

Matabuey
(*Goetzea elegans*)



Photo: USFWS

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
Matabuey (*Goetzea elegans*)

I. GENERAL INFORMATION

A. Methodology used to complete the review: On September 27, 2006, the Service published a notice in the *Federal Register* (71 FR 56545) announcing the 5-year review of the plant Matabuey (*Goetzea elegans*) and requesting new information concerning the biology and status of the species. We opened a 60-day public comment period with this notice; however, no information on matabuey was received from the public during the comment period.

A Service biologist prepared the 5-year review that summarizes new information that since the species was listed on April 19, 1985 and the recovery plan signed on April 28, 1987. In conducting this 5-year review, we relied on the best available information pertaining to historical and current distribution, life history, habitat, and potential threats of this species. New information consists of publications related to research projects conducted by species experts from 1993 to 2007. This draft 5-year review was shared with several peer reviewers (see Appendix A). Comments received were evaluated and incorporated as appropriate.

B. Reviewers

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

Lead Field Office: Jose A. Cruz-Burgos, Caribbean Ecological Services Field Office, Boquerón, Puerto Rico. (787) 851-7297, extension 218.

C. Background

1. Federal Register Notice citation announcing initiation of this review: September 27, 2006; 71 FR 56545.

2. Species Status: Increasing. The species is present in ten localities within the municipalities of Isabela and Quebradillas, one locality in Fajardo, and five localities in the island of Vieques, with evidence of recruitment.

3. Recovery Achieved: 1 (1= 0-25% of species' recovery objectives achieved).

4. Listing History

Original Listing

FR notice: 50 FR 15564

Date listed: April 19, 1985

Entity listed: Species

Classification: Endangered

5. Associated rulemakings: Not Applicable.

6. Review History: The final listing rule and the Beautiful Goetzea Recovery Plan, (USFWS 1987) are the most comprehensive analyses of the species' status and are used as the referenced point documents for this 5-year review.

At the time of listing and when the recovery plan was signed, fewer than 50 individuals of matabuey were known from three sites in the northern karst region of Puerto Rico. Two of the sites are located in the Guajataca Gorge area in the municipality of Isabela. The third site was located in the municipality of Quebradillas (Vivaldi et al. 1981). Historic records included the Luquillo Mountains in eastern Puerto Rico and the Cambalache Commonwealth Forest in the north-central part of the Island (Vivaldi et al. 1981). In 2000, the species was found in the island of Vieques (VNWR 2007).

In 1991 we conducted a 5-year review for matabuey (56 FR 56882). In this review, the status of many species was simultaneously evaluated with no in-depth assessment of the five factors as they pertain to the individual species. The notice stated that the Service was seeking any new or additional information reflecting the necessity of a change in the status of the species under review. The notice indicated that if significant data were available warranting a change in a species' classification, the Service would propose a rule to modify the species' status. We did not recommend a change in matabuey's listing classification.

Every year the Service review species status and incorporates the information in the Recovery Data Call. Recovery Data Call: 1998, 1999, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, and 2012.

7. Species' Recovery Priority Number at start of review (48 FR 43098): 5. At the time of listing, matabuey was recognized as a species with high degree of threat and low recovery potential.

8. Recovery Plan:

Name of plan: Beautiful Goetzea (*Goetzea elegans*) Recovery Plan.

Date issued: April 28, 1987

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? Yes. The species has an approved recovery plan. However, it establishes only non-measurable criteria to reclassify the species to a threatened status. Criteria to delist the species were not included in the plan.

2. Adequacy of recovery criteria

a. Do the recovery criteria reflect the best available information on the biology of the species and its habitat? No. The plan does not include up-to-date information about the species biology and ecology. Only three populations were known when the recovery plan was developed and approved. At present, the species is known from more than fifteen localities, including the island of Vieques. Knowledge on its biology and habitat has expanded.

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 matabuey could be considered for reclassification to a threatened species when:

1. The principal population in Quebrada Bellaca (Isabela) is placed under protective status; and
2. At least three new populations capable of self-perpetuation have been established within protected units of the Commonwealth Forest System in the karst region (e.g., Cambalache or Guajataca), or on Federal land within the Caribbean National Forest, if suitable habitat exists.

The plan specifies that these criteria must be considered minimum requirements, and should be expanded upon if the regenerative potential of natural and *ex situ* populations proves insufficient. The plan also mentioned that, if new populations of mature plants are discovered, it may be preferable to place greater emphasis on protection, rather than propagation, to achieve a minimum number of plants (number not specified).

Criterion 1 has not been met. The Quebrada Bellaca area has not been placed under protective status.

Criterion 2 has not been met. Additional wild populations were found in mainland Puerto Rico and Vieques Island. However, except for one, all others are located in privately owned areas subject to urban development and grazing. Numerous propagation efforts were conducted in the last fifteen years with individuals planted in several municipalities

of Puerto Rico. However, at present we are not aware of established self-sustaining populations.

C. Updated Information and Current Species Status

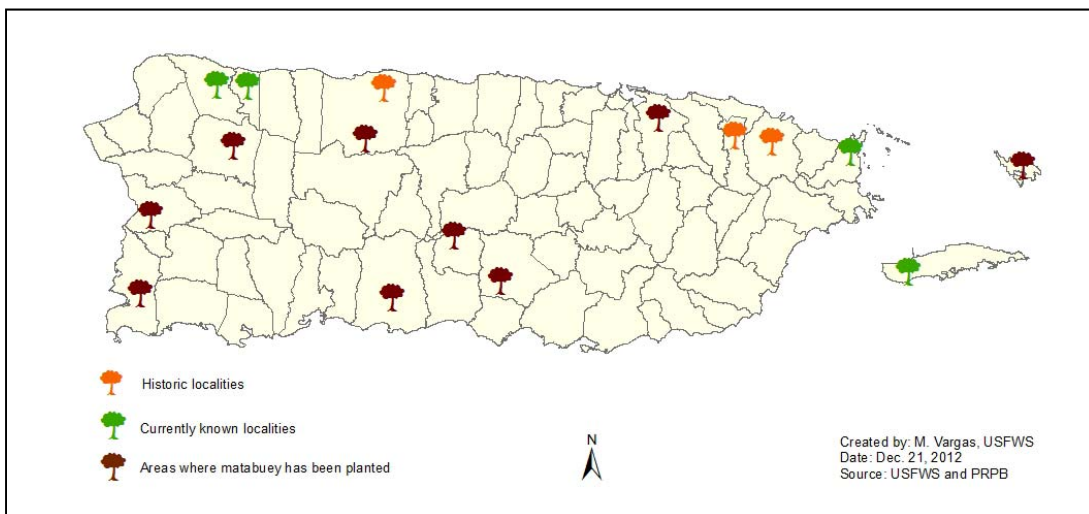
1. Biology and Habitat

a. Abundance, population trends (e.g., increasing, decreasing, stable), demographic features, or demographic trends:

The species was historically known from Quebradillas (type locality), the foothills of the Luquillo Mountains in Río Grande and Canóvanas, and from the Cambalache Commonwealth Forest in Arecibo (Vivaldi et al. 1981, USFWS 1987). At the time of listing, approximately 50 matabuey individuals were known from three populations in Isabela and Quebradillas in the northern karst region of Puerto Rico. The other historic populations of Río Grande, Canóvanas and Arecibo were no longer present. At that time, 10 matabuey individuals persisted along the right of way of the road PR 113, 17 plants existed on the south side of the highway PR 2, and approximately 21 individuals were located in the Quebrada Bellaca area east of Quebradillas (USFWS 1987).

