U.S. FISH AND WILDLIFE SERVICE

Draft Post-Delisting Monitoring Plan for the Puerto Rican Boa (*Chilabothrus inornatus*)

Photo credit: Father A.J. Sánchez-Muñoz (www.kingsnakke.com/westindian)

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February 2022

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Recommended Citation

U.S. Fish and Wildlife Service. 2022. Draft Post-Delisting Monitoring Plan for the Puerto Rican boa (*Chilabothrus inornatus*). South Atlantic-Gulf and Mississippi Basin Regions, GA. 17 pp.

Acknowledgements

The Draft Post-Delisting Monitoring Plan for the Puerto Rican boa was prepared by biologists of the U.S. Fish and Wildlife Service, Caribbean Ecological Services Field Office and the South Atlantic-Gulf and Mississippi Basin Regional Office.

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I. Introduction

Post-delisting monitoring is a requirement of the Endangered Species Act of 1973, as amended (Act; 16 U.S.C. 1531 *et seq*.). Specifically, Section 4(g)(1) requires the U.S. Fish and Wildlife Service (Service) to:

> *"implement a system in cooperation with the States to monitor effectively for not less than five years the status of all species which have recovered to the point at which the measures provided pursuant to this Act are no longer necessary"*

The purpose of this Draft Post-Delisting Monitoring (PDM) Plan (Plan) is to verify that the Puerto Rican boa (PR boa; *Chilabothrus inornatus*) remain**s** secure from risk of extinction after its removal from the protections of the Act. This PDM plan meets the requirement set forth by the Act by monitoring the status of the PR boa for a minimum of 5-years using population sampling events and monitoring of threats. Development of this plan will be finalized with the help of and coordination with the Puerto Rico Department of Natural and Environmental Resources (PRDNER).

II. Role of PDM Cooperators

The monitoring methodology included in this Plan is designed to detect substantial declines in the PR boa population or a change in threats of a magnitude to trigger the need for action or revisit its status. The primary goal of this plan will be accomplished through cooperation with the PRDNER, along with some assistance by other U.S. government agencies and non-government organizations.

Puerto Rico Department of Natural and Environmental Resources

The PRDNER is committed to the conservation, protection, and management of the State's natural resources. Under the Act Section 6 Cooperative Agreement between the Service and PRDNER, the PRDNER has the responsibility of implementing actions to benefit federally listed species, including collaborating on post-delisting monitoring of delisted species, and upon availability, providing funding from Section 6 appropriations for PDM purposes. In addition, the PRDNER is legally mandated to implement the provisions of the State endangered species legislation to protect federally listed species. For this species, the PRDNER will collaborate on the post-delisting monitoring activities including review of draft monitoring reports and data analysis, as well collaborate on enforcement of any applicable State law or regulation under its jurisdiction to ensure protection of the PR boa, even after delisted.

U.S. Fish and Wildlife Service

The Service is required by section 4(g) of the Act to monitor, in cooperation with states, any species delisted due to recovery. The Service's participation on this PDM Plan includes regular coordination and collaboration with PRDNER and other partners for post-delisting monitoring activities and data analysis. The Service will also incorporate additional information on habitat trends and threats (as it becomes available during the monitoring period) that may help in assessing the status of the PR boa during PDM period. The Service may assist in the writing of draft PDM reports, which will be reviewed by PRDNER and

other collaborators for review and input. The Service will distribute final reports and other information to interested parties, approve and document any changes to the PDM Plan, and will conduct any necessary future status reviews of the species. Also, the Service will work with PRDNER to help find available funding for post-delisting monitoring activities and determine when the PDM is complete.

III. Summary of Species' Status at the Time of Delisting

A. Background

The PR boa is a large semi-arboreal nocturnal and nonvenomous snake endemic to Puerto Rico, with the largest recorded sizes around 2 m (6.6 ft) in length (Reagan 1984, Wiley 2003) and possibly capable of reaching larger sizes, particularly in captivity (Tolson 2018, pers. comm.). Most adult individuals in the wild will range between 1-2 m (3.3-6.6 ft) in length (Bird 1994, Puente-Rolón 2012, Mulero-Oliveras 2019), and females tend to be more corpulent than males (Puente-Rolón 2012). The dorsal coloration of the PR boa is variable and has been described from tan to reddish brown to very dark brown, with several dark bars or spots along its body, and juveniles may have a reddish color (Rivero 1998).

