

Recovery Plan
for the
Guajón or Puerto Rican Demon
(*Eleutherodactylus cooki*)



RECOVERY PLAN
for the
GUAJÓN OR PUERTO RICAN DEMON
(Eleutherodactylus cooki)

Prepared by

Jorge E. Saliva, U.S. Fish and Wildlife Service, Caribbean Field Office,
Puerto Rico

Kenneth W. Foote, U.S. Fish and Wildlife Service, Hawaii Field Office,
Hawaii

Sondra I. Vega-Castillo, Box 1112, Ciales, Puerto Rico

for

U.S. Fish and Wildlife Service
Southeast Region
Atlanta, Georgia

Approved: _____
Regional Director, U.S. Fish and Wildlife Service

Date: _____

DISCLAIMER

Recovery Plans delineate reasonable actions that are believed to be required to recover and/or protect listed species. Plans published by the U.S. Fish and Wildlife (Service), are sometimes prepared with the assistance of recovery teams, contractors, state agencies, and other affected and interested parties. Plans are reviewed by the public and submitted to additional peer review before the Service adopts them. Objectives will be attained and any necessary funds made available subject to budgetary and other constraints affecting the parties involved, as well as the need to address other priorities. Recovery plans do not obligate other parties to undertake specific tasks and may not represent the views nor the official positions or approval of any individuals or agencies involved in developing the plan, other than the Service. Recovery plans represent the official position of the U.S. Fish and Wildlife Service, only after they have been signed by the Regional Director or Director, as approved. Approved recovery plans are subject to modification as dictated by new findings, changes in species status, and the completion of recovery actions.

By approving this recovery plan, the Regional Director certifies that the data used in its development represent the best scientific and commercial data available at the time it was written. Copies of all documents reviewed in the development of this plan are available in the administrative record, located at the Boquerón Field Office, in Boquerón, Puerto Rico.

NOTICE OF COPYRIGHTED MATERIAL

Permission to use copyrighted illustrations and images in the final version of this recovery plan has been granted by the copyrighted holders. These illustrations are not placed in the public domain by their appearance herein. They cannot be copied or otherwise reproduced, except in their printed context within this document, without the written consent of the copyright holder.

Literature Citation:

U.S. Fish and Wildlife Service. 2004. Recovery Plan for the Guajón or Puerto Rican Demon (*Eleutherodactylus cooki*). U. S. Fish and Wildlife Service, Atlanta, Georgia. 31 pp.

Copies of this recovery plan are available on the U.S. Fish and Wildlife Service website at:

<http://endangered.fws.gov/RECOVERY/RECPLANS/Index.htm>

ACKNOWLEDGMENTS

The Service gratefully acknowledges Dr. Fernando Bird-Picó*, Dr. Patricia A. Burrowes*, Dr. Miguel García*, Dr. Harold Heatwole, Dr. Rafael Joglar*, Mr. José Sustache*, and Dr. Pedro M. Torres for reviewing and providing comments on this draft recovery plan.

*Appointed peer reviewers have an asterisk by their names.

EXECUTIVE SUMMARY

Current Species Status: The guajón or Puerto Rican demon (*Eleutherodactylus cooki*) hereafter referred as “guajón,” a threatened species of frog, is extremely limited in geographic distribution and habitat requirements. The guajón inhabits crevices and grottoes in and among boulders in the Cuchilla de Panduras mountain range in southeastern Puerto Rico. This endemic species, one of sixteen species of the genus *Eleutherodactylus*, is part of the group commonly known as “coquíes.” The first description of the range of this species included only the localities of the Cuchilla de Panduras mountain range (municipalities of Yabucoa and San Lorenzo). In 1998, its distribution was expanded to include southeast Puerto Rico and west to Patillas-San Lorenzo. In 2000, new populations were discovered from Humacao and Las Piedras, Puerto Rico. The guajón’s habitat is threatened by agricultural, rural, and industrial development, and the associated infrastructure.

Habitat Requirements and Limiting Factors: The guajón occurs at low and intermediate elevations from 18 to 1,183 feet above sea level (36-360.7 meters above sea level) where they inhabit caves formed by large boulders of granite rock known as “guajonales” or streams with patches of rocks without cave systems. This endemic species was previously believed to occur exclusively inside caves containing or adjacent to streams; however, habitat studies by Vega-Castillo (2000) showed that the guajón also lives in rocky streams. Caves are dark inside, although some light enters through gaps formed from the union of two or more boulders of rock. Structurally the caves are complex, in the form of several chambers of irregular shape and size, and at different depths between the surface of the ground and stream. The ecological conditions of the caves are similar: mean temperature and relative humidity are the same at any given month of the year, and they do not have thermal stratification. In streams, the species has been found only in patches of rock in the streambed. The streams are surrounded by secondary forest and can be a perennial, or an ephemeral stream, which forms with heavy rain. Rocks in the streambed form crevices and grottoes. Streams provide a wide variety of retreat sites for the species, such as vegetation over rocks (e.g., moss, ferns and liverworts) that help in the conservation of humidity. Temperature and relative humidity at streams vary within the year.

Recovery Goal: To protect and stabilize existing populations and associated habitat of the guajón, and ultimately remove the species from the List of Endangered and Threatened Wildlife.

Recovery Criteria

1. Permanently protect traditional, non-traditional, and unoccupied guajón habitat, and corridors between existing populations, through landowner agreements, conservation easements, habitat conservation plans, and public outreach.
2. Determine the viability of existing populations (e.g., numbers, breeding success, population genetics, and ecology), and how many viable subpopulations are needed to ensure a self-sustaining overall population.

3. Determine the geographic distribution of all subpopulations needed to ensure a self-sustaining overall population.
4. Survey all potential habitats for new occurrences and evaluate suitability for species introduction.

Recovery Actions Needed:

1. Determine the distribution and population status of the guajón within traditional, non-traditional, and unoccupied habitat.
2. Evaluate the need for protection of essential habitat for the species.
3. Conduct ecological studies to ensure the reproductive success of the guajón and the species' genetic variability.
4. Document the effect of natural and manmade disturbances on the guajón population.
5. Facilitate the recovery of the guajón through public awareness and education.
6. Refine recovery criteria and determine what additional actions are necessary to achieve recovery criteria.

Total Estimated Cost of Recovery: \$796,000.00

Year	Action 1	Action 2	Action 3	Action 4	Action 5	Action 6	Total
2005	17	120	50	25	5		207
2006	17	110	50	25	45		237
2007	17	85	40	30	35		197
2008		55	10		20		75
2009		45	15		20	10	80
Total	51	395	165	80	125	10	846

*Costs estimated in thousands of dollars

Date of Recovery: Delisting should be initiated by in 2025, if recovery criteria are met.

TABLE OF CONTENTS

Background	1
Listing Status.....	1
Description/Taxonomy	2
Population Trends and Distribution	2
Habitat Characteristics	4
Life History/Ecology	5
Reasons for Listing/Current Threats	6
Recovery Strategy	8
Recovery Criteria.....	9
Recovery Goal	9
Recovery Program	
Recovery Actions Step-down Outline and Narrative	13
Implementation Schedule	23
Literature Cited	26
List of Stakeholders and Reviewers	29

Background

The Endangered Species Act of 1973, as amended (16 U.S.C. 1531 *et seq.*) (ESA), establishes policies and procedures for identifying, listing and protecting species of wildlife that are endangered or threatened with extinction. The ESA defines an “endangered species” as “any species which is danger of extinction throughout all or a significant portion of its range.” A “threatened species” is defined as “any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.”

The Secretary of the Interior is responsible for administering the ESA’s provisions as they apply to this species. Day-to-day management authority for endangered and threatened species under the Department’s jurisdiction has been delegated to the U.S. Fish and Wildlife Service (Service). To help identify and guide species recovery needs, Section 4(f) of the ESA directs the Secretary of the Interior to develop and implement recovery plans for listed species or populations. Such plans are to include: (1) a description of site-specific management actions necessary to conserve the species or population; (2) objective measurable criteria which, when met, will allow the species to be removed from the list of threatened and endangered species; and (3) estimates of the time and funding required to achieve the plan’s goals and intermediate steps. Section 4 of the ESA, and regulations promulgated to implement its listing provisions (50 CFR Part 424), also set forth the procedures for reclassifying and delisting species on the federal list of threatened and endangered species. A species can be delisted if the Secretary of the Interior determines that the species no longer meets the endangered and threatened status, based upon the following five factors listed in Section 4(a)(1) of the ESA:

1. the present or threatened destruction, modification, or curtailment of its habitat or range;
2. overutilization for commercial, recreational, scientific, or educational purposes;
3. disease or predation;
4. the inadequacy of existing regulatory mechanisms; and
5. other natural or manmade factors affecting its continued existence.

