

**Species Biological Report for**  
**Coquí llanero (*Eleutherodactylus juanariveroi*)**



**Photo by: C. Pacheco, USFWS**

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This Species Biological Report informs the Draft Recovery Plan for the coquí llanero (*Eleutherodactylus juanariveroi*) (Service 2016). The Species Biological Report is a comprehensive biological status review by the U.S. Fish & Wildlife Service (Service) for the coquí llanero and provides an account of the species' overall viability. The Recovery Plan includes the statutory elements of recovery criteria, actions, and the estimates of the time and cost of those actions. A Recovery Implementation Strategy, which provides the expanded narrative for the coquí llanero recovery activities and the implementation schedule, is available at <http://www.fws.gov/caribbean>. The Recovery Implementation Strategy and Species Biological Report are finalized separately from the Recovery Plan and will be updated on a routine basis.

## EXECUTIVE SUMMARY

The coquí llanero is the smallest and only herbaceous wetland specialist within the genus *Eleutherodactylus* in Puerto Rico. It is only known from a single site in Sabana Seca Ward in the municipality of Toa Baja, Puerto Rico. The historical range of the species is unknown, but a topic of future research. To evaluate the biological status of the coquí llanero we consider the species' viability as characterized by its resiliency, redundancy, and representation (i.e., 3Rs). Currently the coquí llanero has low resilience, redundancy and representation, making it more difficult for the species to withstand and recover from stochastic or catastrophic events. At present, the coquí llanero is represented by only one population. The species is threatened by habitat curtailment and degradation, predation, sea level rise, and it is vulnerable to natural or human induced catastrophic events (e.g., droughts, climate change, spills of pollutants, etc.). In addition, the species has highly specialized ecological requirements including its habitat, which is very limited in availability throughout Puerto Rico. More information is needed to develop a better understanding of the species representation potential. However, due to its reduced geographic distribution, one population, limited dispersal capabilities, and specialized breeding requirements, the species is likely to have reduced adaptive capabilities resulting in low representation. All of these conditions may act in isolation; however it is very likely that two or more of these stressors act simultaneously or in combination, resulting in higher impacts to the coquí llanero and its habitat if recovery efforts are not implemented.

## INTRODUCTION

The Species Biological Report is intended to be an in-depth review of the coquí llanero's biology and threats, an evaluation of its biological status, and an assessment of the resources and conditions needed to maintain long-term viability. The biological report is intended to be an interim approach as we transition to using a species status assessment (SSA) as the standard format that the Service utilizes to analyze species as we make decisions under the Endangered Species Act. The intent is for the species biological report to be easily updated as new information becomes available and to support all functions of the Endangered Species Program from Candidate Assessment to Listing to Consultations to Recovery. Many species will have a Species Biological Report or SSA developed during the listing process. However, for species that are currently listed, such as the coquí llanero, a Species Biological Report or an SSA may be first developed during the recovery process. As such, the Species Biological Report or SSA will be a living document. In this document, we consider what the species needs to maintain viability

by characterizing the status of the species in terms of its resiliency, redundancy, and representation (Wolf et al. 2015).

- Resiliency is having sufficiently large populations for the species to withstand stochastic events (arising from random factors).
- Redundancy is having a sufficient number of populations for the species to withstand catastrophic events (such as a rare destructive natural event or episode involving many populations).
- Representation is having the breadth of genetic makeup of the species to adapt to changing environmental conditions. Representation can be measured through the genetic diversity within and among populations and the ecological diversity of populations across the species' range.

### **Status of the Species**

On October 4, 2012, the coquí llanero, a small endemic Puerto Rican frog, was listed as endangered throughout its range (77 FR 60778). Only one population is known to occur within part of a freshwater herbaceous wetland in the municipality of Toa Baja in northern Puerto Rico. This area of approximately 615 ac (249 ha) was designated as critical habitat for the species (77 FR 60778). The mean population density for the coquí llanero is  $473.3 \pm 186.8$  individuals per ha (or 192 per ac; Ríos-López et al. 2014). Although there is no information on long-term population trends, density decreases during months with lower temperature and less rainfall (i.e., January to April) and it increases during months with higher temperatures and greater rainfall (i.e., May to December; Ríos-López et al. 2014). This is the typical variation pattern of population density for other Puerto Rican *Eleutherodactylus* frogs (Joglar 1998). The coquí llanero was assigned a recovery priority number of 5c, which indicates the species faces a high degree of threat and a low recovery potential with conflict. Recovery potential is considered low for the coquí llanero because of its highly specialized biological requirements and the management challenges of the habitat currently occupied by the species. The wetland occupied by the species is surrounded by development, furthermore; there is no other suitable wetland adjacent to the one occupied. Thus, the possibility that the coquí llanero expands its range is very low, especially because of the low dispersal capabilities typical of small frogs and the lack of suitable habitat in the surrounding areas. Given there is only one known population within a small area, with limited dispersal capabilities, we believe that part of the species recovery is dependent on assisted migration into other similar suitable habitats. Additional populations should be established in protected areas to safeguard the coquí llanero from a stochastic or catastrophic event that can eliminate the only known population.