The PR boa uses both ambush and active foraging modes, eating smaller prey when young and mostly rats as they get larger (Rivero 1998). In general, prey items include rats, mice, bats, lizards, birds (including domestic fowl), frogs, and even land crabs and insects, which have been found in stomach contents (Rodríguez and Reagan 1984, Rodríguez-Durán 1996, Rivero 1998, Wiley 2003, Henderson and Powell 2009, Puente-Rolón 2012).

B. Distribution and Habitat

The PR boa is endemic to Puerto Rico. The species is considered widely distributed across the island and has been detected to occur within protected, rural, and developed areas (Service 2021). The PR boa is considered a habitat generalist tolerating a variety of habitat types (Reynolds et al. 2016). For example: they have been found using caves, rock walls, tree branches, rotting stumps, and buildings. They are also found in rocky areas, haystack hills ("mogotes"), plantations, and various forested areas (e.g., wet montane forest, lowland wet forest, remnant coastal rainforest, mangrove forest, wet and dry limestone karst forests, and pastureland with patches of exotic trees). In addition, they are found adjacent to forested areas, rural, urban and suburban areas, and along streams, forest, and road edges (Tolson and Henderson 1993, Joglar 2005, Henderson and Powell 2009). Likewise, cave systems and their surrounding forests are identified as particularly important because of the ecological resources available (e.g., prey, shelter, thermal gradients, mates) for the PR boa (Puente-Rolón and Bird-Picó 2004), and the high genetic diversity of PR boas using cave habitats (Puente-Rolón et al. 2013).

C. Past and Current Population Size

The PR boa was considered relatively rare by the 1900s (Stejneger 1904) and is probably less abundant now than it was in pre-Columbian times, when Puerto Rico had an extensive forest cover (Reagan 1984). However, the PR boa is more abundant today than what was reported at the time of listing (Service 2021), this is likely due in part to the increase in forested areas in Puerto Rico (Lugo and Helmer 2004; Kennaway and Helmer 2007; Parés-Ramos et al. 2008). In general, the species is found more often in the karst region of northern Puerto Rico, and less often in the dry southern region of the Island (Rivero 1998), where karst formations are less abundant. Different studies have varying density estimates for the PR boa, ranging from 1.24 to 5.6 boas/ha (1.24 to 5.6 boas/2.47 ac) (Tolson 1997; Ríos-López and Aide 2007; Mulero-Oliveras 2019). Using a current demographic projection model, it has been suggested that there may be more than 30,000 boas in Puerto Rico (Tucker et al. 2021). Details of population size and structure of the PR boa can be found in the 2021 Species Status Assessment (SSA; Service 2021).

D. Residual Threats

The PR boa occurs on both private and public land. Individuals that occur outside protected habitat may be vulnerable to deforestation and development. Although forested areas have increased in Puerto Rico, unprotected forests are susceptible to urban development, particularly those near or within urban hubs (Kennaway and Helmer 2007). Consequences of human development on boa habitat include habitat loss and fragmentation as land is deforested for development and areas of suitable habitat are increasingly isolated from each other. Direct impacts on boas include, for example: harassment, harm, and mortality due to trampling with construction and vegetation clearing machinery, road kills, predation by domesticated and feral cats and dogs, competition with other exotic species (i.e., *Boa constrictor*), and persecution by the public and poachers, among others (Service 2021). As PR boa habitat is modified and developed, it increases human-boa conflicts, thus exacerbating these direct impacts and also increasing the need to translocate boas. However, although further encroachment into PR boa habitat is expected, changes in population size within the foreseeable future are not expected to significantly change (Service 2021). For more information on PR boa's biology and threats, refer to the recently completed SSA for PR boa (Service 2021). This report incorporates the best available scientific and commercial data conducted through an in-depth review of the species' biology and threats, evaluates its biological status, and assesses the resources and conditions needed to maintain long-term viability of the PR boa.