Further, a species may be delisted, according to 50 CFR Part 424.11(d), if the best scientific and commercial data available substantiate that the species or population is neither endangered nor threatened for one of the following reasons: (1) extinction; (2) recovery; or (3) original data for classification of the species were in error.

Listing Status

The guajón was listed as threatened on June 11, 1997 (62 FR 31757) pursuant to the Endangered Species Act of 1973, as amended (U.S. Fish and Wildlife Service 1997) due to its restricted distribution, specialized habitat utilization, and threats to their habitat. The Service determined designation of critical habitat not prudent because of the increased risks of vandalism and illegal collection should the exact location of individuals be made public. The guajón is also designated as vulnerable by the Puerto Rico Department of Natural and Environmental Resources (DNER 2004), and is afforded protection by Commonwealth laws.

Description/Taxonomy

The guajón (*Eleutherodactylus cooki*) is a petricolous (i.e., inhabiting rocks) frog species endemic to the southeastern part of Puerto Rico. This species is one of sixteen species of the genus *Eleutherodactylus*, commonly known as “coquíes” that inhabit the island. Joglar (1989) established the phylogenetic relations of frogs from the West Indies, utilizing morphological characteristics belonging to the genera *Eleutherodactylus*. Three groups or classes were recognized for the West Indies: *Eleutherodactylus inoptatus*, *Eleutherodactylus ricordii*, and *Eleutherodactylus unistrigatus*. This species is a member of the West Indies subset of the *Eleutherodactylus unistrigatus* group (Joglar 1989). The guajón is the second largest species of *Eleutherodactylus* in Puerto Rico. The guajón has a solid brown coloration in the dorsal area, white-rimmed eyes, and large, truncate disks (i.e., partially cut) on its feet (Rivero 1998, Joglar 1983 and 1981). The species exhibits sexual dimorphism (separate female and male morphs) regarding size, vocalization, and coloration (Burrowes 2000a and 1997). Females are larger than males; the mean size (snout-vent length) for females is 2.01 inches (50.94 millimeters) and 1.71 inches (43.43 millimeters) for males. The ventral coloration of females is uniformly white, while males are yellow extending from the vocal sac to the abdomen and flanks. Males call for mates by producing 3-7 similar notes (Drewry and Rand 1983). Females produce only a short, acute call when distressed (Burrowes 2000a). Juveniles are brown in color with a dorsal pattern of dark brown inverted parentheses (Joglar *et al.* 1996, Joglar 1998).

Population Trends and Distribution

The guajón is currently known to inhabit crevices, grottoes, and spaces among boulders in the Cuchilla de Panduras mountain range (Maunabo, San Lorenzo, and Yabucoa), and in the municipalities of Patillas, Humacao, and Las Piedras (Figure 1). Such grottoes are commonly referred to as “guajonales.” It is from the grottoes or guajonales where the species lives that the frog derives its name. The species is apparently limited in distribution by the rock formations where it occurs.

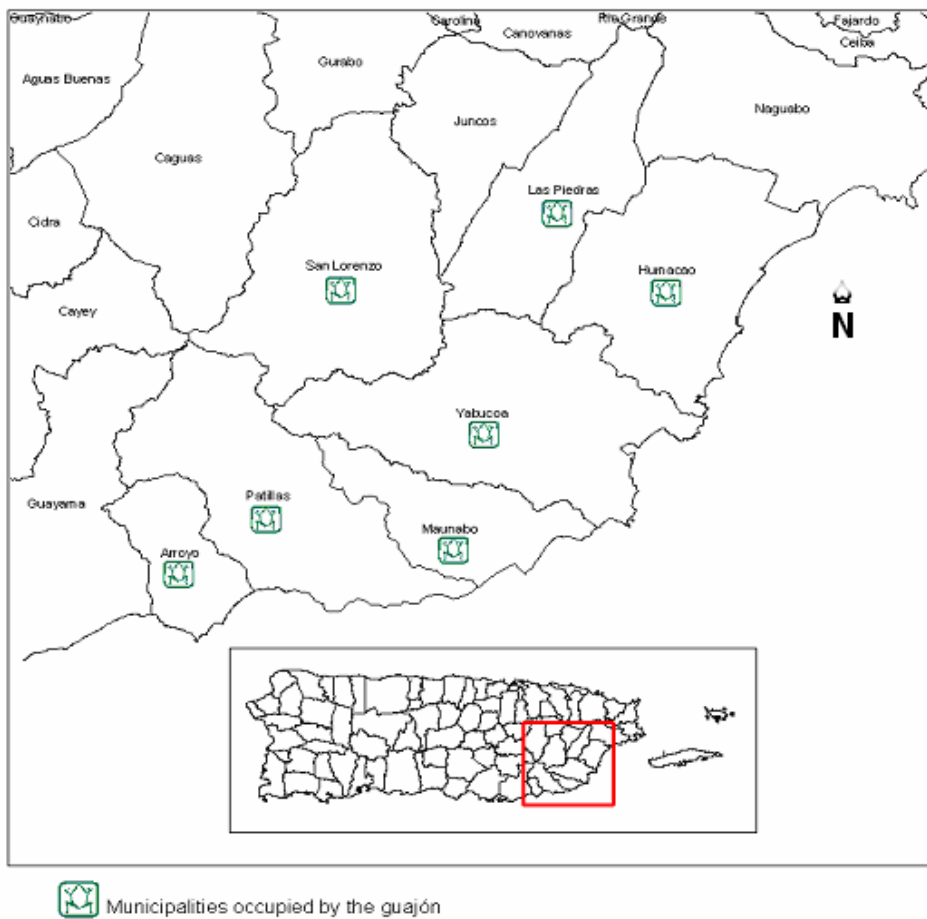
The first description of the range of this species included only the localities of the Cuchilla de Panduras mountain range, where the rock formation is present (Grant 1932). Moreno (1991) also found the species to be restricted to the Cuchilla de Panduras mountain range, and mentioned that this species did not appear to be as common as in past years. During surveys conducted by Drewry (1986) and Joglar (1992), the guajón was found at its historical localities in the municipalities of Yabucoa and San Lorenzo. Rivero (1998) expanded its known distribution to include southeastern Puerto Rico and west to Patillas-San Lorenzo, where the species lives in crevices and grottoes. Vega-Castillo (2000) reported new populations from Humacao and Las Piedras, where the species can be found in rocky streams.

The hidden and complex habitats where the guajón occurs makes it difficult to study and therefore, little detailed information is known about its population’s status and distribution or the health of those known populations. Detailed locality information is lacking for the guajón. Existing maps only indicate general areas or municipalities where the species is known to occur. Site-specific data (i.e., Global Positioning System coordinate points), previously collected by research scientists, used different systems and projections that were

not adequately documented. The Service, therefore, could not produce a detailed distribution map for the species with the data available.

According to Joglar *et al.* (1996), relative abundance for the guajón seemed to decrease during winter when precipitation and air temperature decreased. Burrowes (1997) studied the guajón at a cave system in the Cuchilla de Panduras, where a total of 130 individuals were marked at the site, resulting in a mean population size estimate of 96 individuals, and a mean of 20 new individuals entering the population every six months. Another mark-recapture study conducted by Vega-Castillo (2000) showed mean population size of 436 individuals in a rocky stream in Humacao, and 390 individuals for a rocky stream at Las Piedras.

Figure 1. Distribution map of the guajón



Habitat Characteristics

The distribution of this species is associated with the granitic rocks found in the Cuchilla de Panduras mountain range in southeastern Puerto Rico. Hedges (1989) included this species in the cave/rock ecomorph group of the West Indies *Eleutherodactylus*. The guajón is found at low and intermediate elevations from 18 to 1,183 feet above sea level (36 to 361 meters above sea level), where it inhabits caves formed by large boulders of granite rock known as “guajonales,” and in associated streams with patches of rock without caves systems. Caves are dark inside, although some light enters through gaps formed from the union of two or more boulders. Structurally, the caves are complex, having several chambers of irregular shape and size, and may be at different depths between the surface of the ground and stream (Burrowes 2000a). The ecological conditions of the caves are similar: mean temperature and relative humidity are the same at any given month of the year, and they do not have thermal stratification (Rogowitz *et al.* 1999a, Rogowitz *et al.* 1999b, Burrowes 1997 and Joglar *et al.* 1996). For many years, the guajón was believed to be a highly localized species that occurred exclusively inside caves (Joglar 1998, Burrowes 2000a and 1997), but habitat studies of this species (Vega-Castillo 2000) showed that the guajón also lives in rocky streams.

