

**ATTACHMENT 14**  
**COPY OF THE FIELD PROTOCOLS REQUIRED BY**  
**THE DNER FOR THE PROTECTION OF**  
**ENDANGERED SPECIES**

**FLORA AND FAUNA MANAGEMENT PLAN  
FOR  
CONSTRUCTION OF THE PUERTO RICO STATE ROAD  
PR-10, SECTIONS II-V  
UTUADO-ADJUNTAS, PUERTO RICO.**

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SEPTEMBER 2021

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## **I. - Introduction:**

The Puerto Rico Highway and Transportation Authority (PRHTA) proposes the construction of the remaining sections (II-V) of the PR-10 (the Project), at the municipalities of Utuado and Adjuntas, Puerto Rico (Attachment I):

- Section II: AC-100069
- Section III: AC-100071
- Section IV: AC-100055
- Section V: AC-100076

In written communications (April-11-2021 and April-27-2021) and more recently during a meeting (June-22-2021), the PRDNER requested the PRHTA to provide protocols to manage the potential presence along the alignment, of several target listed species (LSs).

This Flora and Fauna Management Plan (FFMP) is prepared at the request of the PRHTA to describe the procedures to provide guidance to the construction team on how avoid, minimize or manage the construction impacts on LSs, within the approved project limits, during the construction of the proposed alignment.

If the project needs to implement variations in the Project limit as it is approved in the issued permits, authorizations and endorsements, the PRHTA shall determine with the permitting agencies if the changes are substantial and if they shall seek new authorizations or endorsements before proceeding.

The purpose of this FFMP is to aid field teams in the process to ensure that impacts to the LSs are avoided or minimized and provide management guidelines to be implemented if the impacts are unavoidable. To achieve this purpose, the following points should be undertaken:

- a) Warrant that controls and procedures included in the FFMP are implemented during construction activities to avoid, minimize or manage potential adverse impacts LSs within and in adjacent areas to the alignment construction print.



- b) Ensure that the measures are implemented to comply with applicable legislation and specific requirements of the environmental agencies.

## **II. – Regulatory background:**

Section 7 (a)(1) of the Endangered Species Act (ESA) charges Federal agencies to aid in the conservation of listed species, and section 7 (a)(2) requires the agencies, through consultation with the U.S. Fish and Wildlife Service (Service), to ensure their activities are not likely to jeopardize the continued existence of listed species or adversely modify designated critical habitats. Section 7 applies to the management of Federal lands as well as Federal actions that may affect listed species, such as Federal approval of private or State Government activities through the issuance of Federal funding, permits, licenses, or other actions. Any person that injures, captures, or kills an endangered species is subject to penalties under the ESA. If Federal funds or permits are needed, the funding or permitting agency should initiate Section 7 consultation with the Service.

In addition, the PR New Wildlife Act of 1999, also known as the “Nueva Ley de Vida Silvestre” or Act 241 of August the 15<sup>th</sup> of 1999, as amended, and its regulations (particularly the Regulations No. 6765 and No. 6766), also protects the wildlife and its habitat in Puerto Rico.

## **III. - Target species:**

The PRDNER requested the PRHTA to provide protocols to manage the potential presence along the alignment, of the following LSs (from written communications of April-11-2021 and April-27-2021, and during a meeting June-22-2021):

- a. PR BOA (PRB) (*Chilabothrus inornatus*)
- b. PR Broad-Winged Hawk (PRBWH) (*Buteo platypterus brunescens*)
- c. PR Sharp-Shinned Hawk (PRSSH) (*Accipiter striatus venator*)
- d. PR Parrot (PRP) (*Amazona vittata*)
- e. PR Harlequin Butterfly (PRHB) (*Atlantea tulita*)
- f. *Oplonia spinosa*. (Host plant for ovoposition of *A. tulita*)
- g. *Cornutia obovata*.
- h. *Pleodendron macranthum*
- i. *Solanum ensifolium*
- j. *Myrcia paganii*
- k. *Varronia bellonis*

**IV. – Flora and Fauna information previously collected from the proposed alignment impact area:**

- 1) Flora and fauna study by OIKOS at previous alignment route and an additional alternate route (2001-2002): Flora and Fauna Inventory. The study specify that No Endangered species were observed. However it did mention a single anecdotic report of PRSSH from outside the study area and that the presence of PRB was not confirmed but it is probable due to the habitat characteristics. Revising the list of plants reported, *Oplonia spinosa* was not observed.
- 2) Puerto Rican Boa (*Chilabothrus inornatus*) (PRB) protocol implemented during soil study and service road opening by GBA, Sections II, III and IV (2013-2014): Field workers training, field search before and during the service road opening, along trails, along creeks and at abandoned human dwellings. No endangered species were observed.
- 3) Puerto Rican Sharp-Shinned Hawk (*Accipiter striatus venator*) (PRSSH) search during soil study and service road opening by GBA, Sections II, III and IV (2013-2014): Field workers training, field search (including nesting season) from fixed observation points, walking along the service road, forest trails and

creeks. Call reproduction to stimulate bird response: No endangered species were observed.

- 4) Puerto Rican Broad-Winged Hawk (*Buteo platypterus brunessens*) (PRBWH) search during soil study and service road opening by GBA, Sections II, III and IV (2013-2014): Field workers training, field search (including nesting season) from fixed observation points, walking along the service road, forest trails and creeks. Call reproduction to stimulate bird response: A single individual was observed once at a fixed observation point in Section III.
- 5) Vegetation description, including historical aerial photography analysis (1930's) for the purpose of developing a GIS based Habitat Suitability Model for PRSSH and PRBWH.
- 6) Field visit to Section II by United States Fish and Wildlife Service (USFWS) personnel, Eng. David Moreno and GBA personnel (2013): No endangered species were observed.
- 7) GIS Layers (SHP) from USFWS containing the potential distribution of LSs for Puerto Rico. (Attachment II)
- 8) USFWS IPAC Web Service: Updated LSs distribution and critical habitat designations. Guidelines for some species are available. An official species list was requested and generated by IPAC (Attachment III). Four species were included:

A) Birds:

- Puerto Rican Broad-winged Hawk *Buteo platypterus brunnescens*

No critical habitat has been designated for this species. Species profile:

<https://ecos.fws.gov/ecp/species/5512> Endangered

- Puerto Rican Parrot *Amazona vittata* No critical habitat has been designated for this species. Species profile:

<https://ecos.fws.gov/ecp/species/3067> Endangered

- Puerto Rican Sharp-shinned Hawk *Accipiter striatus venator* No critical habitat has been designated for this species. Species profile:

<https://ecos.fws.gov/ecp/species/604> Endangered

B) Reptiles:

- Puerto Rican Boa *Chilabothrus inornatus* No critical habitat has been designated for this species. Species

profile: <https://ecos.fws.gov/ecp/species/6628> General project

design guidelines:<https://ecos.fws.gov/docs/tess/>

[ipac\\_project\\_design\\_guidelines/doc6757.pdf](https://ecos.fws.gov/docs/tess/ipac_project_design_guidelines/doc6757.pdf) Endangered

C) Critical habitats:

- THERE ARE NO CRITICAL HABITATS WITHIN YOUR PROJECT AREA UNDER THIS OFFICE'S JURISDICTION.

Summary for this chapter:

- a) The GIS files from the USFWS (usfws\_complete\_species\_current\_range.shp) produce potential distribution in the project area and a 500m radius for most of the

- species included in Chapter III. No potential distribution data for *Atlantea tulita* is reported in this source for this area (Attachment II)
- b) The USFWS IPAC web system official species list report one reptile species (PRB) and three bird species (PRP, PRBWH, PRSSH) for the project area by the USFWS IPAC web system. There are no critical habitat within the project area. Design guidelines are only available for PRB. (Attachment III)
  - c) Field work conducted along the project area since 2002 to 2014 and a field visit to Section III in 2021, did not produce positive observations of endangered species (with the exception of a single sighting of a sole individual of PRBWH in Section III)

**V. - Communications with the agencies (As per documents supplied to GBA to this date) (Attachment IV):**

1) DTOP (PRHTA):

2012- Environmental Reevaluation: PR-10, Section V.

2) USFWS:

2013- ESA Section 7 Compliance: PR-10, Section II.

2013- ESA Section 7 Compliance: PR-10, Sections III and IV.

3) PRDNER:

2009- Agreement with the PRHTA regarding land acquisition to mitigate impacts to natural habitat (and other issues): PR-10 Sections II to V.

2012- Agreement with the PRHTA regarding land acquisition to mitigate impacts to natural habitat (and other issues): PR-10 Section V.

2021 (11 April) – Update of the land transference process to mitigate impacts to Natural Habitat, request of protocols for certain LSs and other issues. (PR-10, Sections III and IV)

2021 (27 April) - Update of the land transference process to mitigate impacts to Natural Habitat, request of protocols for certain LSs and other issues. (PR-10, Section II)

4) Federal Highway Authority (FHA):

2012- To USFWS: Request for concurrence with ESA Section 7, considering the LSs studies conducted along the proposed alignment and regarding the land acquisition to mitigate impacts to natural habitat. (PR-10, Sections II to V)

2016- To PRHWT A: Determination of no significant changes and validity of the EIS approved for the project. (PR-10, Section III)

Summary for this chapter:

- a) The proposed PR-10 Sections II-V were found in compliance with Section 7 of ESA, conditioned that no significant changes were made to the proposed project and no new information regarding LSs were made available.
- b) The approved EIS is considered valid.
- c) PRDNER requested protocols for certain additional LSs (1 bird, 1 butterfly and 6 plants).
- d) There is an agreement in process between PRHTA and PRDNER to mitigate the impacts of the project to the trees and natural habitat of ecological value by the acquisition and transference to the PRDNER of certain amount of land of equal or greater ecological value.

## VI. - The project area:

The project area is positioned (Attachments I and V) on the Subtropical Wet Forest (Ewel & Whitmore, 1973; Gould & et. al., 2008), and is a low density residential rural area (Gould & et. al., 2008).

The area shows a matrix of young to moderate mature secondary forest with a mosaic of manmade features (roads, houses, power lines, etc.), *Musa* and *Coffea*, both active and abandoned, plantations, bamboo groves, openings (pastures, shrub land, bare soil areas, etc.) and areas occupied by more mature, denser and taller tracks of secondary forest. Residential dwellings are sparsely distributed, more common in Sections II, III and V. No active human dwellings were found in Section IV. However a number of abandoned human dwellings, electric poles, shacks and ornamental plants, indicates that this section supported a greater degree of human activities in the past.

Aerial images taken in 1930's shows drastic deforestation and clearing implemented during those years in significant portions the proposed alignment. Some forest fragments which were spared may now have evolved to more mature secondary forest tracks.

Some forested areas are dominated by *Cecropia peltata*, *Guarea guidonias*, *Zanthoxylum martinicense*, *Cordia sulcata*, *Inga laurina* and *Inga vera*. This cover type contains tall (DBH >20", height>50') emergent trees of *Ochroma pyramidale*, *Castilla elastica*, *Trichillia pallida*, *Guarea guidonias*, *Roystonea borinquena* and *Zanthoxylum martinicense*.

Around houses and roads was common the presence of fruit tree species like *Mangifera indica*, *Mammea americana*, *Psidium guajava* and *Persea americana*.

Understory is irregularly developed, frequently absent or undeveloped, possible due to clearing for coffee cultivation and *Musa* plantations and washing of deposited seed by runoff water on very thin litter mattress and very steep slopes. When present, it was composed by saplings of canopy species, remains of *Coffea* (*arabica* and *robusta*) plantations, *Cyathea arborea* and *Casearia guianensis*.

## **VII. - Impacts from construction activities**

1. - Key aspects of the Project that could result in impacts to terrestrial and aquatic flora and fauna may include:

- a) Clearing of native vegetation (including habitat).
- b) Works around and within watercourses.
- c) Noise, vibration and light impacts.
- d) Disturbance of soils, consequential erosion and the mobilization of sediment.
- e) Use of chemicals / fuels (potential for spills).

2. - Ecological impacts:

- a) Direct and indirect impacts to the flora and fauna species.
- b) Loss of habitat.
- c) Fragmentation of habitats and wildlife corridors.
- d) Barrier effects on wildlife and riparian corridors (such as the erosion of genetic stock, impacts on home ranges, territorial disputes, increased competition etc.).
- e) Spread of weeds and plant diseases.
- f) Spread of feral animals.
- g) Physical, chemical and biological changes to aquatic environments, wetlands etc.



- h) Edge effects (such as weed invasion, pests and disease).
- i) Disturbance to aquatic and riparian habitats potentially resulting in contamination and siltation of waterways.

### **VIII. - Management Plans:**

**Goal:** Avoid or minimize negative impacts to the target species during project construction (Apply to all species included in Chapter IV).

General measures to protect local fauna species:

- Avoid spread of feral animals as a result of construction.
- Minimize barriers to native fauna movement across the alignment.
- Avoid spread of feral animals as a result of construction
- Avoid the increase in distribution of weeds currently existing within the Project areas.
- No new weeds should be introduced to the Project areas.
- No transfer of plant diseases or pathogens to or from the Project work areas.

### **Objectives and Tasks:**

- A) PR Boa (Project Guidelines for this species are provided by the USFW IPAC, (Attachment VIII), no procedure included here will challenge that document). No report of the presence of the PRB have been recorded for the alignment.

1- Establish the project impact limits.

**Tasks:**

- a) Produce a project field work (stakeout, vegetation clearing, earth work) schedule.
- b) Stakeout and clearly identify (fences, flags, etc.) the project impact limits.
- c) No disturbance to flora and fauna outside the approved construction footprint and associated access tracks shall be allowed.

2- Identify potential shelters for the species inside the project impact limits:

**Tasks:**

- d) Physically flag or mark any natural or manmade features which may host the species (structures, debris piles, trees, woody vines).
- e) Use a survey equipment or GNSS receiver with sub-metric capability, to record the position of all natural or manmade structures that may host the species. Refer coordinates to metric State Plane NAD 83.
- f) Find alternatives to avoid/minimize impacts to natural or manmade structures that may host the species.
- g) Install appropriate barriers around potential species shelters determined to be protected.

3- Avoid/Minimize impact during field work (Vegetation clearing, earthwork, operation of heavy machinery):

**Tasks:**

- h) Organize a pre-construction meeting\* to inform all project personnel about the potential presence of the species, the need to protect it and penalties for harassing or harming the species.

- i) Provide graphic information (drawings, pictures, etc.) to be permanently attached to heavy equipment and to the project board, to aid with the identification of the species.
- j) If attainable, arrange for a field inspection during the night prior to site work and disturbance.
- k) Every morning and prior to start any heavy motor equipment or vehicle staying overnight at the site, inspect the interior and engine compartments in search for specimens sheltered there.
- l) Prior to proceed with vegetation clearing and earth work, proceed with vegetation clearing by hand (to the extent of possible) or, at least visual inspection of the areas to be cleared to pre-stress the area and stimulate the species, if present, to move away.
- m) Avoid placing/creating debris piles near forested areas, dispose debris in a manner accordingly with all applicable regulations.

4- Avoid/Minimize damage or disturbance of specimens detected inside the project impact limits:

**Tasks:**

- n) If specimens are detected during the night inspections and no PRDNER or USFWS personnel or other personnel authorized to handle the species are

\*Training will be provided during the pre-construction meeting and attendance shall required for onsite staff who work in areas where LSs may be encountered. For contractors, the training would be required prior to the start of onsite work. Training will be conducted by a qualified wildlife biologist experienced with LSs and Endangered Species Act compliance. Graphic information to be used during the trainings and those to be affixed on the vehicles and heavy equipment, shall be previously reviewed and approved by PRDNER and attached to this document.

available to capture and relocate the specimen(s), do not capture the specimen(s), encourage the specimen(s) to leave the area.

- o)** If specimens are detected during visual inspection or vegetation clearing by hand and no PRDNER or USFWS personnel or other personnel authorized to handle the species are available to capture and relocate the specimen(s), do not capture the specimen(s), encourage the specimen(s) to leave the area.
- p)** If specimens are detected during heavy equipment and vehicle inspections and no PRDNER or USFWS personnel or other personnel authorized to handle the species are available to capture and relocate the specimen(s), do not capture the specimen(s), encourage the specimen(s) to leave the equipment or leave the equipment alone until the specimen(s) leave it by its own.
- q)** If specimens are detected during heavy equipment operation, vegetation clearing using machines or earthwork and no PRDNER or USFWS personnel or other personnel authorized to handle the species, are available to capture and relocate the specimen(s), do not capture the specimen(s). Stop all work in the area and encourage the specimen(s) to leave the area or leave it alone until the specimen(s) leave the area by its own.
- r)** If a dead specimen is detected during heavy equipment operation, vegetation clearing using machines or earthwork and no PRDNER or USFWS personnel or other personnel authorized to handle the species are available to collect the carcass, do not collect the carcass. Stop all work in the area and contact authorized personnel.

## 5- Information collection and feedback:

### **Tasks:**

- s) Keep record of all conservation measures implemented including mitigation measures applied after a case of an accidental killing of specimens of the species.
  - t) Collect GPS positions of any specimen, dead or alive, detected inside the project limits or in other areas related to the project construction print.
  - u) Information to be included in the incidence report shall comprise but not limited to: Name and contact information of the informant, date and time of the incidence, if emergency actions are deemed please indicate so, species name, status (live, dead, etc.) and quantity of specimens, circumstances of the sighting, action taken, and location/specimens and photographs/video (if possible). The report must include both the logo of the PRHTA and Contractor's and the agencies contact information (see Attachment VII). The PRDNER will review the reports, provide feedback to the PRHTA and coordinate necessary actions to be taken if any.
  - v) Record the name and other relevant information of any USFWS or PRDNER personnel capturing or relocating live specimens or transporting dead specimens.
  - w) Report to the USFWS/PRDNER any incidence related with dead specimens found during the project development, during the following 48 hours of the incidence, the sooner the better. All contact with live specimens, of any of the species included in this document or any other endangered species, will be reported both to the USFWS and the PRDNER within the following 24 hours, the sooner the better. The contact numbers are included in Attachment VII.
- B) PR Broad-winged Hawk, PR Sharp-shinned Hawk and PR Parrot (the species here on while inside section "B"): No report of the presence of the PRP have been recorded for the alignment. A single, not related to reproductive activities, sighting have been recorded for both PRBWH and PRSSH.
- 1- Establish the project impact limits.

### **Tasks:**

- a) Produce a project field work (stakeout, vegetation clearing, earth work) schedule.

- b) Stakeout and clearly identify (fences, flags, etc.) the project impact limits.
- c) No disturbance to flora and fauna outside the approved construction footprint and associated access tracks shall be allowed.

2- Identify potential presence/absence of the species and/or nesting sites inside the project impact limits:

**Tasks:**

- d) After any field indication of the presence of the species, review tall trees inside the project impact limits and adjacent areas (200 m radius) in search of nesting structures.
- e) If any species nesting site is observed, use a survey equipment or GNSS receiver with sub-metric capability, to record the position of the tree containing the species nesting structure. Refer coordinates to metric State Plane NAD 83.
- f) Install appropriate flagging around nesting site and buffer radius to avoid disturbances and notify USFWS/PRDNER.

3- Avoid/Minimize impact during field work (Vegetation clearing, earthwork, operation of heavy machinery):

**Tasks:**

- g) Organize a pre-construction meeting\* to inform all project personnel about the potential presence of the species, the need to protect it and penalties for harassing or harming the species.

\*Training will be provided during the pre-construction meeting and attendance shall required for onsite staff who work in areas where LSs may be encountered. For contractors, the training would be required prior to the start of onsite work. Training will be conducted by a qualified wildlife biologist experienced with LSs and Endangered Species Act compliance. Graphic information to be used during the trainings and those to be affixed on the vehicles and heavy equipment, shall be previously reviewed and approved by PRDNER and attached to this document.

- h) Provide graphic information (drawings, pictures, species vocalization sound reproduction, etc.) to be available at the project field office, to aid with the identification of the species.
- i) If attainable, arrange for a field inspection during the days preceding site work and disturbance oriented to detect the present of the species.
- j) If any species nesting site is located, do not to proceed with vegetation clearing or earth work, at the site or within the 200 m radius and notify USFWS/PRDNER.

4- Avoid/Minimize damage or disturbance of specimens detected inside the project impact limits:

**Tasks:**

- k) If specimens are observed: during visual inspection, heavy equipment operation, vegetation clearing using machines or earthwork Stop all work at or near the sighting area, contact the USFWS/PRDNER and proceed with a more detailed field observation for the next 200m to determine if the sighting is related with a nearby nesting site.
- l) If a nesting site is detected: Stop all work at or near the nesting area, contact the USFWS/PRDNER and find alternatives to proceed with the project while avoiding direct impacts or disturbance to the species nesting areas. Alternatives may include: Continue work at the area after the nesting season for the species concluded, continue work at a different portion of the project, proceed with low impact tasks outside the buffer zone.

- m) If no nesting sites are detected at the work site, proceed with caution with any operation involving removal of trees and other tall vegetation.
- n) If a dead specimen is detected during heavy equipment operation, vegetation clearing using machines or earthwork and no PRDNER or USFWS personnel or other personnel authorized to handle the species are available to collect the carcass, do not collect the carcass. Stop all work in the area and contact authorized personnel.

#### 5- Information collection and feedback:

##### **Tasks:**

- o) Keep record of all conservation measures implemented including mitigation measures applied after a case of an accidental killing of specimens of the species.
- p) Collect GPS positions of any specimen, dead or alive, detected inside the project limits or in other areas related to the project construction print.
- q) Information to be included in the incidence report shall comprise but not limited to: Name and contact information of the informant, date and time of the incidence, if emergency actions are deemed please indicate so, species name, status (live, dead, etc.) and quantity of specimens, circumstances of the sighting, action taken, and location/specimens and photographs/video (if possible). The report must include both the logo of the PRHTA and Contractor's and the agencies contact information (see Attachment VII). The PRDNER will review the reports, provide feedback to the PRHTA and coordinate necessary actions to be taken if any.
- r) Record the name and other relevant information of any USFWS or PRDNER personnel capturing or relocating live specimens or transporting dead specimens.
- s) Report to the USFWS/PRDNER any incidence related with dead specimens found during the project development, during the following 48 hours of the incidence, the sooner the better. All contact with live specimens, of any of the species included in this document or any other endangered species, will be reported both to the USFWS and the PRDNER within the following 24 hours, the sooner the better. The contact numbers are included here.

**Note:** Known breeding season for PR Broad-winged Hawk, PR Sharp-shinned Hawk may extent from December to July and from February to June for the PR Parrot. However, development of reproductive (breeding) activities (courtship, pairing, nesting and juvenile dispersal) may be influenced by environmental and anthropogenic causes and it should be considered more likely, but not exclusively, expected to occur during the generally known period of the breeding season. Tasks related to nesting sites search and protection shall be conducted at any period of the year and should not be limited to the known breeding seasons for any of these species.



C) PR Harlequin Butterfly (PRHB) (*Atlantea tulita*) (PRHB) and *Oplonia spinosa*.

(Host Plant): No report of the presence of the PRHB nor its host plant have been recorded for the alignment. The USFWS IPAC web tool do not warns about the potential occurrence of the PRHB in the alignment area.

1- Establish the project impact limits.

**Tasks:**

- a) Produce a project field work (stakeout, vegetation clearing, earth work) schedule.
- b) Stakeout and clearly identify (fences, flags, etc.) the project impact limits.
- c) No disturbance to flora and fauna outside the approved construction footprint and associated access tracks shall be allowed.

2- Identify potential presence/absence of the PRHB and/or reproductive activity evidence (eggs, chrysalis or caterpillars on host plant specimens) on host plants inside the project impact limits:

**Tasks:**

- d) After any field indication of the presence of the species (butterfly) review the shrubby vegetation within the project impact limits at this point and adjacent (20 m radius) areas in search for the host plant.
- e) If host plant(s) specimens are observed, proceed to investigate the presence of reproductive activity of the butterfly.
- f) If host plant(s) specimen(s) is/are observed showing evidence of reproductive activity of the PRHB, use a survey equipment or GNSS

receiver with sub-metric capability, to record the position of the host plant(s). Refer coordinates to metric State Plane NAD 83.

- g) Install appropriate flagging/fencing around host plant showing reproductive activity signs and its 20m buffer radius and notify USFWS/PRDNER.

3- Avoid/Minimize impact during field work (Vegetation clearing, earthwork, operation of heavy machinery):

**Tasks:**

- h) Organize a pre-construction meeting\* to inform all project personnel about the potential presence of the species (both the PRHB and its host plant), the need to protect it and penalties for intentionally harassing or harming the species.
- i) Provide graphic information (drawings, pictures) to be available to heavy equipment operators and other field workers, and posted at the project field office, to aid with the identification of the species (both the PRHB and its host plant).
- j) If attainable, arrange for a field inspection during the days preceding site work and disturbance.
- k) Prior to proceed with vegetation clearing using heavy equipment and earth work, perform vegetation clearing by hand (to the extent of possible) or, alternatively, conduct a visual inspection of the areas to be cleared in order to increase the chances to detect the species (both the PRHB and its host plant).

\*Training will be provided during the pre-construction meeting and attendance shall required for onsite staff who work in areas where LSs may be encountered. For contractors, the training would be required prior to the start of onsite work. Training will be conducted by a qualified wildlife biologist experienced with LSs and Endangered Species Act compliance. Graphic information to be used during the trainings and those to be affixed on the vehicles and heavy equipment, shall be previously reviewed and approved by PRDNER and attached to this document.

- l) If any species reproductive activity is observed, do not to proceed with vegetation clearing or earth work, at the site or within the 20 m radius and notify USFWS/PRDNER.

4- Avoid/Minimize damage or disturbance of the species (both the PRHB and its host plant) detected inside the project impact limits:

**Tasks:**

- m) If PRHB specimens are observed during heavy equipment operation, vegetation clearing using machines or earthwork. Stop all work at or near the sighting area, contact the USFWS and proceed with a detailed field observation to determine if there are host plants specimens and if the sighting is related with reproductive activities.
- n) If a host plant is detected showing signs of the PRHB reproductive activities: Stop all work at or near the host plant area, contact the USFWS and find alternatives to proceed with the project while avoiding direct impacts or disturbance to the host plant and nearby (20 m radius) areas. Alternatives may include: Continue work at the area after the reproductive period concluded, continue work at a different portion of the project, proceed with low impact tasks outside the buffer zone. USFWS, PRDNER or other authorized personnel may also collect the host plant or portions of it, containing the PRHB eggs, chrysalis or caterpillars, and take it to an appropriate facility or location.

- o) If PRHB specimens are observed but no signs of the PRHB reproductive activities are detected at the work site, proceed with caution with any operation involving removal of low vegetation.
- p) If host plant specimens are observed but no signs of the PRHB reproductive activities are detected at the work site, flag the specimen collect it position using survey equipment or GNSS and proceed with caution with any operation involving removal of low vegetation.
- q) If a PRHB dead specimen is detected during vegetation clearing or earthwork and no PRDNER or USFWS personnel or other personnel authorized to handle the species are available to collect the carcass, do not collect the carcass. Stop all work in the area and contact authorized personnel.

5- Information collection and feedback:

**Tasks:**

- r) Keep record of all conservation measures implemented including mitigation measures applied after a case of an accidental killing of specimens of the species.
- s) Collect GPS positions of any PRHB or host plant specimen containing the PRHB eggs, chrysalis or caterpillars, dead or alive, detected inside the project limits or in other areas related to the project construction print.
- t) Information to be included in the incidence report shall comprise but not limited to: Name and contact information of the informant, date and time of the incidence, if emergency actions are deemed please indicate so, species name, status (live, dead, etc.) and quantity of specimens, circumstances of the sighting, action taken, and location/specimens and photographs/video (if possible). The report must include both the logo of the PRHTA and Contractor's and the agencies contact information (see Attachment VII). The PRDNER will review the reports, provide feedback to the PRHTA and coordinate necessary actions to be taken if any.

- u) Record the name and other relevant information of any USFWS or PRDNER personnel capturing or relocating live specimens (PRHB eggs, chrysalis or caterpillars) or transporting dead specimens.
- v) Report to the USFWS any incidence related with dead specimens found during the project development, during the following 48 hours of the incidence, the sooner the better. All contact with live specimens, of any of the species included in this document or any other endangered species, will be reported both to the USFWS and the PRDNER within the following 24 hours, the sooner the better. The contact numbers are included in Attachment VII.
- w) The owner or personal in charge (PICH) of the facilities recipients of PRHB specimens, portions of PRHB specimens, PRHB eggs, chrysalis or caterpillars or other biological material of the PRHB or host plant species, shall certify that they are lawfully authorized to receive this material and the acceptance of such material from authorized personnel.

D) *Cornutia obovata*, *Pleodendron macranthum*, *Solanum ensifolium*, *Myrcia paganii*, *Varronia bellonis*. (Plant Species).

There are no reports, at our knowledge, of the presence of the any of these plant species recorded for the alignment. The USFWS IPAC web tool do not warns about the potential occurrence of these plant species in the alignment area.

The USFWS species distribution GIS file provide potential distribution information (Attachment IV) for all the plant species, excepting *Varronia bellonis*, only for the Section II segment of the alignment (approximately nearby the Chorrera Bridge). In attention to that, the following objectives and tasks shall apply to *Varronia bellonis* for all the alignment and for the Section II to the remaining plant species.

Plant Species	Family	Veg.Type
a. Palo de Nigua ( <i>Cornutia obovata</i> )	LAMIACEAE	TREE
b. Chupacallo ( <i>Pleodendron macranthum</i> )	CANELLACEAE	TREE
c. Erubia ( <i>Solanum ensifolium</i> )	SOLANACEAE	SHRUB
d. Ausú ( <i>Myrcia paganii</i> )	MYRTACEAE	TREE
e. <i>Varronia bellonis</i>	BORAGINACEAE	SHRUB

1- Establish the project impact limits.

**Tasks:**

- a) Produce a project field work (stakeout, vegetation clearing, earth work) schedule.
- b) Stakeout and clearly identify (fences, flags, etc.) the project impact limits.
- c) No disturbance to flora and fauna outside the approved construction footprint and associated access tracks shall be allowed.

2- Identify presence/absence of the plant species inside the project impact limits:

**Tasks:**

- d) If the conditions of the terrain allows it, conduct, in advance of vegetation clearing activities, a linear transect along the alignment to observe the vegetation within the project impact limits in search for the plant species. Conduct additional searches for *Solanum ensifolium* along service roads or other previously impacted areas in connection with the proposed alignment.
- e) If specimens of the plant species are observed, install appropriate flagging/fencing around the plant species specimen(s) and a 10m radius and notify USFWS/PRDNER.

3- Avoid/Minimize impacts during field work (Vegetation clearing, earthwork, operation of heavy machinery):

**Tasks:**

- f) Organize a pre-construction meeting\* to inform all project personnel about the potential presence of the plant species, the need to protect it and penalties for purposely killing, removing or harming the species.
- g) Provide graphic information (drawings, pictures) to be available to heavy equipment operators and field workers and posted at the project field office, to aid with the identification of the plant species.
- h) Prior to proceed with vegetation clearing using heavy equipment and earth work, perform vegetation clearing by hand (to the extent of possible) or, alternatively, conduct a visual inspection of the areas to be cleared in order to increase the chances to detect the plant species.
- i) If specimens of the plant species are observed, install appropriate flagging/fencing around the plant species specimen(s) and a 10m radius and stop all work at this spot and notify USFWS/PRDNER.

4- Avoid/Minimize damage or disturbance of the plant species detected inside the project impact limits:

**Tasks:**

- j) If plant species specimens are observed during heavy equipment operation, vegetation clearing using machines or earthwork. Stop all work at or near the sighting area, contact the USFWS/PRDNER and proceed with a detailed field observation to determine if there are flowers, fruits and/or seeds.

\*Training will be provided during the pre-construction meeting and attendance shall required for onsite staff who work in areas where LSs may be encountered. For contractors, the training would be required prior to the start of onsite work. Training will be conducted by a qualified wildlife biologist experienced with LSs and Endangered Species Act compliance. Graphic information to be used during the trainings and those to be affixed on the vehicles and heavy equipment, shall be previously reviewed and approved by PRDNER and attached to this document.

- k) If plant species specimens are detected bearing flowers, fruits and/or seeds or not: Stop all work at or near the host plant area, contact the USFWS and find alternatives to proceed with the project while avoiding direct impacts or disturbance to the host plant and nearby (10 m radius) areas. Alternatives may include: continue work at a different portion of the project, proceed with low impact tasks outside the 10m buffer zone. USFWS, PRDNER officers or other authorized personnel may determine the viability to transplant the plant to a safe location, collect portions of it or seeds and take it to an appropriate facility or location. Continue work at the area after the permanent measures are taken and receive order to proceed from USFWS/PRDNER.
- l) If a plant species specimen is unintentionally impacted, damaged, removed, or destroyed during vegetation clearing or earthwork and no PRDNER or USFWS personnel or other personnel authorized to handle the species are available to collect the remains, do not collect them. Stop all work in the area and notify USFWS/PRDNER during the following 24 hours.

5- Information collection and feedback:

**Tasks:**

- m) Keep record of all conservation measures implemented including mitigation measures applied after a case unintentionally impact, damage, removal, or destruction of specimens of the species.



- n) Collect GPS positions of plant species specimen(s), dead or alive, detected inside the project limits or in other areas related to the project construction print.
- o) Information to be included in the incidence report shall comprise but not limited to: Name and contact information of the informant, date and time of the incidence, if emergency actions are deemed please indicate so, species name, status (live, dead, etc.) and quantity of specimens, circumstances of the sighting, action taken, and location/specimens and photographs/video (if possible). The report must include both the logo of the PRHTA and Contractor's and the agencies contact information (see Attachment VII). The PRDNER will review the reports, provide feedback to the PRHTA and coordinate necessary actions to be taken if any.
- p) Record the name and other relevant information of any USFWS or PRDNER personnel transplanting plant specimens to a safe location, collecting portions of the plants or seeds and taking them to an appropriate facility or location or transporting remains.
- q) Report to the USFWS/PRDNER any incidence related with dead specimens found during the project development, during the following 48 hours of the incidence, the sooner the better. All contact with live specimens, of any of the species included in this document or any other endangered species, will be reported both to the USFWS and the PRDNER within the following 24 hours, the sooner the better. The contact numbers are included in Attachment VII.
- r) The owner or personal in charge (PICH) of the facilities recipients of specimens, portions of the specimens, seeds, flowers or other biological material of the plant species, shall certify they are lawfully authorized to receive this material and the acceptance of such material from authorized personnel.
- s) The PRHTA will contract with an entity (nursery, plant propagation facility or equivalent) with expertise in plant propagation, growing and planting, to receive, re-plant, stabilize and care for the endangered plant specimens collected from the Project site and the delivery to the final transplanting location. The PRDNER will determine the final location to relocate and plant the specimens (ie. Bosque de Rio Abajo State Forest Att. Sr. Enrique Casanova) and coordinate with the PRHTA the transplanting work to this location when appropriate.

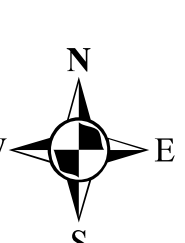
Any fruit or seed collected from live or dead plant specimens will be delivered to the "Banco de Semillas del Herbario de la Universidad de Puerto Rico en Mayagüez" (Contact: Biol. Jeannine Vélez to the 787-832-4040 ext. 3646 and/or [jeanine.velez@upr.edu](mailto:jeanine.velez@upr.edu) / [jeanine\\_velez@yahoo.com](mailto:jeanine_velez@yahoo.com)). The PRHTA will instruct field personnel to collect and save all biological material and contact to the appropriate personnel.

## IX.- Bibliography

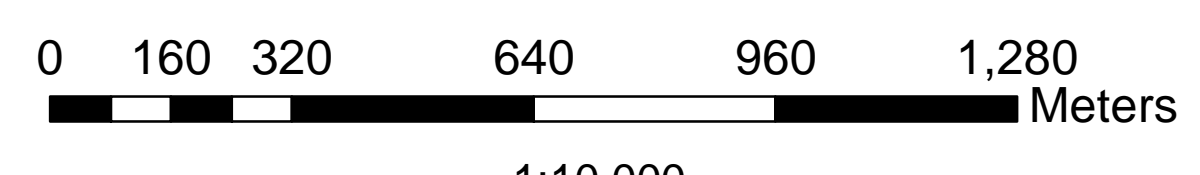
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**ATTACHMENT I: LOCATION MAP**





LOCATION PLAN



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PR-10, SECTIONS II-V  
UTUADO-ADJUNTAS, PUERTO RICO

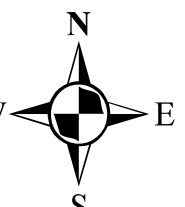
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PROJECT LIMIT

GABRIEL BERRIZ ASSOCIATES  
Plan, Laredo Gonzalez, MPP/PL  
JULY 2021

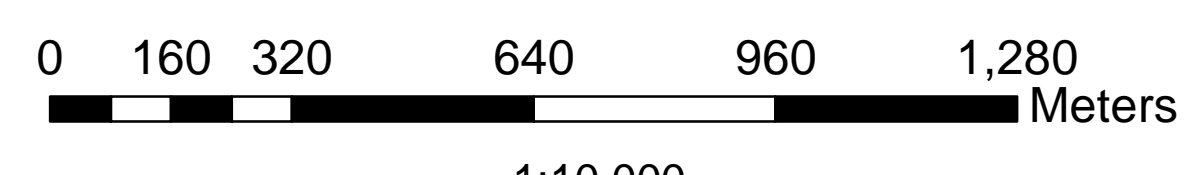




**Leyenda**  
PROJECT LIMIT



**PROJECT LIMITS**

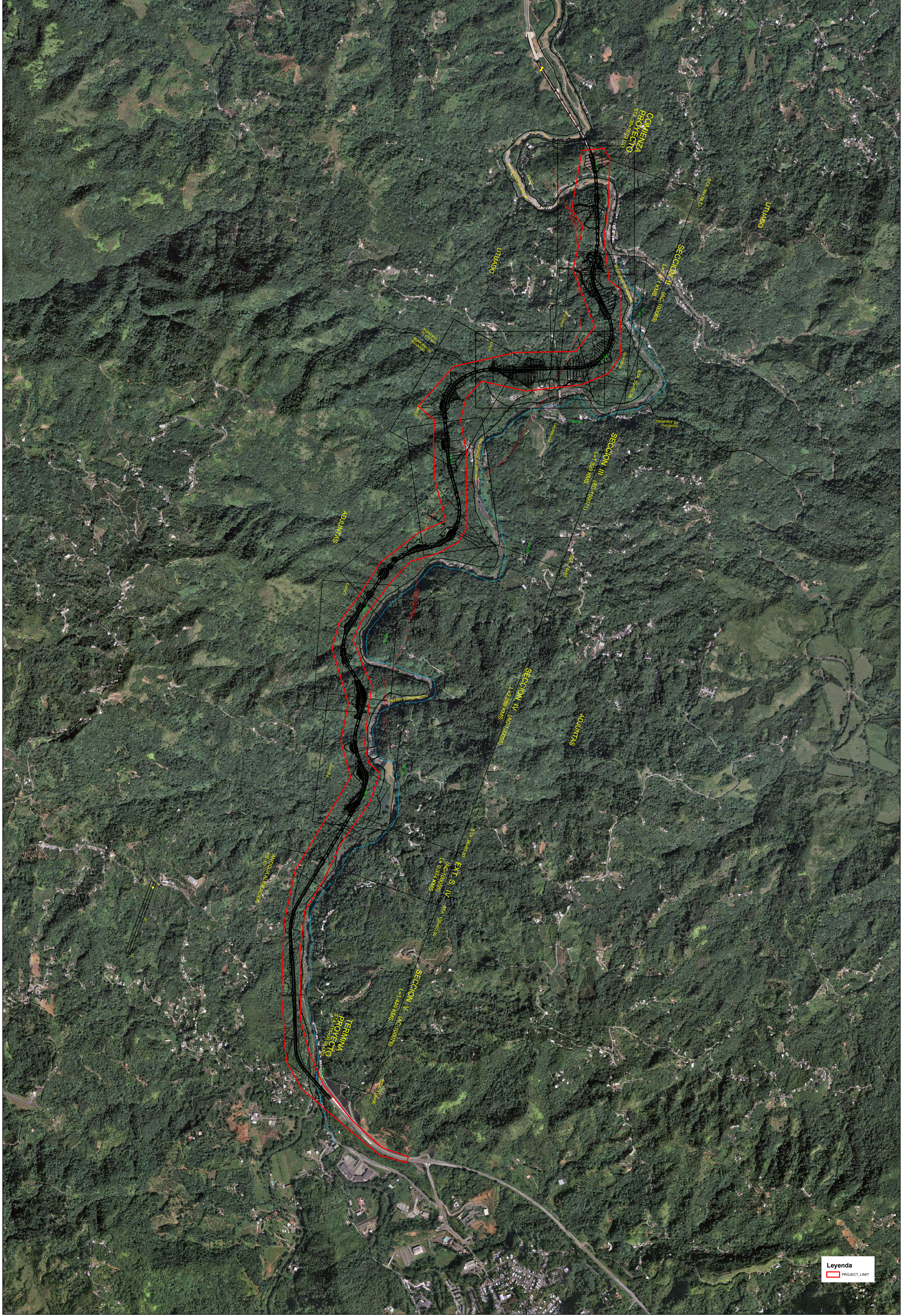


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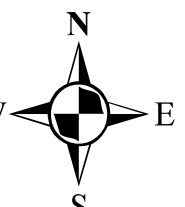
**PR-10, SECTIONS II-V  
UTUADO-ADJUNTAS, PUERTO RICO**

GABRIEL BERRIZ & ASSOCIATES  
Plan. Laredo González, MP, PPL  
JULY 2021

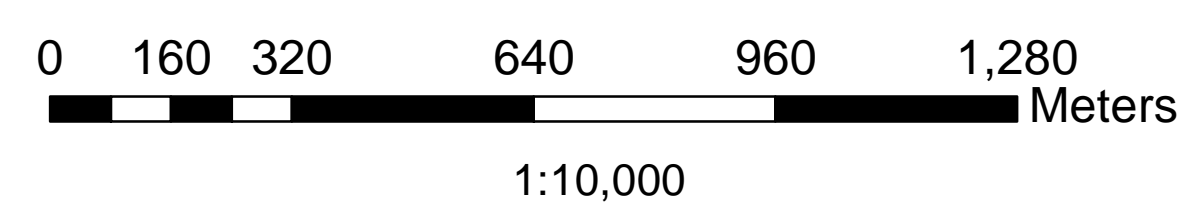




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 PROJECT LIMIT



**PROPOSED PROJECT SECTIONS**

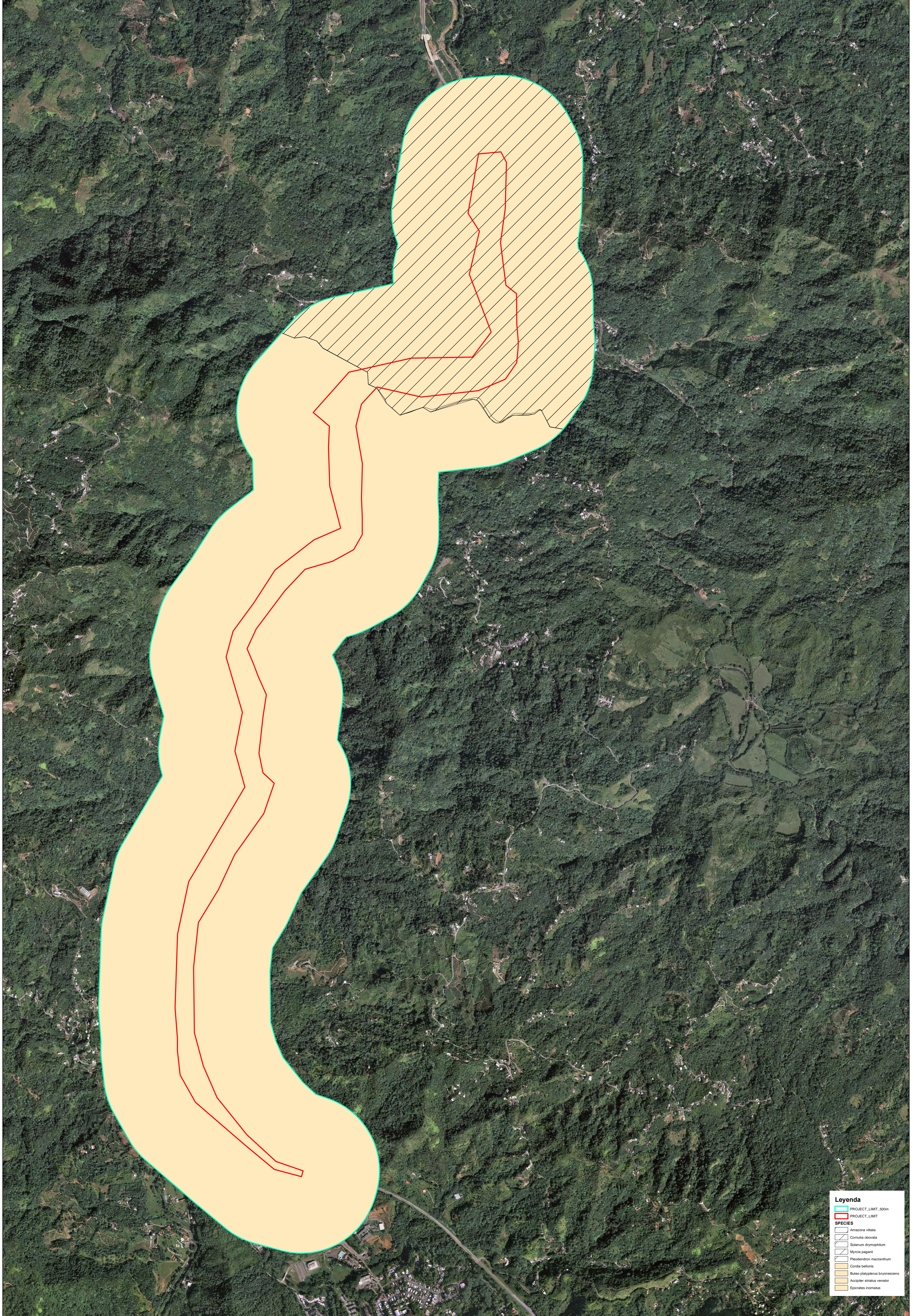


**PR-10, SECTIONS II-V  
 UTUADO-ADJUNTAS, PUERTO RICO**



**ATTACHMENT II: USFWS GIS Based Listed Species Potential Distribution. PR-10 Sections II to V and 500m radius.**





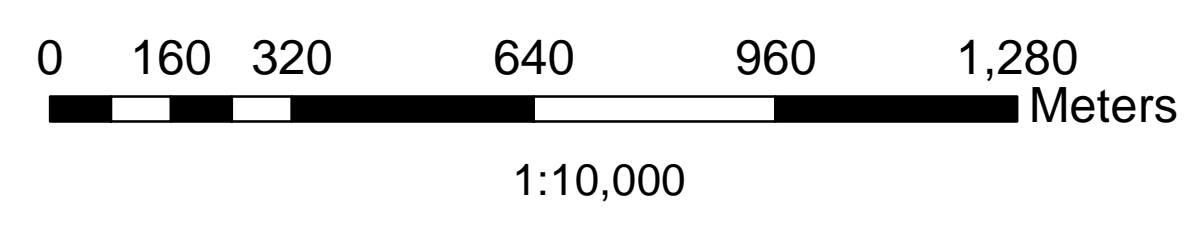
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PROJECT\_LIMIT\_500m  
PROJECT\_LIMIT

**SPECIES**

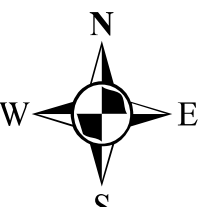
- Amazona vittata
- Cornus obovata
- Solanum drymophilum
- Myrcia pagani
- Pleodendron macranthum
- Cordia alliodora
- Buteo platypterus brunneiceps
- Accipiter striatus venator
- Episcia inornata

**USFWS ENDANGERED SPECIES  
IN PRDNER REQUEST  
(PL & 500m RADIOUS)**



**PR-10, SECTIONS II-V  
UTUADO-ADJUNTAS, PUERTO RICO**

GABRIEL BERRIZ&ASSOCIATES  
Plan. Laredo González, MP, PPL  
JULY, 2021





**ATTACHMENT III: USFWS IPAC Web Service Official List for PR-10 Sections II  
to V.**



## United States Department of the Interior



FISH AND WILDLIFE SERVICE  
Caribbean Ecological Services Field Office  
Post Office Box 491  
Boqueron, PR 00622-0491  
Phone: (787) 851-7297 Fax: (787) 851-7440  
<http://www.fws.gov/caribbean/es>

In Reply Refer To:

July 07, 2021

Consultation Code: 04EC1000-2021-SLI-1042

Event Code: 04EC1000-2021-E-01663

Project Name: STATE ROAD PR-10, SECTIONS II-V

Subject: List of threatened and endangered species that may occur in your proposed project location or may be affected by your proposed project

To Whom It May Concern:

**\*THE FOLLOWING SPECIES LIST IS NOT A SECTION 7 CONSULTATION. PLEASE CONTACT OUR OFFICE TO COMPLETE THE CONSULTATION PROCESS\***

The purpose of the Endangered Species Act (Act) is to provide a means whereby threatened and endangered species and the ecosystems upon which they depend may be conserved. Under sections 7(a)(1) and 7(a)(2) of the Act and its implementing regulations (50 CFR 402 et seq.), Federal agencies are required to utilize their authorities to carry out programs for the conservation of threatened and endangered species and to determine whether projects may affect those species and/or their designated critical habitat.

Federal agencies are required to "request of the Secretary of Interior information whether any species which is listed or proposed to be listed may be present in the area of a proposed action".

The enclosed species list provides information to assist with the consultation process with the U.S. Fish and Wildlife Service (Service) under section 7 of the Act. However, the enclosed species list **does not complete the required consultation process**. The species list identifies threatened, endangered, proposed and candidate species, as well as proposed and designated critical habitats, that may occur within the boundary of your proposed project and/or may be affected by your proposed project.

A discussion between the Federal agency and the Service should include what types of listed species may occur in the proposed action area, and what effect the proposed action may have on those species. This process initiates informal consultation.

When a Federal agency, after discussions with the Service, determines that the proposed action is not likely to adversely affect any listed species, or adversely modify any designated critical habitat, and the Service concurs, the informal consultation is complete and the proposed project

moves ahead. If the proposed action is suspected to affect a listed species or modify designated critical habitat, the Federal agency may then prepare a Biological Assessment (BA) to assist in its determination of the project's effects on species and their habitat.

However, a BA is required for construction projects (or other undertakings having similar physical impacts) that are major Federal actions significantly affecting the quality of the human environment as defined in the National Environmental Policy Act (42 U.S.C. 4332(2) (c)). For projects other than major construction activities, the Service suggests that a biological evaluation similar to a BA where the agency provides the Service with an evaluation on the likely effects of the action to determine whether the project may affect listed or proposed species and/or designated or proposed critical habitat. Recommended contents of a BA are described at 50 CFR 402.12.

If a Federal agency determines, based on its BA or biological evaluation, that listed species and/or designated critical habitat may be affected by the proposed project, the agency is required to further consult with the Service pursuant to 50 CFR 402. In addition, the Service recommends that candidate species, proposed species, and proposed critical habitat be addressed within the consultation process.

More information on the regulations and procedures for section 7 consultation, including the role of permit or license applicants, can be found in the "Endangered Species Consultation Handbook" at:

<http://www.fws.gov/endangered/esa-library/pdf/TOC-GLOS.PDF>

New information based on updated surveys, changes in the abundance and distribution of species, changed habitat conditions, or other factors could change this list. Please feel free to contact us if you need more current information or assistance regarding the potential impacts to federally proposed, listed, and candidate species and federally designated and proposed critical habitat. Please note that under 50 CFR 402.12(e) of the regulations implementing section 7 of the Act, the accuracy of this species list should be verified after 90 days. This verification can be completed formally or informally as desired. The Service recommends that verification be completed by visiting the ECOS-IPaC website at regular intervals during project planning and implementation for updates to species lists and information. An updated list may be requested through the ECOS-IPaC system by completing the same process used to receive the enclosed list.

Additionally, wind energy projects should follow the wind energy guidelines (<http://www.fws.gov/windenergy/>) for minimizing impacts to migratory birds and bats.

Guidance for minimizing impacts to migratory birds for projects including communications towers (e.g., cellular, digital television, radio, and emergency broadcast) can be found at:

<http://www.fws.gov/migratorybirds/CurrentBirdIssues/Hazards/towers/towers.htm>; <http://www.towerkill.com>; and <http://www.fws.gov/migratorybirds/CurrentBirdIssues/Hazards/towers/comtow.html>.

We appreciate your concern for threatened and endangered species. The Service encourages Federal agencies to include conservation of threatened and endangered species into their project planning to further the purposes of the Act. Please include the Consultation Tracking Number in

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the header of this letter with any request for consultation or correspondence about your project that you submit to our office.

**For more information:**

**U.S. Fish and Wildlife Service  
Caribbean Ecological Services Field Office**

**Road 301, Km. 5.1 / Bo. Corozo**

**Boquerón, PR 00622**

**Telephone: (787) 851-7297**

**Fax: (787) 851-7440**

**Email: [caribbean\\_es@fws.gov](mailto:caribbean_es@fws.gov)**

**<http://www.fws.gov/caribbean/es>**

**Send all documents to:**

**U.S. Fish and Wildlife Service**

**P.O. Box 491**

**Boquerón, Puerto Rico 00622**

**Attachment(s):**

- Official Species List
  - USFWS National Wildlife Refuges and Fish Hatcheries
  - Migratory Birds
  - Wetlands
-

## Official Species List

This list is provided pursuant to Section 7 of the Endangered Species Act, and fulfills the requirement for Federal agencies to "request of the Secretary of the Interior information whether any species which is listed or proposed to be listed may be present in the area of a proposed action".

This species list is provided by:

**Caribbean Ecological Services Field Office**

Post Office Box 491

Boqueron, PR 00622-0491

(787) 851-7297

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## Project Summary

Consultation Code: 04EC1000-2021-SLI-1042

Event Code: 04EC1000-2021-E-01663

Project Name: STATE ROAD PR-10, SECTIONS II-V

Project Type: TRANSPORTATION

Project Description: THE CONSTRUCTION OF REMAINING SECTION OF THE STATE ROAD PR-10 IS PROPOSED

Project Location:

Approximate location of the project can be viewed in Google Maps: <https://www.google.com/maps/@18.20480805,-66.73470094529443,14z>



Counties: Adjuntas and Utuado counties, Puerto Rico

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## Endangered Species Act Species

There is a total of 4 threatened, endangered, or candidate species on this species list.

Species on this list should be considered in an effects analysis for your project and could include species that exist in another geographic area. For example, certain fish may appear on the species list because a project could affect downstream species.

IPaC does not display listed species or critical habitats under the sole jurisdiction of NOAA Fisheries<sup>1</sup>, as USFWS does not have the authority to speak on behalf of NOAA and the Department of Commerce.

See the "Critical habitats" section below for those critical habitats that lie wholly or partially within your project area under this office's jurisdiction. Please contact the designated FWS office if you have questions.

1. [NOAA Fisheries](#), also known as the National Marine Fisheries Service (NMFS), is an office of the National Oceanic and Atmospheric Administration within the Department of Commerce.

### Birds

NAME	STATUS
Puerto Rican Broad-winged Hawk <i>Buteo platypterus brunnescens</i> No critical habitat has been designated for this species. Species profile: <a href="https://ecos.fws.gov/ecp/species/5512">https://ecos.fws.gov/ecp/species/5512</a>	Endangered
Puerto Rican Parrot <i>Amazona vittata</i> No critical habitat has been designated for this species. Species profile: <a href="https://ecos.fws.gov/ecp/species/3067">https://ecos.fws.gov/ecp/species/3067</a>	Endangered
Puerto Rican Sharp-shinned Hawk <i>Accipiter striatus venator</i> No critical habitat has been designated for this species. Species profile: <a href="https://ecos.fws.gov/ecp/species/604">https://ecos.fws.gov/ecp/species/604</a>	Endangered

### Reptiles

NAME	STATUS
Puerto Rican Boa <i>Epicrates inornatus</i> No critical habitat has been designated for this species. Species profile: <a href="https://ecos.fws.gov/ecp/species/6628">https://ecos.fws.gov/ecp/species/6628</a> General project design guidelines: <a href="https://ecos.fws.gov/docs/tess/ipac_project_design_guidelines/doc6757.pdf">https://ecos.fws.gov/docs/tess/ipac_project_design_guidelines/doc6757.pdf</a>	Endangered

### Critical habitats

THERE ARE NO CRITICAL HABITATS WITHIN YOUR PROJECT AREA UNDER THIS OFFICE'S JURISDICTION.

# USFWS National Wildlife Refuge Lands And Fish Hatcheries

Any activity proposed on lands managed by the [National Wildlife Refuge](#) system must undergo a 'Compatibility Determination' conducted by the Refuge. Please contact the individual Refuges to discuss any questions or concerns.

THERE ARE NO REFUGE LANDS OR FISH HATCHERIES WITHIN YOUR PROJECT AREA.

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## Migratory Birds

Certain birds are protected under the Migratory Bird Treaty Act<sup>1</sup> and the Bald and Golden Eagle Protection Act<sup>2</sup>.

Any person or organization who plans or conducts activities that may result in impacts to migratory birds, eagles, and their habitats should follow appropriate regulations and consider implementing appropriate conservation measures, as described [below](#).

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1. The [Migratory Birds Treaty Act](#) of 1918.
2. The [Bald and Golden Eagle Protection Act](#) of 1940.
3. 50 C.F.R. Sec. 10.12 and 16 U.S.C. Sec. 668(a)

THERE ARE NO FWS MIGRATORY BIRDS OF CONCERN WITHIN THE VICINITY OF YOUR PROJECT AREA.

### Migratory Birds FAQ

**Tell me more about conservation measures I can implement to avoid or minimize impacts to migratory birds.**

[Nationwide Conservation Measures](#) describes measures that can help avoid and minimize impacts to all birds at any location year round. Implementation of these measures is particularly important when birds are most likely to occur in the project area. When birds may be breeding in the area, identifying the locations of any active nests and avoiding their destruction is a very helpful impact minimization measure. To see when birds are most likely to occur and be breeding in your project area, view the Probability of Presence Summary. [Additional measures](#) or [permits](#) may be advisable depending on the type of activity you are conducting and the type of infrastructure or bird species present on your project site.

**What does IPaC use to generate the migratory birds potentially occurring in my specified location?**

The Migratory Bird Resource List is comprised of USFWS [Birds of Conservation Concern \(BCC\)](#) and other species that may warrant special attention in your project location.

The migratory bird list generated for your project is derived from data provided by the [Avian Knowledge Network \(AKN\)](#). The AKN data is based on a growing collection of [survey, banding, and citizen science datasets](#) and is queried and filtered to return a list of those birds reported as occurring in the 10km grid cell(s) which your project intersects, and that have been identified as warranting special attention because they are a BCC species in that area, an eagle ([Eagle Act](#) requirements may apply), or a species that has a particular vulnerability to offshore activities or development.

Again, the Migratory Bird Resource list includes only a subset of birds that may occur in your project area. It is not representative of all birds that may occur in your project area. To get a list of all birds potentially present in your project area, please visit the [AKN Phenology Tool](#).

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### **What does IPaC use to generate the probability of presence graphs for the migratory birds potentially occurring in my specified location?**

The probability of presence graphs associated with your migratory bird list are based on data provided by the [Avian Knowledge Network \(AKN\)](#). This data is derived from a growing collection of [survey, banding, and citizen science datasets](#).

Probability of presence data is continuously being updated as new and better information becomes available. To learn more about how the probability of presence graphs are produced and how to interpret them, go to the Probability of Presence Summary and then click on the "Tell me about these graphs" link.

### **How do I know if a bird is breeding, wintering, migrating or present year-round in my project area?**

To see what part of a particular bird's range your project area falls within (i.e. breeding, wintering, migrating or year-round), you may refer to the following resources: [The Cornell Lab of Ornithology All About Birds Bird Guide](#), or (if you are unsuccessful in locating the bird of interest there), the [Cornell Lab of Ornithology Neotropical Birds guide](#). If a bird on your migratory bird species list has a breeding season associated with it, if that bird does occur in your project area, there may be nests present at some point within the timeframe specified. If "Breeds elsewhere" is indicated, then the bird likely does not breed in your project area.

### **What are the levels of concern for migratory birds?**

Migratory birds delivered through IPaC fall into the following distinct categories of concern:

1. "BCC Rangewide" birds are [Birds of Conservation Concern](#) (BCC) that are of concern throughout their range anywhere within the USA (including Hawaii, the Pacific Islands, Puerto Rico, and the Virgin Islands);
2. "BCC - BCR" birds are BCCs that are of concern only in particular Bird Conservation Regions (BCRs) in the continental USA; and
3. "Non-BCC - Vulnerable" birds are not BCC species in your project area, but appear on your list either because of the [Eagle Act](#) requirements (for eagles) or (for non-eagles) potential susceptibilities in offshore areas from certain types of development or activities (e.g. offshore energy development or longline fishing).

Although it is important to try to avoid and minimize impacts to all birds, efforts should be made, in particular, to avoid and minimize impacts to the birds on this list, especially eagles and BCC species of rangewide concern. For more information on conservation measures you can implement to help avoid and minimize migratory bird impacts and requirements for eagles, please see the FAQs for these topics.

### **Details about birds that are potentially affected by offshore projects**

For additional details about the relative occurrence and abundance of both individual bird species and groups of bird species within your project area off the Atlantic Coast, please visit the [Northeast Ocean Data Portal](#). The Portal also offers data and information about other taxa besides birds that may be helpful to you in your project review. Alternately, you may download the bird model results files underlying the portal maps through the [NOAA NCCOS Integrative Statistical](#)

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[Modeling and Predictive Mapping of Marine Bird Distributions and Abundance on the Atlantic Outer Continental Shelf](#) project webpage.

Bird tracking data can also provide additional details about occurrence and habitat use throughout the year, including migration. Models relying on survey data may not include this information. For additional information on marine bird tracking data, see the [Diving Bird Study](#) and the [nanotag studies](#) or contact [Caleb Spiegel](#) or [Pam Loring](#).

### **What if I have eagles on my list?**

If your project has the potential to disturb or kill eagles, you may need to [obtain a permit](#) to avoid violating the Eagle Act should such impacts occur.

### **Proper Interpretation and Use of Your Migratory Bird Report**

The migratory bird list generated is not a list of all birds in your project area, only a subset of birds of priority concern. To learn more about how your list is generated, and see options for identifying what other birds may be in your project area, please see the FAQ "What does IPaC use to generate the migratory birds potentially occurring in my specified location". Please be aware this report provides the "probability of presence" of birds within the 10 km grid cell(s) that overlap your project; not your exact project footprint. On the graphs provided, please also look carefully at the survey effort (indicated by the black vertical bar) and for the existence of the "no data" indicator (a red horizontal bar). A high survey effort is the key component. If the survey effort is high, then the probability of presence score can be viewed as more dependable. In contrast, a low survey effort bar or no data bar means a lack of data and, therefore, a lack of certainty about presence of the species. This list is not perfect; it is simply a starting point for identifying what birds of concern have the potential to be in your project area, when they might be there, and if they might be breeding (which means nests might be present). The list helps you know what to look for to confirm presence, and helps guide you in knowing when to implement conservation measures to avoid or minimize potential impacts from your project activities, should presence be confirmed. To learn more about conservation measures, visit the FAQ "Tell me about conservation measures I can implement to avoid or minimize impacts to migratory birds" at the bottom of your migratory bird trust resources page.

---

## Wetlands

Impacts to [NWI wetlands](#) and other aquatic habitats may be subject to regulation under Section 404 of the Clean Water Act, or other State/Federal statutes.

For more information please contact the Regulatory Program of the local [U.S. Army Corps of Engineers District](#).

Please note that the NWI data being shown may be out of date. We are currently working to update our NWI data set. We recommend you verify these results with a site visit to determine the actual extent of wetlands on site.

### FRESHWATER POND

- [PUB](#)

### RIVERINE

- [R5UBH](#)
-

**ATTACHMENT IV: Communications from Agencies.**



U.S. Department  
of Transportation

**Federal Highway  
Administration**

Puerto Rico Division

350 Ave. Carlos Chardon, Suite 210  
San Juan, Puerto Rico 00918-2148

Phone: (787) 766-5600  
Fax: (787) 766-5924 / 766-5603

<http://www.fhwa.dot.gov/prdiv/index.htm>

August 3, 2012

In Reply Refer To:  
HDA-PR

Mr. Edwin E. Muniz  
Field Supervisor  
U.S. Fish and Wildlife Service  
Boqueron Field Office  
P.O. Box 491  
Boqueron, PR 00622

Attention: Ms. Marelisa Rivera

Dear Mr. Muniz:

The Puerto Rico Highway Transportation Authority (PRHTA) has been continually constructing the PR-10 project from Ponce to Arecibo since the Final Environmental Impact Statement (FEIS) was approved in 1979. Only the central portion, approximately four miles long, between Utuado and Adjuntas remains to be constructed. This remaining portion includes segments AC-100055, AC-100069, AC-100071, AC-100074 (this segment is part of the AC-100062 segment reevaluation approved in 2002), and AC-100076 (this segment was previously labeled AC-100065 in the 2005 approved reevaluation).

Since the 1979 FEIS was approved, additional studies have been conducted over the years to address the potential impact to listed species. These include a Flora/Fauna Study in 2002 by Hector Quintero, Ph.D., the report on the Distribution and Abundance of the Endangered Puerto Rican Broad-winged Hawk and the Puerto Rican Sharp-shinned Hawk under the direction of Francisco J. Virella, Ph.D. in 2004, and the 2002 endangered plant study by Franklin Axelrod, Ph.D.

Based on previous letters of Section 7 findings and concurrence (12/8/02 and 5/5/04) from the United States Fish and Wildlife Service (USFWS), the Federal Highway Administration (FHWA) approved reevaluations for the above mentioned remaining segments in 2002, 2003 and 2005. It is our understanding that much of the mitigation for the project has been completed in the acquisition of land near the Rio Abajo Forest, and monitoring reports have been completed as required. Nonetheless, the commitments will still require the implementation of protocol for various species that may be present in the remaining segments, such as the search, capture and relocation of the Puerto Rican Boa.

Due to the length of time since our last consultation with USFWS, the FHWA would like to informally consult with USFWS to reaffirm that construction of the remaining segments is not likely to adversely affect listed species, including the Broad-winged Hawk *Buteo platypterus*


Mr. Edwin E. Muniz  
August 3, 2012

2

*brunnescens*, the Sharp-shinned Hawk *Accipiter striatus vennator*, the Puerto Rican Boa *Epicrates inornatus*, or other listed plant or animal species within the project area. The scope of the project for these segments remains the same as the project scope considered in our previous consultations requested between 2001 and 2005.

It is FHWA's understanding that the efforts of the past studies, monitoring reports and mitigation activities remain satisfactory, and the previous finding of "may affect, but not likely to adversely affect" remains valid. It is therefore FHWA's intent to approve a reevaluation of the project to allow the remaining segments to proceed to construction. Our office will contact Ms. Marelisa Rivera, who has been the USFWS contact for the project during our past consultations, to verify that there are no outstanding issues. In the meantime, if you have any concerns that the project has not met the needed action items specified in our previous consultations, please contact Ms. Cathy Kendall, at [cathy.kendall@dot.gov](mailto:cathy.kendall@dot.gov) or by phone at (850) 553-2225 to let us know so that we can address any issues.

Sincerely,



Martin C. Knopp  
Division Administrator

cc: Luis E. Rodriguez Rosa, PRHTA Director of Programming and Special Studies Area



U.S. Department  
of Transportation  
**Federal Highway  
Administration**

**Puerto Rico &  
U.S. Virgin Islands  
Division Office**

350 Chardon Ave. Suite 210  
San Juan, PR 00918-2161  
Phone: 787-766-5600  
Fax: 787-766-5924

September 15, 2016

In Reply Refer To:  
HDA-PR

Mr. Luis E. Rodríguez Rosa  
Sub-Director  
Program and Special Studies Office  
Puerto Rico Highway and Transportation Authority  
P.O. Box 42007  
San Juan, PR 00940-2007

Subject: Reevaluation PR-10 from Utuado to Adjuntas, PR (Section III)  
PRHTA No.: AC-100071

Dear Mr. Rodríguez Rosa:

The Federal Highway Administration has completed the review of the reevaluation of the EIS, as required by 23 CFR 771.129, for the referenced project dated on June 3, 2016 and supplemented with additional documents submitted between July and September 2016. It has been determined that there have been no changes to the project that affect the original environmental determination. Therefore, the administrative action remains valid.

If you should have any questions or comments, please contact me at [luis.d.lopez@dot.gov](mailto:luis.d.lopez@dot.gov) or at 407-867-6420.

Sincerely,

Luis D. López Rivera  
Environmental Specialist

Enclosure

Cc. Zulma I. Marín Cordero, PRHTA  
Carmen A. Morales Mateo, PRHTA



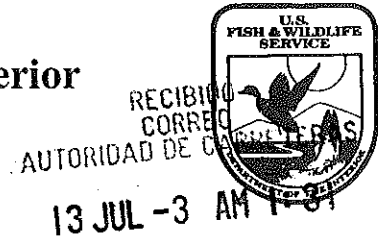


# United States Department of the Interior

## FISH AND WILDLIFE SERVICE

Caribbean Ecological Services  
Field Office  
P.O. Box 491  
Boqueron, PR 00622

JUL 02 2013



In Reply Refer To:  
FWS/R4/CESFO/72-LP-026

Ms. Carmen G. Alicea  
Programming and Special Studies Area  
PR Highway and Transportation Authority  
P.O. Box 42007  
San Juan, Puerto Rico 00940-2007

Re: Progress Report Section II, PR-10, Utuado-  
Adjuntas, Puerto Rico  
AC-100069

Dear Ms. Alicea:

Thank you for your letter dated June 14, 2012, requesting our concurrence with the progress report prepared for Section II of PR-10, Utuado-Adjuntas. Our comments are issued in accordance with the Endangered Species Act (ESA) of 1973, as amended (87 Stat. 884, as amended; 16 U.S.C. 1531 *et seq.*).

The proposed action consists of a new section (from Utuado to Adjuntas) of the proposed highway PR-10 (AC-100069). The purpose of the study is assess the potential impact of the proposed action on two Puerto Rican endangered forest raptor species Broad-winged hawk (*Buteo platypterus brunnescens*) and Puerto Rican sharp-shinned hawk (*Accipiter striatus venator*).

Based on a review of the information provided and that available in our office, the proposed project lies within the range of these federally listed species; however, no suitable habitat for the species is located along the proposed alignment nor individuals or nests sites were observed. Therefore, we concur with your determination that the proposed action would not affect the broad-winged hawk and Puerto Rican sharp-shinned hawk.

This concludes consultation under section 7 of the ESA and no further consultation is necessary, unless additional information concerning impacts to listed species or critical habitat becomes available, or modifications are made to the proposed project.

Thank you for the opportunity to comment on this project. We appreciate your effort to protect endangered species and their habitat. It is the Service's mission to work with others to conserve, protect and enhance fish, wildlife, and plants and their habitats for the continuing benefit of our

people. Please do not hesitate to contact Marelisa Rivera at 787-851-7297, extension 206, should you have any questions concerning our comments.

Sincerely yours,

  
Edwin Mufiz  
Field Supervisor

mrh



# United States Department of the Interior



## FISH AND WILDLIFE SERVICE

Caribbean Ecological Services

Field Office

P.O. Box 491

Boqueron, PR 00622

SEP 12 2013

In Reply Refer To:  
FWS/R4/CESFO/72-LP-026

CESFO COPY  
FILED by ml

Carmen G. Alicea Ruiz  
Programming and Special Studies Area  
PR Highway and Transportation Authority  
PO Box 42007  
San Juan, Puerto Rico 00940-2007

Re: PR-10, (AC-100071 and AC-100055), Utuado-Adjuntas, PR

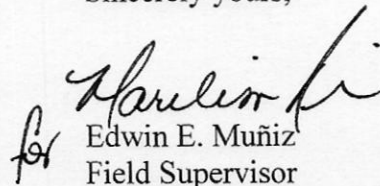
Dear Ms. Alicea:

Thank you for your letter dated August 13, 2013, requesting our comments on the above referenced project. We have reviewed your request for information about endangered and threatened species and their habitats for the above referenced project. Our comments are provided under the Endangered Species Act (Act) (87 Stat. 884, as amended; 16 United States Code 1531 et seq.).

The project consists of the observation of Broad-Winged Hawk and Sharp-Shinned Hawk and their habitats progress report prepared for the PR-10 expansion. The purpose of the study is to assess the potential impact of the proposed action on these two endangered species.

Based on the review of the information provided, the nature of the project, and the site characteristics, we concur with your determination that the proposed project is not likely to adversely affect threatened and endangered species. Therefore, no further consultation is required. Nevertheless, if the project is modified or if information on impacts to listed species becomes available this office should be contacted concerning the need for the initiation of consultation under section 7 of the Act.

Sincerely yours,

  
Edwin E. Muñiz  
Field Supervisor



COMMONWEALTH OF  
PUERTO RICO

Puerto Rico Highway and  
Transportation Authority

Coner  
NLAA

August 13, 2013

Mr. Edwin Muñiz  
Field Supervisor  
Fish and Wildlife Service  
Caribbean Ecological Services Field Office  
PO Box 491  
Boquerón, Puerto Rico 00622

RECEIVED

AUG 20 2013

U.S. Fish & Wildlife Service

**CONSULTATION UNDER SECTION 7 OF ENDANGERED SPECIES ACT  
OBSERVATION REPORT OF BROAD-WINGED HAWK AND  
SHARP-SHINNED HAWK AND THEIR HABITAT  
SECTION III (AC-100071) AND SECTION IV (AC-100055), PR-10  
UTUADO-ADJUNTAS, PUERTO RICO**

Dear Mr. Muñiz:

Enclosed please find one copy of the Observation of Broad-Winged Hawk and Sharp-Shinned Hawk and Their Habitats Progress Report prepared for the subject project. The purpose of the study is to assess the potential impact of the proposed action on two Puerto Rican endangered forest raptor species, Broad-Winged Hawk (BWH) (*Buteo platypterus brunnescens*) and Puerto Rican Sharp-Shinned Hawk (SSH) (*Accipiter striatus venator*).

The report also includes the methodology used to perform the study. According to the report, the conclusions and recommendations are the following:

- No impacts to the Puerto Rican Boa or to other snake species have been documented to the date of the report.
- The construction of the proposed alignment may impact jurisdictional waters of the US, both temporary and permanent.
- To the date of the report no wetlands have been identified along the proposed alignment.
- No individual BWH/SSH individuals or nest sites were observed to the date of the report.
- No critical habitat for BWH/SSH is located along the proposed alignment.
- The Nesting Habitat Suitability Model exposed some forested areas along the proposed alignment which may contain suitable nesting habitat for BWH/SSH.
- Even when more specialized raptor species may use the area during its life cycle for activities other than breeding, existing patchy landscape characteristics along the route appear to suit more an eclectic hawk species, like *Buteo jamaicensis*, which is very common in the zone.

Roberto Sánchez Vilella, Government Center  
PO Box 42007, San Juan, PR 00940-2007  
P. (787) 721.8787  
www.dtop.gov.pr

 facebook.com/dtop

 @DTOP



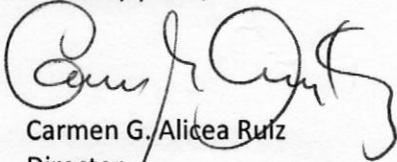
Mr. Edwin Muñiz  
Page -2-  
August 13, 2013

- Territorial defense flights or other interspecific behavior from BWH/SSH individuals as a reaction to RTH presence in the area, were not observed.
- A proposal for the survey protocol to further assess BWH/SSH presence/absence along the southern located PR-10 section III and IV to be implemented during the beginning of the breeding season 2013-2014 is attached to the report (Attachment XIII).

According with the results of this progress report our Agency has determined that the proposed action is not likely to adversely affect Endangered Species. PRTHA request your concurrence with our determination.

For additional information please contact us at 787-721-8787 ext. 1501.

Cordially yours,



Carmen G. Alicea Ruiz  
Director  
Programming and Special Studies Area

6407/CAMM/emf

Enclosure





# United States Department of the Interior



## FISH AND WILDLIFE SERVICE

Caribbean Ecological Services

Field Office

P.O. Box 491

Boqueron, PR 00622

SEP 12 2013

In Reply Refer To:  
FWS/R4/CESFO/72-LP-026

CESFO COPY  
FILED by ml

Carmen G. Alicea Ruiz  
Programming and Special Studies Area  
PR Highway and Transportation Authority  
PO Box 42007  
San Juan, Puerto Rico 00940-2007

Re: PR-10, (AC-100071 and AC-100055), Utuado-Adjuntas, PR

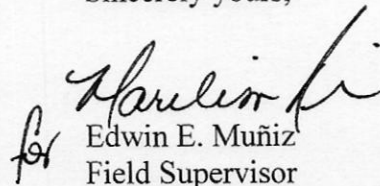
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The project consists of the observation of Broad-Winged Hawk and Sharp-Shinned Hawk and their habitats progress report prepared for the PR-10 expansion. The purpose of the study is to assess the potential impact of the proposed action on these two endangered species.

Based on the review of the information provided, the nature of the project, and the site characteristics, we concur with your determination that the proposed project is not likely to adversely affect threatened and endangered species. Therefore, no further consultation is required. Nevertheless, if the project is modified or if information on impacts to listed species becomes available this office should be contacted concerning the need for the initiation of consultation under section 7 of the Act.

Sincerely yours,

  
Edwin E. Muñiz  
Field Supervisor



COMMONWEALTH OF  
PUERTO RICO

Puerto Rico Highway and  
Transportation Authority

Coner  
NLAA

August 13, 2013

Mr. Edwin Muñiz  
Field Supervisor  
Fish and Wildlife Service  
Caribbean Ecological Services Field Office  
PO Box 491  
Boquerón, Puerto Rico 00622

RECEIVED

AUG 20 2013

U.S. Fish & Wildlife Service

**CONSULTATION UNDER SECTION 7 OF ENDANGERED SPECIES ACT  
OBSERVATION REPORT OF BROAD-WINGED HAWK AND  
SHARP-SHINNED HAWK AND THEIR HABITAT  
SECTION III (AC-100071) AND SECTION IV (AC-100055), PR-10  
UTUADO-ADJUNTAS, PUERTO RICO**

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The report also includes the methodology used to perform the study. According to the report, the conclusions and recommendations are the following:

- No impacts to the Puerto Rican Boa or to other snake species have been documented to the date of the report.
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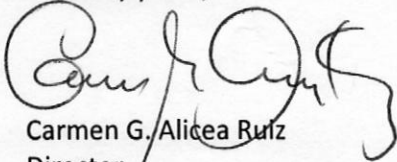
Mr. Edwin Muñiz  
Page -2-  
August 13, 2013

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According with the results of this progress report our Agency has determined that the proposed action is not likely to adversely affect Endangered Species. PRTHA request your concurrence with our determination.

For additional information please contact us at 787-721-8787 ext. 1501.

Cordially yours,



Carmen G. Alicea Ruiz  
Director  
Programming and Special Studies Area

6407/CAMM/emf

Enclosure





GOBIERNO DE PUERTO RICO

Departamento de Recursos Naturales y Ambientales

01 AGO. 2011

Honorable Rubén A. Hernández Gregorat  
Secretario  
Departamento de Transportación y Obras Públicas  
1900 Ave. Fernández Juncos  
Parada 26  
Santurce, Puerto Rico 00940



Estimado señor Secretario:

**Mitigación corte de árboles en Proyecto PR-10  
Municipios Adjuntas y Utuado  
AC-100069 (TRAMO II), AC-100071 (TRAMO III)  
AC-100055 (TRAMO IV), AC-100079 (TRAMO V)  
AC-100074**

Hacemos referencia a su comunicación del 11 de abril de 2011, donde solicita que el Departamento de Recursos Naturales y Ambientales (DRNA) acepte 253.23 cuerdas, pertenecientes a la finca conocida como Hacienda Verde por concepto de mitigación al Reglamento de Planificación Núm. 25, *Reglamento de Siembra, Corte y Reforestación de Puerto Rico*, para los proyectos en epígrafe. Además, solicita que se le exima de presentar el inventario de árboles correspondientes a los mismos proyectos.

En comunicación del 15 de marzo de 2010, el DRNA le informó que las 253.23 cuerdas son un excedente de la finca conocida como Hacienda Verde cuya área total es de 370 cuerdas de las cuales 117 cuerdas ya fueron aceptadas como mitigación, por concepto de la Ley Núm. 241 de 15 de agosto de 1999, conocida como *Nueva Ley de Vida Silvestre*, para los proyectos en referencia. También se le informó que debido a la cercanía de esta finca al Bosque Estatal Río Abajo, la misma debía ser transferida en su totalidad al DRNA para su protección y conservación futura por su alto valor ecológico.

Según la información provista por la Autoridad de Carreteras y Transportación (ACT), el impacto total de estos proyectos es de 117 cuerdas, por lo que la mitigación ofrecida duplica el área que será impactada. Por todo lo antes expuesto, el DRNA acepta la mitigación de las 253.23 cuerdas, sobrantes de la finca Hacienda Verde, como mitigación al Reglamento de Planificación Núm. 25, *supra*, reconociendo su valor y la importancia de los ecosistemas allí presentes.

J.D.  
8440

Honorable Rubén Hernández Gregorat  
Mitigación PR-10, Municipios Adjuntas y Utuado  
Página 2

01 AGO. 2011

En relación a su solicitud de que se le exima de presentar el inventario de árboles, el DRNA reconoce la importancia de los proyectos propuestos para el desarrollo socio económico del área montañosa de nuestra Isla, por lo que se le exige de presentar el mismo.

Le recordamos que es de suma importancia que la ACT comience a la mayor brevedad la transferencia de la totalidad de la finca Hacienda Verde al DRNA y que la misma se haga en cumplimiento con el Reglamento Núm. 7624 de 5 de diciembre de 2008, *Reglamento para la Adquisición de Bienes Inmuebles y Derechos Reales del Departamento de Recursos Naturales y Ambientales*.

De tener alguna duda al respecto, puede comunicarse con la Ing. Johanna Vázquez, Secretaria Auxiliar de Permisos al (787)-999-2200, extensiones 2834 ó 2846.

Cordialmente,



Daniel J. Galán Kercadó  
Secretario

MRS/mrs/ero



# GOBIERNO DE PUERTO RICO

Departamento de Recursos Naturales y Ambientales

27 de abril de 2021

ING GABRIEL HERNÁNDEZ RODRÍGUEZ  
SECRETARIO AUXILIAR  
OFICINA DE GERENCIA DE PERMISOS  
PO BOX 41179  
SAN JUAN, PR 00940-1179

Atención: Gerente de Medio Ambiente

Estimado ingeniero Hernández:

**PR-10, Sección II**  
**AC-100069**  
**Utua y Adjuntas**

**2015-089377-SRM-041470**  
**O-NE-EAR08-SJ-01062-19032021**

**2020-315358-SRM-035038**  
**O-NE-EAR08-SJ-00981-17072020**

**2020-315361-SRM-035039**  
**O-NE-EAR08-SJ-00982-17072020**

**A-PA-DIA01-SJ-00003-19012006**

El Departamento de Recursos Naturales y Ambientales (DRNA) recibió por medio electrónico, el proyecto identificado en el epígrafe. Se propone la construcción de una arteria rural con sección de rodaje de 2 carriles de 3.65 metros cada una sin isleta central, paseos de tres metros a cada lado y bermas que varían entre 1.20 m y 1.85 m. El proyecto se ha dividido en tres secciones para propósitos de subasta y construcción. La alineación del proyecto discurre en dirección norte-sur en una ruta casi paralela del Río Grande de Arecibo a una distancia que varía entre 100 y 150 metros, bordeando las laderas de las montañas que termina justo en el Río. La Sección II aquí presentada contempla la construcción de tres puentes. Además, incluye el movimiento de tierra correspondiente para la construcción del área de rodaje, levantamiento de dos muros de retención, utilidades de drenaje, marcado de pavimento, rotulación, instalación de dispositivos de seguridad y todo aquel trabajo incidental para completar la obra.

Según nuestros expedientes, el DRNA evaluó y emitió un endoso condicionado el 28 de junio de 2006 a los segmentos AC-100069, AC-100071, AC-100055, AC-100065 y AC-100054 para la construcción de la PR-10. En dicha comunicación el DRNA determinó que los diferentes segmentos del proyecto impactarían un hábitat de valor ecológico y requirió la mitigación en proporción 1:1 para el impacto de 275 cuerdas. Esto, en cumplimiento con la Ley núm. 241 de 15 de agosto de 1999, según enmendada y el Reglamento para Regir la Conservación y el Manejo de la Vida Silvestre, las Especies Exóticas y la Caza del Estado Libre Asociado de Puerto Rico (Reglamento Núm. 6765). No



Página 2

obstante, en comunicación del 20 de noviembre de 2008, la Autoridad de Carreteras y Transportación (ACT) informó que el impacto de la totalidad de la alineación del proyecto en evaluación no sería de 275 cuerdas sino de 117 cuerdas.

Posteriormente, la ACT presentó para evaluación de forma individual para propósito de subasta y construcción, las secciones III y IV. El DRNA emitió comentarios el 26 de agosto de 2020 para las mismas y requirió la continuación y culminación del proceso de mitigación en cumplimiento con la Ley Núm. 241, supra y el Reglamento Núm. 6765. Asimismo, se requirió la presentación de protocolos para minimizar impactos a especies de flora y fauna en peligro de extinción y el compromiso de realizar los estudios necesarios para atender los riesgos geológicos en la alineación.

La ACT presentó al DRNA una comunicación del 22 de febrero de 2021, atendiendo los aspectos señalados por el DRNA en la comunicación de 26 de agosto de 2020 para las secciones III y IV. Asimismo, se incluyó comunicación de la compañía consultora en geotecnia Geopráctica Inc y estudios de flora y fauna presentados al *Fish and Wildlife Service*. En comunicación del 11 de abril de 2021 (adjunto), el DRNA emitió comentarios y requerimientos a la nueva información presentada. Debido a que la Sección II aquí presentada forma parte del proyecto evaluado previamente, se deberá presentar la información requerida para las secciones III y IV como parte de este proyecto. Se recomienda que se presente la información para las tres secciones en conjunto y no se divida el proceso de evaluación de las mismas.

Por lo antes expuesto, se deberá cumplir con los requerimientos de la comunicación del 11 de abril de 2021 y presentar lo siguiente para poder continuar con la evaluación del proyecto:

- Protocolos a seguir si se identifican poblaciones o individuos de *Varronia bellonis*, *Cornutia obovata*, *Solanum ensifolium*, *Pleodendrom macranthum*, *Myrcia paganii* y *Atlantea tulita*. Para esta última se debe además monitorear o prestar especial atención a la planta *Oplonia spinosa* para determinar si hay huevos o larvas. Es importante que se indique cómo se procederá si se encuentran algunas de estas especies durante la construcción del proyecto.

Una vez se presente la información relacionada a los protocolos no incluidos, el DRNA estaría en posición de poder emitir su endoso al proyecto.

Cordialmente,



Digitally signed by  
Luis R Sierra-Torres  
Date: 2021.04.27  
13:33:44 -04'00'

Ing. Luis Sierra  
Secretario Auxiliar  
Secretaría Auxiliar de Permisos,  
Endosos y Servicios Especializados

LS/GFS/ACH





# GOBIERNO DE PUERTO RICO

Departamento de Recursos Naturales y Ambientales

11 de abril de 2021

ING GABRIEL HERNÁNDEZ RODRÍGUEZ  
SECRETARIO AUXILIAR  
OFICINA DE GERENCIA DE PERMISOS  
PO BOX 41179  
SAN JUAN, PR 00940-1179

Atención: Gerente de Medio Ambiente

Estimado ingeniero Hernández:

**PR-10, Secciones III y IV**  
**AC-100071 / AC-100055**  
**Utuido y Adjuntas**

**2020-315358-SRM-035038**  
**O-NE-EAR08-SJ-00981-17072020**

**2020-315361-SRM-035039**  
**O-NE-EAR08-SJ-00982-17072020**

**A-PA-DIA01-SJ-00003-19012006**

El Departamento de Recursos Naturales y Ambientales (DRNA) recibió por medio electrónico, el proyecto identificado en el epígrafe. Se propone la construcción de una arteria rural con sección de rodaje de 2 carriles de 3.65 metros cada una sin isleta central, paseos de tres metros a cada lado y bermas que varían entre 1.20 m y 1.85 m. El proyecto se ha dividido en tres secciones para propósitos de subasta y construcción. La alineación del proyecto discurre en dirección norte-sur en una ruta casi paralela del Río Grande de Arecibo a una distancia que varía entre 100 y 150 metros, bordeando las laderas de las montañas que termina justo en el Río. La Sección III incluye cinco puentes sobre quebradas existentes y la Sección IV, incluye siete puentes sobre quebradas existentes.

Según nuestros expedientes el DRNA emitió comentarios el 26 de agosto de 2020 para ambas secciones propuestas. Se requirió la continuación y culminación del proceso de mitigación en cumplimiento con la Ley Núm. 241 de 15 de agosto de 1999, según enmendada y el Reglamento para Regir la Conservación y el Manejo de la Vida Silvestre, las Especies Exóticas y la Caza del Estado Libre Asociado de Puerto Rico (Reglamento Núm. 6765). Asimismo, se requirió la presentación de protocolos para minimizar impactos a especies de flora y fauna en peligro de extinción y el compromiso de realizar los estudios necesarios para atender los riesgos geológicos en la alineación.

La Autoridad de Carreteras y Transportación ha presentado una comunicación del 22 de febrero de 2021 atendiendo los aspectos señalados por el DRNA. Asimismo, se incluye comunicación de la compañía consultora en geotecnia Geopráctica Inc y estudios de flora y fauna presentados al *Fish and Wildlife Service*.

A continuación, nuestros comentarios a la información presentada:



- La ACT informa que el proceso de transferencia al DRNA de la finca Hacienda Verde para el cumplimiento con la mitigación requerida ha sido dilatado por unas deudas que tenía la propiedad con el Centro de Recaudaciones de Ingreso Municipales (CRIM). No obstante, la agencia ya liquidó dicha deuda, por lo que se puede finalizar el proceso del traspaso de los terrenos. Estarán notificando al DRNA para culminar el proceso.
- Con relación a los aspectos geológicos, la carta de la compañía Geopráctica Inc. acoge las inquietudes del Departamento en cuanto al alto riesgo de deslizamientos en secciones de los tramos evaluados. El hecho más importante es que reconocen este factor como uno que puede afectar algunas secciones y que expresan que es considerado en el diseño actual y en la ejecución de tramos ya completados del proyecto de la PR-10 de Utuaado a Adjuntas.
- Con relación a la información requerida para las especies en peligro de extinción, no se presentaron los protocolos a seguir si se identifican poblaciones o individuos de *Varronia bellonis*, *Cornutia obovata*, *Solanum ensifolium*, *Pleodendrom macranthum*, *Myrcia paganii* y *Atlantea tulita*. Para esta última se debe además monitorear o prestar especial atención a la planta *Oplonia spinosa* para determinar si hay huevos o larvas. Es importante que se indique cómo se procederá si se encuentran algunas de estas especies durante la construcción del proyecto.
- Se incluyó como anejo el protocolo para la boa de Islas Vírgenes. Esto debe corregirse e incluir el protocolo para la boa de Puerto Rico.

Una vez se presente la información relacionada a los protocolos no incluidos, el DRNA estaría en posición de poder emitir su endoso al proyecto.

Cordialmente,



Digitally signed by  
Luis R. Sierra-Torres  
Date: 2021.04.11  
14:56:35 -04'00'

Ing. Luis Sierra  
Secretario Auxiliar  
Secretaría Auxiliar de Permisos,  
Endosos y Servicios Especializados

LS/GFS/ACH/RLR/RHV/ach

Cd: Adm. Natalie Quiles Llanes, ACT  
nquiles@dtop.pr.gov



United States Department of the Interior

FISH AND WILDLIFE SERVICE  
Caribbean Ecological Services Field Office  
PO Box 491  
Boquerón, PR 00622



In Reply Refer to:  
FWS/R4/CESFO/72LP-026

Ms. Alexandra Velázquez Delgado  
Acting Director  
Programming and Special Studies Area  
Puerto Rico Highway Authority  
PO Box 42007  
San Juan, Puerto Rico 00940-2007

Re: PR-10 (AC-100069, 100071, 100055 and 100076)  
Utuaado to Adjuntas, Puerto Rico

Dear Ms. Velázquez

Thank you for your letter dated August 11, 2021, requesting comments on the above referenced project. As per your request, our comments are provided under the Endangered Species Act (Act) (87 Stat. 884, as amended; 16 United States Code 1531 et seq.), and the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.).

The Puerto Rico Highway and Transportation Authority (PRHTA) is proposing the completion of the construction of remaining portions of State Road PR-10 located between the Municipalities of Utuaado and Adjuntas, Puerto Rico. The proposed actions for this project consist of:

**Section II (AC-100069):**

- Construction of a PR-10 segment of 1.57 kms of length starting from the intersection of the existing PR-10 with PR-123 at km 49.5 in the Municipality of Utuaado.
- Construction of three concrete bridges:
  - Bridge BR-1 near station 41 +01.00 with a span of 150 meters (18.2344°, -66.719°)
  - Bridge BR-IA near station 44+71.00 with a span of 199 meters (18.23081°, -66.719°)
  - Bridge BR-IB near station 50+96.50 with a span of 80 meters (18.22329°, -66.7181°)

**Section III (AC-100071):**

- Construction of a PR-10 segment of 1.93 kms of length joining to the previous section in the Municipality of Utuaado and runs southeast alongside of Rio Grande de Arecibo until

Municipality of Adjuntas.