### **Taxonomy and Species Description**

In 2007, the coquí llanero was described as a new species of the genus *Eleutherodactylus*, family *Leptodactylidae* (Ríos-López and Thomas 2007). The species represents the 16<sup>th</sup> species of the genus *Eleutherodactylus* described for Puerto Rico. It was named *Eleutherodactylus*

*juanariveroi* in honor of Dr. Juan A. Rivero, a distinguished Puerto Rican herpetologist. The coquí llanero was first collected by Neftalí Ríos and Richard Thomas in 2005 from a freshwater herbaceous wetland within the former U.S. Naval Security Group Activity Sabana Seca (USNSGASS) property and the Caribbean Primate Research Center (CPRC) property, both in the municipality of Toa Baja in northern Puerto Rico (see Species Distribution section).

The coquí llanero is the smallest and only known herbaceous wetland specialist within the genus *Eleutherodactylus* in Puerto Rico (Ríos-López and Thomas 2007). Males have a mean snout-vent length of 0.58 in (14.7 mm), and females 0.62 in (15.8 mm). The nares are prominent and a ridge connects them behind the snout tip, giving the tip a somewhat squared appearance. The species has well-developed glands throughout its body; its dorsal coloration is yellow to yellowish brown with a light, longitudinal, reversed comma mark on each side (Figure 1; Ríos-López and Thomas 2007). The species' advertisement call consists of a series of short, high-pitched notes, with call duration varying from 4 to 21 seconds. Notes are between 7.38 and 8.28 kilohertz, having the highest frequency among all Puerto Rican *Eleutherodactylus*, making the species auditory detection more difficult (Ríos-López and Thomas 2007). Only males call and calling activity starts at approximately 4:30 PM and decreases significantly before midnight (Ríos-López and Thomas 2007).



Figure 1. Coquí llanero lateral and dorsal view (modified from Ríos-López and Thomas 2007).

### Life History

The coquí llanero exhibits direct development by laying eggs outside of the water (such as other *Eleutherodactylus*) and does not have an aquatic, free swimming larval stage (tadpole) as most frogs do. Once the egg has developed, a tiny froglet hatches from the egg and has the same appearance as an adult. However, contrary to the majority of species in the same genus, the coquí llanero does not provide parental care to the egg mass (Ríos-López and Thomas 2007; Ríos-López et al. 2014). The egg masses of the coquí llanero are enclosed on a thick jelly coat that is unique among Puerto Rican *Eleutherodactylus*, and may protect eggs from dehydration, predation and from microbial/fungi overgrow; an important adaptation in the absence of parental care (Ríos-López et al. 2014).

This coquí has the smallest clutch size of all *Eleutherodactylus* species on the Island (mean = 3.3 eggs/clutch, min. 1, max. 5) and most of the time all eggs in a mass are fertilized (Ríos-López et al. 2014). Breeding ecology is considered highly specialized since researchers have only found egg masses of the coquí llanero on the plant *Sagittaria lancifolia* (bulltongue arrowhead) (Figure 2) (Ríos-Lopez and Thomas 2007, Ríos-López et al. 2014). Egg masses are deposited mostly in leaf axils (Figure 2B), and only a few have been found on the leaf surface of *S. lancifolia* (Figure 2C), with more egg masses being deposited in larger plants (Ríos-López et al. 2014). The species also seems to prefer a specific size class of leaf axils (9-12 mm, followed by 6-9 mm inner width) of *S. lancifolia* to deposit egg masses (Ríos-López et al. 2014). Eggs are laid between 1.3 ft (0.4 m) and 3.9 ft (1.2 m) above water level in the wetland (Ríos-López and Thomas 2007). Production of multiple egg clutches has also been documented for the coquí llanero and the species shows strong site dependency for egg deposition (Ríos-López et al. 2014).