Santiago-Valentín (1995) researched the species, particularly on aspects of the reproductive ecology, distribution, and population structure. He visited the historic sites and searched for new localities of matabuey, mainly in Quebradillas and Isabela, and found one hundred seventy-six (176) individuals in eight localities. All plants were found at elevations ranging from 20 to 150 m (66-492 ft) above sea level (Table 1). However, Santiago-Valentín (1995) could not find the species in the northeastern Puerto Rico historic localities nor at the Cambalache and Guajataca Commonwealth Forest (Figure 1) in Arecibo and Quebradillas respectively. Localities 1, 5 and 10 in Table 1 correspond to the localities previously known and described in the recovery plan.

Figure1. Historic and Current Distribution of Matabuey in Puerto Rico.



Santiago-Valentin (pers. comm., 1997) discovered a matabuey population near the forested hills of Finca El Convento in Fajardo. He observed about 9 adults and 20 saplings of different heights. This would be the first report of matabuey for northeastern Puerto Rico since the 1930's.

URS Corporation Southern (2007) conducted flora surveys along the route alternatives of the proposed extension of highway PR 22 from Hatillo to Aguadilla and located 50 additional individuals in two areas (Table 1).

Geo-Marine, Inc. (2000) first reported the matabuey on the island of Vieques while conducting surveys for endangered, threatened and candidate species. During these surveys, they reported approximately 71 individuals in three creeks or ravines (Table 2). Additional surveys have been conducted in the western side of Vieques during the last twelve years, resulting in an estimate of more than 1,200 individuals of matabuey in five forested creeks or ravines (J. Sustache, DNER pers. comm., 2012, Caraballo- Ortíz et.al. 2011, M. Caraballo-Ortíz, pers. comm., 2008).

The number of individuals of matabuey described in the wild has substantially increased since the time of listing. The most recent estimate of at least 1,200 individuals in Vieques, added to the known individuals from other sites in Puerto Rico, result in about 1,700 naturally occurring matabueys in Puerto Rico.

In addition, it is important to note that hundreds of individuals were planted in several other municipalities of Puerto Rico to assist with the recovery of the species (see section d below).

Table 1. Number of adults, saplings and seedlings reported in Isabela, Quebradillas and Fajardo.

Locality Number and Name	Ward and Municipality	Number of Adults	Number of Saplings / Seedlings	Source
1. PR113	Coto, Isabela	5	0	Santiago-Valentín 1995
2. PR2-105.2	Coto, Isabela	30	16 / 47	Santiago-Valentín 1995; Caraballo-Ortíz, 2013 pers. comm.
3. PR2-106.3	Coto, Isabela	1	0	Santiago-Valentín 1995
4. La Sequia	Coto and Llanada, Isabela	15	24 +	Santiago-Valentín 1995; Caraballo-Ortíz, 2013 pers. comm.

5. Quebrada Bellaca	San Jose, Quebradillas	31	42 +	Santiago-Valentín 1995
6. La Salle	Cacao, Quebradillas	1	0	Santiago-Valentín 1995
7. Las Talas A	Cacao, Quebradillas	6	6+	Santiago-Valentín 1995
8. Las Talas B	Terranova, Quebradillas	6	15	Santiago-Valentín 1995
9. Arca de Noé	Coco, Quebradillas	12		URS Corporation Southern 2007
10. PR 2 east PR113	Coto, Isabela	38		URS Corporation Southern 2007
11. Finca los Conventos	Fajardo	9	20	Caraballo et al. 2011 and Santiago-Valentin pers. comm. 1997

Table 2. Number of adults and juveniles reported in Vieques.

Locality Number and Name	Number of Adults	Number of juveniles	Number of Individuals	Source
12. Quebrada Ceiba (two localities)	3	1	4	Geo-Marine 2000
13. Quebrada east support station	2	7	9	Geo-Marine 2000
14. Quebrada off east boundary (four localities)	15+	43+	58+	Geo-Marine 2000
15. Monte Pirata	7		7	Caraballo-Ortíz pers. comm. 2008 and 2013
16. Quebrada Urbana (six localities)			1,215	J. Sustache, DNER, pers. comm. 2012

b. Genetics, genetic variation, or trends in genetic variation:

There is no new information about the genetic variability of the species. We do know that matabuey is mainly self-incompatible (mechanism that prevents self-fertilization) and requires outcrossing (pollination required between two different flowers) for successful seeding and fruiting. Since the current distribution is scattered and populations are very distant, isolation may affect genetic diversity and fecundity.

c. Taxonomic classification or changes in nomenclature:

Matabuey is a member of the nightshade family Solanaceae. Heinrich Wydler first described it based on material he collected in Puerto Rico in 1827 (USFWS 1987). Vivaldi et al. (1981) mentioned that there exists controversy as to the placement of the

genus *Goetzea* within the Solanaceae and to its affinities. He argued that although traditionally it has been placed in the Solanaceae, the genus *Goetzea* differs from the typical elements of the family, and together with four genera it was placed into a family of its own, the Goetzeaceae.

Santiago-Valentín (1995) also treated the genus *Goetzea*, together with three other genera of the Greater Antilles, as a distinct family, the Goetzeaceae. He mentioned that the four genera of this group differ from the Solanaceae in pollen, embryo, and cotyledon morphology. Santiago-Valentín and Olmstead (2003) conducted a phylogenetic analysis to elucidate the evolutionary relationship among four Antillean genera (endemic to the Greater Antilles) and with other major lineages of the Solanaceae. They studied the Hispaniolan genus *Coeloneurum*, the Cuban genera *Espadaea* and *Henoonia*, and the genus *Goetzea* that comprises two species, one endemic to Hispaniola and the other endemic to Puerto Rico. The first three genera are monotypic. None occurs in Jamaica, the other island in the Greater Antilles.