- Construction of four concrete bridges:
  - Bridge BR-2 near station 56+25.00 with a span of 140 meters (18.22329°, -66.7216°)
  - Bridge BR-3 near station 61+25.00 with a span of 180 meters (18.22307°, -66.7265°)
  - Bridge BR-3A near station 66+20.00 with a span of 110 meters (18.21989°, -66.7285°)
  - Bridge BR-3B/3C near station 70+ 10.00 with a span of 315 meters (18.2164°, -66.7276°)

#### **Section IV (AC-100055):**

- Construction of a PR-10 segment of 2.29 kms of length joining to the previous section and continues alongside the Rio Grande Arecibo toward the Capaez Ward of the Municipality of Adjuntas.
- Construction of seven concrete bridges:
  - Bridge BR-4 near station 77+95.00 with a span of 129 meters (18.21171°, -66.7317°)
  - Bridge BR-4A near station 79+85.00 with a span of 115 meters (18.2103°, -66.7328°)
  - Bridge BR-4B near station 81+45.00 with a span of 50 meters (18.20937°, -66.7334°)
  - Bridge BR-5 near station 84+20.00 with a span of 105 meters (18.20697°, -66.7348°)
  - Bridge BR-6 near station 86+30.00 with a span of 134 meters (18.20503°, -66.7342°)
  - Bridge BR-7 near station 90+20.00 with a span of 160 meters (18.20171°, -66.734°)
  - Bridge BR-8 near station 92+40.00 with a span of 80 meters (18.20006°, -66.7338°)

#### **Section V (AC-100076):**

- Construction of a PR- 10 segment of approximate length of 1.81 kms and will interconnect Section IV with the already constructed PR-10 in the Capaez Ward of the municipality of Adjuntas.
- Construction of four concrete bridges:
  - Bridge BR-9 near station 97+ 10. 76 with a span of 284 meters (18.19583°, -66. 73 53°)
  - Bridge BR-10 near station 103+72.58 with a span of 84 meters (18.19115°, -66. 73 78°)
  - Bridge BR-11 near station 105+85.4 with a span of 208 meters (18.1885°, -66. 738°)
  - Bridge BR-12 near station 109+63.89 with a span of 315 meters (18.185°, -66.7378°)



The U.S Fish and Wildlife Service's (the Service) Geospatial Data identified four federally listed species that might be present along the path of remaining sections of PR-10: Puerto Rican boa (*Epicrates inornatus* now known as *Chilabothrus inornatus*), Puerto Rican broad-winged hawk (*Buteo platypterus brunnescens*), Puerto Rican parrot (*Amazona vittata*) and Puerto Rican sharp-shinned hawk (*Accipiter striatus venator*).

After the initial review, PRHTA has determined that the proposed project may affect, but is not likely to adversely affect the Puerto Rican boa, Puerto Rican broad-winged hawk, Puerto Rican parrot and Puerto Rican sharp-shinned hawk. The PRHTA is proposing to implement Best Management Practices (BMP's) and conservation measures previously provided by the Service prior to and during the construction to avoid or minimize impacts to the above mentioned species. Also, PRHTA is limiting the removal of vegetation of the project during the months of April to June to minimize disruption to the species breeding season.

We have reviewed the information provided in your letter and our files, and concur with your determination that the proposed project may affect, but is not likely to adversely affect the above mentioned species. No adverse impacts to designated critical habitat are anticipated. However, the Service recommends that PRHTA take special attention during the breeding season of the species during the months of January to July (instead of April to June) in case any breeding activity is observed within or near the proposed construction area. In view of this, we believe that requirements of section 7 of the Endangered Species Act (Act) have been satisfied.

However, obligations under section 7 of the Act must be reconsidered if: (1) new information reveals impacts of this identified action that may affect listed species or critical habitat in a manner that was not previously considered; (2) this action is subsequently modified in a manner not previously considered in this assessment; or, (3) a new species is listed or critical habitat determined that may be affected by the identified action.

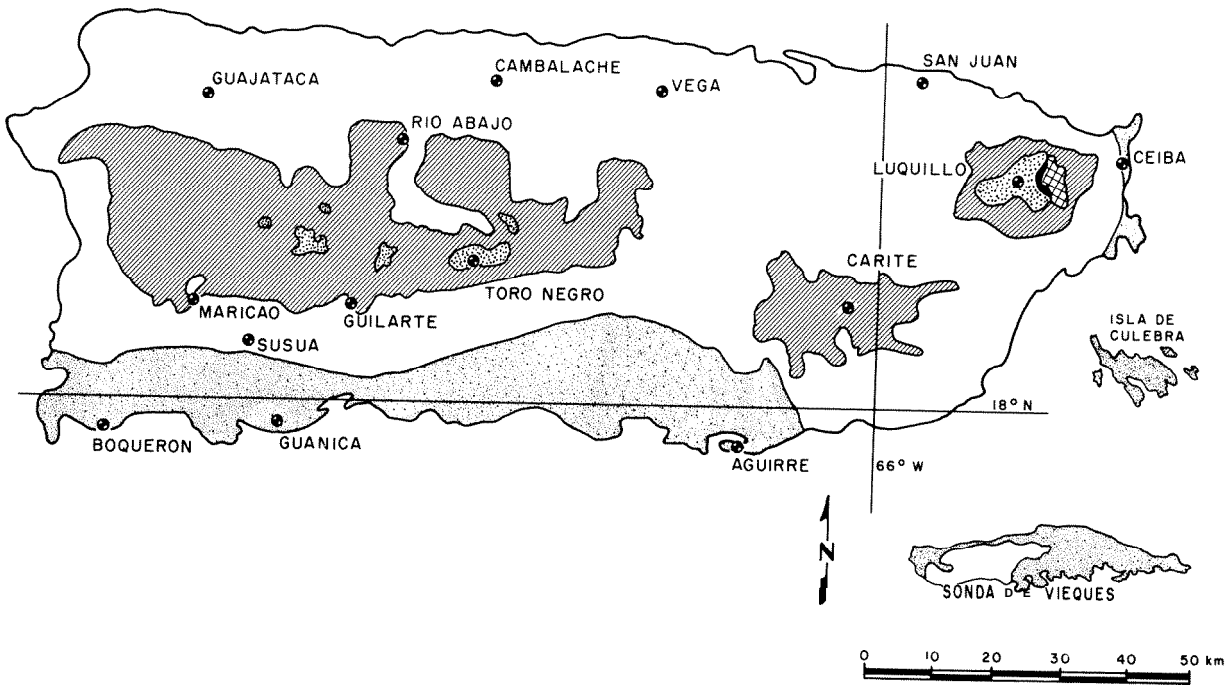
Thank you for the opportunity to comment on this project. If you have any questions or require additional information, please contact Marelisa Rivera at [marelisa\\_rivera@fws.gov](mailto:marelisa_rivera@fws.gov).







Sincerely yours,

Edwin E. Muñiz  
Field Supervisor

drr

**ATTACHMENT V: Puerto Rico Climate Zones.**



% AREA	LIFE ZONE
17.6	 SUBTROPICAL DRY FOREST
58.4	 SUBTROPICAL MOIST FOREST
22.6	 SUBTROPICAL WET FOREST
0.1	 SUBTROPICAL RAIN FOREST
1.2	 LOWER MONTANE WET FOREST
0.1	 LOWER MONTANE RAIN FOREST
100.0	



Life Zones of Puerto Rico and location of public forests and the U.S. Virgin Islands.

\* GOVERNMENT PRINTING OFFICE: 1988 \* 566019 / 85005

**ATTACHMENT VI: Species Management Plan Schedule**



**ATTACHMENT VII: Contact Information.**

All contact with live specimens, of any of the species included in this document or any other endangered species, will be reported both to the USFWS and the PRDNER within the following 24 hour, the sooner the better. The contact numbers are included here.

**U.S. Fish and Wildlife Service (USFWS)**  
**Caribbean Ecological Services Field Office**

Name: Dr. José A. Cruz-Burgos, Threatened and      Telephone: (787) 851-7297  
Endangered Species Program Coordinator              jose\_cruz-burgos@fws.gov

Physical address:                                      Mailing address:  
Road 301, km.5.1, Bo. Corozo                      P.O. Box 491  
Cabo Rojo, Puerto Rico 00622                      Boquerón, PR 00622

**Puerto Rico Department of Natural and**  
**Environmental Resources (PRDNER)**

Name: Dra. Nilda Jimenez                      Telephone: 787-230-5555 / (787) 645-5593  
Endangered Species Coordinator              njimenez@drna.pr.gov

Physical address:                                      Mailing address:  
Carretera 8838, km. 6.3, Sector El Cinco, Río      San José Industrial Park  
Piedras    1375 Ave Ponce de León  
    San Juan, PR 00926

**PUERTO RICO HIGHWAY AND**  
**TRANSPORTATION AUTHORITY(PRHTA)**

Ing. Marilyn Rodríguez Díaz  
Dir. Área de Construcción  
marirodriguez@dtop.pr.gov  
(787) 721-8787 ext. 1101

DR. Angel J. Alicea Rodriguez  
Director Interino Área de Programación y Estudios  
Especiales  
aalicea@dtop.pr.gov  
(787) 721-8787 ext. 1400, 1401

## Station Fact

The Caribbean Ecological Services Field Office (CESFO) was established in 1974, as part of the U.S. Fish and Wildlife Service's (Service) Southeast Region. The CESFO's main office is co-located with the Caribbean Islands National Wildlife Refuge Complex within the Cabo Rojo National Wildlife Refuge (CRNWR). We have jurisdiction on Federal Trust Species (*i.e.*, at-risk species, federally-listed species, migratory birds and inter-jurisdictional fish) in Puerto Rico and U.S. Virgin Islands (USVI; St. Thomas, St. John, and St. Croix).

## Station Mission

The U.S. Fish and Wildlife Service's **mission** is to work with others to conserve, protect, and enhance fish, wildlife, plants, and their habitats for the continuing benefit of the American people.

## Our Goals and Priorities

- Design and implement landscape conservation actions and initiatives to protect, conserve and enhance habitats for at-risk species, federally-listed species, and other Federal trust species within private and public lands in Puerto Rico and the USVI.
- Identify, protect and recover at-risk and federally listed species in partnership with other Federal agencies, Commonwealth and Territorial agencies, non-governmental organizations and private landowners and entities.
- Conserve candidate and federally-listed species, wetlands and aquatic resources throughout project evaluation and consultations under the Section 7 of the Endangered Species Act for projects with Federal nexus.
- Evaluate impacts of contaminants on at-risk species, federally-listed species and other Federal trust species and aid in remediation of impacts and restoration of habitats and resources.
- Develop partnerships with Federal, Commonwealth and Territorial agencies, organizations and citizen groups to understand and address, minimize, mitigate, avoid or remediate climate change impacts on fish and wildlife resources and their habitats.
- Manage the U.S. Fish and Wildlife Service's Puerto Rican Parrot



Recovery Program and be part of an interagency working group that promotes the recovery of this species.

## What we do...

### Endangered Species

- Protect and recover threatened and endangered species through regulatory mechanisms and implementation of high priority recovery actions.
- Promote the conservation of at-risk species so that listing of those species under the ESA does not become necessary.
- List, recover, and re-classify threatened and endangered species.



Under the Endangered Species Act (ESA) we also work with:

- Candidate Conservation Agreements
- Section 7 consultations
- Grants for the implementation of recovery actions
- Incidental Take Permits and Habitat Conservation Plans
- Listing of species and designation of Critical Habitat
- Recovery Planning and Implementation
- Section 10 Permits



### Habitat Restoration Initiatives (Partners for Fish and Wildlife and Coastal Programs)

- Protect and recover at-risk and federally-listed species and other Federal trust species by supporting restoration of high priority habitats in private and public lands. Projects include the establishment of riparian buffers, reforestation, restoration of shade grown coffee plantations, enhancement and protection of coastal lagoons, mangrove forests, salt ponds, native beach dune forests, dry forest, riparian or gut moist forest, and coral reefs.
- Provide financial and technical assistance for voluntary, on-the-ground habitat restoration and conservation projects.
- These programs focus on the enhancement, restoration and protection of ecologically important habitats.
- The programs recognize the need to balance residential, tourist, commercial, agriculture, and industrial needs with conservation of important habitats and species and work closely with other Federal, Territorial, non-governmental organizations, and private partners to carry out restoration projects.

- The programs cover a wide area of Puerto Rico and USVI. The focal areas in Puerto Rico and USVI are dominated by subtropical moist and dry forests. In addition, since the participation is voluntary, the Service can evaluate and accept the collaboration of private landowners located outside the designated focal areas.



Strategic Habitat Conservation Areas

### Fish and Aquatic Conservation Initiative

- Implement initiatives for the conservation, restoration and enhancement of aquatic habitats in Puerto Rico and the USVI. These projects include: restoration and enhancement of aquatic habitats via the removal or modification of physical barriers, replacement or modification of stream-crossing structures, construction of fish ladders, rehabilitation of stream banks, and enhancement of recreational fisheries activities.
- Systematically gather information on the status of native aquatic species, assess their threats and needs and document invasive aquatic species in Puerto Rico and the USVI.
- Educate and engage the public in aquatic resources and conservation.
- Build partnerships with Federal, Commonwealth and Territorial agencies, non-governmental organizations, and private landowners and entities for the conservation of aquatic resources.



Photo by: Patrick Cooney©

### Environmental Quality

- Provide scientific information and technical assistance to all Service's Divisions (e.g., National Wildlife Refuges), other Federal agencies, and Commonwealth and Territorial agencies in the U.S. Caribbean on contamination, cleanup response, pollution, water quality, and pesticide-related resources issues. Emphasis is given to suitable habitats for at-risk, and threatened and endangered species.



- One of the primary responsibilities of the Environmental Contaminants Program is the identification of environmental contaminant problems affecting National Wildlife Refuge lands, migratory birds, and threatened and endangered species. The CESFO has worked extensively on the investigation and cleanup activities of unexploded ordnance on the Culebra Island National Wildlife Refuge and Vieques National Wildlife Refuge to ensure that cleanup levels are protective to wildlife and its habitats.
- Coordinate with Federal and local partners.
- Oil spill response, natural and damage assessments, and restoration plans.



#### Puerto Rican Parrot Recovery Program

- The CESFO has been implementing actions to prevent the extinction and recover the Puerto Rican parrot for almost four decades. We implement high priority recovery actions under a Memorandum of Understanding among the Service, the Puerto Rico Department of Natural and Environmental Resources and the U.S. Forest Service. The main goals of the program are to maintain a healthy and sustainable captive population and establish wild viable and interacting populations in Puerto Rico.
- We are the primary Federal agency responsible for conserving, protecting, and enhancing the Puerto Rican parrot and its habitats.
- Operate the Iguaca Aviary at El Yunque National Forest to support wild parrot populations and new reintroduction efforts for the recovery of the species.
- Manage the wild population at El Yunque National Forest, assist with the reintroduction efforts at the Río Abajo Commonwealth Forest, and co-manage the reintroduction efforts at the Maricao Commonwealth Forest.
- We aim to expand our knowledge on the parrots biology, ecology, and behavior in order to insure the survival of the species in the wild.



- Coordinate interagency recovery efforts through partnerships and best available science.
- Promote awareness and education for the plight of the Puerto Rican parrot.

#### Where can you find us...

U.S. Fish and Wildlife Service  
 Caribbean Ecological Services Field Office  
 Telephone: (787) 851-7297  
 Physical address: Road 301, km.5.1, Bo. Corozo  
 Cabo Rojo, Puerto Rico 00622  
 Mailing address: P.O. Box 491  
 Boquerón, PR 00622



#### For more information visit...

- <http://www.fws.gov>
- <http://www.fws.gov/caribbean/es>
- <http://ecos.fws.gov>
- <http://www.facebook.com/USFWSCaribbean>
- <https://www.flickr.com/photos/usfwssoutheast/sets/72157626859158391/>

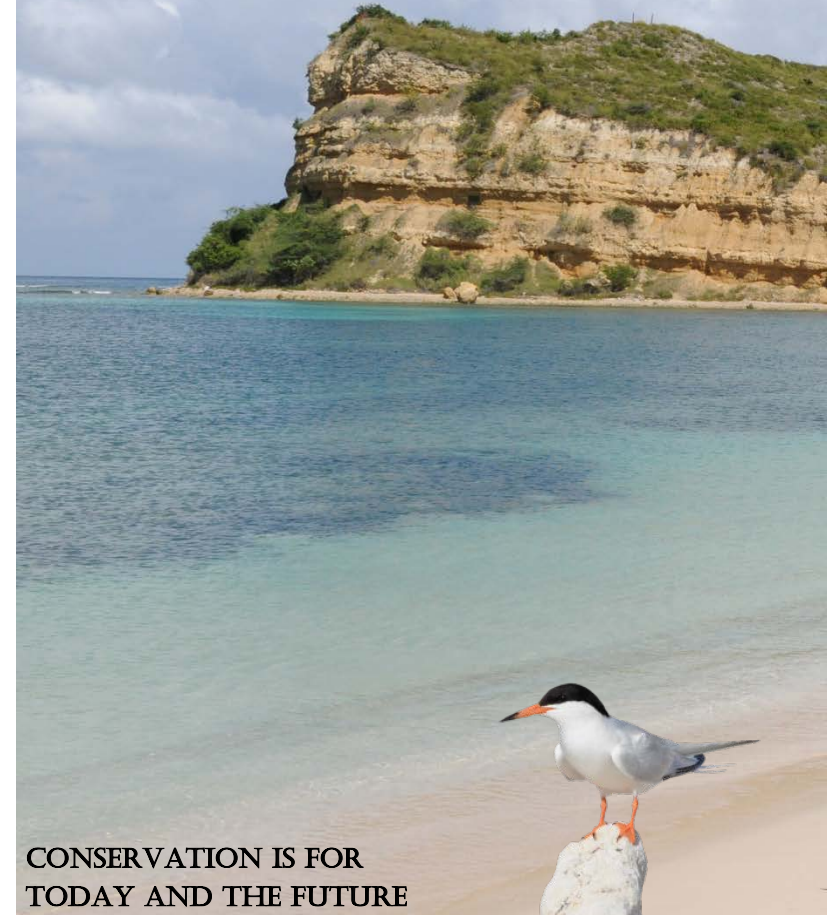


Document prepared by the U.S. Fish and Wildlife Service

U.S. Fish and Wildlife Service



# Caribbean Ecological Services Field Office



CONSERVATION IS FOR  
 TODAY AND THE FUTURE



**ATTACHMENT VIII: Information for the target species.**

**PR BOA (PRB) (*Chilabothrus inornatus*)**



## U.S. FISH AND WILDLIFE SERVICE CARIBBEAN ECOLOGICAL SERVICES FIELD OFFICE

### Conservation Measures for the Puerto Rican boa (*Chilabothrus inornatus*)

Section 7 (a)(1) of the Endangered Species Act (ESA) charges Federal agencies to aid in the conservation of listed species, and section 7 (a)(2) requires the agencies, through consultation with the U.S. Fish and Wildlife Service (Service), to ensure their activities are not likely to jeopardize the continued existence of listed species or adversely modify designated critical habitats. Section 7 applies to the management of Federal lands as well as Federal actions that may affect listed species, such as Federal approval of private activities through the issuance of Federal funding, permits, licenses, or other actions. Any person that injures, captures, or kills a Puerto Rico boa is subject to penalties under the ESA. If Federal funds or permits are needed, the funding or permitting agency should initiate Section 7 consultation with the Service. To initiate a consultation under the Section 7 of the ESA, you must submit a project package with the established minimum requirements. These conservation measures should be incorporated into the project plans to minimize possible impacts to the species.

The endangered Puerto Rican (PR) boa (*Chilabothrus inornatus*, formerly *Epicrates inornatus*) is the largest endemic snake species that inhabits Puerto Rico. The PR boa is non-venomous and does not pose any life threatening danger to humans, but some individuals may try to bite if disturbed or during capture or handling. Its body color ranges from tan to dark brown with irregular diffuse marking on the dorsum, but some individuals lack marking and are uniformly dark. Juveniles may have a reddish color with more pronounced markings. In general, as they mature, their body color tends to darken.



The Puerto Rican boa was federally listed in 1970. Currently, the species has an island-wide distribution and occurs in a wide variety of habitat types ranging from wet montane to subtropical dry forest, and can be found from mature forest to areas with different degrees of human disturbance like roadsides or houses, especially if near their habitat in rural areas. This boa is considered mostly nocturnal, remaining less active, concealed or basking under the sun during the day.

The Service has developed the following conservation measures with the purpose of assisting others to avoid or minimize adverse effects to the PR boa and its habitat. These recommendations may be incorporated into new project plans and under certain circumstances into existing projects. Depending on the project, additional conservation measures can be implemented besides the ones presented in this document.

#### Conservation Measures:

1. Inform all project personnel about the potential presence of the PR boa in areas where the proposed work will be conducted. A pre-construction meeting should be conducted to inform all project personnel about the need to avoid harming the species as well as penalties for harassing or harming PR boas. An educational poster or sign with photo or illustration of the species should be displayed at the project site.
2. Prior to any construction activity, including removal of vegetation and earth movements, the boundaries of the project and areas to be excluded and protected should be clearly marked in the project plan and in the field in order to avoid further habitat degradation into forested and conservation areas.
3. Once areas are clearly marked, and prior to the use of heavy machinery and any construction activity (including removal of vegetation and earth movement), a biologist or personnel with experience on this species should survey the areas to be cleared to verify the presence of any PR boa within the work area.
4. The PR boa is considered more active at night. Thus, in order to maximize its detection, the species should be searched at nights prior to habitat disturbance.
5. Once the area has been searched for PR boas, vegetation should first be cleared by hand to the maximum extent possible. Vegetation should be cut about one meter above ground prior to the use of heavy machinery for land clearing. Cutting vegetation by hand will allow boas present on site to move away on their own to adjacent available habitat. Any stone walls or naturally occurring rock piles must be carefully dismantled by hand as these are refuges for the snake. This will allow any boas present to vacate the site without injury.
6. For all boa sightings (dead or alive), record the time and date of the sighting and the specific location where it was found. PR boa data should also include a photo of the animal (dead or alive), site GPS coordinates, the time and date, and comments on how the animal was detected and its behavior.

7. If a PR boa is found within any of the working or construction areas, activities should stop at that area and information recorded (see #6). **Do not capture the boa.** If boas need to be moved out of harm's way, designated personnel shall immediately contact the Puerto Rico Department of Natural and Environmental Resources (PRDNER) Rangers for safe capture and relocation of the animal (PRDNER phone #: 787-724-5700, 787-230-5550, 787-771-1124). If immediate relocation is not an option, project-related activities at this area must stop until the boa moves out of harm's way on its own. Activities at other work sites, where no boas have been found after surveying the area, may continue.
8. If a PR boa is captured by the PRDNER, record the name of the PRDNER staff and information on where the PR boa will be taken. This information should be reported to the Service.
9. Measures should be taken to avoid and minimize PR boa casualties by heavy machinery or motor vehicles being used on site. Any heavy machinery left on site (staging) or near potential PR boa habitat (within 50 meters of potential boa habitat), needs to be thoroughly inspected each morning before work starts to ensure that no boas have sheltered within engine compartments or other areas of the equipment. If PR boas are found within vehicles or equipment, do not capture the animal and let it move on its own or call PRDNER Rangers for safe capture and relocation of the animal (see #7). If not possible, the animal should be left alone until it leaves the vehicle on its own.
10. PR boas may seek shelter in debris piles. Measures should be taken to avoid and minimize boa casualties associated with sheltering in debris piles as a result of project activities. Debris piles should be placed far away from forested areas. Prior to moving, disposing or shredding, debris piles should be carefully inspected for the presence of boas. If debris piles will be left on site, we recommend they be placed in areas that will not be disturbed in the future.
11. If a dead PR boa is found, immediately cease all work in that area and record the information accordingly (see #6). If the PR boa was accidentally? killed as part of the project actions, please include information on what conservation measures had been implemented and what actions that will be taken to avoid further killings. A dead boa report should be sent by email (see contacts below) to the Service within 48 hours of the event.
12. Projects must comply with all state laws and regulations. Please contact the PRDNER for further guidance.

If you have any questions regarding the above conservation measures, please contact the Service:

- Marelisa Rivera, Deputy Field Supervisor
  - Email: [marelisa\\_rivera@fws.gov](mailto:marelisa_rivera@fws.gov)
  - Office phone 787-851-7297 ext. 206 or mobile 787-510-5219
- José Cruz-Burgos, Endangered Species Coordinator
  - Email: [jose\\_cruz-burgos@fws.gov](mailto:jose_cruz-burgos@fws.gov)
  - Office phone 787-851-7297 ext. 218 or mobile 787-510-5206

**PR Broad-Winged Hawk (PRBWH) (*Buteo platypterus brunescens*)**

**Puerto Rican broad-winged hawk or guaraguao de bosque  
(*Buteo platypterus brunnescens*)**

**5-Year Review:  
Summary and Evaluation**



**U.S. Fish and Wildlife Service  
Southeast Region  
Caribbean Ecological Services Field Office  
Boquerón, Puerto Rico**

**5-YEAR REVIEW**  
**Puerto Rican broad-winged hawk**

**I. GENERAL INFORMATION**

**A. Methodology used to complete the review**

The Service accomplished this review using information obtained from the final rule listing this species under the Act, the recovery plan, peer-reviewed scientific publications, several unpublished research projects, unpublished field observations by U.S. Fish and Wildlife Service (Service), State and other experienced biologists, and personal communications. The Service's lead Recovery biologist for this species prepared this review. On September 21, 2007, the Service published a notice in the Federal Register (72 FR 54061) announcing the 5-year review of the Puerto Rican broad-winged hawk (*Buteo platypterus brunnescens*). The notice requested new information concerning the biology and status of this species. We opened a 60 day public comment period with this notice, but we received no comments or information on this species. This 5-year review summarizes new information that the Service has gathered since the Puerto Rican broad-winged hawk was listed under the Endangered Species Act. The draft of this document was distributed for peer review and comments received were addressed (see Appendix A).

*\*Please see Addendum 1 (pages 18-37) for updated information on the Puerto Rican broad-winged hawk that we have gained while conducting our new five-year review initiated in 2017 (82 FR 29916). Our new signature page is included on page 37. What precedes this new information (pp. 1-17) is the first five-year review announced in September 21, 2007 (72 FR 54061) and completed and signed in 2010.*

**B. Reviewers**

**Lead Region:** Kelly Bibb, Southeast Region, (404) 679-7132  
Nikki Lamp, Southeast Region, (404) 679-7118

**Lead Field Office:** Jorge E. Saliva, Ph.D., Caribbean Ecological Services  
Field Office, Boquerón, Puerto Rico, (787) 851-7297, extension 219

**C. Background**

- 1. FR Notice citation announcing initiation of these reviews:**  
September 21, 2007; 72 FR 54061

2. **Species Status:** 2010 Recovery Data Call: Stable. The Río Abajo Commonwealth Forest supports close to 50% of the currently known population. The most recent study of the population within the Río Abajo Commonwealth Forest (Hengstenberg and Vilella 2004, p.101) indicates that this population continues to be stable since publication of the species' recovery plan in 1997.
  
3. **Recovery Achieved:** 2 (25-50%) of species recovery objectives achieved.
  
4. **Listing History:**  
Original Listing  
FR notice: 59 FR 46710  
Date listed: September 9, 1994  
Entity listed: Subspecies  
Classification: Endangered
  
5. **Review History:**  
The Puerto Rican broad-winged hawk and Puerto Rican sharp-shinned hawk (*Buteo platypterus brunnescens* and *Accipiter striatus venator*) Recovery Plan, approved and signed on September 8, 1997 (U.S. Fish and Wildlife Service 1997), is the most recent comprehensive analysis of the species' status and is used as a reference point document for this 5-year review.  
  
Recovery Data Call: 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009 and 2010
  
6. **Species' Recovery Priority Number at start of review** (48 FR 43098): A recovery priority number of 6 (high degree of threat, low recovery potential) is assigned to the Puerto Rican broad-winged hawk.
  
7. **Recovery Plan:**  
Name of plan: Puerto Rican Broad-winged hawk and Puerto Rican Sharp-shinned Hawk (*Buteo platypterus brunnescens* and *Accipiter striatus venator*) Recovery Plan  
Date issued: September 8, 1997

## II. REVIEW ANALYSIS

### A. Application of the 1996 Distinct Population Segment (DPS) policy

1. **Is the species under review listed as a DPS?** No



2. **Is there relevant new information that would lead you to consider listing this species as a DPS in accordance with the 1996 policy?** No

**B. Recovery Criteria**

1. **Does the species have a final, approved recovery plan containing objective, measurable criteria?** Yes.

2. **Adequacy of recovery criteria.**

**a. Do the recovery criteria reflect the best available and most up-to-date information on the biology of the species and its habitat?** No. Knowledge on the biology, feeding ecology, and habitat use of the broad-winged hawk has expanded, particularly for the population within the Río Abajo Forest (Hengstenberg and Vilella 2004).

**b. Are all the 5 listing factors that are relevant to the species addressed in the recovery criteria (and there is no new information to consider regarding existing or new threats)** No. The plan did not address the five- listing factors in the recovery criteria.

3. **List the recovery criteria as they appear in the recovery plan and discuss how each criterion has or has not been met, citing information.**

The plan established the following downlisting criteria for the Puerto Rican broad-winged hawk:

1. Maintain a Puerto Rican broad-winged hawk breeding population of 60 pairs (20 breeding pairs in El Yunque National Forest, Carite Commonwealth Forest, and Río Abajo Commonwealth Forest, respectively).
2. Reach an island-wide Puerto Rican broad-winged hawk population of 200 individuals (60 individuals in Río Abajo and Carite Commonwealth forests, and 80 individuals in El Yunque National Forest).
3. Gather additional documentation on population trends (*i.e.*, conduct surveys, search for new populations, obtain population biology information, identify mortality factors and threats) and adequate support habitat for both hawk species (*i.e.*, characterize currently used habitat, identify additional habitat, determine spatial and temporal use of habitat).

Criteria #1 and #2 have not been met. Although Hengstenberg and Vilella (2004) estimated 52.2 hawks at the Río Abajo Commonwealth Forest, the sex composition of these 52.2 individuals is unknown. We also do not know if any

of these individuals are non-reproductive juveniles. Therefore, there is no information on the numbers of breeding pairs in any of the forests.

Criterion #3 has been partially met through an agreement between the Service and the Mississippi Cooperative Wildlife Research Unit to study the reproductive biology, abundance, and movement patterns of the broad-winged hawk at the Río Abajo Commonwealth Forest (Hengstenberg and Vilella 2004, p. 20-115).

## **C. Updated Information and Current Species Status**

### **1. Biology and Habitat**

The Puerto Rican broad-winged hawk is a small hawk with dark chocolate-brown upperparts, heavily streaked rufous breast, and a broadly banded black and white tail. Adult male and female are similar in appearance, but the female is slightly larger. This species occurs in elfin woodland, sierra palm, caimitillo-granadillo, and tabonuco forest types of the Río Abajo Commonwealth Forest, Carite Commonwealth Forest, and El Yunque National Forest as well as within hardwood plantations, shade coffee plantations, and mature secondary forests. The Puerto Rican broad-winged hawk population is estimated at about 125 individuals island-wide.

#### **a. Abundance, population trends, demographic features, or demographic trends:**

The Puerto Rican broad-winged hawk is found in mature forests within the subtropical moist, subtropical wet, and rain forest life zones (Ewel and Whitmore 1973, p. 10). It shows a clumped spatial pattern within the forests, associated with certain types of habitats such as tabonuco-palo colorado forest types, tabonuco and caimitillo-granadillo forest types at El Yunque and Carite forests (Delannoy 1997, p. 25). At Río Abajo, they inhabit the limestone hillsides, sinkholes, and valleys between haystack hills or “mogotes” (Delannoy 1997, p. 25).

Puerto Rican broad-winged hawk density and population estimates varied considerably among forests, being highest at Río Abajo Forest and lowest in El Yunque Forest (Delannoy 1997, p. 25). New information on the abundance and demographic features of the population of Puerto Rican broad-winged hawks at the Río Abajo Commonwealth Forest indicates an abundance of approximately 52.2 individuals in the forest; high pair fidelity; a nest survival rate of 0.67 across breeding seasons; and an average annual productivity of 1.1 young per nest (Hengstenberg and Vilella 2004, p.34-35, 52, and 107). At Río Abajo Forest, Puerto Rican broad-winged hawks feed primarily on rats, lizards, and small birds (Hengstenberg and Vilella 2005, p. 411).

We do not have any information on the species abundance, population trends, demographic features or demographic trends for El Yunque and Carite forests.

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

No new information or research exists on the genetics of the Puerto Rican broad-winged hawk.

**c. Taxonomic classification or changes in nomenclature:**

No new information or research exists on the taxonomy of the Puerto Rican broad-winged hawk.

**d. Spatial distribution, trends in spatial distribution, or historic range:**

Llerandi-Román (2006, p. 31) found thirteen Puerto Rican broad-winged hawk territories just outside the boundaries of the Río Abajo Forest, at six different private localities with suitable broad-winged hawk habitat. The territories were along the Tanamá River valley in the northwestern region of Río Abajo Forest.

We do not have any new information on the species spatial distribution at El Yunque o Carite forests.

**e. Habitat or ecosystem conditions:**

Hengstenberg and Vilella (2004, p.69) reported an average annual home range of 106 hectares (ha) and a breeding home range size of 82.5 ha for the Puerto Rican broad-winged hawk at Río Abajo Forest. Delannoy and Tossas (2002, p.25) indicated that reforestation and regeneration of degraded forest lands have added important nest sites for broad-winged hawks at the Río Abajo Forest, which have allowed this species to thrive within this forest despite changing land uses and habitat modification. Hengstenberg and Vilella (2004, p.74) found that, within this forest, Puerto Rican broad-winged hawk nests are located in timber producing plantations and secondary forests, primarily *Callophylum calaba* (palo de María). Hengstenberg and Vilella (2004, p.41) described the nest sites of Puerto Rican broad-winged hawks at Río Abajo Forest as occurring in mature closed-canopy overstory stands sheltering a midstory, with dense understory, in close proximity to a limestone rock wall, and on southwest-facing slopes (sheltered from the easterly trade winds). Closed canopy forests may be the major structural characteristic describing the suitability of Puerto Rican broad-winged hawk habitat (Hengstenberg and Vilella 2004, p.73). Other habitat associations (*e.g.*, pasture, regenerating forests) may lack a closed canopy, but may advantageously offer areas to

locate prey for Puerto Rican broad-winged hawks (Hengstenberg and Vilella 2004, p.73). Hengstenberg and Vilella (2004, p.62) found that adult and juvenile Puerto Rican broad-winged hawks at Río Abajo Forest did not use habitats within the forest in proportion to their availability. Tossas (1995, p.44), Delannoy and Tossas (2000, p.114), and Hengstenberg and Vilella (2004, p.69) suggested that the Puerto Rican broad-winged hawk has reduced space requirements compared to their temperate counterparts, which may be a function of higher prey abundance and interspecific competition in a tropical habitat. Hengstenberg and Vilella (2005, p. 406) cited abandoned shade-grown coffee plantations as part of the secondary forest used by the Puerto Rican broad-winged hawk. They also indicated that the hawks readily used plantation trees such as palo de María and Honduras mahogany (*Swietenia macrophylla*) with thick understory vegetation (Hengstenberg and Vilella 2005, pp. 413 and 414). Hengstenberg and Vilella (2005, p. 414) suggested that Puerto Rican broad-winged hawks do not limit their activities to the Río Abajo Forest, and that their fate in the surrounding private lands may be uncertain. They suggested that Puerto Rico Department of Natural and Environmental Resources (DNER) forest managers should work proactively with the surrounding landowners to promote land-use practices to conserve and to enhance existing forest cover. Additionally, Hengstenberg and Vilella (2005, p. 414) believe that the future patterns of land use around the forest boundary directly and indirectly may affect the ability of the Río Abajo Forest to function as an effective conservation unit for the broad-winged hawk. They also recommended that DNER encourage surrounding private landowners to engage in agro forestry practices using fast-growing plantation species, and that programs for private lands that promote maintenance and enhancement of forest cover (*e.g.*, USFWS Partners for Wildlife) be brought to the attention of the landowners adjoining Río Abajo Forest (Hengstenberg and Vilella 2005, p. 414). The Partners for Fish and Wildlife program in Puerto Rico promotes agricultural land use practices that promote habitat diversity and enhance habitat for listed species and migratory birds, particularly shade-grown coffee plantations.

**f. Other:**

Hengstenberg and Vilella (2004, p.71) found that the vast majority (97%) of Puerto Rican broad-winged hawk movements and home ranges at Río Abajo Forest were confined to the boundaries of the forest. Adult birds used private lands less than 1% of the time, whereas juveniles used private lands 6% of the time, suggesting that adults are able to secure the most suitable tracts of continuous, closed canopy forest while juvenile birds used areas on the periphery of the forest. Hengstenberg and Vilella (2004, p.71) suggested that adult Puerto Rican broad-winged hawks at Río Abajo Forest maintain relatively exclusive territories; with overlap

limited to the outside borders of their respective home ranges. Areas shared by radio-marked Puerto Rican broad-winged hawks were usually limestone hill ridges that bounded the exterior of their territories (Hengstenberg and Vilella 2004, p.71).

## **2. Five Factor Analysis**

### **a. Present or threatened destruction, modification, or curtailment of its habitat or range:**

The final rule (US Fish and Wildlife Service 1994, p.46712) and recovery plan (US Fish and Wildlife Service 1997, p.11) list destruction and modification of habitat as one of the most significant factors that affect the numbers and distribution of Puerto Rican broad-winged hawk. The final rule further indicates that this species is only known from mature montane forests and has not been observed in other upland forested habitats in central parts of Puerto Rico. The Puerto Rican broad-winged hawk has been reported from Río Abajo and Carite Commonwealth forests, and El Yunque National Forest. The Maricao Commonwealth Forest and Toro Negro Commonwealth Forest do not have resident Puerto Rican broad-winged hawk populations. Although Delannoy (1997, p. 25) searched for the presence of Puerto Rican broad-winged hawk in other upland habitats in Utuado, Adjuntas, Orocovis, Jayuya, and Barranquitas, he did not find this species. However, there are unconfirmed reports of the species from these municipalities (Delannoy 1997, p. 27).

Timber harvest, road construction and/or repair in the forests, construction of recreational facilities, construction of power and communication structures, and other management practices that result in a reduction in numbers or diminished habitat quality for the species could be detrimental, since the species is limited in abundance and distribution (Delannoy 1997, p.29; US Fish and Wildlife Service 1997, p.12). The high degree of territory re-occupancy observed in Río Abajo Forest suggests little migration into adjacent habitats, making this population highly vulnerable to habitat alterations and destruction (Delannoy and Tossas 2000, p.115).

Hengstenberg and Vilella (2004, p.101) suggest that, although the Rio Abajo broad-winged hawk population may be relatively stable, it may also be at carrying capacity. They also suggest that, although surrounding private lands may provide corridors or nesting habitat for dispersing individuals, land use practices surrounding private lands may also hinder movement into these areas (Hengstenberg and Vilella 2004, p.101). Permits to build new communication facilities or expand currently existing ones within or near Commonwealth forests are prevalent. There have been proposals to the DNER for the construction of cell towers within Commonwealth forests in the last five years (Toro Negro Commonwealth Forest, Gerardo Hernández, DNER, pers. comm., 2007), but DNER is currently recommending

monopole, multiple-use towers whenever possible instead of constructing new towers and antennae. Therefore, destruction, modification, or curtailment of habitat or range continues to be a threat to the Puerto Rican broad-winged hawk, and the immediacy of this threat is high because of the restricted distribution and limited abundance of the species.

**b. Overutilization for commercial, recreational, scientific or educational purposes:**

At the present time, we are not aware that overutilization of this species for commercial, recreational (*e.g.*, hunting), scientific, or educational purposes has occurred, or is currently occurring. Therefore, we believe that this factor is not a current threat for the Puerto Rican broad-winged hawk.

**c. Disease or predation:**

Parasitism by the warble fly is not currently considered a threat to the Puerto Rican broad-winged hawk because it has not been reported in populations of this species. Predation by red-tailed hawks (*Buteo jamaicensis*) on juvenile Puerto Rican broad-winged hawks has been reported at the Río Abajo Forest, where both species are sympatric (Hengstenberg and Vilella 2004, p.29). The intensity of the antagonistic response of Puerto Rican broad-winged hawks to the presence of red-tailed hawks intruding into their territories (Hengstenberg and Vilella 2004, p.29) suggests that predation and/or competition plays an important role in Puerto Rican broad-winged hawk nest-site selection, nest attendance, and juvenile survival. The magnitude of threat from disease or predation on the Puerto Rican broad-winged hawk is low, and the immediacy of this threat is non-imminent.

**d. Inadequacy of existing regulatory mechanisms:**

In 1999, the Commonwealth of Puerto Rico approved Law #241 known as the “Nueva Ley de Vida Silvestre de Puerto Rico” (New Wildlife Law of Puerto Rico). The purpose of this law is to protect, conserve, and enhance both native and migratory wildlife species within its jurisdiction, regulate permits, regulate hunting activities, and regulate exotic species, among others. In 2004, DNER approved the “Reglamento para Regir el Manejo de las Especies Vulnerables y en Peligro de Extinción en el Estado Libre Asociado de Puerto Rico” (Regulation 6766: To regulate the management of threatened and endangered species in Puerto Rico). The Puerto Rican broad-winged hawk is included in the list of protected species and designated as “critically endangered”. This classification describes species that “faces an extremely high risk of extinction in the immediate future”. This regulation (Article 2.06) prohibits collecting, cutting, or removing, among other activities, listed animals and plants within the jurisdiction of Puerto Rico. The Commonwealth Ley de Bosques #133 (Puerto Rico Forest Law #133)

and Reglamento #6769 de Permisos Especiales para Uso de Comunicaciones y Edificaciones Asociadas a Sistemas Electrónicos de Comunicaciones en los Bosques Estatales (Special Permits for the Use of Communications and Buildings Associated with Electronic Systems of Communication in Commonwealth Forests) further establish criteria for the protection of critically endangered species like the Puerto Rican broad-winged hawk. DNER also developed a Management Plan for the Río Abajo Forest addressing issues like timber harvest and habitat modification, as part of their initiative for the establishment of the second population of the Puerto Rican Parrot in the Rio Abajo Forest (DNER 2006).

Federal regulations also protect the Puerto Rican broad-winged hawk. Under the Migratory Bird Treaty Act (MBTA) (50 CFR Part 21), migratory birds, their parts, nests, or eggs may not be possessed, imported, exported, bartered, and offered for sale, purchase, or barter without a valid permit issued pursuant to the provisions of the MBTA.

Based on the presence of Federal and Commonwealth laws and regulations protecting the Puerto Rican broad-winged hawk, and the absence of evidence supporting lack of enforcement of regulations to protect this species, we believe that inadequacy of existing regulatory mechanisms is no longer a threat to this species.

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

The final rule and recovery plan state that the most important factors affecting the Puerto Rican broad-winged hawk are their limited distribution and low population numbers. The species is susceptible to natural habitat disturbances, such as strong storms and hurricanes, because of their limited distribution and specific habitat requirement of mature montane forests that may not be available in storm-damaged forests (Delannoy 1997, p.27, US Fish and Wildlife Service 1997, p.13). This hawk species has experienced drastic population declines (Delannoy 1997, p.27) attributed to possible direct and indirect effects of hurricane Hugo in 1989 and possibly due to the effect of Hurricane Georges in 1998 (Tossas 2010, pers. comm.).

The final rule states that the potential for illegal shooting of Puerto Rican broad-winged hawk constitutes a serious threat to the continued survival of the species. However, the recovery plan does not mention illegal shooting as a threat to the Puerto Rican broad-winged hawk. There are no records of illegal shooting of this species.

The similar nest-site habitat requirements of the red-tailed hawk may result in aggressive interactions (interference competition), or even red-tailed Hawk predation on the smaller Puerto Rican broad-winged hawk (Delannoy and Tossas 2002, p.24) at the Río Abajo Forest. Hengstenberg and Vilella (2004,

p.29) observed intense territorial aggressive interactions between these two species, where Puerto Rican broad-winged hawks were very successful at deterring intruding red-tailed hawks from their nesting territories. They also documented one instance of red-tailed hawk depredating a juvenile broad-winged hawk (Hengstenberg and Vilella 2004, p.29).

The recent (2006) release of captive-reared specimens of the endangered Puerto Rican parrot (*Amazona vittata*) in the Río Abajo Forest has resulted in interactions between Puerto Rican broad-winged hawks and Puerto Rican parrots, where a hawk was observed attacking a young parrot (M. López, USFWS, pers. comm. 2008). However, Hengstenberg and Vilella (2004, p.111) believe that resident broad-winged hawks in the Río Abajo Forest may indirectly provide some degree of protection to released parrots from predation by red-tailed hawks, because they effectively chase off intruding red-tailed hawks from their territories. Additionally, Hengstenberg and Vilella (2004, p.111) found that Puerto Rican parrots may exceed the size of avian prey taken by broad-winged hawks, and 61% of the prey deliveries to broad-winged hawk nests were rodents and *Anolis* lizards.

We believe that the magnitude of threat from other natural or manmade factors to the Puerto Rican broad-winged hawk is moderate, and the immediacy of threat is non-imminent. The Service is not aware of any records of shooting, poaching, or unintentional killing of this species. Even though major storms may affect habitat for the Puerto Rican broad-winged hawk, there is no evidence indicating that major storms would decimate the existing populations of these species or reduce them to non-sustainable levels.

#### **D. Synthesis**

The Puerto Rican broad-winged hawk is a subspecies endemic to Puerto Rico and restricted to the montane forests of the Cordillera Central, Sierra de Cayey, and Sierra de Luquillo. It was federally listed as endangered on September 9, 1994. This species occurs in elfin woodland, sierra palm, caimitillo-granadillo, and tabonuco forest types of the Río Abajo Commonwealth Forest, Carite Commonwealth Forest, and El Yunque National Forest as well as within hardwood plantations, shade coffee plantations, and mature secondary forests. The Puerto Rican broad-winged hawk population is estimated at about 125 individuals island-wide.

One of the recovery criteria for the Puerto Rican broad-wing hawk has been partially met through an agreement between the Service and the Mississippi Cooperative Wildlife Research Unit by studying the reproductive biology, abundance, and movement patterns of the hawk at Río Abajo Commonwealth Forest. However, information regarding the individuals of El Yunque National Forest and Carite Commonwealth Forest is lacking.



Habitat destruction or modification (Factor A) in the form of timber harvest, development, expansion or maintenance of roads, construction and maintenance of recreational facilities, and construction of power and communication structures have been identified as the primary factors threatening the Puerto Rican broad-winged hawk. In addition, Factor C (predation) and Factor E (other natural and manmade factors) threaten the species through natural events such as hurricanes, potential predation and competition with sympatric red-tailed hawks and human-induced disturbances (*e.g.*, people moving through and around nesting areas, harassment of nesting birds).

Potential conflicts with the establishment and management of Puerto Rican parrots, recently introduced in the Río Abajo Forest, appear to be minimal. There are no substantive data indicating that Factor B (overutilization for commercial, recreational, scientific, or educational purposes) is a threat to Puerto Rican broad-winged hawk. Evidence supporting lack of enforcement of regulations to protect the Puerto Rican broad-winged hawk is absent; therefore, Factor D (the inadequacy of existing regulatory mechanisms) is not a threat to this species.

Based on this analysis, the Puerto Rican broad-winged hawk continues to meet the definition of an endangered species.

### **III. RESULTS**

#### **A. Recommended Classification:**

No change is needed

### **IV. RECOMMENDATIONS FOR FUTURE ACTIONS**

1. Evaluate the abundance and distribution of Puerto Rican broad-winged hawks through island-wide surveys within traditional and non-traditional sites, particularly populations in El Yunque National Forest (due to significant declines between the early 1980s and mid 1990s) and the Río Abajo Commonwealth Forest [due to urban development (*e.g.* road construction) on nesting habitats]. Additionally, evaluate abundance and distribution of the Puerto Rican broad-winged hawk population in the Carite Commonwealth Forest and its adjacent lands. Surveys will need to be conducted during the breeding season between January and mid-July, using distance sampling with fixed points.
2. Using radio-telemetry, determine daily and seasonal movement patterns to obtain valuable information on habitat use and understand the home range dynamics of Puerto Rican broad-winged hawk, particularly at the El Yunque National Forest and the Carite Commonwealth Forest.

3. Establish buffer zones and effective controls to restrict human activities within established hawk territories, particularly during the breeding season. Sections of camping grounds, picnic areas, and plantation forests should be closed to the public during the breeding season.
4. To reduce habitat deterioration and maintain habitat effectiveness, protect and improve habitat adjacent to Puerto Rican broad-winged hawk ranges. This can be accomplished through land acquisition, conservation easements, or landowner incentive programs that promote sustainable land use practices.
5. Given the new information available since publication of the Puerto Rican broad-winged hawk recovery plan, delisting criteria for this species should be revised.

## V. REFERENCES

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- U.S. Fish and Wildlife Service. 1997. Puerto Rican broad-winged hawk and Puerto Rican sharp-shinned hawk (*Buteo platypterus brunnescens* and *Accipiter striatus venator*) Recovery Plan. U.S. Fish and Wildlife Service, Atlanta, Georgia. 23 pp.

## Appendix A

### Summary of peer review for the Puerto Rican broad-winged hawk 5-year review

This 5-year review was reviewed internally by Marelisa T. Rivera and Edwin E. Muñiz. They mostly provided editorial comments. Once the comments were added to the document, it was sent to four independent peer reviewers (see below) via electronic mail. The outside peer reviewers were chosen based on their qualifications and knowledge of the species. We indicated our interest in all comments the reviewers may have about this species, specifically in any additional information on the status and current threats to the species.

#### List of peer reviewers

Dr. Carlos A. Delannoy  
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The deadline for submission of peer review comments was January 31, 2010. Comments were received from two of the four peer reviewers during the comment period. Peer reviewers' comments (C) and the Service's responses (R) are provided below.

#### Comments by Dr. Carlos A. Delannoy:

- C: *Unsuccessful Puerto Rican broad-winged hawk attack because the young parrot defended and repelled effectively against the predator, or a near miss due to misjudgment of the predator? Could the observer judge and tell the difference? [In reference to a personal communication by M. López about an observation of a Puerto Rican broad-winged hawk interaction with a Puerto Rican parrot, in Factor C analysis]*
- R: The policy of the Service is to include comments and information from the general public and scientific community. We do not know if the observer could tell the difference between an attack and a defensive strategy, since he did not provide further explanation or details about the interaction. We included data from scientists that strongly suggested that Puerto Rican broad-winged hawk attacks on Puerto Rican parrots are not likely to occur.
- C: *Shade coffee plantations? Could not find citation for this habitat type used by BWH. Llerandi (2006) cited BWH suitable habitat along the Tanamá River Valley, included shade coffee plantations? I believe you cited Henstenberg and Vilella (2004, page 111)*

*“land use practices may hinder BWH dispersal to adjacent lands to the Río Abajo Forest because these lands were apparently unsuitable for BWH occupancy”. Including shade coffee plantations?*

R: Llerandi-Román (2006) does not mention shade coffee plantations. We updated the literature citations and species background information to include Hengstenberg and Vilella (2005), which better addresses this issue.

C: *Are the Luquillo and Carite forest populations as tightly restricted to forest boundaries as the Río Abajo forest population? 97% of adult BWH home range movements in Río Abajo Forest were confined to forest boundaries (cited in page 6 of this review). Adults used surrounding lands of Río Abajo Forest less than 1%, juveniles 6% of the time. Are BWH interactions with RTH (interference competition) and predation (of BWH juveniles) same in Luquillo and Carite as in Río Abajo Forest?*

R: There are no data available to respond to these questions. However, Recommendation #2 suggests that studies be conducted to determine daily and seasonal movement patterns of Puerto Rican broad-winged hawks to obtain valuable information on habitat use and understand the home range dynamics of this species. We modified this recommendation to highlight the need for studies at El Yunque National Forest and Carite Commonwealth Forest.

Comments by Dr. Adrienne G. Tossas:

C: *What about the other populations? Also, since you are mentioning here the most recent study conducted, a reference should be cited for the previous study as well. For instance, the population continues to be stable in respect to the previous study conducted in... [In reference to the species' status]*

R: In making its determinations, the Service uses the best information and data available. Although we only have current and reliable information for one of the three populations, the one in Río Abajo Forest, it supports the majority of the known individuals, which is close to half (50%) of the currently known individuals. We believe that reliable information and data from 50% of the population of the Puerto Rican broad-winged hawk is reasonable to make inferences about the status of the population. As per Recommendation #1, which suggests conducting Puerto Rican broad-winged hawk population surveys throughout the island population, we acknowledge a need for data on abundance and distribution of the species throughout its known range. A note was included to indicate that the population continues to be stable since the species' recovery plan was published.

C: *Why is the answer no, when there are new data available? [In reference to adequacy of recovery criteria]*

R: It refers to the adequacy of the recovery criteria outlined in the approved recovery plan,

which was not adequate. In other words, the recovery criteria in the approved recovery plan do not reflect the new information available.

C: *I am confused with this category, because I would think that the Sharp-shinned Hawk has less recovery potential than the Broad-winged Hawk, but the former is category three.* [In reference to the species' Recovery Priority Number (RPN)]

R: This section states that the RPN for the Puerto Rican broad-winged hawk at the start of this five-year review is 6. Once the Service internally analyzes the available new information on this species, we evaluate the RPN to determine if it needs to be changed.

C: *Why?* [In reference to addressing the five-factor analysis in the recovery plan's recovery criteria]

R: At the time that the Puerto Rican broad-winged hawk recovery plan was finalized (1997), a five-factor analysis was not a requirement to complete and approve a recovery plan. The current policy of the Service, however, is that a five-factor analysis must be completed as part of any listing action, species status review, and species' recovery plan.

C: *Was criteria # 2 met through this agreement, or only #3?* [In reference to a cooperative agreement between the Service and the Mississippi Cooperative Wildlife Research Unit to study the reproductive biology, abundance, and movement patterns of the broad-winged hawk at the Río Abajo Commonwealth Forest]

R: No. Only criterion #3 was met through this agreement. Section B.3 has been amended to reflect the change.

C: *Average annual productivity.* [In reference to productivity of young per nest]

R: Section C.1.a has been amended to incorporate suggestion.

C: *So, do they under use the habitat, or is it that they need more?* [In reference to the species not using habitat types in proportion to their availability]

R: Hengstenberg and Vilella (2004, p.67) explain that marked Puerto Rican broad-winged hawks used the six general habitat associations within the Río Abajo Forest in a different manner than expected under the hypothesis of proportional use or no selection. Bonferroni confidence intervals were used to determine if a particular habitat was used more than expected, less than expected, or in equal proportion; and found that they used four of the six habitats available (Hengstenberg and Vilella 2004, p.68).

C: *Everything suggested here is really important. But in my opinion this is the most important recommendation!* [In reference to Recommendation #4]

R: We acknowledge the comment. However, we do not prioritize recommendations for actions in 5-year reviews.

**U.S. FISH AND WILDLIFE SERVICE**

**5-YEAR REVIEW of the Puerto Rican broad-winged hawk**

**Current Classification:** Endangered

**Recommendation resulting from the 5-Year Review**

  X   No change is needed

**Review Conducted By:** Dr. Jorge E. Saliva, Caribbean Field Office, Boquerón, PR

**FIELD OFFICE APPROVAL:**

**Edwin E. Muñiz, Lead Field Supervisor, U.S. Fish and Wildlife Service**

Approved Edwin Muñiz Date 10/5/2010

**REGIONAL OFFICE APPROVAL:**

*for*

**Cynthia Dohner, Lead Regional Director, Fish and Wildlife Service**

Approved Aaron L. Valer Date 10/28/2010

## **Addendum I. Summary of new information gathered since the 2010 Puerto Rican broad winged hawk (*Buteo platypterus brunnescens*) 5-Year Status Review**

On June 30, 2017, the U.S. Fish and Wildlife Service (Service) published a notice in the *Federal Register* (82 FR 29916) announcing the five-year status review of *Buteo platypterus brunnescens* (Puerto Rican broad-winged hawk; guaraguao de bosque de Puerto Rico). It requested new information and comments from species experts and biologists familiar with this endangered plant concerning its biology and status. No comments were received from the public.

This addendum was prepared by a Service biologist and the Caribbean ES Field Office Habitat Restoration Coordinator and summarizes information that the Service has compiled since the last Puerto Rican broad-winged hawk (hereafter BWHA) 5-year status review approved on October 28, 2010.

### **I. GENERAL INFORMATION**

#### **C. Background**

##### **5. Review History:**

Recovery Plan: 1997

5-year review: 2010

Each year, the Service also reviews and updates listed species information for inclusion in the required Recovery Report to Congress. Through 2013, we did a recovery data call that included status recommendations such as “Stable” for this hawk. We continue to show that species status recommendation as part of our 5-year reviews. The most recent evaluation for this bird was completed in 2019 to help fulfill the Recovery Report to Congress requirements.

#### **C. Updated information**

##### **1. Biology and Habitat**

###### **State of the Birds Project: Island-wide Surveys conducted by the USGS Mississippi State University Research Coop. Unit between 2016 and 2017.**

In 2016, the Service found that the information available for BWHA was outdated and limited to a small number of public forests. The need for information on the distribution and abundance of this hawk in other forest reserves and private lands was essential to determine the island-wide distribution of this species. For this reason, the Service, in collaboration with the USGS Mississippi State University Research Cooperative Unit, conducted a study between 2016 and 2017 to gather information and data on island-wide BWHA distribution. The principal objectives were to conduct



island-wide monitoring surveys and develop spatial distribution models for this endangered species (Vilella and Gallardo 2018).

Vilella and Gallardo (2018) conducted surveys between March and May during both 2016 and 2017 in forest reserves and surrounding private lands of the northern karst region and principal montane regions of Puerto Rico (Cordillera Central, Cayey Mountains, and Luquillo Mountains) where presence had been previously reported (Delannoy 1997, Miranda-Castro et al. 2000, Hengstenberg 2003, Llerandi-Román 2006).

Given the overall absence of information on BWA presence outside protected areas, Vilella and Gallardo (2018) established a network of 63 observation points (Figure 1). Of these, 4 were found in public lands (Rio Abajo Commonwealth Forest; RAF) and 59 in private properties. Some survey stations were in private lands located along the periphery of RAF, Cambalache Forest, El Tallonal (private reserve), and on two properties acquired by the Puerto Rico DNER (Finca Banco Popular and Finca North Investment). Surveys stations were located in the municipalities of Arecibo (42 points), Utuado (19 points), Camuy (1 point), Ciales (1 point), and Hatillo (1 point). Of all observed individuals, 77 were found in the municipality of Arecibo, 36 in Utuado and 10 inside of RAF, for a total of 123 individuals (Vilella and Gallardo 2018).

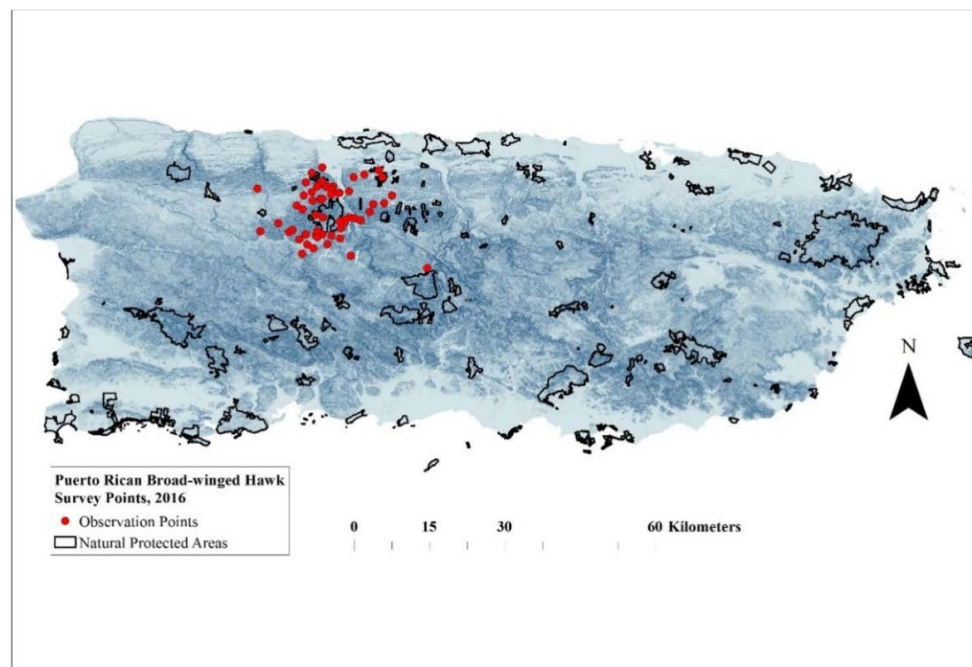


Figure 1: Survey points monitored for Broad-winged Hawks during 2016 (Vilella and Gallardo (2018)).

Vilella and Gallardo (2018) developed geographic models and estimated probability of occurrence (i.e., habitat suitability) for the BWA based on locations and environmental covariates. Model results indicated the moist karst forest region of RAF and surrounding private lands represented the center of the BWA geographic distribution and included the most suitable habitat (i.e., greater probability of occurrence) for the species. Patches of isolated suitable forest habitat were predicted in the eastern portions of the Cordillera Central, the eastern Cayey Mountains, and southern sections of the Luquillo Mountains in El Yunque National Forest (Figure 2). According to the MaxEnt distribution model, the distribution of the BWA was better described by rainfall (Figure 3) and elevation (Figure 4). The greater probability of BWA occurrence (> 60%) was on sites located at elevations of about 150 meters (m) to 700 m (492 feet (ft) to 2297 ft) and a precipitation range of about 100 – 300 millimeters (about 4 to 12 inches) in an area of the island (i.e., moist karst forest) with major topographical relief. The model predicted most of the area (~80%) having the greater probability of BWA occurrence was found on private lands (Vilella and Gallardo 2018).

This study represented the first attempt to model geographic distribution and island-wide habitat suitability for this species using location information on individual sightings and territories linked to relevant environmental variables of the landscape (Vilella and Gallardo 2018). Overall, model results indicated potential distribution of the BWA was centered on the central portions of the moist karst forest region of Rio Abajo Forest and surrounding private lands. Therefore, model results indicate suitable habitat for the BWA exists across Puerto Rico. However, the extent of the predicted geographic distribution and location of suitable habitat are not uniformly distributed across the island but restricted to particular physiographic regions, namely moist karst forest.

Field observations and modeling results highlight the importance of private lands in the periphery of protected areas for conservation and eventual recovery of this endangered raptor. Lack of information regarding the status and ecology of rare species in private lands is common worldwide, though habitat loss and degradation is recognized as a major driver of land use change, with mostly negative consequences for biodiversity (Miller and Hobbs 2002, Hansen and DeFries 2007). Most of the predicted BWA geographic range with a high probability of occurrence was located outside protected areas. Therefore, the ongoing initiative of land acquisitions and conservation easements for the Karst Region should continue to further benefit the BWA. In addition, given the amount of predicted BWA habitat located on private lands outside forest reserves, efforts should be made to expand the amount of protected area in the western sections of the northern karst region located between the Rio Abajo and Guajataca forests. A forest corridor between these reserves would greatly benefit the BWA as well as

other rare and endangered species (i.e., Puerto Rican Parrot (*Amazona vittata*)). This area supports the most suitable habitat for the BWHA identified by our models. The implementation of conservation projects (e.g., landowner's conservation agreements) will require the engagement of conservation organizations, private landowners, and state and federal agencies. Recovery goals would further benefit from research designed to address factors (e.g., nest predation, juvenile dispersal) limiting populations and geographic distribution of these forest raptors. Further, reliable information on population dynamics could guide management actions (i.e., translocations) to enhance and/or establish new populations (Griffith et al. 1989).

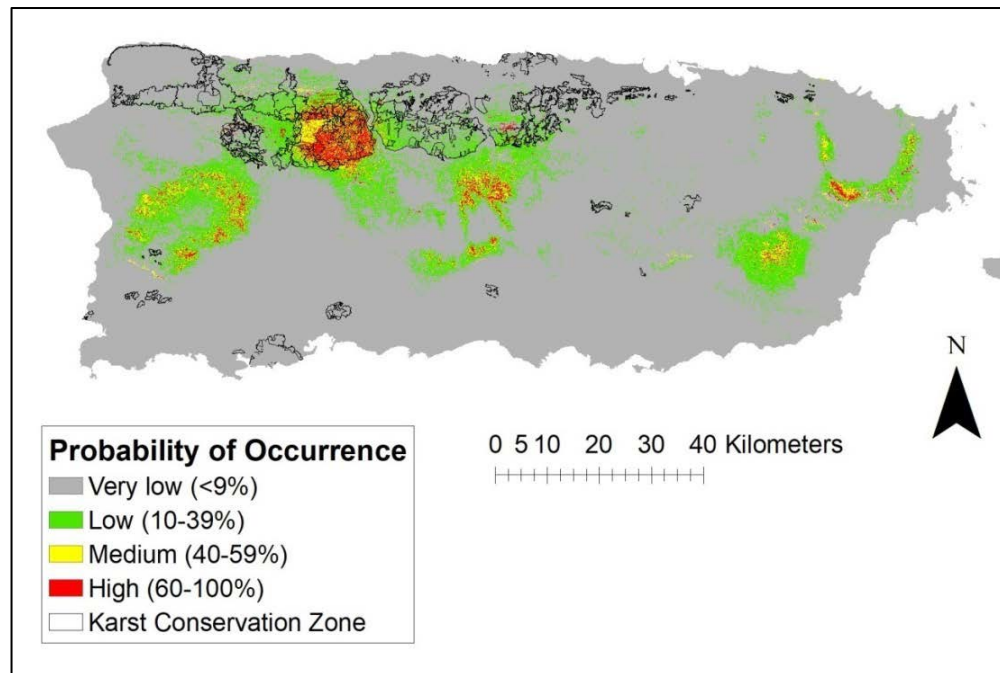


Figure 2. Predicted distribution and occurrence probability of the Puerto Rican broad-winged hawk (*Buteo platypterus brunnescens*) (Vilella and Gallardo (2018)).

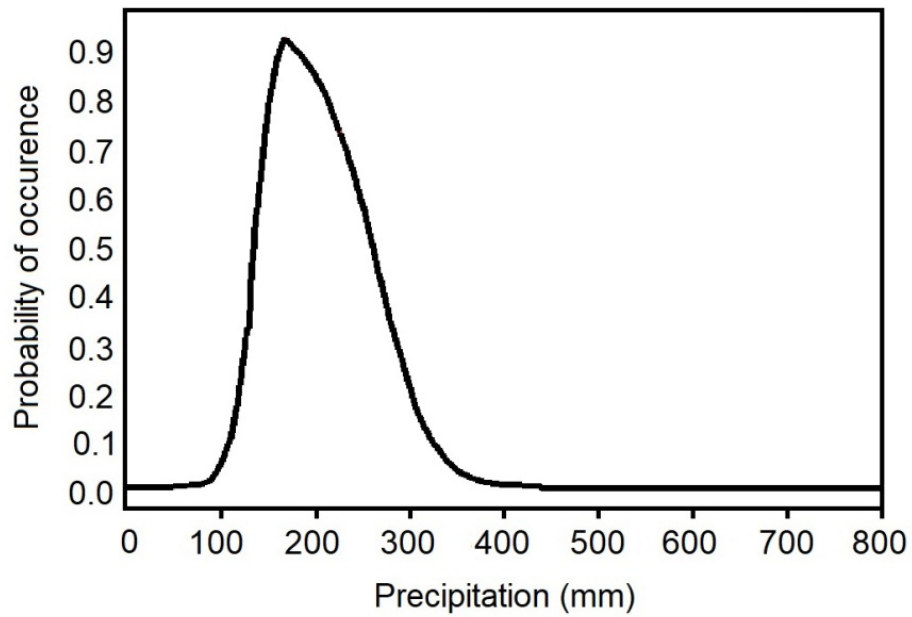


Figure 3. Response curve of rainfall and probability of occurrence of Broad-winged Hawk in Puerto Rico (Vilella and Gallardo (2018)).

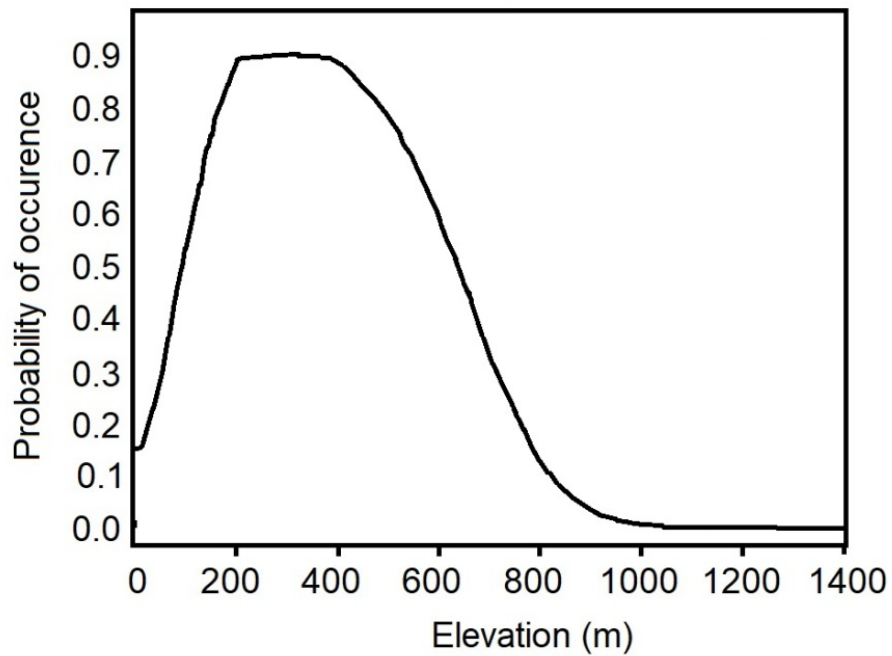


Figure 4. Response curve of elevation and probability of occurrence of Broad-winged Hawks in Puerto Rico (Vilella and Gallardo (2018)).

**Post-hurricane Rapid Population Status Assessment conducted by the Service and the Puerto Rico Department of Natural and Environmental Resources (DNER):**

In January and February 2018, the Service, in collaboration with DNER conducted a post-hurricane rapid population status assessment to determine the status and distribution of the BWA at the Río Abajo State Forest (RAF) and surrounding areas (Rios-Cruz 2018). This area was selected because historically it has been identified as the area where the healthiest and largest population of BWAs occurs. The assessment consisted of three surveys and several field visits to areas with potential habitat for the species. The assessment was conducted using a presence/absence approach to provide a snapshot of the distribution of the species four months after Hurricane María impacted Puerto Rico. The Service also collected additional information relevant for the BWA and other endangered species that might be present in the area. The assessment was conducted from the traditional observational stations used in several previous studies conducted in this forest such as Delannoy, C. A. & A. Tossas (2000); Hengstenberg, D.H. and F.J. Vilella (2004); and Llerandi-Román, I. C. (2006). Moreover, new observational stations were established to cover areas not covered previously by studies conducted in this region. For consistency, we selected the new observational points using the same biological and ecological criteria of the traditional observational stations.

Twenty observational stations were used for these surveys; six stations were placed within the RAF and 14 points beyond the forest boundaries. The number of stations placed within the forest differed drastically with the amount of stations placed outside the forest because the majority of the traditional stations within the forest were inaccessible due to debris that was blocking access after the hurricane.

During the three surveys, a minimum of 19 and a maximum of 34 BWAs were detected within and beyond forest boundaries. Furthermore, 13 additional BWAs were observed during different site visits conducted to nearby areas of the RAF that were not included in the three surveys conducted as part of the assessment. One of these detections represents a new location for the species geographical range (i.e., Limon Ward in the Utuado municipality). Moreover, three BWA nests were also found within the RAF (i.e., 2 active). Two of the nests were found within known traditional breeding territories and one nest within a potential new breeding territory for the species within the forest. All of the nests were built on Maria trees (*Calophyllum antillarum*).

Based on the observations made during the assessment and the field visits, it seemed that the distribution of the species in the RAF and surrounding lands remained stable at least four months after Hurricane María impacted Puerto

Rico. In addition, these findings are encouraging for the species because although the forest was severely affected by Hurricane Maria, there is evidence that the species was still occurring within previously known territories and attempted to breed in the RAF (Ríos-Cruz 2018).

**ARBIMON Acoustics: Species distribution models for 28 species of frogs and birds following Hurricane María (Campos-Cerqueira et al. 2019).**

Campos-Cerqueira et al. (2019) conducted post-hurricane acoustic surveys in March and April of 2018 and 2019 to develop species distribution models and to determine the presence and absence of the BWA in 360 sampling sites in and around four protected areas (i.e., Río Abajo -131 sites, Maricao - 102 sites, Carite – 63 sites, and El Yunque National Forest - 64 sites) (Figure 5). All recorders were placed at least 200 m from the nearest recorder and about 50 m from any road with traffic. The species distribution models were based on ~450,000 1-minute recordings and were used to understand how environmental and climatic conditions influence the occurrence of the species in the 360 sampling sites. These models were also used for predicting species distribution across the entire island. All climatic data were derived from Worldclim (2019), a global climate database. The final data set of the environmental predictors included six climatic variables and forest age (Campos-Cerqueira et al. 2019) (Figure 6).

Two approaches (i.e., Ensemble and Occupancy approaches) were used to develop distribution and occupancy models for the BWA. The Ensemble approach used the present/absent data of the species to create a model using six methods: generalized linear models (GLM), random forest (RF), support vector machine (SVM), boosted regression trees (BRT), classification and regression trees (CARS), and multivariate adaptive regression spline (MARS). This approach allowed them to generate an ensemble of models for each species that captures components of each of the six methods. Models were built using three runs using the subsampling data splitting method, so for each run, 70% of the data was used for training and 30% percent for testing. The Occupancy approach used the present/absent data to create single season occupancy models for the species.

This acoustic research include the most detailed and up-to-date study of the distributions of the BWA in Puerto Rico. Overall, the maps based on the ensemble (i.e. average weighting of six approaches) and occupancy modeling approaches show similar spatial patterns for the species. Furthermore, the top two climate/environmental variables contributing to each model were usually the same for both approaches for a given species. This consistence between the approaches provides strong support of the species distribution maps (Campos-Cerqueira et al. 2019).

These distribution maps were projected to the entire island and for the BWA the results suggested the species had a very narrow distribution occurring only in few sites and regions (Figure 7). The distribution maps and the probability of occurrence (Occurrence Probability from 0 to 0.3) of the species confirmed results from previous studies that have suggested the distribution of the BWA is centered on the moist karst forest region of northcentral Puerto Rico (Campos-Cerqueira et al. 2019; Figure 7). These models and maps also show that for the BWA distribution, forest Age, temperature annual range and precipitation seasonality are the most important climate and environmental variables (Campos-Cerqueira et al. 2019; Figure 7).

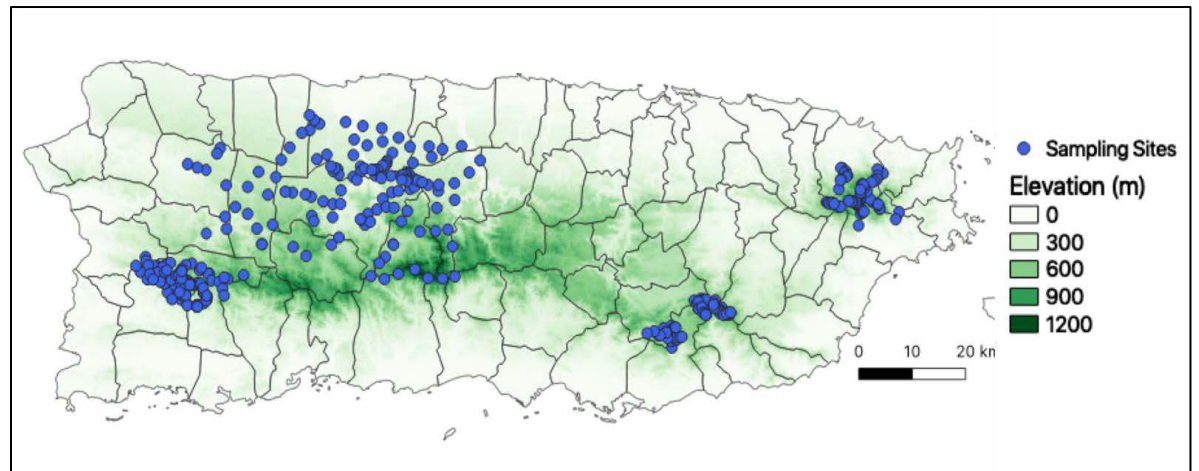


Figure 5. Approximate location of the 360 sampling sites in and around four protected areas in the mountains of Puerto Rico. From east to west: El Yunque National Forest, Carite, Rio Abajo, and Maricao Commonwealth Forests (Campos-Cerqueira et al. 2019).



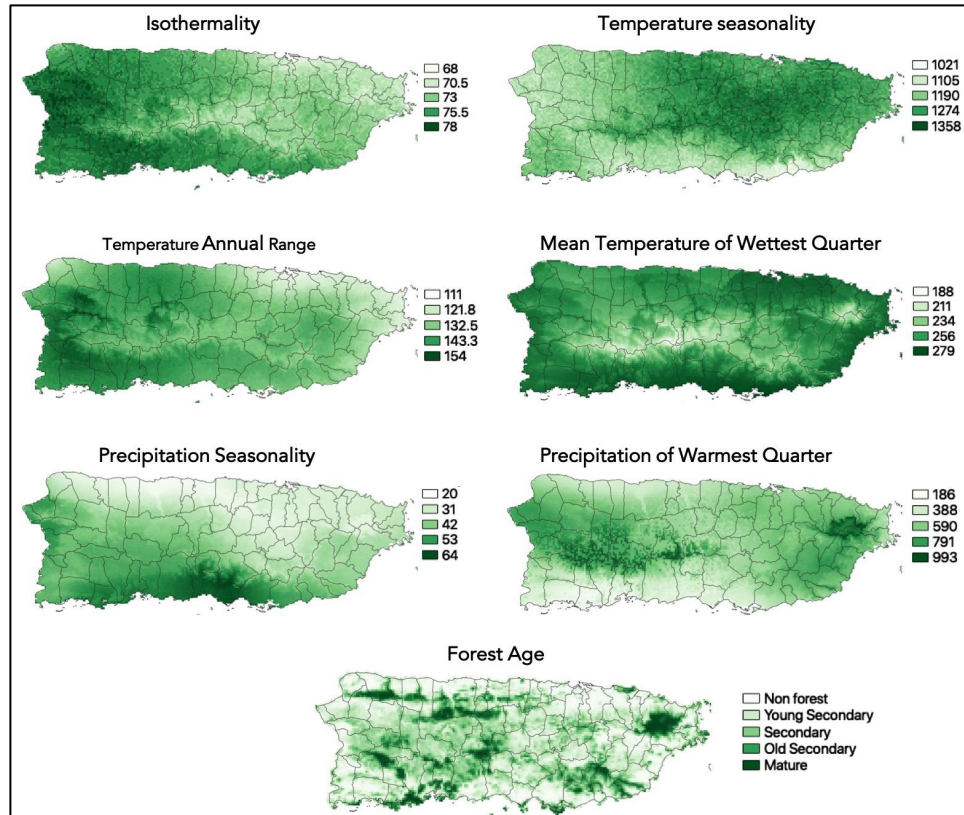


Figure 6. Environmental data used to create species distribution models. The environmental data from WorldClim (2019) are in the latitude / longitude coordinate reference system (not projected) and the datum is WGS84 and have a spatial resolution of 30 seconds ( $0.93 \times 0.93 = 0.86 \text{ km}^2$  at the equator). Temperature data are in  $^{\circ}\text{C} \times 10$ . This means that a value of 231 represents  $23.1 \text{ }^{\circ}\text{C}$ .



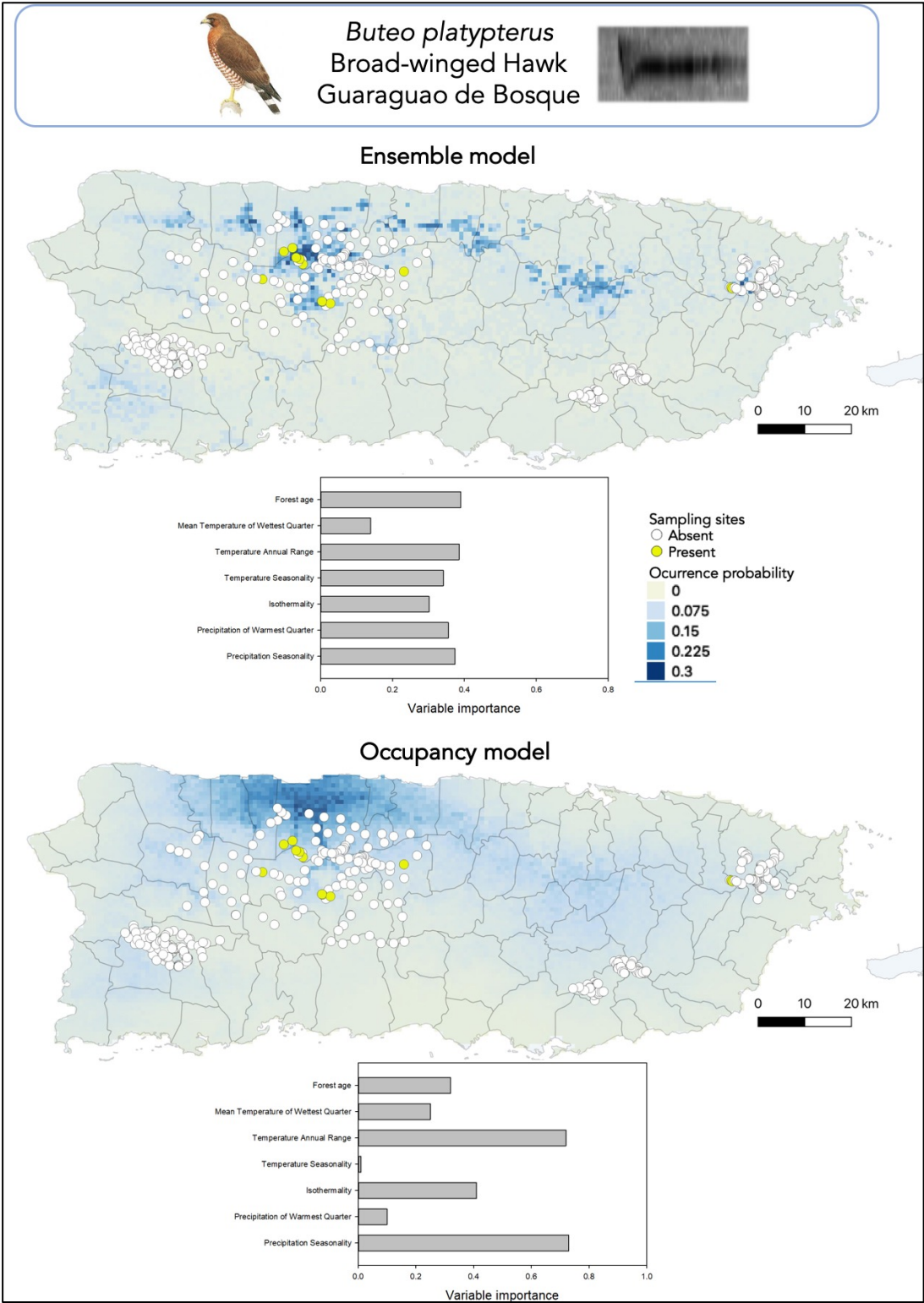


Figure 7. Two BWA distribution maps created using ensemble and occupancy models and the relative importance of the climate and environmental variables for each model (Campos-Cerqueira et al. 2019).

## Threat Factor Analysis

In 1997, the Recovery Plan of this species identified the destruction, modification, or curtailment of its habitat or range (Factor A) as one of the most significant factors that affected the number and distribution of BWHA in Puerto Rico. Other natural or manmade factors affecting its continued existence (Factor E) and the inadequacy of existing regulatory mechanisms (Factor D) were also identified as factors affecting the species at the time of listing (Service 1994, 1997).

Currently, the Service believes the destruction and modification of habitat and the natural and manmade factors such as hurricanes and habitat fragmentation are threatening the BWHA (Factors A and E) and (different from our determination in 2010) to some degree inadequacy of existing regulatory mechanisms on private lands with greater BWHA found on privately owned property (Factor D, see below).

Although the occurrence of this species is still known from mountainous and forested public and private areas in the Island, available information indicates that presently the populations persist in low numbers, and are mostly restricted to forest reserves (i.e., Río Abajo Commonwealth Forest, Carite Commonwealth Forest and El Yunque National Forest) and nearby private lands (Vilella and Gallardo 2018, Rios-Cruz 2018, Campos-Cerqueira et al. 2019).

However, currently, both the PRDNER and USFS manage the forests that sustain the majority of the BWHA populations for conservation purposes (Puerto Rico Statewide Assessment and Strategies for Forest Resources 2010, El Yunque National Forest Land and Resource Management Plan in revision 2017). Habitat modification pressures from agriculture practices, construction of residential projects, and development of new infrastructure adjacent to these forests are currently very low. However, Castro-Prieto et al. (2017) mentioned that urban sprawl is increasing in the boundaries of many protected areas, especially in the east of the Island where the EYNF and the CCF are located.

Improvements to existing infrastructure within these public forests, typical forest management of existing disturbed areas (e.g., trail maintenance, road maintenance, maintenance of communication towers, and recreational facility improvements) and research activities (e.g., species surveys, endangered species reintroductions) are regulated and coordinated with consulting agencies (i.e., PRDNER and USFWS). The above-mentioned activities are not presently affecting BWHA habitat within these forests. However, the timber harvest within Commonwealth forests, especially at the RAF and the expansion of existing facilities (e.g., communication facilities, other utilities,

roads, buildings) within the forests are still a possibility and may result in the degradation of suitable BWA habitat.

Although the threats to the species and its habitat have been minimized within the lands managed and administered by USFS and PRDNER, the species could be threatened with habitat destruction, fragmentation, and degradation in private lands adjacent to RAF, CCF and EYNF. Pares-Ramos et al. (2008) stated that Puerto Rico has experienced an increasing demand for urban structures, particularly residential buildings. As in many developed countries, this translates into a migration from urban centers to suburban areas. Researchers have predicted that this tendency of urban expansion is having an impact on secondary forests (Thomlinson and Rivera 2000) and the remaining agricultural lands as those adjacent to these protected lands. Recent information suggests the BWA is also present in private lands surrounding the RAF at the moist karst region (Rios-Cruz 2018, Vilella and Gallardo 2018, and Campos-Cerqueira et al. 2019). The private lands of this region are known to be susceptible to habitat modification caused by unsustainable agricultural practices and other land uses requiring vegetation clearance (e.g., deforestation, monoculture of minor fruits, livestock related activities, residential use, road improvements). The majority of these areas were converted into agricultural lands several decades ago, resulting in the elimination of native forest, thus, reducing the habitat value for wildlife. Although agriculture in some of these lands was abandoned and the forest is growing back, the previous encroachments on the forested areas and the associated edge effects have degraded the habitat of forest-dependent species such as the BWA.

Vilella and Gallardo (2018), Rios-Cruz (2018) and Campos-Cerqueira et al. (2019) indicated that recent observations and modeling resulted in knowledge of the greater importance of private lands in the periphery of protected areas for conservation and eventual recovery of this endangered raptor. Information regarding the status and ecology of BWA on private lands is still unknown for the species. Most of the predicted BWA geographic range with a high probability of occurrence was located outside protected areas. Therefore, because the new information available suggest that an important part of the species population occurs in private lands without protection, the species continues to be threatened by Factor A (present or threatened destruction, modification or curtailment of its habitat or range).

The BWA continues to be protected by Commonwealth of Puerto Rico approved the Law No. 241-1999, and approved Regulation 6766. This Regulation prohibits collection, killing, or harming species listed under in it, as well as the possessing, transporting, or selling items derived from listed species, and requires authorization from the PRDNER Secretary for any action that may affect designated critical habitat of listed species under this regulation (PRDNER 2004). In addition, the RAF and CCF are protected

under Puerto Rico's Forests Law No. 133-1975 (as amended in 2000), which prohibits causing damage to and collection of flora and fauna in public forests. Moreover, all Commonwealth forests are designated as Critical Wildlife Areas (CWA) by PRDNER. The CWA designation constitutes a special recognition by this agency with the purpose of providing information to other Commonwealth and Federal agencies about the conservation needs of these areas, and assisting permitting agencies in precluding negative impacts as a result of permit approvals or endorsements (PRDNER 2005).

The BWA co-occurs with other species that are listed under the Act. Because of the occurrence of other federally listed species within the same habitat where BWAs are found, any Federal action, funding, or permit within these forests or in adjacent private lands that may affect these listed species requires a section 7 consultation under the Act. Therefore, the BWA may benefit from indirect protection of these listed species as well (i.e., implementation of habitat restoration practices and habitat protection).

Based on the information currently available to us, the Federal and Commonwealth regulatory mechanisms discussed above can ameliorate possible adverse effects to the species and its habitats in private lands, and if implemented they provide for conservation measures for the protected species and their habitat. Lack of enforcement of these laws and regulations continue to be a challenge and may result in negative impacts to the species or exacerbating other negative effects to the species.

The geographic location of Puerto Rico in the Caribbean makes it prone to hurricane impacts (Wiley and Wunderle 1993, p. 320). Hurricanes can have both direct and indirect effects on bird populations, which may determine the characteristics of local avifauna (Wauer and Wunderle 1992; Wunderle et al. 1992). It has been suggested that BWA is susceptible to natural habitat disturbances or catastrophic weather events such as hurricanes due to its restricted distribution, low number of individuals and specific habitat requirement (i.e., mature forests that may not be available in storm-damaged forests) (Service 1994, 1997). Moreover, in September 2017, Puerto Rico was impacted by two major hurricanes: Irma and María. Hurricane Irma (Category 4) passed along the northeast coast of Puerto Rico affecting EYNF. Two weeks later Hurricane María (a high end Category 4 storm with winds of 155 mph) made landfall in southeast Puerto Rico crossed the Island diagonally, and exited near the municipality of Arecibo in the north. This hurricane caused extensive damage, particularly in the moist karst region where the BWA is found.

Hurricane María made landfall in southeastern Puerto Rico moving from southeast to northwest with sustained winds of 250 km/hr, severely affecting habitat of the BWA (i.e., Cordillera Central and northern moist karst). Hurricanes are the most prominent natural disturbance of the Caribbean

islands, with major direct and indirect effects on bird populations. Direct effects of hurricanes include mortality from exposure to hurricane winds, rains, and geographic displacement. Indirect effects include loss of food supplies, loss of nests or roost sites and increased vulnerability to predations. The greatest stress of a hurricane to most upland terrestrial birds occurs after its passage rather than during its impact.

Post-hurricane conditions influence forest succession, with corresponding changes in forest structure and floristic composition as a direct result of defoliation, loss of trees, loss of tree branches, opening of the canopy and formation of light gaps from extensive blowdowns (Boose et al. 2004, Vilella and Gallardo 2016). Therefore, these natural events may have negatively affected critical BWhA resources including, loss of adequate nest structures (branch and nesting trees loss) and an increase of understory and midstory cover from a reduction in canopy cover. These conditions would result in a reduction of suitable habitat conditions for a raptor species adapted to hunting small avian prey under the forest canopy (Vilella and Gallardo 2016). In addition, as stated above hurricanes influence the bird species community preyed upon by the BWhA, which can reduce the survival of this species.

Hurricanes can have positive effects on forest and bird ecology by temporarily increasing forest productivity (Wiley and Wunderle 1993), particularly for species with ample distribution (White et al. 2014). However, the immediate negative effects of these powerful atmospheric events for a species with demographically vulnerable populations, such as the BWhA, outweigh the benefits accrued via short-term primary productivity of vegetation (White et al. 2014). Studies predict an increase in hurricane intensity in the Atlantic, with higher wind speeds and greater amounts of precipitation (Jennings et al. 2014).

Furthermore, general long-term climate changes have been observed, including changes in amount of precipitation, wind patterns, and extreme weather events (e.g., droughts, heavy precipitation, heat waves, and the intensity of tropical cyclones) (Intergovernmental Panel on Climate Change (IPCC) 2014). For example, projected decreases in precipitation in the Caribbean suggest drier wet seasons, and even drier dry seasons (Jennings et al. 2014). As previously mentioned, the BWhA is currently known only from specific habitat types at few locations in Puerto Rico, which makes the species susceptible to the effects of climate change. It has been stated that higher temperatures, changes in precipitation patterns, and any alteration in cloud cover will affect plant communities and ecosystem processes in montane forest of Puerto Rico (Lasso and Ackerman 2003). In fact, the distribution of tropical forest life zones in the Caribbean is expected to be altered due to both intensified extreme weather events and progressively drier summer months (Wunderle and Arendt 2011). Forest types over 800 m (2,624 ft) in elevation also are very sensitive to climate change because of

their occurrence in narrowly defined environmental conditions (Lasso and Ackerman 2003). Although the available information predicting changes in habitat in Puerto Rico due to climate change pertains to EYNF, it is reasonable to expect that similar changes could happen at the RAF and CCF.

Arendt et al. (2013) suggest that approximately 50 percent of the Caribbean birds show medium to high vulnerability to climate change. Based on that information, species that are dependent on specific habitat types, and that have limited distribution or have become restricted in their range, like the BWA, will be most susceptible to the effects of climate change. However, while continued change is expected, the magnitude and rate of that change is unknown in many cases. In tropical and subtropical forests, significant knowledge gaps exist in predicting the response of natural systems to climate change, and uncertainties exist with studies forecasting trends in climate (Jennings et al. 2014). Moreover, regionally downscaled climate models projecting temperature and precipitation patterns at fine scales are not readily available for locations within the Caribbean region, including Puerto Rico (Jennings et al. 2014). While existing large-scale global climate models are useful in determining potential future trends (Angeles et al. 2007), the lack of fine-scale data in Puerto Rico's mountainous regions is troublesome, as variations in climate with elevation over short horizontal distances cannot be captured by existing climate models, especially in predictions of extreme events (Meehl et al. 2007).

