Coquí Llanero SLAMM
Vulnerability of the coquí llanero, *Eleutherodactylus juanariveroi*, habitat to sea level rise

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INTRODUCTION

Worldwide declines of amphibian populations are of great concern to many researchers (Reaser, 1996; Woolbright, 1997; Joglar, 1998; Lips, 1998; Alford and Richards. 1999; Burrowes et al, 2004; Stuart et al., 2004). In 2004, Stuart et al stated that 2468 amphibian species were experiencing some form of population decrease. Habitat loss has been proposed as one of the main reasons for the worldwide reduction of amphibian populations and even the extinction of some species (Reaser, 1996; Woolbright, 1997; Joglar, 1998; Lips, 1998 Alford and Richards, 1999). It can be the result of, natural events, such as hurricanes or intensive droughts, of human activities, such as deforestation, residential or industrial development and agriculture, or global climate change.

Amphibians in Puerto Rico are not impervious to the global conditions that are accelerating the disappearance of species. Eight out of the eighteen species, 44%, are currently listed under some threat category under State Regulations. Four as critically endangered and four as vulnerable. Three haven't been heard or detected in at least twenty years. Such a precarious situation of the local amphibian fauna warrants drastic and proactive measures that will guarantee the conservation of species under any kind of imminent threat (Burrowes *et al*, 2004).

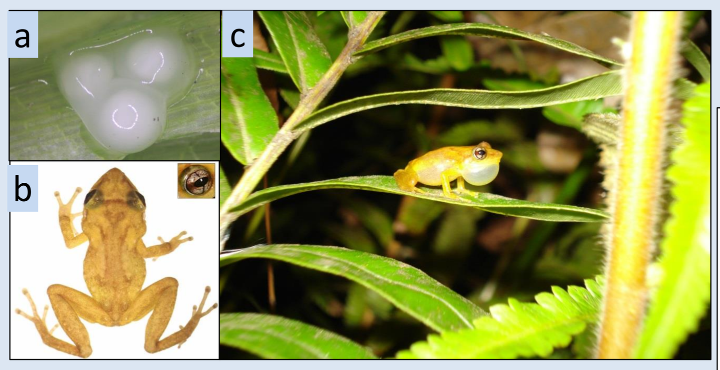

Figure 1. Images of the coquí llanero, *E. Juanariveroi. (a) egg clutch, (b) dorsal view, (c) calling.*

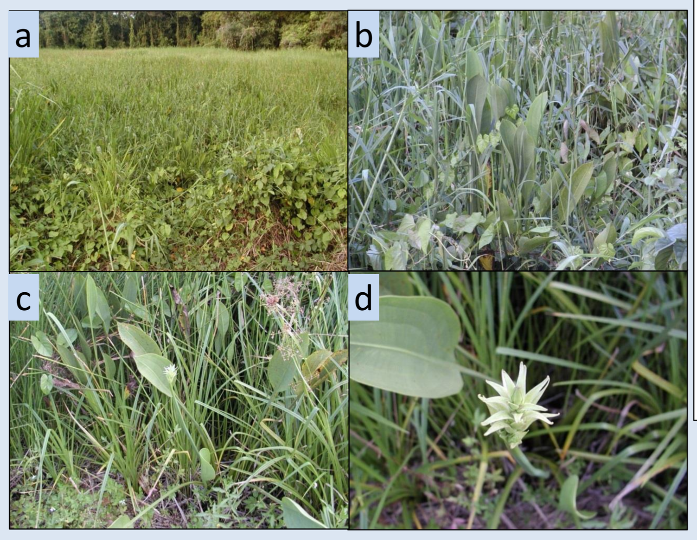

Figure 3. Images of *E. juanariveroi* habitat. (a) Freshwater Marsh, (b, c, d) views of vegetation.