Santiago-Valentín and Olmstead (2003) obtained DNA sequences of specific chloroplast genes for 22 taxa and obtained the nuclear *r* DNA ITS region sequences for eight taxa. The authors maintained the four Antillean genera in the family Solanaceae, but grouped them together with the South America genera *Maternichia* and *Duckeodendron* in a clade (a lineage branch that results from splitting in an earlier lineage), pointing to a broader circumscription of the Goetzeoideae. *Goetzea* and *Espadaea* (sister genera) exhibit flowers with long peduncles, conspicuous funnel-shaped corollas, and broad leaf blades. These two genera grow in mesic conditions. In contrast, the other two Antillean genera have nearly sessile flowers with a much smaller corolla that is deeply lobed nearly to the base, have narrow, spinescent leaves, and occur in extremely dry habitats. *Duckeodendron* is a tall rainforest tree of the central Amazon and *Maternichia* occurs in east and northeast Brazil, where it grows in dry regions. The authors established that this distribution suggests the ancestor of the Antillean genera occurred in dry habitats and, by inference, evolved to occupy more mesic habitats (for *Goetzea* and *Espadaea*). The other two species have adaptations to dry environments. In *Goetzea*, the thin leaf lamina, thin cuticle, and higher frequency of stomata all indicate that it does not exhibit strong adaptations to aridity. This correlates with the life zones and habitat where the species is found. Using this knowledge, we may point out where new populations may be established and recommend new locations.

d. Spatial distribution, trends in spatial distribution, or historic range (e.g. corrections to the historical range, change in distribution of the species' within its historic range, etc.):

By 1981, the species was extirpated from three historic sites (i.e., Río Grande, Canóvanas and Arecibo). Since matabuey was listed in 1985 and its Recovery Plan completed in 1987, the species was only found in the municipalities of Isabela and Quebradillas. Currently, the spatial distribution of the matabuey has increased to ten populations in Isabela and Quebradillas, one population in Fajardo, and five populations in Vieques Island. A number of individuals have been planted and survived in at least nine other municipalities. These planted individuals support the recovery of the species by creating

experimental populations and having a seed bank for future material. Figure 1 illustrates the present and historic distribution of natural populations of matabuey and the municipalities where it has been planted.

Santiago-Valentín (1995) described in detail eight of the ten currently known populations in Isabela and Quebradillas (localities 1-8 in Figure 2). The eight localities occur on the northern karst within the Subtropical Moist Forest Life Zone (Ewel and Whitmore 1973). In the majority of those localities, the plants were growing along the bottom and the banks of wooded ravines or creeks, in a “more or less linear array” of small clusters.

Locality 1. Road PR 113, km 6.6, Coto Ward, Isabela. Five sterile adults (no seedlings) were found in one section of road PR 113, between km 6.6 and 6.8 along the south side of the road, at an elevation of 45-55 m (148-180 ft) (Santiago-Valentin 1995). This section of the road runs along a narrow valley between two limestone hills or “mogotes” and is frequently cut (pruned) to clear the roadside by the Department of Public Works (M. Rivera, USFWS, pers. obs., M. Caraballo-Ortíz, pers. comm., 2013). This locality was historically known and is probably the type location described by Heinrich Wydler. Vivaldi et al. (1981) also reported 10 individuals at both sides of this road.

Locality 2. Road PR 2, km 105.2, Coto Ward, Isabela. This area is located at the south side of highway PR 2, at 55 m (180 ft) of elevation and is approximately 15 square meters (161 sq ft) in size. Santiago-Valentín (1995) found one large flowering adult, four small sterile adults, sixteen saplings, and many seedlings. The mature tree was growing on the lower portion of the “mogote” (steep limestone hill) with its canopy arching over a shady ravine. The majority of the saplings were found on the alluvial flats at the bottom of the ravine, at the perimeter of the canopy of the parental tree. The number of seedlings present declined from 273 in October 1990 to 47 in January 1994, possibly related to flooding after heavy rains (Santiago-Valentín 1995). In 2006, M. Caraballo-Ortíz (pers. comm., 2013) observed over 30 individuals in the area. In addition, he observed one of the largest trees of matabuey dead on the ground.

Locality 3. Road PR 2, km 106.3, Coto Ward, Isabela. This area is located about 200 m (656 ft) from the south side of the road at 70 m (230 ft) of elevation. Santiago-Valentín found one large flowering adult at the edge of a small sinkhole or depression covered by a small patch of secondary vegetation, surrounded by open pastures.

Locality 4. La Sequia, Coto and Llanadas Wards, Isabela. This locality consists of four segments along approximately 2 km (1.2 mi) of La Sequia creek. In each segment, Santiago-Valentín (1995) found a group of individuals. These individuals were located at the south slopes and on large limestone boulders at the bottom of La Sequia creek. For the purpose of this review, we will discuss this locality as a unit and not by segments. In total, he found eight flowering adults, seven sterile adults, twenty-four saplings, and scattered seedlings. Matabuey was growing along the bottom and on the sides of the vegetated creek, which intersects the Guajataca River on its west side. This area is also a historic site for the threatened Puerto Rican crested toad (*Peltophryne lemur*). Marcos

Caraballo-Ortíz visited the area in 2006 and found 10 adult individuals along the creek (M. Caraballo-Ortíz, pers. comm., 2013)

Locality 5. Quebrada Bellaca, San José Ward, Quebradillas. The Quebrada Bellaca area was the largest known population of matabuey in the Quebradillas area (Vivaldi et al. 1981, Caraballo-Ortíz 2007). Approximately, 21 individuals were reported in two segments along a 1.6-km (1mi) section of the ravine. Santiago-Valentín (1995) found 14 flowering adults, 17 sterile adults, 42 saplings and scattered seedlings in four segments along approximately 2 km (1.2 mi) of the creek. The plants occurred along the bottom and sides of the wooded ravine (creek), which drains into the Atlantic Ocean. The habitat and species abundance of the area were very similar to other sites, excluding La Salle and road PR 2, km 106.3. Marcos Caraballo-Ortíz (pers. comm., 2013) observed over 200 individuals of Matabuey which at least 110 individuals were confirmed to be reproductive.

Locality 6. La Salle, Cacao Ward, Quebradillas. Santiago-Valentín (1995) found a single small flowering individual in a gentle hilly area of the upper limestone plateau of the Guajataca River gorge at an elevation of 150 m (492 ft). The surroundings of the locality were deforested and consisted of a small residential area and pasture. The tree was growing in exposed sun and no seedlings or saplings were observed at the locality. On a site visit of the area, M. Caraballo-Ortíz (pers. comm., 2013) saw this individual apparently sick and recently was informed that the tree died.

Locality 7. Las Talas A, Cacao Ward, Quebradillas. Santiago-Valentín (1995) found six flowering plants and six saplings growing in a small cluster of secondary vegetation of approximately 20 square meters (215 sq. ft.) at 100 m (328 ft) of elevation near to an old abandoned dirt road. The area is surrounded by cattle farms. Marcos Caraballo-Ortíz (pers. comm. 2013) reported over 40 individuals grouped together near the road. All individuals were similar in height and some were observed with flowers during the 2005 and 2006 inspections.

Locality 8. Las Talas B, Terranova Ward, Quebradillas. Santiago-Valentin (1995) found 2 flowering individuals, 4 sterile adults and 15 saplings of matabuey in two segments along the bottom of a forested creek at elevations between 55 and 85 m. (180-279 ft) above sea level. The area is approximately half kilometer long. Marcos Caraballo-Ortíz (pers. comm. 2013) observed over 30 individuals of all sizes in this area. He also observed some of the trees cut and used as fence posts (M. Caraballo-Ortíz, pers. comm. 2013).