Federal agencies are mandated to carry out programs for the conservation of endangered species under section 7 of the Act to ensure that any action authorized, funded, or carried out by a Federal agency is not likely to jeopardize the continued existence of a federally listed species. Therefore, projects with a federal nexus would no longer need to provide for the implementation of conservation measures for the PR boa. These conservation measures are designed to avoid and minimize potential effects of project actions on the PR boa and are implemented with varying degrees of success and oversight (Service 2021). In addition, the fact that the PR boa is a cryptic

species and difficult to detect suggests that not all boas are detected in any given survey; thus, it is challenging to avoid and/or detect take of the species.

Therefore, the Service will work together with PRDNER and other agencies, as needed, to develop, recommend and implement strategies that would continue to provide conservation benefits to the species after delisting. For example, the Service and PRDNER may develop an interagency plan for the species post-delisting conservation.

IV. Post-Delisting Monitoring

The proposed methods herein would serve to monitor the species to ensure the current status does not deteriorate, and if a substantial decline in the species (numbers of individuals or populations) or an increase in threats is identified, to enact measures to halt the decline so that re-proposing the species as threatened or endangered is not needed.

Therefore, the focus of the PDM Plan for the PR boa will consist of two components: (1) population surveys; and (2) threat analysis. All snakes that can be captured will be measured, sexed, implanted with a pit tag, and tail clipped for genetic sampling.

A. Population Surveys

1. The most regular PR boa surveys in the past have been conducted in caves. Caves present unique opportunities to count and sample snakes since they tend to concentrate in these habitats and have been identified as targets for conservation for the PR boa (Puente-Rolón et al. 2013). At least three caves within the northern karst region of Puerto Rico and at least one in the south region will be selected for conducting surveys at least twice per year for the entire PDM period. Additional caves can be added for sampling as needed. Researchers have continued monitoring cave ecosystems to conduct PR boa surveys, and data should become available with the implementation of this PDM.

2. Two above-ground sites (i.e., non-cave surveys) in the northern karst have been surveyed for PR boas and density estimates have been calculated for each (Ríos-López and Aide 2007, Mulero-Oliveras 2019). Both of these study areas will be resurveyed at least once during the initial PDM period using the same methodologies in order to compare density estimates across time. If the PDM period extends beyond the initial five years, the benefits of continuing non-cave surveys will be reevaluated at that time. Below we describe the methods and the timeline used in those studies:

    - Ríos-López and Aide 2007
      This study conducted diurnal and nocturnal visual surveys within five transects in the northern karst Sabana Seca area in the municipality of Toa Baja. Transects were sampled 12 times between February 2001 and March 2002 from 8:30 a.m. to 1:30 p.m. and 6:30 p.m. to 12:30 a.m. Snakes were found in three of the five transects for an estimate of 5.6 boas per hectare for each transect. At a minimum, this study will

be conducted once during the initial 5-year PDM period and would take a year to complete.

- Mulero-Oliveras 2019
  This study was conducted in the northern karst region inside Fort Buchanan from 2013 to 2017. Visual surveys were conducted during daylight (8 a.m. to 1 p.m.) and at night (7 p.m. to 12 midnight) by walking in suitable habitat and turning over possible objects used for cover. A total of 38 PR boa were captured over approximately 900 person-hours, for an encounter rate of 0.0422 boas per person-hours, estimating 1.24 to 3.78 boas per hectare. Overall PR boas were more commonly captured or seen during March and May through July. This study will be started as soon as possible during the PDM period, conducted from March to July over at least two years.

3. Another study occurred within El Yunque National Forest, which is also considered important PR boa habitat (Wunderle et al. 2004). This study incidentally encountered snakes while walking or driving in the forest from 11:30 a.m. to 9:30 p.m. during October 1996 to July 2001. A total of 72 snakes were encountered during the study period. This study will be repeated at least once during the initial PDM period, last at least two years, and be coordinated with U.S. Forest Service staff. If the PDM period extends beyond the initial five years, the benefits of repeating this survey will be reevaluated at that time.