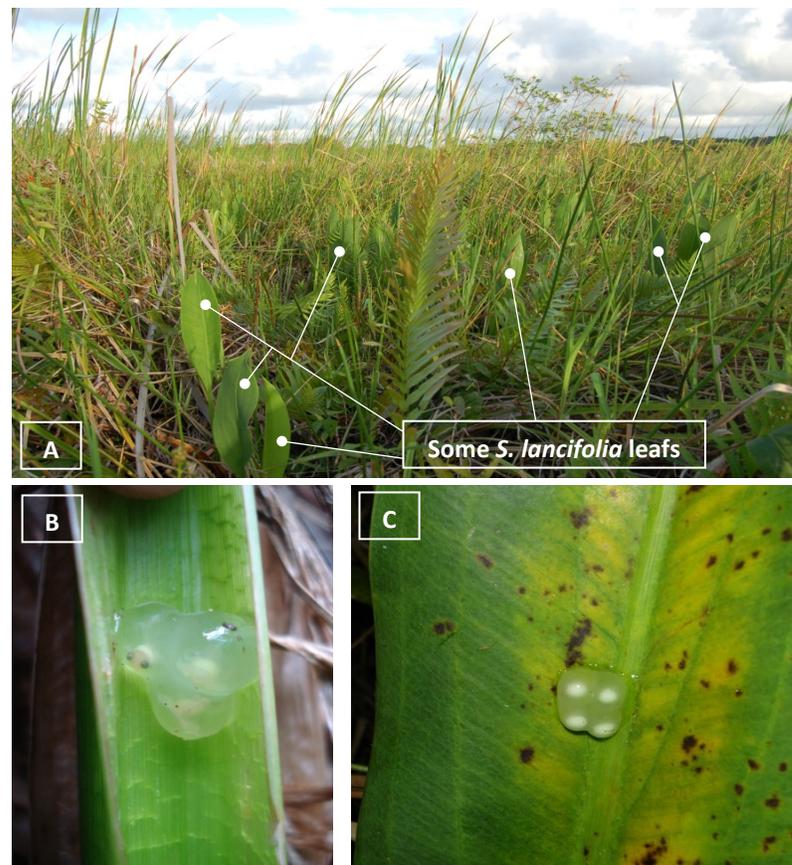


Figure 2: A: *Sagittaria lancifolia* plants within the wetland habitat (Photo by C. Pacheco); B: Coquí llanero egg clutch (3 eggs) on leaf axil (Photo by N. Ríos); C: Coquí llanero egg clutch (4 eggs) on leaf surface (Photo by JP Zegarra).

The life history of other frogs in the genus *Eleutherodactylus* indicates they are opportunistic

feeders where diets reflect the availability of food of appropriate size (Duellman and Trueb 1994, Joglar 2005). The wetland appears to provide a variety of food sources for the species, mostly small insects and other invertebrates.

### Species Distribution and Abundance

The coquí llanero is found only on a palustrine herbaceous wetland at Sabana Seca Ward, Toa Baja (Figure 3 and 4). The coquí llanero has the most reduced geographic distribution among all *Eleutherodactylus* in Puerto Rico (Ríos-López and Thomas 2007). When the species was first discovered and described, it was estimated that the coquí llanero occurs on approximately 445 acres (ac) (180 hectares (ha)) (Ríos-López and Thomas 2007). Joglar (2007) conducted additional surveys and estimated that the distribution of the species occurs on approximately 504.5 ac (204 ha). The Service has designated about 615 ac (249 ha) as critical habitat for this species (see Critical Habitat section below).

The palustrine herbaceous wetland area where the coquí llanero currently exists consists of Federal lands previously managed by the USNSGASS and areas owned by the Commonwealth of Puerto Rico (i.e., University of Puerto Rico and Puerto Rico Land Authority). There have been efforts to locate the coquí llanero in other wetlands outside the Sabana Seca area, but none have been found. The historical range of the species is unknown, however land use history for the Island suggests past habitat destruction and modification may have reduced the species range to the present remnant population (Ríos-López and Thomas 2007). The few remaining palustrine herbaceous wetlands are being extensively searched for the species.



Figure 3: Municipality of Toa Baja boundary (black line) and wetland area where coquí llanero is found (yellow oval). Inset map of Puerto Rico showing the Municipality of Toa Baja in black.

The coquí llanero wetland area (Figure 3, yellow oval) is part of the larger San Pedro swamp system also located in the municipality of Toa Baja. The Puerto Rico Department of Natural and Environmental Resources (PRDNER) recognized the San Pedro Swamp as an important wildlife area principally due to the degradation or disappearance of similar areas nearby, and because of the presence of rare and endangered species in this wetland (PRDNER 2005). The coquí llanero is found at the south section of the San Pedro swamp (Figure 3). The mean population density available for the coquí llanero is  $473.3 \pm 186.8$  individuals per ha (or 192 per ac; Ríos-López et al. 2014). This density estimate is based on visual encounter and audio strip transect surveys between July 2005 and July 2006. Abundance of the population is difficult to estimate since the species is not evenly distributed throughout its wetland habitat. Available information suggests the species' population dynamics are regulated by the availability of suitable *S. lancifolia* for breeding, seasonality in rainfall, and egg morphology adaptations that lead to high egg hatching success without parental care (Ríos-López et al. 2014).

## Habitat

The coquí llanero is only found in a small palustrine herbaceous wetland (3 to 20 feet (1-6 m) above sea level) located on the northernmost limestone belt of Puerto Rico in the Municipality of Toa Baja (Figure 3, yellow oval). This area is within the subtropical moist forest life zone (Ewel and Whitmore 1973). Ríos-López et al. (2014) recorded temperature, relative humidity, and precipitation during their research. The average annual ambient temperatures was 77°F (25°C) and the warmest months were between May and November (i.e., period of coquí llanero highest population density); relative humidity varied little, reaching 100% during the night and 60% during daylight; annual average rainfall was 67 inches (1700 mm), with most of the rain occurring from May to November.