Locality 9. URS Corporation Southern (2007) found 12 individuals in a limestone hill in the proximity of a private zoo called “Arca de Noé”. The trees ranged from 1-6 m (3.2-19.6 ft) in height. This population had not been previously reported.

Locality 10. URS Corporation Southern (2007) found 38 individuals ranging from 1-10 m (3.2-33 ft) in height. Eight individuals were observed with fruits. The general location is near road PR 2 in Coto Ward, Isabela.

Santiago-Valentin (pers. comm., 1997) also discovered a population in northeastern Puerto Rico. This discovery is the first matabuey reported in the northeastern part of the Island since the 1930's, and the first report for the municipality of Fajardo (Figure 3).

Location 11. Finca Los Conventos, Fajardo. Santiago-Valentin (pers. comm., 1997) found nine individuals ranging from 7-8 m (23-26 ft) in height where eight of them had sparse flowers or green fruits. In addition, he found about 20 saplings of different heights. Santiago-Valentin found the population to be healthy and that plant recruitment seemed to be occurring at the time. In 2010, M. Caraballo- Ortíz (pers. comm., 2013) visited the area and observed over 15 individuals with flowers and fruits. He also observed that most of the individuals had been cut in the past (maybe for wood).

In Vieques, more than 1,200 individuals of matabuey have been reported from five forested creeks or ravines in the western side of the Island (Figure 4).

Locality 12. Geo-Marine (2000) conducted plant surveys at the former Naval Ammunition Support Department in a coastal forest located at the western side of Vieques Island as part of the consultation for the transfer of lands to the municipality of Vieques. They found three adults and one juvenile in two localities at Ceiba creek in this area.

Locality 13. Geo-Marine (2000) reported two adults and seven juveniles in one creek east of the Support Department in Vieques.

Locality 14 Geo-Marine (2000) reported more than 15 adult trees and 43 juveniles in 4 localities in a creek off the east boundary of the Naval Ammunitions Support Department. Marcos Caraballo-Ortíz (pers. comm. 2008 and 2013) reported close to 200 individuals of different age classes and several on reproductive status in this same creek.

Locality 15. Marcos Caraballo-Ortíz (pers. comm. 2008) reported a minimum of seven individuals in another creek located north-east of Monte Pirata. He recommended intensive surveys in this last location to better assess the population.

Locality 16. J. Sustache (DNER, pers. comm. 2008 and 2012) reported an estimate of 1,215 individuals (in six sub-populations) in a ravine in western Vieques known as Quebrada Urbana.

Figure 2. Currently known populations in Isabela and Quebradillas, Puerto Rico.

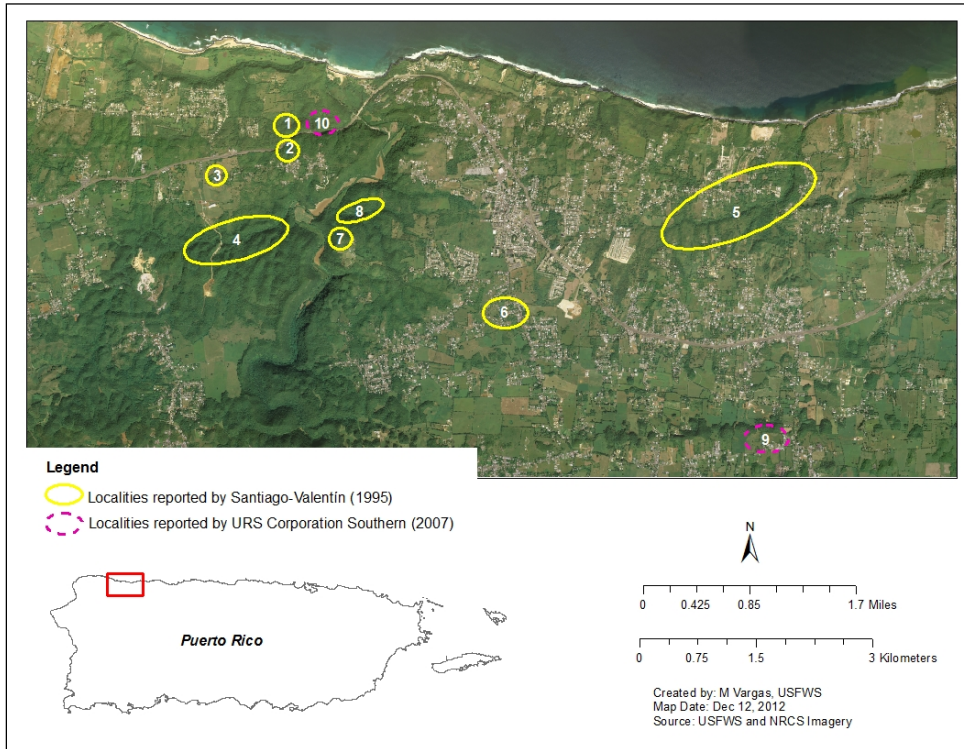


Figure 3. Currently known population in Fajardo, Puerto Rico (Santiago-Valentín, pers. comm., 1997).