The habitat of the guajón includes several life zones as described by Ewel and Whitmore (1973). The variables used to delineate any give life zone are mean annual precipitation and mean annual temperature. The two predominant life zones found within guajón habitat are Subtropical Moist and Subtropical Wet Forests. In addition, Subtropical Lower Montane Wet Forest may be found on most mountains above 1000 meters and occasionally extending down to almost 700 meters. Trees up to 20 meters tall, with rounded crowns, characterize the Subtropical Moist Forest life zone. Many of the woody species are deciduous during the dry season and epiphytes are common. The Subtropical Wet Forest occupies much of the higher parts of Puerto Rico’s mountains. The abundant moisture of this life zone is evident in the character of vegetation. Epiphytic ferns, bromeliads, and orchids are common, the forests are relatively rich in plant species, and the growth rates of successional trees are rapid. This type of forest contains more than 150 species of trees that form a dark, complete canopy at about 20 meters. The third life zone found in the guajón’s habitat is the Subtropical Lower Montane Wet Forest, which may occur at the higher elevations. Open-crowned trees that have coriaceous, dark leaves, giving the canopy a brownish or reddish cast, characterize this forest. The species diversity for this life zone is much less, with 53 tree species found.

Vega-Castillo (2000) reported that in streams, the guajón has been found only in patches of rock in the streambed. The streams can be perennial, or ephemeral formed during heavy rain and are surrounded by secondary forest. Rocks in the streambed form crevices and grottoes. Streams provide a wide variety of retreat sites for the species, such as vegetation over rocks (e.g., moss, ferns, and liverworts) that help conserve humidity. Temperature and relative humidity at streams vary with the months of the year. The foraging habitat of the guajón may extend outside the streambed in vegetated areas as far as 66 to 98 feet (20 to 30 meters) from the water source (Vega-Castillo, pers. obs.).

Life History/Ecology

The call of the guajón is low, and consists of three to seven similar notes, a sound that is different from any other species of *Eleutherodactylus* in Puerto Rico (Drewry and Rand 1983, Rivero 1998). In this species, only the male calls for mates and the vocal activity is more intense during the day than at night (Joglar *et al.* 1996). Night vocal activity began at dusk and the peak calling time is at 2100 hours (Drewry 1970, Drewry and Rand 1983). Males of the guajón call to attract females, and continue to call while attending the clutch (Joglar *et al.* 1996). The reproductive activity and the population fluctuations of the guajón are significantly correlated with precipitation and air temperature (Rogowitz *et al.* 2001, Joglar *et al.* 1996). The reproductive season of this species starts in April and ends in November.

Studies on parental care and sexual selection of this species, conducted by Burrowes (2000a and 1997), showed that the amplexus occurs on rocks where the male places his head over the female pelvic region and wraps his arms around the outer part of the female's hind legs. The amplexic pair remains in this position for 12 hours before oviposition begins. When the oviposition is complete, the male sits over the clutch of eggs to guard and defend it while the female moves away from the eggs (Burrowes 1997). Like most of the *Eleutherodactylus*, the guajón has direct development of eggs, which are laid on humid boulders within grottoes and on flat surfaces (Joglar *et al.* 1996, Burrowes 1997). The preference for this type of microhabitat probably reduces evaporative water loss, and egg predation (Joglar 1998). The mean clutch size of the guajón is 17.35 eggs, the developmental time of eggs is 20 to 29 days, and parental care contributes to hatching success (Joglar *et al.* 1996). Hatching success of this species is 85 percent, with hatchlings remaining together as a group in the nest for several days before dispersing (Burrowes 1997).

Males may guard multiple clutches that are at different stages of development (Burrowes 2000a). Burrowes (2000a) reported that developmental timing between consecutive clutches in the same nest ranged from 4 to 14 days, and one to three developmental stages. Triple and quadruple clutches were less frequent than single and double clutches, and were primarily associated with more secluded crevices or depressions (Vega-Castillo, pers. obs. 2003). Males of the guajón that guard multiple clutches increase their fitness and opportunity for reproduction (Burrowes 2000a). Burrowes (2000a) suggests that different clutches are a result of males mating with different females.

Joglar *et al.* (1996) and Burrowes (1997) described the activity pattern of the guajón in a traditional habitat (caves and grottoes) at San Lorenzo as follows: males remained in the grottoes and crevices of the "guajonales" calling, brooding eggs, tending eggs without brooding, and calling while tending clutches by day. At night, males and females left the grottoes to forage and rehydrate. In rocky, stream habitat, animals exit their retreat site at dusk to forage actively over rocks and vegetation. In both types of habitat, the species exhibits site fidelity and homing behavior, and males that have eggs remain in cavities defending and guarding clutches. In a preliminary study of feeding habits Joglar (1998) reported that the bulk of the diet consisted of insects (Coleoptera, Homoptera, Diptera, Hymenoptera and Lepidoptera), and other invertebrates like spiders, Chilopoda, and Diplopoda.

Burrowes (2000b and 1997) assessed the genetic variation within and among populations of the guajón, in separate cave systems within the historic geographic range of the species and found a high degree of genetic variation and lack of population differentiation in the species. These studies also documented that genetic flow among populations of “guajones” is necessary to maintain the high genetic variability observed in the species. This genetic variability depends on inter-connection between caves, and the availability of clean subterranean waterways as indirect dispersal routes necessary for out-crossing (Burrowes 2000b and 1997). This study also suggested that the species is perfectly adapted to the existing environmental conditions in the caves, and that clean waterways must be maintained between the guajonales to maintain a high degree of genetic variation among the guajón population.

Rogowitz and Sánchez-Rivolea (1999) showed that locomotive performance (i.e., jumping) in the guajón is thermally dependent and the species has the ability to respond to variations in temperature. They hypothesized that thermal dependence of jumping performance has no apparent value in cave habitats and suggested that it is an ancestral trait. However, Vega-Castillo (2000) argued that the ability to respond to variations in temperature allows the guajón to inhabit other habitats, like rocky streams and to forage in adjacent riparian habitat.

Reasons for Listing/Current Threats

Populations of species with a small range, or restricted to a specific habitat, are most susceptible to loss or depletions because of localized human activities that change their habitats (Bury *et al.* 1980; Bury *et al.* 1995). Amphibians are less adaptable than other animals to habitat changes because of physiological constraints. The maintenance of highly permeable, moist, cool skin that allows for efficient respiration generally requires habitats that are humid with low evaporation rate. In addition, small size and slow movement result in relatively poor dispersal capabilities and small home ranges. These physiological factors cause amphibians to be especially sensitive to the abrupt transitions impacting their microclimate and microhabitat (Demaynadier and Hunter 1998).

Changes in forest structure and vegetation may alter microhabitats and microclimates that affect the quality of habitat and the species. Deforestation and earth movement for agricultural, urban, and rural development has a negative impact on the habitats and interrupts the connection between existing populations, thus dispersal and interaction opportunities between sub-populations can be affected, restricting gene flow and jeopardizing the viability of meta-populations. Isolated populations are vulnerable to extinction through random adverse environmental events and human-caused impacts (Soule 1987). Any activity that jeopardizes the gene flow among sub-populations also puts in danger the integrity of the species' gene pool.

The guajón was listed primarily due to its highly restricted geographical distribution and habitat requirements. The habitat of this species is naturally fragmented and the majority of the known populations are on private land where the increased levels of land development currently occurring in southeastern Puerto Rico where the species occurs, threatens to further reduce and fragment the species habitat, distribution, and survival. Being a habitat specialist, the guajón is adapted to particular environmental conditions, and abrupt changes in these conditions could result in population declines.

Road and urban developments result in earth movement, modification of vegetation and streams, and increased noise levels, as well as habitat fragmentation that may interrupt the connection between sub-populations, affecting the genetic variability and population numbers of the guajón. Amphibian populations unable to disperse because of barriers may experience genetic isolation resulting in reduced heterozygosity (i.e., potential reduction in genetic variability and evolutionary fitness). Fragmenting habitat through human intrusions such as roads makes populations less resilient to natural population declines (Pechman *et al.* 1991).

Deforestation near streams can result in erosion and increase flash flooding. Runoff water from slopes during flash flooding drastically disturbs the habitat of the guajón, and high levels of sediment introduced into streams can fill spaces between rocks and decrease the availability of retreat sites among the boulders. Another effect of flash flooding is the flushing and drowning of adults, as well as the destruction of nests. The use of pesticides, herbicides, and fertilizers in agricultural fields could have detrimental effects on survival of the guajón from runoff into waterways adjacent to guajón habitat. Many studies have documented negative impacts of agrochemicals on frogs; impacts include deformities, abnormal immune system functions, diseases, injury and death (Cook 1981; Hine *et al.* 1981; Sanders 1970; Reeder *et al.* 1998; Davidson *et al.* 2001; Hayes *et al.* 2002; Gendron *et al.* 2003). Also, any stream modification (e.g., embankment, channelization) or development (e.g., tourist, urban) within the watershed where the guajón exists could result in an increase of chemical laden sediments and alteration of the streams quality.