B. Genetic Assessment

Some studies have assessed the species genetic diversity (Puente-Rolón et al. 2013, Reynolds and Puente-Rolón 2014). These studies analyzed the genetics of more than 150 PR boas throughout the island. These may be used to detect potential bottleneck scenarios, to calculate an effective population size, and to confirm occurrence from both opportunistic and focused sampling across the island over several years.

Genetic samples will be collected throughout the PDM period using both focused and opportunistic sampling. The samples will be analyzed when at least 100 samples have been collected, the sample size is sufficient to test and compare to past work, and samples represent the geographic extent of the species. Results will be available for assessment in year five of the PDM monitoring period. Samples will be collected from caves in both the northern and southern karst regions and from at least two surface populations. Samples will be stratified by municipality to ensure they are taken throughout the species range on the island and will include at least samples from several municipalities and areas previously covered by Puente-Rolón et al. 2013 and Reynolds and Puente-Rolón 2014.

Genetic analysis of these new samples will be used to assess the number of alleles,

observed heterozygosity, expected heterozygosity, and inbreeding coefficient to compare with the past studies by Puente-Rolón et al. 2013 and Reynolds and Puente-Rolón 2014.

C. Threat Surveys

Threats influencing the viability of the PR boa include habitat loss and fragmentation from development, exotic mammals (namely cats, *Felis catus*), poaching and intentional killings, inappropriate management practices, emergent diseases, hurricanes, and climate change (Service 2021). These threats involve a variety of impacts, which reduce or degrade available habitat and may have direct impacts on the species, for example, road mortality and human persecution.

Each PR boa survey will be paired with a qualitative assessment of threats, changes in threats and habitat condition since delisting, and previous site conditions. The assessment of threats should include assessment of non-native species, habitat disturbance, evidence of poaching, and other potential threats. Additionally, the PRDNER and Service will review available resources to determine any significant threats or impacts to PR boa on an annual basis. These assessments will be summarized in annual and final reports after the proposed monitoring efforts are implemented.

Snake fungal disease (SFD) is considered an emergent threat for the PR boa (Service 2021). Under a cooperative agreement with the Service, Inter American University has conducted island-wide SFD surveys and have already detected the disease in at least ten PR boas. However, these cases do not seem lethal. Samples and results take considerable time to collect and analyze. Thus, these SFD surveys should continue as needed. The results of the ongoing SFD study will be assessed by the Service and PRDNER in conjunction with other available surveys and threats assessments.

D. Habitat Surveys

The Service evaluated available habitat for the PR boa and revealed that the occurrence of PR boas within areas designated for conservation is the most important factor influencing species persistence and viability (Service 2021). In addition, cave systems and their surrounding forests are identified as particularly important because of the ecological resources available (i.e., prey, shelter, thermal gradients, copulation locations) for the PR boa (Puente-Rolón and Bird-Picó 2004), and the high genetic diversity of PR boas using cave habitats (Puente-Rolón et al. 2013). State laws and regulations offer some protection to cave ecosystems within the Karst Conservation Zone (Service 2021).

The likely future scenario for the PR boa population is some further habitat degradation and fragmentation, but the remaining habitat should still sustain an overall viable PR boa population particularly with the continued occurrence of the species within protected lands and forested cave ecosystems (Service 2021). The size of the PR boa population is not expected to abruptly change into the foreseeable

future, nor is the viability of the species as a whole expected to decline markedly within the 30-year time frame (Service 2021).

Thus, the Service will continually gather available information from coordination with partners and surveys for PR boa and other species regarding the amount and quality of the available PR boa habitat. A desktop review of habitat availability will be completed at least once a year. The Service will determine if significant changes have occurred at these times and at the end of the 5-year time period post-delisting while also assessing the potential overall effects on the PR boa population. In addition, the Service is continually engaging partners and implementing habitat conservation projects that not only benefit the PR boa, but multiple other listed and native species.

V. Definition of Response Triggers for Potential Monitoring Outcomes

Effective PDMs require timely evaluation of data and responsiveness to observed trends. In order to assure timely response to observed trends, it is necessary to identify possible outcomes from monitoring that could be anticipated and general approaches for responding to these scenarios. In order to identify thresholds that would trigger alternative responses in the case of the PR boa, it will be necessary to analyze data from the proposed surveys and to identify the range of variability that has been observed with respect to each of the variables that will be monitored during the surveys.

