species, especially without the current introduced threats, would have had similarly high resiliency, redundancy, and representation and therefore the historic viability would have been high (Table 4). The threats added after human introduction would reduce all these factors.

Table 4. Levels of Resiliency, Redundancy, and Representation for Forest Habitats and *Solanum guamense* Prior to Human Contact.

Historical Viability	Resiliency	Redundancy	Representation	Viability
Native Forest	High	High	High	High
<i>Solanum guamense</i>	High	High	High	High

Resiliency

The habitat has decreased in quality and quantity in recent decades due to development, human caused climate change, and the introduction of invasive species. The habitat would not have experienced these threats prior to the arrival of humans. The resiliency of *S. guamense* would have been high because of the amount of high quality habitat.

Representation

No information currently available indicates how many populations existed on any of the islands except Guam. We assume that the genetic variation within the species was not wholly represented on each island, and that there were consequently genetic traits that were unique to each island. We assume this due to the founder effect from movement between islands by birds that likely distributed the seeds and may have occasionally added new seeds from various sources, but we have no way of knowing. If we assume there were also multiple populations on other islands, we assess historic representation as high.

Redundancy

Solanum guamense historically occurred on seven islands, which drastically reduces the chance of one catastrophic event causing the extinction of the species. Therefore historically, redundancy was likely high.

FACTORS INFLUENCING VIABILITY

Threats and Conservation Actions

Seven categories of threats have been identified for *Solanum guamense* (Table 5), and are described below by threats that mainly impact individuals, and threats that mainly effect the species at the population level.

Threats to individuals

The viability of an individual is directly affected by its access to food (proper soil and sunlight), water, and shelter (protection or sufficient root system to withstand typhoons). Climate change has the most direct impact on these factors, including more variable temperatures, more severe alternating periods of droughts and floods, and stronger typhoons (Gingerich *et al.* 2015, entire). These changes can reduce the ability of an individual to survive, especially with additional anthropomorphic threats (USFWS 2015, p.59449). Additionally, there are introduced factors and threats, including grazing pressure by ungulates or invasive invertebrates, as well as habitat alteration and loss due to human activity and development (USFWS 2015, p. 59449; Wandrag *et al.* 2015, pp. 13-18).

Threats to Populations and Species Level Effects

Habitats able to support *Solanum guamense* on Guam, Rota, Saipan, and Tinian are at risk, mainly due to continued habitat loss and destruction from agriculture, urban development, introduced animals and plants, and typhoons (USFWS 2015, p. 59434). We anticipate the effects of climate change will further exacerbate many of these threats in the future (USFWS 2015, p. 59449). Herbivory by pigs and deer, combined with the effects of low numbers of individuals, results in a loss of vigor and genetic diversity. This limits a species ability to compete with other species for resources and adapt to changes in environmental conditions. These factors may have contributed to the decline of *S. guamense*.

Low population numbers can indicate that the species may have gone through a genetic bottleneck. Any surviving plants would likely be genetically similar due to the lack of opportunities for reproduction with other plants because of physical barriers and isolation. When there are a small number of individuals to breed with, there are a limited number of alleles available for reproduction (Stebbins 1957, pp. 337-354). There are no known individuals of *S. guamense*, and if new individuals are discovered in small populations, we might assume that they could suffer from consequences of small population size, such as low genetic diversity, which could diminish the species' ability to adapt and respond to environmental changes, thereby lessening the probability of long-term persistence (Barrett and Kohn 1991, pp. 3-30; Newman and Pilson 1997, pp.354–362). There has not been an exhaustive survey effort to find *Solanum guamense*. Prior to 1994, when the species was last documented, it had extremely small numbers, and was not well studied (Perlman and Wood 1994, pp.135-136).

The Department of the Navy (DON) is in the process of relocating U.S. Marine Corps (USMC) personnel from Okinawa, Japan to Guam, which includes related infrastructure construction and military training activities. Project activities for this relocation include the construction of a main cantonment area, family housing, a live fire training range complex and a variety of other training activities on Department of Defense (DoD) property on Guam. Post-completion of the

project, it is expected that the human population on Guam will increase by approximately 7,400. Additionally, approximately 1,219 acres (493 ha) of limestone forest, 613 acres (248ha) of herbaceous scrub and 3,221 acres (1303 ha) of developed/barren land will be permanently modified as a result of this action (DON 2019, p. “9-9”). While *S. guamense* is not currently present within the project action area, the species is potentially losing 1,219 acres (493 ha) of suitable limestone forest habitat that could have served as a possible location for reintroduction (if new individuals were discovered). Approximately 919 ac (372ha) of this limestone forest slated for removal occurs in the Overlay Refuge, intended for the preservation of threatened and endangered species on the military lands (USFWS 2017, pp. 41, 87; DoD 2019, p. “9-9”).