The wetland is classified as a palustrine emergent persistent seasonally flooded wetland (NWI website). According to Ríos-López et al. (2014), this wetland is seasonally flooded between May and January, and reaches the lowest water depth from late February to early April, which coincides with the lowest population density of the coquí llanero. Ríos-López et al. (2014) also reported an average water depth of 1ft ( $0.28 \pm 0.22$  m) within their study plots. The soils of this wetland consist of swamp and marsh organic deposits from Pleistocene or recent origin or both (Ríos-López and Thomas 2007). The species' habitat may represent a relic of an endemic seasonally to permanently flooded, herbaceous wetland habitat type (Ríos-López and Thomas 2007).

Vegetation surveys in the wetland have identified at least 31 species of vascular plants in the herbaceous dominated assemblage (Ríos-López et al. 2014). This plant community consists of flatsedges (*Cyperus* sp.), beaksedges (*Rhynchospora* sp.), spikerushes (*Eleocharis* sp.), ferns such as toothed midsorus fern (*Blechnum serrulatum*) and the Willdenow's maiden fern (*Thelypteris interrupta*), bulltongue arrowheads (*Sagittaria lancifolia*), Southern cattail (*Typha domingensis*), and a small forest stand of Soursop Tree (*Annona glabra*) (Ríos-López et al. 2014). According to their research, the most abundant plant substrate type in the wetland was ferns (mean cover of 25%), followed by flatsedges, spikerushes, bulltongue arrowheads, and cattail. Although several of these plants have been documented in other sites in Puerto Rico, vegetation composition (i.e., combination and abundance of each plant) appears to be unique in

this ecosystem and apparently not found in other places in Puerto Rico (Ríos-López and Thomas 2007).

Microhabitat conditions may be essential for the conservation of coquí llanero (Ríos-López et al. 2014). For example, researchers found more individuals of the coquí llanero perching and calling on ferns, while using only leaf axils of *S. lancifolia* for egg laying and also for retreat. In addition, the *S. lancifolia* plant may be considered a limiting resource, as it only occupies 7.4% of the vegetation cover in the wetland (Ríos-López et al. 2014). Moreover, differences in egg clutch deposition site further suggest the importance of *S. lancifolia* as a retreat and breeding site (Ríos-López et al. 2014).

The hydrology of the wetland is influenced by precipitation, karst topography, river floodplains and stormwater drainage patterns (GLME 2007). In general, the Sabana Seca area has an east to west inclination where the surface and ground water from the limestone hills to the south of Road PR 867 discharges into the wetland, and eventually goes north and northwest connecting to Caño Campanero, and then to Cocal River, ending in the Atlantic Ocean (Figure 4) (PRDNER 2007b). Given that wetlands are dynamic habitats formed and maintained by water quantity, channel slope, and sediment input to the system through periodic flooding (Mitsch and Gosselink 2007), an increase in land use intensity may be expected to significantly affect water quality and flooding hydroperiod in the coquí llanero's habitat (GLME 2007).

### ***Critical Habitat***

One unit (i.e., Sabana Seca Unit) of critical habitat was designated for the coquí llanero (77 FR 60802). The Sabana Seca Unit is occupied by the species and consists of approximately 615 ac (249 ha) located south of State Road PR 867, west-southwest of Ramón Ríos Román Avenue, east of José Julián Acosta Road, and north of the limestone hills located north of Highway PR 22 in the municipality of Toa Baja (Figure 4). Land ownership within the critical habitat is divided among the University of Puerto Rico, the Puerto Rico Land Authority, and the USNSGASS (Table 1).

The Unit contains the palustrine herbaceous wetland with emergent vegetation where the species occurs. All the essential physical and biological features are found within this unit. These essential features may require special management considerations or protection to insure maintenance or improvement of, and to address any changes that could affect, the existing palustrine herbaceous wetland. For example, filling for development, alteration of water hydrology, degradation of water quality, and changes in vegetation composition that might result from changes in hydrology, inappropriate management practices on adjacent farmlands, or contamination from sources such as leachates from the adjacent Toa Baja Municipal Landfill (TBML).