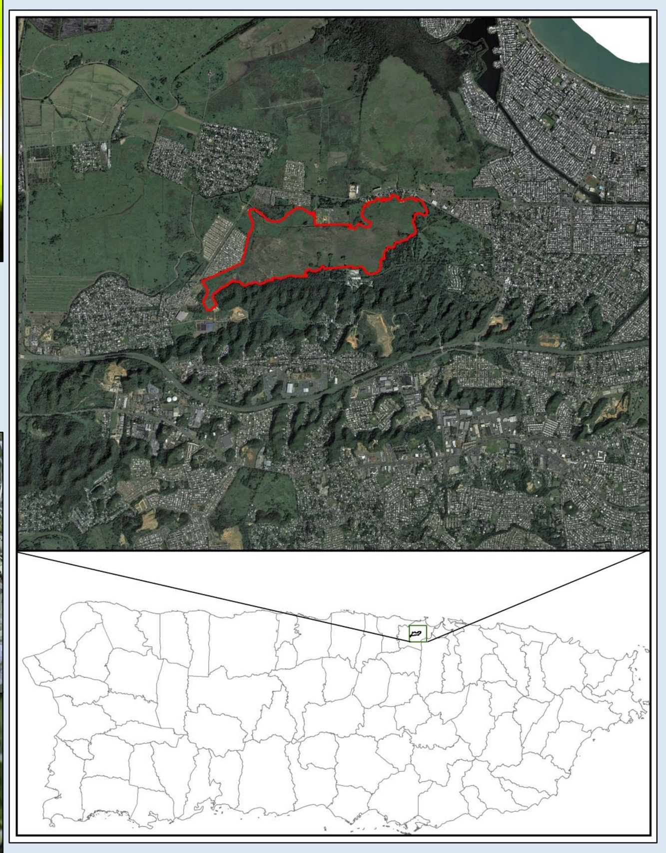

Figure 2. Location of *E. juanariveroi* habitat in the Municipality of Toa Baja, Puerto Rico

TARGET ORGANISM

Eleutherodactylus juanariveroi, commonly known as the "coquí llanero", is the smallest Eleutherodactylid frog species in Puerto Rico (Fig. 1). It ranges in size from an average of 14.7mm in the males to 15.8mm in the females and has the lowest reproduction output of all puertorican coquis with only three eggs per clutch (Rios and Thomas, 2007). It was discovered in 2004 by Dr. Neftalí Ríos López in the Sabana Seca Naval Communications Station grounds in Toa Baja (Fig. 2) restricted to a permanently flooded marsh characterized by a very specific composition of plant species (DRNA, 2007) (Figure 3) Approximately 25% of the vegetation cover is comprised of two rare fern species, *Blechnum serrulatum* and *Thelypteris interrupta*, and a herbaceous species from the *Sagittaria lancifolia* (DRNA, 2007). This composition ofplant species seems to be a critical factor for the permanence of the species in the area. The eggs have only been found inside the axils of *S.lancifolia* (Fig.3) (DRNA, 2007). The eggs of Eleutherodactylus frogs have an extremely permeable outer shell and are very susceptible to desiccation. The axils of this plant are very deep and very close to the water table, hence offering the microclimatic conditions in terms of relative humidity and temperature that the eggs require for their development. The ferns and other plants present in the area are used as standing surfaces for their calling, mating and feeding nocturnal activities (Rios and Thomas, 2007).

SEA LEVEL RISE and the "COQUI LLANERO" HABITAT

Coastal wetlands are extremely vulnerable to sea level rise. The position of wetlands relative to the sea surface will remain constant over time only if the combined effects of land subsidence and rising seas can be balanced by elevation gain from wetland soil formation (Morris et al., 2002; Reed, 2002). The ability of wetlands to migrate inland to areas of decreasing tidal inundation along undeveloped shores is how coastal wetlands can persist in spite of rising seas (Ross et al., 2000). In many areas coastal development just above the extreme high tide line has limited or eliminated opportunities for wetland migration, a phenomenon that has been labeled "coastal squeeze" (Twilley, 1997).

In Puerto Rico, permanent construction is allowed at the edge of sandy beaches or adjacent to coastal wetlands, in many cases directly impacting some portion of the system, and occasionally, sometimes the whole system is filled. This type of development effectively blocks the system from adjacent land and is therefore unable to respond to sea level rise by migrating inland.

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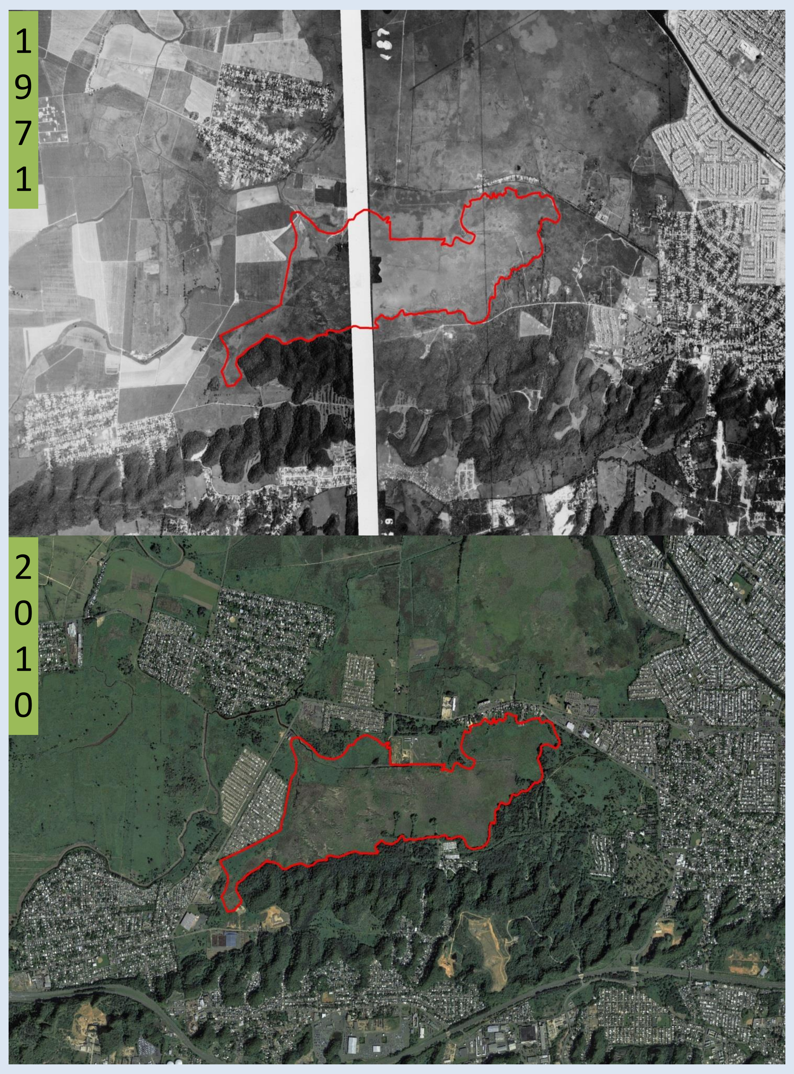