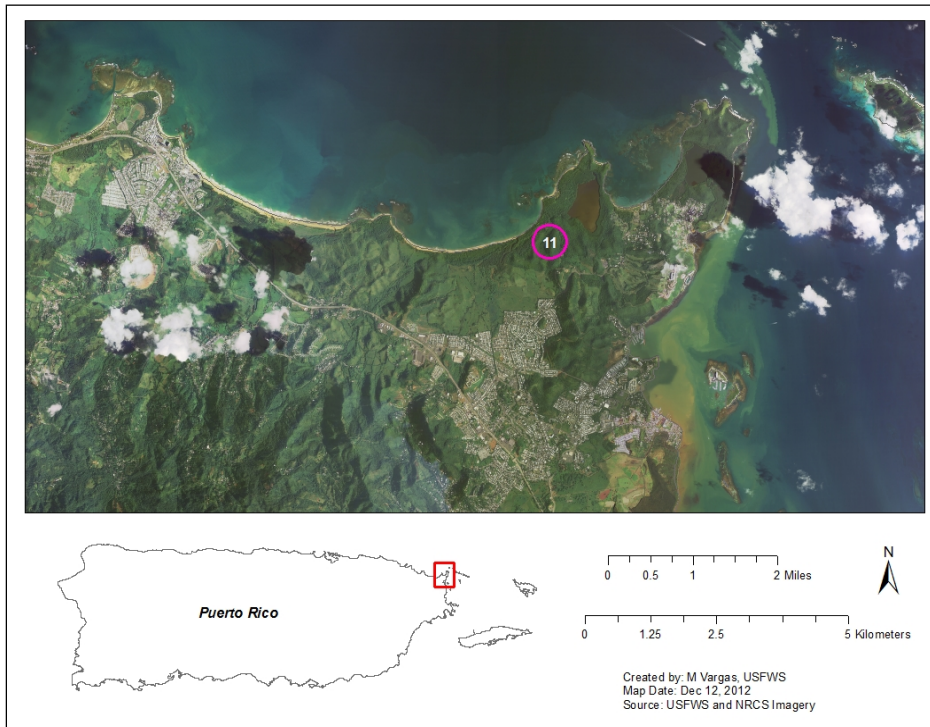
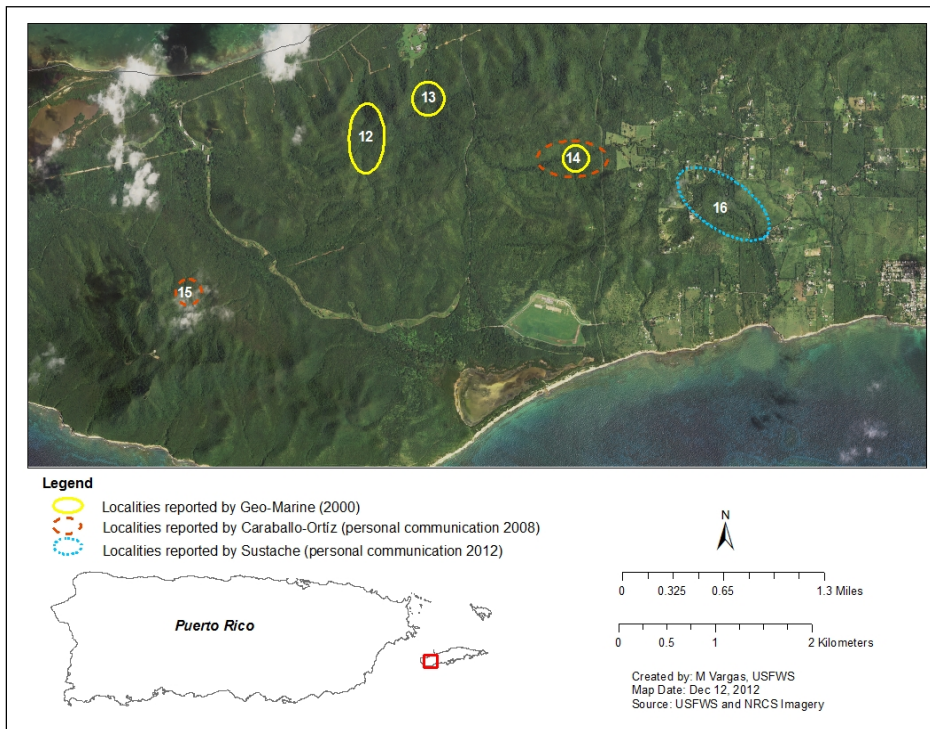


Figure 4. Currently known populations in Vieques Island, Puerto Rico



Vivaldi et al. (1981) did not observe flowers, fruits, or seedlings in Quebradillas, but mentioned that cuttings were collected and planted at the Puerto Rico’s Department of Sports and Recreation nursery and that further attempts to grow the species from cuttings will be carried out at Fairchild Tropical Gardens in Florida. They mentioned that scientists from the Biology Department of the University of Puerto Rico at Río Piedras were attempting to propagate the species using tissue culture techniques. The USFWS (1987) mentioned that propagation from both cuttings and seed were successful on a small scale. At the time the recovery plan was signed, no artificially propagated plants had reach reproductive maturity (USFWS 1987). However, when Santiago-Valentín (1995) conducted propagation experiments, he utilized seeds from cultivated trees located in a greenhouse. We do not have information about when these trees were produced.

Since the mid-1990s, numerous institutions have conducted propagation efforts for matabuey in Puerto Rico and hundreds of seedlings have been planted (M. Rivera, USFWS, pers. obs.). The Service is aware of propagation efforts at the University of Puerto Rico, Mayagüez Campus, the Puerto Rico Botanical Garden in Río Piedras, Puerto Rico Conservation Trust, Puerto Rico Department of Natural and Environmental Resources (DNER), Metropolitan Arboretum Inés Mendoza Park, and the Fairchild Botanical Garden in Miami, Florida. An undetermined number of seedlings and saplings produced through these efforts are given away to the public every year for outreach and planting efforts conducted by local institutions. Hundreds of individuals have been

planted in numerous public properties, Commonwealth forests, parks, along roads, and in private properties as part of reforestation efforts (see Figure 1 for locations). However, no information exists on whether these planted individuals have produced viable populations.

The PRDNER conducted propagation of matabuey in the Cambalache greenhouse in Arecibo since mid-1990 (M. Rivera, USFWS, pers. obs.). They planted six individuals in the Río Abajo Commonwealth Forest (DNER 2006), and an undetermined number of individuals in Gabia farm in Coamo and Toa Vaca farm in Orocovis. At present, the Cambalache greenhouse has approximately 1,000 seeds to grow from the the Vieques population, collected by DNER personnel (J. Sustache, DNER, pers. comm., 2012). In addition, this greenhouse has received seeds from the Puerto Rican Conservation Trust, and has planted seeds from the Quebradilla area (Rovira, DNER, pers. comm., 2008). Botanical gardens in Puerto Rico and Florida have also propagated matabuey for years. The Fairchild Botanical Garden in Florida maintains six individuals of matabuey in their collection and conducts propagation efforts. The Puerto Rico Botanical Garden has been conducting propagation efforts for numerous years and, in 2007, this institution reported over 800 individuals produced from propagation (M. Caraballo-Ortíz, pers. comm., 2007). The Metropolitan Arboretum also propagates the species (Gonzalez, pers. comm., 2008). At the Mata de Plátano private natural reserve in Arecibo the NGO Ciudadanos del Karso planted approximately 100 individuals of matabuey for recovery purposes through a USFWS Partners for Fish and Wildlife project. In 2007, the USFWS also has planted matabuey individuals in the Cabo Rojo National Wildlife Refuge for scientific and educational purposes. In Guaniquilla, Cabo Rojo, the Puerto Rican Conservation Trust (PRCT) has planted approximately 29 individuals of matabuey as part of a habitat restoration project with the USFWS Partners for Fish and Wildlife program, of which 26 were still alive (J. Silva, PRCT, pers. comm., 2008). In addition, in 2012 the Puerto Rican Conservation Trust and the USFWS signed a cooperative agreement to establish and enhance matabuey (among other endangered, threatened and candidate species) on private lands adjacent to or nearby the National Wildlife Refuges in Puerto Rico. The most recent planting of matabuey was at Quebrada Collazo, San Sebastian, in a property that is under a cooperative agreement for the conservation of the threatened palma de manaca (*Calyptronoma rivalis*). Approximately 100+ individuals of matabuey were planted here to enhance the habitat because it shares the same habitat with palma de manaca (i.e., ravines and karst).