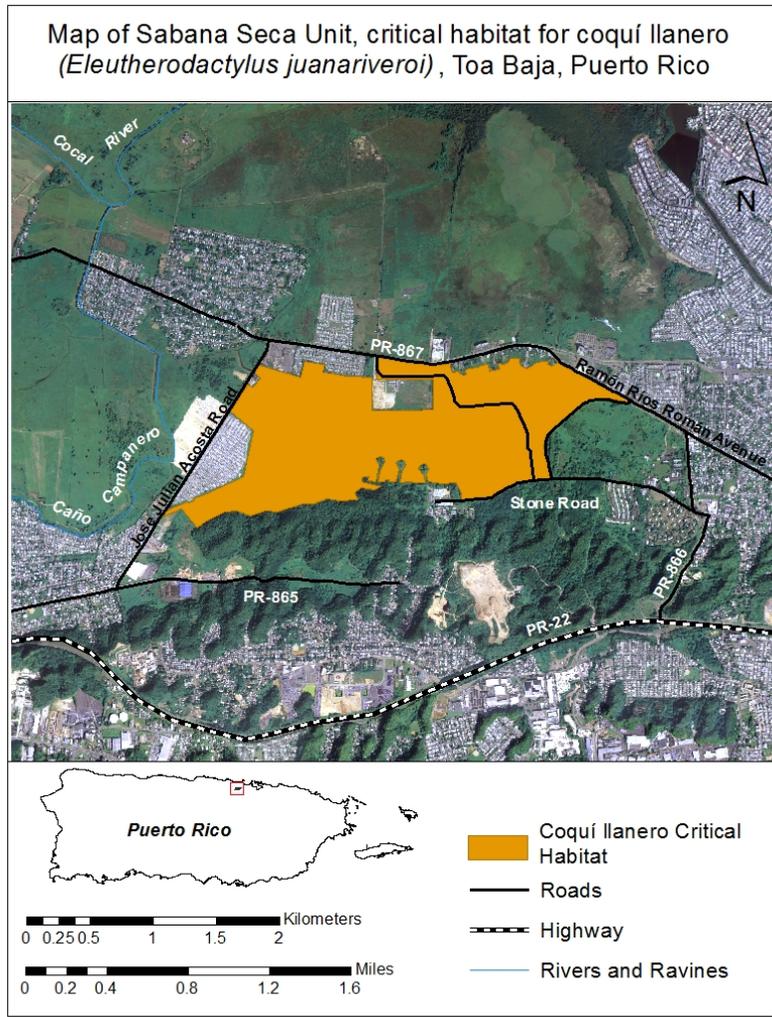


Figure 4. Map of Critical Habitat Designated for the Coquí llanero (77 FR 60802).

Table 1. Critical habitat designated for the coquí llanero (77 FR 60802).

Critical Habitat Unit	Land Ownership	Size of Unit	
		Acres	Hectares
Sabana Seca	Commonwealth of Puerto Rico (University of PR and PR Land Authority).....	97 ac	39 ha
	Department of Defense (closed USNSGASS ).....	518 ac	209 ha
<b>Total</b>		<b>615 ac</b>	<b>249 ha</b>

The primary constituent elements of critical habitat for the coquí llanero are:

- Palustrine herbaceous wetland: Palustrine emergent persistent wetlands that are seasonally to permanently flooded. Ocean-derived salts need to be less than 0.5 parts per thousand (ppt).
- Vegetation and vegetation composition of the palustrine herbaceous wetland: Emergent vegetation characterized by erect, rooted herbaceous hydrophytes usually dominated by perennial plants like ferns, *Sagittaria lancifolia*, flatsedges, spike rushes, vines, and grasses. At least 25% of the plant composition should be ferns and *S. lancifolia* must be present.
- Hydrology: A hydrologic flow regime (i.e., the pathways of precipitation, surface runoff, groundwater, tides, drainage channels and flooding of rivers) that maintains the palustrine herbaceous wetland.

### **Summary of current resiliency, redundancy, and representation**

This amphibian currently persists as only one population within a small area with specific habitat characteristics. The lack of suitable adjacent wetlands, and the surrounding development of the occupied habitat, coupled with the low dispersal capability of the species, makes it dependent on assisted migration in order to maintain its persistence into the future to avoid extinction. The redundancy of the coquí llanero needs to be increased through the introduction of the species into other areas with suitable habitat which are known to be limited. This action is critical since any catastrophic event (e.g., severe drought, sea level rise, and pollution) could eliminate the only existing population of the species. More information is needed to develop better understanding of the species representation potential. However, due to its reduced geographic distribution, and highly specialize breeding requirements, is likely that coquí llanero has reduced adaptive capabilities, resulting in low representation. In conclusion, the resiliency, redundancy, and representation are all low for the coquí llanero.

### **REASONS FOR LISTING/THREATS ASSESSMENT**

On October 4, 2012, the Service listed the coquí llanero as endangered throughout its range primarily due to threats of habitat loss or alteration, and to other natural or anthropogenic factors (77 FR 60778). The following analysis provides an updated threats assessment to this species since listing as they relate to the five listing factors outlined in section 4(a)(1) of the Act.

#### **Factor A: Present or threatened destruction, modification, or curtailment of its habitat or range**

The threats leading to Factor A since the time of listing have lowered in intensity but have not been eliminated. The federally owned area contained within the critical habitat was left in conservation (D. James, NAVFAC Atlantic, pers. comm. 2014). However, there are still possible threats that may impact the species and its habitat. For instance, the current operation of the TBML may constitute a threat to the coquí llanero. This landfill is located inland on top of a limestone hill, 0.5 mi (0.8 km) south of the known habitat for coquí llanero. Although at this time we do not know the intensity of the impacts the TBML runoff waters may cause in the wetland, the polluted discharge or runoff waters from the continued operation of the landfill pose

a threat to the species because underground contaminated waters and leachates reach the wetland where it might change water quality, soils, and consequently plant composition (CPRC 2009, see further discussion below under Factor E). Although the TBML is scheduled to close operations as per the Environmental Protection Agency, activities identified in the closure will direct the TBML storm water drainages towards the wetland. Storm water that drains from the TBML currently flows into coquí llanero habitat and it is contaminated with leachate (EGIS 2007, see Factor E discussion). In addition, the TBML closure measures may adversely affect the hydrology of the wetland by modifying the topography of the limestone hills. This potential modification may affect the suitability of the habitat by altering the hydrology of the wetland, and by contaminating the wetland with more of the landfill runoff.