Recreational use of streams may degrade the habitat quality for the guajón. People that live adjacent to guajón habitat may collect crabs and shrimp using toxic substances (e.g., chlorine), affecting water and habitat quality. The decrease in water and habitat quality can have a serious impact on this and other amphibians that inhabit streams. Waste generated during recreational use of streams produce waste that people may introduce to the streams, for example, caves in the Cuchilla de Panduras mountain range are used as garbage dumps, attracting potential predators and diseases for the guajón.

The lack of enforcement of regulations to protect the guajón, and governmental measures to prevent destruction of its habitat, threaten the survival of the guajón. The Commonwealth of Puerto Rico and the Service have adequate laws in place to protect endangered and threatened species; however, insufficient funding and personnel to properly administer and enforce existing wildlife laws, may result in violations that impact the guajón and its habitat. The absence of an appropriate public education and outreach program to promote public awareness and conservation measures for this species and its habitat, also threaten the recovery of the guajón.

The final rule to list the guajón stated “While collection has not been documented as contributing to the decline of the guajón specifically, large numbers of *Eleutherodactylus* species, including several identified as species at risk, have been documented in scientific collections.” Local artisans for the confection of tourist souvenirs also collect species of *Eleutherodactylus*. Collection of specimens of the guajón for scientific or commercial purposes could pose a serious threat to this species, but has yet to be substantiated with scientific data.

Pathogens and predation have been implicated in the decline of many frog species around the world, but there have not been studies about how disease and predators may affect guajón populations. Recent studies have documented many frog pathogens and diseases; a chytrid fungus (*Batrachochytrium dendrobatidis*) has been identified in the skin of Australian and Panamanian frogs whose populations have declined (Berger 1998, Speare 2001). Although some potential predators of the guajón have been suggested, predation events on adults and juveniles of this species have not been documented. The introduced bullfrog (*Rana catesbeiana*), is mentioned as a potential predator; since this species has been implicated in the decline of many frogs species elsewhere (Davidson *et al.* 2001). The terrestrial and semi-arboreal snakes *Alsophis portoricensis* and *Arrhyton exiguum* are known predators of *Eleutherodactylus* species and small lizards, and are found within the range of the guajón (Rivero 1998).

Predation of guajón clutches by snails, black flies of the family Phoridae, and by conspecific male frogs have been reported, but there has not been an extensive examination on how this predation may adversely affect guajón populations, or if they have formed an evolutionary component of the species life history. Seven other species of *Eleutherodactylus*, as well as the white-lipped frog *Leptodactylus albilabris*, are found within the same habitat as the guajón under rocks, logs, roots, or litter in the Cuchilla de Panduras mountain range (Rivero 1998). However, the extent of competitive interactions (i.e., competition for shelter or food) or predation between these species and the guajón has not been documented. The parasitism by the tick *Ornithodoros talaje* has also been documented, but the effects of this parasite on the species are not known. At least three genera of nematodes, *Parapharyngodon*, *Aplectana*, and *Poekilostrongylus*, have been reported from other *Eleutherodactylus* (Rivero 1998), but their occurrence in the guajón has not been determined.

Recovery Strategy

Thorough surveys of the guajón in traditional, non-traditional and unoccupied habitat should be conducted using the best available amphibian survey methodology, to determine population numbers, population fluctuations, and number of viable populations (wild naturally reproducing populations large enough to maintain sufficient genetic variation, and evolve and respond to natural habitat changes) necessary to protect and stabilize the guajón population.

Activities that may result in the deterioration of guajón habitat in public and private lands, such as proposals for road constructions/improvements, recreational use of streams, agricultural practices, and urban, commercial, and tourist developments, should be carefully evaluated by the appropriate government agencies and parties interested in the recovery of the guajón. Long term leases, conservation easements, designation of guajón conservation areas, enforcement of regulations protecting the guajón, habitat restoration, and land acquisition must be explored as strategies to minimize loss of guajón habitat. This will guarantee that the resources necessary to support a successful breeding population of the guajón are not compromised.

The impact of predators, competitors, and parasites on population numbers of the guajón should be evaluated, through studies of the interactions between potential competitors,

predators, and parasites and the guajón, to determine competitor and predator/parasite management techniques that would need to be implemented to eliminate or minimize the impact of predation, parasitism, and competition on the guajón.

The effect of natural disturbances, such as flooding during storms and hurricanes, on population dynamics (e.g., change in distribution, dispersal) and survival of the guajón should be assessed through monitoring of guajón populations before and after the occurrence of natural disturbances (e.g., monitor changes in: habitat characteristics, location of individuals, mortality, dispersal).

Effective public education and outreach programs are key to the recovery of the guajón. Such programs need to develop interest among stakeholders (e.g. landowners, government agencies, legislators, consultants for development projects, academic community, and general public) on their contribution to recovery activities of the guajón. Understanding the species needs would create an involvement of different groups working towards common goals. This outreach and education program should balance the needs of the target audiences and the guajón, and include the development and distribution of information (e.g., species reports, audiovisual presentations, meetings, media sources) on the recovery needs of the species.

Recovery Criteria

At present, there is limited knowledge on the population abundance, dispersal and biology of the guajón preventing us from developing specific recovery criteria. The following are interim criteria that would lead us to obtain data for the development of more specific, quantifiable criteria that should be met before considering the delisting of this species:

1. Permanently protect traditional, non-traditional, and unoccupied guajón habitat, and corridors between existing populations, through landowner agreements, conservation easements, habitat conservation plans, and public outreach.
2. Determine the viability of existing populations (e.g., numbers, breeding success, population genetics, and ecology), and how many viable subpopulations are needed to ensure a self-sustaining overall population.
3. Determine the geographic distribution of all subpopulations needed to ensure a self-sustaining overall population.
4. Survey all potential habitats for new occurrences and evaluate suitability for species introduction.

Recovery Goal

The goal of the recovery program for the guajón is to protect and stabilize existing guajón populations and associated habitat in the near term and to ultimately recover the species to the point that delisting is warranted (Table 1).

Table 1. Relationship of Recovery Actions and Criteria to Threat and Listing Factors to the Guajón Recovery Planning.

LISTING FACTOR	THREAT	RECOVERY CRITERIA*	RECOVERY ACTIONS
A	Habitat Destruction and Modification	1, 2, 3, 4	11 conduct surveys, 12 identify potential habitat and search for new populations, 21 identify essential habitat, 2211 evaluate public lands, 2212 prevent reduction of habitat, 2213 establish and implement management plans, 2214 protect and manage private lands, 2215 establish corridors and buffer zones, 2216 monitor and reduce human disturbance, 23 restore degraded habitat, 33 determine genetic variability and gene flow, 51 understanding audiences, 52 develop an outreach campaign, 53 execute the outreach campaign, 6 determine additional actions to achieve recovery
B	Collection for Artisan Use	1, 3	11 conduct surveys, 12 identify potential habitat and search for new populations, 21 identify essential habitat, 2215 establish corridors and buffer zones, 2216 monitor and reduce human disturbance, 51 identify target audiences for outreach, 51 understanding audiences, 52 develop an outreach campaign, 53 execute the outreach campaign, 6 determine additional actions to achieve recovery
C	Predators and Parasites	2, 3, 4	11 conduct surveys, 12 identify potential habitat and search for new populations, 21 identify essential habitat, 2213 establish and implement management plans, 2214 protect and manage private lands, 2215 establish corridors and buffer zones, 31 assess breeding ecology, 3231 evaluate introduced predators, 3232 evaluate native predators, competitors, and parasites
D	Inadequacy of Regulatory Mechanisms	1,2,4	2211 evaluate public lands, 2212 prevent reduction of habitat, 2213 establish and implement management plans, 2214 protect and manage private lands, 2215 establish corridors and buffer zones, 2216 monitor and reduce human disturbance, 422 monitor use of agrochemicals, 51 understanding audiences, 52 develop an outreach campaign, 53 execute the outreach campaign,, 6 determine additional actions to achieve recovery

E	Storms and Hurricanes	1,2	11 conduct surveys, 12 identify potential habitat and search for new populations, 21 identify essential habitat, 2212 prevent reduction of habitat, 2213 establish and implement management plans, 2214 protect and manage private lands, 2215 establish corridors and buffer zones, 2216 monitor and reduce human disturbance, 23 restore degraded habitat, 31 assess breeding ecology, 321 assess feeding ecology, 322 assess movement patterns, 41 monitor atmospheric phenomena51 understanding audiences, 52 develop an outreach campaign, 53 execute the outreach campaign,, 6 determine additional actions to achieve recovery
E	Competitive Interactions	2,4	11 conduct surveys, 12 identify potential habitat and search for new populations, 21 identify essential habitat, 2212 prevent reduction of habitat, 2213 establish and implement management plans, 2214 protect and manage private lands, 31 assess breeding ecology, 321 assess feeding ecology, 322 assess movement patterns, 3232 evaluate native predators, competitors, and parasites, 6 determine additional actions to achieve recovery

Listing Factors:

- A. The Present or Threatened Destruction, Modification, or Curtailment of a Species Habitat or Range
- B. Over utilization for Commercial, Recreational, Scientific, or Educational Purposes
- C. Disease or Predation
- D. The Inadequacy of Existing Regulatory Mechanisms
- E. Other Natural or Manmade Factors Affecting its Continued Existence

Recovery Criteria

- 1. Permanently protect traditional, non-traditional, and unoccupied guajón habitat, and corridors between existing populations, through landowner agreements, conservation easements, habitat conservation plans, and public outreach.
- 2. Determine the viability of existing populations (e.g., numbers, breeding success, population genetics, and ecology), and how many viable subpopulations are needed to ensure a self-sustaining overall population.
- 3. Determine the geographic distribution of all subpopulations needed to ensure a self-sustaining overall population.
- 4. Survey all potential habitats for new occurrences and evaluate suitability for species introduction.