Threats to *Solanum guamense* due to invasive species has been a main concern, in addition to habitat loss which has concentrated many of these introduced species such as rats, deer, brown treesnakes, and pigs, into the ever shrinking jungle habitat (Willsey *et al.* 2019, pp. 14-16). In general, invasive species have impacted the landscape in the Mariana Islands, removing pollinators and seed dispersers essential for the forest habitat, and by directly damaging or consuming native vegetation in limestone forests (Wandrag *et al.* 2015, entire). Depending on seed size, rats may destroy seeds when eating them as well as potentially disperse them, however, these seeds will likely end up in less than suitable habitats for germination and seedling persistence (Shiels and Drake 2011, entire). Ungulates were first introduced to the island by humans at least 500 years ago (De Freycinet and Barratt 2003, p. 305). Pigs and deer are the biggest ungulate threats because not only can they consume individuals, but also change the structure of the forest habitat and could make conditions unsuitable for regrowth. The addition of the brown treesnake (*Boiga irregularis*) after World War II and the subsequent removal of most of the island birds did immense damage to how the forest habitat functions. Though the mechanism for seed dispersal in *S. guamense* is unknown, the lack of fruit dispersal in could have potentially prevented the populations from expanding and lowered gene flow among populations as all of the new recruits would have remained close to the parent plants.

Table 5. Summary of Threats to *Solanum guamense*, by Island (USFWS, 2015)

Island	Pigs	Deer	Rats	Brown Treesnake	Typhoons	Climate Change	Low Numbers
Guam	X	X	X	X	X	X	X
Rota		X	X	** X	X	X	X
Tinian			X		X	X	X
Saipan			X	** X	X	X	X
Guguan			X		X	X	X
Asuncion			X		X	X	X
Maug			X		X	X	X
** Confirmed sightings of brown treesnakes have occurred on Saipan and Rota; however, no established populations have been documented.							

Conservation Actions

Conservation efforts associated with ESA consultations may indirectly benefit species such as *S. guamense* in ways such as habitat restoration utilizing ungulate fences, ungulate eradication, and

forest restoration. Undiscovered individuals or populations, if they persist, may benefit from habitat restoration activities. Surveys and habitat restoration activities are currently skewed toward islands/areas where DoD activities occur, generally Guam with some efforts on Tinian and Saipan. Other portions of the species range receive very little, if any, of these efforts. Species-specific programs such as cultivation programs or transplanting efforts are not currently possible as there are no seeds in storage or plants in propagation.

Guam Department of Agriculture (DOAG) submitted a proposal for Habitat Conservation Planning Assistance Grants also known as competitive ESA Section 6 funds to help develop a plan to implement island wide Habitat Conservation Plan to streamline the process for private landowners and developers to attain an incidental take permit that would reduce impacts to threatened and endangered species on Guam. Part of the plan would identify conservation areas within Government of Guam lands to enhance habitat for threatened and endangered species such as *Solanum guamense*.

Experimental Populations

The Guam Plant Extinction Prevention Program (GPEPP) works to prevent the extinction of rare plants on Guam that have fewer than 200 individuals remaining on the island. This includes cultivation of several federally listed plants. Currently there are no known individuals to collect samples or seeds from for GPEPP to propagate of *S. guamense*, but they have the facilities to propagate the species if more individuals are found in the future.

Conservation and Protected Areas

Conservation areas can be a great benefit to endangered species. Habitat destruction has greatly hindered the ability of listed species to survive (USFWS 2015, p. 59461). Plants are especially vulnerable to habitat destruction and modification because the specific microsite habitat characteristics and mutualisms that the species depend upon are often unknown (USFWS 2015, p. 59461). A conservation area can benefit a listed plant species even if that was not its intended purpose simply by allowing the individuals and its habitat to persist without threat of development. Protected lands and conservation areas that are owned by Federal entities are prohibited from affecting listed plants without consulting with the U.S. Fish and Wildlife Service. The following are conservation areas that may assist in the protection and recovery of the species, if individuals or populations can be found.

There are a number of small locations designated as U.S. National Park Service lands along the western coast of Guam. The conservation areas are not known to be locations for *Solanum guamense* but have suitable habitat and may be beneficial for planting in the future if individuals are discovered (Willsey *et al.* 2019, p. 19).

The Guam National Wildlife Refuge (NWR), Ritidian Unit run by the U.S. Fish and Wildlife Service, is the only Critical Habitat designation on Guam for several animal species, Guam Micronesian kingfisher (*Todiramphus cinnamominus cinnamominus*), Marianas crow (*Corvus kubaryi*), and the Marianas fruit bat (*Pteropus mariannus mariannus*). This area could also be suitable habitat for *Solanum guamense* if individuals were discovered or planted. The cliff faces that the species inhabited are directly adjacent to the NWR on AAFB.