Throughout the PDM period, the Service, PRDNER, and partners will assess the effectiveness of current study designs and data collection and incorporate new techniques or other efficiencies as appropriate. Any modifications will be mutually agreed upon by PRDNER and the Service indicating that the changes meet the needs required of PDM and will be documented in any final reports prepared by the Service or submitted to the Service by a collaborator. The PDM analysis will be used to reassess the species' persistence and representation over that period. From the data collected and analyzed, it will be possible to categorize observations into one of the following PDM outcomes:

A. Category I

The Puerto Rican boa population and habitat remain secure without the Act's protections. This would be true if *all* of the following four conditions are met:

1. The PR boa density estimates or counts remain at least within the range of previous studies and do not decrease significantly. The PR boa is known to occur with a range of approximately 1.2 to 5.6 boas per hectare (using methods identified under survey #2, listed above) depending on, for example, the landscape where the species occurs, the suitability of habitat and threats acting upon the population.
2. The PR boa continues to have a widespread distribution and continues to occur within currently known areas and caves. Through qualitative

assessments, the amount and quality of habitat remains relatively stable or does not significantly decrease.

3. No new or increasing threats to the species are observed that are considered to be of a magnitude and imminence that may jeopardize the continued existence of the PR boa within the foreseeable future.

4. The species genetic diversity as described above (Genetic Assessment section) remains the same as presented in Puente-Rolón et al. 2013.

In this case, the PDM would be concluded at the end of the timeframe specified in this Plan (i.e., five years).

B. Category II

The PR boa population and habitat may be less stable than anticipated compared to conditions at the time of delisting, but information does not indicate that the species meets the definition of threatened or endangered. This would be true if *any* of the following four conditions are met.

1. The PR boa density estimates or counts are less than expected for a particular area based on landscape context (i.e., within or outside an urban area) (Service 2021). Density estimates or counts between 20% to 40% less than those previously observed for any given area or for the species overall would reflect a Category II outcome.
2. The PR boa continues to occupy areas designated and managed for conservation. However, the species' widespread distribution has been somewhat reduced and has been extirpated from one area where it was known to occur. The amount and quality of habitat has declined to a degree that negative impacts to the PR boa population are likely in the future if habitat trends continue.
3. There are no new or increasing threats that are considered to be of a magnitude and imminence that may jeopardize the continued existence of the PR boa within the foreseeable future.
4. The species genetic diversity, as described above (Genetic Assessment section), is 20% to 40% lower than the results in Puente-Rolón et al. (2013).

   In this case, the Service and its partners will evaluate if the PDM period should be extended for an additional five years and/or if sampling intensity or methods need to be modified to provide greater precision in detecting trends. Existing data will be analyzed to determine if any management actions should be implemented that would be expected to reverse declines and stabilize or improve population trends for the species.

C. Category III

PDM yields substantial information indicating that threats are causing a decline in the status of the PR boa since the time of delisting, such that listing

the species as threatened or endangered may be warranted. This may be true if *any* of the following four conditions are met.

1. The PR boa density estimates or counts have declined by 40% or more than expected for a particular area based on landscape context (i.e., within or outside an urban area) (Service 2021).
2. The species widespread distribution has been reduced to the point that it has been extirpated from one area designated for conservation and at least one other area where it was known to occur. The amount and quality of habitat has significantly declined to a degree that negative impacts to the PR boa population are evident in population survey results.
3. There are new or increasing threats that are considered to be of a magnitude and imminence that they could threaten the continued existence of the boa within the foreseeable future.
4. The species' genetic diversity, as described above (Genetic Assessment section), has declined by 40% or more than the results in Puente-Rolón et al. 2013.

If *any* of these conditions is true, then the Service should initiate a formal status review to assess the changes in threats to the species to determine whether a proposal for relisting is appropriate. If *all* of these conditions are true, then the Service should promptly propose that the PR boa be relisted under the Act in accordance with procedures in section 4(b)(5).