Recovery Actions-General (see plan for details)

- 1. Determine the distribution and population status of the guajón within traditional, non-traditional, and unoccupied habitat.
- 2. Evaluate the need for protection of essential habitat for the species.
- 3. Conduct ecological studies to ensure the reproductive success of the guajón and the species' genetic variability.
- 4. Document the effect of natural and manmade disturbances on the guajón population.
- 5. Facilitate the recovery of the guajón through public awareness and education.
- 6. Refine recovery criteria and determine what additional actions are necessary to achieve recovery criteria.

Recovery Program

Recovery Actions Step-down Outline and Narrative

1. Determine the distribution and population status of the guajón within traditional, non-traditional, and unoccupied habitat. Additional data are needed on the distribution and population status of the guajón through surveys of historic and potential habitat of the species, to gather information on distribution, relative abundance, and habitat utilization by this species. These data are vital to obtain population biology information.

11. Conduct surveys within the known range of the species. Surveys of historical sites are needed to corroborate the presence and status of the species. Population trends of this species cannot be reliably determined because of lack of data; therefore, continuous assessments of population size are required to determine any change in population numbers. Extensive night searches and examination of daytime retreat sites, combined with mark and recapture studies to estimate population and demography, need to be conducted.

12. Identify potential habitat for the species and search for new populations. All suitable guajón habitat should be surveyed within traditional, non-traditional, and unoccupied habitat, using the appropriate technology and methodology to detect the species (e.g., playback calls, searching all potential hiding places, surveying at minimum during the onset of the rainy and dry seasons, surveying at different times of the year), to obtain more reliable information on the guajón distribution and habitat use.

If the guajón is found at new sites, censuses that include all sites (not samples of sites) should be conducted to determine population size, using appropriate techniques that provide population estimates (e.g., mark-recapture, individual counts, habitat sampling). Data should be collected on characteristics of the habitats where the species is found, and compare those characteristics to the available surrounding areas within traditional, non-traditional, and unoccupied guajón habitats. Combined results of surveys on historical and new localities would be used to create maps of the validated distribution of the species.

2. Evaluate the need for protection of essential habitat for the species. Prevention of habitat loss, fragmentation and degradation is of utmost importance to the recovery of the guajón in southeastern Puerto Rico. The protection of the habitat is a priority, since the guajón is restricted in distribution and is a habitat specialist. The Service, the Puerto Rico Department of Natural and Environmental Resources (DNER), non-governmental organizations, and local communities should evaluate the need for protection of essential habitat for the guajón, and the appropriate mechanisms to achieve protection of this habitat. Essential habitat contains a combination of physical and biological elements that are essential to maintain a self-propagating population of the guajón, and it includes “guajonales,” streams with patches of rocks, and associated riparian habitats.

- 21. Identify essential habitat.** Essential habitat should be identified using Global Positioning Systems (GPS) to produce precise site locations for the species. Geographical Information System (GIS) maps should be developed, identifying essential habitat for the species and including the habitat physical features essential to the conservation of the guajón.
- 22. Protect essential habitat.** Areas within and adjacent to identified habitat of the guajón in the municipalities of San Lorenzo, Humacao, Las Piedras, Maunabo, Patillas, San Lorenzo, and Yabucoa are under severe development pressure, primarily from urban expansion, tourist development, road improvements, and construction of new roads. Measures need to be taken to prevent further loss of existing and potential guajón habitat within and adjacent to the Cuchilla de Panduras mountain range.
- 221. Evaluate public lands that contain suitable habitat for the guajón.** Essential habitat for the guajón identified in Section 21 should be evaluated in terms of Commonwealth agency ownership, and for the most appropriate mechanism to protect such land (e.g., transfer of land to a resource management agency).
- 222. Protect and manage public lands.** Although most of the land where habitat for the guajón exists may be under private ownership, and most nearby public lands (owned by the Commonwealth) have been altered for cattle grazing and crop farming, public lands may be the best alternative to increase habitat for the guajón. Transferring public lands to natural resource management agencies through long term land leases or actual acquisition would prevent the immediate or later future developments of this public lands, and ensure their conservation for the guajón.
- 223. Prevent reduction of habitat by developing and implementing zoning regulations and carefully evaluating development projects.** Low-use special areas should be established with zoning regulations to control or restrict human activities that would impact, further fragment, or eliminate guajón habitat. DNER should consider the designation of essential areas for the guajón (particularly the “guajonales”) as sanctuaries for this species, to secure their long-term protection from development.
- Development projects that may impact traditional, non-traditional, and unoccupied guajón habitat should be carefully evaluated by permitting and natural resources agencies to include and request in their design “green areas” where no development would be allowed. A reforestation program may also be appropriate in the design of development projects within or near guajón habitat.
- 224. Establish and implement management plans that address concerns for the guajón and its habitat.** The Service, the Puerto Rico Department of Natural and Environmental Resources (DNER), non-governmental

organizations, other government agencies, and local communities should prepare management plans for areas designated as conservation areas or sanctuaries for the guajón. These plans should address the importance of these areas in the recovery of the species, as well as protection measures and habitat management actions (e.g., establishment of corridors) to enhance the survival and reproduction of the guajón in those areas.

225. Work with private landowners to protect and manage private lands.

Government agencies and organizations interested in the recovery of the guajón should work with private landowners to promote the protection of guajón habitat in their properties. Cooperative agreements, conservation plans, conservation easements, habitat mitigation banks, and economic incentives are potential tools to promote management of private lands for the conservation and recovery of the guajón. An inventory of privately owned lands where the species inhabits or may occupy in the future should be conducted.

Privately-owned habitat should be protected through the establishment of conservation easements, the development of Habitat Conservation Plans, and the implementation of private land conservation incentive programs (e.g., Partners for Fish and Wildlife) and landowner agreements with the Service and U.S. Department of Agriculture. The Service should also work closely with the DNER to explore additional habitat protection measures such as the Law 183: the Conservation Easement Law of Puerto Rico. Land acquisition should be considered as the last available option for habitat protection.

226. Establish corridors and buffer zones of low human use surrounding known and potential guajón habitat. The known range of the guajón is fragmented and non-contiguous; therefore, habitat corridors should be established between known guajón population sites, to maintain connectivity and dispersal for the species. Since the guajón is associated to streams, juvenile and adult dispersal may occur naturally through stream flow or during episodes of flooding or heavy rains. Riparian buffer zones (no less than 150 meters on both sides of the stream) should be established along streams inhabited by the guajón. Established habitat corridors and riparian buffer zones will be afforded protection via landowner agreements. A buffer zone of at least 300 meters should be established around conservation areas and sanctuaries to lessen the effect of human activity near known and unoccupied guajón habitat. Habitat acquisition, conservation easements, habitat conservation plans, and economic incentives are alternatives to establish buffer zones.

227. Monitor and reduce human disturbance. Caves and streams where the guajón occurs are used for recreational activities; the secondary result of those activities (e.g., garbage, use of chemicals for fishing) put the species at risk. Areas of public use should be identified and categorized according to their levels of use. Areas of high public use should be monitored on a

quarterly basis, and other areas identified as low public use, should be monitored twice a year. The public use areas should be monitored and documented for the following: presence and number of guajones within and near the public areas, number of people using the area, seasonal public use trends (i.e., months of high and low public use, day or night use), types of recreational uses, photograph evidence of public use, origin of recreational users (i.e., name of town and municipality where people are from), and document any illegal or detrimental activity to the habitat and/or species.