Figure 4. Land Use/Land Cover change from 1971 to 2010.

LAND USE/LAND COVER CHANGE

According to Rios and Thomas (2007), the apparently restricted and small range distribution of this species may reflect a remnant population of a once widely distributed herbaceous wetland specialist whose habitat may have been decimated by land use/land cover changes related to agricultural activities taking place after the Spaniard settlement of the sixteenth century and which culminated with only a 5% remnant of forested areas at the beginning of the twentieth century. One such activity, included the drainage of coastal wetlands for the use of land in the cane industry and drained extensive coastal wetlands. When the economy in Puerto Rico shifted from agriculture to industrial during the first half of the twentieth century, the land was abandoned (Grau *et al*., 2003) and although some has reverted to wetlands, most were destroyed and invaded by grasses and other herbaceous vegetation or ultimately converted to urban developments which further permanently reduced the wetland coverage (Lugo and Brown, 1988).

Aerial photography from 1971 and 2010 shows gradual but persistent urbanization in the lands surrounding the habitat of *E. juanariveroi* (Figure 4). The habitat of *E. juanariveroi* is embossed within a complex matrix of surrounding land uses which are rapidly evolving from mainly agricultural and suburban to high density urban and industrial uses.

SLAMM

The Sea Level Affecting Marshes Model, SLAMM, simulates the dominant processes involved in the conversion of wetlands and coasts as well as the long-term changes caused by sea level rise (Clough et al, 2010).

Hypothesis: Sea level rise will have an impact on the habitat of *E. juanariveroi*.

Objective: Apply the SLAMM model to determine if the "coqui llanero" habitat is under imminent threat for current projections of sea level rise for the year 2100.

Methodology: The SLAMM model requires at least three raster sets to run

1. DEM, Digital Elevation Model
2. Slope
3. NWI wetland types adjusted to SLAMM

1. **Resolution:** We used a 5m Lidar derived DEM. Slope and SLAMM Wetland Types rasters were accordingly generated at a 5m resolution.

2. **Sea Level Rise Scenarios:** Recent publications suggest sea level rise may surpass the 0.59m maximum projected by the latest, 2007, IPCC Report. Some current sea level rise projections range from a minimum of around a meter to a maximum of 5 meters (Hansen, 2007; Rahmstorf, 2007; Vermeer and Rahmstorf, 2009; Grinsted et al., 2010; Alley, 2010). We ran sea level rise scenarios of 1, 1.5 and 2 meters for the Toa Baja coastal wetland region.

Results: At the year 2100 SLAMM suggests changes in the coquí llanero habitat at the three sea level rise scenarios (Figure 5). In the 1m SLR scenario there is only conversion of small patches of swamp to mangrove suggesting a rise in the average water level. At the 1.5m SLR scenario there is further conversion of swamp to mangrove and inland fresh marsh and undeveloped upland to regularly flooded marsh mainly near an old drainage channel on the northern portion of the habitat. The 2m SLR scenario shows larger patches of regularly flooded marsh on the northwest and mangrove on the north, along the drainage channel and along the karst hills south of the habitat**.**