Therefore, due to the serious negative impacts that hurricanes may have on the BWA and its habitat and the uncertainty of the potential effects of climate change, we believe the species continues to be threatened by Factor E (threatened by other natural and manmade factors).

## **Synthesis**

Based on the information gathered during this review, the overall population of *Buteo platypterus brunncescens* has remained stable and slowly declining. At present time, about 117 individuals are known to occur in several populations in Puerto Rico, eight less than previous review. The status of the species has not improved, it is currently threatened by habitat destruction and modification for urban and tourist development (Factor A and Factor D), and other natural and manmade factors such as hurricanes and climate change (Factor E). The species might have increased to some extent in the past years, but the Rio Abajo population and its habitat might have been severely affected by Hurricane Maria. Although recruitment and different age classes have been documented in most of the populations, the reproductive biology of the species is not known. We believe that *Buteo platypterus brunncescens* continues to meet the definition of an endangered species.

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**U.S. FISH AND WILDLIFE SERVICE**  
**Puerto Rican broad winged hawk**  
**(*Buteo platypterus brunnescens*) 5-Year Status Review**

**Current Classification:**    Endangered

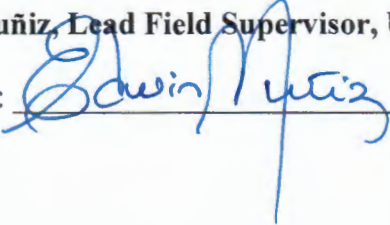
**Recommendation resulting from the 5-Year Review**

  X   No change to listing status, but we recommend a new recovery priority number based on a reduced degree of threat from high to moderate.

**Review Conducted By:** Iván Llerandi-Román and Jesus Ríos-Cruz, Caribbean Ecological Services Field Office, Boquerón, Puerto Rico

**FIELD OFFICE APPROVAL:**

**Edwin E. Muñoz, Lead Field Supervisor, U.S. Fish and Wildlife Service**

Approved by:       Date 9/19/2019

**PR Sharp-Shinned Hawk (PRSSH) (*Accipiter striatus venator*)**

**Puerto Rican sharp-shinned hawk or falcón de sierra  
(*Accipiter striatus venator*)**

**5-Year Review:  
Summary and Evaluation**



**U.S. Fish and Wildlife Service  
Southeast Region  
Caribbean Ecological Services Field Office  
Boquerón, Puerto Rico**

**5-YEAR REVIEW**  
**Puerto Rican sharp-shinned hawk/*Accipiter striatus venator***

**I. GENERAL INFORMATION**

**A. Methodology used to complete the review**

The U.S. Fish and Wildlife Service (Service) accomplished this review using information obtained from the final rule listing this species under the Act, the recovery plan, peer-reviewed scientific publications, several unpublished research projects, unpublished field observations by the Service, State and other experienced biologists, and personal communications. The Service's lead Recovery biologist for this species prepared this following review. On September 21, 2007, the Service published a notice in the *Federal Register* (72 FR 54061) announcing the 5-year review of the Puerto Rican sharp-shinned hawk (hereafter SSHA). The notice requested new information concerning the biology and status of this species. We opened a 60-day public comment period with this notice but we received no comments or information on this species. This 5-year review summarizes new information that the Service has gathered since this species was listed under the Endangered Species Act, information gathered from peer-reviewed literature, unpublished field observations and reports and communications from qualified biologists and species experts. In addition, we sought peer review for this document, and the comments received from the reviewers were evaluated and incorporated where appropriate (see Appendix A).

**B. Reviewers**

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

**Lead Field Office:** Iván Llerandi-Román, Caribbean Ecological Services Field Office, Boquerón, Puerto Rico, (787) 851-7297, extension 224.

**Name of Reviewer (s):**

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## C. Background

### 1. Federal Register Notice citation announcing initiation of these reviews:

September 21, 2007; 72 FR 54061

### 2. Species Status: Declining

As of the date of this signed 5-year review, we believe the status of the SSHA is **declining**. Comprehensive population estimate surveys have suggested that this species has been declining for the last 30 years (Delannoy 1984, 1992, 1997, 2009, Gallardo and Vilella 2014, Vilella and Gallardo 2016, Thorstrom 2017).

In 1992, Delannoy reported that this species drastically declined from an island-wide population estimate of 240 individuals between 1981 and 1985 (Delannoy 1984) to an estimate of 150 between 1991 and 1992 (Delannoy 1992). This represents a population decline of 40% over an eight-year period (Delannoy 1997). After a period of 20 years (1992-2012) without any updated comprehensive information of the population status of this species, surveys within public and private lands covering most of this species' known range have been recently conducted since 2013.

The results of these surveys suggest a decline of the island-wide population from 150 individuals in 1992 to about 100 individuals in 2016 (Vilella and Gallardo 2016, Thorstrom and Gallardo *in press*). In addition, a significant decline of this species have been reported in the Toro Negro Commonwealth Forest (TNCF) and Maricao Commonwealth Forest (MCF), which were previously considered the center of distribution of this species in Puerto Rico (Gallardo and Vilella 2014, Vilella and Gallardo 2016, Thorstrom 2017). Vilella and Gallardo (2016) and Thorstrom (2017) estimated the population of MCF as just 8 individuals and the population in TNCF as 26 individuals indicating a population decline of 53% and 86% in TNCF and MCF, respectively (Thorstrom and Gallardo *in press*).

These researchers also suggest that the geographic distribution of this species in Puerto Rico appears to be centered presently along the more central portions of the Cordillera Central (central mountain range) of the Island and with a higher presence within private lands contrary to what was previously reported (Vilella and Gallardo 2016, Thorstrom 2017). This area includes the region encompassed by the Commonwealth Forests of Guilarte (GCF), TNCF and Tres Picachos, La Olimpia Forest and the surrounding private lands of this region (Gallardo and Vilella 2014, Vilella and Gallardo 2016, Thorstrom

2017). Vilella and Gallardo (2016) also reported the locations of SSHA in the municipalities of Maricao, San Germán, Orocovis, Adjuntas, Jayuya, Juana Diaz, Utuado, Ponce and Peñuelas (Figure 1-2). A single SSHA was located on the northern boundary of Carite Commonwealth Forest (CCF), located in east-central Puerto Rico (Figure 1-2).

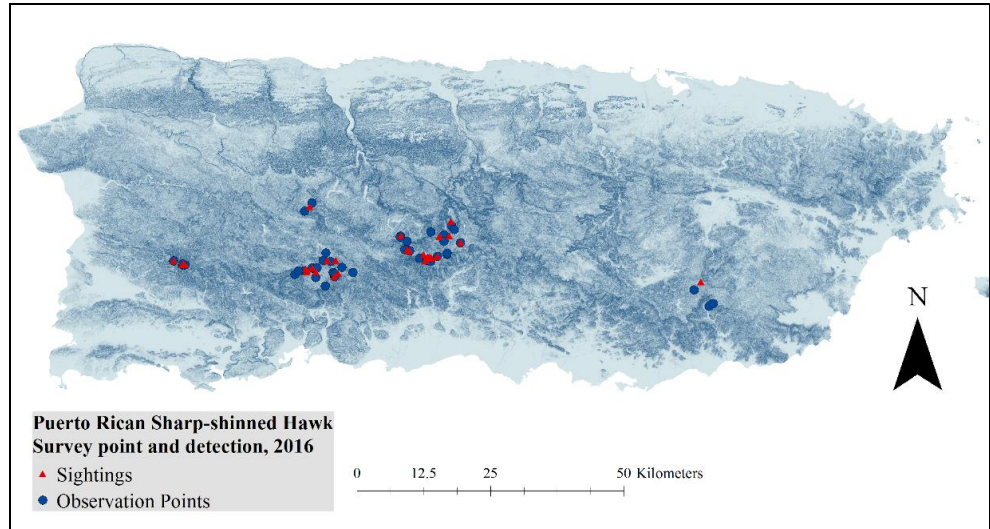


Figure 1. Sharp-shinned hawk (SSHA) survey points and sightings in 2016 (Vilella and Gallardo 2016).

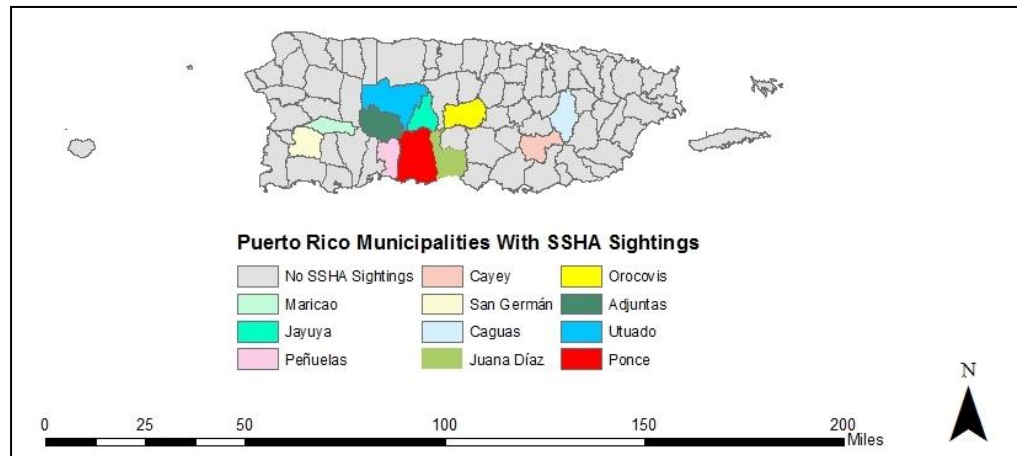


Figure 2. Puerto Rico Municipalities with Sharp-shinned hawk (SSHA) sightings in 2016 (Vilella and Gallardo 2016).

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



**4. Listing History**

Original Listing for the Puerto Rican SSHA

FR notice: 59 FR 46710

Date listed: September 9, 1994

Entity listed: Subspecies

Classification: Endangered

**5. Review History:**

The recovery plan of the Puerto Rican broad-winged hawk and Puerto Rican sharp-shinned hawk (*Buteo platypterus brunnescens* and *Accipiter striatus venator*), approved and signed on September 8, 1997 (Service 1997) along with the progress reports of the research conducted by the Service and its collaborators between 2013 and 2016 are the most recent comprehensive analyses of the status of this species. These documents were used as reference point documents for this 5-year review.

At the time of listing, this species was known to occur in five locations in Puerto Rico: MCF, TNCF, GCF and CCF, and El Yunque National Forest (EYNF former Caribbean National Forest). These four Commonwealth forests are under the administration of the Puerto Rico Department of Natural and Environmental Resources (PRDNER) and EYNF is administrated by the U.S. Forest Service (USFS). An island-wide population was estimated at approximately 150 individuals reported from these locations in 1992 (Delannoy 1997).

The Recovery Plan for this species includes the species' description and information about distribution, abundance, habitat, reproductive biology, and status of the species. Hence, the information included in the plan will not be repeated in this review.

After a period of 20 years (1992-2012) without any updated comprehensive information on the status and distribution of this species, the Service, in collaboration with the Mississippi State University USGS Cooperative Research Unit, has been conducting surveys since 2013 and with The Peregrine Fund since 2015, covering most of this species' known range. The most recent surveys were completed in 2016.

**6. Species' Recovery Priority Number at start of review (48 FR 43098):**

At the time of listing, a recovery priority number of 3 (a subspecies with a high degree of threat, high recovery potential) was assigned to the Puerto Rican sharp-shinned hawk.

**7. Recovery Plan:**

Name of plan: Puerto Rican broad-winged Hawk and Puerto Rican sharp-shinned Hawk (*Buteo platypterus brunnescens* and *Accipiter striatus venator*) Recovery Plan

Date issued: September 8, 1997

**II. REVIEW ANALYSIS**

**A. Application of the 1996 Distinct Population Segment (DPS) policy**

- 1. Is the species under review listed as a DPS? No**
- 2. Is there relevant new information that would lead you to consider listing this species as a DPS in accordance with the 1996 policy? No**

**B. Recovery Criteria**

- 1. Does the species have a final, approved recovery plan containing objective, measurable criteria?**

The sharp-shinned hawk has a final, approved recovery plan but it does not contain objective, measurable criteria to delist the species. The plan has as an interim downlisting criteria that in each of five forests, breeding densities should be restored to the higher levels known in 1983 and 1985 (CCF = 0.42 pairs/km<sup>2</sup>; GCF = 0.82 pairs/km<sup>2</sup>; EYNF = 1.03 pairs/km<sup>2</sup>; MCF = 1.15 pairs/km<sup>2</sup>; and TNCF = 1.45 pairs/km<sup>2</sup>) (Service 1997).

- 2. Adequacy of recovery criteria.**

- a. Do the recovery criteria reflect the best available and most up-to-date information on the biology of the species and its habitat?**

No. The plan does not include up-to-date information about the species' biology, distribution and abundance. Knowledge about the spatial distribution and biology for the species has substantially increased since the time of listing.

- b. Are all the five listing factors that are relevant to the species addressed in the recovery criteria (and there is no new information to consider regarding existing or new threats)? Yes.**

All listing factors that were considered threats at the time of listing are addressed in the recovery criteria.

- 3. List the recovery criteria as they appear in the recovery plan and discuss how each criterion has or has not been met, citing information.**

The plan established the following downlisting criteria for the Puerto Rican sharp-shinned hawk:

- a. Maintain a breeding population of SSHA of not less than 250 pairs in five forests, for a minimum of seven years. In each forest, breeding densities should be restored to the higher levels known in 1983 and 1985 (as mentioned just above).
- b. Gather additional documentation on population trends (*i.e.*, conduct surveys, search for new populations, obtain population biology information, identify mortality factors and threats) and adequate support habitat for SSHA (*i.e.*, characterize currently used habitat, identify additional habitat, determine spatial and temporal use of habitat).

Criterion “a” has not been met. Based on the most recent information available to the Service, the population of SSHA has drastically declined since the comprehensive population surveys conducted in 1991 and 1992 (Vilella and Gallardo 2016 and Thorstrom 2017). The most recent surveys estimated the island-wide population at approximately 75 individuals with a core population of approximately 26 individuals at the TNCF (Thorstrom and Gallardo *in press*). Although recent surveys have suggested this species appears to be centered along the more central portions of the Cordillera Central of the Island and with a higher presence within private lands, the population estimates in these areas remain below 50 individuals (Vilella and Gallardo 2016, Gallardo and Vilella 2017, Thorstrom 2017). The apparent higher presence within private lands is contrary to what was previously reported at the time of listing.

Criterion “b” has been partially met. After the surveys conducted between 1991 and 1992 there was a period of about 20 years (1992 - 2012) in which the comprehensive information on the status and distribution, and the habitat use of this species was virtually minimal or absent. However, since 2013 the Service and its collaborators have been updating the information on the status and distribution of the species. In addition, we have been collecting information on the reproductive biology, genetics and the parasitism

prevalence in the species' reproductive population. However, the lack of monitoring for almost 20 years has not allowed us to determine population trends of this species nor to adequately identify new threats or the magnitude and severity of the threats identified at the time of listing. Moreover, although we have been recently monitoring the SSHA population, due to the lack of trend data it will be difficult to determine how the factors influenced or caused the decline experienced during the past 30 years by this species in Puerto Rico.

## **C. Updated Information and Current Species Status**

### **1. Biology and Habitat**

#### **a. Species' abundance, population trends, demographic features, or demographic trends:**

The SSHA, also known as falcón de sierra and gavián de sierra (Delannoy 2009) is a small woodland raptor with dark slate-gray upperparts and heavily barred rufous (reddish brown) underparts. Adult males and females are similar in appearance, but the female is larger. The SSHA in Puerto Rico exhibits insular population traits, including small clutches, low productivity and extended breeding periods (Delannoy 1984, Vilella and Gallardo 2016). Historic information described this species as rare, uncommon and occurring in restricted habitats in small numbers (Delannoy 1984).

As of the date of this signed 5-year review, updated available information on the SSHA in Puerto Rico indicates populations are small and mostly restricted to montane forest reserves of the central portions of the Cordillera Central of Puerto Rico (Gallardo and Vilella 2014, Vilella and Gallardo 2016, Thorstrom 2017).

After 20 years (i.e., 1992 – 2012) without any new information on the status and distribution information of this species, Vilella and Gallardo (2016) reported at least 47 individuals of SSHA (i.e., 38 adults, 3 juveniles and 6 undetermined ages) recorded in 29 of 52 observation points located along public and private lands of the Cordillera Central between 2013 and 2016. The majority of SSHA detections (i.e., 26 of 47) during this study occurred in private lands. They also reported 17 SSHA territorial pairs, 10 located within public lands and 7 within private lands but no active nests were found. These authors reported the locations of SSHA in the municipalities of Maricao, San Germán, Orocovi, Adjuntas, Jayuya, Juana Diaz, Utuado, Ponce, Cayey and Peñuelas (Figure 1). A single SSHA was located on the northern boundary of CCF, located in east-central Puerto Rico (Figure 1). The results of this study are not fully comparable with the information reported by Delannoy (1984) and Delannoy (1997) because those previous studies were conducted within the forest reserves and did not include private lands. However, at least seven

breeding territories found during previous studies still currently active as observed in recent assessments (Delannoy 1984, Delannoy 1986, Delannoy 1992, Delannoy 1997, Gallardo and Vilella 2017, Thorstrom 2017).

However, during 2015, 2016 and 2017, Thorstrom (2017) and Thorstrom and Gallardo (*in press*) concentrated their survey efforts in the forest reserves and reported preliminary estimates for MCF, TNCF, GCF and CCF (Table 1). Although less searching time (i.e., 33.2%) was spent outside the TNCF during 2015 and 2016, Thorstrom (2017) and Thorstrom and Gallardo (*in press*) visited in 2017 the nest sites visited the previous two years in the TNCF, GCF, MCF, CCF and EYNF totaling 240 observational days (Table 1). These authors suggested the contemporary population and breeding stronghold of SSHA in Puerto Rico is presently in TNCF based on the number of individuals recorded along three years of surveys (i.e., 21 in 2015, 26 in 2016 and 42 in 2017; Table 1).

Table 1. Puerto Rican Sharp-shinned Hawk number of pairs and individuals detected by Thorstrom (2017), and Thorstrom and Gallardo (*in press*) between 2015 to 2017.

Nesting season	Forest reserve	Observational days (#)	Territorial pairs (#)	Non-paired individuals (#)	Total detected individuals (#)
<b>2015</b>	TNCF	119	10	1	21
	GCF	38	3	0	6
	MCF	12	2	2	6
	CCF	2	0	0	0
	EYNF	0	-	-	-
<b>Total</b>		<b>171</b>	<b>15</b>	<b>3</b>	<b>33</b>
<b>2016</b>	TNCF	127	9	8	26
	GCF	23	7	4	18
	MCF	39	4	0	8
	CCF	1	0	1	1
	EYNF	0	-	-	-
<b>Total</b>		<b>190</b>	<b>20</b>	<b>13</b>	<b>53</b>
<b>2017</b>	TNCF	128	16	10	42
	GCF	39	7	3	17
	MCF	37	6	3	15
	CCF	14	0	1	1
	EYNF	22	0	0	0
<b>Total</b>		<b>240</b>	<b>29</b>	<b>17</b>	<b>75</b>

Thorstrom (2017) and Thorstrom and Gallardo (*in press*) reported nesting attempts, productivity and nest success between 2015 and 2017 (Table 2). In 2015, these authors reported 8 nests at the TNCF and the MCF, and no nests were found at the GCF area (Table 2). Fifteen young successfully fledged from 7 nests with a productivity of 1.9 young fledged per nesting attempt, with an overall nest success of 87.5% (i.e., 7 of 8 nests). The nesting attempt that failed was suspected due to bot fly parasitism. In 2016, he reported 12 nesting attempts including 2 second nesting attempts (i.e., 8 in TNCF and 4 in MCF) which failed during the late incubation or early hatch period. Twelve young successfully fledged from 10 first nesting attempts and no

young fledged from the two second attempts. Productivity was 1.0 young per nesting attempt with an overall nest success of 42% (Table 2).

In 2017, Thorstrom and Gallardo (*in press*) documented 18 nesting attempts including two-second attempts (i.e., 12 in the TNCF, 5 nests in the MCF and 1 nest in the GCF; Table 2). Fifteen young successfully fledged from 16 first nesting attempts and no young fledged from the two second nesting attempts. Productivity was 0.83 young fledged per first nesting attempts. In one nesting territory, the first nesting attempt was by a juvenile-plumaged female that failed and a second attempt was in the same nest by an adult-plumaged female that failed too. Four juvenile-plumaged females were breeders during this season. Overall nest success was 33% (6 of 18 nesting attempts). Four (25%) of the 16 breeding females were juvenile-plumaged first year birds (2 in TNCF and 2 in MCF).

Table 2. Puerto Rican Sharp-shinned Hawk nesting attempts, productivity and nest success reported by Thorstrom (2017), and Thorstrom and Gallardo (*in press*) between 2015 to 2017.

Nesting season	Forest reserve	Nesting attempts (#)	Successful nests (#)	Failing nests (#)	Fledglings (#)	Productivity (fledgling/territorial pair)	Overall Productivity fledglings/nesting attempt	Overall nest success (%)
<b>2015</b>	TNCF	6	5	1	12	1.0	1.9	87.5
	GCF	0	0	0	0			
	MCF	2	2	0	3			
<b>Total</b>		<b>8</b>	<b>7</b>	<b>1</b>	<b>15</b>			
<b>2016</b>	TNCF	8	3	5	6	0.6	1.0	42.0
	GCF	0	0	0	0			
	MCF	4	2	2	6			
<b>Total</b>		<b>12</b>	<b>5</b>	<b>7</b>	<b>12</b>			
<b>2017</b>	TNCF	12	5	7	12	0.5	0.83	33.0
	GCF	1	1	0	3			
	MCF	5	0	5	0			
<b>Total</b>		<b>18</b>	<b>6</b>	<b>12</b>	<b>15</b>			

The overall (i.e., first and second nesting attempts) productivity of 1.1 young fledged per nesting attempt and the overall nest success of 47.4% reported by Thorstrom and Gallardo (*in press*) differs from what was reported by Delannoy (1984). From 1978 – 1982, Delannoy (1984) recorded an overall productivity of 0.63 fledglings per nesting attempt, and a 25% nests success including second attempts at the MCF. Thorstrom (2017) suggested the productivity results between 2015 and 2017 were higher than those reported by Delannoy (1984) due to the lower incident of bot fly parasitism registered in these years. Thorstrom (2017) followed a treatment protocol applying a dose of 0.05 ml/10 g of weight of the insecticide Fipronil to prevent and control bot fly (*Philornis spp.*) infestations in nestlings. All SSHA nestlings treated during 2016 had no bot fly infestations and all fledged successfully. No bot fly larvae were observed in nestlings during 2016 contrary to the 2015-nesting season when one nestling was assumed to succumb to bot fly (*Philornis spp.*) infestations at the TNCF and two other nestlings at the MCF.

Of the 20 nest failures, 9 (45%) occurred during the egg stage, 9 (45%) during the nestling period and 2 (10%) unknown. Seven (18%) juvenile-plumage females were breeders during the three nesting seasons.

The preliminary results of surveys by Vilella and Gallardo (2016) and Thorstrom (2017), suggest a decline of the island-wide SSHA population from 150 individuals in 1992 to about 100 individuals in 2017 (Vilella and Gallardo 2016, Thorstrom 2017). This information may suggest a greater population decline because Thorstrom (2017) included public and private lands in his surveys and Delannoy (1997) surveys were conducted just within five protected public lands. In addition, a significant decline of this species has been reported in the TNCF and MCF, which were previously considered the center of distribution of this species in Puerto Rico (Delannoy 1984, Delannoy 1997, Gallardo and Vilella 2014, Vilella and Gallardo 2016, Thorstrom 2017). Previous studies estimated the SSHA population at the MCF as 60-70 individuals during the late 1980s before decreasing to approximately 40 individuals by the early 1990s (Delannoy 1984, Delannoy 1992, Delannoy 1997). Vilella and Gallardo (2016) and Thorstrom and Gallardo (*in press*) estimated the SSHA population at the MCF as just 15 individuals, and the population in TNCF as 42 individuals, indicating a population decline of 26% and 75% in TNCF and MCF, respectively.

The number of SSHAs recently documented at the GCF (i.e., 17 individuals) is similar to the population estimate in 1992 (20 individuals; Delannoy 1997) in the same forest. However, during the same period Thorstrom (2017) did not find nests in this forest. It has been suggested that the distance from the western end of the TNCF and eastern end of the GCF (i.e., about 10 km) might allow a corridor and potential movement and dispersal of SSHAs between both reserves (Thorstrom 2017, Thorstrom and Gallardo *in press*). Therefore, banding or radio tagging the SSHA is recommended to assess movement between both forest reserves (Thorstrom 2017, Thorstrom and Gallardo *in press*) and to determine if the species is also breeding at the GCF (see section IV for further detail).

At this moment, the status of the SSHA in the Sierra de Luquillo and Sierra de Cayey, where EYNF and CCF are respectively located, is uncertain given the reduced monitoring efforts and overall lack of information. During the surveys conducted in 2014 by Vilella and Gallardo (2016) in the CCF, no SSHAs were detected while a single male was observed in the northern sections of this reserve during the 2016 and 2017 breeding season. Previous studies have argued SSHA have been declining in the Sierra de Luquillo for some time, and no recent records exist for EYNF (Delannoy 1997, Vilella and Gallardo 2016, Thorstrom and Gallardo *in press*). Although SSHA have historically shared the same nesting areas as the Puerto Rican parrot (*Amazona vittata*) in EYNF, Service biologists constantly working in that area have reported very few encounters with SSHA. Between 2009 and

2015, the SSHA was only observed twice within the Puerto Rican parrot nesting area (Ríos-Cruz 2017 pers. comm.).

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

During the surveys conducted in 2015, Thorstrom and his colleagues collected several feathers around nest sites for further DNA analysis. In 2016, blood samples were collected from 7 nestlings, 3 adults, and 2 specimens (a nestling found dead at the MCF and an adult male mortality caused during a trapping session at TNCF). These samples, along with the feathers collected in 2015 were sent to the University of North Texas for analysis.

Thorstrom (2017) reported that based on the DNA sequences analysis, the four analyzed feather samples were identical in sequence. The University of North Texas conducted a maximum likelihood phylogenetic analysis to compare the SSHA in Puerto Rico with other similar subspecies of the same genus across its range, and preliminary concluded the Puerto Rican SSHA is a “sister species” to the continental North America subspecies *Accipiter striatus velox*. Based on a generalized molecular clock used for cytb in the literature (2% per million years), that divergence estimate would suggest that the two subspecies diverged approximately 1.3 million years ago (J. Johnson pers. comm., Thorstrom 2017). This suggests that potentially the SSHA in Puerto Rico represent an endemic and separate taxon at least from the mainland populations.

**c. Taxonomic classification or changes in nomenclature:**

No new information or research exists on the taxonomy of the Puerto Rican sharp-shinned hawk. Currently, the species is still as a valid taxon in the Integrated Taxonomic Information System ([www.itis.gov](http://www.itis.gov)).

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

Recent information indicates that the current geographic distribution of this species in Puerto Rico appears to be centered along the more central portions of the Cordillera Central of the Island and with a higher presence within private lands contrary to what was previously reported (Vilella and Gallardo 2016, Thorstrom 2017). This area includes the region encompassed by the Commonwealth Forests of Guilarte, Toro Negro and Tres Picachos, La Olimpia Forest and the surrounding private lands of this region (Gallardo and Vilella 2014, Vilella and Gallardo 2016, Thorstrom 2017). Vilella and Gallardo (2016) reported the locations of SSHA in the municipalities of



Maricao, San Germán, Orocovis, Adjuntas, Jayuya, Juana Diaz, Utuado, Ponce and Peñuelas (Figure 1). During surveys conducted in the karst region of northcentral Puerto Rico in January 2011, 2 SSHA individuals also were observed in the municipalities of Arecibo and Manatí (Tetra Tech, Inc. Final Report 2011).

**e. Habitat:**

Although this species has been observed in other mountainous and forested areas in Puerto Rico outside the five forest reserves that historically have sustained its breeding population (Delannoy 2009), available information indicates populations are small and mostly restricted to montane forest reserves (Vilella and Gallardo 2016). Estimates of SSHA in Puerto Rico suggest a progressive decline in these public lands (Delannoy 1992, Delannoy 1997, Vilella and Gallardo 2016, Thorstrom 2017). Recent information also suggests this species presently might be detected more frequently in private lands of the central portions of the Cordillera Central (Vilella and Gallardo 2016). Nonetheless, the core breeding population apparently is still associated to subtropical montane habitats in TNCF and MCF (Thorstrom 2017).

Previous studies reported the SSHA was associated to montane forests dominated by caobilla (*Podocarpus coriaceus*), caimitillo (*Microphoisis chrysophylloides*), and plantations of maría (*Calophyllum antillanum*) (Delannoy 1986, Delannoy 1997). In 2007, the Puerto Rico-GAP Analysis indicated the availability of 84,859 ha of SSHA habitat, of which 24.4% is on public lands (Figure 3; Gould 2007). Later, in 2012, Vilella and Gallardo (2016) in collaboration with the Service developed a spatial habitat model to improve survey effort in the region of the MCF and adjacent private lands (Figure 3). The habitat model was developed using variables identified as important to SSHA (Cruz and Delannoy 1986) such as land cover types from the Puerto Rico GAP Analysis, forest canopy closure  $\geq 60\%$  and elevations  $\geq 400$  m (1,320 ft.) (Gould et al. 2008). Gallardo and Vilella (2017) estimated 56.1 km<sup>2</sup> of most suitable habitat ( $> 60\%$  of probability of occurrence: Figure 4), which is located over 900 m of elevation and represents  $\sim 0.6\%$  of the island's area. Public lands included only 43.8% of habitat with high probability of occurrence (24.6 km<sup>2</sup>). TNCF, Tres Pichachos, GCF, and EYNF represented 96% of the most suitable SSHA habitat. These authors also suggest that the species distribution shrank and the remaining suitable habitat is isolated in the top of the mountains.

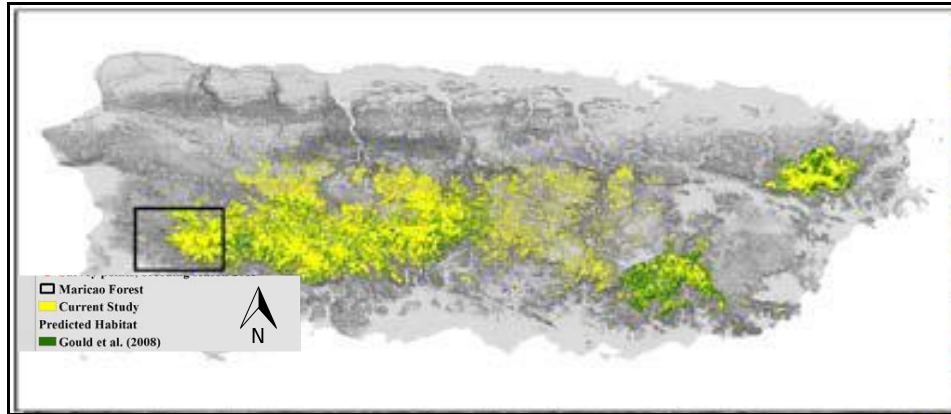


Figure 3. Spatial coverage of SSHA habitat models (Gould et al. 2008, Vilella and Gallardo 2016).

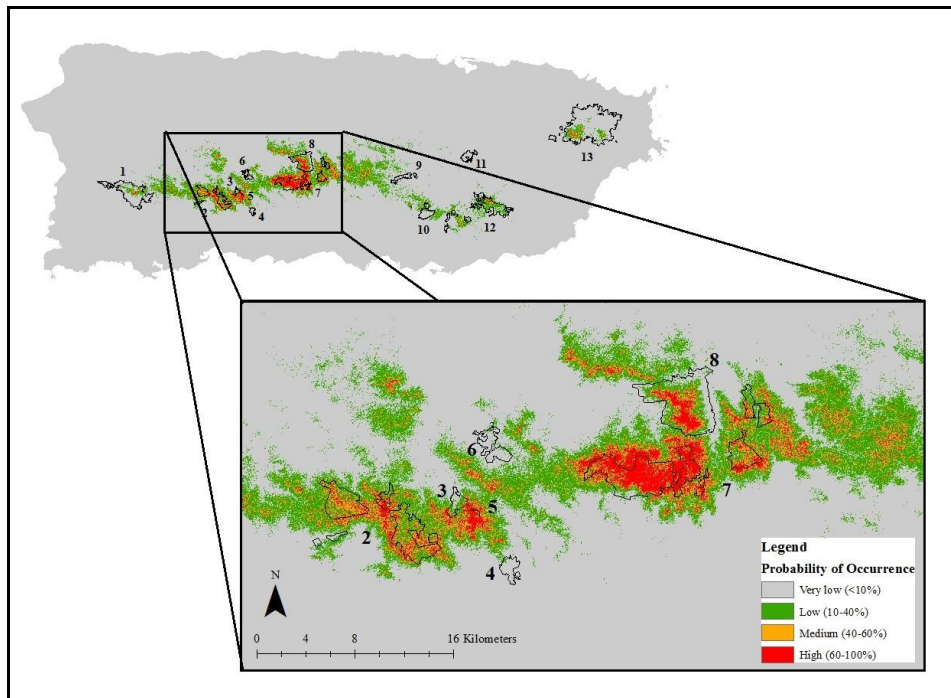


Figure 4. Habitat Suitability Model SSHA developed by Gallardo and Vilella 2017.

Vilella and Gallardo (2016) also described landscape variables of each SSHA sighting and/or nesting location between 2013 and 2016 (Table 3). On average, SSHA's locations were found at 884.4 m of elevation with a canopy closure of 64.1% and were characterized by steep slopes averaging  $19.3^\circ$  (Table 3). Cruz and Delannoy (1986) similarly reported SSHA used areas with steep slopes at MCF where timber plantations averaged  $16.8 \pm 9.1^\circ$  and native forest  $20.4 \pm 8.6^\circ$ .

Table 3. Puerto Rican Sharp-shinned Hawk sighting and/or nesting location landscape variables described by Vilella and Gallardo (2016) between 2013 to 2016.

<b>Landscape Variables</b>	<b>Mean</b>	<b>SE (<math>\pm</math>)</b>	<b>Range</b>
<b>Elevation</b>	884.4 m (2,918.5 ft.)	176.0 m (580.8 ft.)	392.5 - 1225.5 m (1,295.2 – 4,044.1 ft.)
<b>Canopy Closure</b>	64.1 %	10.8 %	30.7 – 76.8 %
<b>Slope</b>	19.3°	5.1°	10.9° - 33.4°

The SSHA in Puerto Rico was previously reported in montane forests at elevations above 400 m (1,320 ft.) (Delannoy 1986, Delannoy 1997, Vilella and Gallardo 2016). Vilella and Gallardo (2016) reported observations of SSHA ranging from 392 m (1,293.6 ft.) to 1220 m (3,960 ft.) between 2013 to 2016. However, most of the SSHA detected by these authors were at elevations between 800 m (2,640 ft.) and 1220 m (3,960 ft.). From the 17 SSHA pairs recorded, only four were detected between 600 m (1,980 ft.) to 800 m (2,640 ft.).

Territories occupied by active SSHA nesting pairs were located above 800 m (2,640 ft.) in areas with moderate slopes, similar to the nesting sites reported for the MCF by Cruz and Delannoy (1986) (Vilella and Gallardo 2016). In addition, all SSHA territories documented by Vilella and Gallardo (2016) were characterized by a forest canopy closure (i.e., >50%) similar to previous studies (Delannoy 1984, Cruz and Delannoy 1986).

Thorstrom and Gallardo (*in press*) reported nesting site characteristics for the TNCF and MCF during 2015, 2016 and 2017.

Breeding season 2015: In the TNCF, the six SSHA nests were located in 5 tree species. The two nests in the MCF differed from the TNCF nests, as both were in and near maintained forest garden landscapes in public use areas and at lower elevations.

Breeding season 2016: In the TNCF, the eight SSHA nests were in 6 tree species and in MCF Forest, the nests were in 4 tree species. Six nesting pairs built new nests that averaged 37 m from their nests built in 2015. The two second nesting attempts, were new nests built 113 and 173 m from their first nesting attempts, respectively.

Breeding season 2017: In the TNCF, the 11 SSHA nests were in 4 tree species with 67% in *Micropholis chrysophylloides*, in the MCF Forest 6 SSHA nests were recorded but one was not used as the pair nested in another nest 180 m north and the first nesting in the GCF was documented. Of the two second nesting attempts observed: one was in the same nest at one site by an adult female that replaced a failed nesting attempt by a juvenile-plumaged female and the other was 130 m from the pair's first nesting attempt.

Summary Nesting Sites Characteristics between 2015 and 2017 (Table 4):

Twenty-nine SSHA nests were in 14 trees species with 38% (n = 11 nest trees) in *Micropholis chrysophylloides* (Caimitillo). Nesting site characteristics for the three breeding seasons were; nest trees averaged 12.5 m (range 6.5-21.7 m) above the ground in trees 40.6 cm in diameter-at-breast height (range 13.2-102.2 cm) and 15.3 m tall (range 8-30 m). Nest trees averaged 993.5 m elevation (range 759-1252 m), on 21.1 degrees (range 1-44°) slopes and 107 m (range 0-370 m) from the nearest creek.

Table 4. Puerto Rican Sharp-shinned Hawk nesting sites characteristics (mean and range) described by Thorstrom and Gallardo (*in press*) between 2015 to 2017.

Forest reserve	Nest height (m)	Nest tree DBH (cm)	Nest tree height (m)	Elevation (m)	Slope	Distance to nearest creek (m)
<b>TNCF (19 nests)</b>	12.3 (7.6 - 21.7)	42.1 (18.1 - 102.2)	15.2 (8 - 30)	1033.6 (902.8 - 1252)	21.4° (5 - 44°)	69.2 (0 - 289)
<b>MCF (9 nests)</b>	10.4 (6.5 - 15)	31.1 (13.2 - 57.3)	12.4 (8 - 17.5)	774.3 (759 - 893)	14.9° (1 - 33°)	243.9 (195 - 370)
<b>GCF (1 nest)</b>	12.8	26.6	15.8	854	17°	115

Although at present approximately 40% of Puerto Rico is covered by mature (i.e., 60-year old) secondary forest (Grau et al. 2003) and the forested lands have increased throughout the years, the SSHA has not shown a geographic expansion to occupy these mature and young secondary forests. Perhaps these secondary forests do not yet have the structural characteristics required to sustain populations of this species (Delannoy 2009). Unfortunately, with the exception of few non-comprehensive surveys and basic information on its natural history (Danforth 1936, Biaggi 1974), no systematic monitoring of this species was conducted until early to mid-1980s (Delannoy 1986, Vilella and Gallardo 2016). Moreover, about 20 years passed until new comprehensive surveys began in 2013. Therefore, no detailed information exists to determine the factors that might have negatively affected the SSHA during those two decades (Vilella and Gallardo 2016, Thorstrom 2017).

## 2. Five Factor Analysis

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

When the species was listed in 1994, destruction and modification of its habitat was identified as one of the most significant factors that affected the number and distribution of SSHA in Puerto Rico (Service 1994, Service

1997). Although this species has been observed in mountainous and forested public and private areas in the Island, available information indicates that presently the populations persist in low numbers, and are mostly restricted to montane forest reserves (i.e., MCF, TNCF, and GCF) (Vilella and Gallardo 2016, Thorstrom 2017).

The majority of the forested areas in Puerto Rico have been impacted by agricultural practices; extraction of timber for construction and charcoal (Dominguez-Cristobal 2000,; Dominguez-Cristobal 2008.); development of infrastructure for utilities and communications; and construction of roads, recreational facilities, and trails, negatively affecting SSHA habitat (Delannoy 1997, Service 1994, 1997).

Currently, both the PRDNER and USFS manage the forests for conservation purposes that sustain the majority of the SSHA populations (Puerto Rico Statewide Assessment and Strategies for Forest Resources 2010, El Yunque National Forest Land and Resource Management Plan in revision 2017). Habitat modification pressures from agriculture practices, construction of residential projects, and development of new infrastructure adjacent to these forests are currently very low. However, Castro-Prieto et al. (2017) mentioned that urban sprawl is increasing in the boundaries of many protected areas, especially in the east of the Island where the EYNF and the CCF are located.

Improvements to existing infrastructure within these public forests, typical forest management of existing disturbed areas (e.g., trail maintenance, road maintenance, maintenance of communication towers, and recreational facility improvements) and research activities (e.g., species surveys, endangered species reintroductions) are regulated and coordinated with consulting agencies (i.e., PRDNER and USFWS). The above-mentioned activities are not presently affecting SSHA habitat within these forests. However, the timber harvest within Commonwealth forests and the expansion of existing facilities (e.g., communication facilities, other utilities, roads, buildings) within the forests are still a possibility and may result in the degradation of suitable SSHA habitat. However, low-intensity management of some timber plantations may increase SSHA suitable habitat structure for hunting (Gallardo pers. comm. 2018).

Although the threats to the species and its habitat have been minimized within the lands managed and administered by USFS and PRDNER, the species could be threatened with habitat destruction, fragmentation, and degradation in private lands adjacent to MCF, GCF and TNCF. Pares-Ramos et al. (2008) stated that Puerto Rico has experienced an increasing demand for urban structures, particularly residential buildings. As in many developed countries, this translates into a migration from urban centers to suburban areas. Researchers have predicted that this tendency of urban expansion is

having an impact on secondary forests (Thomlinson and Rivera 2000) and the remaining agricultural lands as those adjacent to these protected lands. Recent information suggests the SSHA is also present in private lands of the central portions of the Cordillera Central (Vilella and Gallardo 2016). The private lands of this region are known to be susceptible to habitat modification caused by unsustainable agricultural practices and other land uses requiring vegetation clearance (e.g., deforestation, monoculture of minor fruits, livestock related activities, human-induced fires, residential use, road improvements). The majority of these areas were converted into agricultural lands several decades ago, resulting in the elimination of native forest, thus reducing the habitat value for wildlife. Although agriculture in some of these lands was abandoned and the forest is growing back, the previous encroachments on the forested areas and the associated edge effects have degraded the habitat of forest-dependent species such as the SSHA.

Historically, the SSHA has not been frequently detected in EYNF and CCF, and serious concern has been raised regarding the viability of the SSHA populations in eastern Puerto Rico (Delannoy 1997). Although these forests may have suitable habitat for this species, the SSHA populations experienced a 93% and 59% decline in EYNF and CCF, respectively over a 7-year period between the 1980s and 1990s (Delannoy 1997). Delannoy (1997) has suggested that the causes for such decline may be complex, and may have resulted in part from the impact of hurricanes, and the low probability of dispersal due to the isolation of CCF and EYNF from the central mountain range of Puerto Rico. The urban areas around EYNF for example, increased by more than 2,000 percent between 1936 and 1988, and continue to encroach on forested areas (Thomlinson and Rivera 2000). Between 1988 and 1993, urbanization around this forest increased by 31 percent, representing a 5 percent loss in vegetative cover, more than 80 percent of which was dense forest (Thomlinson and Rivera 2000). Recently, Castro-Prieto et al. (2017) reported that from 2000 to 2010 the highest increases in population and housing occurred within 1 km of the boundaries of the protected areas located in the eastern part of the island (e.g., El Yunque National Forest with >800%) and central-east (e.g., Carite Commonwealth Forest with >700%).

Gould *et al.* (2007) suggested there is an increasing urbanization trend of the limited land area of eastern Puerto Rico where these forests are located. Urban development in this region increased more than 15 percent between 1991 and 2003 (Gould *et al.* 2007). Although the most evident land-use changes in the last 25 years have been the intensification of urbanization that surrounds EYNF and CCF (Helmer 2004, Gould *et al.* 2007, Martinuzzi *et al.* 2007), it is not known how much of these lands currently contain SSHA suitable habitat.

The SSHA's restricted distribution makes it vulnerable to habitat destruction and fragmentation. Although the threats to the species and its habitat have been minimized within the lands managed and administered by USFS and PRDNER, the agricultural activities and development projects on private lands adjacent to these reserves might result in the loss of habitat, and probably more important, in fragmentation and isolation of the species' suitable habitat. Delannoy (1997) stated that not only these habitat modifications could result in substantial habitat alteration and fragmentation, but also it could provide an ever increasing and chronic source of human disturbance, reducing significantly, the habitat effectiveness for this species. Any activities that potentially modify the structural features of vegetation in SSHA nesting and foraging areas could reduce the effective population size of this species (Delannoy 1997).

The majority of extant SSHA populations occur in public lands managed for conservation purposes where activities that may affect the species or its habitat are regulated based on agencies management mandates. However, there are some regular maintenance and management actions such as timber harvest, expansion of existing facilities (i.e., communication, buildings and recreational areas), and roads and trail maintenance that may result in habitat destruction and modification within these forests making this species vulnerable to these activities.

Based on the above information, habitat curtailment or modification continues to be a moderate and non-imminent threat to the SSHA. The fragmented habitat resulting from different sources and the apparent unsuitability of the emerging forests appears to be an important cause for the restricted distribution and limited abundance of the SSHA.

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

At present, we are not aware that overutilization of this specie for commercial, scientific or educational purposes has occurred, or is currently occurring. However, in 2015 an adult SSHA breeder female was observed on its nest at TNCF with "Falconry Jesses" attached to its legs (Gallardo 2015 pers. comm.). Apparently, this female was captured and kept illegally in captivity for falconry purposes for an undetermined period.

Although this is the first and only known event of an apparent utilization of this species for recreational purposes ever, the frequency with which this species was recently detected by Vilella and Gallardo (2016) within private lands of the Cordillera Central make this species vulnerable to this threat. However, falconry is not a common activity in Puerto Rico and it is legally regulated by PRDNER. Moreover, a new falconry regulation for Puerto Rico was reviewed by the Service in 2014 and is awaiting approval by the

PRDNER under the State applicable laws. This regulation clearly establishes the specific species that are allowed for falconry purposes and the areas where this activity is allowed in Puerto Rico. The regulation clearly prohibits the use of listed species and the practice of this activity within Commonwealth Forest.

Thus, the Service considers this factor as a low and non-imminent threat to the Puerto Rican sharp-shinned hawk.

**(c) Disease or predation:**

At the time of listing, bot fly (*Philornis* spp.) parasitism was considered a serious threat to this species population in Puerto Rico (Delannoy 1997).

The parasitic larvae of the bot fly can debilitate, affect the growth and development, cause permanent damage to tissues and organs, and it can kill the host (Cruz and Delannoy 1986; Delannoy and Cruz 1991). The rate of infestation varied between years and among forests, but very few SSHA nestlings survived once they were parasitized (Cruz and Delannoy 1986). During the 1980s, mortality of SSHA nestlings was higher in parasitized than unparasitized nestlings in the MCF; suggesting that *Philornis* ectoparasitism had an additive effect in overall mortality (Delannoy and Cruz 1986; Delannoy and Cruz 1991). Moreover, it was reported that bot fly ectoparasitism caused significant SSHA nestling losses in EYNF population by the same period (Snyder et al., 1987, Delannoy 1997) and over one third of nesting failures in the MCF (Delannoy 1984).

Recently, Thorstrom (2017) reported an overall productivity of 1.1 young SSHA fledged per nesting attempt, with an overall nest success of 47%. Forty-two young successfully fledged (i.e., 7 males, 9 females and 26 undetermined age) in MCF and TNCF. These productivity results differ from those reported by Delannoy (1984), and suggested the productivity results between 2015 and 2017 were higher due to the lower incident of bot fly parasitism registered during the three study years (Thorstrom and Gallardo *in press*). However, this low incident of parasitism may be a result of the treatment protocol that was followed by this author where he applied a dose of the insecticide Fipronil to prevent and control bot fly infestations. Thorstrom and Gallardo (*in press*) reported one bot fly infestation on a nestling in 2015, all SSHA nestlings treated during 2016 nesting season had no bot fly infestations and all fledged successfully, and that no parasitic bot fly larvae were observed in nestlings during 2017.

These preliminary results are important because there is no previous information available to determine the influence of this factor given the lack



of research and monitoring efforts on the SSHA during the past 20-25 years (Vilella and Gallardo 2016). However, the Service believes there is enough evidence to determine that bot fly parasitism is still affecting the persistence of this species in Puerto Rico (Delannoy 1986, Delannoy 1997, Vilella and Gallardo 2016, Thorstrom 2017). Although the treatment protocol followed by Thorstrom (2017) seemed to highly decrease the probability mortality of nestlings, at present, the Service does not have conclusive information that would support that without intensive management the bot fly parasitism has diminished in this species.

With regard to predation, although no recent information exists to determine the impacts of pearly-eyed thrashers (*Margarops fuscatus*) on the SSHA population in Puerto Rico, Delannoy (1997) supports the hypothesis that the virtual disappearance of the SSHA at EYNF might have been caused by an increase in pearly-eyed thrashers from the 1970's to the 1980's. This precipitous increase in the thrasher population apparently had a significant and possibly irrevocable impact on the SSHA population (Delannoy 1997). Pearly-eyed thrashers may represent a direct predation threat to SSHA eggs and nestlings; but more importantly, they represent a direct threat to the small-bird food supply of the SSHA (Delannoy 1997). The abundance of small birds is, in general, negatively related to abundance of these thrashers in Puerto Rico, very possibly due to direct predation (Delannoy 1997). According to Delannoy (1997), counts by J. W. Wiley in EYNF through 1986 have indicated steadily increasing thrasher populations coupled with steadily declining populations of other small birds. We do not have recent data on pearly-eyed thrasher impacts but if the pearly-eyed thrasher is in fact negatively affecting SSHA population, the impacts to the species could be irrevocable due to the restricted distribution and limited numbers of SSHA in Puerto Rico.

Furthermore, as other small raptors species in Puerto Rico, the SSHA may be also threatened by the predation of the Red-tailed hawk (*Buteo jamaicensis jamaicensis*). Recently (i.e., March 2018), one adult female was killed at her nest before egg laying. The female was plucked in the nest with primaries and secondary feathers found on the forest floor suggesting the predation due to a Red-tailed Hawk (Thorstrom, pers. comm.)

Therefore, based on the above information disease and/or predation continues to be an important factor threatening the SSHA. The Service considers that the magnitude of this threat is high and imminent because studies suggest that parasitism by the bot fly has an additive effect on the overall nestling mortality (i.e., in addition to other mortality factors).

**(d) Inadequacy of existing regulatory mechanisms:**

In 1999, the Commonwealth of Puerto Rico approved the Law No. 241-1999, known as the New Wildlife Law of Puerto Rico (*Nueva Ley de Vida Silvestre de Puerto Rico*). The purpose of this law is to, among other things, protect, conserve, and enhance both native and migratory wildlife species; declare as property of Puerto Rico all wildlife species within its jurisdiction; issue permits; regulate hunting activities; and regulate exotic species. In 2004, the Commonwealth of Puerto Rico approved the Regulation to Govern the Management of Vulnerable and Endangered Species on the Commonwealth of Puerto Rico (Regulation 6766; *Reglamento para Regir el Manejo de las Especies Vulnerables y en Peligro de Extinción en el Estado Libre Asociado de Puerto Rico*). This Regulation prohibits collection, killing, or harming species listed under in it, as well as the possessing, transporting, or selling items derived from listed species, and requires authorization from the PRDNER Secretary for any action that may affect designated critical habitat of listed species under this regulation (PRDNER 2004). In 2004, the Commonwealth of Puerto Rico included the SSHA in Regulation 6766 as a “critically endangered” (species that are facing an extremely high risk of extinction in the immediate future).

In addition to laws that specifically protect the SSHA, the MCF, TNCF, GCF and CCF are protected under Puerto Rico’s Forests Law (Law No. 133-1975; *Ley de Bosques de Puerto Rico*), as amended in 2000, which prohibits causing damage to and collection of flora and fauna in public forests. Moreover, all Commonwealth forests are designated as Critical Wildlife Areas (CWA) by PRDNER. The CWA designation constitutes a special recognition by this agency with the purpose of providing information to other Commonwealth and Federal agencies about the conservation needs of these areas, and assisting permitting agencies in precluding negative impacts as a result of permit approvals or endorsements (PRDNER 2005).

The Migratory Bird Treaty Act (MBTA) (16 U.S.C. 703-712) provides protection for the SSHA, which is defined as a migratory bird under the MBTA. The MBTA makes it unlawful to pursue; hunt; take; capture; kill; attempt to take, capture, or kill; possess; offer for sale; sell; offer to barter; barter; offer to purchase; purchase; deliver for shipment; ship; export; import; cause to be shipped, exported, or imported; deliver for transportation; transport or cause to be transported; carry or cause to be carried; or receive for shipment, transportation, carriage, or export, any migratory bird, or any part, nest, or egg of such bird, or any product, whether or not manufactured, which consists of, or is comprised in whole or part, of any such bird, or any part, nest, or egg thereof. However, no provisions in the MBTA prevent habitat destruction unless direct (not incidental or accidental) mortality or destruction of occupied nests occurs.

Finally, the SSHA co-occurs with other species that are listed under the Act. Because of the occurrence of other federally listed species within the same

habitat where SSHAs are found, any Federal action, funding, or permit within these forests or in adjacent private lands that may affect these listed species requires a section 7 consultation under the Act. Therefore, the SSHA may benefit from indirect protection of these listed species as well (i.e., implementation of habitat restoration practices and habitat protection).

Based on the information currently available to us, the Federal and Commonwealth regulatory mechanisms are being implemented and are functioning as designed. Lack of enforcement of these laws and regulations has not been identified as having a negative impact to the species or exacerbating other negative effects to the species.

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

Hurricanes

The geographic location of Puerto Rico in the Caribbean makes it prone to hurricane impacts (Wiley and Wunderle 1993, p. 320). Hurricanes can have both direct and indirect effects on bird populations, which may determine the characteristics of local avifauna (Wauer and Wunderle 1992; Wunderle *et al.* 1992). It has been suggested that SSHA is susceptible to natural habitat disturbances or catastrophic weather events such as hurricanes due to its restricted distribution, low number of individuals and specific habitat requirement (i.e., mature forests that may not be available in storm-damaged forests) (Delannoy 1997, Service 1997). Since the 1980s, the SSHA has experienced a drastic population decline (Delannoy 1997, Vilella and Gallardo 2016, Thorstrom 2017, Thorstrom and Gallardo *in press*), attributed in part to direct and indirect effects of Hurricane Hugo in 1989 and Hurricane Georges in 1998. For example, although the effect of Hurricane Georges on this species was not evaluated, Tossas (2006) documented its detrimental effect on bird species preyed upon by the SSHA in MCF. Moreover, in September 2017, Puerto Rico was hit by two major hurricanes: Irma and María. Hurricane Irma (Category 4) passed along the northeast coast of Puerto Rico affecting EYNF. Two weeks later Hurricane María (Category 5) made landfall in southeast Puerto Rico crossed the Island diagonally, and exited near the municipality of Arecibo in the north. This hurricane caused extensive damage, particularly in the forested mountainous region where the SSHA is found.

Changes in forest structure and floristic composition following hurricanes Hugo and Georges probably contributed to the decline of the SSHA in Puerto Rico (Vilella and Gallardo 2016), and the effects of hurricanes Irma and Maria on the species are still unknown. Recent post hurricane rapid population status assessments suggested the Island-wide SSHA population decreased to about 20 individuals after the Hurricane María (Thorstrom and Gallardo *unpublished data*). Post-hurricane conditions influence forest

succession, with corresponding changes in forest structure and floristic composition as a direct result of defoliation, loss of trees, loss of tree branches, opening of the canopy and formation of light gaps from extensive blowdowns (Boose et al. 2004, Vilella and Gallardo 2016). Therefore, these natural events may have negatively affected critical SSHA resources including, loss of adequate nest structures (branch and nesting trees loss) and an increase of understory and midstory cover from a reduction in canopy cover. These conditions would result in a reduction of suitable habitat conditions for a raptor species adapted to hunting small avian prey under the forest canopy (Vilella and Gallardo 2016). In addition, as stated above hurricanes influence the bird species community preyed upon by the SSHA, which can reduce the survival of this species.

Hurricanes can have positive effects on forest and bird ecology by temporarily increasing forest productivity (Wiley and Wunderle 1993), particularly for species with ample distribution (White *et al.* 2014). However, the immediate negative effects of these powerful atmospheric events for a species with demographically vulnerable populations, such as the SSHA, outweigh the benefits accrued via short-term primary productivity of vegetation (White *et al.* 2014). Based on this information, it is possible that the SSHA experience local extirpations as a result of these catastrophic weather events, which could explain the declining SSHA population trend documented in Puerto Rico (Delannoy 1997, Vilella and Gallardo 2016, Thorstrom 2017, Thorstrom and Gallardo *in press*). Studies predict an increase in hurricane intensity in the Atlantic, with higher wind speeds and greater amounts of precipitation (Jennings *et al.* 2014). Therefore, this threat can have serious negative impact on the SSHA and its habitat.

### Climate Change

General long-term climate changes have been observed, including changes in amount of precipitation, wind patterns, and extreme weather events (e.g., droughts, heavy precipitation, heat waves, and the intensity of tropical cyclones) (Intergovernmental Panel on Climate Change (IPCC) 2014). For example, projected decreases in precipitation in the Caribbean suggest drier wet seasons, and even drier dry seasons (Jennings *et al.* 2014). As previously mentioned, the SSHA is currently known only from specific habitat types at few locations in Puerto Rico, which makes the species susceptible to the effects of climate change. It has been stated that higher temperatures, changes in precipitation patterns, and any alteration in cloud cover will affect plant communities and ecosystem processes in montane forest of Puerto Rico (Lasso and Ackerman 2003). In fact, the distribution of tropical forest life zones in the Caribbean is expected to be altered due to both intensified extreme weather events and progressively drier summer months (Wunderle and Arendt 2011). Forest types over 800 m in elevation also are very sensitive to climate change because of their occurrence in narrowly defined

environmental conditions (Lasso and Ackerman 2003). Although the available information predicting changes in habitat in Puerto Rico due to climate change pertains to EYNF, it is reasonable to expect that similar changes could happen at the MCF, TNCF, GCF and CCF, which lies within two of the same life zones as EYNF.

According to Arendt *et al.* (2013), approximately 50 percent of the Caribbean birds show medium to high vulnerability to climate change. Based on that information, species that are dependent on specific habitat types, and that have limited distribution or have become restricted in their range, like the SSHA, will be most susceptible to the effects of climate change. However, while continued change is expected, the magnitude and rate of that change is unknown in many cases. In tropical and subtropical forests, significant knowledge gaps exist in predicting the response of natural systems to climate change, and uncertainties exist with studies forecasting trends in climate (Jennings *et al.* 2014). Moreover, regionally downscaled climate models projecting temperature and precipitation patterns at fine scales are not readily available for locations within the Caribbean region, including Puerto Rico (Jennings *et al.* 2014). While existing large-scale global climate models are useful in determining potential future trends (Angeles *et al.* 2007), the lack of fine-scale data in Puerto Rico's mountainous regions is especially troublesome, as variations in climate with elevation over short horizontal distances cannot be captured by existing climate models, especially in predictions of extreme events (Meehl *et al.* 2007).

### Fires

Fires are not part of the natural processes for subtropical and moist forests (Santiago-Garcia *et al.* 2008). Méndez-Tejeda *et al.* (2015) concluded that the majority of forests fires in Puerto Rico are produced by human actions. However, historical evidence suggests fire frequency in the Island is increasing (Burney *et al.* 1994; Robbins *et al.* 2008). The interactions between climate warming and drying, and past increased human development have the potential to increase the effects of fires (Robbins *et al.* 2008).

Fires are not common in TNCF, GCF, EYNF, CCF and adjacent lands, and are considered human-induced, occurring mostly along roads. Nonetheless, they have the potential to extend into forested lands affecting suitable SSHA habitat. In the MCF area (i.e., municipalities of Sabana Grande and San Germán), fires occur more frequently on the southern dry slopes of the forest and in adjacent private lands, particularly during the dry season (Avila 2014, pers. comm.).

Human-induced fires modify the landscape and ecological conditions of the habitat by promoting growth of nonnative trees and grasses (Brandeis and Woodall 2008). These landscape modifications may reduce the quality and

quantity of potential SSHA habitat. Moreover, habitat modification by fires affects the dispersal of the SSHAs, as fewer forested habitats are available. Although the primary habitat for the SSHA in the forests mentioned above is not prone to fire disturbance because of their location in the highest peaks, suitable habitat at lower elevations might be in danger if fires extend uphill from roads or private lands.

Non-natural factors that might also be affecting the SSHA are the inappropriate selection of sites for recreation development, uncontrolled public visitation (Delannoy (1997)), regular trail maintenance activities, and the lack of Commonwealth Forest-specific management plans for the forest reserves. However, in Factor A we stated that currently agencies manage their forests for conservation purposes. Still, typical forest management of existing disturbed areas (e.g., trail maintenance, road maintenance, maintenance of communication facilities (antennas), and recreational facilities improvements) and research activities (e.g., species surveys, endangered species reintroductions) still occur within these forests. We stated that the maintenance performed on roads, trails, antennas, and recreational facilities is not presently affecting SSHA habitat within these forests. However, practices such as timber harvest, expansion of existing facilities (i.e., communication facilities, access roads, access gates, administration buildings, utilities) within the forests is still a possibility and may result in the degradation of suitable SSHA habitat.

The final rule states that the potential for illegal shooting of SSHA constitutes a serious threat to the survival of the species. However, the recovery plan does not mention illegal shooting as a threat to the SSHA. At present, we are not aware that illegal shooting of the species has occurred, or is currently occurring.

Based on the above information, the limited distribution and low population numbers of this species, the Service considers other natural or manmade factors as high and non-imminent threats to the SSHA.

### **3. Synthesis**

The SSHA is a subspecies endemic to Puerto Rico, and restricted to the montane forests of the Cordillera Central, Sierra de Cayey, and Sierra de Luquillo. This subspecies was listed as endangered under the ESA on September 9, 1994. In 1997, its island-wide population was estimated at 150 individuals. Surveys conducted between 2013 and 2017 indicate the island-wide SSHA population declined to about 100 individuals, and that the species has mostly disappeared from its former center of distribution, the MCF. However, post hurricane rapid population status assessments conducted in 2018 after Hurricane María suggested the Island-wide SSHA population has

decreased now to about 20 individuals (Thorstrom and Gallardo *unpublished data*).

The Recovery Plan of this species identifies habitat destruction and modification, low population numbers and restricted distribution, devastation from hurricanes, parasitism by bot fly, and lack of comprehensive Commonwealth Forests' management plans as the most significant factors affecting the numbers and distribution of the species. However, habitat destruction or modification throughout the range of the SSHA has been identified as one of the major threats to this species. Although this threat is low within the lands managed and administered by USFS and PRDNER, the species is still apparently threatened by the fragmentation of forested lands in the central mountainous range of Puerto Rico.

Natural and manmade factors (i.e., hurricanes, habitat fragmentation) also continue threatening the SSHA. Some of these factors currently represent a higher threat to the species than when it was listed. The additive effect on the overall mortality due to external parasites in nestlings, natural events such as hurricanes, human-induced disturbances (*e.g.*, human-induced fires, illegal poaching), and the undetermined potential effects of changes in climate are considered a cause for the reduction in the overall SSHA population in Puerto Rico that is occurring.

Currently, we do not have substantive data indicating that overutilization for commercial, scientific or educational purposes is a threat to this species. However, the documented event of a SSHA with falconry gear suggests this factor might now represent a threat to the species. Furthermore, there is no evidence supporting lack of enforcement of regulations that protect the SSHA. Thus, the inadequacy of existing regulatory mechanisms is not considered a threat to this species.

In conclusion, the cumulative effects of habitat modification by human actions and natural events make the SSHA more vulnerable to extinction due to its restricted distribution, limited population numbers, and specific ecological requirements. Therefore, urgent conservation and management actions are needed to prevent the extinction of this endangered raptor of Puerto Rico.

### **III. RESULTS**

#### **A. Recommended Classification:**

  X   **No change is needed.**

**B. New Recovery Priority Number:   6  .**

Based on the information gathered for this review, we believe that SSHA has a high degree of threat and low recovery potential. This species is now more vulnerable to extinction than at the time of listing due to its limited distribution, island-wide population progressive decline, virtual disappearance from its former center of distribution, specific ecological requirements, uncertainty of natural events, and the detrimental impacts the habitat modification would have in its diminished populations.

#### **IV. RECOMMENDATIONS FOR FUTURE ACTIONS**

1. Continue the assessment of SSHA populations to determine population trends, abundance and distribution by conducting island-wide surveys within traditional and non-traditional sites. Particularly, it is important to evaluate populations within forest reserves and adjacent private lands. Spreading out surveys into adjacent private lands is particularly important to determine the existence of other SSHA breeding and viable populations.
2. Determine daily and seasonal movement patterns to obtain valuable information on habitat use using radio-telemetry and colored bands to understand the home range dynamics and movement of this species. This may help to assess if there is movement of individuals among forest reserves and to identify potential suitable habitat in non-traditional areas as well as survival of the species.
3. Continue monitoring of breeding pairs at nest sites in TNCF and MCF, and increase the nesting sites searching efforts within GCF and private lands of the Cordillera Central.
4. Determine genetics and demography of the breeding populations and the potential consequences of inbreeding, low recruitment, genetic drift and degradation, effective population size and population viability.
5. Continue the assessment of bot fly parasitism (prevalence and nestling mortality) effects in the SSHA breeding population and determine an action plan to provide treatment when needed to increase their survival and fledging success.
6. Develop SSHA management strategies or plans for each forest reserve to establish buffer zones and effective controls to restrict human activities within established hawk territories, particularly during the breeding season.
7. Protect and conserve private lands adjacent to SSHA habitat or where the species has been detected outside forest reserves through land acquisition, conservation easements, landowner incentive programs or any other appropriate mechanism in order to reduce degradation and promote sustainable land use practices.
8. Given the progressive decline of this species, the gaps of information on its status, and the amount of time (20 years) since publication of its recovery plan,



the delisting criteria for this species should be developed based on the new information presently available.

9. Consider the implementation of management activities such as assisted dispersal release technique developed for the critically endangered Ridgway's Hawk (*Buteo ridgwayi*) in Dominican Republic. This technique is used to assist the dispersal of young hawks into other public or private lands with suitable habitat outside of the typical breeding area documented for the species.

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## Appendix A

### Summary of peer review for the Puerto Rican sharp-shinned hawk 5-year review

This 5-year review was internally reviewed by José A. Cruz-Burgos (Caribbean Ecological Services Field Office [CESFO] Endangered Species Program Coordinator), Marelisa T. Rivera (CESFO Deputy Field Supervisor) and Edwin E. Muñiz (CESFO Field Supervisor). They provided editorial and technical comments that were included in the document. Once the comments were added to the document, it was sent to three independent peer reviewers (see below) via electronic mail. The outside peer reviewers were chosen based on their qualifications and knowledge of the species. We indicated our interest in all comments the reviewers may have about this species, specifically on any additional information on the status and current threats to the species. Most comments and recommendations provided by the reviewers were incorporated into the document and cited accordingly.

#### List of peer reviewers

**Carlos Delannoy**, Species expert, Former Professor at University of Puerto Rico, Mayagüez Campus. Cabo Rojo, Puerto Rico 00623. (787) 464-6412. [cadelannoy@yahoo.com](mailto:cadelannoy@yahoo.com)

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**Julio Gallardo**, Mississippi State University Doctoral Candidate, Department of Wildlife, Fisheries and Aquaculture, USGS Mississippi Cooperative Fish and Wildlife Research Unit, (662) 341-6617. [jcg382@msstate.edu](mailto:jcg382@msstate.edu)

The deadline for submission of peer review comments was May 10, 2018. Comments were received from the peer reviewers during the comment period. Peer reviewers' comments (C) and the Service's responses (R) are provided below.

#### Comments by Mr. Russell Thorstrom:

C: Mr. Thorstrom provided several literature citations to reflect the information from a paper in press (Thorstrom and Gallardo *in press*) which he indicated gives a better update and more information on our knowledge for this species.

R: We incorporated these citations into this five-year review and the paper in the References section.

C: Mr. Thorstrom indicated that surveys conducted between 2013 and 2017 indicate that the island-wide SSHA population has declined to about 100 individuals and not 75 individuals as stated in the five-year review.

R: We incorporated this information into the document.

C: Mr. Thorstrom indicated that no nesting attempts of SSHAs were observed within private lands of the Cordillera Central between 2013 and 2016.

R: We incorporated this information into the document.

C: Mr. Thorstrom provided and suggested to include a summary of the observation days and number of SSHAs observed at each Commonwealth and National Forests between 2015 and 2017. [In reference to the statement, that less searching time during 2015 and 2016 was spent outside TNCF.]

R: We incorporated this information into the document.

C: Mr. Thorstrom provided and suggested to include a summary of the breeding productivity numbers of 2017 and the breeding territorial behavior reported for the three breeding seasons. [In reference to the information originally provided that included breeding productivity of SSHAs during 2015 and 2016 breeding seasons but not during 2017.]

R: We incorporated this information into the document.

C: Mr. Thorstrom suggested to update the SSHA population estimates at the MCF, TNCF and GCF, and the percentage of population declining based on the results reported in Thorstrom and Gallardo (*in press*).

R: We incorporated this information into the document.

C: Mr. Thorstrom suggested to update the SSHA nesting site characteristics as reported in Thorstrom and Gallardo (*in press*).

R: We incorporated this information into the document.

C: Mr. Thorstrom indicated that of 42 young documented and only 1 case of bot fly suggesting that bot fly's parasitism has diminished. [In reference to the statement that the Service does not have conclusive information that would support that bot fly's parasitism has diminished in this species.]

R: The Service still considering that we do not have conclusive information that would support that bot fly parasitism has diminished in this species. However, the Service recognizes that with intensive management the parasitism in this species has been highly decreased. The statement was modified to reflect that without the intensive management of the species the bot fly parasitism still considered a threat that has not diminished in this species.

C: Mr. Thorstrom provided additional information regarding the predation threat SSHA might be facing due to Red-tailed hawks in Puerto Rico. He suggested including a recent predation event where a SSHA was apparently killed by a Red-tailed hawk in the MCF.



R: We incorporated this information into the document.

**Comments by Dr. Carlos Delannoy:**

C: Dr. Delannoy recommended that spreading out surveys into adjacent private lands is particularly important to determine the existence of other SSHA breeding and viable populations. [In reference to the recommendation of continue the assessment of SSHA within traditional and non-traditional sites.]

R: We incorporated this information into the document.

C: Dr. Delannoy stated that in accordance with section IV, recommendation 1 (page 24), Could the Service and its collaborators extend SSHA searches and surveys into the north-central karst region (i.e., near Arecibo and Manatí)? These efforts could once and for all corroborate or dismiss SSHA presence and status (i.e., breeding activity) on these areas.

R: We acknowledge the importance to extend SSHA surveys into non-traditional areas like the north-central karst region of Puerto Rico to comprehensively assess the island-wide status of this species. The Recommendation #1 in Section IV is inclusive when we say: “...to determine population trends, abundance and distribution by conducting island-wide surveys within traditional and non-traditional sites. Particularly, it is important to evaluate populations within forest reserves and adjacent private lands.” We also presented information that corroborates that during surveys conducted in the karst region of northcentral Puerto Rico in January 2011, 2 SSHA individuals also were observed in the municipalities of Arecibo and Manatí (Tetra Tech, Inc. Final Report 2011).

C: Dr. Delannoy recommended that this review would be more informative and complete with a brief discussion related to the genetics and demography of small populations and its consequences. Although we do not know the answers to these questions, it is something to think about, take in consideration and discuss openly.

- Do we still have a core and viable SSHA population in MCF?
- What is the sex ratio of this population? This is pertinent and important because the population sex ratio affects the effective population size.
- How effective (often) is the current recruitment of young SSHA into the breeding population?
- With an estimated population of only eight individuals left in MCF and two active nests in 2015 and 4 nesting attempts in 2016, how much inbreeding is occurring?
- Is the low SSHA effective population size in MCF enough to sustain a viable population?
- How much genetic drift and degradation has occurred in the SSHA populations of MCF and TNCF with the bottleneck experienced in the past 20 years?

R: We acknowledge we do not have at this point the answers for these questions. However, the information the Service and its collaborators has been collecting since 2013 could lead us to answer some of the questions. We included the information in the Section IV as a recommendation.

C: Dr. Delannoy mentioned that the implementation of management practices such as assisted dispersal release is a good choice and should be put to test. If this management technique is implemented in the MCF SSHA population and for some unfortunate reason fails, I suggest the following controversial action. Test the implementation of assisted dispersal of young SSHA [individuals] remaining in MCF and trap all adults and relocate them in other parts of its current range with more robust extant populations. This will bolster, strengthen, and enrich genetically the core population in TNCF. The current SSHA status is very critical. We need urgent conservation and management actions now to prevent extinction. That is the conclusion reached in this review (page 24). I do not think I have pushed the panic button. The SSHA populations have plummeted to extremely low numbers, too low for comfort.

R: As stated in the recommendation section (i.e., Section IV) of this document the implementation of the assisted dispersal technique is at this point under consideration. The main idea behind this technique is to increase genetic diversity and promote dispersal of young individuals into other public or private lands with suitable habitat outside of the typical breeding area documented for the species. We agree with Dr. Delannoy that if this technique fails, other urgent management actions should be taken to prevent the local extinction of the SSHA breeding populations. A captive breeding program and the relocation of individuals from unsuitable habitats are some of the management options.

C: Dr. Delannoy recommended that the Service should consider the alternative of establishing partnerships with the Commonwealth government of Puerto Rico and non-government organizations to start a captive breeding program. This is a last ditch and expensive initiative that should be considered and explored.

R: The Service has a strong partnership with the Puerto Rico Department of Natural and Environmental Resources, the academia and with specialized non-governmental organizations such as The Peregrine Fund to assess and manage the populations of this species. A captive breeding program is under consideration at this moment and an emergency captive initiative is ongoing since March 2018 to assist and guarantee recruitment of the small breeding populations after the Hurricane María.

**Comments by Mr. Julio Gallardo:**

C: Mr. Gallardo mentioned that he think Dr. Delannoy only conducted surveys in protected areas. [In reference to the island-wide population estimate of approximately 150 individuals reported by Delannoy 1997.]

R: We agree with Mr. Gallardo. No modifications are needed because the paragraph included in this document stated that at the time of listing, this species was known to occur



in five protected locations in Puerto Rico: MCF, TNCF, GCF and CCF, and El Yunque National Forest (EYNF former Caribbean National Forest). The information presented in this document is reporting that the island-wide population estimate reported by Delannoy 1997 was based on assessments conducted within these locations.

C: Mr. Gallardo indicated that at least 7 breeding territories found during previous studies still currently active (Delannoy 1984, Delannoy 1986, Delannoy 1992, Delannoy 1997, Gallardo and Vilella 2017, Thorstrom 2017). [In reference to the amount of breeding territories located between 2013 and 2017 within public lands by Vilella and Gallardo (2016), Gallardo and Vilella (2017) and Thorstrom (2017).]

R: We incorporated this information into the document.

C: Mr. Gallardo suggested that the population estimate reported by Thorstrom (2017) may suggests a decline greater than what was reported in this 5-year review (i.e., from 150 in 1992 to about 75 individuals in 2016) because Thorstrom (2017) included private and public lands in his surveys while Delannoy (1997) just included surveys within 5 protected public lands.

R: We incorporated this information into the document.

C: Mr. Gallardo indicated that According with the Integrated Taxonomic Information System ([www.itis.gov](http://www.itis.gov)), species with less divergence than the SSHA are recognized as full species, for example the Cuban Kite (*Chondroierax wilsonii*) and *Bubo blakistoni*. He also indicated that the information reported by J. Johnson (pers. comm.) and Thorstrom (2017) suggests that potentially the SSHA in Puerto Rico represent an endemic and separate taxon at least from the mainland populations, increasing the urgency of conservation and management actions. [In reference to the information reported by J. Johnson (pers. comm.) and Thorstrom (2017) that suggests that the divergence estimate would suggest that the SSHA subspecies diverged approximately 1.3 million years ago from the mainland populations.]

R: We incorporated part of the information into the document. We do not believe this information increase the urgency of conservation and managements actions because the SSHA was listed as a subspecies and it is fully protected by the Endangered Species Act independently of being considered a full species in the future.

C: Mr. Gallardo indicated that Gallardo and Vilella (2017) estimated 56.1 km<sup>2</sup> of most suitable habitat (> 60% of probability of occurrence), which is located over 900 m of elevation and represents ~0.6% of the island's area ad suggested to include a Habitat Vulnerability Model of this species developed by them in 2017.

R: We incorporated this information into the document.

C: Mr. Gallardo indicated that Castro-Prieto et al. (2017) suggested that urban sprawl is increasing in the boundaries of many protected areas, especially in the east of Puerto Rico.

[In reference to the statement that habitat modification pressures from agriculture practices, construction of residential projects, and development of new infrastructure adjacent to forests where the SSHA is located are currently very low.]

R: We incorporated this information into the document.

C: Mr. Gallardo indicated that low-intensity management of some timber plantation might increase suitable habitat structure for hunting. [In reference to the statement that the timber harvest within Commonwealth forests and the expansion of existing facilities (e.g., communication facilities, other utilities, roads, buildings) within the forests are still a possibility and may result in the degradation of suitable SSHA habitat.]

R: We incorporated this information into the document.

C: Mr. Gallardo suggested that Castro-Prieto et al. (2017) provided updated information. [In reference to the statement that between 1936 and 1988 the urban areas around the EYNF increased in more than 200 percent.]

R: We incorporated this information into the document.

C: Mr. Gallardo indicated that Pearly-eyed thrasher is increasingly common in highlands and could be a cause of the increasingly rare low-elevation SSHA territories. For more detail see: Arendt, W.J. 2006. Adaptations of an avian supertramp: distribution, ecology, and life history of the pearly-eyed thrasher (*Margarops fuscatus*). General Technical Report 27. United State Forest Service, International Institute of Tropical Forestry. San Juan, P.R.

R: Although we acknowledge this information, we still we no recent data to determine the impacts of pearly-eyed thrashers (*Margarops fuscatus*) on the SSHA population in Puerto Rico.

C: Mr. Gallardo indicates that the information regarding the Migratory Bird Treaty Act may create confusion because there are not reports in Puerto Rico of wintering Sharp-shinned hawks from mainland. He indicated that this may suggest a potential genetic connectivity with mainland populations and there is no evidence of it, but the opposite.

R: The information was not modified because although the species included into the MTBA list is the *Accipiter striatus* (continental species) this list also covered its subspecies. The SSHA was listed as a subspecies and at this moment, we do not have conclusive results suggesting the SSHA is a full species different from the continental species (*Accipiter striatus*).



U.S. FISH AND WILDLIFE SERVICE

5-YEAR REVIEW of the Puerto Rican sharp-shinned hawk or falcon de sierra  
(*Accipiter striatus venator*)

Current Classification: Endangered

Recommendation resulting from the 5-Year Review

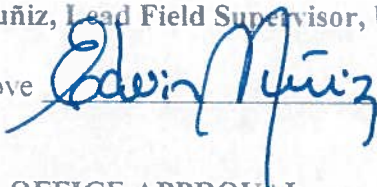
No change is needed

Review Conducted By Iván Llerandi-Román, Caribbean Field Office, Boquerón, Puerto Rico

FIELD OFFICE APPROVAL:

Edwin E. Muñoz, Lead Field Supervisor, U.S. Fish and Wildlife Service

Approve



Date


Aug 8, 2018

REGIONAL OFFICE APPROVAL:

Acting

, Regional Director, Fish and Wildlife Service

Approve



Date

9/7/13

**PR Parrot (PRP) (*Amazona vittata*)**



# PUERTORICAN PARROT RECOVERY

## Ecological Services Sub-Office

November 2010



Iguaca, Puerto Rican Parrot by Tom Mackenzie, USFWS



El Yunque, parrot habitat by Sam Hamilton, USFWS



Parrot eggs by Alejandro Avampini

**Marisel López,**  
**Project Leader**  
**PRPR ES Sub-Office**  
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**Río Grande, PR 00745**  
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### S a n Fa

- Established: 1990.
- Staff: 14 employees
- FY10 budget: \$1.515.842

**We are the primary federal agency responsible for conserving, protecting, and enhancing the Puerto Rican Parrot and its habitats.**

### S a n n

Coordinate interagency recovery efforts through partnerships and using the best available science.

Implement recovery activities, coordinate management and research for the endangered Puerto Rican Parrot (*Amazona vittata*), the only native parrot in U.S. territory.

Release captive-reared parrots into El Yunque National Forest and Rio Abajo Commonwealth Forest, managed by the US Forest Service (USFS) and the Puerto Rico Department of Natural and Environmental Resources (DNER), respectively.

Manage the Iguaca Aviary and provide state-of-the-art veterinary care to captive reared and wild parrots.

Promote conservation of habitat for the Puerto Rican Parrot and other endangered, native, and migratory bird species.

Promote international technology interchange and assist other nations manage vulnerable bird species.

Promote awareness and education for the plight of the Puerto Rican Parrot.

### Ada e ana emen and Da a In e a n

We work with DNER, USFS, and North Carolina State University, using adaptive management and structured decision making to evaluate sites to reintroduce a third population of Puerto Rican parrot.

Refine management practices in collaboration with the US Geological Survey, Mississippi State University, Lincoln Park Zoo, Disney's Animal Kingdom, and the University of Puerto Rico

### A y 010

Conducted two population surveys that show the population in El Yunque is low but remains stable, and the new wild population in Rio Abajo is stable and slowly increasing.

Gathered field data to assess suitable habitat for a third population of Puerto Rican Parrots. Also, designed and coordinated research projects to develop and refine techniques for the reintroduction of captive-raised parrots into the wild.

Continue to restore nest cavities and field infrastructure in El Yunque National Forest. We exchange technology and technical assistance with DNER to conduct similar activities at the Rio Abajo Forest.

Continue to implement innovative solutions to deal with predators, competitors and diseases.

Optimize captive population reproduction by manipulating wild nests and facilitating surrogate parents of active wild nests, among other techniques.

Provided technical assistance to biologists and technicians in Chile and the Dominican Republic to aid vulnerable bird species in those countries.

**Puerto Rican Parrot**  
*(Amazona vittata)*

**5-Year Review:**  
**Summary and Evaluation**

**U.S. Fish and Wildlife Service**  
**Southeast Region**  
**Ecological Services**  
**Rio Grande, Puerto Rico**



**5-YEAR REVIEW**  
**Puerto Rican Parrot (*Amazona vittata*)**

**I. GENERAL INFORMATION**

**A. Methodology used to complete the review:** This 5-year review was prepared by the lead Service recovery biologist for the parrot and summarizes new information that the Service has gathered in the construction of the draft revised Recovery Plan approved and released on June 17, 2008. Public notice of this review was given in the *Federal Register* on September 12, 2005, with a 60-day public comment period. The notice requested new information concerning the biology and status of the species. A 60-day comment period was opened. No information on the Puerto Rican parrot was received from the public.

**B. Reviewers**

**Lead Region:** Kelly Bibb, Southeast Region, (404) 679-7132

**Lead Field Office:** Pablo Torres-Báez, Caribbean Ecological Services Field Office, Río Grande, Puerto Rico.(787) 887-8769, extension 226.

**C. Background**

**1. FR Notice citation announcing initiation of this review:** September 12, 2005; 70 FR 53807.

**2. Species Status: 2007, 2008 Recovery Data Call - Stable.** The population of Puerto Rican parrot in the wild has remained around 50 individuals. This includes the historical population at El Yunque National Forest or YNF (known before as the Caribbean National Forest) and the recently introduced population in the northern karst region in the Río Abajo Forest (RAF). During 2007- 2008 surveys, we detected 26-30 birds at El Yunque National Forest. The last survey for the northern karst region detected 26 birds. The captive populations at both aviaries have increased during the past year, especially during 2007 and 2008 when both aviaries produced a total of 50 and 40 chicks respectively. The captive populations consist of 228 birds.

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

**4. Listing History**

Original Listing

FR notice: 32 FR 4001

Date listed: March 11, 1967

Entity listed: Species

Classification: Endangered

**5. Associated Rulemakings:** None.

**6. Review History:** Since 1973, the Service has conducted periodic surveys to determine the Puerto Rican parrot population trends (Appendix 1). These surveys are conducted by Service biologists from the Puerto Rican Parrot Recovery Field Office, and personnel from the YNF and Puerto Rico Department of Natural and Environmental Resources (DNER).

The Service approved and signed the Puerto Rican Parrot Recovery Plan on April 8, 1987. In July 1989, the captive Breeding Specialist Group published the Population Viability Analysis (PVA) for the species. The PVA analysis was based on the information and expert opinion of the parrot field biologists and population biology of the parrot. The aviary personnel provided information on the captive flock, which proved to be the key for the development of a master plan for the captive population. The final report provided recommendations and identified management needs for the wild and captive populations. The proposal to establish a second captive and wild population to reduce the risk of losing the species to the effects of catastrophic events was among the most important recommendations.

The Service conducted a five-year review for the parrot in 1991 (56 FR 56882). In this review, the status of many species was simultaneously evaluated with no in-depth assessment of the five factors or threats as they pertain to the individual species. The notice stated that the Service was seeking any new or additional information reflecting the necessity of a change in the status of the species under review. The notice indicated that if significant data were available warranting a change in a species' classification, the Service would propose a rule to modify the species' status. No change in the parrot's listing classification was found to be appropriate.

The Service announced the technical agency draft revised recovery plan for the Puerto Rican parrot on June 17, 2008 (73 FR 34313).

**7. Species' Recovery Priority Number at start of review (48 FR 43098):** 2 The Puerto Rican Parrot is recognized as a species with high degree of threat and high recovery potential.

**8. Recovery Plan or Outline:**

Name of plan: Puerto Rican Parrot Recovery Plan.

Date issued: April 8, 1987.

The Service recently released a draft revised recovery plan for the parrot as stated above.



## II. REVIEW ANALYSIS

### A. Application of the 1996 Distinct Population Segment (DPS) policy:

1. Is the species under review listed as a DPS? No.
2. Is there relevant new information that would lead you to consider listing this species as a DPS in accordance with 1996 policy? No.

### B. Recovery Criteria

1. Does the species have a final, approved recovery plan containing objective, measurable criteria? The 1987 Plan contained objective measurable criteria. The recently released Technical Agency/Draft Recovery Plan contains objective, measurable criteria for both downlisting and delisting.
2. Adequacy of recovery criteria.
  - a. Do the recovery criteria reflect the best available and most up-to-date information on the biology of the species and its habitat? Yes.
  - b. Are all of the 5 listing factors that are relevant to the species addressed in the recovery criteria (and there is no new information to consider regarding existing or new threat)? Yes.
3. List the recovery criteria as they appear in the recovery plan, and discuss how each criterion has or has not been met, citing information.

Downlisting the Puerto Rican parrot from endangered to threatened will be considered when:

1. A wild population in the Luquillo Mountains exists with a population size (yet to be determined) that exhibits vital parameters consistent with a trajectory towards maintenance. At present, population growth in the YNF could be expected if the breeding productivity is at least 1.56 chicks per nesting attempt (average rate for the 1990s) and their survival rates should not drop below 90 percent for adults and 50 percent for juveniles. These rates assume that sub-adult survival rates are around 85 percent, age of first breeding is four years old, and at least 60 percent of the adults engage in reproduction each year. A higher number of breeding pairs is essential for vigorous population growth and historically has been stagnant at 2-6 pairs.
2. A second wild population in the northwestern karst region exists with a population size (yet to be determined) that exhibits vital parameters consistent with a trajectory towards maintenance.

3. The reintroduction or creation of at least a third population has been achieved in a suitable forested area in the island reflecting lessons and demographic expectations stemming from work with wild populations and release programs in RAF and YNF.
4. Nesting and foraging habitats (yet to be determined) are protected to support growing populations.

The Puerto Rican parrot will be considered for delisting when:

1. At least three interacting populations exist in the wild and population growth is sustained for 10 years after downlisting has occurred. This length of time will allow monitoring recruitment events and other population attributes in a species that has been characterized by highly variable reproductive and survival rates, at least in the YNF (Snyder et al. 1987, Muiznieks 2003, Beissinger et al. in press). Reviews of the recovery program prior to making a delisting determination will help define more explicitly the range of vital parameter values of a recovered population (see milestones 2 and 3).
2. Long term protection of the habitat occupied by each wild population is achieved.
3. The effects of disease and predation factors are controlled to allow for population viability.

Recovery criteria have not been met. Efforts are underway to address downlisting recovery criterion 1 and 2. Presently, a minimum of 25 individuals survive in the wild in the El Yunque National Forest (YNF) in eastern Puerto Rico and 22 in the Río Abajo Forest (RAF) in north central Puerto Rico. We continue to make progress in the recovery of the species but still have much to learn about the Puerto Rican parrot. As we continue to work towards each of the recovery criteria, we will adapt to information that is gained about the Puerto Rican parrot's basic biology, life history, habitat requirements etc.

## **C. Updated Information and Current Species Status**

### **1. Biology and Habitat**

#### **a. Species' abundance, population trends, demographic features, or demographic trends**

The Puerto Rican parrot is considered one of the 10 most endangered birds in the world (Wiley et al. 2004). Currently, a wild population of 25-28 individuals survives in the El Yunque National Forest (YNF), located within the Luquillo Mountains. Efforts to establish a second wild population began on November 19, 2006 with the release of 22 parrots in the Río Abajo Forest (RAF) located in the karst region of north central Puerto Rico. At present time, 22-28 individuals survive in the RAF. Two captive population facilities hold more than 228 individuals: the Iguaca Aviary



and the José L. Vivaldi Aviary in eastern and west-central Puerto Rico, respectively.

This last aviary is owned and managed by the Puerto Rico Department of Natural and Environmental Resources.

All indications suggest that the parrot was once abundant and widespread on the Puerto Rican Archipelago's major islands (Snyder et al. 1987). The size of historical populations is highly speculative, but may have exceeded a million individuals. The parrot population probably remained reasonably stable until about 1650, when the human population began to increase rapidly. The decline assumed catastrophic proportions in the latter half of the 19th and early 20th centuries when most deforestation of the island took place (Birdsey and Weaver 1982, Snyder et al. 1987). By the early 20th century, the species had disappeared from all of the offshore islands and was restricted to five known areas on the mainland. By about 1940, the only remaining population was in the Luquillo Mountains of eastern Puerto Rico, the largest area of native vegetation left on the island. A summary of population counts in the Luquillo Mountains since 1954 is presented in Appendix 1.

Since 1973, the population has increased 1% annually ( $\lambda = 1.01$ , Appendix 2). Over the last 10 years, however, there has been an annual decrease of eight percent ( $\lambda = 0.92$ ). The number of wild parrots has never surpassed 47 birds, and currently stands at a minimum of 26 individuals (Appendix 1). Due to the nature and behavior of these parrots, surveying the population is challenging. Surveys are regularly conducted in areas currently used by parrots and areas also used by parrots in the past. However, we cannot assume that all individuals are always counted because birds have been known to use other areas in the YNF or adjacent areas in which their presence is sporadic and unpredictable. The most abrupt change in population numbers since 1973 was caused by hurricane Hugo in 1989. It reduced the wild population size from 47 to about 23 individuals. Increases in the number of wild parrots have not been followed by proportional increases in the number of breeding individuals, which has never exceeded 12 (Appendix 2, Appendix 1). Prevalence of low numbers of individuals over a long period of time could lead to problems associated with genetic depression (e.g., survival, reproduction) as documented for other endangered species (e.g., Guam rail, Haig and Ballou 1995). Judging by measurable parameters like fertility and hatching success of the wild population over a 30-year period, there is as yet no indication of such problems (Haig et al. 2004). However, Beissinger et al. (in press) provide documentation regarding egg hatchability that might indicate inbreeding effects in the Puerto Rican Parrot, drawing attention to the importance of a genetic management plan and recovery actions to minimize this problem. Fertility of wild nesting pairs ranged from 66 percent to 100 percent from 1991 to 2002 (Muiznieks 2003, Wunderle et al. 2003).

Only 2 to 6 pairs in the wild population have attempted to breed each year during the history of the parrot recovery program. Appendix 3 summarizes information on breeding productivity from 1985 to 2008. Productivity from 1973 to 2002 was 1.48-chicks/nesting attempt (Appendix 4, Muiznieks 2003). Productivity peaked during

the early 1990s when 1.88-chicks/nesting attempt were produced, but dropped again during the second half of the decade (1.23). Variability in reproductive output remains high, but decreased from before 1989 to an average of 77 percent during the 1990s (Appendix 4). Variability in the 1990s was due to nest failures caused by ectoparasites, nest predation, and difficulties in fostering chicks to the wild during the second half of the 1990s (Muiznieks 2003). Wunderle et al. (2003) summarized individual nest histories from 1973 to 2000.

#### **b. Genetics, genetic variation, or trends in genetic variation**

Genetic problems, although suspected (Snyder et al. 1987, Brock and White 1992), have not been documented in the wild or captive Puerto Rican parrot populations. Recent analyses of fertility rates at J. L. Vivaldi aviary suggest there were no negative effects of maternal, paternal, or zygotic inbreeding on egg fertility or hatching rate in the reproductive success data (Daniels et al. 2001). Failure to find negative inbreeding effects remained true whether the dependent observation was each egg, the proportion of eggs in each year that were fertile or hatched, or the proportion of eggs in each pair's reproduction to date that were fertile or hatched.

Molecular work using microsatellite and ISSR markers suggests a high degree of relatedness among all parrots in wild and captive populations (Haig et al. 2004). Comparison of the same loci in Hispaniolan Parrots (*A. ventralis*) indicated much lower levels of diversity in Puerto Rican parrots. Pedigree analyses including wild and captive birds (see Haig and Ballou 2002 for summary of techniques) indicated that the overall mean effective size ( $N_e$ ) for the current living population of 43 male breeders and 40 female breeders over the past 2.65 generations was 82.9, thus  $N_e/N = 0.37$ . The closer this ratio is to 1.0, the more viable the population is. Hence, this result was not indicative of a robust population. This was also a most optimistic estimate as many founders (i.e., birds with no ancestors in the pedigree who have produced offspring) were assumed to be unrelated when, in reality, they most likely were closely related.