For the most part, the material given to the public, individuals planted in public properties, parks, and along roads, may serve for outreach because many of them are not planted in suitable areas and are maintained as landscape plantings (trees are frequently trimmed and pruned). On the other hand, matabuey planted in Commonwealth forests and in private properties (with conservation agreement) are contributing to the recovery of the species, as suggested in the Recovery Plan. These individuals, with proper management, can provide a stock to possibly enhance the natural populations and help reduce the fragmentation of nearby populations (sub-populations).

e. Habitat or ecosystem conditions:

Santiago-Valentín (1995) studied the habitat requirements of matabuey in Isabela and Quebradillas. The eight populations he found occur in the Subtropical Moist Forest Life Zone as described by Ewel and Whitmore (1973). The plants were growing in a semi-evergreen seasonal forest with an almost continuous upper canopy, having few emergent trees, and vines and lianas were frequent. All locations were on the Aymamón limestone formation; hence, plants were growing on limestone-derived upland soil association (Santiago-Valentín 1995).

Santiago-Valentín (1995) described the isolated ravines with difficult access and small patches of forest as the most characteristic habitat for the species. He proposed that the presence of isolated large trees on disturbed hillsides was an indication that the species was not restricted to ravines in the past. He also found that the matabuey in these forested areas was associated with other rare plant species, including the federally listed species *Schoepfia arenaria*. Santiago-Valentín (1995) suggested that the presence of these rare and listed plants also indicate that the steep, inaccessible limestone hills or “mogotes” and ravines have served as a refuge from human activities. He described habitat requirements for seedlings and saplings based on his results of seed germination and seedling establishment experiments, and the distribution of seedlings and saplings in nature. Germination and establishment of matabuey were better in shaded and mesic environments, and seeds do not tolerate high light incidence and dry conditions, such as open pastures, and seed dormancy is absent (Santiago-Valentín 1995). The higher frequency of germination in the uncleared plots in the forest understory fits the behavior of late successional species. Although seedlings and saplings of matabuey are shade tolerant, contrary to the seeds, Santiago-Valentín (1995) found that the species requires a high light regime to reach maturity. The species can be a canopy component of the subtropical moist forest since it can reach up to 16.7 m (52 ft) in height (taller than previously reported). The canopy layer of the subtropical moist forest can reach up to 20 m (66 ft) in height (Vivaldi et al. 1981).

In summary, Santiago-Valentín (1995) proposed that the matabuey is a species adapted to germinate in the understory of the established forest and then persist in a prolonged seedling/sapling stage in that understory. Maturity is achieved when the plant reaches the canopy with higher light levels. Most likely, this occurs with the formation of gaps, due to the loss of major limbs or to the death of surrounding trees. The species probably also responds to increased light intensity due to hurricane effects. Santiago-Valentín (1995) suggested that the decrease in density from seedling to sapling to the mature stage was indicative of self-thinning. He proposed that it is likely that, while the early stages of matabuey are shade tolerant, the adaptation is not absolute, and that with time those that do not achieve a higher light intensity fail. Based on his observations, seedlings were not present under the majority of the observed reproductive trees. Saplings were often present without seedlings, which suggests that recruitment (successful seedling establishment) is sporadic.

f. Other relevant information

At the time of listing, very limited information was available on the biology of the matabuey, particularly the species reproductive biology. There was no information on fruit and seed production and its frequency. Seedlings were rarely observed.

Santiago-Valentín (1995) has significantly contributed to our knowledge on the species. The diameter at breast height (dbh) and mean height of individuals he studied ranged between 0.5 to 35.2 cm (0.2-14 in) and 0.3 to 16.7 m (1-58 ft), respectively. Reproductive trees had a mean dbh of 12.7 cm (5 in) (S.D.= 7.23) and a mean height of 7.57 m (25ft) (S.D. 3.09). He reported that the smallest individual he observed with flowers had a dbh of 3.5 cm (1.4 in). “Sterile adults” had a dbh of 3.5 cm (1.4 in) or greater that were not seen flowering during the study period. Of the 176 individuals studied by Santiago-Valentín (1995), 18.8% were in a reproductive stage, 21% were sterile adults, and 60.2% were saplings. The abundance of flowers per tree varied, and some trees produced a markedly greater number of flowers than the others. Reproductive trees in sites exposed to light had significantly larger stem diameter than trees in semi-exposed sites. Interestingly, there was no evidence that the number of seedlings under the tree was correlated with the amount of flowers it produced. Of the 12 trees with many flowers, 16.7% (only two) had seedlings under them, ten did not, reflecting that flower set is low among the studied individuals. Of the 21 trees with few flowers, only 5 (23.8%) has seedlings underneath. The frequency of occurrence of saplings under the trees did not correlate with flower abundance. Neither seedlings nor saplings occurred in the three sites lacking an understory. All seedling and sapling populations occurred where an understory was present. The majority of the saplings were observed growing in forest shade.

Santiago-Valentín (1995) reported that trees produce flowers throughout the year, but most frequently in February and in July. Fruits were found mainly between March and August, showing a maximum number of fruits in July. All tests the author carried out for apomixes (switch from sexual to asexual reproduction) and autogamy (self-fertilization) were negative. Hand out-crossed flowers had a significantly higher fruit set than did hand self-crossed flowers. He found that the bananaquit or reinita común (*Coereba flaveola*) was the most frequent bird visitor to the flowers, and the European honeybee (*Apis mellifera*) was the most frequent insect visiting matabuey. The stripe-headed tanager or reina mora (*Spindalis zena*) was the only animal he observed manipulating the fruits of matabuey, picking the fruits from the canopy, not from the forest floor. The author provided a very detailed description of matabuey flowers and fruits.

Santiago-Valentín (1995) conducted seed germination experiments of seeds collected from different sources and using different techniques and media. Both seeds from cultivated trees and natural habitat germinated in Petri dishes and greenhouse tests. Germination was more successful in shade and wet conditions. Fifty to 70% of the seedlings in the mesic and wet pots under shade and dense shade survived 10 months after the seeds were planted. Thirty-three percent of the seedlings in the wet pots under full sun survived, but none of the seedlings in dry pots survived.

Santiago-Valentín (1995) suggested that matabuey is self-incompatible, but additional data were required. Carballo-Ortíz (2007) performed a series of experiments using cultivated trees of matabuey located in the Botanical Garden of the University of Puerto Rico and determined that matabuey is mainly self-incompatible and requires cross-pollination for successful fruit set. He also found that the two most common flower visitors (European honeybee and the native bananaquit) were pollinators of matabuey with similar pollination efficiency. However, the bananaquit is the most frequent visitor with 94.7% of the flower visits.

Carballo-Ortíz (2007) suggests that the maintenance of outcrossing, and its self-incompatibility mechanism in hermaphrodite plant species may be a mechanism to avoid the negative effects of inbreeding since outcrossing generally increase genetic variability of populations. While in the Carballo-Ortíz (2007) study, all experimental trees were siblings (grown from seeds from one cultivated individual) possibly affecting the results, Santiago-Valentín (1995) found similar levels of outcrossing and selfing among trees from different genetic backgrounds. He emphasized the fact that the distribution of existing individuals in the wild is scattered and considerably distant, possibly compromising the genetic diversity of populations. He mentioned that because some fruit with viable seeds were produced in the pollination treatment with self-pollen, a degree of self-compatibility might ensure reproduction in isolation when outcrossing is not successful or possible. Carballo-Ortíz (2007) also found that that matabuey flowers have the capacity of being pollinated in the absence of vectors (automatic self-pollination). Disparity in length of the stamens and styles in the trees prevented them from performing autogamy, and could be interpreted as an additional mechanism to promote outcrossing. Finally, he found that matabuey does not produce fruit by apomixes, and therefore, requires pollen deposition for reproduction. Pollination efficiency of both European honeybee and bananaquit was similar for fruit set, seed set and seed germination. Carballo-Ortíz (2007) did not discard the possibility of geitonogamous pollination (pollination between flowers of the same plant) in the wild.