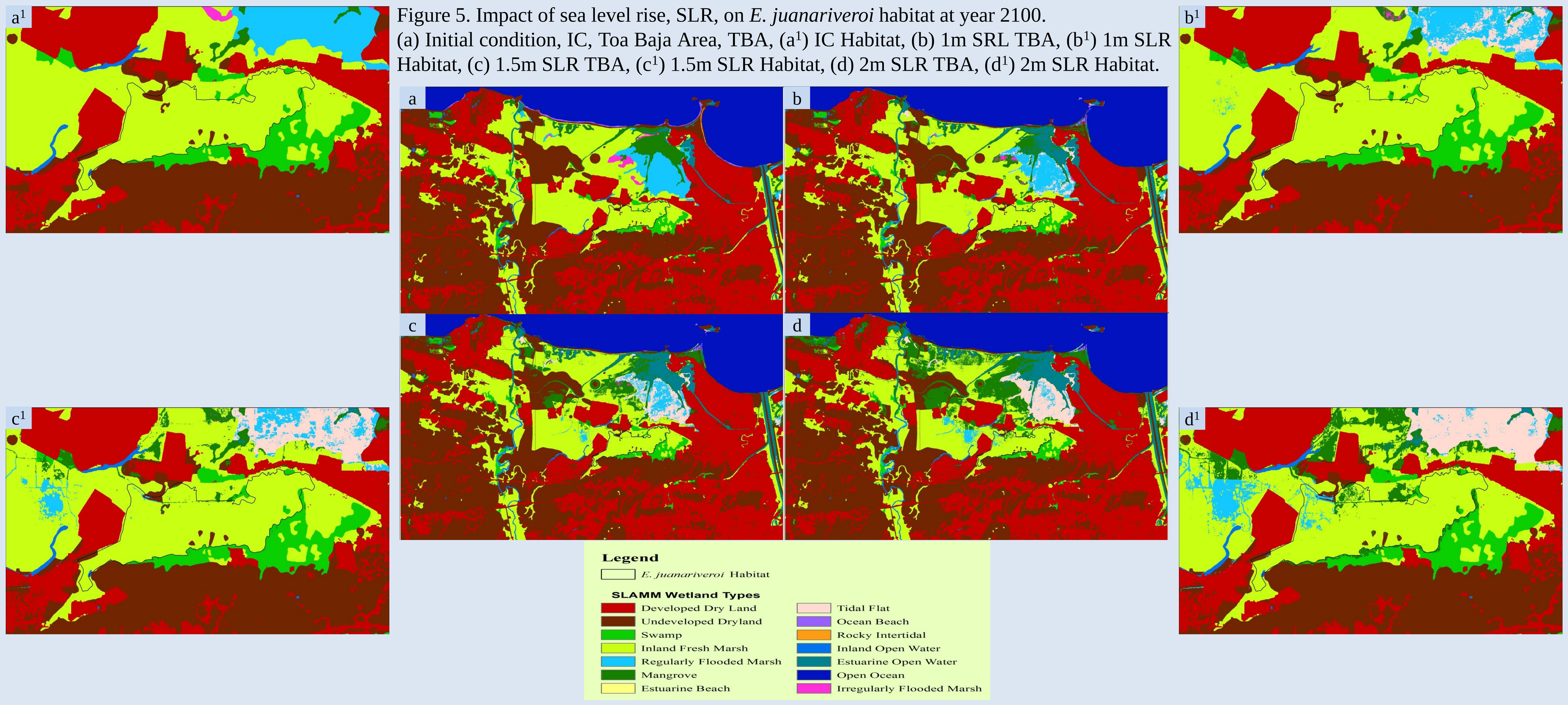

Figure 5. Impact of sea level rise, SLR, on *E. juanariveroi* habitat at year 2100. (a) Initial condition, IC, Toa Baja Area, TBA, (a[1]) IC Habitat, (b) 1m SRL TBA, (b[1]) 1m SLR Habitat, (c) 1.5m SLR TBA, (c[1]) 1.5m SLR Habitat, (d) 2m SLR TBA, (d[1]) 2m SLR Habitat.

CONCLUSIONS AND RECOMMENDATIONS

Land-use/land-cover changes coupled with sea level rise projections warrant the gradual but inevitable demise of the only known habitat of the coquí llanero. Current discussions about proper conservation measures for the coquí llanero include the translocation of a viable breeding population or captive breeding. Both strategies would require extensive field surveys in the hope of identifying similar existing habitats. Nevertheless, it will also require that future land use planning under local development schemes maintain favorable land cover for the species and future sea level rise scenarios will not impact those areas. The SLAMM model provides a simple but effective and efficient tool for the analysis of future potential habitat for the reintroduction of the coquí llanero into new areas and the establishment of viable populations. Translocation may be the faster way of establishing a viable population but it requires a large number of individuals to be extracted from the only known population in Toa Baja. Further analysis is required to determine if it won't hinder the viability of the Toa Baja population. Since the SLAMM sea level rise scenarios suggest a gradual change, the more conservative captive breeding strategy may be the more viable approach.

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