There were 37 birds defined as founders to the captive population (Haig et al. 2004). Pedigree analyses identified an additional 12 birds that could be considered founders if they bred (Appendix 5). There were 178 birds that descended from these founders but the genetic contribution of individual founders has varied greatly, further reducing  $N_e$ . Gene diversity or heterozygosity among the living population was 0.93. Pedigree models begin by assuming 100 percent heterozygosity; hence this result represents a 7 percent loss of heterozygosity over a relatively short period of time. A general goal for the maintenance of genetic diversity has been identified as retention of 90 percent original heterozygosity for 200 years (Soule et al. 1986, Ballou and Foose 1996).

The number of founder genome equivalents (i.e., a measure of founder contribution and allelic diversity that potentially equals the number of founders in the pedigree) in the living population was low at 7.03. The gene drop model indicated this value



could increase to 49 with better population management. Conversely, overall mean kinship (i.e., the mean of kinship coefficients between one individual and all other potentially reproducing members of a population; the higher the value, the more related birds are to each other) was 0.07 and the associated mean inbreeding coefficient was 0.04, neither of which suggests a problem with too close breeding. Unfortunately, this may be an overly optimistic view of mean kinship and inbreeding as the founders brought in from the wild were defined as being unrelated when they were most likely related.

The two flocks should be managed to minimize mean kinship as much as possible. Any parrot targeted for reproduction should be offered a choice of at least 3 individuals of equivalent mean kinship values. This scheme increases the probability of producing genetically, as well as behaviorally, compatible pairs.

**c. New information regarding taxonomic classification or changes in nomenclature**

There is no new information regarding taxonomy for the Puerto Rican parrot.

**d. Spatial distribution, trends in spatial distribution (e.g. increasingly fragmented, increased numbers of corridors, etc.), or historic range (e.g. corrections to the historical range, change in distribution of the species within its historic range, etc.)**

The Puerto Rican parrot is currently present in the wild in both YNF and RAF, including the recently reintroduced population in the latter. Additional details on its spatial distribution are presented under I.C.a. above.

**e. Habitat or ecosystem conditions (e.g. amount, distribution, and suitability of the habitat or ecosystem)**

As we continue to learn more about the Puerto Rican parrot and additional information for improved survey techniques for this bird, we expect to gain a better understanding of its suitable habitat and habitat needs.

**f. Other information**

Population Viability Analyses: In June 1989, the Captive Breeding Specialist Group conducted a Puerto Rican parrot population viability analysis (PVA) workshop (Lacy et al. 1989). The analysis was based on the information and expert opinion of the parrot field biologists and population biology of the parrot. The aviary personnel provided information on the captive flock key to the development of a master plan for the captive population. The final report provided recommendations and identified management needs for the wild and captive populations. The proposal to establish a second captive and wild population to reduce the risk of losing the species to the effects of catastrophic events was among the most important recommendations.

In 2003, updated demographic and environmental parameter estimates, and pertinent data from the 1989 PVA were used to conduct a second viability analysis assessing the status of the species from 1989 to 2002 (Muiznieks 2003). The process involved creating a BASE model to assess population persistence and sensitivity analyses using program Vortex. Model projections over 100 years were of a declining population (stochastic  $r = -0.066$ ). The population went extinct in 997 of 1000 simulations and the persistence of the population was 0. The bleak prognosis results primarily from the low estimates of juvenile survivorship. Other parameters whose estimates changed to the detriment of the species (*vis-à-vis* more modest estimates used in the 1989 PVA) were severity of catastrophes (changed from 25 percent to 50/60 percent) and age of first breeding (empirical evidence suggested that it is 4 or 5, not 3).

In 2006, comprehensive demographic modeling of limiting factors to Puerto Rican parrot population growth (1973-2000) was conducted by Beissinger et al. (in press). Many of the conclusions of their work were in harmony with previous assessments (Lacy et al. 1989, Muiznieks 2003). This is not surprising given that the analysis by Muiznieks (2003) and Beissinger et al. (in press) were based on the same dataset up to year 2000. However, for the first time, Beissinger and colleagues assessed the relative importance of various factors suspected of limiting population growth in the YNF, and raised the possibility that inbreeding might be limiting population growth. The primary factors maintaining the population bottleneck were hurricanes (and extreme rainfall events), via its influence on parrot survival, failure of a larger proportion of the adult population to breed annually, and inbreeding effects manifested in egg hatchability problems. Factors that contribute to stall population growth, but are not as important, included changes in annual survival of juveniles and adults, and individual nest failures.

Re-assessments of the population demography, status and persistence will be conducted in 2008 and 2011. These re-assessments are necessary because new data on vital parameters (e.g., juvenile survival), which also helps reduce parameter uncertainty (e.g., precision), help fine tune our understanding of the factors impinging upon the species demography and provide insights on how recovery actions might be modified to foster population growth and recovery. For example, data on juvenile survival since 2000, for wild or captive reared birds, suggest that annual survival rates have hovered around 0.40 *vis-à-vis* higher values (0.6) used in several assessments in the past (T. White, USFWS-Rio Grande Field Office, pers. comm. 2007).

Sensitivity analyses indicated that none of the values for the 7 parameters used in the model scenarios yielded a positive, mean stochastic growth (see Appendix 6 for description of the analyses). Low juvenile mortality (32 percent) produced the best average stochastic growth rate (Figure 5). Available data suggest that, on average, juvenile survival is substantially lower (about 40 percent) than the 67 percent estimated from 1973-1989 (Snyder et al. 1987). It is likely that red-tailed hawk predation continues to be a major factor influencing juvenile survival (Snyder et al.



1987, White et al. 2005a), although concerns about some fledglings leaving the nest prematurely might be another factor contributing to lower juvenile survival (T. White, USFWS-Rio Grande Field Office, pers. comm. 2007). Certainly, the impact of red-tailed hawks has become easier to discern in recent years with the implementation of the release program and use of radio telemetry (Nimitz 2005, White et al. 2005a). It remains unclear whether red-tailed hawks are exacting a higher mortality rate on juvenile parrots in recent years as compared to prior to 1989. These results underscore the importance of better data to assess the relative importance of age-specific survival rates, particularly during non-hurricane years. Annual survival rates of parrots during the intervening years between hurricanes were not deemed important as a factor limiting population growth (Beissinger et al. in press)

## **2. Five-Factor Analysis (threats, conservation measures, and regulatory mechanisms)**

### **(a). Present or threatened destruction, modification, or curtailment of its habitat or range:**

Protection was afforded in view of the parrots' dramatic range contraction and population decline particularly during the 20<sup>th</sup> century (Snyder et al. 1987). The destruction of the native forests was unquestionably a major factor influencing both parameters. By 1912, the island was more than 80 percent deforested, and of the remaining forests, only about 45,000 acres (18,220 hectares [ha]) remained in virgin condition (Murphy 1916). By 1922, only about 20,000 acres (8,097 ha) in the Luquillo Mountains remained forested, and nearly all of it had been cut to extract timber (Wadsworth 1949, 1951). Parrots are dependent on large diameter trees for nesting cavities (although one former population is known to have also used cliff pot-holes; Wiley 1980, Snyder et al. 1987). The limited availability of cavity trees was invoked to explain poor population growth and lack of new nesting areas (Snyder and Taapken 1977, Wiley 1985).

At present time, the species is mostly found in a portion of YNF (11,274 ha) located within the Luquillo Mountains, which encompass a total of 19,656 ha. We have also documented parrots using private areas bordering the southern, western and northern parts of the Forest. Additional observations have been made near the eastern boundary of the forest, within the township of Naguabo. During the past several decades, portions of the Luquillo Mountains outside of the YNF have become more forested due to a decline in agricultural practices on former pastures and farmlands. Since the mid-1950's, when the parrot population was determined to number only 200 birds, land management activities by the responsible agencies, such as the US Forest Service, have included parrot recovery activities. These include locating parrot nest sites, improving nests, determining parrot range, and ensuring that other future forest management actions do not adversely affect parrots or parrot habitats. In 1986, the YNF Land and Resource Management Plan gave direction for long-term parrot habitat maintenance and improvement, and placed high emphasis on Puerto Rican parrot recovery.

Efforts to establish a second wild population began on November 19, 2006 with the release of 22 parrots in the Río Abajo Forest (RAF), followed by a second release of 24 parrots in December 2007. At present time, around 22-28 individuals survive in the RAF. The RAF is approximately 2,340 ha and is located between Dos Bocas Lake and the Tanamá River in the municipalities of Utuado and Arecibo. This moist limestone forest with very irregular topography, subterranean drainage, caves, natural depressions or sinkholes and haystack hills all characteristic of karst geological development provide suitable habitat for the parrot. Since 1989, the Puerto Rico Department of Natural and Environmental Resources entered an agreement with the Service to manage the RAF consonant with the future parrot recovery activities. Currently, efforts are underway to prepare a management plan focused on watershed areas that will encompass land outside the forest boundaries.

**(b). Overutilization for commercial, recreational, scientific or educational purposes:**

Other factors that may have contributed to the decline of the parrot population in the island and the Luquillo Mountains were nest robbing, crop protection and hunting for food, road construction (e.g., PR-191), guerrilla warfare maneuvers and radiation experiments (Snyder et al. 1987, FWS 1999). Over the past 25 years, these factors have been reduced or eliminated completely. This species is listed and protected by C.I.T.E.S. (Appendices 1 Convention on International Trade in Endangered Species of Wild Fauna and Flora). We believe that overutilization for commercial, recreational, scientific or educational purposes should not be considered a threat.

**(c). Disease or predation:**

Due to the recent documentation of the presence of West Nile Virus in the captive and wild populations, this pathogen presents a potential threat to the welfare of the species.

Red-tailed hawks are the primary avian predator of parrots, an important cause of juvenile and adult mortality (Snyder et al. 1987, Wiley et al. 2004, Nimitz 2005). There is also evidence that red-tailed hawks will enter nest cavities to kill parrots (Wiley 1980). Between 2000 and 2004, 40 captive-reared parrots were released in the Luquillo Mountains. The majority (54 percent) of the documented deaths were due to predation by red-tailed hawks, which claimed at least 21 percent of all released parrots, reaffirming the contention that this raptor was a primary source of mortality for parrots (White et al. 2005a, USFWS unpubl. data).

Other predators affect parrot demography through their impact on breeding productivity (e.g., pearly-eyed thrashers (*Margarops fuscatus*), black rats (*Rattus rattus*)), but intense management practices have curbed their impact. Pearly-eyed thrashers, which were not present in notable numbers in the YNF until the 1950's (Snyder et al. 1987), harass breeding parrots to obtain nest cavities. Thrashers will



also attack parrot eggs and nestlings while exploring unattended nests (Snyder and Taapken 1977). Since 1976, modifying nest sites for parrots and installing thrasher-preferred nest boxes close to parrot nests have largely controlled thrasher depredations. Consistent management protocols have been implemented to reduce the impact of thrashers on the reproductive success of wild parrots, including the use of cameras and active control (White and Vilella 2004). Black rats are normally controlled through the use of poison bait stations strategically located near active parrot nests.

Honeybees (*Apis mellifera*) compete with parrots for nest sites (Wiley 1980, Wiley 1985, Snyder et al. 1987, Lindsey et al. 1994). Although there is no record of honeybees evicting nesting parrots, they take over nest cavities after the breeding season. Often it has been difficult to maintain each of the modified or natural cavities available for prospecting breeding parrots, although currently nests are closed as soon as possible following the nesting season to avoid usurpation by honeybees. The threat posed by bees has been exacerbated since the arrival of Africanized honeybees. Late nesters may be particularly vulnerable to honeybees as occurred in 1994. In this instance, the rapid intervention of a nest guard and subsequent cleaning by US Forest Service (USFS) and USFWS staff personnel saved two parrot chicks.

Sometimes, parrot nests become infested with parasites such as the botfly (*Philornis pici*) and the soldier fly (*Hermetia illucens*). *Philornis* ectoparasitic larvae significantly retard development and can result in death of parrot nestlings and adults (Arendt 1985, Snyder et al. 1987, Arendt 2000). Soldier fly larvae have been implicated in the death of at least one, and possibly two, nestlings. Current nest management practices, such as the use of palo colorado wood chips as nest material in conjunction with the application of carbaryl insecticide (e.g., Sevin), have resulted in the reduction of the presence of insect larvae in nest material.

Other possible predators of parrots in the YNF are the federally listed Puerto Rican broad-winged hawk (*Buteo platypterus brunnusceus*), peregrine falcons (*Falco peregrinus*), and Puerto Rican boa (*Epicrates inornatus*). Although predation of parrots by broad-winged hawks has not been documented in the YNF, the deaths of at least 6 captive-reared parrots released in the RAF between 2006-2007 were attributed to this raptor. This is consistent with reports from Dominica, where broad-wings have been reported preying on chicks of the red-necked parrot (*Amazona arausiaca*; Christian et al. 1996). Boas are predators of parrot nestlings in Jamaica and Dominica (J. Wunderle, USFS, pers. comm., 2004, Koenig et al. 2007). The Puerto Rican boa is not very abundant in the YNF, although its poor detectability likely results in biased-low estimates of the population (Wunderle et al. 2004, Koenig et al. 2007). Although vines are used by boas to access tree cavities (Wunderle et al. 2004), there have been no documented deaths of parrots caused by boas in the YNF.

**(d). Inadequacy of existing regulatory mechanisms:**

The Puerto Rican parrot is currently protected by both Commonwealth and Federal regulations. In 1999, the Commonwealth of Puerto Rico approved the Law # 241 known as the “Nueva Ley de Vida Silvestre de Puerto Rico” (New Wildlife Law of Puerto Rico). The purpose of this law is to protect, conserve and enhance both native and migratory wildlife species; declare property of Puerto Rico all wildlife species within its jurisdiction, regulate permits, regulate hunting activities, and regulate exotic species among others. The Puerto Rico Department of Natural and Environmental Resources approved in 2004 the “Reglamento para Regir el Manejo de las Especies Vulnerables y en Peligro de Extinción en el Estado Libre Asociado de Puerto Rico” (Regulation 6766 to Regulate the Management of threatened and endangered species in Puerto Rico). The Puerto Rican Parrot has been included in the list of protected species and designated as “critically endangered”. Based on the existence of local laws and regulations protecting this species, we believe that inadequacy of existing regulatory mechanisms should not be considered a threat.

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

Additional stressors impinging upon the demography of Puerto Rican parrots are local weather conditions and hurricanes. Weather in the Luquillo Mountains is extremely wet and humid. Exposure to rain limits the adequacy of nesting cavities as chicks and eggs can be lost due to rainwater entering nest cavities (Snyder et al. 1987). Occasionally, parrot chicks also suffer from respiratory diseases acquired in the dampened nest environment. Recent management techniques and new nest design have reduced the incidence of such events (White et al. 2005b).

The dependence of parrots on natural vegetation for food, shelter, and nest sites makes them particularly vulnerable to the impacts of hurricanes (Wiley and Wunderle 1993). Reduced survival and increased movements in search of food were documented for captive-reared Hispaniolan parrots released in Parque Nacional del Este, Dominican Republic, in the aftermath of hurricane Georges in 1998 (Collazo et al. 2003, White et al. 2005c). Circumstantial evidence suggests that Puerto Rican parrots were forced to lowlands in search for food when major hurricanes hit the Luquillo Mountains earlier in the 20th century (Snyder et al. 1987). Given the small size of the wild population, a single, strong hurricane could potentially wipe out the entire current wild population. The frequency of major hurricanes in Puerto Rico (category 3 or higher) is 3 every 100 yrs (Lacy et al. 1989). Hurricane Hugo, in September 1989, illustrated the possibility of catastrophic losses. The wild population in the YNF was reduced to 23, or nearly half of the 47 individuals reported before the hurricane. After a comprehensive review of the demography of parrots since 1973, hurricanes emerged as the single most important factor impeding population growth in the YNF (Beissinger et al. in press).



### 3. Synthesis

Currently, a wild population of 25 to 28 individuals survives in the El Yunque National Forest (YNF), located within the Luquillo Mountains. Efforts to establish a second wild population began in 2006 with the release of 22 parrots in the Río Abajo Forest (RAF) located in the karst region of north central Puerto Rico. At present time, 22-28 individuals survive in the RAF. Two captive population facilities hold more than 228 individuals: the Iguaca Aviary and the José L. Vivaldi Aviary in eastern and west-central Puerto Rico, respectively. The limited distribution and small populations render the Puerto Rican Parrot vulnerable to random natural events such as the hurricanes.

Only 2 to 6 wild pairs have attempted to breed each year during the history of the recovery program. Genetic problems, although suspected, have of yet not been documented in the wild or captive Puerto Rican parrot populations.

The movements and habitat use of the Puerto Rican parrot have been altered in recent years, but these changes are mainly limited to within the YNF.

Although recent significant progress in recovery efforts for the Puerto Rican Parrot has been documented, including improved nesting success in the wild, advances in captive-rearing techniques, and a recently reintroduced second wild population, this species continues to exist as only two small populations in the wild. As such, the Puerto Rican Parrot remains extremely vulnerable to habitat destruction due to increasing rates of urban development in Puerto Rico, the ever-present threat of introduced diseases such as West Nile Virus, and random natural events such as hurricanes. Thus, the Puerto Rican Parrot continues to meet the definition of an endangered species under the Act.

## III. RESULTS

### A. Recommended Classification:

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

## IV. RECOMMENDATIONS FOR FUTURE ACTIONS

1. Continue with the releases of the recently introduced population in the northern karst region in the Río Abajo Forest (RAF).
2. The establishment of the third wild population is a high priority in the recovery program.
3. Continue release of captive-reared parrots to promote growth of the wild population in the YNF using procedures developed to maximize survival.
4. Conduct updated Population Viability Analysis (PVA) for the Puerto Rican Parrot

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Appendix 1. Historical summary of minimum counts of Puerto Rican parrots from 1954 to 2007 in YNF, Luquillo Mountains. The month in which the surveys were conducted is indicated parenthetically. Since 1990 pre- and post-breeding surveys were consistently conducted. Pre-breeding surveys are generally conducted early in the year; post-breeding in mid to late summer. Personnel conducting surveys prior to 1989 are identified by Snyder et al. 1987. Since 1989, surveys have been conducted and coordinated by personnel with the RGFO.

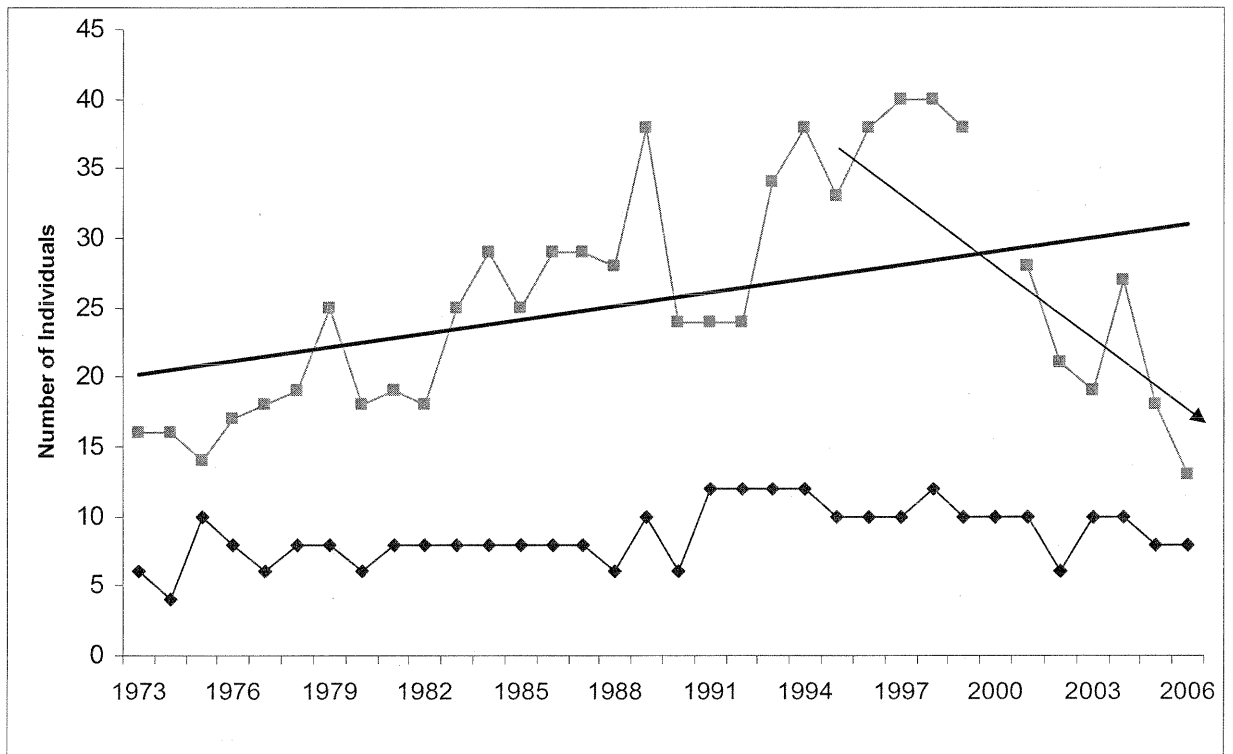
<b>Year (month)</b>	<b>Count</b>
1954 (October)	200
1963 (May)	130
1966 (December)	70
1968 (November)	24
1971 (January)	16
1975 (March)	14
1975 (May)	13
1980 (January)	19
1982 (July)	29
1985 (July)	35

<b>Year</b>	<b>Pre-breeding Count</b>	<b>Post-breeding Count</b>
1986	29 (April)	31 (August)
1986		31 (November)
1989	*	47 (August <sup>bH</sup> )
1989	*	23 (September <sup>aH</sup> )
1990	24 (January)	21 (September)
1991	24 (April)	30 (September)
1992	24 (February)	28 (October)
1993	34 (January)	42 (September)
1994	38 (March)	40 (August)
1995	33 (February)	44 (September)
1996	38 (January)	42 (August)
1997	40	40 (July)
1998	42 (March)	36 (September <sup>aG</sup> )
1999	38	38 (May)
2000		21 (September)
2001	28 (March)	31 (September)

2002	21 (March)	28 (July)
2003	24 (March)	17
2004	26 (March)	31 (July)
2005	27 (March)	17 (August)
2006	16 (February)	23 (June)
2007	18 (January-February)	25 (July)
2008	13 (January)	26 (August)

<sup>bH</sup> before hurricane Hugo, <sup>aH</sup> after hurricane Hugo, <sup>aG</sup> After hurricane Georges,





$\lambda = 1.01$

Appendix 2. Number of Puerto Rican parrots counted during pre-breeding surveys (march-april) in the EL Yunque National Forest from 1973 to 2006. The number of breeding individuals recorded each year are also depicted. The average observed rate of increase (see Caughley 1977) is expressed as the finite rate ( $\lambda$ ).

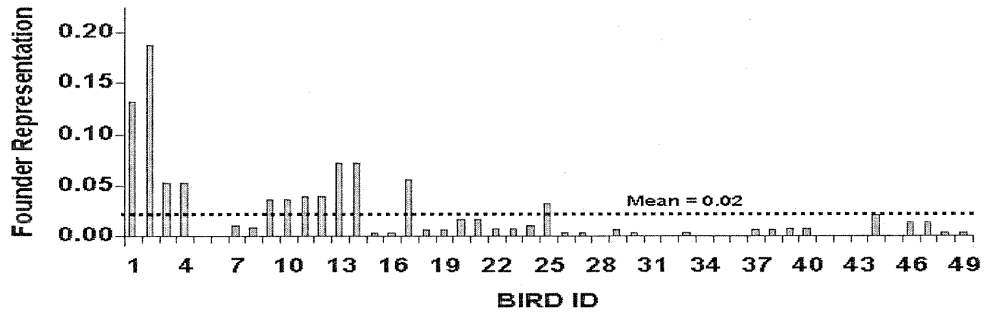
Appendix 3. Breeding productivity of Puerto Rican parrots in the El Yunque National Forest 1985-2008. A detailed account of each nest history was summarized by Wunderle et al. (2003).

Year	Total Fledglings	Number of Active Nests	Fledglings/nest attempt
1985	12	4	3
1986	9	4	2.25
1987	4	4	1
1988	8	4	2
1989	9	3	3
1990	2	3	0.666667
1991	7	6	1.166667
1992	11	6	1.833333
1993	15	6	2.5
1994	14	6	2.333333
1995	15	5	3
1996	7	5	1.4
1997	7	5	1.4
1998	9	6	1.5
1999	3	5	0.6
2000	8	5	1.6
2001	5	5	1
2002	2	3	0.666667
2003	8	5	1.6
2004	7	5	1.4
2005	6	4	1.5
2006	9	4	2.25
2007	8	4	2
2008	6	4	1.5

Appendix 4. Mean productivity (number of chicks/nesting attempt) of Puerto Rican parrots from 1973 to 2002. Values for selected time periods of interest are also presented. The 1973-1989 period ends with the year of hurricane Hugo); 1990-2002 is the period since; the 1990s were divided into two periods because management techniques (e.g., fostering, double clutching) were applied differently. Standard deviations and coefficient of variations are listed for the various time periods.

Year	1973-2002	1973-1989	1990-2002	1990-1995	1996-2002
<b>N</b>	<b>113</b>	<b>76</b>	<b>68</b>	<b>34</b>	<b>34</b>
<b>Mean Productivity (SD)</b>	<b>1.48</b> (1.26)	1.41 (1.31)	1.56 (1.32)	1.88 (1.01)	1.23 (1.33)
<b>Coefficient of Variation</b>	0.85	0.93	0.85	0.54	1.08





Appendix 5. Founder contribution in Puerto Rican parrots. Those individuals whose contribution is under represented need to be selectively paired to increase their contribution to the flock (Haig et al. 2004).

**U.S. FISH AND WILDLIFE SERVICE**  
5-YEAR REVIEW of PUERTO RICAN PARROT (*Amazona vittata*)

Current Classification   E  

**Recommendation resulting from the 5-Year Review**

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

**Review Conducted By:** Pablo Torres, Fish and Wildlife Biologist, Rio Grande Office, Caribbean Field Office.

**FIELD OFFICE APPROVAL:**

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

Approve Edwin Muñiz Date 9/26/08

*Lead Field Offices must ensure that all other Field Offices within the range of the species' have been provided an adequate opportunity to review and comment prior to the reviews' completion. For all species where a change in classification is recommended, written concurrence from other Field Offices is required.*

**REGIONAL OFFICE APPROVAL:**

*for* **Lead Regional Director, Fish and Wildlife Service**

Approve Norman E. Walsh Date 9/24/08

*The Regional Director must sign all 5-year reviews, unless the authority has been delegated by the Regional Director to the Field Supervisor.*



**PR Harlequin Butterfly (PRHB) (*Atlantea tulita*)**

***Oplonia spinosa*.(due to its special relationship with *A. tulita*)**

**Species Status Assessment Report  
for the  
Puerto Rican Harlequin Butterfly  
(*Atlantea tulita*)**

**Version 1.5**

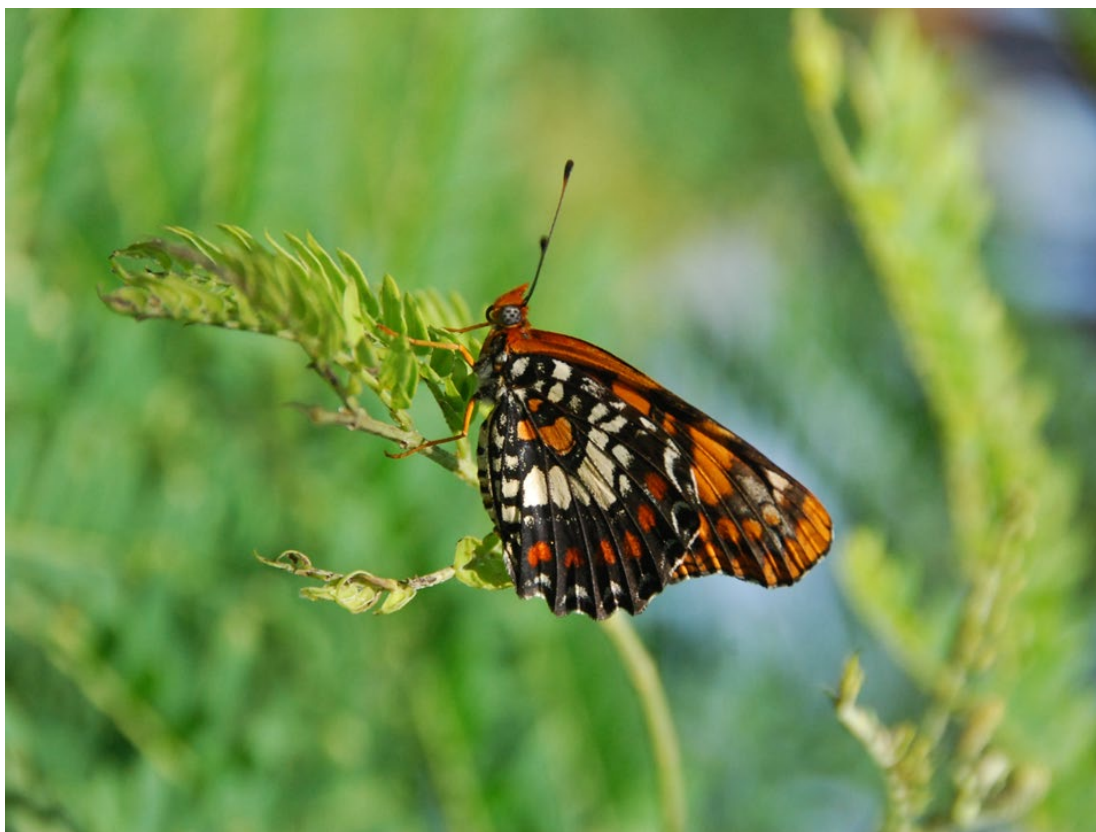


Photo by Carlos Pacheco, U.S. Fish and Wildlife Service

June 2019

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



## ACKNOWLEDGEMENTS

This document was prepared by the U.S. Fish and Wildlife Service's Caribbean Ecological Services Field Office Species Status Assessment Team.

Suggested reference:

U.S. Fish and Wildlife Service. 2019. Species status assessment report for the Puerto Rican harlequin butterfly (*Atlantea tulita*), Version 1.5. June 2019. Atlanta, GA.

## **VERSION UPDATES**

Version 1.4 is the final draft of the Puerto Rican Harlequin Butterfly Species Status Assessment developed by the U.S. Fish and Wildlife Service's Caribbean Ecological Services Field Office prior to formal peer review. Peer review comments were considered and addressed in this version, Version 1.5.



## EXECUTIVE SUMMARY

We, the U.S. Fish and Wildlife Service (Service), developed a species status assessment (SSA) for the Puerto Rican harlequin butterfly (*Atlantea tulita*), a species endemic to the island of Puerto Rico. The Puerto Rican harlequin butterfly (PRHB) was added to the list of candidate species on May 31, 2011, when the Service published a 12-month finding indicating that listing was warranted but precluded by higher priority actions (76 FR 31282, May 31, 2011). This SSA will inform a new 12-month finding to determine whether the candidate species warrants listing.

The SSA process is intended to assess the viability of the species using the conservation biology principles ‘the 3Rs’ – resiliency, representation, and redundancy. In this SSA report we provide a summary of the species’ biology at the individual, population, and species level; describe the factors that have led to its current status and those that are likely to influence its status into the future; assess the current and future health of individual populations given these influences; and describe the implications of predicted health and distribution on the 3Rs.

We identified five extant PRHB populations, each generally small in size, with less than 100 total individuals observed in any given year. Relative to historical conditions, the PRHB distribution is now fragmented among discrete remnants of native forest located in four ecological life zones in Puerto Rico. Land use in the species’ range consists of urban developments, agriculture, and patches of native forest. The species can be positively or negatively influenced at local, landscape, and regional scales by factors like urban development (i.e., habitat modification, fragmentation), agricultural practices (i.e., grazing, haying), anthropogenic fires, pesticides, and climate change. An essential habitat feature for the PRHB is prickly bush (*Oplonia spinosa*), because it is used almost exclusively for egg laying and as a food source for the larval (caterpillar) life stage.

In this SSA, we consider the current condition of the PRHB based on its distribution, abundance, and those factors currently influencing the viability of the species. We evaluate the needs of the species in terms of the 3Rs and examine existing factors that are negatively and positively influencing the species (i.e., threats and existing voluntary or regulatory conservation efforts). Presently, we classified two (2) PRHB populations as having moderately high resiliency and three (3) as having moderately low resiliency. In the absence of highly certain population size or trend estimates, our classifications of resiliency rely heavily on habitat characteristics. The populations classified as having moderately high resiliency (Rio Abajo Commonwealth Forest and Rio Encantado Area) occur in habitats managed for conservation that are surrounded by forest and have a low probability of being affected by human activities. The three populations classified as moderately low (at Isabela, Quebradillas, and Camuy (IQC); Maricao Commonwealth Forest; and Susúa Commonwealth Forest) occur in areas where human activities

may negatively affect the species. Currently, we consider resiliency at the species level (rangewide) to be moderate.

To evaluate the future condition of the PRHB, we placed the broad spectrum of factors that influence species' viability into two main categories: habitat modifications and climate change. Next, we developed three future risk scenarios: (1) conditions staying the same as currently, with slight, insignificant changes in habitat modification, climate, and population sizes (Best Case Scenario); (2) conditions whereby impacts from development and climate change continue increasing at a moderate rate, with some decrease in population sizes (Most Likely Scenario); and (3) conditions whereby impacts from development and climate change continue increasing at a high rate and population sizes decreased substantially (Worst Case Scenario). Climate change was an important factor in our analysis of PRHB future condition, so we named the three scenarios to match the terminology used for the most recent climate change model for Puerto Rico. We chose 25 years as the time frame for the PRHB future conditions analysis because this time frame includes at least 25 generations, thus allowing adequate time to detect trends in populations and habitat conditions. Our predictions associated with this time frame are supported by existing predictive models regarding regional climate change. In particular, potential impacts associated with changing climatic conditions (e.g., estimates for precipitation and drought levels) are based on published climate model projections downscaled for Puerto Rico and the Virgin Islands.

Unless the Best Case Scenario transpires, we predict reductions in the 3R's, particularly redundancy and representation, over the next 25 years. Development for residential, commercial, and tourism uses, both within and adjacent to areas currently occupied by PRHB, will most likely increase over this time period, with attendant loss and degradation of suitable habitat, increased use of herbicides and pesticides, and greater risks of fires. These effects, both individually and collectively, have the potential to cause losses of not only annual reproductive cohorts, but also individual or multiple populations, thereby further reducing species viability. Although the adverse effects of development could be managed, the risk to PRHB viability imposed by forecast changes to climate will be more challenging to address. While the full ecological effects of these changes on the PRHB are unclear, it is likely that substantial changes in overall habitat and microhabitat (e.g., temperature, humidity) for a species whose ecology appears closely linked to specific current conditions (e.g., healthy *Oplonia spinosa* populations) will have negative effects on the PRHB.

At the end of our predictive time horizon (year 2045) at least three (3) of the current five (5) PRHB populations will most likely have been extirpated, with those remaining (i.e., IQC and Maricao) incurring reductions in resiliency. Those predicted to be lost are the populations at Río Abajo Commonwealth Forest, Rio Encantado area, and Susúa Commonwealth Forest, which represents approximately 25 percent of the currently known total population size. Because of



concomitant population reductions in the remaining populations, the overall losses to the total PRHB population will be substantially greater than 25 percent, although impossible to accurately quantify at the current time.

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## CHAPTER 1 – INTRODUCTION AND ANALYTICAL FRAMEWORK

The Puerto Rican harlequin butterfly (*Atlantea tulita*) is endemic to Puerto Rico. We, the U.S. Fish and Wildlife Service (Service), were petitioned to list the Puerto Rican harlequin butterfly (PRHB) in accordance with the Endangered Species Act of 1973 (Act) in February 2009, by the private citizen, Javier Biaggi-Caballero. On April 26, 2010, the Service published a 90-day finding that the petition presented substantial scientific or commercial information indicating that listing may be warranted for the PRHB (75 FR 21568, April 26, 2010). On May 31, 2011, the Service published a 12-month finding indicating that listing this species was warranted but precluded by higher priority actions (76 FR 31282, May 31, 2011). Upon publication of that 12-month finding, the PRHB was added to the candidate species list. A review of the status of this candidate species has been initiated to determine if listing is still warranted. Thus, we conducted a Species Status Assessment (SSA) to compile the best available data regarding the species' biology and factors that influence the species' viability. The PRHB SSA Report is a summary of the information assembled and reviewed by the Service, and incorporates the best scientific and commercial data available. This SSA Report documents the results of the comprehensive status review for the species and serves as the underpinning of the Service's forthcoming decision (12-month finding) on whether the species warrants protection under the Act.

The SSA framework (U.S. Fish and Wildlife Service (USFWS) 2016, entire) is intended to be an in-depth review of the species' biology and threats, an evaluation of its biological status, and an assessment of the resources and conditions needed to maintain long-term viability. The intent is for the SSA report to be easily updated as new information becomes available and to support all functions of the Ecological Services Program of the Service, including Candidate Assessment, Listing, Consultations, and Recovery. As such, the SSA report will be a living document that may be used to inform Endangered Species Act decisions, such as listing, recovery, Section 7, Section 10, and reclassification decisions (the latter four decision types are only relevant should the species warrant listing under the Act). Therefore, we developed this SSA report to summarize the most relevant information regarding life history, biology, and considerations of current and future risk factors facing the PRHB. In addition, we forecast the possible response of the species to various future risk factors and environmental conditions to formulate a complete risk profile for the species.

The objective of this SSA is to describe the viability of the PRHB based on the best scientific and commercial information available. Based on this information, we assess what the species needs to support viable populations and its current condition in terms of those needs, and we forecast the species' conditions under plausible future scenarios. This SSA report considers past, ongoing, and plausible future changes in the environment to help us understand what factors drive the viability of the species.



For the purpose of this assessment, we define **viability** as the ability of a species to sustain populations in the wild. Viability is not a specific state, but rather a continuous measure of the likelihood that the species will sustain populations over time (USFWS 2016, p. 9). Using the SSA framework (Figure 1-1), we consider what the species needs to maintain viability by characterizing the status of the species in terms of its **resiliency**, **representation**, and **redundancy** (USFWS 2016, entire).

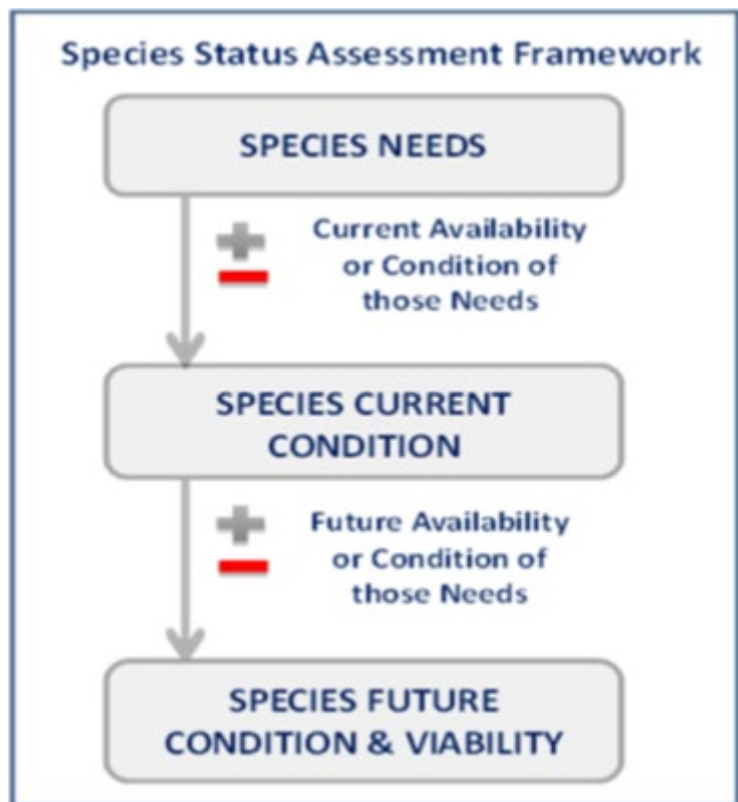


Figure 1-1. Species Status Assessment Framework

**Resiliency** describes the ability of a population to withstand stochastic disturbance. Stochastic events are those arising from random factors such as weather, flooding, or fire. Resiliency is positively related to population size and growth rate and may be influenced by connectivity among populations. Generally speaking, populations need enough individuals, within habitat of adequate area and quality, to maintain survival and reproduction in spite of disturbance. Resiliency is measured using metrics that describe population condition and habitat quality.

**Representation** describes the ability of the species to adapt to changing environmental conditions over time. Representation can be measured through the genetic diversity within and among populations and the ecological diversity (also called environmental variation or diversity) of populations across the species' range. Theoretically, the more representation the species has, the higher its potential of adapting to changes (natural or human caused) in its environment. In

the absence of genetic data, we used the number of life zones harboring resilient populations of the PRHB to assess representation.

**Redundancy** describes the ability of a species to withstand catastrophic events. A catastrophic event is defined here as a rare, destructive event or episode involving multiple populations and occurring suddenly. Redundancy is about spreading risk among populations, and thus, is assessed by characterizing the number of resilient populations across a species' range. The more resilient populations the species has distributed over a larger area, the better the chance is that the species can withstand catastrophic events. For the PRHB, we used the number of known populations to measure redundancy.

To evaluate the biological status of the PRHB both currently and into the future, we assessed a range of conditions to allow us to consider the species' resiliency, redundancy, and representation (together, the 3Rs). This SSA report provides a thorough assessment of the species' biology and natural history and assesses demography, stressors, and limiting factors in the context of determining the viability and risk of extinction for the species.

Importantly, this SSA report does not result in, nor predetermine, any decisions by the Service under the Act. In the case of the PRHB, the SSA report does not determine whether this species warrants protections of the Act, or whether it should be proposed for listing as a threatened or endangered species under the Act. That decision will be made by the Service after reviewing this document, along with the supporting analysis, any other relevant scientific information, and all applicable laws, regulations, and policies. The results of the decision will be announced in the *Federal Register*. The contents of this SSA Report provide an objective, scientific review of the available information related to the biological status of the PRHB.

## CHAPTER 2 –NEEDS OF INDIVIDUALS: LIFE HISTORY AND BIOLOGY

This chapter provides a summary of basic ecological and biological information about the PRHB, including its taxonomy, physical description, life history, and habitat. We then outline the resource needs of individual. We evaluate the life history characteristics to determine the specific biological or environmental resources that are relevant for the species to complete its life cycle and ensure its survival into the future. This information is important for a thorough understanding of the resources the species needs to (1) carry out its life history; (2) have the population persist over time such that it can withstand stochastic events; and (3) have sufficient healthy population distributed such that catastrophic event will not cause the species to go extinct and will also allow it to adapt to changing environmental conditions. These biological and environmental resources needs are later used to compare against relevant influences (see Chapter 4), which helps provide a risk profile for the PRHB.

### 2.1 Taxonomy

*Atlantea tulita* is a valid species belonging to the family Nymphalidae. The currently accepted taxonomy ranking for this butterfly is as follows:

Kingdom: Animalia  
Phylum: Arthropoda  
Class: Insecta  
Order: Lepidoptera (Linneaus 1758)  
Group: Rhopalocera (Boisduval 1840)  
Super-Family: Papilionoidea (Dyar 1902)  
Family: Nymphalidae (Swainson 1827)  
Sub-Family: Nymphalinae (Doubleday 1845)  
Tribe Melitaeine (Newman 1870)  
Genus: *Atlantea* (Higgins 1958)  
Species: *Atlantea tulita* (Dewitz 1877)

Original: *Synchloe tulita* (Dewitz 1877, p. 238); Synonymia: *Coatlantona tulita* (Moschler 1891, p. 96); *Chlosyne perezii tulita* (Forbes 1928, p. 98; Comstock 1930, p. 449).

Currently, the genus *Atlantea* (Higgins 1958), is represented by a single species on each of the Greater Antilles (Figure 2-1; Higgins 1981, p. 174). That is, *Atlantea perezii* (Herrich-Schaffer 1862) in Cuba, *Atlantea pantoni* (Kaye, 1906) in Jamaica, *Atlantea cryptadia* (Sommer & Schwartz, 1980) in Hispaniola, and *Atlantea tulita* (Dewitz 1877) in Puerto Rico (Carrión-Cabrera 2003, p. 1).

The butterfly, *Atlantea tulita*, has been referred to by different common names in the literature. For example, the species has been named as the Puerto Rican harlequin butterfly or the Puerto Rican checker-spot butterfly, but is also known as “La Quebradillana” because the species was



first discovered in the municipality of Quebradillas. For the purpose of this SSA, we refer to the common name as the Puerto Rican harlequin butterfly (hereafter, PRHB).



Figure 2-1. Map showing the distribution of the genus *Atlantea* through the Caribbean Region.

## 2.2 Species Description

The PRHB is a medium size butterfly. The species has a wingspan of about 5.1 to 6 centimeters (cm) (2 to 2.5 inches (in)) wide and is characterized by its orange, brownish-black and beige coloration patterns (Figures 2-2 and 2-3). The butterfly is brownish-black at the thorax area with deep orange markings. The male's abdomen is brownish-black on the dorsal side and has orange and brown bands on the ventral side. The female's abdomen is brownish-black with white bands. Wings are largely brownish-black with sub-marginal rows of deep orange spots and beige cells. The dorsal view of the forewings and the hind-wings, the outer margins are brownish-black. The coastal margin is deep orange with brownish-black markings. The inner margin is brownish-black with some deep orange markings at the half basal wing. The hind wing has a wide black border enclosing a set of reddish-bronze sub-marginal points. As a member of the checker-spot butterfly group, rows of deep orange dots (or cells) is a typical pattern on the species' brownish-black wings. The ventral sides of the forewings are similar to the dorsal sides of the forewings, and ventrally the hindwings are brownish-black with orange basal spots, a complete postdiscal beige band with a band of reddish spots distally, and sub-marginal white half-moons.

The chrysalis (pupa from which the butterfly (adult, or imago) emerges) of the PRHB is black, with orange and white dashes, and yellow pimples (Biaggi-Caballero 2009, p. 4) (Figure 2-4). Chrysalis size is around 3 cm (1.2 in).

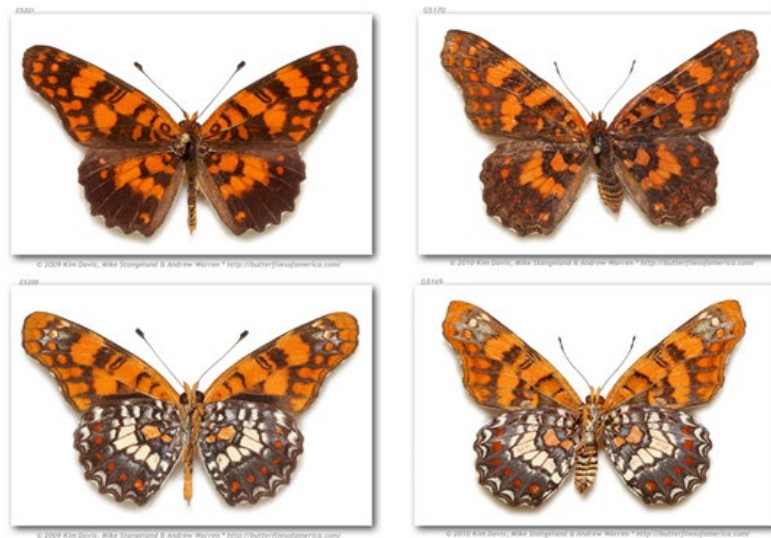


Figure 2-2. Photos showing the dorsal (top) and ventral (bottom) coloration patterns observed in *Atlantea tulita* (Dewitz 1877). Male (left) and female (right). Photo downloaded from <https://www.butterfliesofamerica.com>.



Figure 2-3. Male (left) and female (right) *A. tulita*. The abdomen of the male is a deep orange color with bands, and the abdomen of the female is white with black bands. Source: Carlos Pacheco, Service.

The PRHB caterpillar (larva) is dark orange with a brownish-black to black, thin sub-lateral line, over a thin line of white intermittent dots crossing the body from the head to anal plate (Figure 2-5). The larva is less than 4.76 millimeter (mm)(0.19 in) in first instar (growth stage

between molts) and about 55.8 mm (2 in) in the fifth instar (C. Pacheco, Service, 2018, personal observation). The body of the larva has spines with hairs in each body segment (Figure 2-5).



Figure 2-4. Chrysalis of *Atlantea tulita*. Photos by C. Pacheco, Service.



Figure 2-5. *Atlantea tulita* caterpillar. Photo by C. Pacheco, Service.



The eggs of the PRHB are greenish oily spheres, with a yellowish incipient crown (Figure 2-6).



Figure 2-6. Photo (left) showing the yellowish crown on the eggs laid by *Atlantea tulita* on *Oplonia spinosa*. Photo (right) showing the first instars of the *Atlantea tulita*. Photo by C. Pacheco, Service, 2011.

### 2.3. Life History

Most of what is known about PRHB life history, demography and behavior comes from field observations, information gathered from other species from the same family, and expert opinions.

#### 2.3.1 Life Cycle

The life cycle of the PRHB includes four distinct anatomical stages: egg, larva (caterpillar, with several size phases called instars), chrysalis, and imago (adult). It is a general consensus among the species' experts (A. Morales and E. Estremera, Liga Ecológica Quebradillana; H. Torres, former Assistant Professor from the University of Puerto Rico, Mayagüez Campus; and C. Asencio, former professor Universidad Católica de Ponce) that the life cycle of the PRHB (Figure 2-7) from egg to imago in the wild may take around 125 days (Second Technical Meeting Puerto Rican Harlequin Butterfly Working Group, November 3, 2018). These experts also agree that the length of the life cycle can be affected by factors such as temperature and humidity, particularly at the caterpillar stage.

#### 2.3.2 Dispersal, Mating, and Food Sources

PRHB dispersal and mating behavior has not been thoroughly studied. The butterfly flies slowly and is weak and fragile; thus, the species is considered a poor disperser (Carrión-Cabrera 2003, p. 51). However, Monzón (2007, p. 42) found that the butterfly can disperse up to 1,026 meters (m) (3366.1 feet (ft)), approximately 1 kilometer (km) (0.6 mile (mi)) from one breeding site to another. Additionally, the species has specific ecological requirements for reproduction and its dispersion is apparently limited by the monophagous habit of the first instar of the larvae, which feeds only on prickly bush (*Oplonia spinosa*) (Carrión-Cabrera 2003, p. 40; Biaggi-Caballero 2009, p. 4). Mating behavior has been rarely documented. For other species in the family Nymphalidae, the male grasps the female in flight and brings her to a surface, such as a leaf (Figure 2-8) or the ground, where mating occurs. Carrion-Cabrera (2003, p. 60) estimated the sex ratio of the PRHB as 2.67 males per female. It is not well known if the PRHB mates during a

particular month of the year or year-round. However, all life stages of the PRHB are observed year-round, suggesting that mating and oviposition may occur at any time during the year (Figure 2-9).

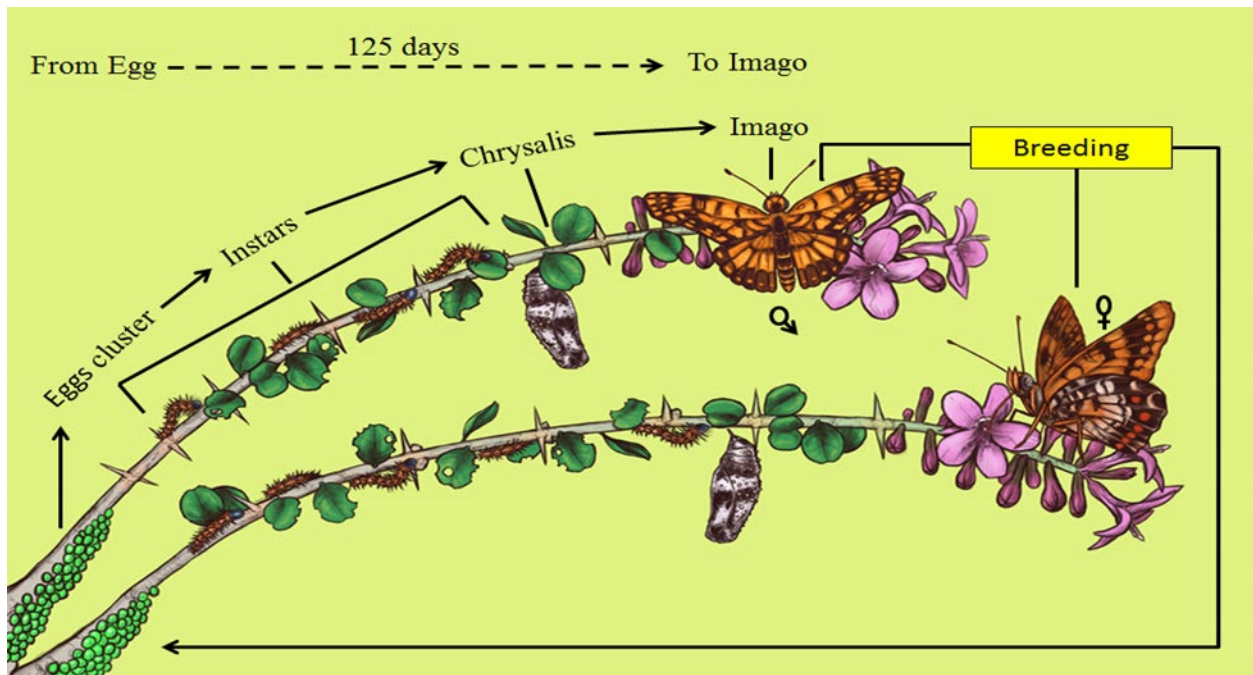


Figure 2-7. Conceptual diagram of the Puerto Rican harlequin life cycle.



Figure 2-8. Photo of Puerto Rican Harlequin butterfly mating. Photo by José Chabert (President of “Fundación EL Pastillo”) at El Pastillo in the municipality Isabela.

Females are multivoltine ovipositors (they produce several broods in a single season) (Biaggi-Caballero 2009, p. 2; 76 FR 31282, May 31, 2011, p. 31283). Eggs and larvae have been found

almost exclusively on prickly bush (*Oplonia spinosa*) (Figures 2-10 and 2-11). The female lays the eggs in rows singly or in pairs, on the underside of tender twigs of the host plant. The species uses the tender vegetative branches of new growth of the host plant for bearing its eggs and feeding during the larval stages (Carrion-Cabrera 2003, p. 40; Biaggi-Caballero and Lopez 2010, p. 2). New growth of *O. spinosa* is observed a few days after rain events, being more abundant during the wet season (from April to November). The female of the PRHB can lay between 50 to 140 eggs in about 45 minutes (Carrion-Cabrera 2003, p.38; Biaggi-Caballero 2009, p. 4). During this process the female appears to be undisturbed by the presence of humans or any other threats (Barber 2018, p. 2).

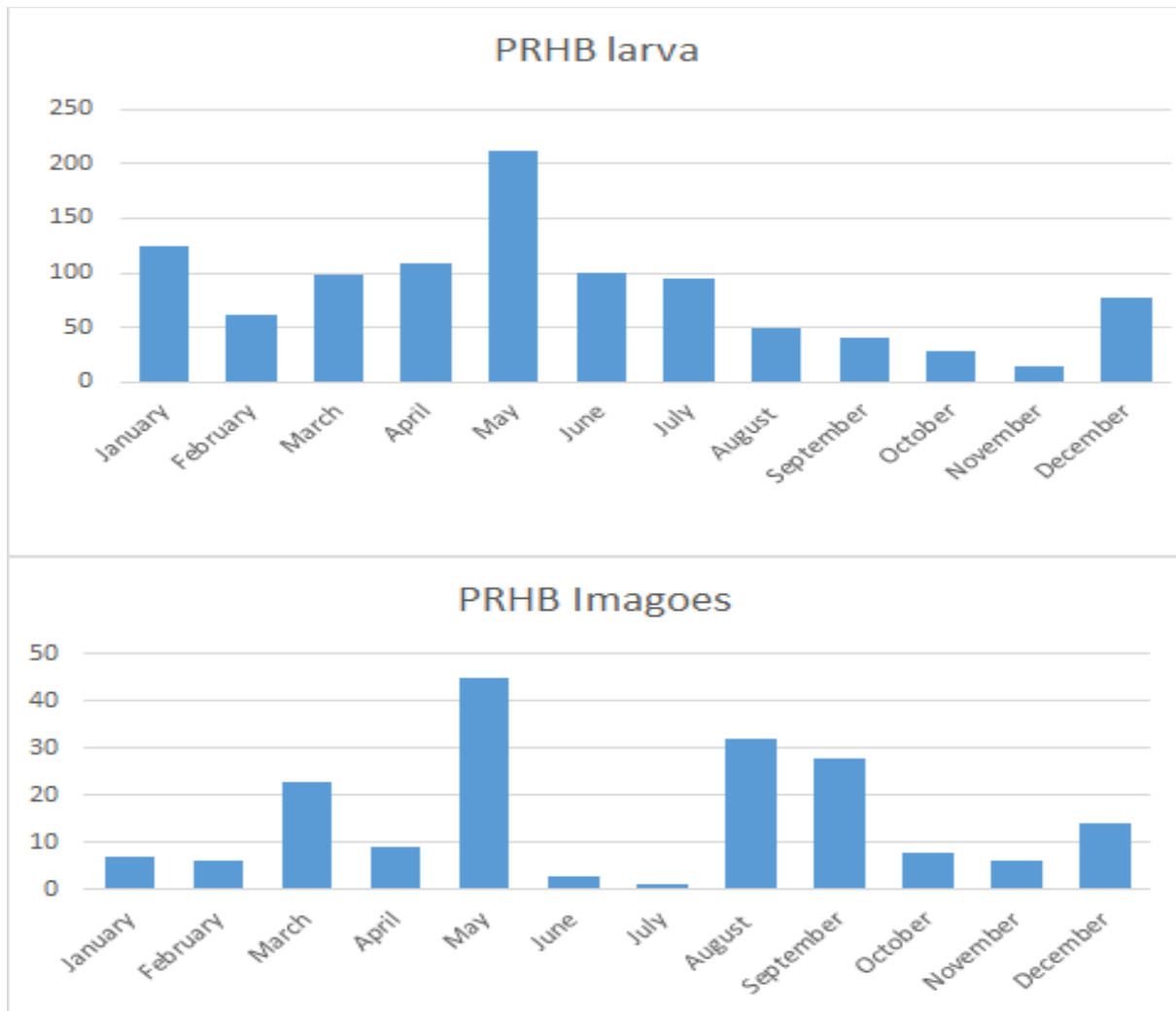


Figure 2-9. Number of observed PRHB larvae (top) and imagoes (bottom) per month throughout the year. Based on information provided by Carrion-Cabreear 2003, Monzon 2007, Biaggi-Caballero 2010, and Barber 2018.

Broods of the PRHB generally contain 50 to 150 eggs, with an average of 102 eggs per brood (Carrion-Cabrera 2003, p.38). The time to egg eclosion and viability (hatching success) rate have not been determined. After egg eclosion, the first instars devour the egg shells and then begin feeding from the most tender parts of the host plant (Biaggi-Caballero and López 2010, p.2). As



the first instar matures, PRHB larvae crawl to the older and woody part of the host plant eating any new growth, including leaves and stems.



Figure 2-10. Left: female *Atlantea tulita* laying eggs on the host plant, prickly bush (*Oplonia spinosa*). Right: eggs of *Atlantea tulita* laid on the new growth (tender part) of *O. spinosa* branches. Photo by José Vargas, 2018.



Figure 2-11. Prickly bush (*Oplonia spinosa*) (left), Family Acanthaceae; endemic to several Caribbean islands and widely distributed in Puerto Rico. Eggs (right) found on prickly bush Source: Willie Hernandez, Liga Ecológica Quebradillana, 2009.

Although the PRHB is believed to be a specialist because of its monophagous habit of feeding only on *O. spinosa*, recently Barber (2016, p. 9) documented a PRHB larva feeding on *Odontonema cuspidatum* (commonly known in Puerto Rico as “coral de jardín”) in Quebradillas (Figure 2-12). Like *O. spinosa*, *O. cuspidatum* is in the family Acanthaceae, but it is native to Mexico and has been introduced to the West Indies as an ornamental shrub (Axelrod 2011, p. 50). In addition, Morales and Estremera (2018, unpublished data) found that the PRHB caterpillar also feeds on *Justicia mirabiloides* (commonly known as West Indian water-willow; or in Spanish as papayo montuno). *Justicia mirabiloides*, which is also in the family Acanthaceae, is a perennial herb native to Puerto Rico and the Virgin Islands. These rare observations of the PRHB caterpillar feeding on plants other than *O. spinosa* were of later instars (possibly 4th or 5th instar). Therefore, it is not known whether the first instar can use other plant species as a food source. Regardless, given the paucity of observations of feeding on other plant species, *O. spinosa* is an essential PRHB food source.

When the caterpillar is fully grown, it makes a button of silk which it uses to fasten its body to a leaf or a twig. Then, the caterpillar's skin comes off the final time, revealing the chrysalis. In the wild, the chrysalis is more often found attached to branches of plants located close to the host plant, but it has been observed attached to dried twigs of the host plant (Biaggi-Caballero 2009, p. 3).

Adult PRHBs have been observed feeding on flowers of several native trees: *Bidens pilosa*, *Bourreria succulenta*, *Bourreria virgata*, *Bursera simaruba*, *Citharexylum fruticosum*, *Coccoloba uvifera*, *Coccoloba diversifolia*, *Coccoloba swartzii*, *Coccoloba costata*, *Coccoloba pubescens*, *Croton rigidus*, *Erithalis fruticosa*, *Guettarda ovalifolia*, *Justicia mirabiloides*, *Lantana camara*, *Lantana involucrata*, *Leucaena leucocephala*, *Oplonia spinosa*, *Paulinia pinnata*, *Pisonia horneae*, *Pisonia subcordata*, *Stigmaphyllon emarginatum*, *Tabebuia heterophylla*, and *Vernonia albicaulis* (76 FR 31282, May 31, 2011, p. 31283; Chabert 2015, p. 2; Barber 2018, p. 3; Vargas 2019, p. 14).



Figure 2-12. Larva of *Atlantea tulita* feeding on *Oplonia spinosa* (prickly bush; left and center) and on *Odontonema cuspidatum* (“coral de jardín” right).

## 2.4. Habitat

The PRHB host plant for egg laying and larval feeding, *O. spinosa*, is a common tropical shrub that is widely distributed in Puerto Rico. According to Lioger (1997, p. 42), *O. spinosa* is a shrub of variable habits that occurs on hillsides and in woods and thickets, at lower and middle elevations in Puerto Rico, Culebra, Vieques, Bahamas and West Indies. Water and nectar sources for adult PRHBs may vary according to the life zone and habitat type. All the sites where the PRHB occurs have a close (within a 1 km radius) water source (e.g., creek, river, pond, among others).

In addition to *O. spinosa*, the a list of the woody plant species known to occur in areas inhabited by the PRHB is provided in appendix I. In some areas where the PRHB occurs, federally listed species such as *Daphnopsis helleriana*, *Schoepfia arenaria* and *Ottoschulzia rhodoxylum* are present (Morales and Estremera 2018, p. 1; Vargas 2019, p. 3). Other rare species that co-occur with the PRHB in some areas include *Minikara pleeana*, *Pisonia woodburyana*, *Drypetes ilicifolia* and *Tabebuia karsoana* (Morales and Estremera 2018, p. 1). The presence of these plant taxa suggests that the areas where the PRHB occurs are relicts of mature forest that might have

survived the massive deforestation of 19<sup>th</sup> and early 20<sup>th</sup> centuries (Morales and Estremera 2018, p. 1).

## 2.5 Summary of Individual Needs

As discussed above, individuals of the PRHB have a variety of resource needs depending on life stage. These needs are summarized in Table 2-1.

Table 2-1. Resources needed by the Puerto Rican harlequin butterfly to complete its life cycle.

Resources needed by each PRHB life stage		Resource Function	Information Sources
<b>Eggs</b>			
	<i>Oplonia spinosa</i> (host plant) with tender vegetative new growth, broadleaf plants, dry-mesic habitat	Breeding	Carrion-Cabrera 2003; Monzón 2007; Biaggi-Caballero 2010;
<b>Caterpillar and chrysalides</b>			
	Food source: <i>Oplonia spinosa</i> (host plant), <i>Odontonema cuspidatum</i> , <i>Justicia mirabiloides</i> . Temperature and relative humidity may be important for larval survival.	Feeding	Carrion-Cabrera 2003; Monzón 2007; Biaggi-Caballero 2010; Barber 2016; Morales and Estremera 2018
	Forested habitat: mosaic of forested habitat with canopy cover between 50 to 85 percent, average canopy height of 20 feet, and plant host cover of more than 30 percent.	Foraging, Sheltering, Migration, Dispersal	Morales and Estremera 2018; Vargas 2019
<b>Adult (imago)</b>			
	Food source: <i>Bidens pilosa</i> , <i>Bidens urbanii</i> , <i>Bourreria succulenta</i> , <i>Bourreria virgata</i> , <i>Bursera simaruba</i> , <i>Chromolaena sinuate</i> , <i>Coccoloba uvifera</i> , <i>Coccoloba diversifolia</i> , <i>Coccoloba swartzii</i> , <i>Coccoloba costata</i> , <i>Coccoloba pubescens</i> , <i>Croton rigidus</i> , <i>Erithalis fruticosa</i> , <i>Guettarda ovalifolia</i> , <i>Lantana camara</i> , <i>Lantana involucrata</i> , <i>Leucaena leucocephala</i> , <i>Oplonia spinosa</i> , <i>Paulinia pinnata</i> , <i>Pisonia horneae</i> , <i>Pisonia subcordata</i> , <i>Randia aculeata</i> , <i>Stachytarpheta jamaicensis</i> , <i>Vernonia albicaulis</i> .	Feeding, Sheltering, Migration, Dispersal	Carrion-Cabrera 2003; Monzón 2007; Biaggi-Caballero 2010; Barber 2016; Morales and Estremera 2018; Vargas 2019
	Forested habitat: mosaic of forested habitat with canopy cover between 50 to 85 percent, average canopy height of 20 feet, forested corridor between suitable breeding sites (with plant host covering more than 30 percent). Water source.	Foraging, Sheltering, Migration, Dispersal	Morales and Estremera 2018; Vargas 2019



## CHAPTER 3. DISTRIBUTION, AND POPULATION AND SPECIES NEEDS.

In this chapter, we summarize the available information on the distribution and populations of the PRHB, the habitat where the species occurs, and those needs that may influence the viability of the species. We first identify the species' historical and current distribution throughout its entire range. Next, we define what we consider as a population and its structure, and we estimate population sizes. Finally, we characterize the needs of the species in terms of population resiliency and species' representation and redundancy (the 3Rs).

### 3.1. Historical Range

The PRHB was first collected and described from the karst hills in the municipality of Quebradillas in northern Puerto Rico (Dewitz 1877, p. 241). Later, the species was reported by William P. Comstock (1930, p. 449) in the municipality of Arecibo (northern Puerto Rico) and also in Quebradillas, and in Tallaboa, a location between the municipalities of Guayanilla and Peñuelas in the southern karst of the Island (Figure 3-1). The northern and southern karst regions are separated from each other by the central mountain range (Cordillera Central) that extends across the interior of Puerto Rico from east to west. Early observations indicated the PRHB occurred at low elevations in coastal areas (Gundlach 1891, p. 125). Much later, in 2003, the species was found at higher elevations in the municipalities of Maricao and Sabana Grande (Figure 3-1), both located within the west-central volcanic region (Carrion 2003, p. 32, Biaggi 2009, p. 3). These reports expanded the known range of the species from the coastal and karst area to the volcanic region, and from low lying coastal areas to elevations around 867 m (2,845 ft) above sea level.



Figure 3-1. Map showing the historical distribution of the Puerto Rican harlequin butterfly.

Many records of PRHB historical locations are from anecdotal reports. Therefore, precise information about locations where the species has been collected or sighted is limited and some records may not be accurate. By 2011, the PRHB was considered endemic to the northern karst region and the west-central section of Puerto Rico (Figure 3-1), since it has not been found in other areas of the Island or in other islands in the Caribbean (76 FR 31282, May 31, 2011).

### 3.2 Current Range

Since the PRHB was added to the candidate species list (76 FR 31282, May 31, 2011), search efforts for the species have been concentrated in its historical collection sites and other areas that harbor suitable habitat in Puerto Rico. Thus, for the purpose of this SSA we consider the species' occurrence as the area where the species has been found in all of its life stages (i.e., imago, larva and egg). Presently, this butterfly is only known to occur in the northern karst region and in the west-central volcanic-serpentine region (Perez-Asso et al. 2009, p. 94; Barber 2018, p. 2, Morales and Estremera 2018, unpublished data, p. 2) (Figure 3-2).

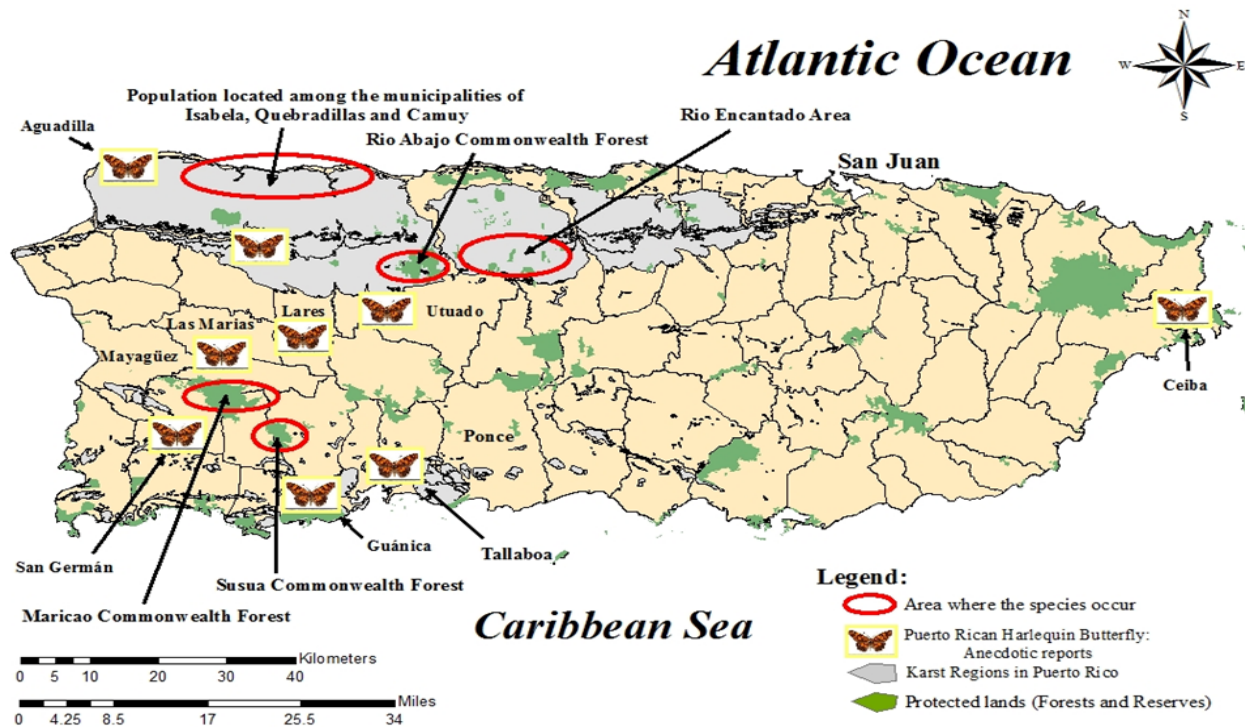


Figure 3-2. Map showing the areas where the Puerto Rican harlequin butterfly populations occur and anecdotal reports of the species in Puerto Rico.

Unfortunately, the fate of the PRHB in the southern karst region is unknown because the species has not been found since 1926 (Biaggi-Caballero and López 2010, p. 4). However, the PRHB has been anecdotally reported (adults, but not other life stages) in other regions, including the municipalities of Aguadilla, Barceloneta, Ciales, Florida, Luquillo, Ceiba, Guánica, San Germán,

Las Marias, and Lares (Rivera Declat 2015, p. 20). Some of these anecdotal reports have been confirmed, while others need to be confirmed.

The PRHB occurs in four life zones: subtropical moist forest on limestone-derived soil, in the northern coastal cliff in Quebradillas (Helmer et al 2002, p. 169); subtropical moist forest on limestone-derived soil in the northern karst region; subtropical wet forest on serpentine-derived soil in the Maricao Commonwealth Forest; and subtropical dry/moist forest on serpentine-derived soil in the Susúa Commonwealth Forest (Ewel and Whitmore 1973, p. 25; Helmer et al 2002, p.169) (Figure 3-3). Although the species has not been detected for many years in the subtropical dry forest in southern karst, this region should be considered as potentially suitable habitat for the PRHB because it harbors *O. spinosa* and some of the plant species that the butterfly stage feeds upon (Carrion 2003, p. 31).

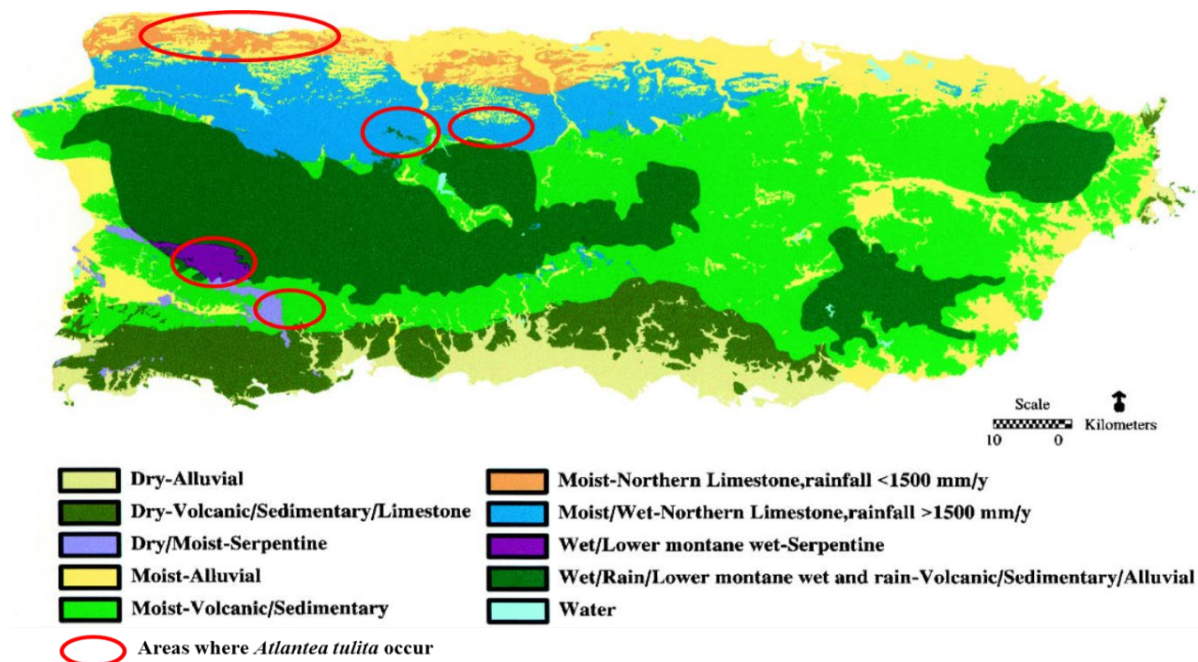


Figure 3-3. Map showing the locations where the Puerto Rican harlequin butterfly occurs in relation with the different forest type and life zones in Puerto Rico. (Helmer et al 2002, p. 169).

### 3.3 Current Distribution and Population Structure

In this SSA we identified five areas currently occupied by the PRHB that we refer to as a population, three in the northern karst region and two in the central-western volcanic-serpentine region (Figure 3-2). Conceptually, we treat each of the five populations as a metapopulation (Table 3-1), or a discrete population composed of local populations (subpopulations) with individuals that can move infrequently from one subpopulation to another (Hanski and Gilpin 1991, pp. 4 and 7). Genetic data to determine true population structure are lacking. However, the gaps in suitable habitat between the metapopulations, as we have defined them, coupled with the



low dispersal capability (approximately 1 km (0.6 mi)) of the PRHB, suggests there is little to no interaction between the metapopulations.

Table 3-1. Puerto Rican harlequin butterfly regions of occurrence, metapopulation locations, and number of subpopulations per municipality.

Region of Puerto Rico	Metapopulation Location	Number of subpopulations	Number of subpopulations per Municipality	
			(Municipality)	(Amount)
Northern Karst Region	Isabela, Quebradillas, and Camuy (IQC)	13	Isabela Quebradillas Camuy	6 6 1
	Río Encantado	3	Arecibo Florida Ciales	1 1 1
	Río Abajo Commonwealth Forest	1	Arecibo	1
West-central Volcanic-Serpentine Region	Maricao Commonwealth Forest	3	Maricao San Germán	1 2
	Susúa Commonwealth Forest	2	Sabana Grande Yauco	1 1
Southern Karst Region	Tallaboa	unknown	Guayanilla Peñuelas	unknown

### 3.3.1 Northern Karst Region Populations

In the northern karst region of Puerto Rico, the PRHB is known to occur in three areas (Figure 3-2): along a coastal cliff in the municipalities of Isabella, Quebradillas, and Camuy (Morales and Estremera 2018, unpublished data, p. 1, Barber 2019, p. 2); In the area of Río Encantado in the municipality of Florida, Ciales and Arecibo (Morales and Estremera 2018, unpublished data, p. 1); and at the Río Abajo Commonwealth Forest, between the municipalities of Arecibo and Utuado (Monzon 2007, p. 51; Morales and Estremera 2018, p. 1).

#### 3.3.1.1 Isabela, Quebradillas and Camuy Metapopulation

In the area of Isabela, Quebradillas, and Camuy (IQC), the species' distribution has expanded since the PRHB was added to the candidate species list (76 FR 31282, May 31, 2011). At that time, the PRHB was known only to occur in four locations within the IQC area: (1) At "El Tunel

de Guajataca” in Isabela, (2) “El Merendero” in Quebradillas, (3) “Puente Blanco” in Quebradillas, and (4) “Puerto Hermina” in Quebradillas. Currently, the species is known to occur in 13 areas within an approximately 400 hectare (ha) (988 acre (ac)) strip of forested habitat on a coastal cliff that extends along the municipalities of Isabela, Quebradillas, and Camuy (Morales and Estremera 2018, unpublished data, p. 1, C. Pacheco, Service, 2018, unpublished data). The species’ range is delimited on the east by the community La Yeguada and Membrillo in Camuy, on the west by the community Villa Pesquera and Pueblo in Isabela, on the north by the Atlantic Ocean, and on the south by State road PR-2, the Royal Isabela Golf Course and some deforested areas utilized for agricultural practices such as cattle grazing (Figure 3-4). In those 13 areas, all life stages of the species (i.e., imago, egg, larva, chrysalis, and adults), and the species’ host plant, have been found in 115 sites (Figure 3-4).

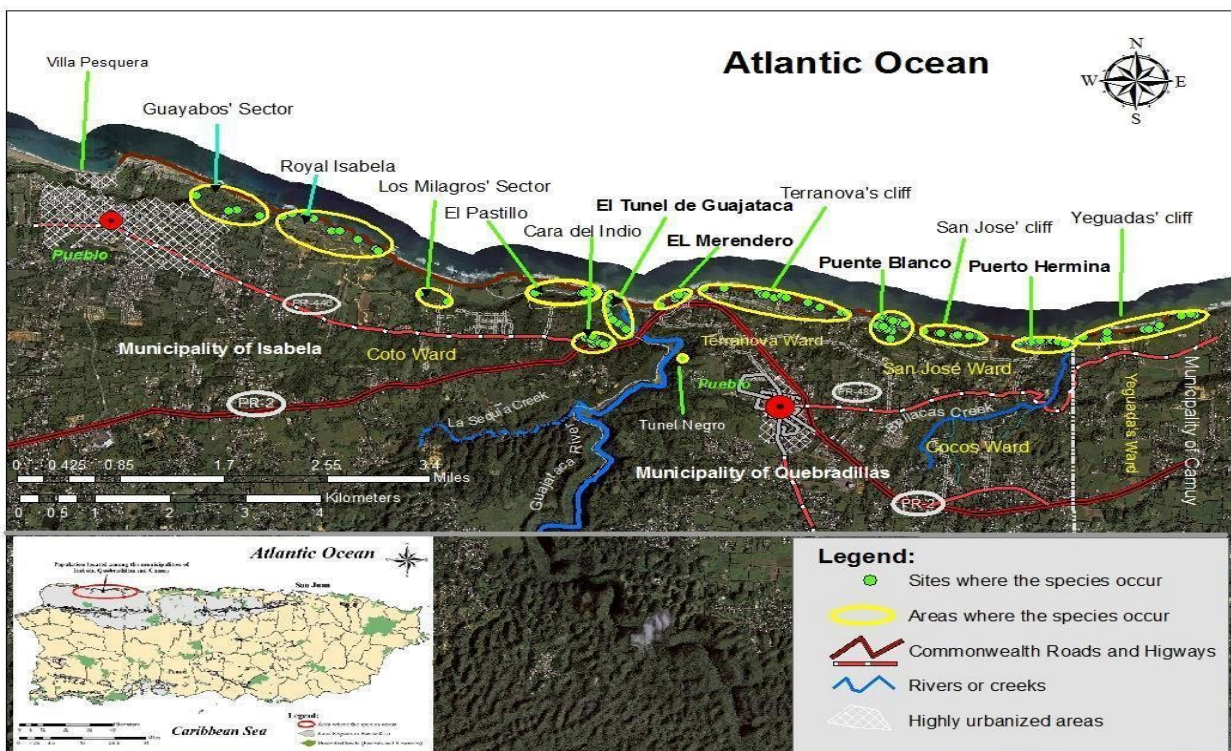


Figure 3-4. Map showing the distribution of the Puerto Rican harlequin butterfly along the municipalities of Isabela, Quebradillas and Camuy.

In the municipality of Quebradillas, the PRHB currently occurs in 5 areas scattered along the coastal forested cliff that extends from El Merendero in Terranova ward through Puente Blanco, to Puerto Hermina in San José Ward. Also, it is found in the forested areas in Puente Blanco and Puerto Hermina. The PRHB also currently occurs farther inland in Quebradillas at Tunnel Negro (Figure 3-4). Within this range, all life stages of the species and its host plant have been observed in 55 sites (Morales and Estremera 2018, unpublished data, entire).

In the municipality of Isabela, the PRHB currently occurs in 6 areas scattered along the forested cliff that extends from El Tunel de Guajataca through El Pastillo beach and Royal Isabela Golf Course, to the Villa Pesquera at Coto Ward (J. Charbert, Fundación El Pastillo, 2018, personal communication; A. Morales, Liga Ecologica Quebradillana, 2018, personal communication; Figure 3-4). Within these areas, all stages of the butterfly and the host plant have been observed in 46 sites. Additionally, in the municipality of Camuy, the species currently occurs along the forested cliff from Puerto Hermina to the community La Yeguada. Within this area, all stages of the species and the host plant have been observed in 14 sites.

### 3.3.1.2 Río Encantado Metapopulation

The Río Encantado area is located to the east of the Arecibo River, within the municipalities of Arecibo, Manatí, Florida, and Ciales in the north-central section of the Island, approximately 50 km (31 miles (mi)) southeast from Quebradillas. This area comprises over 6,474.9 ha (16,000 ac) considered by Federal and Commonwealth conservation agencies as mature native secondary forest, holding the largest tract of continuous forest cover in all Puerto Rico ([www.paralanaturaleza.org/en/rio-encantado-eng](http://www.paralanaturaleza.org/en/rio-encantado-eng)). Presently, the PRHB is known to occur in three (3) areas scattered through the Río Encantado (Figure 3-5; Morales and Estremera 2018, unpublished data, p. 1). Within these areas, all life stages of the species and the host plant have been observed in 8 locations. In addition, imagoes of the PRHB have been sighted in other areas adjacent to Río Encantado (Morales and Estremera, Liga Ecológica Quebradillana, 2018, unpublished data, entire).

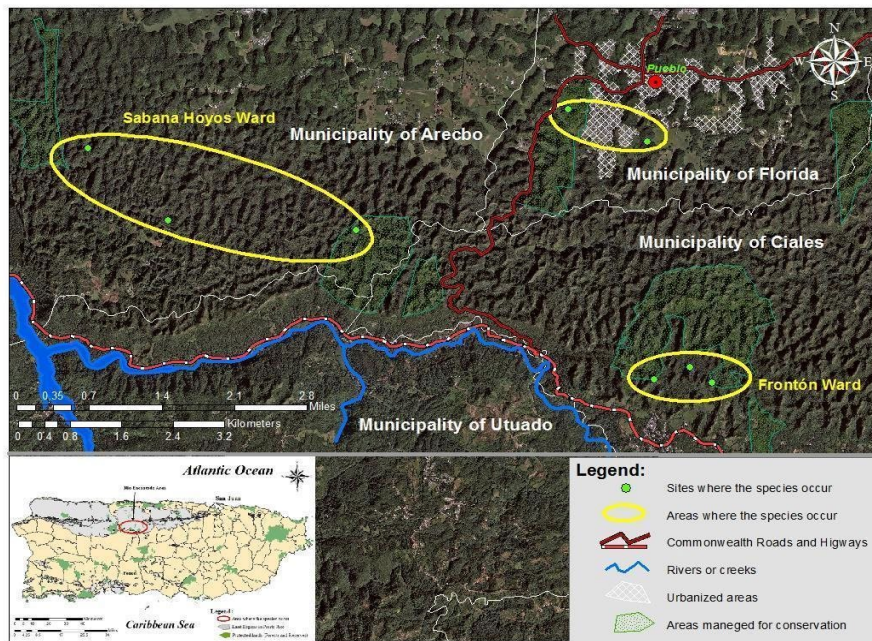


Figure 3-5. Map showing the distribution of the Puerto Rican harlequin butterfly in the Río Encantado area.



### 3.3.1.3 Río Abajo Commonwealth Forest Metapopulation

The Río Abajo Commonwealth Forest is located west of the Arcibo River, between the municipalities of Arcibo and Utuado. This forest is a public land managed for conservation and passive recreation by the Puerto Rico Department of Natural and Environmental Resources (PRDNER; historically Department of Natural Resources, DNR) since 1935 (DNR 1976), and is located approximately 29.9 km (20 mi) southeast of the Quebradillas' PRHB population, outside of the historical range of the species in the northern karst. Within the boundaries of the Río Abajo Commonwealth Forest, the species occurs in 3 locations, one adjacent to the west of State road PR-10 and another two close to Campamento Radley (Figure 3-6). All locations are in El Jobo Ward in Arcibo (Morale and Estremera 2018, Liga Ecológica Quebradillana, unpublished data, p. 7; J. Sustache, PRDNER, 2019, personal communication). In addition, sightings of imagoes of the species have been reported from other areas in Río Abajo Commonwealth Forest (J. Rios, Service, 2012, personal communication; Morales and Estremera, Liga Ecológica Quebradillana, unpublished data, 2018, O. Monseguer, Service, 2019, personal communication).

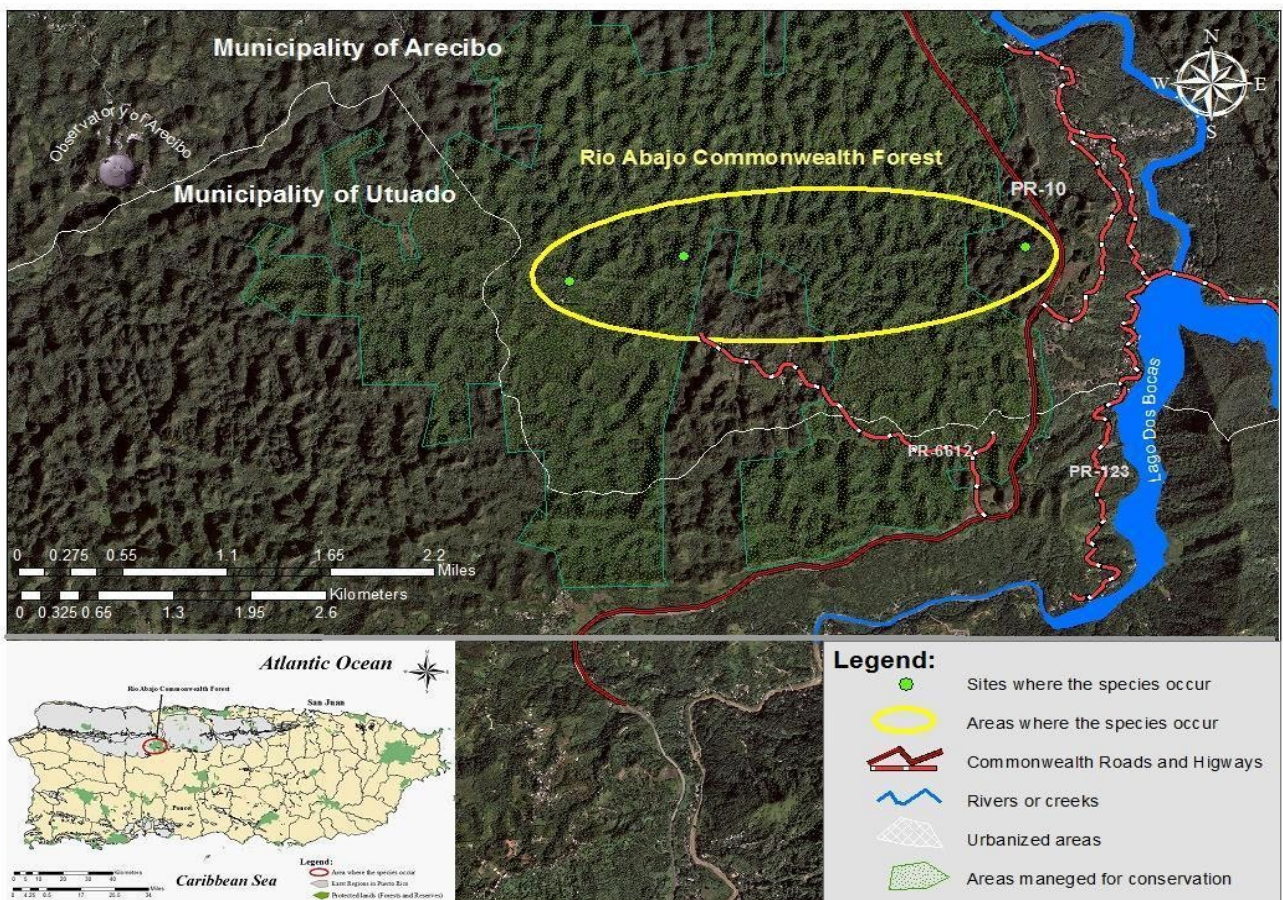


Figure 3-6. Map showing the distribution of the Puerto Rican harlequin butterfly at the Río Abajo Commonwealth Forest.



### 3.3.2 West-central Volcanic-serpentine Region

In the west-central volcanic-serpentine region, the PRHB occurs in the Maricao and Susúa Commonwealth Forests; both are public forests managed for conservation by the PRDNER.

#### 3.3.2.1 Maricao Commonwealth Forest Metapopulation

The Maricao Commonwealth Forest is located in west-central Puerto Rico among the municipalities of Maricao, San Germán, Las Marias, Mayagüez and Sabana Grande, approximately 108.9 km (67.7 mi) west of San Juan (Pérez-Asso et al. 2009, p. 94). At the Maricao Commonwealth Forest, all life stages of the PRHB have been observed in 5 sites (Figure 3-7). Three of these sites are between the km 16.0 (mi 9.9) and km 16.8 (mi 10.4) markers of State road PR-120; one site is close to Campamento Buena Vista, a recreational area located adjacent to the Maricao Commonwealth Forest office; and another in a forested area near the National Parks Company camping area (Figure 3-7; Barber, 2018, pp. 22 and 29; C. Asencio, former professor Universidad Católica de Ponce, 2018, personal communication).