VI. Data Compilation and Reporting Procedures

Reports of any PDM activities accomplished, data collected, and results will be compiled by the Service or PRDNER or submitted to the Service and PRDNER by a collaborator after the completion of any monitoring event. These reports are to be prepared in a timely manner (due no later than 90 days after monitoring event) in accordance with this Plan to ensure that adequate data are being collected, to allow evaluation of the efficacy of the monitoring program, and to provide a periodic assessment of the status of the PR boa. Each report will synthesize all the population monitoring data and comment on observed trends and status of the PR boa with respect to the PDM outcome categories presented in Section V of this Plan. Results of the reports will be discussed among the Service, PRDNER, and any cooperators to plan next steps and determine if methodology or effort should change.

At year five, we will review the available information to determine overall population change and status with respect to threats. If the response triggers in Section V of this document are met or exceeded, the Service will consult with PRDNER to determine whether to conclude the PDM process or to pursue alternative actions. Our determination also will include, if necessary, an evaluation of the threats to the PR boa using the five factors required under the Act to list a species on the Federal List of Threatened and Endangered Wildlife and Plants.

If the decision is to conclude the PDM process, the Service and PRDNER will compile the annual report data into a final monitoring report that will be made available to the public. The final monitoring report will summarize the available data in relation to this PDM. It will include a description of the areas surveyed, the survey protocol, and updated information for the PR boa population.

VII. Estimating Funding Requirements and Sources

Post-delisting monitoring is a cooperative effort between the Service, PRDNER, and other potential partners (e.g., other Federal agencies, universities, other non-governmental organizations, and volunteers). Although the Act authorizes expenditures of both recovery funds and Section 6 grants to the States to plan and implement PDM, Congress has not allocated or earmarked any special funds for this purpose.

Funding these PDM activities will require trade-offs with other competing species needs. Most likely, much of the costs will be provided by cooperating agencies as in-kind contributions. We anticipate using grant programs to fund those activities that go beyond the resources available through in-kind services. The Service, PRDNER, and other cooperators will continue to work together to secure funding to implement this PDM plan.

Based on Service's costs associated with previous recovery monitoring efforts, the expenditures of this PDM plan would be approximately $30 to 60K in 5 years. This includes $5K to $10K per year for each survey either for caves or outside of caves, plus an additional $10K to analyze the genetic samples.

A. Anti-deficiency Act Disclaimer

Post-delisting monitoring is a cooperative effort between the Service, State governments, other Federal agencies, and nongovernmental partners. Funding of PDM presents a challenge for all partners committed to ensuring the continued viability of the PR boa following removal of protections afforded under the Endangered Species Act, as amended. To the extent feasible, the Service and our partners intend to provide funding for PDM efforts through the annual appropriations process. Nonetheless, nothing in this PDM Plan should be construed as a commitment or requirement that any Federal agency obligate or pay funds in contravention of the Anti-Deficiency Act, 31 U.S.C. 1341, or any other law or regulation.

VIII. PDM Implementation Schedule

A specific schedule will be developed in coordination with the PRDNER and other partners in order to ensure that PDM activities are completed within the established time frame. At least one complete PDM survey should be completed within the next five years. Depending on the results, more PDM surveys can be considered.

Implementation surveys for the PDM will include:

- Population surveys:

    - Cave surveys: a minimum of three caves in the northern karst region and one cave in the south region will be surveyed twice each year of the PDM period.
    - Above-ground surveys: We will repeat the visual surveys in the northern karst region at least one year for Sabana Seca, at least two years for Fort Buchanan, and at least two years in El Yunque during the PDM period to compare with past results.
- Each population survey will include a habitat and threats assessment.
- Habitat and threats information will continue to be gathered as it becomes available. Anticipated sources include research articles and other reports that assess PR boa habitat and threats as presented in the PR boa SSA (Service 2021).
- Cooperators will assess impacts related to SFD on PR boas as data are made available.
- Genetic assessment will be conducted at least once in the 5-year period. This will include a target of 100 samples representative of the range of the species and results will be compared to genetic diversity estimates from Puente-Rolón et al. (2013).

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