Flood control measures are implemented during the rainy season to facilitate water flow and prevent flooding of nearby communities such as Ingenio, Villas del Sol, and Brisas de Campanero. Channel-clearing activities may facilitate drainage and drying of the wetland, and accelerate colonization of invasive, herbaceous vegetation along the edges of the channel towards the wetland (Ríos-López 2009). Preliminary studies on the reproductive biology of the coquí llanero suggest that wetland areas subjected to prolonged dry periods (e.g., towards the edges of wetland) are characterized by greater vegetation cover of grasses instead of the native ferns and arrowheads that the coquí llanero depends on for reproduction and survival. These areas also have a disproportionate abundance of coquí llanero egg clutch predators, both native and exotic mollusks and insects (Ríos-López 2009).

Prior to the discovery of the coquí llanero, the land-use history of this area has shown that urban, commercial and recreational development has adversely impacted wetland resources by draining the wetlands and modifying the vegetation (Ríos-López and Thomas 2007). These modifications may have changed the structure of the habitat and limited the range of the species in the area. Current urban and recreational developments surrounding the coquí critical habitat may still impact the coquí llanero and its habitat. An example of these impacts is the slow encroachment of private residential homes on the northeastern end of the critical habitat (USFWS 2010, pers. obs.). According to timeline images (using Google maps imagery), the houses bordering the critical habitat have been expanding their backyards towards the wetland, possibly filling coquí llanero habitat. In addition, another example is the repaving of Redman Road and clearing of the vegetation bordering the road. This action would need to follow some conservation measures to minimize any possible impact to the habitat of the coquí llanero. Although the repaving of this particular road should be intermittent, the clearing or cutting down the road border vegetation (for security of traffic to and from the Caribbean Primate Research Center) may be a recurrent action. This should be monitored to avoid further impacts (see further discussion below under Factor E).

### **Factor B: Overutilization for commercial, recreational, scientific or educational purposes**

At the time of listing (77 FR 60778), there was no information indicating that the coquí llanero is being overutilized. Currently, only a few permitted researchers are conducting studies on the species and/or its habitat. Although collection could be a significant threat to the coquí llanero due to its rarity, any collection of this species will require a permit from the PRDNER and the Service. We do not have information indicating that the coquí llanero is being illegally

collected. Therefore, we continue to conclude that overutilization for commercial, recreational, scientific, or educational purposes is not a current threat to the coquí llanero.

### **Factor C: Disease or predation**

At the time of listing (77 FR 60778), the Service determined that disease was not a threat to the coquí llanero. There is no new information regarding potential disease effects on the species. On the contrary, the most recent information suggest the species' skin glandular secretions and its unique thick jelly egg mass coating protects the eggs from dehydration, predation and from microbial/fungi overgrow (Ríos-López et al. 2014), even from the pathogenic chytrid fungus, *Batrachochytrium dendrobatidis* (Bd). Nevertheless, we should continue monitoring Bd in case it is detected on the coquí llanero.

Predation was identified as a threat, particularly at the dryer edges of the wetland since predators rarely invade more permanent flooded areas of the wetland. When the species was listed, information provided by Ríos-López (2009) indicated that natural predation pressure may be strong and that interspecific competition for breeding sites may be significant. Egg predation by native and exotic invertebrates was observed, with some predators consuming entire egg masses in 3 days (e.g., ants and terrestrial invertebrates; Ríos-López 2009). Additional information found that embryos from examined egg clutches either all hatched or all died, presumably because of predation, referred as common, and dehydration, referred as rare (Ríos-López et al 2014). The researchers recorded natural egg clutch predation or destruction from another coquí species (*E. cochranæ*), crickets, ants and possibly mollusks. Ríos-López et al. (2014) also found that predation increases during the dry season (i.e., January to April), when reproductive activity also decreases. The researchers suggest that future studies should examine the influence of seasonality on prey and predator abundance to determine the relative contribution of each factor (prey availability and predation pressure) to the species' seasonality in egg production, and thus, population fluctuations.

The Service needs to further evaluate this natural predation threat in order to determine its relative contribution to the species status. Climatic variability and/or habitat modification that results in drier conditions within the wetland may exacerbate this predation threat.

### **Factor D: Inadequacy of existing regulatory mechanisms**

At the time of listing (77 FR 60778), the Service determined that inadequacy of existing regulatory mechanisms is not a threat to the coquí llanero. There are several Federal laws and regulations that exist which provide measures to protect the coquí llanero and its habitat. For example, on October 4, 2012, we listed the coquí llanero as endangered and designated its critical habitat, 615 ac (249 ha) of the only known occupied habitat by the species (77 FR 60778). In addition, through a Section 6 agreement between the Service and the PRDNER, when a species is listed under the Endangered Species Act (ESA), the Commonwealth upholds the protections for that species and includes it in their list of threatened and endangered species. The Commonwealth Law No. 241, "Nueva Ley de Vida Silvestre de Puerto Rico" (New Wildlife Law of Puerto Rico) and Regulation 6766 afford protection to the species which prohibit

hunting, capturing or causing damage to any wildlife species, or modifying its natural habitat without authorization of the Secretary of the PRDNER.