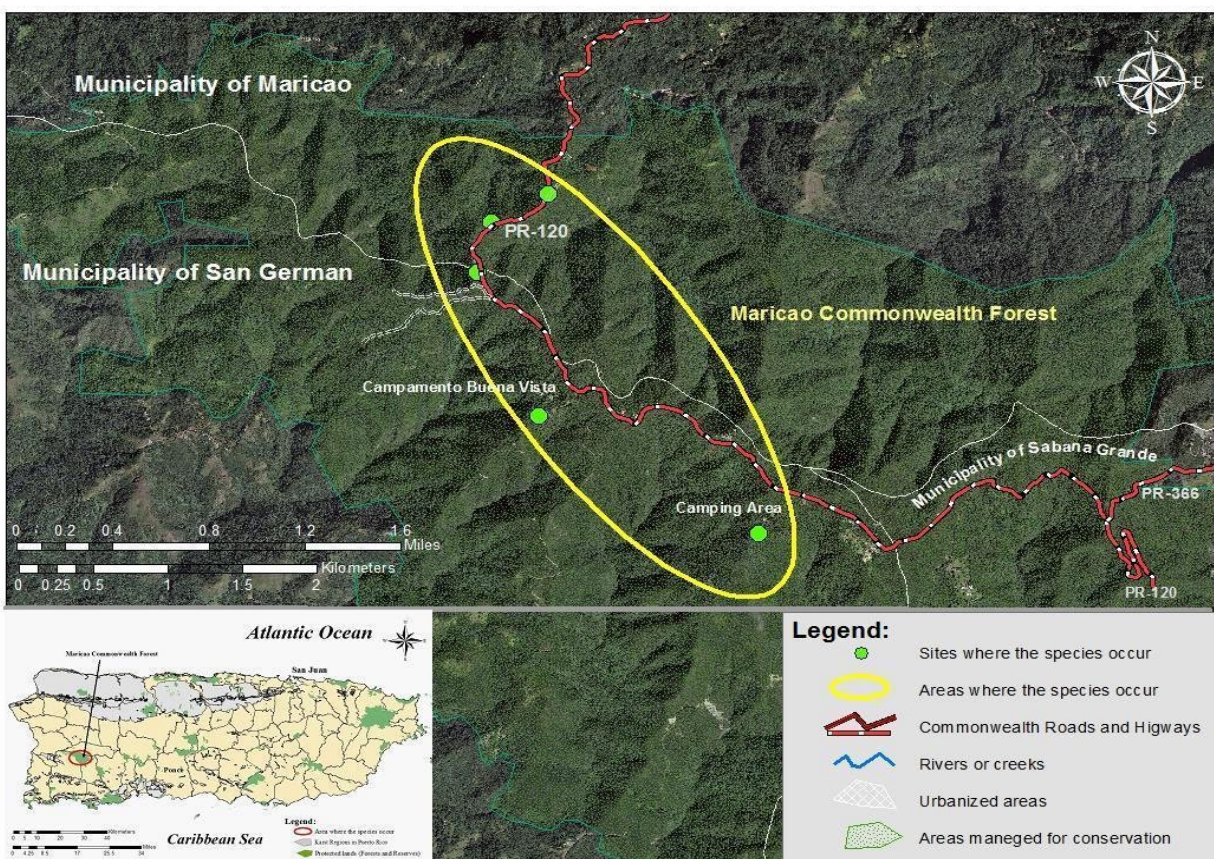


Figure 3-7. Map showing the distribution of the Puerto Rican harlequin butterfly at the Maricao Commonwealth Forest.



### 3.3.2.2 Susúa Commonwealth Forest Metapopulation

The Susúa Commonwealth Forest is located between the municipalities of Sabana Grande and Yauco, approximately 9.5 km (5.8 mi) southeast of the Maricao Commonwealth Forest. The PRHB has been documented in two (2) sites in the Susúa Commonwealth Forest (Figure 3-8; Barber 2016, p. 12). All life stages of the butterfly and the host plant have been observed on two (2) sections of the Eagle’s trail, which is located in the southern section of the forest. Another site is located at Cuchilla Larga sector in the northern section of the forest.

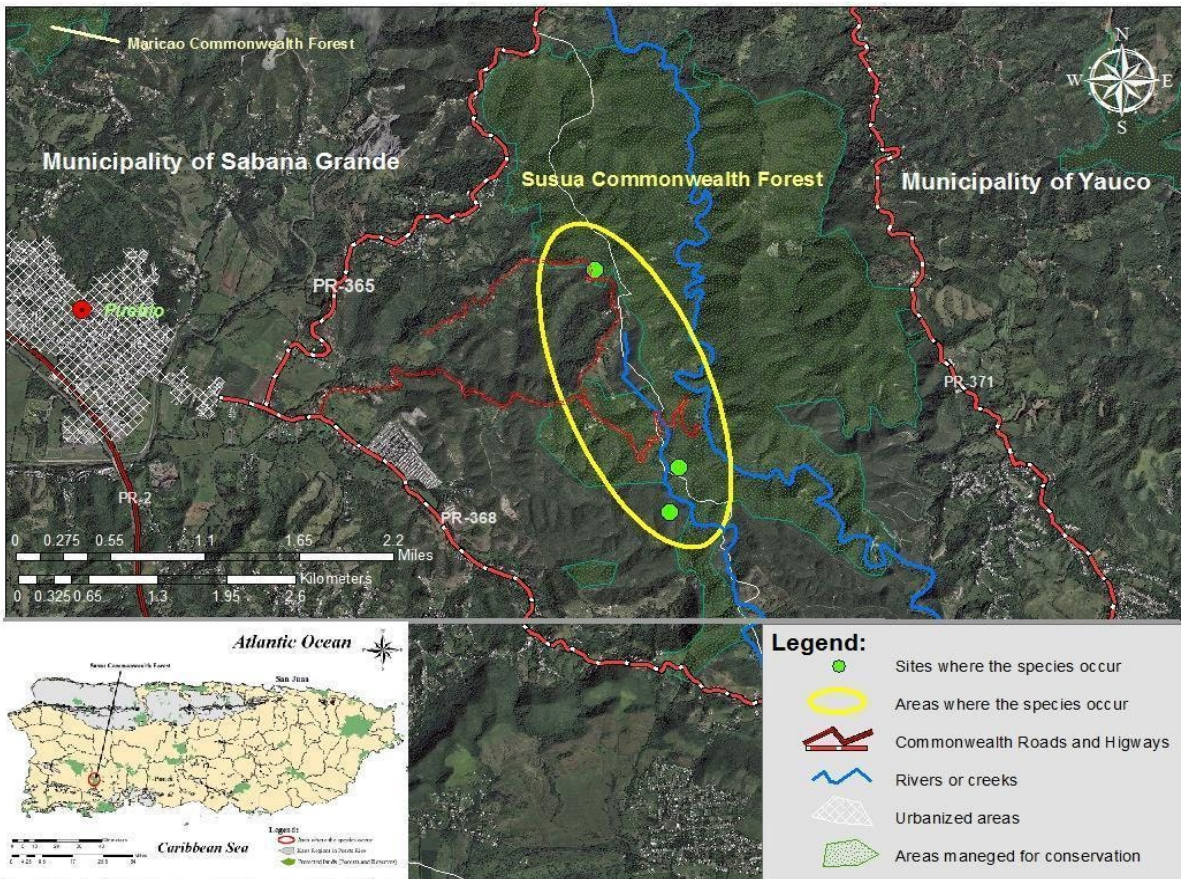


Figure 3-8. Map showing the distribution of the Puerto Rican harlequin butterfly at the Susua Commonwealth Forest.

### 3.4 Population Estimates

Since 2003, there have been several PRHB surveys, although survey methods and objectives have varied. Current (since 2003) population estimates are derived from anecdotal reports, species expert opinion, and number of individuals (imagoes or larvae) observed during single survey events. Thus, the estimated abundance of the species per population may vary according to the methodology implemented during the survey and the source of information. Assessing the overall population size and structure of the PRHB in the wild is considered a daunting task,



particularly because of the apparent seasonality of the species (C. Pacheco, Service, 2019, personal observation). Although imago counts are considered a reliable method to estimate butterfly abundance, we cannot assume that all individuals are counted, because all species stages and instars are not likely to be detected during a single survey. Furthermore, the size and structure of the PRHB population is difficult to determine due to the lack of information regarding factors that can affect the population growth (e.g., amount of viable eggs per host plant, time of eclosion, mortality rate at each stage, among others). For example, the species may lay about 102 eggs per clutch, but subsequent counts after eclosions may yield a low number of imagoes (C. Pacheco, Service, 2019, personal observation). The lack of information on the population dynamics of the PRHB is a limiting factor in defining what constitutes a viable population. Consequently, estimating the overall abundance, population densities, size classes, or population trends for the butterfly is challenging because existing biological studies have not been designed specifically to determine these factors.

#### *3.4.1 Population Estimates in the Northern Karst Region: IQC, Río Encantado, and Río Abajo Commonwealth Forest.*

At IQC, the PRHB occurs in 13 areas (subpopulations), but recent surveys for the species have been conducted in only 7 of those 13 areas. In the municipality of Quebradillas, the surveyed areas include El Merendero, Puente Blanco and Puerto Hermina. By 2003, Carrión-Cabrera (2003, p. 60) observed 235 PRHB imagoes (mature adult stage) during the 12 months of surveys (2 sample days per month) on 0.34 ha (0.83 ac) in El Merendero and Puente Blanco. In addition, Carrión-Cabrera (2003, p. 61) reported that larval counts from April to July and from December to January resulted in between 100 and 200 larvae per survey day (2 man-hours of search efforts). It has been reported that larval abundance is lower during the rest of the year (i.e., February and September to November) (Carrion-Cabrera 2003, p.61). Later, the population was estimated to be 45 or fewer imagoes on any given day in the same area surveyed by Carrion-Cabrera in Quebradillas (Table 3; Biaggi-Caballero 2009, p. 4). The presence of more than one generation observed during the later survey confirms the species' multivoltine (producing several broods in a season) nature (Biaggi-Caballero 2009, p. 4). Based on the above information, by 2010, the PRHB population in the known sites in the municipality of Quebradillas was reported at around 50 imagoes and 100 larvae, for a density estimate of 132 imagoes and 294 larvae per ha (or 54 imago and 120 larva per ac) (76 FR 31282, May 31, 2011). The surveyed area was 2.68 ha (6.67 ac). The density is calculated as the number of individuals counted (abundance) divided by area in which they were observed.

In Isabela, over 200 imagoes of the species were observed during a one-day survey in December 2014, in an area of approximately 1.6 ha (3.9 ac) along the northern coastal cliff in Royal Isabela (J. Chabert, Fundación EL Pastillo, unpublished report 2015, p. 1), which equates to an estimate of 125 imagoes per ha (or 51 imagoes per ac).

More recently, Barber (2018, p. 1) surveyed the species after the Hurricane María in 6 sites (i.e., El Pastillo, El Tunel de Guajataca, Cara del Indio, El Merendero, Puente Blanco and Puerto Hermina) between the municipalities of Isabela and Quebradillas, and reported a maximum of 53 adults and a maximum of 1,381 larva in 2.68 ha (6.67 ac), or an estimated density of 20 imagoes and 515 larva per ha (or 8 imagoes and 207 larvae per acre) (Table 3-2).

The species abundance for the subpopulations in Río Encantado and Río Abajo Commonwealth Forest is currently unknown. The information available for these populations is based on sporadic sightings of the species (larva or imago), but not counts of individuals.

#### *3.4.2 Population estimates in the West-central Volcanic-Serpentine Region: Maricao Commonwealth Forest and Susua Commonwealth Forest*

In the Maricao Commonwealth Forest, the PRHB is known to occur in three (3) areas: along State road PR-120; at Campamento Buena Vista; and at the National Parks Company camping area. By 2011, the PRHB population in the Maricao Commonwealth Forest was estimated in no more than 20 imagoes and over 100 larvae (76 FR 31282, May 31, 2011). Recently, after Hurricane Maria, Barber (2019, p. 4) conducted surveys over 12 months (March 2018-March 2019) in two (2) sites: Los Pinos and La Cantera in Maricao and found a maximum of 21 adults and a maximum of 632 larva in 1.08 ha (2.67 ac), which equates to a density of 19 imagoes and 584 larvae per ha (or 8 imagoes and 236 larvae per ac). Throughout the years, the Maricao Commonwealth Forest manager, Edwin Avila, has observed an undetermined number of imagoes of the PRHB in different sections of the forest (E. Avila, PRDNER, 2016, personal communication).

The occurrence of the PRHB in the Susua Commonwealth Forest has been recently confirmed. Therefore, historical information about status and population estimates of the species is not available (Barber 2016, p. 15). Nonetheless, Wetsy Cordero, Manager of the Susúa Commonwealth Forest, has observed an undetermined number of imagoes of the species in different sections of this forest (W. Cordero, PRDNER, personal communication, 2016). Barber (2016, pp. 12-15) documented one PRHB imago and one larva along Eagle's trail and at the Cuchilla Larga sector, respectively. More recently, Barber (2019, p. 56) surveyed the species in these two sites and reported a maximum of 16 imagoes and a maximum of 83 larvae in 1.08 hectares (2.67 acre) during the 12 months of surveys, an abundance estimated of 15 imago and 77 larva per ha (or 6 imago and 31 larva per ac) (Table 3-2).

Aside from the information provided above, no scientific data regarding the abundance of the species or populations trends are available.

Table 3-2. Number of Puerto Rican harlequin butterflies observed per population.

Region of Puerto Rico	Metapopulation	Number of Individuals Observed	Surveyed Area	Source of Information
Northern Karst Region	Isabela, Quebradillas and Camuy (IQC)	45 or less adults (imago) / 10 to 100 larvae	0.34 ha (0.83 ac)	Carrión-Cabrera 2003, p. 34, Monzón-Carmona 2007, p. 44, Biaggi-Caballero 2010, p. 4
		53 adults (imago) / 1,381 larvae	2.68 ha (6.67 ac)	Barber 2019, p. 4
West-central Volcanic-Serpentine Region	Maricao Commonwealth Forest	12 adults (imago) / no data about larvae	Not determined (unknown)	Asencio 1984, entire
		No more than 5 imagoes / no more than 10 larva	Not determined (unknown)	Carrión-Cabrera 2003, p. 48, Pérez-Asso et al. 2009, p. 94
		21 adults (imago) / 631 larvae	1.08 ha (2.67 ac)	Barber 2019, p. 4



Table 3-2 continued.

Region of Puerto Rico	Metapopulation	Number of Individuals Observed	Surveyed Area	Source of Information
West-central Volcanic-Serpentine Region	Susúa Commonwealth Forest	Unknown (Not observed since 1980's)	Not determined (unknown)	Biaggi-Caballero 2010, p. 4
		16 adults (imago) / 83 larvae	1.08 ha (2.67 ac)	Barber 2019, p. 4
Southern Karst Region	Tallaboa Peñuelas	Unknown (Not observed since 1926)	Unknown	Biaggi-Caballero 2010, p. 4

### 3.5 Habitat Description Per Population

Habitat descriptions and species occurrence records at the subpopulation scale, including floral composition, the distribution of *O. spinosa*, and localities of PRHB eggs, larvae, or imagoes, are available for several sites and are provided in Appendix 3.

### 3.6 Population Needs

Resiliency refers to a species' ability to sustain populations through periods of both favorable and unfavorable environmental conditions and/or anthropogenic impacts. The PRHB needs robust populations (resiliency) to withstand environmental stochasticity (i.e., normal conditions, year-to-year variations in environmental conditions such as temperature, rainfall, drought seasons, etc.), periodic disturbances (e.g., fires, hurricanes, storms), and anthropogenic stressors (e.g., habitat modification, deforestation) (Redford et al. 2011, p. 40).

Certain habitat features influence the demographic attributes that determine PRHB population resiliency (Figure 3-9).

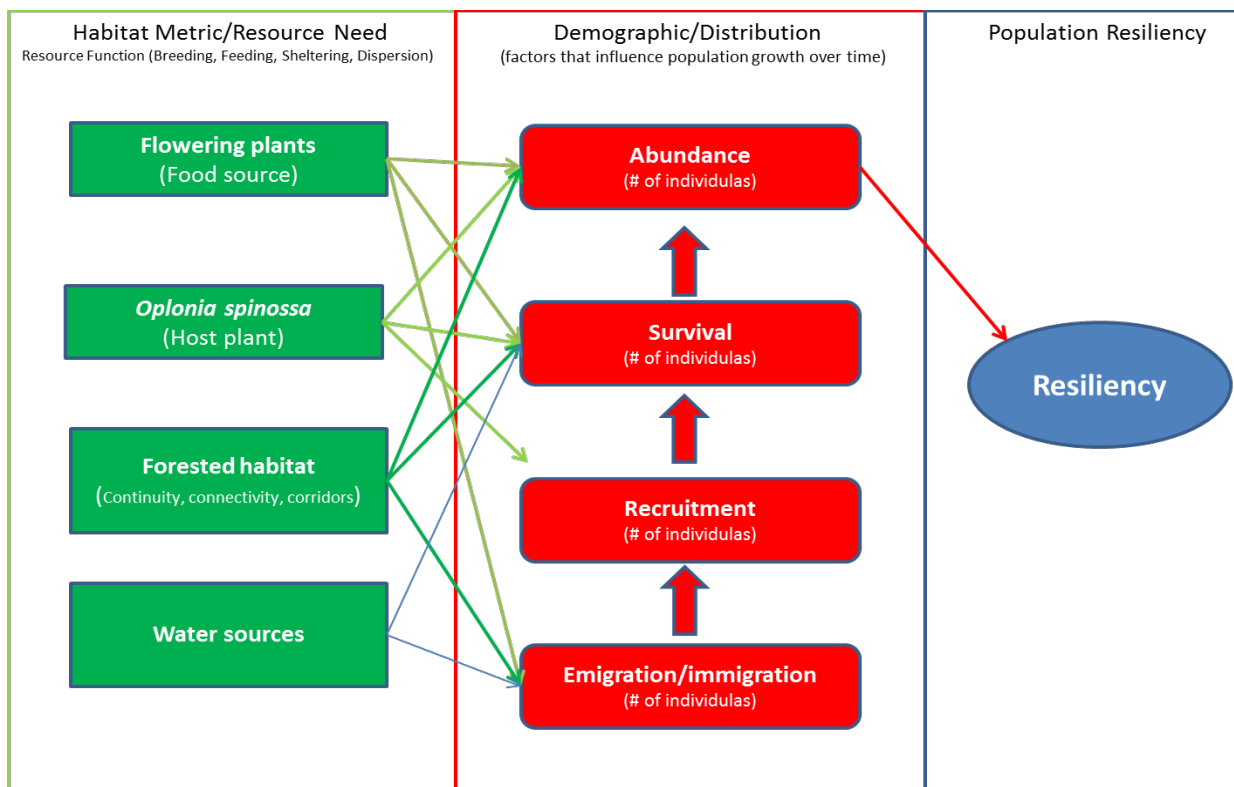


Figure 3-9. Basic conceptual model (or influence diagram) showing what resources may influence the resiliency of the Puerto Rican harlequin butterfly.

### 3.6.1 Interaction or Connectivity Among the Populations.

As discussed above (section 3.3), the PRHB is known from five (5) populations: three (3) in the northern karst region and two (2) in the west-central volcanic region. It is likely that these populations are not interacting, due to the distance between them and intervening habitat fragmentation resulting from past land use practices. However, each metapopulation is comprised of subpopulations distributed across the landscape. Based on the observed dispersal distance to mating sites (Monzón 2007, p. 42), these subpopulations are close enough (approximately 1 km [0.6 mi]) that adult individuals (imagoes) can interact. Persistence of the metapopulation depends not only on the fate of the individual subpopulations, but also on the influence of barriers to dispersal.

Healthy metapopulations rely on discrete high quality habitat patches, presumably those that are separated by less than 1 km (0.6 mi), and are embedded in a landscape matrix with few or only minor barriers to dispersal. We assume that all three factors, (1) short distances separating patches, (2) high quality habitat and (3) few or no dispersal barriers, are essential to ensure

healthy PRHB metapopulation function, but we are uncertain of the relative importance of each factor.

### 3.6.2 Population Size, Demography, and Genetic diversity

The number of individuals comprising a metapopulation (population size) influences population viability through the processes of demographic, genetic, and environmental stochasticity. Metapopulation persistence requires robust demography, sufficient habitat, and some degree of genetic diversity.

Small and isolated populations frequently have low levels of genetic diversity, which reduces their capacity to respond to environmental change and can reduce population fitness via reductions in longevity, fecundity, offspring viability, and dispersal (Mattila et al. 2012, entire; Service 2018, p. 22). A positive relationship between genetic diversity and dispersal is mediated by proximate factors like flight metabolic rate, which can be diminished in small populations with low genetic diversity (Mattila et al. 2012, p. E2496; Hanski 2011, pp. 14401-14402; Rawlins and Lederhouse 1981, p. 387; Vandewoestijne et al. 2008, p. 8; Service 2018, p. 22). Low genetic diversity can also reduce longevity of butterflies and, thus, reproductive output (Vandewoestijne et al. 2008, p. 1). In addition, preservation of allelic diversity - the variety of alternate forms of genes - influences a population's ability to persist in the face of environmental change. High allelic diversity increases the likelihood that individuals will be adapted (i.e., possess genotypes that facilitate high survival) for varying environmental conditions. The interactions between genotype and temperature on flight metabolic rate and dispersal rate in Glanville fritillary butterflies (*Melitaea cinxia*), for example, strongly suggest that heterozygotes at a specific gene can reach higher levels of activity than homozygotes at low ambient and body temperatures but perform poorly at high temperatures (Niitepõld et al. 2009, p. 2230, Service 2018, p. 22). Having individuals with both gene combinations may ensure the population can persist through differing environmental conditions.

Genetic variation can be lost through genetic drift, which is driven by low effective population sizes (Furlan et al. 2012, p. 844). Thus, we believe that preserving the genetic diversity of the PRHB requires maintaining larger populations and connectivity among the populations, but data are not available to determine what constitutes a viable population size. In absence of a population viability analysis (PVA) to support a population target, we use the highest reported population index (amount of individuals counted on a determined time) as an indicator of population resiliency. Barber (2018, p. 1) reported densities of 20 imagoes and 515 larvae per hectare (or 8 imagoes and 207 larvae per acre) in Isabela, Quebradillas and Camuy; 19 imagoes and 584 larvae per hectare (or 8 imagoes and 236 larvae per acre) in the Maricao Commonwealth Forest; and 15 imagoes and 77 larvae per hectare (or 6 imagoes and 31 larvae per acre) in the Susúa Commonwealth Forest. Based on the previous information, we assume that higher



resiliency subpopulations consist of at least 20 imagoes and 500 larvae per hectare (or 8 adults and 200 larvae per acre). However, the sex ratio of a natural PRHB population is unknown.

### *3.6.3 Health of the Populations*

It is well known that butterflies are sensitive to environmental conditions, and experience swings in population numbers from year-to-year that vary among species according to life-history and other factors (Serrat et al 2015, p.207; Service 2018, p. 23). Species that are more sensitive to environmental conditions tend to fluctuate more drastically, and thus, require strong growth rate potential to recover in a short period of time. The PRHB should have a strong growth potential to recover when environmental or human-caused factors result in low survival or reproduction. Presently, the population growth to sustain a healthy population of the PRHB over time is unknown. Monitoring conducted in three (3) of the five (5) populations suggests that there are inter-annual fluctuations in the PRHB abundance and it may be lowest during February and October-November (Carrión-Cabrera 2003, p. 45; Barber 2019, p. 2). Nonetheless, there is no evidence that the species has significant year-to-year fluctuations in population size.

Population health is also affected by dispersal. Although evidence for a positive relationship between adult density and dispersal is not consistent among butterfly species (Konvicka et al. 2011, p. 98; Nowicki and Vrabec 2011, p. 663; Service 2018, p. 23), there is growing evidence that dispersal is positively related to genetic diversity and that genetic diversity is higher in large populations (Vandewoestijne et al. 2008, p. 5). Genetic drift is more likely to occur when populations are small and isolated. Dispersal is necessary for the PRHB to colonize or recolonize remnants of native forest harboring the host plant to facilitate gene flow and reduce the potential for genetic drift and inbreeding depression. Monzón (2007, p. 53) observed that the PRHB in Quebradillas has experienced local extinctions in some subpopulations, followed by re-colonization of un-occupied nearby patches harboring suitable habitat for the species. The author also found that imagoes used forested habitats as corridors between patches of suitable habitat.

Healthy PRHB metapopulations rely on discrete high quality habitat patches separated by less than one kilometer, and which are embedded in a landscape matrix with few barriers for dispersal of the species (Monzón 2007, p. 53, Morales and Estremera 2018, p. 1, Barber 2019, p. 1). All three factors are likely essential to ensure a healthy metapopulation function: short distances between patches; high quality habitat; and few or no dispersal barriers. However, we are uncertain of their relative importance. In a study of another butterfly species with “rather low dispersal ability” distance was the most important determinant of dispersion; habitat quality in recipient patches was second in importance, whereas matrix composition was of less importance (Kalarus and Nowicki 2015, p. 9; Service 2018, p. 23). As previously stated, the PRHB may not typically move greater than 1 km (0.6 mi) between habitat patches separated by structurally similar natural habitats, or through a mosaic of disturbed habitat including houses, roads and grass-dominated fields or pasture. Hence, habitat quality, indicated by factors including density

of *O. spinosa*, amount and quality of adult food sources and low presence of predators, plays an important role in PRHB colonization success.

#### 3.6.4 Habitat Considerations

In addition to population size, the capacity for PRHB populations to grow may be limited by the quantity and quality of the habitat, level of habitat disturbance, and the connectivity among habitat patches (Table 3-3). The minimum extent of habitat that is sufficient to support a healthy local population of this butterfly is unknown, but subpopulations are known to occur in patches of remnant native forests as small as one acre. Subpopulations in patches this small likely rely heavily on the existence of other subpopulations in nearby patches to ensure their long-term persistence.

The PRHB habitat consists of four general forest types already described above (i.e., subtropical moist forest on the northern coastal cliffs, subtropical moist forest on limestone-derived soil, subtropical wet forest on serpentine-derived soil, and subtropical dry/moist forest on serpentine-derived soil). Through this range of habitat types, the species occurs in patches of forest with canopy cover ranging from 50 to 85 percent, and an average canopy height of 6 m (20 ft). Forest connectivity among suitable patches and water sources, are also essential for the species. Historically, natural processes such as drought, hurricanes and storms have maintained a shifting matrix of suitable habitat (Lugo 2000, p. 244). However, anthropogenic disturbances (e.g., urban development, vegetation clearance, human induced fire, agricultural practice) also have been responsible in maintaining shifting matrix of suitable habitat and the essential features for the PRHB (Monzón 2007, p. 12). Moreover, given the short dispersal capability of the species, the frequency and intensity of these disturbances shifting in habitat may promote local extirpations of the PRHB (see Chapter 4- Factors Influencing the Species).

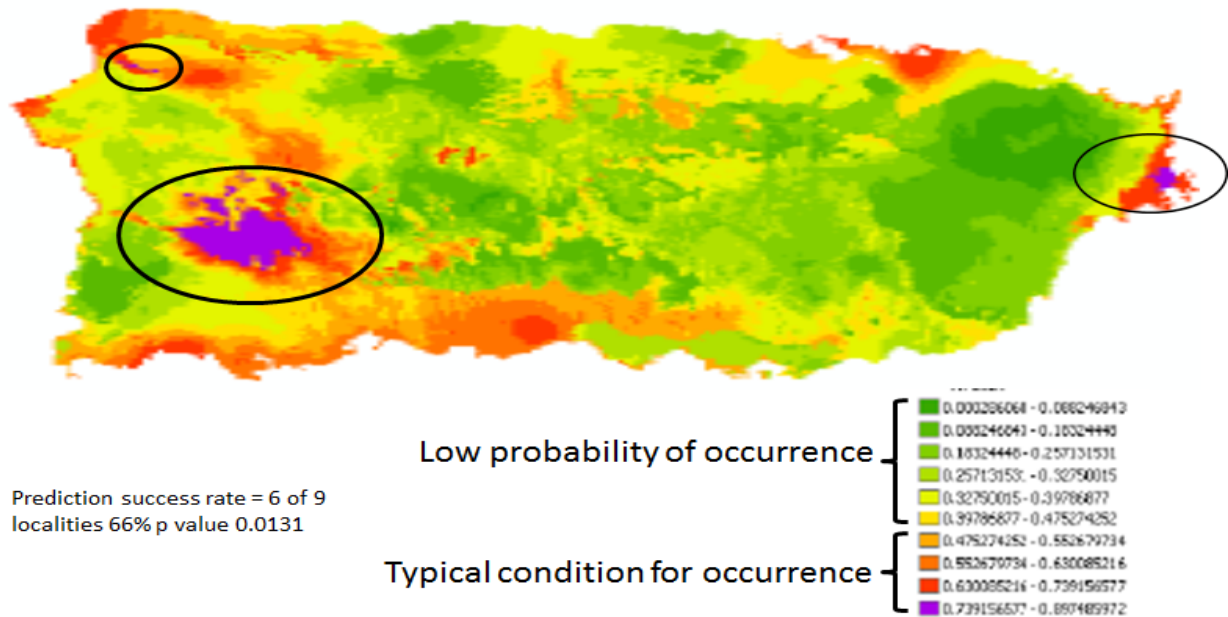
The PRHB occurs at elevations from 3 m (9 ft) to 867 m (2,845 ft) from sea level. However, only certain localities harbor the elements to sustain PRHB reproduction and development. In addition to *O. spinosa*, suitable sites must contain the right temperature and humidity levels (Perez-Asso et al 2009, p. 10). Average daily maximum temperatures where the species occurs range from 82 to 90°F (28 to 32°C), suggesting that the species' ecological niche has evolved within this range of upper thermal tolerance.

*Oplonia spinosa* coverage of more than 30 percent is an essential PRHB need. In 2014, Andrés Vélez (Graduate student from University of Puerto Rico, Mayagüez Campus) developed a habitat model to predict the possible distribution of the host plant *O. spinosa* in Puerto Rico (Vélez 2014, entire). This model was based on herbarium collections of the species. He found that *O. spinosa* may have a wide distribution in Puerto Rico, as well as the PRHB (Figure 3-10). Moreover, he identified three (3) hot spots where *O. spinosa* and the butterfly are predicted to occur.

Table 3-3. Parameters and requirements needed by the Puerto Rican harlequin butterfly at the population level to influence its resiliency, redundancy and representation.

Parameter	Requirements	Influence
Population size	Sufficiently large number of individuals to withstand unfavorable years and to avoid deleterious effects from genetic drift and inbreeding depression.	Resiliency Redundancy Representation
Habitat quality & quantity	Large patches (population-specific, but generally more than 1 acre) of native forest habitat with canopy cover from 50 to 85 percent, canopy height average of 20 feet with plant host covering more than 30 percent of the understory, and water source.	Resiliency
Habitat disturbance frequency and intensity	Low intensity and frequency of disturbance, and timing of disturbance does not occur during mating periods.	Resiliency Redundancy
Connectivity	Forested corridor between breeding sites. Suitable landscape matrix to allow movement between habitat patches (i.e., habitat patches < 1 km or 1000 m apart) on average and permeable land cover between patches	Resiliency Redundancy Representation





Model to predict *Atlantea tulita* and *Oplonia spinosa* distribution was made using Maxent version 3.3.2 (<http://www.cs.princeton.edu/~schapire/maxent/>) Program to develop geographical distribution models of species based on its maximum entropy (Phillips et al, 2006).

Figure 3-10. Map showing predicted areas with potential suitable habitat for *Atlantea tulita* and its host plant, *Oplonia spinosa* (Vélez 2014, entire).

### 3.7 Species Needs

The ecological requisites at the species level include having sufficient numbers, health, and distribution of populations to ensure it can withstand annual variation in its environment (resiliency), catastrophes (redundancy), and novel biological and physical changes in its environment (representation) (Table 3-4).

Table 3-4. Summary of the Puerto Rican Harlequin butterfly needs at the species level

3Rs	Requisites at Species-level	Details
Resiliency	Healthy populations distributed across environmental and habitat heterogeneous conditions	Environmental heterogeneity is having populations occupying areas with temperature and precipitation gradients; wet and dry habitats; and both north and south facing slopes.
Redundancy	Healthy populations distributed across geographical areas with low risks to catastrophic droughts and widespread pest control events	The intensity and duration of drought causing catastrophic losses is unknown,
Representation	Having healthy populations representing the breadth of adaptive diversity and maintaining evolutionary processes	Adaptive diversity is the variation in genetic and phenotypic traits that enable a species to adapt to novel changes. To ensure the breadth of adaptive diversity is preserved, we should maintain populations in their four native ecological settings (life zones) in Puerto Rico and conserve or promote connectivity among populations to ensure gene flow and minimize genetic drift.

Resiliency is the ability to sustain populations in the face of environmental variation and transient perturbations. The PRHB resiliency is a function of the number of healthy populations and the distribution of these populations across heterogeneous conditions. A healthy population is defined above under “Population-level Ecology.” Maintaining populations across its range and across a diversity of environmental conditions helps guard against concurrent losses of populations by inducing asynchronous fluctuations among populations (Sutcliffe et al 1996, p.86). The environmental correlates most likely to influence the PRHB population dynamics include winter-spring temperatures (i.e., cooler temperature), summer-fall temperatures and precipitation (e.g., hot, dry summers; raining). The magnitude of influence these conditions pose depends upon habitat and landscape characteristics (e.g., forest cover, topography, soils, etc.). Generally speaking, with a greater degree of spatial heterogeneity there will be less synchrony among PRHB populations, thereby affording the species’ greater resiliency to environmental disturbance. Additionally, resiliency also requires connectivity among populations for gene flow and demographic rescue. Connectivity between subpopulations (meta-populations) allows gene flow, and thus increases genetic health of a population.

Redundancy at Species-level reflects the ability of a species to withstand catastrophes (i.e., extraordinary events that would be expected to cause population extirpation), and is best achieved by having multiple, widely distributed populations of the PRHB relative to the spatial occurrence of catastrophic events.

As further explained in Chapters 4, Factors Influencing Viability of the Species, we identified drought, hurricanes, and fire as plausible catastrophic factors. Although the species' ability to withstand catastrophes can be influenced by its health (i.e., a demographically robust population is more likely to withstand drought conditions), survival is most strongly influenced by exposure to such events. Exposure is a function of both the number of populations (the more populations, the less likely all will be exposed contemporaneously and to the same intensity) and the distribution of populations (the more widely distributed, the less likely all will be exposed). Thus, generally speaking, the greater the number of populations and the more widely distributed, the more redundancy the PRHB possesses.

Representation at species-level reflects the ability of the species to adapt to novel changes in its environment. Measured by the breadth of genetic or environmental diversity within and among populations, representation gauges the probability that the species is capable of adapting to environmental changes. For adaptation to occur, there must be variation upon which to act (Niitepõld et al. 2009, p. 2230; Lankau et al. 2011, p. 320; Service 2018, p. 29) and functional evolutionary drivers. By maintaining the sources of diversity across the species' range, as well as the processes that drive evolution (particularly gene flow and natural selection), responsiveness and adaptability of the PRHB over time are preserved.

Presently, the genetic diversity of the PRHB and its capabilities to adapt to environmental conditions is unknown. But, given the extremely limited geographic distribution and low number of individuals known of the PRHB, it is highly likely that its genetic variability presented in each population is very low. This would result in a loss of alleles by random genetic drift, which would limit the species' ability to respond to changes in the environment (Honnyay and Jacquemyn 2007, p. 823).

Maintaining the adaptive capacity of a species also requires preserving the processes such as natural selection, gene flow, and genetic drift (Zackay 2007, p. 1; Crandall et al. 2000, p. 291) that allow for evolution to occur (Crandall et al. 2000, p. 290; Sgro et al 2011, p. 327). Natural selection is the process by which heritable traits can become more (selected for) or less (not selected for) common in a population by favoring those traits that enhance survival (Hendry et al. 2011, p. 169). To preserve natural selection as a functional evolutionary process, it is necessary to maintain populations across the breadth of biological and ecological conditions (i.e., historical latitudinal, longitudinal, and elevational gradients, as well as climatic gradients) to which the species may continue to adapt.



## CHAPTER 4 –FACTORS INFLUENCING VIABILITY

In this Chapter we describe the most relevant factors that may negatively or positively influence the continued existence of the PRHB (Figure 4-1). Factors having a negative impact on the butterfly are referred to as risk factors or stressors; whereas factors having a beneficial effect are referred to as supportive factors. We refer to stressors and supportive factors collectively as “influences.” We searched for information (published, unpublished literature, and species expert) to identify past and current negative and beneficial factors that have influenced the status of the PRHB across its historical and current range. Each factor (stressor or supportive) is considered in terms of scale, intensity, and duration, and the impacts it is having on the species and habitat across of its life history stages. Some factors may affect the species at all life stages or all individuals across the species’ range, while others may affect a specific life stage. Additional factors acting on individuals of the species may not rise to the level of affecting the species or population(s).

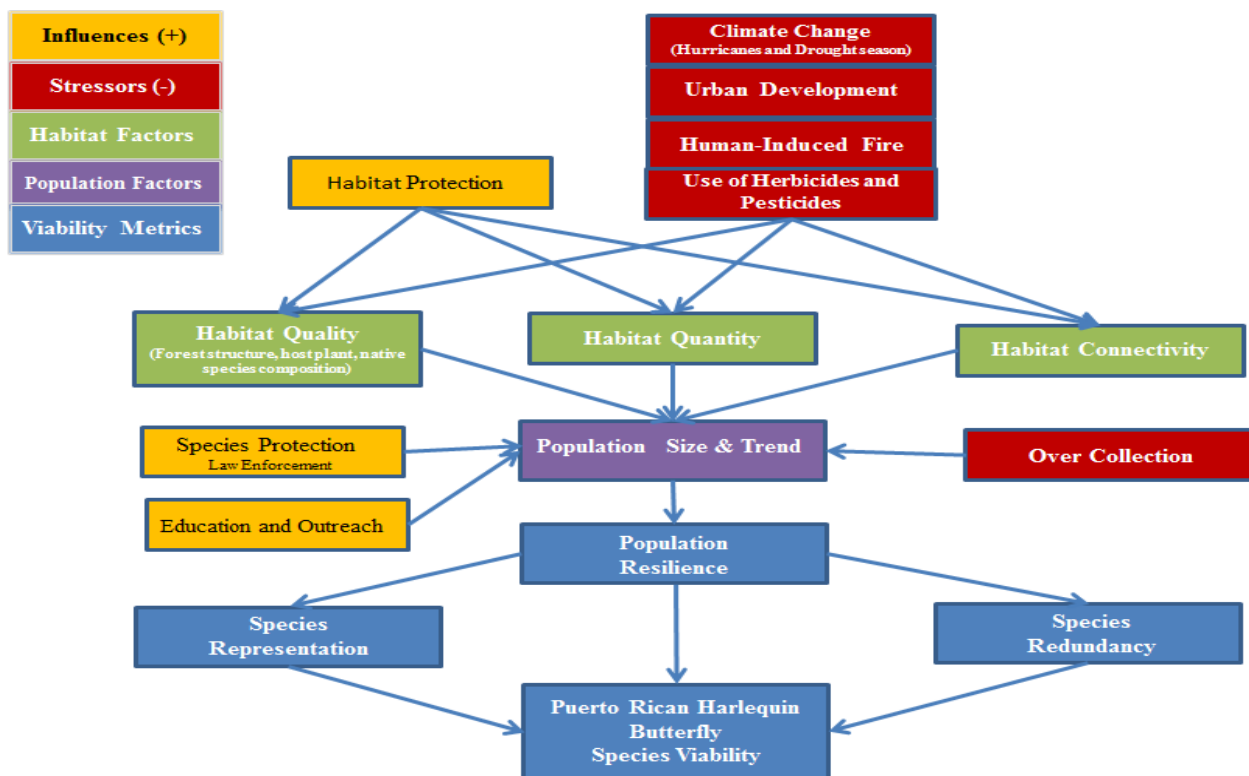


Figure 4-1. Key habitat factors, population factors, and supportive influences and stressors on viability used to assess resiliency, redundancy, and representation for the Puerto Rican harlequin butterfly.

Influences on the PRHB vary from location to location, but stressors include habitat loss and modification by development, clearing vegetation as maintenance activity, predators, human

induced fires and changing climate, and poor enforcement of existing regulatory mechanisms are more wide-spread through its range. There is also evidence that the species has been collected for private entomology collections and un-authorized investigations. Positive influences on the PRHB have been habitat protection, habitat enhancement by reforestation and changes in habitat use.

#### **4.1 Urban Development, Habitat Modification and Fragmentation**

Habitat modification, fragmentation and losses caused by urban development and agricultural practices have been considered as the main factors influencing the decline of the PRHB, and pose continuing threats to the species' continued existence (6 FR 31282, May 31, 2011, p.31285; Barber 2019, p. 2). The species' small range may reflect a remnant population of a once widely distributed butterfly whose habitat was decimated by historic Puerto Rican land uses. Factors responsible for habitat loss, fragmentation, and degradation that we considered for this SSA analyses include conversion of native forest for agriculture or urbanizations; increase of highways and road (vehicle traffic); and land management regimes (vegetation clearance, grazing, haying). During European colonization, land was extensively modified for agricultural practices. A shift in the Puerto Rican economy from agricultural to industry led to land abandonment, and most of these lands were naturally reforested or converted for urban development. The consequences of the loss and fragmentation of natural habitat for the species may be detrimental because the PRHB seems to have low dispersal capabilities, a limited "patchy" distribution, and specialized ecological requirements, including laying eggs and feeding only on *O. spinosa* (6 FR 31282, May 31, 2011, p. 31286).

The PRHB faces significant threats from the existing and imminent destruction, modification, and curtailment of its habitat and geographic range in the municipalities of Isabela, Quebradillas, and Camuy. Historically, conversion of native forests into farms, pastures, or cropland, and in recent history, conversion of these to urban development, roads, recreational parks, and golf courses has been the most significant change in suitable habitat for the species in the IQC area. Most of the suitable habitat for the species, particularly in the municipality of Quebradillas, is currently fragmented by residential and tourist development. Dr. Stuart Ramos (University of Puerto Rico, Mayagüez Campus) reported that in 1997 one of the healthiest subpopulations showed a drastic decrease after the use of heavy equipment to clear vegetation in the Puente Blanco area in Quebradillas (Carrión-Cabrera 2003, p. 13). More recently, Barber (2016, p. 11) reported that in December 2016, in one of the areas where the species occurs in Puente Blanco, the vegetation was bulldozed, resulting in a decline of the *O. spinosa* and the PRHB. In areas where undeveloped land remains, the species' larval food plant is likely to be affected by existing vegetation management practices and agricultural practices that result in deforestation to increase grass lands for cattle grazing.

Although it is likely the historical and ongoing habitat degradation in the IQC area has reduced subpopulation connectivity and space for population growth, which reduces resiliency, persistence of the PRHB IQC population indicates the species can withstand, or at least recover from, some degree of disturbance. In Quebradillas, the PRHB has been observed in habitat previously disturbed by urban and agricultural development. Additionally, the IQC population inhabits a strip of forest that borders other patches of forest in various stages of succession that are fragmented by roads houses and agricultural lands.

PRHB habitat can be modified or lost by single land segregation for houses, large-scale residential and tourism projects, which are planned within and around its habitat in northern Puerto Rico. For instance, in the municipalities of Isabela and Quebradillas, occupied suitable habitat is within an area classified by both municipalities and the Puerto Rico Planning Board (PRPB) as a “Zone of Tourist Interest” (PRPB 2009, online data, at <http://www.jp.gobierno.pr>). A Zone of Tourist Interest (ZIT) is an area that has the potential to be developed to promote tourism due to its natural features and historic value. In 2010, 11 residential development projects were under evaluation around the species’ habitat, possibly affecting 29.4 ha (72.6 ac) in Quebradillas (Figure 4-2; PRPB 2010, online data). Reports from Ernesto Estremera (Ecological Alliance of Quebradilla, 2013, personal communication) indicate that over 20 residential and tourist development projects are proposed within the PRHB’s habitat. However, by 2018, only two new houses had been constructed and another is under construction at the Puente Blanco area (C. Pacheco, Service, 2018, personal observation). Most of these proposed projects may not be constructed in the near future due to the reduction in the economic activity in Puerto Rico; however, land owners have removed vegetation from the proposed projects sites, affecting the suitability of the habitat for the butterfly (C. Pacheco, Service, 2019, personal observation).

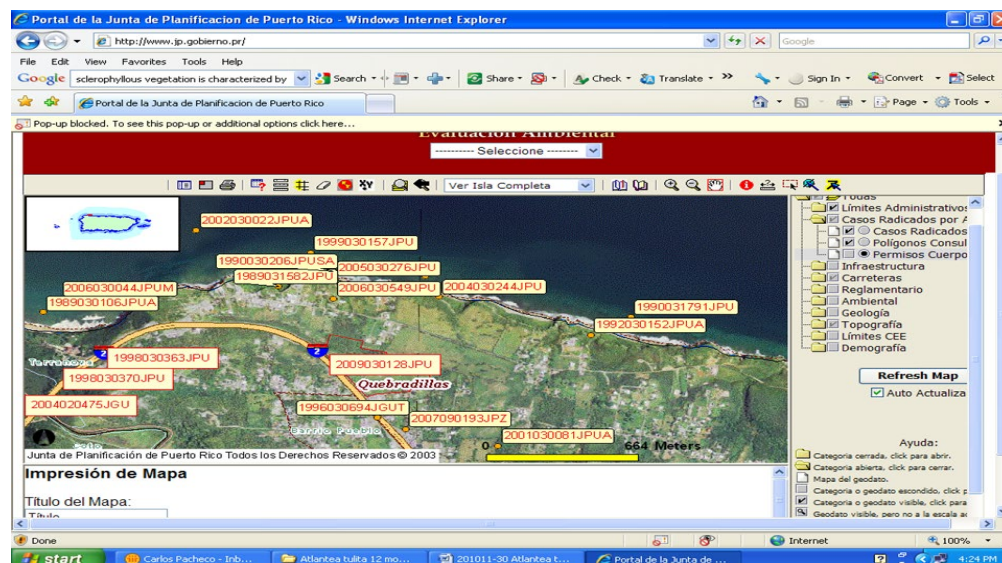


Figure 4-2. Photo showing the location of urban development project proposed for San José ward in Quebradillas. Screenshot taken on 8/2009.



The PRHB also occurs in areas managed for conservation (e.g., Río Abajo Commonwealth Forest, Maricao Commonwealth Forest, Susúa Commonwealth Forest, and Río Encantado Natural Area) or in areas where existing suitable habitat for the species may be protected by Commonwealth Laws and Regulations. However, some populations in or adjacent those areas could be subjected to habitat loss, modification, or fragmentation by urban development or by improvement of the infrastructure to support it. The number of houses around protected areas has continued increasing while human population in Puerto Rico is declining both around protected areas and island-wide (Castro-Prieto et al. 2017, p. 473). By 2016, a total of 32,300 new houses were constructed within 1 km of protected areas, while the human population declined by 28,868 within the same area. At the same time, 90 percent of protected areas showed increases in housing in the surrounding lands, 47 percent showed population declines, and 40 percent showed population increases, revealing strong spatial variations. Many of these new houses or the development of rural communities require construction of additional infrastructure (e.g., access roads, power energy service, water service, communication, among others), that increase their total effect on the surrounding habitats.

Urban development in or around PRHB habitat would directly and indirectly fragment and impact its habitat and would limit its population expansion through the area (Figure 4-3). Establishment of more residential and tourist development projects will result in an increase in access roads, vehicle traffic, and attendant road improvements in proximity to PRHB habitat. Construction of a new access road and improvement of the existing access road to existing or future rural communities may be considered as stressor that could directly (destruction of individuals or host plant) or indirectly (reducing forest habitat and food sources) reduce the populations of the PRHB and its habitat. Moreover, the proliferation of telecommunication towers has increased with the advent of cellular phone and related technologies. In Puerto Rico, towers for cellular communication, radio, television, military, and governmental purposes are a threat to plant species (such as *O. spinosa*) that happen to occur on top of mogotes (limestone hills) or mountaintops. While the towers themselves may not occupy a very large area, construction activities, access roads, and other facilities have a much wider impact, resulting in the elimination of potential habitat for the species. The biological effects of the existing roads and vehicle traffic on the species have not been studied. However, increasing vehicle traffic on roads within the essential habitat of a species that is a weak disperser may result in increased mortality due to collisions and, in some instances, can be catastrophic to species with low number of individuals per population (Glista 2007, p. 85).

The combination of habitat fragmentation and high road density may represent a challenge for the PRHB and could negatively impact the species and its habitat.



Figure 4-3. Photos showing some of the effects to Puerto Rican harlequin butterfly habitat caused by urban developments.

During the period from 1990 to 2010, the human population density of the northern karst region, which is about 75 percent of the entire karst region in area, increased from 1,225.97 inhabitants per square mile to 1,293.28 inhabitants per square mile (PRPB 2010, p. 45). The increase in population density of 5.2 percent during that period occurred despite the great migratory wave and loss of population during the decade of 2000-2010 for all of Puerto Rico, when hundreds of thousands of its residents moved to the metropolitan area and to various cities in the United States.

The proportion that represents the human population of the karst region with respect to entire Puerto Rico has increased over time. According to data from the 2010 Population and Housing Census, the karst region of Puerto Rico had a population of 2,763,178 inhabitants, representing 74.2 percent of the total population for Puerto Rico. However, Puerto Rico's total population has been falling for nearly a decade, and the pace of decline has accelerated in recent years (Figures 4-4 and 4-5; Abel and Deitz 2014, p. 2). Since 2010, the population density of the karst region decreased from 1,326.36 inhabitants per square mile to 1,293.28 inhabitants per square mile. This represents a decrease of 2.6 percent, slightly higher than that of Puerto Rico overall, which was 2.2 percent. (PRAPEC, 2013, p. 18)

According to PRAPEC (2013, p. 19), the number of housing units in the karst region of Puerto Rico has increased in the last 40 years. According to the census of 1980, the total number of housing units was 762,485, and increased to 1,101,041 in the 2010 census, or a 44.4 percent increase. The total inventory of housing units of the Island has also increased in 64.7 percent in the last four censuses (1980-2010) representing a total of 1,636,946 homes for the year 2010. The percent increase of housing units in the karst region has fluctuated, with the largest increase in 1970 of 77.8 percent and the lowest increase in 2010 of 67.3 percent.

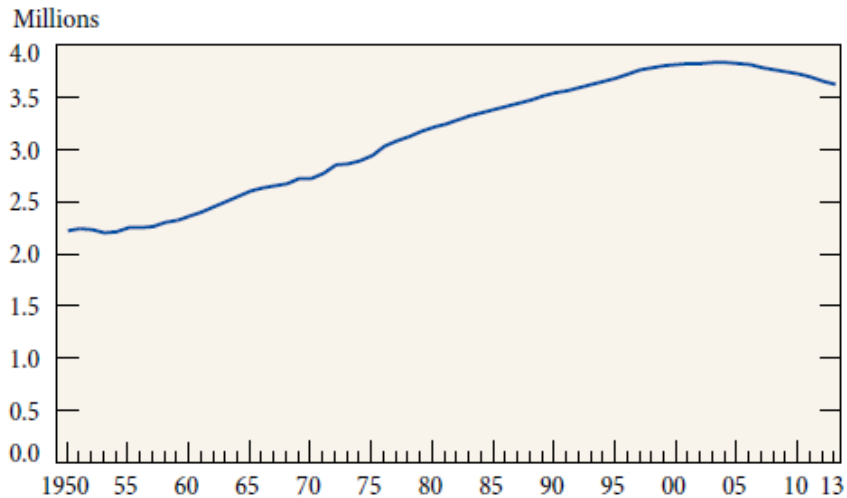


Figure 4-4. Graphic showing the Population in Puerto Rico from 1950 until 2013. Source: U.S. Census Bureau; Moody's Analytics. (Copied from Abel and Deitz 2014, p. 2)

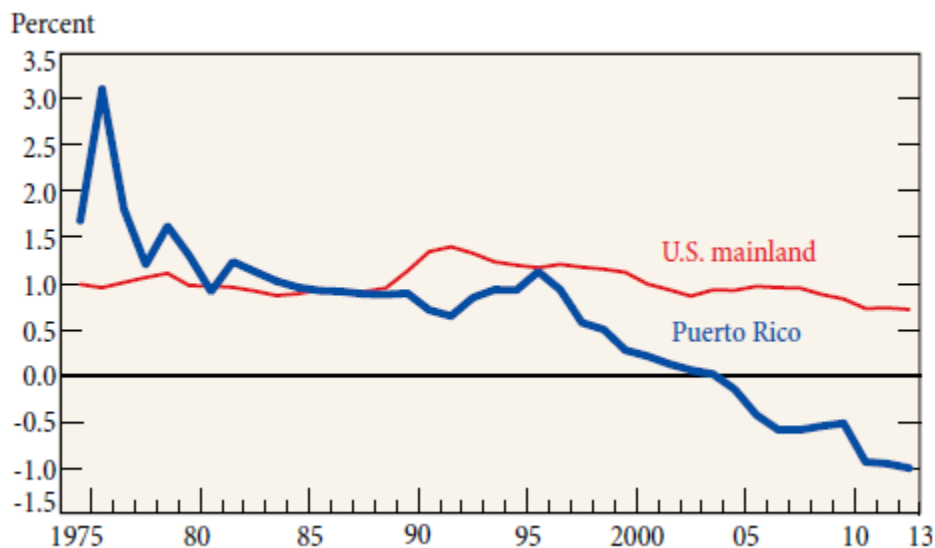


Figure 4-5. Graphic showing the Annual population Growth Rates from Puerto Rico and the U.S. Mainland. Source: U.S. Census Bureau; Moody's Analytics. Copied from Abel and Deitz 2014, p. 2.

## 4.2 Fire

Wildfires are a major ecological disturbance, affecting ecosystem functioning and species composition in forests around the world ( Bond et al., 2005, p. 525; Brandeis and Woodall 2008, p. 557; Santiago-García et al. 2008, p. 604; Mateos et al. 2011, p. 1001). Fire is not a natural event in subtropical dry or moist forests in Puerto Rico (Robbins et al. 2008, p. 530), thus its effects on the PRHB habitat and host plant could be catastrophic. As the vegetation in the Caribbean is not adapted to fires, damage caused by fires to the ecosystems, particularly to plants



species composition, might be irreversible (Santiago-García et al. 2008, p. 604, Brandeis and Woodall 2008, p. 557; Mendez-Tejada et al. 2015, p. 361). Fire can eliminate or modify the habitat of the PRHB either temporarily or permanently, and promote habitat fragmentation (C. Pacheco, Service, 2019, personal observation). A fire may also have a direct impact on the PRHB by killing imagoes, eggs, larvae, and chrysalis on the host plants. Furthermore, human-induced fires modify the landscape by promoting non-native trees and grasses, and by diminishing the seed bank of native species (Robbins et al. 2008, p. 528; Brandeis and Woodall 2008, p. 557). In some cases, fires may maintain extensive areas of young forest and grasslands, slowing the recovery of ecosystems and, therefore, impairing the delivery of ecosystem services (Brandeis and Woodall 2008, p. 557). For example, the nonnative grass *Megathyrsus maximus* is well adapted to fires and typically colonizes areas that were previously covered by native vegetation, and their presence increases the amount of fuel and the intensity of fires (Thaxton et al. 2012, p. 100). Furthermore, Mendez et al. (2015, p. 353) found that changes in climatological factors (such as precipitation, temperature, relative humidity and wind), combined may increase the threat of forest fires.

Human-induced fires are a current threat for the PRHB and its habitat in Quebradillas and Maricao (Biaggi-Caballero 2009, p. 5; Biaggi-Caballero 2010, p. 10, C. Pacheco, Service, 2019, personal observation). Wildfires resulting from natural or anthropogenic origin are growing in size and frequency across Puerto Rico (Brandeis and Woodall 2008, p. 558; C. Pacheco, Service, 2019, personal observation). Although wildfires may occur year-round, the majority of wildfires on the island of Puerto Rico occur primarily in the first three months of the year, corresponding to the dry season. (Figures 4-6 and 4-7; Mendez-Tejada et al. 2015, p. 362). The Maricao Commonwealth Forest has been subjected to human-induced fires, potentially affecting the habitat used by the PRHB. The PRHB occurs on the driest section of this forest, near road PR-120. On February 25, 2005, a human-induced burned more than 400 acres with unknown effects on the PRHB population (Biaggi-Caballero 2010, p. 10). This fire likely had at least temporary effects on the butterfly's habitat, but we have no information regarding these effects and whether or not they were permanent. In Quebradillas, the species' habitat in Puente Blanco, where the most significant population occurs, is threatened by fires associated with clandestine garbage dumps on road PR-4485 (PRDNER, unpublished data, 2010, p. 23). Also, on March 3, 2019, a Service biologist visited the Cuchilla Larga site in the Susúa Commonwealth Forest. There he observed that an area of approximately 25 square meters of the habitat where the species occurs was burned in association with a clandestine garbage dump (C. Pacheco, Service, 2019, personal observation).

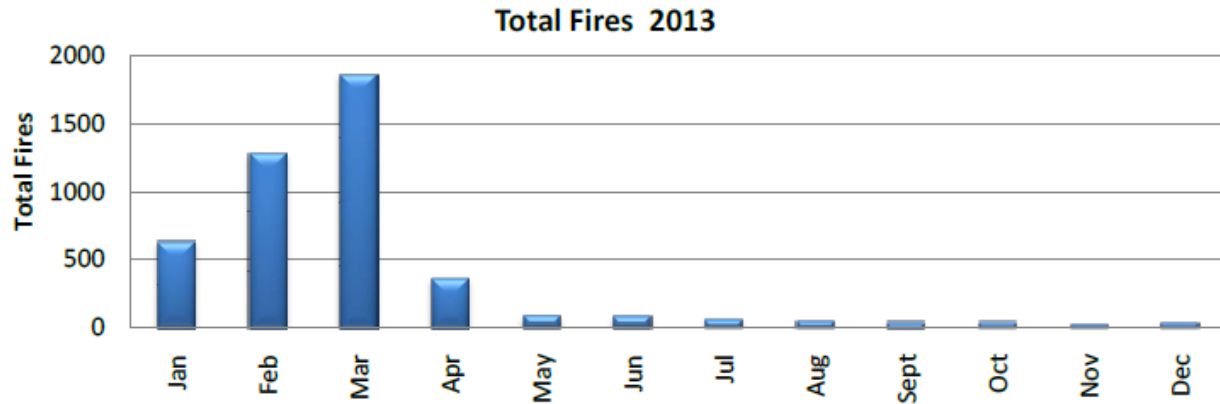


Figure 4-6. Wildfires per month that occurred in Puerto Rico during 2013. (Mendez-Tejeda et al 2015, p. 362).

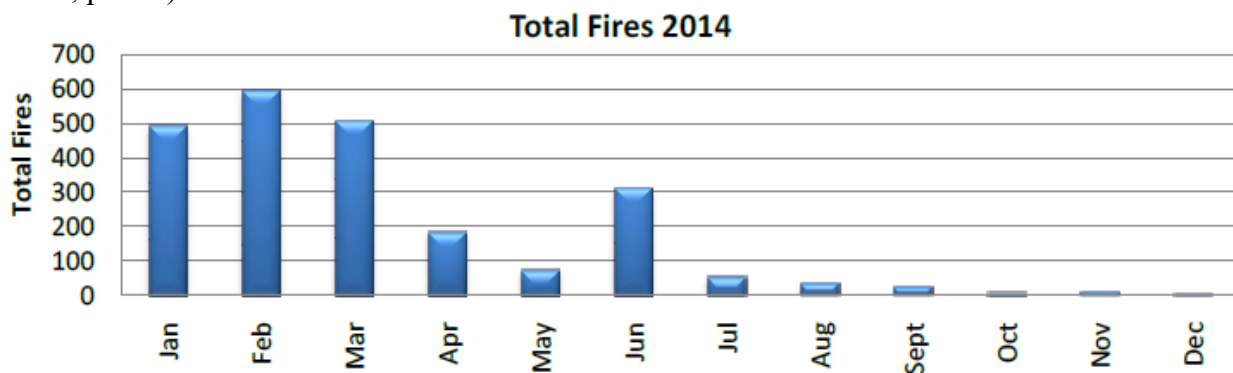


Figure 4-7. Wildfires per month that occurred in Puerto Rico during 2014. (Mendez-Tejeda et al 2015, p. 362).

#### 4.3 Use of Pesticides, Herbicides, and other Mechanisms of vegetation control

Pesticide impacts to the PRHB are primarily influenced by the extent of the butterfly's exposure to pesticides throughout its range. Presently, the majority of Puerto Rican farmlands are dominated by industrial agriculture, a system largely influenced by chemically-intensive food production that depend of pesticides and chemical fertilizers that may have negative effects on the environment and consumer health (Santiago et al. 2016, p. 1). The purpose of pesticides and their primary use in agriculture is to protect crops from pest such as insects, fungi and weeds; therefore, their use has been considered as an essential part to maintaining industrial crops and to increase the level of global food production. Pesticides which include herbicides, insecticides, and fungicides are commonly used throughout the PRHB range on crop fields, along public roads, and on private properties to control plant and animal pests.

Puerto Rico also has a long history of using pesticides, mostly insecticides, for mosquito control in and around urban areas. Fumigation programs are implemented by the local government authorities at Terranova and San José wards in the municipality of Quebradillas to control mosquito-borne diseases (Biaggi-Caballero and López 2010, p. 9). The PRHB is found in both

Terranova and San José wards in areas surrounded by residences. No pesticide use guidelines have been developed for application in areas where the PRHB occurs (Biaggi-Caballero and López 2010, p. 9).

Herbicides are used by conservation agencies, public agencies, and private organizations to control vegetation in an array of areas. The use of herbicides is a current threat to the PRHB and its host plant, which is found on the edges of roads and open areas. Herbicide is frequently used to control woody vegetation and weeds along the access road to Puente Blanco (road PR-4485) and private properties, affecting an undetermined number of *O. spinosa* (C. Pacheco, Service, 2019, personal observation). If this practice is not carefully conducted, herbicides can indirectly impact PRHB populations by eliminating or reducing the host and food plants, particularly if it is applied during critical periods of the life cycle of the butterfly. Generally, herbicides are considered to have minimal effects on insects because the active ingredients target plants. However, the indirect effects of herbicides on the PRHB are not well known.

Vegetation management at El Merendero in Quebradillas may adversely affect the PRHB and its host plant (Figure 4-8). *Oplonia spinosa* grows on both sides of the existing hiking trails and around the picnic areas at El Merendero. Maintenance personnel frequently trim the new growth of this plant to remove vegetation from the trails and picnic areas, which affect the harlequin butterfly as it uses the newest vegetative branches of *O. spinosa* for laying its eggs and feeding during the larval stages (Biaggi-Caballero and Lopez 2010, p. 2). On April 12, 2012, maintenance staff of the municipality of Quebradillas cleared approximately 1 acre (0.4 ha) vegetative cover within the species habitat at El Merendero. Trimming the host plant and clearing the vegetation in these areas may result in mortality of the PRHB eggs and larvae. Further, the coastline of Isabela and Quebradillas is under pressure for urban and tourist development, only small remnants of coastal vegetation conserved in the steeper areas of the northern cliff still exist. In this area, landowners clear vegetative cover to the edge of the cliff in order to have a better view of the ocean (Biaggi-Caballero and López 2010, p. 3; Barber 2016, p. 11; C. Pacheco, Service, 2019, personal observation). Currently, no guidelines about vegetation management and clearing have been developed to avoid or minimize effects to the species and its host plant.

Removal of vegetation for agricultural practices or changing the natural landscape in urbanized areas, use of pesticides and herbicides may result in both short and long term adverse effects to the PRHB. Habitat removal and alteration may have direct impacts and result in eggs, larvae and/or adults mortality. The reproductive behavior of the PRHB, including the cryptic nature of the species' larvae, and the cryptic behavior of the imagoes are conditions that may contribute to these effects. Habitat removal and degradation may also alter spatial arrangement of possible territories or home ranges, may result in losing suitable breeding habitat in the future, would



result in the creation of open corridors for predators, and degraded habitat is more attractive to invasive exotic plant species that may outcompete the *O. spinosa*.



Figure 4-8. Photos showing evidence of vegetation clearances within the Puerto Rican harlequin butterfly range.

#### 4.4 Low Number of Individuals and Specialized Ecological Requirements

The PRHB is currently characterized by perennially low numbers of individuals (less than 100 imagoes observed per year). Little is known about the phenology, natural recruitment, demography and habitat requirements of the species. The low number of individuals per population and its spatial distribution suggest that the species has specialized ecological requirements. The apparently low reproductive rate (average lifetime number of offspring produced by a member of a population) of the PRHB and its specific ecological requirements (e.g., single host plant species) for completing its life cycle, are limiting factors for the species. These characteristics make the species less resilient and resistant to stressors that may impact existing populations. Moreover, Carrion-Cabrera 2003 (p.46) also found that the number of larvae decreased as the number of imagoes increased, suggesting that the population dynamics of the species may be synchronized with a yet undetermined environmental factor.

In the absence of knowledge on the natural recruitment capacity, survivorship at all life stages, and habitat requirements of this species, it is difficult to predict the recovery of the species after stochastic events such as hurricanes, human-induced fire, severe drought, among other. Effects of stochastic events can be exacerbated by the low number of individuals known through entire range of the PRHB. In fact, any of the PRHB populations can be easily extirpated by a stochastic event. However, it is noteworthy that surveys in IQC and Maricao six to 18 months after Hurricane Maria revealed that the PRHB persisted.

#### 4.5 Genetic Variation

Given the extremely low known number of individuals of the PRHB, it is highly likely that its genetic variability is very low. In order to safeguard the remaining genetic diversity, the protection of known adult individuals should be considered as a high priority for the conservation of the species. No information about the genetic diversity or adaptive capacity of

the PRHB to overcome stochastic events is available. However, it is well known that gene flow influences genetic diversity by introducing new alleles into a population, and hence, increasing the gene pool size (Crandall et al. 2000, p. 291; Honnay and Jacquemyn 2007, p. 823; Zackay 2007, p. 1). We surmise that imagoes can fly among subpopulations, keeping some genetic diversity within a given metapopulation. However, it is unlikely that genetic exchange among metapopulations occurs, due to the distance and landscape barriers (e.g. livestock pastures, urban areas) between them. Based on the above, we consider the possible lack of genetic variation as a stressor to the species.

#### **4.6 Climate Change**

Changes in climate can have a variety of direct and indirect impacts on PRHB and its host plant, and can exacerbate the effects of other stressors. Rather than assessing “climate change” as a single stressor in and of itself, we examined the potential consequences to the species and their habitats that arise from changes in environmental conditions associated with various aspects of the climate change. Vulnerability to climate change impacts is a function of sensitivity to those changes, exposure to those changes, and adaptive capacity (IPCC 2012, p. 5; USGCRP 2018, 20:821).

Puerto Rico has a tropical climate, with a mean annual precipitation ranging between 500 mm (19.6 in) and 4,400 mm (173.2 in), and a mean annual temperature between 19.4°C (66.9°F) and 29.7°C (85.5°F) (Castro-Prieto et al. 2016, p. 3). The Intergovernmental Panel on Climate Change (IPCC) concluded that evidence of warming of the climate system is unequivocal (IPCC 2007a, p. 30). More recently, the 2018 U.S. Global Change Research Program (USGCRP) reported that the impacts of climate change are already influencing the environment and more frequent and intense extreme weather and climate-related events, as well as changes in average climate conditions, are expected to continue to damage ecosystems. Numerous long-term climate changes have been observed, including changes in arctic temperatures and ice, and widespread changes in precipitation amounts, ocean salinity, wind patterns, and aspects of extreme weather, including droughts, heavy precipitation, heat waves, and the intensity of tropical cyclones (IPCC 2007b, p. 7). While continued change in climate is certain, the magnitude and rate of that change is unknown in many cases. Species that are dependent on specialized habitat types, that are limited in distribution or that have become restricted to the extreme periphery of their range will be most susceptible to the impacts of climate change. As previously mentioned, the PRHB is currently known from the northern karst region and the west-central volcanic-serpentine region of Puerto Rico, and apparently requires of specific habitat characteristics (e.g., temperature, humidity, among others), making the species susceptible to the effects of climate change.

Studies conducted on other subfamilies of Nymphalidae (e.g., Danainae, Heliconiinae, Lycaenidae), reveal that temperature has a significant influence on imago and larval metabolism, growth rate and metamorphosis, and may affect seasonal colonization (local extinction followed

by recolonization) and migrations (Rawlins and Lederhouse 1981, p. 403; Wong et al. 2015, p. 15; Koda and Nakamura 2010, p. 29; Franke et al. 2019, p. 1). Temperature in the range of the PRHB (Figure 4-9, 4-10, 4-11, and 4-12) is never constant on the scale of a day, week or month, and in many insects that are short-lived, the thermal conditions experienced during early life potentially have a large effect on their fitness (Wong et al. 2015, p. 15).

The continuously changing body temperatures associated with the environmental dependence also make unlikely the evolution of any acclimation mechanisms (Rawlins and Lederhouse 1996, p. 387). For example, the monarch caterpillar shows no indication of temperature acclimation (Wong et al. 2015, p. 16). Higher body temperatures within a 15-30°C (59-86°F) range not only hasten development but also affect other physiological factors influencing growth (Koda and Nakamura 2010, p. 29). Caterpillars of *Danaus chrysippus* have a larger final body size (5th instar) in colder parts of their distribution than those that live in warmer regions, which may explain the variation in the maximum weight of different ecotypes of insects with season and geographical area (Mathavan and Pandian, 1975, p. 63). As temperature increases toward 33°C (91.4°F), rates of ingestion, assimilation, and conversion to tissue all rise as metabolic maintenance costs fall in Palearctic *Danaus chrysippus* larvae (Mathavan and Pandian 1975, p. 63). At 37°C (98.6°F) these same larvae showed abrupt drops in conversion rates associated with falling ingestion rates and rising maintenance costs (Mathavan and Pandian 1975, p. 63). A similar pattern is expected in *D. plexippus* larvae, although at somewhat lower temperatures, since 100 percent mortality was recorded at 35.5°C (95.9°F) in the study. Since time spent feeding changed little during the day and rates of ingestion rise rapidly with body temperature, it follows that much less plant mass is consumed during the morning or evening, than during midday periods when body temperatures are elevated. Exposure to high temperature may also cause dehydration in butterflies, which is a serious threat to butterflies because of their large surface to volume ratio (Pometto 2014, p. 18). Day-fliers, such as the PRHB should have high need for water because they are active during the warmest time of the day, from 9:00 a.m. to 4:00 p.m. (C. Pacheco, Service, 2019, personal observations).



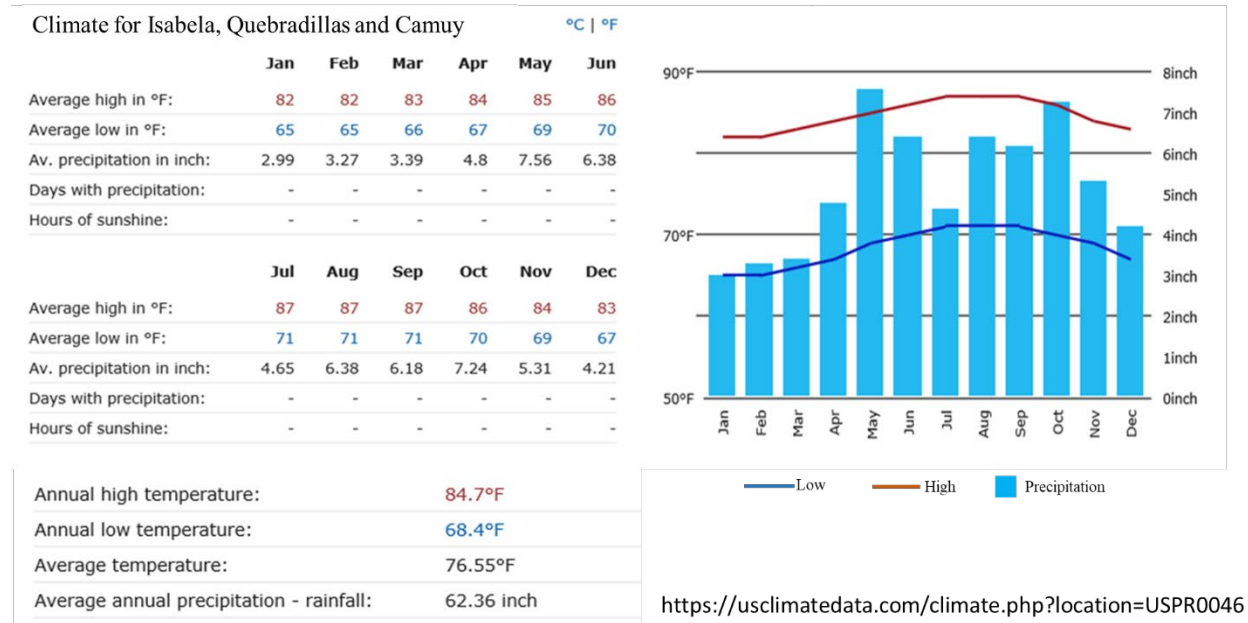
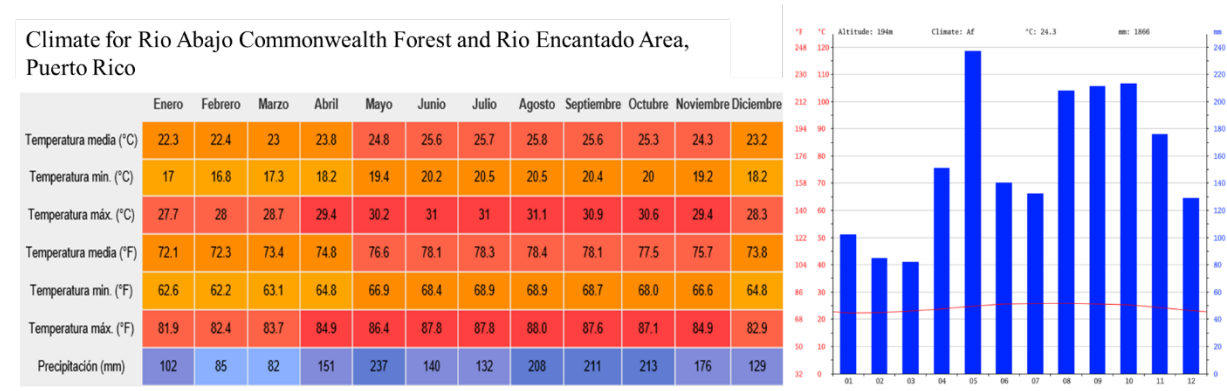


Figure 4-9. Climate data for Isabela, Quebradillas and Camuy



Adapted from: <https://es.climate-data.org/americas-del-norte/estados-unidos-de-america/puerto-rico/florida-766570/>

Figure 4-10. Climate data for the Rio Abajo Commonwealth Forest and Rio Encantado

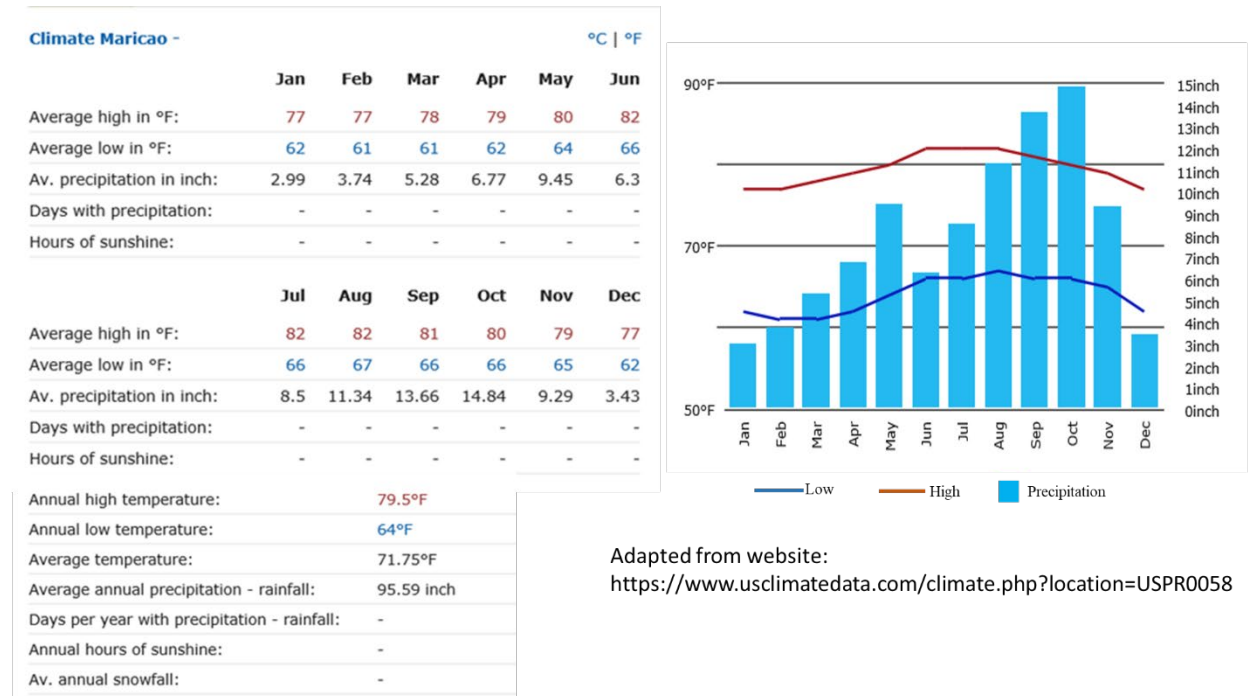


Figure 4-11. Climate data for Maricao Commonwealth Forest

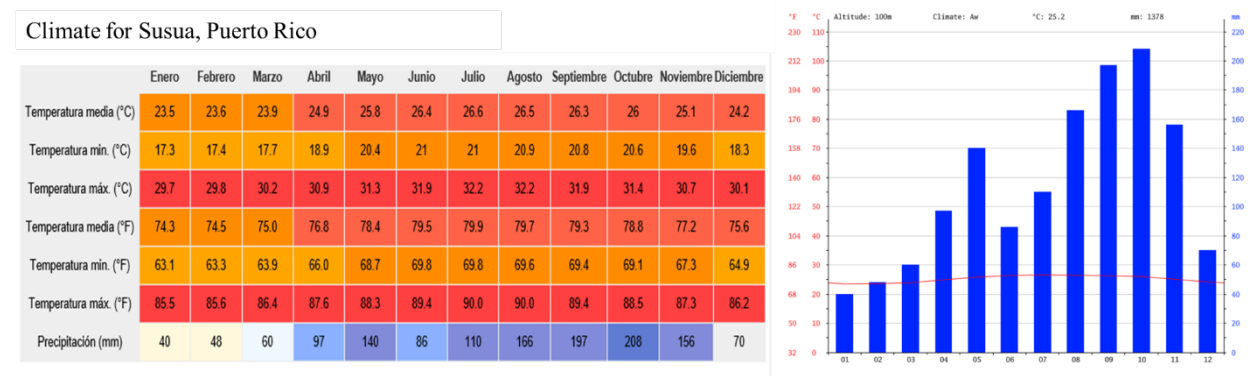


Figure 4-12. Climate data for Susúa Commonwealth Forest.

Puerto Rico is frequently in the path of hurricanes (Figure 4-13), and an expected effect of climate change is an increase in intensity of hurricanes and tropical storms, followed by an extended period of drought (IPCC 2012, p. 4). This change in climate can modify the microclimate, the plant species composition of the PRHB habitat, as well may affect the phenology of the *O. spinosa*. Hurricanes followed by extended periods of drought also may result in changes in soil conditions and microclimate, and may allow other plants (native or non-native, herbaceous or woody) adapted to drier conditions to become established (Lugo 2000, p. 243; Lugo 2008, p. 368). Invasive species (e.g. *Megathyrus maximus*) may spread and colonize

*O. spinosa* habitat, promoting conditions for fires, and altering the microclimate and nutrient cycling of the habitat that is currently suitable for the PRHB.

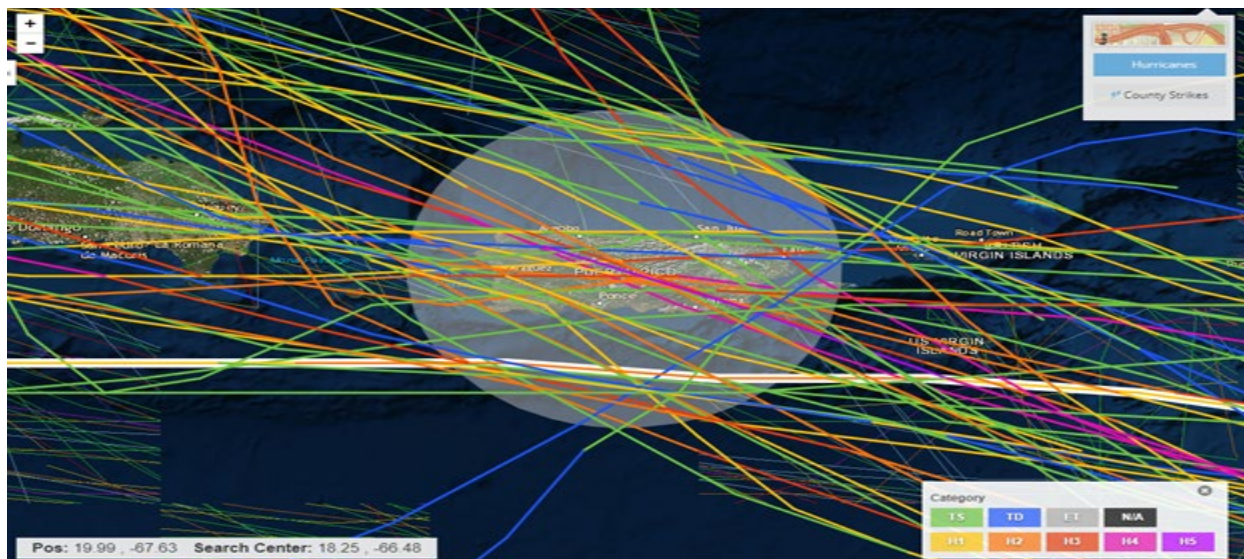


Figure 4-13. Historical hurricane tracks (late 1800s to current) in relation to Puerto Rico (NOAA 2018).

#### 4.7 Over-collection

In addition to the threats mentioned above, we considered the possible effects on the PRHB of overutilization of the species for commercial, recreational, scientific or educational purposes. The PRHB is known for its rarity and restricted range, making the species attractive to collectors and scientists. Collection could be a significant threat to the species due to the few remaining populations, small population size, and the potential for collection to occur at any time due to the easy access by the public to PRHB populations in many locations. Because there is significant uncertainty regarding PRHB biology (i.e., abundance, distribution, habitat requirements, genetics and life history), any collection of imagoes, larvae or eggs without appropriate evaluation of its effects could adversely affect populations. Even limited collection from the remaining populations could have deleterious effects on reproductive and genetic viability of the species and could contribute to its extinction. An undetermined number of PRHB have been collected for scientific purposes and deposited in universities and private collections (J. Biaggi-Caballero 2011, personal communication.). However, at present few researchers are working with the PRHB, and its collection is regulated by the PRDNER. Although we consider collection to be a potential threat to this species, we do not have information indicating that the species is currently being collected for commercial, recreational, scientific or educational purposes.



#### 4.8 Diseases and Predation

Due to the low number of individuals and known populations, disease and predation could certainly be threats to the PRHB. Biaggi-Caballero (2010, p. 8) and Chabert (2015, p. 3) suggested that spiders (i.e., *Misumenus bubulcus*, *Peucetia viridians*, *Argiope argentata* and *Nephila clavipes*) are a possible source of predation to the PRHB (Figure 4-14). They also mentioned lizards (i.e., *Anolis cristatellus* and *A. striatus*), and birds (i.e., *Tyrannus dominicensis*, *Dendroica adelaida adelaida*, and *Quiscalus brachypterus*) as possible predators. In fact, the sudden disappearance of larvae under study suggested depredation (Biaggi-Caballero 2010, p. 8). Moreover, we have found information suggesting that predation by anoles (*Anolis spp.*) and the spider *Argiope argentata* may affect the PRHB (Carrión-Cabrera 2003, p. 41).

Although the PRHB may face predation by spiders, ants, lizards, and birds, we are not aware of any data indicating predation is a significant threat to the species. Neither do we have information regarding any impacts from disease to the PRHB.



Figure 4-14. Potential predators of the Puerto Rican harlequin butterfly.

#### 4.9 Regulatory Protection and Law Enforcement

The PRDNER designated the PRHB as Critically Endangered under Commonwealth Law No. 241 and Regulation 6766 (PRDNER 2004, p. 42; PRDNER 2010, unpublished data, p. 1). Article 2 of Regulation 6766 includes all prohibitions and states that the designation as “critically endangered” prohibits any person from taking the species; including to harm, possess, transport, destroy, import or export individuals, eggs, or juveniles without previous authorization from the Secretary of the PRDNER (PRDNER 2004, p. 28). Although, the PRDNER has not designated critical habitat for the species under Regulation 6766, Law No. 241 prohibits modification of any natural habitat without a permit from the PRDNER Secretary. The Service believes that Law No. 241 and Regulation 6766 provide adequate protection for the species. However, the lack of effectiveness of enforcement makes these policies inadequate for the protection of the habitat of the PPRHB, and particularly its host plant (Biaggi-Caballero 2010, p. 9). Biaggi-Caballero (2010, p. 9) stated that constant violation of the law occurs when the species’ habitat is modified, destroyed, or fragmented for urban development and vegetation-clearing activities. The host plant is considered a common species associated with edges of forested lands and it is not

directly protected by Law No. 241 or Regulation 6766. Previously, we discussed in more detail certain cases of lack of enforcement that have led to threats to the species and its habitat.

#### **4.10 Habitat Conservation**

The establishment of protected areas is the most frequently employed strategy to promote *in situ* biodiversity by conserving natural habitat, preventing its conversion to other uses, and reducing anthropogenic threats (Castro-Prieto et al. 2016, p. 1). The PRHB range includes a number of protected lands (e.g., Río Abajo Commonwealth Forest, Río Encantado Natural Protected Area and Maricao Commonwealth Forest) (Figures 4-15 and 4-16). Currently, over 64,683.4 ha (159,836.4 ac) of native forest along the northern karst belt are covered by the Karst Protection Law (Ley para la Protección y Conservación de la Fisiografía Cársica de Puerto Rico, Ley Núm. 292 de 21 de agosto de 1999) providing some regulatory mechanisms to protect that habitat. Conservation efforts have been directed towards land acquisition and conservation easements by government and non-government organizations (PRAPEC 2013, p. 19). In recent years, protection and management of the habitat that the PRHB share with other federally and state listed species (e.g., Puerto Rican parrot, Elfin woods warbler, among others) has become a high priority for the conservation of those species

For example, the Maricao Commonwealth Forest comprises 3,996.2 ha (9,874.8 ac) of public land managed for conservation (PA-CAT 2016, <http://caribbeanlcc.org/interactive-map>), that harbor habitat for the PRHB. Moreover, in 2000, PRDNER acquired through the USFS Forest Legacy Program a parcel of land of 107 ha (264.4 ac), locally known as “Finca Busigó”, adjacent to the Maricao Commonwealth Forest. This parcel is located approximately 1km from currently occupied PRHB habitat and is managed for conservation (PA-CAT 2016, <http://caribbeanlcc.org/interactive-map>).

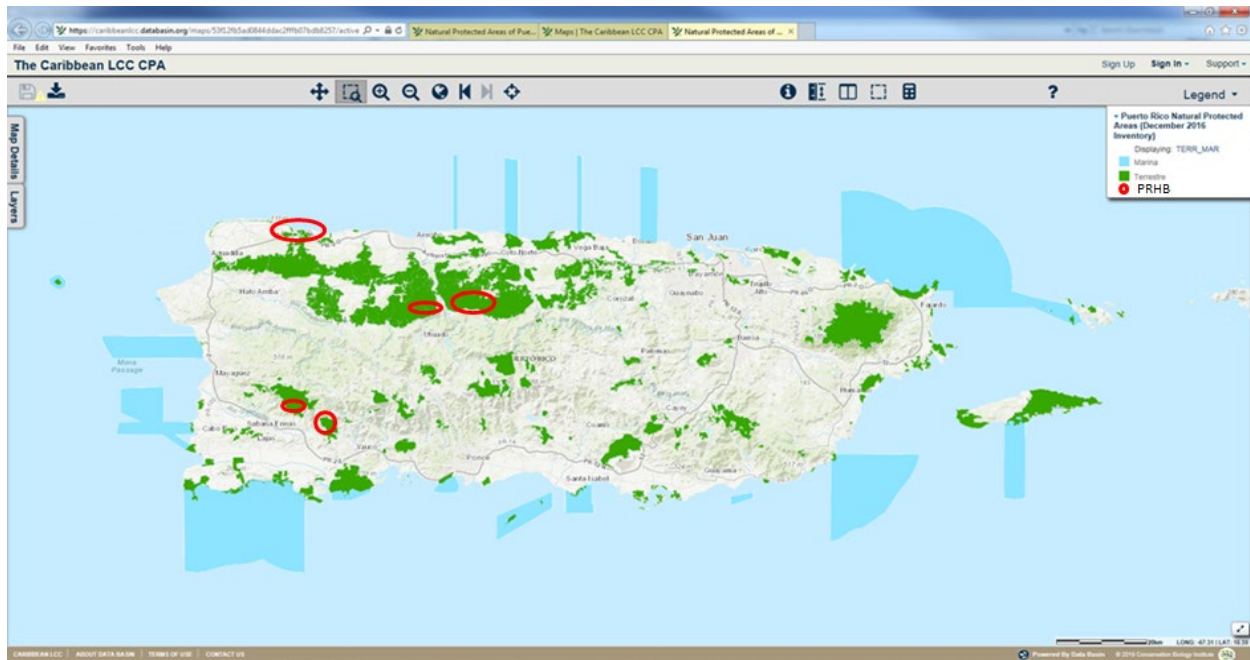


Figure 4-15. Current distribution of the Puerto Rican harlequin butterfly (red circles) in relation with the habitat under protective status (green polygons) in Puerto Rico (PA-CAT 2016, <http://caribbeanlcc.org/interactive-map>).

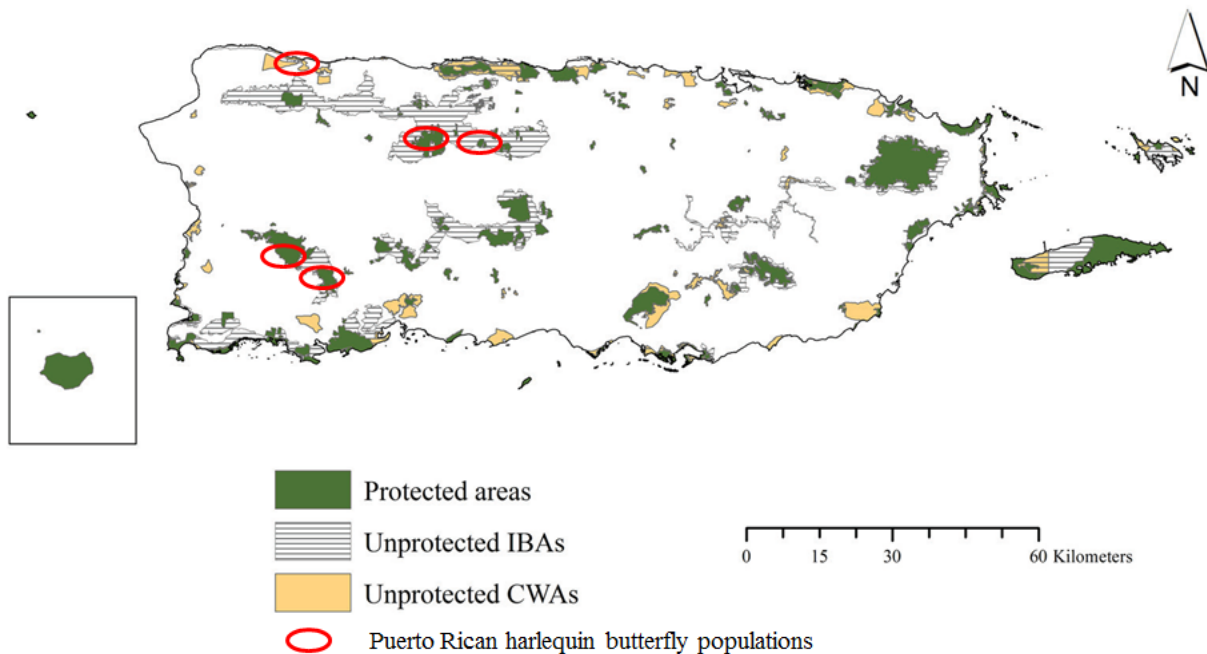


Figure 4-16. Map of Puerto Rico showing critical wildlife areas (CWAs) and important bird and biodiversity areas (IBAs) (Castro-Prieto et al. 2016, p. 11), red circles represent the locations of Puerto Rican harlequin butterfly populations.



#### 4.11 Combined Effects of Stressors and Supportive Influences on Species Viability

The negative and positive effects of habitat alteration from several sources can combine to affect demographic attributes of populations, which, in turn, affects PRHB viability (Table 4-1).

Table 4-1. Habitat modification sources and effects that influence the demographic traits and viability of the Puerto Rican harlequin butterfly populations.

Sources	Effects	Demographic	Population
Commercial and urban development	(-) habitat loss, loss of connectivity, loss of food sources, loss of host plants, increase in vehicle traffic (road kills)	Survival, recruitment, emigration & immigration,	Decrease
Agricultural practices	(-) habitat loss, loss of connectivity (fragmentation), increase of open areas (deforestation/predation), loss of host plant, use of pesticides	Survival, recruitment, emigration & immigration	Decrease
Roads and Highways	(-) habitat loss, fragmentation, increase in vehicle traffic (road kills)	Survival, recruitment, emigration & immigration	Decrease
Hurricanes	(-) loss of food source, changes on forest structure, loss of host plant	Survival, recruitment, emigration & immigration	Decrease
Pest control (use of pesticides)	(-) decrease of suitability of the habitat, decrease of food sources,	Survival, recruitment, emigration & immigration	Decrease
Vegetation clearance (maintenance of green areas) Use of herbicides	(-)habitat loss, loss of connectivity (fragmentation), decrease food sources, decrease forest structure, change in microclimate/conditions, increase of open areas (deforestation/predation), loss of host plant	Survival, recruitment, emigration & immigration	Decrease
Predators	(-) decrease suitability of the habitat, loss of individuals	Survival, recruitment, emigration / immigration	Decrease

Table 4-1 continued.

Sources	Effects	Demographic	Population
Changes on the landscaping with non-native species (invasive species)	(-) outcompete with the host plant, changes on food sources	Survival, recruitment, emigration & immigration	Decrease
Climate change (drought season vs rain season)	(-) changes in species composition, changes in phenology of food source species, changes on suitable habitat condition	Survival, recruitment, emigration & immigration	Decrease
Wildfire (human induced fire)	(-) habitat loss, loss of connectivity (fragmentation), decrease food sources, changes in forest structure, change in microclimate/conditions, increase of open areas (deforestation/predation), loss of host plant, change species composition	Survival, recruitment, emigration / immigration	Decrease
Reforestation	(+) increase in habitat; increase in shelters, increase in food source	Survival, Recruitment, Emigration / immigration	Increase
Land acquisition/ conservation easements	(+) changes in land uses to allow natural reforestation, increase in habitat availability, reduction on stressors, increase in shelters, increase in food source	Survival, Recruitment, Emigration / immigration	Increase

## CHAPTER 5 – CURRENT CONDITIONS

In this chapter, we consider the current condition of the Puerto Rican harlequin butterfly based on its distribution, abundance, and those factors currently influencing the viability of the species. We evaluate the needs of the species in terms of population resiliency and species' representation and redundancy (the 3Rs). Finally, we estimate the current condition of the species using habitat metrics to characterize the 3Rs.