In the Quebrada Bellaca area, Carballo-Ortíz (2007) examined the effect of the spatial distribution on the fecundity and pollinator visitation and examined how fecundity is affected by distance to conspecifics and by flower abundance. He found that the blooming intensity and distances to nearest reproductive neighbors are factors explaining both pollinator visits and fruit set and seed germination. Fruit set decreased significantly when distance to the nearest neighbor increased. He found that when the distance to the nearest conspecifics neighbor was greater than 45 m (148 ft), fruit set dropped to below 50%. In a parallel pattern, seed germination decreased (below 85%) when distance to nearest neighbor was greater than 40 m (131 ft). The highest germination values were observed on nearest neighbors that were within 20 m (67 ft). Only plants in the sample that achieved germination rates of 100% were individuals with blooming neighbors within a distance of 4.5 m (15 ft). These results regarding distance have important implications that need to be considered for the conservation of the matabuey.

2. Five Factor Analysis

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

The final listing rule for the species explains that possible road straightening and widening, periodic trimming of roadside vegetation, potential limestone mining, cattle management practices, and a proposed amusement park complex are threats to matabuey. The recovery plan mentioned that historically, the most important factor limiting the distribution of the species was the conversion of Puerto Rico's lowlands to agriculture in past centuries, and to industrial and housing development in more recent times.

At present, the species is confined to the municipalities of Isabela, Quebradillas, Fajardo and the island of Vieques. All known populations in mainland Puerto Rico are located in privately owned lands or rights-of-way of existing roads periodically maintained by the local government. Santiago-Valentín (1995) concurred with the recovery plan that deforestation of the north coastal plain in post-Columbian times for agriculture and pastures may explain the species' distribution and present restriction to one extreme of its historic range. Santiago-Valentín (1995) found the species in isolated and difficult to access ravines or creeks with small patches of forest. These areas are less affected by human activities, and support a mixture of primary and secondary species (these are species that are found in virgin forests or remnant of virgin forests and disturbed mature forests). Although these areas may have limited use, all of them are privately-owned and human activities, such as harvesting of tubers and selective cutting of matabuey for fence posts, firewood and pathways were documented. Cattle grazing farms surround the majority of the areas and sometimes cattle are present within the habitat. Cattle grazing activities may modify the habitat, affecting the possibility of successful recruitment of seedlings. The Puerto Rico Highway and Transportation Authority is proposing the expansion of the highway PR 22 from Aguadilla to Hatillo, and two of the proposed alternative routes may affect an undetermined number of matabuey in locality 9 and 10 of Figure 2. In addition, indirect effects related to commercial, residential and tourist development associated with the expansion of the highway may affect the species and its habitat.

In Vieques, the species is located along creeks in the western portion of the Island and in one locality in the Monte Pirata area within the Vieques National Wildlife Refuge. The populations located along creeks are outside of the refuge. This land was transferred by the Navy to the municipality for residential and tourism development.

Based on the above, the majority of the populations of matabuey are in private lands currently threatened by various residential, tourist and transportation developments. Matabuey continues to be threatened by habitat destruction and modification of habitat.

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

This factor was not a threat at the time of listing, and we do not have information suggesting that it is a current threat to the species.

(c) Disease or predation;

This factor was not a threat at the time of listing. However, it has been observed that rats occasionally consumed immature fruits in Quebrada Bellaca in Quebradillas, especially when the tree had many fruits (M. Caraballo-Ortiz, pers. comm., 2013). In addition, there is some evidence that livestock probably predate on small trees (M. Caraballo-Ortiz pers. comm., 2013). At present, we do not have any conclusive reports or studies indicating that predation is a threat for the species. Based on these facts we do not consider that predation is a current threat for matabuey.

(d) Inadequacy of existing regulatory mechanisms; and

This factor was not identified as a threat at the time of listing. At present, local laws and regulations protect the species. In 1999, the Commonwealth of Puerto Rico approved the Law No. 241, also 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. In 2004, the DNER approved Regulation 6766 to regulate the management of threatened and endangered species in the Commonwealth of Puerto Rico (“Reglamento para Regir el Manejo de las Especies Vulnerables y en Peligro de Extinción en el Estado Libre Asociado de Puerto Rico”). Matabuey was included by DNER in Regulation 6766 as endangered. Article 2.06 of Regulation 6766 prohibits collecting, cutting, removing, among other activities, listed plants within the jurisdiction of Puerto Rico.

Based on the presence of Commonwealth laws and regulations protecting matabuey, we believe that inadequacy of existing regulatory mechanisms is no longer a threat to this species. However, it is important to note that enforcement on private lands continues to be a challenge as accidental damage or extirpation of individuals (e.g., occasional cutting of individuals during road maintenance, and for fence poles) may occur due to lack of knowledge of the species by private landowners.

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

We believe that current fragmented distribution and reduced number of individuals in several of the existing localities should be considered as important limiting factors or threats to matabuey. Research has demonstrated this species is mainly self-incompatible, and that pollinator visits and fruit set and seed germination is adversely affected by low blooming intensity and high distances to nearest reproductive neighbors. Furthermore, the frequency of sterile adults is high (about 53%). Low fecundity and isolation may affect genetic diversity of the species. The currently known populations also face

dispersal limitation and fragmentation. Although J. Sustache (DNER, pers. comm., 2012) did a rapid assessment in Vieques Island and identified several size classes of matabuey, suggesting population recruitment, without a structured assessment of the entire population we cannot be certain of this fact. Long-term monitoring is needed to corroborate recruitment. In addition, Caraballo-Ortíz (2007) did not find any evidence of recruitment outside the ravine in his study area in the main island of Puerto Rico. Additionally, heavy rain events may contribute to high mortality of seedlings and saplings that are established at the bottom of intermittent drainage systems. Santiago-Valentín (1995) did not report recruitment in three of the eight populations he studied. The majority of the saplings and seedlings were very close to the adult trees. He also found that surrounding grasslands are unsuitable for recruitment. Since the majority of the currently known populations are surrounded by pasturelands, small residential areas and existing roads, the chances for these populations to be expanding are very limited. Because populations are isolated and seed dispersal among populations may not be possible, humans should take active role to reduce the reproductive isolation of individuals by not increasing the continued destruction/modification of its habitat.

Based on the fact that matabuey is mainly self-incompatible, populations show limited dispersal, and that the majority of the populations has limited or no recruitment, we believe that the natural factors mentioned above are a threat to the species.