Guam NWR is part of a larger overlay refuge complex that incorporates a large amount of the Air Force base and some Navy lands as well. We refer to the 2019 Integrated Natural Resources Management Plan (INRMP) for the Navy Joint Region Marianas (DON 2019,p. “9-9” 9.1.5.1) for the definition of Overlay Refuge: “Overlay Refuge lands were established in 1994 and provide a commitment by the DoD and USFWS for a coordinated program with Guam Division of Aquatics and Wildlife Resources (Guam DAWR). The program is centered on the protection of threatened and endangered species and other native flora and fauna, the maintenance of native ecosystems, and the conservation of native biological diversity. The program does recognize that the primary purpose of Overlay Refuge lands is to support the national defense mission of the USAF (Government of Guam [GovGuam] et al. 1993; USAF and USFWS 1994). Approximately 10,193 acres (4,111 hectares) of Overlay Refuge lands are designated on Andersen AFB (Figure 9-2). These lands are currently managed by JRM and were originally identified as providing important habitat for federal ESA-listed threatened and endangered species (e.g., Mariana crow [*Corvus kubaryi*], Guam Micronesian kingfisher [*Todiramphus cinnamominus*], Guam rail [*Gallirallus owstoni*], and *Serianthes nelsonii*) as well as other Guam native species. The Overlay Refuge lands on Andersen AFB consist primarily of limestone degraded forest (2,742 acres [1,110 hectares]), Vitex forest (2,481 acres [1,004 hectares]), and limestone native forest (2,048 acres [829 hectares]). Altogether, these three vegetation communities cover close to 72 percent (%) of the base (DoN 2019,p. “9-9”).

An important location within the Overlay Refuge Lands is Pati Point, which is a recognized key area designated as a Natural Area Reserve on AAFB (Paine 1991, p. 301). This area historically provided habitat for the Mariana crow and Mariana fruit bat (Perlman & Wood 1994, p. 148). This was the last known location of *Solanum guamense*. It has the same limestone cliff face as the cliff above the NWR above AAFB NW Field area and could potentially contain individuals of *S. guamense*, or serve as a reintroduction site if individuals are discovered.

Anao Conservation Reserve is a Government of Guam Conservation Reserve. This reserve is one of the few locations on or near Andersen Air Force Base. Soil and Water Conservation Districts (SWCDs) and the Guam Forestry and Soil Resources Division are established partners in managing this area (NACD 2013, pp. 11-12). This conservation area is a similar habitat to the limestone karst cliff on AAFB and would be appropriate to conduct surveys for *S. guamense*, and may be a suitable habitat for reintroduction if new individuals are discovered.

Solanum guamense may be protected by the Wildlife Conservation Areas on the islands of Asuncion, Guguan or Maug established by the CNMI constitution (Article IX [2]) (DFW 2019, website). The CNMI has three designated terrestrial wildlife preserves on Rota -- Sabana Heights, Wedding Cake, and I’Chenchon Park Bird Sanctuary. There are two federally designated critical habitat areas on Rota for the Rota bridled white-eye, Mariana crow and Mariana fruit bat that contains some suitable habitat for *S. guamense*.

CURRENT CONDITION

Abundance and Population Trends

Solanum guamense has been considered rare since the 1970’s (Stone 1970, p.521). The species, which has been confused with *Solanum torvum*, has not been common even at its description by E. D. Merrill in *Plants of Guam* (1914, pp. 139–140). Currently, there are no known individuals

of *S. guamense*. While it is thought to be extirpated, populations of *S. guamense* may persist on the northern islands, but there have not been recent surveys completed due to their remoteness and difficulty in getting to the islands. The last known population of this plant occurred along the cliff line on Pati point on AAFB (Perlman and Wood 1994, pp. 135–136). Since the population only occurred in an area that was inaccessible to ungulates, ungulates could be seen as a limiting factor. Not much is known about the demographics of *S. guamense* other than there has been no recruitment documented.

Solanum guamense has not been documented since 1994 and may be extirpated from all the islands it was historically known to occur. Therefore, there is no current population structure for *S. guamense* as there are no known individuals in the wild. A healthy population consists of abundant individuals within habitats of adequate area and quality to maintain survival and reproduction in spite of disturbance. Suitable habitat for *S. guamense* is based on the last known location of the species, which was in native limestone forest in northern Guam on the Pati Point cliffs with karst substrate.

Table 6. Current Known Abundance of *Solanum guamense* (USFWS, 2015, p. 59427)

Island	Pop. at Listing	Current Total Species Population
Guam	1 *	0
Rota	0	0
Saipan	0	0
Tinian	0	0
Asuncion	unk	unk
Guguan	unk	unk
Maug	unk	unk
Total	1	0

*last observed in 1994

Summary of Current Conditions of the Species

Solanum guamense currently has extremely low redundancy, resiliency, and representation. While it is possible that some individuals or populations persist, especially on the northern islands where surveys are infrequent, there are currently no known individuals. Given the declining quality and extent of the limestone habitat across the islands, it is likely that any individuals or populations that do persist are at risk of extirpation from stochastic and catastrophic events. There are no seeds, propagules, or individuals in storage or propagation.

Species Viability Summary

We would consider the current viability for *Solanum guamense* as extremely low to zero, given that there are no known individuals. The species may continue to persist within suitable forest habitat on islands within its historic range, but this has not been documented currently. As suitable limestone habitat declines, it is likely that any persisting individuals or populations face increasing threats. While there are no known individuals and no plants in cultivation, the species

is not considered extinct, as there is still a large amount of suitable habitat on many islands within the known range of the species to survey.

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