### 5.1 Rangewide Conditions

Since the PRHB was added to the candidate species list (76 FR 31282, May 31, 2011), new information has become available about its distribution, abundance, habitat and factors that may influence its continued existence. The current distribution of the PRHB is depicted in Figure 3-2. As of 2019, this species has five (5) known populations consisting of 22 subpopulations persisting in four (4) life zones (or ecological settings) across three (3) ecological regions, at elevations from three (3) meters (9 ft) to 867 m (2,845 ft) from sea level. However, in any given year the maximum number of PRHB individuals recorded in its entire range is 90 butterflies and 2,096 caterpillars (Barber 2019, p. 1). Habitat loss and modification, followed by low number of individuals, have been identified as the most important stressors that may affect the continuing existence of this species.

### 5.2 Current Resiliency

In the SSA framework, resiliency is assessed at the population level, which is then scaled up to species redundancy and representation. Based on our knowledge on the PRHB, we believe that species population persistence is primarily influenced by the health of the subpopulations, connectivity among subpopulations, and risk due to stochastic events that may strongly affect the suitability of habitat on which the species depends. Moreover, the needs at individual level (suitable forested habitat with adequate food sources and the host plant, *O. spinosa*) must be met at a larger scale. Connectivity must be adequate not only for an individual's foraging needs, but to connect individual butterflies to a larger interbreeding population, influencing the probability of subpopulation persistence through both rescue effect and genetic health. Unfortunately, we are unable to reliably quantify the causal relationship between the degree of connectivity and subpopulation persistence. Similarly, we are unable to determine a reliable frequency estimate for stochastic events that may result in losses of individuals or habitat for the species. On the other hand, PRHB populations can persist in co-occurrence with predators like birds, spiders and ants, although the most resilient populations occur where these predators are few or absent.

Resiliency scores (Table 5-1) were generated by combining scores for four (4) habitat metrics (Protection/Development Risk, Connectivity/Habitat Fragmentation, Risk of Vegetation clearing/Use of Pesticides, and Susceptibility to Stochastic Events (e.g., human-induced fires,



severe drought, hurricanes, among others) and one (1) population metric (population size or trend). Habitat metrics and the population metric were equally weighted. Each habitat metric was given one (1) point each for a total of 4 points. The population metric was weighted four (4) time higher than the each habitat metric (1) because it is a direct measure. As such, the population metric totals 4 points. Habitat metrics are still important, but do not reflect abundance and therefore do not have more weight than the population metric. Each habitat metric was assigned a score of 1, 2, or 3, and for the population metric was assigned a score of 4, 8, or 12, as described below in Table 5-1.

Table 5-1. Description of how habitat and population factors were scored to determine the Puerto Rican harlequin butterfly resiliency.

H Score	Habitat Metrics Influencing Viability				Population Metrics	P Score
	Habitat Protection	Connectivity/Habitat Fragmentation	Vegetation Clearing/Use of Pesticides	Susceptibility to Stochastic Events	Population size/Trends	
1 point each; 4 points total	Most habitat not protected, at risk of being developed (<34 percent protected)	Isolated subpopulations located at a distance of more than 1 km from the next one; habitat between populations or subpopulations highly disturbed (low connectivity)	Subpopulations located in areas subjected to vegetation clearing (including the use of herbicides) and use of pesticides (mosquito control and agricultural practice)	Subpopulations located in areas more vulnerable to stochastic events (e.g., fire, severe drought, hurricanes, among others)	Relatively low population size (0 to 5 imago and less than 100 larvae per ha) or high degree of uncertainty in population size/trends	4
2 points each; 8 points total	Some habitat protected, with some at risk of being developed (34-66 percent protected)	Subpopulations located within 1 km range; habitat between population moderately disturbed (some forested corridors)	Subpopulations located in areas rarely occur vegetation clearing (including the use of herbicides) or use of pesticides (mosquito control and agricultural practice)	Subpopulations located in areas with moderate vulnerability to stochastic events (e.g., fire, severe drought, hurricanes, among others)	Relatively moderate population size (6 to 20 imagoes and 100 to 500 larvae per ha)	8
3 points each; 12 points total	Most habitat protected (>66 percent)	Subpopulations located within 1 km range; un-disturbed habitat between populations (forested corridors)	Subpopulations located in areas where vegetation clearing (include the use of herbicides) or use of pesticides (mosquito control and agricultural practices) is not expected.	Subpopulations located in areas with lower vulnerability to stochastic events (e.g., fire, severe drought, hurricanes, among others).	Relatively high population size (more than 20 imagoes and more than 500 larvae per ha) and/or growth.	12

The score for each population across all metrics were summed, and final population resiliency categories were assigned as follows:

- Low Resiliency:** <11
- Moderately Low Resiliency:** 11 to 13
- Moderate Resiliency:** 14 to 18
- Moderately High Resiliency:** 19 to 21
- High Resiliency:** > 21

### *5.2.1 Current Resiliency of the Isabela, Quebradillas and Camuy (IQC) Population*

The PRHB currently occurs in a 400 ha (988 ac) strip of forested habitat on a coastal cliff that extends along the municipalities of Isabela, Quebradillas, and Camuy. Currently, this strip of habitat is bounded on the east by the community La Yeguada and Membrillo in Camuy; on the west by the community Villa Pesquera and Pueblo in Isabela; on the north by the Atlantic Ocean; and on the south by state road PR-2, the Royal Isabela Golf Course, and a mosaic of forested patches that vary in size and stages of vegetation succession (Figure 3-1). These forested patches are fragmented by roads, houses and agricultural lands. Forest structure varies in the IQC. At the cliff edges, the vegetation is constantly swept by trade winds from the ocean. As a result of these winds, the trees are stunted and mostly sclerophyllous, and the forest is very thick, making it in most cases impenetrable. Moving from the cliff edge to the south, the canopy coverage increases from zero (0) percent up to 70 percent, and mean tree height up to around 6 m (20 ft) (Barber 2018, p. 14; Vargas 2019, p. 3). Presently, some habitat damage from Hurricane Maria is evident. The habitat appears to be recovering well (Carlos Pacheco, USFWS, 2019, personal observation.), although canopy height and density are significantly reduced from pre-hurricane levels.

Within IQC, the PRHB is regularly observed in 13 areas. Recently, five (5) of the 13 areas of occurrence (subpopulations) were monitored. The areas surveyed were El Pastillo, Cara del Indio and Tunel de Guajataca in Isabela; and El Merendero, Puente Blanco, and Puerto Hermina in Quebradillas. According to the results of the most recent surveys conducted after Hurricane Maria, the maximum total individuals counted in 2018 was 53 imagoes and 1,381 larvae in an area of 2.7 ha (6.7 ac) (Barber 2018, p. 1). Based on this information, the PRHB population has demonstrated resiliency to a severe hurricane, although it is too early to assess longer-term effects.

The PRHB occurs on both private and publicly owned lands, where in many places the species occurs close to urban development or lands used for agriculture. This is the case of the population located among the municipalities of Isabela, Quebradillas and Camuy (Figure 3-4), where the sites of occurrence are adjacent to areas already developed or undergoing development (Figure 4-3). In this population, three (3) of the 13 patches (subpopulations) fall within areas that may provide some protection, as they are in public or private lands managed for conservation, recreation, or as scenic areas. These three patches include El Merendero, El Pastillo, and Royal Isabela (Monzón-Carmona 2007, p. 84; Chabert 2015, p. 1). The other 10 patches are in Isabela and Camuy, and are in private lands subject to development.

Habitat occupied by the IQC population is largely unprotected and is at risk of being developed **(1)**. The IQC subpopulations are within 1 km of each other or forested habitat **(2)**. These subpopulations are located in areas subject to vegetation clearing (including the use of

herbicides) and use of pesticides (mosquito control and agricultural practice) **(1)**. Additionally the subpopulations are located in areas moderately buffered from stochastic events (e.g., fire, severe drought, hurricanes, among others) **(2)**, and population size is high **(12)**. Therefore, the IQC population of the PRHB is considered to have **moderate resiliency (18)**.

### *5.2.2 Current Resiliency of the Rio Abajo Commonwealth Forest Population*

The Río Abajo Commonwealth Forest is public land managed for conservation and passive recreation by the Commonwealth of Puerto Rico since 1935. In this forest, the species occurs in three (3) locations: one is adjacent to the west of PR road 10, and the other two are close to Campamento Radley. All locations are in El Jobo Ward in the Municipality of Arecibo. These sites are located within 1 km of each other. In addition, sightings of imagoes of the PRHB are frequently reported from other areas in Rio Abajo Commonwealth Forest.

The habitat in Río Abajo Commonwealth Forest is protected under Laws No. 133-1975 (12 L.P.R.A., Sec 191), known as *Ley de Bosques de Puerto Rico* (Puerto Rico Forests' Law), as amended in 2000. Section 8 (A) of this law prohibits cutting, killing, destroying, uprooting, extracting, or in any way hurting any tree or vegetation within a Commonwealth forest without authorization of the PRDNER Secretary (12 L.P.R.A. sec. 191f). The PRDNER also identified the Río Abajo Commonwealth Forest as a Critical Wildlife Area (CWA). The CWA designation constitutes a special recognition by the Commonwealth with the purpose of providing information to Commonwealth and Federal agencies about the conservation needs of these areas, and to assist permitting agencies in precluding adverse impacts as a result of permit approvals or endorsements (PRDNER 2005, pp. 247-350).

In the Río Abajo Commonwealth Forest there is substantial habitat protection **(3)**; populations or subpopulations are within 1 km of each other and the habitat between populations or subpopulations is undisturbed forested corridors **(3)**; the populations or subpopulations are located in areas where vegetation clearing (including the use of herbicides) or use of pesticides (for mosquito control and agricultural practice) is not expected **(3)**; the populations or subpopulations are located in areas buffered from stochastic events (e.g., fire, severe drought, hurricanes, among others) **(2)**; and population size is low with a high degree of uncertainty in size and trends **(4)**. Therefore, the population of the PRHB in Río Abajo Commonwealth Forest is considered to have **moderate resiliency (15)**.

### *5.2.3 Current Resiliency of the Rio Encantado Population*

The Río Encantado area comprises over 6,474.9 hectares (16,000 acres) considered by federal and Commonwealth conservation agencies as undisturbed wilderness, holding the largest tract of continuous forest cover in all Puerto Rico ([www.paralanaturaleza.org/en/rio-encantado-eng](http://www.paralanaturaleza.org/en/rio-encantado-eng)). By 2010, Para La Naturaleza acquired approximately 809.3 hectares (2,000 acres) of this land for protection and conservation, and efforts to continue acquiring land are ongoing. Presently, the



PRHB is known to occur in three (3) areas scattered through the Río Encantado area. Within these areas, all life stages of the species and the host plant have been observed in eight (8) subpopulations. In addition, imagoes of the PRHB have been sighted in other areas adjacent to Río Encantado.

Although the Río Encantado area is covered by the Karst Protection Law (Ley para la Protección y Conservación de la Fisiografía Cársica de Puerto Rico, Ley Núm. 292 de 21 de agosto de 1999), private properties within this natural area its surroundings have experienced an increase of rural developments. According to the Karst Water Institute, the karst region of Puerto Rico is one of the 10 most endangered karst ecosystems in the world, and each year, up to 1 square kilometer of limestone rock is lost due to gravel pit extraction (<https://www.paralanaturaleza.org/en/rio-ecantado-eng>).

In the Río Encantado area there is substantial habitat protection, although there are some private lands and rural developments (2); the populations or subpopulations are located within 1 km of each other, and the habitat between populations or subpopulations is undisturbed forest (3), the populations or subpopulations are located in areas where vegetation clearing (including the use of herbicides) or use of pesticides (for mosquito control and agricultural practice) is not expected (3); the populations or subpopulations are located in areas with low susceptibility to, or are buffered from, stochastic events (e.g., fire, severe drought, hurricanes, among others) (2), and population size is low, with a high degree of uncertainty population trends (4). Therefore, the population of the PRHB in the Río Encantado area is considered to have **moderate resiliency (14)**.

#### *5.2.4 Current Resiliency of the Maricao Commonwealth Forest Population*

The Maricao Commonwealth Forest is a public land administered by the PRDNER for conservation. Construction of power and communication structures is one of the threats to habitat in Maricao. The habitats on which the PRHB depends in the Maricao Commonwealth Forest are protected under the *Ley de Bosques de Puerto Rico* (Puerto Rico Forests' Law), as amended in 2000. The PRDNER also identified the Maricao Commonwealth Forest as a Critical Wildlife Area.

In the Maricao Commonwealth Forest habitat protection is substantial (3); the populations or subpopulations are located within 1 km of each other, and the habitat between populations or subpopulations is moderately disturbed (forested habitats fragmented by roads and trails) (2); the subpopulations are located in areas subject to periodical vegetation clearing (trails, road and including uses of herbicides along PR-120) (1); the subpopulations are located in areas subject to stochastic events (e.g., fire, severe drought, hurricanes, among others) (1); and population size is relatively high (more than 20 imagoes and more than 500 larvae per ha) (12). Therefore, the

PRHB population in the Maricao Commonwealth Forest is considered to have **moderately high resiliency (19)**.

#### *5.2.5 Current Resiliency of the Susúa Commonwealth Forest Population*

The Susúa Commonwealth Forest is a public land administered by PRDNER for its conservation. The Forest is recognized as one of the Puerto Rico's Critical Wildlife Areas (PRDNER 2005, p. 275). The habitats on which the PRHB depends in the Susúa Commonwealth Forest are protected under the *Ley de Bosques de Puerto Rico* (Puerto Rico Forests' Law), as amended in 2000.

In the Susúa Commonwealth Forest habitat protection is substantial (**3**); the subpopulations are located within 1 km of each other, and the habitat between subpopulations is moderately disturbed (forested habitats fragmented by roads and trails) (**2**); the subpopulations are located in areas subject to periodic vegetation clearing (trails and road) (**1**); the subpopulations are located in areas subject to stochastic events (e.g., fire, severe drought, hurricanes, among others) (**1**); and population size is relatively low with a high degree of uncertainty in population trends (**4**). Therefore, the PRHB population in Susúa Commonwealth Forest is considered to have **low resiliency (11)**.

### **5.3 Current Resiliency Summary**

There are five extant PRHB populations.. We classified current resiliency as moderately high in one (1) population, moderate in three (3) populations, and low in (1) population (Table 5-2). Our classifications of resiliency rely on habitat characteristics and population size or trend estimates. The population with moderately high resiliency (Maricao Commonwealth Forest) occurs in land managed for conservation, but in this forest the species occurs at edges of trails and roads where vegetation is frequently removed and herbicide applied. Therefore, anthropogenic activities may negatively affect the status of the species. The population in IQC has moderate resiliency, although it occurs in areas where anthropogenic activities may negatively affect the species, because it has the largest known PRHB population size. The populations in Río Abajo Commonwealth Forest and the Río Encantado Area have moderate resiliency because they occur in habitats managed for conservation that are protected from development and other anthropogenic activities. The Susúa Commonwealth Forest population has low resiliency Although this forest is managed for conservation, the species occurs at edges of or along trails where vegetation is frequently removed and herbicide applied, and the PRHB population size is low. Overall (rangewide), PRHB population resiliency is currently moderate, based on our index ( $11 + 19 + 18 + 15 + 14 = 77 \div 5 = 15.4$ ).

Table 5-2. Summary table of the five assessed Puerto Rican harlequin butterfly populations and factors that contribute to their resiliency classification. Values reflecting good conditions for the butterfly are shaded green, while values reflecting unfavorable conditions are shaded orange, and moderate values are shaded yellow.

Population	Habitat Metrics				Population Metric Population Size/Trend Description	Resiliency
	Habitat Protection	Connectivity/ Habitat Fragmentation	Vegetation Clearing/Use of Pesticides	Susceptibility to Stochastic Events		
Isabela Quebradillas and Camuy (IQC)	<34 percent protected (1)	Both (2)	High (1)	Moderate (2)	More than 25 imagoes and more than 500 larva per ha, and/or growth (12)	Moderate (18)
Rio Abajo Commonwealth Forest	Most habitat protected (>66 percent) (3)	Connectivity (3)	Low (3)	Moderate (2)	Relatively low population size (0 to 5 imagoes and less than 100 larvae per ha) or high degree of uncertainty in population size/trends (4)	Moderate (15)
Rio Encantado	Some habitat protected (34-66 percent) (2)	Connectivity (3)	Low (3)	Moderate (2)	Relatively low population size (0 to 5 imagoes and less than 100 larvae per ha) or high degree of uncertainty in population size/trends (4)	Moderate (14)
Maricao Commonwealth Forest	Protected (3)	Both (2)	High (1)	High (1)	Relatively high population size (>20 imagoes and > 100 larvae per ha) and/or growth (12)	Moderately High (19)
Susúa Commonwealth Forest	Protected (3)	Both (2)	High (1)	High (1)	Low population size with high degree of uncertainty in population trends (4)	Low (11)



## **5.4 Current Redundancy**

Redundancy is reflected by the distribution of populations across life zones and the degree to which the spatial arrangement of populations enables the species to persist after stochastic events, such as hurricanes, severe drought or wildfires (Table 5-3). Because the PRHB is a narrow ranging endemic, redundancy is inherently low. The exact historic distribution of the PRHB is unknown, but it is presently disjointed, suggesting populations were once more widely distributed across the Island. This reduction in distribution, could be attributed to wide scale habitat destruction and other factors that have isolated and extirpated populations. Currently, with five (5) very small populations and only one (1) of those considered to have moderately high resilience, the species is not well buffered against the effects of stochastic events. Moreover, conversion of forested habitats for agriculture and urbanization could continue affecting existing populations and the habitat in the current range of the species. Additional habitat conversion, incompatible management practices, and other stressors have further eroded the species redundancy by reducing the number of populations and the geographic area inhabited by the species.

Table 5-3. Current Distribution, Number of Populations and Subpopulations, and Population Index for the Puerto Rican harlequin butterfly.

Region of Puerto Rico	Population	Number of Meta-populations	Population Index	Surveyed Area	Source of Information
Northern Karst Region	Isabela, Quebradillas and Camuy	13	Less than 50 imagoes/10 to 100 larva	1.3 ha (3.2 ac)	(Carrión-Cabrera 2003, p. 34) (Monzón-Carmona 2007, p. 44) (Biaggi-Caballero 2010, p. 4)
			Less than 60 imagoes/ approximately 1,400 larva	2.68 ha (6.67 ac)	Barber 2018, p. 1)
	Río Encantado Area	3	Not determined (imagoes, larvae and chrysalids)	Unknown	Morales and Estremera 2018, p. 1
	Río Abajo Commonwealth Forest	1	Not determined (imagoes, larva and chrysalis)	Unknown	Morales and Estremera 2018, p. 1

Table 5-3 continued

Region of Puerto Rico	Population	Number of Meta-populations	Population Index	Surveyed Area	Source of Information
<b>Central-western Volcanic-Serpentine Region</b>	Maricao Commonwealth Forest	3	12 imagoes/ no data about larvae	Not determined (unknown)	Asencio 1984, p. 1
			No more than 5 imagoes / no more than 10 larvae	Not determined (unknown)	(Carrión-Cabrera 2003, p. 48), (Pérez-Asso et al. 2009, p. 94)
			21 imagoes/631 larvae	1.08 ha (2.67 acres)	(Barber 2018, p. 1)
	Susúa Commonwealth Forest	2	Unknown (Not counted since 1980's)	Not determined (unknown)	(Biaggi-Caballero 2010, p. 4).
16 adults (imago)/83 larvae			1.08 ha (2.67 acres)	(Barber 2018, p. 1)	
<b>Southern Karst Region</b>	Tallaboa Guayanilla/Peñuelas	1	Unknown (Not observed since 1926)	Unknown	(Biaggi-Caballero 2010, p. 4)

### 5.5 Current Representation

The PRHB representation is influenced by the breadth of adaptive diversity possessed by the species and by maintaining the evolutionary processes (i.e., gene flow and natural selection) that drive adaptation. Representation improves with increased genetic and/or ecological diversity within and among populations. Presently there is substantial uncertainty regarding representation



for this species due to lack of knowledge on genetic diversity, adaptive potential and differences between the PRHB populations. Currently, representation appears to be moderate to high because the PRHB occurs in four ecological settings or life zones. Thus, the PRHB seems to have the capability to adapt to different landscapes as long as the fundamental needs for nesting (host plant) and foraging are met.

### 5.6 Summary of PRHB Condition based on the 3Rs

There is sufficient information to conceptualize and estimate the condition of the 3Rs for the PRHB (Figure 5-1). Currently PRHB populations rangewide have representation in two (2) geographic regions and four (4) life zones. There are five (5) metapopulations that serve as a measure of species redundancy. One (1) of those metapopulations has moderately high resiliency, three (3) have moderate resiliency, and one (1) has low resiliency.

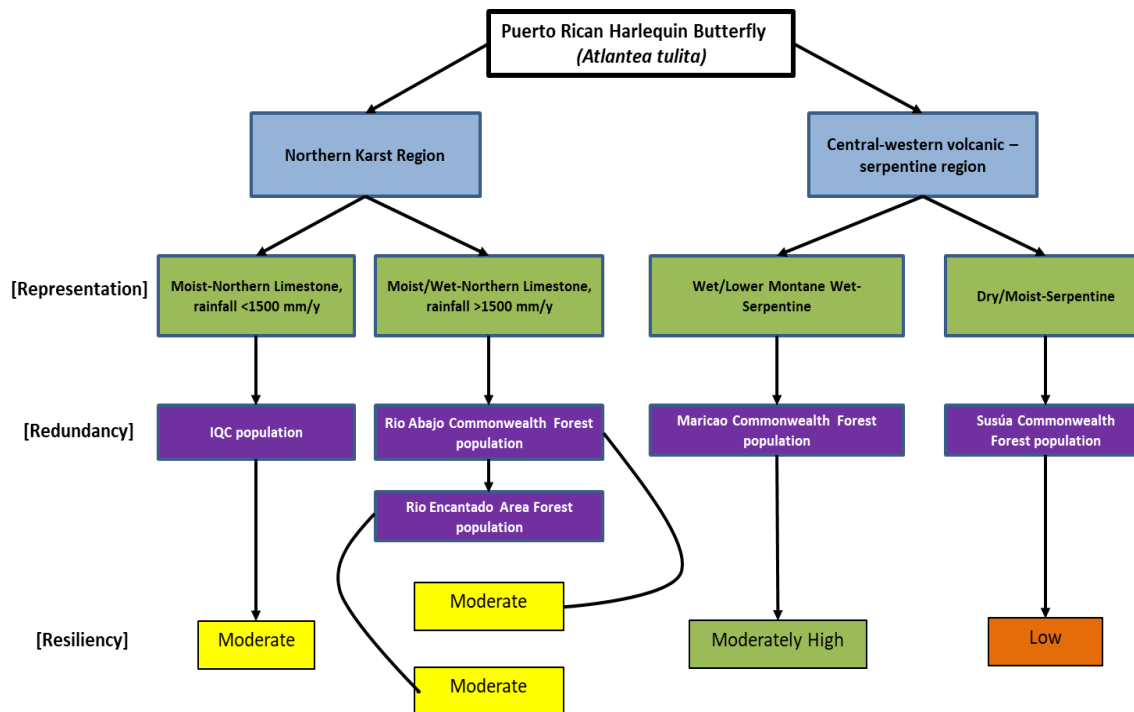


Figure 5-1. Basic conceptual model showing how the Puerto Rican harlequin butterfly is represented (life zones), its redundancy (populations) and its resiliency.

## **CHAPTER 6- FUTURE CONDITION SCENARIOS**

### **6.1 Introduction**

In this chapter, we describe our analysis of the future conditions for the PRHB. To capture and categorize the range of realistic future conditions, we considered the following generalized scenarios for each population: a) best case; b) worst case; and c) most likely case. These scenarios match the most recent climate change scenarios described for Puerto Rico (Henareh et al. 2016, entire). Our analyses relied on available data, expert judgments regarding the consequences of interacting influences, and our assessment of likely future habitat conditions. Because we do not fully understand the interacting causal relationships and are unable to predict future habitat conditions with certainty, our analyses are necessarily predicated upon numerous assumptions. We identify these fundamental assumptions used and discuss the implications of these assumptions in this Chapter.

To analyze species' viability, we considered the current and future availability or condition of resources that the PRHB rely on (see Chapter 3, Section 3.4, Summary of Ecological Needs). The range of what may happen in each scenario is described based on the current condition and how resiliency, representation, and redundancy would be expected to change. For this assessment, we defined viability as the ability of a species to sustain itself over time. To maintain viability, a species must have sufficient abundance and distribution to withstand changes in its biological and physical environment, and environmental stochasticity (e.g., heavy rains, drought).

We chose 25 years as the time frame for the PRHB analysis because this timeframe includes at least 25 generations, thus allowing adequate time to detect population and habitat trends. Our predictions associated with this time frame also are supported by existing predictive models regarding regional climate change. In particular, potential impacts associated with changing climatic conditions (e.g., estimates for precipitation and drought levels) were based on published climate model projections downscaled for Puerto Rico and the Virgin Islands (Henareh et al. 2016, entire).

### **6.2 Future Habitat Loss and Fragmentation by Urban Development**

The primary stressor affecting the future condition of the PRHB is habitat loss associated with urban development (Figure 6-1; Table 6-1) and other land use changes (e.g., agriculture and cattle rearing). These stressors account for direct and indirect effects at some level to all life stages and across the species' range. Additive habitat loss stressors projected for the future also include habitat modification by roadside vegetation clearing, use of pesticides and climate change. Additionally, we consider the susceptibility of the species habitat to catastrophic events (i.e., human-induced fires). All these stressors are predicted to result in alterations of habitat

suitability for the species, which may adversely affect the resiliency, redundancy and representation of the PRHB.

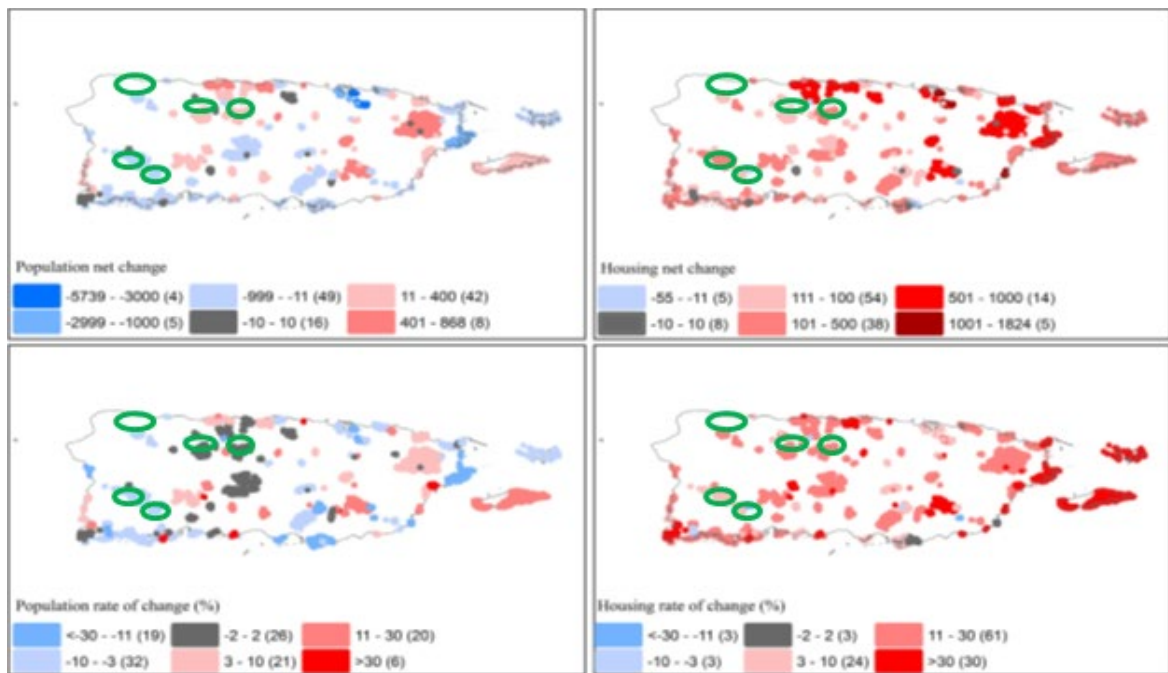


Figure 6-1. Spatial patterns of housing and human population changes within 1 km of protected areas. The number of protected areas in each class is shown in parentheses (Castro-Prieto 2017, p. 477). Green circles indicate the location of the PRHB populations in Puerto Rico.

Table 6-1. Projected housing net change within a 1 kilometer buffer zone around Puerto Rican harlequin butterfly populations from 2020 to 2045. Data derived from Castro-Prieto et al. (2017, pp. 478-479). Worst Case assumes a continuation of urban growth observed during 2000-2010; Most Likely assumes half of observed past growth; Best Case assumes no future growth.

Population	Scenario		
	Worst Case	Most Likely	Best Case
IQC	8 percent per decade	4 percent per decade	0 percent per decade
Río Abajo	16 percent per decade	8 percent per decade	0 percent per decade
Río Encantado	16 percent per decade	8 percent per decade	0 percent per decade
Maricao	9 percent per decade	4.5 percent per decade	0 percent per decade
Susúa	6 percent per decade	3 percent per decade	0 percent per decade



### 6.3 Future Climate Conditions

Temperature, drought, and storm frequency and intensity are projected to increase based on climate models. Concomitant changes in the spatial distribution of life zones in Puerto Rico also are expected as a result of climate change.

#### 6.3.1 Temperature

Temperatures in the U.S. Caribbean have fluctuated over the last 100 years; however, since 1950 temperatures have increased by about 1.5°F (0.83°C) in Puerto Rico (Figure 6-2; USGCRP 2018, 20:819). In this section we present temperature in Fahrenheit degrees first, as published in the USGS source we used. Some climate projections (1960-2099) indicate a 4.6 to 9°C (8.3 to 16.2°F) temperature increase for Puerto Rico (Figure 6-3; Henareh et al. 2016, p. 275) indicating a general consensus on a continued warming trend into the future amongst climate modeling studies for the entire U.S. Caribbean including the USVI. Thus, temperature across the Caribbean is expected to continue increasing over the next century. Global climate models project about a 1.5°F (0.83°C) to 4°F (2.2°C) increase in average temperatures for the U.S. Caribbean in 30 years (year 2050) with the end of the century (2100) estimates showing increases as high as about 9°F (4.9°C) under higher emission scenarios (USGCRP 2018, 20:819). Major consequences of warming, also include significant increases in the number of days in the Caribbean with temperatures over 90°F (32.2°C). For example, since 1970, the average annual number of days exceeding 90°F (32.2°C) has gone up an average of 0.5 days per year (USGCRP 2018, 20:821).

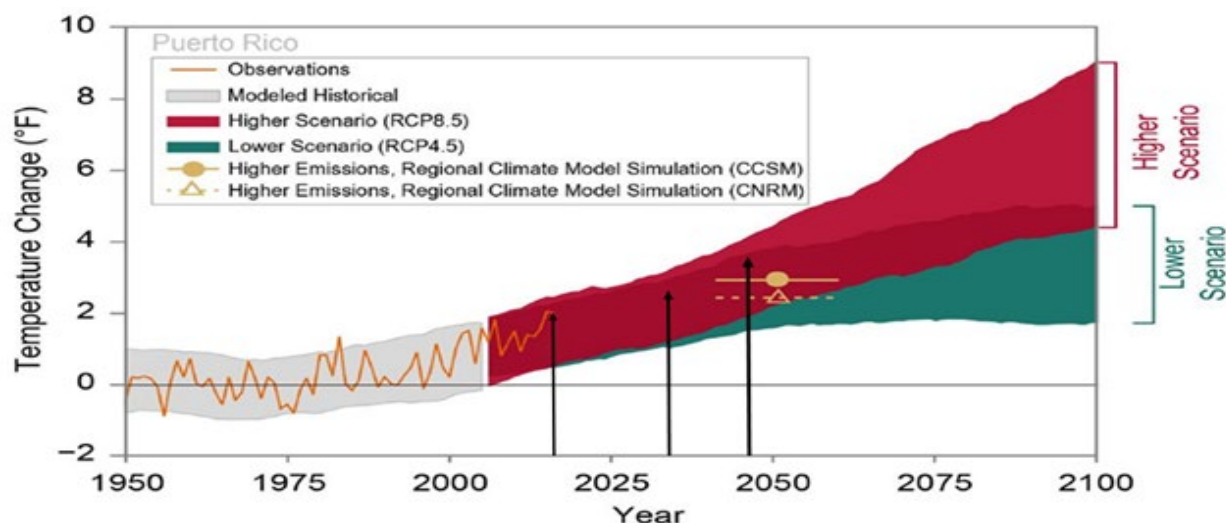


Figure 6-2. Observed and projected temperature changes are shown compared to the 1951-1980 average. Observed data are for 1950-2017, and the range of model simulations for the historical period is for 1950-2005. The range of projected temperature changes from global climate models is shown for 2006-2100 under lower and higher emissions scenarios. Projections from two regional climate models are shown for 2036-2065, and they align with those from global models

for the same period (USGCRP 2018, 20:820). Black arrows denote temperature at current time, an increase at 10 (2030) and 25 (2045) years into the future. Y-axis (data) indicates temperature; X-axis (index) indicates 25-year increments from 1950.

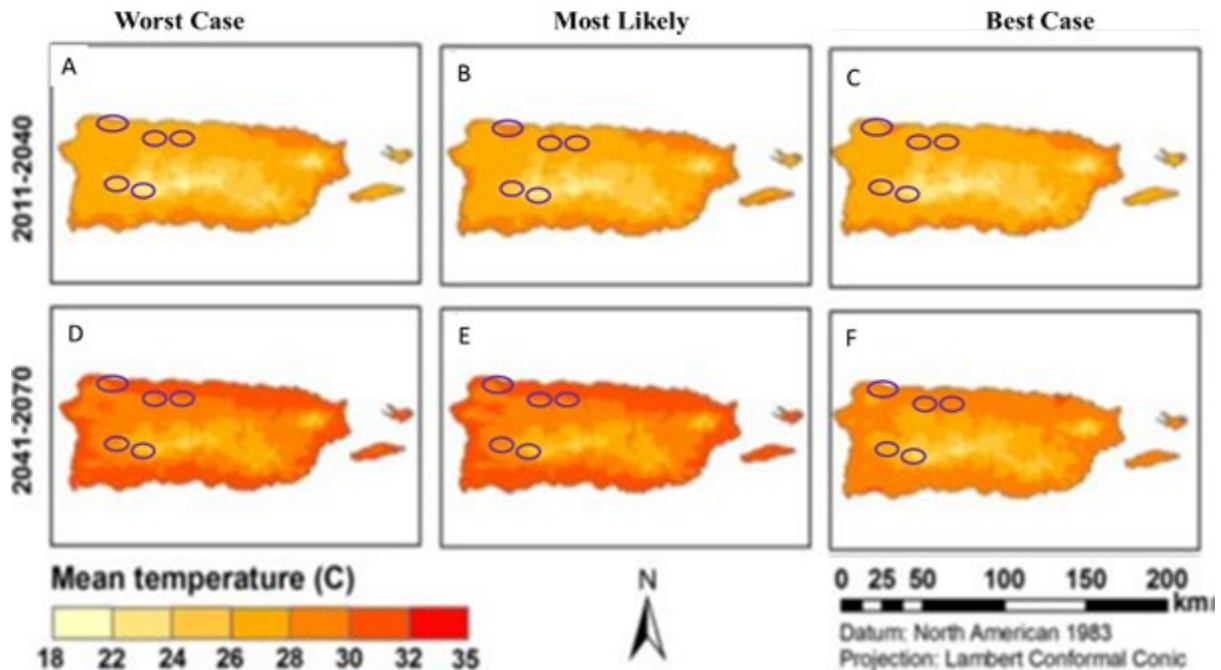


Figure 6-3. Temperature projections for Puerto Rico under three general circulation models (GCM) scenarios (Henareh et al. 2016, p. 277). Purple circles indicate the locations of the Puerto Rican harlequin butterfly populations. Figures A, B and C show current condition and the projection for 20 years (2040); Figures D, E and F show the projection at 50 years (2070).

### 6.3.2 Precipitation and drought stress.

Precipitation is projected to decrease relative to current levels, which combined with further warming, will tend to accelerate the hydrological cycle, resulting in more frequent wet and dry extremes (Jennings et al. 2014, p. 4; Cashman et al. 2010, p. 1). Indeed, the majority of models predict that future decreases in precipitation are likely (Carter et al. 2014, p. 399). Thus, the Caribbean is expected to get more frequent and severe droughts from reduced precipitation and increased evapotranspiration ratio (Figure 6-4) with a concomitant increase in the amount of precipitation produced during hurricane events (Herrera et al. 2018, p. 1). Subtropical dry forests inherently tend to be subject to water deficit for ten months of the year (Miller and Lugo 2009, p. 86) and are expected to become even drier in the future, especially in regions like the U.S. Caribbean (USGCRP 2018, 20: 820). Climate models consistently project significant drying in the U.S. Caribbean region occurring by the middle of the century; that is, by our projected time horizon of 2045 (USGCRP 2018, 20: 820). Although heavy rainfall associated with hurricanes is expected to increase, shifting weather patterns have nevertheless caused total rainfall to decrease in the Caribbean, resulting in more pronounced seasonal droughts (EPA report, 2016, p. 1).

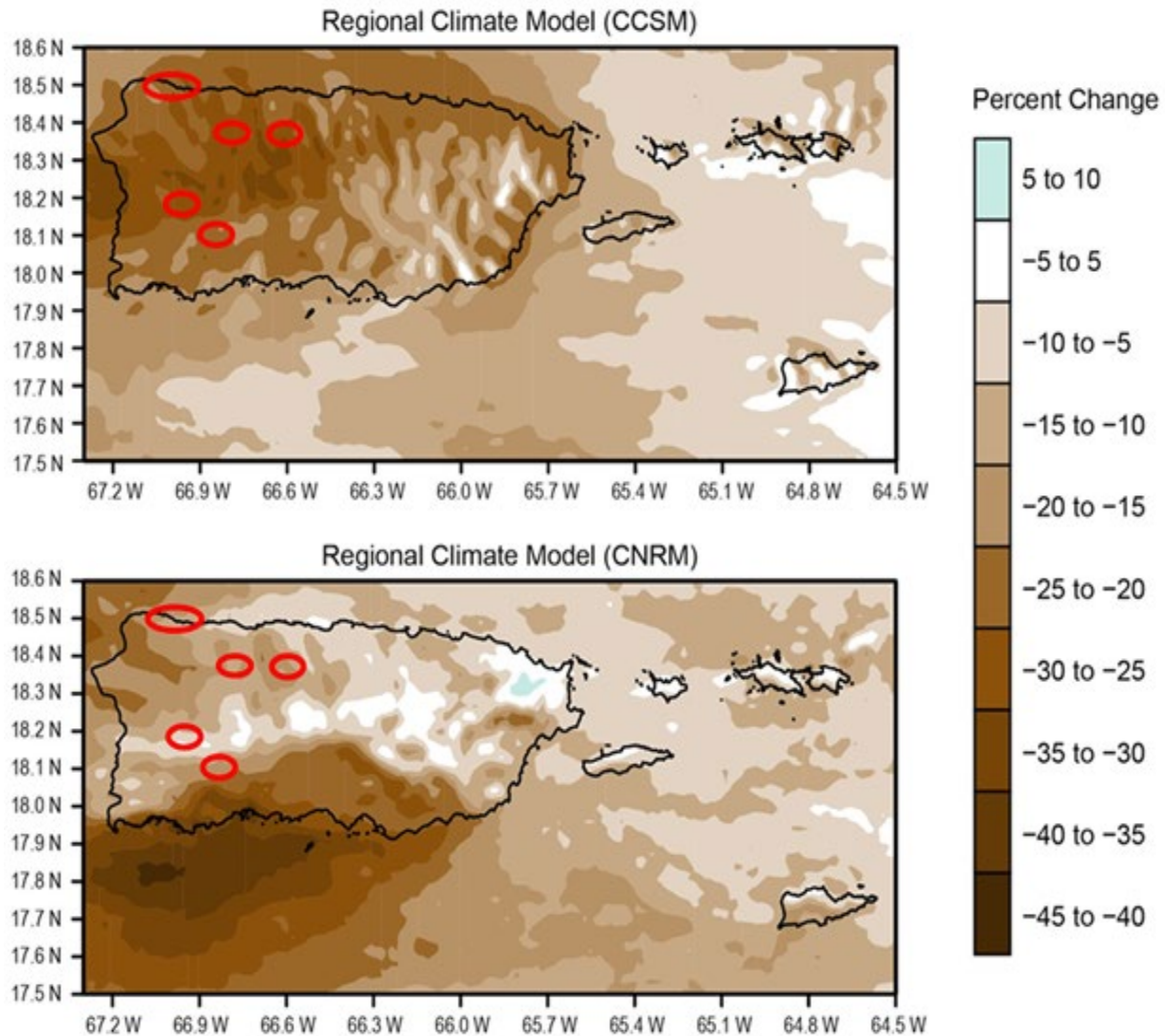


Figure 6-4. Projected Precipitation Change for the U.S. Caribbean. This figure shows the projected percent change in annual precipitation over the U.S. Caribbean region for the period 2040-2060 (lower figure) compared to 1985-2005 (upper figure) based on the results of two regional climate model simulations. These simulations downscale two global models for the higher scenario and show that within-island changes are projected to exceed a 10 percent reduction in annual rainfall. Red circles indicate the locations of the PRHB populations in Puerto Rico.

While we currently do not know the maximum thermal tolerance of the PRHB, studies with other species of Lepidopterans have shown that increases in ambient temperature are associated both with changes in metabolic rates and declines in reproductive success (e.g., Mathavan and Pandian 1975, entire; Koda and Nakamura 2010, entire; Wong et al. 2016, entire). For example, Koda and Nakamura (2010, p. 30) reported that hatchability of *Shijimiaeoides divinus barine* butterfly eggs steadily decreased from 88 percent to 0 percent with increases in ambient



temperatures from 20° to 35°C (68 to 95°F). Under past and current environmental conditions, reproduction of the PRHB occurs in environments with annual average maximum temperatures of 82-90°F (28-32°C); Table 11. However, based on our future climate projections (Table 11), these temperatures are expected to increase by 2.8-3.3°C (5.04-5.94°F) (“Best Case Scenario”) to 4.6-5.5°C (8.28-9.9°F) (“Worst Case Scenario”), resulting in maximum temperatures ranging from approximately 89-98°F (31-36°C) (“Most Likely Scenario”) for all known PRHB populations by 2045. Although the effects of this temperature increase on reproductive success of the PRHB remain uncertain, the cited studies suggest that PRHB reproduction may be adversely affected. Moreover, given that egg-laying and subsequent larval growth of the PRHB is closely associated with new leaf growth of *O. spinosa* triggered by the onset of the rainy season (ca. May-June; Figures 13 and 14), any future climatic aberrations which disrupt or reduce such rains will also likely have a detrimental effect on PRHB reproduction. It is conceivable that an extended drought (as predicted by the MCDD projections, Figure 6-5; Table 6-2) during the rainy season could prevent the species from reproducing in the areas affected, potentially resulting in localized population extirpations.

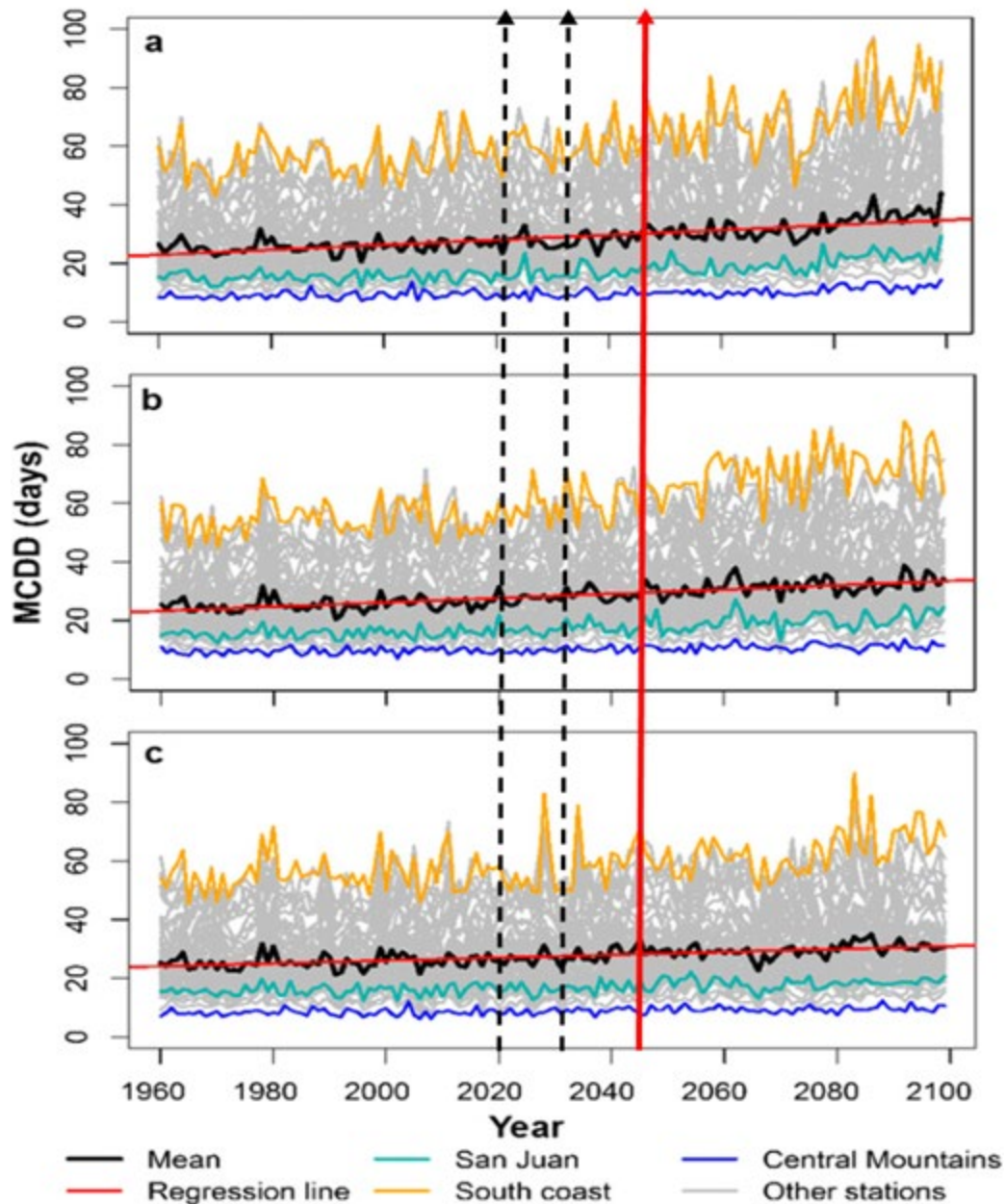


Figure 6-5. Maximum number of consecutive dry days (MCDD) in Puerto Rico. Black arrows represent present time (2020) and 10 years into the future. Red arrow indicates MCDD at 25 years into the future (2045). Panel A represents “worst case scenario”; B represents “most likely scenario”; C represents “best case scenario.” Y-axis (data) indicates days; X-axis (index) indicates 20-year increments from 1960 (adapted from Henareh et al. 2016, p. 276).

Table 6-2. Predicted increases in temperature and maximum consecutive dry days in Puerto Rico by 2045, based on Henareh et al. (2016). Because projections of Henareh et al. (2016) were for 1960-2099, we used 61 percent of their overall projection (85/139 yrs) and assumed a linear trend to estimate temperature increases for 2045. Maximum consecutive dry days were based on interpolation of mean plots in Henareh et al. (2016; Figure 7, p. 276).

<b>Projection to 2045</b>	<b>Best Case</b>	<b>Worst Case</b>	<b>Most Likely</b>
Temperature increase	2.8-3.3°C	4.6-5.5°C	3.9-4.6°C
Maximum Consecutive Dry Days	24 days	32 days	27 days

### 6.3.3 Life Zones

The boundaries of life zones according to the Holdridge System are based on three climatic measurements: annual precipitation, biotemperature and ratio of potential evapotranspiration to annual precipitation (Holdridge 1947, entire; Ewel and Whitmore 1973, p. 4). Figure 3-3 (Chapter 3) illustrates the distribution of the major life zones in Puerto Rico. Dramatic shifts in several life zones in Puerto Rico with potential loss of subtropical rain, moist, and wet forest, and the appearance of tropical dry and very dry forests are anticipated during this century (Henareh et al. 2016, p. 275). In the case of restricted range species, such as the PRHB, these trends may lead to biome shifts and species range loss due to inability of such species to effectively migrate or adapt to these changes (IPCC Report 2018, p. 3: 128). In fact, the number of plant and vertebrate species projected to lose over half of their climatically determined geographic range effectively doubles at 2°C versus 1.5°C of warming (IPCC report, 2018, p. 3:8). However, for insect species this number is effectively tripled by a 2°C temperature increase.

Life zone distribution changes are predicted in Puerto Rico (Figure 6-6; Henareh et al. 2016, p. 277) resulting from the predicted future temperature, precipitation and drought stress conditions. Overall, the current life zones where the PRHB occurs will most likely experience higher temperatures, reduced precipitation and increased drought stress conditions, thus reducing their suitability to sustain the species, thereby potentially resulting in localized extirpations of the species.



Consequently, the capacity of the PRHB to adapt to such conditions is expected to be reduced due to the current small number of populations and individuals.

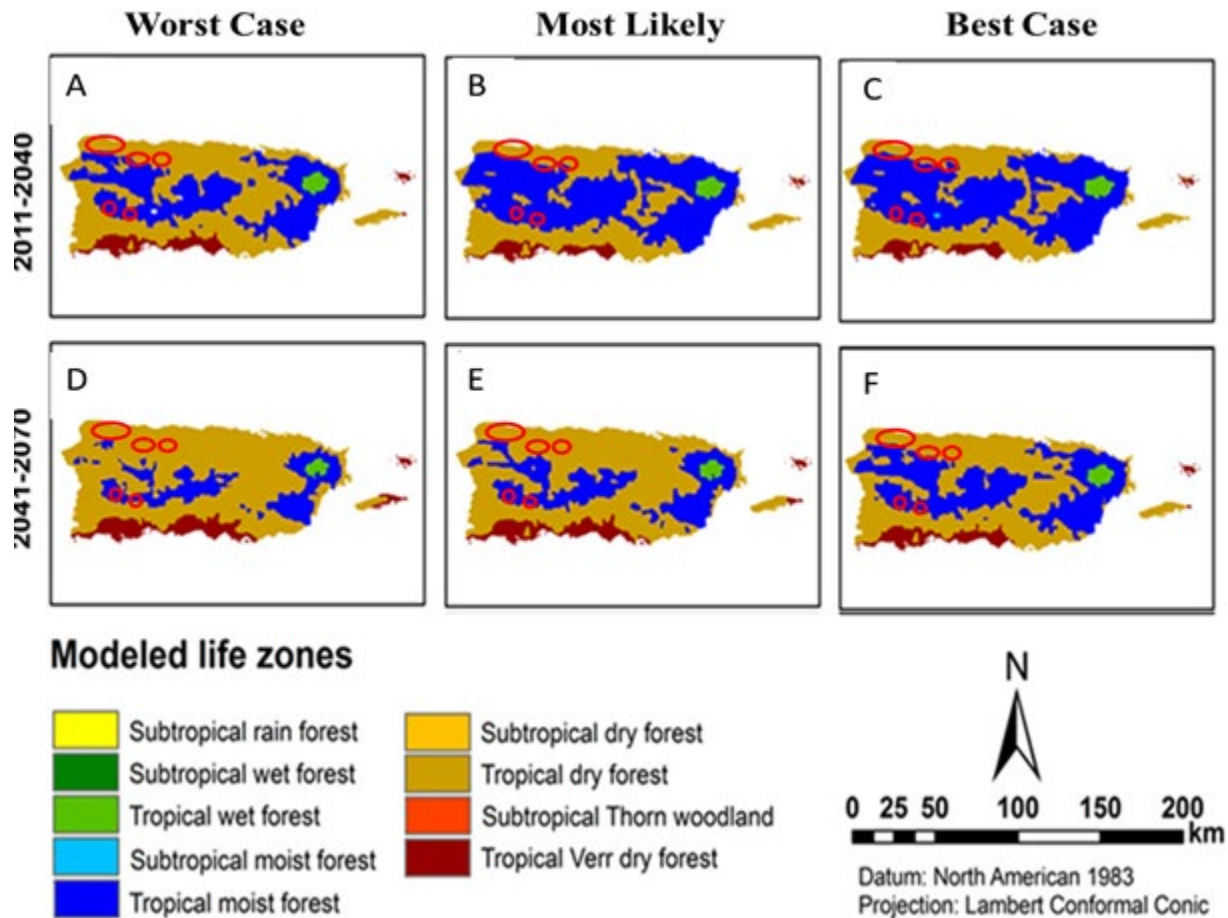


Figure 6-6. Projected life zones from the average of all models under the three future scenarios. Red circles indicate currently known populations of PRHB. Figures A, B and C show current condition; Figures D, E and F show the projection at 25 years (2045) and beyond. Adapted from Henareh et al. (2016), p. 279.

### 6.3.4 Storm Frequency and Intensity

Reconstruction of the past 5,000 years of intense hurricane activity in the western North Atlantic suggests that hurricane variability has been strongly modulated by El Niño during this time, and that the past 250 years has been relatively active in the context of the past 5,000 years (PRCCC Report 2013, p. 31). Accordingly, hurricanes may play an important role in shaping forest structure within the Caribbean (Van Bloem et al., 2005 p. 571; Lugo 2008, p. 368; Feng et al. 2018, p. 2). However, extreme events such as major hurricanes, floods and droughts are projected to increase in frequency and intensity, particularly in the Caribbean region (USGCRP 2018, 20: 127). Indeed, tropical storms and hurricanes have become more intense during the past 20 years, and hurricane wind speeds and rainfall are likely to increase further as the climate

continues to warm. According to regional climate projections by Bender et al. (2010, entire), the frequency of intense (Categories 4-5) hurricanes is expected to increase approximately 1 percent per year over this century. Increasing hurricane intensity and frequency coupled with a species showing reduced populations, low number of individuals, habitat degradation and fragmentation would likely have adverse consequences both for the PRHB and its habitat.

Long-term viability will require resilient populations in locations that are protected from long-term catastrophic but permanent effects of climate change (e.g., catastrophic hurricanes claiming forested habitat). The lack of redundancy in the face of hurricane threats is well illustrated by the path of Hurricane Maria in 2017 (Figure 6-7) and other historical hurricanes (Figure 6-8). Hurricane Maria traversed Puerto Rico in northwest direction, exiting near the city of Arecibo, and causing widespread destruction across the island. The entire range of the PRHB was subjected to hurricane force winds (> 64 knots) as the hurricane passed over, first as a Category 5 hurricane, weakening to a Category 4 hurricane over the Puerto Rico mainland. Feng et al. (2018, p. 2) estimated that Hurricane Maria may have caused mortality and severe damage to 23-31 million trees in Puerto Rico.

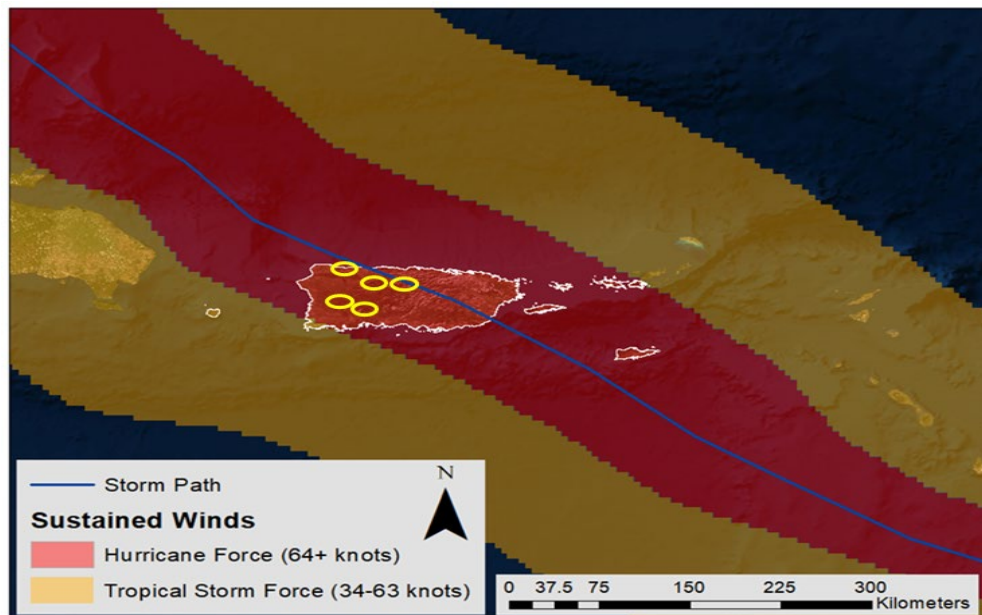


Figure 6-7. Path and wind speed of Hurricane Maria in September 2017. Puerto Rico and the US Virgin Islands are outlined in white, and the approximate range of the Puerto Rican harlequin butterfly is circled in yellow. (Data accessed from National Hurricane Center, National Oceanic and Atmospheric Administration, <https://www.nhc.noaa.gov>, March 27, 2018)

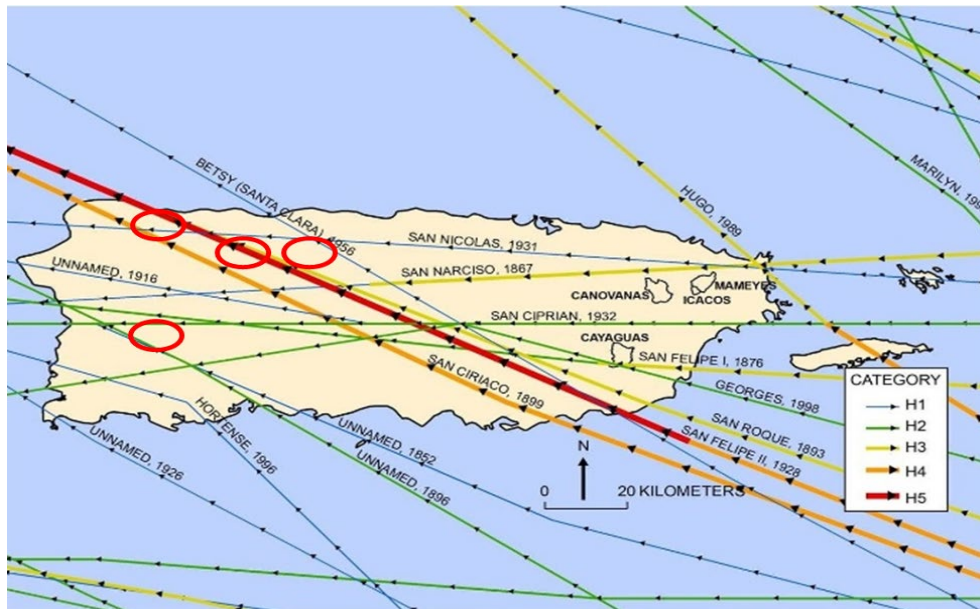


Figure 6-8. A sample of historical hurricanes that have struck Puerto Rico (USGS, public domain <https://www.usgs.gov/media/images/puerto-rico-hurricanes-map>), red circles identify the current locations of the Puerto Rican harlequin butterfly populations (Adapted from Feng et al. 2018, p. 3).

## 6.4 Future Scenarios

Resiliency was scored (Table 6-3) by combining scores for four (4) habitat metrics (Protection/Development Risk, Connectivity/Habitat Fragmentation, Risk of Vegetation clearing/Use of Pesticides, and Susceptibility to Stochastic Events (e.g., human-induced fires, severe drought, hurricanes, among others) and one (1) population metric (population size or trend). For future conditions scenarios, expected changes in habitat are based on scientific data and published documents. The projected population metric is less influential because here it reflects condition of the habitat and, unlike in current condition, it is not a direct measure. The habitat metrics are the drivers that may promote changes in future population (unless the current population is so low that extirpation risk is high). Therefore, habitat metrics had more weight than the population metric in future conditions projections.

For future conditions, each habitat metric was assigned a score of one (1), two (2), or three (3), and each population metric was assigned a score of two (2), four (4), or six (6), as described below in Table 6-3. Habitat metrics were weighted equally, with the overall effect that “habitat” was weighted two (2) times higher than “population.”



Table 6-3. Habitat and population metric values to project future resiliency of Puerto Rican harlequin butterfly populations.

H Score	Habitat Metrics Influencing Viability				Population Metrics	P Score
	Habitat Protection	Connectivity/Habitat Fragmentation	Vegetation Clearing/Use of Pesticides	Susceptibility to Stochastic Events	Population size/Trends	
1 point each; 4 points totals	Most habitat not protected, at risk of being developed (<34 percent protected)	Isolated subpopulations located at a distance of more than 1 km from the next one; habitat between populations or subpopulations highly disturbed (low connectivity)	Subpopulations located in areas subjected to vegetation clearing (including the use of herbicides) and use of pesticides (mosquito control and agricultural practice)	Subpopulations located in areas more vulnerable to stochastic events (e.g., fire, severe drought, hurricanes, among others)	Relatively low population size (0 to 5 imago and less than 100 larvae per ha) or high degree of uncertainty in population size/trends	2
2 points each; 8 points total	Some habitat protected, with some at risk of being developed (34-66 percent protected)	Subpopulations located within 1 km range; habitat between population moderately disturbed (some forested corridors)	Subpopulations located in areas rarely occur vegetation clearing (including the use of herbicides) or use of pesticides (mosquito control and agricultural practice)	Subpopulations located in areas with moderate vulnerability to stochastic events (e.g., fire, severe drought, hurricanes, among others)	Relatively moderate population size (6 to 20 imagoes and 100 to 500 larvae per ha)	4
3 points each; 12 points total	Most habitat protected (>66 percent)	Subpopulations located within 1 km range; undisturbed habitat between populations (forested corridors)	Subpopulations located in areas where vegetation clearing (include the use of herbicides) or use of pesticides (mosquito control and agricultural practices) is not expected.	Subpopulations located in areas with lower vulnerability to stochastic events (e.g., fire, severe drought, hurricanes, among others).	Relatively high population size (more than 20 imagoes and more than 500 larvae per ha) and/or growth.	6

The score for each population across all metrics were summed, and final population resiliency categories were assigned as follows:

- Low Resiliency:**  $\leq 9$
- Moderately Low Resiliency:** 9 to 10
- Moderate Resiliency:** 11 to 13
- Moderate High Resiliency:** 14 to 15
- High Resiliency:**  $\geq 15$

Projected population resiliency under each of the three scenarios is shown in Tables 6-4, 6-5, and 6-6.

Table 6-4. Worst Case Scenario for future conditions (2045).

Population	Habitat Metrics				Population Metric	Resiliency
	Habitat Protection - Development Risk	Connectivity Habitat Fragmentation	Risk of Vegetation Clearing/Use of Pesticides (Low, Moderate or High)	Susceptibility to Stochastic Events (Low, Moderate or High)	Population Size/Trend Description	
Isabela, Quebradillas and Camuy (IQC)	Risk of Development (1)	Habitat fragmented / low connectivity (1)	High (1)	High (1)	Relatively low population size (0 to 5 imago and at less than 100 larvae per ha) or high degree of uncertainty in population size/trends (2)	Low (6)
Rio Abajo Commonwealth Forest	Protected (3)	Connectivity (3)	Low (3)	High (1)	Extirpated	Extirpated
Rio Encantado Area	Some habitat protected, some at risk of being developed (1)	Both (2)	Moderate (2)	High (1)	Extirpated	Extirpated

Table 6-4 continued

Population	Habitat Metrics				Population Metric Population Size/Trend Description	Resiliency
	Habitat Protection - Development Risk	Connectivity Habitat Fragmentation	Risk of Vegetation Clearing/Use of Pesticides (Low, Moderate or High)	Susceptibility to Stochastic Events (Low, Moderate or High)		
Maricao Commonwealth Forest	Protected (3)	Habitat fragmented / low connectivity (1)	High (1)	High (1)	Relatively low population size (0 to 5 imago and less than 100 larvae per ha) or high degree of uncertainty in population size/trends (2)	Moderately Low (8)
Susúa Commonwealth Forest	Protected (3)	Habitat fragmented / low connectivity (1)	High (1)	High (1)	Extirpated	Extirpated

Table 6-5. Most Likely Scenario for future conditions (2045).

Population	Habitat Metrics				Population Metric Population Size/Trend Description	Resiliency
	Habitat Protection - Development Risk	Connectivity Habitat Fragmentation	Risk of Vegetation Clearing/Use of Pesticides (Low, Moderate or High)	Susceptibility to Stochastic Events (Low, Moderate or High)		
Isabela, Quebradillas and Camuy (IQC)	Risk of Development (1)	Habitat fragmented / low connectivity (1)	High (1)	High (1)	Relatively moderate population size (15 to 20 imagoes and 100 to 500 larvae per ha) (4)	Low (8)
Rio Abajo Commonwealth Forest	Protected (3)	Connectivity (3)	Low (3)	High (1)	Extirpated	Extirpated
Rio Encantado Area	Some habitat protected, some at risk of being developed (2)	Connectivity (3)	Low (3)	Moderate (2)	Extirpated	Extirpated



Table 6-5 continued

Population	Habitat Metrics				Population Metric	Resiliency
	Habitat Protection - Development Risk	Connectivity Habitat Fragmentation	Risk of Vegetation Clearing/Use of Pesticides (Low, Moderate or High)	Susceptibility to Stochastic Events (Low, Moderate or High)	Population Size/Trend Description	
Maricao Commonwealth Forest	Protected (3)	Both (2)	High (1)	High (1)	Relatively moderate population size (15 to 20 imagoes and 100 to 500 larvae per ha) (4)	Moderately Low (10)
Susúa Commonwealth Forest	Protected (3)	Both (2)	High (1)	High (1)	Extirpated	Extirpated

Table 6-6. Best Case Scenario for future conditions (2045).

Population	Habitat Metrics				Population Metric	Resiliency
	Habitat Protection - Development Risk	Connectivity Habitat Fragmentation	Risk of Vegetation Clearing/Use of Pesticides (Low, Moderate or High)	Susceptibility to Stochastic Events (Low, Moderate or High)	Population Size/Trend Description	
Isabela, Quebradillas and Camuy (IQC)	Risk of Development (1)	Both (2)	High (1)	Moderate (2)	Relatively high population size (more than 25 imagoes and more than 500 larvae per ha) and/or growth (6)	Moderate (12)
Rio Abajo Commonwealth Forest	Protected (3)	Connectivity (3)	Low (3)	Moderate (2)	Relatively low population size (0 to 5 imago and at less than 100 larvae per ha) or high degree of uncertainty in population size/trends (2)	Moderate (13)
Rio Encantado Area	Some habitat protected, some at risk of being developed (2)	Connectivity (3)	Low (3)	Moderate (2)	Relatively low population size (0 to 5 imago and at less than 100 larvae per ha) or high degree of uncertainty in population size/trends (2)	Moderate (12)

Table 6-6 continued.

Population	Habitat Metrics				Population Metric	Resiliency
	Habitat Protection - Development Risk	Connectivity Habitat Fragmentation	Risk of Vegetation Clearing/Use of Pesticides (Low, Moderate or High)	Susceptibility to Stochastic Events (Low, Moderate or High)	Population Size/Trend Description	
Maricao Commonwealth Forest	Protected (3)	Both (2)	High (1)	High (1)	Relatively high population size (more than 20 imagoes and more than 500 larvae per ha) and/or growth (6)	Moderate (13)
Susua Commonwealth Forest	Protected (3)	Both (2)	High (1)	High (1)	Low population size with high degree of uncertainty in population trends (2)	Moderately low (9)

#### 6.4.1 Future Resiliency

Future resiliency of three (3) of the five (5) PRHB populations is expected to decline to “Extirpated” under our “Most Likely” and “Worst Case” scenarios (Table 6-7). Collectively, these three (3) populations represent approximately 25 percent of the entire known PRHB population. The remaining two (2) populations (i.e., IQC and Maricao) are predicted to persist, but with lower levels of resiliency than currently. Only under the “Best Case” scenario will all five (5) populations persist at levels comparable to current conditions (Table 6-7).

Table 6-7. Summary of PRHB population resiliency under current and future scenarios.

Populations	Current (2020)	Worst Case	Most Likely	Best Case	Approximate percentage of total population <sup>1</sup>
IQC	Moderate (18)	Low (6)	Low (8)	Moderate (12)	53
Río Abajo	Moderate (15)	Extirpated	Extirpated	Moderate (13)	<5
Río Encantado	Moderate (14)	Extirpated	Extirpated	Moderate (12)	<5
Maricao	Moderately High (19)	Low (8)	Moderately Low (10)	Moderate (13)	21
Susúa	Low (11)	Extirpated	Extirpated	Moderately Low (9)	16

<sup>1</sup>Based on most recent (Barber 2018) field counts of imagoes (adult individuals).

#### 6.4.2 Future Representation

According to our “Most Likely” and “Worst Case” scenarios, all areas and life zones which currently harbor PRHB populations are expected to become drier and warmer, with some (i.e., Río Abajo and Río Encantado) progressing from tropical moist forest to tropical dry forest (Figure 61). Under these scenarios, and with only 2 remaining populations (Table 6-7), the species would suffer a substantial decline in representation (as defined in Chapter 1).

#### 6.4.3 Future Redundancy

Given the predicted extirpation of most (3/5) PRHB populations under our “Most Likely” and “Worst Case” scenarios, we expect an attendant and precipitous loss of population redundancy. Moreover, the only remaining populations (i.e., IQC and Maricao; Table 6-7) will most likely also become smaller, more fragmented, and subject to greater environmental stress.



## 6.5 Synthesis and Conclusions

Except for the Best Case scenario, the PRHB apparently faces significant reductions in Resiliency, Redundancy and Representation over the next 25 years. The overall threats to the species can be placed into two main categories: development and climate change. The continuing development – residential, commercial and tourist – both within and adjacent to areas currently occupied by PRHB will most likely increase over this time period, with attendant loss and degradation of suitable habitat, increased use of herbicides and pesticides, and greater risks of human-caused fires. These effects, both individually and collectively, have the potential to cause losses of not only annual reproductive cohorts, but also individual or multiple metapopulations, thereby further reducing species viability. Nevertheless, these adverse effects could potentially be lessened or mitigated by effective land use planning that considers PRHB biological and ecological needs and requirements. However, widespread and continuing lax application and enforcement of existing regulations that aim to protect PRHB habitat suggests efficacy of these measures will be limited in the future.

Although the adverse effects of development can potentially be lessened, the forecast changes in regional and local climate pose a much more daunting and irreversible challenge for the PRHB. The areas currently occupied by the species will most likely undergo increases in temperatures combined with a decrease in total precipitation over the next 25 years. Together, these changes will result in more severe and extensive drought conditions, while shifting some currently mesic life zones towards more xeric ones, further increasing risks of fires. The frequency of intense (Category 3-5) hurricanes will also increase over this time period. While the full ecological effects of these changes on the PRHB are yet unclear, it is likely that substantial changes in overall habitat and microhabitat (e.g., temperature, humidity) for a species whose ecology appears closely linked to specific current conditions (e.g., healthy *O. spinosa* populations) will have negative effects on the PRHB.

In summary, at the end of our predictive time horizon (year 2045) at least three (3) of the current five (5) PRHB populations will most likely have been extirpated, with those remaining (i.e., IQC and Maricao) incurring reductions in resiliency. Those predicted to be lost are the current populations at Río Abajo, Río Encantado, and Susúa, representing approximately 25 percent of the currently known total population size, which is already considered very small (less than 100 total individuals per population observed in any given year). Because of concomitant reductions in the remaining populations, the overall losses to the total PRHB population will be substantially greater than 25 percent, although impossible to accurately quantify at the current time.

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Appendix 1. List of plant species observed in the Puerto Rican harlequin butterfly habitat (Barber 2018, p. 72)

<b>Scientific Name</b>	<b>Common Name</b>	<b>Family</b>
<i>Oplonia spinosa</i>	Prickly bush	Acanthaceae
<i>Odontonema cuspidatum</i>	Coral de Jardín	Acanthaceae
<i>Justicia mirabiloides</i>	West Indian water-willow	Acanthaceae
<i>Bidens pilosa</i>	Spanish needle	Asteraceae
<i>Boureria succulenta</i>	Pigeon-berry	Boraginaceae
<i>Bursera simaruba</i>	Turpentine-tree	Burseraceae
<i>Byrsonimia spicata</i>	Hogberry	Malpighiaceae
<i>Calophyllum calaba</i>	Sant-maria	Calophyllaceae
<i>Capparis flexuosa</i>	Caper tree	Capparaceae
<i>Cecropia peltata</i>	trumpet tree	Cecropiaceae
<i>Cecropia schreberiana</i>	pumpwood	Cecropiaceae
<i>Citharexylum fruticosum</i>	spiny fiddlewood	Verbenaceae
<i>Clusia minor</i>	cupey de monte	Clusiaceae
<i>Clusia rosea</i>	Scotch attorney	Clusiaceae
<i>Coccothrinax barbadensis</i>	Puerto Rico silver palm	Arecaceae
<i>Coccoloba costata</i>	uvilla	Polygonaceae



Appendix 1 continued.

<b>Scientific Name</b>	<b>Common Name</b>	<b>Family</b>
<i>Coccoloba microstachya</i>	puckhout	Polygonaceae
<i>Coccoloba pubescens</i>	grandleaf seagrape	Polygonaceae
<i>Coccoloba uvifera</i>	seagrape	Polygonaceae
<i>Commelina diffusa</i>	climbing dayflower	Commelinaceae
<i>Comocladia glabra</i>	carrasco	Anacardiaceae
<i>Conocarpus erectus</i>	button mangrove	Combretaceae
<i>Croton flavens</i>	yellow balsam	Euphorbiaceae
<i>Dendropanax arboreus</i>	Angelica tree	Araliaceae
<i>Distictis lactiflora</i>	liana fragante	Bignoniaceae
<i>Eugenia biflora</i>	blackrodwood	Myrtaceae
<i>Eugenia confusa</i>	redberry stopper	Myrtaceae
<i>Eupatorium odoratum</i>	no common name	Asteraceae
<i>Erithalis fruticosa</i>	blacktorch	Rubiaceae
<i>Erithalis odorifera</i>	no common name	Rubiaceae
<i>Garcinia hessi</i>	no common name	Clusiaceae
<i>Guettarda pugens</i>	roseta	Rubiaceae
<i>Guettarda scabra</i>	wild guave	Rubiaceae

Appendix 1 continued.

<b>Scientific Name</b>	<b>Common Name</b>	<b>Family</b>
<i>Ilex nitida</i>	Puerto Rico holly	Aquifoliaceae
<i>Krugiodendron ferreum</i>	ironwood	Rhamnaceae
<i>Lantana camara</i>	red-sage	Verbenaceae
<i>Lantana involucrata</i>	buttonsage	Verbenaceae
<i>Leucaena leucocephala</i>	white leadtree	Fabaceae
<i>Neea buxifolia</i>	saltwood	Nyctaginaceae
<i>Neoregelia resinosa</i>	no common name	Bromeliaceae
<i>Passiflora suberosa</i>	corkystem	Passifloraceae
<i>Pimenta racemosa var grisea</i>	bay-rum-tree	Myrtaceae
<i>Plumeria krugii</i>	no common name	Apocynaceae
<i>Poitea paucifolia</i>	retama	Fabaceae
<i>Poitea punicea</i>	caracol illo	Fabaceae
<i>Psidium amplexicaule</i>	mountain guava	Myrtaceae
<i>Randia aculeata</i>	white indigo-berry	Rubiaceae
<i>Rondeletia inermis</i>	cordobancillo	Rubiaceae
<i>Sideroxylon cubense</i>	espejuelo	Sapotaceae

Appendix 1 continued.

<b>Scientific Name</b>	<b>Common Name</b>	<b>Family</b>
<i>Staehytarpeta jamaicensis</i>	no common name	Verbenaceae
<i>Tabebuia haemantha</i>	roble cimarron	Bignoniaceae
<i>Tabebuia heterophylla</i>	white cedar	Bignoniaceae
<i>Tabebuia karsoana</i>	no common name	Bignoniaceae
<i>Terminalia catappa</i>	tropical almond	Combretaceae
<i>Thouinia striata</i>	ceboruquillo	Sapindaceae
<i>Vernonia albicaulis</i>	no common name	Asteraceae



Appendix 2. List of plants identified as Puerto Rican harlequin butterfly nectar sources (Barber 2018, p. 71)

<b>Scientific name</b>	<b>Quebradillas</b>	<b>Maricao</b>	<b>Susúa</b>
<i>Erithialis fructicosa</i>	X		
<i>Paulinia pinnata</i>	X		
<i>Justicia mirabiloides</i>	X		
<i>Oplonia spinosa</i>	X	X	X
<i>Coccoloba uvifera</i>	X		
<i>Bouerria succulenta</i>	X		
<i>Lantana camara</i>	X		
<i>Lantana involucrata</i>	X	X	
<i>Croton rigidus</i>			X
<i>Stachytarpheta jamaicensis</i>	X		
<i>Randia aculeata</i>	X	X	X
<i>Stigmaphyllon emarginatum</i>		X	

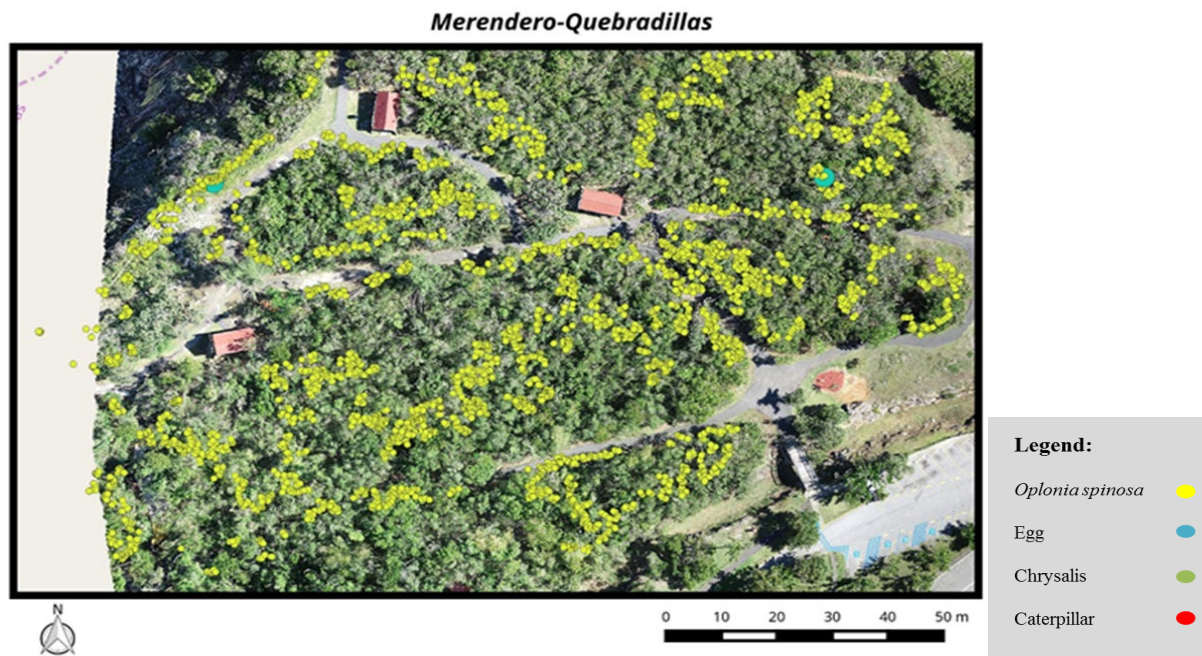
Appendix 2 continued.

<b>Scientific name</b>	<b>Quebradillas</b>	<b>Maricao</b>	<b>Susúa</b>
<i>Vernonia albicaulis</i>	X		
<i>Tabebuia heterophylla</i>	X	X	X
<i>Poitea spp.</i>	X	X	
<i>Bidens urbanii</i>		X	
<i>Citharexylum fruticosum</i>	X		
<i>Guettarda ovalifolia</i>		X	
<i>Chromolaena sinuata (possibly)</i>		X	

### Appendix 3. Local Puerto Rican harlequin butterfly habitat descriptions and species occurrence records.

#### *IQC Habitat*

The Merendero in Quebradillas is the site where the PRHB has been most frequently observed in all of its life stages, which suggests the species is well adapted for the type of habitat at this site. There is a cliff at this site with no canopy coverage to the north and 50-70 percent canopy coverage to the south. *O. spinosa* is found in patches distributed along the northern cliff, and along the edges of the recreational trails and in some forested areas showing some level of disturbance in recent times (Vargas 2019, p. 2; Barber 2019, p. 37) (Map below). Here, *O. spinosa* has been observed mostly in the understory. The floral composition at this site, where there are around 29 plant species from 23 families, favors native species (See Appendix I). The most dominant tree species are the *Coccoloba uvifera* (16 percent), *Tabebuia heterophylla* and *Bursera simaruba* (13 percent each), and *Leucaena leucocephala* (12 percent), with a total of 41 percent of relative plant species abundance (Barber 2019, p. 37; Vargas 2019, p. 2). *Leucaena leucocephala* is the only non-native species that is apparently abundant in this site. The other three dominant species are native trees.



Map showing the *Oplonia spinosa* distribution and locations of the PRHB stages (if found during February survey) at El Merendero in Quebradillas (Vargas 2019, p. 3).



The Puente Blanco site is characterized by a cliff to the north with no canopy coverage and about 50-70 percent of canopy coverage to the south. The host plant *O. spinosa* is found in patchy distribution along the northern cliff, at the edges of a secondary road that provide access Appendix 3 continued.

from Puente Blanco to Puerto Ermina, and in some forested areas showing some disturbance in recent times (Monzón 2007, p. 83) (Map below). Where we observed *O. spinosa*, it occupied most of the understory coverage.



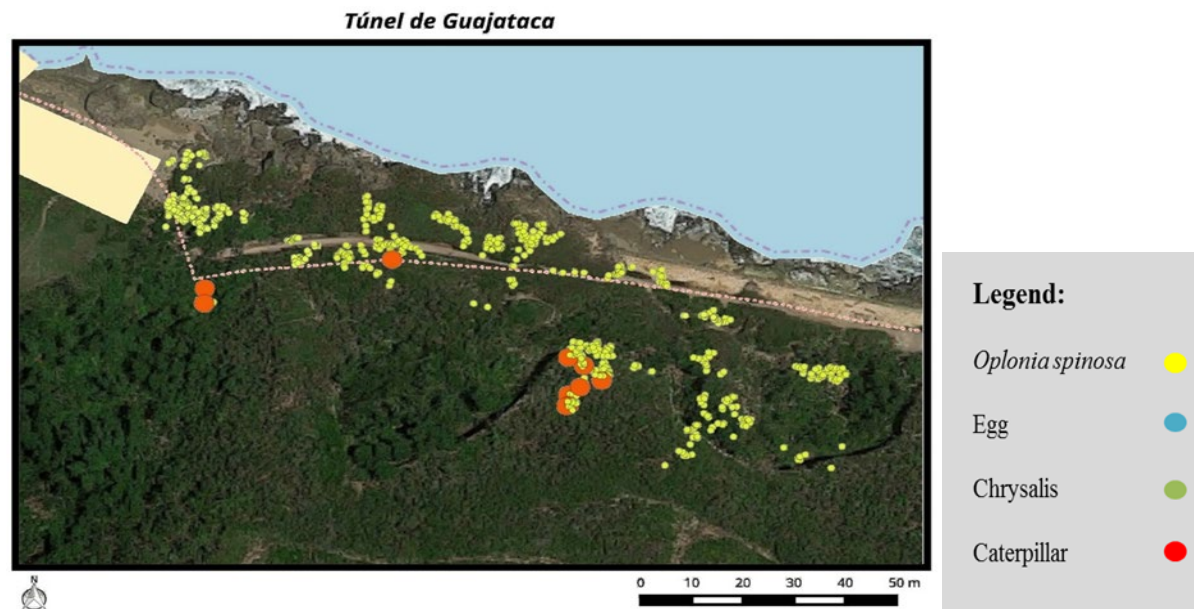
Map showing the *Oplonia spinosa* distribution at Puente Blanco in Quebradillas (Monzón 2007, p. 83).

At El Tunel de Guajataca area, the PRHB is often found along the road that provides access to the tunnel and the beach area, and along the former train rails that run at the base of the coastal cliff (Map below). Along the access road, the canopy cover is almost 100 percent starting at the bottom of the slope up to the beginning of the limestone hill (“mogote”). To the east there is a wetland, and the Guajataca River. The dominant species in this area are *Coccoloba uvifera*, *Ilex nitida*, *Bursera simaruba*, *Chrysophyllum oliviforme*, *Cecropia peltata* and *Clusia rosea*. *Oplonia spinosa* also is found in two sections along the access road (Barber 2019, p. 13). At the former train rail, the habitat is characterized by limited canopy cover (less than 25 percent) with some dwarf vegetation close to the shore, and a limestone wall to the south (Map below). The dominant species are *Coccoloba uvifera*, *Oplonia spinosa*, *Terminalia catappa*, *Conocarpus erectus* and *Suriana maritima*. *Oplonia spinosa* dominates the open areas and under the *Coccoloba uvifera* where it has enough space to disperse.

Appendix 3 continued.



Map showing the *Oplonia spinosa* distribution and locations of the PRHB stages (if found during February survey) along the access road to El Tunel de Guajataca in Isabela (Vargas 2019, p. 4).



Map showing the *Oplonia spinosa* distribution and locations of the PRHB stages (if found during February survey) in the northern coastal cliff at El Tunel de Guajataca in Isabela (Vargas 2019, p. 5).

At Cara del Indio, the PRHB habitat is fragmented by Highway PR #2 (PR-2) on the south, State road PR-113 dissect the habitat on the north, and the Royal Isabela Resort also delimit the habitat Appendix 3 continued.

on the north. Along the segment of the road PR-133, the canopy cover is between 90 percent to 100 percent. *Oplonia spinosa* is found on the face of the limestone hill to the south of the road and at the edge of the cliff (Barber 2019. p. 6) (Map below). Dominant vegetation includes *Ilex nitida*, *Bursera simaruba*, *Commelina diffusa* and *Bidens pilosa*.

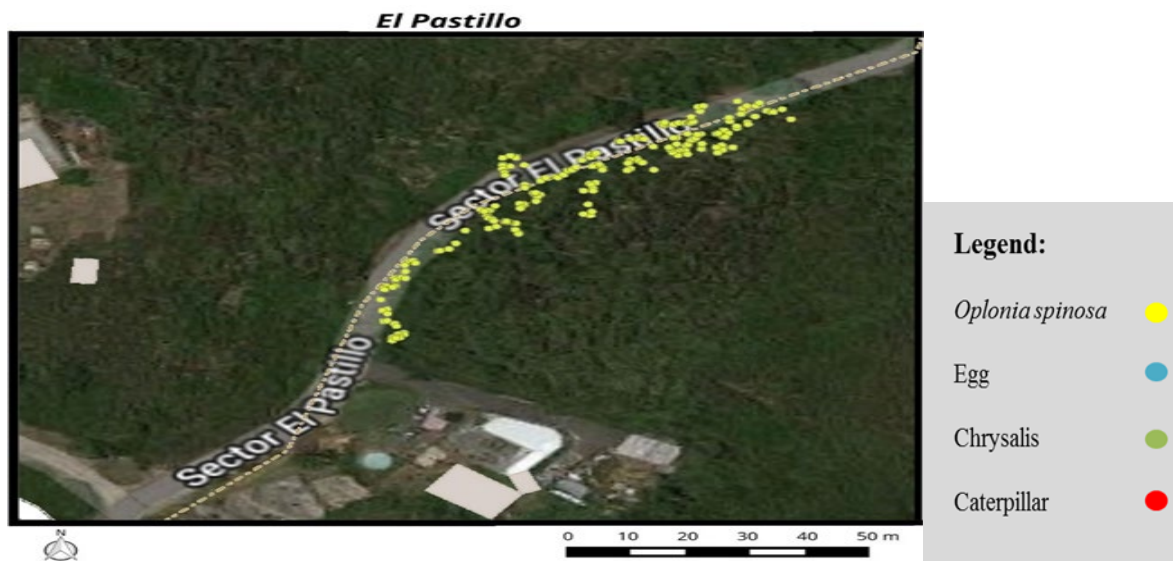


Map showing the *Oplonia spinosa* distribution and locations of the PRHB stages (if found during February survey) at Cara del Indio in Isabela (Barber 2019, p. 6).

At El Pastillo, the PRHB habitat is located on both sides of a secondary road that provides access to El Pastillo beach. The northern side of this road is dominated by *Leucaena leucocephala* and grasses, apparently as a result of habitat disturbances caused by former uses (e.g., cattle grazing) and vegetation removal. The southern side of the road has habitat with semi open areas (up to 75 percent of canopy cover) at the top of a small limestone hill. The dominant species in this area are *Terminalia catappa*, *Bursera simaruba*, *Leucaena leucocephala*, *Hylocereus trigonus*, *Ilex nitida* and some vines. *Oplonia spinosa* is found on both sides of the road, but is more abundant in the southern side (Barber 2019, p. 15) (Map below).



Appendix 3 continued.



Map showing the *Oplonia spinosa* distribution and locations of the PRHB stages (if found during February survey) at El Pastillo in Isabela (Barber 2019, p. 15).

*Río Abajo Commonwealth Forest and Río Encantado Habitat*

Both the Río Abajo Commonwealth Forest and the Río Encantado area, have very irregular topography, haystack hills with very steep slopes, subterranean water systems, caves, and natural depressions or sinkholes, all characteristic of the karst geological formations found along the northern karst belt of Puerto Rico. The majority of the vegetation in these areas is classified as subtropical moist forest, with a reduced representation of a subtropical wet forest at the Río Abajo Commonwealth Forest (Helmer et al 2002, p. 169; Morales and Estremera 2018, p. 1).

Much of the forest surrounding the Río Abajo Commonwealth Forest and the Río Encantado area is composed of secondary vegetation (DNR 1976, p. 126). The vegetation in these areas is more xerophytic than would be expected given the high amount of rainfall received in these areas (DNR 1976, p. 126). According to Morales and Estremera (2018, p. 2), the habitat where the PRHB occur in Río Encantado and Río Abajo Commonwealth Forest is mostly associated to mogotes habitat where the composition, physical structure, morphology and density of the vegetation change from as you move from the bottom to the top of the mogote. Tree species at the base of the mogotes are taller (canopy height average 10.3m (34 ft)) than at the top, where the vegetation is smaller expressing morphological features typically found in warmer and dryer conditions. Soil at the top is mostly shallow and rocky as compared to the soil at the base where it is deeper and moist. *Oplonia spinosa* is mostly found growing on the upper slopes of the mogotes where 90 degree steep walls rise abruptly all the way to the top (Morales and Estremera 2018, p. 2).

### Appendix 3 continued.

#### *Maricao Commonwealth Forest Habitat*

The Maricao Commonwealth Forest exemplifies vegetation types of serpentine soils, and probably has the most diversified flora of any area of the same size in Puerto Rico. The Forest is located on the west end of the Cordillera Central (central mountain range), and receives a mean annual precipitation of 2,500 mm (98.4 in; Ricart and Padrón 2010, p. 3; DNER 1976, p. 184). The rainfall ranges from 70 to 75 mm (2 to 3 in) during the month of January and February to approximately 350 mm (13.7 in) during the month of August, September and October (Ricart and Padrón 2010, p. 3). The mean monthly temperature varies from 20°C (68°F) during February to 23°C (73.4°F) during July, August and September, with a mean annual temperature of 21°C (69.8°F).

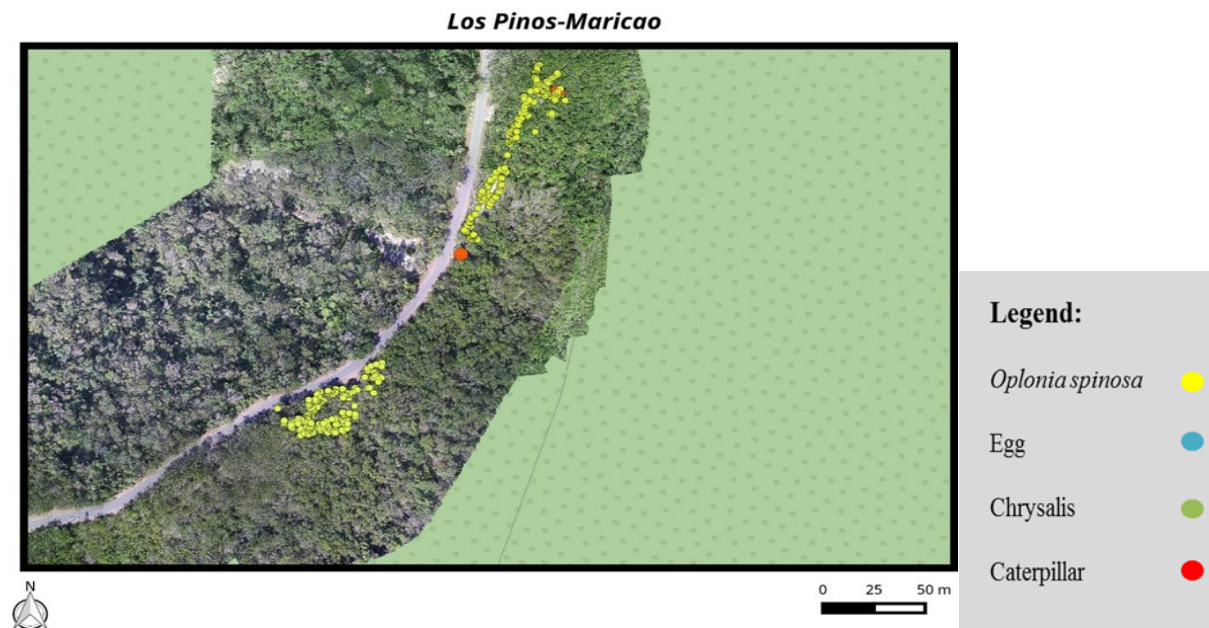
The PRHB is found in an area known as La Cantera, which is limited on the north by the State road PR-120, on the south by a steep cliff, on the west by an abandoned quarry, and on the east by Alto del Descanso trail. From road PR-120 to the Altos del Descanso the canopy cover ranges from 60 percent to less than 10 percent, but may reach up to 100 percent on the west of the Alto del Descanso trail. *Oplonia spinosa* is found from the edge of the road up to the top of the ridge, all in areas previously disturbed by the quarry activities at La Cantera (Barber 2019, p. 22) (Map below). In Alto del Descanso, the establishment of *O. spinosa* can be affected by the high understory and canopy vegetation cover.