Section 7 of the ESA requires Federal agencies to carry out programs for the conservation of threatened and endangered species. Consultation is required in cases where a Federal action, such as Federal funding or permit, is associated with the potential project that may impact the coquí llanero or critical habitat. For example, the Service has been informally consulting with the University of Puerto Rico Primate Research Center, the USNSGASS, and the TBML for actions related to potential effects on the coquí llanero or its habitat as a result of the actions carried out by these entities. None of these informal consultations have resulted in a may affect determination for the coquí or in adverse modification for its critical habitat.

Based on the presence of Federal and Commonwealth laws and regulations protecting the coquí llanero, and the absence of evidence supporting lack of enforcement of regulations to protect this species, the Service continues to believe that inadequacy of existing regulatory mechanisms is not a threat to the species at this time.

**Factor E: Other natural or manmade factors affecting its continued existence.**

At the time of listing (77 FR 60778), the Service identified the following threats under this factor: highly specialized ecological requirements, potential water and soil pollution, potential effects from herbicides, potential effects from brush fires, competition from the whistling coquí (*Eleutherodactylus cochranæ*), climate change, and human access or use.

The Service considers climate change coupled with the species highly specialized ecological requirements as the threat of most concern under this factor, which can have a variety of direct and indirect impacts on the coquí llanero and can exacerbate the effects of other threats, especially those related to habitat (Factor A). Climate change, including extremes in precipitation, is forecast to be one the most significant drivers of ecological change in the future (Lawler et al. 2009, as cited in Walls et al. 2013). Walls et al. (2013) specify that variations in seasonal rainfall affect wetland hydrology and the timing of amphibian reproduction, which may modify the composition of communities and interfere with the dynamics of competitive predatory interactions.

Climate related research from Puerto Rico includes a 14-year study at El Yunque National Forest (a different habitat than where the coquí llanero occurs) that suggests juvenile *Eleutherodactylus* are likely unable to survive extensive droughts and the potential risk of desiccation may affect adult foraging during extended dry periods (Stewart 1995). Further analysis of weather data from 1970 to 2000 by Burrowes et al. (2004) indicated a significant warming trend and an association between years with extended periods of droughts and the decline of frogs in Puerto Rico.

Although the Burrowes et al. (2004) research was conducted before the discovery of the coquí llanero, the species seems to have persisted such climatic changes (significantly drier than average) and population fluctuations (potential declines) during the 1970s and 1990s, which represent periods of amphibian extirpations and declines. Of course, assuming that during that

period, the coquí llanero existed in the only known locality. However, Burrowes et al. (2004) suggested amphibians were being affected by a possible synergistic interaction between drought and the chytrid fungus, the fungus which does not seem to affect the coquí llanero (see Factor C).

The effects of climate change on amphibians are likely complex, and may affect survival, growth, reproduction, and alter habitats including vegetation and hydrology (Blaustein et al. 2010). According to Walls et al. (2013) and citations within, insufficient rainfall, extreme drought and/or shortened hydroperiods have been linked with declines in anuran calling activity and local extinctions, among others. Ríos-López et al. (2014) found the coquí llanero's phenology was explained by rainfall only, a somewhat unexpected result because water variables are unlimited resources in the species' wetland habitat and because the species' reproductive mode (direct development of terrestrial eggs) are expected to be less dependent on rainfall for hatching success, when compared to temperature related variables.

Information presented by Ospina et al. (2013) specify that temperatures in Puerto Rico are expected to increase by 1.1 °C during the next 100 years and that sites like the coquí llanero wetland habitat will probably become dryer during the dry season and wetter in the rainy season (Ramirez-Beltrán et al. 2007; and Harmsen et al. 2009, as cited in Ospina et al. 2013). Ospina et al. (2013) found that the coquí llanero calling activity (from automatic recorders) responded negatively to temperature and precipitation, possibly related to its small body size and the exposed location of calling sites (i.e., ferns), thus increasing the individuals water loss and decreasing calling and reproductive activity.

This calling response somewhat contradicts results from Ríos-López et al. (2014), in which density increased (from visual and auditory detections) during warmer and rainy months. Methods used between the researchers were different and may help explain some of the differences. Still, research by Ospina et al. (2013) explains the logic that the smaller coquí llanero would be more prone to dehydration during hot days, than larger species such as the common coquí (*E. coqui*) or the whistling coquí (*E. cochranae*), and thus, needing to reduce its calling reproductive activity.