D. Synthesis

Matabuey is a canopy species that requires an intact understory for successful recruitment of seeds and saplings. It is a species of mesic-forested habitats, currently limited to ravines and creeks in both Puerto Rico and Vieques. At the time of listing, the matabuey was believed to be restricted to the municipalities of Quebradillas and Isabela, and its abundance was estimated at 50 individuals. Populations from the municipalities of Canovanas, Rio Grande and Arecibo were extirpated. Currently, there are more than 1,200 individuals in the wild distributed in 16 populations in Quebradillas, Isabela, Fajardo, and the Island of Vieques. Propagation efforts have produced over 500 plants that were introduced in nine municipalities. However, their status is unknown. Still there is a disjoint distribution of the species on both ends of mainland Puerto Rico.

The species is mainly self-incompatible and requires out-crossing for successful flower and fruit set. Studies have shown that fecundity of matabuey is affected by distance to conspecifics and by flower abundance, which appear to be driven by visits of specific pollinators. Matabuey is apparently pollinated by the common bananaquit and honeybees, but seeds appear to be dispersed only by the endemic striped-headed tanager, which does not have an even distribution in Puerto Rico.

The recovery criteria for reclassifying the species to threatened establishes that the principal population in Quebrada Bellaca (Isabela) is placed under protective status; and at least three new populations capable of self-perpetuation have been established within protected units of the Commonwealth Forest System in the karst region (e.g., Cambalache or Guajataca), or on Federal land within the Caribbean National Forest, if

suitable habitat exists. The criteria to reclassify the species have not been met, and the plan did not include criteria to delist the species. The largest population in mainland Puerto Rico occurs in the Quebrada Bellaca area. This area is under the acquisition priorities of the DNER, but is not currently protected. This area continues to be threatened by urban development. The remaining populations in mainland Puerto Rico are also on privately-owned lands that continue to be threatened with habitat destruction and modification by development, road construction and maintenance, grazing, and cutting. In Vieques, only one small population with seven individuals is located within the Vieques National Wildlife Refuge. Remaining populations are located in areas subject to urban and tourist development.

The propagation efforts have been numerous, but self-sustainable populations in protected areas have not been documented. Successful recruitment of seedlings from propagated plants is limited.

In general, in the last decade, surveys have found other populations of matabuey and more than 1,200 individuals accounted for in Puerto Rico with evidence of recruitment, but limited dispersal in some populations. Although there is an increase in numbers of matabuey, most individuals are located on privately owned lands with a high threat of urban development, leaving matabuey in danger of extinction for the near future. Based on the above discussion, we still consider matabuey to be endangered.

III. RESULTS

A. Recommended Classification:

 X **No, no change is needed.**

IV. RECOMMENDATIONS FOR FUTURE ACTIONS

The recovery plan should be revised to establish measurable reclassification criteria and develop delisting recovery criteria as more information is learned on this plant.

Further studies on pollination and seed dispersal are needed to determine the pollination and seed dispersal strategies in Vieques Island. We should assess if any of these dispersal mechanisms are limiting population growth and distribution expansion.

Isolated populations may require conservation efforts to augment number of individuals and ensuring interchange of genetic representation from other localities.

The Quebrada Bellaca area in Isabela should be acquired and a buffer zone established to reduce the impacts of the adjacent and upstream activities to the integrity of the system.

The Service needs to work with the municipality of Vieques to implement conservation measures on creeks and ravines, including the protection of watersheds by zoning. A private-lands initiative is needed to further protect the adjacent land and streams.

Both DNER and the Service should re-evaluate propagation efforts and introduction requirements for the species. Current efforts should be carefully evaluated to ensure that these efforts are consistent with the biological and ecological limiting factors of the species, and to ensure establishment of viable populations in protected areas. Santiago-Valentín recommended that reintroductions efforts for the recovery of the species must target the establishment of new populations on protected lands following reproductively functional spatial patterns of planting. Based on his study, trees could maintain up to 100% germination (in the case of few-flowered trees) if they are separated by 4.5 m (15 ft) or less. Other considerations should include the presence and abundance of the bananaquit and the striped-headed tanager as the main pollinator and the seed dispersers, respectively. An interesting research project would be to determine seed shadows (an area on the ground where seeds do not fall due to canopy for example), time of gut passage, and viability of seeds.

Isolated populations should be enhanced with propagated material with genetic representation from other localities.

Efforts should continue to protect privately-owned populations.

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**U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW of Matabuey (*Goetzea elegans*)**

Current Classification. Endangered

Recommendation resulting from the 5-Year Review

- Downlist to Threatened
- Uplist to Endangered
- Delist
- No change is needed

Review Conducted By Maritza Vargas, Caribbean Ecological Services Field Office

FIELD OFFICE APPROVAL:

Lead Field Supervisor, U.S. Fish and Wildlife Service

Approve  Date 7/22/2013

REGIONAL OFFICE APPROVAL:

^{for}
Lead Regional Director, Fish and Wildlife Service

Approve  Date 8-29-13

Appendix A. Summary of peer review for the 5-year review of *Goetzea elegans* (Beautiful goetzea/matabuey)

A. Peer Review Method: We requested peer review from several knowledgeable individuals. We indicated our interest in all comments the reviewers may have about matabuey, specifically in any additional information on the status and the current threats of the species. The due date of the peer review comments was on March 4, 2013. Responses were received from one of these peer reviewers.

List of Peer Reviewers

Dr. Eugenio Santiago
Department of Biology
University of Puerto Rico, Rio Piedras Campus
Box 23360
San Juan, Puerto Rico 00931-3360
Phone: 787-764-0000, ext. 2905
E-mail: goetzea@yahoo.com

Mr. Marcos Caraballo-Ortíz
Department of Biology
University of Puerto Rico, Rio Piedras Campus
Box 23360
San Juan, Puerto Rico 00931-3360
maco_pr@yahoo.com

Mr. José Sustache
Department of Natural and Environmental Resources
P.O. Box 9066600
San Juan, Puerto Rico 00940
Phone: 787-999-2200, ext. 2642
E-mail: jsustache@drna.gobierno.pr

Dr. Pedro Acevedo
National Museum of Natural History
MRC-166/Botany
Smithsonian Institution
PO Box 37012
Washington, DC 20013-7012
Phone: 202-633-0963
E-mail: acevedop@si.edu

B.. Summary of Peer Review Comments/Report: Peer reviewer responses were supportive of the information and assessment presented in this review. The peer review gave us distribution and population structure information. We also learned that the report on

matabuey in Cambalache Commonwealth forest is a planted individual and not a historical location. The reviewer stated that the report was based on a herbarium specimen and that it specifies it was planted. Referring to the recovery criteria from the recovery plan, the reviewer also stated that the Isabela, Vieques, and Fajardo populations are important to the conservation of the species, and that the protection of these populations should consider the genetic diversity and the connectivity of the populations (creation of corridors to promote genetic flow between nearby populations).

C. Response to Peer Review: The Service was in agreement with all comments received from the peer reviewer. Comments were evaluated and incorporated into the 5-year review as appropriate.