Map showing the *Oplonia spinosa* distribution and locations of the PRHB stages (if found during February survey) at La Cantera in Altos del Descanso area, Maricao Commonwealth Forest (Barber 2019, p. 22).

### Appendix 3 continued.

Los Pinos site is limited on the south by the State road PR 120 and on the north by the right of way of a Puerto Rico Energy and Power Authority (PREPA) distribution lines. In general, the canopy cover at this site fluctuates from 60 percent to 85 percent, with the exception of the areas along the road, trails, and underneath the power lines. *Oplonia spinosa* is found in 2 patches: one along a trail that provides access to the PREPA power line towers, and the other on a cliff to the north of the road (Barber 2019, p. 29) (Map below). Both patches are no more than 30m (98.4 ft) from each other.



Map showing the *Oplonia spinosa* distribution and locations of the PRHB stages (if found during February survey) at La Pinos, Maricao Commonwealth Forest (Barber 2019, p. 29).

#### *Susúa Commonwealth Forest Habitat*

The Susúa Commonwealth Forest lies between the humid Cordillera Central and the dry coastal plains of the southern coast of Puerto Rico (DNER 1976, p. 224). Mean annual precipitation in this forest is 1,413 mm (55.6 in) and mean annual temperature is 23.9°C (75°F). Rainfall is generally heaviest in August, September and October and the driest season fall during February and March. The Susúa Commonwealth Forest represent not only the influence of a climatic transition zone (dry to moist), but also a combination of volcanic and serpentine soils. Over 90 percent of the Susua forest is classified as serpentine outcrop which consist of loses rocks scattered on the surface (DNER 1976, p. 224)

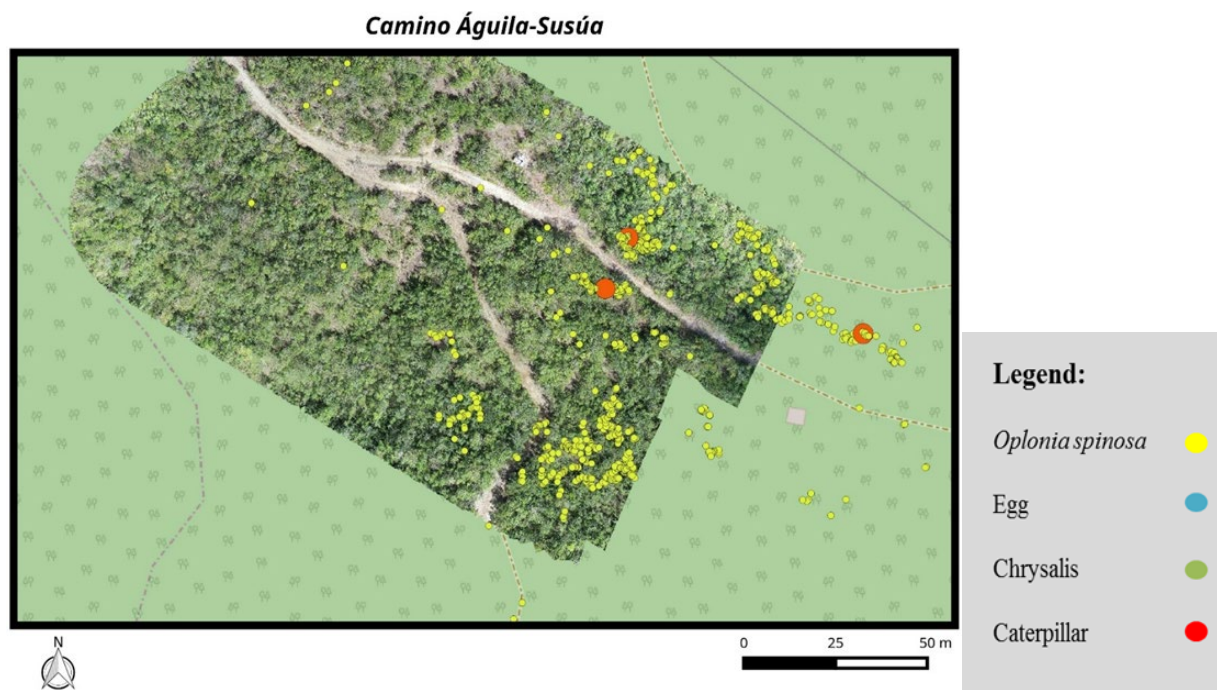
The Susúa Commonwealth Forest presents two vegetation associations: dry slope forest and gallery forest, falling in the sub-tropical dry/moist life zone on serpentine-derived soil (Helmer et



Appendix 3 continued.

al. 2002, p. 169). The serpentine-derived soil supports unique vegetation, which harbors several endemic species, but does not support any significant agriculture and timber production (DNR 1976, p. 224). Trees are slender, open crowned, and usually less than 12 m (40 ft) tall. The understory is open due to its excessively drained soil, which supports little herbaceous growth. The native vegetation has been significantly affected as a result of past land uses (e.g., harvest for charcoal) (DNR 1976, p. 224).

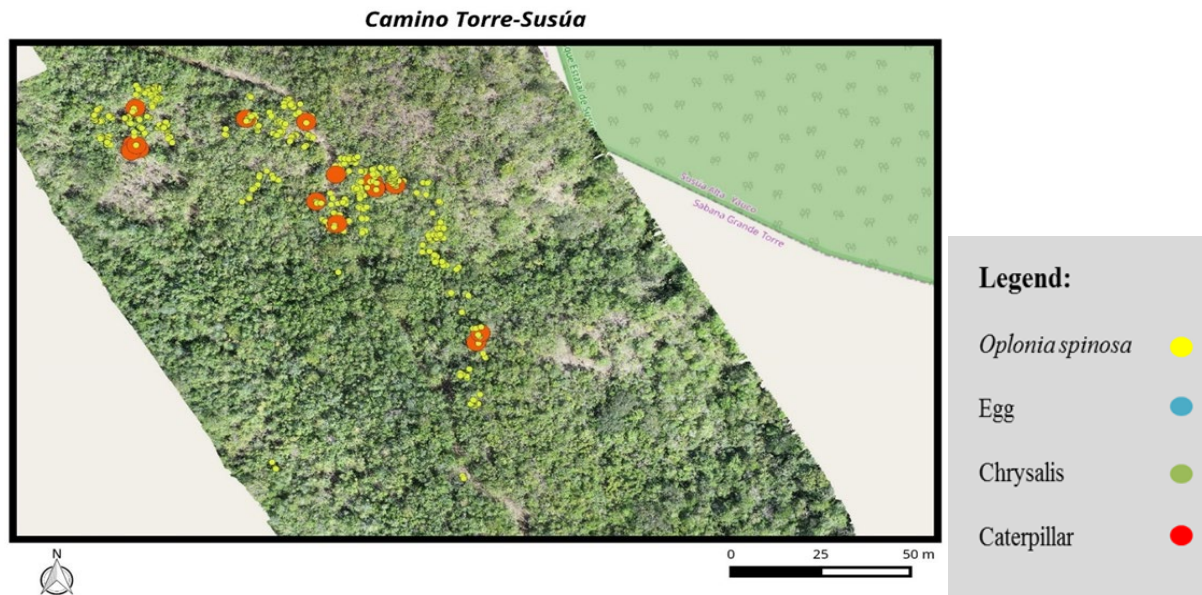
Within this forest, the PRHB occurs at Camino Torres (Torres trail) where the canopy cover ranges from 50 percent to 85 percent. Dominant species include: *Swietenia macrophylla*, *Thrinax morrisii*, *Tabebuia haemantha*, *Quadrella indica*, *Randia aculeata*, *Oplonia spinosa*. *Oplonia spinosa* is found in clusters outside the main trail in open areas or close to the ravines (Barber 2019, p.63) (Map below).



Map showing the *Oplonia spinosa* distribution at Torres trail, Susua Commonwealth Forest (Barber 2019, p. 63).

The PRHB also occurs in the Águila trail area where the canopy cover ranges between 10 percent to 85 percent (Barber 2019, p.64) (Map below). The species that dominate this landscape are *Oplonia spinosa*, *Tabebuia haemantha*, *Bursera simaruba*, *Thrinax morrisii*, *Swietenia macrophylla*, *Arthrotydium farctum*, *Garcinia hessii* and *Pimenta racemosa*.

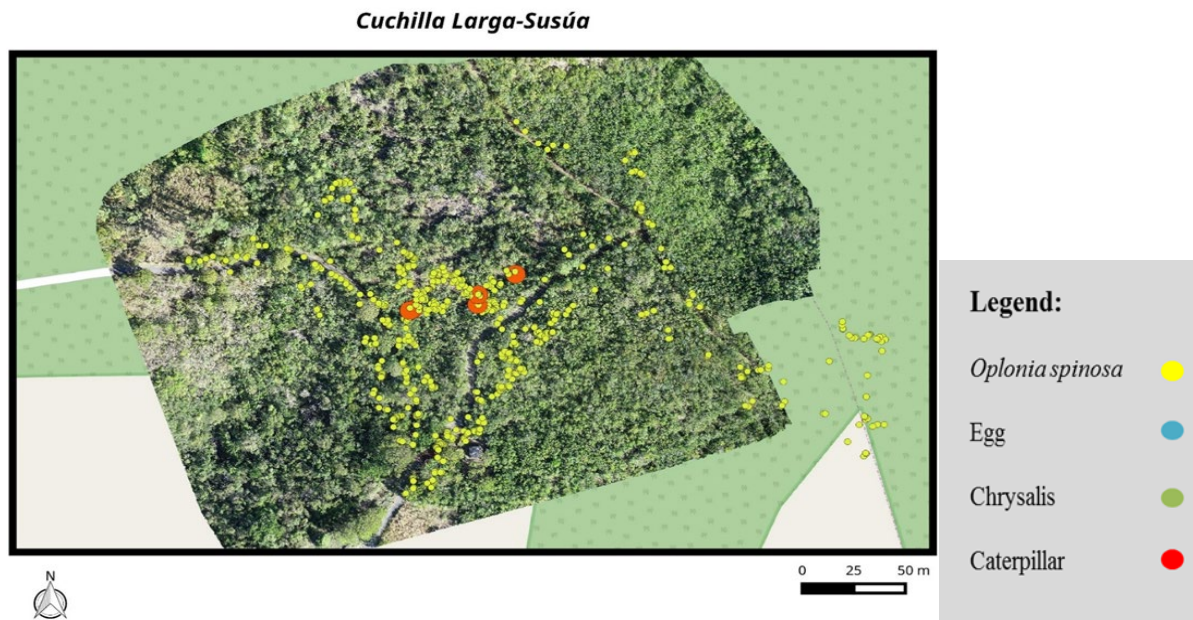
Appendix 3 continued.



Map showing the *Oplonia spinosa* distribution and locations of the PRHB stages (if found during February 2019 survey) at Camino Aguila, Susua Commonwealth Forest (Barber 2019, p.64).

The Cuchilla Larga is another PRHB site, located on the northwest section of the Susúa Commonwealth Forest, closer to the Maricao Commonwealth Forest (Map below). The canopy cover may vary between 50 percent to 85 percent. The dominant vegetation includes *Randia aculeata*, *Tabebuia haemantha*, *Chromolaena odorata*, *Clusia rosea*, *Swietenia macrophylla*, *Comocladia dodonaea*, *Pimenta racemosa*, *Neolaugeria resinosa*, *Bursera simaruba*, *Thrinax morrisii*, *Oplonia spinosa*, *Garcinia hessii*, and *Quadrella indica* (Vargas 2019, p.12).

Appendix 3 continued.



Map showing the *Oplonia spinosa* distribution and locations of the PRHB stages (if found during February 2019 survey) at Cuchilla Larga, Susúa Commonwealth Forest (Vargas 2019, p.11).



**Cornutia obovata.**

# Palo de Nigua

*Cornutia obovata*  
Familia: *Verbenaceae*

## Descripción

El palo de nigua es un árbol siempreverde, el cual puede alcanzar un altura de 15 pies y un diámetro de 11 pulgadas. Sus hojas son simples y opuestas.

## Información Biológica

El palo de nigua se encuentra en los bosques siempreverdes de la región de mogotes o colinas de piedra caliza al norte de Puerto Rico y las montañas de la Cordillera Central en el municipio de Barranquitas. Actualmente, la población total alcanza solo una media docena de individuos.

## Distribución

El palo de nigua es un árbol endémico de Puerto Rico, descrito originalmente en las montañas de la Cordillera Central cerca de Barranquitas. Actualmente, la especie se puede hallar solo en varias localidades en los mogotes de Arecibo y en una localidad en el municipio de Barranquitas.

## Amenazas

Los factores que amenazan al palo de nigua son la deforestación y destrucción de hábitat, y su distribución limitada. En la zona de mogotes al norte de Puerto Rico, la alteración de mogotes para la extracción de materiales de construcción también puede resultar en la eliminación total de los mogotes.

## Medidas de Conservación

El palo de nigua fue incluido en la lista federal de especies en peligro de extinción el 7 de abril de 1988. Dicha acción requiere que las agencias federales consulten con el Servicio Federal de Pesca y Vida Silvestre antes de llevar a cabo cualquier actividad que pueda amenazar la existencia de esta especie o resulte en la modificación o destrucción de hábitat esencial para esta. El Servicio Federal de Pesca y Vida Silvestre también ha desarrollado un programa de propagación para la especie con el objetivo de poder reintroducir individuos en un futuro.

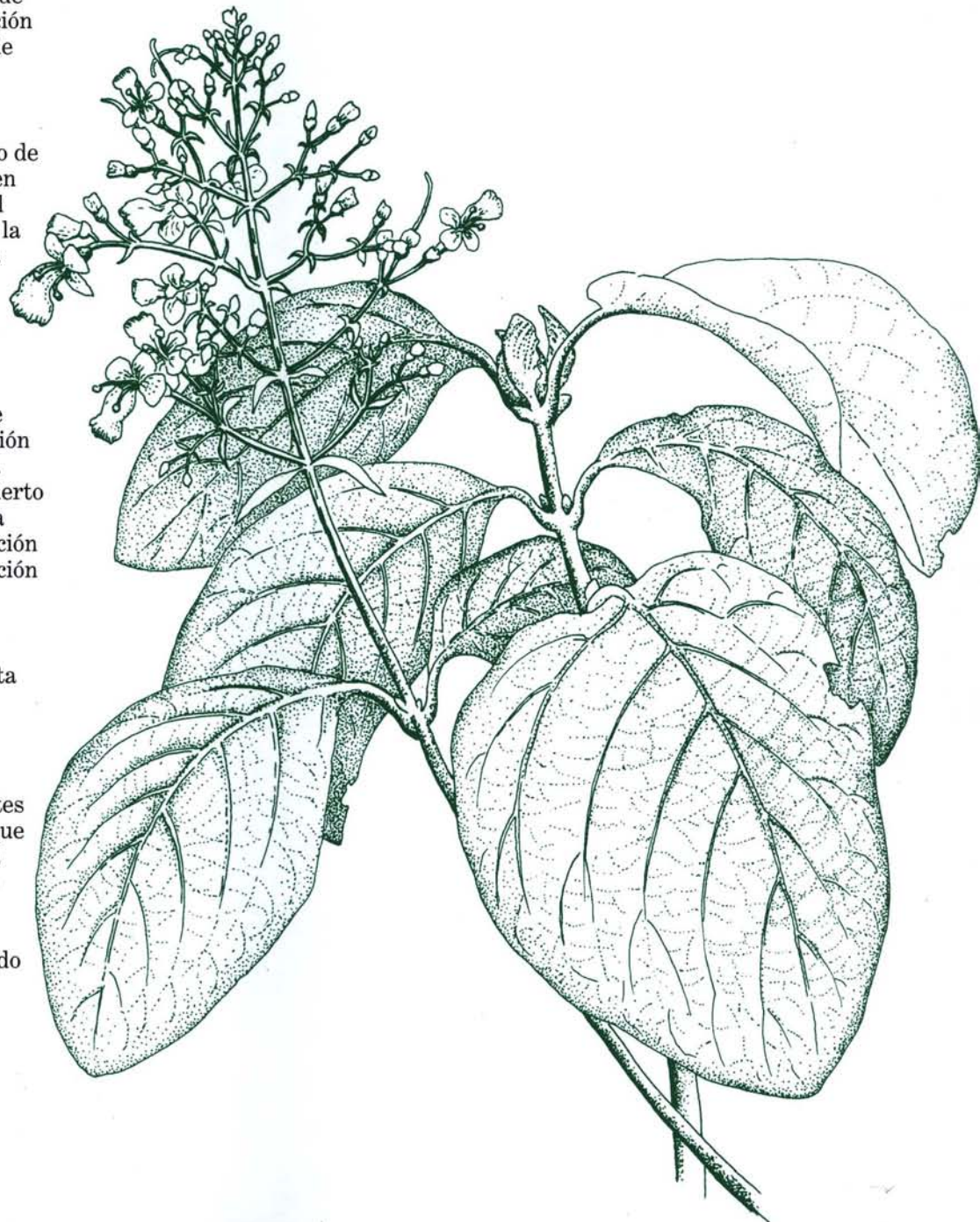
## Referencias

U.S. Fish and Wildlife Service. 1988. Endangered and threatened wildlife and plants: Determination of endangered status for *Cornutia obovata*. Federal Register, 53:11610-11612.

U.S. Fish and Wildlife Service. 1992. *Cornutia obovata* and *Daphnopsis hellerana* Recovery Plan. U.S. Fish and Wildlife Service, Atlanta, Georgia. 22 pp.

## Para Más Información

Llame al Servicio Federal de Pesca y Vida Silvestre, Oficina del Caribe, al 787/851 7297, o escriba al Apartado Postal 491, Boquerón, Puerto Rico 00622.





**Palo de Nigua  
(*Cornutia obovata*)**

**5-Year Review:  
Summary and Evaluation**

**U.S. Fish and Wildlife Service  
Southeast Region  
Caribbean Ecological Services Field Office  
Boquerón, Puerto Rico**



**Palo de Nigua  
Photo by Omar Monsegur (USFWS)**



**5-YEAR REVIEW**  
**Palo de Nigua / *Cornutia obovata***

**I. GENERAL INFORMATION**

- A. Methodology used to complete the review:** On April 9, 2010, the U.S. Fish and Wildlife Service (USFWS) published a notice in the *Federal Register* (75 FR 18232) announcing the 5-year review for Palo de Nigua (*Cornutia obovata*), and requested new information concerning the biology and status of the species. A 60-day comment period was opened; however, no information was received from the public during the comment period.

This 5-year review was prepared by the recovery lead biologist and summarizes the information that the Service has gathered in the Palo de Nigua file since the plant was listed on April 7, 1988. The sources of information used for this review included the original listing rule for the species, the recovery plan for Palo de Nigua, and information provided by the University of Puerto Rico, Mayagüez Campus (UPRM), the Puerto Rico Department of Natural and Environmental Resources (PRDNER), the Puerto Rico Conservation Trust (PRCT), and the USDA Forest Service.

The Service and UPRM signed a cooperative agreement to gather and summarize new information on Palo de Nigua. Under this agreement, botanists from UPRM, Drs. Duane A. Kolterman and Jesús D. China, conducted literature research on the species, consulted with other specialists, and examined herbarium data from the University of Puerto Rico at Mayagüez (MAPR), Río Piedras Botanical Garden (UPR), University of Puerto Rico at Río Piedras (UPRRP), PRDNER, New York Botanical Garden (NY), U.S. National Herbarium (US), and the University of Illinois (ILL). Service biologists then completed the 5-year review and assessed and determined the appropriate status recommendation for these species. Since the few known experts on the species compiled most of the information or were consulted for this 5-year review, we did not obtain additional peer review.

*Please see Addendum I (page 16) for updated information on this plant that we have gained while conducting our new 5-year review initiated in 2019 (84 FR 28850). Our new signature page is included on page 20. What precedes this new information (pp. 2-15) is the 5-year review announced in April 9, 2010 (75 FR 18232) and completed and signed in 2014.*

**B. Reviewers**

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

**Lead Field Office:** Omar A. Monsegur, Caribbean Ecological Services Field Office, Boquerón, Puerto Rico. (787) 851-7297, extension 217.

**C. Background**

- 1. FR Notice citation announcing initiation of this review:** April 9, 2010; 75 FR 18232.

**2. Species Status:**

As of the date of this 5-year review, we believe the status of *C. obovata* is uncertain. Little monitoring has been conducted on the natural populations of the species. Only one natural population has been monitored (Monte Torrecilla site in 2012). Therefore, we deemed the status of the species as uncertain.

**3. Recovery Achieved:**

1 (1-25%) of species recovery objectives achieved for *C. obovata*.

**4. Listing History**

Original Listing

FR notice: 53 FR 11610

Date listed: April 7, 1988

Entity listed: species

Classification: endangered

**5. Associated rulemakings:** Not Applicable.

**6. Review History:**

*Cornutia obovata* was first collected in 1885 by the German collector Paul Sintenis on the area of Monte Torrecilla in the municipality of Barranquitas in central Puerto Rico. By the time of listing, the species was known from the type locality, the Río Abajo Commonwealth Forest, and from an additional locality in the vicinity of the Arecibo Observatory (USFWS 1988).

The final rule (53 FR 11610), and the Recovery Plan for *Cornutia obovata* and *Daphnopsis helleriana* (hereafter the “Plan”), approved on August 7, 1992 (USFWS 1992), are the most comprehensive analyses of the status of the species. Thus, these documents were used as baseline reference documents for this 5-year review. In the 1988 final rule, the Service reviewed the best available scientific and commercial information, analyzed the five listing factors and their application to the species, and listed *C. obovata* as endangered. The Service identified Factor A (present or threatened destruction, modification, or curtailment of its habitat or range), Factor D (the inadequacy of existing regulatory mechanisms), and Factor E (other natural or manmade factors affecting its continued existence) as the main threats for the species. The recovery plan included the description of the species and information about its distribution, habitat characteristics, reproductive biology, and conservation. Hence, the information included in the plan will not be repeated in this review.

The Service conducted a 5-year review for *C. obovata* in 1991(56 FR 56882). In this review, the status of many species was simultaneously evaluated with no in-depth assessment of the five factors as they pertain to the individual species. The notice stated that the Service was seeking any new or additional information reflecting the necessity of a change in the status of the species under review. The notice also indicated that if

significant data were available warranting a change in a species' classification, the Service would propose a rule to modify its status. No new information was received. Therefore, the Service did not recommend a change in this plant's listing classification.

Every year the Service reviews the status of listed species and update species information in the Recovery Data Call (RDC). The last RDC for *C. obovata* was completed in 2013.

Recovery Data Call: 1998, 1999, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012 and 2013.

## **7. Species' Recovery Priority Number at start of review (48 FR 43098): 5**

At the time of listing, *C. obovata* was recognized as species with a high degree of threat and a low recovery potential.

## **8. Recovery Plan:**

Name of plan: Recovery Plan for *Cornutia obovata* and *Daphnopsis hellerana*

Date issued: August 7, 1992

## **II. REVIEW ANALYSIS**

### **A. Application of the 1996 Distinct Population Segment (DPS) policy**

The Endangered Species Act (Act) defines species to include any distinct population segment of any species of vertebrate wildlife. This definition limits listing as distinct population segments (DPS) only to vertebrate species of fish and wildlife. Because the DPS policy is not applicable to plant species, it is not further addressed in this review.

### **B. Recovery Criteria**

**1. Does the species have a final, approved recovery plan containing objective, measurable criteria?** The species has an approved recovery plan establishing delisting as the recovery objective. However, the plan does not contain specific measurable recovery criteria for delisting.

#### **2. Adequacy of recovery criteria**

##### **a. Do the recovery criteria reflect the best available and most up-to-date information on the biology of the species and its habitat?**

No. The plan does not include up-to-date information about the species' distribution and abundance. Knowledge about the spatial distribution and habitat requirements for the species has increased since the time of listing.



**b. Are all of the 5 listing factors that are relevant to the species addressed in the recovery criteria?**

All listing factors that were considered threats at the time of listing are addressed in the recovery criteria.

**3. List the recovery criteria as they appear in the recovery plan, and discuss how each criterion has or has not been met, citing information.**

1. The privately owned populations are given protected status.
2. At least three new self-sustaining populations in Commonwealth Forest units such as Río Abajo or Guajataca have been established.

Criterion 1 has not been initiated. The private land that harbors *C. obovata* populations has not been acquired or given any other protected status. The only natural populations that occur within areas managed for conservation are within the Río Abajo Commonwealth Forest and the Susúa Commonwealth Forest (Figure 1). However, the status of these populations remains unknown due to the lack of monitoring. The type locality and largest known population (Monte Torrecilla) remains as privately owned lands (G. Hernandez, PRDNER; pers. comm. 2013).

Criterion 2 has been partially initiated. One experimental population was established within the Toro Negro Commonwealth Forest and further individuals have been established within Cañon San Cristobal (natural area managed by the Puerto Rico Conservation Trust, PRCT). However, the minimal information collected in or from these sites indicates these populations cannot be considering self-sustaining at this point and long-term monitoring is needed.

**C. Updated Information and Current Species Status**

**1. Biology and Habitat**

**a. Species' abundance, population trends (e.g. increasing, decreasing, stable), demographic features, or demographic trends**

*Cornutia obovata* is a rare shrub or small tree, up to 10 m in height, endemic to Puerto Rico (Little et al., 1974; Liogier, 1995). It is known from several localities in northern and south central Puerto Rico, occurring at elevations of 250 to 925 m (830 to 3,071 ft) (Axelrod, 2011). It appears to occur primarily on limestone derived soils although one population extends to volcanic substrates (i.e., Monte Torrecilla population). Only seven individuals in three populations were known at the time the species recovery plan was approved (USFWS, 1992): five from Río Abajo Commonwealth Forest, one from the Arecibo Observatory area, and one from Monte Torrecilla in the municipality of Barranquitas.

According to the information currently available to the Service, about 19 individuals of *C. obovata* exist within the following natural areas: Monte Torrecilla, Susúa Commonwealth Forest, Río Abajo Commonwealth Forest, Sumidero Tres Pueblos, and the Arecibo Observatory (Table 1). However, there is no long-term monitoring of these natural populations, so population trends, demographic features, phenology, and demographic trends are unknown.

The species is in cultivation at the Caguas Botanical Garden, the Río Piedras Botanical Garden, Cañon San Cristobal (natural reserve managed by PRCT), and Parque Doña Ines (Figure 1; Luis Muñoz Marín Foundation) (Santiago 2011, Monsegur, USFWS, pers. obs. 2013).

**Table 1. Status of the known *C. obovata* populations in Puerto Rico.**

Site Name	Municipality	Number of individuals	Source of Information / Reference
Monte Torrecilla	Barranquitas	9	Geraldo Hernández, PRDNER pers. comm., 2013
Susúa Commonwealth Forest	Sabana Grande	3	Woodbury and Vivaldi, report, USFWS file, 1981
Río Abajo Commonwealth Forest (I)	Utua/Arecibo	5	USFWS, Recovery Plan, 1992
Sumidero Tres Pueblos	Camuy	1	Miguel “Papo” Vives, pers. comm., 1982
Arecibo Observatory	Arecibo	1	USFWS, Recovery Plan, 1992
*Toro Negro Commonwealth Forest	Orocovis	*6	Geraldo Hernández, PRDNER pers. comm., 2013
*Fundación Luis M. Marín	San Juan	*2	Alberto Areces, FLMM pers. comm., 2012
*Cañon San Cristóbal	Barranquitas	*20	María de Lourdes González, PRCT, 2013
*Caguas Botanical Garden	Caguas	1	O. Monsegur, USFWS pers. obs., 2013
*Río Piedras Botanical Garden	San Juan	1	Eugenio Santiago, UPRRP, 2011
<b>Total number of individuals</b>		<b>At least 49 individuals in the wild (30 planted)</b>	

\* Experimental populations and planted individuals. See comments and further description under section F. “Other relevant information”.

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

There is no new information on genetics, genetic variation, or trends in genetic variation of *C. obovata*. However, it would be reasonable to expect some genetic differentiation between the populations in northern and south central Puerto Rico, given their disjunction and the differences in elevation, substrate, and rainfall between these regions.

## c. Taxonomic classification or changes in nomenclature

There are no recent taxonomic or nomenclatural changes for the species. *Cornutia obovata* is the accepted name in the most recent checklists for the flora of Puerto Rico (Axelrod 2011) and the West Indies (Acevedo-Rodríguez and Strong 2012).

## d. Spatial distribution, trends in spatial distribution, or historic range

*Cornutia obovata* is considered as endemic to the main island of Puerto Rico. At the time of listing (1988) the species was known from the type locality at Monte Torrecilla, the Río Abajo Commonwealth Forest, the Arcibo Observatory, and an additional unconfirmed population at the Susúa Commonwealth Forest (Figure 1). A single individual was later recorded by Miguel “Papo” Vives from the *Sumidero Tres Pueblos* (Figure 1), an area managed by the *Compañía de Parques Nacionales de Puerto Rico* in the municipalities of Camuy, Hatillo and Lares. This locality lies within the same geographical area as the Río Abajo Commonwealth Forest and the Arcibo Observatory, and thus, it is not considered as a change in the spatial distribution or the range of the species.

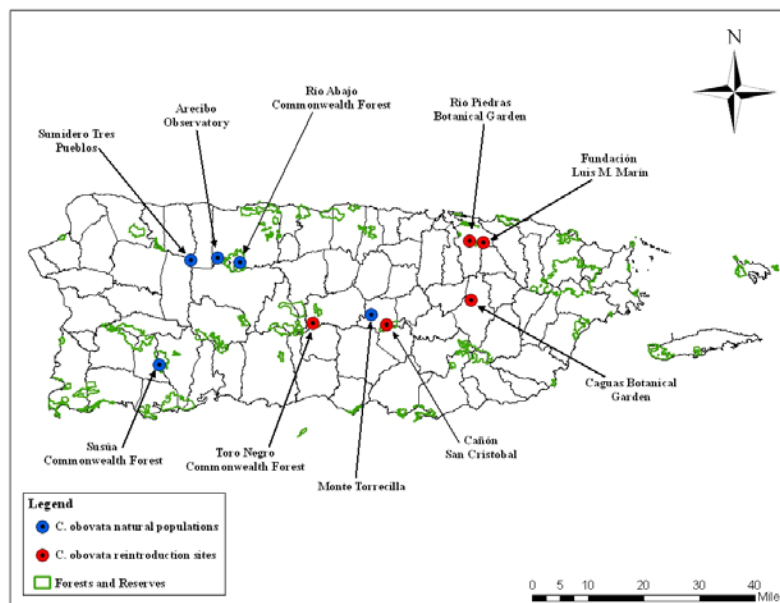


Figure 1. Map showing the general distribution of *Cornutia obovata* (blue circles) (USFWS data). The red circles indicate experimental populations or areas where the species is under cultivation.



#### **e. Habitat or ecosystem condition**

*Cornutia obovata* occurs within the subtropical moist forest and subtropical wet forest life zones of northern and south central Puerto Rico (Ewel and Whitmore, 1973). Rainfall ranges from 1,100 to 2,200 mm (44-88 in.) per year in the subtropical moist forest, and from ca. 2,000 to 4,000 mm (ca. 80-160 in.) per year in the subtropical wet forest (Ewel and Whitmore, 1973). The Susúa population occurs on soils derived from serpentinite bedrock of the El Cacique-La Taína complex. The Arecibo populations occur on soils derived from limestone of the Rock outcrop-Tanama complex and the Soller-rock outcrop complex. The Barranquitas population occurs on soils derived from igneous bedrock of the Humatas clay series. Elevations at all these sites range from 220 to 1,000 meters (730-3,300 ft) asl.

The northern karst region of Puerto Rico harbors several protected areas (i.e., Río Abajo, Guajataca, and Cambalache Commonwealth Forests) that include mature secondary forest and remnants of native forest that may include suitable habitat and probably undetected populations of *C. obovata*. This is a cryptic species that can be difficult to identify in the wild, unless it is flowering or fruiting. Thus, it is highly probable that the distribution of *C. obovata* extends along the northern karst region, and probably also to the Susúa Commonwealth Forest given historical records are correct.

#### **f. Other relevant information**

Santiago (2011) collected seeds of *C. obovata* at Monte Torrecilla and germinated them in 2003. He reported evidence suggesting that the seeds were produced via selfing and obtained a low germination rate of 15% (6/40). He mentioned ongoing efforts by the PRCT to collect and propagate seeds of the species. Such efforts have continued, and the species is being successfully propagated from seeds by the PRCT. As indicated on Table 1, the PRCT have planted at least 20 individuals within a property they manage at the municipality of Barranquitas (Cañon San Cristobal).

On December 2012, the PRCT provided the Service with 32 individuals of *C. obovata* to be planted for recovery purposes. The Service transferred 22 of these individuals to Tropic Ventures Research and Education Foundation to be planted within Las Casas de la Selva, an area adjacent to the Carite Commonwealth Forest and managed for conservation. This effort is part of an agreement between the Service and Tropic Ventures to establish populations of several listed plants within Las Casas de la Selva property. The remaining 10 individuals provided by the PRCT will be transferred to the manager of the Guajataca Commonwealth Forest to be planted within the forest boundaries. These two actions are in accordance with the recovery actions established in the recovery plan for the species (USFWS 1992).

## 2. Five Factor Analysis

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

#### **Forest management and deforestation for urban development.**

At the time of listing, deforestation for agriculture and urban development, and construction of communication facilities were identified as a threat to *C. obovata*. Based on the best available information, the known natural populations and the core of the suitable habitat for *C. obovata* occur within areas managed for conservation (e.g., Río Abajo Commonwealth Forest). Furthermore, the Service has no evidence about plans to expand the Arecibo Observatory. However, the largest natural population, and type locality at Monte Torrecilla (located on private land), remains threatened by future expansion or maintenance of communication facilities.

We believe the present or threatened destruction, modification, or curtailment of the species' habitat or range remains a threat to *C. obovata* on private lands. Since we have no evidence of direct impacts to known individuals, and the majority of known populations lie within properties managed for conservation, we consider the threat of habitat destruction or modification to be low in magnitude and non-imminent.

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

Overutilization for commercial, recreational, scientific, or educational purposes was not identified as a threat to the species in the final listing rule. The Service has no evidence that *C. obovata* is being threatened by this factor. Therefore, the overutilization for commercial, recreational, or educational purposes is not considered a current threat to the species.

### (c) Disease or predation:

Disease or predation was not identified as a threat to the species at the time of listing. Based on the best available information, this factor is not a current threat to *C. obovata*.

### (d) Inadequacy of existing regulatory mechanisms:

The Río Abajo Commonwealth Forest is protected by Law No.133 (12 L.P.R.A. sec. 191) 1975, as amended, known as *Ley de Bosques de Puerto Rico* (Forest Law of Puerto Rico), as amended in 2000. Section 8 (A) of Law No. 133, prohibits cutting, killing, destroying, uprooting, extracting, or in any way hurting any tree or vegetation within a Commonwealth forest without authorization from

the Secretary of the PRDNER. The Río Abajo Commonwealth Forest is also a designated Critical Wildlife Area (CWA) by the Commonwealth of Puerto Rico. The CWA designation constitutes a special recognition by the Commonwealth with the purpose of providing information to Commonwealth and Federal agencies about the conservation importance and needs of CWAs, and assisting permitting agencies in precluding negative impacts as a result of permit approvals or endorsements (PRDNER 2005).

The Commonwealth of Puerto Rico also approved Law No. 241 in 1999, known as *Nueva Ley de Vida Silvestre de Puerto Rico* (New Wildlife Law of Puerto Rico). The purpose of this law is to protect, conserve, and enhance both native and migratory wildlife species, declare as the property of Puerto Rico all wildlife species within its jurisdiction, regulate permits, hunting activities, and exotic species, among other activities. This law also has provisions to protect habitat for all wildlife species, including plants. In 2004, the PRDNER approved Regulation 6766, *Reglamento para Regir el Manejo de las Especies Vulnerables y en Peligro de Extinción en el Estado Libre Asociado de Puerto Rico* (Regulation 6766 to Regulate the Management of Threatened and Endangered Species in the Commonwealth of Puerto Rico). Article 2.06 of this regulation prohibits collecting, cutting, and removing, among other activities, listed plant individuals within the jurisdiction of Puerto Rico. *Cornutia obovata* was listed under Regulation 6766 as critically endangered.

Despite the existence of the laws and regulations mentioned above, *C. obovata* extends to private lands. The enforcement of laws and regulations within private properties continues to be a challenge as accidental damage or extirpation of individuals has occurred due to lack of knowledge of the species by private landowners and law enforcement officers. However, at present we are unaware of any damage to *C. obovata* on private properties. Therefore, based on the existence of Commonwealth and Federal laws and regulations protecting listed species, we believe the inadequacy of existing regulatory mechanisms is no longer a threat to the species.

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

**Hurricanes, Landslides and Climate Change.** Due to the low number of populations and individuals, hurricanes were identified as a threat to *C. obavata* on the final rule. As an endemic to the Caribbean, this tree species should be well adapted to tropical storms disturbance. However, as stated in the final rule, the low number of populations and individuals pose a threat to the species by making it susceptible to stochastic events such as hurricanes. In fact, there is no evidence on the extent of the damage to *C. obovata* populations caused by Hurricane Georges, which affected the entire island of Puerto Rico in 1998.

The heavy rains associated with tropical storms and hurricanes in the mountains of Puerto Rico often lead to landslides, which are part of the forest dynamics.



However, the effects of landslides are exacerbated for small relic populations as is the case of *C. obovata*. Moreover, the frequency of landslides may increase, as landslides are triggered by severe rain events, whose frequency and severity is expected to increase due to climate change (Hopkinson et al. 2008). For example, given the steep topography of Monte Torrecilla, a massive landslide may extirpate the largest known population of *C. obovata*.

Vulnerability to climate change impacts is a function of sensitivity and exposure to those changes, and the adaptive capacity of the species (Glick et al. 2011). Therefore, shifts of vegetation communities are expected as temperatures and moisture regimes are altered by climate change. Under this scenario, the populations of *C. obovata* may be displaced or outcompeted by native or exotic species with wider environmental plasticity. Climate change may also compromise natural recruitment by affecting seed germination and/or the survival of seedlings.

Despite the low number of populations and individuals of *C. obovata*, at this time the Service considers hurricanes, landslides and climate change as moderate and non-imminent threats to the species. Climate change is occurring gradually and the frequency of severe hurricanes in Puerto Rico is low.

**Genetic Variation.** Along with reduced population size, negative impacts of habitat fragmentation may result in erosion of genetic variation through the loss of alleles by random genetic drift (Honnay and Jacquemyn 2007). These factors may limit the ability of a species to respond to a changing environment (Booy et al. 2000). Given the extremely small population size and low number of known natural populations of *C. obovata*, it is likely that their genetic variability is low. As previously indicated, only the population at Monte Torrecilla is composed by 9 individuals, the remaining sites are comprised by 1-5 individuals.

Based on the above, we consider that lack of genetic variation is a high and imminent threat to *C. obovata*.

**Lack of Natural Recruitment.** Lack of natural recruitment represents one of the major threats to *C. obovata* as there is no evidence of seedlings on the wild despite the production of fruits (Geraldo Hernández, PRDNER, pers. comm. 2013). According to Santiago (2011) germination under nursery conditions seem to be low, suggesting the possibility of selfing on the wild populations. Without natural recruitment or successful augmentation from captive propagated individuals, populations (natural and reintroduced) of *C. obovata* are likely to become extirpated as older individuals naturally die. Despite future efforts to enhance natural populations by planting seedlings and saplings, it is unknown if planted individuals will develop into mature plants capable of reproduction. Therefore, we consider the lack of natural recruitment a high and imminent threat to *C. obovata*.

Overall, hurricanes, landslides, climate change, genetic variation, and lack of natural recruitment are threats to *C. obovata*. Due to the small number and size of populations, the Service considers these threats as high in magnitude and imminent.

### 3. Synthesis

*Cornutia obovata* was listed as endangered in 1988. Only seven individuals in three populations were known: five from Río Abajo Commonwealth Forest, one from the Arecibo Observatory area, and one from Monte Torrecilla in the municipality of Barranquitas.

According to the information currently available to the Service, about 19 individuals exist in the wild within the following natural areas: Monte Torrecilla, Susúa Commonwealth Forest, Río Abajo Commonwealth Forest, *Sumidero Tres Pueblos* and the Arecibo Observatory. Despite the slight increase in the known number of individuals, the majority of the localities are comprised of single individuals. Furthermore, no monitoring of those natural populations has occurred. Thus, we believe that during the last decade the overall status of this species was uncertain.

The largest known population of *C. obovata* (i.e., Monte Torrecilla) is represented by about nine individuals. No natural recruitment has been documented for this population. Due to the low number and small size of existing populations, the species remain threatened by deforestation, hurricanes, landslides, climate change, genetic variation, and lack of natural recruitment.

## IV. RECOMMENDATIONS FOR FUTURE ACTION

1. Studies should be conducted on the species phenology and reproductive biology to address other limiting factors affecting the species (e.g., lack of pollinators or seed dispersers).
2. The population at Monte Torrecilla should be monitored to collect seed material for recovery purposes. A protocol to collect seed material should be developed and implemented to avoid impacting the natural recruitment of the species.
3. All known populations should be marked and monitored on a regular basis, and additional visits should be made after hurricanes or other major disturbances to determine any possible adverse effects on the populations.
4. Studies should be conducted of the patterns of genetic variation, in order to develop a plan to preserve the species' germplasm.

5. The very small wild populations should urgently be enhanced, using seeds or vegetative propagation (e.g., air layering, tissue culture, etc.) if necessary, taking into account the species' patterns of genetic variation.

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U.S. FISH AND WILDLIFE SERVICE  
5-YEAR REVIEW of *Cornutia obovata*

Current Classification: Endangered

Recommendation resulting from the 5-Year Review:

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

Review Conducted By: Omar A. Monsegur, Caribbean Ecological Services Field Office,  
Boquerón, Puerto Rico.

FIELD OFFICE APPROVAL:

Lead Field Supervisor, Fish and Wildlife Service

Approve *Mauricio Li*

Date March 25, 2014

REGIONAL OFFICE APPROVAL:

<sup>For</sup>  
Lead Regional Director, Fish and Wildlife Service

Approve *David O. Sullivan*

Date July 15, 2014

**U.S. FISH AND WILDLIFE SERVICE**  
**5-YEAR REVIEW of the Palo de nigua**  
*(Cornutia obovata)*

**Addendum 1. Summary of new information obtained since the 2014 Palo de nigua 5-Year Status Review.**

**I. GENERAL INFORMATION**

On June 20, 2019, the U.S. Fish and Wildlife Service (Service) published a notice in the Federal Register (84 FR 28850 28853) announcing the five-year status review of the Palo de nigua (*Cornutia obovata*). It requested new information and comments from species experts and biologists familiar with this endangered tree concerning its biology and status. No comments were received from the public. This addendum presents the information that the Service has gathered for the species since the last Palo de nigua 5-year status review was approved in September 2014.

**C. Updated information**

**Distribution and abundance:**

*Cornutia obovata* is a rare shrub or small tree endemic to Puerto Rico. The previous 5-year status review placed the population at about 49 individuals of *C. obovata* occurring within the following natural areas: “Monte Torrecilla”, Susúa Commonwealth Forest, Río Abajo Commonwealth Forest, “Sumidero Tres Pueblos”, and the Arecibo Observatory (USFWS 2014).

In 2018, the Puerto Rico Department of Natural and Environmental Resources (PRDNER) reported one additional individual of *C. obovata* in the municipality of Ciales (PRDNER 2018). At present, no additional individuals have been reported, and there is no information available regarding the status of the original localities. Furthermore, no assessments have been conducted on the impacts from Hurricane María (September 2017) on the species.

Based on the information available to us, there are very few individuals of *C. obovata* in the wild. The PRDNER and the Puerto Rico Conservation Trust have carried out some propagation on their lands, but the results of these have not been reported.

**Threats:**

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

At the time of listing, *C. obovata* was considered threatened by deforestation for agriculture and urban development. While deforestation for agriculture is no longer a threat, other threats to habitat remain. Although at least three of the known localities are within protected lands, the largest natural population, and type locality at “Monte Torrecilla” is located on private land, and the population remains threatened by potential future expansion or maintenance of



communication facilities on that peak. The expansion of existing telecommunication facilities or construction of new facilities may occur within the species range. Thus, we continue to believe that this factor applies.

**Overutilization for commercial, recreational, scientific, or educational purposes:**

At the time of listing, overutilization for commercial, recreational, scientific or educational purposes was not considered a threat to the species. Presently, we have no information evidencing that this factor is a threat to the species. Therefore, we are not considering overutilization for commercial, recreational, scientific, or educational purposes as a threat to the *C. obovata*.

**Disease or predation:**

Disease or predation were not identified as a threat to the species at the time of listing. Based on the best available information, this factor is not a current threat to *C. obovata*.

**Inadequacy of existing regulatory mechanisms:**

In 2014, we concluded that the inadequacy of existing regulatory mechanisms was not a threat to this species (USFWS 2014). Presently, we have no new information or evidence that the inadequacy of existing regulatory mechanisms are threatening the species. However, the enforcement of these regulatory mechanisms is a challenge, particularly with the construction and maintenance of telecommunication towers.

**Other natural or manmade factors affecting its continued existence:**

In the 2014 5 year status review, *C. obovata* was considered threatened by natural or manmade factors that can affect its continued existence (USFWS 2014). Unfortunately, the overall status of the species has been poorly monitored. However, the limited information suggests that threats discussed previously in 2014 continue to apply.

Finally, climate change is a factor that might affect the species because of the increase of hurricanes and tropical storms intensities, change rainfall patterns, drought, fires and soil fertility (IPCC 2007).

*C. obovata* continues to have a restricted natural distribution with low numbers of individuals. This makes it vulnerable to extinction. Under natural conditions, healthy populations with robust numbers of individuals and recruitment should be adapted to withstand tropical storms and hurricanes. However, small populations could be severely impacted by hurricanes, resulting in extirpation of relic individuals and entire populations.

The islands of the Caribbean are frequently affected by hurricanes. In fact, category 4 Hurricane María affected Puerto Rico in September 20, 2017. It is well known that successional responses to hurricanes can influence the structure and composition of plant communities in the Caribbean islands (Lugo 2000; Van Bloem *et al.* 2003; Van Bloem *et al.* 2005; Van Bloem *et al.* 2006).

Currently, this species suffers from lack of information, and in the absence of knowledge on its natural recruitment capacity and habitat requirements; it is difficult to predict its recovery after natural events such as hurricanes and tropical storms (USFWS 2014).

Due to its limited distribution and low number of natural populations, we consider the cumulative effects of hurricanes, genetic variation, and exotic and invasive species (plants) as detrimental to *C. obovata* as a whole. The population dynamics of the species is poorly known (e.g., suspected depressed genetic variability, lack of natural recruitment, and competitive abilities (Honnay 2007), there are only few known populations, and there is a lack of information to determine what constitutes a viable population. Therefore, we consider threats from climate change to be high in magnitude, because the species has only a few known individuals in a limited range, if a hurricane makes landfall high winds, landslides, and torrential rains could affect the numbers of these limited populations. Climate change threat however is not imminent; we consider this more of a long-term threat.

### **Synthesis:**

Based on the limited new information gathered for this review, additional surveys for *C. obovata* are needed to determine the species overall status throughout Puerto Rico. These surveys should include suitable habitat outside of traditional areas. Available information indicates the species continues to have low population numbers. The known natural populations continue to be threatened by expansion of telecommunication facilities, low numbers in the natural population, and cumulative effects of hurricanes, genetic variation, and exotic and invasive plant species. Although the species has been planted in PRDNER forests and other conservation lands, monitoring and reporting of the status of these introduced populations is lacking.

The Endangered Species Act defines as endangered any species that is in danger of extinction throughout all or a significant portion of its range. Therefore, based on the information gathered during this review, we believe *C. obovata* continues to meet the definition of endangered.

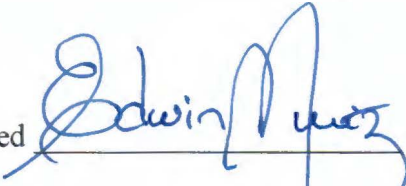
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FY 2020 APPROVAL\*

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

Approved  Date March 9, 2020

In 2014, Southeast Region Field Supervisors have been delegated authority to approve 5-year reviews that do not recommend a status change.

Field Supervisor signature on this document reflects:

1.  We have no new information received, no new public comments, and the original five factor analysis remains an accurate reflection of the species current status.
2.  We have obtained a small amount of new information that we have summarized in Addendum 1, received no new public comments, and the original five factor analysis remains an accurate reflection of species current status.

**Pleodendron macranthum**

**Chupacallos**  
**(*Pleodendron macranthum*)**  
**and**  
**Uvillo (*Eugenia haematocarpa*)**

**5-Year Review:**  
**Summary and Evaluation**

**U.S. Fish and Wildlife Service**  
**Southeast Region**  
**Caribbean Ecological Services Field Office**  
**Boquerón, Puerto Rico**



**Flower of Chupacallos and fruits of Uvillo.**  
**Photos by Omar Monsegur (USFWS)**



**5-YEAR REVIEW**  
**Chupacallos / *Pleodendron macranthum***  
**&**  
**Uvillo / *Eugenia haematocarpa***

**I. GENERAL INFORMATION**

- A. Methodology used to complete the review:** On April 9, 2010, the U.S. Fish and Wildlife Service (USFWS) published a notice in the *Federal Register* (75 FR 18232) announcing the 5-year review for Chupacallos (*Pleodendron macranthum*) and Uvillo (*Eugenia haematocarpa*), and requested new information concerning the biology and status of the species. Since these species share almost the same range, habitat, and threats, both species were included into a single document. A 60-day comment period was opened; however, no information was received from the public during the comment period.

This 5-year review was prepared by a USFWS recovery biologist and summarizes the information that the USFWS has gathered in the Chupacallos and Uvillo files since the plants were listed on November 25, 1994. The sources of information used for this review included the original listing rule for the species, the recovery plan for Chupacallos and Uvillo, and information provided by the University of Puerto Rico, Mayagüez Campus (UPRM), the Puerto Rico Department of Natural and Environmental Resources (PRDNER), the Puerto Rico Conservation Trust (PRCT), and the U.S. Forest Service (USFS). In 2011, USFS, under an agreement with USFWS, led an interagency effort that included the USFS, USFWS, and PRDNER to survey and evaluate the status of known populations of Uvillo located at El Yunque National Forest. Under the agreement, the USFS also compiled all available information and provided the new information to the USFWS regarding the status and threats to the species populations.

Additionally, USFWS and UPRM signed a cooperative agreement to gather and summarize new information on Chupacallos. Under this agreement, botanists from UPRM, Dr. Duane A. Kolterman and Dr. Jesús D. Chinae, conducted literature research on the species, consulted with other specialists, and examined herbarium data from the University of Puerto Rico at Mayagüez (MAPR), Río Piedras Botanical Garden (UPR), University of Puerto Rico at Río Piedras (UPRRP), Department of Natural and Environmental Resources of Puerto Rico (SJ), New York Botanical Garden (NY), U.S. National Herbarium (US), and the University of Illinois (ILL). In addition, between March 25 and 27, 2011, USFWS biologist Omar Monsegur conducted a field trip to El Yunque National Forest along with Dr. Kolterman and Dr. Chinae to search for known populations of Chupacallos. The lead USFWS biologist then completed the 5-year review by assessing the species and determining the appropriate status recommendation for these species.

## B. Reviewers

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

**Lead Field Office:** Omar A. Monsegur, Caribbean Ecological Services  
Field Office, Boquerón, Puerto Rico. (787) 851-7297, extension 217.

## C. Background

**1. Federal Register Notice citation announcing initiation of this review:** April 9, 2010;  
75 FR 18232.

**2. Species Status:**

In 2013, we believe the status of Chupacallos is uncertain and that the overall status of Uvillo is improving. Little monitoring has been conducted on the natural populations of Chupacallos. For this reason, we deemed the status of the species as uncertain. In the case of Uvillo, several new populations have been recorded and there is evidence of natural recruitment. Moreover, three of the new populations lie within areas managed for conservation.

**3. Recovery Achieved:** Uvillo: 2 (26-50%) of species recovery objectives achieved  
Chupacallos: 1 (1-25%) of species recovery objectives achieved

**4. Listing History**

Original Listing

FR notice: 59 FR 60565

Date listed: November 25, 1994

Entity listed: species

Classification: endangered

**5. Associated rulemakings:** Not Applicable.

**6. Review History:**

*Eugenia haematocarpa* was first collected in 1939 from Barrio Maizales in the municipality of Naguabo by Leslie R. Holdridge, but was named in 1963, 24 years later, by Henri Alain Liogier (59 FR 60565). Further collections have been made from the El Verde area in the Luquillo Mountains and from a privately-owned property located adjacent to the Carite Commonwealth Forest in the municipality of Cayey (USFWS 1998). *Pleodendron macranthum* was discovered by the French botanist August Plee in 1822-1823, and was first described by Baillon under the genus *Cinnamodendron* (59 FR 60565).

The final listing rule (59 FR 60565) and the Recovery Plan for *Pleodendron macranthum* and *Eugenia haematocarpa* (hereafter the “Plan”), approved on September 11, 1998 (USFWS 1998), are the most comprehensive analyses of the status of both species and are used as the baseline references documents for this 5-year review. In November 25, 1994, the USFWS reviewed the best available scientific and commercial information, analyzed the five listing

factors and their application to these species, and listed *Pleodendron macranthum* and *Eugenia haematocarpa* as endangered (59 FR 60565). The USFWS identified Factor A (present or threatened destruction, modification, or curtailment of its habitat or range), Factor D (the inadequacy of existing regulatory mechanisms), and Factor E (other natural or manmade factors affecting its continued existence) as the main threats for the two species. Examples of these threats included clearing of vegetation, forest management practices, the plants' limited distribution, and hurricanes. The 1998 recovery plan included the description of the two species and information about their distribution, habitat characteristics, reproductive biology, and conservation. Thus, the information included in the plan will not be repeated in this review.

Every year the USFWS reviews the status of listed species and update species information in the Recovery Data Call (RDC). The last RDC for Chupacallos and Uvillo was completed in 2013. Recovery Data Call: 1998, 1999, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, and 2013.

**7. Species' Recovery Priority Number at start of review (48 FR 43098): 8.**

At the time of listing, Chupacallos and Uvillo were recognized as species with a moderate degree of threat and a high recovery potential.

**8. Recovery Plan:**

Name of plan: Recovery Plan for *Pleodendron macranthum* and *Eugenia haematocarpa*  
Date issued: September 11, 1998

**II. REVIEW ANALYSIS**

**A. Application of the 1996 Distinct Population Segment (DPS) policy**

**1. Is the species under review listed as a DPS?**

The Endangered Species Act (Act) defines species to include any distinct population segment of any species of vertebrate wildlife. This definition limits listings as distinct population segments (DPS) only to vertebrate species of fish and wildlife. Because the DPS policy is not applicable to plant species, it is not addressed further in this review.

**B. Recovery Criteria**

**1. Does the species have a final, approved recovery plan containing objective, measurable criteria?** The species have an approved recovery plan establishing downlisting and ultimately delisting as the recovery objectives. The plan's downlisting criteria are in part measurable. We did not have enough information to define one of the criteria at the time of the plan's development.

**2. Adequacy of recovery criteria**



**a. Do the recovery criteria reflect the best available and most up-to-date information on the biology of the species and its habitat?**

No. The plan does not include up-to-date information about the species' distribution and abundance. Knowledge about the spatial distribution and habitat requirements for both species has increased.

**b. Are all of the 5 listing factors that are relevant to the species addressed in the recovery criteria?**

All listing factors that were considered threats at the time of listing are addressed in recovery criteria.

**3. List the recovery criteria as they appear in the recovery plan, and discuss how each criterion has or has not been met, citing information.**

The two species will be considered for downlisting when the following criteria are met:

1. An agreement between the USFWS and the USFS concerning the protection of Chupacallos and Uvillo within the Caribbean National Forest property has been prepared and implemented.
2. An agreement between the USFWS and the PRDNER concerning the protection of these two species in Commonwealth Forests, specifically Río Abajo, for Chupacallos, has been prepared and implemented.
3. New populations (the number of which will be determined by appropriate scientific studies) capable of self-perpetuation have been established within protected areas.

Criterion 1 has been partially initiated. There is no formal agreement between the USFS and USFWS for the implementation of a management plan to protect Chupacallos and Uvillo. Nonetheless, under Section 7 of the Endangered Species Act (ESA), Federal agencies are mandated to carry out programs for the conservation of endangered species. Under the ESA, it must be ensured that any action authorized, funded, or carried out by a Federal agency is not likely to jeopardize the continued existence of an endangered species. The USFS and USFWS have developed a good communication relationship, and USFS always consults with USFWS to avoid and minimize impacts to listed species and their habitat at El Yunque National Forest. Further coordination is needed for the long term monitoring of natural populations and propagation of Chupacallos and Uvillo.

Criterion 2 has been partially met. The Río Abajo Commonwealth Forest has an approved management plan that recognizes the presence of Chupacallos within the forest. Furthermore, PRDNER has listed Chupacallos as endangered, and as part of their list of critical elements. Species on the list of critical elements receive special consideration when evaluating development actions within suitable habitat. However, there is no formal agreement in place between USFWS and the PRDNER to protect Chupacallos populations within the Río Abajo Commonwealth Forest. Further coordination is needed

for the long term monitoring of natural populations and the propagation of Chupacallos. Because the species is not monitored on the forest, adverse impacts to the populations could be occurring due to forest management practices (e.g., opening of new trails and research projects).

Criterion 3 has been initiated. Several natural populations of Uvillo have been reported since the species was listed in 1994. The Puerto Rico Conservation Trust (PRCT) has conducted an exhaustive evaluation of two recently discovered population in the municipality of Cayey in two properties known as Las Robledas, and Sotomayor del Toro and have consulted with the USFWS about adequate management practices for these populations. USFWS biologists visited the population at Las Robledas and it seems to be healthy and may set the standards to establish further viable populations within these areas (Las Robledas and Sotomayor del Toro) and other Commonwealth protected areas. Furthermore, a germination experiment with Uvillo is being conducted by the PRCT in their greenhouse at Río Piedras, which is expected to improve our knowledge on the propagation of this species.

Despite the lack of available information about the natural populations of Chupacallos, this species was successfully propagated by Dr. Eugenio Santiago (professor at UPRRP). The material produced in this effort has been used to establish a new experimental population of Chupacallos in an area adjacent to the aviary of the Puerto Rican parrot at El Yunque National Forest. However, more information on the reproductive biology and ecology of this species is needed in order to establish what constitute a viable population. Thus, further research and monitoring of planted individuals of Chupacallos is needed.

## **C. Updated Information and Current Species Status**

### **1. Biology and Habitat**

#### **a. Species' abundance, population trends (e.g. increasing, decreasing, stable), demographic features (e.g. age structure, sex ratio, family size, birth rate, age at mortality, mortality rate, etc.), or demographic trends**

*Pleodendron macranthum* (Chupacallos) is a small to medium size aromatic evergreen tree that was known from 11 individuals within El Yunque National Forest and about 10 individuals within the Río Abajo Commonwealth Forest at the time of listing. The populations at El Yunque National Forest consisted of 9 trees at the Jimenez Ward and two separated trees at Mameyes II Ward in Río Grande. However, none of these populations was located during the latest surveys conducted by MAPR personnel in March 2011. Since two of the historical localities were represented by a single individual, it is likely they have been extirpated due to stochastic events such as hurricanes (See factor E). A site with three planted individuals at El Portal Visitor Center, also at El Yunque National Forest, was recorded during the assessment conducted by botanists of the University of Puerto Rico (Table 1). The individuals at El Portal Visitor Center are managed by USFS for outreach and future seed production. The ten individuals from the Río Abajo Commonwealth Forest are found in two separate populations (specific number of

individuals per population not specified). The current status of these natural populations is unknown as they have not been recently visited and their exact locations are unknown.

Since there is no long term monitoring of the natural populations and some of the historical populations seem to be lost or extirpated, we cannot make inferences about the status or demography of Chupacallos. The USFWS suspects that further populations of the species may occur within the El Yunque National Forest and probably in some remnants of native forest in the Río Abajo Commonwealth Forest. However, similar to the historically known natural populations, these may be comprised of few individuals with little or no natural recruitment and might also be threatened by stochastic events such as hurricanes and landslides.

Overall, the majority of the known individuals of Chupacallos are planted trees. There are 97 known individuals in the wild, and 70 percent have been planted (Table 1). Of the 21 naturally-occurring individuals, none have been observed during the last decade.

**Table 1. Status of the known Chupacallos populations in Puerto Rico.**

Site Name	Municipality	Number of individuals	Source of Information / Reference
*El Portal, El Yunque N. F.	Río Grande	3	Luis Rivera, USFS, pers. comm., 2011
*Iguaca Aviary, El Yunque N. F.	Río Grande	22	Jesus Rios, USFWS, 2012
*Las Perdices, Río Abajo Commonwealth Forest	Arecibo	5	Jesus Rios, USFWS, 2012
*Río Piedras Botanical Garden	San Juan	6	Eugenio Santiago, UPRRP, 2011
Jiménez, El Yunque N. F. (Jimenez)	Río Grande	9	USFWS, Recovery Plan, 1998
Mameyes II A, El Yunque N. F.	Río Grande	1	USFWS, Recovery Plan, 1998
Mameyes II B, El Yunque N. F.	Río Grande	1	USFWS, Recovery Plan, 1998
Río Abajo Commonwealth Forest (two populations)	Utua/Arecibo	10	USFWS, Recovery Plan, 1998
*Guavate, Carite Commonwealth Forest	Cayey	30	PRDNER, Forest Service Bureau 2011.
*Río Abajo Commonwealth Forest (Las Cruces)	Arecibo	10	Omar Monsegur, USFWS, 2012
<b>Total number of individuals</b>		<b>97 (70% are planted individuals)</b>	

The asterisk (\*) represent experimental populations and planted individuals. See comments under section f “other relevant information”



*Eugenia haematocarpa* (Uvillo) is a small evergreen tree reaching 6 meters (20 feet) tall that was originally known from the Sierra de Luquillo (El Yunque National Forest) and from the Sierra de Cayey. At the time of listing in 1998 the species was known to have about 134 individuals: approximately 119 individuals in six populations at El Yunque National Forest, and one population of about 15 individuals in a private property adjacent to the Carite Commonwealth Forest. The number of individuals per populations at El Yunque National Forest was not specified in the listing rule or the Recovery Plan. During the latest surveys conducted in 2011, USFS personnel visited an Uvillo population located at Río Gurabo and reported 12 individuals. They also visited a population on road PR 186, km. 12.3, and found 27 individuals (Luis Rivera 2011, USFS pers. comm.). Other historical Uvillo populations known from El Yunque National Forest were not evaluated by USFS personnel during 2011.

The status of the original population of 15 Uvillo at the private property adjacent to the Carite Commonwealth Forest is unknown. The species has been reported from four additional locations in the Sierra de Cayey area. Two of the new populations were located within the Sierra de Cayey by Pascarella (2000). The first population reported by Pascarella consisted of several individuals (number not specified) with evidence of natural recruitment (small juvenile plants). The second population had five individuals with recent evidence of flower and fruit production, but without evidence of natural recruitment.

The other two new locations of Uvillo are from the properties known as Finca Las Robledas and Sotomayor del Toro, also within the Sierra de Cayey and managed by the PRCT (E. Santiago 2011, UPRRP). Eugenio Santiago (UPRRP) indicated these populations are comprised of approximately 150 individuals in Las Robledas and at least six individuals in Sotomayor del Toro. Based on an evaluation by USFWS biologists, Las Robledas population seems to be healthy and shows evidence of natural recruitment despite the apparent lack of natural dispersion mechanisms, except for gravity (seeds dispersion occurs only downhill). The population seems to be improving and it is expected to continue expanding and slowly colonizing adjacent secondary growth forest.

However, it is important to mention that the core of the population lies along a ridge that is the boundary between the PRCT property and other private lands, and some clusters of individuals (amount not determined) lie within properties that are not managed by the PRCT (see Factor A). Based on the discovery of these new populations, the overall status of Uvillo populations along the Sierra de Cayey appears to be improving, and there is a high probability that further populations may occur within the Carite Commonwealth Forest and surrounding areas.

The range of Uvillo has expanded and now extends to the northwestern corner of Puerto Rico. A new locality was reported in 2011 at the municipality of Isabela by Marcos Caraballo and Dr. Eugenio Santiago (UPRRP). This site comprises a single reproductive individual with no evidence of natural recruitment. The species was also located in two locations within the boundaries of the Guajataca Commonwealth Forest (José Román 2012, PRDNER pers. comm.). One population contained at least 30 individuals of different size classes with natural recruitment evident. Uvillo also occurs in a different location within the Guajataca Commonwealth Forest, with one individual found (José Román 2012, PRDNER pers. comm.).

Despite the lack of long term monitoring of the status of *Uvillo* at El Yunque National Forest and the original population in the Sierra de Cayey, the overall status of the species seem to be improving as six new populations have been reported and the number of known individuals has doubled to about 247 plants (Table 2). Three of these populations show evidence of natural recruitment. However, further long term monitoring is needed to determine the status of these populations.

**Table 2. Status of the known populations of *Uvillo* populations in Puerto Rico.**

Site Name	Municipality	Number of individuals	Source of Information / Reference
Cordillera Jaicoa	Isabela	1	Marcos Caraballo and Eugenio Santiago, 2011 UPRRP.
Guajataca Commonwealth Forest 1	Isabela	30	José Roman 2012, PRDNER pers. comm.
Las Robledas (PRCT)	Cayey	150	Eugenio Santiago, 2012 UPRRP.
Sotomayor del Toro (PRTC)	Caguas	6	Eugenio Santiago, 2012 UPRRP.
Río Grande (El Verde), El Yunque N. F.	Rio Grande	27	Luis Rivera, USFS, pers. comm., 2011
Río Gurabo, El Yunque N. F.	Las Piedras	12	Luis Rivera, USFS, pers. comm., 2011
Carite/Muñoz Rivera	Guayama	Several	Pascarella 2000
Carite	Guayama	5	Pascarella 2000
Guajataca Commonwealth Forest 2	Isabela	1	José Román 2012, PRDNER pers. comm.
Cayey Hist. Site	Cayey	15	USFWS, Recovery Plan, 1998
<b>Total number of individuals</b>		<b>At least 247</b>	

- Only two of the six populations reported in the Recovery Plan were assessed in 2011 by USFS at El Yunque National Forest.

**b. Genetics, genetic variation, or trends in genetic variation (e.g. loss of genetic variation, genetic drift, inbreeding, etc.)**

There is no new information on genetics, genetic variation, or trends in genetic variation of Chupacallos or *Uvillo*.

**c. Taxonomic classification or changes in nomenclature.**

There are no recent taxonomic or nomenclatural changes for *P. macranthum*, which was originally described as *Cinnamodendron macranthum*. Its closest relative, *P. ekmanii*, is a very rare tree from Haiti (Little et al., 1974) whose present status is unknown. The other member of the Canellaceae family in Puerto Rico is *Canella winterana*, a dry forest species.

There is no new information about taxonomic reclassification or changes in the nomenclature for *E. haematocarpa*.

**d. Spatial distribution, trends in spatial distribution, or historic range.**

The natural distribution of Chupacallos remains limited to the Luquillo Mountains in El Yunque National Forest and to the Río Abajo Commonwealth Forest (Figure 1.). Few individuals were planted within the Carite Commonwealth Forest by PRDNER personnel. However, although the Carite area harbors suitable habitat for Chupacallos, this forest has never been considered part of the natural range of the species.

Uvillo was originally reported from the Luquillo Mountains and from a single locality within the Sierra de Cayey (Figure 1.). The range within the Cayey region has expanded to include four additional localities, as new populations have been discovered in this area. Therefore, we expect that further populations may occur within this area, including within the boundaries of the Carite Commonwealth Forest. Furthermore, during the last decade, at least three new populations have been reported in the municipality of Isabela, extending its distribution now to the northwestern corner of Puerto Rico.

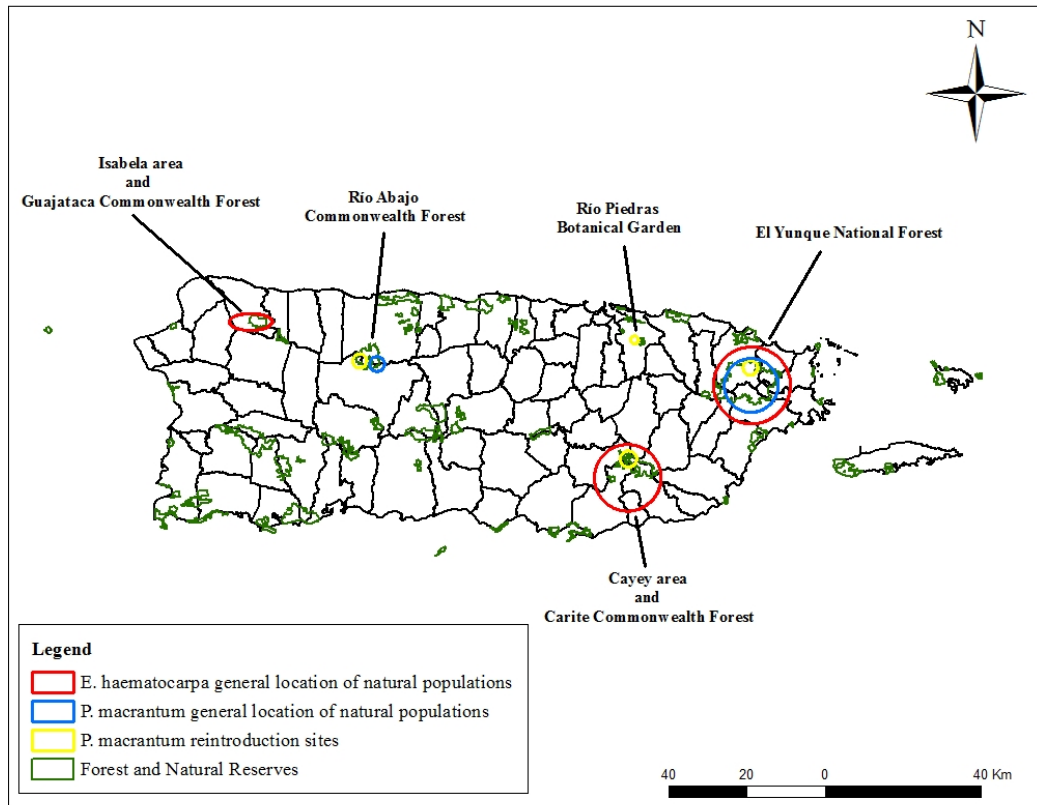


Figure 1. Map showing the general distribution of Chupacallos (blue) and Uvillo (red). The yellow circles indicate reintroduced populations of Chupacallos. Note that there are no reintroduction efforts for Uvillo.



**e. New information addressing habitat or ecosystem condition (e.g. amount, distribution, and suitability of the habitat or ecosystem)**

Chupacallos is endemic to the northeastern and north central, regions of Puerto Rico and may be found in the northwestern region. The species occurs primarily within the subtropical wet forest life zone, probably extending into the lower montane wet forest zone (Ewel and Whitmore 1973). These life zones were once extensively deforested for agriculture and charcoal production, and are currently undergoing forest regeneration. Areas in which agricultural activities have been abandoned and forest regeneration has occurred may harbor undetected populations of Chupacallos or provide possible sites for the establishment of new populations. The majority of known populations of Chupacallos occur within protected forests, although it is a cryptic species that may be difficult to identify in the wild, unless it is flowering or fruiting.

Uvillo occurs primarily within the subtropical moist forest and the subtropical wet forest life zones (Ewel and Whitmore 1973), which also were extensively deforested for agriculture and charcoal production. New information indicates that the range of Uvillo now extends to the northwestern corner of Puerto Rico and that it also grows in moist limestone forest. The northern karst region of Puerto Rico harbors several protected areas (i.e., Río Abajo, Guajataca, and Cambalache Commonwealth Forests) that include mature secondary forest and remnants of native forest that may include suitable habitat and undetected populations of Uvillo. Areas in which agricultural practices have been abandoned and forest regeneration has occurred may provide possible sites for the establishment of new populations of Uvillo.

**f. Other relevant information.**

Little is known about the reproductive biology and propagation of Uvillo or Chupacallos. The PRDNER (2011) established a protocol for the planting of Chupacallos in the Carite Commonwealth Forest, outside the species' historical range (i.e., *ex situ* conservation). The project included the propagation and planting of 20 to 30 individuals of Chupacallos, followed by a routine monitoring schedule. The monitoring efforts were interrupted by lack of personnel, and the present status of the planted individuals remains unknown, as they have not been visited recently. The material planted at the Carite Commonwealth Forest was donated by Mr. Pedro Juan Rivera Lugo, although the source of the seed material was not specified (PRDNER 2011).

Further surveys were conducted by Dr. Eugenio Santiago (UPRP 2011), who in 2002 collected and germinated seeds of Chupacallos from El Verde (within El Yunque National Forest). Santiago (2011) reported that the seeds maintained viability for only a short time. He observed flowering three years after those trees were planted, but no fruit or seed production was documented. In 2006, seven juvenile individuals of Chupacallos from the propagated material were planted in three different sites within the University of Puerto Rico Botanical Garden (i.e., *ex situ* conservation). By 2011 all but one of these

individuals remained alive (Santiago 2011). In 2011, the USFWS received 35 individuals of Chupacallos from Dr. Santiago for conservation purposes.

Twenty-two individuals were planted in 2011 within the boundaries of the El Yunque National Forest in an area adjacent to the Iguaca Aviary, which is managed by the USFWS (Monsegur 2011). After a year of being planted, all individuals remained alive and were actively flowering (Omar Monsegur, USFWS, pers. obs. 2012.). Ten additional individuals that had been provided by Dr. Santiago were planted on October 2012 at the Río Abajo Commonwealth Forest. It is expected that the material planted at El Yunque National Forest and the Río Abajo Commonwealth Forest will set fruits as one individual from the same batch maintained for outreach at the USFWS Nursery in the Cabo Rojo National Wildlife Refuge is already fruiting (Omar Monsegur, USFWS, pers. obs. 2012.).

For Uvillo, despite the discovery of new populations, few propagation efforts have been conducted with this species. Material from Las Robledas is being germinated at the nursery of the PRCT at Río Piedras. Nonetheless, a recent site visit to Las Robledas indicates plants flower vigorously and flowers are frequently visited by honeybees (*Apis mellifera*) (Omar Monsegur, USFWS, pers. obs. 2012.). Aside from the above, there is no more information on the biology or reproductive ecology of Uvillo.

## **2. Five Factor Analysis (threats, conservation measure, and regulatory mechanisms)-**

### **(a) Present or threatened destruction, modification or curtailment of its habitat or range:**

#### **Forest management and deforestation for urban development.**

At the time of listing, forest management practices such as the establishment and maintenance of plantations, selective cutting, trails maintenance, and shelter construction were identified as threats to both Chupacallos and Uvillo. Based on the available information, the core of the known populations of Chupacallos and Uvillo occurs within the boundaries of Federal, State, or other protected areas. Within these areas, there is no direct evidence of populations or individuals being affected by forest management practices. Therefore, USFWS no longer considers forest management practices a threat to Chupacallos or Uvillo.

However, the largest known population of Uvillo lies within Las Robledas along a ridge that marks the boundary of several private properties and some clusters of individuals lie within neighboring properties that are not managed by the PRCT. Boundary management practices (clearing and fencing) may affect individuals along these areas. Similarly, land clearing for agricultural purposes and urban development may affect the small populations of Uvillo within private properties at the Sierra de Cayey, including the private properties adjacent to Las Robledas.

Undetected populations of Chupacallos and Uvillo might be affected by deforestation for urban development on the periphery of El Yunque National Forest. In the northern Karst

region, suitable habitat for these species may be affected by rock quarries, particularly in the Quebradillas and Isabela area.

The present or threatened destruction, modification, or curtailment of the species habitat or range remains a threat to Chupacallos and Uvillo. However, since the majority of the known populations lie within properties managed for conservation and there is no direct evidence of populations being affected by habitat destruction or modification, we consider this threat to be low in magnitude and non-imminent.

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

Overutilization for commercial, recreational, scientific, or educational purposes was not identified as a threat to the two species in the final listing rule. Although both species are attractive and might have some cultivation potential, we have no evidence that Chupacallos and Uvillo are currently threatened by this factor. Therefore, the overutilization for commercial, recreational, or educational purposes is not a current threat to either species.

**(c) Disease or predation:**

Disease or predation were not identified as a threat to these species at the time of listing. Based on the best available information, disease or predation are not a current threat to either species.

**(d) Inadequacy of existing regulatory mechanisms:**

The Carite, Río Abajo and Guajataca Commonwealth Forests are protected by Law No.133 (12 L.P.R.A. sec. 191) 1975, as amended, known as *Ley de Bosques de Puerto Rico* (Puerto Rico's Forest Law), as amended in 2000. Section 8 (A) of Law No. 133, prohibits cutting, killing, destroying, uprooting, extracting, or in any way hurting any tree or vegetation within a Commonwealth forest without authorization of the Secretary of the PRDNER. These forests are also designated Critical Wildlife Areas (CWAs) by the Commonwealth of Puerto Rico. The CWA designation constitutes a special recognition by the Commonwealth with the purpose of providing information to Commonwealth and Federal agencies about the conservation needs of these areas and assisting permitting agencies in precluding negative impacts as a result of permit approvals or endorsements (PRDNER 2005).

The Commonwealth of Puerto Rico also approved Law No. 241 in 1999, known as *Nueva Ley de Vida Silvestre de Puerto Rico* (New Wildlife Law of Puerto Rico). The purpose of this law is to protect, conserve, and enhance both native and migratory wildlife species, declare as the property of Puerto Rico all wildlife species within its jurisdiction, regulate permits, hunting activities, and exotic species, among other activities. This law also has provisions to protect habitat for all wildlife species, including plants. In 2004, the PRDNER approved Regulation 6766, *Reglamento para Regir el Manejo de las Especies Vulnerables y en Peligro de Extinción en el Estado Libre Asociado de Puerto*



*Rico* (Regulation 6766 to Regulate the Management of Threatened and Endangered Species in the Commonwealth of Puerto Rico). Article 2.06 of this regulation prohibits collecting, cutting, and removing, among other activities, listed plant individuals within the jurisdiction of Puerto Rico. Uvillo was listed under Regulation 6766 as endangered, whereas Chupacallos was listed in the regulation as critically endangered.

In the case of the populations occurring within the El Yunque National Forest, these are protected under the Endangered Species Act of 1973 (16 U.S.C. 1531-1544, 87 Stat. 884), as amended. Section 7 of the Endangered Species Act requires Federal agencies to insure that any action authorized, funded or carried out by them is not likely to jeopardize the continued existence of listed species or modify their critical habitat. Plant collection within the boundaries of the forest is regulated and requires a research permit, as well as a permit from the PRDNER.

Suitable habitat may extend to private properties. The enforcement of laws and regulations on these private lands continues to be a challenge as accidental damage or extirpation of individuals has occurred with other federally listed species due to lack of knowledge of the species by private landowners and law enforcement officers. However, at this time we are unaware of any damage occurring on private property. Therefore, based on the presence of Commonwealth and Federal laws and regulations protecting these species, the inadequacy of existing regulatory mechanisms is no longer be a threat to either of these species.

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

**Hurricanes, Landslides and Climate Change.** Due to the low number of populations and individuals, hurricanes were identified as a threat to Chupacallos and Uvillo on the final rule. As an endemic to the Caribbean, these tree species should be well adapted to tropical storm disturbance. However, the low number of populations and individuals pose a threat to these species by making them more susceptible to stochastic events such as hurricanes. It is not clearly evident the extent of the damage to the populations of these species by Hurricane Hugo, which devastated El Yunque National Forest in 1989, or by Hurricane Georges, in 1998. The heavy rains associated with tropical storms and hurricanes in the mountains of Puerto Rico often lead to landslides, which are part of the forest dynamics in Puerto Rico. However, the frequency of landslides is expected to increase, as landslides are triggered by severe rain events or droughts, whose frequency and severity is expected to increase as a result of climate change (Hopkinson et al. 2008). Given the steep slopes on which these species usually grow (associated to remnants of forest that were not cleared due the inaccessibility of the area), massive landslides may extirpate entire populations. This is particularly true for Chupacallos, which is represented by small populations with almost no natural recruitment. Therefore, a landslide can extirpate an entire population of Chupacallos, and it may also be a threat to some of the small populations of Uvillo at El Yunque National Forest and the Carite Commonwealth Forest.

Climate change is predicted to increase the frequency and strength of tropical storms and can cause severe droughts (Hopkinson et al. 2008). Vulnerability to climate change impacts is a function of sensitivity to those changes, exposure to those changes, and the adaptive capacity of the species (Glick et al. 2011). Shifts of vegetation communities are expected as temperatures and moisture regimes are altered by climate change. Under this scenario populations of Chupacallos and Uvillo may be displaced or outcompeted by native or exotic species with wider environmental plasticity. Climate change may also compromise natural recruitment by affecting the survival of seedlings.

Despite the low number of populations and individuals (particularly for Chupacallos), at this time the USFWS considers hurricanes, landslides and climate change a moderate and non-imminent threat to both species. Climate change is occurring gradually and the frequency of severe hurricanes is low.

**Genetic Variation.** Along with a decreasing population size, negative impacts of habitat fragmentation may result in erosion of genetic variation through the loss of alleles by random genetic drift (Honnay and Jacquemyn 2007), and may also limit the ability of a species to respond to a changing environment (Booy et al. 2000). Given the extremely small population size and low number of known natural populations of Chupacallos, it is likely that their genetic variability is low. As previously indicated, all reported populations consist of less than 10 individuals, and in some cases they are represented by a single individual.

Despite the reports of new populations of Uvillo, this species may be affected by genetic depression due to the low number of individuals in some populations, as it is evident that the species was severely affected by former habitat fragmentation due primarily to extensive deforestation for agriculture. However, the wide distribution and geographical isolation of the species, from the eastern to the northwestern side of the Island (i.e., El Yunque National Forest, Sierra de Cayey, and Guajataca Commonwealth Forest), with different environmental conditions, suggests that the species may show high inter-population genetic variability. In order to safeguard the remaining genetic diversity, the origin and survival of reintroduced individuals needs to be monitored as well as their development into mature individuals. The protection and monitoring of known adult individuals should be considered a high priority for the conservation of Chupacallos and Uvillo.

Based on the above, we consider the lack of genetic variation is a high and imminent threat to Chupacallos, and a low and non-imminent threat for Uvillo.

**Lack of Natural Recruitment.** Lack of natural recruitment represents one of the major threats to Chupacallos (Luis Rivera 2011, USFS, pers. comm.). Despite evidence of flower and fruit production and good germination under nursery conditions, it is evident that previously known populations were not recruiting; seedling and sapling stages were missing. Nonetheless, all the reintroduced individuals of Chupacallos at El Yunque National Forest are flowering. However, no fruit production has been documented (Jesus Rios, USFWS, pers. comm. 2012). A single fruit was documented on an individual

maintained for outreach purposes at the USFWS greenhouse at Boquerón National Wildlife Refuge (Omar Monsegur, USFWS, pers. obs. 2012.). No flower or fruits have been documented on individuals planted at the Río Abajo Commonwealth Forest (Omar Monsegur, USFWS, pers. obs. 2012.).

Without natural recruitment or successful augmentation from captive propagated individuals, populations (natural and reintroduced) of Chupacallos are likely to become extirpated as older individuals naturally die. Despite future efforts to enhance natural populations by planting seedlings and saplings, it is unknown if planted individuals will develop into mature plants capable of reproducing. Therefore, we consider the lack of natural recruitment a high and imminent threat to Chupacallos.

Based on the distribution, abundance, and observations on flower and fruit production of Uvillo, it does not appear to be affected by lack of natural recruitment. The majority of known populations of this species are producing flowers and fruits, and natural recruitment is evident in the wild. However, further monitoring is needed to determine what constitutes a viable population and if the species dispersing seeds successfully.

Overall, hurricanes, landslides, climate change, genetic variation, and lack of natural recruitment are threats to Chupacallos. Due to the small number of populations, these threats are high in magnitude and imminent for this species. For Uvillo, USFWS considers the threats by hurricanes, landslides, climate change, genetic variation, and lack of natural recruitment as low and non-imminent.

### **3. Synthesis**

Chupacallos and Uvillo are federally listed as endangered. Based on the available information, Chupacallos is known from about 22 individuals in 5 natural populations and 75 individuals planted in six localities. The main reintroduction efforts have been conducted within the Río Abajo Commonwealth Forest and the El Yunque National Forest. The status of the reintroduction effort at the Carite Commonwealth Forest by PRDNER is unknown as the individuals have not been recently monitored. Uvillo is currently known from approximately 247 individuals in nine natural populations. No information is available about reintroduction or population enhancement efforts being conducted for Uvillo.

Early population assessments for both species date back to the early 1990's, prior to the time when the two species were listed. However, little to no monitoring has been conducted in recent years on the natural populations that occurred within the El Yunque National Forest or the Sierra de Cayey area. Therefore, we believe that during the last decade the overall status of these species was uncertain.

Information gathered as part of surveys for this review validate the uncertain status for the natural Chupacallos populations and highlight the need for more exhaustive surveys of the habitat within El Yunque National Forest and the Río Abajo Commonwealth Forest in order to identify new populations of the species. Moreover, it is essential to



revisit previously known natural populations to determine their status. Overall, Chupacallos seems to be seriously threatened by lack of natural recruitment.

The case of Uvillo is noteworthy, as the distribution of the species has expanded to the northwestern corner of Puerto Rico (i.e., Quebradillas and Isabela). One of the recently reported populations lies within the Guajataca Commonwealth Forest and shows evidence of natural recruitment. Furthermore, four new localities have been reported in the Sierra de Cayey area, one comprised by over one hundred individuals and with clear evidence of natural recruitment. The number of known individuals has doubled since the time of listing. The evidence of abundant fruit production and the occurrence of populations within at least four natural areas managed for conservation highlight the recovery potential of the species as well as the need to revise the species' recovery plan. Further research on the reproductive biology of the species and long term monitoring of natural populations are needed to establish measurable criteria to delist the species. Based on our threats analysis, this endangered plant remains threatened by habitat modification at rights of way, vegetation clearing and development pressures on private inholdings. Therefore, Uvillo still meets the definition of an endangered species.

#### **IV. RECOMMENDATIONS FOR FUTURE ACTION**

1. Studies should be conducted on both species' phenology and reproductive biology to address other limiting factors affecting these species (e.g., lack of pollinators or seed dispersers).
2. All known populations should be marked and monitored on a regular basis, and additional visits should be made after hurricanes or other major disturbances to determine any possible adverse effects on the populations.
3. The previous *ex situ* conservation efforts (individuals reintroduced to the wild) should be monitored and further similar efforts should be undertaken to enhance the status of both species.
4. The USFS and USFWS should develop a comprehensive survey program to inventory areas with potential habitat. This program should include training to field biologists of both agencies so these personnel is able to recognize listed species on the field.
6. The populations that are actively producing seeds need to be identified and monitored to collect seed material for recovery purposes. A protocol to collect seed material should be developed and implemented to avoid altering the natural recruitment of the species. Enhancement of natural populations should be considered particularly for Chupacallos. The development of adequate propagation techniques is essential for the recovery of these species.

7. The recovery plan should be revised to establish measurable downlisting and delisting criteria, including how many individuals constitute a self-sustainable population and how many populations would be needed to delist these species.
8. Studies should be conducted to determine the patterns of genetic variation within and among populations in order to develop a plan to preserve the species genetic variability.

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**U.S. FISH AND WILDLIFE SERVICE**  
**5-YEAR REVIEW of *Pleodendron macranthum* and *Eugenia haematocarpa***

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**Current Classification:** Endangered

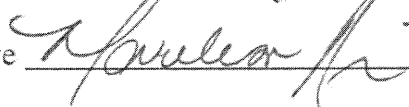
**Recommendation resulting from the 5-Year Review:**

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

**Review Conducted By:** Omar A. Monsegur, Caribbean Ecological Services Field Office,  
Boquerón, Puerto Rico.

**FIELD OFFICE APPROVAL:**

**Lead Field Supervisor, Fish and Wildlife Service**

Approve 

Date 3/19/2014

**REGIONAL OFFICE APPROVAL:**

**for**  
**Lead Regional Director, Fish and Wildlife Service**

Approve 

Date 6-29-14

**Solanum ensifolium**

**Erubia**  
*Solanum drymophilum*

**5-Year Review:  
Summary and Evaluation**



**Photo provided by J. Sustache, PRDNER**

**U.S. Fish and Wildlife Service  
Southeast Region  
Caribbean Ecological Services Field Office  
Boquerón, Puerto Rico**

**5-YEAR REVIEW**  
***Solanum dryophilum* / Erubia**

**I. GENERAL INFORMATION**

- A. Methodology used to complete the review:** On April 9, 2010, the Service published a notice in the *Federal Register* (75 FR 18232) announcing the 5-year review of the plant *Solanum dryophilum* (erubia), and requesting new information concerning the biology and status of the species. A 60-day comment period was opened; however, no information was received from the public during that period.

Then, the Service signed a cooperative agreement with the University of Puerto Rico, Mayagüez campus (UPRM), to gather and summarize available information on erubia. Botanists from the UPRM, Drs. Duane A. Kolterman and Jesús D. Chinaea, reviewed available literature, consulted with specialists, and examined herbarium data, including specimens from the herbarium of the UPRM (MAPR), Río Piedras Botanical Garden (UPR), University of Puerto Rico at Río Piedras (UPRRP), Puerto Rico Department of Natural and Environmental Resources (PRDNER), New York Botanical Garden (NY), U.S. National Herbarium (U.S.), and University of Illinois (ILL), and prepared a report.

A Service biologist then completed this 5 year review using the information provided by UPRM, unpublished information provided by the PRDNER regarding the status and distribution of the species in Puerto Rico, and information gathered by the Service since the plant was listed on January 26, 1988, including the original listing rule and the recovery plan for the species. Other sources of information included peer-reviewed literature, and personal communications with qualified biologist and experts on the species. We did not seek additional peer review on this 5 year review since Dr. Kolterman, Dr. Chinaea, PRDNER botanists, and Service biologist, O. Monsegur (who was working with Maritza Vargas), are leading experts on this and other plants that share habitat with erubia. Therefore, we believe to have gathered the best available information on erubia for this review.

**B. Reviewers**

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

**Lead Field Office:** Maritza Vargas, Caribbean Ecological Services Field Office, Boquerón, Puerto Rico. (787) 851-7297, extension 215

**C. Background**

**1. Federal Register Notice citation announcing initiation of this review:** April 9, 2010; 75 FR 18232



**2. Species Status:** Unknown. The status and distribution of erubia has not been re-evaluated since 1992 (USFWS 1992). No new comprehensive surveys of this plant have been completed. When the recovery plan for erubia was signed, only 150 plants were known from one locality at *Las Piedras del Collado* (also known as *Las Tetas de Cayey*) in the municipality of Salinas. It was thought at that time that this plant occurred in the Lares area as well, but it could not be confirmed. Although other individuals have been documented in other municipalities, all populations have been poorly monitored and their current status is unknown (Figure 1).

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

#### **4. Listing History**

##### Original Listing

FR notice: 53 FR 32827

Date listed: August 26, 1988

Entity listed: species

Classification: endangered

**5. Associated rulemakings:** Not Applicable

**6. Review History:** A species' review was conducted for erubia in 1991 (56 FR 56882). In this review, the status of various species was simultaneously evaluated with no in-depth assessment of the five factors or threats as they pertain to the individual species. The notice stated that the Service was seeking any new or additional information reflecting the necessity of a change in the status of the species under review. The notice also indicated that if significant data were available warranting a change in a species' classification, the Service would propose a rule to modify the species' status. No change in erubia's listing classification was found to be appropriate.

The final rule and the *Solanum drymophilum* Recovery Plan are the most comprehensive analyses of the species' status and are used as the reference point documents for this 5-year review. Every year the Service reviews the status of listed species and updates species information in the Recovery Data Call.

Recovery Data Call (RDC): 1998, 1999, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013 and 2014.

**7. Species' Recovery Priority Number at start of review (48 FR 43098):** 2C. At the time of listing, erubia was recognized as a species with a high degree of threat and high recovery potential. It was also identified as having conflict with construction or other development projects.

#### **8. Recovery Plan:**

Name of plan: *Solanum drymophilum* Recovery Plan

Date issued: July 9, 1992

## II. REVIEW ANALYSIS

### A. Application of the 1996 Distinct Population Segment (DPS) policy

The Act defines species to include any distinct population segment of any species of vertebrate wildlife. This definition limits listings as distinct population segments (DPS) only to vertebrate species of fish and wildlife. Because the DPS policy is not applicable to plant species, it is not addressed further in this review.