- 23. Restore degraded habitats.** Some guajón habitats have been destroyed or degraded due to activities such as illegal garbage dumping, erosion and deforestation caused by land clearing and earth removal. These areas will be identified and evaluated for their potential as restored habitat. If restoration is considered appropriate and feasible, restoration activities should try to replicate natural habitat features (e.g., vegetated streams with rocks containing crevices, caves, etc.) that the Service believes are required by the guajón. The Service, non-governmental organizations, and local communities can assist in the restoration efforts. Areas containing garbage and/or contaminants should be cleaned in compliance with Federal and Commonwealth regulations; native vegetation will be planted, and conservation measures implemented to reduce erosion into streambeds that may possibly carry chemical contaminants.
- 3. Conduct ecological studies to ensure the reproductive success of the guajón and the species' genetic variability.** Little information exists on the ecological factors affecting site-selection, breeding performance, and survival of the guajón. The high genetic variability observed in the known population needs to be maintained through habitat management and habitat conservation measures, and newly discovered guajón populations need to be studied to determine their genetic relatedness with the known population.

 - 31. Assess breeding ecology.** Environmental conditions that limit, maintain, or enhance reproduction and survival of guajón offspring should be evaluated to determine the best management practices that would ensure a self-propagating, genetically-variable population of the guajón (e.g., availability of interconnecting suitable habitat, distance to nearest unoccupied habitat, stream flow) in traditional and unoccupied habitat. Quantitative (i.e., number of adults in breeding condition, number of clutches and eggs per clutch, egg size, number of eggs that hatch successfully) and qualitative (e.g., presence of guarding male, oviposition site characteristics, egg development) data from egg clutches should be taken.
 - 32. Document other ecological information.** Other aspects of natural history such as feeding ecology, movement, inter-specific competition, and predation should be determined in traditional and unoccupied habitats to assess their importance in the ecology and survival of the guajón.

- 321. Assess feeding ecology.** Foraging behavior should be determined by direct observations of foraging frogs during the peak of their active period outside their retreat sites. Guajón stomach contents should be analyzed (e.g., stomach flush method) and quantitative studies of prey availability should be conducted to determine prey preference of the guajón.
- 322. Assess movement patterns.** Studies should be designed using mark-recapture techniques, to observe and record daily movement patterns (i.e., adults moving in and out of hiding places) and juvenile movement from nest-site location, to detect dispersal patterns (e.g., juveniles being dispersed by stream flow, moving landward, or remaining near nest-site location) and potential antagonistic relationships between adults and juveniles.
- 323. Monitor presence of predators, competitors, parasites, and pathogens.** Interactions between the guajón and predators, competitors, and parasites in traditional, non-traditional, and unoccupied guajón habitats must be monitored, and control/protection strategies must be developed and implemented.
- 3231. Evaluate the effect of introduced potential predators.** Rats and bullfrogs are both found within the range of the guajón, and are known predators of other species of frogs. Techniques to control these species within guajón traditional and unoccupied should be considered, but the procedures to eliminate or control these species must not pose a danger to the guajón, livestock, pets, or humans.
- 3232. Evaluate the effect of native predators, competitors, parasites, and pathogens.** Native predators and parasites should be evaluated as to their impact on the guajón. The snakes *Alsophis portoricensis* and *Arrhyton exiguum* are found within the range of the guajón and feed on juvenile and adult *Eleutherodactylus* species. Snails also prey upon clutches of eggs, and the tick *Ornithodoros talaje* has been found in specimens of the guajón. At least three genera of nematodes, *Parapharyngodon*, *Aplectana*, and *Poekilostrongylus*, have been reported from other *Eleutherodactylus*, and the fungus *Batrachochytrium dendrobatidis* has been identified in tropical frogs, but their occurrence in the guajón has not been determined. Control programs for these predators, pathogens, and parasites, if deemed necessary to ensure the survival of the guajón, need close monitoring for their effect on the target species and the guajón.

Surveys to determine the presence, abundance, and effect of potential competitors of the guajón (i.e., *Leptodactylus*)

albilabris, other *Eleutherodactylus* species), and careful monitoring of their activities within guajón habitat (e.g., behavioral studies) should be conducted to evaluate the extent of competitive interactions and mechanisms to minimize the impact of these species on the guajón survival and recovery.

33. **Determine genetic variability and gene flow among populations.** Studies of genetic variability and gene flow within and among historical and new populations are needed to know the vulnerability of the species. Emphasis should be given to guajón populations at unoccupied and non-traditional (e.g. rocky stream) habitats. Tissue samples from the guajón should be taken from toe clippings; and no more than one toe must be cut per hand or foot. Cellulose acetate electrophoresis, DNA-based techniques like polymerase chain reaction (PCR), or other appropriate techniques should be used to determine genetic variability among populations.
4. **Document the effect of natural and manmade disturbances on the guajón populations.** Populations of most species fluctuate in response to natural factors such as catastrophic events like storms and hurricanes. Widespread animal species are often habitat generalists, and natural catastrophic events may have less negative effects on the species. However, small and fragmented populations of a species are more vulnerable to loss by such random events because of their limited distribution.
41. **Monitor effects of atmospheric phenomena on guajón populations.** Weather patterns could play a significant role in the guajón population, since deforestation and earth movements near streams caused by major storms and hurricanes may put the habitat and populations of the guajón at risk through flash flooding, erosion, and sedimentation. Guajón surveys should be conducted after strong weather conditions within the range of the species to record any impacts (e.g., mortality, loss of habitat) on the guajón population.
42. **Detect presence and monitor levels of contaminants, including the use and effect of agrochemicals.** Frogs are highly sensitive to environmental changes and contaminants. Toxic substances in the habitat (e.g., pesticides, herbicides, fertilizers) may pose contamination threats to frogs. Agricultural practices in Puerto Rico usually involve the use of pesticides and other agrochemicals. Active and abandoned crops are found within the geographic range of the guajón. Although, the sensitivity of the guajón to agrochemicals is not known, their effect on other frog species has been documented. If the presence of contaminants is detected in the habitat of the guajón, the use of the contaminant agent(s) should be discontinued, and measures taken to decrease exposure to the species.
5. **Facilitate the recovery of the guajón through public awareness and education.** The public must clearly understand guajón conservation issues and the need for regulatory and management actions. The following steps are intended as guidelines for the development, implementation and evaluation of an outreach plan for the guajón. Steps are designed in sequential order.

51. **Assess target audiences.** Interviews should be conducted to assess the attitudes and perceptions of our target audience towards the guajón. Baseline data should be collected to assess the level of awareness of guajón conservation issues. Awareness, attitudes and perceptions data will help us determine the effectiveness of this outreach campaign after it is implemented. Target audiences may include, but are not limited to private landowners, government agencies, legislators, the media, environmental planners, and consultants for development projects, schoolchildren, recreational users, and educators. Communities adjacent to guajón habitat, and those communities from which recreational users originate (i.e., towns and municipalities), would be the key locations for outreach activities.
 52. **Develop an outreach campaign.** Using the information gathered for task 51, a Draft Outreach Plan should identify and prioritize communication goals for each target audience. Each goal should be accompanied by a list of outreach activities that could potentially move our communication goals forward. The Draft Outreach Plan should be presented to a wide number of individuals representing multiple interests and their input should be incorporated into a final plan. An informal comment period may be opened to gather input from the public at large.
 53. **Execute the Outreach Plan.**
 531. **Develop outreach materials.** Educational materials must be relevant, clear, and concise. A theme should be developed to provide unity with a logo and a tag line. A wide variety of materials may be designed and distributed for outreach or educational purposes, such as species fact sheets, audiovisual presentations, educational posters and brochures. The type of materials produced, along with its content, would vary according to the identified target audience.
 532. **Carry out outreach activities as outlined in the Outreach Plan.** Venues must be selected to deliver our messages and meet our audiences at their convenience.
 533. **Involve the media.** Efforts must be made to inform the general public via the media. Items produced for the media may be news releases that highlight conservation efforts, video, presentations, displays, and special events.
 54. **Evaluate the effectiveness of the Outreach Plan.** Conduct an assessment of public awareness, perceptions and attitudes towards the guajón and compare results with data collected in step 51. An evaluation report should be produced identifying the effectiveness of the actions implemented and should also make recommendations.
6. **Refine recovery criteria and determine what additional actions are necessary to achieve recovery criteria.** As additional information on the biology, ecology, and

management of the guajón is accumulated, it will be necessary to better define, and possibly modify, recovery criteria. If there are any actions not included in this recovery plan, which during the recovery process become recognized species needs, they should be incorporated into the plan.

Implementation Schedule

Recovery plans are intended to assist the U.S. Fish and Wildlife Service and potential Federal, State, and private partners in planning and implementing actions to recover and/or protect endangered and threatened species. The Implementation Schedule that follows lists the actions and estimated costs for the recovery program for the Puerto Rican Demon or guajón (*Eleutherodactylus cooki*). It is a guide for meeting the recovery goals outlined in this plan. Parties with authority, responsibility, or expressed interest to implement a specific recovery action, are identified in the Implementation Schedule. When more than one party has been identified, the proposed lead party is indicated by an asterisk (*). The listing of a party in the Implementation Schedule does not require, nor imply a requirement, that the identified party has agreed to implement the action(s) or to secure funding for implementing the action(s). However, parties willing to participate may benefit by being able to show in their own budgets that their funding request is for a recovery action identified in an approved recovery plan and is therefore considered a necessary action for the overall coordinated effort to recover the guajón.