Ospina et al. (2013) further suggest that if climate predictions for Puerto Rico are correct, then one can expect population of the smaller frogs to decline, such as the coquí llanero and the grass coquí (*E. brittoni*), and making them more vulnerable to climate change. The calling frequency decline of the coquí llanero detected by Ospina et al. (2013) does not necessarily reflect a decline in the population and the authors suggest further studies should try to determine if the calling rate from automatic recorders is correlated with the density of calling males. The Service needs to assess how resilient the coquí llanero would be to some of the predicted changes in climate.

Ríos-López et al. (2014) explain that developing climate change conservation measures is challenging, particularly because predictions of population dynamics rely on a better understanding of the ecological mechanisms of interest, and the type of climate data being collected may result in different interpretations. Ultimately, climate patterns and events that promote droughts and less rain would drive populations of all coquí species in Puerto Rico towards a declining trend by directly affecting the reproductive output of the population.

Moreover, it is expected that climate change affects the rate of rising sea level (Blaustein *et al.* 2010). We consider sea level rise a likely threat based on results from a Sea Level Affecting Marshes Model prepared by D. Davila (2013). The model suggested the gradual but inevitable demise by 2100 of the only known occupied habitat for the coquí llanero. Since there is limited suitable habitat within the Commonwealth (seven potential sites in all Puerto Rico), this threat could risk the entire species existence. Sea level rise would impart more pressure towards the species and in its habitat since the possible sea (salt) water intrusion would consequently change the physical and ecological characteristics of the freshwater wetland, changing the vegetation and affecting the reproduction since this species is dependent on a specific freshwater plant. Since the known occupied habitat of the coquí llanero is only about 17 meters in elevation, the possible predicted sea level rise may have detrimental effects on the species as mentioned above. Moreover, the majority of the potential sites identified by D. Davila are near coastal areas that may suffer from the same detrimental effects. Based on this prediction, it is recommended to safeguard the genetic material of this species by establishing ex-situ populations.

Other potential threats such as herbicides, brush fires and competition will always be present to some degree. As specified in the listing rule (77 FR 60778), there is no direct use of herbicides within the species habitat. Although there is probably some herbicides and/or pesticides entering the wetland habitat system from the surrounding communities, or even from spraying for mosquito control, there is no specific indication that these components are negatively impacting the species.

Available information indicates no reported fires have occurred within the species designated critical habitat (Figure 4). Reported illegal fires have mostly occurred on the San Pedro Swamp north section (Figure 3), presumably from land crab hunting activity. The proximity of the critical habitat to this area and other commercial and urban developments certainly increase the exposure and susceptibility of fires occurring within the critical habitat. If a brush fire were to occur within the designated critical habitat, it could highly degrade the wetland's plant composition, facilitate establishment of invasive weeds and cattail, cause direct take of frogs and egg masses, and further encroach the frog's already limited habitat.

Competition threats from the whistling coquí (*E. cochranæ*) will also be present, especially towards the drier and more disturbed edges of the wetland. As previously discussed, climate change and habitat modification may exacerbate this threat by facilitating the whistling coquí invasion further into the wetland. The whistling coquí rarely invades more permanently flooded areas of the wetland, suggesting a synergism between hydrology alteration and competition that may result in magnified negative biological interactions against the coquí llanero (Ríos-López 2009). The Service needs to further evaluate this competition threat in order to determine its relative contribution to the species status.

Other threats such as the potential effects from water and soil pollution from the proximity of the TBML to the species habitat were identified (e.g. landfill leachates entering the wetland). However, there is still no information indicating any negative responses of the species to potential soil and water pollution. The Service will continue to assess and consult on measures being implemented by the TBML to improve leachate management and runoff into the species wetland.

As explained above, natural (e.g., specialized ecological requirements and climate change) and anthropogenic (e.g., brush fires) factors are still considered threats to the coquí llanero and its habitat. Furthermore, while these threats may act in isolation, it is very likely that two or more of these stressors act simultaneously or in combination, resulting in higher impacts (pressures) to the coquí llanero and its habitat.

## **ONGOING CONSERVATION EFFORTS**

1. The Mayor of Toa Baja signed Municipal Ordinance Number 31 (Series 2006-2007) on September 13, 2006, to prohibit harm or destruction of the habitat of the coquí llanero in the Municipality of Toa Baja
2. The Navy set aside land of the former USNSGASS which was designated as essential habitat for conservation. Also, they included a quitclaim deed advising the potential buyers about the presence of threatened and endangered species in the area as well as other important natural resources (e.g., wetland).
3. Scientists have conducted studies on the species and its habitat in an effort to better understand the ecology and behavior of the coquí llanero and thus, help with the recovery of the species. The Service has been in contact with the species expert in order to develop and promote research projects that would help guide recovery actions.
4. The Service has provided technical assistance for various projects. The Caribbean Primate Research Center (CPRC) has requested pre-planning technical assistance with regard of conservation measures on possible repaving on their main access road and discussion of possible standard operating procedures to maintain the vegetation on the borders of the road.
5. Public awareness and outreach for the general public via factsheets and other multimedia like electronic pages on the Service webpage, Facebook, and Flickr.

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