### B. Recovery Criteria

1. **Does the species have a final, approved recovery plan containing objective, measurable criteria?** Yes, erubia has an approved recovery plan (USFWS 1992) establishing reclassification from endangered to threatened status as the recovery objective. The plan also contains measurable recovery criteria for downlisting. However, the plan does not contain specific measurable recovery criteria for delisting the species.
2. **Adequacy of recovery criteria**
  - a. **Do the recovery criteria reflect the best available and most up-to-date information on the biology of the species and its habitat?** Yes. When the recovery plan was signed, very little information on the species' biology, life history, habitat requirements and abundance was available. At present, we still do not know the status of the species.
  - b. **Are all of the 5 listing factors that are relevant to the species addressed in the recovery criteria?** Yes. All listing factors that were considered threats at the time of listing are addressed in recovery criteria.
3. **List the recovery criteria as they appear in the recovery plan, and discuss how each criterion has or has not been met, citing information.**

*Solanum drymophilum* could be considered for reclassification to a threatened species when:

- (1) The privately-owned population site is given protected status.
- (2) At least two new self-sustaining populations in Commonwealth forest units or otherwise protected lands have been established.

The Plan specifies that if new populations are discovered, it may be preferable to place greater emphasis on protection, rather than on propagation, in order to achieve a minimum number of plants.

Criterion 1 has been initiated. Efforts have been made to protect populations on privately owned lands. Out of four known sites (Figure 1) three are on private owned lands. Through section 7 consultation and technical assistance, the Service has protected individuals within the scope of various development projects, by recommending mitigation areas (e.g., Highway PR-10). Nevertheless, other populations within private lands (e.g. sites in the municipality of Florida) have not been protected. Moreover, although part of the land encompassing the area known as *Piedras del Collado* (previously known as Tetas de Cayey) have been designated as a natural reserve under the PRDNER, it does not include the area where the population of erubia is located. The PRDNER is aware of the situation and has planned to include such area as part of the reserve once they identify the funding for acquisition (PRDNER 2004).

Criterion 2 has been initiated. Propagation and planting of erubia has been conducted in the Río Abajo Commonwealth Forest in the northern karst region of Puerto Rico (PRHTA 1995, PRDNER, unpublished report, 2013). However, the Service is not aware of the status of those plants. In addition, there have been unsuccessful efforts to date to attempt to introduce erubia into the Guajataca Commonwealth Forest, also in the northern karst. This introduction has proven difficult because of the lack of seeds, their slow growth rate, and the attack of seedlings by fungus at the nursery (PRDNER 2011). In 2012, the PRDNER collected fruits from some individuals in the municipality of Florida to germinate at the Guajataca Commonwealth Forest; however, the germination of those seeds was not successful.

## **C. Updated Information and Current Species Status**

### **1. Biology and Habitat**

#### **a. Species' abundance, population trends (e.g. increasing, decreasing, stable), demographic features, or demographic trends**

At the time of listing, about 150-200 individuals of erubia were known to occur in an area known as Piedras del Collado in the Sierra de Cayey, municipality of Salinas, in east-central Puerto Rico (Figure 1; Table 1; Vivaldi and Woodbury 1981; 53 FR 32827). The species was also known to occur in the municipalities of Naguabo (Sierra de Naguabo, 53 FR 32827) in eastern Puerto Rico, and Lares in the west-central mountain region of Puerto Rico. Currently, no population estimates are available for these populations and it is believed that the Naguabo and Lares populations were extirpated (Figure 1; Vivaldi and Woodbury 1981; 53 FR 32827).

Additional populations had been reported from the municipalities of Florida and Arecibo in northern Puerto Rico (Figure 1; Table 1; PRDNER, unpublished report, 2013). These reflect new populations identified since the recovery plan was written. In Florida, erubia had been reported in two sites. One of the sites had three individuals with flowers and fruits in different stages of maturity. No information is available for the other site in Florida (PRDNER, unpublished report, 2013).

The population from Arecibo was discovered in 1994 while conducting field studies in the right of way and adjacent areas for Highway PR-10, proposed back then. There is no information on how many individuals were in this population at the time of these studies. However, approximately 50 individuals in the right of way and adjacent areas of the highway were removed during construction activities of the highway. Thirty eight of those 50 individuals were relocated by PRDNER (PRHTA 1995). The remaining individuals were reported to be taken during construction.

The Botanical Research and Herbarium Management System (BRAHMS) database includes a total of four specimens of erubia collected between 1983 and 1989: three from the Río Abajo Commonwealth Forest, and one from the Piedras del Collado. There are also a dozen specimens at the NY Herbarium, including one collected by Sintenis in 1885 at Monte Llano in the municipality of Cayey. Unfortunately, the herbarium vouchers provided no information on the status of the population at the time the samples were collected.

Table 1. Currently known locations and number of individuals of *Solanum drymophilum*.

Location	# Individuals	Current Status	Source of Information
Piedras del Collado	150	Unknown	USFWS 1992
Florida Site A	1	3	PRDNER, unpublished report, 2013
Florida Site B	No numbers reported	Unknown	PRDNER, unpublished report, 2013
Arecibo	>50 (population numbers not reported only the ones removed)	Unknown	PRHTA 1995

**b. Genetics, genetic variation, or trends in genetic variation (e.g. loss of genetic variation, genetic drift, inbreeding, etc.)**

There is no new information available on the genetics or genetic variability within the species.

**c. Taxonomic classification or changes in nomenclature**

Two questions have been raised in this regard: one is regarding the nomenclature of the species and another regarding its taxonomy - whether it is distinct from the widespread and variable species, *Solanum bahamense* (Bahama nightshade).

Strickland-Constable et al. (2010) stated that *Solanum ensifolium* has long been known as *S. drymophilum*, based on a misinterpretation of the original provenance of the type of *S.*



*ensifolium*. Both names refer to the same species, but *S. ensifolium* is an older name (1852) than *S. drymophilum* (1909). However, *Solanum ensifolium* is the name that is accepted in the recent checklists for Puerto Rico (Axelrod 2011) and the West Indies (Acevedo-Rodríguez and Strong 2012).

Strickland-Constable et al. (2010) also stated that although *S. drymophilum* is very similar morphologically to *S. bahamense*, both the parsimony analysis and the haplotype data show that they are clearly distinct.

The Service will continue monitoring the taxonomic analysis of this species and will reach a decision once the apparent conflict is solved. For now, we will continue using *Solanum drymophilum* as the official scientific name of erubia until consensus is found.

#### d. Spatial distribution, trends in spatial distribution, or historic range.

Erubia is known from several localities in northern and south central Puerto Rico, at elevations ranging from 70 to 825 m (230-2,706 ft) (Axelrod 2011). It appears to occur mainly on limestone and also on volcanic substrates. At the time of listing, the only known extant population of erubia was located at Piedras del Collado in the municipality of Salinas. However, the species was also known from the Sierra de Naguabo in the municipality of Naguabo and the municipality of Lares (Figure 1). According to Axelrod (2011), erubia was also known from the southern coastal lowlands of the municipality of Coamo (we did not find further information on this area). Recent information indicates that erubia is still extant in the municipality of Salinas, Florida and Arcibo (Figure 1).

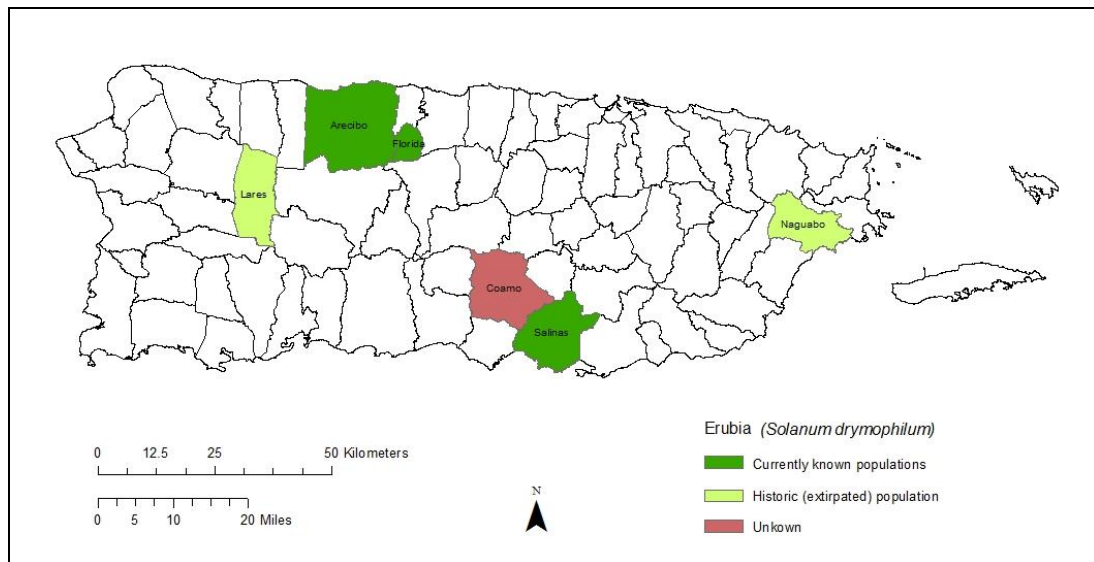


Figure 1. *Solanum drymophilum* known historic and present distribution (areas represent the municipalities where the species has been reported).

Erubia has a very limited spatial distribution within its localities. Drs. Kolterman and China (UPRM) evaluated 23 specimens deposited in herbaria between 1983 and 1989, and mapped their collection site using the information provided in the labels (Figures 2-4; D. Kolterman and J. China, UPRM, unpubl. data, 2013). They used the point-circle method (Chapman and Wieczorek 2006), which assigns coordinates to the location of the collection as well as an estimate of the uncertainty (in meters) based on the locality descriptions obtained from the specimen labels.

The following habitat descriptions are based on the sites with uncertainties smaller than 300 m (984 ft), namely the specimens and populations located at the Piedras del Collado. These population sites and specimen localities occur on the soil type Rock land. However, the most recent geological map indicates that the bedrock at this site, the Robles formation, is a sequence of volcanic sandstone and siltstone that contains minor pillowed lava and limestone (Bawiec 2001). The elevations at this area range from about 800 to 840 m (2,624 to 2,755 ft) above sea level.

The other geo-referenced specimen locality descriptions were too vague to provide accurate information on habitat characteristics. However, the westernmost localities have uncertainty circles that completely overlap the karst belt. Thus, indicating that these plants were collected over limestone substrate at elevations substantially lower than the ones at Piedras del Collado. The localities at Santa Isabel (the southernmost locality) and the one at Guayama (the easternmost locality) have uncertainty circles overlapping several substrate types.

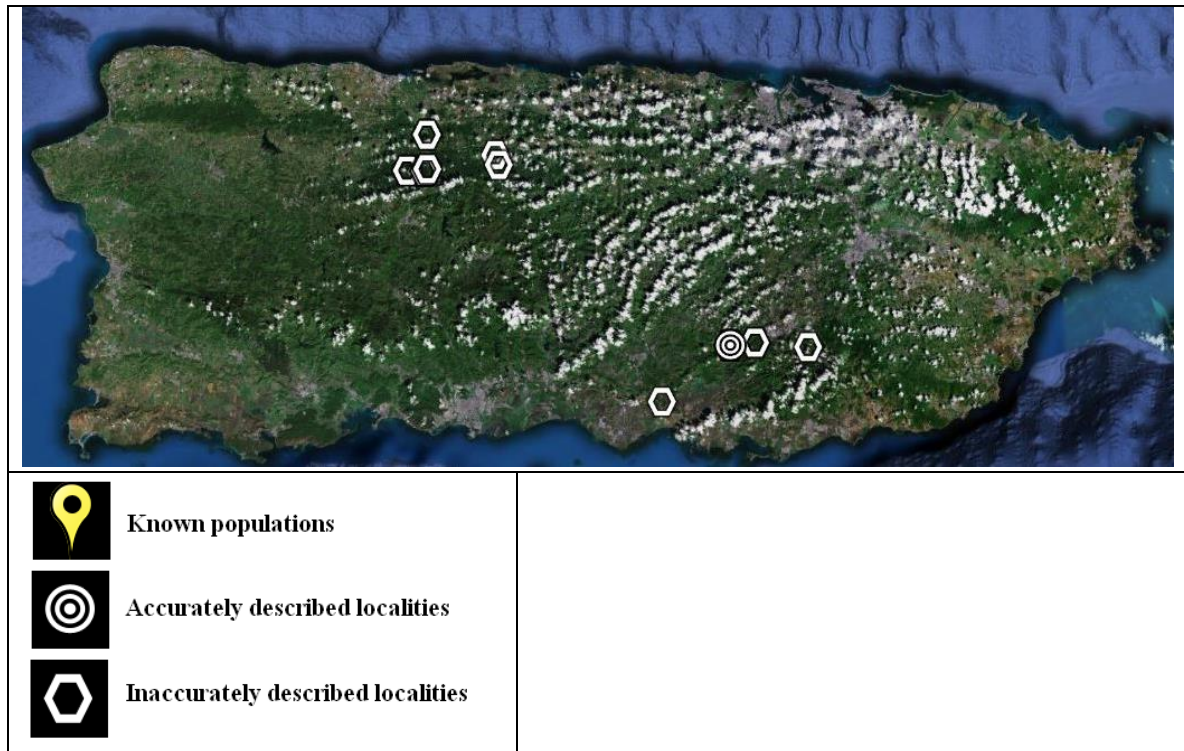


Figure 2. Available specimen localities from herbaria for *Solanum drymophilum*.

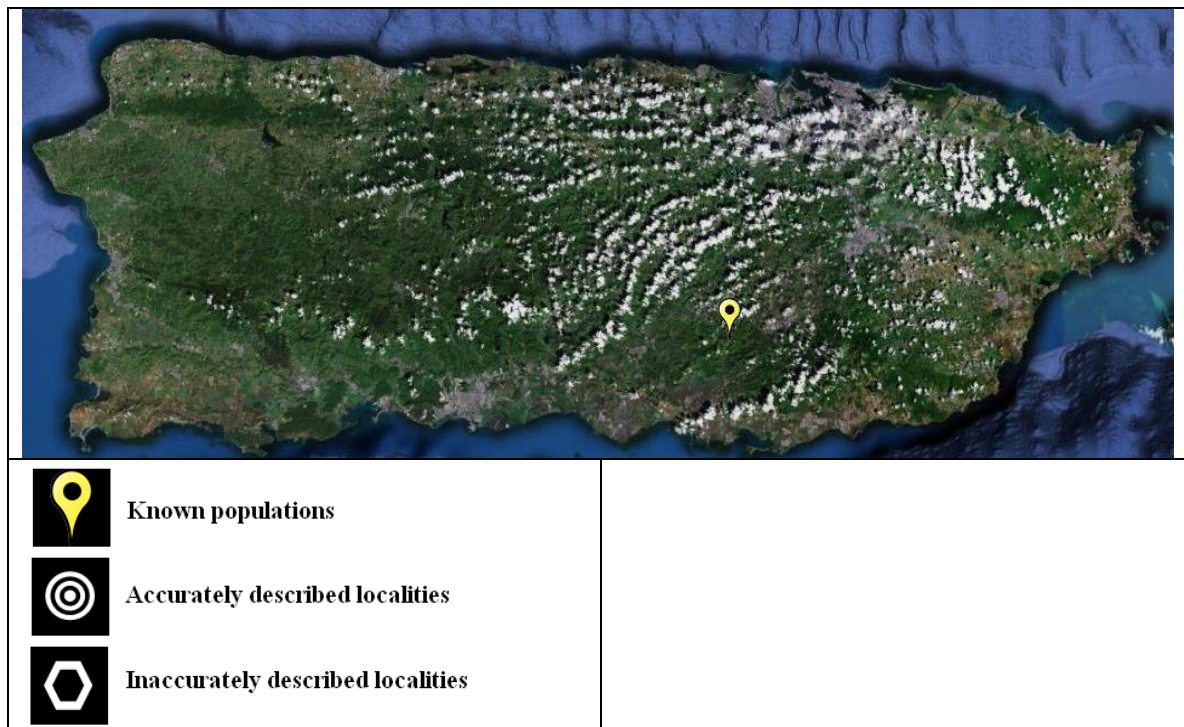


Figure 3. Reported population of *Solanum drymophilum* in the municipality of Salinas.



Figure 4. Images of *Solanum drymophilum* specimen from the MAPR Herbarium.

**e. Habitat or ecosystem conditions:**

There is no new information regarding habitat or ecosystem conditions for erubia.

**f. Other relevant information**

The PRDNER (2011) reported on their unsuccessful efforts to reintroduce erubia in the Guajataca Commonwealth Forest. They encountered difficulties in plant hardening, slow growth, poor seed availability, and fungal infection in the shade house. The seedlings that were transplanted into the forest did not survive.

**2. Five Factor Analysis**

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

Although some erubia populations occur on protected areas (e.g., Río Abajo Commonwealth Forest), most of the known populations occur on privately-owned lands that could be affected directly or indirectly by urban development or lack of appropriate habitat management.

Piedras del Collado is a Natural Reserve managed by the Puerto Rico DNER. However, the erubia population is located outside the protected area. Based on our analysis of aerial views through Google map timeline (from 1994-2014 in Google Earth), the area is



subject to urban projects, telecommunication towers and tourist attractions that may pose a threat to the habitat of erubia. The possible expansion of these existing projects may result in habitat modification such as erosion and human induced fires (see Factor E below for more information on the threat by human induced fires). These projects are located on the same slope where erubia is located. The expansion of existing construction projects or new construction in the area could destabilize the topography and cause erosion and landslides. Moreover, these developments contribute to the fragmentation of the habitat preventing connectivity with other undetected erubia populations in the area.

Although we do not have a clear understanding on what would be the optimal habitat condition for erubia to thrive (i.e., population expansion and recruit naturally), the most recent information indicates that erubia occurs in disturbed sites with poor soils and exposed topography (PRDNER 2013). Other individuals of the same Genus (e.g., *Solanum conocarpum*) have been found in habitat with these same characteristics. In the municipality of Florida, the two known populations occur in relatively-opened areas that have been modified for agriculture (i.e., coffee plantation) and soil extraction (e.g. quarry). These areas although disturbed by their use, had some type of land management where they provided habitat for the species (e.g. reducing the growth of vines and other vegetation). Currently, these areas are no longer in agriculture or quarry activities, and the natural growths of vegetation (e.g. vines and shrubs) have changed the vegetation structure of the area, probably affecting the recruitment of new individuals of erubia (PRDNER 2013).

The overall karst area of Arecibo, Ciales and Florida is recovering from previous land use practices, allowing the habitat to transform in mature secondary forests. Apparently the vegetation structure changes have affected erubia since the species is barely present in these areas. The low number of individuals (approximately 1 to 3 individuals) in addition to the lack of recruitment in these populations can result in the possible extirpation of erubia from these locations in the near future.

In areas near Road PR-10 (between Utuado and Arecibo), there has been road maintenance activities to repair damages caused by landslides and a project to stabilize the road. However, since Road PR-10 was constructed with Federal funds, repair activities are coordinated with the Service through section 7 consultation. Habitat modification occurring from landslides and subsequent repairs and maintenance allows invasive species to colonize impacted areas (see Factor E below for more information on the threat by invasive species), which result in habitat modification that can affect erubia. Actions such as mentioned above could modify the habitat and affect individuals of erubia directly and indirectly; however, we do not have evidence that these activities are currently occurring and affecting individuals of erubia.

Based on the above information, we believe that potential urban development or expansion of existing constructions, habitat modification caused by road maintenance, landslides, overgrowth of vegetation and the lack of site management are threats to erubia. However, these threats are non-imminent and of low magnitude.

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

Overutilization for commercial, recreational, scientific or educational purposes was not considered to be a threat to the species at the time of listing. Currently, there is no evidence that erubia is being affected by this factor.

**(c) Disease or predation:**

Disease or predation was not considered to be a threat to the species at the time of listing. Currently, there is no evidence that erubia is being affected by any disease or predation. Therefore, we do not consider this factor as a current threat to the species.

**(d) Inadequacy of existing regulatory mechanisms:**

The inadequacy of existing regulatory mechanisms was considered to be a threat to erubia at the time of listing. However, currently there are laws and regulations that protect federally and locally listed species.

Following listing, erubia acquired protection under the Endangered Species Act of 1973, as amended. In 1999, the Commonwealth of Puerto Rico approved Law No. 241, also known as *Nueva Ley de Vida Silvestre de Puerto Rico* (New Wildlife Law of Puerto Rico). The purpose of this law is to protect, conserve, and enhance both native and migratory wildlife species, declare as the property of Puerto Rico all wildlife species within its jurisdiction, regulate permits, hunting activities, and exotic species, among other activities. This law also has provisions to protect habitat for all wildlife species, including plants.

In 2004, the Puerto Rico Department of Natural and Environmental Resources (PRDNER) approved the *Reglamento 6766 para Regir el Manejo de las Especies Vulnerables y en Peligro de Extinción en el Estado Libre Asociado de Puerto Rico* (Regulation 6766 to regulate the management of threatened and endangered species in the Commonwealth of Puerto Rico). Erubia was included in the list of protected species of this regulation and designated as endangered. Article 2.06 of Regulation 6766 prohibits collecting, cutting, removing, among other activities, listed plant individuals within the jurisdiction of Puerto Rico.

Nonetheless, suitable habitat for erubia extends to private properties. The enforcement of laws and regulations on private lands continues to be a challenge as accidental damage or extirpation of individuals has occurred with other federally listed species due to lacks of knowledge of the species by private landowners and not enough law enforcement officers. However, at this time we are unaware of any damage occurring to erubia on private properties. Therefore, based on the presence of Commonwealth and Federal laws

and regulations protecting this species, we do not consider the inadequacy of existing regulatory mechanisms as a threat to erubia.

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

Erubia is a plant that seems to thrive in disturbed habitat with open canopy. However, there are natural and manmade factors that affect its survival.

It is known that people have intentionally cut down and eradicated erubia to protect livestock from this spiny shrub (PRDNER 2004). Also, erubia might be confused with its close relative, *S. bahamense*, or other spiny shrubs that are considered to be a “weed”; hence it might be cut down or killed with herbicides. Currently, we do not have information on the frequency of occurrence of this action, so we do not know how big an impact this possible threat is or if it still exists. Furthermore, there have been observations that horses are found in the area where erubia is known to exist and they modify the vegetation by grazing, thus creating openings for invasive species that may outcompete native vegetation (PRDNER 2004).

Fire is not a natural event in subtropical moist or wet forests in Puerto Rico. Therefore, vegetation in the Caribbean is not adapted to fires since this disturbance does not naturally occur on these islands (Brandeis and Woodall 2008; Santiago-García et al. 2008). Human-induced fires could modify the landscape by promoting exotic trees and grasses, and by diminishing the seed bank of native species (Brandeis and Woodall 2008). For example, the exotic *Megathyrsus maximus* (guinea grass) is well adapted to fires and typically colonizes areas that were previously covered by native vegetation. In fact, the presence of this species increases the amount of fuel, hence the intensity of fires.

Currently, human induced fires are a threat to erubia, particularly in the municipalities of Salinas and Cayey, where fire events occur on a yearly basis. These events directly affect the slopes of the Piedras del Collado, promoting the establishment of exotic invasive species (e.g., *Leucaena leucocephala* and *Megathyrsus maximus*), which directly threaten individuals of erubia and its habitat by invading those disturbed areas. Non-native species can be very aggressive and compete with native species for sunlight, nutrients, water, and ground cover. Once established, these alien species dominate the landscape, and the novel forest is characterized by a decrease in the number of endemics (Lugo and Helmer 2003). The impacts of invasive species are among the greatest threat to the persistence of native rare species and their habitat (Thomson 2005). Therefore, damage caused by fires to the ecosystems, particularly to juvenile plants, might be irreversible. Adding invasive species would exacerbate the threat to the species.

Furthermore, changes in climate can have a variety of direct and indirect impacts on species, and can exacerbate the effects of other threats. Rather than assessing climate change as a single threat in and of itself, we examined the potential consequences to species and their habitats that arise from changes in environmental conditions associated with various aspects of climate change. Vulnerability to the effects of climate change is a

function of sensitivity to those changes, exposure to those changes, and adaptive capacity (IPCC 2007, Glick et al. 2011).

An expected effect of climate change is the increase in intensity of hurricanes and tropical storms, followed by extended period of drought (IPCC 2007). These events may alter the surrounding vegetation around the populations of erubia. Hurricanes followed by extended periods of drought may result in changes in soil conditions and microclimate and may allow other plants (native or non-native, herbaceous or woody) adapted to drier conditions to become established (Lugo 2000). As previously mentioned, invasive species such as *Leucaena leucocephala* and *Megathyrus maximus* may spread and colonize the habitat of erubia, and could increase the frequency and intensity of fires, and alter the microclimate and nutrient cycling of the habitat that the species depends on. The threats to erubia could be exacerbated due to the small size of the populations, low number of individuals, and its occurrence at montane elevations where higher impacts are expected because winds may be stronger and with the rain events of the storms rain events could cause landslides.

Due to its limited distribution and number of natural populations, we consider the cumulative effects of human induced fire, exotic invasive plant species, and climate change is detrimental to erubia as a whole. The population dynamics of the species is poorly known. Furthermore, there is lack of natural recruitment, poor survivorship in nurseries, and apparent low seed bank. The lack of information certainly limits our ability to develop actions for the recovery of the species and to determine what constitutes a viable population to enhance the erubia's recovery in the wild.

### 3. Synthesis

Erubia was listed as endangered in 1988. The species is currently known from three locations: Piedras del Collado (i.e., Tetas de Cayey) in the municipality of Salinas, within and adjacent the boundaries of the Río Abajo Commonwealth Forest in Arecibo, and near Road PR-140 in the municipality of Florida.

Presently, the overall status of the species in Puerto Rico is unknown. Since 1991, the information regarding the species' status, population trends, phenology, habitat requirements, and the status of its habitat is limited. Comprehensive field surveys on erubia should be conducted in areas where the species was traditionally found and in non-traditional sites that based on current knowledge may harbor suitable habitat for the species. There is a profound lack of information on the species' biology and habitat, which has hampered recovery efforts.

Based on our analysis, erubia is currently threatened by Factor A (present or threatened destruction, modification, or curtailment of its habitat or range), and by Factor E (other natural or manmade factors affecting its continued existence). Habitat modification and degradation caused by urban expansion and lack of land (onsite) management (i.e. coffee plantations and quarry) threaten erubia. Climate change (e.g., hurricanes and tropical storms), human-induced fires, invasive species, and anthropogenic factors (e.g., direct



cutting and eradication of erubia individuals) are also considered threats to this species. Although these threats are considered non-imminent, the restricted number of populations and low number of individuals make them moderate to high in scope.

Overutilization for commercial, recreational, scientific, or educational purposes, the inadequacy of existing regulatory mechanisms and disease/predation are not current threats to erubia.

The Endangered Species Act defines as endangered any species that is in danger of extinction throughout all or a significant portion of its range. We believe that based on the information gathered during this review, erubia still meets the definition of endangered.

### III. RESULTS

#### A. Recommended Classification:

X No change is needed.

**Rationale:** The status of this species is unknown and the information we have on the species is limited.

#### B. New Recovery Priority Number: 8

**Recommendation:** Based on the information gathered for this review, we believe that the new recovery priority number for erubia is 8, which indicates the species faces a moderate degree of threat but has a high recovery potential.

### IV. RECOMMENDATIONS FOR FUTURE ACTION

1. The recovery of the species should focus primarily on the protection of the known populations and their habitat. The area where erubia exists in Las Piedras del Collado should be incorporated into the already designated natural reserve.
2. Comprehensive field surveys on erubia should be conducted within historical sites and in non-traditional sites with suitable habitat to determine the existence and distribution of the species and its current status.
3. Enhance existing populations with propagated individuals.
4. Studies should be conducted of the species' phenology and reproductive biology to figure out another way to effectively propagate the species.

5. Studies should be conducted on the patterns of genetic variation, in order to develop a plan to preserve the species' germplasm.
6. All the populations should be monitored on a regular basis, and additional visits should be made after fires, hurricanes, landslides, or other major disturbances.

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**U. S. FISH AND WILDLIFE SERVICES 5 YEAR REVIEW OF *Solanum drymophilum***

**Current Classification:** Endangered

**Recommendation resulting from the 5- Year Review:**

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

**Review Conducted by:** Maritza Vargas, Caribbean Ecological Services Field Office, Boquerón, Puerto Rico.

**FIELD OFFICE APPROVAL:**

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

Approved: 

Date

10/22/2015

**REGIONAL OFFICE APPROVAL:**

Lead Regional Director, U.S. Fish and Wildlife Service

Approved: 

Date

10/30/15

*Acting Chief Div. of Restoration & Recovery*

**Myrcia paganii**

*Myrcia paganii*

**5-Year Review:  
Summary and Evaluation**

**U.S. Fish and Wildlife Service  
Southeast Region  
Caribbean Ecological Services Field Office  
Boquerón, Puerto Rico**



**Images of specimens from the University of Puerto Rico, Mayagüez Campus  
Department of Biology Herbarium**

**5-YEAR REVIEW**  
*Myrcia paganii*

**I. GENERAL INFORMATION**

**A. Methodology used to complete the review:**

On April 9, 2010, the U.S. Fish and Wildlife Service (Service) published a notice in the *Federal Register* (75 FR 18232) announcing the 5-year review for *Myrcia paganii*, and requested new information concerning the biology and status of the species. A 60-day comment period was opened; however, no information was received from the public during that period.

Then, the Service signed a cooperative agreement with the University of Puerto Rico, Mayagüez campus (UPRM), to gather and summarize available information on *M. paganii*. Botanists from the UPRM, Drs. Duane A. Kolterman and Jesús D. China, reviewed available literature, consulted with specialists, and examined herbarium data, including specimens from the herbarium of the UPRM (MAPR), Río Piedras Botanical Garden (UPR), University of Puerto Rico at Río Piedras (UPRRP), Puerto Rico Department of Natural and Environmental Resources (PRDNER), New York Botanical Garden (NY), U.S. National Herbarium (U.S.), and University of Illinois (ILL), and prepared a report.

A Service biologist completed this 5-year review using the information provided by UPRM and that gathered by the Service since *M. paganii* was listed on September 29, 1997, including the original listing rule and the recovery plan for the species. A compendium on the rare plants of the northern karst of Puerto Rico was also used as reference for this review (Trejo-Torres et al. 2011). We did not seek additional peer review on this 5 year review since Drs. Kolterman and China, and Service biologist Omar Monsegur are leading experts on *M. paganii*. This review includes the best available information on the species.

**B. Reviewers**

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

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

**C. Background**

- 1. FR Notice citation announcing initiation of this review:**  
April 9, 2010; 75 FR 18232



2. **Species Status:** We consider the status of *M. paganii* as uncertain because no monitoring has been recently conducted to determine the status of its natural populations.
3. **Recovery Achieved 1** (1 = 0-25 % of species' recovery objectives achieved).
4. **Listing History**

Original Listing

FR notice: 59 FR 8138

Date listed: February 18, 1994

Entity listed: Species

Classification: Endangered

5. **Associated rulemakings:** Not Applicable.
6. **Review History:**

The February 18, 1994, Final Rule (59 FR 8138), and the *Myrcia paganii* and *Auerodendron pauciflorum* Recovery Plan, approved and signed on September 29, 1997 (USFWS 1997), are the most comprehensive analyses of the status of *M. paganii*, and were used as the referenced point documents for this 5-year review.

Each year the Service reviews and updates listed species information to benefit the required Recovery Report to Congress. Through 2013, we did a recovery data call that included showing status recommendations like "Uncertain" for this plant. We continue to show that species status recommendation in 5-year reviews. The most recent evaluation for *M. paganii* was completed in 2015.

7. **Species' Recovery Priority Number at start of review (48 FR 43098):** 8. At the time of listing, *M. paganii* was recognized as a species with a moderate degree of threat and a high recovery potential.
8. **Recovery Plan:**  
Name of plan: *Myrcia paganii* and *Auerodendron pauciflorum* Recovery Plan.  
Date issued: September 29, 1997.

## II. REVIEW ANALYSIS

### A. Application of the 1996 Distinct Population Segment (DPS) policy

The Act defines species to include any distinct population segment of any species of vertebrate wildlife. This definition limits listings as distinct population segments (DPS) only to vertebrate species of fish and wildlife. Because the DPS policy is not applicable to plants, it is not addressed further in this review.

## **B. Recovery Criteria**

### **1. Does the species have a final, approved recovery plan containing objective, measurable criteria?**

Yes. The species has an approved recovery plan (USFWS 1997), which establishes delisting as the recovery objective for *M. paganii*. However, the plan does not contain measurable recovery criteria for delisting. The plan neither defines the number of individuals needed for a self-perpetuating population.

### **2. Adequacy of recovery criteria**

#### **a. Do the recovery criteria reflect the best available and most up-to-date information on the biology of the species and its habitat?**

No. The plan does not include up-to-date information about the species' distribution and abundance. A few new populations have been documented since the plan was written.

#### **b. Are all of the 5 listing factors that are relevant to the species addressed in the recovery criteria?**

Yes.

### **3. List the recovery criteria as they appear in the recovery plan, and discuss how each criterion has or has not been met, citing information.**

The recovery plan specifies that *M. paganii* could be considered for delisting when:

1. Populations on privately owned land area placed under protective status.
2. New populations (the number of which should be determined following the appropriate studies) of the species, capable of self-perpetuation, have been established within protected areas such as the Guajataca Commonwealth Forest, the Cambalache Commonwealth Forest, or the Río Abajo Commonwealth Forest.

Criterion 1 has been partially met. Some of the new records of *M. paganii* are on private properties managed for conservation (i.e., El Tallonal and Mata de Plátano in the municipality of Arecibo). However, we do not know how many individuals are elsewhere in unprotected land.

Criterion 2 has not been initiated. The species has not been observed in reproductive status; hence, fruits have not been described. However, Trejo-Torres et al. (2011) reported seedlings in the Guajataca Commonwealth Forest, although the number was not specified. Propagation techniques for the species have not been developed.

These are minimum requirements and could be expanded upon if the regenerative or propagative potential of natural and ex situ populations proves to be insufficient when developed. Alternatively, if new populations of the species are discovered, it may be preferable to place greater emphasis on protection, rather than on propagation, in order to achieve the minimum number of plants necessary for recovery.

## **C. Updated Information and Current Species Status**

### **1. Biology and Habitat**

*Myrcia paganii* is a rare evergreen tree of the Myrtaceae family, endemic to Puerto Rico, which grows up to 20 m (65.6 ft) in height (Little et al. 1974, Liogier 1994). It is currently known only from few locations within the limestone hill region of northwestern Puerto Rico, where it grows at elevations of 150 to 250 m (492-820 ft) on steep hills and top of hills (USFWS 1997, Axelrod 2011, Trejo-Torres et al. 2011).

#### **a. Species' abundance, population trends (e.g. increasing, decreasing, stable), demographic features, or demographic trends**

*Myrcia paganii* was originally described from a sterile specimen collected by Sintenis in the 1880s (Little et al. 1974), and appears to occur primarily on limestone substrates. By the time the species was listed, only eight individuals in three locations were known: six individuals in a population south of the municipality of Arecibo, and two isolated individuals in the municipality of Quebradillas (USFWS 1997). In 2003, J.C. Trejo-Torres (Centro de Investigación Científica de Yucatán, México) searched for the individuals to the south of Arecibo, but did not find any (Trejo-Torres et al. 2011).

Based on the BRAHMS database (Kolterman and Chinaea 2013) and herbarium collections deposited at UPR herbarium in Río Piedras, *M. paganii* has been recorded in the municipalities of Isabela, Quebradillas, Camuy, Utuado, and Arecibo. According to Trejo-Torres et al. (2011), in 2001 Pedro Acevedo (U.S. National Herbarium, Smithsonian National Museum of Natural History) and Danilo Chinaea (UPRM) found a population of 10 individuals in the Biáfara sector in Arecibo. In 2005, during a flora and fauna study for the Senderos de Miraflores project in the Biáfara sector, Ruiz-Lebrón and Puente-Rolón also reported two populations of *M. paganii* comprised of 12-20 individuals (Departamento de la Vivienda de Puerto Rico 2009).

In work conducted during 2002-2006, Trejo-Torres et al. (2011) found a total of 103 individuals of *M. paganii*. Ninety four of these individuals were found in four different areas within the northern karst region of Puerto Rico: Guajataca Commonwealth Forest (50 individuals, some were seedlings, number not specified), the private natural reserves of Mata de Plátano and El Tallonal (22 individuals), Biáfara sector, Arecibo (18 individuals; same population found by Acevedo and Chinaea in 2001), and Piedra Gorda Ward, Plazuela sector in Camuy (4 individuals) (Figure 1). Nine other individuals were found in 2006 by M. Caraballo (UPRRP) in the Toro Negro Commonwealth Forest (Trejo-Torres et al. 2011; Figure 1).

In addition, J. Sustache (PRDNER, pers comm. 2015) provided information to the Service regarding the location of *M. paganii* in Quebradillas (1 sterile individual found at one of the proposed routes for highway PR-22), and El Tallonal (19 individuals, including adults and juveniles). According to J. Sustache, he does not have the specific location of the individuals at El Tallonal, thus we are not certain these are the same individuals reported by Trejo-Torres et al. (2011). Despite the observation of Trejo-Torres et al. (2011) of the occurrence of some recruitment, the limited information about the status of these populations is not enough to determine population trends or demographic features. In fact, Trejo-Torres et al. (2011) described the species as extremely rare.

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

There is no new information on genetics, genetic variation, or trends in genetic variation of *M. paganii*.

**c. Taxonomic classification or changes in nomenclature.**

No recent taxonomic or nomenclatural changes are known for the species. *Myrcia paganii* is the accepted name in the recent checklists for Puerto Rico (Axelrod 2011) and the West Indies (Acevedo-Rodríguez and Strong 2012). However, Trejo-Torres et al. (2011) stated that the inclusion of *M. paganii* within the *Myrcia* genus is not certain. They suggested that *M. paganii* might belong to the genus *Psidium* as suggested by the only flower of this species that has been found. Trejo-Torres et al. (2011) did not provide further supporting evidence on this regard. We do not believe that current existing information supports a change in taxonomy at this time. Nonetheless, we are aware of the information and will work with experts on this plant to get a better understanding and reach a consensus regarding its taxonomic classification.

**d. Spatial distribution, trends in spatial distribution, or historic range.**

*Myrcia paganii* was known to be endemic to the northwestern Karst region (subtropical moist forest; Ewel and Whitmore 1973) of Puerto Rico. Further populations of *M. paganii* have been recently documented within the private natural reserves of El Tallonal and Mata de Plátano in the municipality of Arecibo (Trejo-Torres et al. 2011). The core known population within the northern karst region of Puerto Rico highlights the importance of the karst habitat for the species. However, it is noteworthy the recent record of the species within the Toro Negro Commonwealth Forest (subtropical wet forest; Ewel and Whitmore 1973). This represents the first record of the species occurring on volcanic derived soils.





Figure 1. Reported populations of *Myrcia paganii* in Puerto Rico.

#### e. New information addressing habitat or ecosystem condition

Most forested areas within the subtropical moist forest life zone, where *M. paganii* primarily occurs, were extensively deforested for agriculture and charcoal production during the 19<sup>th</sup> and early 20<sup>th</sup> Centuries. The northwestern karst region of Puerto Rico appears to be the most important area for the species as it harbors several protected areas (i.e., Río Abajo, Guajataca, and Cambalache Commonwealth Forests) containing mature secondary forest and remnants of native forest that may provide suitable habitat and probably undetected populations of *M. paganii*. Similarly, areas in which agricultural practices have been abandoned and forest regeneration has occurred may provide habitat for the establishment of new populations of *M. paganii*.

However, new information indicates that the range of the species now extends to the subtropical wet forest in volcanic derived soils of the central mountain range of Puerto Rico (i.e., Toro Negro Commonwealth Forest; Trejo-Torres et al. 2011). This evidence suggests that undisturbed forest remnants within the central mountain region of Puerto Rico may also harbor undetected populations of *M. paganii*.

#### f. Other relevant information.

Liogier (1994) described the flowers and fruits of *M. paganii* as unknown. Trejo-Torres et al. (2011) indicated that the only reproductive structure of this species that has been found is a flower that was missing its petals and stambres. So far little is known about the reproductive biology of the species and there is no information related to attempts of propagation or studies related to the species phenology. Moreover, all the examined herbarium specimens and images were sterile material.

## 2. Five Factor Analysis

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

In the final rule, the Service identified habitat destruction and modification as a factor affecting *M. paganii*. Certainly, those individuals occurring in protected areas are not expected to be affected by habitat destruction or modification. However, individuals on privately-owned lands are a concern to the Service as modification of habitat can occur at any given time. During the last decade, the Service has reviewed various projects in the northern karst region of Puerto Rico, where *M. paganii* is known to occur.

At present, the Service is working with the Puerto Rico Highway and Transportation Authority (PRHTA) on a consultation under section 7 of the Endangered Species Act (ESA) for highway PR-22 in northern Puerto Rico. This highway will run through the municipalities of Isabela and Quebradillas, and one of the proposed alignments could affect *M. paganii* populations and habitat at *La Cara del Indio* area in Isabela. This project represents the main current threat to the species. Therefore, the Service, PRHTA, and the Puerto Rico Department of Natural and Environmental Resources (PRDNER) are working together to develop alternatives and conservation measures to avoid possible adverse effects from this project on *M. paganii*.

Senderos de Miraflores is another project proposed in an area near the historical *M. paganii* populations in the Biáfara sector in Arecibo. The Environmental Impacts Statement for this project highlights the presence of *M. paganii* within the boundaries of the property. Between 2006 and 2009 the Service provided comments and recommendations to avoid impacting the species. However, as of today this project has not been constructed.

Based on the above information, we believe that the present or threatened destruction, modification, or curtailment of the species' habitat or range is a low and non-imminent threat to *M. paganii*.

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

Many Myrtaceae are attractive small trees, thus *M. paganii* might have some cultivation potential. However, based on the available information, we have no evidence that this species is used for such purposes. Furthermore, there is no evidence that it has been affected by overutilization for scientific or educational purposes. Therefore, we do not consider this factor as a threat to the species.

### (c) Disease or predation:

Disease or predation was not identified as threat to *M. paganii* at the time of listing. Based on the best available information, we do not consider this factor to be a current threat to the species.

**(d) Inadequacy of existing regulatory mechanisms:**

Following listing, *M. paganii* acquired protection under the Endangered Species Act of 1973, as amended. In 1999 the Commonwealth of Puerto Rico approved Law No. 241-1999, also known as Nueva Ley de Vida Silvestre de Puerto Rico (New Wildlife Law of Puerto Rico). The purpose of this law is to protect, conserve, and enhance both native and migratory wildlife species, declare as the property of Puerto Rico all wildlife species within its jurisdiction, regulate permits, hunting activities, and exotic species, among other activities. This law also has provisions to protect habitat for all wildlife species, including plants. In 2004, the Puerto Rico Department of Natural and Environmental Resources (PRDNER) approved the Reglamento 6766 para Regir el Manejo de las Especies Vulnerables y en Peligro de Extinción en el Estado Libre Asociado de Puerto Rico” (Regulation 6766 to regulate the management of threatened and endangered species in the Commonwealth of Puerto Rico). *Myrcia paganii* was included in the list of protected species of this regulation and designated as endangered. Article 2.06 of Regulation 6766 prohibits collecting, cutting, removing, among other activities, listed plant individuals within the jurisdiction of Puerto Rico.

Nonetheless, suitable habitat for *M. paganii* extends to private properties. The enforcement of laws and regulations on private lands continues to be a challenge as accidental damage or extirpation of individuals has occurred with other federally listed species due to lack of knowledge of the species by private landowners and law enforcement officers. However, at this time we are unaware of any damage occurring to *M. paganii* on private properties. Therefore, based on the presence of Commonwealth and Federal laws and regulations protecting this species, we do not consider the inadequacy of existing regulatory mechanisms as a threat to *M. paganii*.

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

Hurricanes. As a species endemic to the Greater Antilles, *M. paganii* should be adapted to tropical storms disturbance. However, the low number of populations and individuals pose a threat to the species by making it susceptible to stochastic events such as hurricanes.

Climate Change. Vulnerability to climate change impacts is a function of sensitivity and exposure to those changes, and the adaptive capacity of the species (Glick et al. 2011). Under this scenario, the populations of *M. paganii* may be displaced or outcompeted by native or exotic species with wider environmental plasticity. Climate change may also compromise natural recruitment by affecting seed germination and/or the survival of seedlings. Nonetheless, at present there is no information regarding the competitive abilities of *M. paganii* nor its seed germination capability and survival.

Despite the low number of populations and individuals of *M. paganii*, at this time the Service considers hurricanes and climate change as a moderate and non-imminent threats

to the species. Climate change is occurring gradually and the frequency of severe hurricanes in Puerto Rico is low.

Genetic Variation. Given the very small numbers of individuals reported in wild populations of *M. paganii*, it is highly likely that its genetic variability is very low. This would result in a loss of alleles by random genetic drift (Honnay and Jacquemyn 2007), which would limit the species' ability to respond to a changing environment (Booy et al. 2000). Also, there may be genetic differences among populations. Until studies of the species' genetic variation are conducted, efforts should focus on preservation and/or propagation of multiple individuals from all wild populations. Based on the above, we consider the lack of genetic variation as a likely threat to the species.

Phenology and Breeding system. The reproductive biology of *M. paganii* is unknown, and we believe that the small and isolated populations may be affected by lack of natural recruitment. Many Myrtaceae flower sporadically and for very short periods of time. If the species is self-incompatible (not able to self-pollinate), its sexual reproduction would be severely limited. Thus, we consider the reproductive biology of the species and the small size of populations as threats to the species.

Overall, hurricanes, climate change, genetic variation, phenology, and breeding system are threats to *M. paganii*. Due to the small number and size of populations, the Service considers the cumulative effects of these threats as high in magnitude and imminent.

### **3. Synthesis**

*Myrcia paganii* was listed as endangered on February 1994. The species was known to occur only in the northern karst of region of Puerto Rico, where eight individuals in three locations had been detected at the time it was listed: six individuals in a population south of the municipality of Arecibo, and two isolated individuals in the municipality of Quebradillas. The BRAHMS database from the University of Puerto Rico, Mayagüez Campus, includes a total of eight specimens collected in the municipalities of Isabela, Quebradillas, and Arecibo. The species has been also detected in the municipalities of Camuy and Utuado. More recent specific locations includes the private natural reserves of El Tallonal and Mata de Plátano in Arecibo, Biáfara sector, also in Arecibo, and Piedra Gorda Ward, Plazuela sector in Camuy. Also, *M. paganii* was documented in the Toro Negro Commonwealth Forest. This finding represents an expansion of the know range of the species to the subtropical wet forest in volcanic derived soils. Despite more individuals have been located since the species was listed, no monitoring has been conducted. Hence, population and demographic trends and features, and phenology are unknown for the species.

Threats to *M. paganii* include habitat modification, particularly in private lands due to urban development, and road constructions. However this threat is considered low and non-imminent. Natural factors such as hurricanes, climate change, genetic variation, phenology, and breeding system are also considered threats to *M. paganii*. Despite additional populations of *M. paganii* have been reported, these threats are exacerbated by



the low number of known individuals and the limited distribution of the species. Therefore, we believe that *M. paganii* remains in danger of extinction and should continue to be protected as an endangered species.

#### **IV. RECOMMENDATIONS FOR FUTURE ACTION**

1. The recovery of *M. paganii* should focus on the protection of known populations and their habitat.
2. Conduct studies to determine the current status of wild populations. Additional visits should be made after hurricanes or other major disturbances.
3. Conduct studies on the species' phenology and reproductive biology, including its breeding system.
4. Conduct studies to determine the genetic variation in order to develop a plan to preserve the species' germplasm.
5. Currently known populations should be enhanced using seeds if available or vegetative propagation (e.g., air layering, tissue culture, etc.) if necessary. Ideally, the species' patterns of genetic variation should be known first.

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**U.S. FISH AND WILDLIFE SERVICE  
5-YEAR REVIEW of *Myrcia paganii***

**Current Classification:** Endangered

**Recommendation resulting from the 5-Year Review**

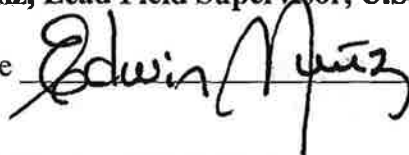
Downlist to Threatened  
 Uplist to Endangered  
 Delist  
 No change is needed

**Review Conducted By:** José A. Cruz-Burgos, Caribbean Ecological Services Field Office, Boquerón, Puerto Rico

**FIELD OFFICE APPROVAL:**

**Edwin E. Muñiz, Lead Field Supervisor, U.S. Fish and Wildlife Service**

Approve



Date

9/16/2015

**REGIONAL OFFICE APPROVAL:**

**Lead Regional Director, U.S. Fish and Wildlife Service**

Approve



Date

6/16/16

**Varronia bellonis**



# Cordia bellonis

Familia: *Boraginaceae*

## Descripción

*Cordia bellonis* es un arbusto siempreverde que puede alcanzar un altura de 6.5 pies, con ramas delgadas con vellos. Sus hojas son oblongadas y alternas.

## Información Biológica

*Cordia bellonis* ha sido encontrado en la parte occidental de la Cordillera Central de Puerto Rico en áreas abiertas expuestas al sol. En la actualidad, la población total de *Cordia bellonis* alcanza solo unos 200 individuos distribuidos en tres bosques estatales: Maricao, Susúa y Río Abajo. En 1995, la mayor parte de los individuos en Río Abajo (un 80%) fueron transferidos temporamente durante la construcción de la carretera PR 10 al Vivero de Cambalache del Departamento de Recursos Naturales y Ambientales de Puerto Rico para su eventual reintroducción.

## Distribución

*Cordia bellonis* es un arbusto endémico de Puerto Rico. En la actualidad, se puede encontrar en estado silvestre solo en los bosques estatales de Maricao, Susúa y Río Abajo.

## Amenazas

La especie está amenazada por la destrucción y modificación de hábitat, las prácticas de manejo forestal y su distribución limitada.

## Medidas de Conservación

*Cordia bellonis* fue incluida en la lista federal de especies en peligro de extinción el 10 de enero de 1997. Dicha acción requiere que las agencias federales consulten con el Servicio Federal de Pesca y Vida Silvestre antes de llevar a cabo cualquier actividad que pueda amenazar la existencia de esta especie o resulte en la modificación o destrucción de hábitat esencial para esta. El Servicio Federal de Pesca y Vida Silvestre también está considerando el desarrollo de un programa de propagación para la especie con el objetivo de poder reintroducir individuos en un futuro.

## Referencias

U.S. Fish and Wildlife Service. 1997. Endangered and threatened wildlife and plants: Determination of endangered status for the plant *Cordia bellonis*. Federal Register, 62:1644-1647.

U.S. Fish and Wildlife Service. 1998. Technical/Agency Draft Recovery Plan for *Cordia bellonis*. U.S. Fish and Wildlife Service, Atlanta, Georgia. 28 pp.

## Para Más Información

Llame al Servicio Federal de Pesca y Vida Silvestre, Oficina del Caribe, al 787/851 7297, o escriba al Apartado Postal 491, Boquerón, Puerto Rico 00622.



*Cordia bellonis*  
(no common name)

**5-Year Review:  
Summary and Evaluation**

**U.S. Fish and Wildlife Service  
Southeast Region  
Caribbean Ecological Services Field Office  
Boquerón, Puerto Rico**



**Flower of *Cordia bellonis*.  
Photo by Omar Monsegur (USFWS)**



**5-YEAR REVIEW**  
***Cordia bellonis* (no common name)**

**I. GENERAL INFORMATION**

- A. Methodology used to complete the review:** On September 27, 2006, the U.S. Fish and Wildlife Service (Service) published a notice in the *Federal Register* (71 FR 56545) announcing the 5-year review of the plant *C. bellonis*. The notice requested new information concerning the biology and status of the species and a 60-day public comment period was opened. No information was received from the public during that period.

This 5-year review was prepared by a Service biologist and summarizes the best available information that the Service has gathered on the species. The sources of information used for this review included the original listing rule for the species, its recovery plan, distribution and status reports on the plant, and published literature. The most updated information on the species consists of a master thesis by Sánchez-Cuervo (2006) and a recent research paper (2014) based on Sánchez-Cuervo work. Since this review was completed by some of the only known experts for the species, we did not seek additional peer review.

**B. Reviewers**

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

**Lead Field Office:** Omar A. Monsegur Rivera, Caribbean Ecological Services Field Office, Boquerón, Puerto Rico, (787) 851-7297, extension 217.

**C. Background**

1. **Federal Register Notice citation announcing initiation of this review:** September 27, 2006; 71 FR 56545
2. **Species Status:**  
As of the date of the publication of this 5-year review, we believe the status of *C. bellonis* is improving. The species is currently known from the Maricao, Susúa and Río Abajo Commonwealth Forests, and also extends along some localities within the northern moist karst region of Puerto Rico. The majority of the impacts to the species occur as part of trails and roads maintenance (particularly at the Maricao Commonwealth Forest). However, based on the latest assessments on the species' distribution, it is more common and

widespread within the Maricao and Río Abajo Commonwealth Forests than previously thought.

3. **Recovery Achieved** 3 (50-75 % of species' recovery objectives achieved).

4. **Listing History**

Original Listing

FR notice: 62 FR 1644

Date listed: January 10, 1997

Entity listed: species

Classification: endangered

5. **Review History:**

The January 10, 1997 final rule (62 FR 1644) and the Recovery Plan for *C. bellonis* approved and signed on October 1, 1999 (Service 1999) are the most recent comprehensive analyses of the species' status and are used as the reference point documents for this 5-year review.

At the time of listing, *C. bellonis* was known from three different locations: Maricao, Río Abajo, and Susúa Commonwealth Forests. Approximately 210 individuals were reported from these locations: 87 in Maricao, 118 in Río Abajo, and 5 in Susúa (Service 1999). The Recovery Plan for *C. bellonis* (Plan) includes the species' description and information about distribution and abundance, habitat, reproductive biology, and status of the species. Hence, the information included in the plan will not be repeated in this review. The Plan identifies habitat destruction and modification as the most significant factors affecting the numbers and distribution of the species.

Each year, the Service reviews and updates listed species information to benefit the required Recovery Report to Congress. Through 2013, we did a recovery data call that included showing status recommendations, such as "Stable" or "Improving" for this plant. We continue to show that species status recommendation as part in our 5-year reviews. The most recent evaluation for this plant was completed in 2016.

6. **Species' Recovery Priority Number at start of review (48 FR 43098):** 5

At the time of listing, *C. bellonis* was recognized as a species with high degree of threat and low recovery potential.



7. **Recovery Plan:**  
Name of plan: Recovery Plan for *Cordia alliodora*  
Date issued: October 1, 1999

## II. REVIEW ANALYSIS

### A. Application of the 1996 Distinct Population Segment (DPS) policy

The Endangered Species Act (Act) defines species to include any distinct population segment of any species of vertebrate wildlife. This definition limits listing as distinct population segments (DPS) only to vertebrate species of fish and wildlife. Because the DPS policy is not applicable to plant species, it is not further addressed in this review.

### B. Recovery Criteria

**1. Does the species have a final, approved recovery plan containing objective, measurable criteria?** The species has an approved recovery plan establishing delisting as the recovery objective. However, we still need to determine if the establishment of new populations or enhancement of existing populations is needed for the recovery of the species. If these actions are needed, the Service needs to establish the number of individuals that comprise a sustainable population.

#### 2. Adequacy of recovery criteria.

**a. Do the recovery criteria reflect the best available and most up-to-date information on the biology of the species and its habitat?**

No. The plan does not include up-to-date information about the species' biology, distribution and abundance. Knowledge about the spatial distribution and biology for the species has increased substantially since the time of listing.

**b. Are all the 5 listing factors that are relevant to the species addressed in the recovery criteria (and there is no new information to consider regarding existing or new threats?)**

Yes. All listing factors that were considered threats at the time of listing are addressed in the recovery criteria.

**3. List the recovery criteria as they appear in the recovery plan, and discuss how each criterion has or has not been met, citing information. For threats-related recovery criteria, please note which of the 5 listing factors are addressed by that criterion. If any of the 5 listing factors is not relevant to this species, please note that here.**

The plan established two delisting criteria for *C. bellonis*:

1. A management plan that considers the protection and recovery of the species has been prepared and implemented for the Maricao, Susúa, and Río Abajo Commonwealth Forests.
2. New populations (the number of which should be determined following the appropriate studies) capable of self perpetuation have been established within the protected areas.

Criterion 1 has been partially met. The Río Abajo Commonwealth Forest has an approved management plan that recognizes the presence of *C. bellonis* within the forest and highlights the conservation of this species. The Maricao and Susúa Commonwealth Forests do not have an approved management plan. Nonetheless, these forests are managed for conservation, and the prime habitat for *C. bellonis* is protected. Furthermore, Puerto Rico Department of Natural and Environmental Resources (PRDNER) listed *C. bellonis* as endangered, and included it as part of their list of critical elements. Thus, the species is supposed to receive special consideration when evaluating development actions within its suitable habitat. Nonetheless, further coordination between the PRDNER and the Service is needed to improve the long term monitoring of natural populations, and to develop guidelines on the management (propagation and reintroduction) of *C. bellonis*. Since the species is not consistently monitored, adverse impacts to the populations may occur due to forest management practices (e.g., opening of new trails and research projects).

Criterion 2 has not been met. Attempts to establish new populations have been conducted at the Río Abajo and Susúa Commonwealth Forests. However, the little information available indicates that the attempts to translocate material rescued from the right of way of highway PR-10 were unsuccessful. According to Sánchez-Cuervo et al. (2014), these efforts did not result in a self-sustainable population and the majority of the plant material did not survive. Additionally, despite the propagation potential of *C. bellonis*, it is important to determine the minimum number of individuals to establish self-sustainable populations based on the species dioecious reproductive biology (separate sexes), and better define the criteria for the selection of reintroduction sites.

### **C. Updated Information and Current Species Status**

## 1. Biology and Habitat

- a. **Is there relevant new information regarding the species' abundance, population trends, demographic features, or demographic trends? Yes.**

**Species abundance:** Approximately 210 individuals of *C. bellonis* were reported at the time the recovery plan for the species was approved in 1999. In 2006, Sánchez-Cuervo studied some aspects of the population and reproductive ecology of *C. bellonis* in the Maricao Commonwealth Forest. Her research also included a population assessment of the known populations at the Río Abajo and Susúa Commonwealth Forests. Research localities were selected based on previous studied areas by Drs. Breckon and Kolterman from the University of Puerto Rico, Mayagüez Campus (UPRM; 1993, 1994, and 1996), and information obtained from herbarium vouchers kept at the UPRM herbarium (MAPR). Thus, Sánchez-Cuervo's research focused on historical sites. Population survey efforts conducted by Sánchez-Cuervo included approximately 300 hours, mainly concentrated in the Maricao Commonwealth Forest. These surveys were conducted between June and December, 2004; January-December, 2005; and February 2006. Approximately 226 individuals of *C. bellonis* were reported by Sánchez-Cuervo (2006) from the Maricao (192), Río Abajo (34) and Susúa (0) Commonwealth Forest. However, initial surveys under an ongoing project between the Service, PRDNER and the Royal Botanical Garden (KEW) to determine the population status of *C. bellonis* (Coop. Agreement F15AC01225) shows that as of the day of this review there are at least 275 detected individuals within the Maricao (255) and Río Abajo Commonwealth Forest (20), with further surveys planned along the northern karst and the Susúa Commonwealth Forest (Hamilton 2017).

As the sections below detail, here is a summary from each Commonwealth Forest:

<b>Maricao</b>	<b>Rio Abajo</b>	<b>Susúa</b>
2006 – 192 individuals	1994 – 118 individuals	1992 – 5 individuals
2016 – 255	2006 – 34 individuals	2006 – none found

individuals	2012 – none found	2014 – none found
2017 – further surveys to proceed and more individuals are expected to be found	2016 – 34 individuals 2017 - further surveys to proceed and more individuals are expected to be found	Further surveys to proceed soon in this forest

Maricao Commonwealth Forest:

According to the data collected by Sánchez-Cuervo (2006), the highest concentration of individuals of *C. bellonis* was found within the Maricao Commonwealth Forest. A total of 84 adults and 108 seedlings were found in five main areas within the Maricao Commonwealth Forest, ranging from a single individual to small groups. From these 192 individuals, approximately 158 were reported as new individuals (non-registered in previous surveys by Breckon and Kolterman): 14 males (8.8%), 8 females (5.06%), 28 non-reproductive (no flower production during the study period) adults (17.72%), and 108 seedlings (63.35%). However, the latest surveys under Coop. Agreement F15AC01225 (2016-2017) detected at least 255 plants (different size classes) at Maricao, with the caveat that surveys were limited to accessible areas, and there are several watersheds with pristine vegetation and suitable habitat that remains unexplored, and thus the number of individuals is expected to be greater (Hamilton 2017). Further surveys under this agreement are planned to target these areas that remain unexplored.

Río Abajo Commonwelath Forest:

*Cordia bellonis* was unknown from the Río Abajo Commonwealth Forest until it was found in 1994 during the construction of road PR-10. Approximately, 118 individuals were found in 12 localities along the project right of way at that time. Ninety-five (82%) of these individuals were removed and transferred to the PRDNER tree nursery at the Cambalache Commonwealth Forest for future reintroduction in suitable sites (Puerto Rico Highway Transportation Authority, 1995). In February 1997, sixteen additional plants were removed from the project area for future reintroduction at the project mitigation site within the Río Abajo Commonwealth Forest. From these 111 individuals, only 61 survived at the Cambalache nursery, and were later introduced in four locations within the mitigation site at the Río Abajo Commonwealth Forest during 2002 and 2003. Only 34 of these individuals of *C. bellonis* were observed by Sánchez-Cuervo (2006) during her visits to the Río Abajo Commonwealth Forest in August 2004, and July and November, 2005. According to Sánchez-Cuervo et al. (2014) during a subsequent follow-up assessment in 2102 to follow up on the status of individuals



previously surveyed on 2006, no individuals were found, leading them to suggest a complete extirpation of the species from the Río Abajo Commonwealth Forest. However, the latest information available to the Service indicates that the species may be more common and widespread within the Río Abajo Commonwealth Forest than previously thought. This species has been recently recorded in this forest by the Service at Los Puercos, Las Perdices, and Santa Rosa Power Station (O. Monsegur, Service, 2008-2015, pers. obs.). These observations included reproductive material (flowering plants) and several seedlings, and these records were not associated to previously known sites or the mitigation areas from the construction of road PR-10. Moreover, the recent surveys (2016-2017) under Coop. Agreement F15AC01225 recorded at least 20 plants (different size classes) at several sites within the Río Abajo Commonwealth Forest, thus confirming the species still occurs within this protected area (Hamilton 2017). One of the individuals was located at one of the reintroduction sites of material translocated from PR-10. As the case of the Maricao Commonwealth Forest, there is plenty of suitable habitat at the Río Abajo Commonwealth Forest that remains unexplored and further surveys are planned.

#### Susúa Commonwealth Forest:

The species was reported for the first time in the Susúa Commonwealth Forest in 1992 where a small population of 5 individuals was recorded (Breckon and Kolterman 1993). This area was also visited by Sánchez-Cuervo (2006) and (Sánchez-Cuervo et al. 2014) but no individuals of *C. bellonis* were found. Since these assessments were limited to the previously known locality, the Service cannot conclude the species is extirpated from the Susúa Commonwealth Forest. There is plenty of suitable habitat for the species within this forest, and the areas have not been properly surveyed. Habitat conditions at the northernmost boundaries of the Susúa Commonwealth Forest are similar to Maricao Forest, and surveys of suitable habitat are planned for 2017 under Coop. Agreement F15AC01225.

**Population trends:** As reported by Sánchez-Cuervo (2006), the number of populations of *C. bellonis* in historical areas (within these three Commonwealth Forests) showed a considerable overall reduction (68%) between 1990 and 2005. According to her population estimates, the Maricao population was reduced 61%. The adult population once reported along road PR-120 was reduced by 38%, and the one reported close to the Maricao fish hatchery was reduced by 91%. In addition, the individuals (21) once reported from

road PR-362, also in Maricao were not found. Other areas such as the trail to “Casa de Piedra” (2 plants), and the Maricao River area (11 plants) following the same route previously reported by Breckon and Kolterman (1993), were also visited but not found, except for one individual in the Maricao River location. Although Sánchez-Cuervo (2006) reported a population reduction in the Maricao Commonwealth Forest, her results indicate a reduction only from historical locations (traditional sites) previously reported by Breckon and Kolterman (1993). Breckon and Kolterman reported *C. bellonis* from 17 localities in three main areas within the forest. The data presented by Sánchez-Cuervo (2006) indicates that the species is currently present in 46 localities in 5 main areas of the forest, and thus it is more widespread within the forest. Nevertheless, it is important to highlight that this reduction from the historical sites may be the result of the biology of the species. *Cordia* species are considered early colonizers and gap species, so a reduction in the number of individuals may be anticipated as the vegetation develops and the canopy closes. Moreover, the scrambling growth form (vine growing over other trees) of *C. bellonis* makes it difficult to detect the species once it reaches the canopy. In fact, the ongoing surveys under Coop. Agreement F15AC01225 indicate that the species remains present at the areas surveyed by Sánchez-Cuervo over a decade ago (Hamilton 2017). As of the date of this review the Service has no evidence of a population decline or extirpation of natural populations within the last decade.

According to Sánchez-Cuervo (2006), population trend studies conducted in Río Abajo showed that, based on the amount of individuals (118) originally reported for this locality during the 1990s, *C. bellonis* has decreased by 71%, based on the amount of individuals (118) originally reported for the Río Abajo area during the 1990s. Sánchez-Cuervo (2006) found that the number of individuals transplanted to the mitigation areas in Río Abajo decreased by 44% when compared to the original amount of individuals (61) transplanted at Río Abajo Commonwealth Forest and the amount of plants (34) found by her in 4 locations during the study period. Moreover, a follow-up assessment of this area in 2012 resulted in no individuals found (Sánchez-Cuervo et al. 2014). The overall decline of this species in Río Abajo might be associated with the construction of highway PR-10, and the translocation of plant material originally located along the construction right-of-way. Nonetheless, Service biologist O. Monsegur documented seedlings of *C. bellonis* along the dirt road that goes from the entrance to the José Vivaldi aviary to the Santa Rosa power station within the Río Abajo Commonwealth Forest (O. Monsegur, Service, 2008-2015, pers. obs.). O. Monsegur also found several mature individuals in other areas of this forest that

harbors remnants of native vegetation (i.e., Las Perdices wetland and Los Puercos trail). The current surveys under Coop. Agreement F15AC01225 confirmed the observations by O. Monsegur (2008-2015), and also documented the species at one of the reintroduction sites from material transplanted due to construction of highway PR-10. The study by Sánchez-Cuervo (2006) does not account for several new localities discovered within the municipalities of Ciales and Utuado, expanding the range of the species outside the boundaries of the Río Abajo Commonwealth Forest. The mogotes (haystack hills) from Utuado to Ciales includes an outstanding amount of habitat for the species that remains unsurveyed for the species.

Regarding the *C. bellonis* population originally reported for the Susúa Commonwealth Forest, Sánchez-Cuervo (2006) reported it as extirpated. However, she limited her surveys to the historically known population, and thus her study does not account as a comprehensive survey of the species suitable habitat at Susúa.

As stated above, the Service currently has an ongoing project in collaboration with the PRDNER and KEW to determine the population status and for gene bank development of *C. bellonis* (Coop. Agreement F15AC01225). Under this project, the species has been relocated along the traditional sites surveyed by Sánchez-Cuervo (2006), and further new localities has been identified at the Maricao and Río Abajo Commonwealth Forest, showing the species is more common than originally anticipated and that populations are stable (Hamilton 2017). This project also partners with the PR Parrot project at the Maricao Commonwealth Forest, and monitoring (2012-present) of the individuals along “Los Viveros Trail” show a stable population with evidence of natural recruitment.

**Demographic features:** Studies on the population structure conducted by Sánchez-Cuervo (2006) indicate that from the 226 individuals reported for the Maricao (192) and Río Abajo (34) forests, 9.73% were females, 13.27% males, 29.20% non-reproductive, and 47.78% were seedlings. Specific distribution in Maricao was reported as 10.93% (21) females, 15.62% (30) males, 17.18% non-reproductive individuals, and 56.25% seedlings. Sánchez-Cuervo (2006) determined that the proportion of sexes was not significantly different from 1:1. However, she assumed that this proportion could change if sexes of non-reproductive individuals are determined. According to an analysis of the spatial distribution of sexes, there is no evidence indicating that sexes are spatially distributed (distribution coefficient  $S=0.0047$ ) (Sánchez-Cuervo, 2006).

Only one female was found in the Río Abajo Commonwealth Forest by Sánchez-Cuervo (2006). At the time of her study, the rest of the population (33) was composed of non-reproductive individuals and no seedlings were observed. However, as mentioned above, the Service documented several seedlings and adult individuals in the Río Abajo Commonwealth Forest, indicating that natural recruitment is occurring (O. Monsegur, Service, 2008-2015, pers. obs.). Recent surveys (2016-2017) by the Service, PRDNER and KEW (Coop. Agreement F15AC01225) also recorded juvenile plants along “Las Perdices Trail” showing further evidence of natural recruitment (Hamilton 2017).

Sánchez-Cuervo (2006) also made observations on mortality of seedlings found under the canopy of *C. bellonis* female plants from June 2004 to February 2006 at the Maricao Commonwealth Forest. The amount of seedlings recorded for this area (108) varied due to mortality events. In June 2004, 59 seedlings were found. This amount increased in April 2005 when 49 additional seedlings were observed, but only 19 survived (Sánchez-Cuervo 2006). Data on the recruitment of new plants was also collected during this period. According to Sánchez-Cuervo (2006), recruitment does not occur every year. She noted that no recruitment occurred in February 2004 in known localities compared to 2005. The recruitment period occurred during the short dry season and the beginning of the rainy season. According to her observations, recruitment occurs in one or two months around the fructification period (February) suggesting a short latency period.

Seedling mortality was high (46%) due to natural causes (31%) and to human-induced disturbance (16%), as well. Between April and August 2005 (rainy season), the mortality rate was low compared to observations made in February 2006 (dry season) when the highest seedling mortality rate was registered (Sánchez-Cuervo 2006). Thus, seedling mortality is likely the result of water stress during droughts. Although germination season seems to be adequate, a lot of seeds did not germinate due to desiccation (or hydrologic stress). This finding is consistent with the observation by Service biologist O. Monsegur (2012), who found a germination success of less than 5% under nursery conditions.

**Species phenology:** Phenology studies were also conducted by Sánchez-Cuervo (2006) in reproductive individuals of the Maricao population. Observations were made from August 2004 to February 2005, and from August through November 2005. Information regarding the amount of individuals with buds and flowers, in addition to data collected regarding the amount or number of plants



with mature and/or immature fruits, was collected during this period. In general, the flowering period of *C. bellonis* occurs during the rainy season. According to Sánchez-Cuervo's observations, phenology behavior was very similar between years 2005 and 2004 with a slight difference in the amount of individuals with buds, flowers, and immature fruits for the same seasons. No information regarding flower production in each sex was recorded due to the amount and size of the flowers and the height of the branches.

The fructification period was recorded from the end of the rainy season and continues until the dry season (September-February). Immature fruits were synchronic from October to December and mature fruits from November to January. Sánchez-Cuervo (2006) was not able to quantify the amount of flowers and fruits per plant, however, she indicated that fruit production was minimal compared to flower production. Observations made on female individuals indicate that fruits in *C. bellonis* plants mature unequally. Female plants were seen with mature and immature fruits at the same time, and all fruits were single seeded. No evidence of fructification was observed in any male individuals (Sánchez-Cuervo 2006).

Sánchez-Cuervo (2006) also conducted diurnal and nocturnal observations during the flowering period from August to November 2004 in 3 females and 6 males to document the presence of floral visitors or pollinators. She documented 4 species of insects visiting the flowers. The most frequent visitor was a moth from the Noctuidae family (Lepidoptera), and the second most abundant species of visitor was the honey bee (*Apis mellifera* L. (Hymenoptera:Apidae)). Other two species from the Syrphidae (fly) and Pompilidae (wasp) families were also recorded. Sánchez-Cuervo (2006) also collected some specimens of the visitors to determine the presence of pollen in their bodies. Since no pollen from *C. bellonis* was detected on any insect part, it was not possible to determine the presence of a "true" pollinator for the species. These visitors caused no harm to the floral parts and there was no preference to visit either male or female plants.

Sánchez-Cuervo (2006) conducted diurnal and nocturnal observations in Maricao during the fructification period of November 2005 to determine the potential seed dispersal agents for *C. bellonis*. Her observations indicated that the majority of the fruits matured in the plant until the pericarpus (wall of the ripened fruit) was colonized or invaded by fungus and fell directly on the floor. The majority of seedlings observed were found under the canopy of female plants. According to Sánchez-Cuervo (2006), seed dispersal could be carried out by birds because of the pericarpus morphology and color of the fruit.

Sánchez-Cuervo (2006) carried out germination experiments to determine light conditions, percent of viability and mortality, and average monthly growth of seeds. A total of 60 pre-treated seeds were collected from 6 female individuals and planted in different shade conditions in January 2005. No germination occurred after three months. Further efforts were made, but no seed germinated during her experiments. Failure was attributed to two possible factors: inadequacy of substrate for planting, and low viability of seeds. Further germination trials by Service biologist O. Monsegur (2012) suggest it is very likely that the species shows a low seed viability, or may require seed scarification to germinate.

Data to obtain information on average monthly growth was collected by Sánchez-Cuervo (2006) from 40 seedlings which germinated approximately in February and March 2005 after the previous fructification season (September 2004-February 2005). Seedlings grew an average of 0.46 cm from April to May and presented an average height of 3.23 cm at the beginning of the observation period (April 2005). The highest growth rate (0.83) and an average height (5.44 cm) were recorded in October, during the rainy season. Data from material germinated at the tree nursery of the Cabo Rojo National Wildlife Refuge indicated that individuals may develop into reproductive plants in less than 2 years if maintained under nursery conditions (O. Monsegur, Service, 2012, pers. obs.).

**b. Is there relevant new information regarding the species' genetics, genetic variation, or trends in genetic variation (e.g. loss of genetic variation, genetic drift, inbreeding, etc.)?**

There is no new information on the genetics, genetic variation, or trends in genetic variation of *C. bellonis*.

**c. Is there relevant new information regarding taxonomic classification or changes in nomenclature?**

*Cordia bellonis* was traditionally lumped into the genus *Cordia*, a group of approximately 250 or more species of trees and shrubs of tropical and subtropical regions. However, recent taxonomical treatments recognized *Varronia* as a monophyletic group based on vegetative, floral, and pollen morphology (Miller and Gottschling 2007). *Varronia* comprises multi-stemmed shrubs with condensed inflorescence and evenly serrate leaves (Sánchez de Stapf 2010). *Varronia* is currently represented in the West Indies by about 66 valid species (Acevedo-Rodríguez and Strong 2012). Axelrod (2011) recognized seven species found in Puerto Rico, with *V. bellonis* and

*V. wagnerorum* being endemic to the Island, and *V. rupicola* extending to the island of Anegada, in British Virgin Islands. For the purposes of this document, we will continue using the name (*C. bellonis*) as it was published at the time of listing.

- d. Is there relevant new information regarding the species' spatial distribution, trends in spatial distribution, or historic range (e.g. corrections to the historical range, change in distribution of the species within its historic range, etc.)? Yes.**

At the time of listing, the species was known from three localities: Maricao, Río Abajo, and Susúa Commonwealth Forests. Sánchez-Cuervo (2006) studies were conducted in these three historical locations. Within these areas, the species remains segregated, finding solitary individuals in some localities and aggregates of plants comprised by no more than eleven individuals in other areas, but according to Sánchez-Cuervo (2006) observations during her visits to the Susúa Commonwealth Forest, the population (5 plants) once reported in 1992 was not present. Moreover, Sánchez-Cuervo et al. (2014) also suggested the species may be extirpated from the reintroduction sites at Río Abajo Commonwealth Forest. However, in the case of Río Abajo, the species have recently been recorded by the Service in nontraditional sites (i.e., Los Puercos trail, Las Perdices trail, and Santa Rosa Power Station). Moreover, recent surveys (2016-2017) under the ongoing collaboration between the Service, PRDNER and KEW identify further new localities at the Maricao and Río Abajo Commonwealth Forest (Coop. Agreement F15AC01225) (Hamilton 2017). The initial findings from this effort indicate the species is more common and widespread within these forests, but the scrambling growth form of the species requires greater efforts to detect the individuals.

Moreover, the latest available information to the Service from herbarium collections (MAPR, SJ and UPRRP) shows that the species has been collected in the municipality of Ciales and Utuado within similar habitat to the Río Abajo Commonwealth Forest. Both sites occur on moist limestone substrate along the northern karst region, expanding the species range outside the boundaries of the Río Abajo Commonwealth Forest. It is important to mention that botanical exploration at these new sites has been minimal, and there is a large amount of habitat that needs to be surveyed. Thus, the species is more widespread along the northern karst region of Puerto Rico.

- e. Is there a relevant new information addressing habitat or ecosystem condition (e.g. amount, distribution, and suitability of the habitat or ecosystem)? Yes.**

Some ecological characteristics of female plants in the Maricao population were studied by Sánchez-Cuervo (2006). Soil samples under the canopy of female plants with and without seedlings were taken to determine the occurrence of any factor that may influence the presence/absence of seedlings and its survival. Soils were analyzed for organic matter, phosphorus content, and pH. The results showed no significant differences in soil content and pH. These results seem to indicate that none of these factors determine seedling establishment.

Soil samples under the canopy of female plants of *C. bellonis* were also analyzed for seed bank formation. Observations made indicate that this species do not form seed banks possibly due to soil depth (low profile). Soil type may also influence the establishment of seed banks under *C. bellonis* plants. Seed producers were found in serpentine soils and Nipe and Rosario soil series. These soils are characterized by their clay-like and sticky texture, which can make the seed emergence to the soil surface difficult. However, seedbank formation may not be discarded as it has been documented for other related species such as *V. rupicola*, and this may represent a strategy to colonize areas or colonize gaps when conditions are favorable.

**f. Is there any other relevant information on species?**

Additional studies on population structure and population size included the estimation of basal diameter of plants. Reproductive adults registered a larger size distribution (1.3-2.85 cm). Data collected to compare basal diameter showed no significant differences among sexes, although according to Sánchez-Cuervo (2006) observations, male plants tend to have a smaller basal diameter if compared to female plants. Basal diameter measurements were significantly different among non-reproductive and reproductive individuals. Sánchez-Cuervo (2006) was not able to determine age at first maturity through size distribution. However, at Maricao reproductive plants were recorded from 0.5 cm basal diameter. Nonetheless, recent observations by Service biologist O. Monsegur indicate that material propagated and maintained under nursery conditions at the Cabo Rojo National Wildlife Refuge may reach reproductive size within two years. This observation is consistent with the reproductive biology of an early colonizer or gap adapted species.

**2. Five Factor Analysis**



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

When the species was listed in 1997, destruction and modification of its habitat was identified by the Service as the most significant factor affecting the amount and distribution of *C. bellonis*. The species' rarity and restricted distribution makes it vulnerable to habitat destruction and modification. In general, the species is adapted to survive in secondary successions and other zones directly or indirectly altered by human activities like fire or tree felling. *Cordia bellonis* grows on road edges and trails, in open, exposed areas since the light exposure seems to be an important factor for the flower production of the species (Sánchez-Cuervo 2006), and all available information indicates the species is a gap colonizer. The species' location along road margins makes it vulnerable to impacts associated to road management activities. According to Sánchez-Cuervo (2006), during 2004 and 2005, road maintenance activities were performed at least six times in the Maricao forest, notably affecting the individuals closer to road edges. These were reproductive individuals and seedlings. Sánchez-Cuervo (2006) indicated that 46% of these *C. bellonis* individuals were at risk of being totally eliminated due to their proximity to road edges and trails, 35% were exposed to cutting of some branches, while 19% did not present any risk at all.

Nonetheless, the latest surveys (2016-2017) by the Service, PRDNER and KEW (Coop. Agreement F15AC01225) have detected the species along multiple areas along PR-120 at the Maricao Commonwealth Forest (Hamilton 2017). These initial findings indicate the species has not been extirpated from the areas surveyed by Sánchez-Cuervo (2006), and the Service is developing a comprehensive assessment of the species and implementing a long term monitoring project. Moreover, there is an outstanding amount of habitat that remains unexplored and undisturbed, and the Service has recently identified new localities of *C. bellonis* within remote and inaccessible remnants of pristine habitat (not associated to disturbed sites or roads) in the Maricao (i.e., Maricao and Bonelli Rivers Watersheds) and Río Abajo (i.e., Las Perdices and Los Puercos Trail) Commonwealth Forests. Thus, at present time the Service considers the habitat modification as a low and non-imminent threat.

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

At the time of listing, taking for these purposes were not documented as a factor responsible for the decline of the species. Based on the best available information, we continue to consider that the species is not threatened by this factor.

**(c) Disease or predation:**

At the time of listing, disease or predation were not considered a threat to *C. bellonis*. Based on the best available information, we continue to consider that the species is not threatened by this factor.

**(d) Inadequacy of existing regulatory mechanisms:**

At the time of listing *C. bellonis* was not on the list of species protected by the Commonwealth of Puerto Rico. The inadequacy of existing regulatory mechanism was considered as a threat.

The Maricao, Río Abajo and Susúa Commonwealth Forests are protected by Law No.133 (12 L.P.R.A. sec. 191) 1975, as amended, known as *Ley de Bosques de Puerto Rico* (Forest Law of Puerto Rico), as amended in 2000. Section 8 (A) of Law No. 133, prohibits cutting, killing, destroying, uprooting, extracting, or in any way hurting any tree or vegetation within a Commonwealth forest without authorization from the Secretary of the PRDNER. These forests are also designated as Critical Wildlife Areas (CWA) by the Commonwealth of Puerto Rico. The CWA designation constitutes a special recognition by the local government with the purpose of providing information to Commonwealth and Federal agencies about the conservation importance and needs of CWAs, and assisting permitting agencies in precluding negative impacts as a result of permit approvals or endorsements (PRDNER 2005).

In 1999, the Commonwealth of Puerto Rico approved Law No. 241, known as *Nueva Ley de Vida Silvestre de Puerto Rico* (New Wildlife Law of Puerto Rico). The purpose of this law is to protect, conserve, and enhance both native and migratory wildlife species, declare as the property of Puerto Rico all wildlife species (including plants) within its jurisdiction, regulate permits, hunting activities, and exotic species, among other activities. This law also has provisions to protect habitat for all wildlife species. In 2004, the PRDNER approved Regulation 6766, *Reglamento para Regir el Manejo de las Especies Vulnerables y en Peligro de Extinción en el Estado Libre Asociado de Puerto Rico* (Regulation 6766 to Govern the Management of Threatened and Endangered Species in the Commonwealth of Puerto Rico). Article 2.06 of this regulation prohibits collecting, cutting, and removing, among other activities, listed plant individuals within the jurisdiction of Puerto Rico. *Cordia bellonis* was listed under Regulation 6766 as critically endangered.

The habitat of *C. bellonis* extends to private lands. The protection of this species within private properties continues to be a challenge as accidental damage or extirpation of individuals of federally listed species has

occurred due to lack of knowledge of the species by private landowners. However, at present we are unaware of any ongoing damage to *C. bellonis* in private properties. Therefore, based on the existence of Commonwealth and Federal laws and regulations protecting listed species, we believe the inadequacy of existing regulatory mechanisms is not a current threat to the species.

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

**Human-Induced Fires.** Fire is not a natural event in subtropical dry or moist forests of Puerto Rico. The vegetation in the Caribbean is not adapted to fires, as this disturbance does not naturally occur on these islands, and in the case of Puerto Rico, it is usually associated with human activities (Brandeis and Woodall 2008, Santiago-García et al. 2008). Human-induced fires could modify the landscape by promoting non-native trees and grasses, and by diminishing the seed bank of native species (Brandeis and Woodall 2008). In some cases, fires may maintain extensive areas of young forest and grasslands, slowing the recovery (natural regeneration) of ecosystems, and therefore, impairing the delivery of ecosystem services (Brandeis and Woodall 2008). Furthermore, the presence of non-native grasses may increase the amount of fuel and the intensity of fires. Damage caused by fires to the ecosystems, particularly to juvenile plants and natural recruitment, might be irreversible.

The limited number of known populations and the low number of individuals per population makes some populations of *C. bellonis* vulnerable to human induced fires. However, this is only considered a threat along the drier southern slopes of the Maricao Commonwealth Forest (municipalities of San German and Sabana Grande), where scattered populations may occur. These areas have not been adequately surveyed for the species due the remoteness and inaccessibility of the habitat, and thus may harbor undetected populations of *C. bellonis*. In fact, in March 2005, Sánchez-Cuervo (2006) reported various wildland fires in the Maricao Commonwealth Forest. These fires did not directly affect any of the known *C. bellonis* populations because fires occurred in drier and lower southern slopes of the forest far away from the currently known populations (historically known sites). However, Sánchez-Cuervo (2006) indicated that road widening has occurred in areas where this species has been reported to transport equipment and personnel to the areas affected by fires. Based on the above information, the Service considers human-induced fires as a low and non-imminent threat to *C. bellonis*.

**Hurricanes, Flooding, Landslides and Climate Change.** As an endemic to the Caribbean, *C. bellonis* should be well adapted to tropical

storms disturbance. However, the low number of individuals per population poses a threat to the species by making it more susceptible to stochastic events such as hurricanes. Moreover, climate change is expected to increase the frequency and strength of tropical storms (Hopkinson et al. 2008). Vulnerability to climate change impacts is a function of sensitivity to those changes (e.g., changes rain regime and moisture availability), exposure to those changes, and adaptive capacity (e.g., capacity to colonize further available habitat) (Glick et al. 2011).

It was reported by Sánchez-Cuervo (2006) that the majority of *C. bellonis* individuals (10 of 11) previously reported by Breckon and Kolterman (1993) growing along the margins of the Río Maricao were extirpated by flooding events during Hurricane Georges (1998). Further monitoring by Service biologist O. Monsegur along this area has detected only a few individuals along the river margins. Moreover, natural landslides are common within serpentine soils along the Maricao and Susúa Commonwealth Forests, and it is expected that the frequency of this disturbance increases as a result of severe rain events. Thus, individuals of *C. bellonis* growing in steep slopes and low profile soils may be affected by landslides during heavy rain events.

Despite the low number of known populations and individuals, the Service considers hurricanes and landslides as a low and non-imminent threat to the species.

**Reproductive Biology.** As previously discussed *C. bellonis* is a dioecious species (having male and female plants apart). Therefore, distance between plants of *C. bellonis* and low number of individuals per population could be a limiting factor for the species. Sánchez-Cuervo (2006) observed that three female plants did not produce any fruits during 2004 and 2005. She noticed that one of these females was located 42.5 meters away from the closest male plant within the same area. Another plant was located 940.8 meters away from the closest male plant along that same road. In general, 47% of the females are located more than 100 meters away from their closest male plant and 52% are located less than 100 meters away from its closest male individual (range = 3.5-940.8m, median = 186.4m, s.d. = 241.7). The distance between plants, in terms of dispersal of the species' genetic material, is likely to be more important as a limiting factor than fruit dispersal (Breckon and Kolterman, 1993). Pollen flow, must necessarily involve two different plants and probably occurs only over a relatively short distances. Therefore, the distance between individuals may pose a threat to the species especially due to the dioecious breeding system of *C. bellonis*. In the case of isolated individuals, these would be incapable of reproducing and may be considered as functionally extinct populations. The above highlights the threats to the species by habitat fragmentation and the lack of



connectivity between populations. Since the majority of the species' habitat remains undisturbed and further populations have been discovered, the Service considers the species reproductive biology as a moderate and non-imminent threat to the species.

### 3. Synthesis

At the time of listing, *C. bellonis* was known from three different localities: Maricao, Susúa and the Río Abajo Commonwealth Forests. Approximately 210 individuals were reported from these forests: 87 in Maricao, 118 in Río Abajo, and 5 in Susúa. Sánchez-Cuervo (2006) updated population estimates in these areas and provided new relevant information about population structure, mortality and recruitment, phenology, floral visitors, seed dispersal agents, germination and average monthly growth of seedlings. According to her findings, the species may be extirpated from the Susúa Commonwealth Forest, and some historical locations in the Río Abajo and Maricao Commonwealth Forests were not located during her research. She reported 192 individuals in Maricao and 34 individuals in Río Abajo, for a total of 226 individuals in these two forests. Of the 192 individuals in Maricao, 158 were new or not previously reported, the majority of which were seedlings. It is important to highlight that Sánchez-Cuervo's (2006) research targeted historical populations previously reported by Breckon and Kolterman (UPRM). However, as mentioned earlier the initial surveys under the ongoing project between the Service, PRDNER and the Royal Botanical Garden to determine the population status of *C. bellonis* (Coop. Agreement F15AC01225) has identified at least 275 individuals of *C. bellonis* within the Maricao (255) and Río Abajo Commonwealth Forest (20), with further surveys planned along the northern karst and the Susúa Commonwealth Forest (Hamilton 2017). According to the latest information available to the Service the species is more widely distributed throughout the Maricao and Río Abajo Commonwealth Forests, and probably in the upper watershed of Río Loco in the Susúa Commonwealth Forest (Hamilton 2017). Service staff has also identified new populations within nontraditional sites at the Río Abajo Commonwealth Forest. Moreover, the distribution of the species in northern Puerto Rico has expanded, and now extends to the municipalities of Ciales and Utuado. Both in Maricao and Río Abajo forests, there is clear evidence of natural recruitment of the species, and different size classes (seedling, juveniles and adults) are present.

Destruction and modification of habitat continue to be a threat to the species. Sánchez-Cuervo's suggested that 46% of *C. bellonis* individuals are at risk to be totally eliminated due to its proximity to road edges and trails, and 35% are exposed to be affected by the cutting of branches. However, this threat is limited to historical localities located along road

and trails subject to maintenance within the Maricao Commonwealth Forest. Even so, the Service is not aware of a substantial decline in the number of individuals due to habitat modification. For example, monitoring of individuals over a period of 5 year (2012-2016) along “Los Viveros Trail” in the Maricao Commonwealth Forest showed no evidence of population decline or extirpation of the approximately 40 individuals known along the trail, and there is evidence of recruitment of new individuals. Moreover, these sites has been reevaluated as part of the ongoing monitoring (2016-2017), and confirming this population is stable (Hamilton 2017). These surveys have relocated the majority of the populations at the sites surveyed by Sánchez-Cuervo (2006) along PR-120, and found no extirpation has been recorded at these sites (Hamilton 2017).

Another factor that may pose a threat to *C. bellonis* is the distance between individuals because of the plant dioecious breeding system in which isolated individuals would be incapable of sexual reproduction. Distance between plants may limit the exchange of genetic material and pollen transfer. Nonetheless, as previously mentioned, recent surveys and observations indicate the species is more widespread and common within its habitat, and there is plenty of suitable habitat that may harbor undetected populations, and provides for the recovery of the species. Thus, the Service considers all the above mentioned threats as low and non-imminent. The Service is currently conducting a comprehensive survey of the species prime habitat in collaboration with other partners (PRDNER and KEW) in order to identify new populations and update the species distribution and abundance. Monitoring of the populations since 2010 has not recorded any population decline or unusual mortality of individuals at the known populations in the Maricao Commonwealth Forest, and the species has been located at several new localities within the Rio Abajo Commonwealth Forest.

### III. RESULTS

#### A. Recommended Classification:

- Yes, downlisting to Threatened.
- Yes, uplisting to Endangered.
- Yes, delist.
- No, no change is needed.

As mentioned in this review, the species appears to be more widespread within its habitat. The prime habitat for *C. bellonis* is already protected, and is one of the best remnants of native vegetation in Puerto Rico. It is important to highlight that this species survived the almost entire deforestation of Puerto Rico with less than 6% of

remaining forested by the 1930s, compared to the current trend of over 50% of the island covered by forest. The original low number of individuals and mortality associated to habitat disturbance appear to be a bias toward a convenience sampling along roads and trails. The prime habitat for the species occurs on steep topography and inaccessible sites. The Service is currently conducting a thorough sampling of the habitat to update the species distribution and abundance, and collecting samples for a population genetic study. The ongoing research includes the development of a habitat suitability model to determine the extant amount of suitable habitat and to identify areas that need to be surveyed. Based on the low and non-imminent threats and the above mentioned conditions, the best information available indicates the species is not on the brink of extinction and therefore, does not meet the definition of an endangered Species.

**B. New Recovery Priority Number: 14.**

Based on the information gathered for this review, we believe that *C. bellonis* has a low degree of threat and high recovery potential. Despite its dioecious reproductive biology, it is feasible to propagate the species, and one of the outcomes of the ongoing fieldwork is the identification of reproductive female individuals. Thus, a propagation protocol and program considering the species population genetics may be developed in the near future.

**IV. RECOMMENDATIONS FOR FUTURE ACTIONS**

- a. The PRDNER and the Service should develop a comprehensive survey program to inventory areas with potential habitat for *C. bellonis* in Río Abajo, Susúa and Maricao Commonwealth Forests.
- b. Studies should be conducted to determine the patterns of genetic variation within and among populations in order to develop a plan to preserve the species genetic variability.
- c. Development of a habitat suitability model for the species.
- d. Development of management plans or establishment of management practices in areas where the species occur to avoid and/or minimize impacts by road or trails maintenance activities.

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**U.S. FISH AND WILDLIFE SERVICE**  
**5-YEAR REVIEW of *Cordia alliodora* (no common name)**

**Current Classification** Endangered

**Recommendation resulting from the 5-Year Review**

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

**Review Conducted By** Omar Monsegur, Caribbean Ecological Services Field Office

**FIELD OFFICE APPROVAL:**

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

Approve  Date April 3, 2017

**REGIONAL OFFICE APPROVAL:**

**Lead Regional Director, Fish and Wildlife Service**

Approve  Date 6/13/12