Section 7 (a)(1) of the Endangered Species Act (ESA) directs all federal agencies to utilize their authorities in furtherance of the purposes of the ESA by carrying out programs for the conservation of threatened and endangered species. Tasks 23, 33, 41, and 42 address the monitoring component of the recovery plan to ensure that these data will be collected and evaluated in order to estimate delisting date. The cost estimates provided are based on the Implementation Schedule and identify foreseeable expenditures that could be made to implement the specific recovery tasks during a 5-year period. Actual expenditures by identified agencies/partners will be contingent upon appropriations and other budgetary constraints.

Recovery Actions Priorities

Priorities in column 1 of the following Implementation Schedule are assigned as follows:

- Priority 1 An action that must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future.
- Priority 2 An action that must be taken to prevent a significant decline in species population/habitat quality or some other significant negative impact short of extinction.
- Priority 3 All other actions necessary to provide for full recovery of the species.

ACRONYMS USED IN THE IMPLEMENTATION SCHEDULE

FWS	U.S. Fish and Wildlife Service
R4	FWS, Southeast Regional Office, Atlanta
ES	FWS, Caribbean Field Office
DNER	Puerto Rico Department of Natural and Environmental Resources
UNI	University researchers
GOV	Other Local, Commonwealth and Federal agencies
NGO	Non Governmental Organization
LAND	Private landowners
\$K	Cost in thousands of dollars
FY	Fiscal Year

IMPLEMENTATION SCHEDULE

Task Priority	Task Description	Task Number	Task Duration	Responsible Organization		Cost Estimates (\$000)					Comments
				FWS	Other	FY 05	FY 06	FY 07	FY 08	FY 09	
1	Conduct surveys within the known range of the species.	11	3 years	R4, ES	DNER, UNI	10K	10K	10K			
1	Identify potential habitat for the species and search for new populations.	12	3 years	R4, ES	DNER, UNI	7K	7K	7K			
1	Evaluate public lands that contain suitable habitat for the guajón.	221	2 years	R4, ES	DNER, UNI	10K	5K				
1	Protect and manage public lands.	222	Cont.	R4, ES	DNER, GOV, NGO	10K	10K	10K	10K	10K	
1	Prevent reduction of habitat by developing and implementing zoning regulations, and carefully evaluating development projects	223	Cont.	R4, ES	DNER, GOV	10K	15K	15K	10K	10K	
1	Establish and implement management plans that address concerns for the guajón and its habitat.	224	10 years	R4, ES	DNER, UNI GOV, NGO	20K	20K	15K	10K	10K	
1	Work with private landowners to protect and manage private lands.	225	10 years	R4, ES	DNER, GOV, LAND, NGO	15K	10K	10K	10K	10K	

Task Priority	Task Description	Task Number	Task Duration	Responsible Organization		Cost Estimates (\$000)					Comments
				FWS	Other	FY 05	FY 06	FY 07	FY 08	FY 09	
1	Establish corridors and buffer zones of low human use, surrounding known and potential guajón habitat.	226	10 years	R4, ES	DNER, UNI, LAND, GOV	25K	20K	15K			
1	Monitor and reduce human disturbance.	227	5 years	R4, ES	DNER, GOV	10K	10K	10K	5K	5K	
1	Restore degraded habitats.	23	10 years	R4, ES	DNER, UNI, LAND, GOV	20K	20K	10K	10K		
2	Assess feeding ecology.	321	3 years	R4, ES	DNER, UNI	10K	10K	5K			
2	Assess movement patterns.	322	3 years	R4, ES	DNER, UNI	10K	10K	5K			
2	Evaluate the effects of introduced potential predators.	3231	5 years	R4, ES	DNER, UNI	10K	10K	10K			
2	Evaluate the effects of native predators, competitors, parasites, and pathogens.	3232	5 years	R4, ES	DNER, UNI	10K	10K	10K			
2	Determine genetic variability and genetic flow among population.	33	10 years	R4, ES	DNER, UNI	10K	10K	10K	10K	15K	
3	Monitor effects of atmospheric phenomena on guajón populations.	41	10 years	R4, ES	DNER, UNI	15K	15K	20K			

Task Priority	Task Description	Task Number	Task Duration	Responsible Organization		Cost Estimates (\$000)					Comments
				FWS	Other	FY 05	FY 06	FY 07	FY 08	FY 09	
3	Monitor the use and effect of agrochemicals.	42	5 years	R4, ES	DNER, UNI, LAND, GOV	10K	10K	10K			
3	Assess target audiences.	51	Cont.	R4, ES	UNI, LAND, GOV, NGO	5K	5K				
3	Develop an outreach campaign.	52	Cont.	R4, ES	DNER, UNI, GOV, LAND, NGO		10K	10K			
3	Execute the Outreach Plan.	53	Cont.	R4, ES	DNER, UNI, LAND, NGO		25K	20K	15K	15K	
3	Evaluate the effectiveness of the Outreach Plan.	54	Cont.	R4, ES	DNER, GOV, NGO		5K	5K	5K	5K	
3	Refine recovery criteria and determine what additional actions are necessary to achieve recovery criteria.	6	Annual	R4, ES	DNER, UNI, LAND, GOV, NGO					15K	
Total Cost: \$846K											

Literature Cited

- Berger, L., *et al.* 1998. Chytridiomycosis causes amphibian mortality associated with population declines in the rain forests of Australia and Central America. *Proceeding of the National Academy of Sciences of the United States of America* 95:9031-9036.
- Burrowes, P. A. 1997. The reproductive biology and population genetics of the Puerto Rican cave-dwelling frog, *Eleutherodactylus cooki*. Unpublished Ph. D. Diss., The University of Kansas. 131 pp.
- Burrowes, P. A. 2000a. Parental care and Sexual Selection in the Puerto Rican Cave Dwelling Frog, *Eleutherodactylus cooki*. *Herpetologica* 56(3): 375-386.
- Burrowes, P. A. 2000b. Population genetics of the Puerto Rican Cave Dwelling Frogs, *Eleutherodactylus cooki*. *J. Herpetology*. 33(4): 706-711.
- Bury, R. B., C. K. Dodd, Jr. and G.M. Fellers. 1980. Conservation of Amphibians of the United States: a review. U.S. Fish and Wildlife Service. Res. Publ. 134:1-34.
- Bury, R. B., P. S. Corn, C. K. Dodd, Jr. R. W. MacDarmid, and N. J. Scott, Jr. 1995. Amphibians. Pp. 124-126 in: *Our Living Resources*. U.S. Department Int., National Biological Service, Washington, D.C.
- Cook, A. S. 1981. Tadpoles as indicators of harmful levels of pollution in the field. *Environmental Pollution*. Series A 25. 123-133.
- Davidson, C., H. B. Shaffer and M. R. Jennings. 2001. Declines of the California red Legged Frog: Climate, UVB, Habitat, and Pesticides Hypotheses. *Ecological Applications*. 11(2): 464-479.
- Demaynadier, P. G. and M. L. Hunter Jr. 1998. Effects of silvicultural edges on the distribution and abundance of amphibians in Maine. *Conservation Biology* 12(2): 340-352.
- Departamento de Recursos Naturales y Ambientales. 2004. Reglamento para Regir las Especies Vulnerables y en Peligro de Extinción en el Estado Libre Asociado de Puerto Rico.
- Drewry, G. E. 1970. The role of amphibians in the ecology of Puerto Rican Rain Forest. The Rain Forest project, Annual report. Puerto Rico Nuclear Center, A.E.C., U.P.R. 16-63.
- Drewry, G. E. 1986. Golden coquí recovery survey and brief status evaluation of five other Puerto Rican *Eleutherodactylus* species. Trip report prepared for the Caribbean Field Office, U. S. Fish and Wildlife Service. 49 pp.

- Drewry, G. E. and A. S. Rand. 1983. Characteristics of an acoustic community: Puerto Rican frogs of the genus *Eleutherodactylus*. *Copeia* 1983 (4): 941-953.
- Ewel, J.L. & J.L. Whitmore. 1973. The ecological life zones of Puerto Rico and the U.S. Virgin Islands. USDA Forest Service. Res. Pap. ITF-18.
- Gendron, A. D., Marcogliese, D. J., Barbeau, S., Christin, M. S., Brousseau, P., Ruby, S., Cyr, D. & Fournier, M. 2003. Exposure of leopard frogs to a pesticide mixture affects life history characteristics of the lungworm *Rhabdias ranae*. *Oecologia*: 135; 469-476.
- Grant, C. 1932. A new frog from Puerto Rico. *J. Dept. Agric. Puerto Rico* 16: 145-148.
- Hayes, Tyrone B., Collins, A., Lee, M., Mendoza, M., Noriega, N., Ali Stuart, A., and Vonk, A. 2002. Hermaphroditic, demasculinized frogs after exposure to the herbicide atrazine at low ecologically relevant doses. *Proc. Nat. Acad. Sci.* 99(8): 5476-5480.
- Hedges, S. B. 1989. Evolution and biogeography of West Indian frogs of the genus *Eleutherodactylus*: slow-evolving loci and the major groups. In Woods, C. (ed). *Biogeography of the West Indies*, pp. 305-370. Sandhill Crane Press, Florida.
- Hine, R. L., B. L. Les, and B. F. Hellminch. 1981. Leopard frog populations and mortality in Wisconsin, 1974-1976. Wisconsin Department of Natural resources tech. Bull. 122: 1-39.
- Joglar, R. L. 1981. Estudio fenético del género *Eleutherodactylus* en Puerto Rico. Unpublished M.S. Thesis. University of Puerto Rico, Mayagüez Campus. 133 pp.
- Joglar, R. L. 1983. Estudio fenético del género *Eleutherodactylus* en Puerto Rico. *Carib. J. Sci.* 19(3-4): 33-40.
- Joglar, R. L. 1989. Phylogenetic relationships of the West Indian frogs of the genus *Eleutherodactylus*: a morphological analysis. In Woods, C. (ed). *Biogeography of the West Indies*, pp. 371-408. Sandhill Crane Press, Florida.
- Joglar, R. L. 1992. Status survey of four species of *Eleutherodactylus*: Final report. Report prepared for the Caribbean Field Office, Fish and Wildlife Service. 41 pp.
- Joglar, R. L., P. A. Burrowes, and N. Rios. 1996. Biology of Puerto Rican cave dwelling frogs, *Eleutherodactylus cooki*, and some recommendations for its conservation. In R. Powell, and R. W. Henderson (eds.). *Contributions to West Indian Herpetology: A tribute to Albert Schwartz*, pp. 251-258. Society for the study of amphibians, and reptiles. Ithaca, New York.

- Joglar, R. L. 1998. Los Coquíes de Puerto Rico: Su Historia Natural y Conservación. Editorial de la Universidad de Puerto Rico. San Juan, Puerto Rico, 232 pp.
- Moreno, J. A. 1991. Accounts of those species considered to be concern. In Moreno, J. A. (ed.). Status y distribución de los anfibios y reptiles de Puerto Rico, pp. 9-10. Publ. Cien. Misc. No. 1 DRNA de Puerto Rico.
- Pechman, J. H. K., D. E. Scott, R. D. Semlitsch, J. P. Caldwell, L. J. Vitt, and W. Gibbons. 1991. Declining amphibian populations: The problem of separating human impacts from natural populations. *Science* 253:892-895.
- Reeder, A. L., G. L. Foley, D. K. Nichols, L. G. Hanson, B. Wilkoff, S. Faeh, J. Eisold, M. B. Wheeler, R. Warner, J. E. Murphy, and V. R. Beasley. 1998. Forms and prevalence of inter-sexuality and effects of environmental contaminants on sexuality in cricket frogs (*Acris crepitans*). *Environmental Health Perspectives* 106: 261-266.
- Rivero, J. A. 1998. Los anfibios y reptiles de Puerto Rico. Editorial Universitaria. San Juan, Puerto Rico, 152 pp.
- Rogowitz, G. L. and J. Sánchez-Rivolea. 1999a. Locomotor performance and aerobic capacity of the cave coquí, *Eleutherodactylus cooki*. *Copeia* 1999 (1). pp. 40-48.
- Rogowitz, G. L., M. Cortés-Rivera and K. Nieves-Puiggoller. 1999b. Water loss, cutaneous resistance, and effects of dehydration on locomotion of *Eleutherodactylus* frogs. *J. Comp. Physiol.* 169B: 179-186.
- Rogowitz, G. L., C. L. Candelaria, L. E. Denizard, and L. J. Meléndez. 2001. Seasonal Reproduction of a Neotropical Frog, the Cave Coquí (*Eleutherodactylus cooki*). *Copeia* 2001(2): 542-547.
- Sanders, H. O. 1970. Pesticide toxicities to tadpoles of the western chous frog (*Pseudacris triseriata*) and Fowler's toad (*Bufo woodhousii fowlwri*). *Copeia*: 246-251.
- Speare, R. 2001. Developing management strategies to control amphibian diseases: Decreasing the risk due to communicable diseases. School of Public Health and Tropical Medicine. James Cook University: Townsville.
- Soulé, M. 1987. Viable populations for conservation. Cambridge University Press, Great Britain. 189 pp.
- U.S. Fish and Wildlife Service. 1997. Endangered and Threatened Wildlife and Plants; Threatened status for the Guajón. Federal Register Vol. 62: 31757.

Vega-Castillo, S. I. 2000. Habitat description and comparison of the Puerto Rican Demon or Guajón, (*Eleutherodactylus cooki*) at two localities on the Eastern part of Puerto Rico. M.S. Thesis, University of Puerto Rico, Mayagüez Campus.

List of Stakeholders and Reviewers

Stakeholders★

Peer Reviewers (*)

Hon. Luis E. Rodríguez ★
Secretary
Department of Natural and
Environmental Resources
P.O. Box 600096,
Puerta de Tierra, PR 00906

Fernando Lloveras San Miguel, Esq. ★
Puerto Rico Conservation Trust
Box 4747
San Juan, Puerto Rico 00902

Hon. Angel Cintrón ★
President
Puerto Rico Planning Board
P.O. Box 41119
San Juan, PR 00940-1119

Center for Biological Diversity ★
1333 North Oracle Road
Tucson, Arizona 85705

Maunabo Development Corporation ★
9 Cesar Ortiz
Maunabo, Puerto Rico 00707

Dr. Ariel Lugo ★
International Institute of Tropical
Forestry
U.S. Forest Service
P.O. Box 25000
San Juan, Puerto Rico 00928-5000

Hon. Esteban Mujica, President ★
Environmental Quality Board
Box 11488
Santurce, Puerto Rico 00910

Dr. Juan Martínez, Director ★
Natural Resources Conservation Service
IBM Plaza, Suite 604
Hato Rey, Puerto Rico 00918-4123Ms.

Ms. Esther Rojas, Executive Director ★
Fundación Puertorriqueña de
Conservación
Urb. Sagrado Corazón
382 Ave. San Claudio
P.M.B. 97
San Juan, Puerto Rico 00926-4107

Hon. Erasto Fernández Perales ★
Mayor
Apartado 8
Maunabo, PR 00707

Hon. Angel R. Peña Rosa ★
Mayor
Apartado 68
Las Piedras, PR 00771

Hon. Angel Ramos ★
Mayor
Apartado 97
Yabucoa, PR 00767

Hon. Julio Cesar López Gerena ★
Mayor
Apartado 178
Humacao, PR 00792

Hon. Victor Figueroa Orozco ★
Mayor
Apartado 1289
San Lorenzo, PR 00754

Hon. Pilar Roadriguez Rivera ★
Mayor
Apartado 698
Patillas, PR 00723

Hon. Reinaldo Pirela Figueroa ★
Mayor
Apartado 477
Arroyo, PR 00714

Fernando Bird-Picó (*)
Department of Biology
University of Puerto Rico
Mayaguez Campus
Mayaguez, Puerto Rico 00681

Patricia A. Burrowes (*)
Department of Biology
University of Puerto Rico
Río Piedras Campus
Box 23360
San Juan, Puerto Rico 00931-3360

Rafael L. Joglar (*)
Department of Biology
University of Puerto Rico
Río Piedras Campus
Box 23360
San Juan, Puerto Rico 00931-3360

Alberto R. Puente-Rolón (*)
Box 1112
Ciales, Puerto Rico 00638

Gordon L. Rogowitz (*)
Department of Biology
University of Puerto Rico
Río Piedras Campus
Box 23360
San Juan, Puerto Rico 00931-3360

José A. Cruz-Burgos (*)
HC-02 Box 9950
Juncos, Puerto Rico 00777

Mr. Vicente Quevedo (*)
Natural Heritage Program
Department of Natural and
Environmental Resources
P.O. Box 9066600
San Juan, Puerto Rico 00906-6600

Miguel A. García (*)
Terrestrial Ecology Section
Endangered Species Coordinator
Department of Natural and
Environmental Resources
P.O. Box 5587
San Juan, Puerto Rico 00906

José A. Sustache-Sustache (*)
H-01 Box 16807
Humacao, Puerto Rico 00791

Carlos Ruíz-Lebrón (*)
HC-01 Box 7402
Las Piedras, Puerto Rico 00771